Using HYSPLIT Back Trajectories to Improve Understanding of Tropical Thin Cirrus Cloud Formation Mechanisms

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-1. Introduction-

- Thin tropopause transition layer cirrus (TTLC) are potentially important to the Earth's radiation budget, troposphere-stratosphere exchange, and stratospheric dehydration.
- Their formation mechanisms likely impact the radiative and microphysical properties of the clouds.

-2. Objectives-

- Assess and improve the accuracy of determining TTLC formation mechanisms using the object classification method
- Estimate the formation mechanisms of a representative set of TTLC objects identified from CALIPSO (a satellite lidar instrument that measures thin clouds and aerosols) data using the HYSPLIT back trajectory model

-4. Running the HYSPLIT Trajectory Model-

- Use wind fields to trace an air parcel backward in time

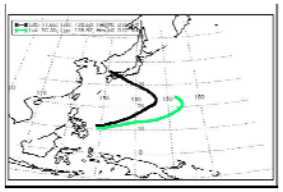


Figure 3. A HYSPLIT backward trajectory occurring in the Western Pacific (plotted in IDL) for February 21st, 2008.

-3. Classifying TTLC from CALIPSO Images-

Figure 1. CALIPSO images of convective TTLC. Each image features a different object classification: (Top) Edge of Anvil,(Middle) Thinning or Aging Anvil, (Bottom) Above Developing DMC.

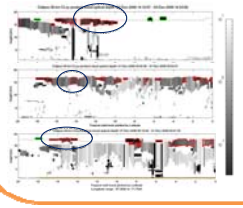
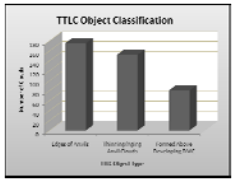


Figure 2. TTLC object classifications from December 2008 CALIPSO images.

- 169 CALIPSO images were analyzed, 96 (56.8%) had convective elements to them, leaving 73 (43.2%) to be entirely non- convective.
- Of the 96 images with some convection, a total of 407 clouds were identified as convective.
- Combining the statistics for the first two classifications, 80.3% appear to be formed by convective detrainment.



-5. Examining Statistics of Back Trajectories-

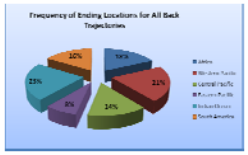


Figure 4. Frequency of back trajectories ending in each region.

- 23% of all back trajectories end in the Indian Ocean, while 8% end in the Eastern Pacific (normalized by area of region)

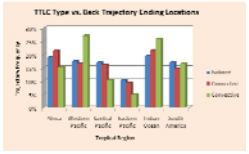


Figure 5. Trajectory frequency for ending locations by TTLC type.

- Of convective clouds, 27% end in the Western Pacific and 5% end in the Eastern Pacific

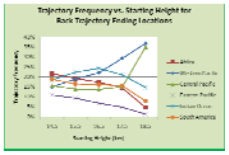


Figure 6. Trajectory frequency for ending locations by starting height.

- Western Pacific: An upward trend is observed
- Eastern Pacific: A downward trend is observed

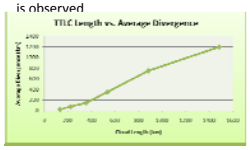


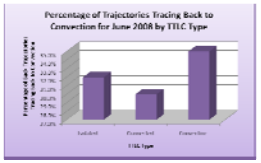
Figure 7. Relationship between TTLC length and average divergence.

- Average divergence for TTLC lengths < 49 km is 134 km
- Average divergence for TTLC lengths > 1000 km is 1484 km

-6. Identifying TTLC Tracing Back to Convection-

Figure 8. Percentage of back trajectories tracing to convection for each TTLC type.

Of 2567 back trajectories from June 2008 analyzed, 836 (32.6%) traced back to convection, leaving 1731 (67.4%) not tracing back to convection.



-7. Conclusions-

Classifying TTLC from CALIPSO Images:

- 43% of convective TTLC occur at anvil edges, while 37.3% are associated with thinning or aging anvils
- 19.7% of convective TTLC appear to form above developing DMC
- 80.3% of TTLC appear to be formed by convective detrainment

Examining Statistics of Back Trajectories:

- Fewest back trajectories end in the Eastern Pacific. Most convective clouds end in the Western Pacific and the least end in the Eastern Pacific. → Eastern Pacific has less convection due to subsidence, while the Western Pacific tends to have more convection.
- As starting height increases, the percentage of back trajectories ending in the Western Pacific also increases, while the percentage of back trajectories ending in the Eastern Pacific decreases. → Generally the tropopause is higher over the Western Pacific and lower over the Eastern Pacific.
- As TTLC length increases, the average divergence of the back trajectories increases. → Possibly related to differing wind fields throughout the length of the cloud, and this affects the path of the trajectories.

Identifying TTLC Tracing Back to Convection

- 67.4% of the trajectories from June 2008 did not trace back to convection.
- Of the trajectories that had convective ending points, convective TTLC had the greatest percentage (34.9%) of trajectories tracing back to convection.

-8. Future Work-

- Extend trajectory analysis for tracking back to convection from one month to entire year
- Investigate the sensitivity of the back trajectories to the choices made in the HYSPLIT input
- Compare the kinematic back trajectories from this project with diabatic back trajectories
- Examine whether refinement can be made to the object classification method based on comparison to the back trajectories

-9. Acknowledgements-

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