Investigating Instrument-Specific Variability in Cloud Microphysics in Deep Convective Regimes

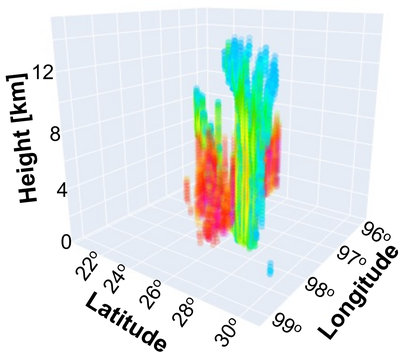
Kevin M. Smalley, Hassan Beydoun, and Aaron Donahue
Lawrence Livermore National Laboratory, Livermore, CA, USA.

Lawrence Livermore National Laboratory

1. Motivation

- Space-borne radars onboard CloudSat, GPM, and TRMM have been used to analyze vertical macrophysical cloud structures.
- We expect that clouds of the same type in similar regimes exhibit similar macrophysical characteristics.
- CloudSat is optimal for non-precipitating and lightly precipitating conditions, while GPM and TRMM excel in heavier precipitation.
  - *Despite these limitations, we anticipate that vertical variability in cloud macrophysics can be constrained within different cloud regimes, specifically **deep convection**, as observed by space-borne radars.*

2. Satellite Observations



Platforms:

- CloudSat (2006 – 2017)
- TRMM (2006 – 2014)
- GPM (2014 – 2017)

Focus Variables:

- Cloud Water Content (CWC)
- Rain Water Content (RWC)
- Ice Water Content (IWC)

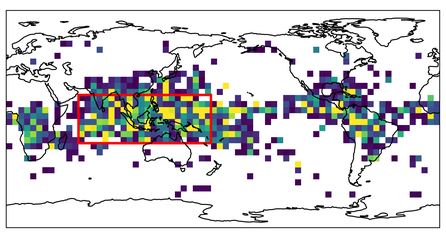
TRMM = Tropical Rainfall Measuring Mission
GPM = Global Precipitation Measurement Mission

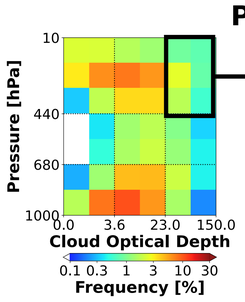
3. Cloud Regime Separation

Define cloud regimes using Joint Histograms of MODIS cloud optical depth and cloud-top pressure (Cho et al. 2021)

Focusing on:

- Deep Convection over the Indo-Pacific warm pool region

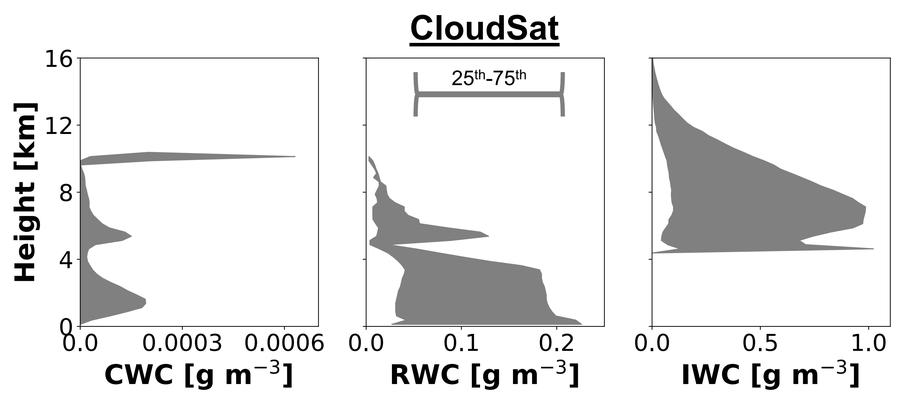




Focus only on the most optically thick and tallest clouds

4. Matched Observational Differences

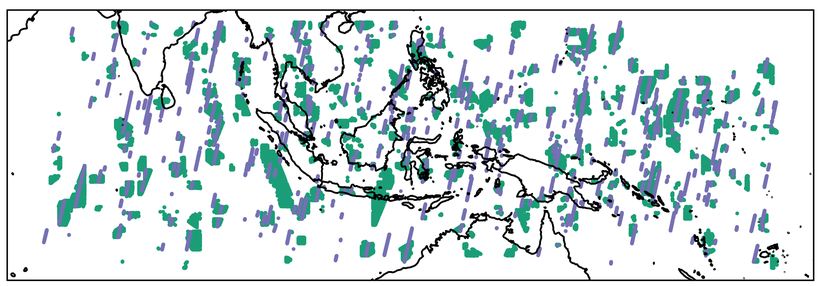
Compare colocated observations: { CloudSat-TRMM (2006 – 2014); CloudSat-GPM (2014 – 2017) } → Combine TRMM and GPM results (GPM/TRMM) and compare to CloudSat



The vertical distribution and overall shape of cloud water are more constrained by GPM and TRMM than by CloudSat.

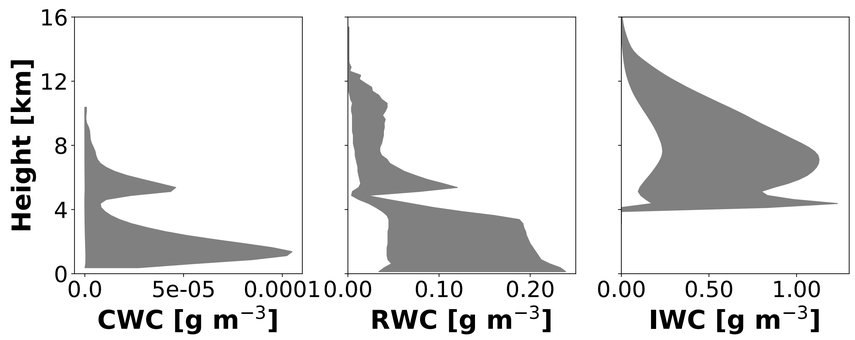
5. Expanded CloudSat Analysis

Analyze all valid CloudSat results between 2006 and 2017



GPM/TRMM CloudSat

Colocations are sparse!!



An expanded set of CloudSat observations does not reduce the variability in the vertical distribution of cloud water.

6. Main Takeaway and Future direction

- Over the Indo-Pacific warm pool region, cloud regime can effectively constrain cloud water variability from the perspective of GPM and TRMM, but not from the perspective of CloudSat.
  - *These results are preliminary and ongoing.*

- Future work will focus on investigating if a similar analysis can constrain the variability in the drop size distributions at a given altitude within a set of clouds.

Reference:
Cho, N., J. Tan, and L. Oreopoulos, 2021: Classifying Planetary Cloudiness with an Updated Set of MODIS Cloud Regimes. *J. Appl. Meteor. Climatol.*, **60**, 981–997, https://doi.org/10.1175/JAMC-D-20-0247.1.

Work from LLNL is performed under the auspices of the US DOE by LLNL under Contract DE-AC52-07NA27344. LLNL-POST-870646

For more information contact Kevin Smalley at smalley5@llnl.gov