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Impact of Greenland's topographic height on precipitation and snow accumulation

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The Greenland Ice Sheet (GrIS) is one of the most dominant orographic obstacles for atmospheric flow in the Northern Hemisphere. Within an idealized framework, we investigate the potential impact of a reduced Greenland topography upon precipitation, snow accumulation, and atmospheric circulation over the GrIS. Using the global atmospheric model ECHAM5-HAM at about 1° spatial resolution (T106) and with present-day climatological mean conditions, we perform four 16-year sensitivity experiments that are identical except for the height of the GrIS topography: one control simulation with the present-day Greenland topography, and three simulations under the simplified situations where topographies are reduced to 75%, 50%, and 25% of the present-day height.
In the control simulation, total precipitation and snow accumulation are in reasonable agreement with observations, reanalyses, and previous modeling studies. High precipitation over Greenland occurs mainly in the coastal regions and maximizes in the southeast, predominantly during autumn and winter, and less pronounced on the western slopes, distinctly peaking during summer.
The reduction of Greenland's topography leads to statistically significant increases in GrIS-averaged annual total precipitation (TP) and snow accumulation that are approximately linear with on average +11% (TP) and +4% (snow) per 25% topographic height reduction. Spatially, the overall increase is composed of statistically significant increases in eastern, northern, and central Greenland, and decreases on the western slopes. In principle, the gain in snow accumulation raises the possibility of a negative feedback that would stabilize the height of the GrIS. However, this feedback is likely overcompensated by enhanced ablation (positive feedback), as surface air temperatures strongly increase with reduced topographic height.
The analysis of changes in circulation patterns indicates that flatter topographies allow the flow to penetrate farther inland, enabling precipitation in regions that are presently desert-like. Prominent circulation features change with lower topography, in particular the all-season Greenland Anticyclone and the wintertime Icelandic Low become weaker.
Preliminary analysis on the global scale implies that the reduction of Greenland's topographic height affects the Northern Hemispheric circulation through the weakening of the winter polar vortex and a shift towards the negative phase of the Arctic Oscillation.

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