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Detection of vegetation phenology across Japan by using digital time-lapse cameras

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Many recent studies have reported earlier timings of leaf flush and later timings of leaf fall around the world with progress of recent global warming. Seasonal change (phenology) of vegetation is an indicator for the climate change, and also is one of the important parameters for terrestrial ecosystem models to estimate the carbon balance. For detection of the long-term changes in vegetation across wide areas, remote sensing technique is expected as a useful tool. However, due to the limitations of spatial resolution and observing frequency, it is difficult to detect the species specific environmental responses by satellite. Therefore, we collected high temporal and spatial resolution images by using digital time-lapse cameras. The purpose of this study is to detect phenology at a community or a species level for various types of vegetation across Japan, and to analyze the relationships between phenology and temperature.

We used the images of live camera archives such as "Phenological Eyes Network (PEN)", "Internet Nature Information System" of the Ministry of the Environment, "Mt. Hiei live camera" of Kyoto Prefectural University, "Cyberforest" of Tokyo University and so on, which were taken in 2002-2014. Images of approximately 120 site·year at 20 sites across Japan were analyzed. The areas of interest for vegetation a community or a tree within the images were selected for analysis. RGB digital counts in each pixel in the areas were extracted and Green Ratio Index (GR= G/ (R + G + B)), which varies seasonally reflecting leaf greenness, was calculated at daily step. The time series of GR showed the maximum rate of change on the timings of leaf flush and leaf coloring, consequently, the dates of start/end of green leaves (SOG/EOG) were estimated. Furthermore, we investigated the relationships of the inter-annual variations between SOG/EOG and the temperature at each site.

The estimated SOG/EOG showed large variations across both years and areas, although earlier or later phenological trend during 2002-2014 was not recognized so far. Nationwide earlier SOG in 2002, 2004 and 2009, and later EOG in 2005, 2010 2012 were found. When the green leaved season started earlier than other years, it tended to end relatively later. Vice versa, when the green leaved season started later than other years, it tended to end relatively earlier. Such tendency of earlier or later SOG sometimes differed from the districts even in the same year. SOG or EOG of each community or species had high correlations with the mean temperature during respectively March-April or September at each sites. The impact of the climate change was discussed from the view point of species-specific and site-specific temperature sensitivities of the estimated SOG/EOG.

For assessment of the impact of climate change on vegetation, we need to observe the phenology at more sites for longer term. We plan to install more cameras and to analyze much more data including the uploaded images on the Internet. In addition, it is necessary to keep updating the existing camera systems and to administrate the observation networks sustainably.

Keywords: Time-lapse camera, Phenology, RGB, temperature sensitivity

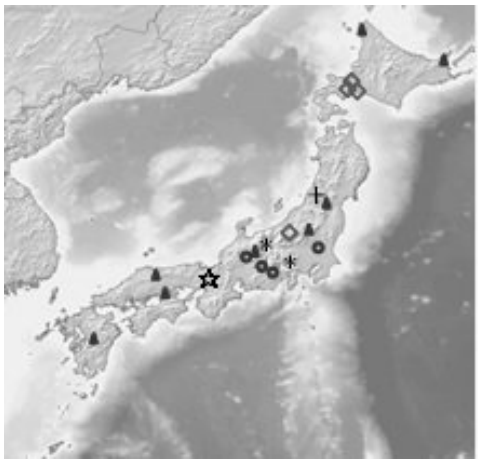

Fig.1 Study sites of PEN(○), Internet Nature Information System(▲), Cameras of National Institute for Environmental Studies(◇), Mt.Hiei live camera(☆), Cyberforest(*),and Mt Chokai live camera(+).