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Advanced precipitation scheme in ICOLMDZ with improved microphysics and subgrid cloud-hydrometeor interactions to better simulate polar precipitation

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The current assessment of the ice sheet surface mass balance and more generally of the atmospheric branch of the high latitude water cycles mostly relies on climate model simulations. The ability of climate models to reproduce the polar precipitation not only depends on the simulation of the atmospheric dynamics and on the advection of moisture towards the poles but also on the representation of the subgrid scale cloud and precipitation processes that govern the formation and growth of snowflakes and rain drops. The ICOLMDZ model, atmospheric component of the IPSL-CM Earth System Model, is intensively involved in polar-oriented studies and recent developments were carried out to improve the representation of mixed-phase and ice clouds. However, recent studies also evidenced substantial shortcomings and biases that persist in the simulation of the polar precipitation, both in the Arctic and in the Antarctic. This study presents the development of a new precipitation scheme in the ICOLMDZ model that includes both an advanced microphysical treatment of snowfall and subgrid vertical overlap considerations to properly account for the interactions between hydrometeors and clouds. Particular attention is also paid to the numerical treatment of the different processes to ensure numerical convergence and stability at typical time steps used in global climate models. The scheme is then evaluated using regional simulations conducted over Adélie Land, East Antarctica and the Svalbard Archipegalo. The simulated vertical profiles of precipitation and microphysical tendencies are compared with observational data from a ground-based polarimetric radar deployed during the APRES3 campaign as well as from airborne radar and lidar data collected during the THINICE campaign. Perturbed parameter ensemble experiments are also conducted to assess the parameteric sensitivity of the model and to disentangle calibration issues from genuine structural biases. Results show that the model is now able to physically capture the vertical evolution of the snowfall and to simulate more realistically the melting layer. Future applications of the new precipitation scheme including simulations of the Antarctic surface mass balance with ICOLMDZ can now be envisaged.