Global distributions of various types of precipitation systems from radar and passive microwave observations

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Horizontal view of a storm

- Radar rain
- Radar echo aloft
- Microwave rain
- Microwave TB
- Infrared TB
- Radar vertical structure
Where are the shallow precipitation systems in tropics (TRMM)?

Liu and Zipser 2009

TRMM radar echo top < 4.5 km
Where are the congestus in tropics and subtropics (CloudSat)?

CloudSat
- Echo top in 5-8 km
- Bottom < 1.5 km
- Maximum echo > -5 dBZ

TRMM
- TB11 in 235-273 K
- With surface precipitation

Wall et al. 2013
Where are the strongest storms on Earth (GPM)?

Deep convection indicated by 20 dBZ echo top

Intense storms Indicated by 40 dBZ echo top
An intense storm over Russia at 62° N from the GPM

40 dBZ at 13 km
There are more passive microwave observations.

Colder 85 GHz TB $\leftrightarrow$ deeper storm
Occurrence of 85 GHz PCT < 150 K from SSMI (F08-F15) in JJA (%)

Legend:
0.00001 0.00003 0.00006 0.00016 0.00040 0.00100 0.00251 0.00631 0.01585 0.03981
More than just show where they are

• Variation of precipitation and storms at different time scales

• Precipitation retrieval uncertainty analysis

• Latent heating contribution from various types of precipitation systems and its tie to the climate modeling

• Relationship between thunderstorms and the global electric circuit

• Impact of storms on the atmospheric chemistry and the troposphere-stratosphere exchange of trace gases

• ...
Variation of precipitation and storms at different time scales

Diurnal

Seasonal

Inter-annual

Precipitation contribution from systems with different sizes over Southeast US (100W-80W, 29N-36N) (mm/yr)
Precipitation retrieval uncertainty analysis

Radar sees more rain in small and shallow systems over ocean.

Radar vs. Passive microwave retrievals

Liu and Zipser 2014 J. Hydrometeor
Latent heating contribution from various types of precipitation systems and implications to the climate modeling

Color: LH contribution                Contours: convective fraction

Liu et al. 2014 J. Climate
Relationship between thunderstorms and the global electric circuit

Liu et al. 2010 JAS
Liu et al. 2012 JGR
Impact of storms on the atmospheric chemistry and the troposphere-stratosphere exchange of trace gases

Area of radar echo overshooting tropopause

Liu and Zipser 2005, 2009, JGR
Summary

• In the era of the explosion of information, event based data analysis method could greatly improve the accessing and assessment of large volume of satellite data.

• There are MANY important scientific questions that need to be addressed from the perspective of different types of weather/convective systems.

One example, where are we going to expect what types of severe weather (e.g. very intense convection with large hail; lightning storms; heavy precipitation events) in the future under a warmer climate?
Occurrence of 85 GHz PCT < 175 K from SSMI (F08-F15) in JJA (%)
Vertical view of a storm
Where are the rainiest systems on Earth?

Categorized by volumetric rainfall

DJF

MAM

JJA

SON
Where are the large area of cold clouds?

Clouds with infrared TB $< 210$ K ($\sim 13.5$ km in tropics)
Where are the thunderstorms

Categorized by flash counts per storm

DJF flashcounts per storm (#)

99.09% (7490953 PFs) 0.81% (60998 PFs) 0.09% (6781 PFs) 0.0090% (678 PFs) 0.0010% (75 PFs)
0.0 - 3.0 3.0 - 38.0 38.0 - 152.0 152.0 - 360.0 360.0 - 889.0

MAM flashcounts per storm (#)

99.10% (7929482 PFs) 0.80% (64166 PFs) 0.09% (7017 PFs) 0.0090% (718 PFs) 0.0010% (79 PFs)
0.0 - 4.0 4.0 - 50.0 50.0 - 183.0 183.0 - 379.0 379.0 - 839.0

JJA flashcounts per storm (#)

99.04% (6284280 PFs) 0.80% (71892 PFs) 0.09% (7335 PFs) 0.0090% (752 PFs) 0.0010% (83 PFs)
0.0 - 4.0 4.0 - 49 49 - 169 169 - 353 353 - 762

SON flashcounts per storm (#)

99.05% (7715499 PFs) 0.85% (66445 PFs) 0.09% (6845 PFs) 0.0089% (692 PFs) 0.0010% (76 PFs)
0.0 - 4.0 4.0 - 47 47 - 165 165 - 353 353 - 854