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Process-based analysis of land carbon flux predictability

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The land-atmosphere CO_2 exchange exhibits a very high interannual variability which dominates variability in atmospheric CO_2 concentration. Despite efforts to decrease the discrepancy between simulated and observed terrestrial carbon fluxes, the uncertainty in trends and patterns of the land carbon fluxes remains high. This difficulty raises the question to what extent the terrestrial carbon cycle is even predictable, and which processes explain the predictability. In this study, the perfect model approach is used to assess the potential predictability of net primary production (NPP) and heterotrophic respiration (Rh) by using initialized ensemble experiments simulated with the Max Planck Institute Earth System Model. In order to determine which processes are causing the derived predictability patterns, carbon flux predictability was decomposed into individual drivers. Regression analysis was used to determine the contribution of the predictability of different environmental drivers to the predictability of NPP and Rh (Soil moisture, temperature and radiation for NPP and soil organic carbon, temperature and precipitation for Rh). The main drivers of NPP predictability are soil moisture and temperature, while the predictability signal from radiation is lost after the first month of simulation. Rh predictability is predominantly driven by soil organic carbon, temperature and locally by precipitation. This decomposition of predictability shows that the relatively high Rh predictability is due to the generally high predictability of soil organic carbon. The assessed seasonality in predictability patterns can be explained by the change in limiting factors of NPP and Rh over the wet and dry months. This leads to the adjustment of carbon flux predictability to the predictability of the currently limiting environmental factor. Differences in the predictability between initializations can be attributed to the interannual variability in soil moisture and temperature predictability. This variability is caused by the state dependency of nonlinear ecosystem processes. These results reveal the crucial regions and ecosystem processes to be considered when initializing a carbon prediction system.