Impact of equatorial and gravity waves on the structure and evolution of Tropical Tropopause Layer cirrus clouds

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Cirrus clouds in the Tropical Tropopause Layer (TTL) control the final dehydration of air masses before they enter the stratosphere, and hence have a significant impact on the global radiation budget and on climate. Despite their importance, significant uncertainties remain regarding TTL cirrus clouds and their evolution in a changing climate. This is due to the interaction of processes with different scales, from microphysical processes associated with the formation and growth of ice crystals to large scale dynamical processes which impose temperature and wind forcing that contribute to structure the clouds. Among those dynamical processes, it has long been emphasized that equatorial waves and gravity waves are a major factor in controlling the occurrence of the clouds. Recent aircraft observations by Kim et al [2016] have furthermore demonstrated non trivial relations between the occurrence of cirrus and temperature anomalies due to waves in the TTL. In particular, they have emphasized different wave-cirrus relation between the tropical western and eastern Pacific. These observational findings challenged our understanding of TTL cirrus-wave interaction.

In this work, the influence of equatorial and gravity waves on the growth and motion of ice crystals is explored theoretically using simplified (but realistic) analytical and numerical frameworks. In particular, we show the existence of a *wave-driven localization* of ice crystals, in which the crystals with the longest residence times (hence the most likely observed) are confined within specific regions of the wave characterized by a relative humidity near saturation. Our results are consistent with the observational findings by Kim et al., including the geographic variability, and might explain those. Furthermore, they carry implications for dehydration by TTL cirrus: the location where the wave driven localization occurs exhibits a *positive vertical wind anomaly* which slows down the sedimentation of ice crystals. Using aircraft observations, we show that this effect might reduce the dehydration induced by TTL cirrus by as much as 20%

Key words: Tropical Tropopause Layer, cirrus clouds, gravity waves

References

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