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Evaluation of the present and future general circulation over Greenland simulated by the IPCC AR5/CMIP5 GCMs with the help of a circulation type classification

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Future projections of the Greenland ice sheet melt are based on General Circulation Model (GCM) simulations. In particular, the reliability of downscaling methods forced by these simulations depends on the quality of the atmospheric circulation simulated by GCMs. Therefore, it is essential to analyse and evaluate the GCMs modelled general circulation for current climate (1961-1990).
Atmospheric circulation type classifications offer a very interesting approach for evaluating the GCM-based circulation at a daily time scale compared to the most used methods based only on monthly means. Indeed, the circulation type classification allows a precise and detailed analysis of each circulation type and so, it gives much more information on the ability of GCMs to simulate the different circulation types and consequently the climatic variability of a region. In fact, exceptional circulation events over Greenland, which cannot be taken into account by the monthly mean approach, have much more impact on the melt than the mean atmospheric state.
Thus, an automated correlation-based atmospheric circulation type classification (CTC) is used for evaluating the new GCM outputs (available on http://cmip-pcmdi.llnl.gov/cmip5/) computed for the upcoming IPCC report (AR5). The daily geopotential height at 500 hPa simulations of the GCMs for current climate are compared to the NCEP-NCAR 1 and the ECMWF reanalysis data for the summer months (JJA), when melt is the most important. To achieve this, the classification is first done for the reanalysis data over 1961-1990 and afterwards, the types of the reanalysis based CTC are imposed for classifying the GCM datasets over 1961-1990 (from the historical experiment) to allow a direct type per type comparison based on the frequency distribution of each dataset. This approach also gives the opportunity to study the intraclass repartition differences between the reanalysis and the GCMs. After the evaluation of the GCM simulations for current climate, the future projections driven by RCP concentrations or emissions (2011-2040, 2041-2070 and 2071-2100) from the best matching GCMs are analysed in the same way.
For current climate, it clearly appears that only a few GCMs are able to reproduce reliably the variability of the atmospheric circulation over Greenland during summer. The differences of frequency between the GCMs and the reanalysis are mainly due to biases of the geopotential height which is systematically over or underestimated by most GCMs and to the underestimation of the variability of the circulation by most GCMs.
For future projections, no new circulation types are detected, but rather a general increase of the mean geopotential height regardless of the circulation type. It is also important to note that for many GCMs, the uncertainty of the current climate simulations (given by the differences of the classification results between the GCM simulations for current climate and the reanalysis data for the same time) are of the same order than the projected changes for future climate. Therefore, these projections may be questionable.