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Photosynthesis drives interannual variability in net carbon-exchange of pine forests at different latitudes

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Abstract

The atmospheric carbon dioxide growth rate exhibits large interannual variations which are largely influenced by year-to-year fluctuations in land-atmosphere fluxes which are in turn driven by large-scale biomass burning and climatic variability. Various studies of terrestrial ecosystem fluxes have sometimes shown conflicting results regarding climate influences on interannual variability in gross photosynthesis and net carbon uptake. The conflicting results are at least partly caused by differences in methodologies or limited length of time over which measurements were made. This study introduces an observation-driven methodology that provides insights to the interannual variability of the ecosystem carbon exchange and relation to climatic conditions. The methods were applied on 9-years of near continues eddy-covariance measurements in boreal, temperate and maritime pine forests. The data from all three sites were collected, processed and quality-checked in a consistent manner. At all three sites, the net ecosystem exchange of carbon dioxide (NEE, net of photosynthesis and respiration) was a stronger sink than the long-term mean, on days characterized by low incident radiation, low vapor pressure deficit and high precipitation. Annual anomalies in NEE were dominated by anomalies in GPP that were correlated with incident radiation and vapor pressure deficit. Although temperature generally showed little direct effect on NEE, it became important when the mean daily air temperature exceeded 25 °C. On such days the mean global radiation exceeded 250 Wm^{-2} but gross photosynthesis (GPP) decreased likely because the maximal vapor pressure deficit exceeded 2 kPa inhibiting photosynthetic uptake. However, the high temperature also stimulated respiration and as result positive anomalies in NEE occurred. At the boreal site, extreme climatic conditions in summer rarely met the criteria to inhibit photosynthesis. Climatic extremes in summer were more severe in the South than in the North, and had larger effects in the South. At the moment we are moving from a

daily resolution towards an event based resolution which should allow to better understand the effect of climatic interactions on the carbon fluxes.