FOREST VEGETATION ANALYSES BY GCOM-C/SGLI ACCOMPANIED WITH FIELD DATA

R. Suzuki[a,*], R. Ishii[a], H. Kobayashi[b,a], A. Higuchi[c], and S. Nagai[a]

[a] Research Institute for Global Change, Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Showamachi, Kanazawa, Yokohama, Kanagawa 236-0001, Japan - (rikie, r.ishii, nagais)@jamstec.go.jp
[b] Department of Environmental Science, Policy and Management, University of California, Berkeley, USA - hkoba@berkeley.edu
[c] Center for Environmental Remote Sensing, Chiba University, Chiba, Japan - higu@faculty.chiba-u.jp

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ABSTRACT:

For the modeling and prediction of the global environment, investigation of the vegetation productivity, that dominates the global carbon cycle, is essential. Moreover, since vegetation provides us the resource of food, log, and fuel, the monitoring of vegetation dynamics and the analysis on its relation to climate change are significant. This study has two objectives. First is to develop an estimation algorithm of the forest Leaf Area Index (LAI), which represents the photosynthetic potential. The algorithm will be applicable to the measurement by the sensor "Second Generation Global Imager (SGLI)" of the satellite "Global Change Observation Mission (GCOM)-C" planed in fiscal year 2014. Second is to construct long-term satellite-derived vegetation dataset from which we can analyze the geographical distribution of vegetation and its decadal change. We make an attempt to bridge 13-year SGLI time series of vegetation data to the time series by other satellites such as NOAA's Advanced Very High Resolution Radiometer (AVHRR) etc. Field surveys will be carried out at the field sites of a black spruce forest in Fairbanks, USA and a temperate forest in Takayama, Japan to acquire the ground truth for the two objectives.

1. INTORODUCTION

For the modeling and prediction of the global environment, investigations of the terrestrial vegetation photosynthetic productivity, that dominates the global carbon cycle, is essential. Moreover, since vegetation provides us the resource of food, log, and fuel, the monitoring of vegetation geographical distribution and its long-term temporal change, and the study on their relation to climate/weather impacts are significant for the understanding of the climate-vegetation relationship.

Japan Aerospace Exploration Agency (JAXA) plans to launch a new satellite series, Global Change Observation Mission (GCOM)-C, which has the sensor "Second Generation Global Imager (SGLI)", an optical sensor that has a function of multi-viewing angle observation (-45 degrees, nadir, and +45 degrees along the satellite path). Also, it is anticipated that the 13-year temporal coverage by the three generations of GCOM-C satellite series will enable us to investigate the decadal vegetation change at a global scale.

This paper introduces the outline of our study that was proposed to enhance the applicability of SGLI data to the study of the vegetation dynamics (LAI estimation and vegetation spatio-temporal change). This study has two major objectives targeting the data application of the forthcoming SGLI observation. First objective is to develop the algorithm to estimate LAI considering the Bidirectional Reflectance Factor (BRF) of land surface that will be provided by the multi-view angle measurement of SGLI. BRF is one of the key information for designing 3D forest radiative transfer model from which we can estimate reliable forest LAI. Improvement in the estimation accuracy for LAI will be anticipated by incorporating BRF to

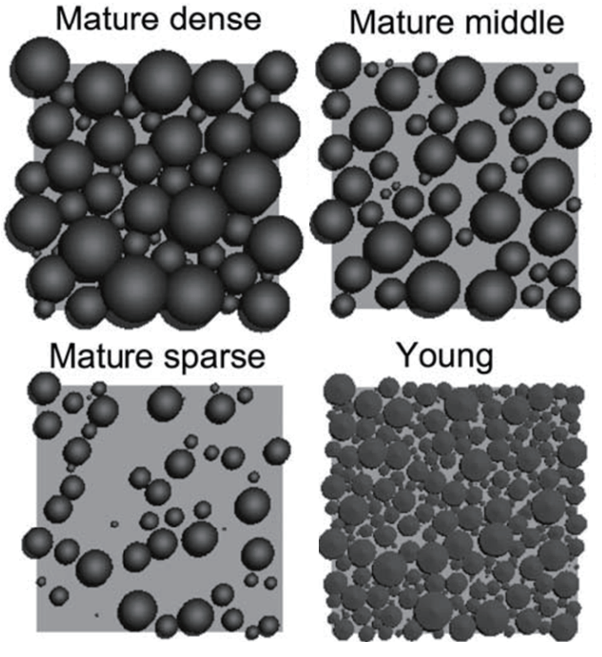

Figure 1. Examples of modeled larch forest scenes (30 x 30 m). The nadir view images show the locations of all trees and their projected canopy area. (After Kobayashi *et al*., 2010)

the 3D forest radiative transfer model based on SGLI measurement.

Second objective is to construct a reliable database of the long-term time series of the satellite-derived vegetation by bridging the time series observed by previous and current satellites such as NOAA / Advanced Very High Resolution Radiometer (AVHRR), Terra & Aqua / Moderate-resolution Imaging Spectroradiometer (MODIS), and SPOT / VEGETATION (VGT). We aim that this constructed time series will be able to bridge to the 13-year time series of three generation GCOM-C/SGLIs for studies on the decadal scale vegetation dynamics.

2. LAI ESTIMATION BY GCOM-C/SGLI

For the estimation of forest LAI, we will use the Forest Light Environmental Simulator (FLiES) model, a three-dimensional Monte Carlo canopy radiative transfer model (Kobayashi and Iwabuchi, 2008; Kobayashi *et al.*, 2010). FLiES can be configured by the structure (tree stand density, height, species, and floor condition of forest) of various actual forests. Fig. 1 is examples of the image of a simulated forest by FLiES. FLiES can estimate the forest LAI by comparing with reflectance data of satellite though the inversion analysis.

An example of estimated LAI of larch forest canopy in mid-July 2000 over eastern Siberia is indicated (Fig. 2) (Kobayashi *et al.*, 2010). By applying SPOT/VGT data, FLiES successfully estimated the canopy LAI of the larch forest there. However this LAI is estimated from BRF measured at a single view angle, because SPOT/VGT measures the land surface reflectance from a single viewing angle. The multi-viewing angle data of SGLI will enable us to estimate the forest LAI more accurately by using FLiES.

Prior to the launch of GCOM-C, data of the sensor "Multi-angle Imaging Spectro-Radiometer (MISR)", that has a function of multi-viewing angle observation similar to SGLI, are used as test data for estimating LAI by the FLiES. Based on the multi-viewing angle data of MISR, we will improve FLiES for the better LAI estimation algorithm which will be applicable to SGLI data.

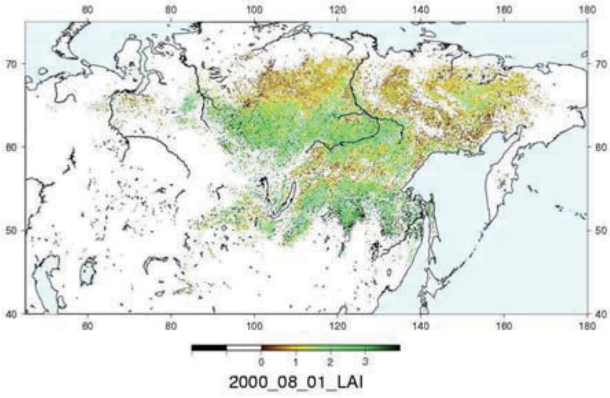

Figure 2. Example of estimated LAI distribution by satellite data (SPOT/VGT) and 3D forest radiative transfer model “FLiES.” Larch canopy LAI for 1–10 August 2000 over eastern Siberia is displayed.

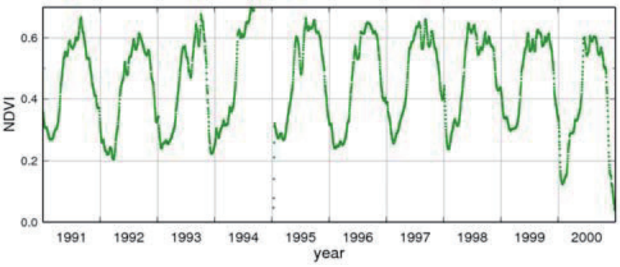

Figure 3. An example of NDVI time series from 1991 to 2000. This time series is composed of daily mean NDVI (8-km resolution) over the land areas of Japan derived from NOAA/AVHRR observation. Daily NDVI values were derived by the temporal window operation (Suzuki and Kondoh, 2005).

3. BRIDGE OF VEGETATION DATA TIME SERIES OF MULTIPLE SATELLITES

Long-term satellite data, which are majorly available since 1981 by NOAA/AVHRR observation, have provided us opportunities to analyze the interannual and decadal changes and trend of vegetation at a global scale. Fig. 3 displays an example of the time series of Normalized Difference Vegetation Index (NDVI) derived by NOAA/AVHRR observation over Japan from 1991 through 2000. Prominent seasonal variation of NDVI can be seen delineating the seasonal change of the vegetation. Goetz *et al.* (2005) demonstrated an increasing trend in NDVI over northmost tundra region in North America based on data of NOAA/AVHRR observation from 1982 through 2003. Increasing trends of NDVI have been pointed out by many previous studies in relation to the global warming. Suzuki *et al.* (2007) found the interannual covariability between actual evapotranspiration and NDVI from 1982 through 2000 over northern Asia.

It is expected that the time series of satellite-derived vegetation data will be prolonged by the observation of operating and future satellites included the three generations of GCOM-C. However satellite-derived vegetation data are usually contaminated by many unfavorable factors: cloud, degradation of sensors, satellite orbital drift, and aerosol due to major volcanic eruptions and wild fires. Also gaps of the data quality among satellites/sensors are considerable. For the creation of reliable long-term satellite-derived vegetation data, rigorous processes for bridging among several satellites’ time series, and for the reduction of those contaminations are required.

We will develop a methodology to bridge the time series from previous and operating satellites, and to reduce the contamination. These efforts lead to a construction of a reliable baseline data for long-term global vegetation change study, and the data can be able to bridge to the 13-year time series of vegetation data obtained from the observation of GCOM-Cs.

4. FIELD SURVEY FOR GROUND TRUTH DATA

The measurement of optical sensors for land is only a value of radiance reflected from land surface of the Earth, and it does not inherently have any information about vegetation. Validations of the satellite measurement by ground truth data are inevitable for the analysis of the terrestrial vegetation. We will positively incorporate the field data of forest that are

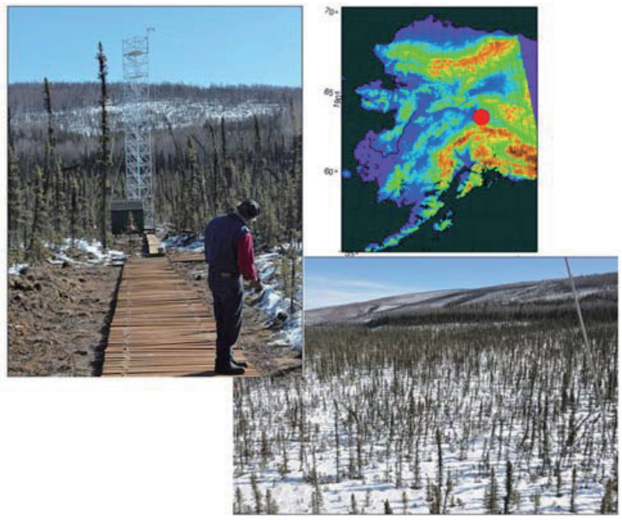

Figure 4. The boreal forest (right-bottom picture) of the observation site in the Poker Flat Research Range (PFRR) of University of Alaska Fairbanks (UAF), and the canopy tower (left picture) constructed in the site. Red point in the map indicates the location of PFRR. (Photograph: Dr. Taro Nakai, IARC/UAF)

acquired by field surveys and observations at domestic and over-sea sites.

For the development of FLiES, forest census information (location of tree stands in plot, and their trunk diameter and height etc) will be acquired at field sites. Moreover, the spectral reflectance of the forest including the BRF will be measured for the model development. For the validation for the satellite-derived vegetation time series, multi-year forest data (spectral reflectance and visual images for phenology monitoring) at the supersite, Takayama, Japan, will be applicable.

A forest site having a canopy tower has been constructed in a boreal forest (sparse black spruce forest) in the Poker Flat Research Range at Fairbanks, Alaska, USA (Fig. 4). We plan a field survey for the forest census, and the BRF of the forest from the top of the tower by using hand held spectro-radiometer. This site will be take a important part in the acquisition of the ground truth data for satellite remote sensing including GCOM-C/SGLI in addition to the Takayama site.

5. CONCLUDING REMARKS

Coupling of satellite remote sensing, field survey, and modeling creates invaluable synergy which produces robust result in terms of LAI estimation, and subsequently, the vegetation photosynthetic productivity, which is one of the key parameters to understand the global carbon cycle. Also, the data bridging approach for the time series of several satellites is essential for modeling the vegetation change. Efforts are being made so that we will be able to extract the potential of SGLI at its maximum through those works.

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