Drivers of C sink activity in European grasslands inferred from flux measurements

Jean-François J.-F. Soussana, Katja Klumpp, Romain Lardy, Tiphaine Tallec

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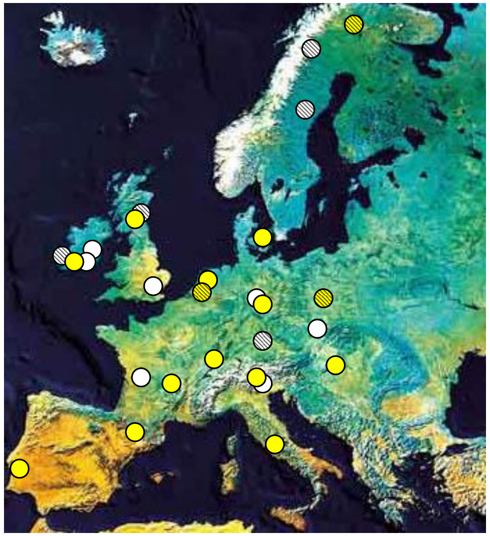
Jean-François Soussana[1], Katja Klumpp[1], Romain Lardy[1], Tiphaine Tallec[1]

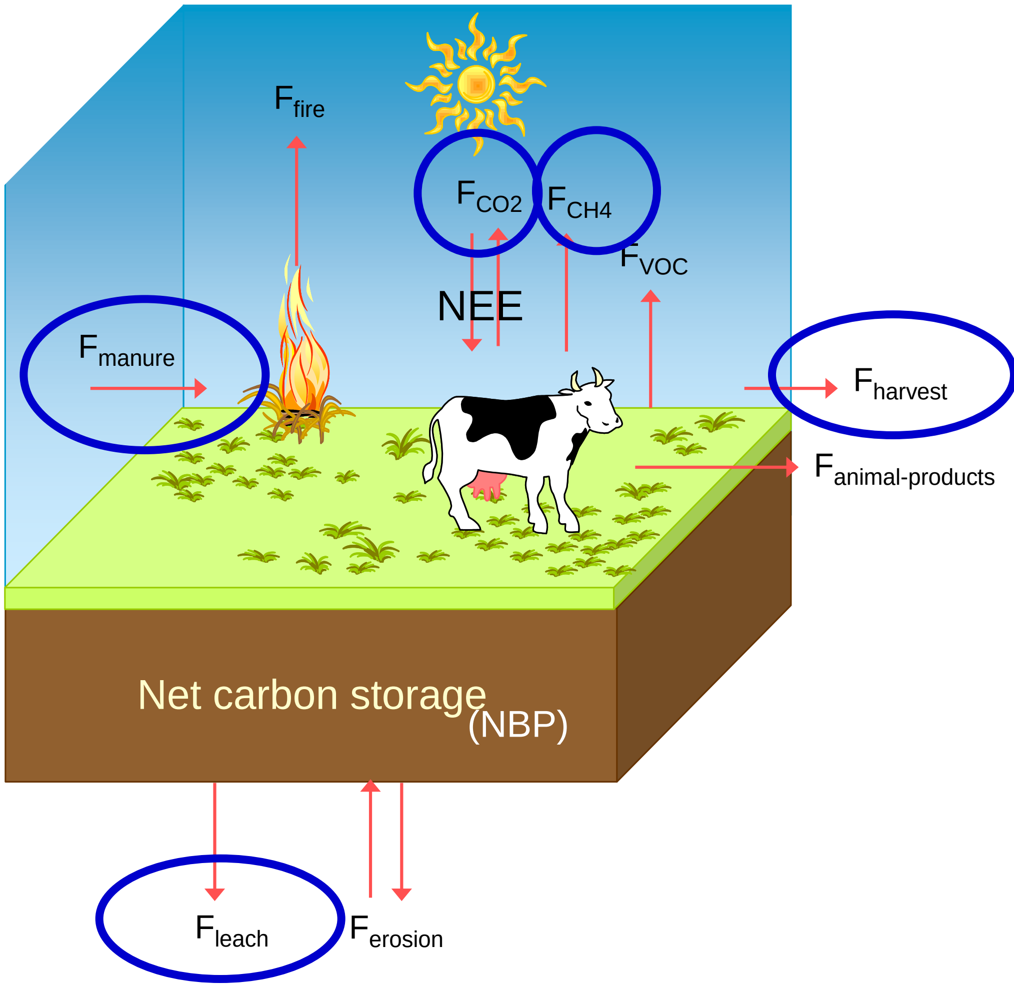
and CarboEurope grassland and wetland activity members.

1. INRA, Grassland Ecosystem Research (UR 874, UREP)

Clermont-Ferrand, France

C fluxes in a grassland ecosystem





Measurements at grassland and wetland sites in CarboEurope IP project

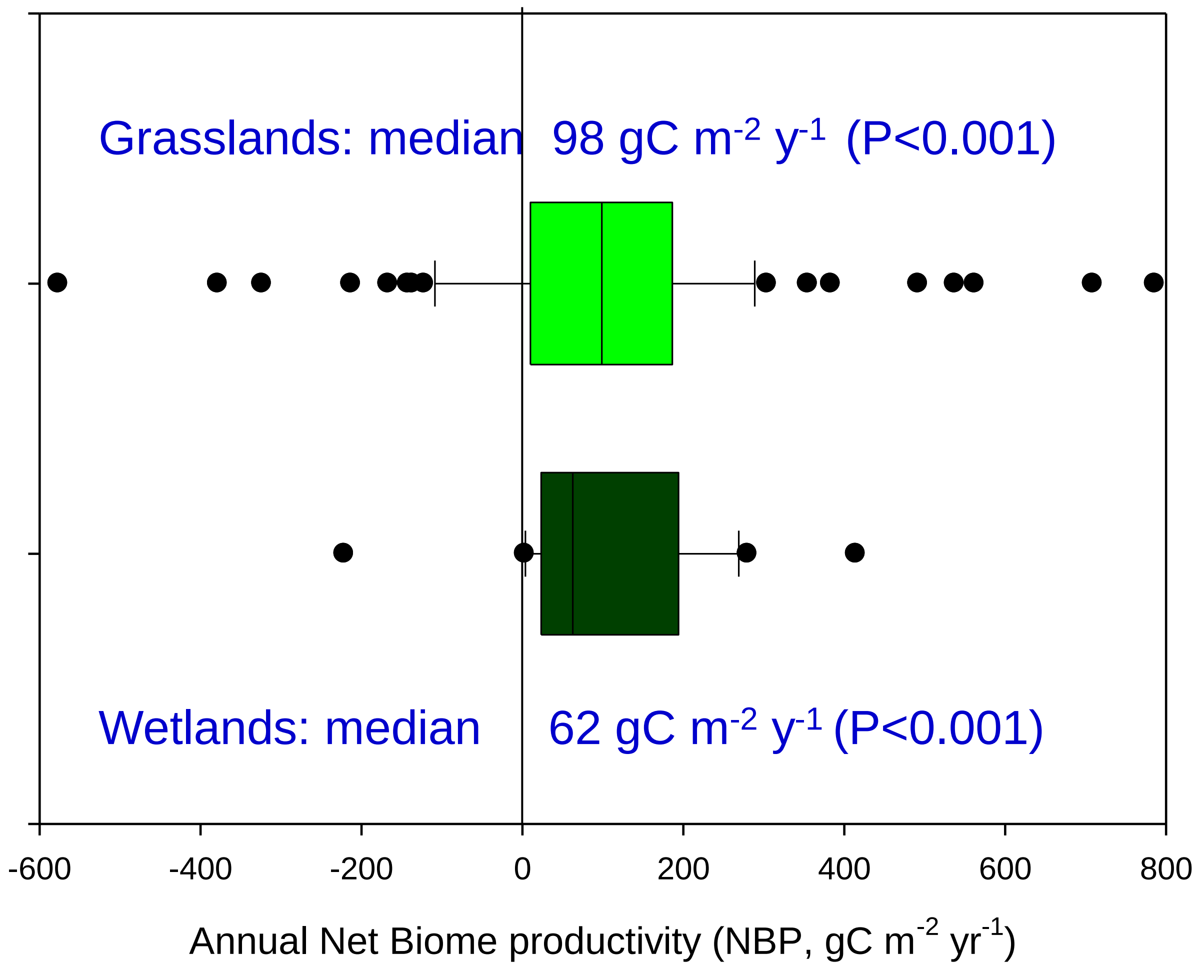
Simplified carbon balance (Net Biome Productivity) :

$$NBP = (NEE - F_{CH4\text{-}C}) + (F_{manure} - F_{harvest} - F_{animal\text{-}products}) - F_{leach}$$

(Soussana and Tallec, 2009, Animal, in press)

Annual NBP of grasslands and wetlands (89 site-years)

C source

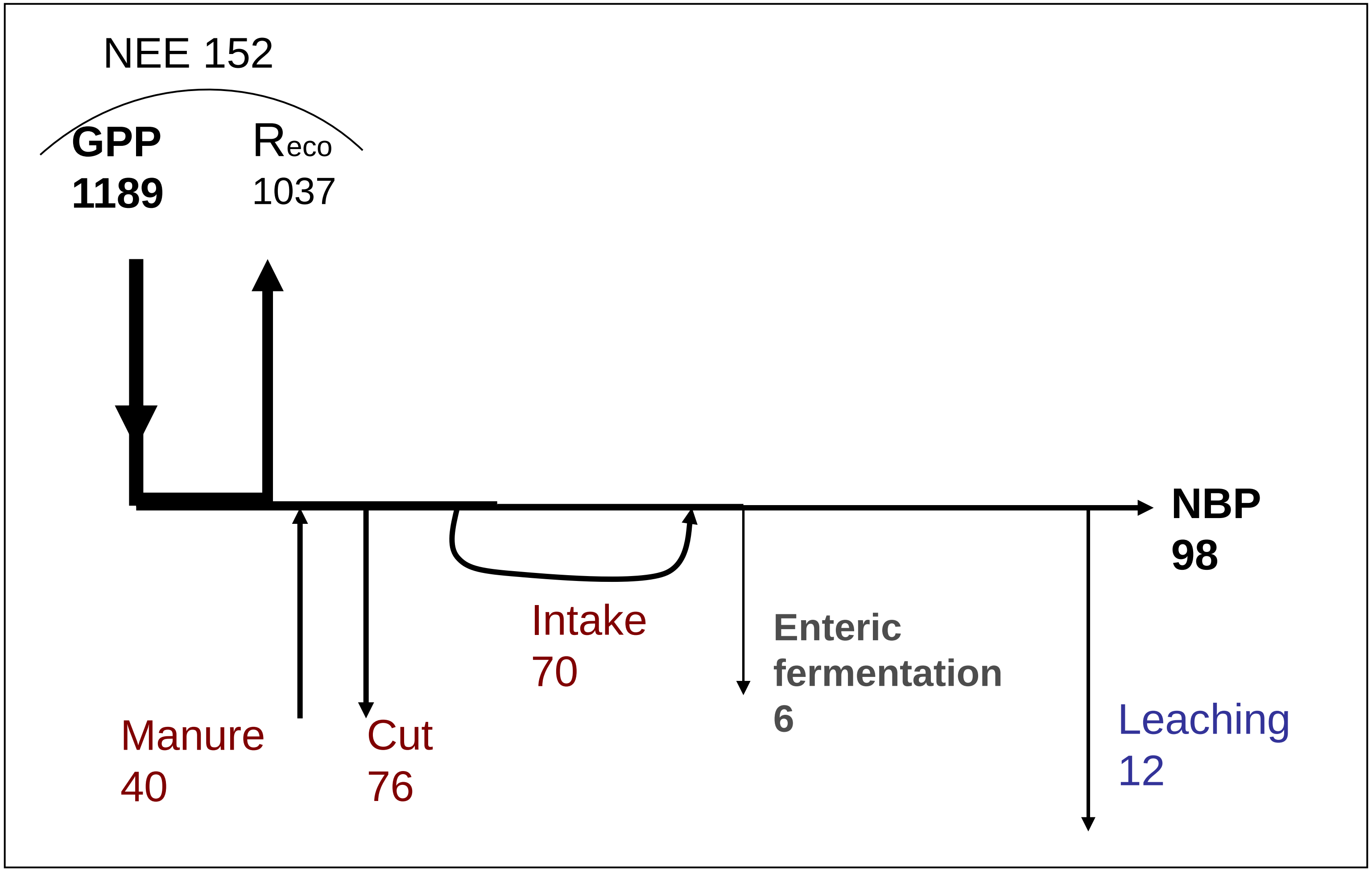


C sink

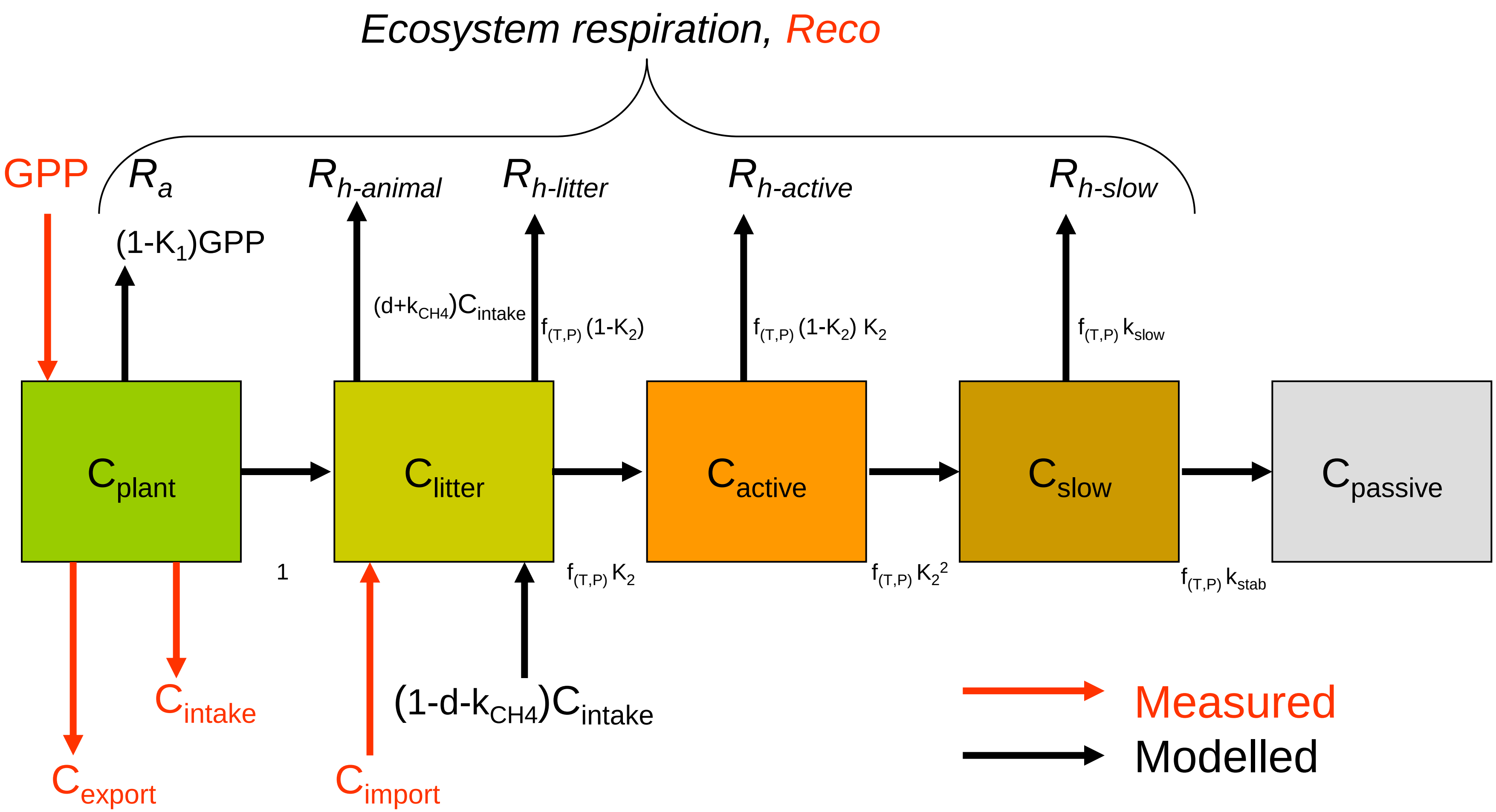
21 grasslands sites (3 sown); 7 wetland sites.

3 sites out of 28 are C sources to the atmosphere

Mean carbon fluxes (g C m^{-2} yr^{-1}) at European grassland sites



Simple C cycle model (5 state variables, 3 soil parameters)



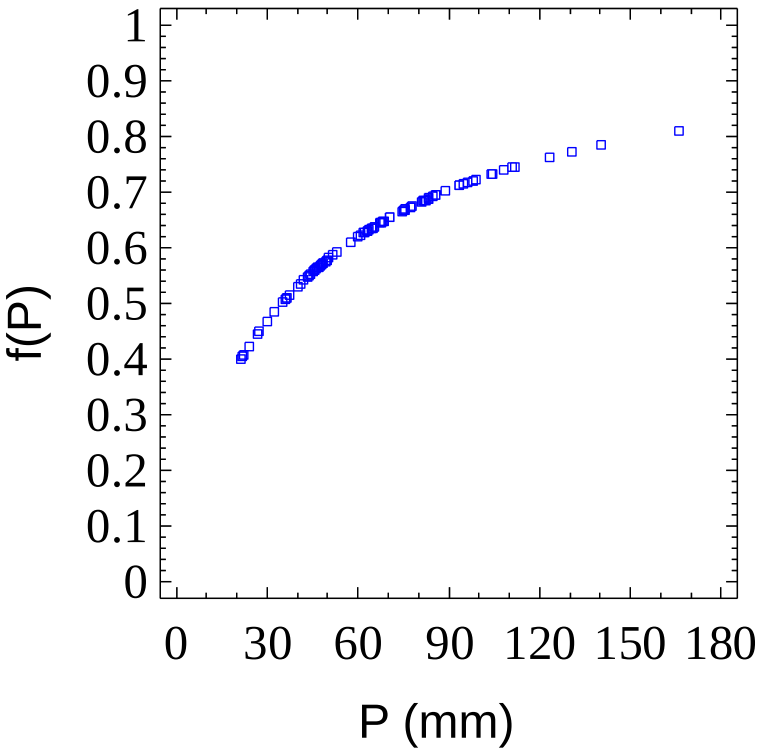
Daily time step. Forced by measured C fluxes (except Reco)

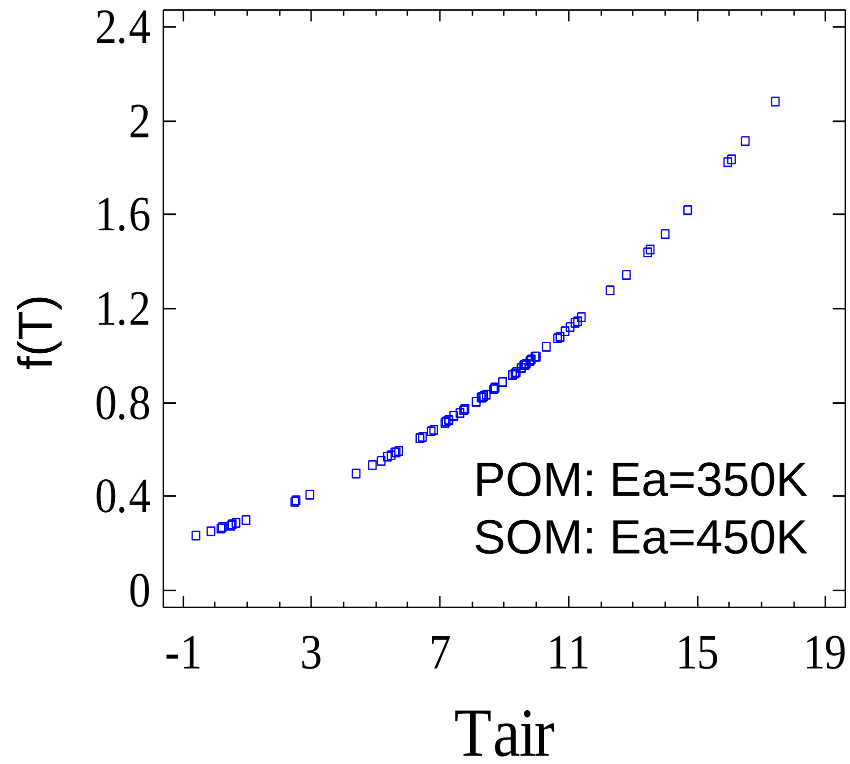
Predicts Reco and NBP

C_{plant}, C_{litter} and C_{active} initialised at equilibrium

C_{slow} initialised from SOC (0-30 cm) measurements

Fitted temperature and precipitation response functions of soil respiration



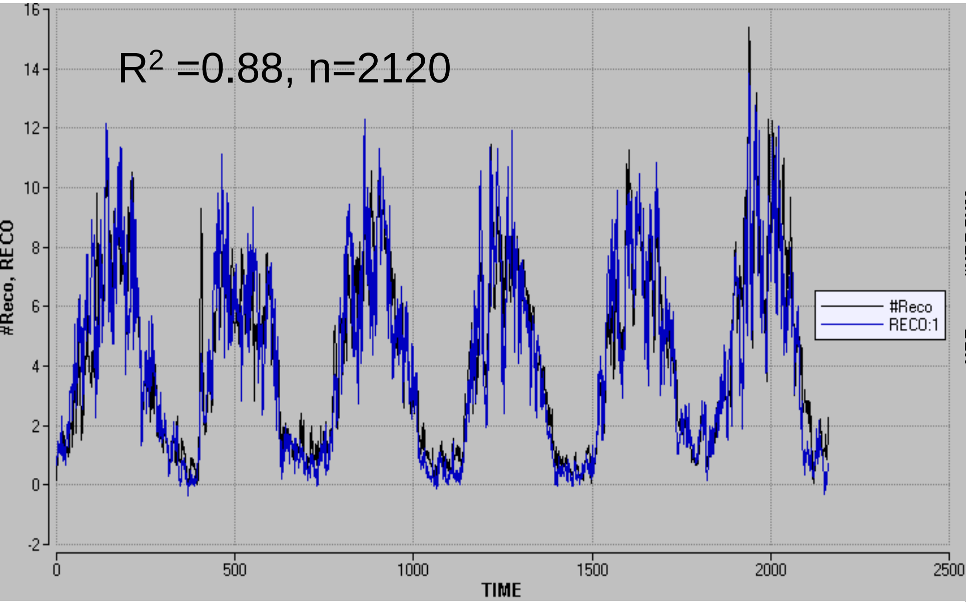


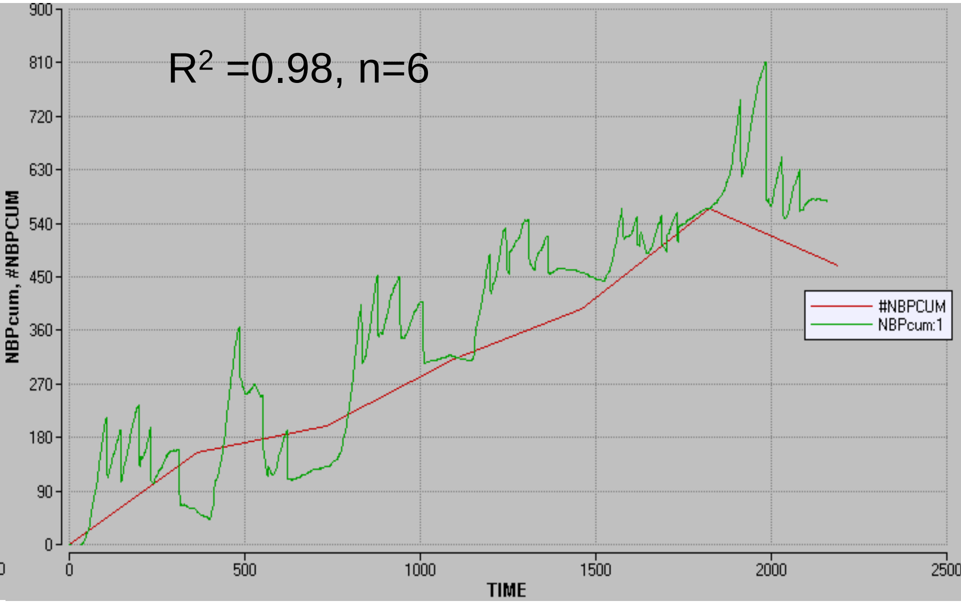
$$f(T,P)=\left(\frac{\alpha.k+P(1-\alpha)}{k+P(1-\alpha)}\right)e^{Ea\left(\frac{1}{T_{ref}-T_0}-\frac{1}{T-T_0}\right)}$$

(Lloyd and Taylor, 1994 for temperature)

Fitting model to daily Reco and annual NBP data

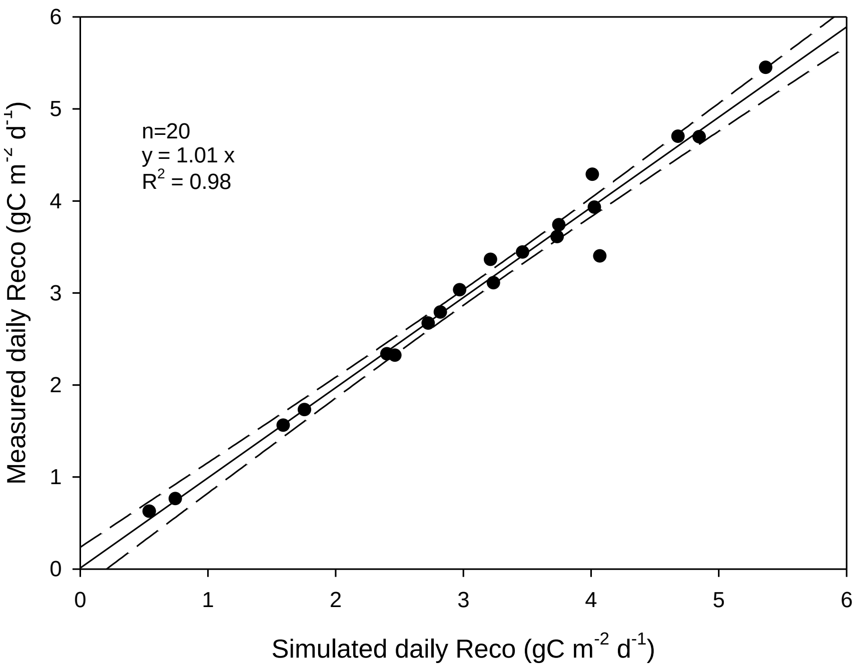
(AT-Neustift site)

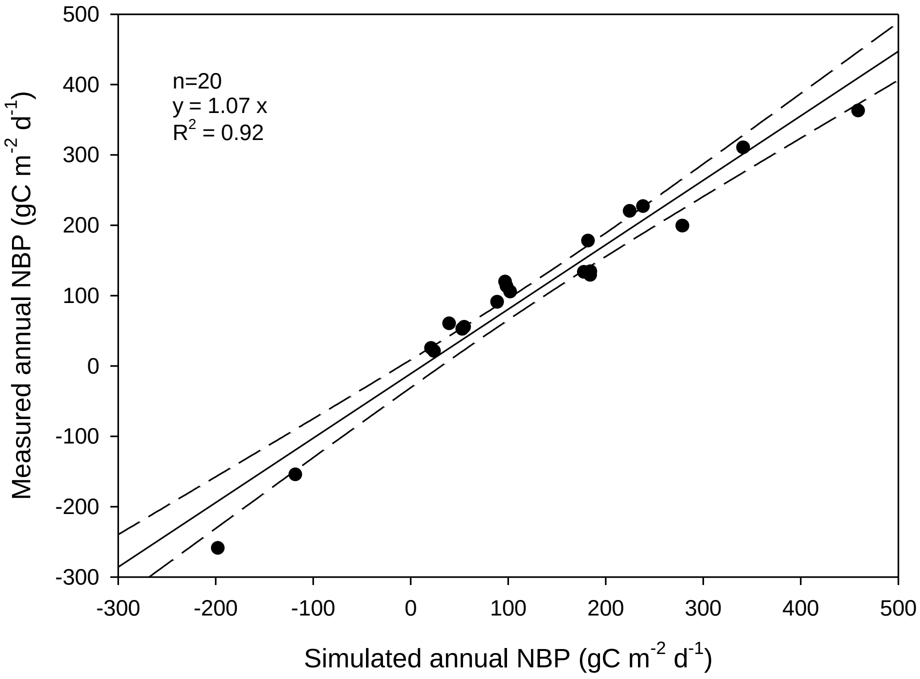




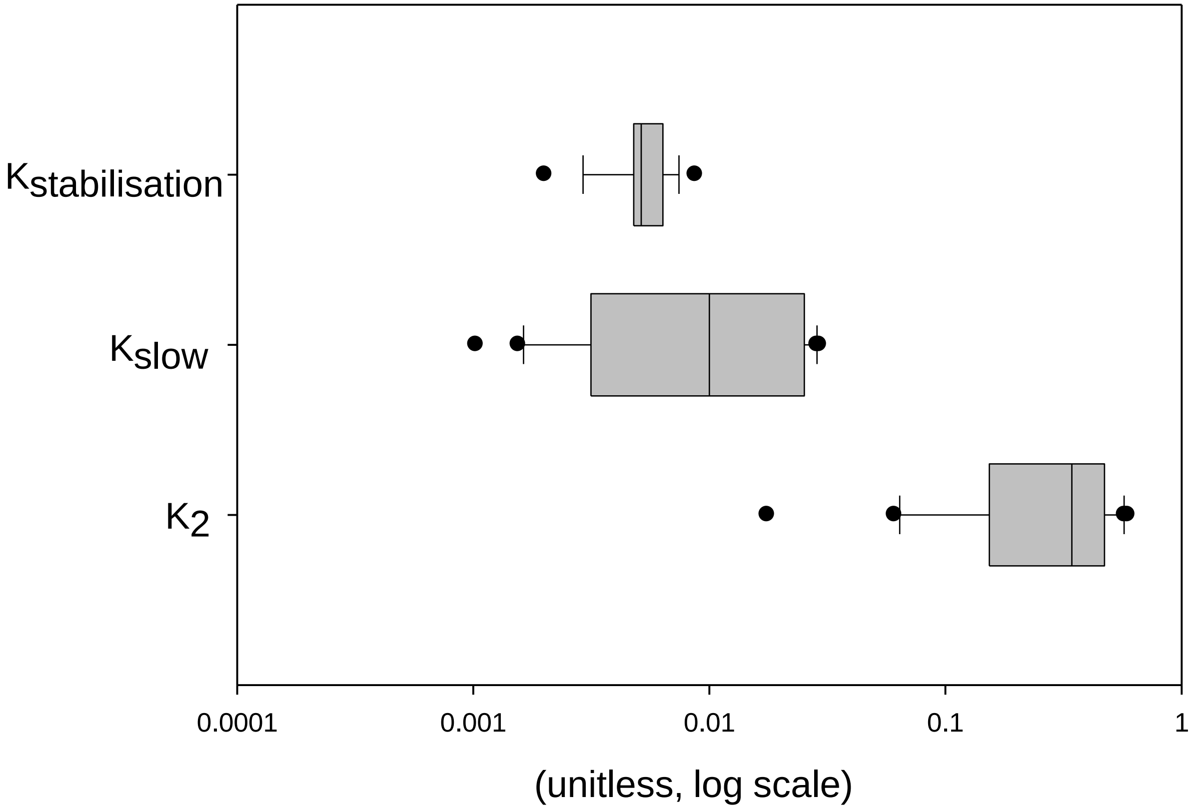
Monte-Carlo procedure mean	(mean s.e. for 10 runs)	
Mean slow $C_{initial}$ =	16.5	(0.48)
Mean K_2 =	0.32	(0.018)
Mean K_{slow} =	0.013	(0.0016)
Mean K_{stab} =	0.0059	(0.00105)

Measured vs. simulated Reco and NBP for 20 sites (with optimized K_2, K_{slow}, K_{stab})

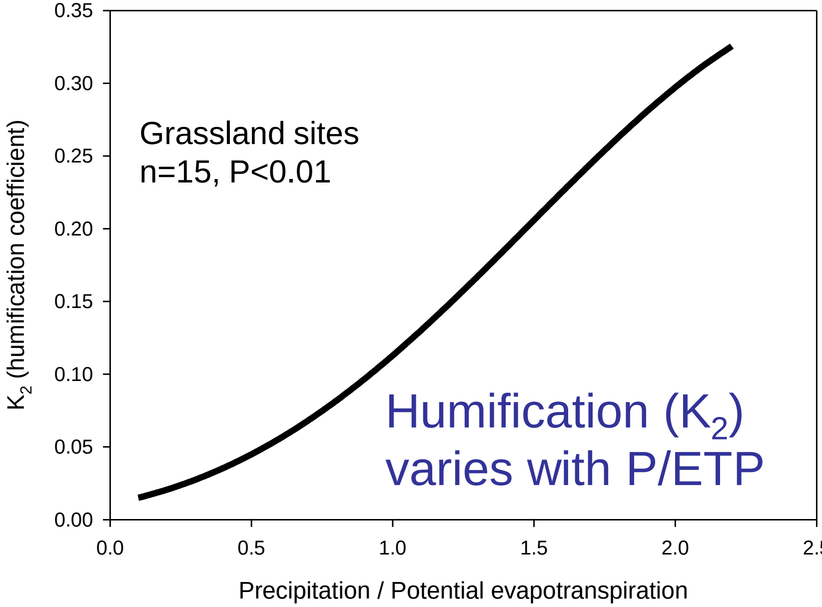


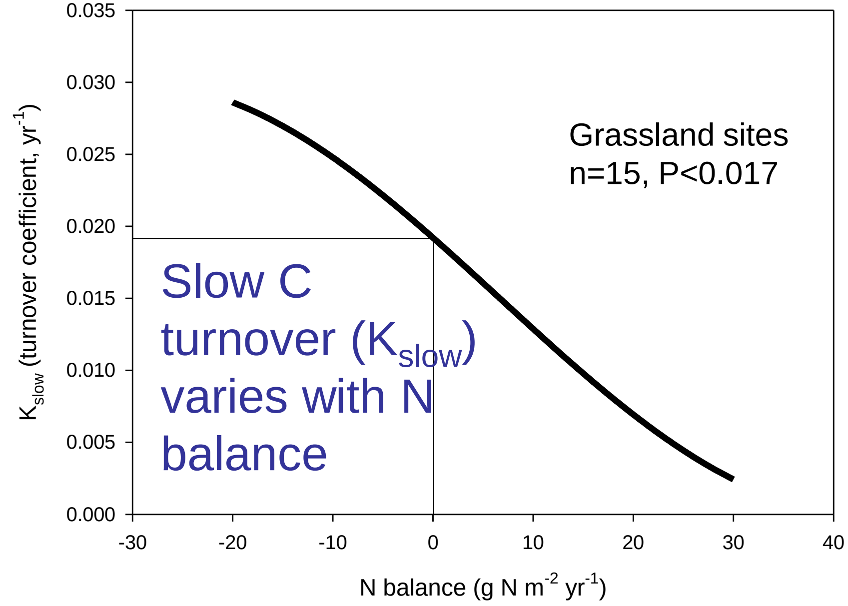


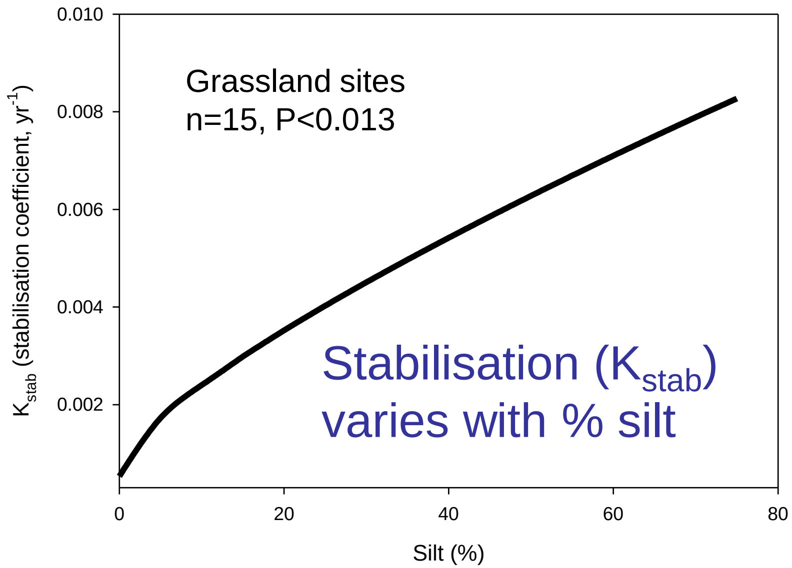
Variation among sites in soil parameter values



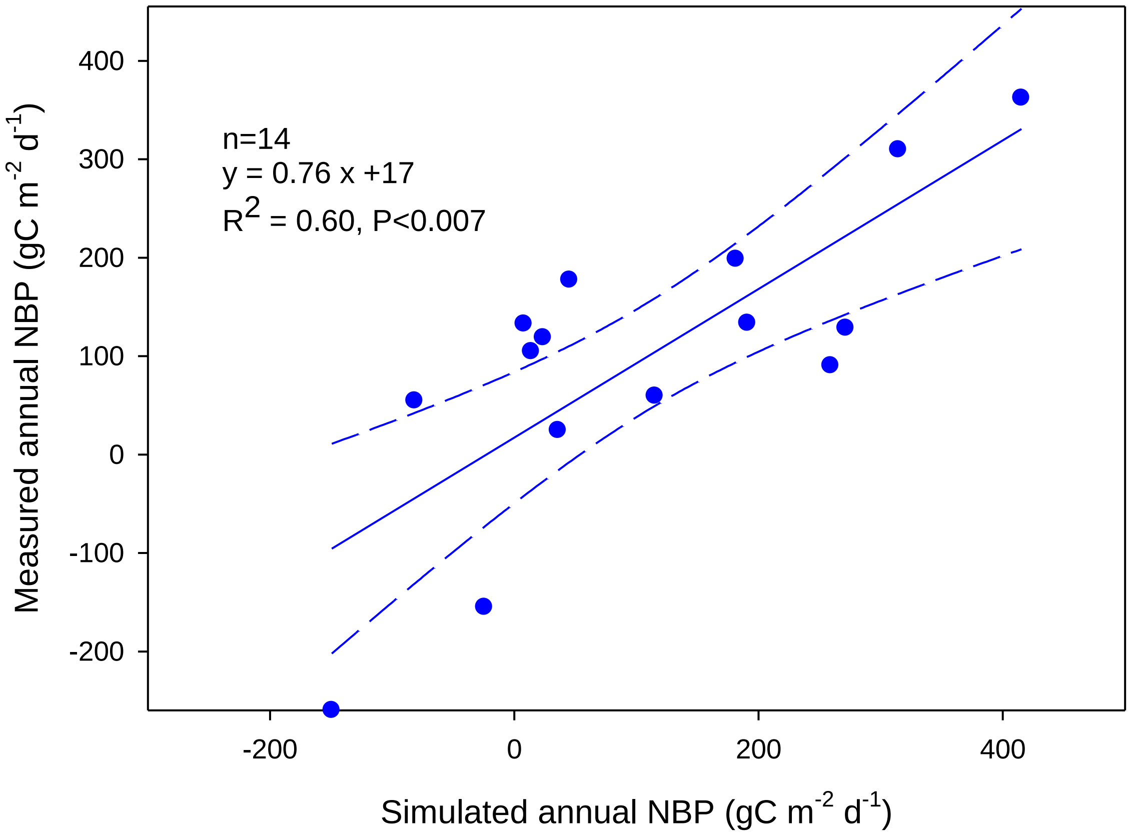
Best fits for soil parameters







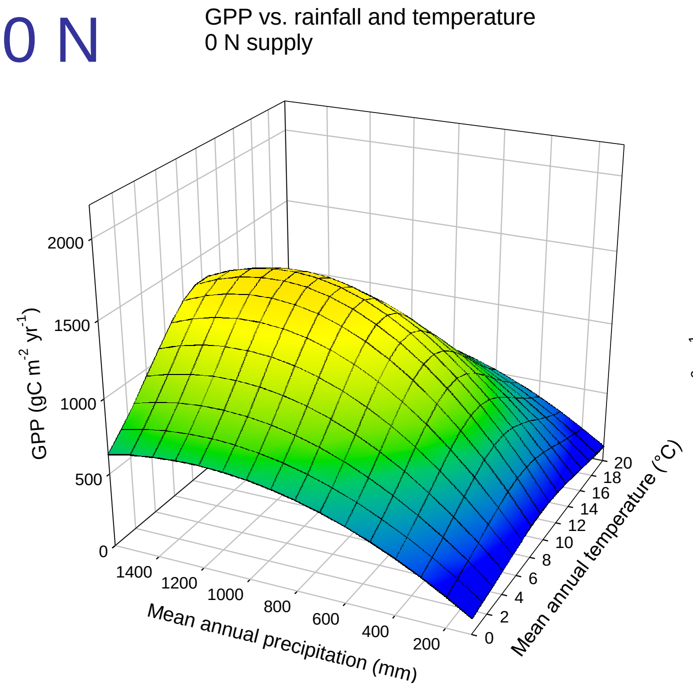
Simulated vs. measured annual NBP with fitted soil parameters



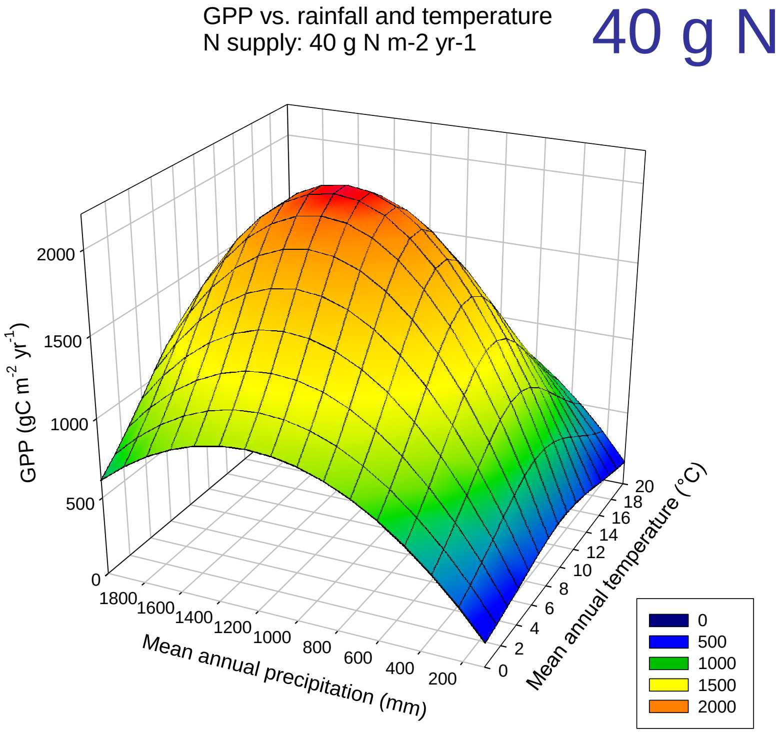
C sink activity is inferred from GPP, climate, management and texture

Annual GPP varies with temperature (T), precipitation (P) and N

0 N



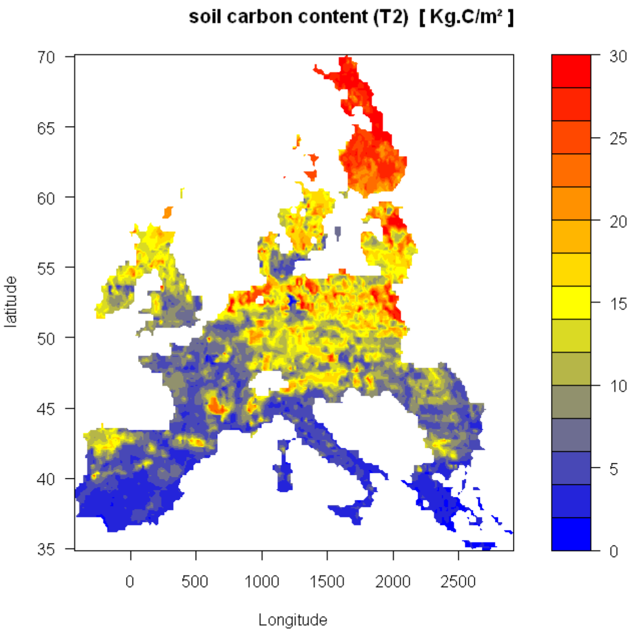
40 g N m^{-2} yr^{-1}

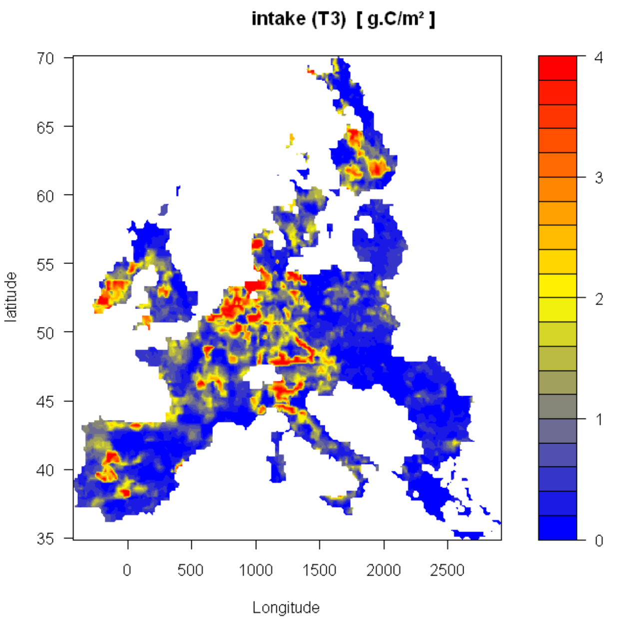


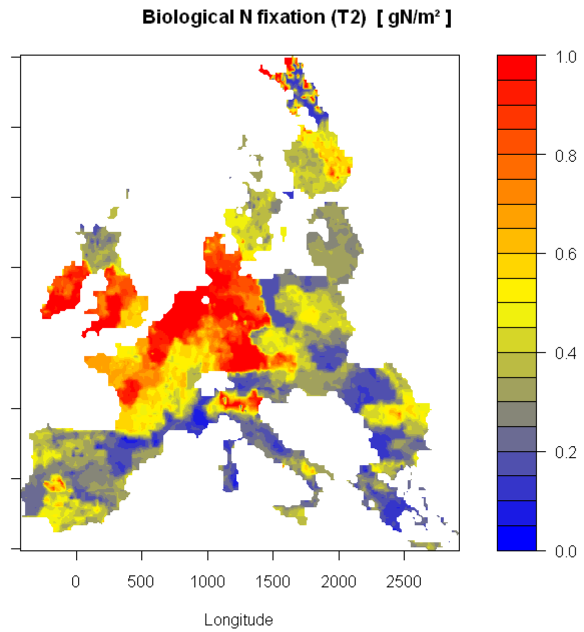
$$GPP = (N_s + e)(a P + b P^2) / (1 + ((T - c)/d)^2) \quad (n=84, r^2=0.748, P<0.0001)$$

N = atmospheric N deposition (EMEP)+N fertiliser supply

European grasslands statistics

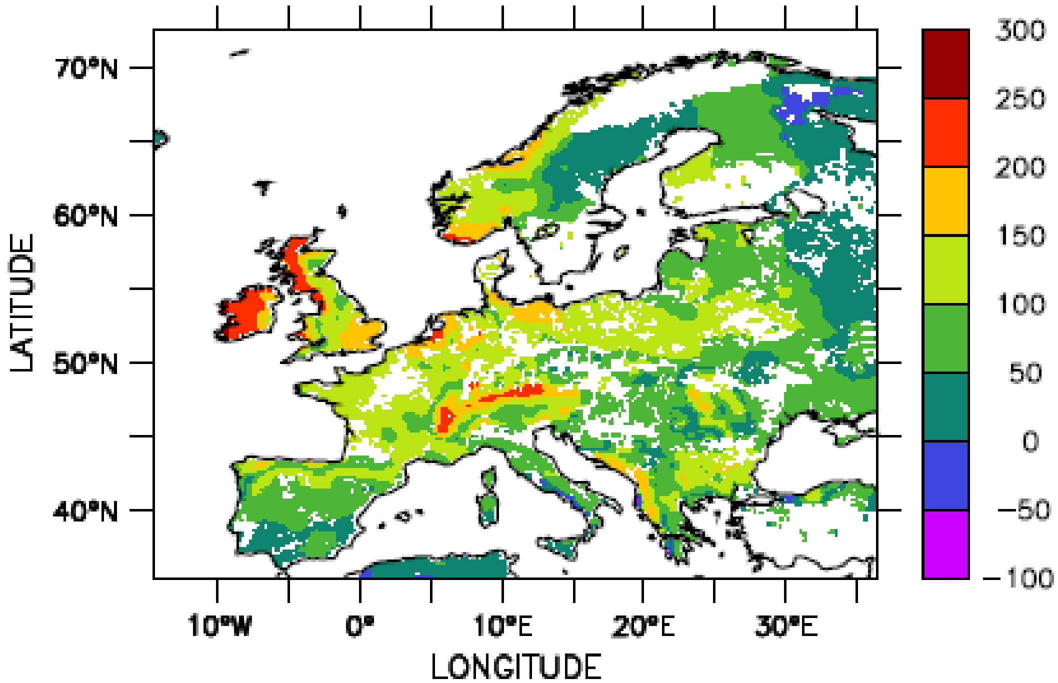






Simple model upscaled to the scale of Europe

A first estimate of carbon sequestration in European grasslands



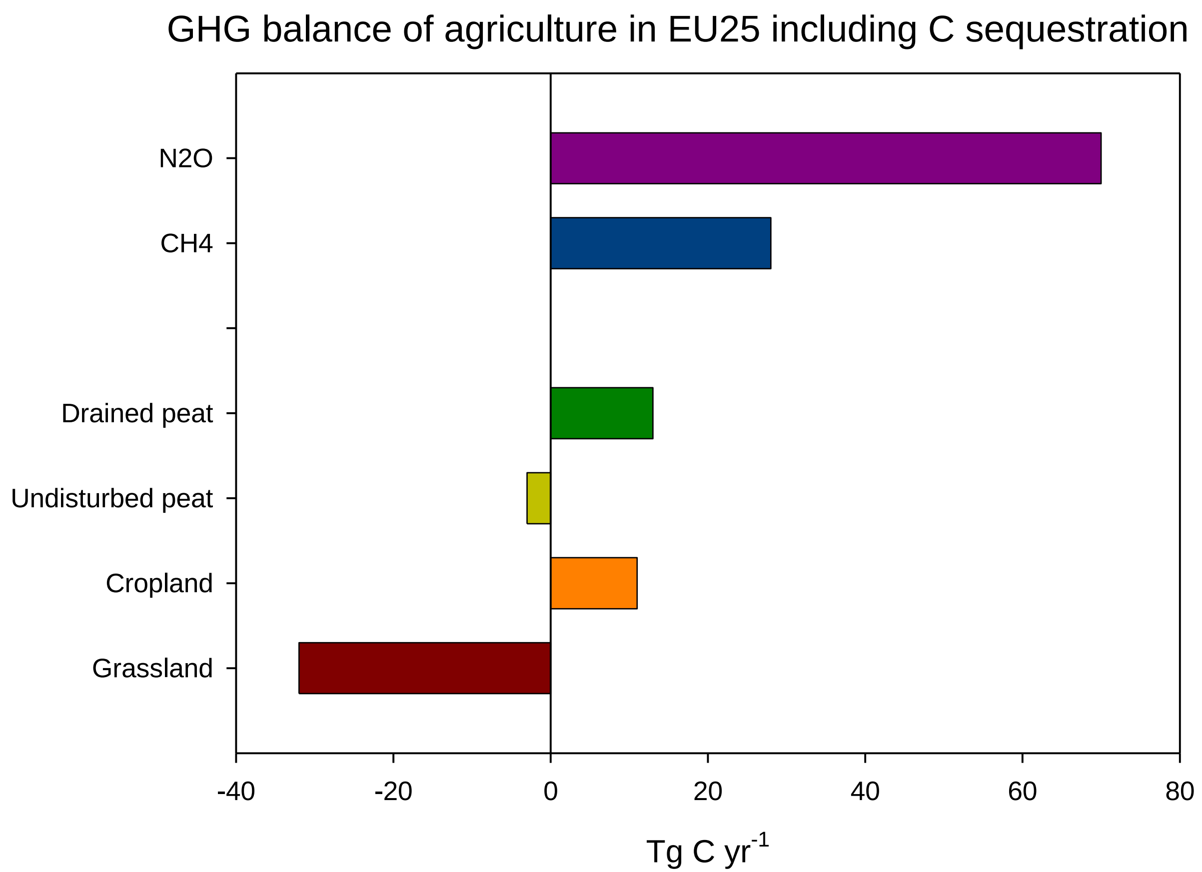
NBP (gC m−2)

C sink (NBP) reaches 6 % of gross photosynthesis, similar to forests

Direct plus indirect emissions of N_2O and CH_4 lead to a 45 % trade-off

(Soussana et al., in prep.)

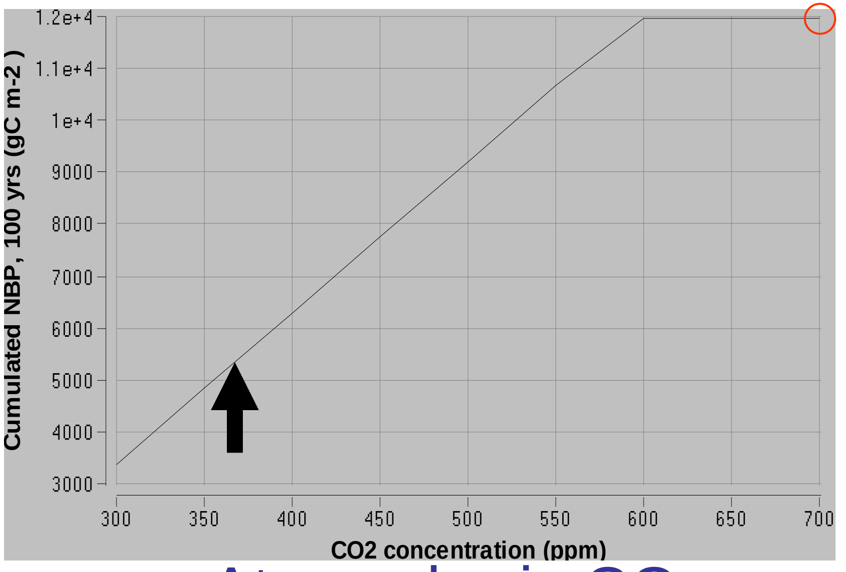
The GHG balance of the agriculture sector in Europe



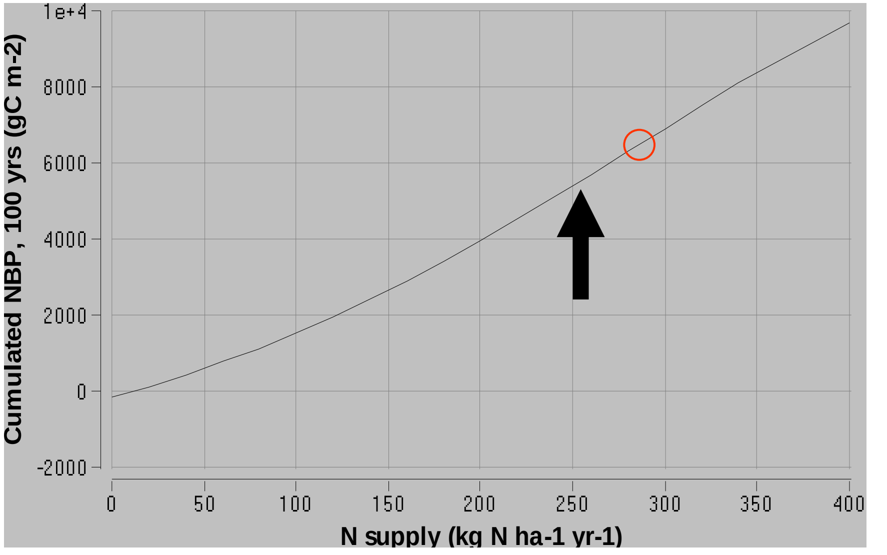
Grassland C sequestration would play a significant role for the European agriculture sector

(Schulze et al., submitted to Nature Geosciences)

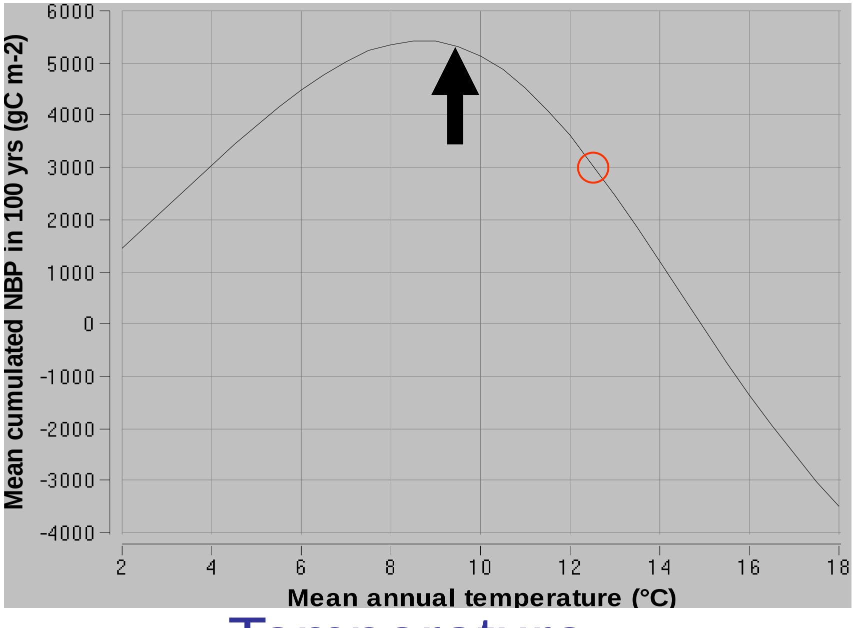
C sink (NBP) sensitivity over 100 yrs (CH-Oensingen)



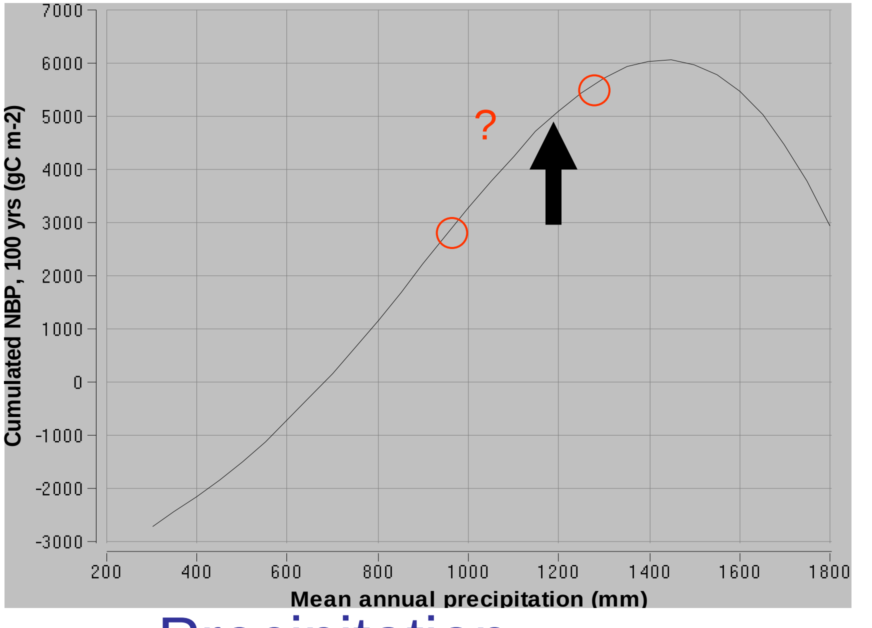
Atmospheric CO_2



N supply



Temperature



Precipitation

Attribution of grassland C sink
(gC m^{-2} yr^{-1})

- Global change

1°C warming	-1	
80 ppm CO_2 rise	19	
Atm. N deposition	3	

- Direct anthropogenic

Land use/management	*12*	*(inferred)*

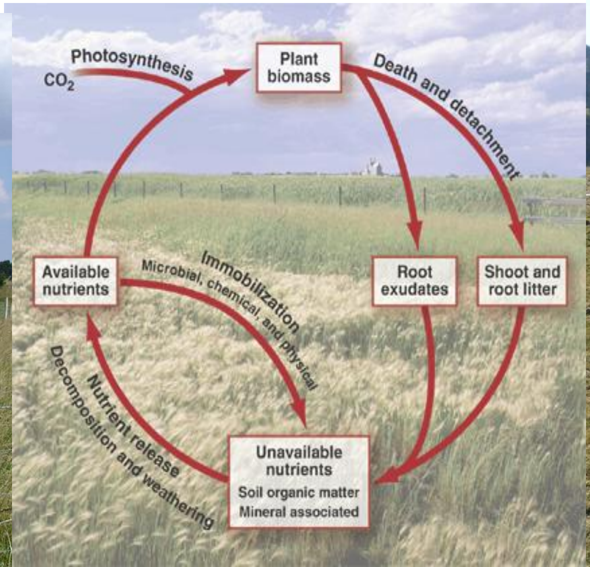
2/3 of the current C sink would be caused by global change

Conclusions

- Improved understanding by inferring soil C dynamics from C flux measurements
- Model shows a major role of nutrients deficiency which accelerates C turnover (priming effect, Fontaine & Barot, 2005)
- This simple model can be used for upscaling and attributing C sink to either global change or direct anthropogenic activity (UNFCCC)
- More complex models (e.g. CENTURY included in PASIM) do not yet have the same predictive ability



Thank you



Photosynthesis
CO_2
Plant biomass
Death and detachment
Root exudates
Shoot and root litter
Available nutrients
Immobilization
Microbial, chemical, and physical
Nutrient release
Decomposition and weathering
Unavailable nutrients
Soil organic matter
Mineral associated