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Enhanced seasonal CO_2 exchange caused by amplified plant productivity in northern ecosystems

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Atmospheric monitoring has shown an increase in the seasonal cycle of carbon dioxide (CO_2) in high northern latitudes (> 40°N) since the 1960s. The much stronger increase of the seasonal CO_2 amplitude in high latitudes compared to low latitudes suggests that northern ecosystems are experiencing large changes in carbon cycle dynamics. However the underlying mechanisms are not yet fully understood and current climate/carbon cycle models under-estimate observed changes in the seasonal CO_2 amplitude.
Here we aim to explain the observed latitudinal gradient of seasonal CO_2 amplitude trends by contrasting observations from long-term monitoring sites of atmospheric CO_2 concentration, satellite observation of vegetation greenness, and global observation-based datasets of gross primary production and net biome productivity, with results from the LPJmL dynamic global vegetation model coupled to the TM3 atmospheric transport model.
Our results demonstrate that the latitudinal gradient of the enhanced seasonal CO_2 amplitude is mainly driven by positive trends in photosynthetic carbon uptake caused by recent climate change and mediated by changing vegetation cover in boreal and arctic ecosystems. Climate change affects processes such as plant physiology, phenology, water availability, and vegetation dynamics, ultimately leading to increased plant productivity and vegetation cover in northern ecosystems in the last decades. Thereby photosynthetic carbon uptake has reacted much more strongly to warming than respiratory carbon release processes. Continued long-term observation of atmospheric CO_2 together with ground and satellite observations of land surface and vegetation dynamics will be the key to detect, model, and better predict changes in high-latitude land/carbon cycle dynamics.