Geophysical Research Abstracts
Vol. 21, EGU2019-6931, 2019
EGU General Assembly 2019

Evaluation of snowfall in GCMs in the Arctic using CPR/CloudSat observations

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A realistic representation of snowfall in the general circulation models (GCMs) is important to accurately simulate snow cover, surface albedo, high latitude precipitation and thus, the radiation budget. Hence, in this study, the latest decade-long snowfall estimates from the active Cloud Profiling Radar on board NASA's CloudSat satellite are used to evaluate the GCMs. Although 10 years of snowfall estimates are now available from CPR/CloudSat, this time period is still shorter considering that the natural variability can occur on multi-decadal time scales. CloudSat nonetheless, provides the most reliable estimates of snowfall to date globally and hence such evaluation provides insight into how well models can simulate snowfall to a first order.
In this study, the following questions are addressed:
1. How well do the GCMs (atmospheric only) used in the framework of the EU PRIMAVERA project simulate the northern high latitude snowfall?
2. Does increasing the spatial resolution improve the snowfall representation in these models?
3. Do the models simulate the snowfall variability associated with the different phases of Arctic Oscillation realistically?

We report that the statistical distributions of snowfall vary considerably between the models and CloudSat observations. While CloudSat shows exponential distribution of snowfall, the models show Gaussian distribution. As a result, the 10 and 50 percentiles, representing the light and median snowfall, are overestimated by a factor of 3 and 1.5 respectively in the models investigated here. The overestimations are strongest during the winter months compared to autumn and spring. The extreme snowfall represented by the 90 percentiles, on the other hand, is positively skewed underestimating the snowfall estimates by a factor of 2 in the models in winter compared to the CloudSat estimates. These biases can be attributed to simplified parameterizations used in the representations of complex ice processes. The simulated snowfall estimates are found to be insensitive to a change in resolution, although some regional improvements can be identified within a particular model. The characteristic snowfall variability associated with the positive phase of AO over Greenland Sea and central Eurasian Arctic seen in our observational reference is well captured by the models.