Short term extremes in NEE: drivers and responses in natural ecosystems

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Co-author policy: Data providers and researchers from within the Fluxnet community who are interested in this topic will be invited to contribute. A first draft manuscript will be prepared and circulated among those who showed interest. Intellectual input concerning the draft manuscript will result in co-authorship.

Sites: boreal, temperate and tropical forests, wetlands and natural grasslands with more than 2500 daily observations (at least 80 % of the daily half-hourly measurements are original observations). Analysis showed that approximately six years of data was needed to estimate a robust long-term seasonal NEE (cv [23]).

Background: The growth rate of atmospheric carbon dioxide (CO_2) varies annually and most of this variability has been attributed to CO_2-fluxes between terrestrial ecosystems and the atmosphere (Bousquet *et al.*, 2000). Biomass burning (van der Werf *et al.*, 2004) and climatic variability (Dai & Fung, 1993; Kindermann *et al.*, 1996; Braswell *et al.*, 1997; Tian *et al.*, 1998; Gerard *et al.*, 1999; Randerson *et al.*, 1999) influence CO_2-fluxes and thus the growth rate of atmospheric CO_2. However, this top-down information, mainly derived from inverse and global modeling, provides relatively little insight into the mechanisms driving the relationships between climatic variability and terrestrial ecosystem processes that influence net ecosystem exchange.

Although our understanding of carbon cycling in terrestrial ecosystems improved considerably since the development of the eddy covariance technique (Baldocchi, 2003), conflicting results have been reported regarding the relationships between climatic drivers and the inter-annual variability in NEE. Several studies related the variability in NEE to the variability in mean monthly temperature in spring time, summer or fall (Goulden *et al.*, 1998; Black *et al.*, 2000; Monson *et al.*, 2002; Hollinger *et al.*, 2004), monthly radiation (Barford *et al.*, 2001; Aubinet *et al.*, 2002), monthly vapor pressure deficit (Aubinet *et al.*, 2002), summer drought (Goulden *et al.*, 1996), snow depth in winter (Goulden *et al.*, 1996), leaf area index (Aubinet *et al.*, 2002; Barr *et al.*, 2004) and canopy duration (Barr *et al.*, 2007). The apparently conflicting results may at least partly be caused by the low temporal resolution used in some analyses. Monthly or seasonal relationships between climatic drivers and NEE might be spurious because weather and NEE vary on a day-to-day basis and longer time periods may include offsetting positive and negative anomalies. In addition, simple relations between CO_2-fluxes and single climatic variables are not particularly helpful and do not represent the more complex interactions of multiple climatic factors and ecosystem processes.

The net exchange of CO_2 between terrestrial ecosystems and the atmosphere is determined by the difference between photosynthetic CO_2-uptake and CO_2-release through autotrophic and heterotrophic respiration, which respond differently to climate and other factors (e.g. substrate availability for heterotrophic respiration; Janssens *et al.*, 2001; Law *et al.*, 2002). Thus, different climatic conditions can result in similar rates of net ecosystem CO_2-exchange. Net ecosystem CO_2-exchange is typically one order of magnitude smaller than the nearly offsetting terms of photosynthesis and respiration (Goulden *et al.*, 1996; Valentini *et al.*, 2000). Consequently, small changes in photosynthesis and respiration have to be detected in order to explain relatively large changes in NEE. Nevertheless, if climatic variability is causing anomalous NEE fluxes, the relationships between climate and flux anomalies is likely to be revealed by analyzing high-resolution time series covering several years with different climatic conditions.

Aims: This study proposes to use long-term (> 2000 days) NEE time series as a first step in understanding the short-term mechanisms underlying anomalies in ecosystem CO_2-fluxes. To this aim, this study: (1) identifies and quantifies daily anomalies in NEE, (2) determines whether these are mainly due to anomalous photosynthesis, anomalous respiration or a combination of both and (3) identifies which combinations of climatic conditions coincide with anomalies in NEE that contribute to the intra-annual variability in NEE.

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