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Assessing CO_2 Uptake by the Haean Landscape: Linking a Physiologically-based Canopy Model and MODIS Vegetation Indices

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18

Problem Statement

Estimating CO_2 uptake at landscape scale and the subsequent conversion of GPP to yield of agricultural crops requires the aid of remote sensing (RS). RS indices together with land cover maps allow description of crop stand development at many different locations. The observed phenology, however, reflects changes in both the amount of aboveground chlorophyll (LAI) and associated physiology of photosynthesis. We aim to relate NDVI to a single model parameter that describes seasonal structural as well as functional change in the carbon uptake capacity of crop canopies and can be effectively used to describe landscape level GPP in Haean Catchment.

Objectives

- Utilize existing eddy covariance determinations of GPP to determine seasonal courses of carboxylation capacity (Vc_{uptake}) of major crops in Haean Catchment (Fig 1. Step 1)
- Approximate for each major crop an approximate fixed seasonal description of canopy physiology
- Estimate a "mixed" parameter (Fig 1. Step 2: LAI_{adj}) to account for all remaining seasonal change in carbon uptake capacity
- Relate LAI_{adj} to RS indices at daily time scale
- Determine seasonal change in RS indices for the Haean Catchment and estimate GPP with highest possible resolution
- Eventually combine the GPP analysis with other information to obtain spatial estimates of ET and NEE for Haean Catchment

Materials and Methods

We estimated Vc_{uptake} for major Haean crops with locally measured and with network eddy covariance data: paddy rice from Korea, Japan and Spain, sugar beet as a radish surrogate from Europe, potato from Haean and Europe, soybean from USA. Data for the 5th major crop cabbage are not available. The procedures shown in Fig. 1 are conducted for each crop.

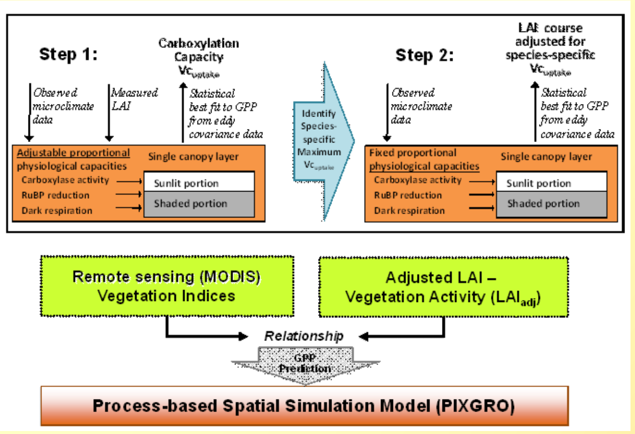

Fig. 1. Relationships between measured data, derived PIXGRO production model parameters, and MODIS vegetation indices

Additional analysis is carried out with paddy rice to determine whether there are geographical differences in canopy function and development.

Results

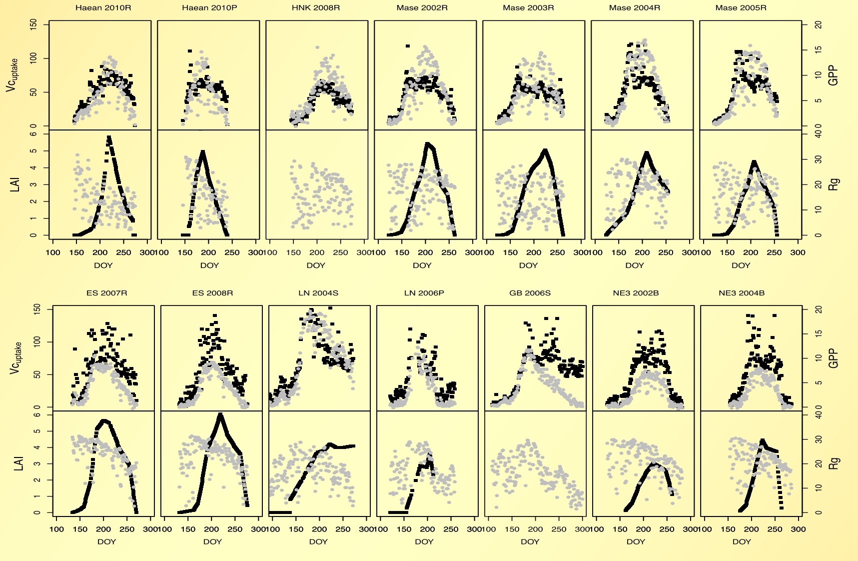

Fig. 2. Seasonal course of global radiation (R_g), GPP, LAI, and Vc_{uptake} at each eddy site. R stands for Rice, P for potato, S for sugar beet, and B for soybean.

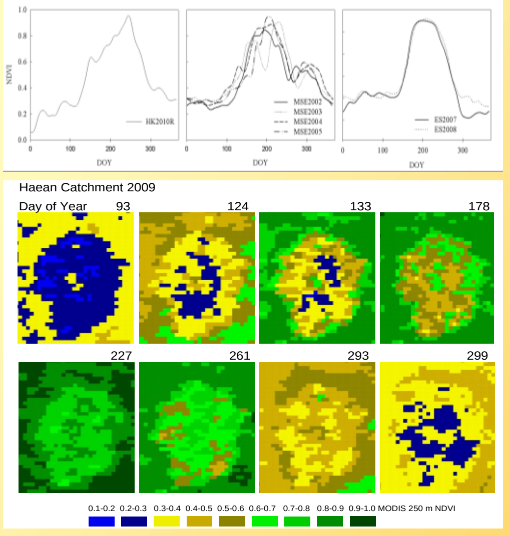

Fig. 3. A comparison of MODIS 250 m NDVI at paddy rice sites Haenan, Korea, Mase, Japan and El Saler, Spain (upper); seasonal variation of NDVI at the Haean Catchment in 2009 (lower)

Analyses of Step 1 (cf. Fig.2) provide the basic response characteristics for uptake capacity (Vc_{uptake}) of major crops. Development of statistical routines provide MODIS smoothed vegetation indices also on a daily time scale (cf. Fig. 3). Applied at 250 m resolution, we obtain a picture of apparent changes in landscape physiology in Haean Catchment (Fig. 3). A broad analysis of rice response is being undertaken (Fig. 4).

Ongoing work relates to deriving in Step 2 the time courses for LAI_{adj}, coupling these to the vegetation indices, and applying the result to assess GPP at landscape scale.

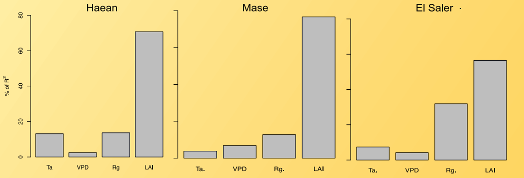

Fig. 4. Relative importance of variables influencing GPP of rice at Haenan, Korea, Mase, Japan and El Saler, Spain ;*Y = a (Air temperature) + b (VPD/Relative Humidity) + c(Radiation) + d (LAI) + h*