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Spatial-temporal responses of Arctic amplification to carbon-concentration and carbon-climate feedbacks in CMIP6 simulations

The modelled and field study has proved that the Arctic region is experiencing a phenomenon known as Arctic amplification (AA), characterized by a rapid warming rate that is two to three times higher than that of the Northern Hemisphere (NH) or global. In previous studies, the AA is mostly attributed to the physical process underlying temperature changes and sea ice changes, with little attention paid to the impact of ecosystem processes especially carbon cycle. In this study, 3 experiments from 11 Earth system models (ESMs) were used to investigate their spatial temporal pattern of AA, and the potential causes. These experiments were designed for quantifying the responses of biogeochemical process to changes in temperature (carbon-climate) and atmospheric CO_2 (carbon-concentration).

The results of this study found that the speed of Arctic warming is ~2 times faster than the NH when considering the response of biogeochemical process to temperature changes and considering to both temperature and atmospheric CO_2 changes. The warming is concentrated in the Arctic Ocean, with land being slightly weaker. The spatial distribution remained unchanged throughout the entire period of experiment. By contrast, in the experiment only considering the response of biogeochemical process to changes in atmospheric CO_2, the range of warming rate is larger but fluctuating (1~4, the mean value is 2.5), and the warming is mainly focused on the Barents Sea. The study also found that the interaction between these two responses increased temperature and melting of sea ice. However, the reduction in evapotranspiration was lessoned. The excessive heat resulting from reduced evapotranspiration can be transported to higher latitudes, leading to further melting of sea ice and enhancing the effects of AA.

The study showed that while the CMIP6 models agree on temperature trends and changes in sea ice and evapotranspiration, they have more uncertainties at high latitudes and in measuring the response to atmospheric CO_2 changes. This indicates that there is a need to improve models by accurately evaluating the effects of CO_2 and biogeochemical response in order to better understand Arctic warming.

Keywords: Geography, Physical Geography, Ecosystem Analysis, Arctic amplification, Carbon cycle feedbacks, CO2 physiological effect, CMIP6

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