Controls on the temporal evolution of subtropical boundary layer clouds using a Lagrangian approach

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I. A Lagrangian approach

Cloud cover (CC) and other planetary boundary layer (PBL) properties may take many hours to respond to environmental forcings. To study this, here we sample the same clouds repeatedly in time in order to assess the effects of environmental variables while following the flow. Over 169,000 Trajectories are analyzed. Trajectories begin along the CloudSat/CALIPSO curtain and are sampled by the A-Train and ERA-Interim every 12 hours for 48 hours.

II. Subtropical study regions

Low clouds in the subtropics are studied due to their strong effects on climate. Warm, optically thick low clouds reflect abundant subtropical sunlight, while they emit IR upward through a clear atmosphere. Small changes in the environmental controls on these clouds may have a profound effect on climate. Here, we follow their evolution within the red boxes shown above. Regions are chosen to encapsulate the cloud cover maximum and the transition regions from Sc to Cu.

III. Lagrangian timescales

In the Lagrangian reference frame, the time-evolution of clouds and other PBL properties is, on average, shown to occur on characteristic timescales. Anomalies tend to regress to the mean with consistent e-folding times (τ). This was not observed in the Eulerian reference frame, it is unique to the Lagrangian perspective.

IV. Defining the null

In the Lagrangian reference frame, the null hypothesis is not for cloud cover in tracked parcels to experience 0% change. Instead, cloud amount will be expected to change based on (1) the climatological mean gradient in cloud cover along the trajectory and (2) the initial anomaly. We deal with (1) by converting all cloud retrievals to anomalies and (2) by calculating a ‘residual’ change which accounts for the behavior in III.

V. Comparing cloud and PBL controlling variables

Variables are normalized along the x-axis using their standard deviation (σ) to compare their strength on CC evolution. Subsidence, PBL depth, free-tropospheric humidity, lower tropospheric stability, and droplet concentration all independently control cloud cover.

VI. New products and study regions will allow for continued insights

We identify closed vs. open cells to study Lagrangian cellular transitions and we are developing a 2-D rain rate product from CloudSat and AMSR/E 89 GHz passive microwave retrievals. Future work will focus on cloud evolution within and poleward of the subtropics.

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References: