remote sensing

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Editorial

Editorial for the Special Issue "Understanding Biosphere–Atmosphere Interactions with Remote Sensing"

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The terrestrial biosphere interacts with the free atmosphere through the exchange of momentum, energy and mass. This process is mediated by the atmospheric boundary layer, influencing both weather and climate across a range of scales. In recent decades, remote sensing observations from multiple platforms have emerged as potential tools to quantify the surface fluxes and biosphere characteristics. This will allow researchers to investigate the physical, chemical, and biological processes that drive biosphere–atmosphere interactions. Recent advancement in new platforms offers new insights into the quantitative remote sensing of the biosphere. Some examples include unmanned aerial vehicles (UAVs), remote sensing techniques, and sensors, including but not limited to thermal infrared, multispectral, hyperspectral, solar-induced chlorophyll fluorescence, and light detection and ranging (LiDAR) capable of unprecedented spectral and spatiotemporal resolutions. Despite the progress in remote sensing of the biosphere–atmosphere interface at various temporal and spatial scales, integrating the observations to understand the bidirectional feedback remains a challenge due to the complexity of interactions.

The special issue was aimed at exploring the use of remote sensing data from passive or active sensors onboard any ground/airborne/spaceborne platforms or its combinations with modeling efforts or other datasets in understanding the interaction at the biosphere–atmosphere interface from local to global scales. A total of five manuscripts, four research articles and a review, were published from twelve submissions after the rigorous review process. The major topics covered in this Special Issue mostly utilized in situ measurements and remote sensing data, retrieved by ground/satellite-based sensors. The topics also included evaluations of uncertainties in remote sensing data products over different land cover types and climate regimes to understand the limitations of retrieval algorithms and improve confidence in remote sensing observations.

Two papers [1,2] in this Special Issue focus on improving the estimation of evapotranspiration (ET), using both direct and indirect methods. Jiang et al. [1] compared daily evapotranspiration (ET) estimations using direct calculation (DC) and temporal scaling by constant reference evaporative fraction methods, using long-term field and satellite data obtained from Moderate-resolution Imaging Spectroradiometer (MODIS) sensors. These data cover the period from late April 2009 to late October 2010 at the Yucheng site in China. They validated the estimated ET using eddy covariance (EC) ET from the Yucheng site, both with and without the correction of energy imbalance, and found that the DC method performed with higher accuracy when compared to uncorrected EC measurements. The study provides scientific guidance for developing an operational method for accurate daily ET estimates, with the potential to be applied across various climate types and geographic locations.

Chen et al. [2] evaluated the performance of multiple high spatial resolution evapotranspiration products over the Lancang–Mekong River Basin (LMRB), Southeast Asia. They compared the MODIS global terrestrial evapotranspiration product (MOD16), the ET

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product based on the Penman–Monteith–Leuning equation version 2 (PML-V2), the ET product based on the Breathing Earth System Simulator (BESS), and the ET product of the Global Land Surface Satellite (GLASS) with eddy covariance ET from 11 sites over different vegetation types in the LMRB region. Their results revealed that PML-V2 performs best in evergreen broadleaf forests, BESS performs best in deciduous broadleaf forests and croplands, and GLASS performs best in shrubs, grasslands, and mixed vegetation. Indeed, all of the above products performed well compared with MODIS ET. Their study reveals the inconsistent performance of the four ET products and discusses the possible ways to improve the accuracy of ET products over LMRB.

Ren et al. [3] explored the use of long-term MODIS normalized difference vegetation index (NDVI) and climate data (precipitation and temperature), derived from the meteorological stations, to evaluate the effects of climate change on vegetation growth in the Yellow River Basin (YRB) from 2000 to 2019. The results indicate that the spatial variations of precipitation, temperature, and NDVI were heterogeneous, and the correlations between NDVI and climate variables varied with seasons in the YRB from 2000–2019. Both NDVI and climatic variables exhibited overall increasing trends during this period. Exceptions to this were a number of locations in the northern, southern, and southwestern regions of the YRB. This study contributes to improving the current understanding of the spatiotemporal relationships between precipitation, temperature and vegetation dynamics in the YRB region and provides guidance on the restoration efforts of the functional ecosystem in this area.

Azevedo et al. [4] presented a method for predicting soil respiration using plant productivity in a subarctic tundra site in northern Sweden. They used NDVI from a handheld spectrometer and chamber-based soil CO2 efflux measurements to establish the relationship between aboveground plant productivity and belowground soil respiration. Their results indicate that a combination of ground-based remote sensing products (NDVI) and in situ sampling of soil temperature adequately predicted soil respiration and highlighted the more complicated relationship between vegetation productivity and soil organic carbon in a highly heterogeneous ecosystem. This study highlights the potential to estimate and map soil respiration at a landscape scale using high-resolution UAV and multi-spectral satellite imagery, especially important for understanding soil carbon dynamics in a warming Arctic.

Cai et al. [5] reviewed the current progress in direct and indirect estimation methods of ecosystem water use efficiency (WUE), a key variable for understanding the ecosystem of carbon–water coupling, by remote sensing. They examined various methods for estimating WUE by utilizing ecosystem level gross primary production (GPP)/evapotranspiration (ET) from ground-based eddy covariance observations, processed-based models and remote sensing. This review also assessed the challenges in WUE remote sensing, uncertainties and limitations of the above-mentioned methods for WUE estimation, and possible ways of improving WUE remote sensing by data fusion, analytical models, intelligent algorithms and big data platforms. This review gives insight into multiple approaches, new mechanistic models for our understanding of ecosystem carbon–water cycle coupling across different scales.

Utilizing remote sensing technology to elucidate biosphere–atmosphere interactions is a challenging and emerging research topic that has the potential to remain an area of great interest to the scientific community in the coming decades. The five manuscripts published here reveal meaningful progress on different aspects of this research by providing new methods and techniques and demonstrating the use of conventional in situ measurements in improving and validating remote sensing data products. The Special Issue highlights the potential of using remote sensing to study biosphere–atmosphere interactions across various spatial and temporal scales and serves as a steppingstone for further efforts to integrate multisource remote sensing observations using advanced methods for a better understanding of bi-directional feedbacks at the biosphere–atmosphere interface.

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