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The influence of Earth's hypsometry on global sea level through a glacial cycle and into the future

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Earth's topography and bathymetry is shaped by a complex interplay between solid-Earth processes that deform the Earth from within and the surface processes that modify the outer shape of the Earth. At the surface, an ultimate baselevel set by global sea level marks the defining transition from erosion to deposition. Over geological time scales, this baselevel has resulted in a distinct hypsometric distribution (distribution of surface area with elevation), with the highest concentration of surface area focused in a narrow elevation range near present-day sea level.

This particular feature in Earth's hypsometry makes the global land fraction very sensitive to changes in sea level. Indeed, a sea-level change will result in a significant change in the land fraction as dictated by the hypsometric distribution, thereby modulating the very same sea-level change. However, it remains unexplored exactly how sea-level changes have modified the global land fraction over past glacial cycles and into the future.

Here we analyse how Earth's hypsometry has changed over the last glacial cycle as large ice sheets waxed and waned particularly in Scandinavia and North America. These changes in global ice volume resulted in a significant global excursion in sea level, modulated regionally by solid-Earth deformation, gravitational effects, and effects from Earth's rotation. These changes modified Earth's hypsometry, and therefore the global land fraction at any given time. Consequently, we can map out how Earth's hypsometry has influenced global mean sea level (GMSL) over time. To examine this relationship between Earth's hypsometry and sea level further, we look to the deep future, to a scenario where both the Greenland Ice Sheet and the Antarctic Ice Sheets will melt away completely over multi-millennial timescales. This scenario is not meant to represent a realistic future scenario per se, but it allows us to define the hypsometric GMSL correction needed for any GMSL that the Earth has experienced recently or will experience in the future.