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TITLE: Reconstructions of the 1900?2015 Greenland ice sheet surface mass balance using the regional climate MAR model

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ABSTRACT:

Abstract. With the aim of studying the recent Greenland ice sheet (GrIS) surface mass balance (SMB) decrease relative to the last century, we have forced the regional climate MAR (Modèle Atmosphérique Régional; version 3.5.2) model with the ERA-Interim (ECMWF Interim Re-Analysis; 1979?2015), ERA-40 (1958?2001), NCEP?NCARv1 (National Centers for Environmental Prediction?National Center for Atmospheric Research Reanalysis version 1; 1948?2015), NCEP?NCARv2 (1979?2015), JRA-55 (Japanese 55-year Reanalysis; 1958?2014), 20CRv2(c) (Twentieth Century Reanalysis version 2; 1900?2014) and ERA-20C (1900?2010) reanalyses. While all these forcing products are reanalyses that are assumed to represent the same climate, they produce significant differences in the MAR-simulated SMB over their common period. A temperature adjustment of +1 °C (respectively ?1 °C) was, for example, needed at the MAR boundaries with ERA-20C (20CRv2) reanalysis, given that ERA-20C (20CRv2) is ? 1 °C colder (warmer) than ERA-Interim over Greenland during the period 1980?2010. Comparisons with daily PROMICE (Programme for Monitoring of the Greenland Ice Sheet) near-surface observations support these adjustments. Comparisons with SMB measurements, ice cores and satellite-derived melt extent reveal the most accurate forcing datasets for the simulation of the GrIS SMB to be ERA-Interim and NCEP?NCARv1. However, some biases remain in MAR, suggesting that some improvements are still needed in its cloudiness and radiative schemes as well as in the representation of the bare ice albedo. Results from all MAR simulations indicate that (i) the period 1961?1990, commonly chosen as a stable reference period for Greenland SMB and ice dynamics, is actually a period of anomalously positive SMB (? +40 Gt yr?1) compared to 1900?2010; (ii) SMB has decreased significantly after this reference period due to increasing and unprecedented melt reaching the highest rates in the 120-year common period; (iii) before 1960, both ERA-20C and 20CRv2-forced MAR simulations suggest a significant precipitation increase over 1900?1950, but this increase could be the result of an artefact in the reanalyses that are not well-enough constrained by observations during this period and (iv) since the 1980s, snowfall is quite stable after having reached a maximum in the 1970s. These MAR-based SMB and accumulation reconstructions are, however, quite similar to those from Box (2013) after 1930 and confirm that SMB was quite stable from the 1940s to the 1990s. Finally, only the ERA-20C-forced simulation suggests that SMB during the 1920?1930 warm period over Greenland was comparable to the SMB of the 2000s, due to both higher melt and lower precipitation than normal.

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