Tropical Radiative Heating Profiles - Improved Retrievals and Clustering Methodologies

Sally McFarlane, Nathaniel Beagley, Jennifer Comstock, Julia Flaherty

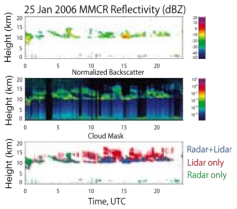
Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

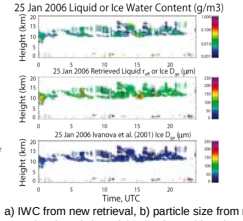
Introduction

- **Vertical structure of radiative heating is important to local and large-scale dynamics**
- **Original heating rate profiles used radar-only retrievals; we improve the cloud property retrievals and heating rate profiles by combining radar and lidar data**
  - **➔ Multiple year dataset of new cloud properties & heating rates at all three tropical ACRF sites**
- **To expand heating rates to larger spatial scale we explore use of clustering and classification to predict vertical cloud and heating structures from passive satellite data**

1. New retrieval combines radar + lidar for better characterization of cloud properties

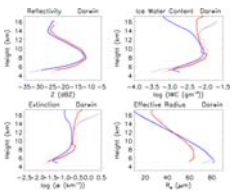


a) radar reflectivity, b) lidar backscatter, and c) combined cloud mask. Adding lidar improves detection of thin cirrus.

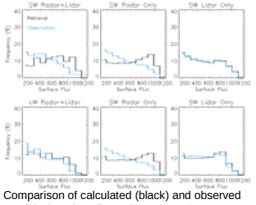


a) IWC from new retrieval, b) particle size from new retrieval, and c) particle size from old retrieval. Radar-lidar periods are used to tune radar-only and lidar-only retrievals to improve retrieval.

2. Comparison to other methods + flux closure gives retrieval uncertainties

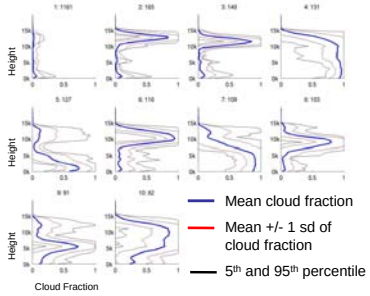


Comparison of average profiles at Darwin for PNNL retrieval (blue) and Delanoe/Protat retrieval (red).

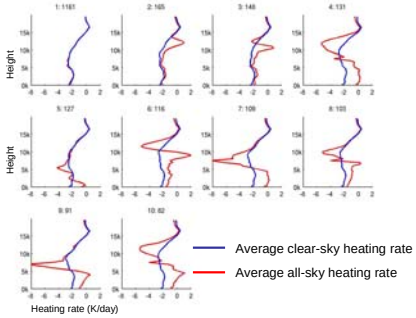


Comparison of calculated (black) and observed (blue) surface fluxes for Delanoe/Protat retrieval (top) and PNNL retrieval (bottom).

3. Cloud clusters derived from ARM radar data show recognizable vertical structures in clouds & radiative heating.

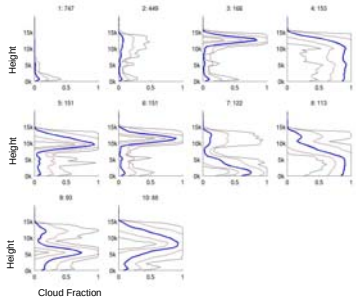


Cloud clusters derived from 9 months of ACRF radar data at Manus show characteristic vertical structures of cirrus (b,c,f), deep convection (d), congestus (g), stratiform (j), and mid-level clouds (h,i).



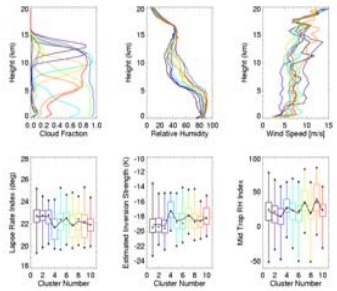
Average longwave radiative heating rate profiles for each cluster show characteristic structures: heating throughout thin cloud layers (b), heating at cloud base and cooling at cloud top for thick clouds (c,f,h,i).

4. Details of clustering method affect clusters; need criteria for determining best set of clusters.

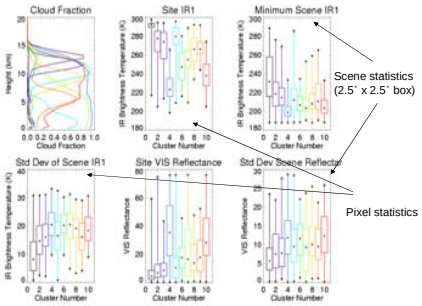


Clusters based on cloud fraction + cloud top height. Some differences are seen between these and original set of clusters (figure on left). Main difference is creation of a low cloud cluster (top left panel) and merging of two mid-high classes.

5. Environmental state characteristics and satellite observations show differences associated with clusters.



Average (top panels) and box plots (bottom panels) of environmental state characteristics for each cluster. Primary separation is between convective and non-convective cloud types.



Box plots of observed satellite parameters for each cluster show separation between clusters; primarily differences between cirrus, mid-level, and convective clouds.

6. Next step: use satellite and reanalysis data to classify each observation into a cluster.

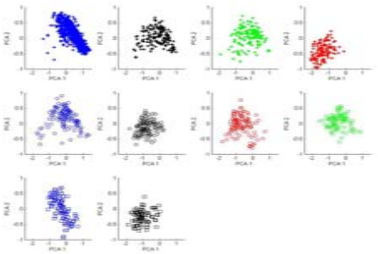


Illustration of classification in two dimensions. Plots show first two principal components of the satellite dataset. Clusters that do not overlap can be distinguished from each other in the classification methodology.

- Add reanalysis data to get more separation between classes
- Add spatial and temporal information from satellite data
- Explore other classification methods
- Adjust number of clusters

U.S. DEPARTMENT OF ENERGY

Contact: Sally McFarlane

sally.mcfarlane@pnl.gov **(509) 375-6402**

www.pnl.gov