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# On the possibility of ice on Greenland during the Eocene-Oligocene transition

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The Eocene-Oligocene transition (∼34 Ma) is one of the major climate transitions of the Cenozoic era. Atmospheric $CO_2$ decreased from the high levels of the Greenhouse world (>1000 ppm) to values of about 600-700 ppm in the early Oligocene. High latitude temperatures dropped by several degrees, causing a large-scale expansion of the Antarctic ice sheet. Concurrently, in the Northern Hemisphere, the inception of ice caps on Greenland is suggested by indirect evidence from ice-rafted debris and changes in erosional regime. However, ice sheet models have not been able to simulate extensive ice on Greenland under the warm climate of the Eocene-Oligocene transition. We show that elevated bedrock topography is key in solving this inconsistency. During the late Eocene / early Oligocene, East Greenland bedrock elevations were likely higher than today due to tectonic and deep-Earth processes related to the break-up of the North Atlantic and the position of the Icelandic plume. When allowing for higher initial bedrock topography, we do simulate a large ice cap on Greenland under the still relatively warm climate of the early Oligocene. Ice inception takes place at high elevations in the colder regions of North and Northeast Greenland; with the size of the ice cap being strongly dependent on the climate forcing and the bedrock topography applied.