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Editorial

Preface: Earth Observations for Addressing Global Challenges

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As climate change has been of great concern worldwide for many years, addressing global climate challenges is the most significant task for humanity. Thus, the Group on Earth Observations (GEO) has launched initiatives across multiple societal benefit areas (agriculture, biodiversity, climate, disasters, ecosystems, energy, health, water, and weather), such as the Global Forest Observations Initiative, the GEO Carbon and greenhouse gas (GHG) Initiative, the GEO Biodiversity Observation Network, the GEO Blue Planet, and so on. Related topics have been addressed and deliberated throughout the world.

Remote sensing has become an indispensable tool for monitoring the environment. Recent advances in satellite remote sensor technology and retrieval algorithms have advanced climate studies, observations of land, oceans, and the atmosphere. The monograph "Earth Observations for Addressing Global Challenges" presents results of recent research concerning innovative techniques and approaches based on remote sensing data, the acquisition of Earth observations, and their applications in the contemporary practice of sustainable development.

There are two review papers in this monograph; both are related to the European H2020 Operational Network of Individual Observation Nodes (ONION) project. The aim of the paper by Lancheros et al. [1] is to identify the technological opportunity areas to complement the Copernicus space infrastructure in the horizon 2020–2030 for polar region monitoring, which is assessed through of comprehensive end-user need and data gap analysis. They reviewed the top ten use cases, identifying 20 measurements with gaps and 13 potential EO technologies to cover the gaps identified, and found that the top priority is the observation of polar region to support sustainable and safe commercial activities and the preservation of the environment.

The same authors further presented a review paper [2] for an optimal payload selection based on the ability to cover the observation needs of the Copernicus system in the time period 2020–2030. Payload selection is constrained by the variables that can be measured, the power consumption, weight of the instrument, and the required accuracy, and spatial resolution. They conclude that the most relevant payloads capable of filling the measurements gaps are: Global Navigation Satellite Systems (GNSS) -R at 10 km spatial resolution; X-band imaging Synthetic Aperture Radar (SAR) at 1 km spatial resolution; and multispectral optical instrument with bands in the visible (VIS) (10 m of spatial resolution), near infrared (NIR) (10 m), medium wavelength infrared (MWIR) (1 km), and thermal infrared (TIR) (1 km); and the high temporal resolution of one hour required can only be achieved if a sufficiently large number of space crafts are used.

For the climate change issue, snow albedo feedback is one of the most crucial feedback processes that control equilibrium climate sensitivity, which is a central parameter for better prediction of future climate change. Xiao et al. [3] used remote sensing data to quantify snow albedo radiative forcing and its feedback, and found that the strongest radiative forcing is located north of 30°N. They also demonstrated three improvements in the study, which were: determining the snow albedo with high spatial and temporal resolution satellite-based data; providing the accurate data for model parameterization; and effectively reducing the uncertainty of snow albedo feedback.

Thanh Hoan et al. [4] investigated the land surface thermal signatures among different land-use types in Hanoi. The surface urban heat island (SUHI) that characterizes the consequences of the UHI effect was also studied and quantified. The SUHI is newly defined as the magnitude of temperature differentials between any two land-use types (a more general way than that typically proposed in the literature), including urban and suburban. Relationships between main land-use types in terms of composition, percentage coverage, surface temperature, and SUHI in inner Hanoi in the recent two years 2016 and 2017 were examined. High correlations were found between the percentage coverage of the land-use types and the land surface temperature (LST). A regression model for estimating the intensity of SUHI from the Landsat 8 imagery was derived. It was demonstrated that the function of the vegetation to lower the LST in a hot environment is evident. Results suggest that the newly developed model provides an opportunity for urban planners and designers to develop measures for adjusting the LST, and for mitigating the consequent effects of UHIs by managing the land use composition and percentage coverage of the individual land-use type.

Urban landscapes also affect the formation of convective storms. Thus, the effect of urbanization on local convections and lightning has been studied very extensively. A long-term study has been carried out taking cloud-to-ground (CG) lightning data (1998–2012) from Tai-Power Company, and particulate matter (PM10), sulfur dioxide (SO_2) data (2003–2012) from the Environmental Protection Administration (EPA) of Taiwan, in order to investigate the influence of land use/land cover (LULC) change through urbanization on CG lightning activity over Taipei taking into account in situ data of population growth, land use change and mean surface temperature (1965–2010) by Kar and Liou [5]. It was observed that there was an increase of 60%–70% in the flash density over the urban areas compared to their surroundings. The spatial distribution of the CG lightning flashes follows closely the shape of the Taipei city heat island, thereby supporting the thermal hypothesis. The PM10 and SO_2 concentrations showed a positive linear correlation with the number of CG flashes, supporting the aerosol hypothesis. These results indicate that both hypotheses should be considered to explain the CG lightning enhancements over the urban areas. The results obtained are significant and interesting and have been explained from the thermodynamic point of view.

The 2015–16 El Niño event was one of the most intense and long-lasting events in the 21st century. The quantified changes in the trace gases (ozone (O3), carbon monoxide (CO) and water vapor (WV)) in the tropical upper troposphere and lower stratosphere (UTLS) region were delineated using Aura Microwave Limb Sounder (MLS) and Atmosphere Infrared Radio Sounder (AIRS) satellite observations from June to December 2015 by Ravindrababu et al. [6]. Prior to reaching its peak intensity of El Niño 2015–16, large anomalies in the trace gases (O_3 and CO) were detected in the tropical UTLS region. A strong decrease in the UTLS (at 100 and 82 hPa) ozone (~200 ppbv) in July-August 2015 was noticed over the entire equatorial region, followed by large enhancement in the CO (150 ppbv) from September to November 2015. The enhancement in the CO was more prevalent over the South East Asia (SEA) and Western Pacific (WP) regions where large anomalies of WV in the lower stratosphere were observed in December 2015. Dominant positive cold point tropopause temperature (CPT-T) anomalies (~5 K) are also noticed over the SEA and WP regions from the high-resolution Constellation Observing System for Meteorology, Ionosphere and Climate (COSMIC) Global Position System (GPS) Radio Occultation (RO) temperature profiles.

To improve the accuracy of classification with a small amount of training data, Kim et al. [7] developed a self-learning approach that defines class labels from sequential patterns using a series of past land-cover maps. In this approach, by stacking past land-cover maps, unique sequence rule information from sequential change patterns of land-covers is first generated, and a rule-based class label image is then prepared for a given time. After the most informative pixels with high uncertainty are selected from the initial classification, rule-based class labels are assigned to the selected pixels. These newly labeled pixels are added to training data, which then undergo an iterative classification process until a stopping criterion is reached. The classification of various crop types in Kansas, USA was performed utilizing Moderate Resolution Imaging Spectroradiometer (MODIS) normalized difference vegetation index (NDVI) data sets and cropland data layers (CDLs) from the past five years. From a practical viewpoint, using three or four CDLs was the best choice for this study area. Based on these experiment results, the presented approach could be applied effectively to areas with insufficient training data but access to past land-cover maps. However, further consideration should be given to select the optimal number of past land-cover maps and reduce the impact of errors of rule-based labels.

Leaf area index (LAI) is a key input for many land surface models, ecological models, and yield prediction models. In order to make the model simulation and/or prediction more reliable and applicable, it is crucial to know the characteristics and uncertainties of remotely sensed LAI products before they become inputs into models. In a study by Li et al. [8], a comparison of four global remotely sensed LAI products—Global Land Surface Satellite (GLASS), Global LAI Product of Beijing Normal University (GLOBALBNU), Global LAI Map of Chinese Academy of Sciences (GLOBMAP), and MODIS LAI, was conducted. Direct validation by comparing the four products to ground LAI observations both globally and over China demonstrated that GLASS LAI exhibits the best performance. Comparison of the four products shows that they are generally consistent with each other; large differences mainly occur in the southern regions of China. LAI difference analysis indicates that evergreen needleleaf forest (ENF) and woody savannas (SAV) biome types and temperate dry hot summer, temperate warm summer dry winter, and temperate hot summer no dry season climate types correspond to high standard deviation, while ENF and grassland (GRA) biome types and temperate warm summer dry winter and cold dry winter warm summer climate types are responsible for the large relative standard deviation of the four products.

The Inner Mongolia Autonomous Region (IMAR) is a major source of rivers, catchment areas, and ecological barriers in the northeast of China, related to the nation's ecological security and improvement of the ecological environment. A detailed study of the response of vegetation to different climatic factors has been conducted by He et al. [9] using the method of grey correlation analysis based on pixel, the temporal and spatial patterns; trends of enhanced vegetation index (EVI) were analyzed in the growing season in IMAR from 2000 to 2015 based on MODIS EVI data. Combined with the air temperature, relative humidity, and precipitation data from the study area, the grey relational analysis (GRA) method was used to study the time lag of EVI to climate change. It was found that the growth of vegetation in IMAR generally has the closest relationship with precipitation. The growth of vegetation does not depend on the change of a single climatic factor. Instead, it is the result of the combined action of multiple climatic factors and human activities.

Accurate and continuous monitoring of the production of arid ecosystems is of great importance for global and regional carbon cycle estimation. However, the magnitude of carbon sequestration in arid regions and its contribution to the global carbon cycle is poorly understood due to the worldwide paucity of measurements of carbon exchange in arid ecosystems. The MODIS gross primary productivity (GPP) product provides worldwide high-frequency monitoring of terrestrial GPP. The study by Wang et al. [10] examined the performance of MODIS-derived GPP by comparing it with eddy covariance (EC)-observed GPP at different timescales for the main ecosystems in arid and semi-arid regions of China. It was revealed that the current MODIS GPP model works well after improving the maximum light-use efficiency (εmax or LUEmax), as well as the temperature and water-constrained parameters of the main ecosystems in the arid region. Nevertheless, there are still large uncertainties surrounding GPP modelling in dryland ecosystems, especially for desert ecosystems. Further improvements in GPP simulation in dryland ecosystems are needed in future studies, for example, improvements in remote sensing products and the GPP estimation algorithm, implementation of data-driven methods, or physiology models.

The diurnal cycle in atmospheric water over Switzerland is analyzed in the study Hocke et al. [11] using the data from the Tropospheric Water Radiometer (TROWARA). TROWARA is a ground-based microwave radiometer with an additional infrared channel observing atmospheric water parameters in Bern, Switzerland. TROWARA measures with nearly all-weather capability during day- and nighttime with a high temporal resolution (about 10 s). Using the almost complete data set from 2004 to 2016, this study derives and discusses the diurnal cycles in cloud fraction (CF), integrated liquid water (ILW), and integrated water vapor (IWV) for different seasons and the annual mean. The diurnal cycle in rain fraction is also analyzed; it shows an increase of a few percent in the late afternoon hours during summer.

Combined together in one manuscript, these papers demonstrate a variety of approaches that satellite remote sensing can offer to address the global challenges of Earth observations. Space infrastructure and observation needs; land surface thermal signatures, arid ecosystems and snow albedo; El Niño and the diurnal cycle in atmospheric water; all are essential components to advance our knowledge about the Earth environment.

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