Overview of the CO_2 flux, meteorology and canopy phenology monitoring at the Mae Klong and Sakaerat DEF towers

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Abstract

The authors have been conducting long-term continuous observation of fluxes, i.e. exchange of CO_2, light, heat, water and so on, between the forest ecosystems and the atmosphere, and other relevant meteorological parameters at the towers in the mixed deciduous forest (MDF) in Mae Klong watershed research station and the dry evergreen forest (DEF) in Sakaerat Environmental Research Station. The towers are known as “MKL and SKR flux tower sites" among international flux monitoring communities such as AsiaFlux Network, and are also known as ones of the oldest CO_2 flux monitoring towers in Thailand, located in a typical Southeast Asian tropical seasonal forests.

Flux and meteorology monitoring at the MKL and SKR towers

At each of the two towers, more than 50 meteorological and relevant items are measured and recorded every 10-30 minutes. The overview of the long-term continuous monitoring, such as monitored items, instrumentation, and some results obtained in the previous period of the monitoring, is introduced. We are currently attempting automation of data acquisition, processing and compilation in a database by making the tower and instruments online and accessible from the server computer located in AIST Tsukuba, to improve the continuousness of the measurement and the maintenance efficiency, for further long-term monitoring.

Phenology monitoring using daily fixed-view photographs of forest canopies

As one of the topics of the monitoring at the towers, the phenology monitoring by taking daily fixed-view photographs looking down the forest canopies and automatic discrimination of phenological events by numerical analysis of seasonal patterns of daily “RGB normalized intensities”, monochromatic intensities of respective channels of RGB, normalized by the panchromatic intensity over the field of interest in the image, is introduced (Maeda, Gamo and AIST, 2004, patented in Japan). The method was developed in the Takayama TKY flux tower where AIST group has been operating the flux monitoring since 1993. We have applied the method also to the MKL and SKR towers. The photos have been taken by the originally-developed automated fixed-view camera system, installed on the MKL and SKR towers since 2006. Some results of the image analyses that indicate the characteristics of the two forest types are presented.

“Looking both the forest and the trees” – Phenology of MDF around the MKL tower

In the mixed deciduous forest around the MKL tower, some observations on the community scale (>200m) such as flux measurement on the tower and satellite vegetation indices show seasonal patterns very similar to that of an evergreen forest, e.g. larger values of GPP (Gross Primary Production) and satellite NDVI (Normalized Difference Vegetation Index) even in the winter (the dry season), while every tree gets leafless once in the dry season. The normalized intensities of the canopy photographs described in the previous section, averaged over the whole field of the view (approximately 200m in radius) also showed small seasonal variation as if the forest is evergreen.

In order to reveal the reason of this fact, we conducted an analysis of the photo images on the scale of individual trees by dividing the field of the view. The result showed that the timings of the offset and onset of foliation were quite different among the tree species around the MKL tower. And the trees having old leaves, the ones with new leaves, and leafless trees were coexisting during the dry season. Hence the forest canopies in the whole field of view had been not totally leafless during the dry season. This heterogeneity not only spatial but also temporal due to the variety of tree species mixed in the forest seemed to be one of the causes of the obscure seasonal variation of the normalized intensities on the community scale.

The analyses of the photo images on the individual tree species also showed that the seasonal patterns of the normalized intensities were peculiar to each species indicating characteristics of the leaf phenology and events specific to the species. For example, the greenness of *Xylia xylocarpa* started to decrease just after completion of opening new leaves and continued decreasing even in the rainy season. On the other hand, *Shorea Siamensis* kept greenness throughout the rainy season. The yellow blossoms of *Dillenia parviflora* that endure only for a few days a year could be also detected in the time series of the normalized intensities.

“Always green, but changes with rain” – Phenology of DEF around the SKR tower

The top canopies of the forest around the SKR tower consists of evergreen trees that have always green color. Even in such forest, the normalized intensities showed seasonal variation corresponding to its phenology. While the drastic change of the normalized intensities of the photographs in deciduous forests appear during the dry season by the senescence of old leaves and emergence of new leaves, the largest change in the forest around the SKR tower appeared in the middle of rainy season, around June, July, and August. According to the detailed observation of the photographs and the in-situ eye observation at the tower, this is due to the emergence of the new leaves covering the surface of the canopies and subsequent change of their colors associated with maturing process. This is difficult to detect by satellite vegetation indices because of the clouds during the rainy season.

In the three years from 2006 to 2008, the greening-up period was during 210-240 DOY and almost same among the years from 2006 to 2008, as if it is dependent on the photoperiod. However, the green-up in 2009 occurred in 270-300 DOY, 2 months later than the previous 3 years. The inter-annual comparison of climatic parameters showed that the soil water content during 200-220 DOY was small at the same level as the dry season due to the smaller rainfall caused by El Nino in the beginning of the rainy season. Then the greening-up was initiated by the rapid

increase of the soil water with the heavy rain after 240 DOY. This suggests that the rainfall in the early rainy season is strongly coupled with the delay of the greening-up.

From the aspect of the long-term trend of climate change, according to the observation by the Thai meteorological department, the rainfall amount at Nakhon Ratchasima observatory during the so-called dry season from November to April has been increasing year by year since the middle of 1990's. Further investigation for the influence of such shift in the seasonal variation of rainfall on the water-limited forests in Thailand should be encouraged.