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Estimation of the Antarctic surface mass balance using the regional climate model MAR (1979-2015) and identification of dominant processes

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We evaluate new simulations of the polar-oriented regional climat model (RCM) MAR forced by three reanalyses, ERA-Interim, JRA-55 and MERRA2, for the period 1979-2015, over the Antarctic ice sheet. We compare MAR results to the last outputs of the RCM $RACMO_2$ forced by ERA-Interim. We show that MAR and $RACMO_2$ perform similarly well in simulating coast to plateau SMB gradients, and we find no significant differences in their simulated SMB when integrated over the ice sheet or its major basins. More importantly, we outline and quantify missing or underestimated processes in both RCMs. Along stake transects, we show that both models accumulate too much snow on crests, and not enough snow in valleys, as a result of drifting snow transport fluxes not included in MAR and probably underestimated in $RACMO_2$ by a factor of three. Our results tend to confirm that drifting snow transport and sublimation fluxes are much larger than previous model-based estimates and need to be better resolved and constrained in climate models. Sublimation of precipitating particles in low-level atmospheric layers is responsible for the significantly lower snowfall rates in MAR than in $RACMO_2$ in katabatic channels at the ice sheet margins. Atmospheric sublimation in MAR represents 363 Gt yr^{-1} over the grounded ice sheet for the year 2015, which is 16 % of the simulated snowfall loaded at the ground. This estimate is consistent with a recent study based on precipitation radar observations, and is more than twice as much as simulated in $RACMO_2$, because of different time residence of precipitating particles in the atmosphere. The remaining spatial differences in snowfall between MAR and $RACMO_2$ are attributed to differences in advection of precipitation, snowfall particles being likely advected too far inland in MAR.