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Investigating the convective origin of tropical tropopause layer cirrus with Lagrangian trajectories.

Erik Johansson, Bernard Legras, and Aurélien Podglajen
Laboratoire de Météorologie Dynamique (LMD), CNRS, ENS-PSL/Ecole Polytechnique/Sorbonne Univ., France

High clouds play an important role in modulating Earth's radiation budget by either trapping longwave radiation emitted from Earth or reflecting incoming shortwave radiation. Furthermore, several studies have pointed out the importance of high clouds in the mass transport between the troposphere and the stratosphere. Most of the upward mass transport from the troposphere into the stratosphere occurs in the tropical region. Here the transition zone between the thermally driven troposphere and the wave-driven stratosphere is usually referred to as the tropical tropopause layer (TTL), and it can extend over several kilometres.

High clouds in the tropics can form in different ways. They can be associated with convective clouds either by convective overshoots or remnants of convective clouds, and they can be created in situ, e.g., by the ascent of dry air, due to gravity waves, leaving a small quantity of water vapour that will undergo deposition into ice. The difference origin creates a vast variety of high clouds ranging from thin cirrus to thick anvils, all with different radiative properties. Due to the altitude and the extreme conditions, high clouds are hard to study. In situ measurements are often limited in either time or space, and high clouds are often masked by low clouds from the ground. Passive satellite instruments are limited to resolving the vertical distribution of clouds and cannot see the thinnest ones. The advent of active sensors onboard satellites has brought a wealth of detailed information on the distribution of high altitude clouds, including the thin ones. However, this information has not been fully used to study the genesis of such clouds.

In this study, we use the Lagrangian model TRACZILLA to do a climatological study of the origin of high clouds in the tropical region. To drive the Lagrangian model, we use a decade-long dataset from the cloud detecting lidar onboard the CALIPSO satellite, infrared brightness temperatures from geostationary satellites and reanalyse data (diabatic and kinematic vertical motions) from ERA5. We benefit from recent progress in the reanalysis that produces high-quality wind and heating rates in the tropopause region. The analysis aims to separate the clouds formed by in situ condensation in clear air from rising motion from those that are remains of anvils directly formed from convective towers. We describe the climatology of this cloud formation mechanism in the tropical band and its variability, with an accent on the summer monsoon season, which generates the largest amount of thin cirrus.