Reduced mass loss from the Greenland ice sheet under stratospheric aerosol injection

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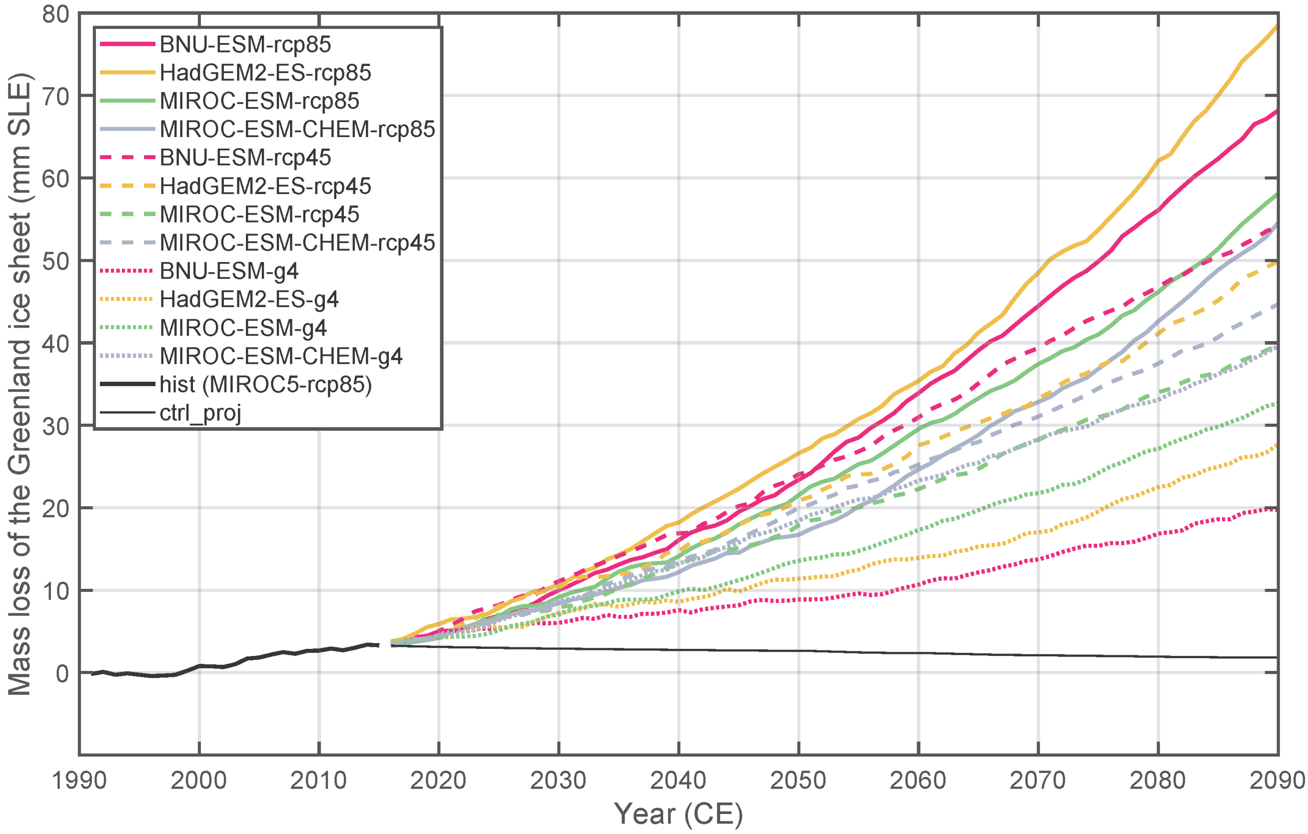
Sea level rise from the ice sheets is one of the chief impacts of greenhouse gas emissions. The Greenland ice sheet is expected to contribute some ten centimetres to ~1 metre of global sea level equivalent (SLE) this century (Goelzer et al., 2020, doi: 10.5194/tc-2019-319). In the longer term, Greenland will likely lose more than 90% of its ice sheet unless summer temperatures are kept to less than 2˚C above pre-industrial levels (Pattyn et al., 2018, doi: 10.1038/s41558-018-0305-8). Stratospheric aerosol injection (SAI) has been proposed as a potential method of meeting the IPCC 1.5˚C or 2˚C global temperature rise targets. In this study, we use the SICOPOLIS (www.sicopolis.net) and Elmer/Ice (elmerice.elmerfem.org) dynamic models driven by changes in surface mass balance and temperature to estimate the sea level rise contribution from the Greenland ice sheet under the IPCC RCP4.5, RCP8.5 and GeoMIP G4 (Kravitz et al., 2013, doi: 10.1002/2013JD020569) scenarios. The G4 scenario adds 5 Tg/yr sulfate aerosols to the equatorial lower stratosphere (equivalent of ~1/4 of the 1991 Mt. Pinatubo SO_2 emission rate) to the IPCC RCP4.5 scenario, which itself approximates to the Paris NDC (Nationally Determined Contributions) greenhouse gas emission commitments. The figure shows the mass loss of the Greenland ice sheet under the three scenarios with four earth system models (BNU-ESM, HadGEM2-ES, MIROC-ESM, MIROC-ESM-CHEM), simulated with the SICOPOLIS model. Relative to a constant-climate control run (ctrl_proj), the losses from 2015 to 2090 are 63 [53, 76] mm SLE for RCP8.5, 45 [38, 52] mm SLE for RCP4.5 and 28 [18, 38] mm SLE for G4 (mean and full range). Thus, the mean mass loss under G4 is about 38% smaller than that under RCP4.5 and 55% smaller than that under RCP8.5. We aim to repeat all simulations with the full-stress Elmer/Ice model to assess model-induced uncertainty.

Keywords: Greenland, Ice sheet, Climate change, Geoengineering, Modelling


BNU-ESM-rcp85
HadGEM2-ES-rcp85
MIROC-ESM-rcp85
MIROC-ESM-CHEM-rcp85
BNU-ESM-rcp45
HadGEM2-ES-rcp45
MIROC-ESM-rcp45
MIROC-ESM-CHEM-rcp45
BNU-ESM-g4
HadGEM2-ES-g4
MIROC-ESM-g4
MIROC-ESM-CHEM-g4
hist (MIROC5-rcp85)
ctrl_proj
Mass loss of the Greenland ice sheet (mm SLE)
80
70
60
50
40
30
20
10
0
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
Year (CE)