Diurnal Cycle of Ice Water Content impacted by deep convection in the Tropical Upper Troposphere with an emphasis over the Maritime Continent

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In order to understand the diurnal cycle in water budget (ice and water vapour) in the Tropical Tropopause Layer (TTL, ~ 11-17 km), we use ice water content (IWC) and water vapour (WV) observations from the Microwave Limb Sounder (MLS, Version 4.2x) and surface precipitations from the Tropical Rainfall Measurement Mission (TRMM, Version 007) instruments over the same period (2004 to 2017) focusing on the austral convective season: December, January and February. MLS measurements are only considered in the upper troposphere (UT) at 146 hPa below the cold point of the tropical tropopause. MLS observations are performed at 01:30 Local Time (LT) and at 13:30 LT whilst TRMM surface precipitations data base allowed us to generate the data with both, a 20 minutes and an hour time resolution to follow the diurnal cycle of the surface precipitation over the tropics. TRMM and MLS datasets have been gridded within 2°x2° horizontal bins. Firstly, we choose six tropical highly convective zones: South America, South Africa, Pacific Ocean, Indian Ocean, and the Maritime Continent region (MC), split into MC land (MCl) and MC ocean (MCo). Because we found that the surface precipitation is spatially highly correlated with IWC in the UT over the 6 convective zones (R = 0.7), while it is not true for WV (R = 0.2), we decided to use the surface precipitation as a proxy of deep convection reaching the UT. The methodology in the study assumes that IWC increases proportionally with surface precipitation during the first hours of the growing phase of convection (early afternoon over land and early morning over ocean) and the ratio between the minimum of surface precipitation and the surface precipitation measured at 13:30 LT over land and the one at 01:30 LT over ocean, is used to calculate an estimation of the diurnal cycle of IWC in the UT. We calculate the absolute relative concentration difference during the convective decreasing phase (at 01:30 LT over land and 13:30 LT over ocean) between IWC measured by MLS (IWC_{MLS}) and IWC estimated from the diurnal cycle of surface precipitation (IWC_{estim}). Over the 6 zones, IWC_{estim} is consistent with the diurnal cycle of surface precipitation to better than 26 % (0.5 $mg.m^{-3}$). Over the MCl region, we find a better agreement ($IWC_{MLS}-IWC_{estim}$ ~ 4 % (0.1 $mg.m^{-3}$)) than over the MCo region ($IWC_{MLS}-IWC_{estim}$ ~ 26 % (0.5 $mg.m^{-3}$)). Secondly, we focus on MC at local scales comparing 8 MC seas and islands. We show that, over Sulawesi, Java, East Indian Ocean, Arafura Sea and Java Sea, the IWC_{estim} is consistent with the diurnal cycle of surface precipitation ($IWC_{MLS}-IWC_{estim}$ < 20 % (1.1 $mg.m^{-3}$)) but, over New Guinea, Sumatra and Borneo, the consistency is much less robust ($IWC_{MLS}-IWC_{estim}$ > 36% (1.9 $mg.m^{-3}$), even reaching 50% (3.7 $mg.m^{-3}$) for Borneo). The diurnal cycle of IWC over these three later regions is likely to be affected by other local surface phenomena (sea breeze, relief, distance to the coast, etc.) impacting upward transport to the UT.

Key words: Tropical Tropopause Layer, diurnal cycle, ice, Maritime Continent