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Classifying ice water content profiles of high-level clouds from AIRS/CALIPSO/CloudSat observations to better assess cloud radiative effects

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About 40% of all clouds on Earth are high-level clouds (< 440 hPa), which have a noticeable effect on the energetic budget of the atmosphere: optically thick clouds reflect the incoming solar radiation while thinner clouds act as “greenhouse films” preventing escape of the Earth’s infrared radiation to space. Accurate modelling of the radiative properties of high-level clouds is essential both for estimating their energetic effects and for the retrieval of bulk microphysical properties from infrared observations. It requires knowing the scattering and absorbing characteristics of cloud particles, amount of ice in the cloud, and variation of these parameters if the cloud is extended. In this work, we concentrate on vertical distribution of ice water content (IWC) in the high-level ice clouds.

For the analysis, we used a synergy of the active and passive sounders of the A-Train satellite constellation. Relatively high spectral resolution of the Atmospheric InfraRed Sounder (AIRS) allows the identification of cirrus clouds and the retrieval of their physical and bulk microphysical properties as well as their horizontal extent. Active sounders, the CALIPSO lidar and the CloudSat radar, provide the vertical structure of the clouds: the radar-lidar GEOPROF dataset (Mace et al., 2007) contains the vertical extent and position of each cloud layer while the liDARraDAR dataset (Delanoë and Hogan, 2010) gives the IWC profiles and effective ice crystal sizes. In addition, we use environmental parameters from ERA Interim reanalyses.

We have classified IWC vertical distributions according to their profile shape and found that a) they can be sub-divided into four major types; b) profile shape mainly depends on the integrated IWC of the cloud; c) there is a weak correlation between vertical wind and dominating profile type. We discuss an impact of different IWC profile types on the energetics of the atmosphere and on bulk microphysical properties retrieval, using the calculations performed with the 4A/OP+DISORT radiative transfer code (http://4aop.noveltis.com/). Obtained statistics on IWC profile types can be used for validation of the models.

References

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