ESTIMATION OF CARBON AND HEAT FLUXES BY REMOTE SENSING

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ABSTRACT

Terrestrial carbon and heat fluxes are important elements in the earth system in order to understand both consequence and cause of the climate change. For instance, atmospheric CO2 concentration is strongly controlled by the terrestrial biosphere. The rate of carbon uptake by photosynthesis activities is called as gross primary production (GPP), which can be estimated by a biosphere model based upon the light use efficiency (LUE) concept and input from remotely sensed data.

$$GPP = APAR \times LUE = (FPAR \times PAR) \times (LUEmax \times S)$$

where PAR is photosynthetically active radiation (MJ/m²/month), APAR is absorbed PAR (MJ/m²/month), FAPR is the fraction of absorbed PAR, LUE is the light use efficiency (gC/MJ) based upon the quantum efficiency of vegetation growth, and S is the stress. Furthermore, net primary production (NPP) and net ecosystem production (NEP) are defined as the rates of atmospheric carbon uptake by vegetation and the carbon exchange between the atmosphere and biosphere respectively. NPP can be estimated by subtracting the carbon flux for respiration of vegetation from GPP. Accurate estimates of the spatial and temporal patterns of GPP, NPP, and NEP are necessary to understand both the current-day and future terrestrial carbon cycles. A biosphere model, BEAMS (Biosphere model integrating Eco-physiological And Mechanistic approaches using Satellite data; Sasai et al., 2005), was used to calculate GPP, NPP, and NEP. Heat fluxes were also important to understand environmental conditions in vegetated terrain. We focused on the latent heat flux, which is closely related to photosynthetic and hydrological processes, and is calculated by summing up the three components; evapotranspiration, interception evaporation at leaf surface, and ground evaporation in our model.

The spatial distribution and temporal variations of the carbon and heat fluxes were estimated in Tokai region, central Japan, by using the MODIS and ASTER data products, meteorological data, vegetation and climate parameters, digital elevation models (DEM) as inputs to BEAMS. We confirmed that the estimated carbon and heat fluxes were consistent with the actually measured data at the ground flux sites. High NPP values were distributed over the vegetated hilly and mountain areas, and they gradually decrease towards the urban and alpine areas. The temporal trend analysis showed that NPP values averaged over the Tokai region were slightly decreasing from 2001 to 2004, although NPPs in the forests in the Pacific side and alpine regions were increasing. In general, NPP became lower when we incorporated the nitrogen cycle into BEAMS. This result indicates that nitrogen is a controlling factor to restrict plant growth in this region. It has been also proven that the spatial, seasonal, and inter-annual variations of the latent heat fluxes in this region were closely related to the climate and vegetation conditions. These results are useful to understand the status and temporal variations in carbon and heat fluxes on local to regional scales.