Differences in Characteristics of Precipitating and Non-Precipitating Warm Clouds

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Motivation

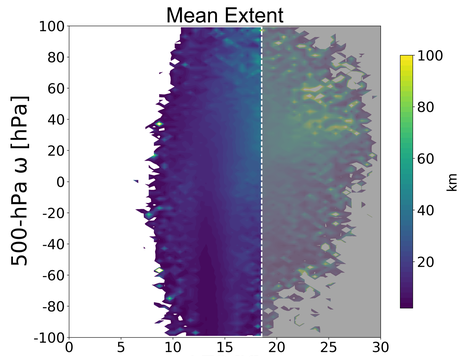
- Previous studies (e.g., Burnet and Brenguier, 2010) suggest larger warm clouds may be more likely to rain due to larger thermals which can resist the effects of mixing and entrainment.
- We hypothesize that larger shallow cumulus clouds are more likely to produce precipitation and that the precipitation likelihood for a given cloud size is modulated by the environment.
- ➢ *Here we use CloudSat/CALIPSO data and reanalysis to analyze warm clouds in shallow cumulus regimes to test this hypothesis.*

Data

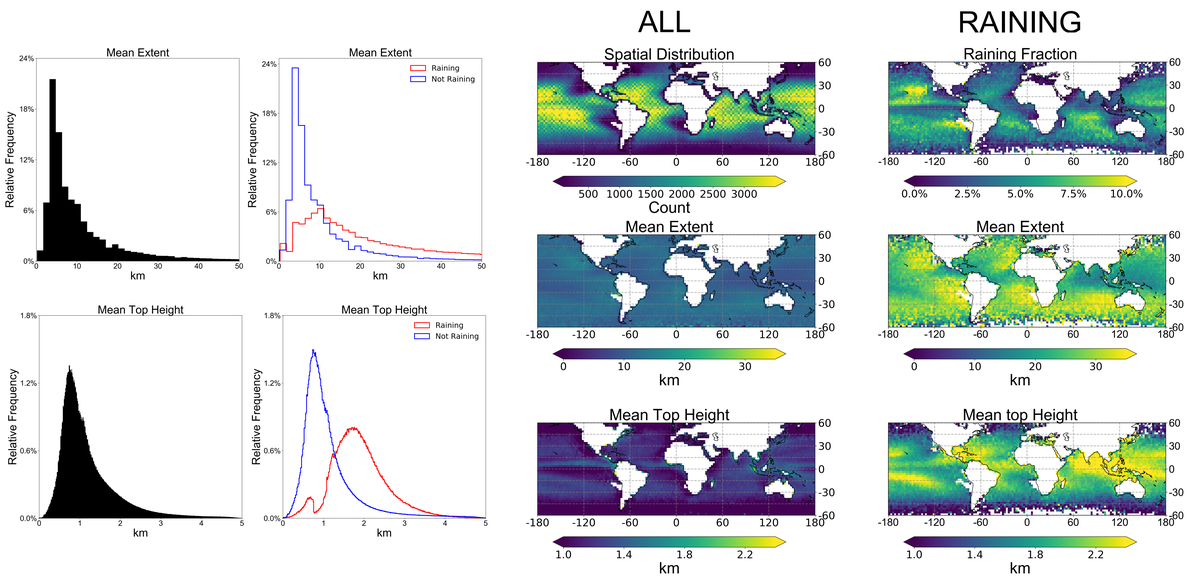
- Region: Global oceans between 60 South and 60 North
- Timeframe: 08/12/2006 – 12/31/2010
- Cloud Objects: CloudSat/CALIPSO
- Environmental Characteristics: ERA-Interim

Shallow Cumulus Object Analysis

- Shallow cumulus regimes identified using LTS < 18.55 K (Klein and Hartmann 1993)
- Filter outliers with along-track extent > the 98th percentile
- Examine rain likelihood as a function of cloud top height, environmental total column water vapor (CWV), and along-track cloud extent



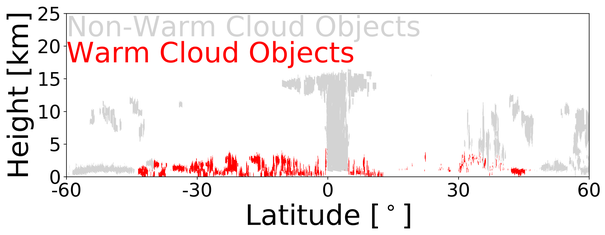
Shallow Cumulus Characteristics



- Raining cloud objects are larger with higher cloud tops than their non-raining counter parts.
- Most cloud objects occur in the central ocean basins, however, the largest fraction of raining warm cloud objects occur in stratocumulus to shallow cumulus transition regions.

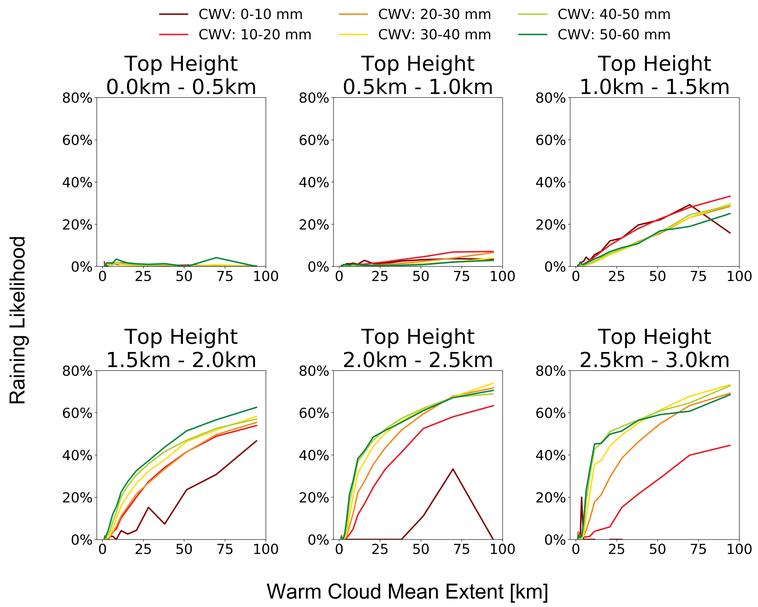
Cloud Identification

- Warm cloud object identification:
  - 2B-GEOPROF-LIDAR Cloud Fraction
  - 2B-GEOPROF Cloud Mask
- Raining cloud objects:
  - 2C-PRECIP-COLUMN precipitation flag
- Analysis limited to:
  - Clouds larger than a single pixel
  - Oceanic clouds
  - Cloud top height < freezing level height



- Identify cloud object characteristics:
  - along-track extent, top height, raining fraction

Rain Likelihood



- Cloud objects with top heights below 1 km rarely rain regardless of size.
- As cloud objects become taller, they become more likely to rain.
- For a given cloud top height, larger clouds are more likely to rain than smaller clouds.
- As the environment moistens, cloud objects are more likely to rain.
- For a given moisture environment and cloud top height, rain is more likely for larger clouds.
- The likelihood of rain is most sensitive to environmental moisture for smaller clouds.

Summary

- The majority of shallow cumulus cloud objects occur in the central ocean basins, but the relative frequency of warm rain increases in stratocumulus-to-shallow cumulus transition regions.
- Raining shallow cumulus cloud objects are larger and taller than their non-raining counter parts.
- In general, as shallow cumulus cloud objects become larger, they become more likely to rain.
- For a given cloud size, rain likelihood increases as the environment moistens.
- The increase in rain likelihood with cloud size is slower for dryer environments.

References:

Burnet F., and J-L. Brenguier, 2010: The onset of precipitation in warm cumulus clouds: An observational case study. *Q. J. R. Meteorol. Soc.,* **136,** 374-381, DOI:10.1002/qj.552.

Klein, S. A., and D. L. Hartmann, 1993: The Seasonal Cycle of Low Stratiform Clouds. *J. Climate,* **6,** 1587-1606, https://doi.org/10.1175/1520-0442(1993)006<1587:TSCOLS>2.0.CO;2.

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