Relationship between Latent and Radiative Heating Fields in the Tropics from synergistic satellite data

Xiaoting CHEN [(1)], Claudia J. Stubenrauch[(1)],Giulio Mandorli[(1)]

[(1)] Laboratoire de Météorologie Dynamique / Institut Pierre-Simon Laplace, (LMD/IPSL), Sorbonne Université, Ecole Polytechnique, CNRS
4 Place Jussieu,75005, Paris, France
EMail: xiaoting.chen@lmd.ipsl.fr

ABSTRACT

Upper troposphere (UT) clouds are most abundant in the tropics and often form as cirrus anvils from convective outflow, building mesoscale systems (MCS). While latent heating is released into the atmosphere by the precipitating parts of these MCSs, the long-lasting anvils play also a crucial role in modulating the Earth's energy budget and heat transport.

CIRS (Clouds from IR Sounders) data, retrieved from AIRS (Atmospheric Infrared Sounder) and IASI (Infrared Atmospheric Sounding Interferometer) measurements, sensitive to cirrus, provide cloud height and emissivity horizontal structure. CALIPSO lidar and CloudSat radar observations provide the vertical structure of clouds, in particular their radiative heating rates, though only along narrow nadir tracks. For a complete 3D view, these heating rate profiles (FLXHR) have been extended in space and time by Stubenrauch et al. (2021, 2023), using artificial neural network (ANN) regression on CIRS cloud properties and ERA-Interim atmospheric and surface properties (provided by ECMWF). In order to link these to the latent heat, we are using SLH latent heating profiles from the Tropical Rainfall Measuring Mission (TRMM). While TRMM provides a diurnal sampling over a month, the instantaneous spatial coverage at a specific local time is only about 3%. Therefore, we also expanded these latent heating profiles over the whole tropics, using ANN regression.

The latent heating averaged over 1:30 am / pm represents well the TRMM diurnally sampled latent heating over ocean, whereas it misses the afternoon deep convection over land. Nevertheless, our study agrees with previous studies that the radiative heating of UT clouds enhance the tropical latent heat by approximately 22%. We investigate the variability of this enhancement and show the relationship between monthly mean latent heating and radiative heating at different spatial scales. Furthermore, we present results on the relationship between the horizontal and vertical structure of UT clouds.

References

Stubenrauch, C. J., G. Caria, G., S.-E. Protopapadaki, and F. Hemmer (2021). 3d radiative heating of tropical upper tropospheric cloud systems derived from synergistic a-train observations and machine learning, Atmospheric Chemistry and Physics, 21(2),1015–1034.

Stubenrauch, C. J., Mandorli, G., & Lemaitre, E. (2023). Convective organization and 3D structure of tropical cloud systems deduced from synergistic A-Train observations and machine learning. Atmospheric Chemistry and Physics. 23. 5867-5884. 10.5194/acp-23-5867-2023.