A modeling case-study of a tropical tropopause layer cirrus : roles of dynamics and microphysics and cirrus impacts

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Cirrus clouds in the tropical tropopause layer (TTL) control dehydration of air masses entering the stratosphere and contribute to the local radiative heating. In this study, we aim at understanding, through a real case simulation, the formation and life cycle of a cirrus cloud event in the TTL. We also aim at quantifying the impacts of the cirrus in the TTL and its sensitivity to the microphysics and dynamics in the simulation.

To do this, we use the Weather Research and Forecast (WRF) model to simulate a large scale TTL cirrus event happening in January 2009 (27-29) over the Eastern Pacific, which has been previously described from satellite observations (Taylor et al., 2011). Comparisons of the simulated and observed cirrus show a fair agreement, and validate the reference simulation regarding cloud extension, location and life time. The simulations are then used to understand the cloud formation. It is confirmed that the cirrus forms due to adiabatic cooling and large-scale uplift rather than from ice lofting from convective anvils. The uplift results from the equatorial response (equatorial wave excitation) to a mid latitude Potential Vorticity intrusion. Sensitivity tests are then performed to assess the relative importance of microphysical assumptions, and of initial and boundary conditions in our simulations. In general, as much sensitivity is found on the (comparable) initial conditions than on the microphysics for the simulation of the large scale characteristics of the cloud field (area, location). On the other hand, the cloud induced sedimentation flux and water redistribution strongly depends on the microphysics scheme, and will in turn control future cloud events.

Last, the fair agreement with the observations allows to estimate the cloud impact in the TTL from the simulations. We show that the cirrus has a small but not negligible impact on the radiative budget of the local TTL. However, we do not find a strong influence of the cloud radiative heating on the simulated dynamics, and we propose possible explanations for this behavior. We also quantify the vertical redistribution of water by the cloud and emphasize the importance in our case of both re and dehydration in the vicinity of the cirrus, as well as their dependence on microphysical assumptions.

References

Taylor, J.R., Randel, W.J., and Jensen, E.J. *ACP*. **2011**, 11, 10085--10095.