Interannual variability of net ecosystem productivity in forests is explained by carbon flux phenology in autumn

To investigate the importance of autumn phenology in controlling interannual variability of forest net ecosystem productivity (NEP) and to derive new phenological metrics to explain the interannual variability of NEP. North America and Europe. Flux data from nine deciduous broadleaf forests (DBF) and 13 evergreen needleleaf forests (ENF) across North America and Europe (212 site-years) were used to explore the relationships between the yearly anomalies of annual NEP and several carbon flux based phenological indicators, including the onset/end of the growing season, onset/end of the carbon uptake period, the spring lag (time interval between the onset of growing season and carbon uptake period) and the autumn lag (time interval between the end of the carbon uptake period and the growing season). Meteorological variables, including global shortwave radiation, air temperature, soil temperature, soil water content and precipitation, were also used to explain the phenological variations. We found that interannual variability of NEP can be largely explained by autumn phenology, i.e. the autumn lag. While variation in neither annual gross primary productivity (GPP) nor in annual ecosystem respiration (Re) alone could explain this variability, the negative relationship between annual NEP and autumn lag was due to a larger Re/GPP ratio in years with a prolonged autumn lag. For DBF sites, a longer autumn lag coincided with a significant decrease in annual GPP but showed no correlation with annual Re. However, annual GPP was insensitive to a longer autumn lag in ENF sites but annual Re increased significantly. These results demonstrate that autumn phenology plays a more direct role than spring phenology in regulating interannual variability of annual NEP. In particular, the importance of respiration may be potentially underestimated in deriving phenological indicators.

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