

# **Amplified Arctic warming by phytoplankton under greenhouse warming**

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Phytoplankton have attracted increasing attention in climate science due to their impacts on climate systems. A new generation of climate models can now provide estimates of future climate change, considering the biological feedbacks through the development of the coupled physical–ecosystem model. Here we present the geophysical impact of phytoplankton on future climate projections, which is often overlooked in future climate projections. A suite of future warming experiments using a fully-coupled ocean-atmosphere model that interacts with a marine ecosystem model reveals that the future phytoplankton change influenced by greenhouse warming can amplify Arctic surface warming considerably. The warming-induced sea ice melting, and the corresponding increase in shortwave radiation penetrating into the ocean, both result in a longer phytoplankton growing season in the Arctic. In turn, the increase in Arctic phytoplankton warms the ocean surface layer through a direct biological heating, triggering additional positive feedbacks in the Arctic, and consequently intensifying the Arctic warming further. Our results establish the presence of marine phytoplankton as an important potential driver of the future Arctic climate changes.

**Key words:** Arctic Amplification, biological feedback