Land surface temperature retrieval for Himawari 8 Advanced Himawari Imager (AHI) data

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Land surface temperature (LST) is the radiative skin temperature of land surfaces, which plays vital roles in Earth surface energy balance and various land surface processes at local and global scales. It has been newly endorsed as an essential climate variable (ECV) by the Global Climate Observing System (GCOS) in 2016, recognizing its importance to characterize climate change and corresponding impacts. Products derived from satellite data has provided the unique opportunity to monitor LST dynamics at various spatial (e.g., regional and global) and temporal (e.g., daily, monthly) scales. However, current LST products still cannot meet requirements for climate studies proposed by GCOS (i.e., high accuracy and precision at 3-hour and 1-km). Fortunately, with rapid increasing interests and developing technologies, new satellite sensors have been launched into space for monitoring LST together with other ECVs. In 2015, Japanese Meteorological Agency (JMA) has launched geostationary satellite Himawari 8 with Advance Himawari Imager (AHI) to replace its predecessor MTSAT-2 for numerical weather prediction and environmental monitoring. Because of its frequent scanning mode (10 minute), improved spatial resolution and sensor characteristics, AHI data has provided the unique opportunity to monitor LST dynamics over the rapid changing Asia/Oceania regions. In this study, we develop the emissivity explicit split window algorithm to retrieve LST using AHI split window channels (11.2 μm and 12.4 μm). The emissivity data used in the retrieval are dynamic values corresponding to surface vegetation and snow dynamics. Based on ground station measurements in China and Australia, retrieved AHI LST has shown promising accuracy and precision. However, the retrieval performance have notable dependence on solar zenith angle and land surface types. Daytime LST retrieval over sparse vegetated areas (e.g., woodland and shrubland) has notable overestimation especially in summer time. Cross comparing with operational polar-orbiting satellite LST products, AHI has shown good consistency with MODIS and VIIRS LST despite different sensor characteristics and viewing geometry. This algorithm is originally developed for GOES-R Advance Baseline Imager (ABI) data. Since AHI and ABI share almost the same sensor characteristics, this study presents the feasibility and effectiveness of the algorithm on AHI data. In the future, by combining AHI LST with LST products derived from Meteosat SEVIRI data and upcoming GOES-R ABI data, the LST community could ultimately provide essential product to promptly monitor land surface thermal anomalies at regional and global scales.

Keywords: land surface temperature, AHI, split window, climate change

Spectro-polarimetric BRDF measurement of leaves and reflectance model

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Spectral reflectance of a plant is one of the major methods of the modern remote sensing, which strongly depends on the combination of the sunlight incidence and observation view angle of the satellite camera. In this study, single leaf' s spectral images of Coffea canephora Pierre, Epipremnum aureum, and Fragaria ×ananassa are taken by Liquid Crystal Tunable Filter (LCTF) camera with rotating linear polarizing film at hundreds of different angles for Bidirectional Reflectance Distribution proposals in a laboratory. The advantage of using an image of the multispectral camera is able to crop surface area of a leaf that means it is possible to select an arbitrary size of the field of view. This kind of measurement setup produces an error less than a spectroradiometer. We separated polarized and unpolarized reflectance of a leaf and the product of those two parts is the total reflectance which is equal to reflectance measurement result without a linear polarizer. The result showed that polarized reflectance strongly depends on relative azimuth angle and zenith light source angle relative to the camera and unpolarized part almost does not depend on angles. Results indicated that polarized part is caused by waxy cuticle which is a transparent outer layer, there is no relationship between polarization degree and chemical compounds inside a healthy leaf, and it became a problem of multilayered structure scattering. These indicators lead to reflectance model of a leaf which consists of two layers which are transparent layer and structure layer. This simple model shows an almost same spectral signature as that produced without a linear polarizer. The model explains bidirectional reflected light on the plants, allowing to take an image of slope downward angle.

Keywords: Unpolarized reflectance, polarized reflectance, waxy cuticle, BRDF model, two-layer reflectance, spectral imaging

Constructing river stage-discharge rating curves using remotely sensed river cross-sectional inundation areas and river bathymetry

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Remote sensing from satellites and airborne platforms provides valuable data for monitoring and gauging river discharge. One effective approach first estimates river stage from satellite-measured inundation area based on the inundation area-river stage relationship (IARSR), and then the estimated river stage is used to compute river discharge based on the stage-discharge rating (SDR) curve. However, this approach is difficult to implement because of a lack of data for constructing the SDR curves. This study proposes a new method to construct the SDR curves using remotely sensed river cross-sectional inundation areas and river bathymetry. The proposed method was tested over a river reach between two USGS gauging stations, i.e., Kingston Mines (KM) and Copperas Creek (CC) along the Illinois River. First a polygon over each of two cross sections was defined. A complete IARSR curve was constructed inside each polygon using digital elevation model (DEM) and river bathymetric data. The constructed IARSR curves were then used to estimate 47 river water surface elevations at each cross section based on 47 river inundation areas estimated from Landsat TM images collected during 1994-2002. The estimated water surface elevations were substituted into an objective function formed by the Bernoulli equation of gradually varied open channel flow. A nonlinear global optimization scheme was applied to solve the Manning’s coefficient through minimizing the objective function value. Finally the SDR curve was constructed at the KM site using the solved Manning’s coefficient, channel cross sectional geometry and the Manning’s equation, and employed to estimate river discharges. The root mean square error (RMSE) in the estimated river discharges against the USGS measured river discharges is 112.4 m^3/s. To consider the variation of the Manning’s coefficient in the vertical direction, this study also suggested a power-law function to describe the vertical decline of the Manning’s coefficient with the water level from the channel bed lowest elevation to the bank-full level. The constructed SDR curve with the vertical variation of the Manning’s coefficient reduced the RMSE in the estimated river discharges to 83.9 m^3/s. These results indicate that the method developed and tested in this study is effective and robust, and has the potential for improving our ability of remote sensing of river discharge and providing data for water resources management, global water cycle study, and flood forecasting and prevention.

Keywords: Landsat TM imagery, digital elevation model, river bathymetry, Manning's equation, river stage and discharge, Bernoulli equation

A General Algorithm for Estimating Secchi Disk Depth from Landsat 5 TM and 7 ETM+ data in Indonesian Lakes

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Secchi Disk Transparency (SDT) or simply known as water clarity is one key parameter for evaluating water quality. Long term SDT monitoring data is urgently needed to conduct a better water environment study and management. However, lack of available data measured from past to now and even in the future is a common problem in developing countries. Generating SDT data over long periods will give a substantial contribution for that matter. Remote sensing is the most appropriate option for recording a spatially continuous vast coverage of environment change condition. Among the operational satellites, Landsat has the longest continuous mission for earth observation with the fine spatial resolution. Accordingly the objective of this research is to develop a general algorithm to estimate SDT using time series of Landsat 5 TM and 7 ETM+ images. The general algorithm will be applicable for Landsat image collections with different dates and locations. The images acquired on different location, date and atmospheric conditions were standardized by performing Rayleigh correction using 6S with no aerosol computed. Further the aerosol effects were minimized by subtracting it using band 5. Extracted corrected reflectance from Landsat images and corresponding in-situ SDT measurements collected from 2011 to 2014 (ranging from 0.5 m to 18.6 m) were used for model calibration. The other in-situ SDT measurements collected in 1992 or 1993 and corresponding Landsat images were used to validate the developed algorithm. As a result, the model calibration involved band 1 and the ratio between band 1 and band 3 gave high determination coefficients of .97 and the model validation provide acceptable result. Consequently, the developed model can be used to generate long term SDT value to fill or complement the data gap for further water environment study and management.

Keywords: Secchi Disk Depth , Remote Sensing, Landsat, Water quality

Fusarium Wilt detection on Davao del Norte, Philippines using Satellite Images of Landsat-8 and Diwata-1

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Banana Industry is one of the largest agricultural sector in the Philippines. It is ranked 3rd in the world as top producer of Cavendish banana and was valued by Food and Agriculture Organization (FAO) of United Nations at $1.1 billion last 2014. Unfortunately, on the succeeding year, the industry experienced huge losses. It suffered 5.35% decrease in production, loss $500 million in profit and 2000 hectares of banana plantation. These losses are effects of Fusarium Wilt outbreak that has affected the Davao Region, which is the top producer of Cavendish banana in the country.

Fusarium Wilt or more popularly known as “Panama disease” is a disease caused by several pathogens referred to as *Fusarium oxysporum.* It is a vascular disease that causes yellowing and wilting of banana leaves which eventually kills the tree, preventing it to bear fruits and to reproduce. It has affected the 5 provinces in Davao Region with an area over 20,000 sq. km.

In stopping the spread of the disease, early detection of the existence of the disease is the key and remote sensing using satellite images can be an indispensable tool. Landsat-8 has been widely use for vegetation monitoring and has a huge potential on detecting the disease because of it having a wide range of bands and resolution of 30 m. Diwata-1, which is the 1st microsatellite of the Philippines, is equipped with Liquid Crystal Tunable Filter (LCTF) which enables super multi-color imaging and increase the spectral resolution of a camera greatly. As compared to Landsat-8’s 11 bands, Diwata-1 has 587 bands. With this high spectral resolution, it can provide more detailed information, making healthy vegetation more distinguishable from unhealthy ones.

In this study, ground spectral measurements were done in a Panama disease infested farm in Davao del Norte using FieldSpec 4 spectroradiometer. A ground-based LCTF imager were also used to capture Panama disease infected trees at spectral resolution same with Diwata-1’s camera. Banana trees at the area were geo-tagged using GPS. Cross-analysis comparing spectral data of healthy from Panama-disease-infected tree and other diseases found in the banana tree were done to create a decision tree for LCTF-based imagers and for Landsat-8 spectral resolution. This decision tree were then applied to the LCTF Imager’s images acquired in the area and to Landsat-8 images. The resulting areas identified using the decision tree matches the geo-tagged trees in the ground. Spectral response of Diwata-1’s camera were then simulated by using its transmittance and ground spectral measurements and wavelengths sensitive to Panama disease were identified.

Keywords: Remote Sensing, Vegetation disease, Satellite Images

Estimation of Rice Yield Based on the Integration of UAV Remote Sensing and Solar Radiation Data

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1. Introduction

Crop monitoring using Unmanned Aerial Vehicle (UAV) remote sensing is an important contributor to the improvement of yield and quality, based on precision agriculture. Besides, yield prediction information before harvest is important for farmers in planning harvesting work. In agricultural remote sensing, there are many studies about estimation of yield using satellite data. The most popular method for estimating yield is derivation of regression model between a vegetation index and measured yield. However, these model’s estimation accuracy depends on the geographic location. In other words, there is a problem in widespread applicability of the estimation model.

The main objective of this study was to investigate an alternative applicable model for estimation of yield of paddy rice based on UAV remote sensing and solar radiation datasets. A secondary objective was to explore the possibility of expanding the yield estimation method developed from UAV remote sensing to satellite remote sensing.

2. Methods and Materials

2.1. Field measurement

UAV remote sensing datasets for three rice varieties (*Koshihikari, Fusaotome, Fusakogane*) acquired in three locations (*Chiba, Niigata, Saitama*) were analyzed. In Chiba, we observed two fields which are located at the Chiba Prefectural Agriculture and Forestry Research Center. Two fields were subdivided into 48 compartments with different cultivation conditions (transplanting day, varieties, amount of fertilizer). Observation equipment were an electric-powered Multicopter (enRoute Zion QC630, MEDIX JABO H601G, DJI Phantom2) and digital camera (visible image: RICOH GR, green, red, near-infrared image: BIZWORKS Yubaflex). Flight altitude was 50m.

2.2. Data processing

Ortho photographs were generated using the SfM/MVS technique. The images taken with Yubaflex, after conversion to radiance, were used to create the ortho mosaic images using SfM / MVS software. After that, we calculated vegetation indexes (NDVI, etc.) using the ortho mosaic photos. At that time, we added NDVI $_{\text{pure vegetation}}$($NDVI_{pv}$), where in pixels with NDVI value greater than 0 are taken to be vegetation, as one of the vegetation indexes.

2.3. Other data

Two types of solar radiation datasets were analyzed. One was the Daily Photosynthetically Active Radiation (PAR) data (JAXA) estimated from Aqua/MODIS while another was Global Solar Radiation (GSR) from 1 km mesh agricultural weather data (NARO).

To apply the UAV method to satellite remote sensing, MODIS 8days composite data and crop survey data (Ministry of Agriculture, Forestry and Fisheries) in three prefectures (*Chiba, Ibaraki, Nagano*) were analyzed.

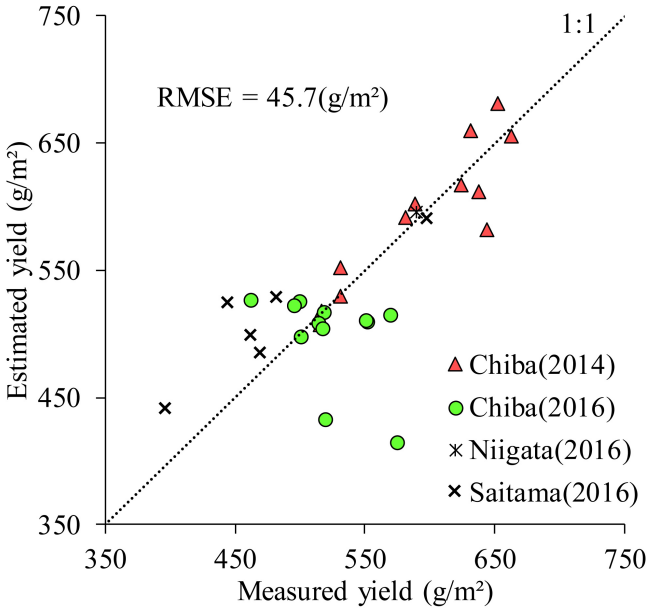
3. Results

(1) With respect to *Koshihikari*, the average solar radiation of the 20-day period from the heading stage was found to have the highest correlation to yield. With respect to *Fusaotome* and *Fusakogane*, the average solar radiation of the 30-day period from the heading stage had the highest correlation to yield.
(2) Applying the yield estimation models to another year or location resulted in a RMSE of PAR-based model of 45.7g/m². On the other hand, RMSE of GSR-based model was 24.8g/m². GSR-based model outperformed PAR-based model.
(3) As a result of application of the UAV method to satellite remote sensing in three prefectures, *Ibaraki* and *Nagano* yields were found to have higher correlation to solar radiation. In the percentage of *Koshihikari* in paddy fields in *Ibaraki* and *Nagano* was about 80%. On the other hands, it was less than 70% in *Chiba*. For this reason, the correlation between yield and solar radiation in *Chiba* was considered to be affected by varietal difference.

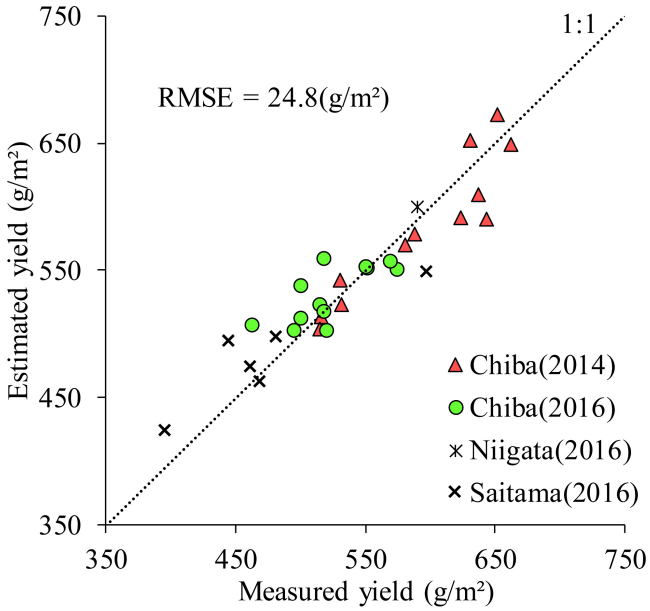
4. Discussion and Conclusion

The models in this study were considered to be evaluating the production of assimilation products by photosynthesis. Hence, we were able to apply the same models to other years and regions.
The models for estimation of yield of paddy rice provided in this study would work as applicable models for estimation of yield of paddy rice using the integration of UAV remote sensing and solar radiation.

Keywords: UAV remote sensing, solar radiation, variety



a) Yield estimation using PAR



b) Yield estimation using global solar radiation

Spatial Correlations of Land Cover Changes, Surface Temperature and NDVI in Arid Regions: A Case Study in Kashgar City, China

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Land surface temperature (LST) is one of the important parameters in the physics of land surface processes from local to global scales. Researches on urban LST have increased and mitigations only focused on the big cities already developed. In contrast, there are few attentions to developing cities with large populations. Kashgar city is one of the typical city in arid regions, and is located in north-west China, south-west of Xinjiang Uyghur Province of China. Population reaches more than 506,640 in 2014. With increasing population, expansion of urban area has accelerated temperature rese in Kashgar city. Originally, a high temperature in the area is inherent in continental arid climate combined with increasing anthropogenic activities, urbanisation, resulted from impacts on the local environment changes, such as local worming. For these reasons, local government have to need to measurements to adopt local climate change but it is difficult to know how and when to adopt. Therefore the main objective of this study is first, to investigate land use/cover changes (LUCC) of Kashgar city by using multi-temporal satellite remote sensing data, through an objective-based image classification method by the eCognition. Land use changes are studied based on change detection method. Second, calculated NDVI as the ratio between measured reflectance in red (R) and near-infrared (NIR) spectral bands of Landsat images, to examine the relationship between LST and greenness. Third, to produce LST map applied the mono-window algorithm by using the thermal band of Landsat data. Finally, validation of satellite-derived LST using local meteorological data. Results from the LUCC and change detection shows that an increase in impervious surface areas was significant, while an area of cultivated land and natural vegetation decreased rapidly. The surface of Kashgar city is mainly dominated by bare land, built-up land and marble surface material. This area showed very high temperature. The changes in LUCC were found to have led to a variation in surface temperature, as well as a spatial distribution pattern of the local warming. In addition, the results from the higher value of Moran`s index of a city center, where builted up rooftops and marble surface. The NDVI and LST results will provide helpful information for local governments with development guidelines and policy decisions.

Keywords: Arid Region , Kashgar City, LST

Estimation of Water Consumption of Winter Wheat in the North China Plain Using Remote Sensing Technology

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The North China Plain (NCP) is one of the most important regions of agricultural production in China. Winter wheat is a major crop in this region. Water consumption of winter wheat greatly exceeds precipitation of the same period. Increase of winter wheat yield mainly depends on irrigation. Over-exploitation of groundwater resources for irrigation has resulted in the decline of the groundwater table and severe environmental problems. The objective of this study is to accurately estimate crop water consumption and irrigation water consumption in the study area. A model to estimate actual crop evapotranspiration was established combining Penman-Monteith method with remote sensing data. Estimated actual evapotranspiration of winter wheat between 2001 and 2013 had good consistency with field observed evapotranspiration in Luancheng Station of Hebei Province, Weishan Station and Yucheng Station of Shandong Province (RE= -1.3%, RMSE=54.8mm). Irrigation water consumption also had good consistency with declining rate of groundwater table at hydrological stations of Hebei Plain. Moreover, planting area of winter wheat in Northern Hebei Plain and Southern Hebei Plain had a declining trend from 2001 to 2013. Before and after 2001, decline rate of regional groundwater table of Northern Hebei Plain and Southern Hebei Plain decreased significantly. Thus, decrease of planting area of winter wheat had a significant influence on protection of groundwater resources. The proposed model in this study can also be applied in the estimation of water footprint and irrigation water management in other regions.

Keywords: North China Plain, Evapotranspiration, Remote sensing, Groundwater, Irrigation water consumption

Asymmetric temperature sensitivities of plant phenology in warmer and cooler springs are affected by climate factors in Europe

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Understanding temperature sensitivity of vegetation is important for predicting the effects of climate change on terrestrial ecosystem. Previous studies paid much attention on phenological response of plants to temperature elevation. Temperature elevation has induced and is expected to induce high temperature fluctuations combining with changes in other climate factors. However, little attention has been paid on phenological responses to temperature variations under different background temperature and these responses in relation to other climate factors.

Using the European phenology database PEP725, we examined the species-specific temperature sensitivities in warmer springs and cooler springs for start of spring (SOS) of woody species with more than 30 years phonological observations. Linear regression analyses were applied to determine the temporal correlations between SOS and spring temperature in warmer and cooler springs, and correlation analyses were further used to assess the relationship between temperature sensitivities and other factors.

We found that phenological responses to temperature in warmer springs (Tsw) were significantly greater than in cooler springs (Tsc). In warmer springs, the temperature sensitivity was higher in response to decreasing spring temperature. Moreover, we found that the temperature sensitivity varies with chilling days and precipitation. This study suggests that phenological sensitivity to temperature variation may differ in springs with different temperatures, i.e., temperature sensitivity is asymmetric between a warm and a cold spring, and the differential response can be further interacted with other climate factors.

Keywords: Phenology, Europe, temperature sensitivity

Applying Desertification Monitoring Method to Mu Us Desert Considering Seasonal Changes

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Desertification is one of the biggest environmental issues that we face today. There have been significant efforts to reduce the impacts of desertification and restore ecosystems affected by it, being reforestation the most common mitigation measure applied. In order to maximize these efforts, it is necessary to monitor the desertification of those regions. As remote sensing technique is suitable to detect environmental changes in large area, it has long been used for monitoring desertification. Most of previous studies focuses on calculating vegetation index (e.g. NDVI) or classifying land cover from satellite images of specific period in a year. In those studies, however, only satellite images of summer are used for monitoring. As the distribution of vegetation varies over seasons or months, using only satellite images of a specific period like summer has a limitation in analyzing overall desertification tendency. Therefore, this study focuses on detecting band radiance changes of each pixel over the time, and designs Time Dependent Desertification Index (TDDI). Landsat satellite images of Mu Us desert, Inner Mongolia, in various seasons from 2007 to 2016 are used to analyze the desertification index. The TDDI value map of the Mu Us desert area is produced and it is expected to help identify overall tendency of desertification considering seasonal factors. Furthermore, this new method can be applied to other environmental fields where seasonal changes need to be considered.

Keywords: monitoring, desertification, remote sensing, Mu Us desert

Possible Impacts of Returning Farmland to Forest and Grassland on Local Temperature in the Ecotone between Agriculture and Animal Husbandry in China

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LUCC activities change the surface albedo, evapotranspiration and other biological geophysical processes and carbon cycling, greenhouse gas emissions and other bio-geochemical processes, so that at different time and space scale, the local, regional and global scale climate impact. Using the LUCC data, the meteorological stations were divided according to the land use types, and the adjacent sites were matched in space. The temperature difference between the paired sites was analyzed. It was found that the conversion of cropland to forest and grassland was significantly lower in the growing season effect. In the case of precipitation precipitation, the trend of summer temperature difference between the site of returning farmland to forest site and its invariable site is -1 ℃ / 10a, while that of returning farmland to grass is the most obvious in spring, the trend is -0.3 ℃ / The effect of returning farmland to forest is more obvious than that of returning farmland to grassland, and the effect of cooling is not significant.

Keywords: Climate Change mitigation, surface cooling, Returning Farmland to Forest and Grassland Effect

Remote Estimation of Euphotic Zone Depth for Turbid Inland Waters: A Case Study in Lake Kasumigaura, Japan

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Euphotic zone depth (*Z*eu) is defined as the depth where photosynthetic available radiation (PAR) is 1% of its surface value. It is of great importance in studying water biogeochemical processes. Satellite remote sensing is a powerful technique to monitor *Z*eu, as it can cover large areas at very frequent intervals. Several remote-sensing algorithms for estimating *Z*eu have been developed for oceanic water bodies; however, remote estimation of *Z*eu is still a challenging task for inland waters. In this study, an existing semianalytical algorithm was modified for remotely estimating *Z*eu in turbid inland waters by replacing the original quasi-analytical algorithm (QAA) by QAA_Turbid, an algorithm specially developed for remotely estimating total absorption and backscattering coefficients in turbid waters. Performance of the modified algorithm was evaluated using *in situ* radiometric data collected in Japan’ s Lake Kasumigaura, known to be very turbid. Results showed that yielded acceptable estimation accuracy for *Z*eu (ranging from 1.15 to 2.26 m) with root-mean-square error (RMSE) of 0.12 m, normalized root-mean-square error (NRMS) of 8.01%, and mean normalized bias (MNB) of −1.84%, significantly outperforming the original version as well as three other *Z*eu retrieval algorithms. Application to the satellite images also yielded acceptable performances. These results indicate its great potential for operational estimation of *Z*eu over widespread turbid inland waters from satellite observations.

Keywords: Euphotic zone depth, remote sensing, inland waters

An Automatic Land Cover Updating Algorithm Based on NDVI Downscaling and Object-oriented Change Detection

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Land cover mapping and continuous updating are of great significance to climate change and land resource management. Recently, China released the first 30-m global land cover product GlobeLand30 with two years (2000/2010). GlobeLand30 was produced by a pixel-, object- and knowledge-based (POK) information extraction strategy, which guarantees high accuracy and consistency globally. However, the POK method cannot allow an automatic and quick updating for this product, and the existing land cover updating method has a lot of problems, e.g. the pixel-based classification method is not suitable for the high resolution image, and the pseudo-changes remove method based on the pixel NDVI time series results in ‘salt and pepper’ phenomenon. Thus an effective and efficient land cover product updating method is urgently needed. To address these problems, this research aimed to automatically update GlobeLand30 at object scale with downscaling NDVI time series data.
The automatic updating method involves two main algorithms. (1) Land cover updating algorithm by integrating downscaled NDVI time series. This algorithm requires the land cover map at time T_1, Landsat images at time T_1 and T_2, and MODIS yearly NDVI time series data at two years. The MODIS NDVI time series data at 250m resolution was downscaled at 30m by NDVI-LMGM model (Rao et al., 2015, doi:10.3390/rs70607865). All pixels in the T_1 and T_2 Landsat images are selected as training samples individually corresponding to the land cover map at T_1, and then we get the posterior probability of pixels belonging to every class. Then change pixels are detected by change vector analysis in posterior probability (CVAPS). Finally, the changed pixels are removed from both training samples, and classification and the change detection repeatedly until the changed/unchanged pixels between two iterations are 99% consistent. (2) Land cover updating method based on object-oriented analysis. The Landsat images are firstly segmented and an optimal scale factor is determined by the method proposed by Yang et al. (2016, doi:10.1109/JSTARS.2016.2615073). The training sample selection, classification and change detection methods are the same as above.
We choose Beijing/Tianjin/Tangshan region as the study area, and used Landsat OLI data and MODIS NDVI data in 2013 to update the GlobeLand30 2010 product. Result shows that the new method eliminates ‘salt and pepper’ phenomenon, and the land cover update accuracy is 86.71%. Besides, the optimal scale segmentation can help obtain the highest land cover update accuracy than any single scale segmentation. The object-based NDVI time-series data can help to remove more than 90% pseudo-change caused by phonological difference and spectral confusion. The automatic updating method can help to produce new global land cover maps at 30m spatial resolution.

Keywords: Land Cover Update, Object-based, NDVI downscaling

Detection of plant root orientation using ground-penetrating radar

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With the function of water absorption, nutrient transportation and storage, root system plays a significant role in plant ecosystem [1]. Nevertheless, subject to the inconvenience of underground investigation, surveys on root system under natural circumstance have lagged far behind those on the aboveground part. Due to its in situ and non-destructive nature, ground-penetrating radar (GPR) has recently been applied for field investigation of plant roots, such as automatic three-dimensional reconstruction of root system and quantitative inversion of root parameters. It is the discrepancy between the roots and surrounding soils that creates a dielectric constant contrast, forming clear hyperbolic reflections on the GPR radargram. The intensity and shape of the reflecting signals from roots are substantially affected by the root orientation and as well the relative geometry between the root in subsurface and GPR survey direction on ground surface. However, no previous study has utilized the information on intensity and shape of root’ s GPR reflection to map its orientation, which is crucial in interpreting radargram and rebuilding three-dimensional root system architecture. In this study, a mathematical formulation of hyperbolic reflection formed by a single root was first deduced based on principles of electromagnetic wave propagation and the relationship between the shape of the GPR signals and root orientation was analyzed. Then using such formulation, curve fitting was conducted on both simulated and field collected dataset by GPR. Information on the horizontal orientation and vertical inclination of a single root was acquired according to the formulation coefficient retrievals. Based on this, a method for retrieving the horizontal orientation and vertical inclination angle of a single root from a given GPR image was proposed. This method took advantage of mathematical modeling with curve fitting in root orientation estimation. Meanwhile, conditions for this method application and factors impacting on the extraction of root orientation information were analyzed. The results indicated fairly precise root orientation estimation. The proposed method has extended the application of GPR in root investigation, advancing the frontier of non-invasive root system architecture mapping.

Keywords: ground-penetrating radar, root orientation, curve fitting

Environmental assessment of coastal degradation of Southern Corniche of Jeddah coast using remote sensing and GIS

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During the last three decades, human interference with the environment has changed the outlook of the Southern Corniche of Jeddah (SCJ). Satellite images acquired from the Enhanced Thematic Mapper Plus (ETM+) 2010, Thematic Mapper (TM) 1990, Multi-spectral scanner (MSS) 1973 and Ikonos image of 2009 were used to detect of the nearshore zone degradation and to assess environmental changes induced by human activities. The visual interpretation of these images revealed a great change in the shoreline and in coral reef habitats. The reef flats were filled and the coastal land was cut for the purpose of expanding the seaport platforms and constructing of coastal road. This study revealed changes in mangroves as indicated by the loss of the mangrove area and a decline in the rate of growth of mangrove trees (*Avicennia marina*) during the past of 20 years due to anthropogenic activities and high salinity. The present study shows that satellite remote sensing (RM) integrated with geographic information system (GIS) are very effective tools for coastal changes detection. The high-resolution satellite data such as Landsat ETM+ 2010, TM 1990, MMS 1973 and IKONUS 2009 data are excellent source to provide information accurately.

Keywords: Remote Sensing, GIS, Environmental degradation

Multiple Remote Sensing Indicators for Understanding Spatiotemporal Trends Across a Changing Landscape in North and South America.

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Identifying and understanding the nature of changing landscapes is one of the great challenges in a time of intense Earth observation. There are abundances of remotely sensed data and computing capacity now available to researchers, which enables moving beyond the use of one or a few sensors or datasets for the generation of static or limited land cover/land use products. Using multiple time series datasets at complementary spatial, temporal, and spectral scales to study land surface dynamics should improve the detection and interpretation of complex processes; the result should be a more accurate and detailed analysis of landscape trends, including the distribution and severity of changes and their possible causes and potential consequences. Therefore, we have conducted an analysis based on a variety of remote sensing products covering North and South America across an approximately fifteen-year period with spatial resolutions extending from 500m to 1 degree, including (1) NBAR-based vegetation indices, albedo, land surface temperature, and evapotranspiration from MODIS, (2) air temperature, water vapor, and vegetation optical depth from AMSR-E and AMSR2, (3) surface air temperature, water vapor, and relative humidity from AIRS, and (4) surface shortwave, longwave, and total net flux from CERES. We applied the non-parametric Seasonal-Kendall trend test to these time series, both annually and on a seasonal basis (summer & winter), to identify hotspots of significant change. We partitioned the data by indicators of human impact and ecoregion, such as the Human Influence Index, Anthropogenic Biomes, and Ecoregions of the World.
We formulate our question as a suite of testable hypotheses about changes in the vegetated land surface, as follows:
(H1) Areas of significant positive change occur in areas of moderate human impact, due predominantly to agricultural land uses;
(H2) Areas of significant negative change that occur in areas with low human impact, arise predominantly from forest pests and forest fires; and
(H3) Areas of significant negative changes that occur in areas with high human impact, appear predominantly associated with the expansion of human settlements, particularly cities.
The results indicate significant benefit from the multiple data stream approach to studying land surface dynamics.

Keywords: Global Change, MODIS, AMSR, Human Influence, Ecoregions, Anthromes

Temporal and Spatial Distribution Characteristics of AOT (Aerosol Optical Thickness) and Its Implication in Yangtze River Delta, China

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The spatial distribution, seasonal, inter-annual and the periodic variation tendency of aerosol optical thickness (AOT) in Yangtze River Delta were observed with ATSR and MODIS data from 1995 to 2015. Relationships between AOT and urban construction area, car ownership, high pollution industry product output and the consumption of electric power, coal, and fuel are analyzed and the economic and social impacts on aerosol optical thickness over the Yangtze River Delta. The result shows that:

1) The AOT yearly change in Yangtze River Delta shows a gradual increase from 1995-2015 with the average growth rate of 0.04/10a, is consistent with that of the national’ s, and plays a stimulating role with the rate of 82%. Three stages can be distinguished: 1995-2002 (the first stage) and 2010-2015 (the third stage) shown an upgrade trend, and the 2002-2010 (the second stage) fluctuates. However, the AOT in this study area grown faster than the national’ s in the first stage, whereas the third stage is on the opposite.

2) The AOT monthly change over Yangtze River Delta is in “W” shape with greater fluctuation in contrast to the wave shape of the country. The Yangtze River Delta is characterized with AOT the most obvious enhancement in autumn.

3) The Yangtze River Delta is one of the areas suffering heavy AOT in China. The AOT distribution is impacted greatly by the topography with the high AOT distributing in the low-lying northern plains, while the southern hilly area exhibiting low AOT. The high AOT zone distributes along the western and northern area of Shanghai mega city, and gradually extends northward and south of Jiangsu Province.

4) Transportation, high pollution industry production and fossil energy consumption are common factors impacting the annual variation of AOT in Yangtze River Delta. The decrease of high pollution industry product output recently contributes a lot to the reduction of AOT in Shanghai, which is in consistent with downward increasing trend of AOT during 2010-2015.

Keywords: ATSR, MODIS, AOT, Yangtze River Delta, Human activity

