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Carbon balance of tropical peat ecosystems

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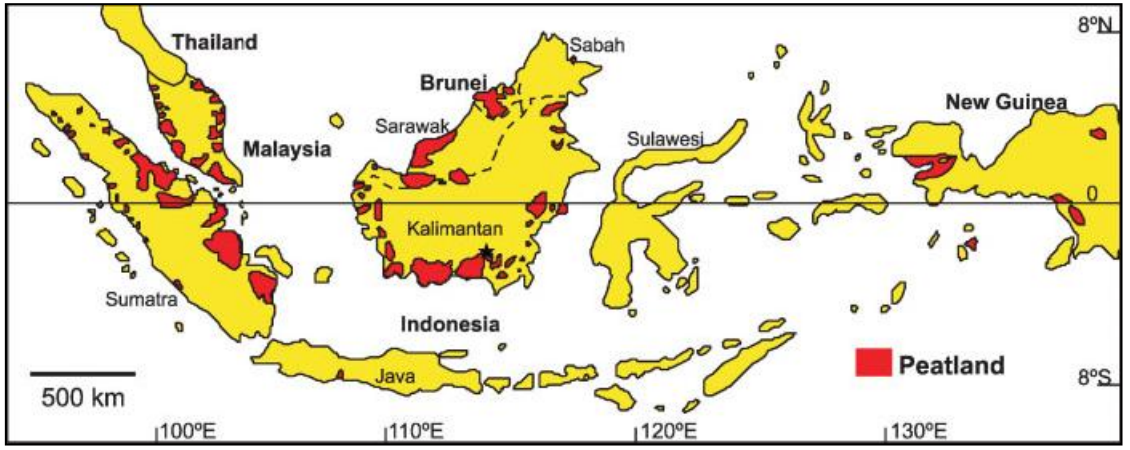
SATREPS

JapanFlux

Tropical peatland in SE Asia

- In SE Asia, pealtlands are widely distributed in the area of about 250,000 km^2 and store 68.5 Gt of soil carbon, which accounts for 11-14% of global peat carbon (Page *et al*., 2011).
- Although the tropical petalands naturally coexists with swamp forest, the peatlands have been devastated by logging and land development since the 1970's, and 20% of peat swamp forest has been deforested and mostly drained for the last decade (Miettinen *et al.*, 2011).
- The risk of large-scale fires increases with the disturbance, because such disturbances typically dry peat and leave much plant debris, which are flammable (Page *et al.*, 2002).



Distribution of tropical peatlands in SE Asia (Page *et al.,* 2004)

El Niño drought

Disturbances
- Drainage
- Fires

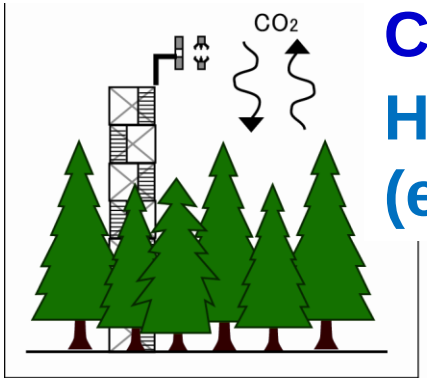
Carbon balance

Water balance

CO_2 and water vapor fluxes has been measured using the eddy covariance technique at three different land-use types:

1. Almost undrained swamp forest (UF)
2. Drained swamp forest (DF)
3. Burnt forest after drainage (DB)

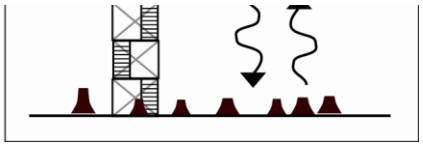
Undisturbed (control) Disturbed



CO_2 flux

H_2O flux (evapotranspiration)

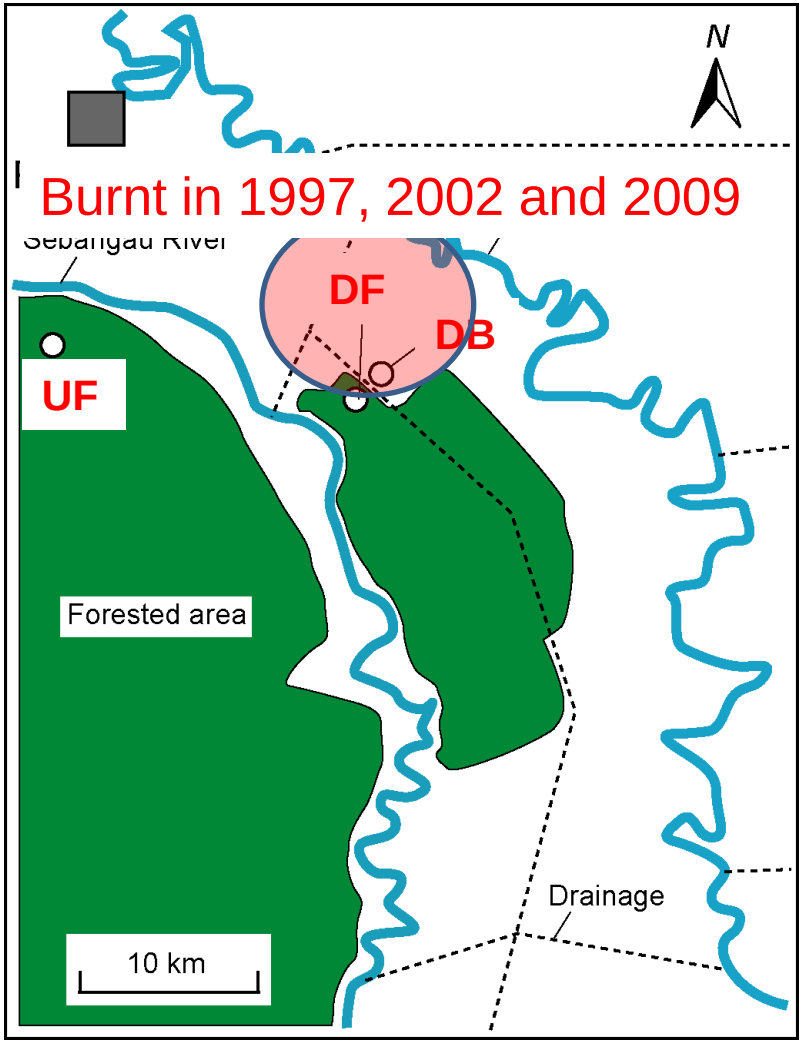
vs.

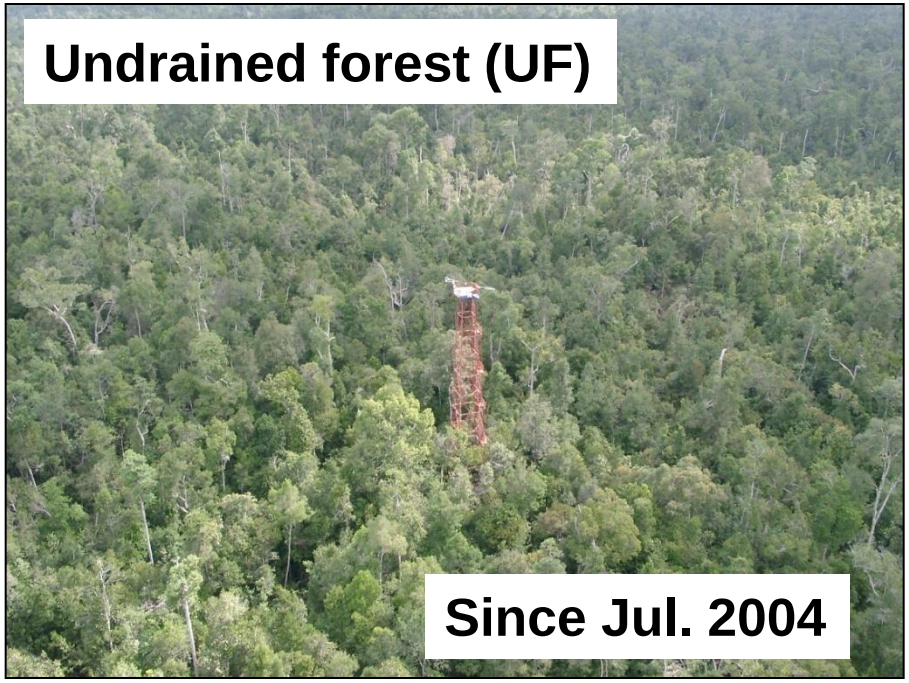


Study area

- Disturbed peatland near Palangkaraya
- Ex-Mega Rice Project (MRP) area (Block C)
- 3 towers (UF, DF and DB)

Palangkaraya, the capital of Central Kalimantan province (2º20′S, 114º20′E)





Since Nov. 2001

Method to measure CO_2 flux

Using the eddy covariance technique, eddy CO_2 flux has been measured to assess NEE.

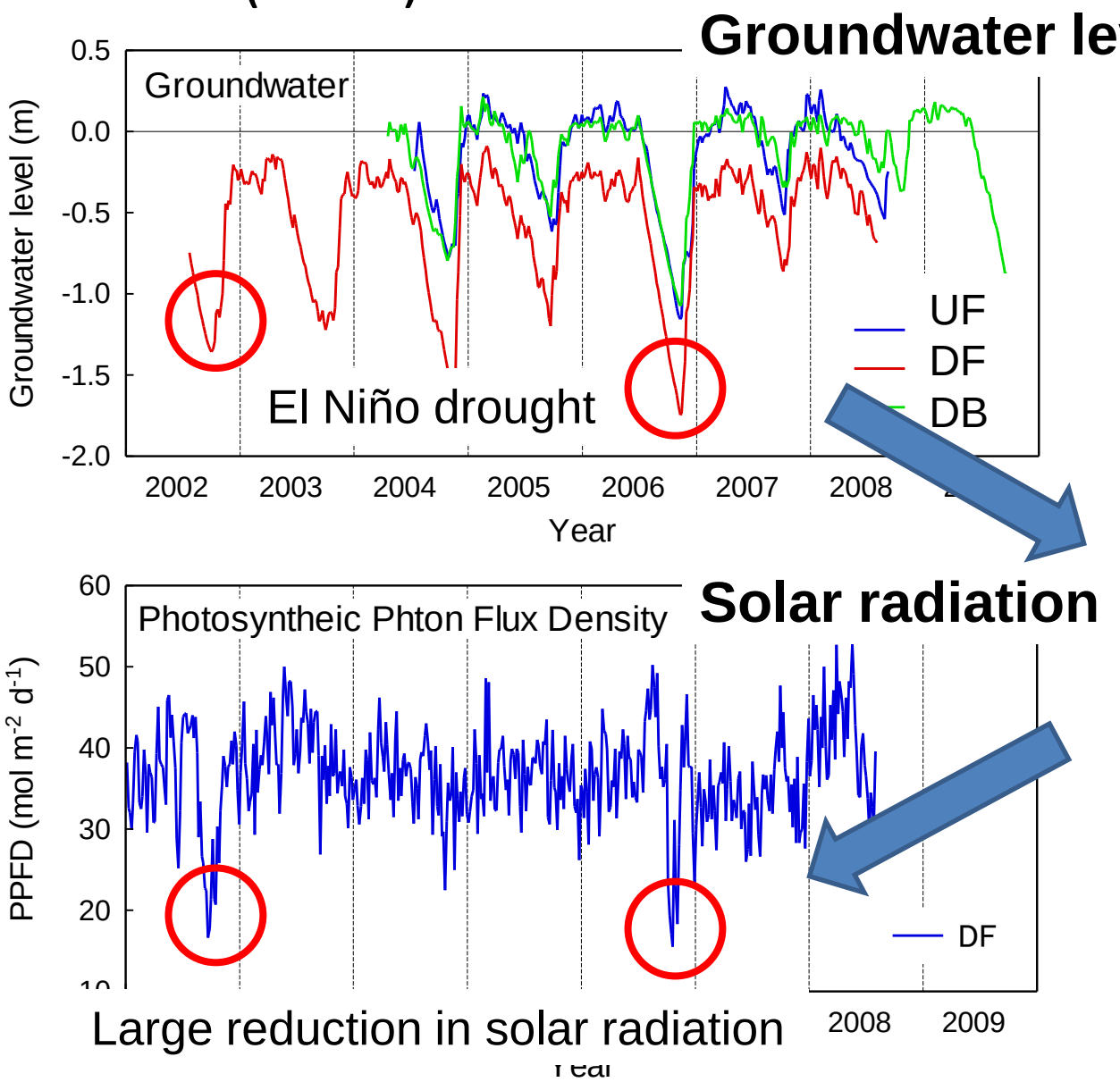
NEE = Eddy CO_2 flux + CO_2 storage change
= RE - GPP

NEE: Net Ecosystem CO_2 exchange
GPP: Ecosystem photosynthesis
RE: Ecosystem respiration

Using an empirical model, NEE was partitioned into RE and GPP.

NEE > 0 $\rightarrow$ RE > GPP $\rightarrow$ CO_2 source to the atmosphere

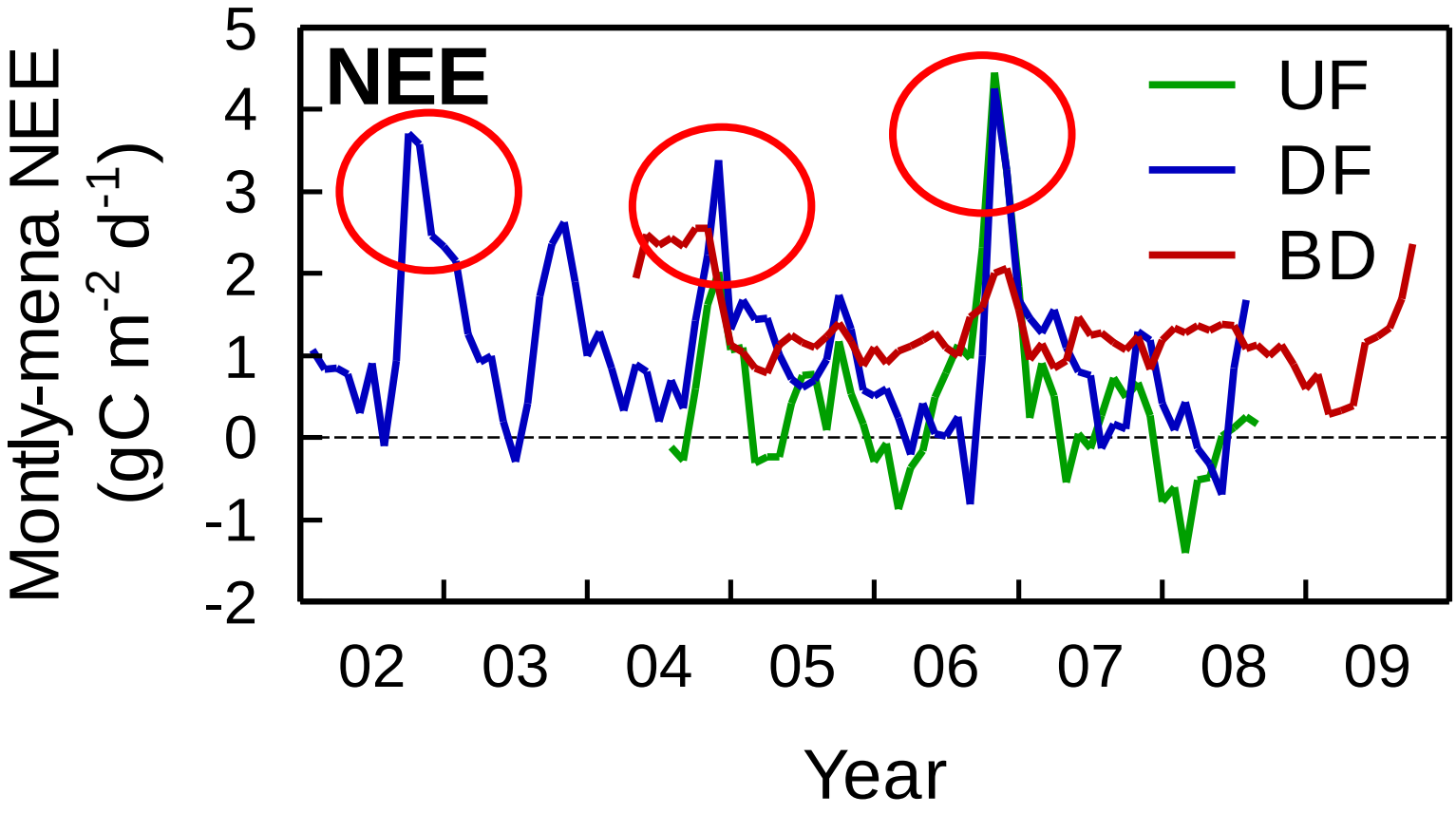
Seasonal variations in groundwater level (GWL) and solar radiation (PPFD)



Large-scale fires

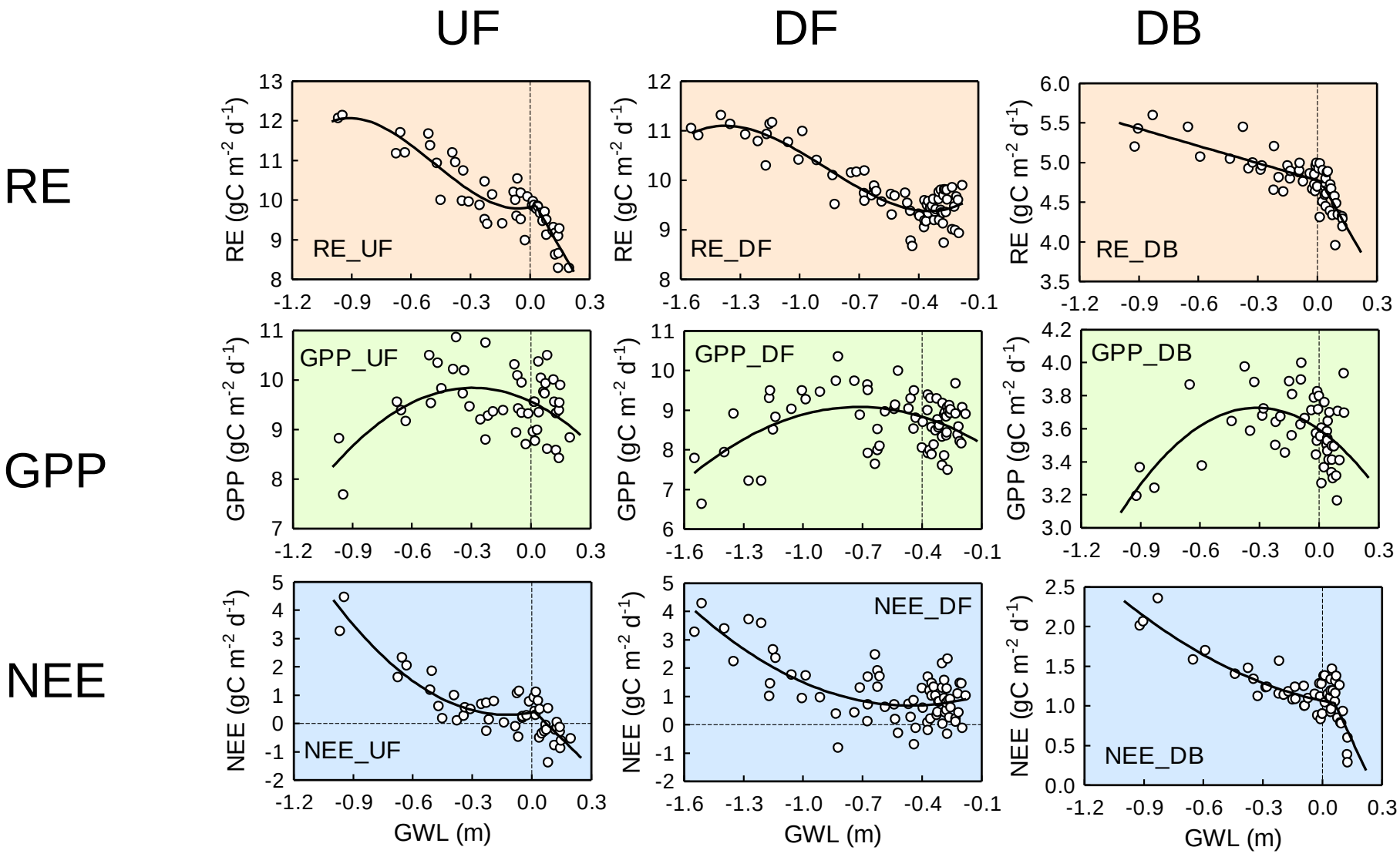
Seasonal variation in net CO_2 exchange (NEE)

NEE = RE - GPP



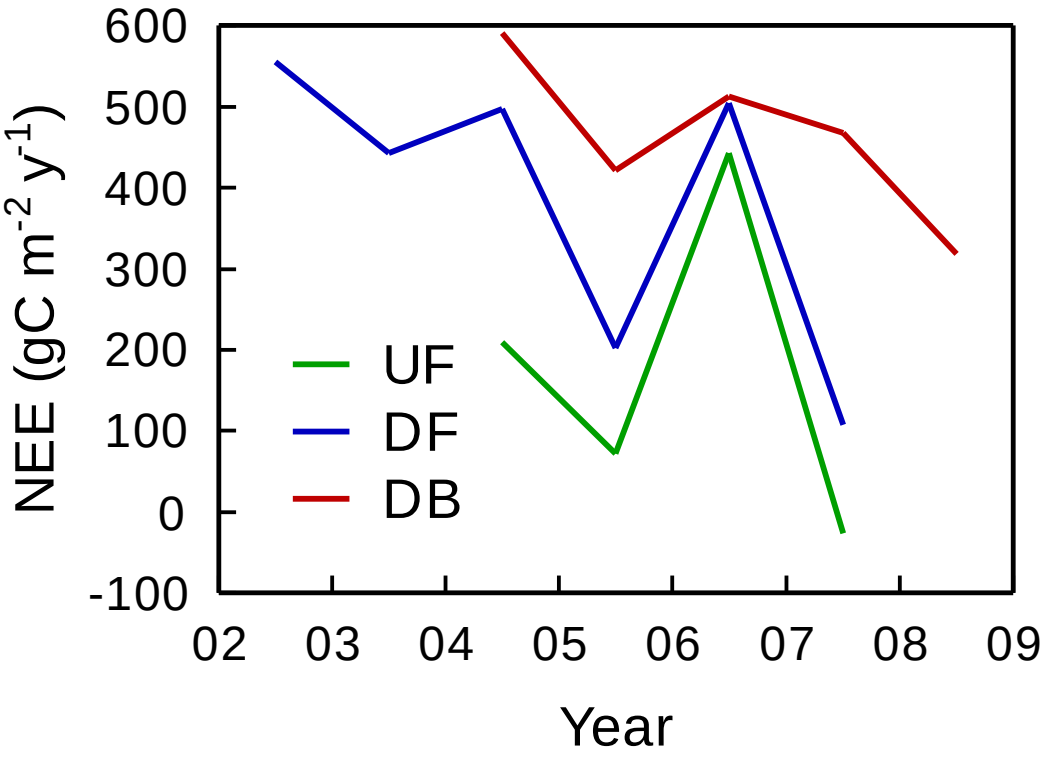
Large increases were found in the dry seasons of 2002, 2004 and 2006, El Niño years, because of shading by dense smoke and the enhancement of oxidative peat decomposition due to low GWL.

CO_2 flux vs. GWL (monthly means)



Hirano et al., 2012

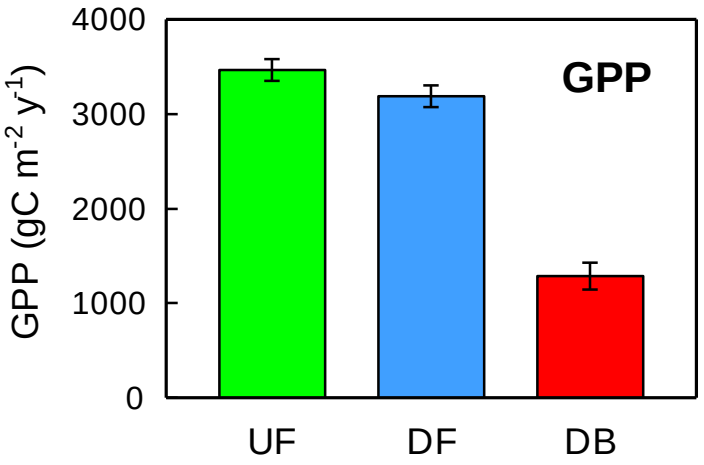
Interannual variation in NEE



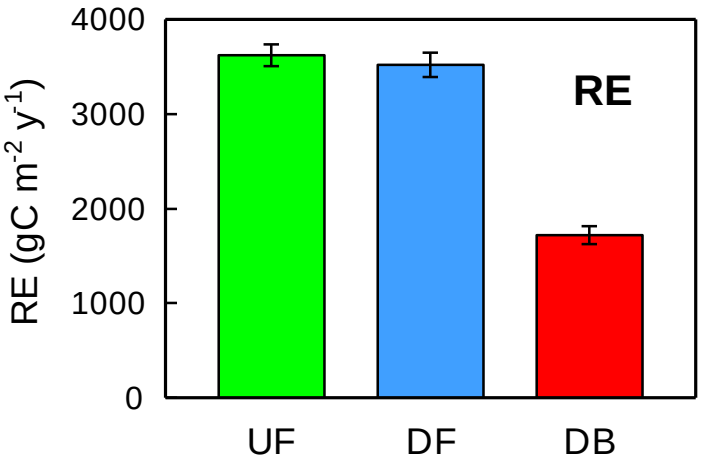
- Annual NEE was positive at all sites in all years, except in 2007 in UF.
- Interannual variation was large in the forest sites (UF and DF).
- NEE was more positive in El Niño years and less positive or slightly negative in La Niña years.

Comparisons of GPP, RE and NEE among three sites

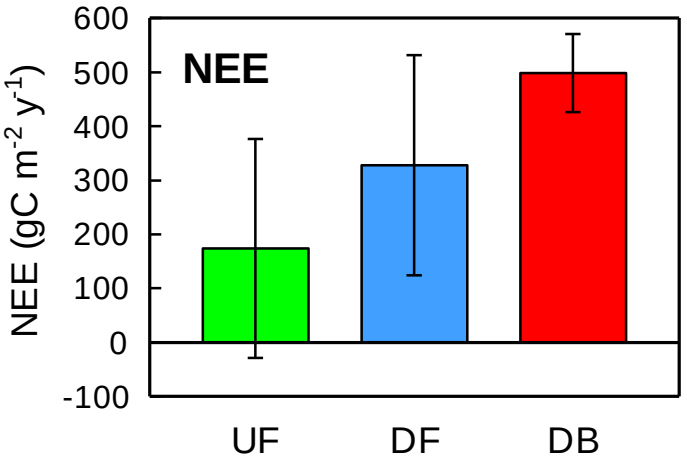
Four years from 2004 to 2008



UF > DF >> DB



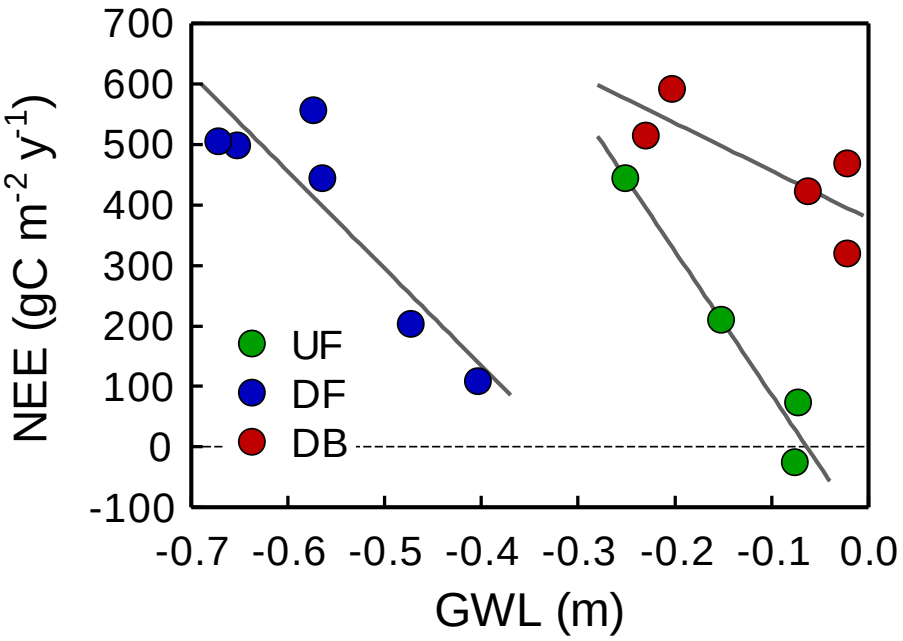
UF > DF >> DB



CO_2 emission: DB > DF > UF

NEE > 0 even in the UF site

Annual NEE vs. annually mean GWL



Hirano et al., 2012

A negative linear relationship for each site
→ Enhancement of oxidative peat decomposition under low GWL

Slope: UF > DF > DB → Undisturbed peatland is more sensitive.

Annually mean GWL is a robust indicator to assess annual CO_2 balance.

Oxidative peat decomposition vs. GWL in burnt site

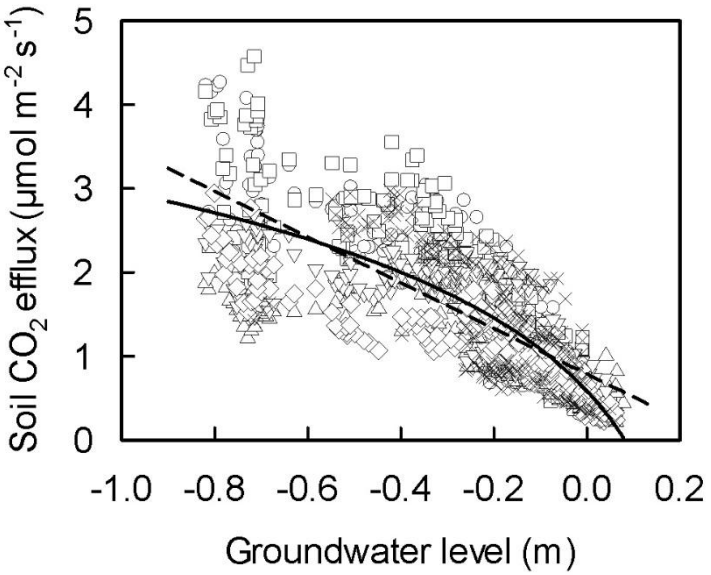
With 6 automated chambers From 2004 to 2005

Fires

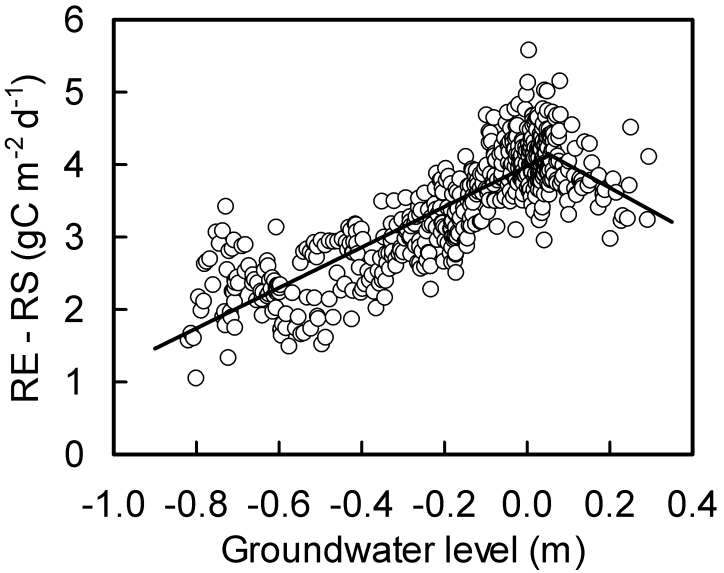
Little vegetation

Heterotrophic respiration
(oxidative peat decomposition)

Peat decomposition (RS)



RE –RS (= autotrophic respiration & decomposition of litter and CWD)



Hirano et al., in press

Summary and conclusions

- Three peat swamp forests functioned as CO_2 sources, including the almost undrained forest (UF), for four years. The CO_2 emissions increased with disturbance levels (DB > DF > UF).
- Interannual variation in annual NEE was large in the forest sites. The NEE was more positive in El Niño years and less positive or slightly negative in La Niña years.
- Ecosystem respiration (RE) or CO_2 emissions increased as groundwater level (GWL) decreased, because of enhanced peat decomposition under oxic conditions.
- DOC flux was largest at the drained forest.
- Annual evapotranspiration (ET) was significantly smaller at the burnt site, leading to larger runoff.
- Annual NEE and ET increased or decreased linearly as annually mean GWL decreased. This linearity indicates that annually mean GWL is a robust indicator to assess annual CO_2 balance and ET.