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Assessment of surface snowfall rates and their connection to cloud microphysics in reanalysis data and global climate models

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Cloud feedbacks are a major contributor to the spread of climate sensitivity in global climate models (GCMs) [1]. Among the most poorly understood cloud feedbacks is the one associated with the cloud phase, which is expected to be modified with climate change [2]. Cloud phase bias, in addition, has significant implications for the simulation of radiative properties and glacier and ice sheet mass balances in climate models.

In this context, this work aims to expand our knowledge on how the representation of the cloud phase affects snow formation in GCMs. Better understanding this aspect is necessary to develop climate models further and improve future climate predictions.

This study aims to improve the understanding of the link between the representation of cloud phase and surface snowfall in historical simulations, comparing them to a combination of satellite remote sensing and reanalysis data. We use the cloud and snowfall products from CloudSat satellite and the European Centre for Medium-Range Weather Forecast Re-Analysis 5 (ERA5), producing a global surface snowfall rate climatology for each dataset.

We compare the outputs from the Coupled Model Intercomparison Project Phase 6 (CMIP6) climate models to the snowfall rate climatology produced by CloudSat and ERA5. Comparing historical simulations from climate models with CloudSat will relate the already identified cloud phase biases with snowfall biases in specific regions for the past decade. Statistical analysis is carried out to determine cloud phase and precipitation (liquid and solid) biases and their potential connection to each other in the climate models.

The results show that, globally, CMIP6 models can reproduce some of the characteristics of liquid water content and snowfall, as seen in ERA5. In addition, a comparison between ERA5 and the CMIP6 models shows that CMIP6 models underestimate the ice water path. Then, we look at the regional differences of ice water path, liquid water path, and surface snowfall to better understand

how the individual CMIP6 models perform in different regions—showing an overestimation of ice water path in the southern and northern hemisphere extratropics. At the same time, surface snowfall is within the ERA5 standard deviation. When comparing the ERA5 ice water path to surface snowfall, we identify a positive relationship between the two, independent of the latitudes. On the other hand, the CMIP6 ensemble mean or CMIP6 models individually do not indicate a positive relationship. The next step of this ongoing research is to investigate the relationship between cloud phase (ice, liquid water path) and surface snowfall rate based on CloudSat retrievals.

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