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# Evaluation of the cloud water phase in CMIP5 models using CALIPSO-GOCCP

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Evaluation of clouds in climate models is essential judging from the strong impact of clouds on the earth's radiation budget. Cloud phase influences many cloud properties and leads to different cloud interactions with the climate system. Since june 2006, CALIPSO satellite has provided new measurements of backscattered lidar profiles, which have been used to evaluate the cloud description in CMIP5 climate models through a lidar simulator (CFMIP Observation Simulator Package, COSP). In this study, we present results of this evaluation focused on vertical structure of clouds, global coverage and coverage above "hard to observe regions" such as the desert and polar regions, and partition between liquid and ice in clouds.
The total cloud cover is underestimated in all models and continental cloud covers (at low, mid, high altitudes) are highly variable depending on the model. In the tropics, all models underestimate the low cloud amount and none of them correctly simulate the top of deep convective compare to observations. In the Arctic, the modelled low cloud amounts are slightly biased compared to observations and seasonal variation not reproduced.
Thanks to a new cloud phase diagnosis in the GCM-Oriented CALIPSO Cloud Product (GOCCP) and its counterpart within the lidar simulator, we evaluate the cloud phase in LMDZ5B model. Comparisons show that, contrary to ice clouds, liquid clouds are largely underestimated in the model. Liquid clouds occur at temperatures as cold as -40°C in the observations, but only as cold as -20°C in the model. They are dominant at temperatures warmer than -21°C in observations but only warmer than -12°C in the model. In agreement with theory, statistical observations show that liquid and ice co-exist between 0°C and -40°C, and that the cloud phase depends not only on the temperature but also on humidity. For comparison, ice and liquid do not co-exist in the model, and the modelled cloud phase does not reproduce the observed sensitivity to the atmospheric humidity.
A specific focus on Arctic region shows that a lack of liquid-containing Arctic clouds contributes to a lack of "radiatively opaque" states in LMDZ5B model. The surface radiation biases found in this one model are found in multiple models, highlighting the need for improved modelling of Arctic cloud phase.
Further analysis will use learning from this study to investigate how changes in the LMDZ5B cloud phase parameterization (and possibly other models) impact cloud fractions, temperatures and fluxes for inter-annual and long term period simulations.