Predictions of NEE and GPP variations with temperature increasing in an Alpine Meadow on the Tibetan Plateau

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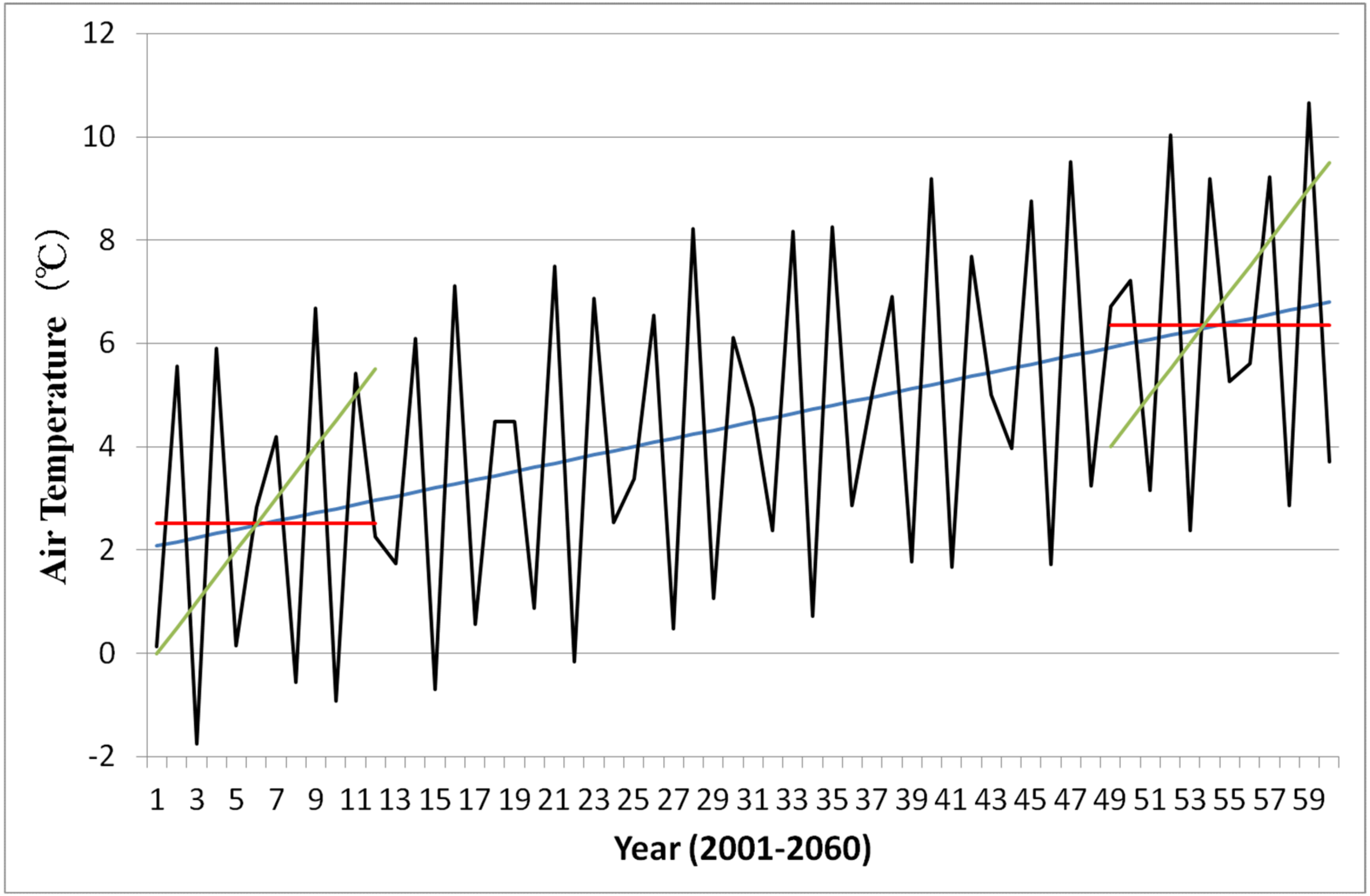
Introductions

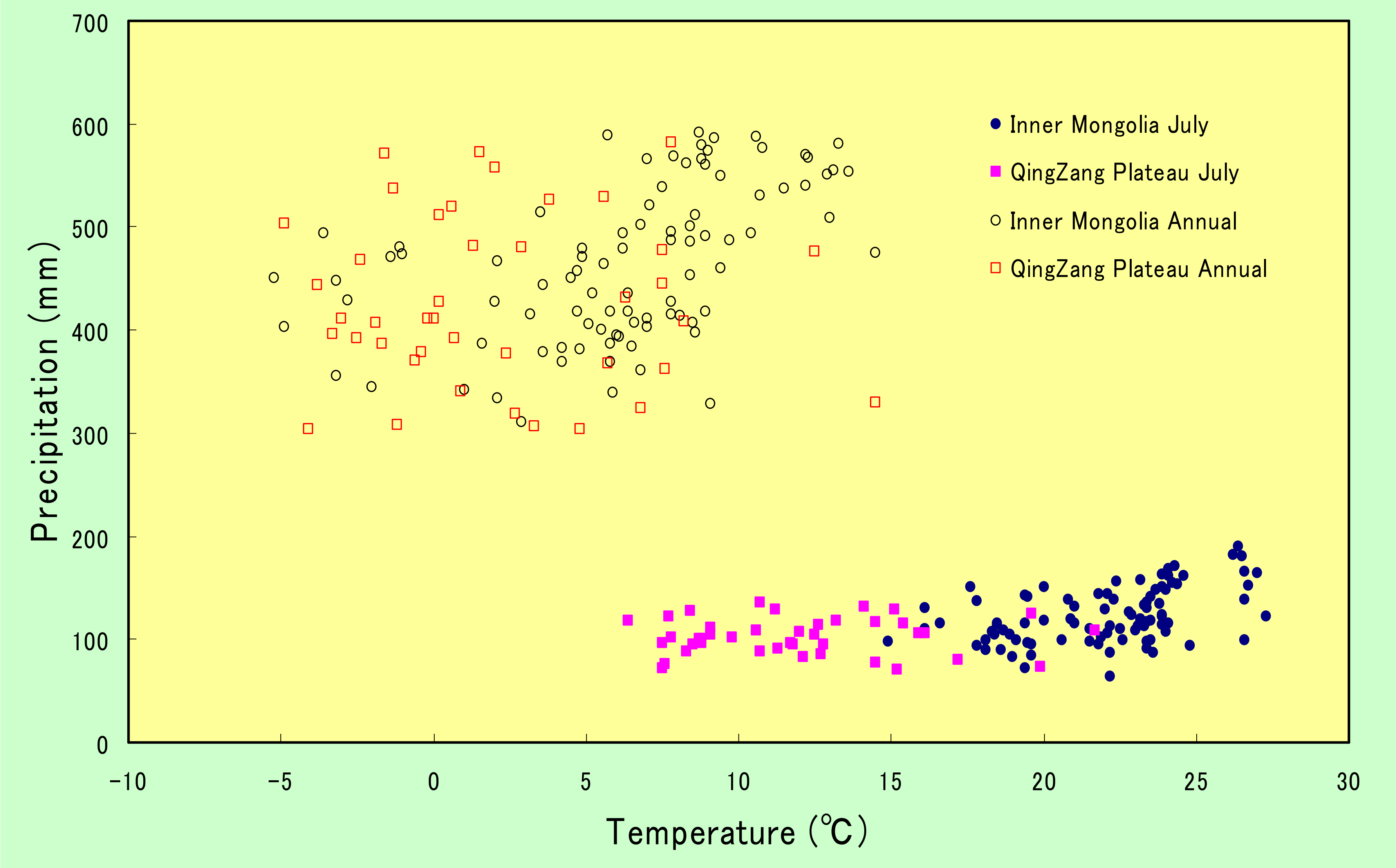
- Grassland occupies about 50% of the Tibetan Plateau (TP) and acts as a carbon sink nowadays.
- Climate warming may increase the productivity of the grassland on the Plateau. It may also accelerate carbon releasing at the same time.
- **Can we have a simple model for evaluating and predicting the Net ecosystem CO_2 exchange (NEE) on TP for future climate change?**
- **Here we perform a statistical model from our 14 years observations to predict the NEE changes with temperature increasing.**



Air Temperature (℃)
Year (2001-2060)
12
10
8
6
4
2
0
-2
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59

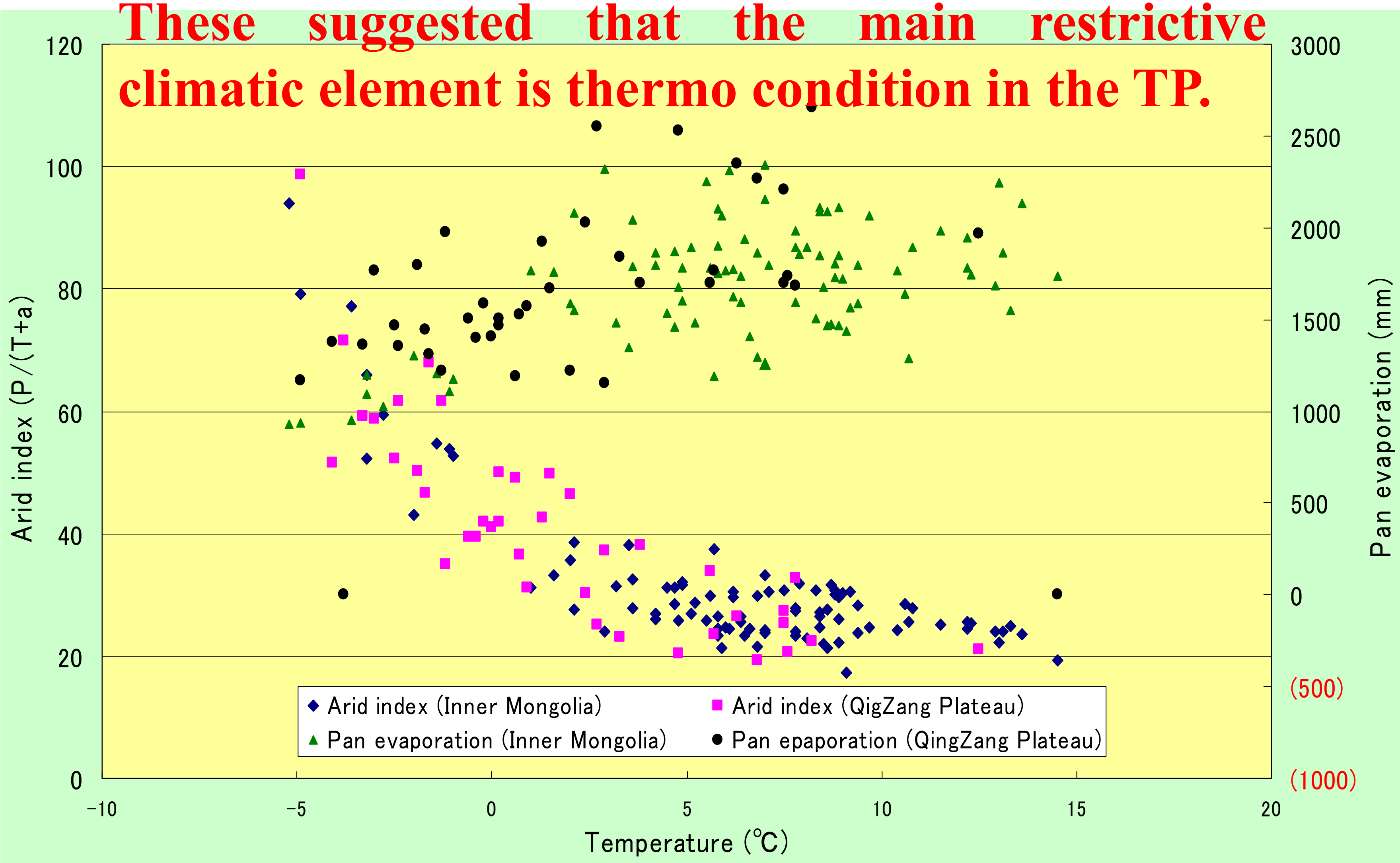
Grass land in China

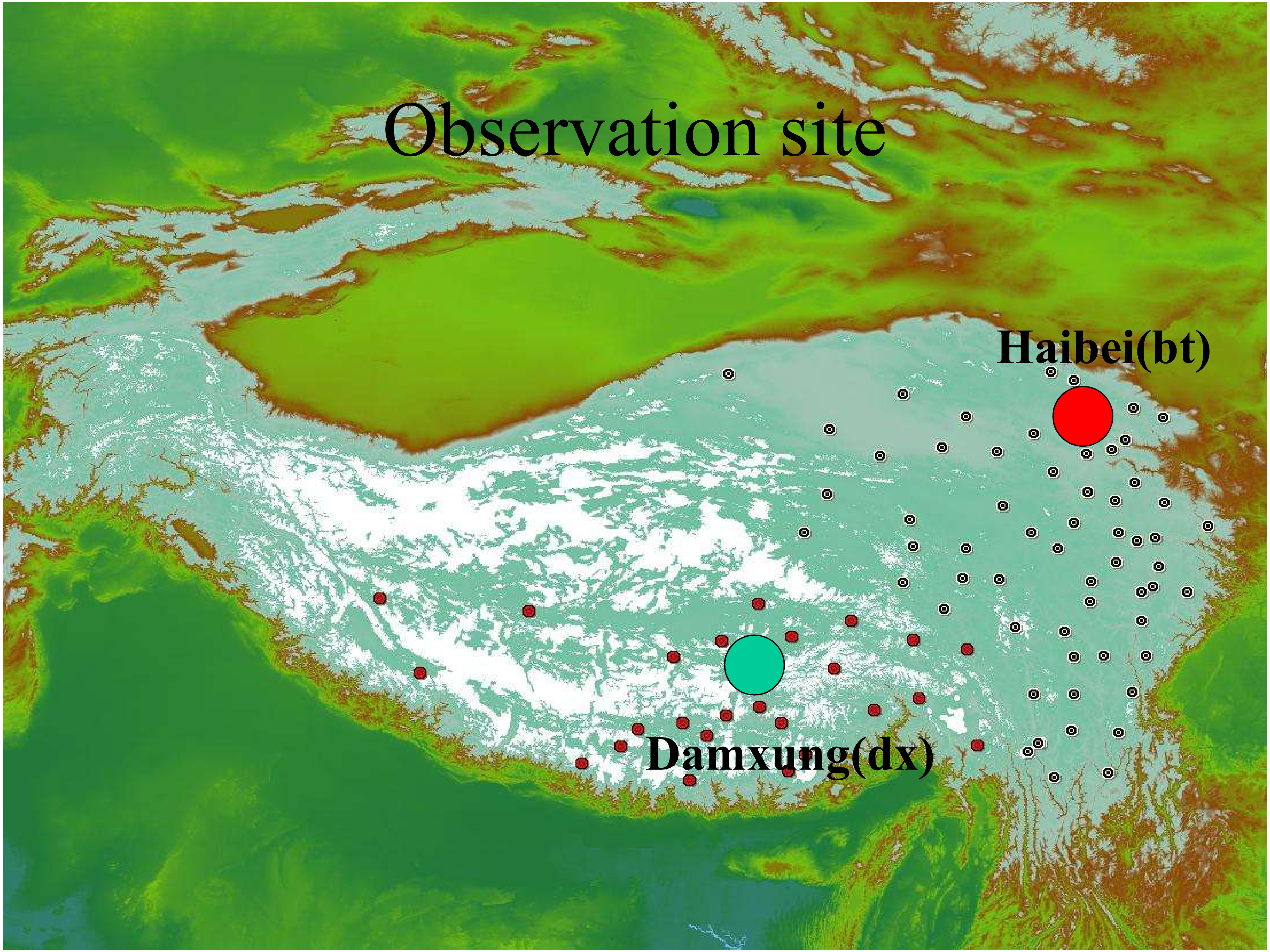
Precipitation and temperature in the grassland of China

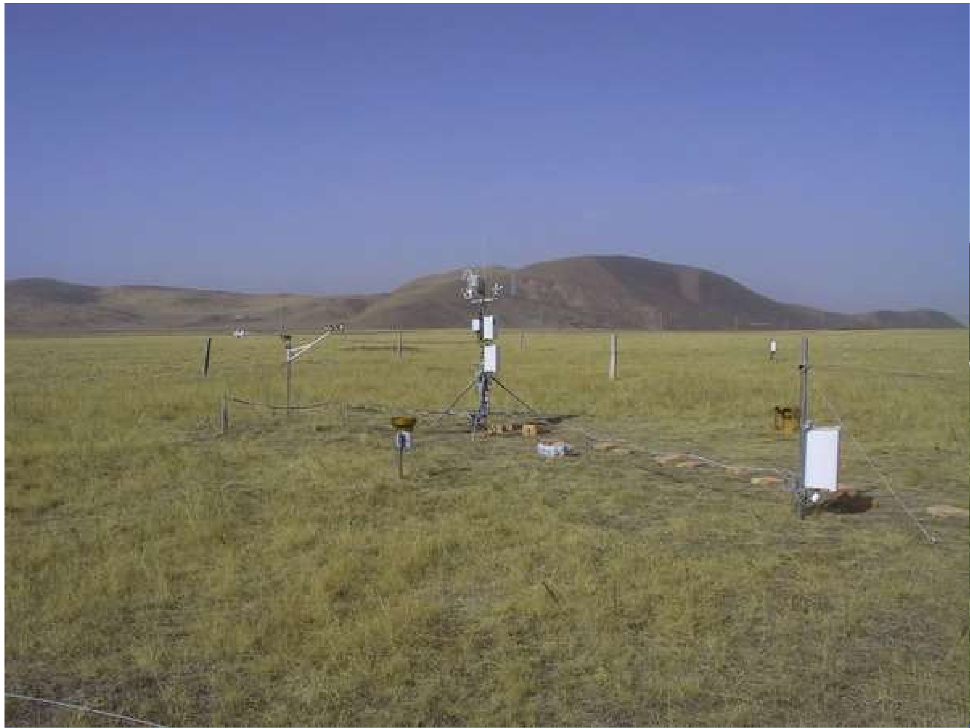


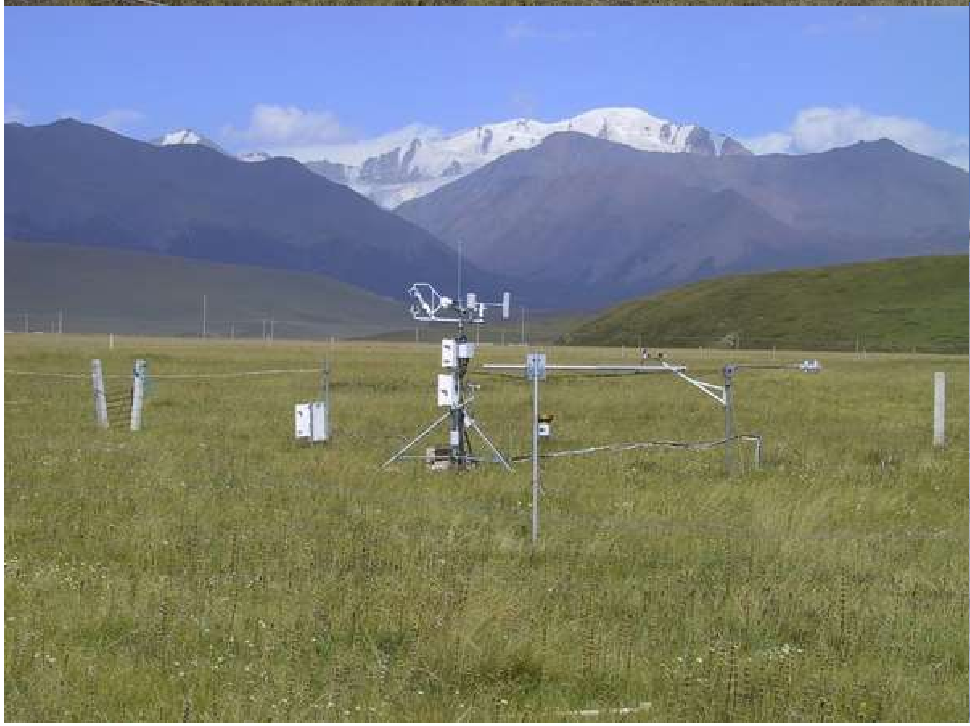
Arid index and pan evaporation in the grassland of China

These suggested that the main restrictive climatic element is thermo condition in the TP.

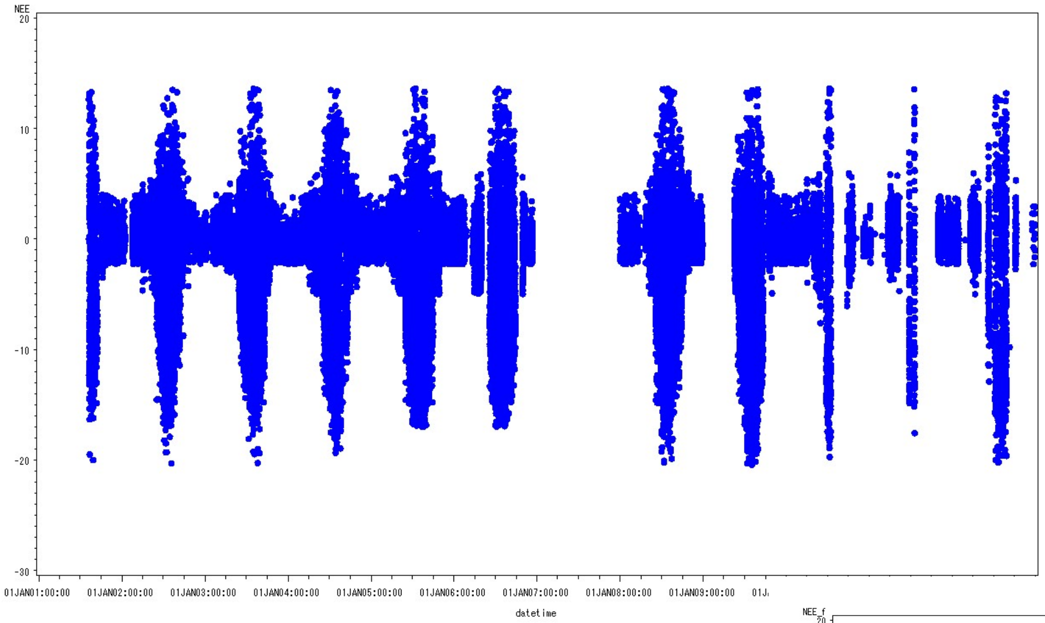



Observation site
Haibei(bt)
Damxung(dx)



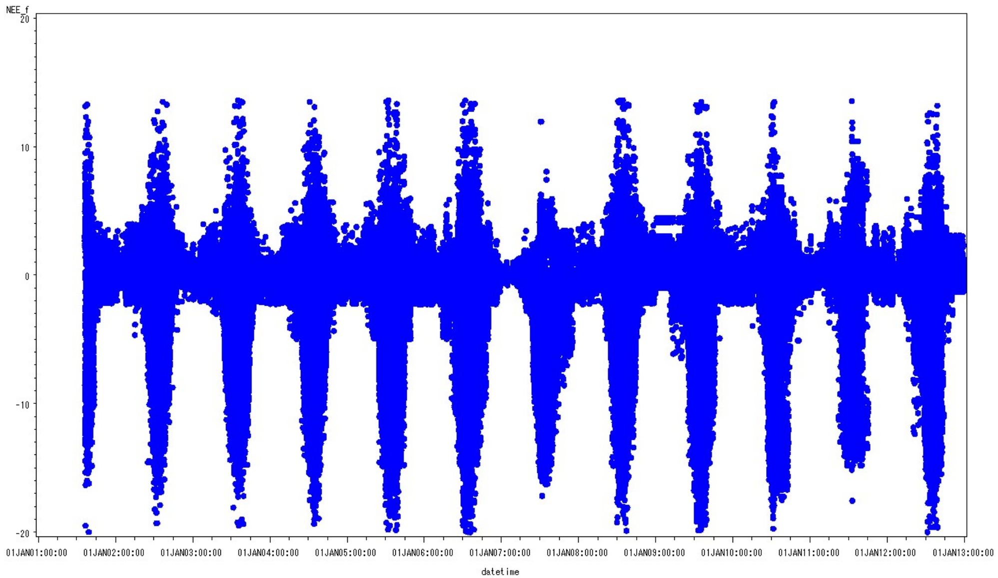



DATA: ***Flux-gap-filling and partitioning:*** “**Eddy covariance gap-filling & flux-partitioning tool** of **The Max Planck Institute for Biogeochemistry**”



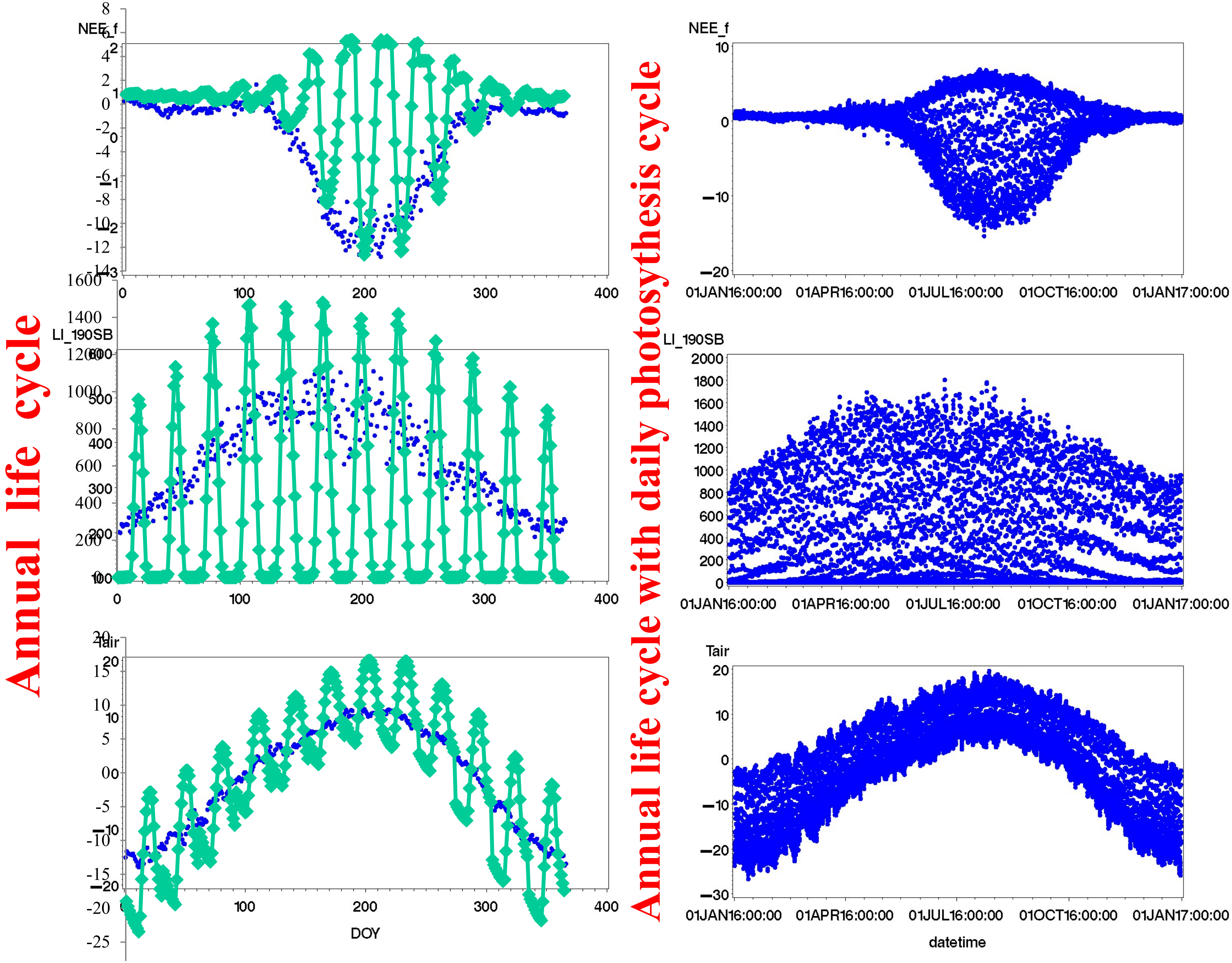
Before gap-filling

After gap-filling



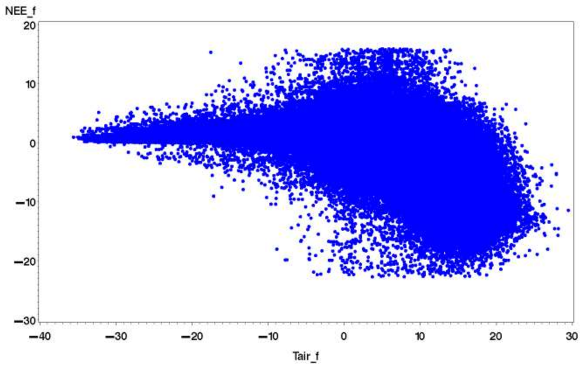
Two data set were used

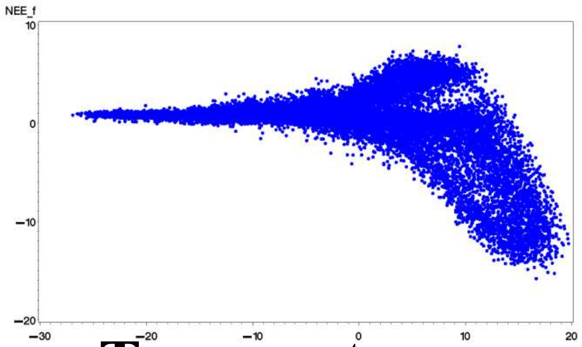
Data in 2007 were deleted

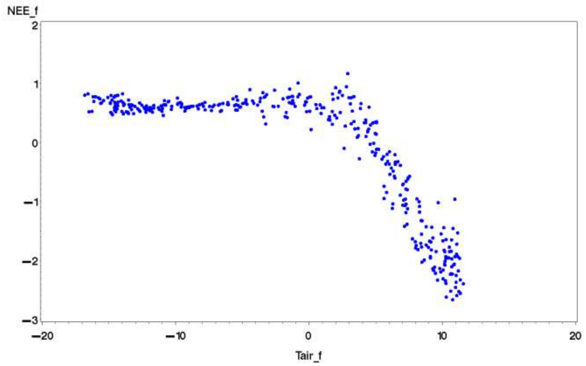


Annual life cycle
Annual life cycle with daily photosynthesis cycle
NEE_f
LI_190SB
Tair
DOY
datetime
01JAN16:00:00
01APR16:00:00
01JUL16:00:00
01OCT16:00:00
01JAN17:00:00

Observation results：relation between NEE and temperature and light





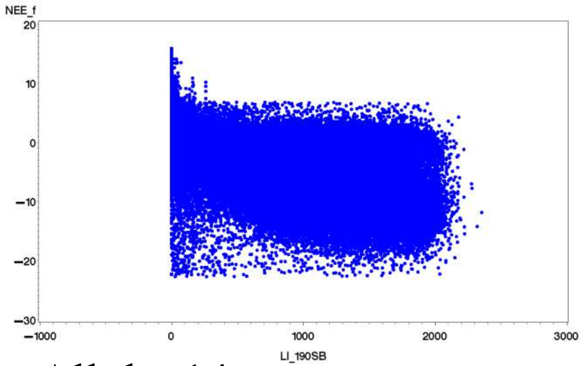


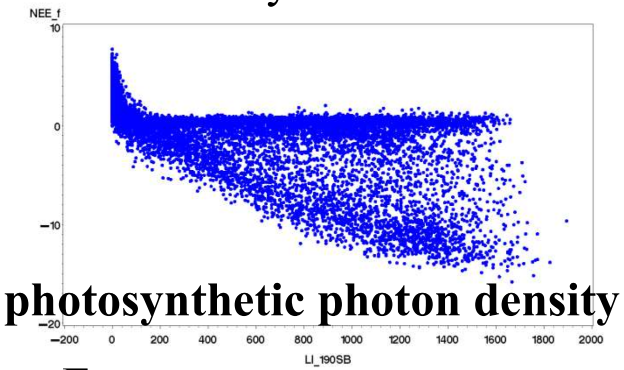
Temperature

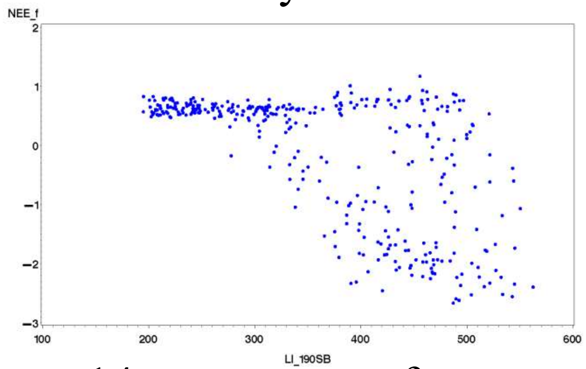
All the 14 years
30 minutes data

Every year
daily mean data

14 years mean of
daily mean data







photosynthetic photon density

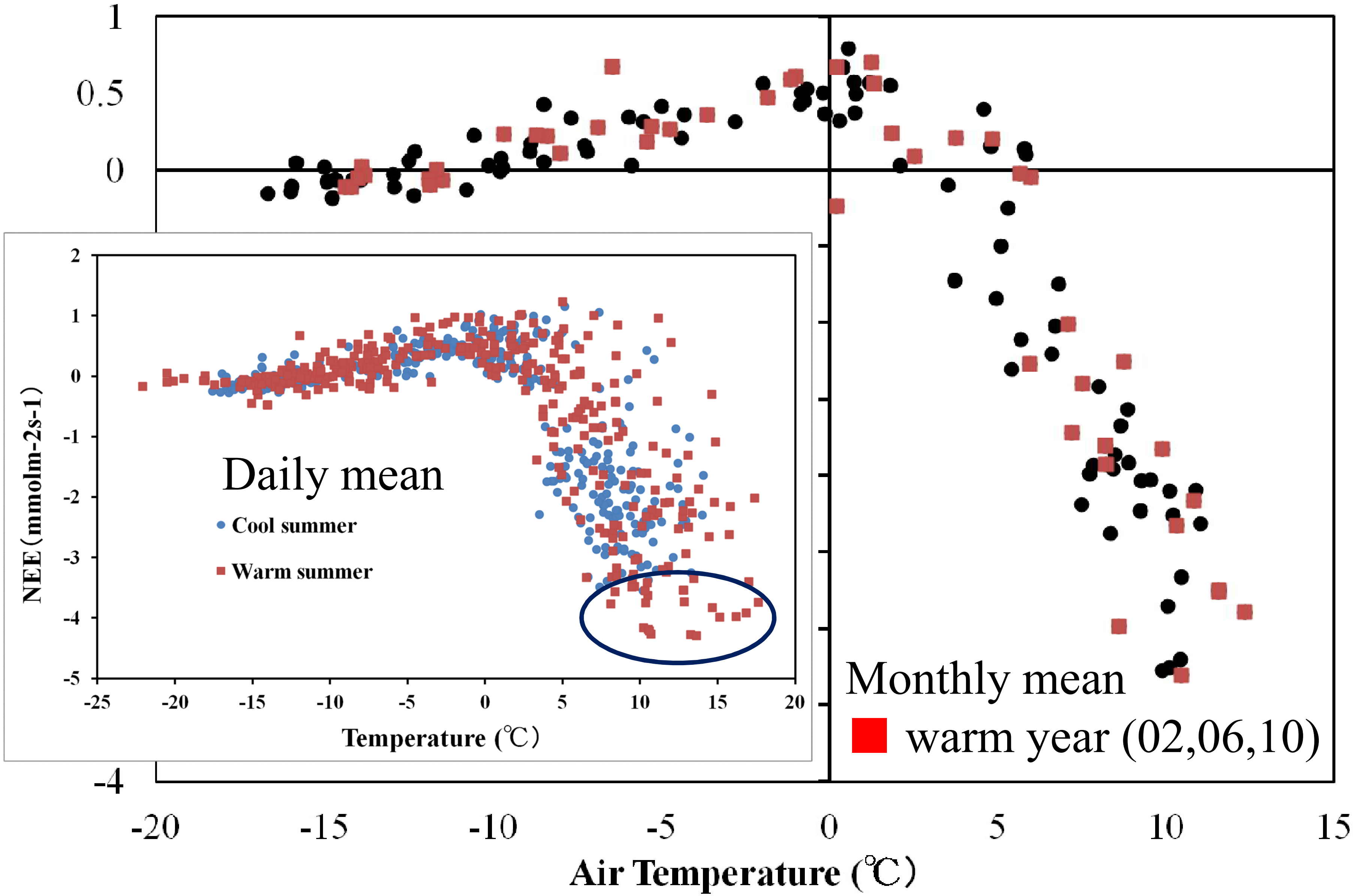
All the 14 years
30 minutes data

Every year
daily mean data

14 years mean of
daily mean data

Daily mean NEE has a very good relationship with temperature but not photosynthetic photon density.

Relationship between temperature and NEE



Observation results

- **There are not climate warming trend during the 14 years** at the observation point. In contrast, air temperature in April and in October seems decreasing during the 14 years. Therefore, **the annual NEE variation with time has no trend during the 14 years**. However, the difference between warmest month (12.4° C in July, 2010) and coldest month (9.2° C in July, 2003) in summer was 3.2° C and the difference of NEE between the same two months was -21gC/m^2. This means that **climate warming with 3° C in summer would not change the carbon sink and in contrast it would increase the carbon restoration** in the alpine meadow on the Tibetan Plateau.

Analysis Methods

Fitting Michaelis-Menten light response function statistically to get the relationship between NEE and T

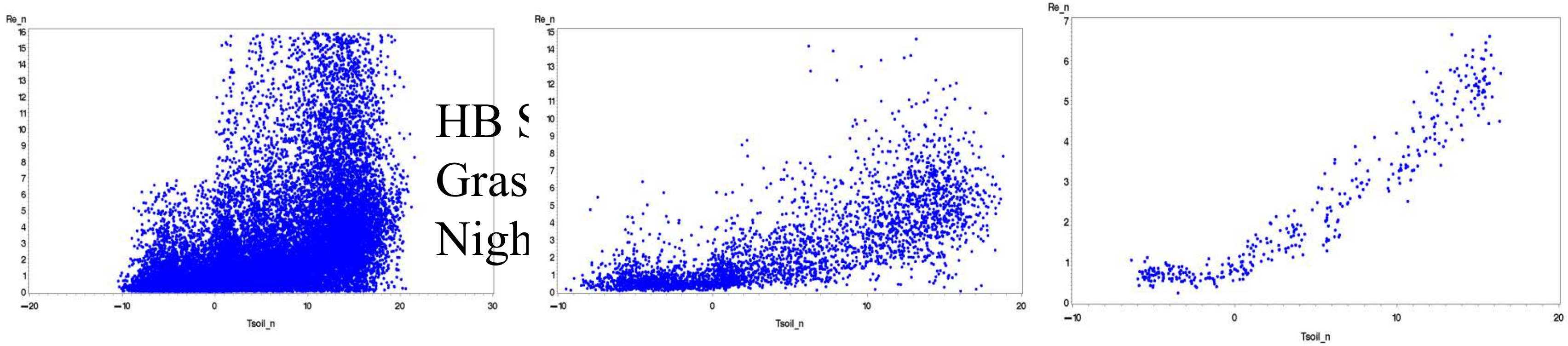
$$NEE_{pred}(T) = NEE_M(Par, \mathrm{Re}(T)) + \Delta Nee(T)$$

$$NEE_M = -\frac{\alpha A\max Par}{\alpha Par + A\max}(T_{air} or T_{soil}) + \mathrm{Re}(T_{soil})$$

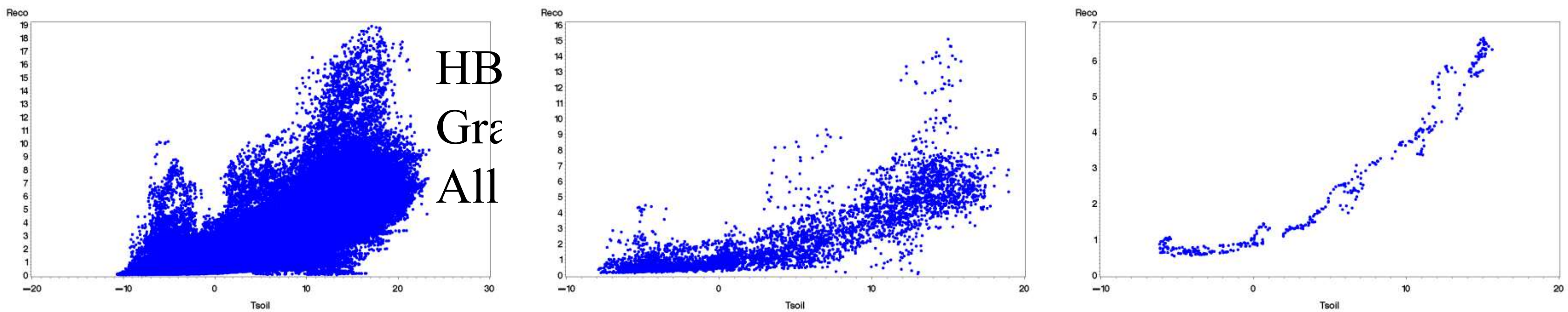
$$\mathrm{Re} = ae^{bT_{Soil}}$$

$$Q_{10} = \left(\frac{\mathrm{Re}_2}{\mathrm{Re}_1}\right)^{10/(t2-t1)} = e^{10b}$$

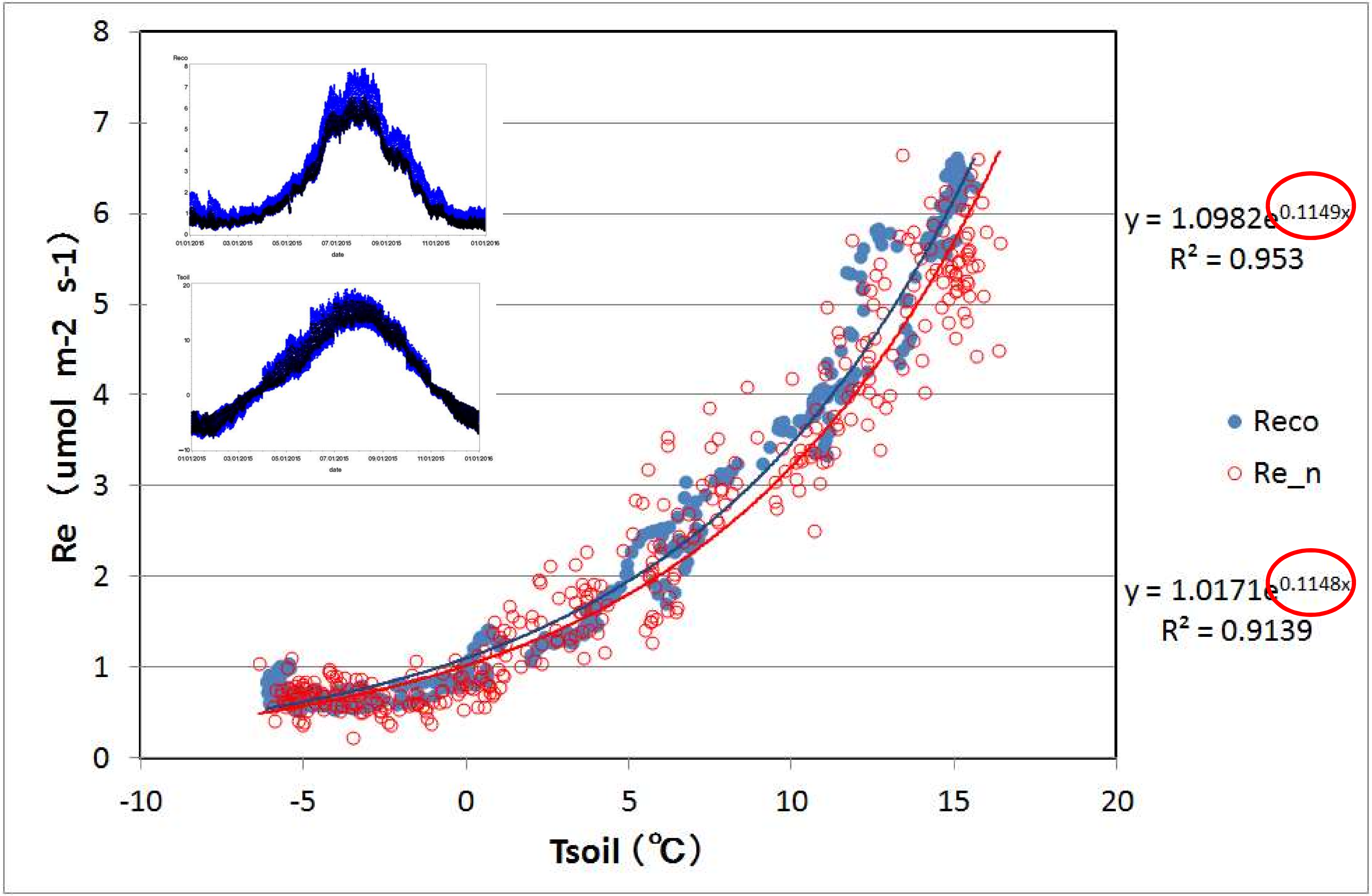
Result 1: Relationship between Reco and Tsoil of 5cm



All the 14 years 30 minutes data | Every year daily mean data | 14 years mean of daily mean data



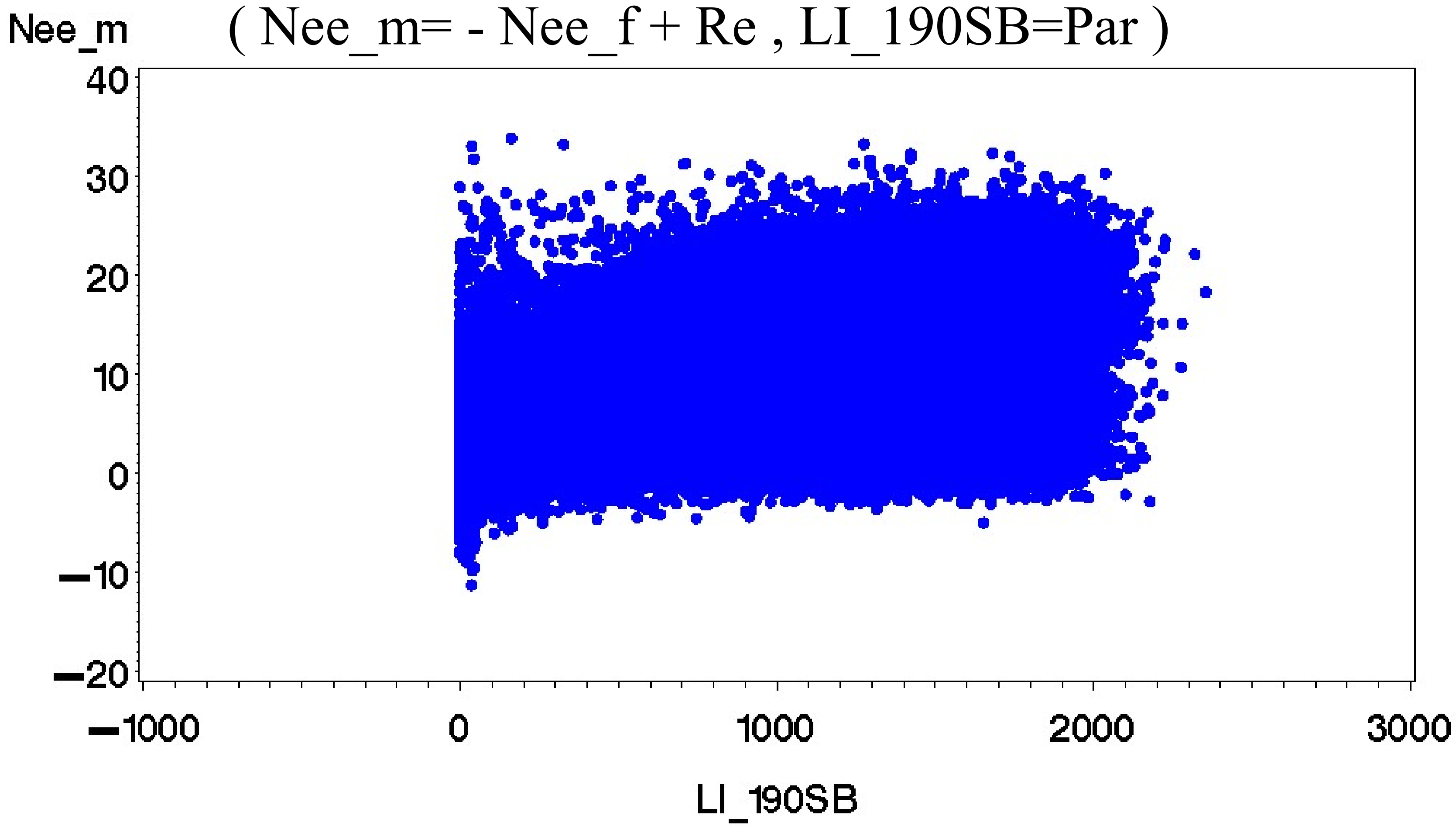
Result 1: Relationship between Reco and Tsoil of 5cm



Result 2: Fitting the Michaelis-Menten light response function

$$NEE_M = -\frac{\alpha A\max Par}{\alpha Par + A\max}(T_{air} or T_{soil}) + \mathrm{Re}(T_{soil})$$

(Nee_m= - Nee_f + Re , LI_190SB=Par)

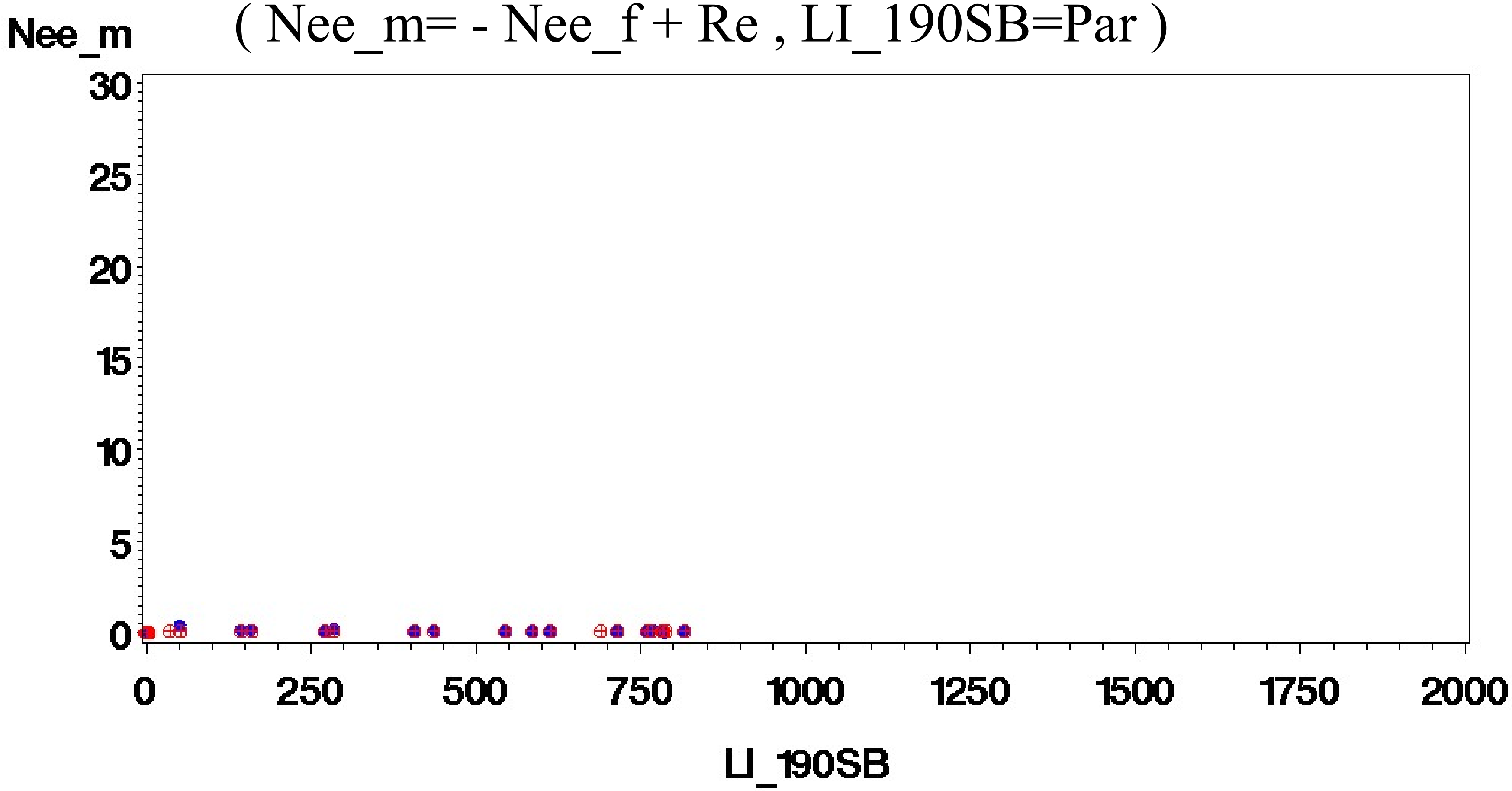


Fitting the Michaelis-Menten light response function

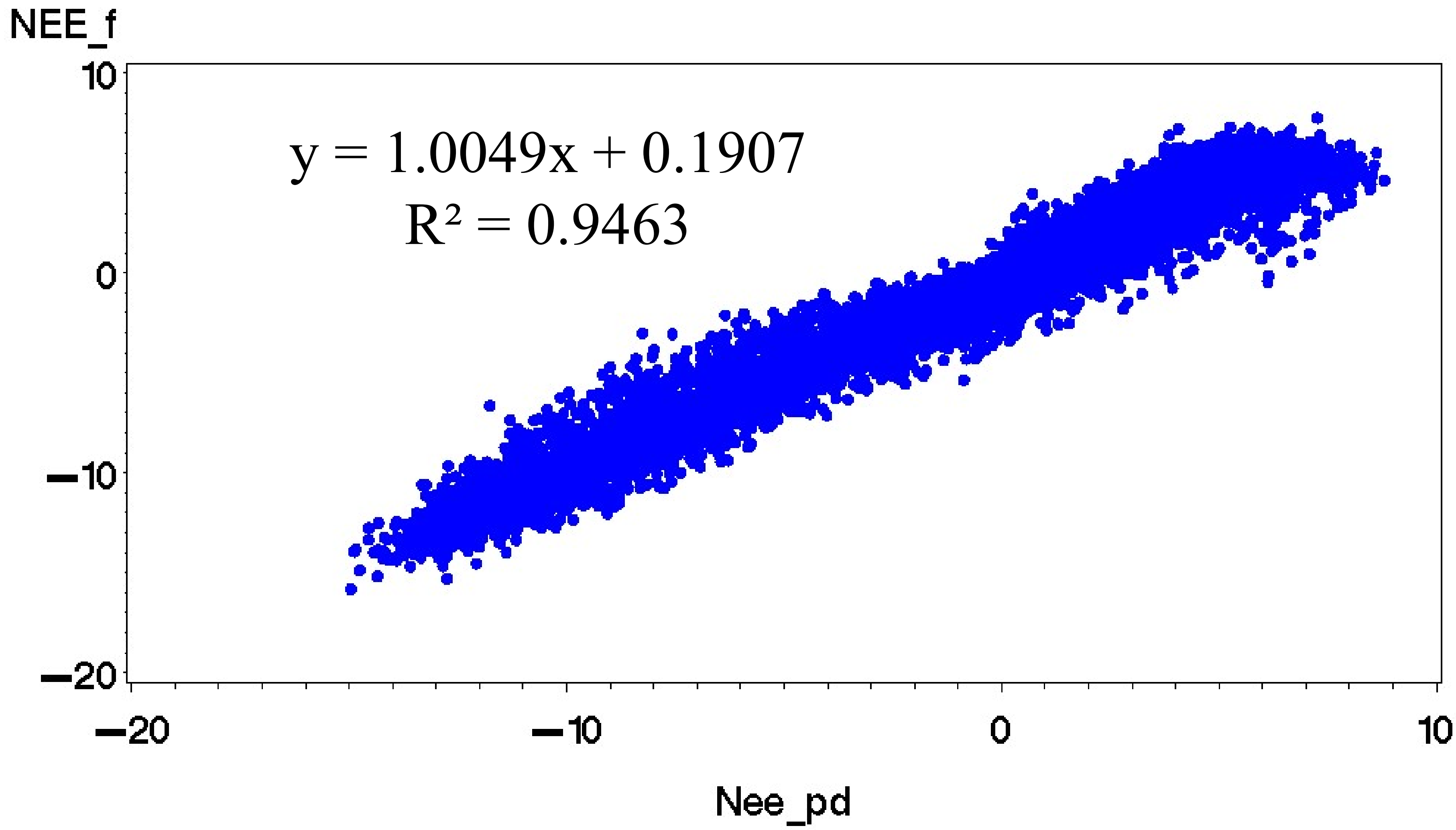
$$NEE_M = -\frac{\alpha A\max Par}{\alpha Par + A\max}(T_{air} or T_{soil}) + \mathrm{Re}(T_{soil})$$

Month=1 Day=1

(Nee_m= - Nee_f + Re , LI_190SB=Par)

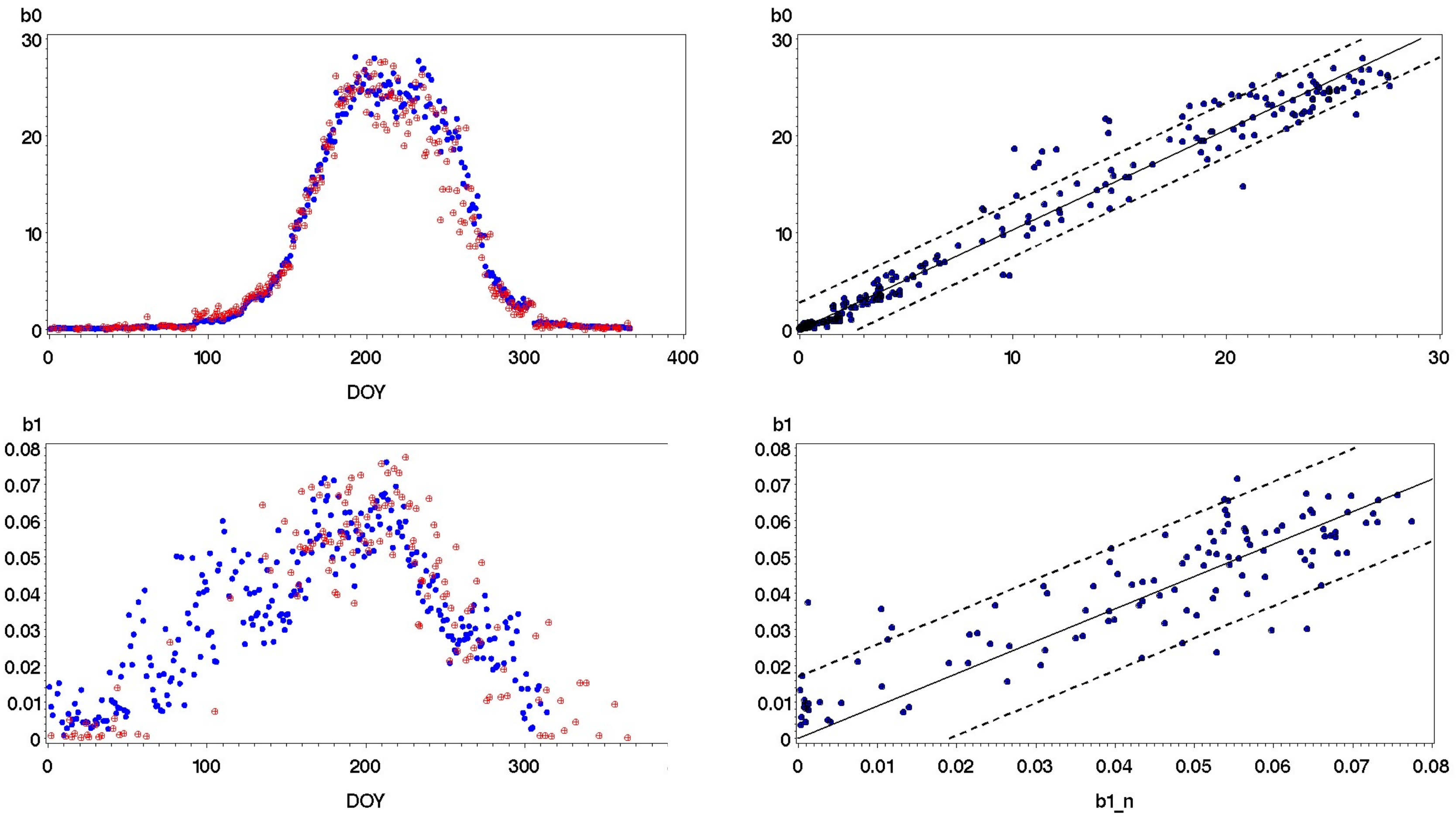


Result 2: Nee fitting results

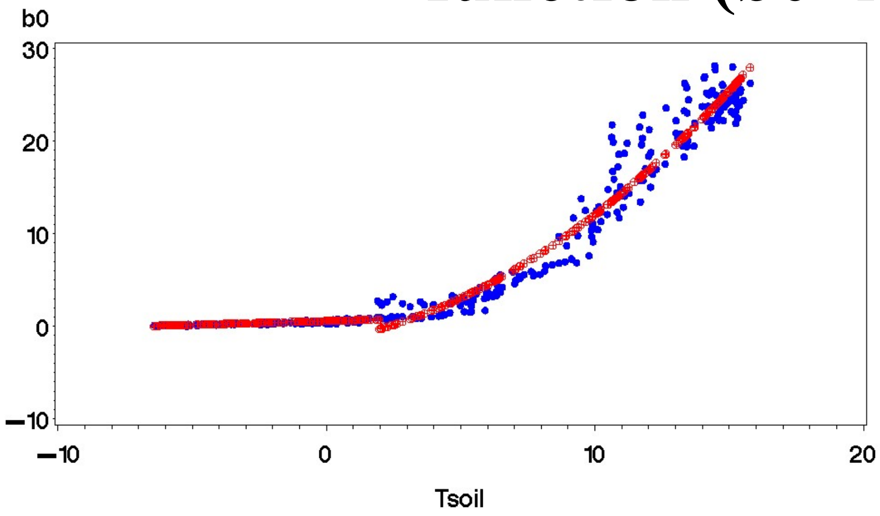


Fitting parameters (b0: Amax,B1:α)

●: all data, ⊕: no filling, dot line: confidence limits(95%)



Result 3: Relationship between temperature and the coefficients of Michaelis-Menten light response function (b0=Amax, b1=α)

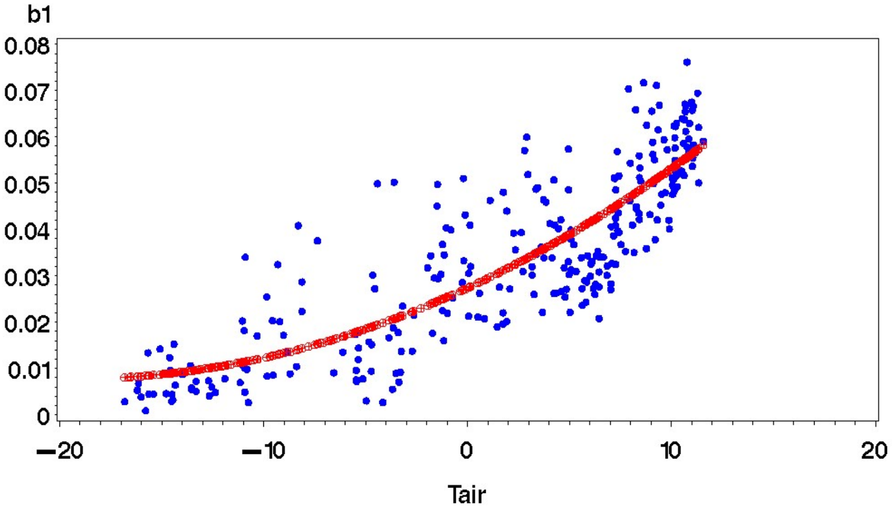


$Amax=0.57+0.08\mathbf{Tsoil}$

for Tsoil<2.0°C

$Amax=-1.62+0.5\mathbf{Tsoil}+0.09\mathbf{Tsoil}^2$

for Tsoil<=2.0°C



$\alpha=0.027+0.002\mathbf{Tair}+0.00005\mathbf{Tair}^2$

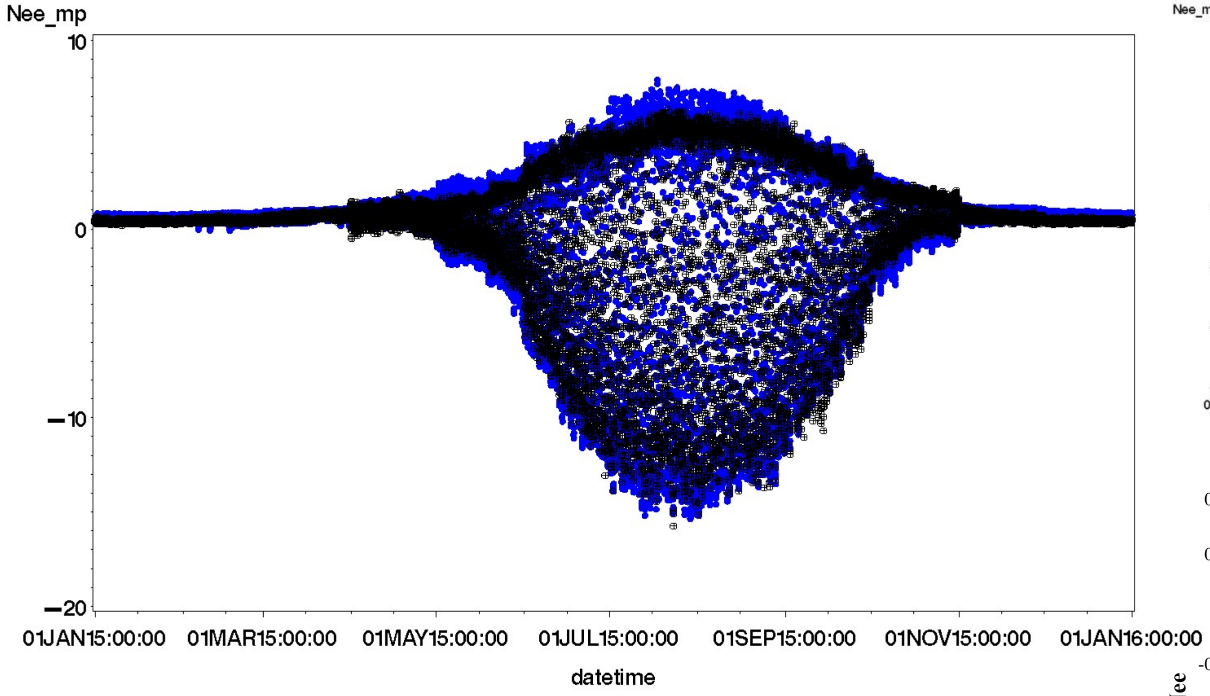
Analyses results 4: Statistical Model

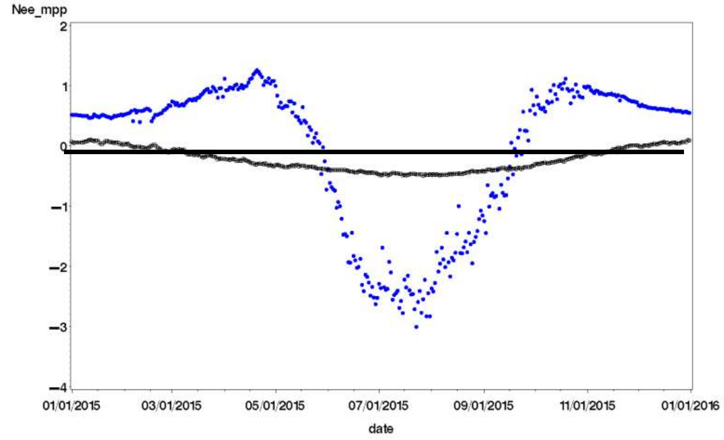
$$NEE_{pred}(T) = NEE_M(Par, \mathrm{Re}(T)) + \Delta Nee(T)$$

$$NEE_M = -\frac{\alpha A\max Par}{\alpha Par + A\max}(T_{air}) + \mathrm{Re}(T_{soil})$$

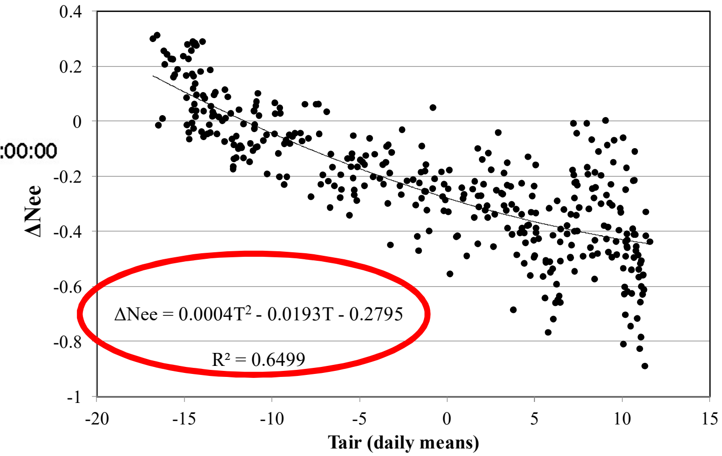
ΔNee (T)

Predect 1 parameter fixed



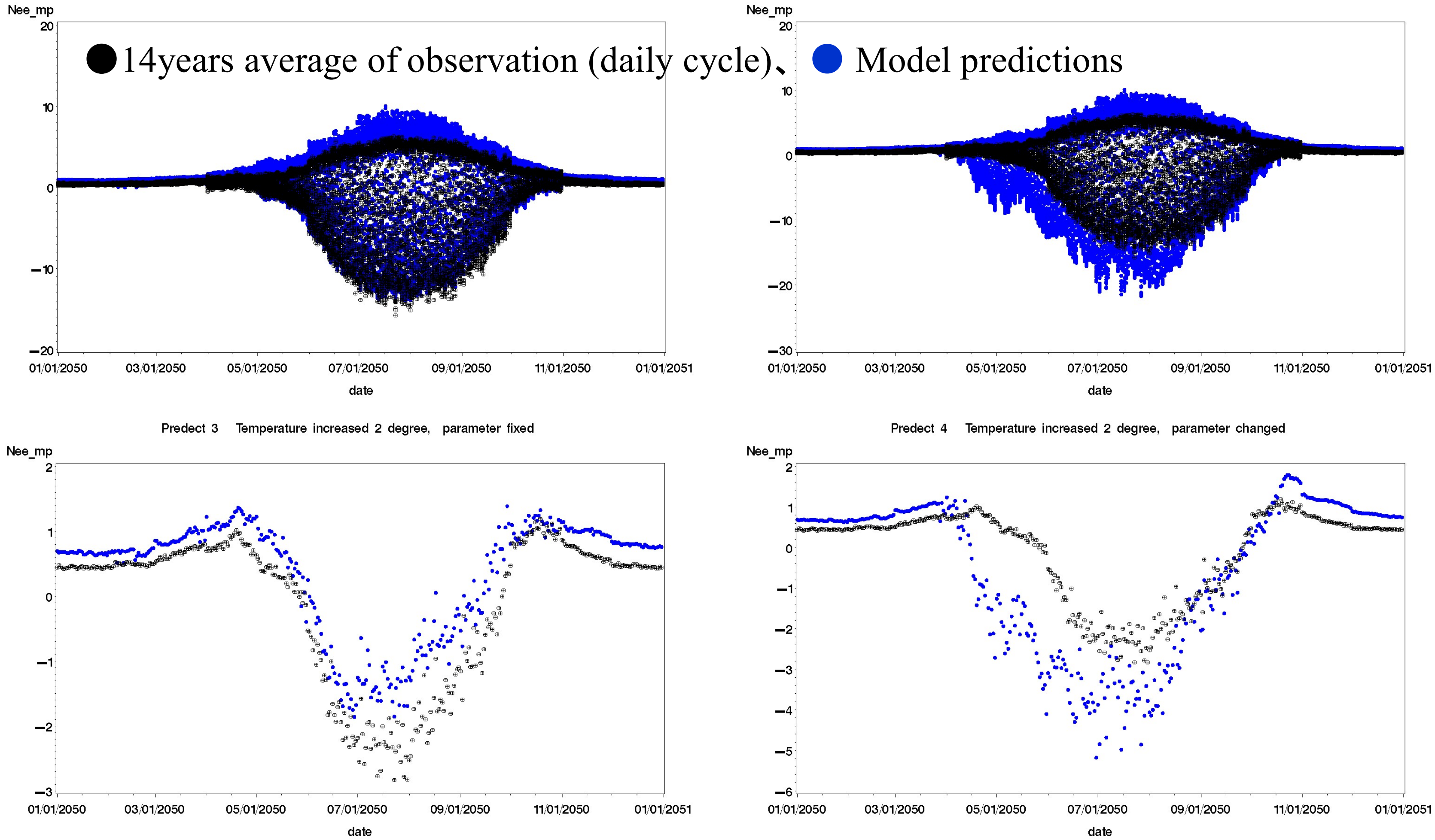


● 14years average of observation (daily cycle)
● Model predictions



Model prediction 1: for all the temperature increasing 2°C

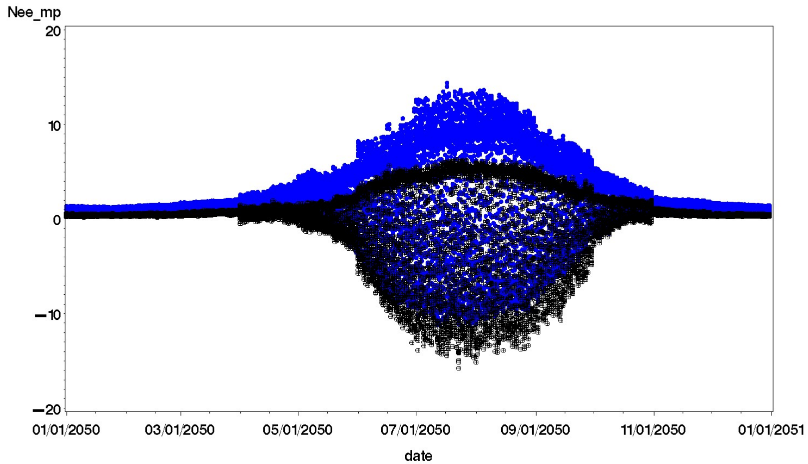
Parameters Fixed / Parameters changed



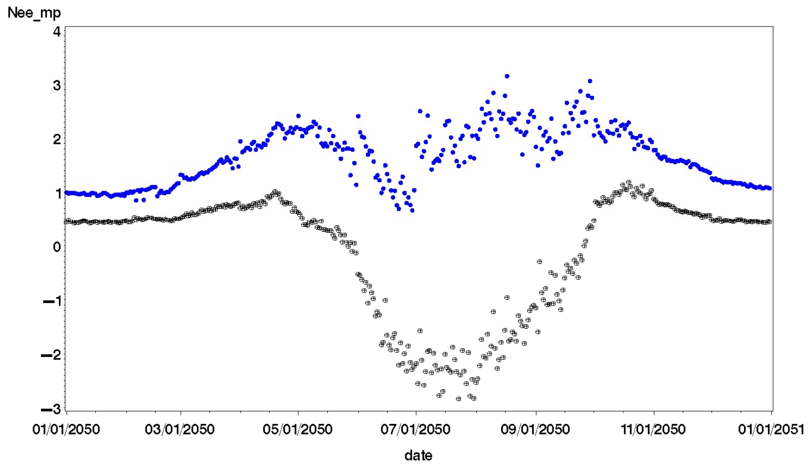
Nowadays 42gC/㎡ sink will become 238gC/㎡ sink!

Model prediction 2: for all the temperature increasing 5°C

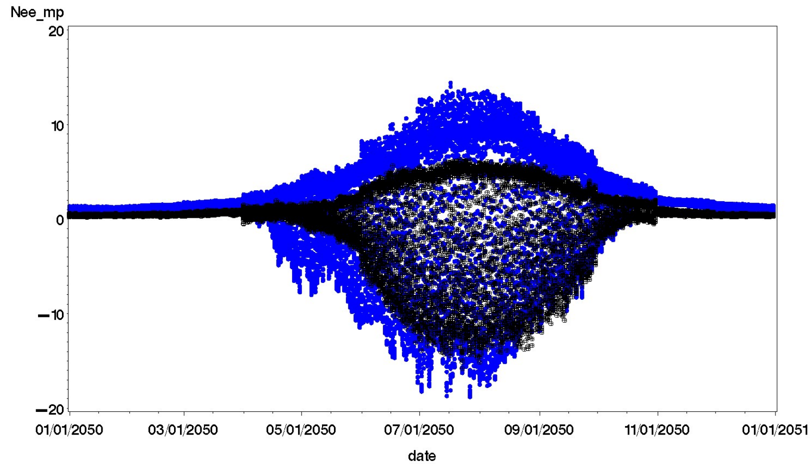
Parameters Fixed



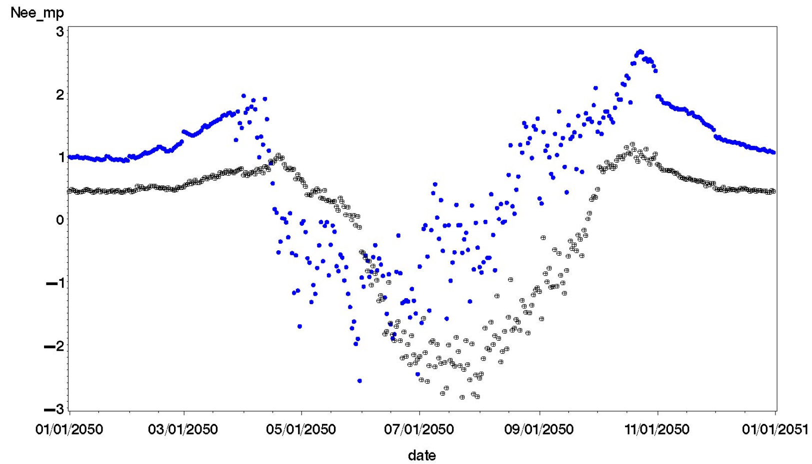
Predect 5 Temperature increased 5 degree, parameter fixed



Parameters changed



Predect 6 Temperature increased 5 degree, parameter changed

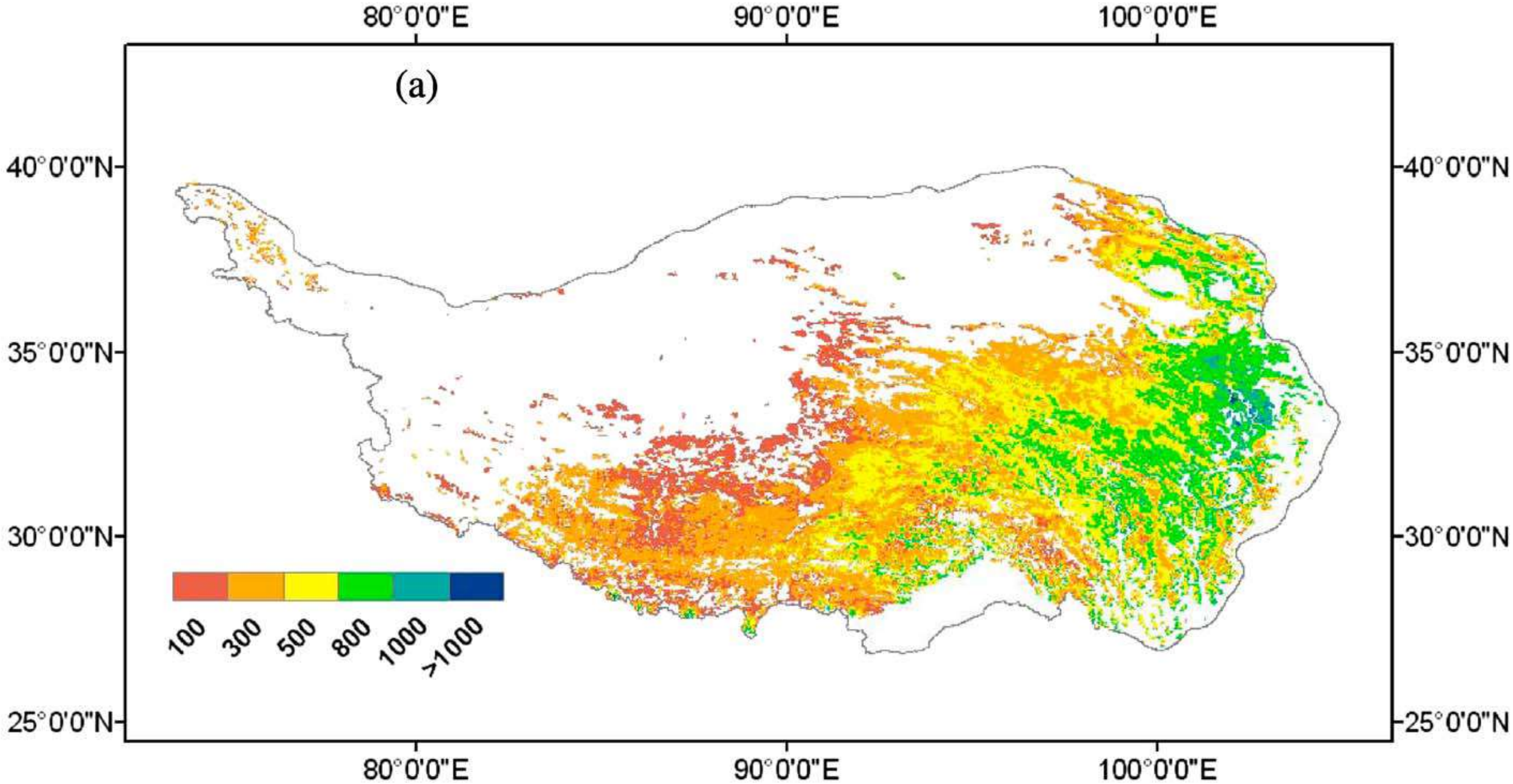


Nowadays' 42gC/㎡ sink will become to 263gC/㎡ gC/㎡ sources!

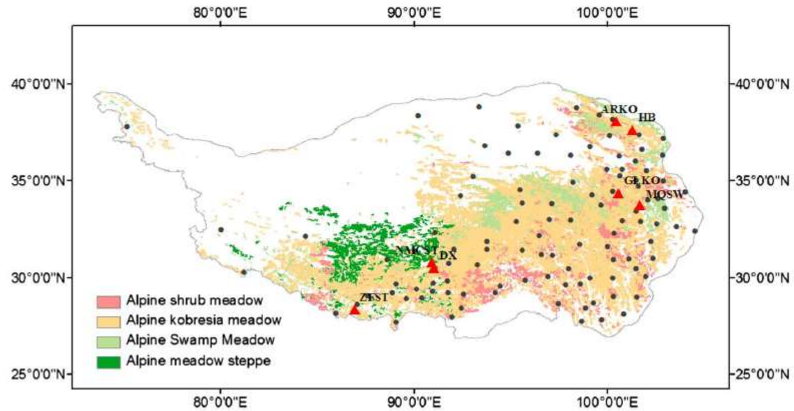
Conclusions

- 14 years observations show that there were no temperature increasing and therefore **the annual NEE has no trend during the 14 years. However about 3 °C warm summer let more CO_2 absorption.**
- **Daily cycle of NEE** fits the Michaelis-Menten light response function very well (may explain over 90% of annual NEE amount). **the coefficients of the function (Amax, α) have very large seasonal variations.**
- There are very clear relationship between temperature and the coefficients.
- By using the statistical fitting model, **increasing of CO_2 absorption can be expected if all the temperature increasing 2°C**. However, if all the temperature increasing 5°C, these CO_2 absorption will be changed to large amount of releases (**from sink to source**).


Thank you for attention!
（背景：ブダラ宮2009）

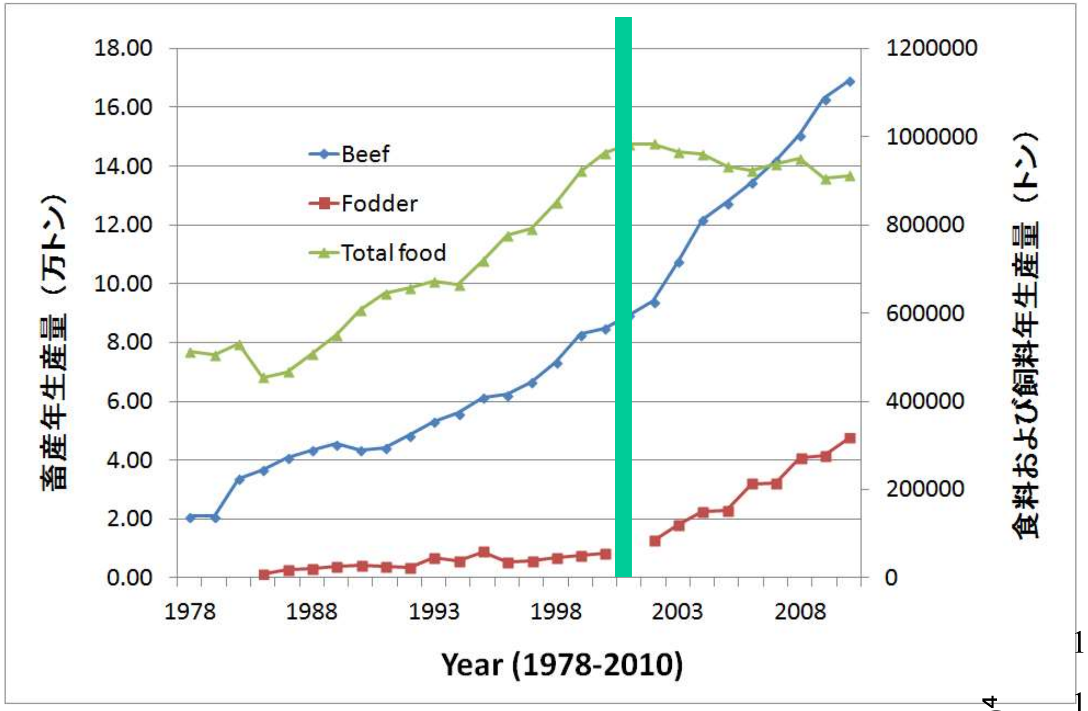


チベット高原における草原のGPP（gC/m²/年）を広域分布（2003－2008平均）



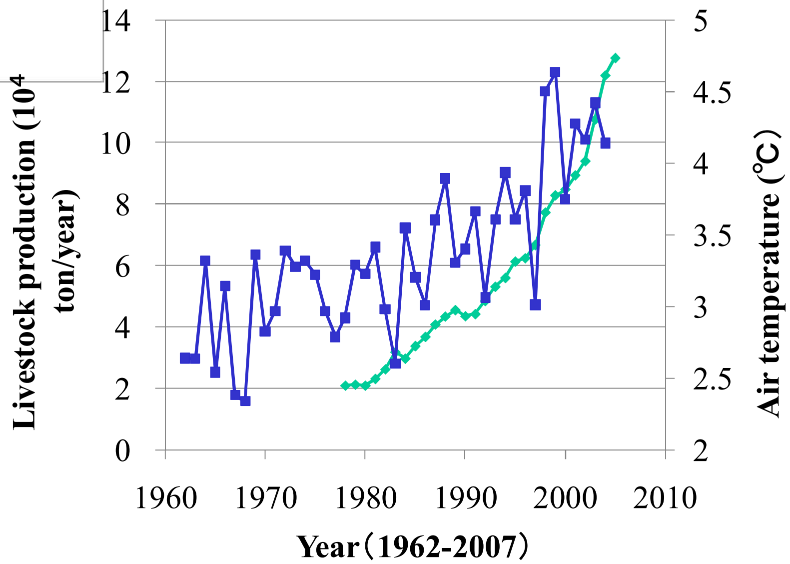
チベット高原における各種草原およびフラックス観測サイトの分布

チベットにおける
畜産生産量および食料と飼料生産量の推移および気温上昇



気温の上昇も、2000年から停止したにもかかわらず、畜産生産量は増加し続けている。

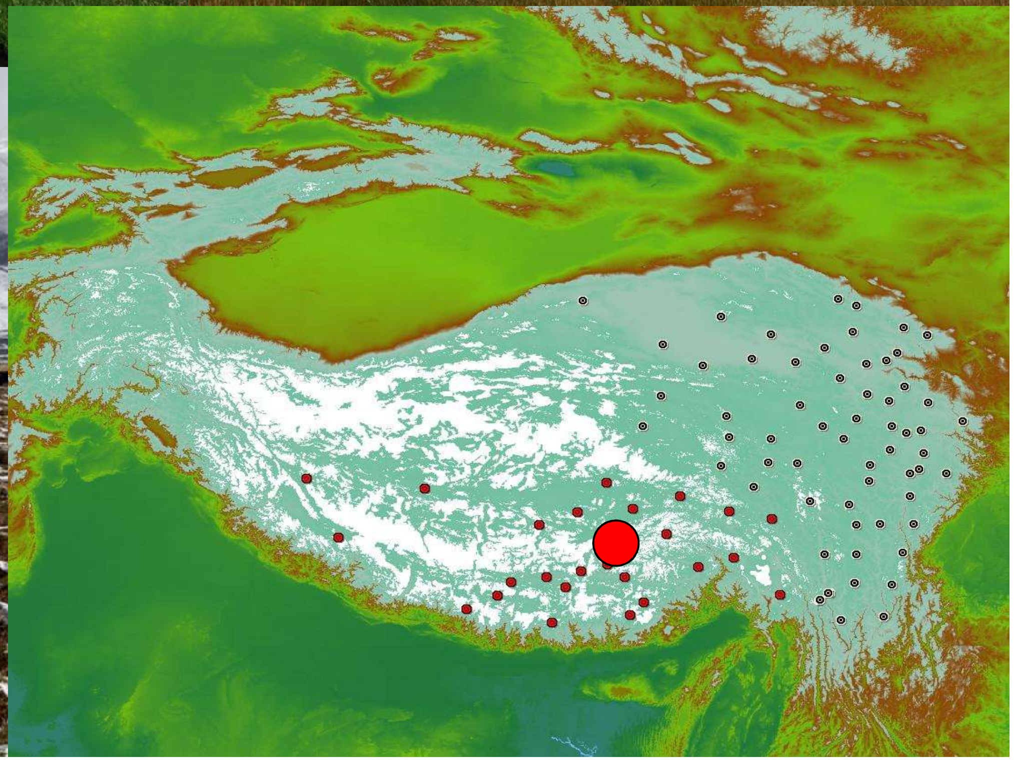
チベットにおける食料生産量は2000年から増加しなくなったが、畜産生産量は益々増加し続けている。



Observation site B: Damxung, wetland

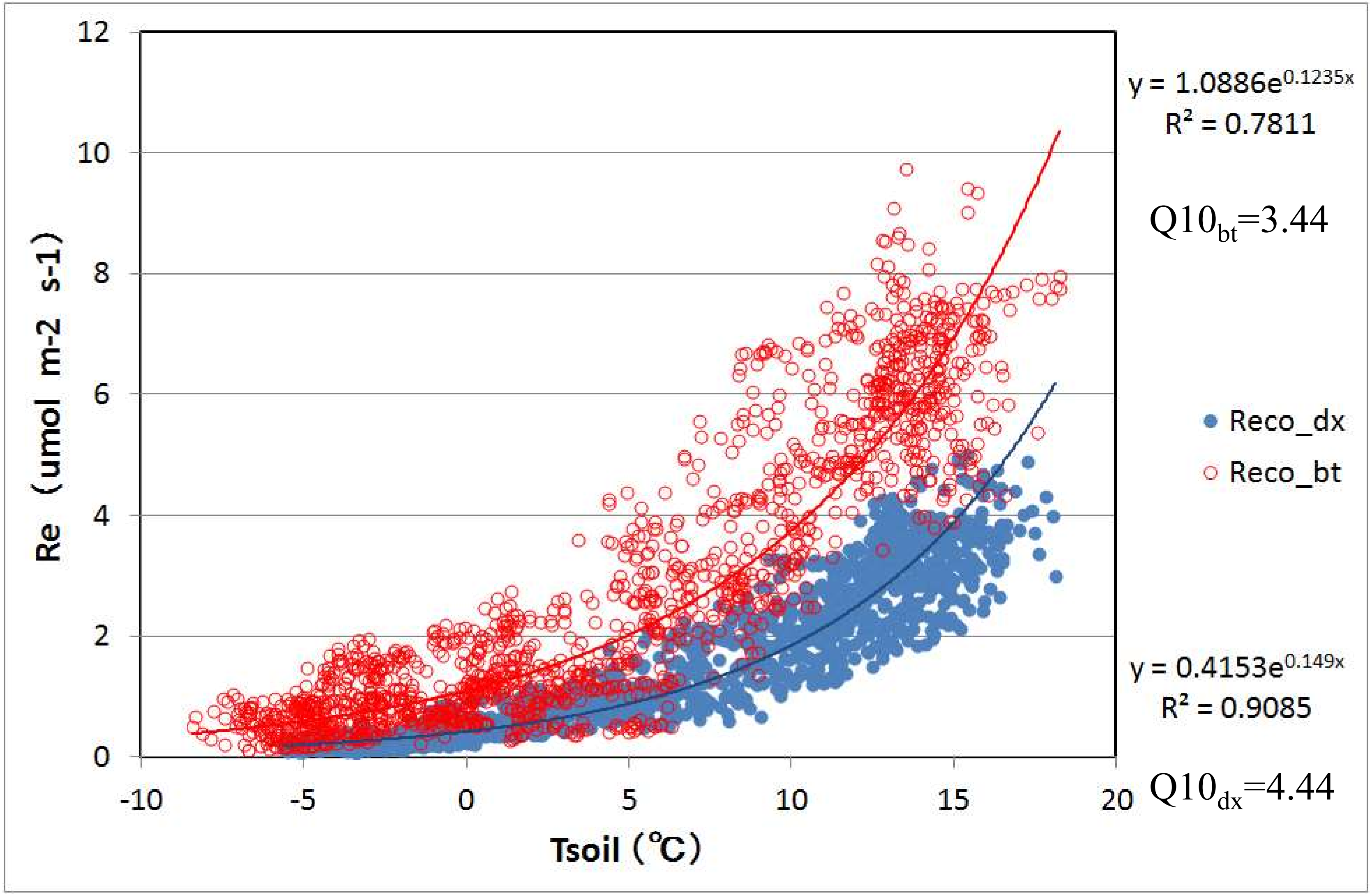
(30° 28'N, 91° 04'E, 4280m a.s.l.)

Since June. 8, 2009



Result 1: Relationship between Reco and Tsoil of 5cm

Comparison of the two sites



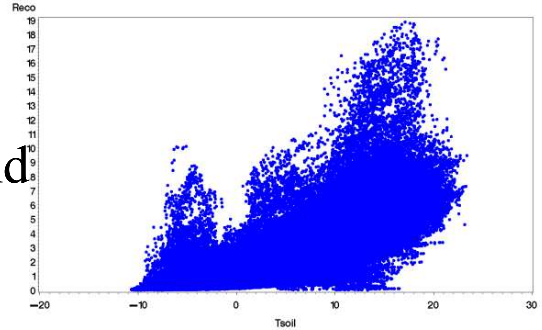
$Q10_{bt}$=3.44

$Q10_{dx}$=4.44

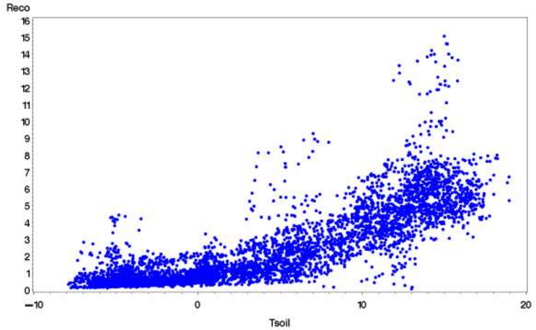
Result 1: Relationship between Reco and Tsoil of 5cm

Comparison of the two sites

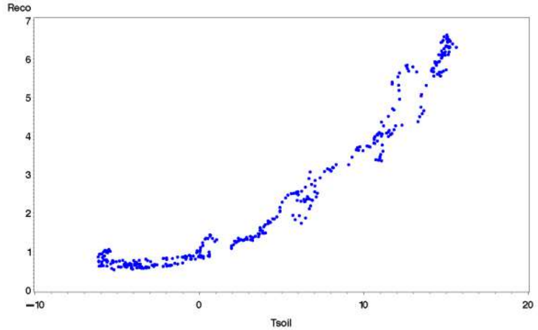
HB Site
Grassland



All the 14 years
30 minutes data

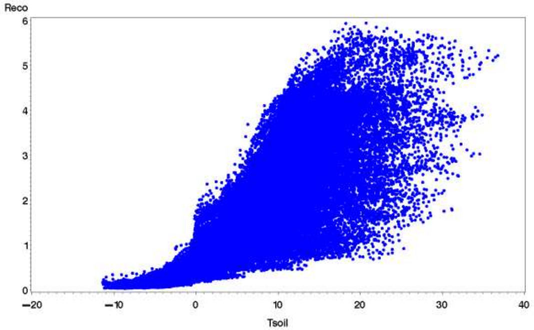


Every year
daily mean data

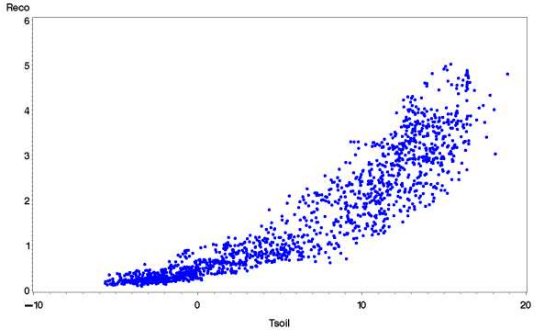


14 years mean of
daily mean data

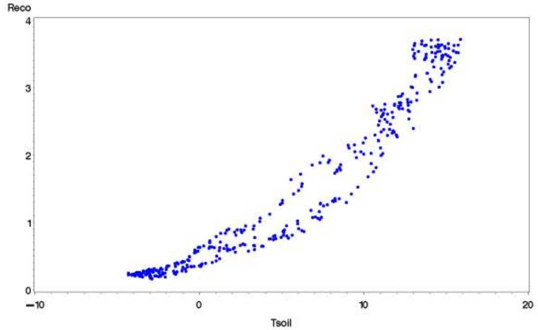
DX Site
Wetland



All the 4 years
30 minutes data

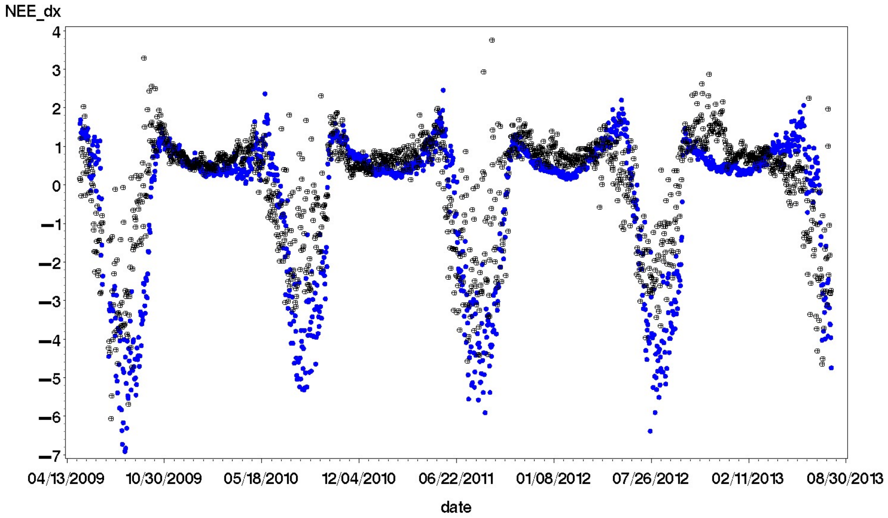


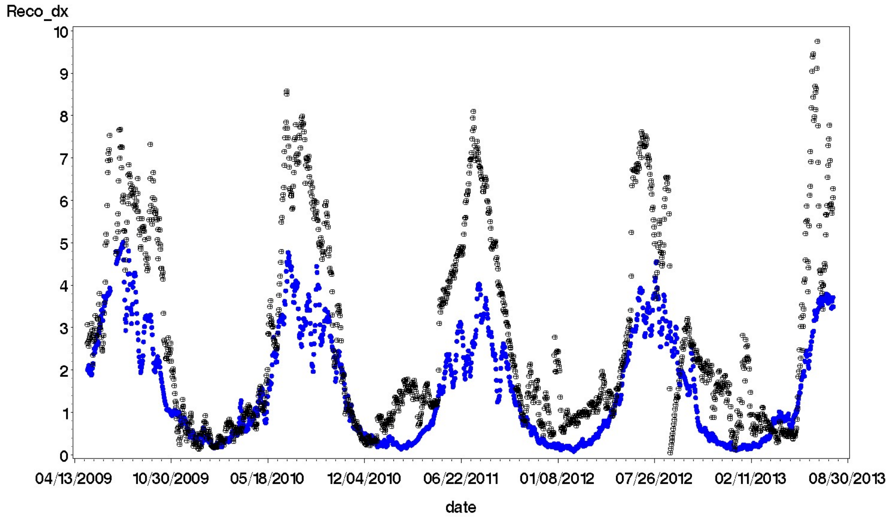
Every year
daily mean data

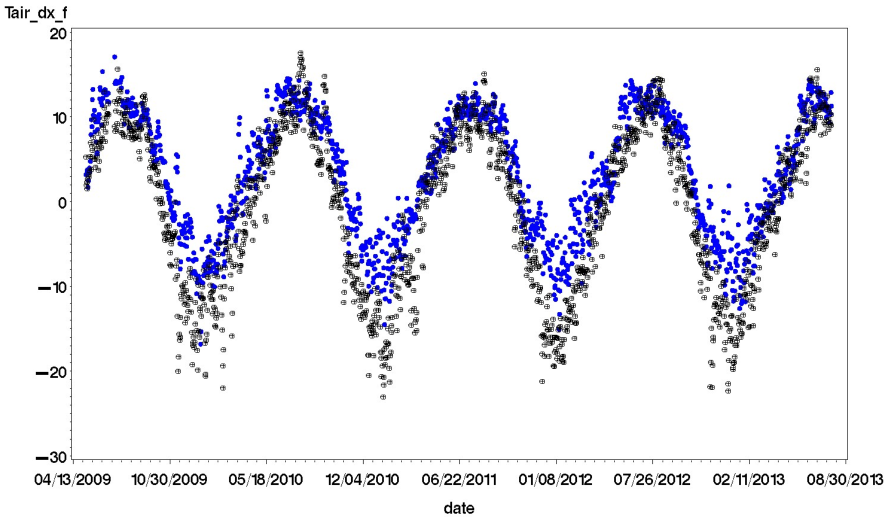


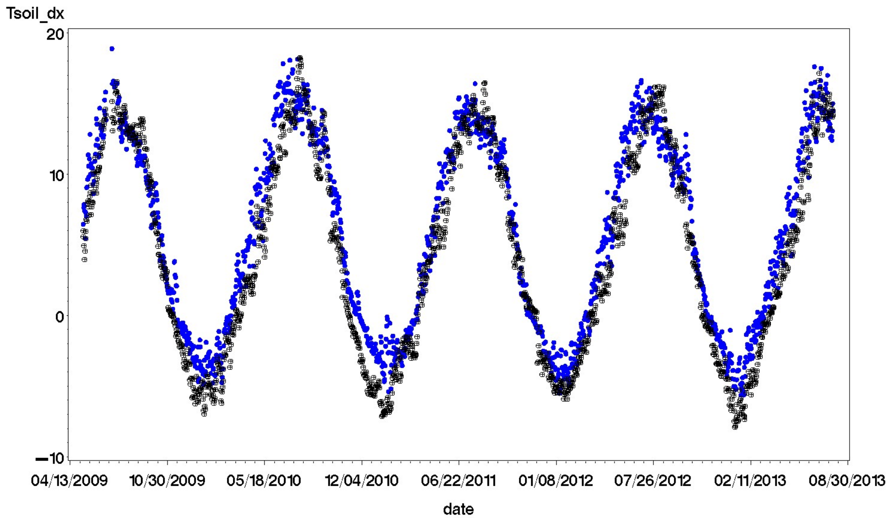
5 years mean of
daily mean data

Comparison of Re and T between the two type ecosystems

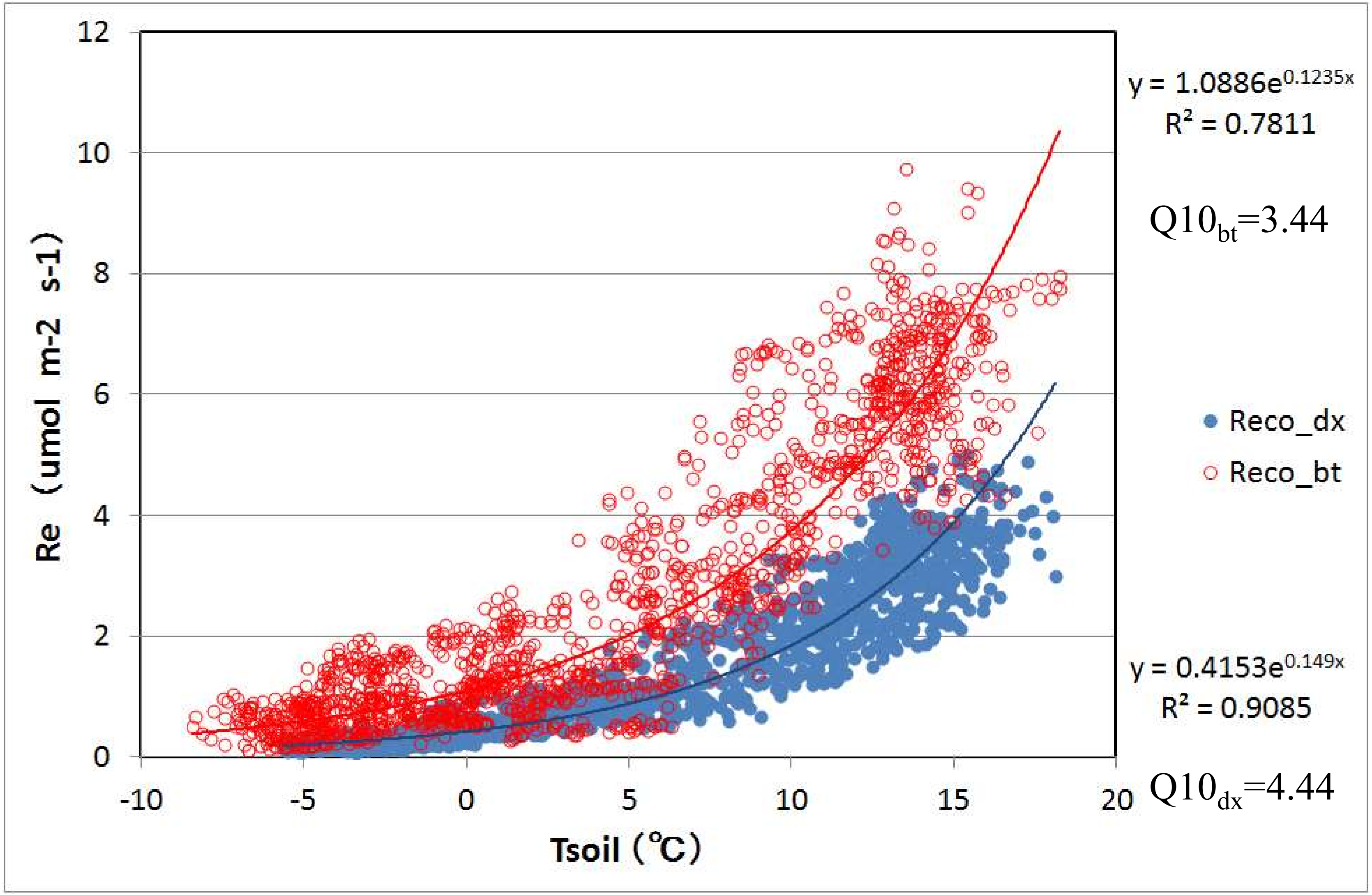


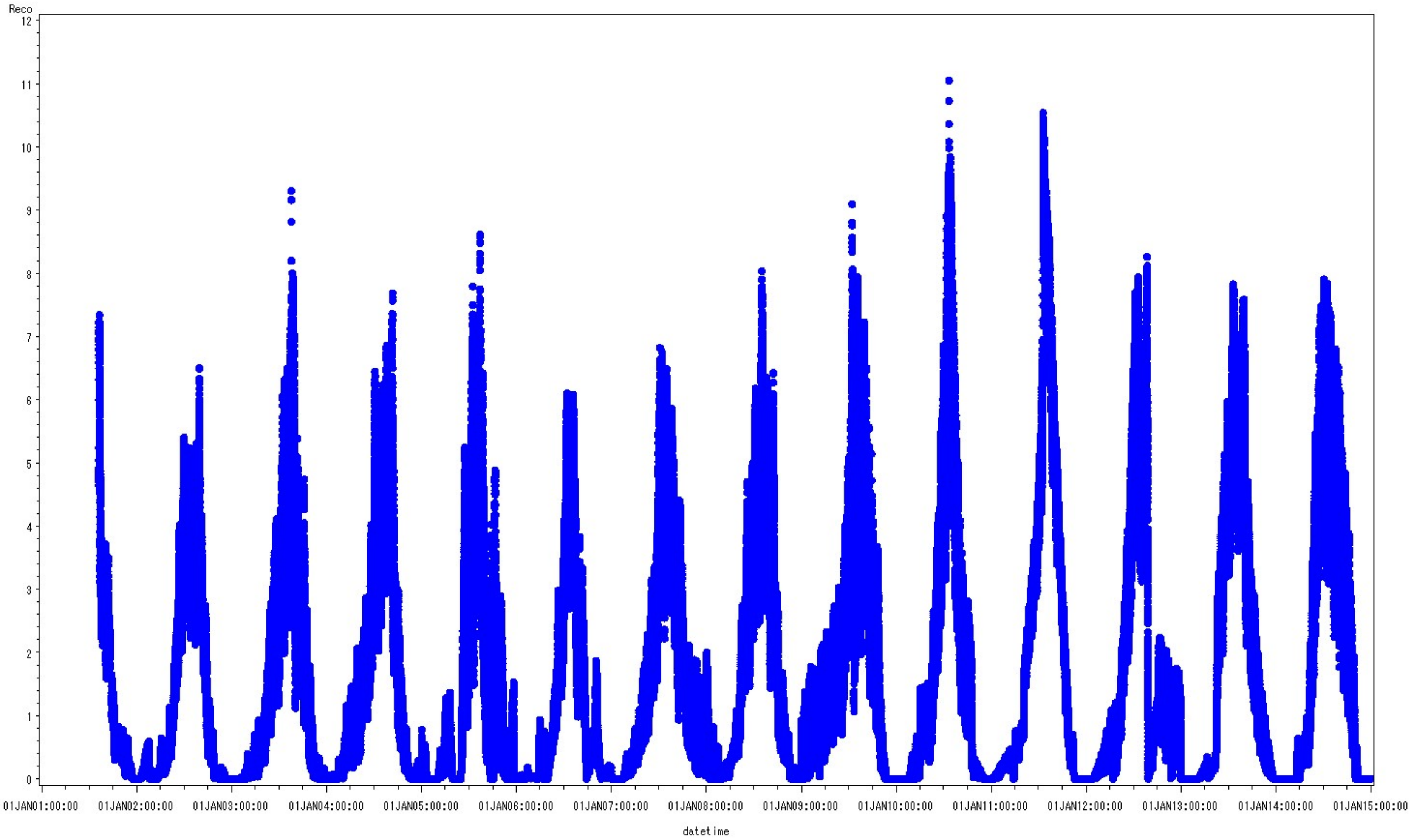






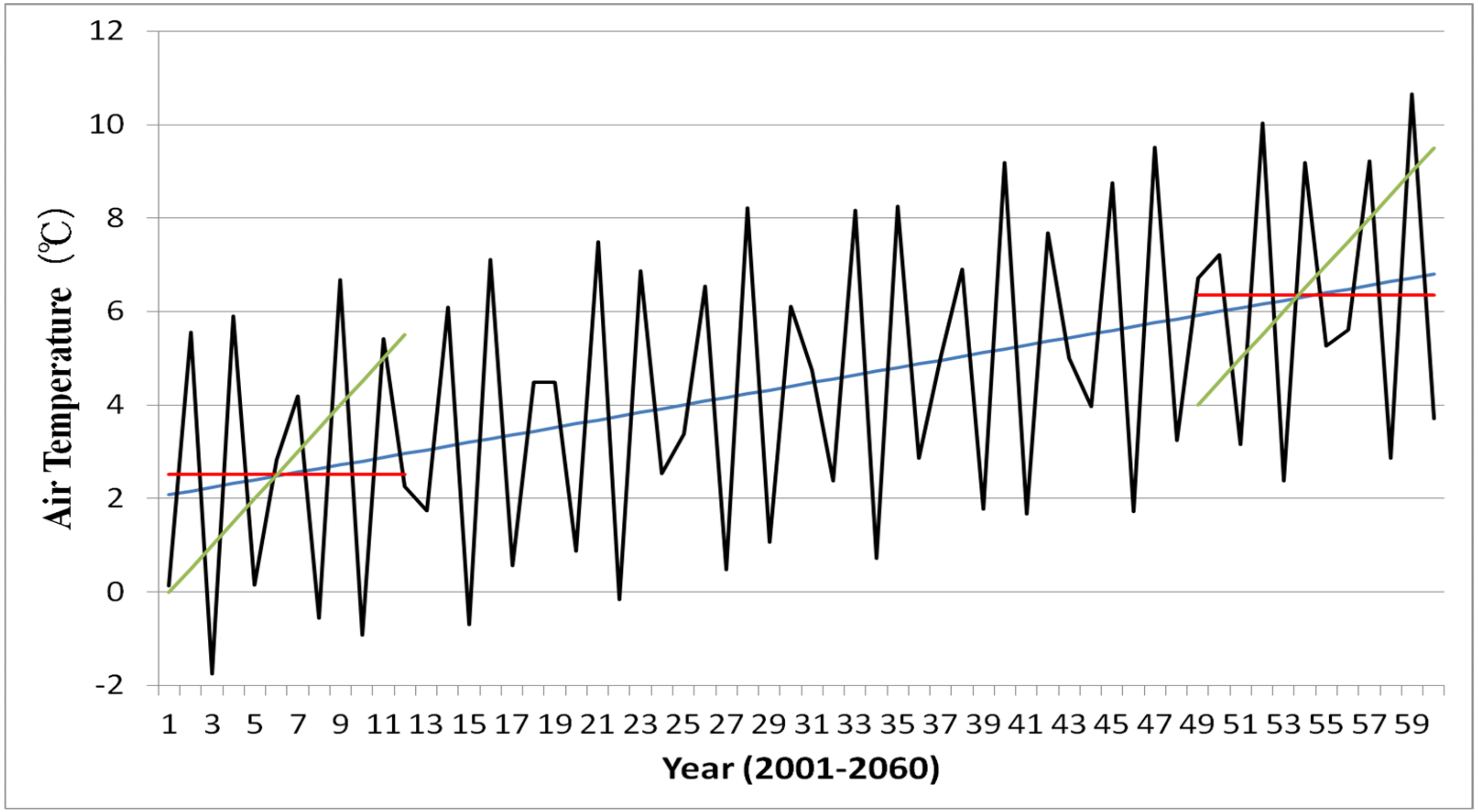
Result 1: Relationship between Reco and Tsoil of 5cm





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

将来温暖化による、このシンクの変化は



未来50年間気温が4度上昇と仮定しよう。現在の気温変動は4度の幅がある。これで求めた気温との関係は50年後のフラックスを予測する。