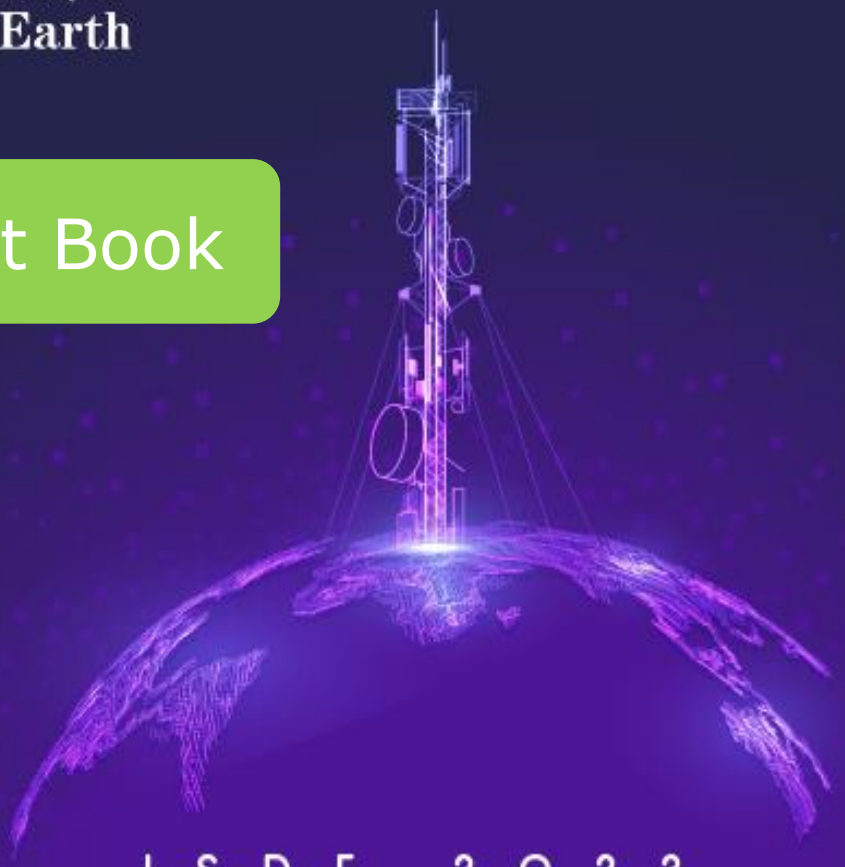
International Society for Digital Earth

Abstract Book



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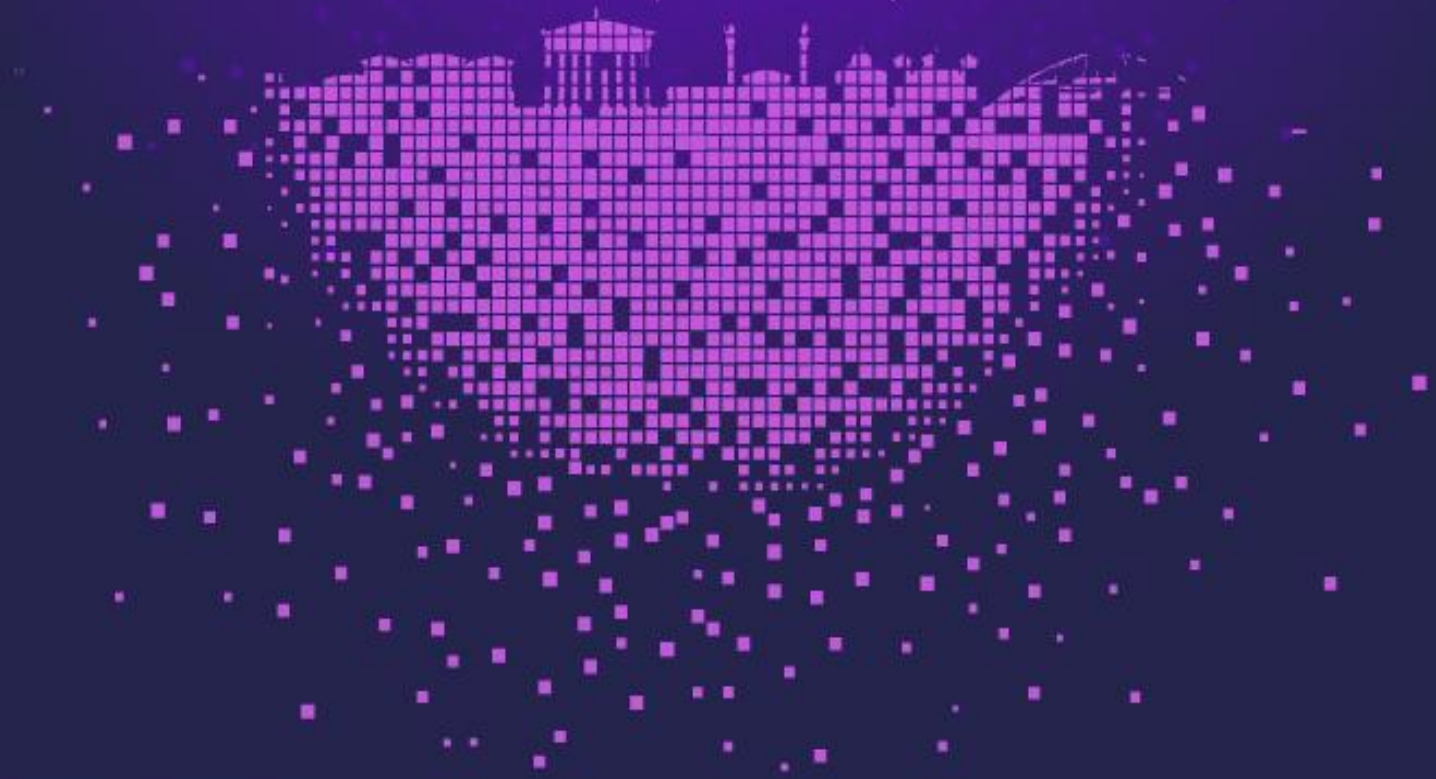

PROFESSIONAL CONGRESS ORGANIZER

ORAL PRESENTATIONS

Earth Observation for Hydrological Events A, July 11, 2023, 4:00 PM - 5:30 PM

Spatial and temporal distributions of waterlogging disasters in the summer of 2021 in Mainland China and their possible impacts

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Waterlogging is the most serious meteorological disaster affecting crops in China besides drought. The occurrence of waterlogging has a great impact on the safety of people's life and properties and the growth and development of crops. From July to August 2021, the precipitation in many places in northern China reached the historical observation extreme value, while the occurrence and development of surface waterlogging in the corresponding period and its temporal and spatial characteristics have not been effectively studied. In this study, the high-precision soil water data (0—10 cm) obtained from the daily soil water data of the soil water stations in Mainland China and the soil water daily products retrieved from passive microwave remote sensing satellite SMAP were used to calculate the soil surface relative water content combined with the soil field capacity data. The soil's relative water content of greater than or equal to 90% for 10 consecutive days was taken as the standard. The spatial-temporal distribution of the waterlogging damage in Mainland China from July 1 to August 25 in 2021 was analyzed, and the results were comprehensively analyzed on the basis of the cultivated land distribution and precipitation data in Northeast China. The results show the following. (1) Compared with the original SMAP microwave soil moisture product, the accuracy of the fused soil moisture product is significantly improved. (2) The longest duration of soil relative water content greater than or equal to 90% in paddy fields in Northeast China was 56 days, indicating that the proposed method could accurately reflect the situation of relative soil water content. (3) Northeast and Northern China were severely affected, with the most extensive waterlogging in the west part of Heilongjiang Province and the entire area of the Hebei, Henan, and Shandong provinces. The arable area affected by waterlogging accounted for approximately half of the total arable land area in China, and the area of the worst-hit area was 1.940 ×105 km2. (4) The west part of the Heilongjiang province and the Hebei, Henan, and Shandong provinces received more precipitation than in previous years, which is consistent with the waterlogging disaster areas.

Quantifying water security using hyperresolution hydrological modelling on top of an Open Data Cube (ODC)

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For many areas across the globe physically-based hydrological models have a fundamental role helping devise a comprehensive and robust plan for future climate change adaption and preparedness informing water management and flood initiatives. The current research is situated at the junction of three areas: hydrological physical modelling, satellite Earth observation data and cloud computing technology. During the past two decades the development of hydrological predictions at spatial resolution on the order of 1 km or less has been recognised as a grand challenge in hydrology. Now that the advances in satellite and sensor technology coupled with the development of cloud computing have enable the advancement of hydrology as a data-intensive science, there is a considerable impetus and interest in future research and approaches in the use of these emerging technologies to develop new insights that contribute to fundamental aspects of the hydrological sciences. This presentation will include a preliminary data pipeline integrating analysis ready data (ARD) through the implementation of the Open Data Cube data exploitation architecture with a physically-based, spatially-distributed hydrological model (SHETRAN), and a glimpse into the relevance of Earth observation data cube solutions in lowering the technology and Earth observation data barriers in the field of hyperresolution hydrological modelling.

Evaluating PlanetScope and Sentinel-2 Data in Representing Changes in Land Use and Land Cover in a Watershed

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Accurate and up-to-date mapping of Land Use Land Cover (LULC) changes is crucial for a wide range of applications, including watershed management, urban planning, in environmental monitoring, and climate change studies. This study compares the performance of the two most recent optical satellite data, PlanetScope and Sentinel-2, for LULC mapping. The study was carried out in the Imphal watershed, India. Two popular classification algorithms, namely Maximum Likelihood (ML) and Random Forest (RF) were applied. The classification accuracy was assessed using various accuracy metrics such as overall accuracy, Kappa coefficient, and user and producer accuracies. The study area was categorized into nine major LULC classes. The results showed RF performed better than ML using both PlanetScope and Sentinel-2 data. Also, Planetscope data, with an overall accuracy of over 97%, provided higher classification accuracy than Sentinel 2, which had an overall accuracy of 94%, when using the RF classifier. This suggests that PlanetScope data may be more effective for producing accurate and reliable LULC. However, further research is needed to determine the specific strengths and weaknesses of PlanetScope under different environment settings.

Monitoring Stability Features of the Three Largest Ice Shelves in Antarctica

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Ice shelves play a crucial role in supporting the stability of the Antarctic ice sheet. However, climate change is taking a toll on these vast floating platforms. Satellite observations reveal that the warming climate is causing increased melting at the surface and base of some ice shelves, including fracturing, ice front collapse, grounding line retreat and ice velocity acceleration. These processes destabilize ice shelves, accelerate ice sheet mass loss, and speed up sea level rise. The three largest ice shelves in Antarctica, the Ross, Filchner-Ronne, and Amery Ice Shelves, are located in the particularly important positions in terms of the ice sheet structure. To analyze the stability and trend of these ice shelves, we have employed remote sensing data from multiple sources and developed a new theoretical framework to extract and evaluate their key parameters. These key parameters include changes in elevation, mass balance, ice shelf front, basal melting, surface ice velocity, grounding line, and structural features such as rifts, surface meltwater, and suture zones. We have also analyzed the stability of these ice shelves by comparing with the Larsen B, Pine Island, and Totten ice shelves in Antarctica, which have been experiencing fast changes in recent years. Based on our systematic and in-depth study, our findings show that the three largest ice shelves are currently undergoing natural changes that do not threaten their stability in the short term. Nevertheless, the evolution of the ice shelves under global climate change remains uncertain, making long-term observation and monitoring essential to assess their impact on sea level rise.

Mid-term progress of SDG 13 Climate Action in China estimated from Big Earth Data

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It is warned in recent United Nations (UN) Sustainable Development Goal (SDG) report that Climate Action (SDG 13) is in most serious data shortage among all 17 SDGs, while only 20 percent of countries have data for SDG 13 until 2022. Here we use Big Earth Data, which includes remote sensing, statistics, surveying and policy analysis data, to calculate and present China's mid-term progress of 2030 Agenda. It is found that among the 5 estimated indicators (SDG 13 has 8 indicators in total), China have already achieved its 2030 target for 3 indicators including 13.1.1 loss in disasters, 13.1.2 national mitigation, 13.1.3 local mitigation, but have to face challenge in 13.3.1 climate change education, and face great challenge in 13.2.2 greenhouse gas (GHG) emission. These results estimated from Big Earth Data fill data gaps and provide spatial information for SDG 13 implementation in China, and they show that China has made great progress in disaster mitigation since 2015, but still facing great challenge in GHG emission. These achievements and imbalance will provide guidance for policy-maker in the second half process of SDG Agenda.

Desert Locust Swarms impact on the local vegetation along India-Pakistan border and their possible development trends

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The Desert Locust (Schistocercagregaria) has been an important agricultural pest at least since biblical times. Desert Locust Swarms in Northeast Africa and the India-Pakistan border swept through many countries at the end of 2019 and in early 2020. Large areas of farmland and natural vegetation were eaten, threatening local agricultural and animal husbandry production. The occurrence and development of Desert Locusts of African is closely related to climatic factors such as local precipitation (soil moisture), temperature, wind speed and wind direction. So what climatic conditions contributed to this Desert Locust Swarms? and the Locust Swarms near the India Pakistan border where is the closest Locust Swarms to China has become a hot spot for research and Chinese media. How did the Locust Swarms near the India-Pakistan border effect on the local vegetation? What is its development trend? Is it possible to fly into China? The impact of Desert locusts of the Indian-Pakistani border on local plants was analyzed by using time series satellite remote sensing data. The climatic factors connection with takeoff and migration of the Desert Locust Swarms were summarized based on past literatures, and the expansion trend of the Desert Locust Swarms and its possibility of entering China were analyzed based on the climatic characteristics such as precipitation and temperature in Africa and West Asia. It was concluded that: (1) due to the vegetation gnawing by the Desert Locust Swarms, the Normalized Difference Vegetation Index(NDVI) of the large-scale area decreased obviously compared with normal years in January and February 2020 in Indian-Pakistani border area, and the area of NDVI decreased was enlarged in February compared to January; (2) Several rare cyclones(two in 2018,one in 2019) that brought strong precipitation to eastern Africa and the Arabian Peninsula played an important role for this Africa horn-West Asia locust plague; (3) After analyzing the swarms takeoff temperature and Desert Locusts suitable breeding moisture(precipitation conditions), it suggested that the Locust Swarms had rare chance to migrate to eastern India, and it is even less likely to enter China.

The role of big Earth data in understanding climate change

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Climate-related changes have already been observed at various spatial and temporal scales, along with frequent extreme climate events and emerging issues in great complexity. Meanwhile, the impacts of climate change are expected to become increasingly more severe for more people and places as the amount of warming increases. However, great challenges and uncertainties exist in understanding climate change and its complex impacts, largely due to the limited availability and compatibility of large-scale data. Climate change research is based on multiple parameters, using global datasets that cover long time periods and that have increasingly finer temporal and spatial resolutions. As data volumes continuously expand and more parameters are considered in climate modeling and analysis, traditional spatial data management and analysis is reaching a bottleneck. There is, therefore, an urgent need to make use of big data and cloud computing to allow more integrated investigations and a synthesis of the complex changes in the climate in the context of Earth systems. Big Earth data empowered by Earth observation technology has great potential for use in the integrated analysis of climate change at global and regional scales and for supporting an informed response by human society to common challenges such as climate warming, extreme climate and weather, and climate-related disaster risks.

As the mean land surface air temperature has increased at almost twice the rate of the mean global warming rate, extreme heat events have become more frequent and more intense over major land areas, especially the vast Eurasian and African continental areas. Long-term and reliable spatial datasets are key to effectively capturing the details of large-scale heatwaves on which to base informed actions. The terrestrial biosphere and atmosphere interact through a series of feedback loops. Vegetation and land-cover types are largely determined by the dominant climate regime and are sensitive to climate change and variability. Variability in terrestrial vegetation growth and phenology can modulate fluxes of water and energy to the atmosphere, and thus affect the climatic conditions that in turn regulate vegetation dynamics. Major spatial heterogeneity exists in interactions between climate change and ecosystem dynamics, and, therefore, more reliable high-resolution datasets are essential for capturing the spatio-temporal patterns of interactive changes in the climate and terrestrial ecosystems. New generation digital Earth platform empowered by big Earth data and cloud data analysis engine is now facilitating new insight into complex climate change and its impacts.

Reference

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Analysis of the spatial-temporal variations and influencing factors of ice velocity in Greenland and Antarctica

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As an essential parameter for glaciers, ice sheets, and ice shelf dynamics, ice velocity is of great significance for assessing mass balance, climate change, sea level rise, and ice sheet stability. At present, a large number of studies on the ice flow velocity in the polar regions have been carried out. However, there is a lack of comparative analysis of the ice velocity change between the Greenland and Antarctica ice sheet. and which factor plays a major role in ice velocity change is still unclear. Based on the available ice velocity data of the Antarctic and Greenland ice sheets, this paper conducts research on the spatial-temporal variation of annual ice velocity from 2000 to 2018.

The linear trend analysis of velocity change anomalies from 2000 to 2018 indicates that the velocity change rate of the two ice sheets is consistent, that is, it has decelerated continent-wide but accelerated in local regions. Apart from that, there are potential connections between the different hydrological basins of the ice sheets with correlation coefficients greater than 0.6. Furthermore, different types of glaciers lead to different ice velocity changes. In Greenland, most of the marine-terminating glaciers (58%) are accelerating, while almost all land-terminating glaciers (97%) are decelerating and it shows a strong trend of retreat in recent decades. In comparison, there is a general acceleration of ice velocity in the area where the Antarctic ice shelf (69%) meets the ice sheet, near the grounding line. In addition, by taking the climatic conditions (temperature and precipitation), bed topography, and glacier characteristics (ice thickness and slope) as influencing factors, the Random Forest algorithm is used to rank the intensity of influencing factors on the change rate of ice velocity. The results show that ice thickness and bed topography are the dominant factors of ice velocity change under the combined action of all factors, followed by slope and climate.

Finally, this paper also discusses the development environment of different types of glaciers and their differences in sensitivity to climate change, as well as the important role played by the ocean in destabilizing glaciers. In general, the acceleration and deceleration of different types of glaciers are related to the hydrothermal environment in the regions where glaciers develop. Compared with land-terminating glaciers, the edges of marine-terminating glaciers are located in lower bed topography and have thinner ice layers. As a result, it is closer to the ocean and more vulnerable to the ocean's thermal cycle than other regions, and the glacier's ability to lose mass is stronger and accelerated. Near the marine-terminating grounding line, when the water pressure under the ice is close to the downward pressure of the ice, the ice sheet decoupling from the ice bed, reducing the foundation friction and enhancing the basement sliding, so the velocity increase near the marine-terminating grounding line is more drastic. However, the movement of land-terminating glaciers is affected by the expansion of the subglacial drainage system, and the ice flow velocity accelerates and decreases while the melting continues to increase. Besides, in Antarctica, where the ice shelf meets the ice sheet, the slope is steep and heavy ice bodies accumulate. At the same time, the interaction between the underlying surface and the ice bed is more intense. The resulting melting reduces friction, making the ice more likely to slip, and thus accelerating the ice flow more significantly. The spatial-temporal variation of ice velocity and its influencing factors provide a theoretical reference for glacier modeling.

A preliminary study on Geometric Characteristics for moon-based/spaceborne Bistatic SAR Earth Observation

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With the rapid development of earth system science, a new understanding of the complete Earth system has highlighted the crucial importance of integrated observations, especially in research involving large-scale geoscience phenomena. As a unique active sensor with all-weather and all-weather capabilities, Synthetic Aperture Radar (SAR) has been widely used in recent decades for earth observation. However, the existing spaceborne, airborne, and ground-based SAR systems are difficult to provide temporally consistent and spatially continuous geophysical data at the global scale. As Earth's only natural satellite, the Moon is a very promising Earth observation platform due to its unique orbit, vast surface, and long-term existence.

In this paper, we propose a Moon-Based/Spaceborne Bistatic Synthetic Aperture Radar (MS BiSAR), formed by a high-power transmitter on the moon and a receiver on the high-orbit satellite, for earth observation. Three contributions are made. The first is to develop the reference systems transformation of MS BiSAR earth observation, considering of Moon's and Earth's attitudes, and the position of the Moon, Earth, and satellite. Second, the simulation system and geometric model of MS SAR are established. Finally, we determine three possible MS combinations, and preliminarily analyze the geometric characteristics for MS BiSAR earth observation.

The basic geometric relationships of the moon, earth, and satellite are introduced firstly. Based on research needs, the reference system, the ephemeris, and the orbit propagators used in this paper are determined. Subsequently, the transformation process involving six reference systems is discussed and analyzed in detail. Then a simulation system and geometric model of MS BiSAR of Earth observation is established by using ephemeris and orbit propagators with reference frame transformations. The orbits of three possible receiving satellites, including geostationary orbit (GEO), inclined geosynchronous orbit (IGSO), and highly elliptical orbit (HEO), are determined. Based on the geometrical model, the earth observation geometric parameters of MS combinations, such as subsatellite points, are calculated and analyzed. Finally, the coverage of MS BiSAR is defined and calculated, and the characteristics of which are summarized.

The simulation results show that MS BiSAR can achieve large-scale observation coverage of the Earth’s surface and daily revisit of most areas, which is a significant improvement over the existing low Earth orbit satellite SAR. Meanwhile, different orbits of the receiver lead to the difference in coverage for MS BiSAR earth observation, receivers based on GEO and IGSO satellites can provide good coverage over a third of the Earth's sphere and can increase coverage at the middle and high latitudes with increasing orbital inclination. For the combination of the HEO satellite platform and lunar platform, better coverage of polar regions can be achieved. However, none of these combinations can achieve complete coverage of the Earth. To achieve global observation, a receiving constellation consisting of at least three satellites in geosynchronous orbit (GEO or IGSO) is needed. As for polar observation, at least two HEO satellites are needed to achieve coverage of Antarctica andArctic. Preliminary simulation research indicates that such an MS BiSAR could make a significant contribution to the monitoring and understanding of large-scale geoscience phenomena.

3D Mapping using Low-cost PPP-GNSS and LiDAR

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The advanced integration of cyber-space and physical-space is crucial to the realization of a super-smart society that utilizes data and the latest frontiers of science and technology, which is expected to help solve social complex systemic problems such as climate change in the world today. It is particularly important to accurately sense 'when', 'where', and 'what' is happening in physical-space. If the accuracy of sensing information is low, the accuracy of big data analysis and AI-based analysis and prediction in cyber-space will deteriorate. If the accuracy of analysis and prediction deteriorate, the accuracy of data fed back to the physical-space will also be deteriorate. It results that making impossible to properly control things and events in the physical-space.

High-precision satellite positioning technology is expected to be a key technology of sensing 'when' and 'where' in the outdoor physical-space with high accuracy. In particular, PPP (Precise Point Positioning) method, which performs high-precision positioning without using a base station, is expected to be widely used in the future due to its convenience, cost, and flexibility in positioning range.

CLAS-PPP (Centimeter Level Augmentation Service-PPP) is a positioning method that performs precise positioning by receiving positioning augmentation signals from the Japanese positioning satellite system QZSS and GEONET (GNSS Earth Observation Network System). CLAS receivers have been cost almost between USD 5,000 and USD 20,000, but last year u-blox released a new receiver NEO-D9C, a compact and lightweight CLAS receiver for around USD 100.

We demonstrated verification of the positioning accuracy using NEO-D9C and the ZED-F9P, a dual-frequency multi-system receiver. At a stationary point, we obtained a convergence of about 5 cm in the horizontal direction and about 20 cm in the vertical direction. This is much better than stand-alone positioning and slightly worse than PPK (Post Processed Kinematic) positioning. We also performed positioning of moving object. We demonstrated positioning while driving about 270 km mainly on highways, and found a fix rate of about 80%.

On the other hand, due to recent innovations in technology related to automated driving, LiDAR (Light Detection and Ranging) 3D scanner equipment that used to cost around USD 20,000 or USD 30,000 can now be purchased for as little as USD 1,000. We operated a combination of such LiDAR equipment and SLAM (Simultaneous Localization and Mapping) technology to work on real-time and 3D mapping. However, although LiDAR-SLAM can create relative 3D maps, these maps do not have geographic coordinates.

We have been promoting research on the use of CLAS-PPP to provide coordinates to the 3D map created using LiDAR-SLAM. The point cloud data obtained from LiDAR-SLAM is given multiple coordinates measured by CLAS-PPP as GCPs (Ground Control Points), and the coordinates are assigned to the entire 3D map. At the conference, we present the results of the verification of the accuracy of the 3D map obtained by this method in addition to CLAS-PPP positioning results.

Enhanced monitoring of water storage in on-farm reservoirs by combining optical remote sensing and LiDAR data

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The development of artificial reservoirs plays a significant role in regulating the spatial and temporal distribution of irrigated rainfall, ensuring sustainable agricultural development. The increasing availability of high-resolution optical and LiDAR observation makes it possible to monitor the water storage capacity of small on-farm reservoirs (OFRs). Many studies have used the area-storage relationship to estimate the storage capacity of large reservoirs, which is not effective for OFRs with nearly constant water surface areas, as detected by remote sensing data. In this study, we proposed an effective method to estimate the water storage of irrigated OFRs by combining high-resolution optical remote sensing and LiDAR data. Firstly, we accurately determined the water surface area using object-oriented segmentation based on GF-2 imageries. Then, we obtained water depth using ICESat2 data and construction data of OFRs. Finally, we estimated water storage using two different methods (i.e., the area-storage and depth-storage). Our methods perform well in calculating water storage using both water area and depth, with an accuracy of 98.8% and 95.2%, respectively. This method improves the accuracy of estimating the water storage capacity of irrigation OFRs by minimizing inaccuracies in analyzing changes in water storage capacity based solely on water area dynamics using low-resolution remote sensing optical imageries. The proposed method shows great potential for promoting the efficient utilization of irrigated water resources by observing the accurate water storage of irrigated OFRs.

Earth Observation for drought monitoring in four different biogeographical regions in Europe

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Drought is an extreme weather phenomenon that is expected to appear more frequently and severely (Slette, et al., 2019). On the one hand, droughts affect various sectors, such as ecological agricultural, and economic (Chiang, et al., 2021). On the other hand, climate change and various human activities, such as urbanization and deforestation, affect the development and severity of drought (Haile, et al., 2020). In this study, we used earth observation techniques to assess and observe drought incidents in four study areas in Europe, each of them belonging to a different biogeographical area. The biogeographical areas examined were the Atlantic (Netherlands), the Mediterranean (Greece), the Alpine, and the Continental (Italy). Intending to assess drought, we estimated the following indicators: the Normalized Difference Vegetation Index (NDVI), the Normalized Difference Water Index (NDWI), the Normalized Difference Moisture Index (NDMI), and the Modified Normalized Difference Water Index (MNDWI) over ten years. High-resolution Remotely Sensed Imagery was used for this purpose within the Google Earth Engine Platform, resulting in the spatial distribution of the above-mentioned indices over the study areas. Last but not least, a cross-case analysis was conducted to reveal and highlight common characteristics and spatial patterns of drought incidents between the four different territories, using additional information from the CORINE Land Cover (CLC) classes to depict the impact that drought has on the various land covers.

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An intercomparison of multi-typed productions for capturing the precipitation characteristics and derived agricultural drought in the Amur River Basin over the Sino-Russian border region

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Precipitation data is crucial for the researches on the agriculture production, vegetation growth, and other topics in the fields of resources, ecology, and environment. With multi-channel input from satellite/radar inversion, numerical prediction modeling, and data extrapolation from ground rain gauges, the gridded precipitation productions (PPs) were commonly applied into various scientific researches. Facing the increasing multi-typed datasets, how to validate PPs' applicability and improve their subsequent monitoring capabilities become the important links for ensuring the accuracies of the precipitation-based research. In this study, the performance of four mainstream PPs, including the European Centre for Medium Range Weather Forecasts Reanalysis V5 (ERA5), ERA5-Land, Multi-Source Weighted-Ensemble Precipitation (MSWEP), and integrated multi-satellite retrievals for Global Precipitation Mission (GPM), were evaluated for capturing the characteristics of precipitation intensity and derived agricultural drought among the crop-enrichment area over the Sino-Russian border region. Results show that: In general, GPM is the capability-balanced precipitation product in the different experimental scenarios especially with high value of RMSE, quantitative accuracy score and well identification on the seasonal precipitation intensity. ERA5-Land data had strong overall characterization abilities to depict the annual distribution from the spatial/ stationary outcomes, also obtaining the advantages in the daily multi-parameter consistency verification. while through identical evaluation by using the monthly data among different agroclimatic areas, the outstanding performances of MSWEP and GPM products are emerged in the sections of Russia and China, respectively. For the aspects of evaluating precipitation intensities and agricultural drought based on daily and monthly precipitation, GPM and MSWEP are still proven to have the finer performances based on the combined agricultural thematic areas (ATAs); however, seasonal effects and affiliated materials feature were found as the main factors in exhibiting the identification capability under the different scenarios. Despite good handling with the intensity recognition in the Eastern Chinese part, the rest capabilities of ERA5 need to be improved by extending the sources for calibrating the gauged data and the information of the dry-wet condition. Through this study, all the findings will donate to recognizing the characterization of PPs' performances and supporting the optimal production selection for this resource-rich area towards the different oriented applications.

Sustainable Development Satellite Constellation Serves UN 2030 Agenda for Sustainable Development

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The International Research Center of Big Data for Sustainable Development Goals (CBAS) is the world's first international research institution to serve the 2030 Agenda for Sustainable Development (2030 Agenda) with big data, established under the Chinese Academy of Sciences (CAS). The implementation of the 2030 Agenda is faced with an urgent need for data and methods. As an efficient means of data acquisition and scientific research, Earth Observation can make a significant contribution to the implementation of the 2030 Agenda. In 2021, the United Nations adopted the "Space2030" agenda to serve the implementation of the 2030 Agenda through space technology. Therefore, the international community needs more and better satellite data specifically for SDGs indicators to explore the mechanism and evolution of the interaction between human activities and the natural environment and their impact on human sustainable development, to systematically clarify the various factors affecting human sustainable development on Earth and explore their intrinsic links and synergies, to recognize the core of sustainable development in three dimensions: economic, social and environmental. We will also develop and evaluate policy approaches to global change, and directly serve food security, ecological and environmental protection, disaster prevention and mitigation, natural resource development, and other areas of national interest and livelihood. This will support the realization of the sustainable development agenda, enable the world to fully understand the current challenges and find more appropriate and intelligent solutions for sustainable development.

The development and operation of a series of Sustainable Development Science Satellites is one of the primary missions of CBAS. The Sustainable Development Science Satellite 1 (SDGSAT-1) is the first in the series of Sustainable Development Science Satellites operated by CBAS. To meet the needs of monitoring, evaluating, and researching on SDGs, SDGSAT-1 aims to depict traces of anthropic activities by synergetic observation day and night through its three sensors, so as to provide support for studying indicators of the interaction between human and nature and serve the realization of global SDGs. Space technology and its applications, represented by satellite Earth observation, can provide accurate and reliable information on the status and changes of earth elements such as atmosphere, ocean, rivers, soil, crops, natural resources, and infrastructure, which can help achieve the SDGs and their specific indicators.

The current Earth observation satellites can already support part of the research and application of space observation of SDGs, but they are far from meeting the scientific needs of SDGs, and many SDG targets still lack the support of space observation, especially the lack of strategic and systematic coordination and planning of satellite constellations. Analyzing the space observation needs of SDG indicators and developing the theoretical basis for SDGs constellations is a necessary way for sustainable development. In the current and foreseeable future, it is necessary to further strengthen the top-level coordination of satellites, make good technical prepositioning, and use the SDG satellite constellation to strengthen the technical reserve of integrated design, batch production, and standardized integration of multifunctional constellations; strengthen the load technology research for the composite of SDGs such as land, ocean, environment, atmosphere, and human activities; establish a complete satellite R&D, rocket launch, in-orbit management We will establish a complete industrial chain of satellite R&D, rocket launch, in-orbit management, image reception, and scientific application of SDGs, and provide effective design solutions, data and products of SDG satellite constellation for the realization of 2030 Sustainable Development Agenda by relying on science and technology innovation.

The planning of the SDG satellite constellation is based on the following five principles: (1) complementary relationship with the existing satellite observation system, effectively compensating for the deficiencies of the existing satellite observation system in SDG indicator monitoring capability; (2) advanced and feasible payload configuration; (3) scientific nature of the satellite mission; (4) satellite data and products can effectively meet the urgent demand for SDG indicators; (5) high-precision integrated monitoring of SDG targets in key regions. The construction of the Sustainable Development Satellite Constellation will provide an effective contribution to the United Nations 2030 Agenda for Sustainable Development.

Research on in-orbit detection method for moving targets of dual-line array satellite images

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In recent years, with the development of imaging sensors and the popularization of satellite constellations, both spatial and temporal resolution of optical remote sensing satellites has been rapidly improved, and the technology of moving object detection develops as well. Moving target detection, that is, the use of satellite remote sensing technology to detect the motion status of ground moving targets, is widely used in transportation, smart city, national defense strategy and other fields, and has important civil and military value.

For a long time, SAR(Synthetic Aperture Radar) satellites have been widely used to solve the problem of moving target detection because of their advantages of active remote sensing, and video satellite-based researches have also gradually increased. As the technology of optical satellites finds its way into the application to this problem, remote sensing satellites equipped with dual-line array cameras have gained a lot of attention. This kind of camera adopts dual-line array push-scan imaging, the resulting panchromatic double-band remote sensing data cover a wide range and have adjustable imaging time difference. For the characteristics of this data, we propose a moving target detection scheme that combines frame difference and deep learning methods, using continuously captured image data, after pre-processing processes such as cloud removal, radiometric correction, geometric correction, registration, frame difference, etc., and then applying a two-step detection algorithm based on deep learning to the processed images. As result we achieve the detection of moving targets for objects with small size, weak features and slow speed characteristics in complex scenes.

Development of an IDL widget to automate the NL-DisTrad algorithm for downscaling the coarse resolution of satellite Data Product

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An IDL widget was developed to automate the ANN-based Non-Linear Radiant Temperature Disaggregation (NL-Dis/Trad) algorithm. It downscaled the coarse resolution satellite data product of Land Surface temperature (LST) to a finer resolution, which was better suited for UHI and Heat Stress mapping. The widget automatically processed the input raw satellite data bands and disaggregated the MODIS LST (spatial resolution 960m) to that of Landsat-7 ETM+ at 60m. The NL-Distrad algorithm used the relationship between NDVI and LST at a coarse resolution, for hot edge pixels, to model the LST residuals at the same coarse resolution. Using an Artificial neural Network (ANN) model, the residuals at finer resolution were determined and these resulting residuals were added to the modelled LST at a fine resolution. The ANN model used NDVI of neighborhood pixels, as it was assumed that the LST of a pixel will be influenced by the vegetation in surrounding pixels.
Some satellites do not carry thermal sensors, but can provide fine resolution NDVI. As this widget required LST and NDVI datasets at coarse resolution, and only NDVI at finer resolution, it may be used to disaggregate the MODIS temperature data to a resolution comparable to that other band's reflectance datasets. This hybrid model (Hot edge model + ANN model) was validated by comparing the automatically disaggregated LST to the observed ETM + LST. This LST data could be used to map spatial distribution of UHI intensity.

A new method of diagnosing the permafrost changes using the Frost Number Model with Kappa coefficient for future adaption

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Permafrost is one of the key components of the cryosphere, mainly distributed in the high latitude and high altitude regions of the northern hemisphere, which is extremely sensitive to climate change. In the context of global warming, permafrost is degrading at different magnitudes worldwide. Permafrost degradation will seriously affect the regional hydrological cycle, carbon cycle, ecological environment, and engineering construction. In this study, based on the frost number model, the frost number F is calculated according to the air freezing/thawing index obtained from the downscaled CMIP6 datasets. Then, a new method incorporating the optimal frost number threshold Ft with kappa coefficient is used to diagnose the distribution of frozen ground. The range of Ft is between 0 and 1, so values of Ft from 0 to 1 with an interval of 0.01 are assigned to diagnose the distribution of frozen ground. Then the optimal Ft can be determined by comparing the simulated frozen ground distribution maps with the widely accepted frozen ground distribution map. Here, the kappa coefficient is used as the index to measure the classification accuracy to find the optimal Ft. Finally, the optimal Ft is used to diagnose the global frozen ground distribution under four scenarios (SSP126, SSP245, SSP370, and SSP585) with the downscaled CMIP6 datasets.

The simulation results show that under all scenarios, the degradation rates of permafrost in the mid-period (2040-2060) are similar, which are between 17.08% and 23.28%. In the far period (2080-2099), the degradation rates of permafrost under different scenarios change significantly, ranging from 18.18% to 60.61%. Especially under the SSP585 scenario, the degradation rate of permafrost is expected to be the highest. The new method of diagnosing permafrost change presented in this study is more objective than the previous ones which rely on experience and has the potential to get more reasonable permafrost changes under different scenarios, which are helpful to adaptive management strategies to reduce the adverse effects of frozen ground degradation on natural, economic, and social systems.

Unpacking the inter- and intra-urban differences of the association between health and exposure to heat and air quality in Australia using global and local machine learning models

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Environmental stressors including high temperature and air pollution cause health problems. However, understanding how the combined exposure to heat and air pollution affects both physical and mental health remains insufficient due to the complexity of such effects mingling with human society, urban and natural environments. Our study roots in the Social Ecological Theory and employs a tri-environmental conceptual framework (i.e., across social, built and natural environment) to examine how the combined exposure to heat and air pollution affect self-reported physical and mental health via, for the first time, the fine-grained nationwide investigation in Australia and highlight how such effects vary across inter- and intra-urban areas. We conducted an ecological study to explore the importance of heat and air quality to physical and mental health by considering 48 tri-environmental confounders through the global and local random forest regression models, as advanced machine learning methods with the advantage of revealing the spatial heterogeneity of variables. Our key findings are threefold. First, the social and built environmental factors are important to physical and mental health in both urban and rural areas, and even more important than exposure to heat and air pollution. Second, the relationship between temperature and air quality and health follows a V-shape, reflecting people's different adaptation and tolerance to temperature and air quality. Third, the important roles that heat and air pollution play in physical and mental health are most obvious in the inner-city and near inner-city areas of the major capital cities, as well as in the industrial zones in peri-urban regions and in Darwin city with a low-latitude. We draw several policy implications to minimise the inter- and intra-urban differences in healthcare access and service distribution to populations with different sensitivity to heat and air quality across urban and rural areas. Our conceptual framework can also be applied to examine the relationship between other environmental problems and health outcomes in the era of a warming climate.

New remote sensing products of Snow cover, SWE and Snow Albedo over China

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Snow cover plays an important role in the energy balance and atmospheric circulation due to its high albedo and low thermal conductivity. snowpack is changing significantly in the context of a warming climate. There is an obviously change trend of snow area, snow cover days, and maximum snow water equivalent (SWE) in China. Aiming at the three key snow remote sensing parameters of snow area, SWE and snow albedo, this research developed a series of new remote sensing products in China with the remote sensing datasets, based on the characteristics of China's snow cover area and combined with ground survey data.

Firstly, the main snow remote sensing products (Snow cover, SWE and Snow albedo) produced by NASA, ESA, JAXA, etc. were comprehensively evaluated in the three typical snow areas, which is in northern Xinjiang, Qinghai-Tibet Plateau and Inner Mongolia-Northeast. The evaluation results provided a guide for the development of new products. Secondly, a multi-level decision tree snow extent extraction algorithm, a semi-empirical statistical SWE inversion algorithm suitable for snow cover characteristics in China, and a snow albedo inversion algorithm based on ART (Asymptotic Radiative Transfer Theory) model and considering forest area characteristics and cloud removal treatment were developed. Finally, a cloudless snow area product with a daily resolution of 5 km in China from 1980 to 2020 and a daily resolution of 500 m in China from 2000 to 2020 was produced with an accuracy of more than 90%, using AVHRR-AVH09 and MODIS-MOD09GA datasets by data fusion and machine learning methods; a SWE product with a daily resolution of 25km in China from 1980 to 2020 was produced with a RMSE of 10mm, using SSMR, SSM/I, SSMIS, MWRI, AMSR-E, AMSR-2 datasets; a daily snow albedo product with resolution of 1km in China from 2000 to 2020 were produced with a RMSE of 0.11, using MODIS-MOD09GA and MOD10A1 datasets.

The analysis of snow change indicated that China's snow cover showed a decreasing trend from 1980 to 2020, and the year 2000 was a cut-off point, it was significantly before 2000 larger than after 2000. Also, the SWE showed an increasing trend in most part of the north-eastern China and the northern Xinjiang, and a decreasing trend in the south-eastern Tibet Plateau, China from 1980 to 2020.The above results provide high-precision, long-time series data support for the distribution of snow resources in China, meet the data needs of climate change research, water resources assessment and disaster prevention and mitigation.

Coupling Topographic Factors and Sentinel-1/2 Data for Soil Salinity Mapping

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Soil salinization is a critical and global environmental problem. Mapping and monitoring effectively the spatial distribution of soil salinity is essential. The main work is to map soil salinity in Shandong Province located on the Yellow River Delta of China using Sentinel-1/2 re-mote sensing data and digital elevation model (DEM) data coupled with soil sampling data combined with four regression models, Support Vector Regression (SVR), Stepwise Mul-ti-Regression (SMR), Partial Least Squares Regression (PLSR) and Random Forest Regression (RFR). The methods were used to establish regression models and predict the spatial distribution of soil salinity in the Yellow River Delta. The results revealed that compared with the other regression models, the PLSR model has the best performance (R2 = 0.66, and RMSE = 1.30). We concluded that the model can be used effectively for quantitative estimation of soil salinity and provide a useful tool for ecological construction.

FarmaDSS: Development of an Innovative DSS System for the Production of Cotton Using Remote Sensing, IoT Sensors and Advanced Agricultural Models

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The agricultural sector is constantly called upon to increase the competitiveness of its products and at the same time to make the best possible use of the available production factors. Under the scope of the internationalization of transactions and trade, farm decision making, both at farm and regional level, is highly dependent on a wealth of information and data. Therefore, the acquisition of information - data in agriculture is closely related to making the right decisions, as they are necessary tools to reach the desired outcome.

Greece is the largest producer of cotton in the EU, owning more than 80% of the total European production. Cotton is a crop of great economic importance for the Greek agricultural sector and represents more than 8% of the total agricultural production.

Two major, eternal and most costly problems in cotton cultivation are the control of the harmful insect Helicoverpa armigera and irrigation. Both issues require integrated management, in regard to environmental protection and efficiency. Therefore, it is necessary to apply timely and targeted sprays, especially for combating Helicoverpa armigera. Equally important is the application of rational irrigation, not only to save water resources and avoid pollution of the recipients, but also to achieve the ideal balance between productive and vegetative growth, therefore increasing production, improving the efficiency of fertilization, improving product quality and finally reducing production costs.

During FarmaDSS project, a modern informational Decision Support System (DSS) was developed, providing a valuable advisory tool for the agronomist and the farmer. The system combines the use of innovative means of data recovery from IoT sensors, data and remote sensing applications, while it was based on the development of specialized models for determining irrigation needs, forecasting and estimating Helicoverpa armigera infestation as well as automated crop stage calculation procedures. Its main objective is the immediate decision-making for the management of the cotton crop. The developed applications (web & mobile) provide fast response and high precision tools, easy to use by both experts and farmers, which contribute to:

- early warning and monitoring of the existence of Helicoverpa armigera
- monitoring soil moisture of the crop with real-time data and the quantitative information for irrigation
- the reduction of the effort for monitoring the fields by the experts providing advice to the producers
- rationalization of the use of inputs protecting the environment, by limiting excessive irrigation and the inflow of chemical products into the aquatic ecosystem
- saving resources and achieving integrated management of cotton cultivation in Greece

For the monitoring of cotton crops at field level, modern IoT sensor technologies with real-time communication capabilities as well as the data of the collection / analysis and processing of the Sentinel-2 satellite data, of the Copernicus program, are used. The data fusion of IoT sensor measurements, satellite data and models is the most important scientific innovation of the system, as it leads to high quality/validity estimates related to crop soil moisture and monitoring of Helicoverpa armigera.

A geospatial data infrastructure based on open-source technologies and software has been developed to manage both IoT sensors and satellite data, as well as model data. For the development of the database that was implemented, and which is used for the structured storage of all data, including user data, as well as the levels of information produced during the processing of this data, the FOSS DBMS PostgreSQL was used with the spatial extension of PostGIS. PostgreSQL has been chosen as the database for the IoT measurements. Geoserver (including image mosaic extension) is used to manage, process and share the multidimensional grid data. The data are presented through an interactive cartographic application developed using the ReactJS javascript application development framework and React Native for powering native mobile applications. The System presents in a friendly and intuitive way, both the raw data and the analysis data at field level in the form of interactive graphs and maps. Finally, via the Farm Calendar provided, the user organizes and manages all the tasks that need to be done per plot.

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Spatial and temporal variation in the carrying capacity of grasslands in Mongolia

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The carrying capacity was developed to estimate the capacity of the grassland resource to sustainably carry livestock in the long term. It had been an important indicator using for the grassland ecosystem evaluation and dZud risk forecast. In this study, we used remote sensing data and ancillary data to propose a framework to estimate the aboveground biomass (AGB) and the carrying capacity of grassland (GCC) using the Google Earth Engine (GEE) environment. We analyzed the spatial and temporal changes in the GCC and the grassland carrying status index (GCSI) in Mongolia during 2010-2020. Our study demonstrated the effectiveness of AGB and GCC estimation using the Carnegie-Ames-Stanford Approach (CASA) model with the root-to-crown ratio method within the GEE environment. The AGB model validation showed good performance with an R2 of 0.67-0.71 and RMSE of 22.91-28.94 g/m2. Significant increases in AGB and GCC over the 21 years were found in Mongolian grasslands and most provinces. The average GCSI increased significantly in the whole country and all provinces, indicating the increasing stocking density and the overexploited status of grassland in recent years. The multi-regression analysis further showed that the dramatic increase in livestock populations contributed more than 85% to the variations in the GSCI for the whole grassland of Mongolia. These results will be useful and helpful in supporting sustainable grassland management and the sustainable livelihoods of herders in Mongolia.

Automation applied to zoning of agricultural field when studying erosional soil losses

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We conducted our study of soil loss processes modeling on the example of Oka River basin located in central part of European Russia, where agricultural fields in many cases located on sloping surfaces with complex microrelief topography. In such a case, also a complex digital-modeling-based approach to soil loss assessment is demanded, as ignoring of soil runoff differentiation across the sloping surfaces leads to significant errors. Consequently, in order to create a methodology for estimation of soil loss forming in the entire area of agricultural fields, it is necessary to ensure zoning of homogeneous (in the meaning of soil erosion processes) areas in a studied area.
In recent years, the radiocaesium method that we applied in our study has been actively used to for estimation of soil loss in agricultural areas. The method assumes modeling of dependencies between values of Chernobyl origin radioactive Caesium-137 deposit in soil material, geomorphometric parameters of topography microrelief, and soil material runoff. In other words, the soil loss is estimated basing upon the Caesium-137 deposit measurements using computational modeling. Quantitative accounting of microrelief parameters provided usually in Geographic Information Systems (GISs) when the modeling is implemented. Additionally, very and ultra high resolution remote sensing data can be attracted to recognize landforms of microrelief topography.
In the current material we summarize and discuss the GIS-based computational modeling methodology elaborated to ensure zoning of homogeneous soil loss sectors of agricultural fields and identifying of the minimal erosion belt in the plowed slope area. The last one sector appears to be an area where the soil loss is (almost) not observed, and the Caesium-137 deposit estimation can be established as a reference (benchmark) deposit value when implementing radiocaesium the method. This reference value is used as a model calibration parameter in computational analysis of soil loss. In situ data were collected in 2014-2017 in the area of agricultural field in the Oka / Sukhaya Orlitsa river basin (Orel district, Orel region, Russia). Basing on in situ data analysis and testing of soil loss computational models (calibrated in different ways), we concluded that it in the study area it is possible to establish a reference plot within the boundaries of the minimal erosion belt. The minimal erosion belt in its turn can be zoned basing upon catchment area mapping as an agricultural field sector where catchment area value varies between 100 and 500 sq. m. While the minimal erosion belt is zoned using catchment area mapping, homogeneous soil loss sectors are zoned basing upon catchment area and profile curvature (of microrelief topography) mapping. This approach is well-suitable for GIS-based automation, so we implemented the zoning and computational modeling of soil loss for our study area in open source QGIS software.

Integration of sparse multi-source earth observation data with deep learning for crop type and yield estimation in smallholder farming areas

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A profound amount of global food production is contributed by smallholder farmers. Hence, information concerning crop health, crop type, and crop yield in smallholder farming areas would be essential for planning and making informed decisions about food security, agricultural insurance, and crop market stability. Even though current advances in image processing and the availability of multi-modal satellite imagery provide an opportunity for monitoring agricultural landscapes with fine temporal and spatial granularity, the generation of crop type information and annual and seasonal crop statistics in smallholder farming areas is still a challenging task. This is mainly attributed to complex farm patterns characterized by fragmentation, intercropping and spatial occupancy with complex terrain. More importantly, in tropical smallholder farming areas the extensive prevalence of thick clouds in the growing season poses a formidable challenge to utilize available optical sensors which call for the proper fusion of sparse multi-source multi-temporal earth observation data. The study site is situated in the northwestern part of Ethiopia, where the smallholder farming system is the mainstay of livelihood production. In this study, we have fused cloud-free sparse time series optical and radar images from Sentinel-2, PlanetScope, and TerraSAR-X dual polarimetry radar observations in the peak growing season. For training and validation of deep learning models, spatially distributed crop-type samples were collected from the field and further visual inspection and quality check of samples is done using mono-time SkySat high-resolution optical images. For modeling crop yield, field-based measurement of leaf area index and crop yield data are also collected from selected farm plots. After proper cloud masking and spatial co-registration of all datasets, time series temporal profiles were generated for model training and testing. Sparse data fusion is done on spectral, feature, and decision level fusion using state-of-the-art deep learning models for time series earth observation, viz, Transformers, Inception time, Long-short Term Memory Networks (LSTM), temporal Convolutional Neural Networks (tempCNN) and Gated Recurrent Units (GRUs). Using the same data and procedure, a performance comparison is also done with known machine learning models – random forests and support vector machines using both mono-source and fused inputs. Results show that in the mono-source scenario, though time series-based deep learning models surpassed the performance of random forest and support vector machines the performance difference is not by a big margin. During multi-temporal sparse time series fusion, in all experimental setups decision-level fusion performs better than feature-level fusion. Beyond performance variations among models and specific crop types, multi-temporal sparse earth observation data fusion has yielded promising results to map crop types in complex smallholder farming areas where an overall F-1 score of ~80% is achieved. Results of modeling yields from dominant crops indicate that ~90% of crop yield variance can be explained by spectral and vegetation indices from time series earth observation datasets. Beyond indicated results, the study identifies challenges and further gaps to be addressed in crop type mapping and yield estimation in tropical smallholder farming areas.

Flooding mapping and analysis for Sentinel-1 SAR images based on clustering of deep features extracted from temporal autoencoder

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Flood mapping using synthetic aperture radar (SAR) data is a low-cost and wide-coverage means. Moreover, SAR has day-and-night, all-weather observation abilities. Accurate flood mapping and multi-temporal analysis are essential for researchers to develop more precise flood prediction models and for management to make more targeted disaster relief plans. Depending on the number of images used, SAR image flood mapping can be categorized into single-, dual-, and multi-temporal types. The dual-temporal type is the most common one. The SAR image flood mapping problem can be transformed into a change detection or a dual-temporal semantic segmentation problem. Currently, satellite-based SAR sensors, in particular the Sentinel-1, are capable of stable and uniform data acquisition in the temporal dimension. In this context, the advantages of multi-temporal data can be fully exploited for more accurate flood mapping and in-depth analysis of flooded areas. In this paper, we focus on this topic.

The deep learning (DL) technology, especially the deep convolutional neural network (DCNN) models, provides a promising direction for robust flood mapping. The supervised methods need ground truth provided by experts' manual delineation with the help of multi-source supporting information. These human-supervised methods need high-quality labels under various conditions, which are very costly. In addition, the manual delineation is subject to human subjectivity and bias. For the problem of multi-temporal flood mapping and analysis, unsupervised DL seems essential. Due to the complexity of the problem, in many cases, human annotators have no way of knowing what categories need to be annotated and how to do so. Human-supervised annotation is not very realistic in such cases. Therefore, this research explores the DL-based methods without human supervision for flood mapping and analysis in SAR imagery. Deep temporal autoencoder is a suitable DL framework. Aiming at this goal, we propose an unsupervised flood mapping and analysis method based on clustering deep features generated by deep temporal autoencoder.

The core of our proposed model is an encoding-decoding autoencoder. The encoding and decoding parts comprise convolution and trans-convolution layers, respectively. Since the convolution layers are performed in the temporal domain, the bottleneck features of the autoencoder can represent the most critical deep features in the temporal domain of multi-temporal SAR images. We then use these deep features to perform clustering, which enables unsupervised classification based on the pixels' characteristics in the time domain. On this basis, flooded areas can be extracted, and a more detailed analysis can be performed.

In this research, we select Bangladesh as a studying case. Bangladesh is a low-lying country. Every year, the rainy season, combined with the effects of tropical cyclones, brings severe flooding to the country, one of the least developed countries designated by the United Nations. Flooding has caused substantial economic and life losses to the country. We used 84 Sentinel-1 SAR images from 3 January 2020 to 25 September 2022, i.e., one image every 12 days. We used Sentinel-1 Interferometric Wide Swath mode Ground Range Detected products. We only selected the VV polarization channel. The images are preprocessed by Google Earth Engine, and their pixel spacing is about 30 meters. The analyzed data volume is 4109 (height) * 3689 (width) * 84 (temporal), i.e., about 1.19G samples. The scene covers about 120km (north-south) * 110km (east-west). Currently, the autoencoder only extracts essential information in the temporal domain. Each pixel in the scene is represented by a 5D deep bottleneck feature vector. We then used the KMeans algorithm to cluster pixels into 15 classes. By analyzing the unsupervised classification results obtained by clustering the deep bottleneck features, we found that the model can mine the data for multi-temporal information, based on which it can perform flooded area extraction and provide semantics-contained in-depth analysis of the flooded areas. Furthermore, by analyzing the autoencoder-reconstructed data of the clustering centers, we can confirm that the model can mine the temporal-domain characteristics of the scene and can interpret each cluster's temporal properties. This study can be followed up with developments in both modeling and applications. The modeling side's developments include embedding clustering into the overall model, fusing multi-polarization information, integrating spatial information, and considering more appropriate autoencoder architectures. Developments in applications focus on more accurate extraction and semantic analysis of flooded areas.

Hyperspectral Image Classification and Feature Importance Assessment based on CNN and Grad-CAM

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With the development of sensor technology, more accurate and timely remote sensing imagery with high spectral and spatial resolutions can be acquired and applied to several domains such as land cover mapping and environmental parameter retrieval. Hyperspectral images (HSIs) acquired from newly developed sensors can collect hundreds of spectral bands as well as high spatial resolution at the same time. Image classification is one of the most important research tasks in hyperspectral remote sensing image processing; this task often requires the identification of the class of each pixel with a small number of training samples. However, the high dimension of the spectral information produces the Hughes phenomenon which can significantly reduce classification accuracies, which makes it is hard to get higher interpretation accuracies when dealing with such increased spectral resolution imagery. In recent years, deep learning methods, especially those using Convolutional Neural Networks (CNNs), have been widely used in hyperspectral image classification tasks. However, hyperspectral images have rich spectral information, and the problem of information redundancy often exists when each band is used as input features for CNNs. There is a lack of a method for analyzing the importance of spectral features in the image classification process. To address the problem of spectral feature redundancy in hyperspectral image classification, this study proposes a feature importance evaluation method based on CNN and Grad-CAM (Gradient-weighted Class Activation Mapping). This method uses all bands of each pixel in the hyperspectral image as input features and applies a one-dimensional CNN for image classification. This study has improved the Grad-CAM algorithm by modifying the dimensions to obtain a "heatmap" of the input spectral features. By normalizing this heatmap, the contribution of spectral features to the classification of a particular category can be determined. For samples correctly classified in each category, the feature importance analysis process is repeated, resulting in an assessment of the importance of spectral features for each category. Based on the improved Grad-CAM algorithm, the contribution of each band of hyperspectral data to each class label in the classification process is analyzed. The proposed method is applied to the Indian Pine Test Site 3 data, and the results show that the overall accuracy of the method in land cover classification is 86.75%. Among the 16 land cover types, there are 10 types with significantly important spectral bands.

Weakly Supervised Semantic Segmentation for Dwelling Extraction in Refugee Camps from Very-High-Resolution Satellite Imagery

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Sustainable Development Goals (SDGs) 2, 3, and 6 advocate providing adequate living resources such as clean water, nutritious food, medical services, and sanitation to refugees and their host countries based on the commitment "Leave no one behind". It is therefore important to know the potential refugee population in need. However, it is difficult to get such information, e.g. during disasters. Updated footprints of refugee dwellings derived from satellite imagery can be beneficial as indicators for population estimation to support humanitarian operations for refugees.
In recent years, deep learning approaches show high potential in extracting the footprints by learning features from data rather than knowledge-based rulesets. However, traditional strong supervised learning requires a large number of high-quality annotations for training, which is usually lacking in such specific cases as dynamic and unstructured refugee camps.
Weakly Supervised Semantic Segmentation (WSSS) approaches are designed to alleviate the problem of lacking high-quality annotations. WSSS approaches utilize less spatially informative annotations such as bounding boxes, scribbles, points, and image-level class labels to perform a pixel-level segmentation of images. In this research, we chose image-level class labels for the refugee-dwelling-extraction task because they require the lowest effort to generate yet the most challenging option to create satisfying results.
We follow a typical two-step WSSS training framework to transfer image-level labels lacking spatial information to produce dense prediction masks. The first step is to generate pseudo-pixel-level masks based on Classification Activation Maps (CAMs) from a classification network. Secondly, the pseudo masks together with corresponding images will be used to train a semantic segmentation network to produce higher-quality masks.
Based on the above two-step framework, the quality of CAMs plays a crucial role in the final prediction results. In this research, we adopted the Self-supervised Equivariant Attention Mechanism (SEAM) approach to produce CAMs, which is a classical WSSS approach and is frequently used in ablation studies. The SEAM adopts consistency regularization on CAMs from multiple affine-transformed images to provide self-supervision for model optimization. It utilizes a Siamese network combining equivariant regularization (ER) and a pixel correlation module (PCM) together with three joint losses to improve the quality of CAMs.
Besides, compared to public benchmark datasets such as the ISPRS 2D Semantic Labeling Contest, the datasets for refugee dwellings are usually much smaller with a lower spatial resolution. Therefore, instead of training networks from scratch, we use a pretrained semantic segmentation network (U-Net with DenseNet121 as a backbone) from SpaceNet4: Off-Nadir Buildings data challenge for both classification and semantic segmentation tasks. The SpaceNet4 dataset consists of WorldView-2 satellite imagery pan-sharpened to around 0.5 m, which is similar to the image data we use in refugee camp settings.
We compare the performance of the proposed approach under multiple settings for this extraction task, e.g. utilizing pretrained weights or not, fusing multilevel feature maps from only encoder blocks or from both encoder-decoder blocks, using global average pooling and global max pooling to convert CAMs to fully connected outcomes. The experiences could be beneficial for similar research in the future. Additionally, we use Super-Resolution (SR) models to upscale input images instead of bilinear interpolation to reserve more boundary information. For semantic segmentation, we use the same network from the classification task rather than using another different network. A conditional random field (CRF) layer was added at the end of the network to increase the quality of final predictions.
The results show that pretrained weights from SpaceNet4 can improve the accuracy of CAMs. Upscaling by SR models can bring improvements under multiple settings. Overall, GAP outperforms GMP in this case. The number of image patches without target objects could be an important hyperparameter for similar tasks. In this study, we noticed, that increasing the number of images without dwellings compared to the number of images with dwellings can harm networks by activating more background areas. It is mainly caused by the imbalanced nature of the data we used. The percentage of refugee dwellings only accounts for around 9%. The highest Intersection over Union (IoU) of dwellings of the CAMs is around 0.66. After the semantic segmentation, the IoU value of the final prediction reaches 0.68 which could be satisfying for specific humanitarian operations e.g. in very dynamic and training sample-scarce settings.

A Latent Space Deblurring Algorithm for Optical Remote Sensing Image Based on Reference Image

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High-quality remote sensing images have played an important role in change detection, urban planning, environmental monitoring, and so on. However, affected by many factors such as camera shake, defocus, and atmospheric disturbance, the observed images often suffer from loss of important texture information caused by image blurring. This may affect the accuracy of downstream tasks with irreversible loss. To solve this problem, many optimization-based algorithms and learning-based algorithms have been proposed. However, most of these methods are based on a single blurry image. Due to the lack of high-frequency information, the images restored by these algorithms still have some deficiencies in edge and texture details.

In this work, we propose a novel reference-based blind image deblurring model which transfers the high-quality textures from registered reference image to assist image deblurring by a Feature Level Matching Module (FLMM). In FLMM, we use the first four layers of the pre-trained semantic feature extraction network VGG19 to extract the features from both blurry images and reference images. Then, we calculate the correlation maps of the blurry images and reference images with an attention mechanism which contain valuable texture information of the reference images. Moreover, considering the influence of limited computational resources, we apply the model in the latent space compressed by powerful pre-trained autoencoders.

The dataset we used is sourced from the United States Department of Agriculture (USDA), which takes remote sensing images of U.S. states every year. We select the remote sensing images of California captured in 2018 as the reference images and the image captured in 2020 as ground truth. The dataset contains multiple image categories such as farmland, mountains, and towns. The training set contains 1138 image pairs of size 160x160 while the testing set contains 240 image pairs of the same size. Ablation experiments indicate the effectiveness of our algorithm by using reference images. and the comparative experiments on the testing set prove that our method outperforms many state-of-the-art single-image deblurring approaches in both quantitative evaluation and visual results.

European Ground Motion Service for built heritage: a case study from Cyprus

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The recently launched European Ground Motion Service (EGMS) [1] provides consistent and reliable information about ground motion, with millimetre accuracy over large areas. It is based on the multi-temporal interferometric analysis of the European Copernicus Sentinel-1 radar sensors and its products are calibrated with a dense European Global Navigation Satellite System (GNSS) network.

EGMS could be of great importance in monitoring cultural heritage sites as an early warning system for local and national authorities responsible for heritage management and protection. Moreover, EGMS data are particularly useful for less accessible areas, which are more difficult to monitor with other means.

This study investigates the EGMS ground motion data over Paphos district in western Cyprus. Paphos district covers almost 1,400 square kilometres that constitutes the 15.1% of the total area of the island. This area is home of 147 ancient monuments and archaeological sites protected by the Antiquities law of the Republic of Cyprus. Few of them are also inscribed in the UNESCO World Heritage List, such as Paphos site, including the Ancient Nea Paphos and the Tombs of the Kings [2-4].

Average ground movement values for Paphos district were downloaded as ortho-product from the EGMS and were further processed into the ArcGIS-Pro environment. The ortho-product is provided as two separate data layers containing vertical (Up) and east-west (East) displacements. The east-west displacement values range between +21.3 to -39.9 mm and the vertical ones range between +11.8 to -21.0 mm.

In addtion, time-series of vertical and east-west displacement values at each pixel are also available every 6 days (satellites' revisit frequency) from 2016 onwards. This information can be useful for the identification of trends and patterns in a spatio-temporal context. Site-specific statistical analysis could also include the computation of correlation lengths, crossings, and the magnitude of change between consecutive times focusing on key time periods (e.g., close to identified earthquake events).

Further statistical analysis was carried out, by creating different buffer zones around the monuments. An average displacement of -7.146 mm/year east-west and -1.375 mm/year vertical was estimated. In addition, specific archaeological sites within the Paphos district, have been further studied using EGMS data, to estimate annual ground motion displacements. For example, time series interferometric results for the 'Tombs of the Kings' necropolis, indicate a mean velocity of -1.20 mm/year.

In addition, numerical models of selected monuments using finite element modeling will be constructed to simulate the damage potential on the monuments from these vertical and horizontal displacements. The recorded displacements at the locations of the selected monuments will be applied at the supports of the numerical model to compute the resulting stresses on the monuments walls accounting thus for soil structure interaction and mapping damage patterns on the monument. This will provide information on the damage inflicted on the monument by ground movement and differentiate it from damage on the monument from previous seismic events.

This study is part of the multidisciplinary ENGINEER project, which brings together geoinformatics and structural engineering intended for ancient monuments and sites.

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Remote sensing monitoring of power consumption along the China-Pakistan Economic Corridor

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Spatiotemporal monitoring of electric power consumption (EPC) provides vital information on regional economic conditions and contributes to decision-making regarding energy sustainable development, especially for large population-based developing countries. Pakistan is a fast developing but also an extremely short of electricity country, with weak power infrastructure. The power problems in Pakistan are mainly reflected in four aspects: the contradiction between the accelerated modernization process and the increase of power consumption demand, the unreasonable structure of industrial power consumption and household power consumption, the unreasonable structure of fossil fuels and clean energy, and the huge gap between the rich and the poor in power consumption. The construction of energy projects is the key priority of China-Pakistan Economic Corridor (CPEC), including power stations and transmission projects, which will greatly alleviate power shortages in Pakistan. Estimation of CPEC construction since the electric power consumption, understanding the power consumption of time and space change pattern, and analyzing the energy changes in Pakistan power consumption before and after the completion of the project will have great significance on optimizing investment programs and power plant and reasonable layout. It will also be helpful for the adjustment of the energy structure, energy future cooperation with Pakistan electric power sustainable development to provide data support and decision-making basis.

To provide a consistent dataset of EPC in Pakistan and a comprehensive assessment of changes in its spatiotemporal patterns during the last decades, we used NASA NPP/VIIRS DNB black marble product to estimate the monthly and yearly EPC in Pakistan at a 15 arc second spatial resolution for the period 2013 to 2020. The geographically and temporally weighted regression model (GTWR) model was employed to model the space-time relationship between electricity consumption and nighttime light radiance. The linear regression model and GTWR were compared for EPC estimation. GTWR model considers both the spatial nonstationary of geographic data and temporal effects in the calculation model. The accuracy is higher than that of previously used linear EPC estimated models.

Spatial distribution pattern of power consumption in Pakistan was then analyzed. Overall, Pakistan's electricity consumption is mainly concentrated in the eastern plain region, and the eastern region is higher than the western region. The direction of power consumption in Pakistan is obvious, with a northeast - southwest distribution. The change slope of time series of power consumption can reflect the change trend of power consumption. The larger the change slope is, the faster the regional economy develops. Overall, power consumption in Pakistan increased rapidly from 2013 to 2020. In 2020, compared with 2013, power consumption increased by 2.7684 billion Kwh, with an average annual increase of nearly 350 million Kwh. Power consumption showed an increasing trend from west to east.

Since the start of year 2020, the COVID-19 pandemic has swept across the globe. COVID-19 affected the electricity power sector with multidimensional impacts on consumers and power production. We calculated the grided monthly EPC according to the monthly composite nighttime light product (VNP46 A3). The monthly EPC for the year 2019 and 2020, as well as the annual mean of EPC from 2013 to 2020, and the monthly COVID-19 cumulative cases in 2020 were compared. Overall, EPC in 2020 shows 3.6% decrease compared with 2019. The monthly EPC trend of 2020 is similar to that of 2019, when the EPC is higher from January to May, and from November to December and lower from Jun to September. Compared with 2019, at the beginning of 2020, the EPC of Pakistan showed a slight increasing trend. However, as the situation of COVID-19 situation worsened, the EPC from March showed a decreasing trend. The decreasing percentage in 2020 compared with the same month in 2019 was from 1.1% to 16.9%, with the highest decreasing percentage in May, 2020. The EPC decreasing trend shows a lag effect compared with the COVID-19 cases increasing trend. The EPC of selected districts showed similar variation trend and more details at the districts level. In summary, the dataset provides new insight into the change processes and impacts of policies as well as outbreaks emergencies such as COVID-19 at fine spatial and temporal resolutions, especially for developing countries like Pakistan.

Comparison and assessment of SDGSat-1 data on monitoring urban wetlands and thermal environment-Taking Beijing city as an example

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Wetlands play an important role in regulating the regional thermal environment, and satellite remote sensing monitoring data have irreplaceable advantages in understanding the dynamic relationship between regional wetlands and thermal environment at large scale. Compared with the widely used medium-resolution satellite data, such as Landsat and Sentinel, not only does the newly launched Sustainable Development Science Satellite (SDGSAT-1) carry three different sensors, multi-spectral, thermal infrared and low-light sensors at the same time, but it also has higher spatial resolution in the thermal infrared band, and adds two blue light bands (374-427nm and 410-467nm) that is suitable for water environment monitoring in the visible light band, providing a new means for carrying out regional ecological environment research. In this paper, taking Beijing as the research area, we firstly carried out wetland classification and land surface temperature inversion by using the multi-spectral and thermal infrared data of SDGSAT-1 satellite; then compared them with Sentinel-2 data and Landsat 8 TIRS data in terms of wetland mapping and land surface temperature inversion, respectively. The results show that, despite showing similar overall accuracy of urban wetland mapping, the SDGSAT-1 satellite data has more advantages than Sentinel satellite data on identifying wetland characteristics, which could contribute to the two bands of 374-427nm and 410-467nm, that are more sensitive to water bodies. In terms of the impacts of urban wetlands on land surface temperature, the derived relationship based on SDGSat-1 satellite data shows more spatial details, which could thank to the higher spatial resolution of the thermal infrared band of SDGSat-1 satellite, comparing to the 100m spatial resolution of Landsat data. It reflects the spatial difference of the impact of wetlands on various urban land use. Therefore, SDGSat-1 satellite data has shown significant comprehensive advantages in monitoring urban wetlands and thermal environment, providing more contribution to Sustainable Development Goals in future.

A Rule and Graph-based Approach for 3D Roof Reconstruction from ALS Point Cloud Data

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With the growing global population, urbanization, and the need to reduce carbon emissions to mitigate climate change, the demands for renewable energy significantly increases (Murdock et al. 2021). Therefore, solar energy has become a key player in the energy sector due to its clean, abundant, and renewable nature (Li and Han 2022). In urban areas, building-integrated photovoltaics systems represent attractive options (Romero Rodríguez et al. 2017), that can be installed on building rooftops and facades by reducing the land use (Saretta et al. 2020; Han et al. 2022).

To optimally design BIPV systems in densely built contexts(Florio et al. 2021), the solar potential of the building must be estimated from solar irradiance data and geometry model. Geometry models are mostly 3D models in LoD2 that provide detailed roof structure information. Existing related methods of 3D roof reconstruction from point cloud data (Chen et al. 2017; Peters et al. 2022) extract roof plane at first, and then reconstruct the 3D roof by topology analysis of roof planes and further extraction of roof vertices and edges. The accumulated errors during this multiple process affect the accuracy of extracted roof vertices and edges, increasing the uncertainty associated to the whole 3D model. It is, therefore, necessary to find a solution develop a method to directly extract roof vertices and edges from point cloud data, and to accurately reconstruct 3D roof structure.

In this study, to achieve the automatic 3D roof reconstruction with less accumulate errors, we propose a new method to directly extract roof vertices and predict edges from point cloud data. The workflow of the proposed method includes two main processes: (1) roof vertex detection and (2) edge prediction and structure reconstruction. The summarized description of this method is as follows.

(1) During the process of roof vertex detection, firstly, the raw point cloud data of a building roof is rotated based on its dominant direction and then is voxelized, to regular the point cloud data and reduce noises. Secondly, vector-based rules for voxel filtering are defined to extract voxels on some “primary” roof edges, where the voxels on each extracted roof edge have the same z-values. Then, the segments of these primary roof edges are extracted and simplified by rules based on vector and neighbor analysis. Finally, the endpoints of these segments can be extracted as the roof vertices. The information obtained in this process, including roof vertices and the segments of primary roof edges, will be used to predict complete roof edges and reconstruct the 3D roof structure.

(2) During the process of edge prediction and structure reconstruction, firstly, by using these primary edge segments as constraint, the constrained Delaunay triangulation of the roof is obtained. Then, the constrained Delaunay triangulation of the roof is regarded as an undirected graph, and its contained triangles are extracted by the algorithm of finding the minimum cycle basis of this graph. These triangles are regarded as the preliminary result of the roof’s 3D structure. To further simplify the triangulation to obtain a simpler roof structure representation, these triangles are clustered by using DBSCAN algorithm based on their normals. Each cluster corresponds to a roof surface. Hence, furthermore, each triangle cluster is transformed into a graph and then the triangles in a cluster are merged by the graph algorithm of finding the cycle with maximum area. The merging results of clusters, which are presented as graphs with vertices and edges, will be transformed into polygons and output as roof surfaces with right topology.

The proposed new method will be validated on a custom roof dataset in Trondheim, Norway. Different roof types, including primary and combined roof types, will be covered by the custom dataset, to ensure the complete validation. Vertex distance errors on x-, y- and z-axis, as well as the precision and recall of extracted vertices and edges will be calculated respectively, to quantitatively evaluate the performance of the proposed method. The expected experiment result is that the proposed method can reconstruct the 3D roof structures with low vertex distance errors and relatively high precisions and recalls. In the future, this result will be further applied and tested into the solar energy simulation, to support the practical application of renewable energy.

Two Deep-learning Models for Floating Green Tide Detection from satellite images acquired in the Yellow Sea

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Since 2007, the floating green tide in the Yellow Sea has become a perennial marine ecological disaster, attracting widespread academic attention. Satellite remote sensing is the most important technology to monitor the occurrence and development of floating green tides. However, due to the limitations of satellite imaging mechanisms, resolutions, repeat cycles, and various inversion algorithms, the results of green tides detected by different satellites are quite different, even reaching an order of magnitude.

We collected 112 MODIS images containing algae patches under clear sky conditions in the Yellow Sea from 2008 to 2021. These MODIS images are geometrically and radiometrically corrected 250-m spatial resolution true-color imagery (Bands: 1/4/3). Meanwhile, the SAR images were also collected from the ESA's Sentinel-1 (92 images) and Chinese GF-3 (31 images) satellites. We used Sentinel-1 Level-1 ground range detected dual-polarization (VV and VH) wide interferometric images with 10-m spatial resolution and 250-km swath and the Chinese GF-3 SAR fine stripe mode Ⅱ dual-polarization (HH and HV) image with 10-m resolution and 100-km swath. All SAR images were acquired between 2015 and 2019. To build the deep-learning models for algae detection, we manually labeled 1055 pairs of samples for MODIS images, among which 633/106/316 were used for training/validation/validation. For the Sentinel-1 SAR images, we also manually labeled 8441 samples, among which 4421/1896/2124 were used as the training/validation/testing dataset, respectively. Then, through careful training of label samples, we obtained deep-learning models for green tide detection. Finally, we used the proposed deep-learning models to deal with nearly fifteen years of optical and SAR images and obtained a big dataset of daily algae coverage from 2007-2022 for optical MODIS images and 2015-2022 for SAR images.

Based on the satellite's imaging and floating algae's domain knowledge, we propose a deep-learning algorithm to deeply fuse the detection results from optical and microwave synthetic aperture radar (SAR) images under different sea conditions to extract floating green tide information. The imaging and domain knowledge considered in this study mainly include band channel components and their combinations as input, the new loss function for algae-water sample imbalance, etc. As a result, the deep-learning model reached a high-level extraction capability, i.e., the accuracy of 97.03%/99.83% and mean intersection over union (IOU) of 48.57%/86.31%, and it's widely applicable to optical images such as MODIS/GOCI and SAR images such as Sentinel-1/Gaofen-3. However, the most widely used method for expressing algal life stages is through algae coverage area, which is usually consistent with its life state. For this reason, based on the imaging mechanisms of two different satellites, optical and SAR, this paper redefines and obtains an important physical parameter of floating algae, the "floating ratio" of green algae patches, to represent the entire life process of "emergence-outbreak-maintain-dissipation" more accurately. In addition, specifically for the algae extraction of SAR images, generally only the intensity information of the SAR image is used, but in fact, the texture information derived from the intensity is more prominent for the expression of algae features. To this end, we propose another texture-enhanced seaweed extraction model with a combination of the attention mechanism of the image channels. Compared with simple model parameter tuning, we found that introducing physical mechanisms represented by texture features significantly impacts the improvement of algae extraction accuracy. Furthermore, the model has a wide range of applicability and generalization capabilities.

It was applied to Sentinel-1 SAR images from 2019 to 2021, and it was found that during the drifting process of green tides in the past three years, the surrounding environmental factors affected the scale and duration of seaweed outbreaks. The detection results show the scale and duration of the green tide in 2020 are far smaller than those in 2019 and 2021 because of the lower average nitrate concentration in 2020, but the surrounding temperature and current field have not changed significantly. Moreover, this study also found that the intensity of algae outbreaks has little effect on the absolute value of environmental factors but has a higher correlation with their change rates. These research results are significant for further understanding the green tide outbreak mechanism and preventing and controlling green tide disasters.

Marine pollution and SAR dark spot of sea surface

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Marine pollution has become one of the most pressing environmental issues in our world, which greatly affects the sustainable development of the Earth system. With its ability of all-day, all-weather, high-resolution, and certain penetration capability, spaceborne Synthetic Aperture Radar (SAR) has been one of the most powerful tools to monitor the ocean. Besides ships and waves, most SAR images of the ocean display various kinds of dark spots with different shapes, scales, distributions, and so on. They are universal phenomena in SAR images of the sea surface, but some of them are related to marine pollution. Oil spills, biogenic oil films, and other atmospheric and oceanic phenomena such as rain cells, upwellings, currents, and internal waves appear as dark spots in SAR images. They reduce the roughness of the sea surface, decrease the Bragg scattering of the sea surface and electromagnetic waves, and cause weak signal intensity in SAR images. Oil spills from ships, platforms, or pipelines are one main kind of marine pollution. They affect all marine mammals, fish, crustaceans, birds, and may bring significant harm to marine ecosystems, local economies, and coastal society. Biogenic oil films often derive from rich organic substances related to aquaculture farms or waste discharge in coastal regions. Similar to oil spills, they also harm the environment and marine ecosystem. Comparatively speaking, other kinds of SAR dark spots may have less relation with marine pollution.
Based on Sentinel-1 and some other spaceborne SAR images, we will analyze the imaging mechanism and characteristics of different kinds of dark spots in SAR ocean images and discuss the correlation between marine pollution and SAR dark spots. Then, we propose a new processing method based on deep learning for the detection and identification of different kinds of SAR dark spots. This work will be helpful to support the rapid detection of marine pollution and promote ocean sustainable development.

Artificial Intelligence Aided Remote Sensing of the Intermediate Ocean

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Oceans at a depth ranging from ~100 to ~1000-m (defined as the intermediate water here), though poorly understood compared to the sea surface, is a critical layer of the Earth system where many important oceanographic processes take place. Advances in ocean observation and computer technology have allowed ocean science to enter the era of big data (to be precise, big data for the surface layer, small data for the bottom layer, and the intermediate layer sits in between) and greatly promoted our understanding of near-surface ocean phenomena. During the past few decades, however, the intermediate ocean is also undergoing profound changes because of global warming, the research and prediction of which are of intensive concern. Due to the lack of three dimensional ocean theories and field observations, how to remotely sense the intermediate ocean from space becomes a very attractive but challenging scientific issue. With the rapid development of the next generation of information technology, artificial intelligence (AI) has built a new bridge from data science to marine science (called Deep Blue AI, DBAI), which acts as a powerful weapon to extend the paradigm of modern oceanography in the era of the metaverse. This presentation first introduces the basic prior knowledge of water movement in the ~100 m ocean and vertical stratification within the ~1000-m depths as well as the data resources provided by satellite remote sensing, field observation, and model reanalysis for DBAI. Then, three universal DBAI methodologies, namely, associative statistical, physically informed, and mathematically driven neural networks, are elucidated in the context of intermediate ocean remote sensing. Finally, the unique advantages and potentials of DBAI in data mining and knowledge discovery are demonstrated in a top-down way of “surface-to-interior” via several typical examples in physical and biological oceanography.

The vertical fine structure of warming and cooling events in the near-surface layer of the ocean: Observed from wave-powered profiling float

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Understanding the complex hydrology and rapid structural evolution of the near-surface layer of the ocean remains a challenge. To investigate the fine structure of stratification in the near-surface layer of the ocean, the instrument Wave-powered Profiling Float (WPF) was used to observe the upper-ocean stratification in the offshore of Yantai City, Shandong Province, China for 14 days in November 2019, focusing on the study of warming events and a cooling event. High vertical resolution (1cm) profiles in the near-surface layer of the ocean were acquired through WPF observations to elucidate the vertical fine structure. Through the use of Ordinary Least Squares (OLS) regression analysis, the correlation between upper ocean heat capacity (UOHC) and tidal height, as well as sea surface temperature, was investigated. The results showed that during winter nights, tidal height significantly influenced warming events. However, during Cold Air Outbreaks (CAOs), the impact of temperature on UOHC was greater than that of tidal height. and CAOs soon cooled the ocean surface and were able to disrupt the stratification within hours. In the regression analysis of warming and cooling events, it was found that there was obvious diurnal variation. This study enhanced short time scale variability of the vertical fine structure observed in the offshore areas would be important in ocean-atmosphere system studies.

Deep learning-based reconstruction of temperature in the upper layers of the South China Sea from satellite observations

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Based on an attention U-net deep learning model, this study aims to reconstruct the temperature in the upper 100 m of the South China Sea with high spatial and temporal resolution from satellite observations of surface parameters. The model inputs include sea surface temperature, sea level anomaly, sea surface wind and wind stress curl. 5-d vertical temperature profiles with 0.5° grid from simple ocean data assimilation (SODA) reanalysis from 1993 to 2017 were used as labels to establish the model. Samples before 2016 were set as training and validation datasets in the ratio of 9:1 and the remaining in 2017 were testing data. The estimated water temperature is in good agreement with SODA reanalysis. With the additional input of wind stress curl, the RMSE near the thermocline is reduced significantly by up to 10.9%. Compared with some linear and machine learning models, the attention U-net model performs much better in the marginal sea, especially in shallow waters and regions with complex dynamic processes.

HASM quantum machine learning

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Moore's law states that the number of transistors on a microprocessor chip will double every two years or so. It was worldwide acknowledged that Moore's law was nearing its end. In other words, the miniaturization of transistors has been an essential progress in computers mainly to speed up their computation. Such miniaturization has approached its fundamental limits. Fortunately, the development of quantum computing brings light to solve this problem. The method for high accuracy surface modelling (HASM) is an approach to reinforced machine learning. It can be transformed into a large sparse linear system and combined with the Harrow-Hassidim-Lloyd (HHL) quantum algorithm, by which a HASM-HHL algorithm was developed for quantum machine learning. HASM has been successfully operated on classical computers to conduct spatial interpolation, upscaling, downscaling, data fusion and model-data assimilation of eco-environmental surfaces, such as digital terrain models, climate change, carbon stocks, CO2 concentrations, soil properties, COVID-19, species diversity, and ecosystems. In all of these applications, HASM has produced more accurate results than other methods, thereby foreshadowing the advantages that would likely follow the adoption and use of HASM-HHL for such applications. Ideally, HASM-HHL can maintain the high accuracy of classical algorithms, and meanwhile it can achieve exponential speedup compared to the classical algorithms, which has been demonstrated by several case-studies in Poyang Lake Basin.

Deep learning method for large-scale automatic lake extraction using Sentinel-2 imagery

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Lakes are important natural resources related to human survival and development. Lake extraction from remote sensing images is an important approach to monitoring water resources. With the development of deep learning technology in the remote sensing field, deep learning models have also been utilized for lake extraction. Compared with traditional methods, methods based on deep learning models are able to learn more complex and nonlinear characteristics of lakes.

Therefore, we built a neural network based on the novel Transformer architecture to extract lakes from remote sensing images. Due to the similarity between lakes and cloud shadows, in terms of spectral characteristics, cloud shadows are often misclassified as lakes during lake extraction. We thus produced training datasets that contained different proportions of cloud shadows so that we could explore how cloud shadows affected the accuracy of lake extraction.

Sentinel-2 imagery, European Space Agency (ESA) WorldCover 10 m 2020 product are utilized to produce the training datasets. To produce the image data of the training datasets, three water-sensitive bands (short-wave infrared, near infrared, and red) were utilized, since water bodies are strongly absorbed at these three bands. To produce the ground truth data of the training data efficiently, the ESA WorldCover 10 m 2020 product was utilized to assist lake labeling. We use ten scenes of Sentinel-2 images in Tibetan Plateau in 2020 to make about 5000 384×384 pixel-sized training samples. The validation dataset was produced using two additional Sentinel-2 images, which contained 220 samples with sized 384×384 pixels. The 220 samples contained differently-sized lakes and different types of cloud shadows so as to evaluate the ability of the proposed network to address cloud shadow interference.

We found that, when the training dataset contained 4% cloud shadows, the obtained model could effectively handle the misclassification of cloud shadows and improve the accuracy of lake extraction, and with this model, the evaluation results over the validation dataset achieved an overall accuracy (OA) of 0.9954 and a Kappa of 0.9568. In addition, the Transformer-based network was applied in the endorheic basin of Tibetan Plateau to further evaluate the generalization ability of the network over a large area. The Global Surface Water (GSW) dataset from the European Commission Joint Research Centre was used as a reference to validate our results in this area.

Our study shows that the Transformer-based network demonstrated very good performance in the lake extraction from Sentinel-2 imagery, as confirmed from the accuracy evaluation results and prediction results in the endorheic basin of the Tibetan Plateau. With the Transformer-based network, lakes could be directly extracted from remote sensing images, with no additional pre- or post-processes required to refine the lake extraction results. Therefore, the Transformer-based network could be applied in large-scale areas for automatic lake extraction.

The cloud shadow interference issue in lake extraction could also be addressed by the proposed network. We found that increasing the proportion of cloud shadows in the training dataset was an effective way to avoid cloud shadows being misclassified as lakes. Additionally, we observed that, the higher the proportion of cloud shadows in the training dataset, the higher the accuracy of the trained network.

The training dataset containing cloud shadows played an important role in addressing cloud shadows misclassified as lakes. However, we also found that boundary accuracy for the extracted lakes was not impacted by the proportion of cloud shadows in the training dataset. No matter whether the training data contained cloud shadows and irrespective of their proportions (i.e., higher or lower), there were no significant differences in the lake boundaries for the extracted lakes.

In summary, the proposed Transformer-based network demonstrated excellent performance in lake extraction from remote sensing images. By adding a certain proportion of cloud shadows to the training dataset, the network was better able to address the interference of cloud shadows; thus, we did not need to select clear-sky images or eliminate the interference of cloud shadows by additional processing methods when extracting lakes. The trained network could also be used for automatic lake extraction in a large area due to its robustness. In addition, this study also shows that Transformer-based networks could have great application potential in remote sensing image classification.

Feasibility of nighttime lights data for the estimation of time-series gross domestic product and monitoring of industrial zones

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This study aims to expand the usage of nighttime light data beyond the cross-sectional domain to the time-series domain, specifically in estimating GDP on a quarterly or monthly basis. The official agencies often take time to calculate this data, and higher frequency GDP data are not available for each month or smaller geographic areas such as provinces or communes. Therefore, this research investigates the feasibility of utilizing nighttime light satellite data to estimate quarterly time-series GDP data in Japan from 2012 to 2022, including analyzing nighttime lights of industrial zones for the possibility of monitoring their operation. The results show that the original nighttime lights possess a moderate correlation with real quarterly GDP, and with proper processing, including albedo normalization and seasonal decomposition, nighttime lights could show a strong correlation with seasonal adjusted quarterly GDP. The study suggests that future research should focus on normalizing or processing data to the daily level to further improve the capability of nighttime light data to timely estimate quarterly GDP, as factors such as albedo should be modeled at the instant time. Overall, this study provides evidence that nighttime light data can be a useful tool for estimating economic activity, not only in the cross-sectional but also in the time-series domain, particularly in regions where official statistics are limited or unavailable or when faster GDP estimation than official sources is needed. It also shows the possibility of using nighttime lights to monitor industrial zones' operations. The study contributes to the growing body of literature on using satellite data for economic analysis, highlighting the potential of nighttime light data to provide timely and high-frequency estimates of economic activity.

Deep Unsupervised Building Extraction from High Resolution Remote Sensing Images

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Building footprint information is critical for building digital geographic information bases and urban planning. Deep learning algorithms have achieved gratifying results in building extraction from high spatial resolution remote sensing images. However, the limitations of annotation hinder the development of deep learning. In this paper, we propose an Unsupervised Knowledge Transfer (UKTrans) framework for extracting buildings from unlabeled remote sensing images. The proposed method breaks the limitation of training data by providing pre-trained models. It is this way that allows the network to adaptively perform automatic building footprint extraction without using any labeled data or pre-training the network outside of it. Considering the style difference between the training area and the detection area, a style transfer mechanism is introduced. In addition, a knowledge integration module is proposed to comprehensively consider building style differences, structural information, multi-scale features, and road negative sample information. Good building masks are obtained by integrating information from multiple sources. Aiming at the problem of boundary fragmentation, a simple and effective post-processing method is used to obtain regular and reliable building boundaries. The performance of UKTrans is demonstrated on three public datasets from WHU, Massachusetts and Inria. Overall, UKTrans can meet the needs of extracting high-precision building footprints from high resolution remote sensing images.

Sea Ice Concentration Product based on HY-2B SMR

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Sea ice concentration is the main parameter describing sea ice in polar regions, defined as the percentage of sea ice cover per unit area. The SIC data obtained based on the brightness temperature data of the spaceborne microwave radiometer can obtain a wide range of sea ice conditions in quasi real-time because it is not affected by weather conditions. It is an important data source for scientific research such as ship planning, numerical forecasting, and climate change. This paper uses the method of retrieving polar SIC using the HY-2B satellite scanning microwave radiometer to obtain a SIC dataset that is consistent with NSIDC products. The results are preliminarily verified using field observation data and SAR data. The main conclusions are as follows: (1) The key to this method is to project the bright temperature data of each channel of the F18 microwave radiometer and HY-2B scanning microwave radiometer in 2019 into the polar stereo projection grid, Excluding observed outliers and land area data, matching data were obtained using a spatiotemporal matching method with a 1h temporal resolution and a 25km spatial resolution. Linear regression calculations were performed using matching data from three days per month to calculate the monthly regression coefficients for each channel, and the brightness temperature data of the HY-2B microwave radiometer were corrected based on these regression coefficients. (2) Weather effects have a significant impact on the accuracy of retrieved SIC data. Two weather filters, GR (36.5/18.7) and GR (23.8/18.7), are used to effectively remove chaotic SIC caused by atmospheric water vapor, liquid water in clouds, rainfall, and other phenomena over open sea areas. For areas that cannot be effectively removed by weather filters, a sea ice mask is used to correct the residual stray sea ice in open water. The land pollution effect is the main cause of errors in SIC data sets. The generation of five types of coastal templates and the calculation of the minimum summer density template for microwave radiometers at the northern and southern poles have effectively corrected a large number of false sea ice caused by land pollution, but there is an excessive correction phenomenon in lake areas. (3) Based on this method, the Arctic and Antarctic SIC is retrieved and the sea ice range is calculated separately. Statistical analysis is conducted to verify the accuracy of the dataset. The trend of sea ice range change is basically consistent with that of NSIDC products; Compared with field observation data, inversion results are all underestimated, while the average deviation in the Arctic is relatively large, at 10.36%, which is much greater than the average deviation in the Antarctic of 2.73%. The correlation coefficient in the Arctic (0.813) is smaller than the correlation coefficient in the Antarctic matching data (0.916). The standard deviation between the Arctic and Antarctic matching data is not significantly different, at 16.97% and 15.25%, respectively. The results of this study have laid the foundation for the release of China's autonomous satellite's polar SIC business products, which can ensure the continuity of polar sea ice records facing disruption for nearly 40 years.

Opportunities and Challenges of Sustainable Development in the Mongolian Plateau Driven by Big Earth Data

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The Mongolian Plateau is an important ecological shelters in Northeast Asia and a sensitive region for global climate change. Due to climate change and human activities, the sustainable development of Mongolian Plateau has been affected by natural disaster or resources, environmental, and ecological problems for a long time, such as desertification, grassland degradation, grassland fires and dust storms and so on. The development of big earth data and artificial intelligence (AI) technologies offers opportunities for the sustainable development in this region. Focusing on the key common problems and needs of resources and ecological environment in the Mongolian Plateau ecological shelters, this paper adopts the "big data + AI" approach to break through the regional long-term data bottleneck, design algorithm model integration tools and autonomous-controllable computing environment. It will provide remote sensing algorithm application scenarios and cases in land cover mapping, grass production estimation, surface water extraction, long time series desertification inversion, dust storm dynamic monitoring, grassland carbon storage capacity assessment, ecologically fragile zone division, grass and husbandry balance regulation, etc. The research results of multiple types of algorithms, data and tools will be developed to significantly improve and promote the ability of intelligent computing, big data analysis and visualization application services for the construction of the Mongolian Plateau ecological shelters. Meanwhile, it supports cross-border regional collaboration and provides user interaction services for multi-scale scenarios such as Mongolian Plateau-Transect -Herdsman household. The knowledge findings provide a transformative 'data-driven' paradigm to support the sustainable development in Mongolian Plateau.

Real transportation connections accounting applied to enhance settlement field potential models

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Population density is one of valuable factors of economic development and ecological stability in inhabited areas. It appears to be a key point of interest when studying and forecasting humanitarian risks of any nature. Population density study practice in human geography domain assumes application of Geographic Information Systems (GISs) to ensure mapping and geospatial data analytics. GIS application in this case, can be denoted as a traditional instrument. However, implementation of new automation technologies in GISs lead to complexing and convergention of population density studies. For instance, machine learning implementation in GIS helps to automate the settlement gravity model computations and ensures indirect estimation of population density field.

Classic approach to direct estimation (description, modelling) of the population density is the application of gravity model to the settlement. The model derives physics idea of interaction between spatial objects (between settlements in our case). The approach assumes interpolation of a geographical variable called settlement field potential (SFP). GISs are applied as a tool for computations and mapping automation. The term used to entitle the variable and computational formula are varying from author to author, while the general idea remains common, - the variable estimates the degree of mutual impact of the objects (settlements) onto each other according to their scale and distance. The population value is used in many cases as scale parameter, while distance is estimated as a straight-line distance between settlements (at least in the studies known to the us).

Bearing in mind that we are operating in geographic coordinate space, we can conclude that the straight-line distance have no unified interpretation. Especially in wide area regions, where its estimation will wary depending on map projection. Moreover, when we are dealing with population, transportation or economical interactions between settlements, we cannot operate in Cartesian coordinate space. All the interactions will be realised through nonstraight/nonlinear connections, for instance through the road network. In such a case, closely located objects can be split by geographic barrier of any nature, and asses distance in the transportation network can be extremely longer than nominal Cartesian distance. In connection to this, our study is devoted to implementation of gravity model able to account distances in transportation network distances. This model is demanded when investigating transborder regions, where people migrations through the state border are possible in

We use the Russia-Kazakhstan transborder region as the ground test area. To design a needed (computational) model we elaborate methodology that assumes integration of road graph computations (to estimate distances), desktop GIS software (to automate SFP computations and mapping), and spatial analytics (to assess mapping results in the meaning of geographic correctness).

Current results of our study incorporate the data conversion and processing techniques designed to estimate and map SFP for the studied region, a set of algorithms (program code) that implements these techniques, and a map series produced for the Russia-Kazakhstan transborder region that illustrates performance of elaborated methodology, and makes it possible to ensure comparative analysis road-graph-based modeling to the straight-line-based.

Why Have Soil Data Harmonization Efforts Not Succeeded in Fulfilling the Digital Earth Visions So Far?

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Now more than ever, soil health is high on the agenda due to its importance for food production, security, climate change mitigation and other ecosystem services, among others as emphasised by the seven United Nations Sustainable Development Goals. Digital Earth should become a game changer by providing access to reliable, harmonised data collected at local, national, continental and global levels, to allow informed decision-making at all scales to support, among others, soil health improvements.
This paper is structured as follows. Firstly, it introduces an overview of the current status of soil data modelling, standardisation of relevant aspects of the data models, and legacies, closely connected to the traditional 'soil schools' that originated in the 19th century. The way forward for broader adoption of structured soil data provisioning and exchange is not through the creation of yet another soil information model for international unification. Instead, this paper presents the data modelling achievements of the Global Soil Information System (GloSIS), developed under the Global Soil Partnership hosted by the Food and Agriculture Organization of the United Nations.
The GloSIS ontology unites the core spatial elements of existing soil data models, making it feasible to map these to the GloSIS ontology, while utilising the OGC (Open Geospatial Consortium) Observations and Measurements model (O&M, ISO 19156) at its core, enabling flexible provision of both existing and emerging concepts pertaining to soil data. The initial GloSIS data model was developed in UML, taking into account all requirements from Geography Markup Language (GML), and including all required codelists. Based on this UML model an XML schema was created.
Subsequently, an ontology was derived from the GloSIS UML Model, enabling the publication of soil-related Linked Data. By utilising Linked-Data technologies such as JSON-LD, data providers can continue to provide their tried and tested models, while indicating the correct semantic mapping through utilisation of the GloSIS Ontology. Data consumers can easily align all required data sources to the structure of the GloSIS Ontology, providing harmonised access to disparate data sources.
Based on this semantic annotation approach, the approach chosen for GloSIS can help lay part of the foundation of the Digital Earth, both through the vast amount of soil relevant data that can be unlocked through this approach, as well as by serving as a model for how other thematic communities can align their diverse data holdings via a generalised ontology. In the end, the way towards soil data harmonisation under the umbrella of the Digital Earth will be presented, including examples demonstrating the value of harmonised data, like being able to retrieve (and thus analyse) harmonised observations for a specific physioChemical property from multiple data sources (different data sets from different endpoints).

Process-oriented ocean spatiotemporal dynamic data mining for time-series of raster datasets and scientific discoveries

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Advanced Earth-observing technologies make it possible to acquire lengthy time series of multiple remote sensing images from optical sensors, altimeters, scatterometers, synthetic aperture radar imaging, which provide a foundation for the study of ocean dynamics in basins or global oceans. An ocean dynamic provides information on when and where marine environments change as well as how they evolve in space and time. In a comparison focusing on changes in terrestrial dynamics over time, the ocean dynamic focuses on the evolution in space and time. However, focusing on the discrete objects, the spatiotemporal data mining has a great challenge of founding dynamic evolutions. The main reasons lie in followings. 1)The traditional spatiotemporal mining methods take a point, a line, a polygon or a voxel as an analyzing unit, which focus on more attentions on spatial characteristics than the temporal changes. 2) A scale of data acquisition is different from the one of oceanic dynamic evolution, thus, the scale of data acquisition-driven representing models, extracting algorithms and data mining technologies consider few temporal relationships and limits their dynamic analysis. To deal with the above challenges, this paper abstracts the dynamic property from production through development to dissipation into an ocean process, takes it as a scale of analysis, and proposes a novel approach of ocean dynamic analysis, named as PoSTDM (Process-oriented ocean spatiotemporal dynamic mining approach). PoSTDM, firstly, defines the process semantics with a hierarchical abstraction of “geographical process-evolution sequence- instantaneous state ”. Then, based on the process semantics, an ocean dynamic representing model, a marine abnormal variation extracting method, and an ocean dynamic mining model are developed. Finally, a real dataset of monthly sea surface temperature anomaly (SSTA) during the period of Jan. 1950 to Dec. 2021 is to explore their evolving structures in Pacific Ocean. Results demonstrate the effectiveness and the advantages of PoSTDM: the evolutionary structure of sea surface temperatures in Pacific Ocean are found, and the association patterns between the evolving structures of SSTA and the types of ENSO are addressed. These new findings may help better understand global climate change.

Global Three-Dimensional Aerosol Structure Construction with Regional Spectral Radiation Matching

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Aerosol vertical structure (AVS) plays an important role in the Earth's climate system. The spectral radiance matching (SRM) method can effectively reconstruct the aerosol three-dimensional structure, but it is affected by the donor-recipient matching accuracy. To overcome this problem, in this paper, the SRM algorithm is improved by using area spectral radiation matching instead of single-pixel spectral matching. First, the cost function is constructed by the multispectral radiometric difference between the off-nadir recipient pixel neighborhood and the potential donor neighborhood within the MODIS scan. The best donor-recipient match is selected by minimizing the cost function. Then, the corresponding donor pixel aerosol profile information from CALIPSO observations is assigned to the recipient pixel, which fills the gaps between CALIPSO track and achieves a true AVS global estimate. Finally, the algorithm accuracy is verified by reconstructing the track with CALIPSO observations. The experimental results show that the correct matching rate of this method is 79% and 72% at 30km and 100km extensions, which is 4% and 7% higher than that of SRM algorithm.

Geospatial User Feedback as a knowledge network through NiMMbus system

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Nowadays, in an era marked by the habits associated with social networks in digital environments, it is very common to give an opinion about a product, provide a comment or simply indicate that you "like" something. Regarding geospatial products, many times we also have an opinion to provide about an experience working with a specific layer, or maybe we have found the way to solve a dataset problem, or sometimes we have identified a new methodology and want to notify to others about the discovery.

Geospatial User Feedback (GUF) is an OGC standard, originated in the EU FP7 GeoViQua project. It is based on metadata mainly produced by the users of geospatial data products or services, as they use and gain experience with them, so that is directly related to their background while working with a given geospatial resource. It provides a data model that includes ratings, comments, usage reports, citations to publications. Most of the elements are actually used broadly to communicate information and knowledge gained by using the dataset.

NiMMbus is a platform that provides an interface for user feedback based on GUF, that works directly on the website (www.nimmbus.cat) and also can be easily integrated into existing servers or online data catalogues, by a data or metadata identifier. It allows to provide comments, ratings (evaluations), making questions or user reports of dataset problems, and proposing solutions to those problems (among other possibilities), all of them related to the use or interpretation of a dataset by the one that has been using it.

NiMMbus is a growing system that has evolved from the EU H2020 NextGEOSS project, and now it is improving due the H2020 EIFFEL and H2020 ILIAD projects.

On geoinformation field, most of the time, the metadata is created by the producer of it, so it is mostly showing the production interest or the purposes of it, the main objective of its creation. On the other side, a user can find different ways of working with the same data at the time that can report positive or negative experiences using it, provide comparison between datasets or layers and, if users or consumers from different backgrounds are also considered, they can evaluate the same dataset from different points of view, enriching the final knowledge associated to it.

Some of the benefits of working with GUF through NiMMbus is that other users can easily understand what the dataset or the tool is about, at the time than knowing the experience that other users had when working with it. This can also help to the producer, as can improve the product based on the user feedback items. However, one of the most outstanding benefits of implementing GUF through NiMMbus is the possibility of including "Reproducible Usage".

Reproducible Usage is the possibility to exchange new knowledge, through the addition of a code that will automatically work for another user that incorporates it to their project. This was implemented on the H2020 ECOpotential web map project (maps.ecopotential-project.eu), which is connected to NiMMbus through a widget. The portal has analytical capabilities which allow creating new layers thanks to a layer calculator. So, for example, if any user has created a new index for Remote Sensing useful for the management of Protected Areas and has save it, another user or consumer can use that tool, adding it to their navigator, and use it later. The latter is a simple example, but the same idea could be applied to eventually linking it to a Jupyter Notebook with a code for a more complex reproducible usage.

NiMMbus is a platform, then, that has been created to connect through the GUF the experiences of both users and producers of datasets and geospatial tools, by building a knowledge network associated with the interconnection of experiences with geospatial information. It also helps in creating communities and in a better flow of incremental knowledge created by several actors in the community.

Big Earth Data-driven Design and compilation of Resources and Environment Atlas of South Asia along the Belt and Road

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Located in the southern part of the Eurasian continent, South Asia is the central region connecting Central Asia, West Asia and overland routes to Europe. It is located at the throat of the world's busiest Indian Ocean shipping route, and has always been the hub of economic and cultural exchanges on the Eurasian continent. As key regions and natural partners of the Belt and Road Initiative, the China-Pakistan Economic Corridor, the Bangladesh-China-India-Myanmar Economic Corridor and the China-Nepal India Economic Corridor have been implemented or planned. However, South Asia has a large population, diverse cultures, and significant differences in economic development levels within the region. In addition to the complex topography, Indian Ocean monsoon and climate change, the region suffers from frequent natural disasters such as floods, droughts, glacial lake outburst and mountain disasters, as well as water shortages, and is faced with such prominent problems as a fragile ecological environment, degradation of resource endowments and natural disaster risks. This has brought great challenges to the security construction of the Belt and Road Initiative in South Asia and the sustainable development within the region. Therefore, the big Earth data information of natural resources, ecological environment, disaster risk and social economy in South Asia is an important basis for scientific cognition and response to these issues.

Under the guidance of geological principles, the resource and environment atlas forms the collection of thematic information and knowledge map by using information theory, system theory and location theory, and through the analysis and synthesis of various phenomena and elements. Atlas is rich in information, and is an important scientific tool for intuitive understanding of a region. In recent years, with the development of cutting-edge technologies such as digital Earth and big Earth data, atlas design and compilation have new connotations in the new era. In the past ten years, with the support of the Strategic Priority Research program “Big Earth Data Science Engineering (CASEarth)” by the Chinese Academy of Sciences, we have formed a systematic analysis method, datasets and data platform for the research on South Asia. On this basis, the team adopts the expression perspective of multi-scale, multi-level and multi-thematic integration from the two dimensions of time and space to design and compile the Belt and Road Atlas of resources and environment in South Asia. Starting from the depths of history, the atlas set several sets of "lenses", such as the global scale, the continental scale, the South Asian subcontinent scale, the sub-national scale of South Asia, the economic corridor scale, and the node city scale. With the support of 43 sets of geographic base maps, the multi-scale information nesting, correlation and spatiotemporal association was formed. Starting from the four first-level topics of natural environment, natural resources, natural disasters and social economy, 53 second-level topics and 310 third-level topics were organized from the top down. The atlas realized the knowledge integration from the description of the state of resources and environment to the analysis of spatio-temporal trends, and then to the risk assessment. Through rigorous logical design, the "digital Silk Road" was implemented and the South Asia view under the Belt and Road Initiative was presented in an orderly manner within this atlas.

This paper reviewed the data basis and compilation background of the atlas, introduced the design of the atlas in detail, including layout design, base map system and content design, and showed the specific cases of the sequence map group, the South Asia map group, the country map group and the corridor map group. Based on this, the innovations and highlights of the atlas are summarized. The atlas takes into account the overall design requirements of the epochal character, scientificity, integration and literature value. It helps to understand the resource and environmental issues that may be faced in the planning or construction of economic corridors in South Asia and within the region, as well as potentially sensitive areas of ecological environment and natural disaster risk. The atlas fills a gap in mapping and documentation on cross-border resources and environment in South Asia, and will serve as a regional scientific reference for China's efforts to promote healthy, green and safe neighborhoods and global relations.

Study on Evaluation of Human Security Indicators (HSI) using Geographic Information System

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Human security is a concept for safeguarding people's freedom from fear and want as well as ensuring people's right to live in dignity. Sustainable Development Goals (SDGs) and human security are closely related and go hand in hand with each other. Japan, as a developed country, has achieved many of SDGs in terms of national averages with exception of gender equality and some environmental issues. However, it still confronts with serious issues from the perspective of the objective of SDGS to achieve societies where no one is left behind. The issues include poverty of children, violence against children and women, situation of people with disabilities, and LGBT, the youth poverty, social isolation in the elder people, and situation of refugees and foreign workers in Japan.

In this study, we visualized various issues of human insecurity of people in Prefectures of Japan (47 prefectures) and Municipalities in Miyagi Prefecture, Japan (35 Municipalities) using Geographic Information System. It clarified who and where to focus on, what kind of efforts should be strengthened, and what kind of improvement was needed to achieve the objective of no one being left over. Miyagi Prefecture was selected as the target region because it was severely damaged by the Great East Japan Earthquake in 2011 and has a low human security index by prefecture, which is thought to be a concentration of various regional issues.

The indicators consisted of the three main components of Human Security: "life", " livelihood " and "dignity". The indices consisted of life indicators (23 indicators), livelihood indicators (42 indicators), and dignity indicators (26 indicators) in the Japanese prefectural version. Furthermore, the Japanese municipal version (Miyagi Prefecture) consisted of life indicators (26 indicators), livelihood indicators (48 indicators), and dignity indicators (25 indicators). In selecting the index, we used data compiled mainly by public institutions, referring to many previous studies. We organized a project team of about 20 people, centered on experts in each field, and discussed and examined.

In addition to the objective data, a subjective evaluation was also conducted by questionnaire survey. Since it is difficult to incorporate subjective evaluations in existing statistics, a questionnaire survey was conducted on the Internet to supplement statistical data and Residential area, generations, and gender were equally assigned and analyzed. From the above questionnaire, we grasped the actual situation of "Self-fulfillment" and "social connection", and calculated each index at prefecture level and municipality level.

As result of analysis, prefectures in the Hokuriku region have high overall indices, but low "self-fulfillment" and "social connection". Because there is a gap between the livelihood of people based on objective statistical data and subjective factors. It became clear that measures to raise the subjective factor were urgent. In Hokkaido and Tohoku prefectures, the index values are low, and there are many issues such as health, income, employment and women's empowerment.

The analysis of municipalities in Miyagi Prefecture shows that the Life index and Dignity index are high in Sendai city and its suburbs, and thus the Overall index tends to be high. The municipalities in the coastal areas that were severely damaged by the earthquake have lower life and dignity indices, and therefore lower overall indices." Self-fulfillment" and "social connection" were also lower in coastal municipalities, indicating that coastal municipalities in Miyagi Prefecture face various challenges in building a community where no one is left behind.

Multi-scale Remotely Sensed Estimation of Fractional Vegetation Cover in Desert Steppe, Inner Mongolia, China

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Desert steppe ecosystem belongs to one of the fragile terrestrial ecosystems and it is easily affected by climate changes and human activities. Fractional vegetation cover (FVC), the ratio of vegetation occupying unit area, is a key parameter for describing vegetation quality and reflecting ecosystem changes. It is also a controlling factor in transpiration, photosynthesis and other terrestrial processes. So FVC is a quite important parameter for to represent ecosystem's characteristics and especially which is for fragile ecosystem such as desert steppe. This study conducted multi-scale (10m, 20m, 60m, 300m and 500m) remotely sensed estimation of fractional vegetation cover for the year of 2021 in a part of desert steppe ecosystem by using NDVI–SMA (normalized difference vegetation index and spectral mixture analysis) model based on Sentinel-2 MSI and Sentinel-3 OLCI/SLSTR images. Validation of modelled FVC mainly used ground truth pictures which were obtained by digital camera in 2021. The study area is located in the middle part of Dorbod Banner, Inner Mongolia, China, between 110°54´E and 111°50´E, and 42°00´N and 42°35´N. As the research purpose and final results, this study discussed simple satellite based NDVI-MSA model how effective for FVC estimation in desert steppe region and its accuracy is how affected by spatial resolution of original sentinel images used in the model.
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In Situ Earth Observation data requirements as key basis towards a full Digital Earth

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Vast amounts of in situ data are produced from different sources, including ground-based, sea-borne or air-borne monitoring systems. In situ sensors can be carried by air balloons, ground stations, among others, and can be produced by several actors, from researchers, public map agencies, private companies or citizen scientists. However, while a common understanding exists for satellite-based Earth observations' data sharing and management, the in situ data domain still faces challenges associated to its heterogeneity and fragmentation, including issues related to the accessibility, interoperability, quality and legal aspects, making difficult its use and reuse. Willing to fill this gap, the InCASE project has designed a Geospatial in-situ REQuirements database model ("G-reqs") aimed to collect and manage the in situ data requirements in the context of the Group on Earth Observations (GEO). Following the FAIR and the GEO Data Management Principles, the G-reqs model provides a standard methodology for the gathering of in situ data user requirements, as well as requirements for products that define the parameters (in terms of spatial, temporal coverage or quality target) that future datasets measuring Essential Variables should fulfil. The usefulness of the G-reqs lies in its capability to collect, share and analyse requirements, detect gaps and barriers, as well as help to make recommendations to data providers for the production of fit-for-purpose in-situ global-coordinated datasets towards a full Digital Earth. The model was implemented in a web form and was tested by the EuroGEO community, represented by pilots of the EU H2020 e-shape project. The entire Earth Observation community of users (researchers, decision-makers looking for policy indicators, remote sensing agencies in need of cal/val data, Machine Learning modellers, etc.) is invited to use the G-reqs as a mechanism to document its in-situ data needs (https://g-reqs.grumets.cat). G-reqs is at an early stage and it will evolve based on lessons learned. This work is inspired by the World Meteorological Organization (WMO) OSCAR requirements database, the OSAAP (formerly NOSA) from NOAA, and the Copernicus In-Situ Component Information System (CIS2). This work is done by the InCASE project, funded under the EEA – European Commission (RTD) Service Level Agreement on “Mainstreaming GEOSS Data Sharing and Management Principles in support of Europe’s Environment”.

Integration of a decentralized cloud-integrated spatial data infrastructure (SDI) and the Copernicus ecosystem in a public authoritiy: Lessons learned and solutions

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Digitization of public authorities is an essential component to meet today's societal challenges which are defined by overarching political programs such as European Unions' green new deal or United Nations' Sustainable Development Goals. In order to tackle these complex problems and to contribute effectively, public authorities have to be empowered to handle large and heterogeneous data from a wide variety of sources. This applies in particular to authorities that have to work with large amounts of geodata, such as earth observation data from the European Copernicus program (e.g. Sentinel 1-5). For public authorities, however, the efficient management of big data, the use of artificial intelligence, launching new disruptive software solutions as well as the implementation of viable infrastructures for data computation and storage represent immense challenges. Strict IT security rule sets, specific data governance requirements and lacking organizational capabilities often hinder public authorities from operating modern technologies such as commercial cloud computation platforms and web-based centralized storage systems as well as impede open data policies. Consequently, local isolated solutions for data infrastructures are developed and implemented by 'reinventing the wheel', resulting in duplication of efforts and resource needs, and translating into substantial monetary costs.
To overcome these obstacles, we present a solution on how to establish a modern cloud-integrated SDI at a public authority in the agricultural sector. A practical example is used to describe the setup of our SDI and the integration of the cloud platform CODE-DE, which was developed specifically for the national analysis of Copernicus' Earth observation data for German public authorities.
We indicate how additional modern software solutions (e.g. data cubes, Git and OGC web services) can be coupled within our public authority for seamless communication and usage of different types of (geo)data from different sources. Using the example of determining production-related dates in sugar beet cultivation in Germany, we show how our SDI works. Sentinel-2 data are processed in the cloud, geodata from other sources and locations are implemented in the workflow on-the-fly and the results are integrated in a datacube to share them with web services.
We summarize our lessons learned into four major key findings that hamper the establishment and unrestricted use of such an SDI. These are, (A) the lack of organizational strategies that, (B) bring all stakeholders together from the very beginning of the SDI development in an agile management project environment. The infrastructure solutions to be established must be planned for the long term with regard to (C) human resources as well as necessary investment in infrastructure, and the internal and external use and sharing of the resulting data should be fixed in a (D) geodata governance framework.
The decentralized and cloud-integrated SDI proposed, potentially serves as blueprint for public authorities. The goal is to support authorities on their way to becoming modern data product and service providers by leveraging the enormous potential of integrating big geospatial data, including EO imagery into their analysis frameworks.

Inspiring Citizen Science Innovation on China's Monitoring of Water-related Sustainable Development Goals

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The global challenge of sustainable development is contained in the 17 United Nations Sustainable Development Goals (SDGs) to which China has committed. While water is at the heart of sustainable development as stated in the UNESCO-WWAP report. For SDG 6 (on the quality, availability and management of freshwater resources, aimed at ensuring global water and sanitation sustainability) at the heart of the water topic, it affects 15 of 17 SDGs（e.g. SDG 3 health effects of contaminated water). Despite the importance of water, China still lacks data on the implementation of water-related SDGs, especially SDG 6. In addition, the emergence and spread of COVID-19 has been a major setback in global ambitions to achieve Goals. More efforts are required to focus on developing and leveraging the wealth of real-time data available from multiple data resources, including non-traditional sources. and citizen science (CS), as scientific activities in which non-professionals voluntarily participate and work with experts, is exactly one of non-traditional ones. Evidences on CS application into SDGs have been found in many western countries (e.g. UK, US). While China, an eastern country, only a few CS water-related projects are active and most of the public do not even know the terminology of CS. Whether CS can also add value to the indicator measurement of water-related SDGs is a question worth discussing and answering.

To this end, this study used participant observation and semi-structured interview methods to evaluate the effectiveness of 24 existing water-related CS projects in China, based on a modified CS assessment framework with three dimensions (scientific, participatory, socio-ecological and economic). There are 4 major outcomes: 1) Water-related CS projects are mainly divided into four types in China, consisting of freshwater monitoring, drinking water monitoring, water-related ecosystem observation and water education; 2) Since China's policy is inclined towards the construction of ecological civilisation, among these four types of projects, the projects with more government support are the third and fourth types; 3) In order for citizen science to be more widely accepted and promoted in China, it is best to use the term public participation, which can not only dispel the doubts of the government, but also narrow the distance with the public; and 4) Although the current water education project does not contribute data to the SDGs, it can be designed to assist the other three types of projects to complete interactive training, thereby helping to monitor water-related SDGs indicators. This is also one of the main feasible paths for China to expand its water-related CS projects in the future.

Innovative tools for lake water quality monitoring, citizen science and data sharing with SIMILE project

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The management of environmental resources by government and public administrations requires thorough knowledge of the phenomena occurring on the territory. Among critical assets, water quality is one of the most sensitive matters, in particular due to the effects of climate change. In this framework, the SIMILE (Integrated monitoring system for knowledge, protection and valorisation of the subalpine lakes and their ecosystems) project, funded in 2019 by the Italy-Switzerland Interreg programme, aimed at providing the cross-border public administrations with innovative tools for monitoring the water of the main Insubric lakes, Como, Maggiore and Lugano. The idea behind the project is to take advantage of different techniques complementing each other from the temporal and spatial point of view. The considered techniques include: in situ monitoring with high frequency sensors mounted on buoys and platforms, periodical production of water quality parameters maps, exploiting satellite imagery, and the contribution of citizen science thanks to a smartphone application which has been developed in the framework of the project. All data are shared online, both with experts and citizens, through web applications and a business intelligence platform.
The remote sensing surveying aims at covering the full surface of the lakes providing knowledge of the lake water quality on a periodical basis. The C2RCC processor is used to obtain Chlorophil-a and Total Suspended Matter maps, at least on a weekly basis, from the images acquired by the Ocean and Land Colour Instrument of Sentinel-3 satellite. The Barsi method is applied to produce Lake Surface Temperature maps from Landsat 8 Thermal Infrared Sensor, at least on a monthly basis. The processing is performed in SNAP open source software and has been automatised including refinements such as coregistration and outlier rejection. The maps are managed in a collaborative platform based on Geonode (https://www.geonode.eo.simile.polimi.it/) and the time series of maps can be explored through a WebGIS (https://www.webgis.eo.simile.polimi.it/). The availability of time series of maps allows for further investigations, e.g. to explore the presence of zones with homogenous behaviour with respect to the parameters under study.
A smartphone application called SIMILE, free and open source, implemented both for Android and iOS and available on the stores, has been developed in order to allow both experts and citizens to acquire pictures and parameters. Citizens can single out phenomena that cannot be covered by the other considered techniques, from the spatial point of view, with respect to the limited number of buoys (three for Como lake, one for Maggiore lake and one platform for Lugano lake), and from the temporal point of view, with respect to the periodical production of maps from satellite imagery. The smartphone application allows to acquire pictures as well as details regarding water quality, such as temperature, transparency, pH, but also the presence of algae or foams, among others. The data are stored into a MongoDB database and are shared through a Web application (https://simile.como.polimi.it/SimileWebAdministrator/). The application allows for the management of the data as well as for the display of statistics of the acquired information. During the four years of project, the data acquisition performed by citizens has been fostered through didactic and promoting activities with secondary schools (60 classes in 16 schools have been involved), sport and leisure associations and municipalities. The mobile application has been integrated in the Canton Ticino warning system for the observation of phenomena on the lake, proving the usefulness of exploiting new technologies, involving citizens to support the local administration. Training courses have been provided to the local public administrations regarding each technological component of the project, in order to increase the knowledge of the operators and to train them to perform the processing, to foster the sustainability of the monitoring after the end of the project. The use and the implementation of open source applications contributes to the sharing of knowledge and promotes the development of other products with similar goals and improves as well the sustainability of the activities freeing the public administrations from the software licenses. The sharing of all data through the web applications as well as the direct involvement of citizens in the lake water quality monitoring raises the attention to the protection of the environment.

DestinE User Community: Stakeholder engagement for co-creating DESP use cases

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The DestinE Use Cases Project, executed by a Consortium led by RHEA Group with the Aristotle University of Thessaloniki and Trust-IT, regards the selection and implementation of a first set of Use Cases meant to demonstrate the ability of the DestinE infrastructure in general, and the DestinE Service Platform (DESP) in particular, to provide actionable information and decision support to its end-users. The project aims also at actively engaging the broad community of DestinE stakeholders, gathering their requirements, and encouraging their direct involvement and guidance in the continuous evolution of the DestinE infrastructure towards the future Phases of the Initiative.
The establishment of a strong (both in terms of numbers of members and interactions) and vibrant DestinE User Community seems crucial in informing the successful and well-targeted development and initial operations of the DESP as well as guiding the evolution and sustainability of the platform in later phases of DestinE to respond to the priorities set by European and International policy frameworks. The aim is to create a network where the continuous interactions amongst users/developers, as well as stakeholders/partners, will enhance the development and improvement of DestinE capabilities, but also catalyse cross-sectorial collaborations. This community will be comprised by multiple and diverse types of stakeholders including scientists, policy makers, industry representatives, and the general public which are split into Communities of Practice per Use Case (i.e. groups of members who share a common interest in a particular domain area or scientific topic).
An open, transparent, and inclusive invitation process is established that aims to embrace new members and various levels of participation. Formal community governance structure appoints key instances required for successful community management while standards and rules define how members participate and interact with one another encouraging contributions made by all.

Evaluating ethical values in current cartographic practices

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In the last few years, a concern in the geospatial community regarding the use of geographic information and ethics is observed. National Mapping Agencies i.e. Ordnance Survey and at least 16 international organizations have signed the Locus Charter and other initiatives such as The Benchmark Initiative and Ethical Geo have appeared. In this framework, a set of commonly shared principles for the responsible use of geospatial and location data has immerged including privacy and vulnerability protection, minimization of intrusion, provision of accountability, prevention of individual identification, etc.

Cartography is a geospatial discipline that has always been aware of the ethical dimension of maps and ethical questions regarding map-making are of increased concern to professional cartographers. According to Dent, the cartographers' code of ethics includes statements such as: strive to know your audience, do not intentionally lie with data, always show all relevant data when possible, don't discard contrary data because it is contrary, strive for accurate portrayal of data, avoid plagiarizing, symbol selection should not bias map, a map should be repeatable and pay attention to different cultural values and principals

Users should be aware that maps although realistic are representations and as a result, they may include bias in which information they portray and which data they ignore. Map making without respect to ethics is related to the easiness to create maps with tools available on the web. People that are not aware of cartographic science, cartographic best practices, and code of ethics can very easily produce maps that may look good, are impressive, and are easy to use but are not consistent with standards and conventions. This creates many problems as there is no guarantee that the resulting maps are well-designed and accurate, they may transmit a false message to the readers and as a result may raise several ethical issues.

In this paper, some ethical problems observed in current cartographic practices are commented such as:

- the broad use of the choropleth map as the basic method for the thematic portrayal of spatial phenomena. In the cases that the map must emphasize magnitude such as the number of inhabitants rather than intensity such as the number of inhabitants per square kilometers, proportional symbols are more appropriate than the choropleth map
- the dominant use of the Web Mercator as the cartographic projection in slippy maps and custom-created web maps despite the problems in area distortion and the erroneous application of formulas for the sphere with ellipsoid geographic coordinated in WGS84 provided by GNSS
- the application of narrative cartography for a specific communication goal by providing a focused sequence of maps, text, graphs, diagrams, and other images. As Monmonier (1996) states this may result in a yin-yang between deception and insight and advises viewers to be suspicious of systems that present processed data as irrefutable facts and forbid interference with the narrative progress.
- the integrative visual analysis of spatial-temporal data through the combined presentation of linked graphs, tables, and maps makes the user believe that he has full control of data exploration but despite the flexibility and interactivity of the system, the user can only see what the selected data and the environment tools permit

Assessment of the impacts on the global environment by the Covid-19 pandemic lockdown and the Russian invasion using satellite time-series image – A case study in Ukraine and East Asia

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The rapid globalization of the economy in recent years has forced factories and other facilities to locate overseas. Moving forward, today, global supply chains and complex economic transactions have formed. Under these circumstances, the COVID-19 pandemic and lockdown restrictions occurred in 2019, moreover, Russia's invasion of Ukraine in 2022, resulted in major changes in the economy, society, and environment.
This study aims to capture these recent abnormal changes objectively and quantitatively using satellite images and show two case studies.
1) Monitoring nighttime light (NTL) change has the potential to analyze socioeconomic activities specifically in estimating GDP, using time series VIIRS images. As the study in the East Asia region, NTL could show a strong correlation with seasonal adjusted quarterly GDP. It also shows the possibility of using nighttime light to monitor specific industrial zones' operations
2) Using the Tropospheric Monitoring Instrument (TROPOMI) instrument on board the Sentinel-5P, spatiotemporal variation of the tropospheric NO2 Vertical Column Densities (VCDs) in Ukraine are analyzed before and after the COVID-19 pandemic and Russia's invasion considering a weather normalization by machine learning techniques. Since the mid-lockdown era, the NO2 pollution levels show a consistent reduction of an average of -15% in the cities. Within the 5 months of the war, most of the cities that are under attack have observed a low reduction in NO2 pollution levels.
This study shows the information on the digital earth extracted from the analysis of the Satellite images could provide timely and high-frequency estimates of socioeconomic activity.

Retrieval of 30m spatiotemporal continuous Leaf Area Index (LAI) using a Temporal Convolutional Network approach

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Vegetation influences the climate and global carbon cycle by taking up atmospheric carbon dioxide through photosynthesis and cooling Earth's temperature (Knorr et al., 2010). Leaf Area Index (LAI) is one of the most widely used biophysical variables in climate and ecosystem models and is recognized as Essential Climate Variables (ECVs) by the Global Climate Observing System (GCOS) (Gcos, 2016).
Global LAI satellite products have been generated at coarse spatial resolutions (250m or coarser). However, many applications (e.g., regional environmental changes and sustainable development) urgently require the LAI time-series seamless products at fine scales (10-30m), which are not available worldwide. Landsat is the first fine-resolution satellite for global land monitoring since 1972, but it suffers from severe observational irregularity and data gaps. Although great efforts have been made to retrieve 30m vegetation biophysical parameters from Landsat data, such as the RT model based (Bayat et al., 2020; Houborg et al., 2015; Fang et al., 2003), statistical or machine learning based (Kang et al., 2021; Fang et al., 2003; Walthall et al., 2004), and hybrid methods (Fang and Liang, 2003; Jin et al., 2022), however, these single-phase based algorithms are sensitive to noises in the input reflectance data, resulting in gaps or fluctuations in time-series LAI products. There are no global long-term seamless products from the discontinuous Landsat data yet. The valuable Landsat archive has not been fully utilized. It requires breakthroughs in both big data handling and inversion methodology.
Machine or deep learning models have become powerful tools in remote sensing information extraction areas, and we have demonstrated its advantage in accuracy and efficiency in generating the 250m GLASS LAI using a long short-term memory (LSTM) model. However, deep learning for large area mapping at fine resolution requires both high-performance computing facilities and proper organization of multiple satellite data. Previous research adopts cloud computing platforms such as Google earth engine and Amazon Web Services are usually based on single phase or yearly-composited Landsat image (Liu et al., 2021; Zhang et al., 2021), to fully utilize the spatiotemporal information in Landsat observations, the Landsat data should be organized in tiled grids-analysis ready data (ARD), which can facilitate time series analysis and generate composite results of large areas.
The flowchart of the seamless 30m LAI product algorithm is as follows. A LAI -reflectance training dataset is built at global-distributed representative sites for model development. Since there is no 30m global time-series continuous LAI dataset currently, the 250m GLASS LAI is used to surrogate the Landsat LAI, and the corresponding aggregated 250m Landsat surface reflectance data is paired at the selected global representative and homogeneous pixels. The state-of-art deep learning model (Temporal Convolutional Network, TNN) was explored to translate the time series Landsat reflectance to LAI variables. We found the LSTM model achieves the best robustness and computational efficiency. The accuracy of the estimated 30m LAI is validated against extensive public field measurements, with R2 of 0.7, RMSE of 0.9.
We construct the Landsat Analysis Ready Data (ARD) via the cloud computing facility in Wuhan University, and implement the optimal deep learning model to produce the seamless 30m 8-day LAI product from 2000-2025 over China. Currently, the results at two special regions in China have been generated: the Greater Bay Area with frequent cloud coverage and Northeastern China with frequent snow coverage. The generated LAI 30m product is spatiotemporal continuous and consistent with the coarse resolution GLASS products with finer spatial resolution.

Adding Semantic Interoperability to the Green Deal Data Space with Essential Variables products and user requirements

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In the implementation of the INSPIRE Directive, several technical specifications and guidance were developed. Among them, the data and service sharing guidance provides a set of standard interfaces for deploying data on the web and the data specifications provides a strong framework for semantic interoperability. The level of detail of this documentation was targeting the agencies of the member states involved in the development of INSPIRE. The experience demonstrated that this level of strong interoperability is difficult to deploy into practice. But, while the agencies were busy implementing INSPIRE, other big data players emerged and, with that, the need for a more inclusive space where data can be shared. The European Commission is pushing for the Green Deal Data Space (GDDS) as an accessible and interoperable data collection, combined with digital infrastructure and artificial intelligence solutions that should facilitate evidence-based decisions and expand the capacity to understand and tackle environmental challenges. This ambitious objective will require extending the number of actors providing data beyond the government agencies. In the Horizon Europe AD4GD project, we are conducting research and applying innovative approaches to include in-situ networks, the environmental observation infrastructures, the citizen science networks, Internet of Things data flows, and the remote sensing data into a common environmental data space enriched by machine learning modelling results. In this heterogeneous environment, only loosely coupled services and soft interoperability arrangements can be successfully deployed. In AD4GD, we believe that the combination of the new OGC APIs and a new semantic framework based on the concept of Essential Variables could provide the right level of interoperability for the GDDS to work. The Essential Variables (EV) was an effort started by the Global Climate Observing System (GCOS) with the Essential Climate Variables that, with time, was generalized and extended to other domains such as Biodiversity, Water, Oceans and more recently to Agriculture. The Essential Variables is focused on defining a minimum set of environmental variables that need to be measured to understand the status and evolution of the Earth system. For each EV variable, several products are defined, and their requirements defined. Independently of the origin or data format, current existing datasets can be mapped to these EV products. The AD4GD project is exploring ways of applying this mapping that can be accepted by all actors and stimulate the creation of a machine-readable vocabulary. In parallel, the InCASE project (funded by the EEA) is working to collect in-situ data requirements and connect them to the producer requirements for EV products and metrics. InCASE is building a requirements database called G-reqs connected to the EV framework. AD4GD is testing this approach for semantic interoperability in three pilot cases about water quality in Berlin lakes, biodiversity connectivity in the Barcelona metropolitan area, and air quality in northern Italy. The AD4GD project is co-funded by the European Union, Switzerland and the United Kingdom under the Horizon Europe program.

UNPT: unsupervised point clouds translation for better 3D perception

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3D perception of the unknown environment is of crucial importance for auto-driving (AV), mobile mapping systems (MMS), and urban reconstruction. Nowadays, most the approaches train the model on the source dataset and apply the pre-trained model to the target dataset directly, where the distribution difference between the source domain and the target domain is neglected. Because of the inconsistency of domain distribution, the performance of the model on the target dataset is always significantly poor than on the source one. In order to mitigate the performance degradation, recent works have introduced multi-modalities fusion [1] and knowledge distillation (KD) [2] to utilize images as auxiliary information. Meanwhile, some approaches have proposed that unsupervised domain adaptation (UDA) [3] is beneficial to smoothly improve model performance. However, we are interested in solving the problem at its root: translating point clouds from one domain to another domain without supervision to mitigate the domain gap. If we analyze the translation problem from probabilities modeling perspective, the key challenge is to learn the joint distribution of point clouds from different domains. Specifically, point clouds from two individual domains could be regarded as two different marginal distributions. Inspired by the great success in unsupervised image-to-image translation (UNIT) [4], in this paper, we propose a new method: unsupervised point clouds to point clouds translation (UNPT) based on generative adversarial network (GAN) and variational autoencoder (VAE). To our knowledge, this is the first approach on point cloud translation. Experiments on large-scale public datasets KITTI and SynLidar indicate that point clouds generated by UNPT are realistic and with obvious target domain styles.

We will briefly describe our method and implementation in this paragraph. Like prior works [5,6], we first convert sparse point clouds into a dense equirectangular perspective image with spherical projection, where the first channel represents the depth and the second represents the intensity. Then we feed the perspective images into the UNPT network, a lightweight network similar to UNIT. The weight-sharing layers of UNPT force network mapping images from different domains to a share-latent representation, while the decoder layers of VAE reconstruct the share-latent representation to a target domain.

In order to prove the effectiveness of the proposed UNPT, we design translation experiments on KITTI and SynLidar datasets. KITTI is a self-driving dataset with sequential point clouds in the urban environment, and SynLidar is a virtual point clouds dataset in several scenes like cities, towns and harbors. In our experiment, we feed point clouds frames from KITTI and SynLidar to the UNPT network and generate frames with different styles from input(called fake_KITTI and fake_SynLidar following).

Quantitatively measuring the performance of the generator is difficult. We report the widely used metric in image generation, Jenson-Shannon Divergence (JSD) between the empirical distribution. As the JSD evaluates distribution differences, the smaller its value, the better generator's performance. We approximate the distribution through a birds-eye view 2D histogram for both reference sets and generating sets. The results show that the JSD between fake_KITTI and KITTI is 0.1247, and the JSD between fake_SynLidar and SynLidar is 0.1505. Due to the lack of comparable methods, we check the counterpart point clouds generation method [5]. JSD between samples generated by their method and real KITTI samples is 0.16 approximately, which indicates our method achieves comparable results under a much harder task.

In conclusion, we propose a novel point clouds generation method UNPT for unsupervised point clouds translation. Our results have shown that translating point clouds from one domain to another domain is feasible, even though we don’t have any corresponding frames from the same scenes . Furthermore, the generated point clouds are realistic. But our method still has 2 limitations. Firstly, the generated point clouds describe tiny objects like pedestrians and bicycles poorly. Secondly, the training process is unstable as the network is easy to fall into local optimum. In future work, we will explore utilizing the diffusion model to generate more realistic point clouds.

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Transferrable Earth observation analyses in semantic EO data cubes using semantic querying across sensors

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Recently, the concept and architecture of a semantic Earth observation (EO) data cube has been proposed (Sudmanns et al., 2021), which builds on EO data cube's infrastructural advantages, but allow semantic querying by selecting, combining, or specifying occurrences or behaviour of categories instead of reflectance values only. A semantic EO data cube is defined as an EO data cube, where for each observation at least one nominal interpretation (i.e., a category) is available and can be queried in the same instance (Augustin et al., 2019). Based on the categories, analyses can be executed in more human like data cube queries compared to other approaches because the categories are already closer to user's vocabulary (e.g., "vegetation", "water"). Since in our approach the same set of semantic categories can be derived from different sensors (e.g. Sentinel-2, Landsat), semantic interoperability and transferrable analysis, which remains one of the main challenges for EO analysis, can be reached between multiple sensors and data cubes.
The semantic enrichment, which is the pre-requirement to generate the categories has to be fully automated to make it applicable in big EO data context, which is not a trivial task. We rely in our semantic EO data cubes on the software SIAM (Satellite Image Automated Mapper, Baraldi et al., 2019) for the spectral categorisation of the image data, which creates information layers containing categories using a knowledge-based and physical-model-based decision tree that can be executed fully automated, is applicable worldwide and does not require any samples. Having this characteristics any multispectral optical sensor can be used as long as the sensor values are at least calibrated in top of atmosphere reflectance. Different sets of spectral categories (different granularities) can be produced and some of them are dependent on the sensor configuration (from sensors like Landsat or Sentinel-2 and their higher number of spectral bands, a finer granularity can be derived compared to e.g. 4-band VHR sensors). For cross sensor analysis, 33 spectral categories are shared across all sensors, which is a compromise of categories, that can be derived from any multispectral, calibrated satellite sensor. These 33 categories allow inter-sensor comparison (e.g. change detection), but still keep a fine enough granularity for sophisticated analyses.
In this study we will demonstrate the transferability of semantic queries making use of the 33 categories (plus additional data sets hosted in the different data cube, like e.g. a DEM) in different regional semantic EO data cubes based on different sensors (Sentinel-2, Sentinel-3, Landsat and AVHRR family). To address interoperability of semantic query models in the different semantic EO data cubes, we will also reflect on the need for proper metadata description of semantic data cube. Here, we employ layouts, which need to be defined to create a machine and human-readable description of the data and information available in the data cube. In addition, automated cross-checks need to be implemented based on the data used in each model and its potential transfer to different semantic EO data cubes. We will also discuss issues of scale (spatial and temporal) which may occur due to the different sensor resolutions.

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Digital Earth Science Platform Supporting the SDG Applications: Infrastructure, Framework and Visualization

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With the advent of big data and data-intensive science, Digital Earth is rapidly developed. From scientific understanding of the Planet Earth to promoting industrial innovation, the Digital Earth Platforms have improved the capabilities of social management, urban governance and decision-making. We have developed the Digital Earth Science Platform to provide a new impetus for data-driven scientific discovery at the era of Big Data. The paper first reviews the history of the development of Digital Earth Science Platform, and then introduces the key technologies of the Digital Earth Science Platform from the following aspects: the cloud infrastructure, the geospatial data management and computing framework, and the visualization of spatiotemporal big data. Cloud computing infrastructure of Digital Earth Science Platform has been set up which has a computing power of 2 petaflops and storage of 50 petabyte. The data engine of Digital Earth Science Platform has been introduced integrating distributed storage with HBase and cluster storage, which make it possible to integrate multi-source big earth data efficiently. With the powerful computing engine, it has integrated traditional image processing algorithms, deep learning algorithms, spatial analysis algorithms, and information simulation algorithms so that it can support efficient information extraction from big earth data. Visualization engine plays an important role on scientific information visualization and process simulation for geosciences. Consequently, it has the ability to serve scientific discovery, decision support and public science popularization by comprehensive analysis of spatial-temporal big data. Finally, we will show the applications of Digital Earth Science Platform in supporting Sustainable Development Goals, such as natural disaster risk analysis and early warning, construction and safety monitoring for large-scale projects, ecological environment monitoring, and agricultural monitoring.

Towards a spatial metaverse: Building immersive virtual experiences with digital twin and game engine

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Emerging geospatial and digital technologies have made possible to efficiently capture the physical environment in three dimensions in order to build more realistic representation, as a “virtual replica” of the real-world. A city digital twin can then be built as a cyber-physical system to connect the virtual replica with real time data via the Internet of Things (IoT). In parallel, the advances in gamification and virtual reality have provided us new ways to engage virtual activities or scenarios with more immersive experiences than traditional digital visualisation tools. Inspired by the concept of “metaverse”, the aim of this paper is to develop and implement a conceptual and methodological framework of creating immersive virtual experiences, by integrating several emerging technologies in reality capture, digital twins, gamification and Virtual Reality (VR). The workflow has been applied for a university campus in Melbourne, Australia, which has rich heritage and contemporary buildings and complex city landscapes. The campus physical environment, including buildings, landscape and street furniture, was re-constructed into a photorealistic 3D model using context capture from point-clouds and oblique photogrammetry; a campus digital twin was built on the 3D model with streamed near-real-time microclimate sensors readings; finally, spatial metaverse application was developed in game engine to enable first-person view of the campus wayfinding and navigation via VR interactions and avatar characters. The project has contributed to bridge GIS and gamification in the form of accomplishing a backbone of spatial metaverse. Synchronously sharing this metaverse prototype has the potential to immerse users within a virtual reality experience and feeling that uses real-world spatial data, therefore filled the gaps in geovisualisation and allowing us to bring abstract back to reality.

Digital Twin Human Geographic Environment

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The human geographic environment is a comprehensive environment formed by the interaction of human activities and the geographic environment, which is complex and highly vulnerable. It is of great disciplinary significance and application value to introduce the digital twin method to build a new framework of research on human geography issues, as this framework has the characteristics of driving the virtual according to the real, controlling the real according to the virtual, and the coordinated evolution of both the virtual and the real. It is also beneficial to avoid disturbing the real environment, explore complex problems in depth, and optimize the control scheme of real geographical problems. Based on the review of relative research in China and abroad, we propose a conceptual model of the digital twin human geographic environment and elaborate on its systematic connotation. The major components of this system include the real human geographic environment, the virtual human geographic environment, and the information interaction between them. Through the digital twin construction and simulation of the geographic environment, human activities, as well as human-nature interaction, we can realize the virtual and real synergy, complementary advantages, and co-evolution between the virtual and the real environment. Furthermore, we put forward a technical framework with bilateral technology roadmap for the implementation of digital twin human geographic environments. One route is to complete the comprehensive perception and twin reproduction of the real human geographic environment through digital accurate mapping to the virtual geography environment, and the other route is to achieve intelligent feedback of the virtual human geographic environment and its manipulation on the real human geographic environment through multi-channel virtual-real interaction. On the basis of the above, we design a hierarchical construction scheme of the digital twin human geographic environment platform which covers five sub-platforms, including collaborative monitoring and environmental awareness platform, multimodal full-scale database, intelligent modeling and simulation technology integration, high-performance spatiotemporal computing engine, and cross-domain knowledge application for decision-making. Supported by the Nanchang Sub-Center of the UNESCO International Natural and Cultural Heritage Space Technology Center, we take the digital twin of Jiangxi Bailudong Academy, the education base of Chinese Confucian culture, as a typical case to demonstrate the construction method, main function, and result form of the digital twin human geographic environment. We draw the conclusions from three perspectives: (1) The digital twin human geographic environment should be taken as a creative method for the exploratory learning of human geography; (2) The digital twin human geographic environment is currently the best way to build a geographic metaverse with human activities; (3) The virtual geographic environment can provide theoretical basis to the construction of the digital twin human geographic environment. Last but not least, the purpose of this study is to throw bricks and spark jade, so as to arouse scholars' thinking on the research of coupling digital twins and human geographic environment, and to jointly promote the sustainable development of human geography.

Large-scale land subsidence and relative sea level rise in coastal areas of China revealed by multi-source observation data

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The global mean sea level rise (SLR) is accelerating and has reached 3.2 mm/yr over the last decades. Combining with local ground subsidence, relative sea level rise (RSLR) rate will be dozens of times the global mean sea level rise in some areas with serious subsidence. The RSLR will lead to an increase in the frequency of floods and storm surges, salinization of surface and ground waters, coastal erosion, and degradation of coastal habitats, which will have a serious impact on coastal cities and low-lying areas. In this study, we employ multi-source observations, including satellite SAR, global navigation satellite system (GNSS), satellite altimetry, and tide gauge, to investigate the stability in China's coastal areas through extracting land subsidence and RSLR. The large-scale vertical land motion (VLM) rates of China's continental coastline are first obtained from multi-track Sentinel-1 data with the assistance of GNSS observations. Then, the absolute SLR rates are calculated using satellite altimetry products, and the RSLR rates are calculated by combining with the VLM rates. The results show that the most severe land subsidence occurred near Bohai Bay and Yellow River Estuary, and the maximum VLM rate exceeds -200 mm/yr in Dongying. In most coastal areas of China, the rate of sea level rise is 3-8 mm/yr, with a maximum rate exceeding 10 mm/yr. The magnitude of VLM is much higher than that of the absolute SLR, so land subsidence plays a dominant role in RSLR analysis. Overall, there are 1136 km, 118 km, and 30 km coastlines with RSLR rates over 20 mm/yr, 50 mm/yr, and 100 mm/yr, respectively. Based on VLM and RSLR rates, we extend the initial exploration of inundation prediction in coastal cities with low elevation and severe subsidence. The combination of multi-source observations makes it able to quantify land subsidence and RSLR rates along with the coastal areas at a national or global scale, which can provide auxiliary information for government urban planning and decision-making.

Supporting place-based disaster risk assessment: An Indonesian-language book-based education initiative in Indonesia

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Indonesia is known for its complex natural hazards. To reduce the potential impact of disaster occurrences, the Indonesian government has arranged regulations to ensure that disaster risk assessments are conducted at both the national and local levels in order to provide reliable disaster risk information. However, there is a lack of understanding of the essence of disaster risk elements and a lack of systematic geospatial assessments of disaster risk. Although the analysis has to be more particular for smaller scope areas, disaster management agencies regrettably usually generalise disaster risk assessment for all administrative levels. Disaster risk assessment documents at the local government were usually prepared with assistance from the central government (through third parties), but lesson learned from the process were usually overlooked. As a result, many disaster risk assessments do not follow local conditions, and local authorities tend to be passive in assessing disaster risk.

Addressing this risk, the first author undertook a research project to distil the emerging consensus on best practice in geospatially informed risk assessment, narrating a book entitled "Understanding and Assessing Disaster Risk." The manuscript was developed over seven months by the author, which included support through the Australia Awards Indonesia scholarship program, run by the Australian and Indonesian governments for senior professionals seeking academic development towards improved practice in their workplace. The subsequent 284-page book was published as a non-profit endeavour in January 2023, with the aim of assisting local governments in mapping disaster risk independently and in more detail so that they do not always use national data, which has a very large scale. This book is accompanied by online information about the components that affect disaster risk and their importance in influencing the level of disaster risk in an area. It is intended that this publication creates awareness about opportunities for risk assessment that supports doing better for the Indonesian people and their surrounding environment, towards the United Nations Sustainable Development Goals. Examples are provided within the text about current good practice in disaster risk assessment in Indonesia, particularly in local regions where there is now very little training and information available.

Several innovative measures have been used to gain community awareness of the content. This has included an independent volunteer organization 'BARASIAGA' - founded by the author in 2021 – which was involved in hosting a book review talk show by inviting related parties to discuss the book content and the significance of disaster risk assessment. This activity was intended to further mainstream the essence of disaster-risk-forming elements at the community and policymaker level and to build awareness of the importance of mitigation and preparedness to reduce disaster risk. It has also included a local university in collaboration with the Association of Indonesian Geologists undertaking a similar event, towards improvement in one of the Indonesian provinces as 'lessons learned in disaster management', in West Nusa Tenggara.

Key lessons learned arising from the book, regarding Indonesia's geospatial capabilities and journey in disaster management for and by local communities, will be shared at the ISDE2023 conference through a presentation. This experience and feedback from the conference delegates will be used to help prioritise these key learnings into an English-language journal paper for the International Journal of Digital Earth.

Adaptive identification of potential landslide hazards combining InSAR technology and disaster background indicators

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Landslides cause billions of dollars of damage and thousands of deaths worldwide every year, and accurate identification of potential landslide hazards and timely targeted measures are effective methods for disaster prevention and mitigation. Interferometric Synthetic Aperture Radar (InSAR) plays an important role in monitoring geological hazards such as landslides, but there are certain limitations in its data acquisition and processing, so modeling analysis is also needed in the identification of potential landslide hazards in conjunction with the disaster background indicators. Specifically for the deep learning model used, existing scholars tend to use fixed-size windows for modeling, while different sizes of landslides have different needs for window sizes, and assigning different size windows will theoretically lead to better recognition effects or improve recognition efficiency. Therefore, this study proposes an adaptive identification method combining InSAR technology and disaster background indicators, and applies it to the study of potential landslide hazard identification in Yongping County, Yunnan Province, China. The results show that the combined use of InSAR technology and disaster background indicators in terms of topography, geology, hydrology and human activities can characterize landslide features to a large extent and contribute to the subsequent modeling of potential landslide hazard identification. More importantly, by measuring the richness of deformation through the average of the pixel deformation difference within the current window of a pixel point in the image, the convolutional neural network (CNN) with different window sizes is adaptively selected, and the results of adaptive identification of potential landslide hazards (precision: 85.30%, recall: 83.03%, F1-score: 84.15%) are better than the fixed window modeling method, which proves the effectiveness of the proposed method. This method can help to improve the intelligent identification system of potential landslide hazards, and can also play an important role in other geological hazards identification.

Innovative, collaborative, and cost-effective disaster preparedness: A case of Bali-Tsunami Early Warning Systems (B-TEWS)

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Bali Province is one of the most popular tourists' destinations in Indonesia. Due to its geological situation and climate variabilities, Bali is prone to different types of natural disasters. The National Development Planning Agency (BNPB) considers tsunami as one of the main threats for Bali. It is therefore, urgent for Bali to have a comprehensive disaster preparedness mechanism, including the early warning systems (EWS).

EWS should be accessible and inclusive for all people living in the hazard zones in Bali. This, however, one of the main limitations of the existing EWS for Tsunami is that is only covers less than 5% of the population in Bali. Expensive EWS infrastructure and only provided by the government are the two main reasons of this limited scope issue. The government's financial limitations have resulted in a limited number of EWS that are still very far from the quantity that is needed.

To address these problems, the first author initiated the establishment of Bali-Tsunami Early Warning System (B-TEWS). B-TEWS is an innovation in disaster preparedness that follows the principles of collaboration and cost-effective. B-TEWS uses simple and much affordable yet reliable technology applications that encourage the increased participation of the private sectors to provide early warning independently. The technology used is based on GSM and Digital Radio and can be developed for multi-hazard early warning, whether tsunami, volcanic eruption, or others.

The B-TEWS prototype product has been successfully produced and utilized by the PLN Bali Regional Distribution Office, the Indonesian Red Cross - Bali Chapter, and the hotel where the 2022 G20 Summit will hold in Nusa Dua. In the beginning of early 2023, B-TEWS has been preparing to replace all (9 units) of public tsunami early warning sirens previously built by the government.

The B-TEWS system provides an affordable, reliable solution that uses geospatial information to help people prepare for tsunamis. The author discusses how data is curated and communicated to be available at the right time and in the right place for community support. The paper also demonstrates how this cost effective and practical solution addresses the United Nations aim of "leave no-one behind".

Rapid Greenhouse Mapping based on Interactive Object-Scene Awareness: A Case Study of China

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Greenhouse cultivation plays a vital role in food management and economic development of modern agriculture. However, in recent years, extreme weather caused several meteorological disasters, harming food production in greenhouses. Rapid and accurate greenhouse mapping using high spatial resolution imagery can provide us with spatial distribution information of the affected greenhouses to assist with disaster rescue. Considering that the existing greenhouse mapping methods are faced with the problem of quickly and accurately locating greenhouse area scenes in large-scale areas and the problem of distinguishing rotated greenhouse objects in dense scenarios when applied with limited resources in emergency scenarios, we propose a novel interactive object-scene awareness and mapping framework, called GreenhouseNet, for rapid greenhouse mapping and meteorological disaster assessment in large-scale areas. The GreenhouseNet framework is executed in a two-stage manner, i.e., object-guided rapid greenhouse area scene positioning, where a greenhouse area scene classifier is introduced with the object information by a pretrained object detector model to enhance the scene classification performance, and scene-aware dense greenhouse rotated object detection, where a scene-aware object feature fusion module is presented to adopt the scene context to distinguish dense greenhouses. Six regions in China were selected for evaluation, where the proposed GreenhouseNet framework outperformed the state-of-the-art methods. Shandong province and Liaoning province in China were adopted as the study areas for rapid greenhouse mapping and disaster assessment, and the results illustrated that the GreenhouseNet framework is nearly 24% faster and 57% faster than the existing methods, respectively. Results demonstrated that 95,238 greenhouses were affected by the flood disaster that took place in Shouguang, Shandong in August 2018, while 259,512 greenhouses were affected by the snowstorm disaster that took place in Liaoning in November 2021. Our findings demonstrated a reliable and promising framework for greenhouse mapping and meteorological disaster assessment.

PolarGO: A polar spatiotemporal information integration platform with real-time online 3D visualization services on polar regions

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The Arctic and the Antarctic are related to the destiny of human beings and the sustainable development of global goals. In the context of global warming and increasing ice melting, bipolar regions draw the focus of international community. We developed a comprehensive GIS platform, namely PolarGO, specifically focusing on bipolar regions. This platform integrates the polar environment and human activities, presenting the real-time polar activities and their spatio-temporal changes. More than twenty countries' polar footprints are collecting into this platform, including China, France, Russia, UK, US and so on.
PolarGO combines real-time data and historical data on polar vessels and aircraft. This platform has a 3D digital earth to present the polar activities. This platform is designed to publicly supply real-time online polar information to international communities.

Geographically corrected clustering applied to establish medical service areas

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Medical service areas are established traditionally with respect to observed and expected (forecasted) number of patients in the serviced territory, while the service areas zoning is aimed onto balancing of attending medicals workload. In our material, we discover a case study of service areas zoning for tuberculosis dispensaries of Saint Petersburg city (Russia). Originally, the process of phthisiatric service areas zoning is bases upon splitting of living buildings list compiled for some administrative territory. The list splitting is based upon the number of actual tuberculosis infection cases observed in serviced territory. No interdependencies in infection are took into account, and consequently interdependent foci of infection (or simply infection clusters, composed of a number of living buildings, where infection and reinfection cases are dependent on specific social activities of locals) can be split into several service areas. Such a splitting affects the effectiveness of contraepidemic activities in its turn, while split infection cluster parts can be serviced without coordination of medical activities. As the infection cases are grouped also spatially when forming infection clusters, and due to high social impact and dangerousness of infectious diseases and rapid spatiotemporal dynamics of their development, the issue of geospatial analysis and Geographic Information Systems (GISs) implementation when establishing medical service areas appears to be relevant. GIS-based automated analysis in this case have to ensure operative restructuring of medical service areas with respect to formed structure of infection clusters.

In our case study we geocoded 33936 records of infection cases with 2.57% error (33063 records geocoded successfully. The K-means and DBSCAN methods were explored to ensure clustering of geocoded retrospective data were, while K-means was established as most suitable. Standard-deviation-based and Elbow methods were applied to establish number of clusters, ratio of the number of clusters to infection cases dispersion was used as the trigger value. Built clusters were mapped using QGIS open source software and used as a reference data to provide updated zoning of phthisiatric service areas for entire administrative territory of Saint Petersburg. Elaborated methodology was documented and considered as a possible for implementation into technological chain of Saint Petersburg phthisiatric service.

Application of satellite remote sensing for emergency response of Sichuan Luding M6.8 earthquake supported by domestic and international mechanisms

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Data, especially remote sensing images after disaster is very important for emergency response. For the efficiency and effective response of major disaster response, especially for the rescuing and relief work after a disaster, rapid acquisition of effective remote sensing data for disaster monitoring and assessment is crucial. National Disaster Reduction Center of China has established a standard working procedures for emergency response. When a major disaster occurs, the acquisition cooperation mechanism for remote sensing data will be triggered to obtain remote sensing data of domestic and international. At 12:52 am on Sept. 5, 2022, a 6.8-magnitude earthquake hit Luding County, Ganzi Prefecture, Sichuan Province, at a depth of 16 kilometers. Due to the severity of the disaster, Earthquake Relief Headquarters Office of the State Council and the Ministry of Emergency Management announced Level 2 for the national earthquake response. The National Commission for Disaster Reduction and the Ministry of Emergency Management announced level III for the national relief response.

After the earthquake, National Disaster Reduction Center of China launched the acquisition cooperation mechanism for remote sensing data in accordance with the standard emergency response procedure. By Sept. 11, a total of 161 images had been obtained from 29 civilian and commercial satellites, with 53 times observation from satellites, among which the effective data before-disaster were 12 images from 3 satellites and the effective post-disaster were 32 images from 10 satellites. The earliest post-disaster image obtained was the GF-3 satellite image at 19:11 on Sept。 5 (about 7 hours after the earthquake). The monitoring showed that a landslide area (102.05。 E, 29.59。 N) was detected within about 3 kilometers northwest of the epicenter. The landslide had damaged the internal road of Hailuogou Scenic spot, which was about 200 meters long. Landslide debris was suspected to have rushed into Hailuogou. International Chater for Disaster provided 80 pre-disaster images and 42 of post-disaster images (including 8 SAR images). Because of the cloudy and rainy weather for the first few days of the earthquake, SAR images were especially useful at that stage. Pre-disaster images were mainly used as reference images, such as using for landslide area pre-disaster situation map, or temporary settlement location selection (displayed in three-dimensions together with DEM data), etc., so as to provide basic information for rescue teams in front. Post-disaster data were mainly used to monitor the layout of centralized resettlement sites, disaster relief facilities, houses of the villages near the epicenter, and accessibility of nearby roads, as well as to identify potential secondary disasters such as landslides and barrier lakes in the worst-hit areas. The monitoring results will be sent to the first-line emergency rescue site staff and relevant departments of MEM, providing reference information for post-disaster emergency rescue and relief decision making.

Simulation of River Basin Flood Based on Digital Earth

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The river network in southern China is densely covered, and the water volume in the river channel will increase sharply when encountering a long-term rainfall process, and the low-lying and flat areas around the river channel are prone to flooding. In this paper, taking Chengdu as a demonstration area, based on the digital earth platform, the monitoring and simulation of the river flow state is realized. The main steps include:

First, extract the river channel information. The optimized AGREE algorithm is used to extract the DEM data according to the river vector data and the vector line as the baseline by setting the buffer zone; the M&V filling and digging algorithm is used to fill the DEM depressions to obtain a depression-free DEM.

The second step is to use the D8 algorithm to calculate the flow direction; calculate the surface net rainfall intensity in the basin during the rainfall process based on the SCS-CN model. According to the calculation formula of actual runoff with different soil types and CN values in different periods, the actual runoff of each grid cell on the ground can be obtained.

The third step is to combine the hydrodynamic equations to calculate the total amount of water flow collected from the slope unit to the channel unit, and then combine the water flow direction in the channel to complete the instantaneous flow calculation of the channel section. The continuity equation and the momentum equation are combined to calculate the water flow velocity. The time required for the water flow to flow out of the slope surface unit is obtained by the ratio of the unit slope length to the flow velocity. There are three main sources of water volume in a channel unit: the influx of the slope confluence network, the net water volume of rainfall falling into the channel unit, and the inflow of the previous channel unit.

The fourth step is to classify the river course risk level. Statistically analyze the flood data of the flood-prone river sections over the years, and compare and analyze the calculation results of the instantaneous flow of the river section according to the flow value corresponding to the maximum flood peak passing through the border. Through the section analysis of the river section, the ultimate bearing capacity of each unit in the channel is calculated. The water balance of the river section flow greater than the ultimate carrying capacity of the river is divided into grades according to the ratio of the maximum flood peak flow value.

Taking Chengdu City as a demonstration area, based on Digital Earth, the river flow state monitoring simulation is carried out to verify the effectiveness of the above method. The real-time flow simulation of the river channel is to simulate the real-time flow information of the river channel water flow after the distributed hydrological calculation is completed on the GPU computing server side, and the image of the river flow flow information is rendered into the form of the earth's surface layer through the large-scale map rendering algorithm by using webgl. The simulation of river flow direction is to simulate the flow direction of river water flow through the dynamic streamline rendering algorithm and use webgl to render the form of dynamic streamline through the dynamic streamline rendering algorithm after the distributed hydrological calculation is completed on the GPU computing server side.

Water Body Information Extraction of Qilu-1 Data with CNN-based SAR Image Feature Enhancement

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Wetlands play a vital role in maintaining ecological balance, habitat security, and biodiversity. As the precious natural resource, 20% of the known species in the world live in wetlands. However, the wetland ecological systems are fragile, which are sensitive to flood, drought, and human activities. Thus the monitoring of wetlands has become a hot issue. Synthetic Aperture Radar (SAR) plays a key role in providing high-resolution images of the earth observation in all weather and all day-night, which is widely used in wetlands monitoring, such as water body information extraction. Due to the high resolution and the low reflection coefficient of water in SAR images, it's easy to separate water from the ground objects, making SAR become essential in water body information extraction.

Qilu-1 satellite operates at Ku-band and achieves the highest resolution of 0.5m. Qilu-1 SAR data provides the detailed edges between the complex land regions and the water bodies, which can be valuable for delineating the detailed water bodies. However, it also poses challenges. SAR images usually suffer from speckle and additive noise, which have a bad effect on the classification of detailed delineation between water bodies and land areas. Thus this problem makes it difficult for fine water mask detection.

In this paper, we apply the CNN-based SAR image feature enhancement to improve the performance of water body information extraction of the Qilu-1 SAR data. First, the framework contains the CNN-based SAR image filter based on the statistical model of amplitude information. This preprocess can achieve the efficient suppression of the artifacts while maintaining the detailed information of different areas. Second, we apply the threshold method of water body information extraction based on the preprocessed SAR image. Combining the CNN-based feature enhancement and the threshold method, the accuracy of water body information detection can be improved and the extracted edge of water bodies can be refined.

The experiments have been conducted on the SAR data of the Qilu-1 satellite, which operates at 16.7 GHz. Qilu-1 is the first Ku-band SAR satellite of China’s high-resolution earth observation project. In this paper, we process the Qilu-1 SAR image of the Caohai wetland (Guizhou, China). The experimental SAR data covers the region between 104°12' to 104°18'E and 26°49' to 26°53'N, which is the largest natural lake in this province with the surface area of 25km^2 in the high flow period. and the experimental results confirm that the proposed method for water body extraction of the Qilu-1 SAR data can achieve the fine extraction of water body information and provide accurate information for wetlands monitoring.

Spatio-temporal monitoring method of landslide using multi-source remote sensing data

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Landslide itself is a complex process of interdisciplinary multi-factor interaction. The monitoring of poor accessible high-mountain landslides which are often very destructive, has always been difficult for landslide monitoring. Due to the influence of landslide creep, the landslide will cause changes in surrounding environmental conditions, which will affect the growth status of the landslide overlying vegetation. In the process of field geological investigation, the existence of abnormal vegetation growth is also found. So for high-mountain landslides with vegetation cover, we take optical remote sensing technology to monitor the vegetation change and indirectly monitor the development of landslide creep, which brings new ideas for landslide monitoring and provides technical support for landslide disaster perception early warning. On the other hand, the surface deformation information can be used to directly monitoring landslide. Moreover, the landslide sensitivity information considering multiple triggers can give the overall development trend. Hence, we use multi-source time-series data from multiple factors to comprehensively give detailed landslide spatio-temporal monitoring results, combined with the vegetation abnormal information of optical remote sensing, the surface deformation information of radar remote sensing, and the multi-factor landslide sensitivity information. The case analysis results of the Jizong Shed-Tunnel landslide in Sichuan-Tibet lifeline and the Temi landslide along Jinsha River prove the reliability and effectiveness of our research ideas.

SDG Big Data Platform

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The Sustainable Development Goals, i.e., SDGs, introduced by United Nations (UN) and committed by 193 countries, are the blueprint to achieve a better and more sustainable future for all people on the planet. SDGs address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice, and the goals cover all three key development pillars: economic, social, and environment, as well as enablers such as institutional coherence, policy coherence, and accountability.

Big Earth Data is big data in the field of Earth science with spatial attributes, especially the massive Earth observation data generated by space technology. Such data is mainly produced at a large spatial scale by scientific devices, detection equipment, sensors, socio-economic observations, and computer simulation processes. Similar to other types of big data, Big Earth Data is massive, multi-sourced, heterogeneous, multi-temporal, multi-scaled, and non-stationary. But more than just that, it has strong spatiotemporal and physical correlations, and the data generation methods and sources are controllable. Big Earth Data science is interdisciplinary, encompassing natural sciences, social sciences, and engineering. It systematically studies the correlation and coupling of the Earth system based on data analysis. Earth is observed and studied as a whole by simultaneously employing big data, artificial intelligence, and cloud computing, so as to understand the complex interactions and development processes between Earth's natural system and the human social system. Big Earth Data can make an important contribution to the realization of SDGs.

The CASEarth Big Earth Data system can support the implementation of SDGs by converting Big Earth Data to relevant information, providing policy-making support, constructing and integrating an index system, and studying the relationships and couplings between various SDG targets from the perspective of the Earth system. It can also support the monitoring and evaluation of SDG indicators through data-sharing platforms and cloud infrastructure by providing data, online calculations, and visual presentations.

At 2021, we released the SDG big data platform, which provides a comprehensive and integrated display of SDGs-oriented data, resources, and achievements for three service scenarios: researchers, decision makers, and the public. The platform provides online access to resources, SDG workbench and decision support visualization system in both Chinese and English.

Over the past year, we expanded the capabilities of the CASEarth cloud environment. The demonstration of the distributed platform construction plan has been completed. The platform continues to run stably and serves special applications. In 2022, 72,000 computing jobs will be completed, consuming 30.7 million CPU hours.

We completed the classification system of big earth data and SDG classification system to provide computing-oriented data products and sharing services, and realize the introduction and production of satellite data on the cloud. We developed 35 global SDG big data products, 41 global regional SDG big data products, 18 SDG big data products in China, and 11 SDG big data products in typical regions of China.

Based on the cloud native technology architecture, we have reconstructed the SDGs workbench. Users only need to use a browser to complete the entire process of scientific research activities.

Cloud native technologies empower organizations to build and run scalable applications in modern, dynamic environments such as public, private, and hybrid clouds. Containers, service meshes, microservices, immutable infrastructure, and declarative APIs exemplify this approach.

These techniques enable loosely coupled systems that are resilient, manageable, and observable. Combined with robust automation, they allow engineers to make high-impact changes frequently and predictably with minimal toil.

Based on the cloud native technology architecture, we have reconstructed the SDGs workbench. We have built a cloud-native environment composed of multiple container clusters on the CASEarth Cloud, including two service clusters and one management cluster, providing cloud-native databases, cloud-native programming environments, machine learning model training, data visualization, container image repository, code repository, DevOps and other services.

We have integrated the existing research tools such as SDG indicator calculation, SDG data product production, Earth Data Minor, and deep learning cloud service platform on the SDGs workbench; support users to access and use various shared data directly in the code. So as to provide users with one-stop resource integration and application services, users only need to use a browser to complete the entire process of scientific research activities.

Micro-scale urban operation model based on large-scale cell phone signaling data and its application in epidemic control policy evaluation

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The government has taken measures such as community lockdown to cope with the COVID-19 pandemic, which has successfully controlled the spread of the disease but also had a significant impact on social and economic structures. Simulating the changes in COVID-19 transmission under government measures and quantitatively analyzing their effects can help the government make better decisions. This study aims to construct a spatiotemporal network of infectious diseases coupled with population mobility at the parcel level, considering the interaction of populations within a city for disease simulation and prediction. Firstly, this study uses mobile phone signaling data to construct an urban running model to simulate population interactions between communities and explore the activity patterns of urban populations. Then, using vector communities as modeling units, a network for the transmission of infectious diseases under the influence of population movement is constructed, and different scenarios of disease development in the city are simulated, visualized, and predicted. Finally, we quantify the changes in both population mobility and cumulative infection and construct a loss function to evaluate different COVID-19 prevention policies, exploring the most appropriate community lockdown policy. The study is simulated and predicted in Shenzhen, and the results show that (1) the city operation model accurately simulates large-scale community-level population movement, and the correlation between communities with high outflow proportions during peak working hours and residential land use is greater than 0.7, and the inflow and outflow of the population within a day are basically equal. (2) The model successfully simulates the initial spread of the epidemic in Shenzhen, the results have a high similarity to the real data, and the model successfully predicts the trend of disease development under different scenarios. (3) the optimal parameter combinations under different situations are successfully obtained, and the results show a mutually constraining relationship between population mobility patterns and cumulative infections, pursuing lockdown intensity alone can reduce the cumulative infection, but it often leads to excessive loss in population mobility, which is not the optimal solution. The results of this study will help public health departments and clinical doctors understand the transmission mechanism of infectious diseases and plan prevention and control measures, which is of great significance for maintaining social stability in cities.

Understand relationships between geo-spatial features and Covid-19 hospitalisations based on multi-source data and machine learning models

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Uncovering the relationships between geospatial features with Covid-19 features is a challenging and confounding cross-disciplinary topic, which attracts global attention to public health, air quality, environmental sustainability, urban planning, inequalities in education, medical treatment, living conditions, etc. Both environmental and anthropogenic aspects should be considered to better understand the relationships between Covid-19 and geospatial features. This research aims to provide an innovative data-driven method to discover the relationships between Covid-19 and multi-source geospatial features from different disciplines. It is well understood that machine learning (ML) models can learn complex relationships between features in a dataset automatically. However, these learned relationships are typically implicitly encoded and are thus inaccessible due to the black-box nature of most ML models. Therefore, we aim for training supervised predictive machine learning models and combine those with state-of-the-art explainability methods to uncover the learned relationships. These relationships provide important clues on understanding how geospatial features may affect features related to Covid-19, of which the hospitalization rate is the main focus in this research. The area of interest in this research includes all of the municipalities in Germany. The research period spans from the outbreak of Covid-19 in Germany in March 2020 to the time when 65% of the German population was fully vaccinated in Oct 2021.

First, we integrate data from multiple spatial data sources including social data, cultural data, air pollution data and Covid-19 feature data for a longer time period. Second, we train three machine learning models on the integrated dataset. This allows the models to learn the relationships between the spatial features and the Covid-19 features. Third, we use SHapley Additive exPlanations (SHAP), a method for explaining AI models, to rank the relevance of each feature. After that, we choose the model which performed best and illustrate the results. Finally, we discuss and conclude the methods of uncovering the relationship between Covid-19 and geospatial features. For the exploratory and analytical purposes to serve researchers who are interested in further advancing this research, we are developing a frontend dashboard and a processing backend, which has the data loaded and can be used for further processing.

Our ultimate research purpose is to develop a machine learning model to uncover the relationships between Covid-19 hospitalisations and a mixture of features derived from both environmental and anthropogenic aspects. We provide a transferable innovative data-driven method of uncovering the relationships between the heterogeneous and cross-disciplinary geospatial features with target features. The output will deliver key information regarding public health effects, control of emissions, medical treatment equality, and education equality at the municipality level in Germany.

Keywords: Geospatial features, Covid-19, multi-source data, data integration, machine learning models

Estimation of radiative fluxes at the top and the bottom of the atmosphere from multispectral satellite data

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This presentation will first introduce the top-of-atmosphere albedo and outgoing long-wave radiation products estimated from multispectral satellite data, and then introduce the radiation flux products of the Global LAnd Surface Satellite (GLASS) product suite, including the downward shortwave radiation, broadband albedo, longwave radiation, net radiation and evapotranspiration. It will mainly include the algorithm of these products, product characteristics and the spatiotemporal variation of the surface radiation balance.

Refined Extraction of Desertification Information by Coupling Multi-source Big Earth Data and Deep Learning to Support SDG15.3

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Desertification refers to land degradation in arid, semi-arid and dry sub-humid areas caused by various factors such as climate change and human activities (UNCCD, 1994) and is one of the most serious ecological, environmental and socio-economic problems in the world. As such, the United Nations Convention on Combat Desertification (UNCCD) introduced the concept of "Land Degradation Neutrality (LDN)" in 2015 and included it as one of the United Nations Sustainable Development Goals (SDGs) (SDG15.3). Remote sensing technology has become the main means of desertification monitoring at present. Compared with the single vegetation indicator method, the traditional supervised/unsupervised classification method and the feature space model, visual interpretation has the highest accuracy in desertification information extraction. However, the visual interpretation method has high labour and time costs, and it is difficult to solve the fast and efficient extraction of desertification information in a large area.Deep learning can extract surface information by simulating human visual perception mechanisms and by continuously iterating to learn the rich features that images have. Therefore, the combination of deep learning and multi-source Earth big data is expected to improve the accuracy of large-scale desertification information extraction. This study firstly determines the regional desertification grading system; then, based on Landsat, Sentinel 2A and GF-1 data, various traditional remote sensing desertification information extraction methods are used to obtain the preliminary regional desertification degree distribution results respectively, and multiple sources and segmentation scales deep learning labels of different desertification degrees are automatically constructed based on the voting mechanism; finally, texture, vegetation, soil, topography and climate features are selected and convolutional neural network(CNN) model is used to achieve automatic extraction of desertification fine information. This study can provide a new technical tool for the rapid extraction of fine desertification information at large scale, and better serve the accurate assessment of Land degradation Neutrality.

Urban spatial information analysis with multi-source large-scale long-time-series data: A case study of Wuhan, China

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Accurate urban spatial information analysis can provide scientific support and decision-making for urban environmental protection and urban planning in the current rapid urbanization process. However, how to obtain adequate dataset, select high-quality training samples, and adopt hight-performance model for analyzing, are all big challenge in real applications. To tackle these problems and make improvements of urban spatial information analysis, in this work, mudium resolution remote sensing image data, i.e., Landsat 5, 7, 8, as well as Sentinel-1, STRM, together with OpenStreetMap data, are utilized to do analysis. Here, to get more spatial information and avoid the problem of missing data or low-quality data, large scale long-time-series remote sensing images are chosen, i.e., Landsat 5 is from 1986 to 2011, and Landsat 7 is from 1999 to 2021, Landsat 8 is from 2013 to 2021 and Sentinel-1 is from 2015 to 2021. In addition, high-quality training samples are selected from OpenStreetMap volunteered data for current year (i.e., 2021), and transfer learning is used to generate samples for the other years (from 2000 to 2020). To further enhance the accuracy of land cover mapping, a small number of accurate samples are selected manually from Google Earth Engine platform. Finally, multiple random forest model is used to do land cover mapping. Wuhan, the captical city of Hubei, is experiencing rapid urban expansion. In this paper, we set Wuhan as our case study area, and analyze her urban expansion, especially about the increase of urban impervious layer area, and the decline of vegetation area. Based on the urban mapping production of 2010 and 2022, it can be noticed that the impervious area of Wuhan is increasing, while the area of farmland, grassland, and forest is decreasing.

Urban forestry for sustainable communities: Evidence from New York City

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Urban trees could provide multiple ecosystem services (e.g., carbon storage and sequestration, air pollution removal, urban heat island effect mitigation, and residential energy conservation) for building ecologically vital and socially just cities. However, simply increasing tree cover does not necessarily guarantee the provision of expected ecosystem services to various groups of people as trees are often unequally distributed. Spatial distribution of trees has important implications for many aspects of urban sustainability, such as environmental justice and public safety. This seminar will focus on the roles of street trees for environmental justice and urban crime in New York City. Through the combined use of remote sensing imageries, google street view, citizen science, and socioeconomic data, I will first introduce how the underprivileged and vulnerable subpopulations are disproportionally affected by uneven distribution of street trees. Then the impacts of street trees on crime, as well as how their associations are moderated by tree structure, streetscape elements, and tree management, will be presented. The revealed findings have important implications for the implementation of tree-planting programs in tackling the dual tasks of alleviating environmental inequity and reducing crime, and could help translate sustainable urban planning into specific actions of tree management and streetscape design that can be taken by government and local stakeholders.

Multi-hazard susceptibility mapping: air pollution, urban heat island, and flooding in Milan, Italy

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Resilience can be defined as the ability to withstand and recover from unforeseen events whose frequency has increased in the last years. Additionally, the climate change effects have been reflected in the increase in temperature and pollution levels, especially in dense urban areas. Providing local authorities with a decision support system is a path to building urban resilience. A crucial step in the creation of a decision support system is the initial assessment of the hazard susceptibility of a city. This study will be focused on three hazards that particularly threaten the city: air pollution, Urban Heat Island (UHI), and flooding. The city of Milan is located in the Lombardy region (Italy), a well-known pollution hotspot due to its surrounding topographical components (the Alps in the north and west, and the Apennines in the south) which contribute to low wind circulation in the Po Valley, leading to the accumulation of air pollutants. The combination of this effect with the city's urban layout enhances the rise of temperatures causing the UHI phenomenon. Furthermore, Milan has been affected since the last century by the flooding of the Seveso river. Heavy rains lead to its overflow and the consequent failure of sewer systems (on average more than 2.5 times per year).

The assessment of hazard susceptibility is carried out using Machine Learning (ML) and Deep Learning (DL) techniques fed with hazard historical occurrences and conditioning factors data to produce hazard susceptibility maps. An extensive literature review was conducted to analyse the workflows followed to model the susceptibility to each particular hazard, retrieving state-of-the-art ML/DL techniques, conditioning factors, and data pre-processing methodologies. The ML/DL models used for the single hazard susceptibility assessment align with the conclusions drawn from the literature review.

Air pollution is defined as the presence of toxic chemicals or compounds in the air, at levels that pose a health risk. The Air Quality Index (AQI) is a standard metric used by governments to categorise the severity of air pollution. According to the European Environment Agency (EEA), the AQI is based on the concentration of PM10, PM2.5, O3, NO2, and SO2. The air pollution susceptibility is estimated for each of the mentioned pollutants as well as the corresponding AQI: it will consist of a categorisation based on the concentrations of the pollutants with respect to the limit values proposed by the EEA. Air pollution susceptibility is assessed in the city of Milan using Long Short Term Memory (LSTM) and Convolutional Neural Network (CNN) DL models to leverage the data's spatial and temporal characteristics. The historical in-situ data of these pollutants is retrieved from the local environment protection agency, ARPA Lombardia. The conditioning factors data of this hazard include meteorological, land cover, topographic, and socio-economic data.

UHI are urban areas composed of structures, e.g., buildings, roads, and other infrastructures, that become 'islands' of higher temperatures with respect to outlying areas, which are usually caused by a high infrastructure concentration and lack of green areas. UHI are modelled by means of the Random Forest (RF) ML model. The UHI categorisation is based on the air temperature and Land Use Land Cover (LULC) classifications which are derived from local authorities' datasets (ARPA Lombardia and Regione Lombardia) and Copernicus datasets (ERA5). Relevant UHI conditioning factors include meteorological factors and topographic factors, e.g., elevation, slope, and aspect. Morphological characteristics of the city are also key to consider, e.g., building heights, and distance to roads.

Urban flooding susceptibility in Milan is assessed by means of RF, Artificial Neural Networks (ANN), and Support Vector Machines (SVM). The historical occurrences of the flooding events which provide the binary-dependent input to the models are retrieved from Regione Lombardia. The conditioning factors include precipitation, geohydrological factors (e.g., topographic wetness index, and lithology), and topographic/morphological data (e.g., digital terrain model, distance from rivers, and slope). The probability of flooding provided by the model serves as the basis for categorising the levels of susceptibility.

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The Analysis of Land-use/Land-cover via a CA-Mokov Model associated with the Land Planning Policy

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Accurate simulation of the process of urban land change can help people understand the mechanism of human–land interaction better, and the simulation results can provide a basis for optimizing land resources and formulating environmental resource policies. By combining a CA–Markov model with multi-source data, we simulated the land-use/land-cover changes in Shenzhen in 2015 under distinct scenarios. The Kappa coefficient of the experiment showed that the prediction results using multi-source data are more accurate than the predictions that do not use such data. After the land policy was added as the constraint, the accuracy of the results was improved greatly. The predictions are more in line with actual land-use/land-cover changes in Shenzhen. Under the planned intervention development scenario, we predicted the land-use/land-cover changes from 2016 to 2019 on the basis of previous data in Shenzhen from 1988 to 2015. We also provided a data set of Shenzhen's land-use change response to Shenzhen policy under the influence of multi-source data, which covered the land-use/land-cover data of Shenzhen from 1988 to 2019 with a spatial resolution of 30 meters.

Understanding spatiotemporal patterns of social events based on social media data

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Social events such as massive protests are likely to turn into social conflicts, even cause violence thereafter, which play a negative role in urban governance and society stability. Recently, there have been many massive protests occurred in different cities all over the world, which have caused collective human behaviors resulting in various urban sustainable issues. A better understanding of their spatiotemporal patterns, including how a protest is triggered, how a protest is propagating over time and over geography, what geospatial factors may influence the location of a protest occurring, etc., could help urban governors make better decisions for protecting citizens and make effective urban sustainable policies. Social media has been a popular venue for sharing such information before, during and after social events. By analyzing not only the textual information but the tagged geoinformation involved in a massive social media dataset related to the events, one can investigate the key components of the events mentioned above. Hence, this work focuses on applying a data-driven framework to a geo-tagged twitter dataset collected for the 2019-2020 Hong Kong protests as a case study. We explore the features of the data through the lens of a set of quantitative analysis such as sentiment analysis, time series analysis and spatial analysis, trying to capture the underlying spatiotemporal pattern of the protests and their violent conflicts. We hope it may provide a scientific basis for the prediction of social events and to supply ideas for the exploration of the theory of their occurrence and propagation, further benefiting enhancing capabilities of resilience in cities.

Exploring the opportunities for GIS-enabled resilient communities, through trackless trams and transit activated corridors

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Around the world, large parts of suburban areas on the periphery of cities remain without quality mobility transit for residents and travellers, along main roads and primary corridors. This is experienced as repeated and growing congestion with associated reductions in urban value for housing and commercial real-estate. These challenges have significant implications for addressing the United Nations Sustainable Development Goals (UN SDGs), as they are endemic in the challenges of sustainable cities and communities (SDG-11), in addition to providing access to food (SDG-2), medical services (SDG-3), work (SDG-8) and reducing greenhouse gas emissions (SDG-7).

Geospatial technologies have transformed the way that mobility can be enabled in suburbia, providing end-user focused experiences that are affordable in construction and maintenance. Geospatial technologies also enable the implementation of 'Net Zero Corridors' through accurately matching transport demand with supply and enabling renewable energy use through data-rich appreciation of peak electricity needs and reliable supply.

This paper summarises research from a national desktop study in Australia, regarding a new kind of mid-tier transit called 'Transit Activated Corridors' (TACs), by a team of multi-disciplinary researchers from three universities. The researchers enquired into the question, "how can decision-makers build on traditional planning around boulevards and also enable urban regeneration processes along main roads". The authors also explored how data about 'where' could be part of solving 'how' cities can operate effectively through integrating urban planning and transport outcomes.

The paper comprises a discussion of how a specific type of geospatially enabled mid-tier transit 'Trackless Tram' could help provide not only a better solution for urban transport, especially along main roads that connects to rail stations, but also assist with how urban regeneration can be facilitated through 'Transit Oriented Development' (TOD) around train stations. The authors also present the project output in the form of an open-access searchable database that collates research outcomes and examples of industry best practice. The paper summarises the database contents, considering how Trackless Trams could catalyse urban regeneration, including other societal benefits such as affordable housing.

This paper provides an important distinction for planning and design professionals, enabling a breakthrough in geospatially sensitive development that is intense around good services and urban activity rather than diffuse with associated car dependent urban sprawl. The resource is of immediate relevance for decision-makers considering business cases for mass transit corridors for multiple-benefit outcomes. It also provides a rich data set for future research that can enable new elements such as 'Net Zero' to be integrated into urban and transport planning.

Brute Force Parallel Computation of the Czech Republic Area Coverage by Aerial Firefighting Resources for Combating Wildland Fires Based on Historical Data

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Because of climate change, wildland fires now endanger citizens' lives, health, property, and the environment in places that were very rare in the past. Because of these facts, the Fire Rescue Service of the Czech Republic pays great attention to the preparation for combating these kinds of fires, including careful planning of the necessary resources.

One of the essential parts of the system of combating wildland fires is aerial firefighting. Many approaches can be chosen to determine the optimal coverage of the area of the Czech Republic with assets for aerial firefighting these kinds of fires. A final comparison of the results obtained with various approaches can provide even deep insight into this topic.

One of the possible approaches can be based on the spatial distribution of the airfields and historic wildland fire data in the Czech Republic. This approach can be formulated in the following way: "For a given number of airfields, order the various selection of the airfields from the most to the least favorable configuration. Then, determine the number of necessary airfields for sufficient coverage of the area of the Czech Republic ". As an evaluation criterion for this comparison, the sum of the distances from the historical wildland fires to their nearest airfield in a given airfield configuration naturally suggests. Because this approach is only one of the possible approaches used for selecting the most favorable configuration, we are looking not only for the most favorable configuration found with this approach but for the ordered set of the configuration.

The above mention approach uses two primary sets of data. First is the set of all airfields situated in the area of the Czech Republic. Each airfield is equipped with an attribute signalizing how the program can include it in the computation. The airfield can be left out from the computation (like, for example, military airports in some scenarios), included mandatory in each configuration (like, for example, the airfields belonging to the Police of The Czech Republic in some scenarios) or can be added to the computation without any further conditions. The second set of data used for computation is a carefully selected extract of the wildland fires occurring in the Czech Republic in the past years from the databases of all emergencies maintained by the National Operational Centre of the Fire and Rescue Service of the Czech Republic.

The calculation was done through an in-house developed Python program. Because of the large amount of time necessary for calculating the ordering criterion for all possible configurations, the parallelization of the computation through the Python processes was used as much as possible. Fortunately, its usage leads to a substantial shortage of time necessary for the calculation.

In addition, data wrangling procedures were used to reduce problems with incorrect or missing data before the wildland fires data sets were used.

The previously mentioned approach to comparing the various configuration of the airfields used for the coverage of the area of the Czech Republic with means of aerial firefighting for combating wildland fires is one of the backgrounds for public procurement focused on the completion of the existing means in this area.

It also demonstrates one of the general approaches to the coverage analysis of the serviced objects with services from a given point set.

The algorithm used for preparing one of the backgrounds for planning the coverage of the area of the Czech Republic with means for aerial firefighting of the wildland fires utilizes the data forming part of the digital earth model (airfields and places of historical wildland fires). It infers new relationships between them and further enriches the original model with new data (various airfields configuration sorted from most to the least favorable). These new data serve as one of the many data used for the formulation of public procurement focused on the substantial improvement of public service - public safety provided by the state.

SAR-Transformer: Decomposing InSAR time series and uncovering the temporal patterns of land deformation

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Synthetic aperture radar interferometry (InSAR) time series analysis has emerged as a powerful tool for detecting and monitoring land deformation at high temporal and spatial resolutions (Ma et al. 2019). However, interpreting InSAR time series can be challenging due to the complex coupling of trend, seasonal and noise components (Ferretti et al. 2011). Traditional model-based methods may result in incomplete or inaccurate assessments due to the difficulty of setting appropriate models and parameters (Hanssen 2001). Therefore, the use of data-based deep learning methods has gained increasing attention due to their ability to provide robust and efficient solutions (LeCun et al. 2015; Wu et al. 2023).

Despite the potential benefits of using deep learning for InSAR time series analysis, there exist several challenges that need to be addressed. Firstly, the lack of ground truth data for training deep learning models is a major issue since InSAR time series data typically contain a large number of images and are coupled with atmospheric noises, making it difficult to perform manual labelling (Ferretti et al. 2001). Secondly, the irregular time intervals between InSAR measurements, which mainly depend on the type of satellite used, also pose a challenge (Ferretti et al. 2011). Even for InSAR time series from the same satellite, the interval may be variable due to the lack of satellite acquisitions at certain times (Zhao et al. 2021).

To address these challenges, this paper proposed a novel SAR-Transformer network with special timestamp encoding, which was trained and tested with simulated data. Specifically, we first generated trend, seasonal, and noise components respectively and then added them together to obtain the simulated InSAR time series. The trend component includes constant, linear, accelerate, and decelerate types, which were simulated using linear and log functions with random parameters. The seasonal component was generated using the sine function with a fixed period of one year and a randomly varying amplitude and offset. The noise component was modeled as Gaussian white noise. Using the simulated data, we developed and trained the SAR-Transformer model. In the model, we designed a special timestamp encoding module to explicitly encode the temporal information into the input data, enabling the network to learn the irregular time intervals of the InSAR time series data more effectively. The overall model leverages the self-attention mechanism of the Transformer architecture to capture the temporal dependencies between different time steps (Vaswani et al. 2017).

Experiments were conducted on both simulated and real InSAR time series datasets. The performance of the proposed method was compared with traditional linear fitting and Seasonal and Trend decomposition using Loess (STL) methods (Cleveland et al. 1990). The results showed that the proposed method outperformed the other methods on the simulated dataset, with the highest mean absolute error (MAE) of 0.454 mm and mean squared error (MSE) of 0.328 mm. Specifically, the trend components had lower MAE and MSE (0.241 mm and 0.110 mm) compared to those of seasonal components (MAE of 0.378 mm and MSE of 0.226 mm). This finding suggests that the seasonal components are harder to accurately capture. Furthermore, the method was applied to high-resolution COSMO-SkyMed and medium-resolution Sentinel-1 data of the Hong Kong Boundary Crossing Facilities, where it successfully characterized several temporal patterns, including long-term deformation trends and seasonal variations. These patterns were validated using precipitation and tide data.

In conclusion, this paper proposed a novel SAR-Transformer approach for InSAR time series analysis, which can potentially improve the accuracy and efficiency of InSAR time series analysis, and provide a more comprehensive understanding of underlying geophysical processes. In the future, further research will explore how to simulate more complex training data combined with physical models and generalize the proposed method to more regions.

Integration of Susceptibility, Vulnerability and Hazard Factors for Landslide Risk Assessment: A Case Study of Sichuan Province, China

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As one of the most influential natural hazards, landslides can cause enormous loss of life and property, as well as destruction of the natural ecosystem. It is necessary to assess landslide risk to support decision-making and operational strategies in disaster prevention and reduction. However, the landslide has a complex formation mechanism in which various interacting factors (e.g. rainfall, earthquake, human activities) collectively contribute to slope instability and mass movements. To address the limitation in landslide assessment, this study integrates machine learning (ML) techniques, and the analytic hierarchy process (AHP) approach to improve the accuracy, efficiency, and reliability of landslide susceptibility and vulnerability mapping. The studies have been conducted to incorporate data (including satellite images) from 6,107 historical landslide events in Sichuan province of China. Firstly, several geo-environment factors including elevation, slope, aspect, curvature, topographic wetness index (TWI), distance to drainage, distance to fault, distance to road, normalized difference vegetation index (NDVI), and rainfall are used to construct explanatory variables. The AdaBoost-Logistic ensemble model was applied to generate the landslide susceptibility map. Secondly, we used 7 factors relating to ecological and socio-economic vulnerabilities to assess the total vulnerability of landslide disasters. Those vulnerabilities include population density, the normalized difference built-up index (NDBI), the naturalness index. AHP was employed to determine the weight of each factor and integrate vulnerability criteria for the assessment. Finally, the overall landslide risk assessment for Sichuan province was generated, which is an integrated index that considers landslide susceptibility and vulnerability. It is worth noting that the AdaBoost-Logistic was the top performers in landslide susceptibility mapping (LSM), compared with the state-of-the-art ML models of AdaBoost, logistic regression. The performance of the AdaBoost-Logistic ensemble model was evaluated by area under curve (AUC) of receiver operating characteristics (ROC) of 0.926. The result of this study shows that 11.99%, 43.33%, 36.28%, 6.04% and 2.36% of the study area is in very low-risk, low-risk, medium risk, high-risk, and extremely high-risk, respectively. In addition, high and extremely high-risk areas are mainly distributed in the southern and central eastern parts of Sichuan Province, and the number of landslides in the area accounted for 76.83% of the total. This presented landslide risk assessment results support selecting priority measures in landslide risk reduction and management.

Registration to the Canine Search and Rescue Attestation Exams – System Integration with Spatial Data Processing on client and server side

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Canine search and rescue is an important and irreplaceable part of the system for reaction to emergencies. Search and rescue dogs are trained to find missing people after a natural or man-made disaster, like the 2023 Turkey-Syria Earthquake or the 2020 Beirut explosion. The dogs detect the human scent and have been used to search for missing living or dead persons in the rubble of houses, avalanches, natural terrains, and water. The dog and its handler must be appropriately trained and prepared to cope with such a difficult task. Before the dog handler and dog is allowed to participate in search and rescue operations, they must undergo the attestation exams.

The web application was created to make the application for attestation exams more comfortable for dog handlers and easily processable for persons responsible for organizing the attestation exams.

The created web application uses web form for collecting various data concerning the dog handler and its dog, including attachments, verifies its validity, and sends it to the servlet hosted on the web application server where there are further processed. Finally, the servlet sends all the data in the form of an MS Excel workbook to the responsible person via email with the given attachments.

There are various standards and procedures on how to create a web application. Still, because of the particular demands of the people responsible for organizing the attestation exams, these standards and producers will not be suitable for this particular case. Because of that, a little-bit low-level programmed application based on servlets and JavaServer Pages (JSP) using JavaScript was developed, tested, and deployed.

To shorten the development time as much as possible and avoid malfunctioning the final application, the various well-established components were integrated to carry out desired tasks. Special attention was paid to the processing of spatial data. Spatial data play a crucial role during the management of emergencies. Because of that fact, every used information should be equipped with its georeference if this is possible, reasonable, and useful. In this application, the spatial position of the permanent and temporal residence of the dog handler was processed in various ways. On the client side of the application, running in a web browser, the user selects the position of their permanent and temporary residence by clicking on the map. The corresponding coordinates were sent to the reverse geocoding server, which converted them to the addresses. In the permanent residence case, the obtained address was split into its parts to prefill the fields used to store the permanent residence data.

The primary spatial reference system used in this application was S-JTSK / Krovak East North (EPSG 5514 (102067)) because its usage is mandatory in the civil information system in the Czech Republic. However, unfortunately, systems used for navigation or air transport prefer the WGS 84 (EPSG 4326) spatial reference system. In order to cope with this problem, on the application's server side, the S-JTSK / Krovak East North coordinates of the dog handlers' permanent residence were transformed to the WGS 84 coordinates by using the well-established ArcGIS Server coordinate transformation web service. The one rest web service was used by another rest web service.

Verifying the user inputs in the three-tier architecture web application is usually done with different settings and mechanisms in the web browser client, application server, and database. So a particular web service was established to unify these settings and mechanisms between the web browser client and application server, which serves any client the rules for user input verification in the form of the JSON file. The same settings and mechanisms are used on the server side for data verification.

Above mentioned web application extensively consumes and processes spatial data and relationships between them. They are a substantial part of the digital earth model, such as data concerning permanent residence, reverse geocoding procedures, and the transformation relationships between different coordinate systems. The data enable more easy registration of the dog handlers and dogs to attestation exams and simplifies the procedures leading to its deployment in the case of emergency.

Multi-temporal change detection based on radar and optical satellite imagery to monitor the reconstruction and recovery process in Haiti after Hurricane Matthew

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The Hurricane Matthew, which occurred in October 2016, was one of the strongest hurricanes to hit the island of Haiti. The hurricane caused a significant amount of damage to infrastructure, homes, and crops, leading to a humanitarian emergency in the region. Additionally, the hurricane caused floods and some landslides, resulting in a large number of deaths and displacement of population. The impacts of Hurricane Matthew in Haiti were particularly devastating due to the country's vulnerability to extreme weather events and the lack of infrastructure and basic services to address the emergency. Therefore, while in the immediate aftermath the priority was given to early response and humanitarian emergency, in the months and years after the main concern was related to ensuring a recovery process consisting of not only the reconstruction of damaged buildings and infrastructure, but also a re-organization of urban settlements and the environment that would ideally decrease the exposure to future events [1]. This study examines the ability of Synthetic Aperture Radar (SAR) and optical and synthetic aperture satellite Sentinel-1 and Sentinel-2 satellite images Sentinel 1 and Sentinel 2 to detect changes due to severe hydro-meteorological after a natural disaster events such as the one that occurred in Haiti, and those that are proxies subsequent analysis with data from these satellites of the infrastructure recovery process on the island implementing SAR amplitude [2] and multispectral change detection methods, the study aims to understand assessed the extent of the damage caused by the hurricane, including the identification of the most affected areas, i.e. the Grand'Anse and southern regions, whose main cities are Jérémie and Les Cayes, respectively. In particular, the study monitors spatially mapped the temporal evolution of surface changes due to infrastructure or buildings, vegetation, and flood-affected crop areas to understand the dynamics of the rebuilding construction and recovery process on the island at various time intervals, i.e. with a monthly frequency during the post-event phase lasting until the end of 2016 and by semesters in the years 2017-2020. Furthermore, the study seeks to provide information for proper decision-making in disaster and reconstruction planning, including identifying priority areas or the most affected zones, assessing the progress of reconstruction efforts over time, and identifying areas that changed land use after the event. This time-series analysis approach was used to evaluate the differences between satellite images before and after the hurricane using data from Sentinel 1 and Sentinel 2 missions, allowing the identification of areas affected by the natural disaster. By analyzing the differences in the radar backscatter of Sentinel 1 signal, areas that had a change in infrastructure and soil moisture were identified, and with Sentinel 2 data, the analysis of the impact on vegetation cover and as a reference for other areas. The contextual interpretation of the latter areas was aimed to more data with semi-annual dates were used for post-event reconstruction analysis to analyze identify whether if there was a true and adequate reconstruction process across on the island was adequate and made in way that improved resilience to future events or, instead, potentially led to cascading susceptibility to natural hazards (e.g. new buildings in landslide-prone areas). The results indicate that the hurricane caused a very strong disruption in infrastructure, especially homes in the affected areas, which were mostly destroyed by the hurricane. Large areas of crops were affected by flooding events, and there was a significant decrease in vegetation cover, affecting conservation areas and natural parks. Data from the reconstruction process carried out after the natural disaster were obtained, differentiating possible areas where there was a change in land use after the reconstruction process. As the ultimate goal, the study also seeks to provide information for proper decision-making in disaster management and reconstruction planning, including identification of priority areas or the most affected zones, assessment of the progress of reconstruction efforts over time, and identification of the areas that changed land use after the event. Therefore, the discussion focuses on the implications of these findings for disaster management and reconstruction planning in the affected region are discussed. The achieved information suggests that radar SAR data and optical sensors can be valuable tools for monitoring the effects of natural disasters and analyzing the reconstruction processes in affected areas.

Global exacerbation of episodic local vegetation greenness decline by drought since the 21st century

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The stability of ecosystem function is severely affected by the decline in vegetation caused by extreme climates, such as droughts and heat waves. Extreme climate has been prevalent over the past 20 years and droughts are expected to increase even further in the future. Satellite-based remote sensing products have been widely used to monitor global vegetation greenness and primary productivity, as well as to investigate the ecological impacts of droughts. But currently, the spatial and temporal response of episodic large-scale vegetation greenness decline to drought at the global scale are still unclear. Droughts may not always result in extreme vegetation responses. Thus, this study took an impact-driven approach by first monitoring global events of large-scale vegetation greenness decline over the last 20 years before attributing them to droughts and other natural disasters. The study focused on drought-induced vegetation extremes and their impacts, and the spatiotemporal characteristics of drought-influenced vegetation decline events and their interannual trends over the period 2000-2019 were explored. The detrend NDVI data was utilized as the indicator of vegetation growth, and a spatiotemporally contiguous recognition method was proposed to identify episodic large-scale vegetation decline events globally. The method was based on a spatial and temporal perspective, defining large-scale vegetation decline events in terms of duration (lasting at least two months), degree of vegetation decline, and area (at least 100,000 km2), and identifying drought-induced vegetation decline events by matching them to recorded disasters events in WMO reports and the literature. The results showed that (1) the spatiotemporally contiguous recognition method proposed by this paper was proven to be accurate in identifying the hotspot regions of large-scale vegetation decline. A total of 243 large-scale vegetation decline events were recognized globally during 2000-2019 drived by the method. Drought-related vegetation decline events accounted for 90.13% of the total number of events, of which 41.98% were caused by drought alone and 48.15% by a combination of drought and heat waves. (2) The global large-scale vegetation decline caused by drought was mainly concentrated in spring and summer, with hotspot areas mainly distributed in the low-elevation areas at middle and low latitudes, especially at 15°S~35°S, 15°N and 35°N, where decline lasted for longer periods. These regions covered north-western Africa, the Sahel, the Middle East, Central Asia, western India, the border of north-eastern China and Mongolia, western and south-central United States, northern Mexico, southern Africa, Australia, and southern and north-eastern South America. (3) Since 2000, there has been a significant increase in episodic local vegetation decline caused by drought globally. Particular, the severity of drought-induced vegetation decline grew significantly since 2010 at the regions where covered the latitudes of approximately 15°N, 30°N and 65°N. Additionally, the severity of vegetation decline ranging from 20°S to 30°S weakened significantly since 2010. These findings were expected to provide the valuable scientific understanding for global vegetation decline and ecosystem responses to frequent drought events, and also offer new perspectives for analysis of global vegetation growth and ecosystem management.

Spatial downscaling of precipitation in geological hazard-prone areas based on multi-factor two-stage random forest regression

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Detailed and accurate precipitation data is critical for hydrological and meteorological studies of mountainous regions. The precipitation data provided by the Tropical Rainfall Measuring Mission (TRMM) 3B42 is suitable for monitoring precipitation variation on a global scale. However, the spatial resolution of the TRMM is approximately 27 km, limiting its applications for geological hazard monitoring. Previous studies have demonstrated that higher spatial resolution precipitation can be predicted using downscaling techniques fusing spatial information from coarse-resolution precipitation and detailed textures of fine-resolution factors. Nonetheless, these techniques have not been applied and tested for geological hazard-prone mountainous areas. This study aims to fill this research gap by proposing a multi-factor, two-stage random forest model, namely, the MTRF, which increases the resolution of TRMM 3B42 precipitation by a factor of 54 to achieve a spatial resolution of 0.5 km. Firstly, fine-resolution factors that may carry information related to precipitation, such as topography, the normalized digital vegetation index (NDVI), and surface temperature, were selected as input variables and used to fill in the gaps to obtain high-resolution inputs. Secondly, a two-stage random forest model was trained at a coarse resolution to establish statistical relationships between precipitation and the input factors. Finally, the trained multi-factor two-stage random forest (MTRF) model was driven by fine-resolution input factors to obtain higher resolution precipitation data. The proposed MTRF model was developed and applied to China's mountainous and disaster-prone Sichuan province. The results indicate that MTRF improves the spatial resolution of TRMM 3B42 precipitation by a factor of 54, with an R-square of 0.81 and an RMSE of 9.76 mm. Furthermore, MTRF was compared with the widely used geographically weighted regression (GWR) downscaling method, using precipitation data from independent observation periods to evaluate both methods. MTRF consistently outperforms the GWR downscaling method (RMSE = 10.53 mm for MTRF, RMSE = 12.87 mm for GWR), demonstrating that it effectively captures the key features associated with precipitation. Additionally, this study examines the importance of auxiliary factors in the downscaling model and finds that several key factors and the spatial variation of these factors play a vital role. Specifically, topography and temperature were identified as the two most important factors for MTRF to detect coarse spatial resolution of precipitation, especially in high-altitude areas. In conclusion, the findings of this research suggest that the coarse spatial resolution (27 km) of TRMM 3B42 precipitation can be efficiently and accurately downscaled to a higher resolution (0.5 km) using the proposed MTRF model, thus contributing to a better understanding of dynamic precipitation patterns in areas prone to geological hazards.

Detection and Characterization of Active Faults in Shandong Province, China using InSAR Time-Series Analysis

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The role of active faults in site selection for engineering projects and seismic building design is crucial due to the potential for slow-moving secondary faults, with a velocity of several millimeters per year, to cause damage to buildings. These faults, which differ from seismic faults that trigger earthquakes, pose a significant threat to public safety. Therefore, continuous monitoring of active faults and assessment of their long-term micro-movements are imperative. Interferometric Synthetic Aperture Radar (InSAR) has emerged as a promising tool for detecting active faults and measuring their movements. In this study, we focused on Pingyi County in Shandong Province, China, and analyzed 60 Sentinel-1 Synthetic Aperture Radar (SAR) images from 2017 to 2022, using the Small Baseline Subset InSAR time-series method to obtain deformation rates of the area. A total of 492 interferograms were obtained based on the 300 m and 300 days spatial-temporal criterion. To mitigate the atmospheric noise in the interferograms, we used the Common Scene Stacking method. Our results revealed a distinct discontinuity in the rate map, indicating the location and movement of several faults. One of the distinguishable faults highlighted by the rate map is the Mengshan-Shanqian (MS) fault, which is moving towards the satellite along the Line-of-Sight (LOS) direction at a velocity of 2 mm/year in the northern part, while the southern part is relatively stable. The obvious discontinuity in the rate map agrees well with the geological documents recorded by the local government and indicates the location and direction of the MS fault. Another active fault that has caused damage to buildings in the field survey is the Cangshan-Nishan (CN) fault. Our InSAR rate map also provides information on the location, direction, and the deformation rate of the CN fault. Additionally, by decomposing the LOS velocity into the fault trending direction, we obtained the left-lateral characteristic of the CN fault, which is consistent with geological studies. Overall, InSAR offers a unique and effective tool for monitoring active faults with large coverage and low cost. The insights provided by InSAR can be utilized to determine the direction, location, deformation rate, and characteristics of movements of active faults, which are critical in ensuring public safety and making informed decisions regarding engineering site selection and building seismic design.

Can remote sensing-based crop classifications be used to monitor biodiversity in agricultural landscapes?

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Biodiversity in agricultural landscapes is crucial because it represents a very delicate balance between food security and ecosystem health. On the one hand, it is important to design a diverse landscape to create habitat richness and to achieve valuable ecosystem services. Increasing the number of edges of agricultural fields by reducing patch size, for instance, can create more habitat, which can have a positive effect on the occurrence of different species. On the other hand, the landscape still needs to provide sufficient yields, for which larger field sizes are supportive, to accommodate the increasing population with changing eating habits and to cover feed and fuel. However, a well-balanced landscape system can also be mutually dependent, in that, for example, increased crop diversity can be conducive to increasing crop yields. Thus, factors which affect biodiversity are directly connected. Monitoring biodiversity in agricultural landscapes supports to map the interconnections between the multiple influencing factors inside the sensitive system. The analysis of diversity in agriculture is examined in terms of crop diversity, habitat diversity and small structures as well as landscape elements.
Since the usage of public crop type information like the European Land Parcel Information System (LPIS) is often restricted by data protection regulations and with the increasing availability of dense and open remote sensing imagery, more satellite-based products are being developed. For assessing crop type diversity in agricultural landscapes, several products in the form of crop type classifications are available. These maps are based on various remote sensing methods with diverse validation strategies and have different class type catalogues. This leads to differences in the classification results and geometry of the available Germany-wide maps, in terms of crops type distribution and occurrence. In this study, we investigate how well these crop type classification products fit or even could replace LPIS information. In order to assess the applicability of the different land use maps, we focus as a first step on the comparison of their specific classification results in the form of the actual crop type identification. For this purpose, we transfer the classification content to the geometry of the LPIS data and thus focus on the comparison of the crop types themselves. To assess the data-fitness-for-use, we determine different data quality metrics by deriving multiple biodiversity metrics (e.g. Shannon Index, Number of Crops) from the various input data and analyse them statistically. As part of the analysis, we have created a workflow that can be flexibly adapted to the different properties of the crop type classifications. The calculation of the different biodiversity metrics can also be adapted by changing various alternative options, as well as new metrics can be added. As a result, the different data quality metrics are visualised as a multidimensional application data matrix, which allows the evaluation of the data quality from the user's perspective.
For the first time, biodiversity metrics for the agricultural landscape in Germany are presented on the basis of various crop classifications (Blickensdörfer et al., 2022, Preidl et al., 2020). This shows that an area-wide derivation of significant biodiversity metrics using remote sensing-based products is in general possible. With the help of multidimensional application data matrices of the data quality metrics, we show how well crop classifications work as an alternative to LPIS information for deriving biodiversity metrics in agricultural landscapes.

Processes and Tools for enabling Interoperability between Citizen Science and Expert Biodiversity Data in Agriculture

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The emerging OGC APIs aim to support anyone to provide and use geospatial data from a wide variety of domains on the web, and to integrate this data with any other type of information. In the H2020 project "Farmer clusters for Realising Agrobiodiversity Management across Ecosystems" (FRAMEwork), we develop and implement tools and processes that enable interoperability between Citizen Science data and Expert data in Farmer Clusters. A Farmer Cluster is a farmer-led group of farmers, specialising in different cropping and farming systems working together in their locality with the objective to ensure that their efforts are complementary and to work towards shared biodiversity goals. Biodiversity monitoring data is collected in several formats and through different applications in 11 pilot Farmer Clusters spread among 9 countries across Europe. This biodiversity monitoring data is consequently stored and curated in a Data Hub as metadata records and its associated biodiversity datasets. Such metadata is useful and understandable and it enables collaboration between the different stakeholders of the project. The Data Hub, hosted by CREAF, is a GeoNetwork repository which is an open-source catalogue application to manage spatially referenced resources. In case the data is public, it is transformed with tools that are developed and tested in the project. They are based on the OGC STAplus, an extension to the OGC SensorThings data model/API which has been developed and based on requirements from the Citizen Science community. STAplus was initially designed in the COS4Cloud project (Co-designed citizen observatories for the EOS-Cloud) and its use is also foreseen in the CitiObs project (Enhancing Citizen Observatories for healthy, sustainable, resilient and inclusive cities) as a mechanism to interoperate among air quality observatories. The nat2sta tool allows to transform iNaturalist observations into STAplus records, which in turn are uploaded and can be visualised and queried in map visualisations such as the MiraMon Map Browser. The STAplus instance is hosted by Secure Dimensions and it is based in their FROSTplus development available on GitHub. The nat2sta tool has been tested with biodiversity observations collected in one of the pilot Farmer Clusters during a BioBlitz in April 2022 in Born (Luxembourg), as part of the global City Nature Challenge. Data scientists can explore this data and different stakeholder groups can discover and query the data in the MiraMon Map Browser. They can perform analysis and statistics or build time series and observe evolution of biodiversity variables. Further tools, such as the csv2sta which recognises CSV observations and ingests them in a STAplus service instance, are developed to guarantee FAIR data principles and to ensure data interoperability with other formats of biodiversity data collected in the field. One goal is to link these tools and processes with an open access Information Hub to support FRAMEwork networks, sharing activities, information, data and resources across farmers, scientists, policy makers and citizens. The described processes and tools will facilitate sharing and harmonisation of farmer and citizen-based, high-quality information on biodiversity in farming contexts. (This work has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No 862731.)

Whole Process Monitoring and Conservation of Biodiversity in Qilian Mountain National Park

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Biodiversity has three components: species diversity, genetic diversity and ecosystem diversity. Biodiversity is a stable ecological complex composed of living organisms such as animals, plants and micro-organisms within a given area, and is the sum of the various forms of life. Biodiversity is an important component of humanity's own living environment, and the conservation of biodiversity is related to the future sustainable development and long-term development of humanity.

Qilian Mountain National Park is a key ecological function area and a priority area for biodiversity conservation in China, as well as one of the first ten pilot national parks established in China. The complex ecosystems of Qilian Mountain National Park include various forest ecosystems, grassland ecosystems, glacier ecosystems, wetland ecosystems, desert ecosystems, etc. These complex and diverse ecosystems mosaic together to form an ecological environment suitable for a variety of plant and animal habitats, laying the ecological foundation for the national park' biodiversity.

Three typical ecosystems, namely forest ecosystem, alpine ecosystem and glacial tundra ecosystem in Qilian Mountain National Park, were selected as models to establish an IOT monitoring system, together with a thermal infrared wildlife monitoring system and a field survey system for endangered species to form a ground biodiversity monitoring system in Qilian Mountain National Park. Detailed monitoring of typical ecosystems and human activities based on high-resolution remote sensing images. Medium- and high-resolution remote sensing imagery will be used to create long time series of vegetation indices and automatic change detection algorithms will be used to detect changes in human activity in the Qilian Mountain National Park. Fine monitoring of industrial and mining, tourism, hydropower and other human activities rectification based on UVA image. Based on the above, the Qilian Mountain National Park " space-air-ground" integrated whole process monitoring technology.

The Qilian Mountains National Park is divided into grids with administrative divisions and ecosystems, mapping vegetation indices, hydrological and meteorological data, and multi-source remote sensing images to the grid, and integrating the multi-source heterogeneous data of " space-air-ground " integrated monitoring to form the "Qilian Mountains National Park Whole Process Monitoring System", which realizes real-time, high-frequency, multi-scale network monitoring of biodiversity and provides technical and data support for biodiversity conservation.

HiLPD-GEE: High spatial resolution Land Productivity Dynamics calculation tool using Landsat and MODIS data

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Land productivity is one of the sub-indicators for measuring SDG 15.3.1. Land Productivity Dynamics (LPD) is the most popular approach for reporting this indicator at the global scale. A major limitation of the existed products of LPD is the coarse spatial resolution caused by remote sensing data inputs, which cannot meet the requirement of fine scale land degradation assessment. To resolve this problem, this study developed a tool (HiLPD-GEE) to calculate 30 m LPD by fusing Landsat and MODIS data based on Google Earth Engine (GEE). The tool generates high-quality fused normalized difference vegetation index (NDVI) dataset for LPD calculation through gap filling and Savitzky–Golay filtering (GF-SG) and then uses the method recommended by the European Commission Joint Research Centre (JRC) to calculate LPD. The tool can calculate global 30-m LPD in any spatial range within any time window after 2013, supporting global land degradation monitoring. To demonstrate the applicability of this tool, the LPD product were produced for the countries involved in the Great Green Wall (GGW) initiative. The analysis proves that the 30 m LPD product generated by HiLPD-GEE could reflect the land productivity change effectively and reflect more spatial details when compared with the 250 m LPD product. The identified hotspot areas of land degradation also provide an important insight for the GGW initiative.

Validation of high-resolution global canopy height maps and their applicability to biodiversity modelling

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Forest ecosystems cover more than 4.1 billion hectares of the Earth's surface and provide a number of ecosystem services including regulation of the global carbon cycle or acting as reservoirs of unique species and/or high biodiversity. It is well recognised that the vertical structure of the forest canopy, including its height, is directly linked to the aboveground biomass and primary productivity, both being key components of carbon stock and flux. These facts, together with the high level of forest ecosystem threat induced by climate change, place the fine-grain global mapping of forest height among the important goals of the forest remote sensing community. Until recently, we lacked comprehensive global data on the spatial patterns of vegetation structure. This has changed over the past two decades with the great improvement and expansion of laser altimetry, a.k.a. Light Detection and Ranging (LiDAR). However, spaceborne LiDAR sensors collect data along discrete transects and hence only provide discrete samples of forest height and structure. A common approach for producing a continuous high-resolution global map of vegetation height is to train statistical or machine learning models that combine LiDAR measurements with spatially continuous ancillary data from optical sensors. This enables the estimation of vegetation height at locations unmeasured by LiDAR. In this manner, the first global canopy height map was produced in 2010, combining GLAS (Geoscience Laser Altimeter System instrument onboard the first ICESat mission) with MODIS data. In 2018, NASA launched two LiDAR space missions and has been continuously providing accurate data on the 3D structure of the Earth's surface since. These are the Ice, Cloud and land Elevation Satellite-2 (ICESat-2) and the Global Ecosystem Dynamics Investigation (GEDI, onboard the International Space Station - ISS), the latter being specifically designed for vegetation mapping. Recently, the Global Land Analysis and Discover team at the University of Maryland integrated the GEDI data with Landsat and SRTM data, creating a 30 m spatial resolution global forest canopy height map (https://glad.umd.edu/dataset/gedi/). More recently, EcoVision Lab team at ETH Zurich integrated GEDI data with Sentinel-2 images to develop a high-resolution canopy height model of the Earth (https://langnico.github.io/globalcanopyheight/) with a spatial resolution of 10 m. Such maps were, for example, used to assess the association between canopy height and global water availability, test the hypothesis of a global relationship between plant species richness and canopy height, or produce a global map of terrain elevation at 30 m grid spacing. Despite their unprecedented resolutions, however, global vegetation height products suffer from quality issues related to the performance of developed models and input data quality (e.g. high GEDI error in forest height on steep slopes, poor accuracy of terrain height estimates in dense forests), and require independent evaluation. By studying the accuracy of existing vegetation height maps, it is possible to identify the causes of errors and the approaches that lead to the most accurate canopy height estimates. Furthermore, errors are propagated to any subsequent analysis using such data. Therefore, we investigated the accuracy of two recent global canopy height maps in various types of forests using airborne laser scanning data as a reference and assessed the usability of the maps for biodiversity modelling using a virtual species approach. Our results show that the evaluated maps contain large errors, some of which are common to both maps. The accuracy of estimated canopy height was highly dependent on the canopy height itself, resulting in underestimates of horizontal heterogeneity of canopy height. Finally, biodiversity models using global canopy height maps lead to a considerable decrease in models' discrimination ability and to mischaracterisation of species niches.

Geospatial Data for Immovable Cultural Heritage Properties in International Cartographic Standards

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The structuring, validation and exchange of spatial data are important topics in modern society, and properties with the status of immovable cultural heritage require a specific approach for these activities. The problem of gathering geo-information can be solved by multiple methods, while that of data structuring and exchange requires a wide-ranging solution. One such solution is the standardization of the transfer of geospatial information in order to make geoinformation accessible so that it can be used by a wide range of users. Of course, the problem also affects the national spatial data infrastructure. On the other hand, standards have an abstract structure and their application requires deep understanding and analysis.
In the scientific research, an approach is presented in which any type of data on immovable cultural heritage (spatial or non-spatial) of different types, different data sources, with different degrees of detail and others are harmonized centrally and uniformly by exchanging between different systems and users uniformly and without loss of information based on the current international cartographic standards.
The results of this project are related to: building a methodology for structuring the geospatial data for properties with the status of immovable cultural values from various sources (including free ones) and implementing them in practice through a spatial database linked to a geoinformation system with a metadata base; presentation of a systematic and practically applied procedure for exchanging not only the data and their structure through XML-based specifications, but also geodata services; preparation of various types of cartographic products (2D and 3D) based on the classified data, as well as extraction of additional information from these products by an automated method. All results are intended to be obtained in accordance with international cartographic standards.
The research methodology includes international standardization in geospatial data for real cultural value to be committed from the beginning of the processes - from the collection and structuring of data, through their validation, classification, coding, processing, analysis, storage and exchange to the final cartographic product, extraction of added information from it and combining it with other products for maximum applicability. The research methodology is based on the standards and specifications of the leading standardization organizations - International Standardization Organization (ISO) and its technical committees (TC), the industrial consortium Open Geospatial Consortium (OGC), the international consortium World Wide Web Consortium (W3C), the European standardization body CEN, the TC equivalent of ISO, the international Object Management Group (OMG), which are the foundation of national spatial data infrastructure. Following the guidelines defined in the output of standardization bodies - standards and specifications, the end result is the implementation of the XML/GML markup languages according to XML Schema (XSD), as well as the implementation on the spatial datasets of the unified services Web Feature Services (WFS), Web Map Services (WMS), Web Tile Services (WTS) and others in the chosen field of real estate.
The widespread usability and support of XML/GML by all modern GIS predetermines the uniformity of the approach to transition from concept to application through geodata services for properties with the status of immovable cultural values. This unification is an important step towards achieving the interoperability that is fundamentally needed at all levels – from the local to the national decision-making level.

5D-ARCH-AID:Air Documentation of Architectural Heritage at Risk – The 5D-ARCH-AID Web Platform

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The European Heritage Building stock is getting older, and historic places' abandonment is a fact in many regions. The considerable potential of heritage-led regeneration in historic cities, villages, and the countryside can become a real game-changer toward a greener and more sustainable Europe, enabling and amplifying its social and economic recovery. Consequently, the digital methodologies for documenting, recording, and protecting monuments and historic buildings have expanded over the last decade. Small Flying Objects (SFO) can play an essential role in this direction, speeding up the processes and providing more accurate data. In the project "5-Dimension Architectural Air Documentation" (5D-ARCH-AID), we developed an innovative service that combines a well-established historic building documentation methodology (HERMeS) and SFOs' technology for 3D reconstruction to create a conservation plan that can further engage the research and the local community. The protected medieval historic settlement of Ano Syros, Cyclades, Greece, was used as a case study.

In this paper we present the 5D-ARCH-AID inclusive online web platform where the digital heritage data produced during the project were integrated and are available at the disposal of local administration and public authorities, visitors, heritage enthusiasts, experts, professionals, other SMEs, and the creative sector.

The Web Platform is organized so that the user / visitor can explore a unique case study of digital documentation in five dimensions for the historic settlement of Ano Syros (Cyclades), which combines the renowned HERMeS historic building documentation methodology, documentation from Small Flying Objects (SFOs) and digital technologies for 3D modelling and 5D documentation of cultural imagery.

The web platform was developed on Free and open-source software (FOSS) and constitutes an e-tool developed to help users identify pathology issues, track vulnerability, risk assessment, and enhanced collapse and heritage loss prevention and it is accessible via the following link: http://5darchaid.getdata.gr/. Furthermore, we assume it constitutes an advanced transferable solution at domestic and international levels to generate conservation plans, shape decisions, make interventions, engage the community, and attract tourism.

Via the developed web platform, the user has access to :

1. the Historic Documentation of Ano Syros
2. the Documentation of the Building Stock. The user has access to the on-site documentation of 171 buildings of the historic settlement, via a user-friendly interface. The documented buildings are presented georeferenced on geospatial background and are categorized based on the available information provided for them. Moreover, the user can select a building of interest and have access to several detailed information about its history, structure, typology, pathology, intangible heritage (if any) etc.
3. The 3D Models that were produced during the project. Through this portal the user has access to point clouds, sizing more than 150 GB, documenting Ano Syros and selected emblematic buildings in 3D. Moreover, the user has the ability to interact with these data, being able to navigate, take measurements, clip and export his measurements. These functionalities are described in the technologies section further in the document. More specifically, the user can access to:

•The 3D photorealistic model of the entire settlement of Ano Syros captured by aerial photographs.

•The 3D photorealistic models of the exterior the 5 emblematic buildings of the settlement. For the Cathedral of Agios Georgios also the interior was captured using Matterport technology and is available to the user.

•The Digital mapping of the network of routes within the Ano Syros settlement.

4. The documentations of the Intangible history of Ano Syros settlement (4D data). The user can listen to stories and statements about the buildings of Ano Syros and the documented stories are related with the relevant buildings of the settlement.
5. The Conservation Plan for the settlement of Ano Syros (5D data). Through this portal the user has access to the resulting in Conservation Plan for Ano Syros. The top 10 buildings less preserved, that need conservation/restoration in Ano Syros are also freely available to the end users, along with their documentation details.
6. A Virtual Tour within the historic settlement of Ano Syros is also available for the user combining 2D & 3D viewers

Comparison Of 3D Models of Objects Based on Handheld Scanner and Close-Range Photogrammetry

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Two different technologies were used to create 3D models of architectural objects. A digital camera was used to apply the close-range photogrammetry methods. The obtained results are compared with 3D models created by a handheld scanner based on hybrid technology.
Close-range photogrammetry technology uses the central projection of the photograph as the fundamental mathematical model. The geometry and position of the object are determined by ray bundle reconstruction in which, for each camera, each image point, together with the corresponding perspective center, determines the spatial direction of the ray to the corresponding object point. When the image geometry within the camera and the location of the imaging system in object space are known, then each image ray can be defined in 3D object space.
The technology that the handheld scanner uses is based on structured LED light, invisible infrared light and a built-in color camera in one device. It projects a structured light pattern onto the object and captures the ways in which the object deforms the light pattern. Projecting and capturing multiple overlapping stripes from two or more positions allows the differentiation of object depth values, according to the principle of triangulation. The object is used as a reference between successive scan positions.
Experiments were carried out by scanning and capturing plaster objects of different sizes and geometries. Three criteria were used in the comparative analysis of the obtained results - capture time, texture, geometry and accuracy.

Comprehensive Monitoring, Early Warning and Protection of Immovable Cultural Heritage

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Immovable cultural relics include ancient sites, ancient tombs, ancient buildings, cave temples and stone carvings, important modern historical sites and representative buildings, and other historical and cultural relics with historical, artistic and scientific values. Most of the immovable cultural relics are directly exposed to the natural environment in the open air, and are vulnerable to air pollution and acid rain, accelerating damage and deterioration. Therefore, it is of great significance to carry out fine monitoring of immovable cultural relics, mitigate the disaster risk of immovable cultural relics, and strengthen the emergency management capacity and preventive protection of cultural relics.

Establish an IOT monitoring system for the micro-environment of immovable cultural relics and the cultural relics themselves, while identifying the type and area of surface deterioration of cultural relics based on object-oriented deep learning algorithms. Obtain high-resolution optical remote sensing images of a large area around immovable cultural relics to finely monitor them and the surrounding environmental elements. Using radar data penetration, independent of weather factors and other characteristics, to monitor the surface micro-deformation of immovable cultural relics bearing environment at the millimetre level. Through the above monitoring means, the construction of "sky - air - ground" integrated monitoring system of immovable cultural relics, accurate identification, and early warning of immovable cultural relics risk sources.

Based on the construction of the above monitoring system, the construction of a comprehensive database of immovable cultural heritage resources, the development of immovable cultural heritage resources risk monitoring and early warning system, cultural heritage resources data management system, cultural heritage resources promotion and display system, integrated built immovable cultural heritage risk monitoring and resource data management platform for the protection and promotion of immovable cultural heritage work to provide reference. Currently has built a comprehensive information system for the Loulan site, the Shanxi Digital Great Wall Information System and the Bazhong Cave Temple cultural relics data management and monitoring and early warning system.

POSTER PRESENTATIONS

Coffee Break / Poster Session A, July 12, 2023, 3:30 PM - 4:30 PM

P01. Urban Mapping in Coastal Regions of South Aegean Volcanic Arc Islands using Earth Observation data

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Coastal environments are known both for their stunning morphological characteristics and for the economic opportunities they provide, including the fishing and tourism industries. However, the South Aegean Volcanic Arc (SAVA) islands are at an ever-increasing risk due to climate change, a growth in tourism, and persistent coastal urban sprawl in some areas, necessitating careful planning and decision-making. Moreover, the use of Geospatial Intelligence (GEOINT) was based on the combination of Earth Observation (EO) images and geospatial information, in order to identify vulnerable areas and predict urbanization rates. Specifically, this work focuses on urban mapping using a machine learning algorithm, semi-automatic satellite-derived bathymetry (SDB), and the delineation of coastal zone boundaries in Thira (Santorini island complex) and Milos islands. Additionally, this work aims to identify inaccuracies in existing open-source datasets, such as the European Settlement Map (ESM), which is related in the unique combination of the architectural style and bare-soil characteristics of Cyclades islands. The results illustrated that the average urbanization expansion during the time period 2016–2021 in specific areas was higher than 22% in both islands. Thus, the findings of this research could help in the holistic management of similar coastal regions in the context of climate change adaptation, mitigation approaches, and multi-hazard risk assessment.

P02. Web GIS applications of Kefalonia - Ithaca UNESCO Geopark and National Park of Mt. Ainos

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Story Maps are a widespread effective tool for creatively presenting maps in the context of narrative text, images, videos, 3D representations, embedded items, and other multimedia content. The compelling interactive content is published in a web-based application in order to communicate information and disseminate scientific data to a broad non-technical audience. In this work, a storytelling methodology was implemented, integrating ESRI Web-GIS platform online (Cole, 2017), for the purpose of presenting and visualizing “Ainos National Park” and “Kefalonia and Ithaca UNESCO Global Geopark” funded by the Operational Programme of Ionian Islands 2014-2020 and co-funded by Greece and the EU). Spatial, geological, ecological and physical data were incorporated into two individual web-based platforms together with thematic webmaps concerning the protected areas of Kefalonia and Ithaka, the trails, the land cover of Mt. Ainos National Park and the unique geosites and georoutes of the Geopark as well. The scope of these applications is to introduce Kefalonia and Ithaka physical and geological environment to scientists, tourists and a wide audience in a way that the users of the platform could interact with the content and get information in a friendly manner.

P03. Web INTEractive management tool for coal Regions in transition

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Scheduled decommissioning of coal mining in Europe requires innovative management strategies to support coal regions in transition. WINTER is an Accompanying measure project initiated in 2022 and funded from the Research Fund for Coal and Steel (RFCS) aiming to develop a web interactive platform for the management of coal regions in transition to provide guidance and facilitate stakeholder engagement. It will examine 3 EU countries (Germany, Greece and Poland) which are still in the beginning of the transition process or have accomplished the transition in the past years and have gained experience in the socioeconomic, institutional and management dimensions. The best practices will be identified by exchanging information and knowledge regarding the main transition challenges (environmental and socioeconomic) in each region (Western Macedonia, Ruhr area and Konin region). WINTER will go beyond the state of the art as the developed guidance (best practices, legislation and post-mining land use scenarios) will be integrated and visualised into a user-friendly interactive platform in order to be used by the relevant stakeholders. The spatiotemporal evolution of coal mine areas from 2018 to 2022 will be analysed in order to highlight the land use changes as well as the main post-mining land use scenarios will be visualized for each area. This will be achieved with the innovative utilisation of machine learning based on Copernicus data in an effort to develop renewable energy source (RES), combined with the socioeconomic evolution in specific regions. Finally, a future goal of the interactive management tool is to be extended and adapted in other coal regions in transition facing similar challenges.

P04. Assessment of Wind Energy Resources and Micro-Siting Optimization in Complex Terrain Wind Farms

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Wind energy is a crucial renewable energy resource that plays a significant role in mitigating greenhouse gas emissions, alleviating energy crises, and promoting sustainable development. This study addresses the intuitive and empirical issues in the micro-siting process of wind farms by integrating multi-source data and investigating the wind energy distribution in a specific region in China, while also considering the wake effect model of wind turbines. By coupling the Large Eddy Simulation (LES) method with the Genetic Algorithm (GA), this research explores the key issues in optimal wind turbine siting and layout, establishing a comprehensive technical system for micro-siting in wind farms. Based on this, a wind energy resource assessment visualization system for wind farms has been developed to support decision-making in wind energy development and utilization. The main research contents are as follows:

(1) Wind energy resource assessment based on meteorological data: By configuring the WRF model and using collected meteorological data as boundary conditions for simulation, the analysis of the simulation results identifies specific locations with abundant wind energy resources.

(2) Micro-siting model research for wind farms: This study investigates the wake effect model of wind turbines and employs a Genetic Algorithm for the initial layout optimization of wind turbines. Finally, the LES method is used to simulate the power output of wind farms in complex terrains.

(3) Design and implementation of the wind energy resource assessment visualization system for wind farms: Based on the analysis, processing, and modeling related to wind energy resource assessment and wind turbine siting, a 3D wind farm visualization system based on Cesium has been developed by integrating the various functional modules. This system enables rapid visualization analysis of wind farm wind energy resources, providing highly reliable assessment and analysis results, effectively supporting decision-making for wind energy development in China.

P05. A high-quality big ocean data processing and product development system

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The ocean is an important part of the earth system, which is important for human survival and sustainable development. Therefore, high-quality ocean in situ profile observation data and gridding datasets are fundamental for ocean and climate researchers. To improve data quality and use efficiency, we have developed a high-quality data processing and product development process, which includes data collection and processing, data quality control, data lattice, L0 and L1 datasets development, etc. As a result, we have made three improvements compared to other marine data management and product development technologies.

Firstly, an intuitive ocean dark data management platform Easy Data-Management (EasyDM), was designed and developed to standardize data management and sharing. This system is mainly used to manage the scattered data in the hands of scientific researchers. EasyDM was jointly constructed and managed by the data owners and centers. In addition, the system was embedded with common marine survey data keywords and data record formats. Users can customize a data storage sheet dynamically by selecting the embedded keywords according to the topic data. After converting the original data to the selected data format, the system automatically establishes the database for data storage. The system contains built-in data and a user management system. The data and users are classified and set using different labels. Users can customize their data usage (e.g., public sharing, protocol sharing, personal use, etc.) and scope.

Secondly, we have developed a more advanced marine data quality control system (CODC-QC). Unlike many existing QC procedures, no assumption is made of a Gaussian distribution law as the oceanic variables (e.g., temperature and salinity) are typically skewed. Instead, the 0.5% and 99.5% quantiles are used as thresholds to define the local climatological ranges parameter ranges. The local climatological ranges for temperature and temperature gradient are calculated on 1-degree boxes at each standard level. However, except for some spatially homogeneous areas of the global ocean apart from the oceanic fronts, using a large influence bubble (Data statistics area) leads to the undesirable increase of the variable ranges because the data selection would include profiles from different water masses. Here, we developed a new selection algorithm that considers the anisotropy of the temperature distribution within the influence bubble. Furthermore, to cope with the impact of topographic barriers, we consider the distribution of the bottom barriers between the bubble center and selected profiles and retain only those profiles for which no topographic obstacle exists between the central bubble point.

Finally, we integrated the IAP-mapping technology developed by team members in the early stage to improve the quality of data products. IAP mapping is the ensemble optimal interpolation method with a dynamic ensemble (EnOI-DE). It has been widely used in the development of IAP data products. As a result, we have optimized the grid computing efficiency and accelerated the product development time through distributed computing technology.

The L0 dataset (a quality-controlled ocean temperature profile dataset, CODCv1) and L1 dataset (gridding dataset, IAP) have been rapidly released through this process. As a result, L0 and L1 products are publicly shared and widely used in global climate change research.

P06. A cross-case analysis of spatiotemporal variations in surface temperatures of three different urban areas in Greece, using time-series Remotely Sensed data

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Global climate destabilization as a result of increased urbanization is one of today's most urgent issues. United Nations report that in Europe approximately 73% of its population lives in cities, and by 2050 it will reach 82%. (United Nations, 2018). To facilitate this understanding and comprehend the impact of this urban growth on climate change, it is essential to accurately detect and estimate the urban area development and its patterns, alongside with microclimate parameters such as Land Surface Temperature (LST). The extraction of LST and the spatio-temporal analysis of urban development with Remote Sensing techniques can effectively contribute to this effort. This study uses a vegetation index-based technique for extracting LST from Landsat 8 satellite imagery in three selected areas in Greece with different physical and urban dynamics: one coastal area in the Northern part of Greece, one urban area in the mainland and one small city in the South of Greece. Computation of Normalised Difference Indices such as Normalised Vegetation Index (NDVI) and Normalised Water Index (NDWI) is also performed for the examined areas, over a five-year period. Finally, a cross-case comparative analysis is performed aiming to identify significant common and diverse characteristics and spatial patterns of spatiotemporal variations of LST in these three different geographical regions of Greece.

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P07. WMO: A Useful Ontology for the Semantic Enrichment of Wetland Monitoring Data

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Rich observation data generated by ubiquitous sensors are vital for wetland monitoring, spanning from the prediction of natural disasters to emergency response. Such sensors use different data acquisition and description methods and, if combined, could provide a comprehensive description of the wetland. Unfortunately, these data remain hidden in isolated silos, and their variety makes integration and interoperability a significant challenge. In this work, we develop a semantic model for wetland-monitoring data using an agile and modular approach, namely, wetland-monitoring ontology (WMO), which contains five modules: wetland ecosystem, monitoring indicator, monitoring context, geospatial context, and temporal context. The proposed ontology supports the semantic interoperability and integration of wetland-monitoring data from multiple sources, domains, modes, and spatiotemporal scales. We also provide two real-world use cases to validate the WMO and demonstrate the WMO's usability and reusability.

P08. Global monthly ocean dissolved oxygen concentration datasets based on BGC-Argo

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Ocean dissolved oxygen plays a significant role on biogeochemical cycle, and on ocean health evaluation as well. Also, the ocean deoxygenation is known to all, however, due to the lack of data, the status of global ocean dissolved oxygen is still unclear. World Ocean Atlas 2018 (WOA18), one known ocean dissolved oxygen of the public spatial datasets, which is based on several kinds of survey data, and has a climatology monthly scale. The climatology monthly scale limits to depict the dynamic characteristics of ocean dissolved oxygen, especially on the global change conditions. Array for Real-time Geostrophic Oceanography (Argo) is a major component of the Global Ocean Observing System, and the BGC-Argo has provided more than 26 thousands of oxygen profiles date to Dec. 2022, and will continuously obtain 2 thousands of profiles each year. Although, these oxygen profiles provide a promising source to analyze the dynamic characteristics of ocean dissolved oxygen at global scale, as driven by ocean currents, these profiles irregularly distribute in space, and the amount of data in time is still scarce. Thus, we designed a reconstructed model based on the CatBoost algorithm to develop monthly ocean dissolved oxygen concentration datasets at global scale from BGC-Argo profiles. The reconstructed model studies the relationships between the dissolved oxygen with temperature and salinity using the Argo floats simultaneously equipped with dissolved oxygen, temperature and salinity profiles during the period of Jan. 2010 to Dec. 2022, and then reconstructs the oxygen profiles based on Argo floats only equipped with temperature and salinity profiles during the period of Jan. 2005 to Dec. 2022. The original dissolved oxygen profiles and the reconstructed dissolved oxygen profiles were used to generated the dissolved oxygen datasets. The developed dissolved oxygen datasets cover the global ocean during the time period of Jan. 2005 to Dec. 2022 at depths in standard layer above 2000 dbar, with a spatial resolution of 2 degree, and a time resolution of month. These developed ocean dissolved oxygen datasets may improve the application capabilities of Argo data, also will promote the realization of the 'Global Ocean Oxygen Decade" proposed in the "The United Nations Decade of Ocean Science for Sustainable Development".

P09. Integrate self-supervised learning and self-training to improve the domain adaptation for high-resolution remote sensing semantic segmentation

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The advancement of deep learning has brought great progress on the semantic segmentation task on high-resolution remote sensing images, changing the workflow and improving the performance. However, when the data to be processed has a big domain gap with the training data, deep learning performance is hard to guarantee and usually has a drop. For example, when the new task's data encounter the following situation: different geographical landscapes, different atmospheric conditions, or different ground sampling distances, it might cause changes in the data distribution and the deep neural network produces poor prediction results. The idea of labeling data for each new task is unrealistic due to the high cost of large-scale pixel-level annotations. Therefore, unsupervised domain adaptation(UDA) for remote sensing data has gained widespread attention for its effectiveness to alleviate performance degradation. In UDA, there are two key factors. The first one is how to extract the domain-invariant features working well on both the source domain and target domain, and the second is how to weaken the tendency of the source domain for the scarcity of target domain annotations. Generative adversarial network(GAN) is adopted in UDA by many researchers because the discriminator can be made to focus on the domain-invariant features during the process of adversarial learning. But the GAN approach suffers from an unstable training process and extra memory usage. Hence, a method integrated of self-supervised learning(SSL) and self-training is proposed based on the above factors in this paper, and here are four contributions: (1) Domain-invariant features are obtained with SSL. Compared to the adversarial loss, SSL-based features can not only minimize the inter-domain discrepancy but also be able to explore the intra-domain knowledge, helping downstream tasks like semantic segmentation. (2) The self-training is utilized with the exponential moving average(EMA) teacher network and a rare class sampling method. Reducing the prediction loss on the pseudo labels will improve the consistency of the network on the target domain dataset. (3) A multi-scale context fusion module is designed and inserted to modify the Swin-UNet.
The experiment results show that by combing the module, the UDA performance is enhanced. Besides, supplementary experiments with different network architectures are conducted, and a phenomenon can be observed that a good network with low prediction error on the source domain always produces good results even if no UDA method is used. (4) A training strategy with feeding both the scene (the downscaled image containing the large geographic range) and the patch of the high-resolution remote sensing image to the network is employed to help the network learn the long-range context information as well as the details since the remote sensing image is with relatively complex scene content. The method we propose achieves the SOTA results on the public dataset. In addition, some visualization results are presented to prove how the above-mentioned approaches improve the discrimination of the features and align the features with the target domain.

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P10. Land Surface Temperature Retrieval from Daytime Gaofen-5 Single-Channel Mid-Infrared Remote Sensing Data

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Land surface temperature (LST) is a key parameter affecting the exchange of energy between the land surface and the atmosphere [1] and has attracted extensive attention in various fields. Thermal infrared remote sensing is an important technique for the efficient acquisition of LST over a wide area but suffers from deficiencies such as the signal saturation of high-temperature (>70℃) targets, high influence by atmospheric water vapor, and sensitivity to emissivity noise. The mid-infrared (MIR) channel is located in the peak radiance wavelength range (3-5μm) of 500-1000℃ targets and has the advantages of greater atmospheric transmittance and more robust to emissivity errors, which has the potential to improve the performance of LST remote sensing retrieval. Since daytime MIR data include both solar and atmospheric radiance components that are difficult to separate, there are few methods for LST retrieval using daytime MIR data, including Day/Night algorithm [2], split-window algorithm [3, 4], and kernel-based algorithm [5]. However, the existing methods require at least more than 2 MIR channels, the Day/Night algorithm also relies on the continuous day and night observations with constant emissivity during the interval, and the kernel-based method needs multi-angle data to estimate the emissivity, and the data requirements for multi-channel, short revisit periods, and multi-angle observations limit the applicability of the methods. In this paper, a practical LST retrieval algorithm using only a single MIR channel daytime data was proposed. The solar and atmospheric radiance components in the MIR channel were eliminated using reanalysis data [6] and atmospheric radiative transfer models, while the emissivity is estimated by a look-up table based on the land cover type [7], and the daytime LST is solved by inverting the radiance transfer equation. Compared with the traditional methods, the proposed method can be applied to high-resolution remote sensing data with a long revisit period, for example, Chinese Gaofen-5 (GF5) MIR remote sensing image with 40m spatial resolution and revisit period longer than 20 days [8], and its LST retrieval cannot be directly performed due to the difficulty of forming multi-angle and multi-temporal image pairs in a short period of time, which improves the utilization level of MIR remote sensing data. The proposed algorithm was applied to the GF5 MIR data of multiple regions, covering a variety of land surface types such as grassland, cropland, and desert. The accuracy verification results using the ground measurement data show that the RMSE of the LST is less than 2.5K, and the retrieval results have similar spatial distribution with the split-window algorithm based on the TIR channel, which proves the effectiveness of the proposed method.

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P11. Mapping Aquaculture Areas with Sentinel-2 Time Series on Google Earth Engine based on Ensemble Learning: A Case Study of Fujian Province, China

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Aquaculture is an important source of food and livelihood for hundreds of millions of people around the world and contributes to the “zero hunger” and “no poverty” goals directly related to the Sustainable Development Goals (SDGs). Spatial distribution information is crucial for monitoring and managing aquaculture properties and further improving the sustainability of the aquaculture industry, which illuminates the necessity of mapping the areas of landside clustering aquaculture ponds. Previous studies tended to extract the spatial information of aquaculture ponds by knowledge-driven methods, such as visual interpretation, threshold segmentation, or morphological processing. Those methods require complicated parameter setting, which challenges the professional qualifications of the users. In the era of big data, data-driven methods such as machine learning have become indispensable tools for knowledge discovery, as the volume of data continues to explode in practically every research domain. However, studies that use machine learning methods to identify aquaculture areas remain limited. In this study, we proposed an ensemble learning method for identifying and mapping aquaculture areas from Remote sensing time series data and achieved this method on Google Earth Engine (GEE). Ensemble learning algorithm stacking is considered to be an excellent model fusion algorithm, which can integrate machine learning models with excellent performance to better understand variable features and improve the integrated model’s generalization capacity. Firstly, we selected and extracted the spectral, textural, and spatial features related to aquaculture ponds. The Normalized Difference Water Index (NDWI) and the Normalized Difference Vegetation Index (NDVI) were extracted from Sentinel-2 time series data and served as spectral features. We then implemented the Grey-Level Co-occurrence Matrix (GLCM) method on the NDWI data and extracted the Angular Second Moment (ASM), Entropy (ENT), and Inverse Differential Moment (IDM) as textural features. The spatial features, including elevation and slope, were extracted from the Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) dataset. This characteristic space represented a comprehensive reflectance of aquaculture information and served as the input data of the ensemble learning model. Second, we integrated gradient boosting decision tree (GBDT), random forest (RF), and support vector machine (SVM) through ensemble learning algorithm stacking to construct a novel aquaculture identification model. The proposed model was trained and optimized using input features from the ground-truth training dataset. Third, an ensemble learning model with optimal parameters was generated to identify aquaculture and non-aquaculture areas. We finally tested the classification accuracy of the proposed method in Fujian Province, China. The results showed that our model had better performance than individual models. The proposed method provides an available solution for mapping aquaculture areas over a large region and shows high spatiotemporal transferability and potential with support from GEE.

P12. Mixed reality: Game design based on Digital Earth technology

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As a crucial technology of Digital earth, virtual reality means a virtual space based on some real geographic information, therefore appears a compound of virtual and reality. In some degree, virtual reality is also the essence of computer game, therefore digital earth and computer game share the same characteristic from this point of view.

According to the present situation, Digital Earth takes part in computer game in different ways. In traditional computer game just like the Assassin's Creed series and Watch Dog series, they choose some real historical architectures and build models of them, such as Notre Dame de Paris in 'Revolution', Athen Acropolis in 'Odyssey', and the Great Sphinx in 'Origins'. These realistic space lets the player leap into history, shuttling between virtual and reality. Compare with the Assassin's Creed, Watch Dog series choose some distinctive cities just as Chicago, San Francisco to create realistic space, whether architectures or cities, the aim is to give the player better game experience.

But in augmented reality game, real environment directly become a part of the game, like Pokémon Go. This game integrates the real environment with virtual character seamlessly, showing strong interactive sensation.

In future, to take advantage of Digital Earth technology better, mixed reality could be a possible approach. From the aesthetic point, mixed reality means more fantastic and more interesting. It can combine some different architectural styles, to make a brand-new visual style, and create a more fantastic space. It is a new city but the player would have feeling of familiarity, they can recognize some features but contain the feeling of freshness.

From the technological point, mixed reality means deep interaction and immersion. Player may confuse the virtual and the reality. They enter into a real game world, just like the beginning of the game history.

P13. A Deep Learning Model for Hurricane Wind speed and Rainfall information retrieval from SAR Imagery

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It is well known that hurricanes are natural hazards that can cause significant societal impacts and severe economic losses yearly. The landfall of hurricanes is generally accompanied by strong winds and large-scale persistent rainfall, severely impacting residents' production life. Therefore, it is necessary to conduct effective hurricane landfall intensity forecasts for disaster risk reduction. Getting accurate surface wind speed and rainfall estimation, especially at high-wind and coastal conditions, is crucial for hurricane intensity forecast accuracy. Satellite remote sensing was widely applied to monitor global hurricane activity. Space-borne synthetic aperture radar (SAR) images were used to estimate hurricane winds and rainfall based on deep learning technology in this present study.

Deep learning technology has been continuously demonstrated to be applicable for retrieving marine elements from satellite remote sensing imagery. It has significant superiority over traditional physical or statistical algorithms based on its fast computational speed and great nonlinear curve-fitting capability. and that makes it a high requirement for the model training datasets. To build the deep-learning model for Hurricane wind speed and rain rate retrieval, we collected 39 Sentinel-1 SAR images acquired under hurricane conditions from 2016 to 2021. These SAR images are all level-1 Ground Range Detected data acquired at interferometric-wide (IW) mode and extra-wide (EW) mode with VV/VH polarization. Meanwhile, the co-located airborne Stepped Frequency Microwave Radiometer (SFMR) observations, which can provide simultaneous wind speed and rain rate measurements, were also collected as the truth data. Finally, we got 26,862 matchup samples extracted from 39 Sentinel-1 satellite images. Among this, 23,937 samples as the training dataset, and the remaining 2925 samples as the test dataset.

Hurricanes have unique morphological characteristics near the eye region, with the strongest wind speed and rain rate outside the hurricane eye. For this reason, we can clearly see hurricane footprints from synthetic aperture radar (SAR) images. Based on the principles of imaging SAR and characteristics of hurricane SAR image, we make full use of the three types of hurricane information obtained from SAR images to improve further the retrieval accuracy of sea surface winds and rain rates: (1) routine physical information based on the radar incidence angle at the surface and the radar signature in the storm, (2) texture information based on the pattern of similar pixels in an image, and (3) morphological information based on the distance from the Center of the hurricane. A deep convolutional neural networks model incorporating this information was proposed.

Then, we used the proposed model to test the remaining SAR images. As a result, introducing texture and morphological information to routine physical information significantly impacts the improvement of hurricane wind and rainfall estimation accuracy. The model-predicted hurricane wind speed and rain rate show good accuracy, with a root mean square error (RMSE) of 3.52 m/s and 4.35 mm/hr on the test dataset. The correlation coefficient were 0.92 and 0.85 compared with the SFMR wind and rainfall field.

In addition, as SAR images can image the two-dimensional ocean surface with high spatial resolution, the retrieved SAR wind and rainfall field can be widely used in morphology studies, as the intense transient vorticity features and strong wind gradient can be observed near the inside edge of the hurricane eyewall from SAR images. Moreover, the proposed model can also be used to exhibit a hurricane surface structure and dynamically forecast its evolution. As is known, there is a strong correlation between the structure of hurricanes and their intensity. Close tracking of hurricane structures can help substantially reduce economic losses and human casualties due to natural calamities and contribute to the earth’s sustainable development.

P14. Potentials, limitations, and influencing factors of UAV-based soil moisture mapping for precision agriculture

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Remote sensing-based retrieval of soil moisture is a common procedure in many fields but the spatial scale of these analyses is barely suitable for precision agriculture purposes. Recent advances in the application of Uncrewed Aerial Systems (UAS) led to the development of several examples of successful soil moisture (SM) mapping. We have already provided an effective workflow through the combination of thermal infrared and multispectral UAS imagery and machine learning algorithms to assess soil moisture content even in a ploughland having low heterogeneity (Bertalan et al. 2022). However, there are still several components that can limit the reliability of possible outputs. Our aim was to (i) highlight the main factors biasing or even impeding the UAS-based aerial SM-mapping, and (ii) introduce a sensitivity analysis of these factors from the perspective of soil moisture mapping accuracies.

Field circumstances are different by surveys, and provide advantageous or disadvantageous conditions for data collection: meteorological parameters (wind speed > 30 km/h, rain, high temperature, and insufficient light) and soil parameters (impervious wetness status), thus, both the survey and the reference soil data collection can be impossible. While only these factors are enough to cancel the flights due to safety reasons, poor light conditions (e.g. due to extensive cloud cover and/or sunset) do not impede the survey but the optical images will be of low quality with a high signal-to-noise ratio.

The technical parameters within the radiometric data processing could also strongly affect SM retrieval. In our case, the Pix4Dmapper software provides the possibility to calculate absolute reflectance values within the multispectral bands through three main calibration methods. These values could vary in case we apply the camera data only, or using either the sun irradiance sensor of the multispectral camera, or even combine them with the IMU data of the downwelling light sensor.

Another issue could arise from the fact that UAV-based mosaics captured by visible, multispectral, and thermal-infrared (TIR) sensors are usually generated with different ground sampling distances (GSD). A reasonable combination of these data for estimating soil moisture through machine learning algorithms would require input data having a unified GSD. In most cases, TIR imagery has the lowest GSD, therefore visible and multispectral data should be downsampled. However, within the above-mentioned aerial mapping software seven different downsampling algorithms exist, thus, an improperly selected downsampling method could result in data bias.

The relatively low GSD can generally decrease the efficiency of the input image alignment for the Structure-from-Motion algorithms due to the relatively high homogeneity of the bare soil surface of agricultural plots. Image structure could be increased by lower flight altitudes but that could exponentially extend the image acquisition time. TIR sensors are also limiting the surveyed area since the increase in flight altitude and in parallel, the decrease in image quality could affect the identification of ground control points that are used for the exterior orientation of the imagery within the aerial mapping workflow. Uncooled VOx microbolometer-type TIR cameras could be also affected by the overheating of the sensor itself during extensive image acquisition sessions in high air temperatures, which could even lead to missing out on image expositions.

Our poster presentation is summarizing the interdependence and sensitivity analysis outcomes of the above-mentioned environmental and technical aspects of UAS-based soil moisture mapping.

Reference:

Bertalan, L., Holb, I., Pataki, A., Négyesi, G., Szabó, G., Kupásné Szalóki, A., Szabó, S. (2022). UAV-based multispectral and thermal cameras to predict soil water content – A machine learning approach. Computers & Electronics in Agriculture 200, 107262.

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P15. Deep Learning Strategies for Mapping desert-fringe Mediterranean Vegetation Patterns

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Pre-trained and Newly trained strategies are implemented based on Dense-net Architecture for classifying high-resolution images of complex vegetation patterns. The development of an extensive database of orthophoto images representing different vegetation and soil pattern categories of ecosystems evolved at the desert margins of the south-eastern Mediterranean basin was instrumental for training and testing Deep Learning startegies for mapping and monitoring these environments' under current climate change and urbanization pressures. The Pre-Trained model utilizing IMAGE NET for the transfer learning performed better than the newly trained DL method. Yet, with the fast convergence of the Newly-Trained model and its adaptation to the specific ecological pattern recognition task it might be preferred in this application field.

P16. Quantifying the impacts of the Covid-19 pandemic lockdown and the Russian invasion on Sentinel 5P column NO2 variability in Ukraine

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In this work, we give a complementary assessment of satellite-derived column NO2 variability induced by the COVID-19 pandemic lockdown and the Russian invasion in Ukraine from the Tropospheric Monitoring Instrument (TROPOMI) instrument on board the Sentinel-5P. We acknowledged the impact of meteorological effects on air pollution variabilities which have not been considered in the previous studies in Ukraine. First, we have developed a weather normalization using machine learning techniques under the business-as-usual (BAU) conditions based on the meteorological features from ERA5-Land hourly dataset, the ensembled surface NO2 from Copernicus Atmosphere Monitoring Service (CAMS) incorporating other spatial and temporal features. We demonstrate how the change in weather parameters could importantly influence the column NO2 concentrations which are needed to be accounted for, in order to obtain reliable estimates. By decoupling the weather effects, we found that since the mid-lockdown era, the NO2 pollution levels show a consistent reduction on an average of -15% in the cities with at least 0.3 million inhabitants. In the first month of the war from February 24th, 2022, the overall reduction is observed in most major urban areas with an average of -10.84%. The invasion has caused a huge ongoing refugee which result in an increase in NO2 concentration levels in the western border cities for one week since February 24th. Within the 5 months of the war, most of the cities that are under attack have observed a low reduction in NO2 pollution levels with an average of -11.9% to -3.3%.

P17. Intraseasonal sea ice concentration variability over the Weddell Sea during austral autumn

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The sea ice concentration (SIC) over the Weddell Sea displays obvious intraseasonal variability during austral autumn with a dominant frequency of 5 to 20 days. The intraseasonal SIC variability is manifested as development of sea ice anomalies from the northeastern Antarctic Peninsula toward the central Weddell Sea. Rossby wave train associated with the internal atmospheric variability featuring circumglobal zonal wavenumber 4 pattern induces the development of anomalous surface winds and sea ice drifting, leading to the SIC anomalies directly. The thermodynamical processes associated with the intraseasonal SIC variability include the air temperature, the moisturizing of the lower troposphere, the latent and sensible heating, and the downwelling longwave radiation, which contribute to the variation of the local greenhouse effect over the Weddell Sea, and thus lead to the sea ice variation. The investigation of the intraseasonal SIC variability helps the understanding of sea-ice-atmosphere interaction over the Antarctic region.

P18. Automated Estimation of Railway Ballast Volumes from LiDAR Data

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The ballast layer plays a key role in railroad maintenance and the geometry of the track structure. Ballast also holds the track in place as the trains roll over it. Track ballast is packed between the sleepers and on the sides of railway tracks.
An imbalance in ballast volume on the tracks can lead to safety issues as well as a quick degradation of the overall quality of the railway segment. If there is a lack of ballast in the track bed during the summer, there is a risk that the rails will expand and buckle slightly due to the high temperatures. Furthermore, the knowledge of the ballast quantities that will be excavated during renewal works is important for efficient ballast management. The volume of excavated ballast per meter of track can be calculated based on excavation depth, excavation width, volume of track skeleton (sleeper and rail) and sleeper spacing.
Since 2012, SNCF has been collecting 3D points cloud data covering its entire railway network by using 3D laser scanning technology (LiDAR). This vast amount of data represents a modelization of the entire railway infrastructure, allowing to conduct various simulations for maintenance purposes. This paper aims to present an automated method for ballast volume estimation based on the processing of LiDAR data.
The estimation of abnormal volumes in ballast on the tracks is performed by analyzing the cross-section of the track. Further, since the amount of ballast required varies depending on the track configuration, the knowledge of the ballast profile is required. Prior to track rehabilitation, excess ballast is often present in the ballast shoulders. Based on 3D laser scans, a Digital Terrain Model (DTM) was generated and automatic extraction of the ballast profiles from this data is carried out. The surplus in ballast is then estimated by performing a comparison between this ballast profile obtained empirically, and a geometric modelization of the theoretical ballast profile thresholds as dictated by maintenance standards. Ideally, this excess should be removed prior to renewal works and recycled to optimize the output of the ballast renewal machine.
Based on these parameters, an application has been developed to allow the automatic measurement of ballast profiles. We evaluated the method on a 108 kilometers segment of railroad LiDAR scans, and the results show that the proposed algorithm detects ballast surplus that amounts to values close to the total quantities of spoil ballast excavated.

P19. Geo-Intelligent retrieval framework based on machine learning in the cloud environment: A case study of soil moisture retrieval

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Soil moisture is one of the important parameters in Earth system models. In recent years, the retrieval based on machine learning and data fusion of multi-source satellite observation data has become one of the effective methods to obtain soil moisture information at a large scale. However, most retrieval studies need to download remote sensing original data first, then preprocess, train the retrieval models, and finally generate products in the offline environment. In order to meet the requirements of long temporal series of large-scale area retrieval, and with the widespread use of machine learning in retrieval studies, the amount of remote sensing data and necessary computing resources are gradually increasing. Moreover, studies usually use a single machine learning retrieval model for the entire study area, which lacks the consideration of geographical differences and spatial heterogeneity of soil moisture. Therefore, we established a geo-intelligent soil moisture retrieval framework completely based on the cloud environment (composed of GEE, Colab, and Google Drive). In this study, a variety of machine learning algorithms were used to fuse multi-source observation data mainly including MODIS data and other auxiliary data, and the Continental United States (CONUS) was taken as the experimental area to generate soil moisture data with a resolution of 500m. In addition, this study combines geographical correlation with machine learning models to cope with the spatial heterogeneity of surface soil moisture. Overall, on the basis of site-based validation, the retrieval model trained under the framework performed well, with estimation accuracy of 0.7163 and 0.0383 m3·m-3 in terms of coefficient of determination (R^2) and unbiased root mean square error (ubRMSE). The establishment of the cloud retrieval framework provides convenience for the whole retrieval process and also provides a new idea for other retrieval studies of geological parameters.

P20. Simulating the future through observations of the past: Concretizing the role of Geosimulation in the Geoinformatics discipline

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Geoinformatics can be defined both as a scientific discipline concerned with the handling of spatial data and as a tool for location-based decision making which can be applied for environmental management. As a scientific discipline, current definitions exclude the relatively recent subdiscipline of Geosimulation and only encompass the subdisciplines of remote sensing, cartography, and spatial analysis. As a tool for decision making, specified methods range only from the acquisition of spatial data to its analysis. To enhance the methodological repertoire of Geoinformatics, its core fields and objectives need to be redefined. We write this position paper with two main objectives. First, we argue the necessity to redefine Geoinformatics as a discipline to include Geosimulation as one of its subdisciplines. By doing so, a general framework for Geoinformatics can be established that positions the subdisciplines of Geoinformatics along the methodological timeline of observation, processing, analysis, and simulation. This proposed framework also brings forward our second objective which is to rebrand Geoinformatics as a tool that can be used for "simulating the future through observations of the past". To provide sample applications of utilizing Geoinformatics as this tool, we showcase three environmental management projects that utilized simulations of future scenarios of the environment to inform policy making. All of the environmental management projects followed a methodological framework of using remote sensing to acquire spatial data, using GIS to process and analyze the acquired spatial data, and using spatial modeling to simulate future scenarios. We anticipate two implications for concretizing the role of Geosimulation in Geoinformatics. First, this widens the environmental application of Geoinformatics from understanding just the past and current conditions of an environment to understanding also the possible future conditions. Second, the general framework establishes a common template for the construction of a research methodology which spans from observation to simulation. The proposed redefinition of Geoinformatics also promotes the enhancement of the collaboration between Geosimulation and the other subdisciplines of Geoinformatics. We conclude the paper by advocating that this new perspective in Geoinformatics will also bring value in strengthening the curriculum of Geoinformatics in schools.

P21. A Preliminary Study on the Relationship between Urbanization Indicators and Biodiversity Indicators: A Case Study in the Chubu Region of Japan

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The study aims to examine methods for quantitative assessment and management of biodiversity, and to clarify the relationship between human activities and biodiversity. Simultaneous solutions to problem complexes such as climate change countermeasures, biodiversity conservation, and disaster management are being sought. It has been pointed out that biodiversity conservation and its mainstreaming are lagging behind. To realize a biodiversity-friendly social economy, we must first understand the impact of human activities on biodiversity. It is commonly believed that urbanization decreases biodiversity, but in fact, it is known that many species are being replaced even within urbanized areas due to human modification of the landscape and rearrangement of nature. The use of remote sensing and geographic information systems (GIS) is indispensable to understand which areas have seen an increase in biodiversity in recent years and what factors have contributed to this increase. In this study, human activities are overviewed in terms of urbanization indices, biodiversity in terms of the number of vegetation species, and each index is created at a spatial resolution of a cubic mesh (approximately 1 km square), visualized in GIS, and the relationship between them is examined using the Chubu region of Japan as a case study. The results showed that biodiversity is particularly high in mountainous areas with Satoyama, which are expected to be utilized for biodiversity conservation. Satoyama is a traditional rural landscape between mountains and plains, where people have lived together with nature for many years in Japan. It was found that even in urbanized areas, there are places where biodiversity is higher than a certain trend. In addition, more areas with zero biodiversity were identified in areas with small populations and large industrial areas than in urbanized areas, indicating that the presence of people may have a positive impact on preventing biodiversity loss. This study is the first step in the use of remote sensing and geographic information systems (GIS) for future biodiversity assessment, conservation, and management. The results of this study can be used as a reference for quantitative evidence-based assessment methods, especially in the OECM for achieving 30 by 30 and in the Ministry of the Environment's original initiative in Japan to certify sites as nature-symbiosis sites. In the future, this research will be further deepened by conducting multidimensional, multiannual, and multiresolution studies so that the indicators can capture biodiversity with high regional characteristics and multiple layers and respond to uncertainties caused by climate change and other factors.

P22. Seabed Sediment Classification with Deep Dense Dilated Pyramid and Adaptive Graph Convolution Network

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Seabed sediment classification can provide basic data supporting for the exploration, development, and utilization of marine resources. The seabed sediment has the characteristics of large spatial size differences and strong distribution heterogeneity. In particular, multi-beam technology can not directly observe the geological characteristics of seafloor materials. Deep learning methods have made great progress in optical and radar remote sensing fields. However, there are few studies on multi-beam acoustic image processing. Based on the obtained backscatter intensity and bathymetric data, this study first constructed a semantic segmentation dataset of seabed sediment, including 5 types: seafloor sediment, gravel, sand, clay, and bedrock. Sample size is 128 pixels × 128 pixels and the whole dataset was divided into training, validation, and test sets with a ratio of 6:2:2. This study proposed a seabed sediment classification model based on a deep dense dilated pyramid and adaptive graph convolution network. 1) Depth dense dilated pyramid module: it can expand the receptive field through parallel sampling of dilated convolution at different depths and sampling rates. and then a channel shuffling attention was further used to fully mix the channels, in order to obtain multiscale fusion features with better representation capability for seafloor sediment features. 2) Adaptive graph convolution network module: a graph convolution network based on the above feature map and adaptive adjacency matrix was constructed to learn the global spatial context information of seabed sediment. Results show that the proposed model had a good performance and outerperformed all the other comparison algorithms. For example, compared to DeepLabV3, HRNet, and Swin-UNet, the OA metric has increased by 3.95%, 14.28%, and 15.14%, and mIOU by 8.05%, 29.26%, and 25.12%, respectively. In summary, the proposed model can effectively classify the seabed sediment.

P23. An Earth Observation Data Processing Pipeline for Vector Borne Diseases Modeling

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The repeated West Nile Virus (WNV) outbreaks in an increasing number of European countries during the past twelve years, highlight the growing risk of mosquito-borne diseases to the human population. The plethora of available monitoring data and the need for supportive tools for decision making gave rise to the development of an early warning system for WNV in Greece, which provides predictions for the mosquito populations and WNV cases for the upcoming period.
The system has a data processing pipeline that ingests and transforms large amounts of Earth Observation (EO) data. This data approximate the environmental, meteorological and geomorphological conditions in multiple regions at the time and place where in-situ mosquito collections are taking place, but also in the location where WNV cases have been registered with the health authorities.
This data processing module is comprised of two different Earth Observation data processing platforms (a CreoDIAS platform and the Google Earth platform) which are the repositories and sources of EO data, that work on upscaling and downscaling as needed to generate images of a common 500x500m resolution. The processed images for the supported regions are then ingested into a DataCube that stores them locally for fast access and provides a programmatic interface via a Python library which enables the generation of statistical features that represent the conditions on the ground for each mosquito collection and each registered WNV case.
In summary we believe that this EO data processing pipeline provides great benefits in the generation of relevant data used for statistical analysis and modeling purposes.
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P24. Analysing the relationship between land use and subsidence in the Randstad in the Netherlands

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Subsidence is a big problem in many coastal countries around the world, including the Netherlands. It causes damage to buildings and infrastructure and is likely to increase the flood risk in deltas all over the world. Costs associated with subsidence are estimated to be in the billions of dollars globally and are expected to keep increasing in the future. Subsidence in the Randstad in the Netherlands is mainly identified as anthropogenic subsidence and is caused by oxidation and compaction due to loading. One of the factors that plays an important role in anthropogenic subsidence is the way that the surface is used by humans, also known as land use. This research aims to identify how and to what extent subsidence is linked to land use in the Randstad area in the Netherlands.
To achieve the research goals, we used an InSAR-derived dataset for land subsidence, which was provided by the Dutch Centre for Geodesy and Geo-information. For land use, a dataset developed by Wageningen University & Research was used. Firstly, in order to analyse if subsidence in each of the land use classes differed significantly, a Welch test and Games-Howell post-hoc test were employed. Secondly, a method developed by Minderhoud et al. (2018) was used, in which subsidence rates were predicted based on land use classes in a subset of the data. The predicted subsidence values were then compared to the measured subsidence based on the associated land use class, using a linear regression model. This indicated to which extent the calculated subsidence values per land use class were able to predict the measured subsidence values in the validation subset of the data. A clear but weak link was found between land use and subsidence in the research area. Unexpectedly, higher subsidence rates were mainly found around natural areas and agriculture, as opposed to open and dense land use classes. The strongest link was found between infrastructure and subsidence.
Due to limitations of the input data, only tentative conclusions could be drawn based on this analysis. The unequal spatial distribution of the InSAR-derived subsidence data likely influenced the results of the Welch test for land use classes with low amounts of measurements. Further research is therefore required in order to confirm the relationships of these land use classes with low amounts of measurements and subsidence. This research confirms a weak but significant relationship between land use and subsidence in the Randstad area in The Netherlands. It is the first step towards identifying the structures that cause subsidence and informing policy decisions about how to prevent subsidence in the Randstad area.

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P25. Correcting precipitation measurements at high altitudes using remote sensing data and in-situ meteorological observations

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Long-term under-catch of precipitation measurements has been reported in many studies, but most of these studies did not involve the high-altitude regions because of the scarcity of observation. Aiming for a more transferability and robust correction method for the precipitation measurements, we used a machine-learning-based regression method (XGBoost) to correct the under-catch of precipitation measurements by merging the in-situ meteorological data and remote sensing precipitation products. Our results suggest that the machine learning method outperformed the traditional statistical method in almost all cases. Introducing remote sensing data, especially the GSMaP precipitation, could replace part of the role of in-situ wind speed on precipitation correction, indicating a wide applicability chance of using remote sensing data rather than in-situ meteorological observation to correct the precipitation. Our results also indicate that the machine learning method with remote sensing data had better transferability than the traditional statistical method when we cross-validated the method in sites located in different countries.

P26. National-Scale Mapping of the landside clustering of aquaculture ponds from Sentinel-1 and Sentinel-2 Time Series on Google Earth Engine

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Aquaculture is a crucial part of the food production sector and plays an important role in bridging the gap between the supply of and demand for aquatic food in most parts of the world, especially in developing Asian countries. Spatial distribution information is crucial for monitoring and managing aquaculture properties and further improving the sustainability of the aquaculture industry, which illuminates the necessity of mapping aquaculture ponds on a regional, national, or global level. Previous studies tended to identify aquaculture ponds based on their geometric or spectral features, where misclassifications could be easily found from non-aquaculture water bodies with similar characteristics. Considering that aquaculture ponds are usually spatially clustered, their spatial locations and relationships provide potential chances to further distinguish aquaculture ponds from other water bodies. However, studies that used the spatial features of aquaculture ponds to achieve accurate identification are still lacking. In this study, we proposed a method for mapping the landside clustering of aquaculture ponds from Sentinel-1 and Sentinel-2 Time Series and achieved it on Google Earth Engine (GEE). We combined Sentinel-1 and Sentinel-2 time-series images to calculate water indices and applies a threshold segmentation method to extract water bodies. Based on the geometric characteristics of the extracted water bodies, a decision tree model is used to extract aquaculture areas. In particular, we further improved the classification results considering that aquaculture ponds have a spatial clustering characteristic. Based on the differences in spatial clustering characteristics between aquaculture ponds and other water bodies, this study proposes a post-processing method named “erosion-dilation” for water body classification. If a certain area exhibits a higher distribution density of aquaculture areas, the probability of water bodies within that area being aquaculture ponds is higher; conversely, if a water body is isolated, the probability of it being an aquaculture pond is lower. We selected Sri Lanka as the study area and achieved national-scale mapping based on the proposed method. The results show that the total area of Sri Lankan aquaculture areas is 32.83 square kilometers, and the overall classification accuracy of the identification results is 92.50%, with a Kappa coefficient of 0.85. The proposed method performs well in a large-scale complex environment, significantly improving the accuracy of remote sensing identification of aquaculture ponds and providing technical support for intelligent monitoring and spatial optimization of aquaculture areas.

P27. Uncertainty-Aware Network for Building Extraction from High-Resolution Remote Sensing Images

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Building extraction aims to segment building pixels from remote sensing images, and plays an essential role in many applications, such as city planning and urban dynamic monitoring. Over the past few years, deep learning methods with encoder-decoder architectures have achieved remarkable performance due to their powerful feature representation capability. Nevertheless, due to the varying scales and styles of the buildings, general deep learning models often suffer from the uncertain prediction and cannot accurately distinguish the complete building footprints from the complex distribution of the ground objects, leading to a large extent of omission and commission. In this paper, we introduce the concept of uncertainty and propose a novel encoder-decoder network named Uncertainty-Aware Network (UANet) for building extraction. Specifically, after adopting the encoder to extract multi-level features, our proposed method firstly utilizes a Scene Capture Module (SCM) to improve the scene-aware capability of all-level features and adopts a Feature Pyramid Fusion strategy to obtain a relatively coarse extraction map. Secondly, based on the prior knowledge provided by the coarse extraction map, we propose a Prior Information Guide Module (PIGM) to realize the enhancement of high-level features from both spatial and semantic aspects. Finally, we propose an Uncertainty-Aware Fusion Module (UAFM) and innovatively invent an Uncertainty Rank Algorithm (URA) to facilitate level-by-level feature refinement and obtain the final refined extraction map with low uncertainty. To verify the performance of our proposed UANet, we conduct extensive experiments on three public building datasets, including the WHU building dataset, the Massachusetts building dataset, and the Inria aerial image dataset. The results demonstrate that the proposed UANet outperforms other state-of-the-art algorithms on the three datasets.

P28. Deep triplet networks based on multimodal data for high-resolution land use change detection

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Monitoring land use change using high-resolution remote sensing imagery has an important role to play. Existing automated change detection methods typically rely on comparing pairs of remotely sensed images. However, the radiometric differences between time phases result in paired images with significant false alarms. In addition, some subtle changes may be overlooked during image comparisons, leading to missed change detection results. In practical production, it is common to have already a historical classification base map with a historical remote sensing image. The changed areas can be extracted by comparing the historical classification map with the latest image.
To address the limitations of traditional change detection methods, we developed a new change detection approach MapChange, which aims to extract change areas and update the base map by comparing multimodal historical classification maps and paired images. By introducing the classification map of the previous time phase as a priori information, the effects of radiometric differences can be overcome, and obtain additional information to facilitate the identification of change locations.
A high-resolution multimodal data change detection dataset was constructed to evaluate our proposed approach, which comprises classification maps of the two temporal phases and extracts the change maps between them. A deep learning-based multimodal change detection network called Triplet Network was proposed, which processes the features of the images of the two temporal phases through an encoder with shared weights. The historical classification map of the previous temporal phase is also input into the Triplet Network to assist in localizing the change regions. By fusing features from different temporal phases of different modalities, regions where the latest image is inconsistent with the historical classification map are finally extracted. To achieve the classification of the second temporal phase, we introduced an auxiliary head for classification, which was eventually combined with the results of the binary change detection to update the historical map.
Our experimental results demonstrate that our proposed network outperforms existing methods based on image comparison in terms of accuracy, proving that introducing classification maps as a priori information can effectively enhance change detection.

P29. Variation of sea ice area in Peter the Great Bay, Sea of Japan from 2011-2020 based on GOCI images

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The Peter the Great Bay, situated in the Sea of Japan, is one of the southernmost regions in the Northern Hemisphere that undergoes seasonal sea ice coverage. The seawater freezes every winter, starting from December and persisting until the following April. Sea ice can pose a significant threat to the safety of ship navigation, and therefore, studying the ice conditions in the Peter the Great Bay can provide essential theoretical support for ensuring the safe operation of maritime transportation. This study utilized geostationary ocean color imager (GOCI) data that had a high proportion of cloud-free images during the period 2011-2020 to monitor the characteristics of the sea ice area in the Peter the Great Bay. After eliminating the cloud-obscured images, a total of 600 GOCI satellite images were used to extract the sea ice area using the Normalized Difference Water Index (NDWI) method. The results demonstrated that the sea ice in Peter the Great Bay exhibits notable inter-annual and seasonal variability. Analysis of sea ice area trends from 2011 to 2020 revealed a significant overall decrease, with a marked downward trend particularly notable between 2011/2012 and 2015/2016. Furthermore, examination of the seasonal variation of sea ice area in Peter the Great Bay indicated a unimodal pattern. In terms of spatial distribution, sea ice in Peter the Great Bay initially emerges in the northwestern coastal waters of Amur Bay and Posyet Bay. As temperatures decrease, sea ice gradually develops from coastal waters towards the central region of the bay, and floes tend to accumulate more on the eastern coast due to the influence of winter northwest winds. Regarding the spatiotemporal distribution of sea ice near important ports, the ice period is longest at Posyet Port, followed by Vladivostok Port.

P30. Image Variation Detection Based on Geometric Invariant Moments

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Image processing is a key step to data application for remote sensing images. But image variation such as scale variation, brightness variation, rotation and so on always affects the quality of image processing, which may have an adverse effect on the application even result a wrong decision. In addition, different methods of various image processing technology have their own applicable conditions, it also has positive significance to choose an appropriate method that estimate the image variation. Moreover, remote sensing image processing has a large amount of computation and automation is the trend of image processing, on which image variation detection can play an important role. Based on the above considerations, we hope to find a simple method to distinguish the scale variation, brightness variation and rotation of the images. Moments are used to characterize the geometric features of the image by using the concept of the moment in mechanics, and its result is only a number. So if using the geometric moments to distinguish the geometric features of the image, a simple and fast goal can be achieved. In this paper, each order moments are analyzed. As a result of different order moment having its own invariance to scale variation, brightness variation and rotation, it can be made a judgement on the type of image variation through the combination of different order moments. The experiments show that the combination of different moments could distinguish scale variation, brightness variation and rotation of the images simply and efficiently.

P31. Polar Sea Ice Monitoring Using HY-2B Satellite Scatterometer and Scanning Microwave Radiometer Measurements

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The Ku band microwave scatterometer (SCA) and scanning microwave radiometer (SMR) onboard HY-2B can simultaneously supply active and passive microwave observations over the polar region. In this study, using the active microwave scatterometer and passive microwave scanning radiometer observations of the HY-2B satellite, a monthly polar ice water discrimination model and Arctic sea ice type classification model based on the SVM method were established, and the sea ice extent products and sea ice type products from 2019 to 2021 were calculated. The results of this study were evaluated with OSISAF, MODIS, SAR and other multisource data. The classification distance and correlation coefficient were used to select the scattering parameters of SCA and the microwave radiation parameters of SMR suitable for ice water discrimination and sea ice type discrimination, which reduces the redundancy of the input data. At the same time, including SMR brightness temperature data can obtain better ice water discrimination results than SCA data alone. The sea ice extent results obtained by HY-2B products are between NSIDC 15% and NSIDC 30%, and the result of OSISAF is lower than those of the other three sea ice extents. The difference between HY-2B and NSIDC 15% is the smallest. The results of this study are evaluated by using the results of MODIS ice water recognition, and the overall accuracy is up to 96%. The results of Arctic MYI extent agree with the OSISAF products. Using the results of SAR sea ice type recognition to evaluate the same results of this study, the overall accuracy is better than 86%. The recognition method of FYI/MYI needs to be further studied to improve the stability and classification accuracy.