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Mixed-phase clouds: a journey between observations and climate models

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In numerical weather prediction and climate models a particular challenge is represented by the simulation of mixed-phase clouds. These clouds occur in a temperature range between 0℃ and -38℃, their hydrometeors can either consist of supercooled water or of ice, and the coexistence of both is very likely. The partitioning into liquid and ice in this regime depends on many factors (e.g. cloud dynamics, aerosols as ice nuclei, ice multiplication processes…) and varies therefore depending on cloud types, regions and seasons. To adress this complex problem, we first analyse observations, followed by the comparison of the findings with the climate models outputs. We use four years satellite data observations (from 1 June 2009 to 31 May 2013) to analyse the cloud phase distribution under different conditions. Several datasets are used to investigate the liquid and ice cloud distribution in order to account for uncertainties in the observations. The considered datasets are based on passive and active sensors on-board polar orbiting satellites.

In our analysis, special attention is paid to the geographical distribution of different cloud types and how the supercooled liquid fraction (SLF) in each cloud type is related to the temperature. The cloud types are assigned according to a cloud classification based on "cloud top pressure - cloud optical thickness"joint histograms. Despite temperature and phase mismatches between the datasets, systematic dependencies of the supercooled liquid fraction versus temperature are found comparing the different cloud types at different height and in separate latitude bands: in particular, SLF is larger in the Southern Hemisphere than in the Northern Hemisphere, except for the continental low-level clouds, for which the opposite occurs.

Other results show the importance of the atmospheric boundary layer and, presumably, of the aerosol distribution for the mixed-phase clouds: While the high-level clouds present similar patterns comparing them over continental/maritime regions and for Northern/Southern Hemispheres, low- and mid-level clouds show regional dependencies.

Initial results from the analysis of global climate models reveal good agreement between observations and models when comparing how SLF changes with the temperature, while remarkable differences are found on how the size of the liquid cloud droplet effective radius change with SLF for different cloud types and over different regions.

Category

Meteorology / Atmospheric Physics

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