Geophysical Research Abstracts
Vol. 18, EGU2016-7550, 2016
EGU General Assembly 2016

Contrasting current and projected changes in surface mass balance components across the Greenland Ice Sheet

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Comparison of the last decade's low surface mass balance (SMB) on the Greenland ice sheet to the changes that are projected for a warming future allows the current mass loss to be placed in a broader perspective. We compare changes in SMB components in HIRHAM5 regional climate model experiments forced by current ERA-Interim reanalysis data and by future projections with the EC-Earth general circulation model. The EC-Earth-forced experiments run over time slices 1991-2010, 2031-2050 and 2081-2100 for both RCP4.5 and RCP8.5.

SMB decreases considerably in the in the last decades of the ERA-Interim experiment. The changes between the early and later part of this experiment are therefore compared to changes in the future scenarios relative to the baseline 1991-2010 EC-Earth-forced experiment.

A major increase in melting and runoff, particularly along the western margin, is common to both the current and projected situations. Over the reanalysis period, accumulation has decreased in many places, particularly in the south. This is linked to the dominant circulation pattern in the last decade and enhances the effect of increased melt and runoff in producing the recent low SMB. In the projections, however, accumulation increases and thereby partially offsets the mass loss. This offset is so efficient that only in the warmest scenario in the latest time slice is the SMB decline significantly stronger than the current one. In the mid-term in the RCP4.5 experiment, central East Greenland sees an increase in accumulation which is not yet countered by increased melt and runoff. Consequently, this basin even has an increased SMB.

The increase in accumulation (both rain and snow) is projected to lead to significant SMB increase in the interior parts of the ice sheet. Rain fractions tend to increase, as seen already in reanalysis period. As melting intensifies in the ablation zone and the percolation zone migrates upward into areas that see increased snowfall, the refreezing rate decreases at low elevations and increases at intermediate ones. At high elevations, the refreezing rate continues to be at 100%.

These results are explored in the context of a wider set of CMIP5-based climatologies in order to assess the representativeness of the estimates based on HIRHAM/EC-Earth.