Complex Terrain and Ecological Heterogeneity (TERRECO): Evaluating Ecosystem Services in Mountainous Landscapes

Energy and CO$_2$ exchange between agro-ecosystems and the atmosphere over a complex terrain in Korea

UNIVERSITÄT BAYREUTH

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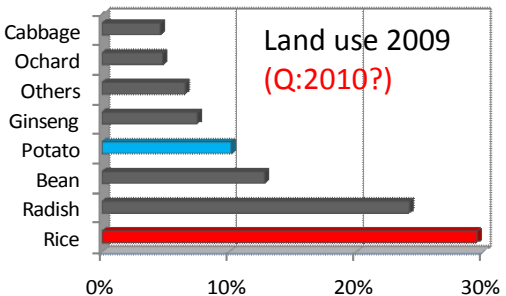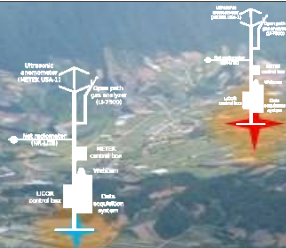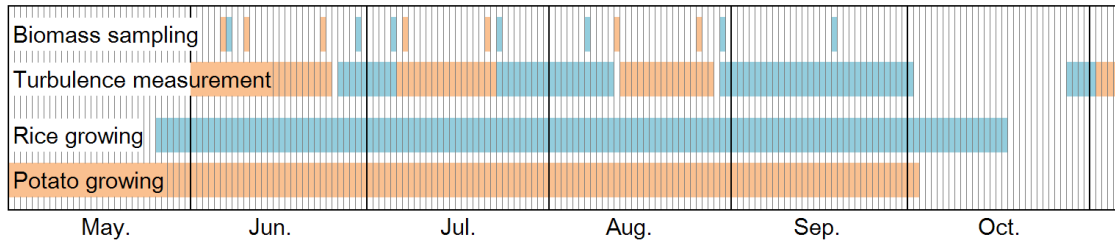, University of Bayreuth, Germany

Bayreuther Zentrum für
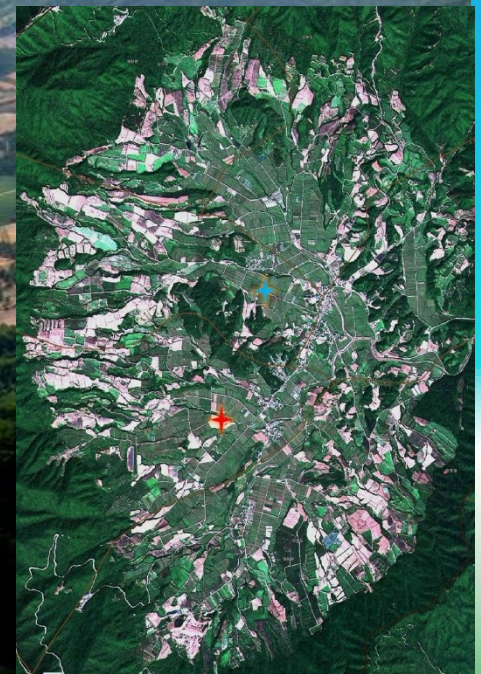Ökologie und Umweltforschung
BayCEER

TERRECO

Objectives

- Eddy-covariance technique ~ complex terrain
  - Site selection and footprint analysis
  - Data quality control
  - Gap-filling
- Energy and CO_2 exchange over croplands at Haean
  - Monsoon
  - Length of growing season
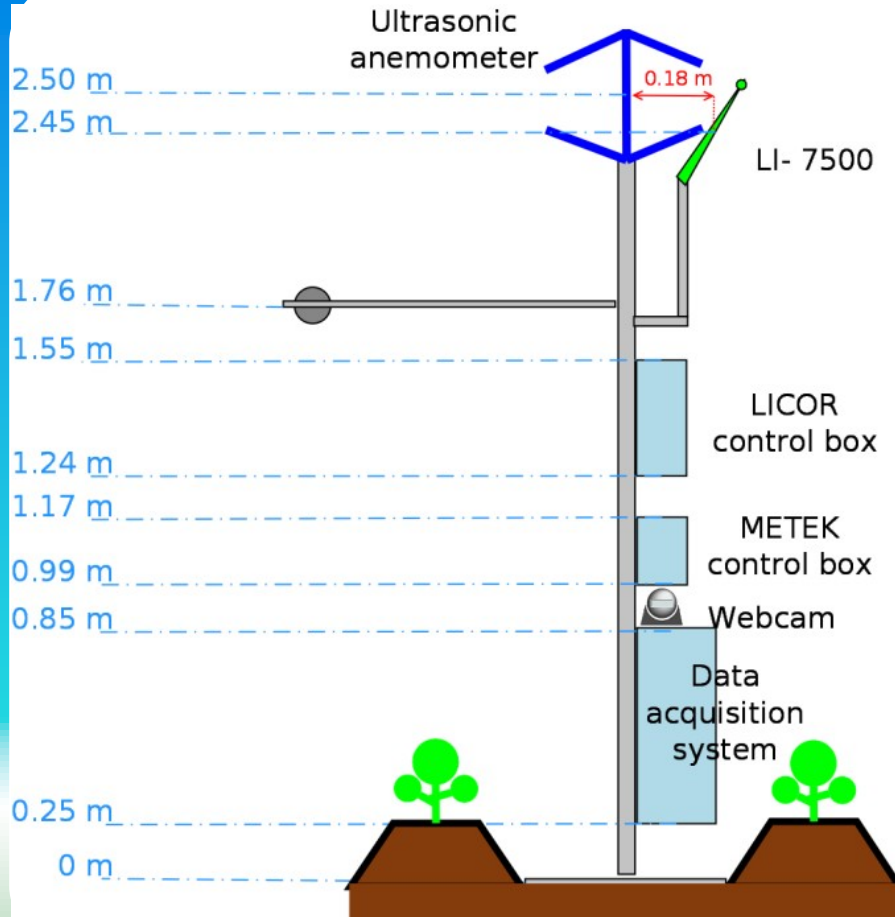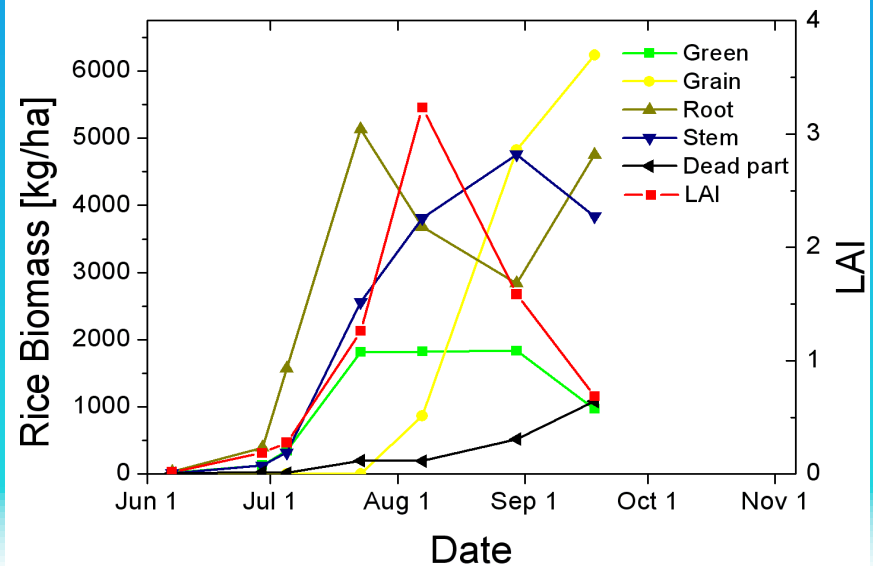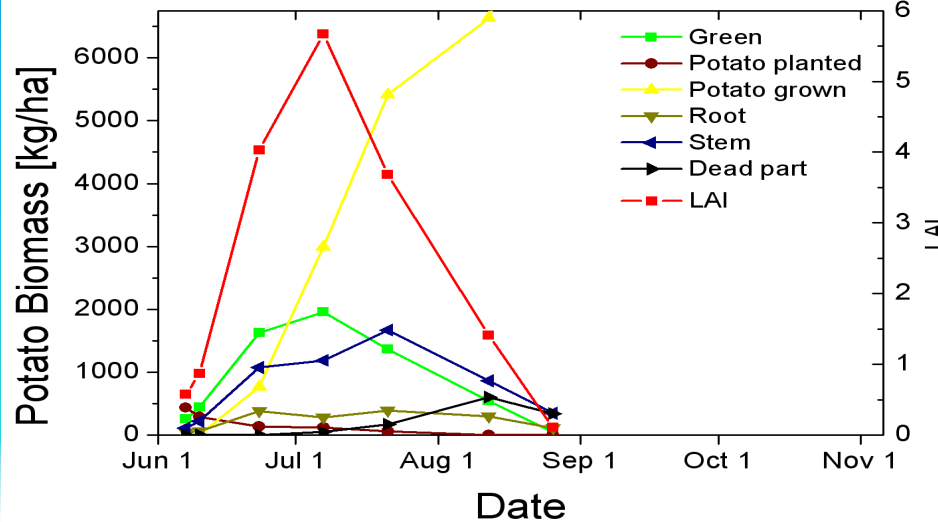- Input or validation for models

Field campaign 2010

Biomass sampling
Turbulence measurement
Rice growing
Potato growing

May.   Jun.   Jul.   Aug.   Sep.   Oct.

Land use 2009
(Q:2010?)

Cabbage
Ochard
Others
Ginseng
Potato
Bean
Radish
Rice

0%   10%   20%   30%

Yanggu County Office (2010)

Eddy-covariance

$$F = \overline{w'x'}$$

TK2 (Mauder and Foken, 2004)
TK3 (Mauder and Foken, 2011)

Biometric measurements
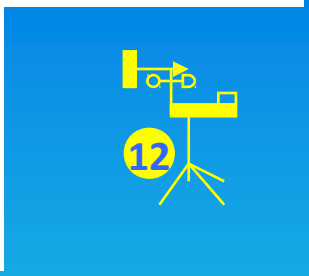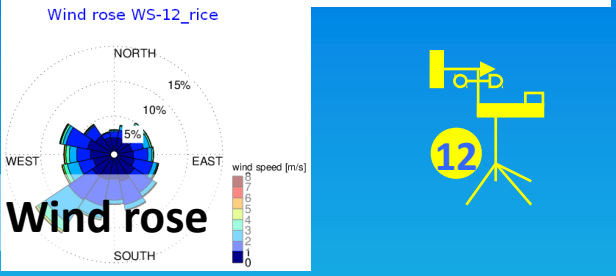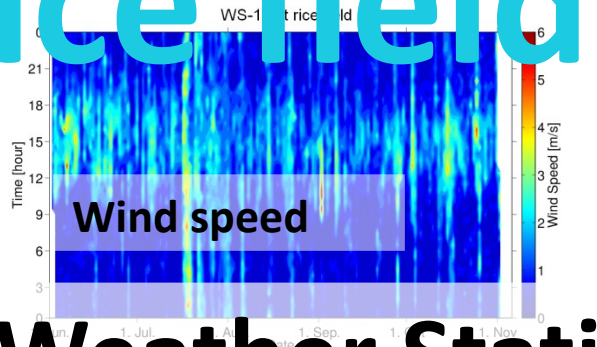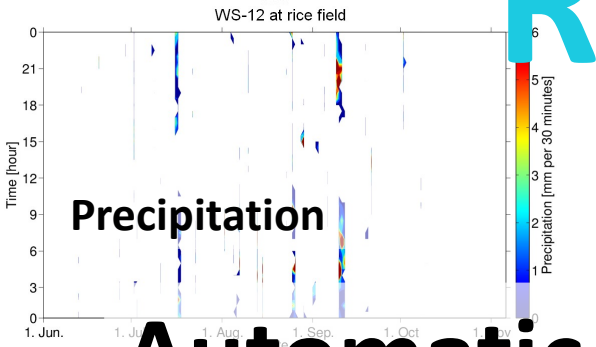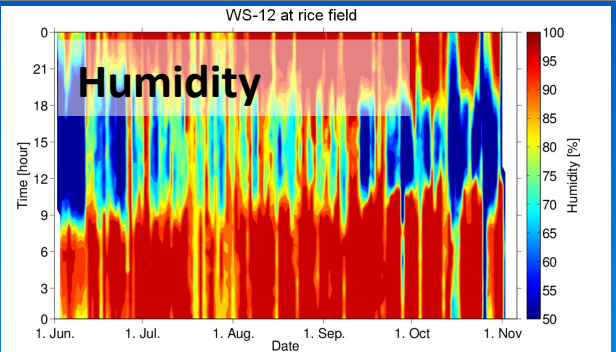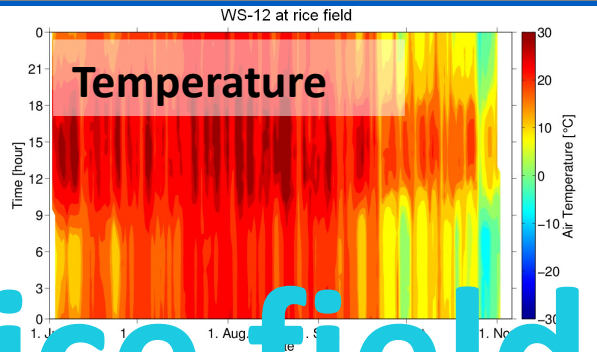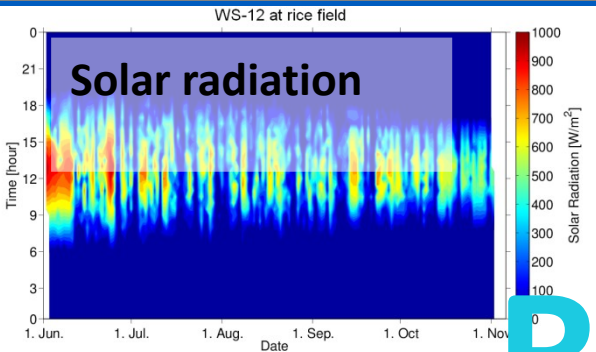
Automatic Weather Stations (AWS)

Rice field

Potato field

rice

rice

rice강원도
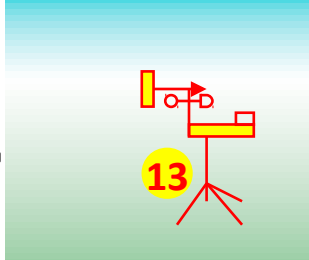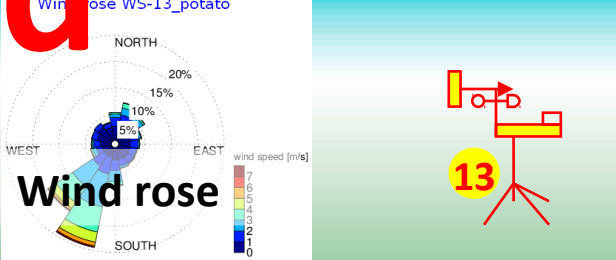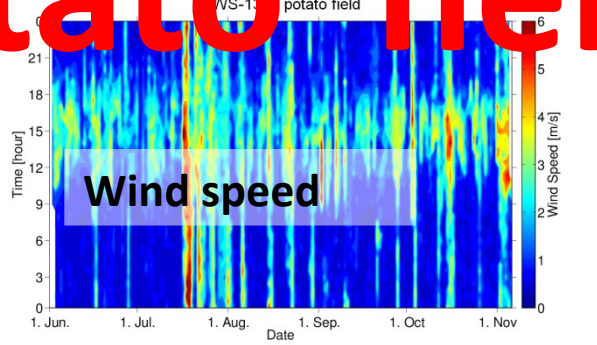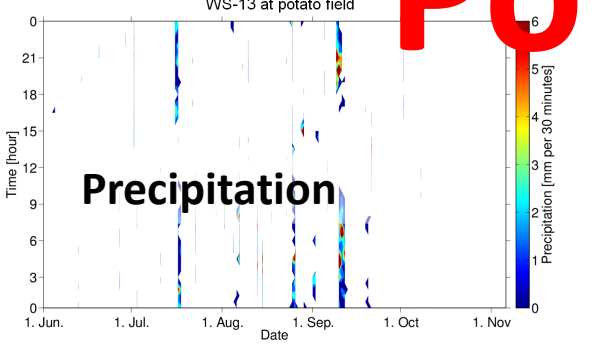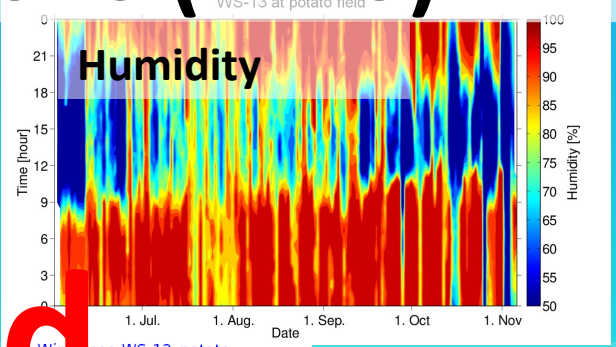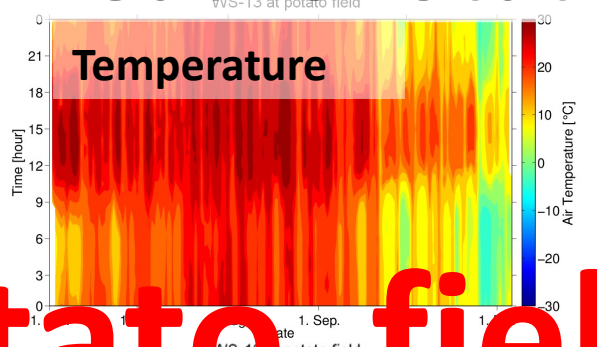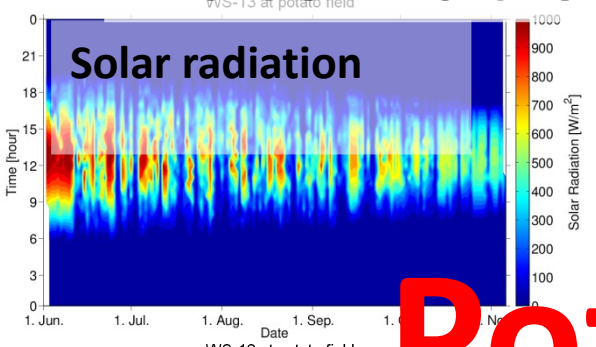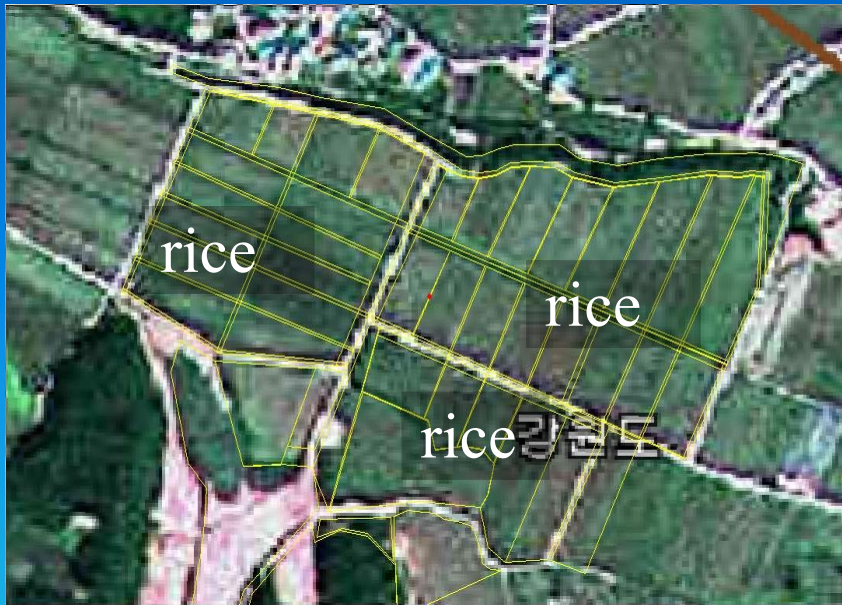
Altitude Rice Field, Haean, Korea

Legend
	436		450
	437		451
	438		452
	439		453
	440		454
	441		455
	442		456
	443		457
	444		458
	445		459
	446		460
	447		461
	448		463
	449		

0 20 40   80   120 160 Meters
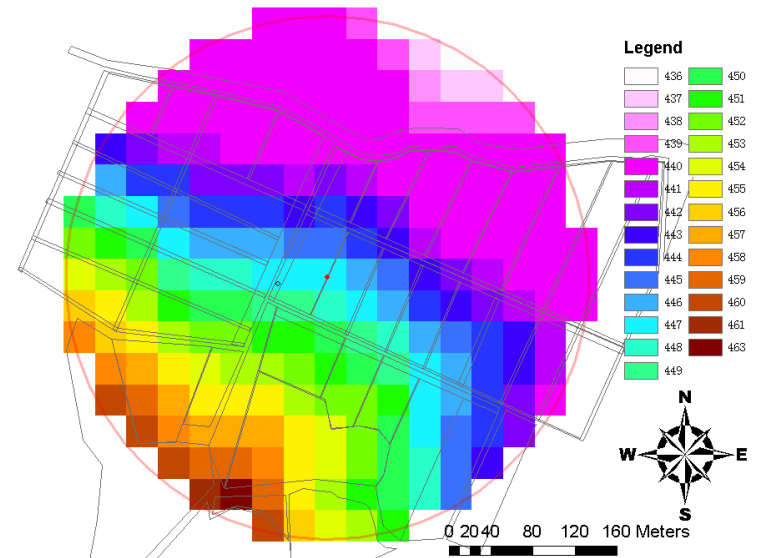
Aspect Rice Field, Haean, Korea

Legend
- Flat
- North
- Northeast
- East
- Southeast
- South
- Southwest
- West
- Northwest
- North

0 20 40   80   120 160 Meters

Slope Rice Field, Haean, Korea

Legend
Slope_Rice
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6

0 20 40   80   120 160 Meters

Altitude Potato Field, Haean, Korea

Aspect Potato Field, Haean, Korea
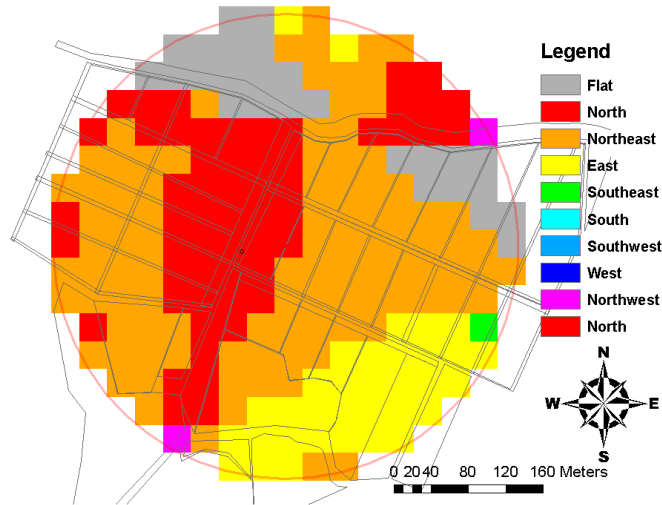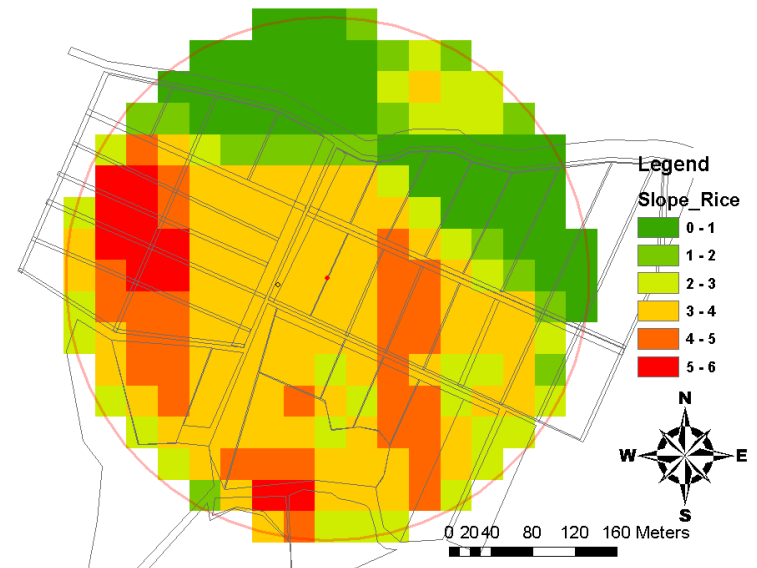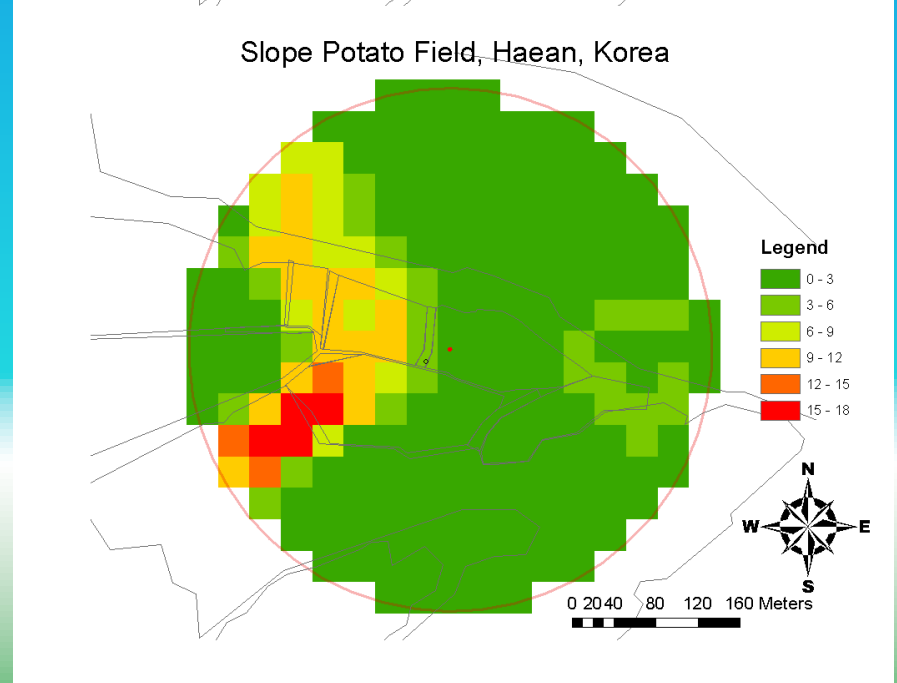
Slope Potato Field, Haean, Korea
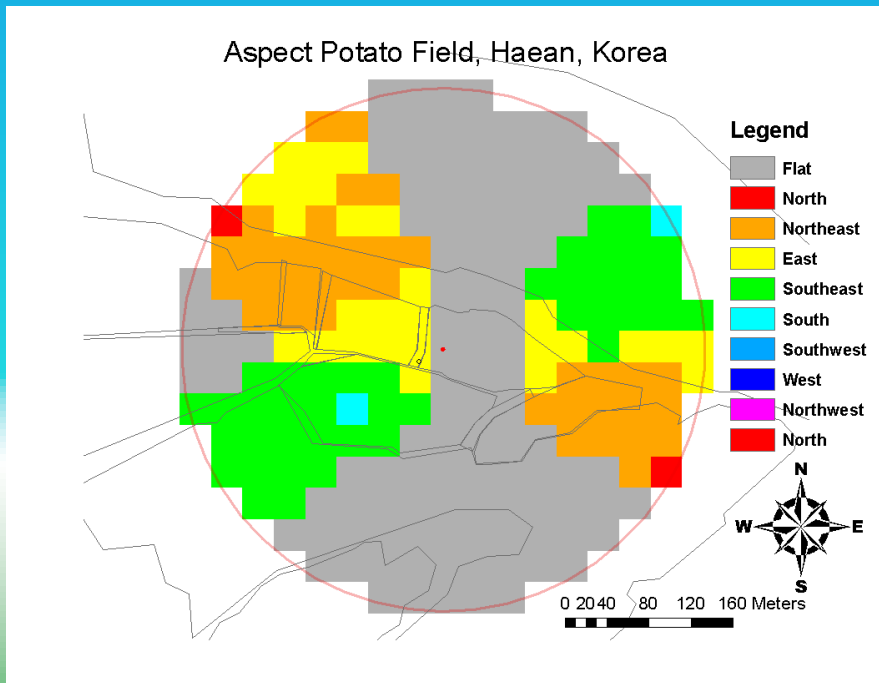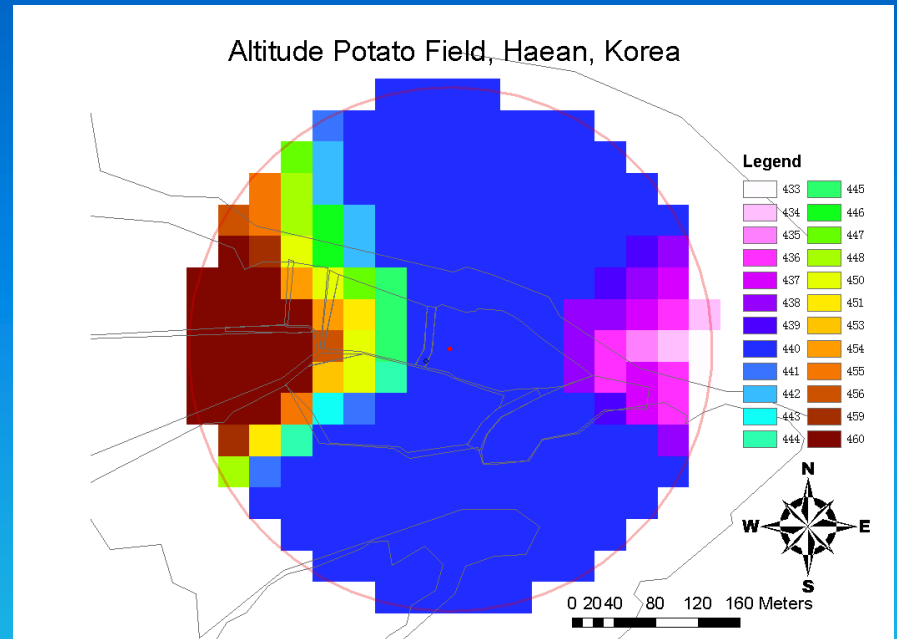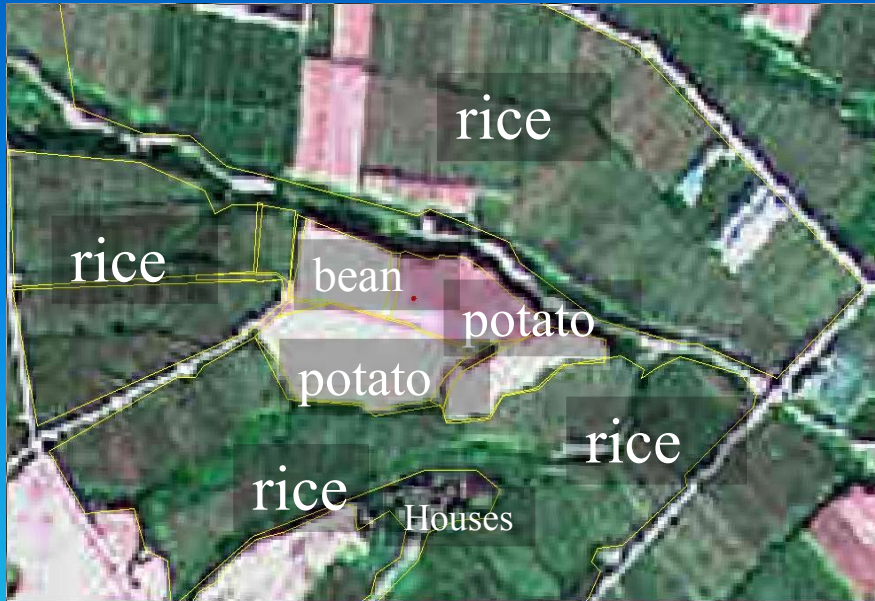
Footprint

Potato field

Rice field

Data flow

Weather station

High frequency (20 Hz) data of wind, temperature, H_2O, CO_2

Instrument error code (AGC)

 # Mauder and Foken (2004)

Spike check

Energy and CO_2 fluxes

Quality controlled fluxes

 # Göckede et al. (2008)

Gap-filling

Footprint

Fluxes without gaps
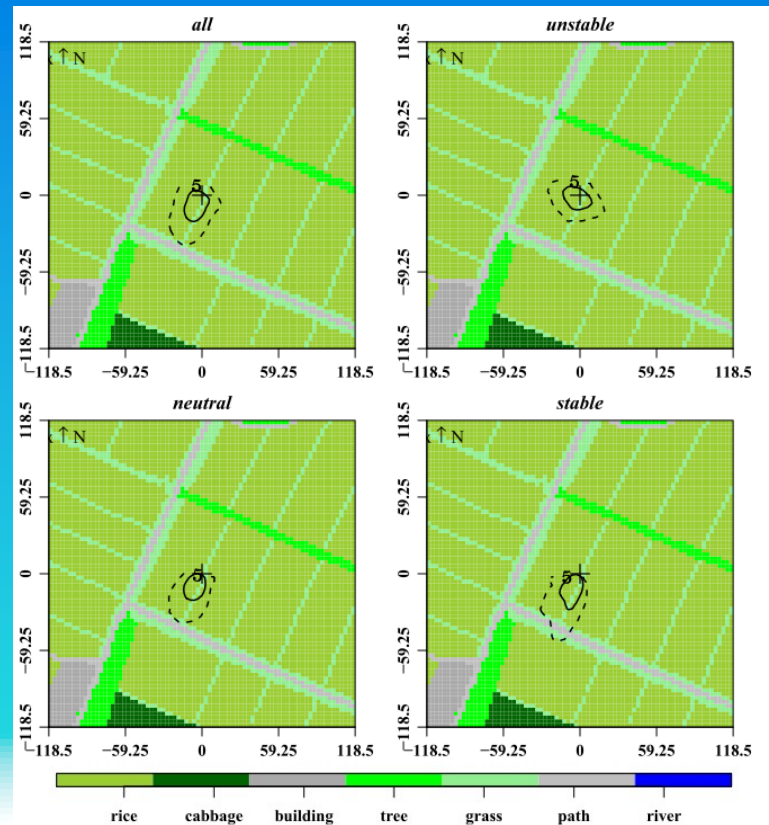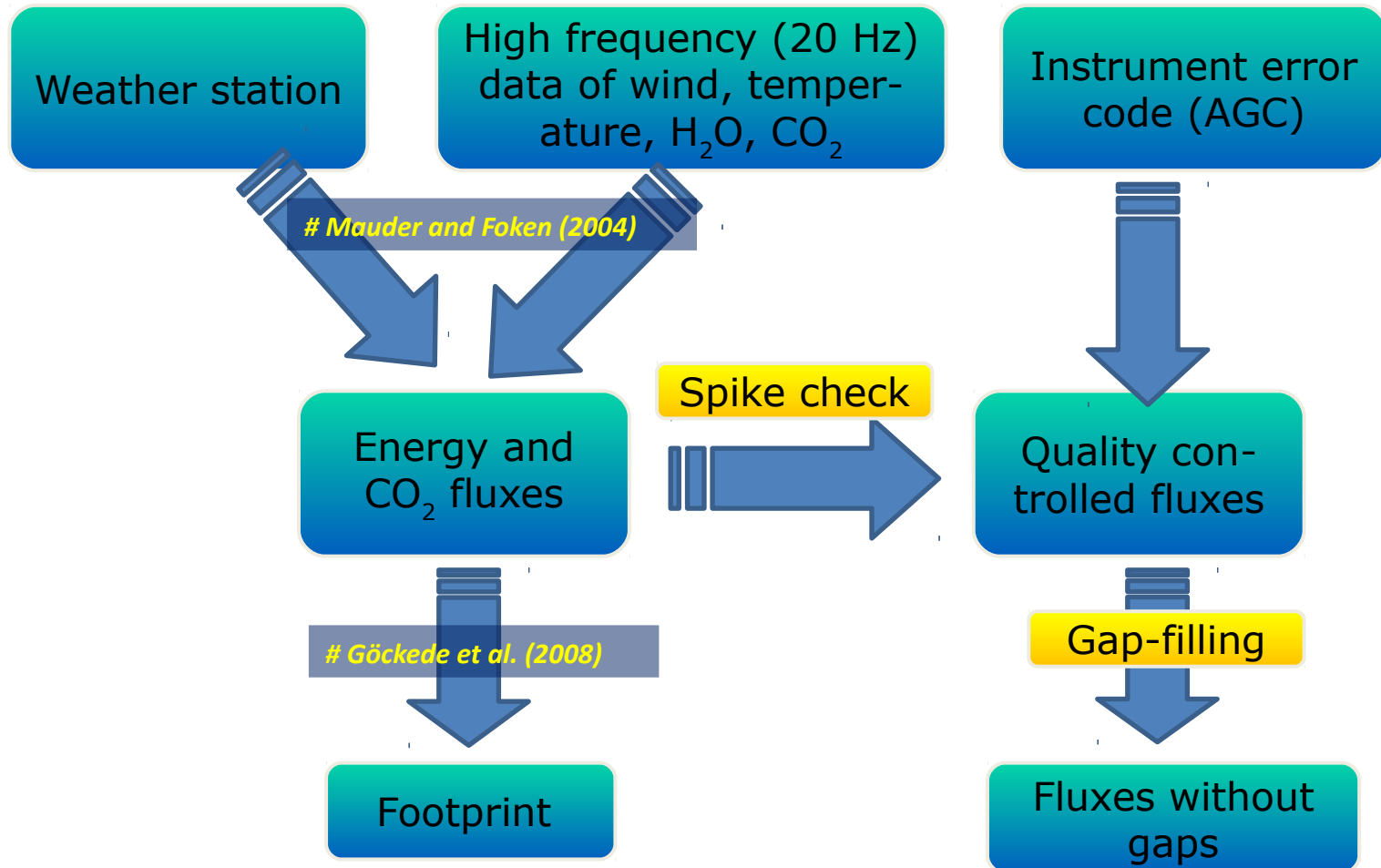
Data flow (what's new)
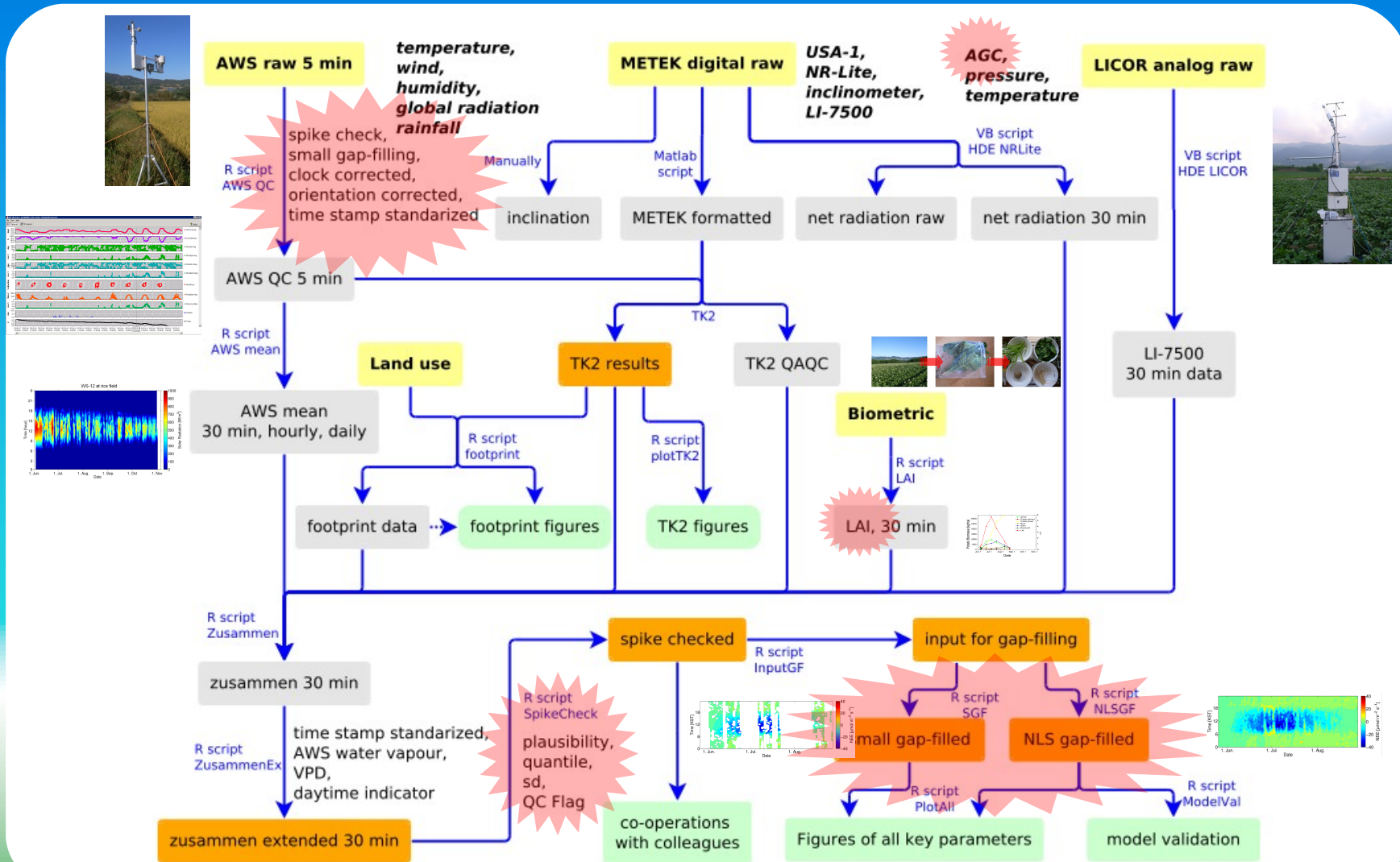
Quality control

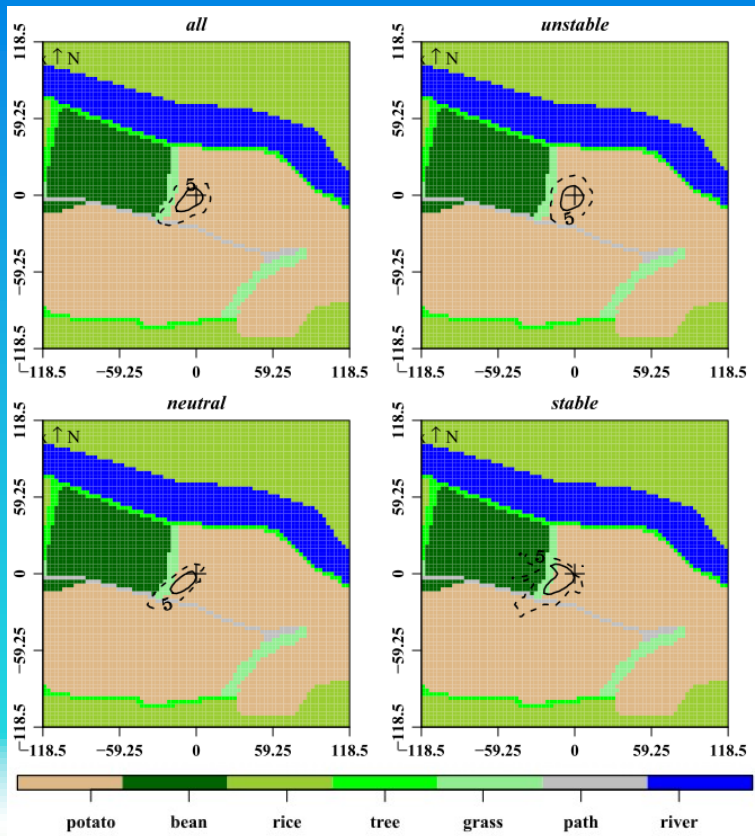| Steps	Period 1	Period 2	Period 3	Overall
w/CO_2 threshold check	99.6%	99.9%	99.7%	99.7%
Instrument error check	86.8%	70.9%	72.0%	78.0%
w/CO_2 spike check	86.2%	68.9%	70.1%	76.6%
NEE Threshold check	86.2%	68.9%	70.1%	76.6%
NEE quality flag check*	82.1%	68.4%	68.0%	74.1%
NEE spike check	78.6%	65.1%	63.9%	70.5%

* data with quality flag of 7, 8, 9 were rejected (Foken and Wichura, 1996; Foken et al., 2004).

Gaps
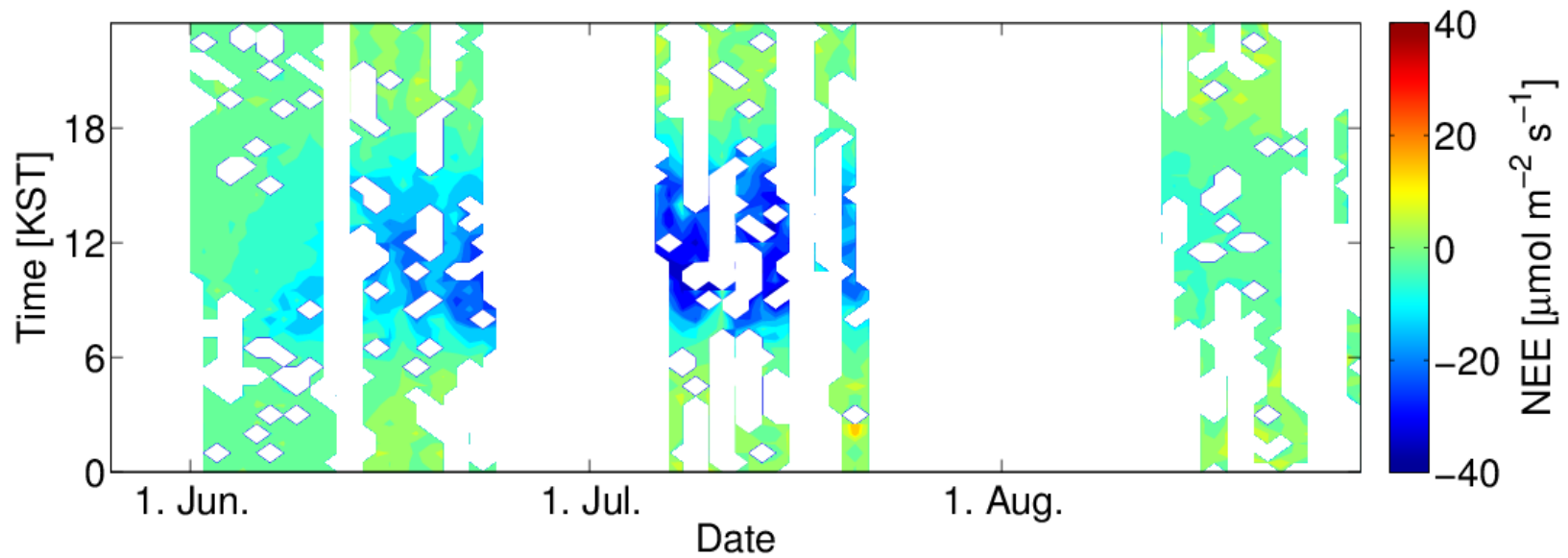
Gap-filling strategy for CO_2 flux

	Daytime	Nighttime
R_{eco}	gaps	Measured and gaps
NEE	Measured and gaps	NEE = R_{eco}
GPP	GPP = NEE-R_{eco}	0

Gap-filling strategy for CO_2 flux

	Daytime	Nighttime
R_{eco}	gaps	Measured and gaps
NEE	Measured and gaps	NEE = R_{eco}
GPP	GPP = NEE - R_{eco}	0

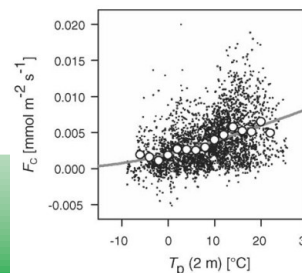$$F_d = \frac{\alpha R_g \beta}{\alpha R_g + \beta} + \gamma$$

$$F_{R,eco} = F_{R,10}\, e^{E_0[(1/(283.15 - T_0)) - (1/(T - T_0))]}$$

Michaelis and Menton, 1913;
Falge et al., 2001

Lloyd and Taylor, 1994;
Falge et al., 2001
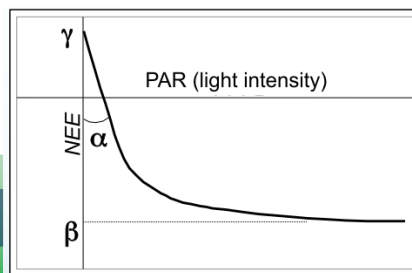
Light response curve
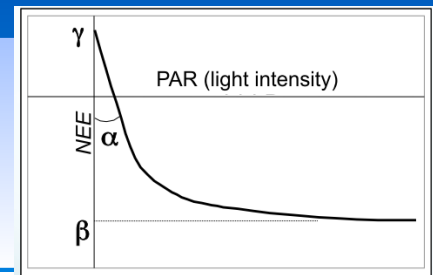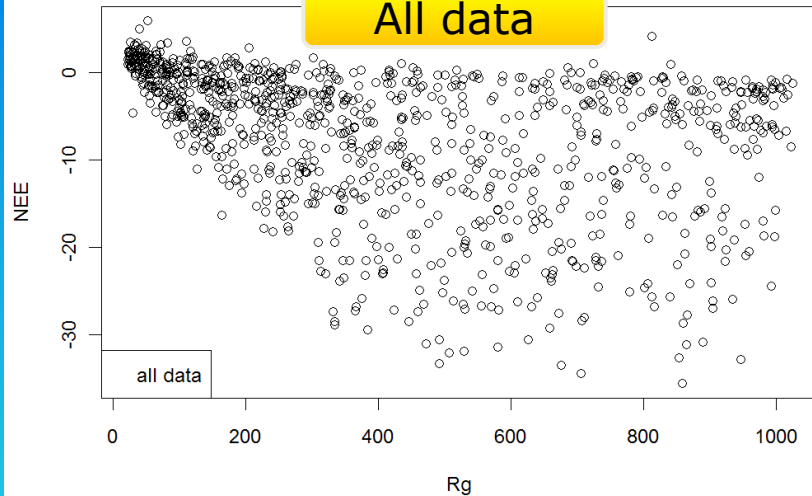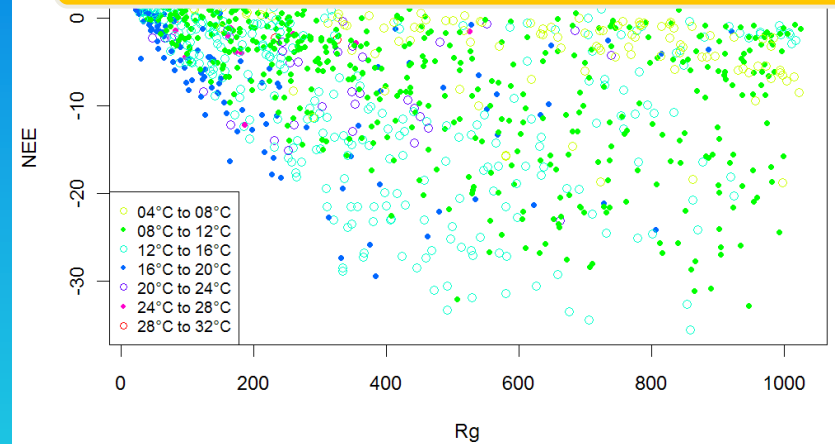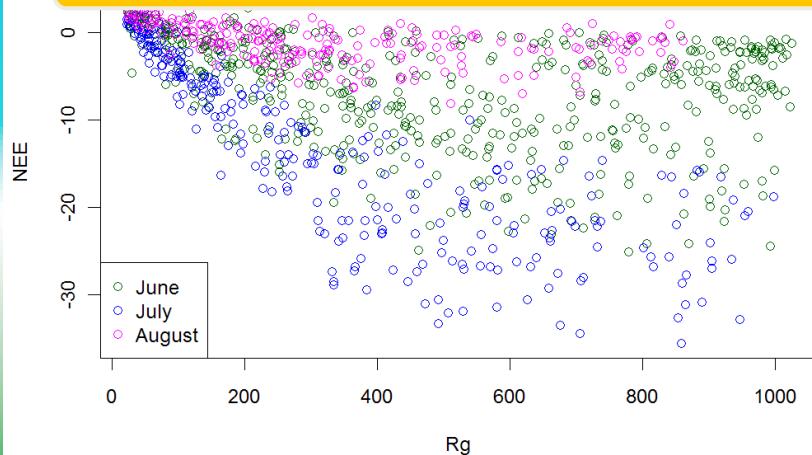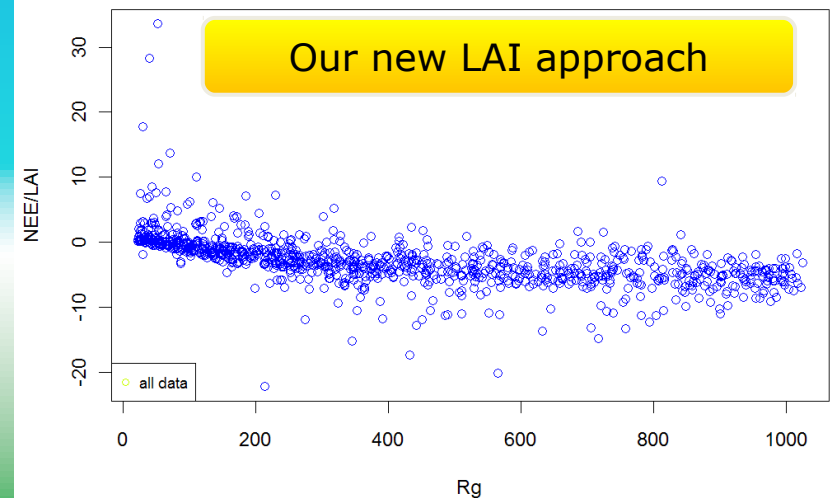
Gap-filling

Models	Temperature bins	LAI factor*	Day bins	VPD bins	VPD factor**
1-T	Yes	No	No	No	No
2-D	No	No	Yes	No	No
3-T-L	Yes	Yes	No	No	No
4-T-L-Vf	Yes	Yes	No	No	Yes
5-L-Vb	No	Yes	No	Yes	No
6-L-Vb-Vf	No	Yes	No	Yes	Yes
7-D-L-Vf	No	Yes	Yes	No	Yes

* *Fd* iwas replaced with *Fd* = Fd* / LAI
** An exponential function was introduced (# Lasslop et al., 2010).

Performances of gap-filling models: daytime NEE
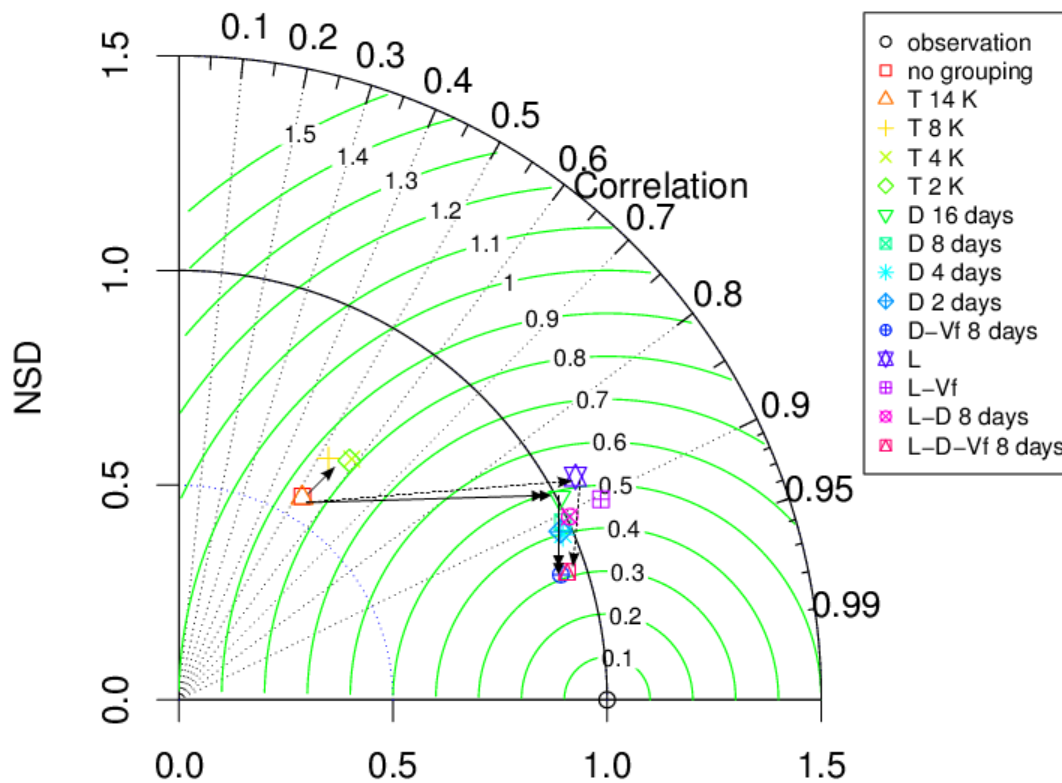
| Methods	E	d
1-T_bin02	0.31	0.73
1-T_bin04	0.3	0.74
1-T_bin08	0.23	0.7
1-T_bin14	0.26	0.66
1-T_bin28	0.26	0.66
2-D_bin02	0.83	0.96
2-D_bin04	0.84	0.96
2-D_bin08	0.81	0.95
2-D_bin16	0.76	0.94
3-T-L_bin02	0.78	0.95
3-T-L_bin04	0.78	0.95
3-T-L_bin08	0.72	0.93
3-T-L_bin14	0.73	0.93
3-T-L_bin28	0.71	0.93
4-T-L-Vf_bin02	0.8	0.95
4-T-L-Vf_bin04	0.8	0.95
4-T-L-Vf_bin08	0.79	0.95
4-T-L-Vf_bin14	0.78	0.95
4-T-L-Vf_bin28	0.77	0.95
5-L-Vb_bin250	0.74	0.94
5-L-Vb_bin500	0.78	0.95
5-L-Vb_bin1000	0.76	0.94
5-L-Vb_bin2000	0.7	0.93
6-L-Vb-Vf_bin250	0.74	0.94
6-L-Vb-Vf_bin500	0.77	0.95
6-L-Vb-Vf_bin1000	0.77	0.95
6-L-Vb-Vf_bin2000	0.73	0.93

Taylor (2001)

E: Nash–Sutcliffe model efficiency coefficient
d: index of agreement
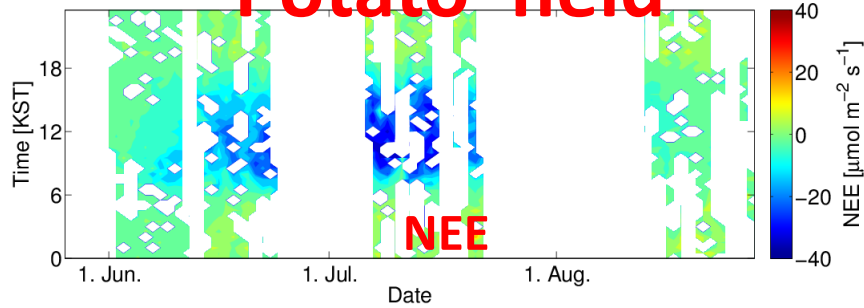
Fluxes: observed
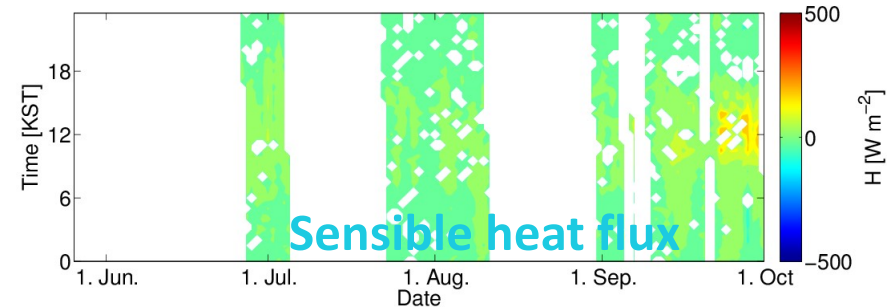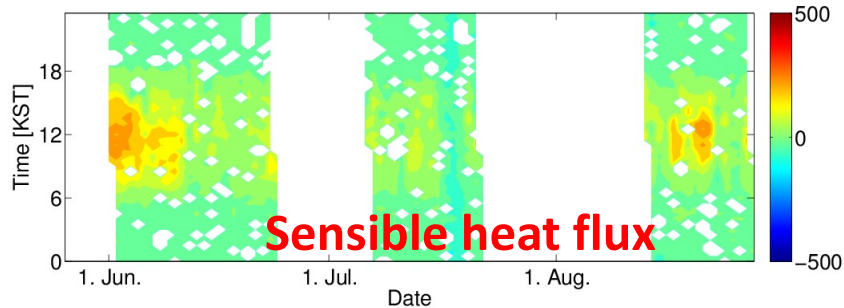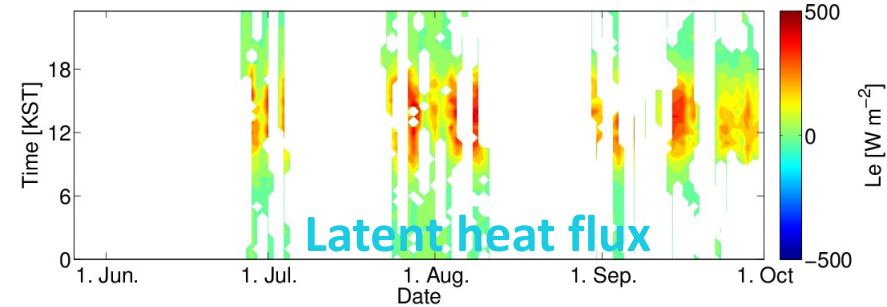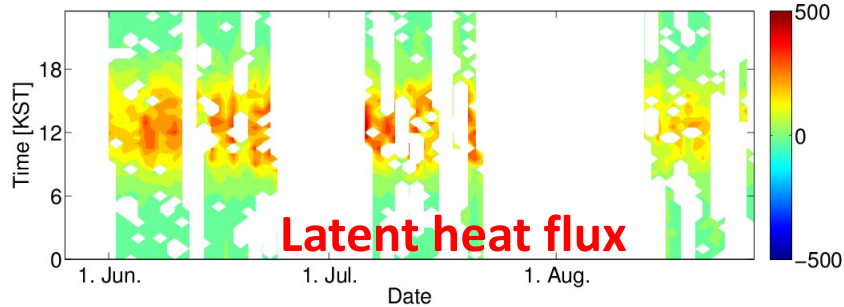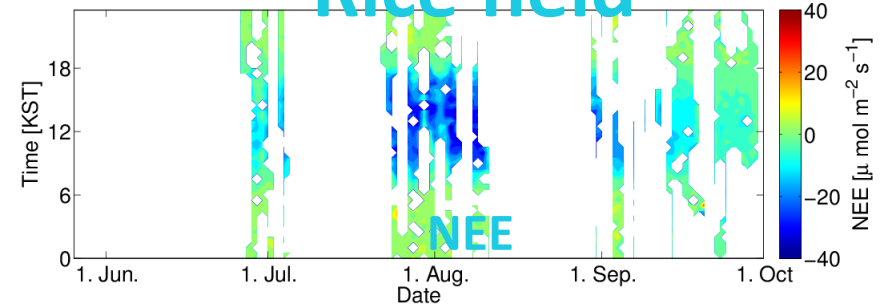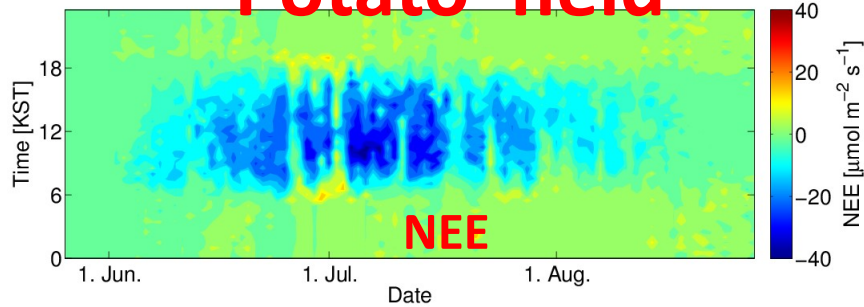
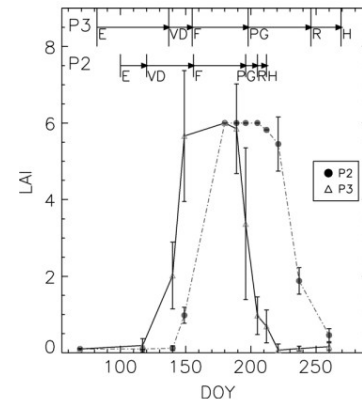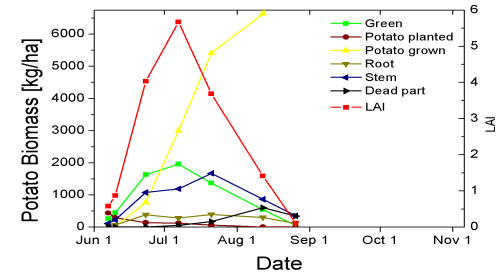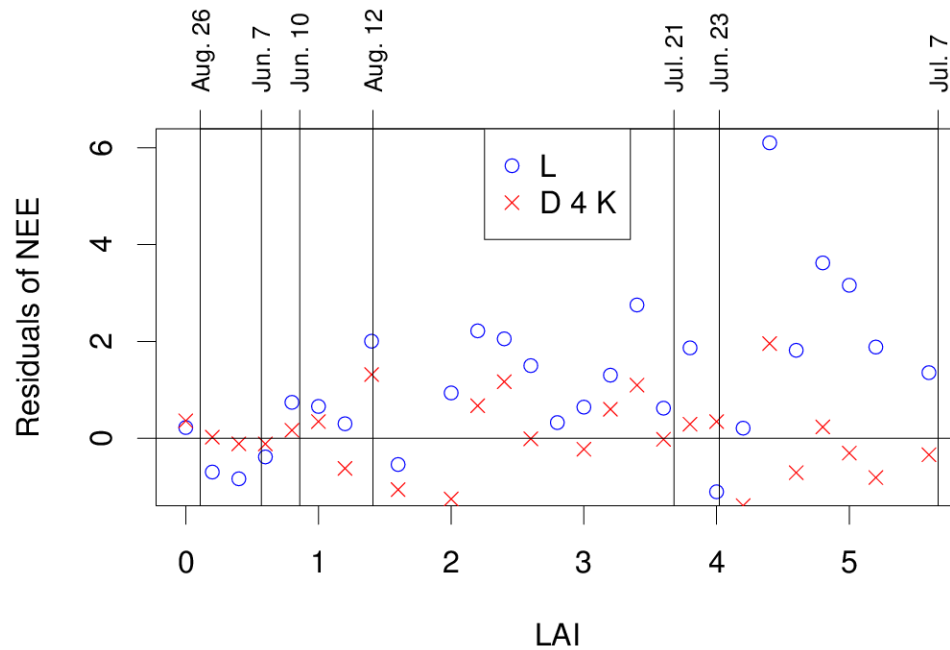# Fluxes: gap-filled
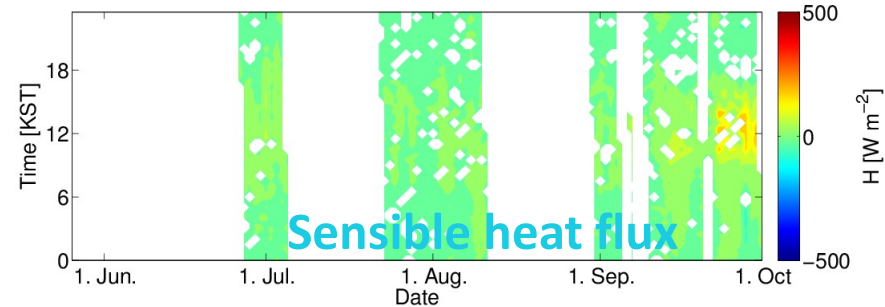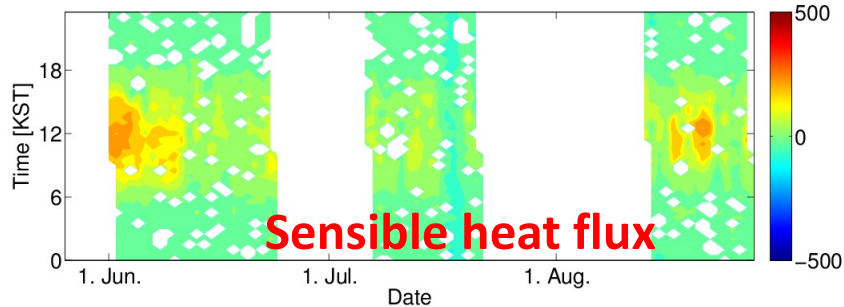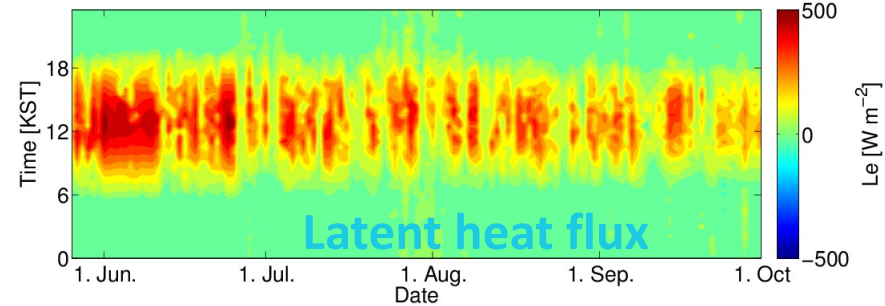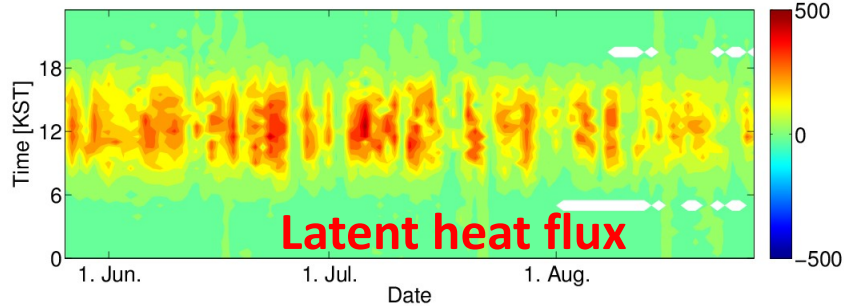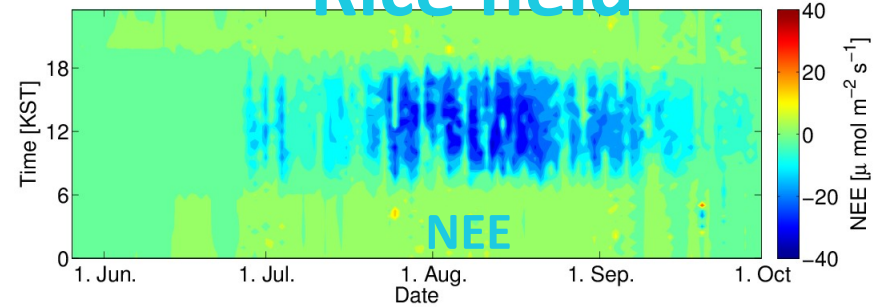
Residuals

Fig. 5. Retrieved LAI for two potato fields (P2 and P3) with different calendar. Phenological observations are indicated on top. P2 has a longer cycle than P3: emergence is earlier and harvest is later than for P2. E stands for Emergence, VD for Vegetation Development, F for Flowering, PG for Potato Growing, R for Ripening an H for Harvest.
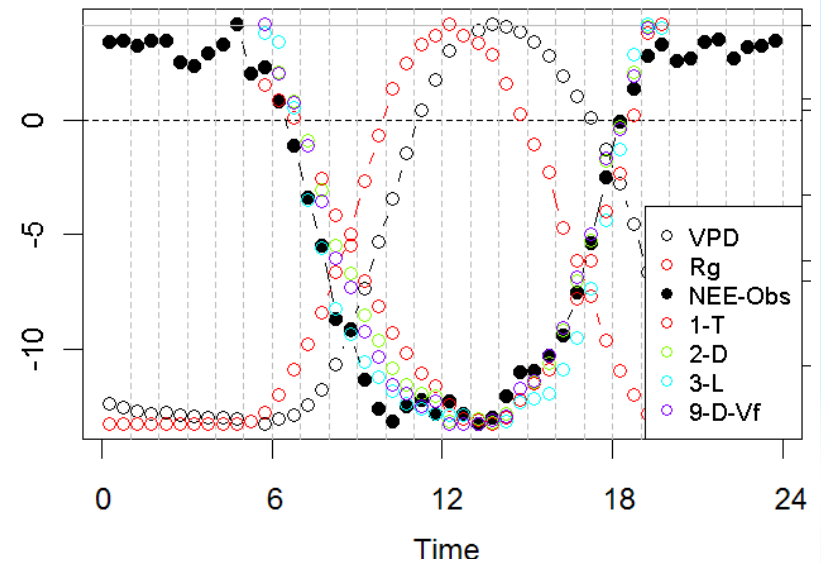
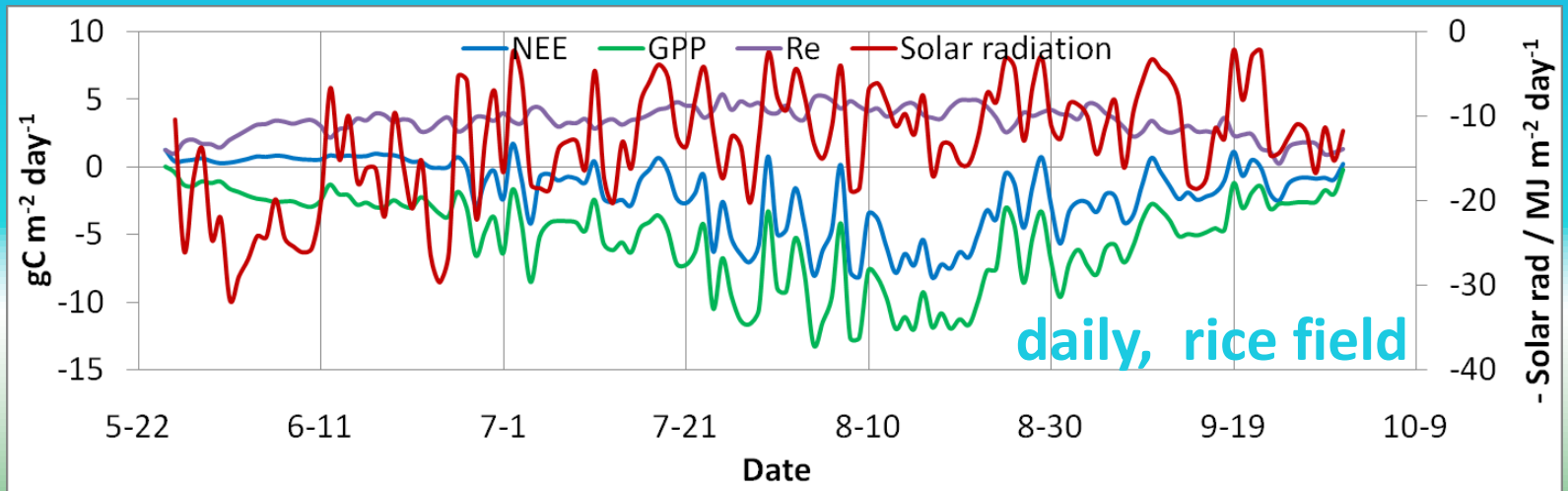# González-Sanpedro et al. (2008)
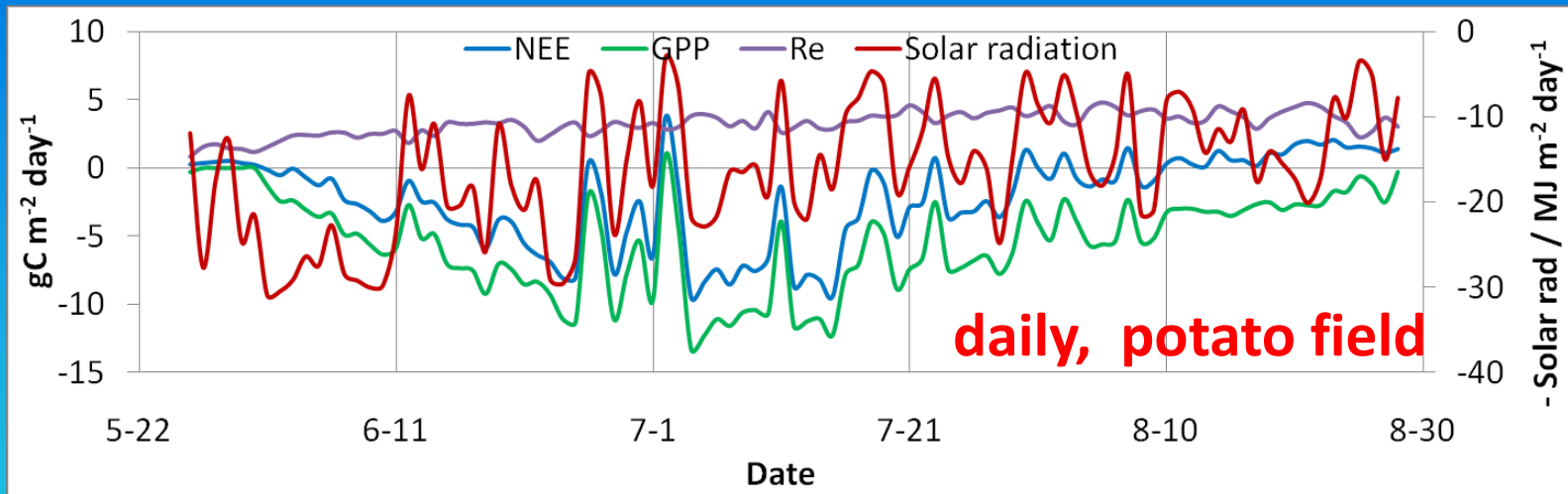
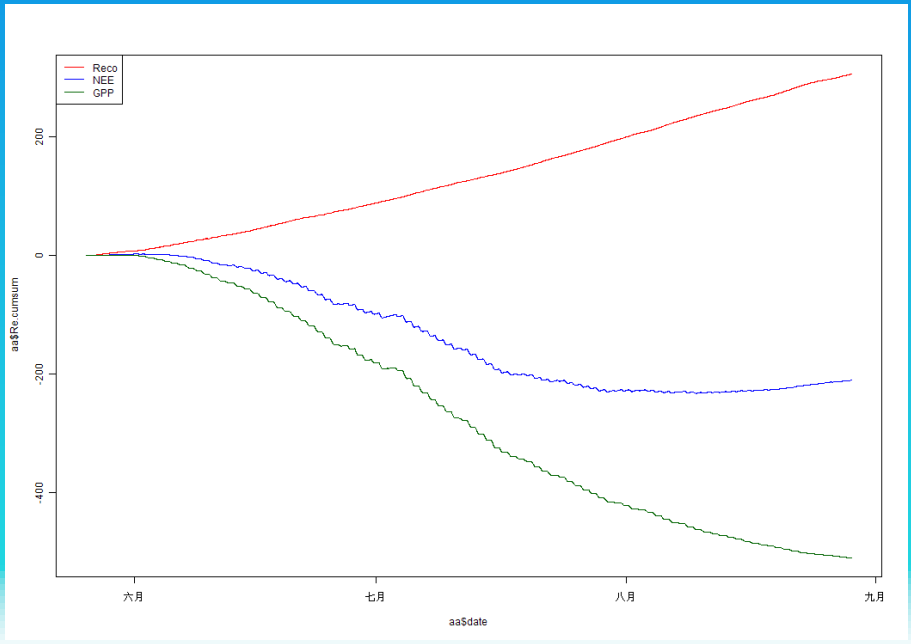# Mean diurnal cycle

Potato field

Rice field

Daily mean
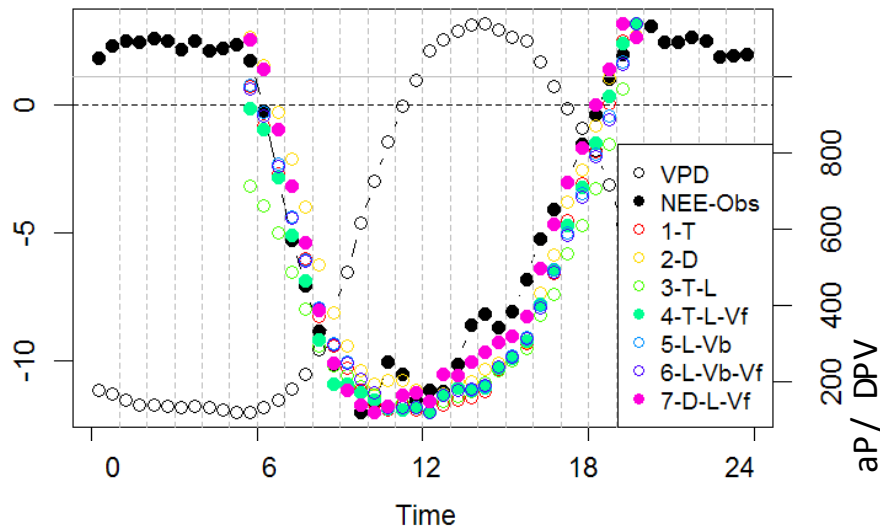
daily, potato field

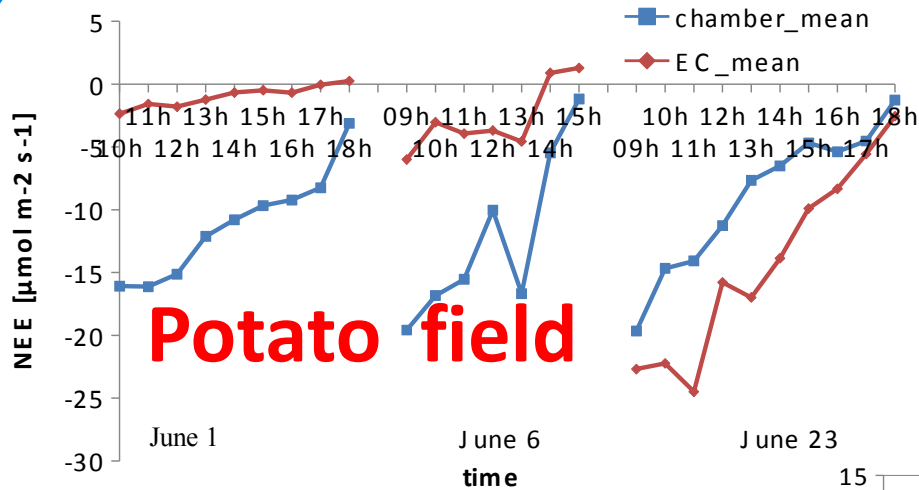daily, rice field

Cumulative

Potato field

Rice field
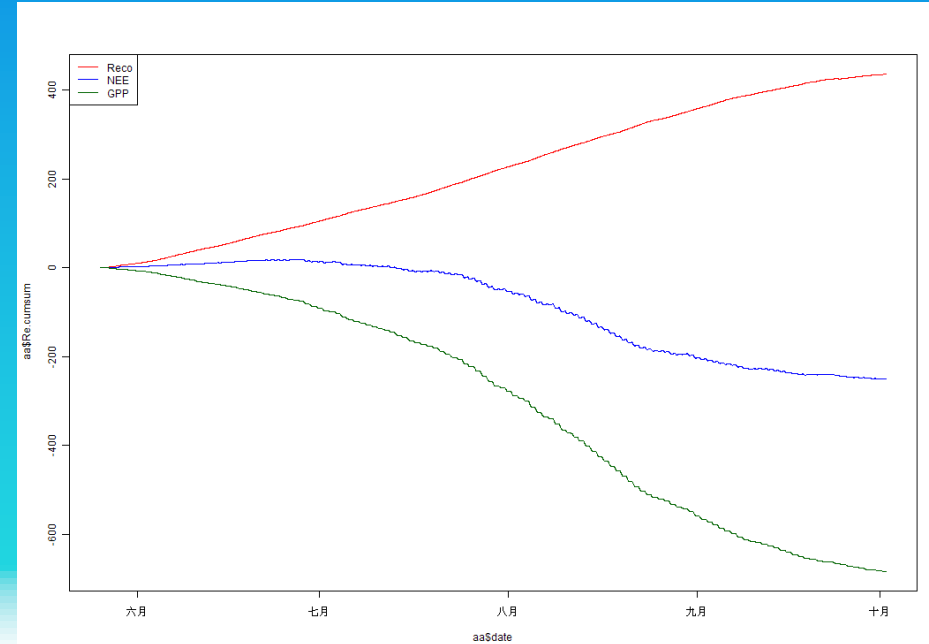
Comparison with chamber measurement

Co-worker: Steve Lindner
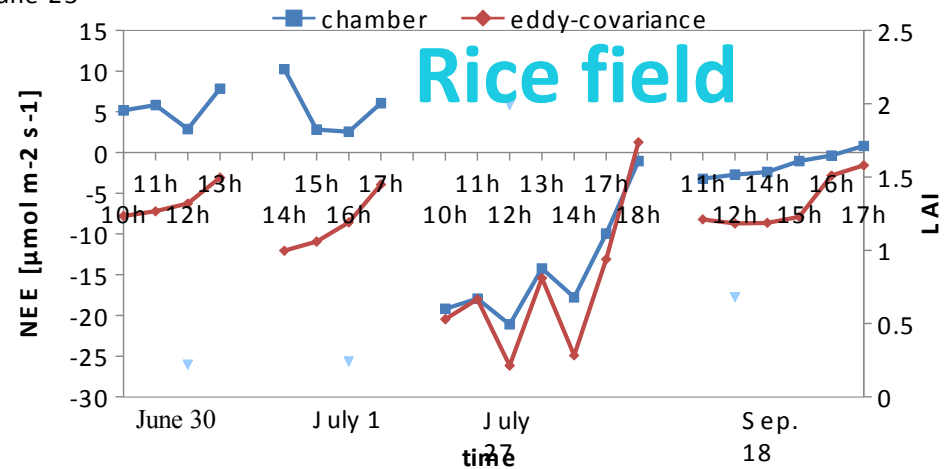
Comparison of WRF model with observations

Co-worker: Dr. Jea-Chul Kim, Dr. Adrei Serafimovich

Fichtelgebirge, Germany

Heaen, South Korea
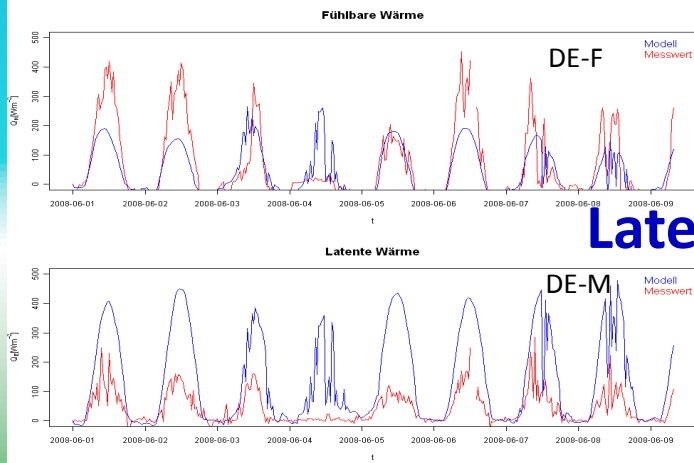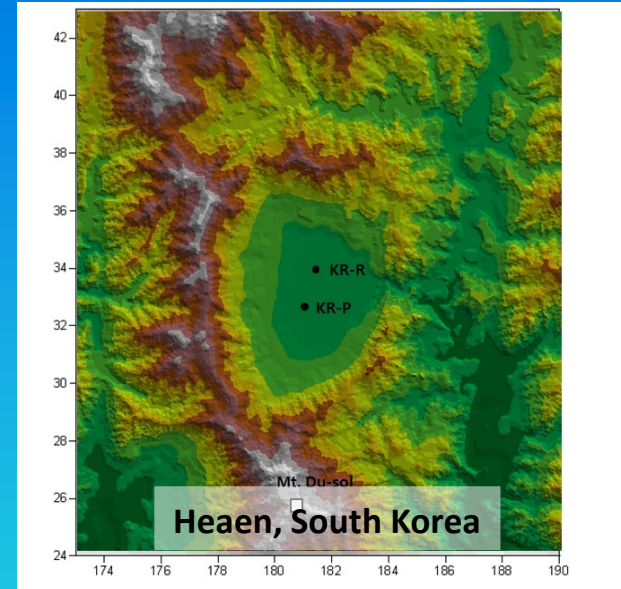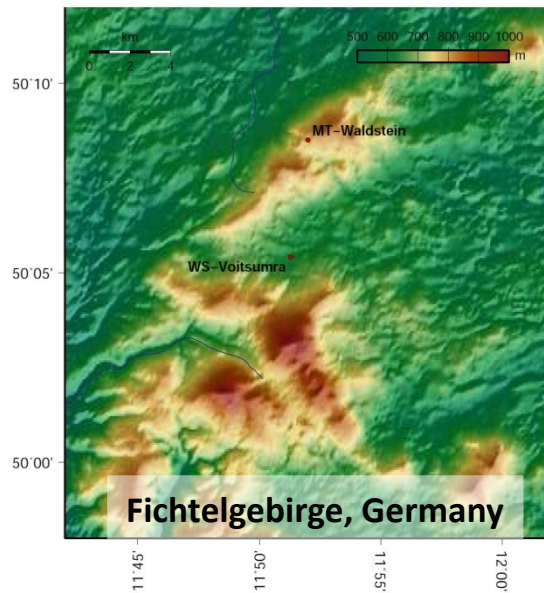
Latent Heat Flux
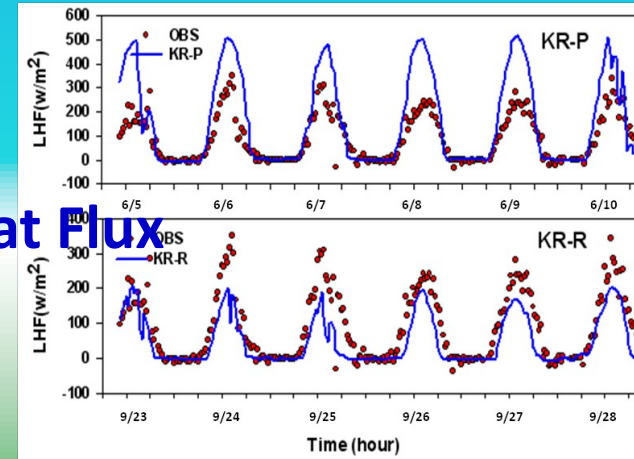
Red : OBS
Blue : WRF

Conclusion

- Eddy-covariance technique ~ complex terrain
- Gap-filling
- CO2 flux
  - Mid-season depression
  - Late-season source at potato farm
- Further co-operation work

Publications

- Zhao, P. et al., 2011. Documentation of the Observation Period, May 12th to Nov. 8th, 2010, Haean, South Korea, Universität Bayreuth, Abt. Mikrometeorologie, Print, ISSN 1614-8916, Arbeitsergebnisse 45.

- Zhao, P. and Lüers, J., *in progress*. Gap-filling strategy for net ecosystem exchange of carbon dioxide at a rapidly-growing cropland in South Korea.

- Kim J.-C., Zhao P., Serafimovich, A., Thieme, C., Lüers J., Lee C. B., Tenhunen J., Foken T., *in progress*: Analysis of meteorological features using observations and models in a basin area

- Zhao P., Lee B., Lindner S., Lüers J., Tenhunen J., Foken T., *in plan*: Influence of monsoon and crop management on CO2 uptake over farmlands in South Korea

Thank you for your attention.