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

*Yuhan Rao[1], Yunyue Yu[2], Peng Yu[2], Heshun Wang[2], Yuling Liu[2]

1. University of Maryland, College Park, 2. Center for Satellite Applications and Research, NOAA/NESDIS

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

*Begzsuren Tumendemberel[1]

1. Hokkaido University

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

*Feifei Pan[1]

1. University of North Texas

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

*Fajar Setiawan[1,3], Bunkei Matsushita[2], Takehiko Fukushima[2]

1. Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, Japan, 2. Faculty of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, Japan, 3. Research Center for Limnology, Indonesian Institute of Sciences (LIPI)

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

Benjamin Jonah Magallon[1], *Yukihiro Takahashi[1]

1. Graduate School of Science, Hokkaido University

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

UAVリモートセンシングと日射量データの統合による収量推定
Estimation of Rice Yield Based on the Integration of UAV Remote Sensing and Solar Radiation Data

*濱 侃[1]、田中 圭[2]、望月 篤[3]、新井 弘幸[4]、平田 俊之[4]、八幡 竜也[4]、Nduati Eunice[5]、鶴岡 康夫[3]、近藤 昭彦[6]
*Akira Hama[1], Kei Tanaka[2], Atsushi Mochizuki[3], Hiroyuki Arai[4], Toshiyuki Hirata[4], Ryuya Yawata[4], Eunice Nduati[5], Yasuo Tsuruoka[3], Akihiko Kondoh[6]

1. 千葉大学大学院理学研究科・日本学術振興会特別研究員DC、2. 日本地図センター、3. 千葉県農林総合研究センター、4. 金井度量衡株式会社、5. 千葉大学大学院理学研究科、6. 千葉大学・環境リモートセンシング研究センター
1. JSPS Research Fellow (Graduate School of Science, Chiba University), 2. Japan Map Center, 3. CHIBA Prefectural Agriculture and Forestry Research Center, 4. Kanaidoryoukou Co., Ltd., 5. Graduate School of Science, Chiba University, 6. Center for Environmental Remote Sensing, Chiba Univ.

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.

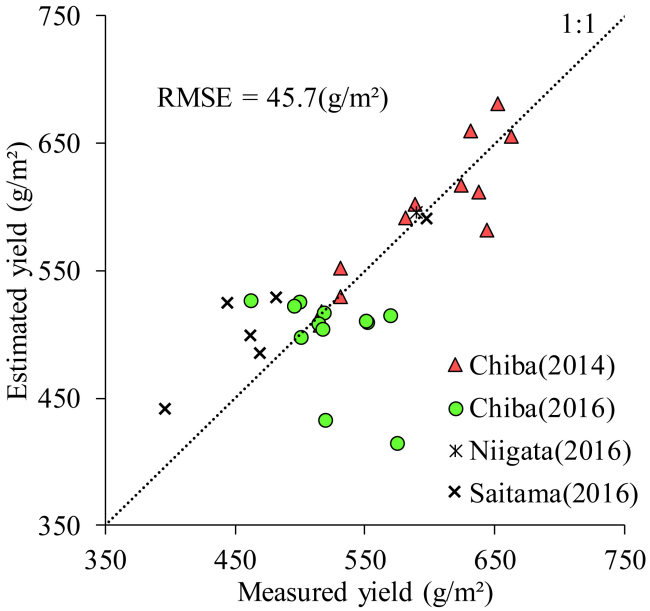
3. Results

(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.

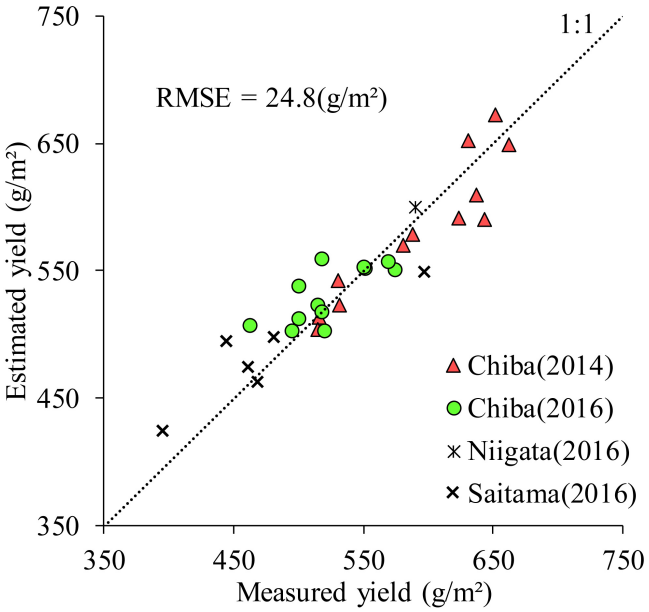
4. Discussion and Conclusion

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.

キーワード：UAVリモートセンシング、日射量、品種
Keywords: UAV remote sensing, solar radiation, variety



a) Yield estimation using PAR



b) Yield estimation using global solar radiation

