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Disentangling the effects of climate variability and functional change on ecosystem carbon dynamics using semi-empirical modelling

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The ecosystem carbon balance is affected by both external climatic forcing (e.g. solar radiation, air temperature and humidity) and internal dynamics in the ecosystem functional properties (e.g. canopy structure, leaf photosynthetic capacity and carbohydrate reserve). In order to understand to what extent and at which temporal scale, climatic variability and functional changes regulated the interannual variation (IAV) in the net ecosystem exchange of CO_2 (NEE), data-driven analysis and semi-empirical modelling (Lasslop et al. 2010) were performed based on a 13 year NEE record in a temperate deciduous forest (Pilegaard et al 2011, Wu et al. 2012). We found that the sensitivity of carbon fluxes to climatic variability was significantly higher at shorter than at longer time scales and changed seasonally. This implied that the changing distribution of climate anomalies during the vegetation period could have stronger impacts on future ecosystem carbon balances than changes in average climate. At the annual time scale, approximately 80% of the interannual variability in NEE was attributed to the variation in the model parameters, indicating the observed IAV in the carbon dynamics at the investigated site was dominated by changes in ecosystem functioning. In general this study showed the need for understanding the mechanisms of ecosystem functional change. The method can be applied at other sites to explore ecosystem behavior across different plant functional types and climate gradients. Incorporating ecosystem functional change into process based models will reduce the uncertainties in long-term predictions of ecosystem carbon balances in global climate change projections.

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