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Inter-annual variability of carbon exchange and extreme events at the Loobos pine forest

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Introduction

At the seasonal to inter-annual time scale large variations in net uptake exist as a result of changing weather conditions. It is therefore important to investigate the inter-annual variability of the uptake of forests as accurately as possible and relate it to physiological and physical constraints of the biosphere-atmosphere system. Present model concepts on NEE are well capable to reproduce average conditions, however they fail to reproduce short term variations. If we are able to explain these variations this will help to improve explaining inter-annual variability.

We analysed the impact of extremes on inter-annual variation observed in measurements of eddy-covariance fluxes over the years 1997-2012 over a mid-latitude pine forest in The Netherlands. To improve our understanding of these variations, we tried to quantify and make a distinction between variations caused by environmental conditions by means of ecosystem response curves for real and maximum response.

We analysed the remaining variation by looking at changes in site conditions, such as aging and nitrogen availability and disturbances caused by abrupt events such as storms, frost, harvest, fire etc.

Results

Based on annual totals, the inter-annual variability in NEE is the result of variations in Reco and, to a lesser extent, GPP. There is no evidence that annual meteorological averages are the main drivers for inter-annual variation in observed NEE.

Response functions
However at a monthly time step there is a strong correlation between GPP and radiation and to a lesser extend with temperature and maximum vapour pressure deficit. The correlation with VPDmax reflects the strong control VPD has on the stomatal closure of this eco-system.
Reco correlates best with air temperature, marginally better than with superficial soil temperature. Including superficial soil moisture in the function slightly increases the correlation.
Fitted response curves show that non-stressed ecosystem respiration, at 10 degrees, increases from about 3.28 μmol m-2 s-1 at the start of the period, to about 4.45 μmol m-2 s-1 in 2006, with a strong increase in the year 2001. No relation was found with precipitation or with air temperature.
The ecosystem respiration is also known to be affected by soil moisture and ecosystem characteristics such as below- or aboveground biomass development . Therefore we also determined best fits of Reco,10 on a monthly basis, with one corresponding fitted value of Ea kept constant during the year.

Effects of extreme events
For the Loobos site there are two distinct types of extreme events during the period studied: droughts and storm damage. Typical storms causing serious damage to pine forest in The Netherlands are short events with temperatures around zero and solid precipitation accumulating on the tree crowns. The weight of the accumulated snow causes branches and complete tree tops to snap. The effect of these extreme event on GPP/Reco is investigated.