Ecosystem-atmosphere exchange of carbon dioxide and water vapour in typical East-Asian croplands

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Background & motivation

- TERRECO: energy and matter flux data for models (e.g. PIXGRO, WRF, Hydrus 2/3D)
- Data-sets from eddy-covariance technique: gap-filling
- Summer monsoon

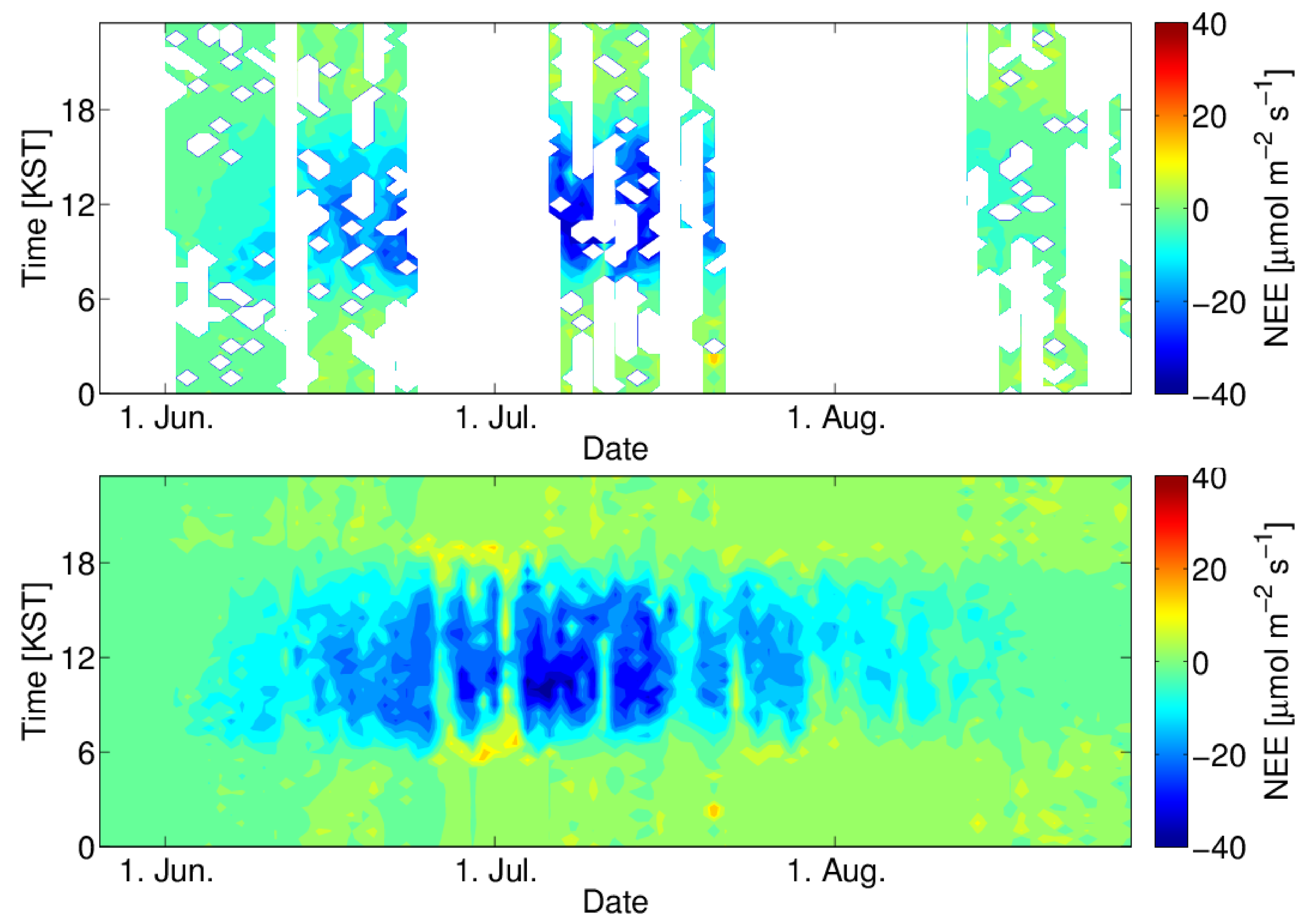


Fig. 1. Hovmoller diagrams of NEE data before (top) and after (bottom) gap-filling

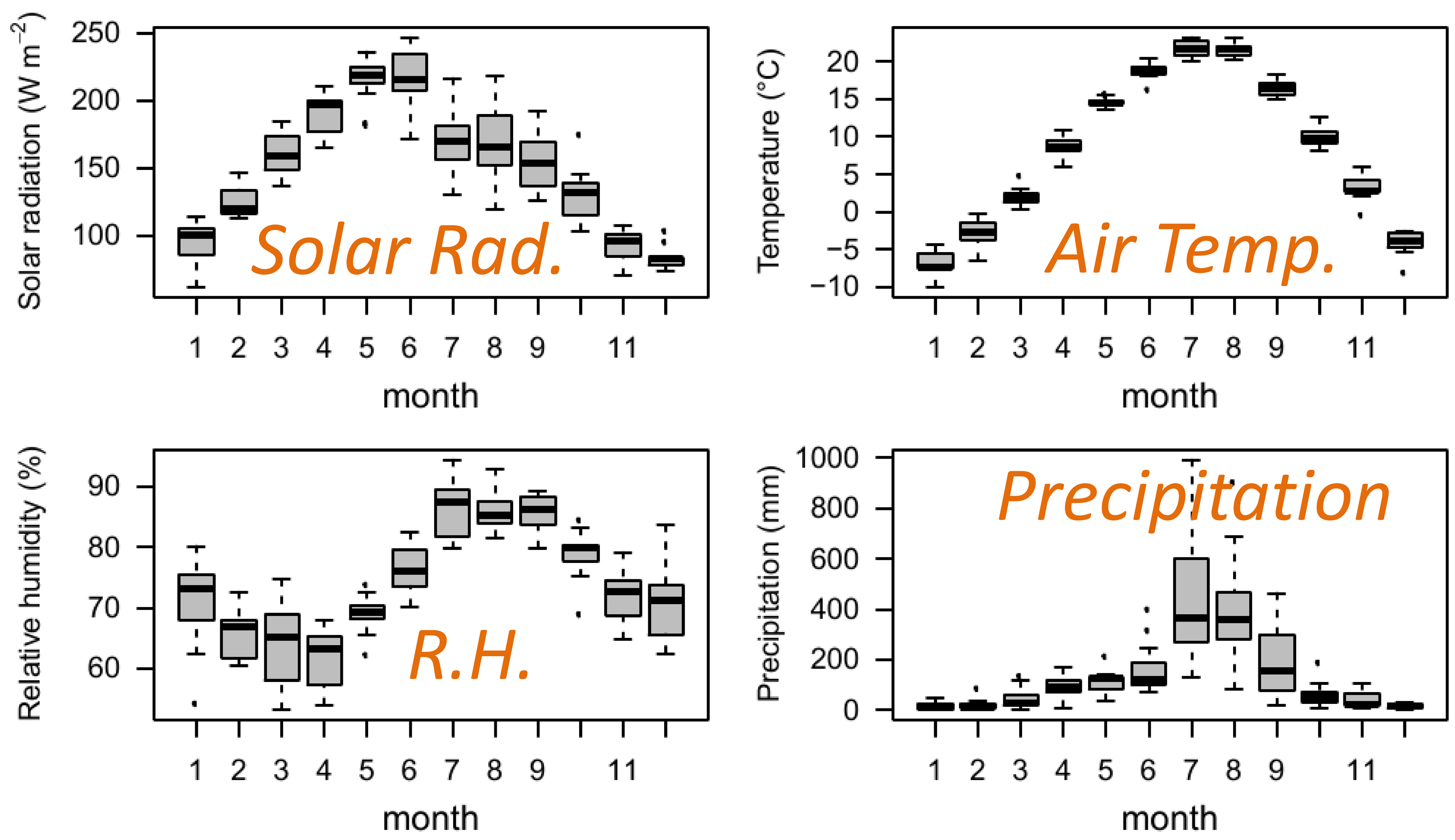


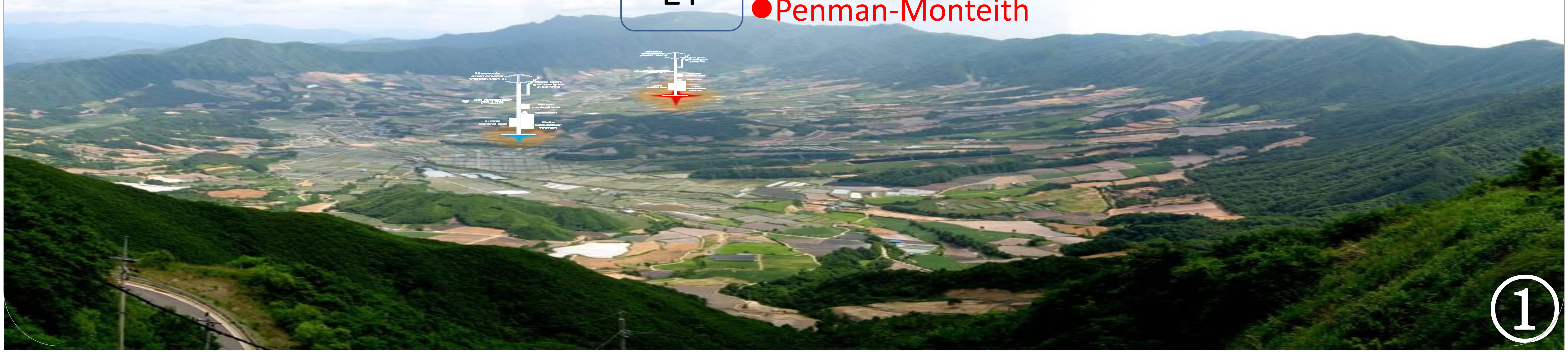
Fig. 2. Climate conditions in the research region

Meterials & methods

Field campaigns

- TK2
- QC
- Footprint
- Outlier filter
- Energy-balance correction

Flux data with gaps → NEE (Michaelis-Menten) / ET (Penman-Monteith) → Flux data without gaps → Flooded vs. Non-irrigated



Hypothesis 1: Michaelis-Menten model could be improved for the simulation of carbon dioxide flux and therefore for the gap-filling of NEE data.

Results

$$\mathrm{NEE} = R_{\mathrm{eco}} + \frac{\alpha R_{\mathrm{g}} \beta}{\alpha R_{\mathrm{g}} + \beta}$$

R_{eco}

$$R_{\mathrm{eco}} = R_{\mathrm{ref}} e^{E_0\left(\frac{1}{T_{\mathrm{ref}}-T_0} - \frac{1}{T-T_0}\right)}$$

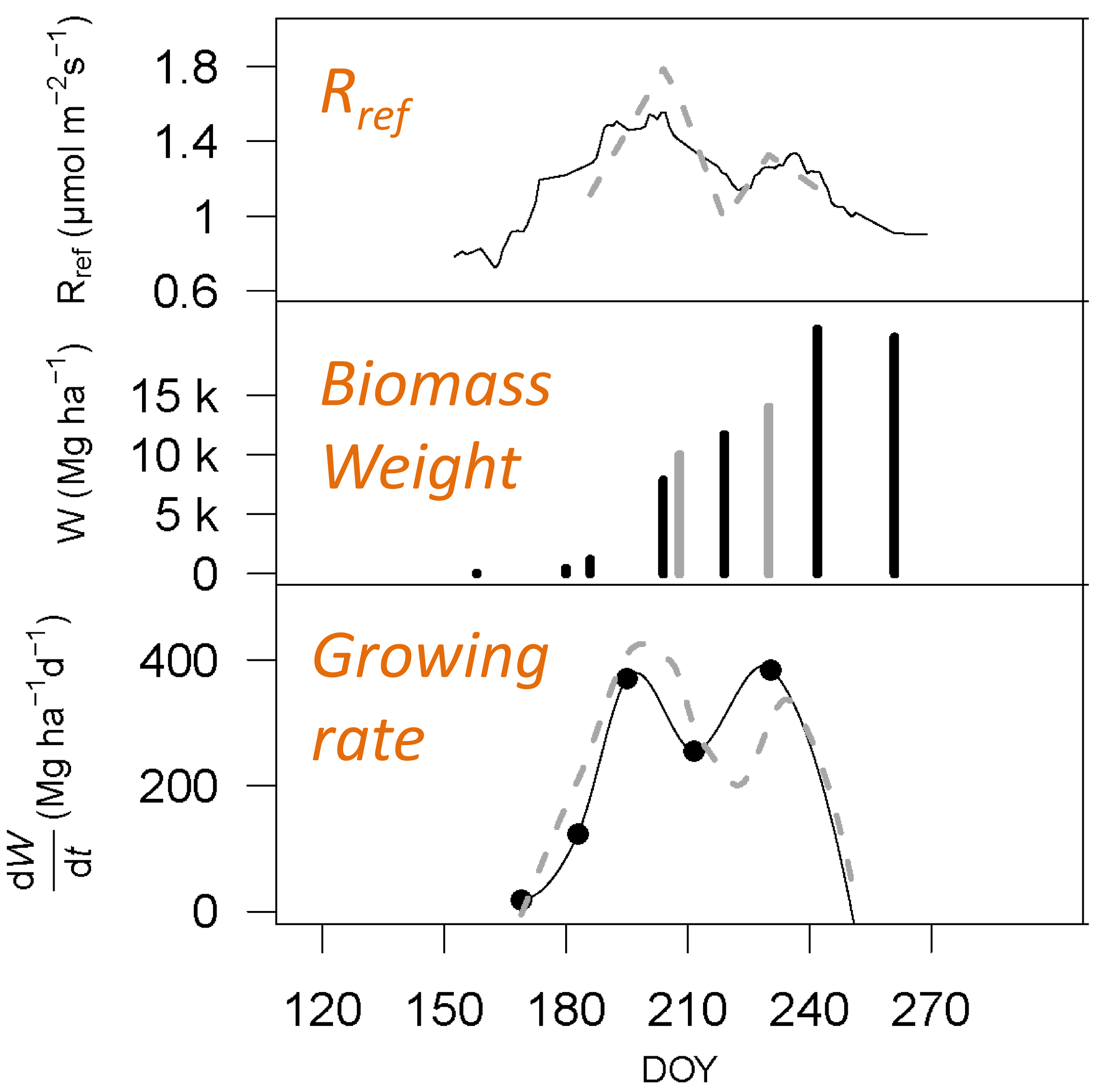


Fig. 3. Seasonal course of R_{ref} above-ground biomass dry weight, and growing rate of above-gournd biomass

$$R_{\mathrm{plant}} = a\frac{\mathrm{d}W}{\mathrm{d}t} + bW$$

Construction + maintenance

GPP

$$\mathrm{GPP} = \frac{\alpha R_{\mathrm{g}} \beta}{\alpha R_{\mathrm{g}} + \beta}$$

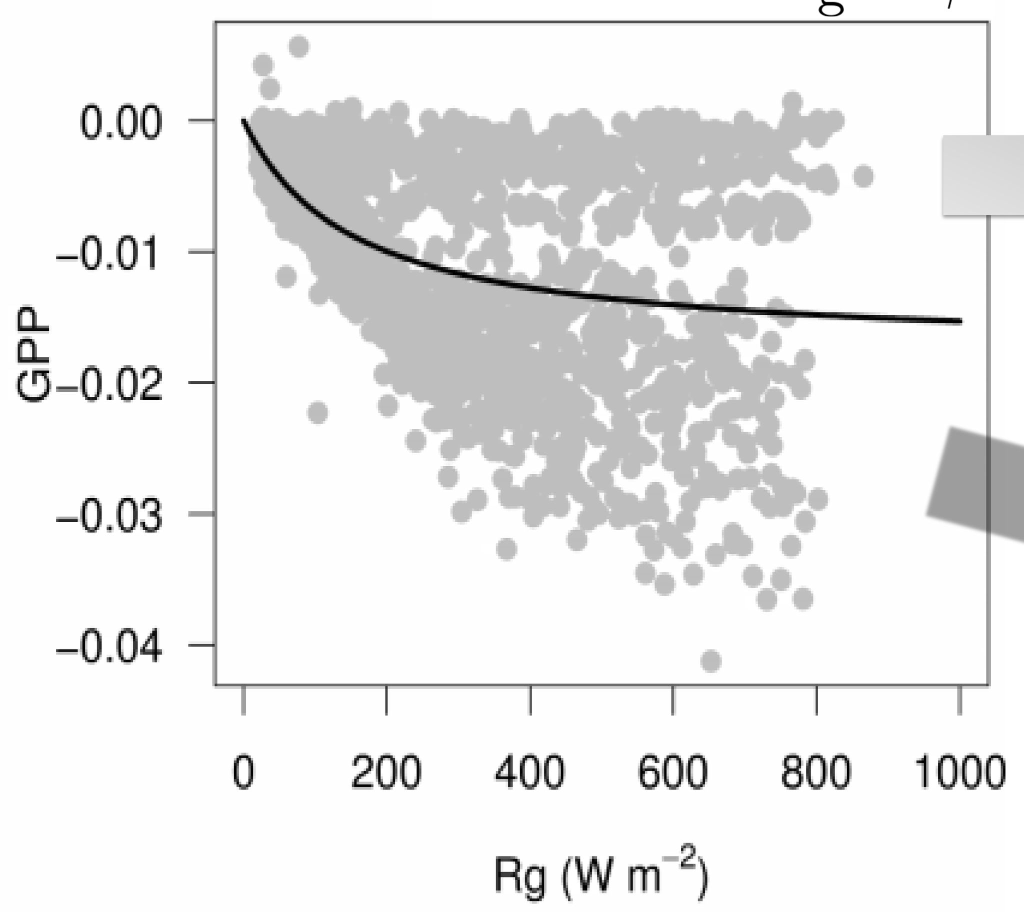


Fig. 4. Visualization of Michaelis-Menten function

Temperature? No.

- Temperature range
- Temperature window approach

Humidity? No.

- High humidity
- Except the early stage of potato

Growing stage? Yes.

- 2-day time windows for potato, 4-day for rice
- linear relationship between parameters and LAI

$$\mathrm{GPP} = \mathrm{LAI}_{\mathrm{act}} \frac{\alpha' R_{\mathrm{g}} \beta'}{\alpha' R_{\mathrm{g}} + \beta'}$$

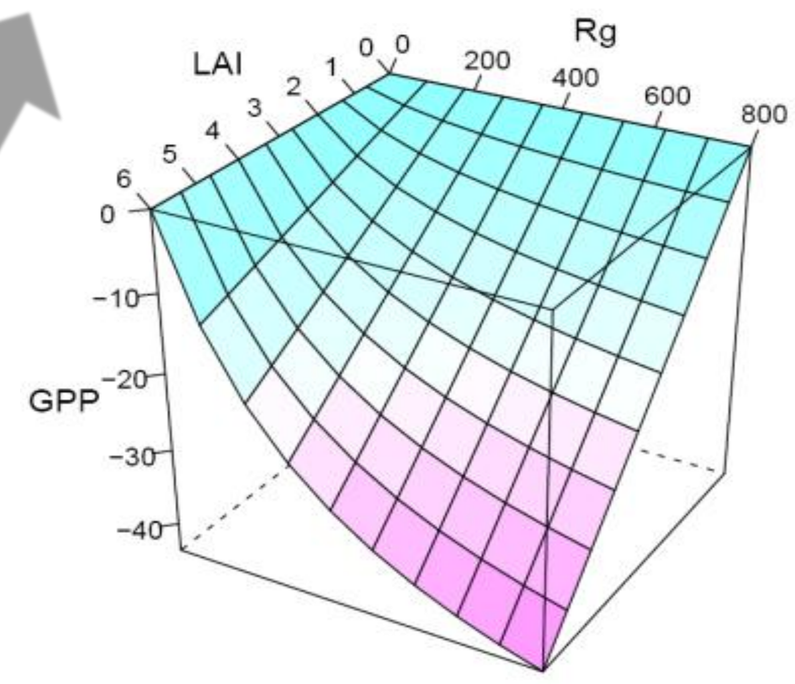


Fig. 5. Visualization of leaf-light response fuction

Conclusions

- Controlling factors
  - ○ GPP: LAI, solar radiation ○ R_{ref}: W, dW/dt
- Site-specific optimization of time window approach and the leaf-light response function are efficient gap-filling methods.
- Michaelis-Menten model is improved by including the influence of vegetation condition.

Hypothesis 2: PM-KP method could be a better alternative than PM-FAO model for the estimation of evapotranspiration over croplands.

Results

$$\text{Penman-Monteith: } Q_{\mathrm{E}}^{\mathrm{PM}} = \frac{s_{\mathrm{c}}(-R_{\mathrm{n}}-Q_{\mathrm{G}})+\frac{\rho c_{\mathrm{p}}(e_{\mathrm{s}}-e_{\mathrm{a}})}{r_{\mathrm{a}}}}{s_{\mathrm{c}}+\gamma(1+\frac{r_{\mathrm{s}}}{r_{\mathrm{a}}})}$$

r_s : stomatal resistance

PM-FAO

$$r_{\mathrm{s}} = \frac{r_{\mathrm{si}}}{\mathrm{LAI}_{\mathrm{active}}}$$

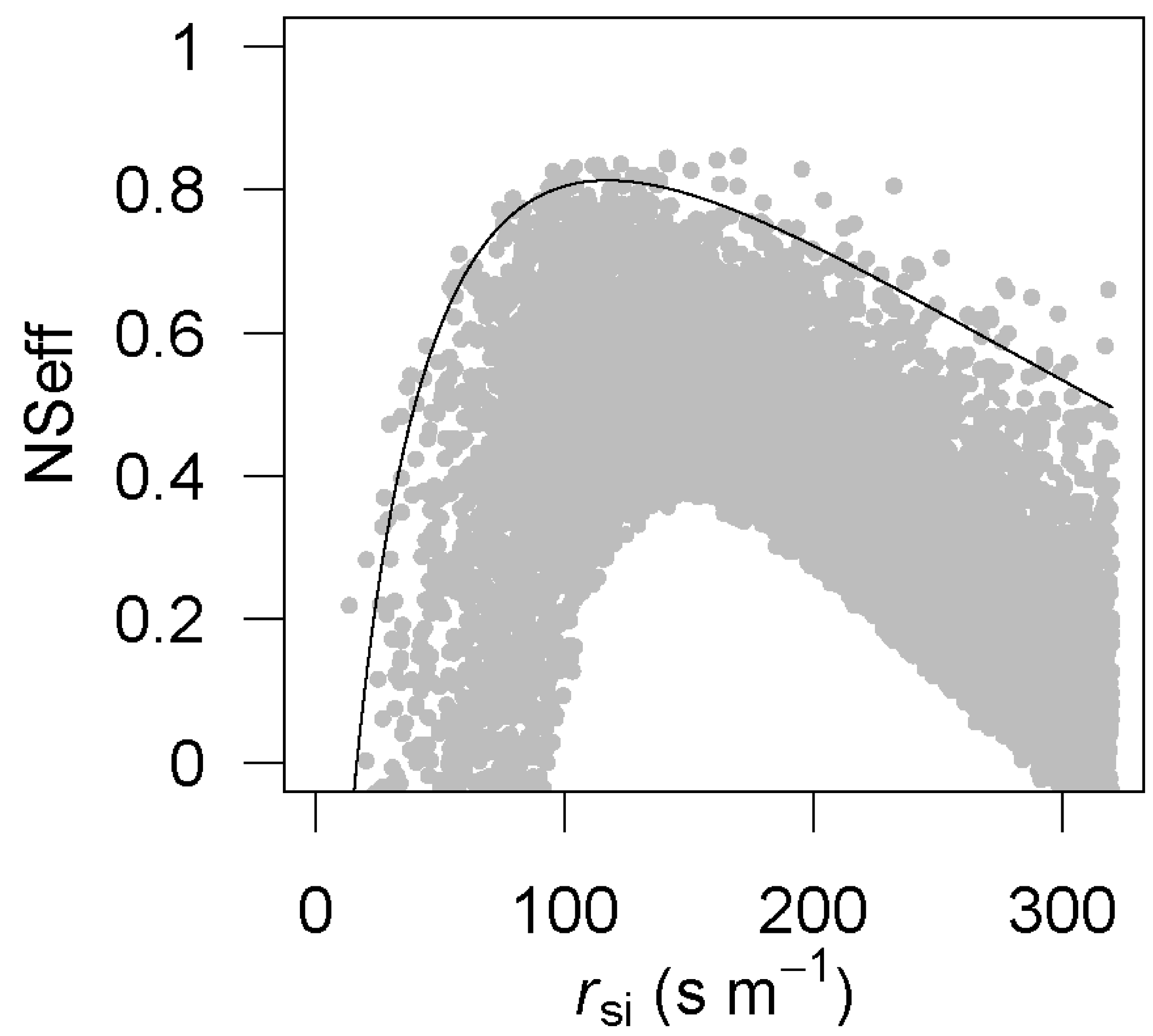


Fig. 6. Sensitivity graph for model efficiency to r_{si} (potato)

- Literature value: 70 to 80 s m^{-1}
- Optimized value: 117 s m^{-1} (potato), 38 s m^{-1} (rice)
- Transpiration dominated crop

PM-KP

$$\frac{r_{\mathrm{s}}}{r_{\mathrm{a}}} = a\frac{r^*}{r_{\mathrm{a}}} + b$$

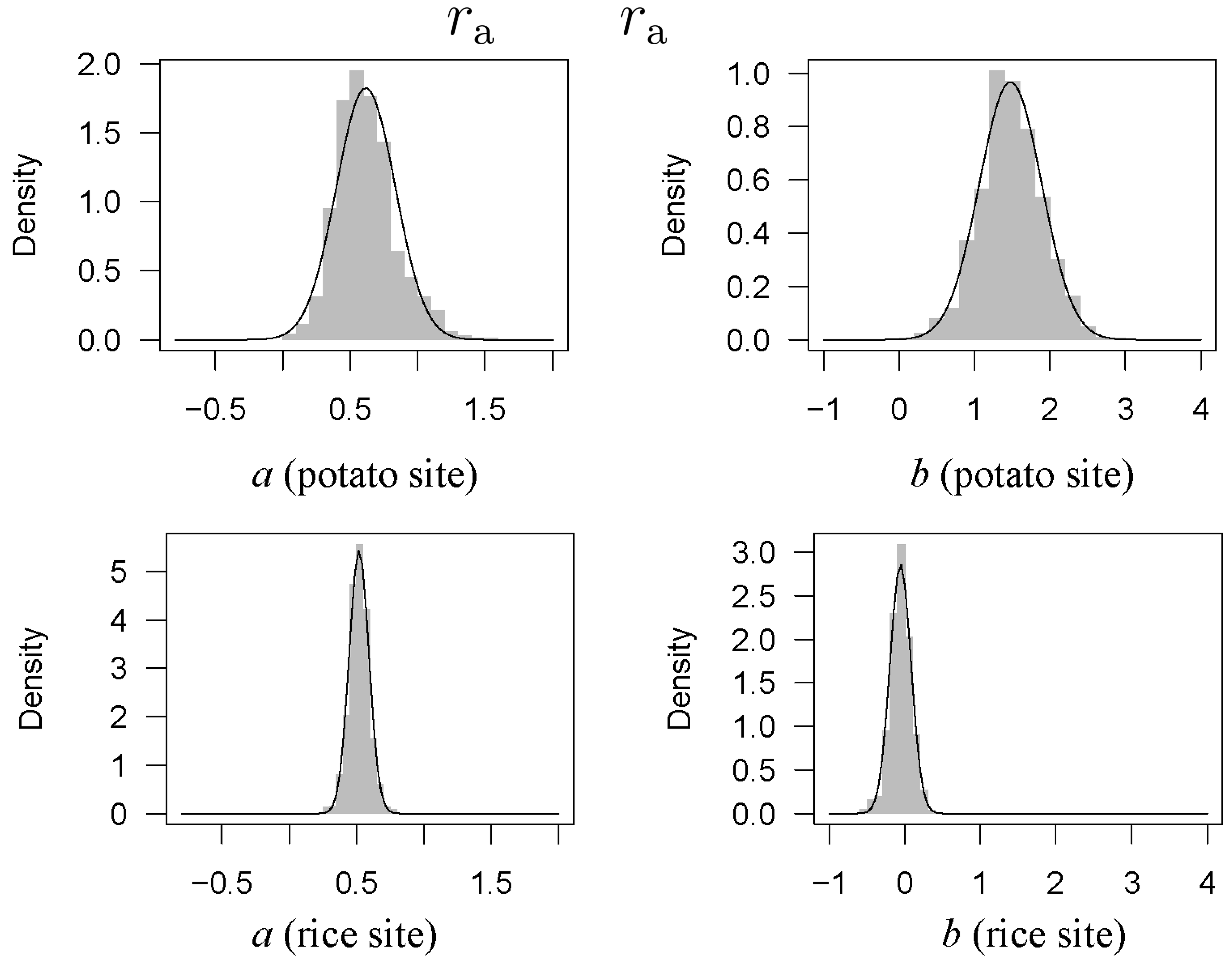


Fig. 7. Distributions of a and b

- 20 randomly-sampled records? sufficient for rice, but not for potato
- Evaporation dominated crop

Conclusions

PM-FAO	PM-KP
good for transpiration dominated cropland; better if r_{si} is site-specifically calibrated	good for evaporation dominated cropland

Hypothesis 3: Land-use change between flooded and non-irrigated crops could result in great difference in energy and matter exchange in croplands.

Conclusions

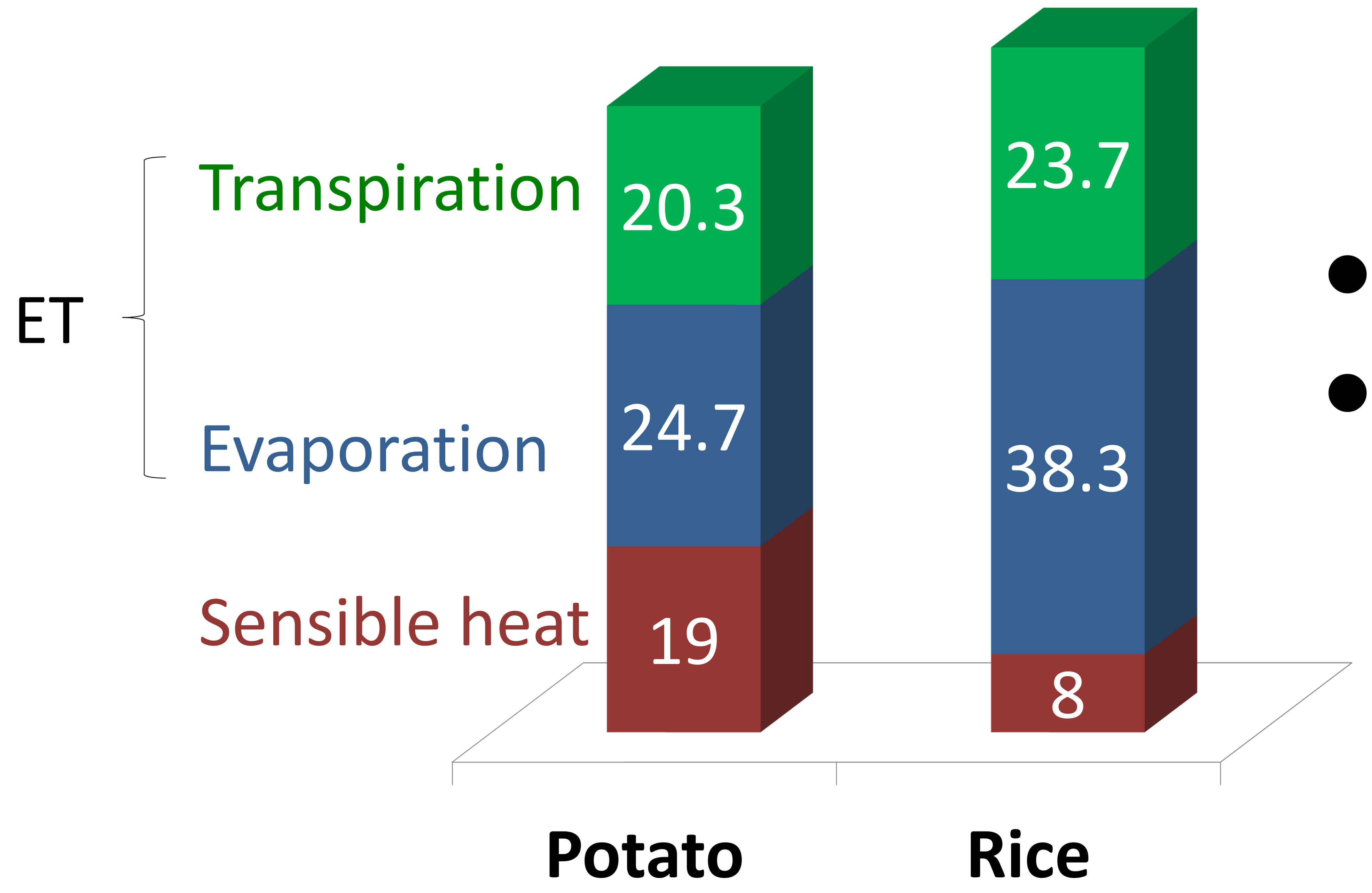


Fig. 8. Seasonal mean turbulent energy fluxes (in W m^{-2})

- Sensible heat: H_{potato} : H_{rice} = 2.4 : 1
- Latent heat: E_{potato} : E_{rice} = 0.7 : 1

- NEE_{potato} : NEE_{rice} = 0.80 : 1
- GPP_{potato} : GPP_{rice} = 0.88 : 1

- Conversion between different croplands could result in evident impact on energy and carbon balance

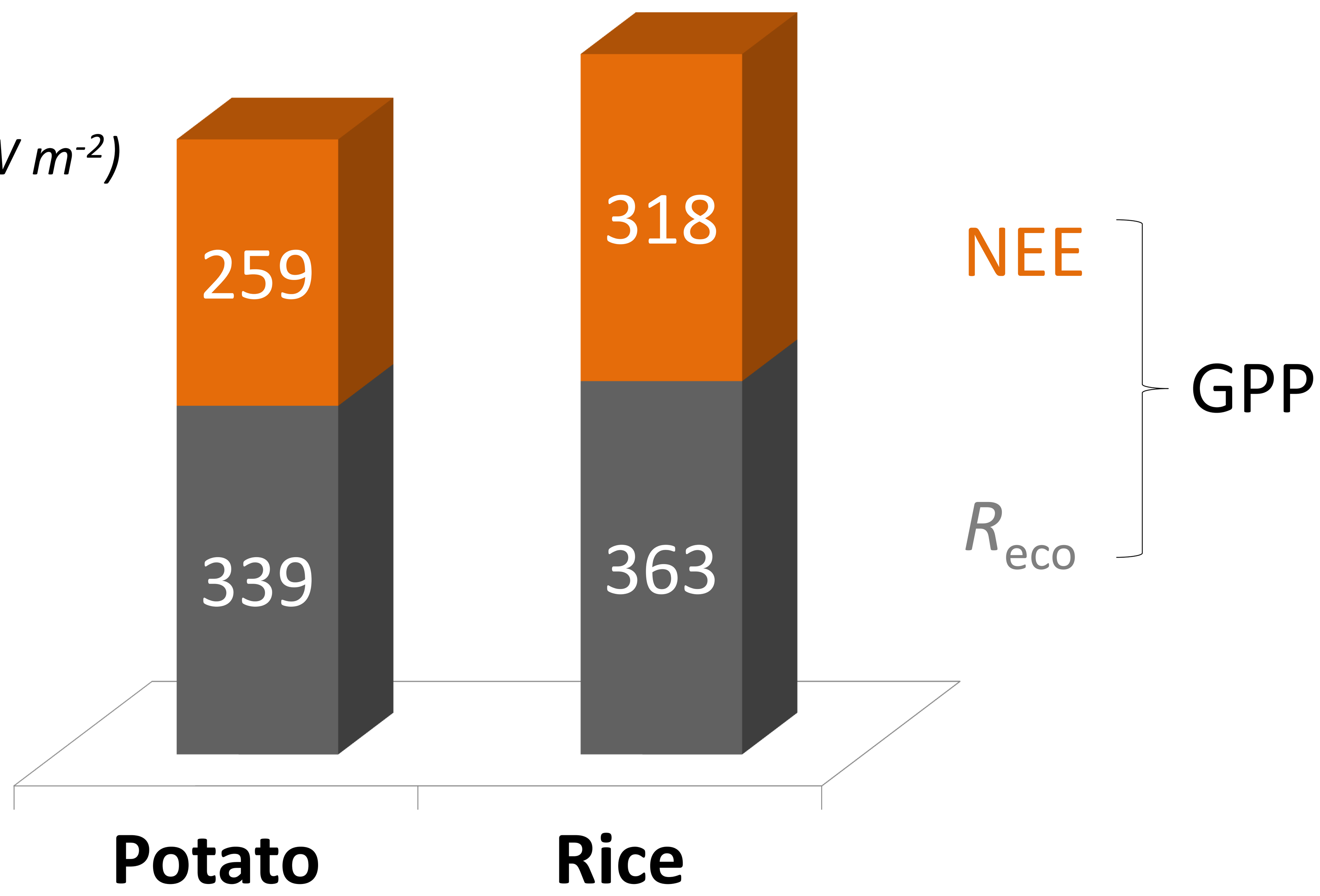


Fig. 9. Seasonal flux of CO_2 exchange (in gC m^{-2})

Outlook

- Gap-filling methods for other ecosystems
- Light-leaf response function should be further evaluated
- Crop response to climate change