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WHAT IS COOLING THE TROPOPAUSE ABOVE TROPICAL CYCLONES?

Starting in the late 1940s, several studies described a cold signal near the tropopause above tropical cyclones (TCs), sometimes referred to as the "upper cold core" or "convective cold top." The mechanisms responsible for this **tropopause-level cooling (TLC)** have not yet been determined, perhaps pertaining to the lack of observations with suitable resolution near the tropical tropopause. This study is motivated by:

1) Suggestions often made to the author that TLC is likely explained by **cloud top radiative cooling**. I imagine these suggestions could have stemmed from the tendency of the TC literature to analyze the highest/coldest/most overshooting cloud tops. Deep convection typically reaches altitudes below 15 km over the tropical oceans, which is at least 2 km below the tropopause.
2) Observations of TLC on **synoptic scales**, i.e. larger scales than those of the convective core in TCs. This suggests that either cold air is transported from the core to large radii, or that cold air is generated at large radii by **processes other than cloud top radiative cooling**.
3) The possible **implications of TLC**: colder tropopauses imply destabilization of the upper troposphere to convection, which could impact convection (especially during cyclogenesis) and the rate of intensification. TLC in the core and at radii that are often considered the environment also increase Maximum Potential Intensity in the eyewall subsidence framework (Miller, Holland) and the Carnot heat engine framework (Kleinschmidt, Emanuel). Lastly, TLC implies further dehydration of air masses that penetrate into the lower stratosphere.

In order to reconcile perceptions about the structure of the upper troposphere and lower stratosphere, we provide **statistics of cloud top heights, tropopause heights, and radiative temperature tendencies in TCs**. Two high-resolution satellite data sets are used for this: GPS Radio Occultation temperature retrievals from the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC), and radar/lidar-derived cloud top heights and temperature tendencies from the CloudSat TC overpass data set (maintained by Natalie Tourville at the Cooperative Institute for Research in the Atmosphere).

Early results show that in TCs, even the top 1% highest cloud tops do not reach the average height of the tropopause. On average, negative temperature tendencies from radiative processes occur 2-5 km below the cold signal derived from COSMIC retrievals –even in the west Pacific and the southern hemisphere where clouds reach the highest. In fact, positive temperature tendencies from radiative processes are even found near the tropopause at large radii. This suggests that **dynamical processes must play a role in cooling the tropopause above TCs**.