Using model-data fusion to analyze the interannual variability of NEE of an alpine grassland

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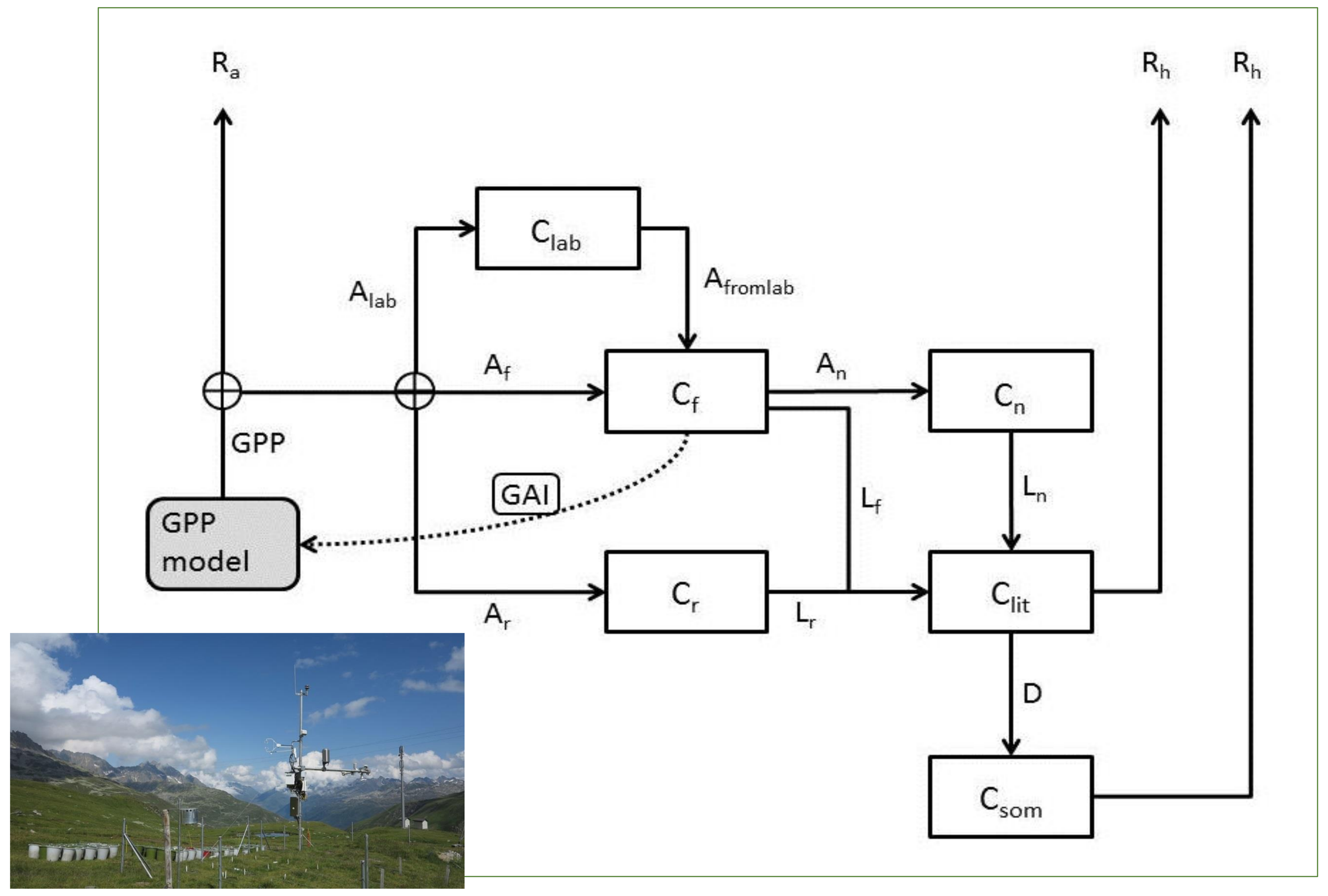
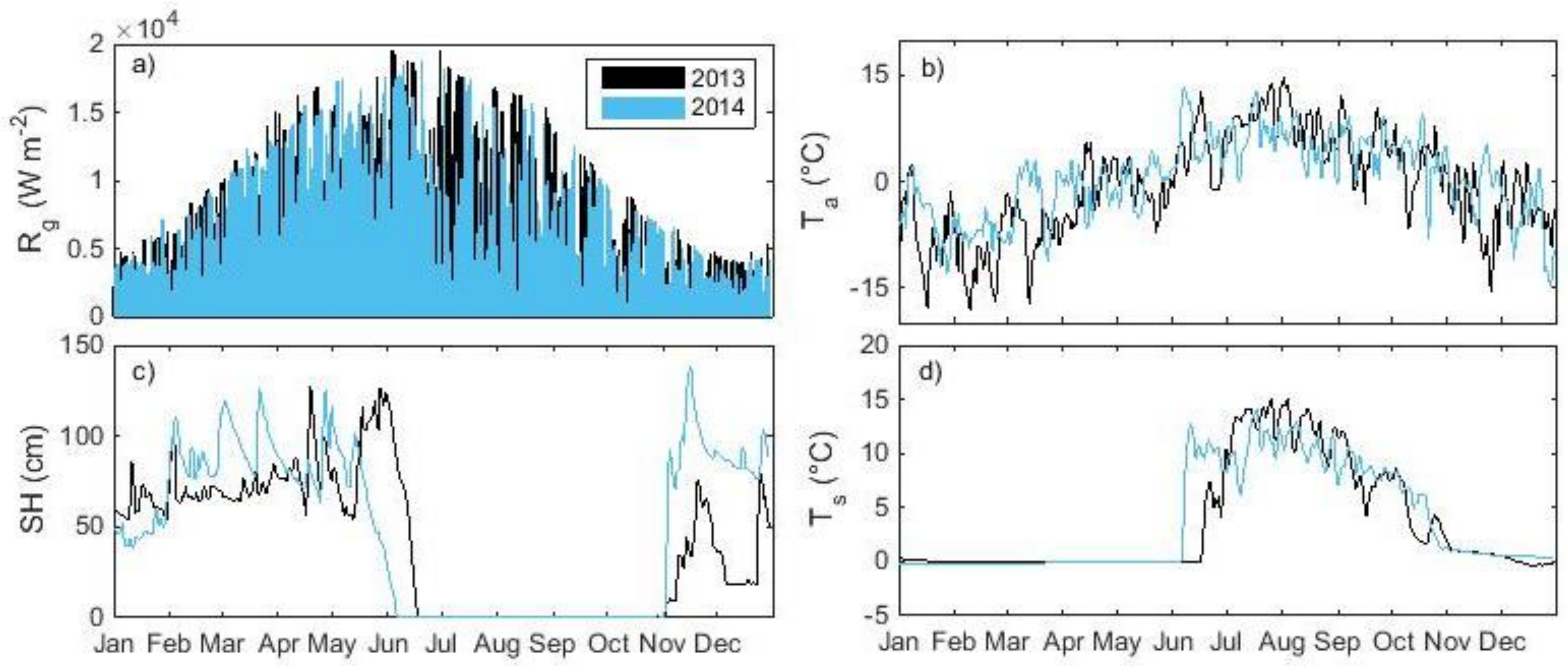


(I) Schematic representation of the ecosystem C model.

Background: Differences in CO_2 fluxes of a high mountain grassland near Furka Pass in the Swiss central Alps at an elevation of about 2400 m a.s.l. during two growing seasons (20.06.2013 – 08.10.2014) differing in snow melt date were investigated. To disentangle the effect of different growing season length, the biotic response to spring environmental conditions, and the direct effect of the weather conditions during the growing season on the NEP*, a modeling approach was applied. To this end, an ecosystem mass balance C model was constructed based on the DALEC+) model to represent the major C fluxes among six carbon pools (I). By calibrating the model with NEP data from individual years, two sets of parameters were retrieved which were then used to run the model under environmental conditions of the same as well as the respective other year in a factorial design (Tab. 1).

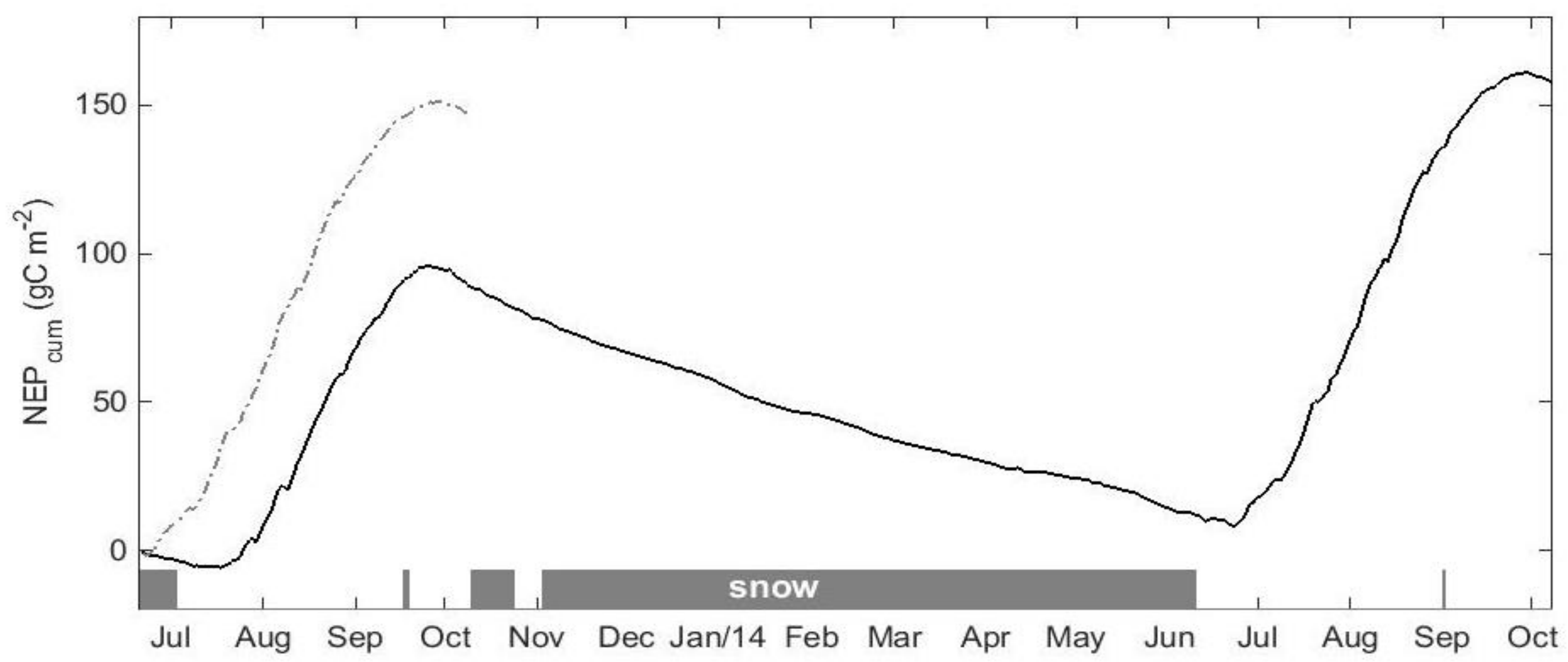
Tab. 1 Four possible forward model runs.

Model run	Model input	
	Environ. conditions	Parameter set
2013_para13	2013	2013
2013_para14	2013	2014
2014_para13	2014	2013
2014_para14	2014	2014



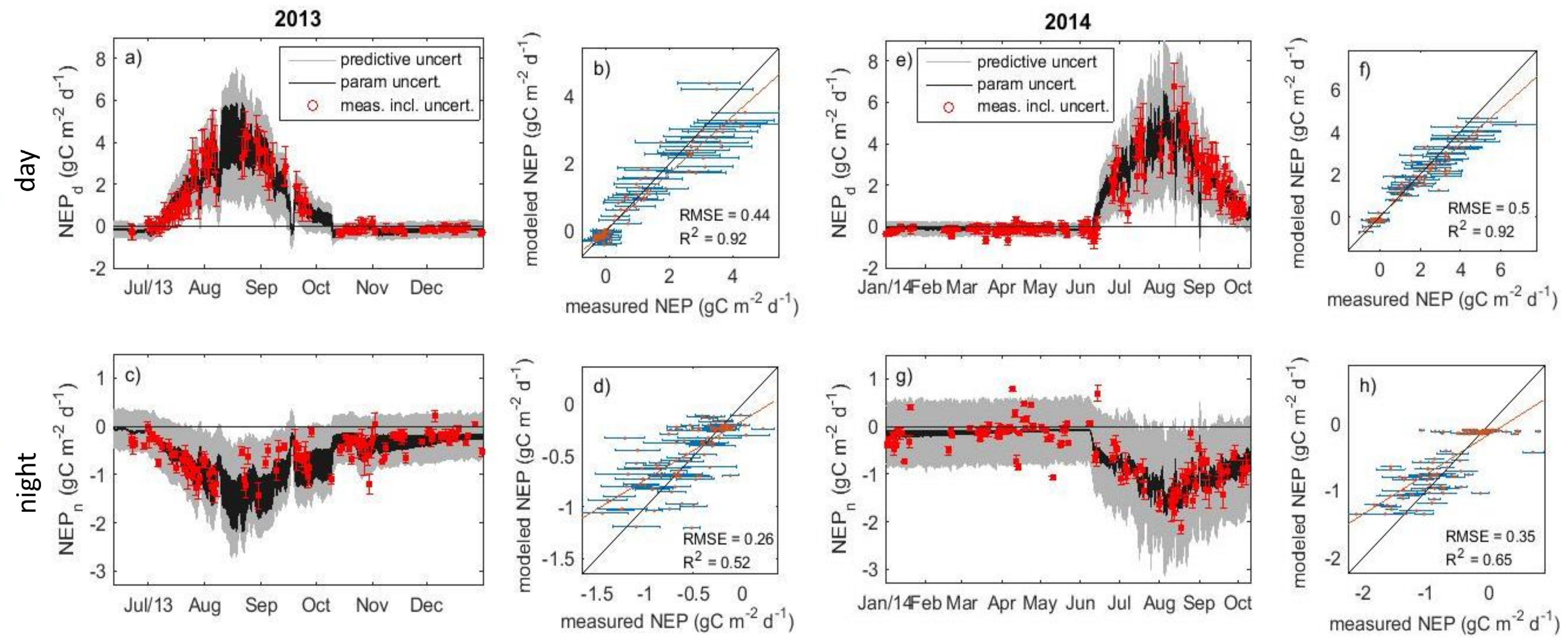
(II) Annual course of (a) daily sum of global radiation; (b) daily mean air temperature; (c) daily snow height; (d) daily mean soil temperature.

Results 1: The annual course of the weather conditions for the two years is shown above. A major difference was seen in the snow cover duration in spring, which lasted about 20 days longer in 2013 than in 2014 (II). The CUP** started later in 2013 and lasted from day 198-269 compared to days 173-271 in 2014. During those times, about 100 and 150 g C m^{-2} were taken up, respectively (III).



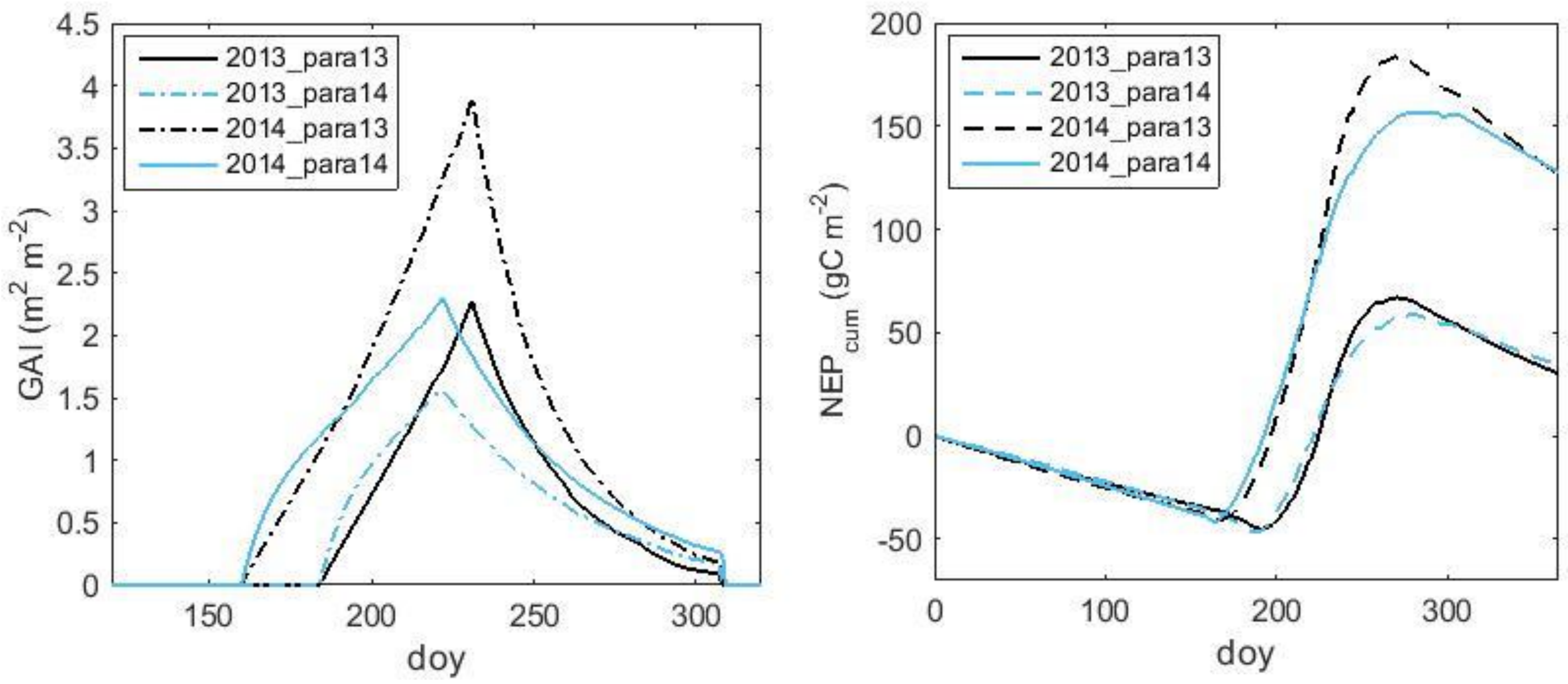
(III) Cumulative NEP during the entire measurement period. Snow cover duration is indicated by the grey bars at the bottom of the figure. The dotted grey line represents the cumulative NEP of 2014 shifted to the same day when measurements started in 2013 (doy 172).

Conclusions: Overall, the grassland acted as a net sink for CO_2 with higher uptake during the CUP 2014. Comparing simulated NEP of the four model runs showed that with the same meteorological forcing, the annual NEP was about the same for both parameter sets. However, comparing the two years, the NEP was always lower under 2013 environmental conditions. Thus, the results of our study indicate that the lower cumulative CO_2 uptake during the year with a longer persistence of the snow cover in spring was primarily due to the shortened growing season.



(IV) Comparison between measured and simulated day- (a, b, e, and f) and nighttime (c, d, g, and h) NEP during 2013 (left panels) and 2014 (right panels).

Results 2: The model performed well in simulating NEP, especially during daytime (IV).
The simulated GAI*** (V, left) increased more rapidly at the beginning of the growing season with 2014 parameters. However, under the same environmental conditions, the 2013 parameters resulted in higher maximum GAI, with the highest value for 2014 environmental conditions and 2013 parameters (2014_para13-simulation).
This directly influenced the GPP**** and is also reflected in NEP (V, right).
In both years, using the 2014 parameters led to a more rapid start of the CUP, while at the end of the CUP the cumulative NEP was higher with 2013 parameters. The annual balance was about the same for both parameter sets within the same year, with an annual NEP of about 35 g C m^{-2} in 2013 and 130 g C m^{-2} in 2014.



(V) Simulated GAI (left) and cumulative NEP (right) using a factorial combination of the environmental conditions and parameter sets of the two study years to drive the model.

*NEP – net ecosystem production (positive values of NEP represent a net uptake of CO_2 by the ecosystem) | **CUP – carbon uptake period, defined as the period when the 5-day-mean of NEP is positive | ***GAI - green plant area index (area of green plant matter per ground area) | ****GPP – gross primary production | +) Fox et al. 2009, Williams et al. 2005

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