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GrSMBMIP: Intercomparison of the modelled 1980-2012 surface mass balance over the Greenland Ice sheet

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The Greenland Ice Sheet (GrIS) mass loss has been accelerating at a rate of about 20 +/- 10 Gt/yr^2 since the end of the 1990's, with around 60% of this mass loss directly attributed to enhanced surface meltwater runoff. However, in the climate and glaciology communities, different approaches exist on how to model the different surface mass balance (SMB) components using: (1) complex physically-based climate models which are computationally expensive; (2) intermediate complexity energy balance models; (3) simple and fast positive degree day models which base their inferences on statistical principles and are computationally highly efficient. Additionally, many of these models compute the SMB components based on different spatial and temporal resolutions, with different forcing fields as well as different ice sheet topographies and extents, making inter-comparison difficult. In the GrIS SMB model intercomparison project (GrSMBMIP) we address these issues by forcing each model with the same data (i.e., the ERA-Interim reanalysis) except for two global models for which this forcing is limited to the oceanic conditions, and at the same time by interpolating all modelled results onto a common ice sheet mask at 1 km horizontal resolution for the common period 1980-2012. The SMB outputs from 13 models are then compared over the GrIS to (1) SMB estimates using a combination of gravimetric remote sensing data from GRACE and measured ice discharge, (2) ice cores, snow pits, in-situ SMB observations, and (3) remotely sensed bare ice extent from MODerate-resolution Imaging Spectroradiometer (MODIS). Our results reveal that the mean GrIS SMB of all 13 models has been positive between 1980 and 2012 with an average of 340 +/- 112 Gt/yr, but has decreased at an average rate of -7.3 Gt/yr^2 (with a significance of 96%), mainly driven by an increase of 8.0 Gt/yr^2 (with a significance of 98%) in meltwater runoff. Spatially, the largest spread among models can be found around the margins of the ice sheet, highlighting the need for accurate representation of the GrIS ablation zone extent and processes driving the surface melt. In addition, a higher density of in-situ SMB observations is required, especially in the south-east accumulation zone, where the model spread can reach 2 mWE/yr due to large discrepancies in modelled snowfall accumulation. Overall, polar regional climate models (RCMs) perform the best compared to observations, in particular for simulating precipitation patterns. However, other simpler and faster models have biases of same order than RCMs with observations and remain then useful tools for long-term simulations. It is also interesting to note that the ensemble mean of the 13 models produces the best estimate of the present day SMB relative to observations, suggesting that biases are not systematic among models. Finally, results from MAR forced by ERA5 will be added in this

intercomparison to evaluate the added value of using this new reanalysis as forcing vs the former ERA-Interim reanalysis (used in SMBMIP).

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