IRS2012-323
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012
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Study of the cloud water phase (liquid/ice) observed by CALIPSO, and evaluation of the description of the water phase transition in a climate model (LMDZ5/IPSL)

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The transition between liquid and ice water in clouds has been documented indirectly for a while at global scale using the cloud temperature observed by passive remote sensing instruments. This technique is particularly difficult to use above reflecting surfaces such as the continents and the polar regions, and it is not resolved vertically, so it does not provide information on the vertical distribution of the water phase in clouds.

Here we use the CALIOP level 1 lidar polarization measurements to observe directly the cloud particle sphericity (and non sphericity) : liquid clouds are composed of spherical particles and ice clouds of non spherical crystals ; and to document the vertical structure of the cloud water phase at global scale. We built a water phase diagnostic (liquid, ice, undefined) in the GCM-Oriented Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) Cloud Product (GOCCP) and we analysed the water phase transition in clouds using 5 years of GOCCP data. A specific focus is given to tropical and polar regions.

In order to evaluate the description of the cloud water phase in a climate model (LMDZ5/IPSL), we developed a cloud water phase diagnostic within the satellite simulator COSP (CFMIP Observation Simulator Package). The definition of the water phase diagnostic in the simulator is consistent with the one used in GOCCP observations. By comparing the observations (GOCCP) and the ensemble « model+simulator » ouputs we show that liquid clouds are largely underestimated by the model, especially in the tropics and the poles. The model is not able to simulate significant liquid cloud fraction above 3.5km. Liquid cloud temperature seldom pass out 256°K whereas in observation it can reach 236°K. On the other hand, warmest liquid cloud are not enough represented as well. Ice clouds are quite well located. However their cloud fractions are too high and their temperatures too cold. Finally, we notice the mixed-phase cloud temperature is too warm and not enough spread in LMDZ.