Title: Investigation of vegetation functions by satellite remote sensing accompanied with ground-based forest survey in Alaska

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Members’ roles: Development of the algorithm to estimate the forest photosynthetic potential and biomass by satellite remote sensing data in the boreal forest in Alaska
BACKGROUND:
Significance of vegetation functions in the environmental carbon cycle for the understanding of climate change

- **Carbon flow** between land surface and atmosphere through photosynthesis and respiration → Requirement to estimate the leaf area index (LAI), a biophysical parameter of photosynthetic potential, by satellite remote sensing.

- **Carbon stock** → Requirement to estimate the biomass of vegetation by satellite remote sensing.
OBJECTIVES:

A) Forest above-ground biomass mapping by ALOS/PALSAR
   a. Algorithm development to estimate the forest above-ground biomass (FAGB)
   b. Reduction the contaminations in ALOS/PALSAR data due to the terrain effect
   c. Monitoring of the FAGB change of forests by forest surveys as a ground truth of satellite remote sensing

B) Observational study of the bi-directional reflectance distribution function (BRDF) of the boreal forest for accurate estimation of LAI and FAGB for GCOM-C/SGLI remote sensing

C) Investigation of boreal forest phenology as revealed by satellite remote sensing (cf. Aqua, Terra/MODIS) accompanied with ground-based survey
METHODOLOGY:

In FY2012, we have mainly carried out following research activities concerning with the objectives (A) and (C).

■ For the objective (A)

a. The estimation algorithm of FAGB by ALOS/PALSAR was refined.

b. In addition to FAGB, the estimation algorithms for tree height, diameter at breast height (DBH), and tree density of forest by ALOS/PALSAR was established.

c. The essential information for the definite estimation of LAI of black spruce forest from satellite remote sensing was collected by cutting-off 16 trees in PFRR in August, 2012.

■ For the objective (C)

➢ The monitoring of the seasonal change of forest landscape was continued by the fish-eye time-lapse camera system at the top of the 17m observation tower in PFRR.
Algorithms for estimating FAGB, tree height, DBH, and tree density by the backscatter intensity (HV mode) of ALOS/PALSAR were established for boreal forests along Dalton Highway. The FAGB distribution was mapped based on the refined algorithm.
**RESULT:**

Estimation of photosynthetic potential of black spruce tree in PFRR

We carried out forest survey by cutting-down 16 black spruce trees in PFRR in August 2012, and measured the leaf area etc. for highly reliable estimation of Leaf Area Index (LAI) by satellite remote sensing data and 3D forest radiative transfer model.

Expected map of LAI based on satellite data and 3D forest radiative model
RESULT:

Validation of seasonal variation of satellite-observed vegetation index (NDVI) by fish-eye images at the tower of PFRR

Seasonal pattern of cloud-free daily satellite-observed NDVI values (MODIS) during Jan. 2010 to Dec. 2011 in Poker Flat Research Range (PFRR). Typical images of the forest landscape by the interval camera installed at the top of the 17m observation tower are presented at the top of figure.

The seasonal change of the proportion of (a) red, (b) green, and (c) blue that were extracted from the fish-eye images in 2011.
Expected outcomes of FY2012:

- The refined algorithm of ALOS/PALSAR for the FAGB estimation provides the accurate geographical distribution of the carbon stock which is required for the carbon cycle modeling.

- The cutting-down tree survey creates the definite allometry equation for the LAI estimation of needle leaves of black spruce tree.

- The monitoring of the forest landscape seasonality by fish-eye camera gives us the idea of seasonality of the ecosystem of the evergreen boreal forest which is useful for interpreting satellite remote sensing data.
Our joint analysis elaborated and demonstrated a methodology to map the FAGB, a major part of carbon stock in the carbon cycle, by using ALOS/PALSAR data.

We developed observational methodologies to estimate the photosynthetic potential, a major part of carbon, based on estimating the definite LAI and monitoring the seasonality of black spruce forest.
Challenges and Concerns:

◆ Quantifying the forest floor:

Since the boreal forests are generally sparse, the part viewable from satellite remote sensing should be largely occupied by forest floor. We have to extract some quantity from satellite data in terms of the forest floor for evaluating the vegetation. Such forest floor information will be related to the soil respiration dynamics.