Increasing summer net CO_2 uptake in high northern ecosystems on land

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Warmer temperatures and elevated atmospheric CO_2 concentrations over the last several decades have been credited with increasing vegetation activity and photosynthetic uptake of CO_2 from the atmosphere in the high northern latitude ecosystems: the boreal forest and Arctic tundra. At the same time, fire frequency and severity are increased, and some regions of the boreal forest show signs of stress due to drought or insect disturbance. Here we examine CO_2 fluxes from northern boreal and tundra from 1986 to 2012 estimated from two inverse models (1. using the NIES/FRCGC transport model at JAMSTEC and 2. using the TM3 model at the MPI-BGC). We have also used the normalized difference vegetation index (NDVI), as a proxy for photosynthetically active aboveground biomass, produced by NASA-GIMMS from measurements of the Advanced Very High Resolution Radiometer (AHVRR) satellite . Both inverse models used atmospheric CO_2 concentrations and wind-fields from interannually variable reanalysis. In the arctic zone, the latitude region above 60°N excluding Europe (10°W – 63°E), neither model finds a significant long-term trend in annual CO_2 balance. The boreal zone, the latitude region from 50°N to 60°N, again excluding Europe, absorbed an extra 8–11 TgC yr^{-1} over the period from 1986 to 2006, resulting in an annual CO_2 sink in 2006 that was 170–230 TgC larger than in 1986. In both latitudinal zones, the seasonal amplitude of monthly CO_2 fluxes increased due to increased uptake in summer. The uptake increase in summer in the arctic zone is nullified by increased fall CO_2 release for maintaining the constant annual uptake. Both models showed a seasonal flux amplitude increase of nearly 1% yr^{-1} in the arctic zone, over twice the trend in the boreal zone fluxes. These findings suggest that the boreal zone has been maintaining and likely increasing CO_2 sink strength over this period, despite browning trends (decreased NDVI) in some regions, changes in fire frequency and land use. Our results showed no indication of a large-scale positive climate-carbon feedback caused by warming temperature on high northern latitude terrestrial CO_2 fluxes as of 2012.