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Freshwater forcing on the greenhouse Arctic climate in the Late Cretaceous: Implications from proxies and model simulations

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The Arctic experiences contrasting environmental changes under icehouse and greenhouse conditions. Unique tracers of greenhouse conditions recorded in Upper Cretaceous sediments provide basic mechanisms controlling this sensitive system. Based on dinoflagellate cysts and foraminifera from the Campanian and Maastrichtian in the Norwegian-Greenland seaway, Barents Sea, and Lomonosov Ridge, we show that this area experienced a progressive surface freshening during the Late Cretaceous. This is indicated by the organic-walled dinoflagellate cyst assemblage from the Norwegian-Greenland seaway and by shallow water benthic foraminifera from the Lomonosov Ridge, further suggesting brackish conditions in the surface water of the Arctic Basin. The freshening is explained by the influx of fresh water into a more isolated Arctic Basin via river discharge from the surrounding continents. In contrast to surface water proxies, benthic foraminiferal assemblages from the Norwegian-Greenland Seaway indicate higher deep water salinities during the Campanian. Multiple correspondence analyses as well as model simulations confirm the reconstructed sea surface freshening and suggest a salinity driven stratification within this seaway. The deep seaway can contribute to a long-term warm climate in the Arctic by a continuous exchange of the brackish and saline water masses between the Arctic Basin and the Western Tethys. During the Maastrichtian, a more restricted connection between these two regions could have reduced sea surface salinity in the Arctic Basin. Our Earth System Model simulations indicate a clear stratification pattern of the Arctic Basin with a strong temperature gradient of warm deep waters overlain by colder layers. The model demonstrates that such a water column structure could occur as an effect of the bidirectional water mass circulation. We suggest that such a ‘heat pump system’ is responsible for a long-term warming and stabilization of the Arctic climate during the Late Cretaceous.
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