

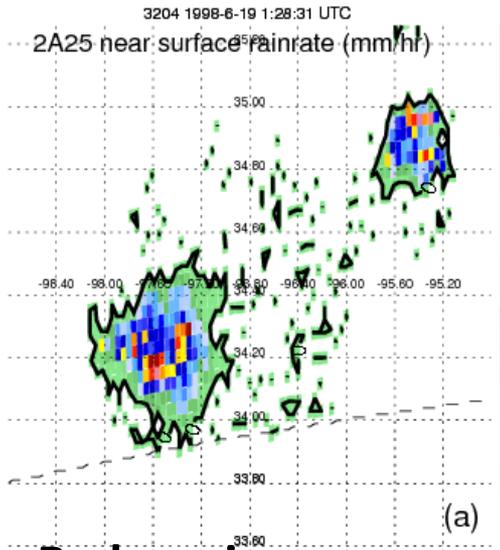
# Global distributions of various types of precipitation systems from radar and passive microwave observations

Chuntao Liu

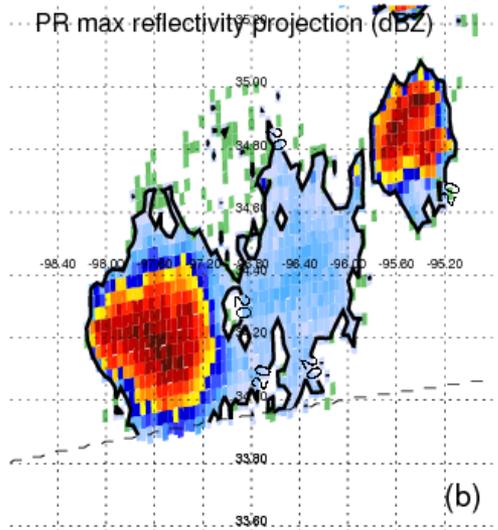
Department of Physical and Environmental Sciences  
Texas A&M University – Corpus Christi

# Horizontal view of a storm

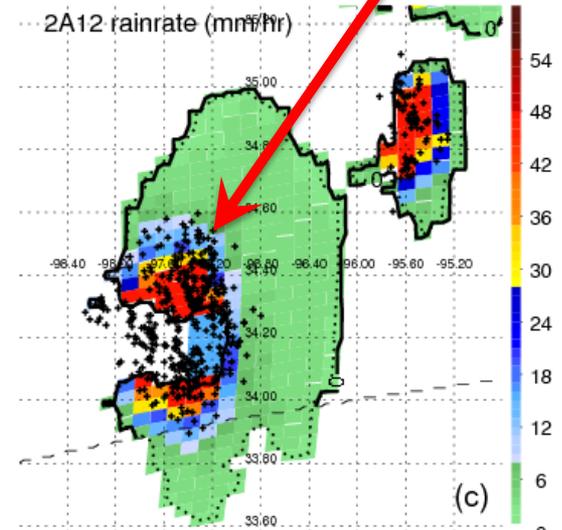
flashes



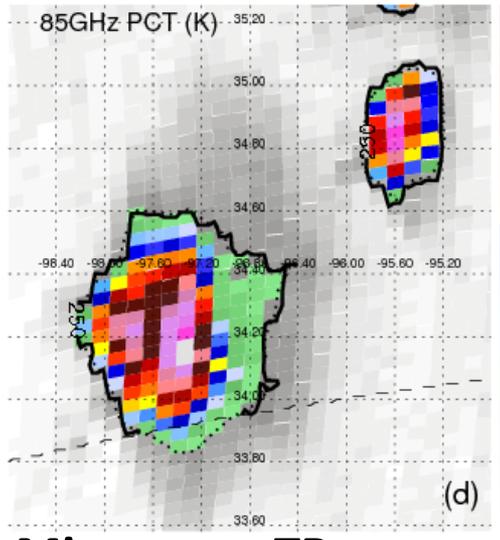
**Radar rain**



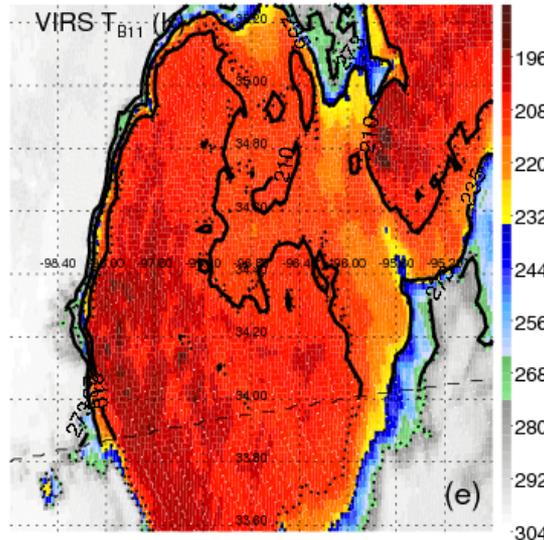
**Radar echo aloft**



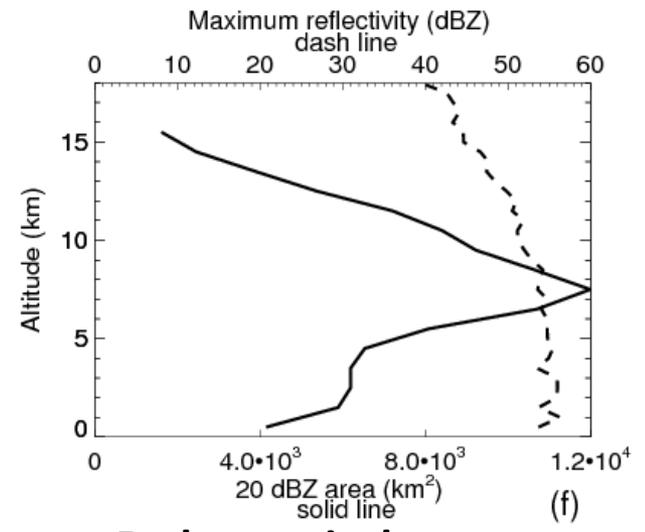
**Microwave rain**



**Microwave TB**

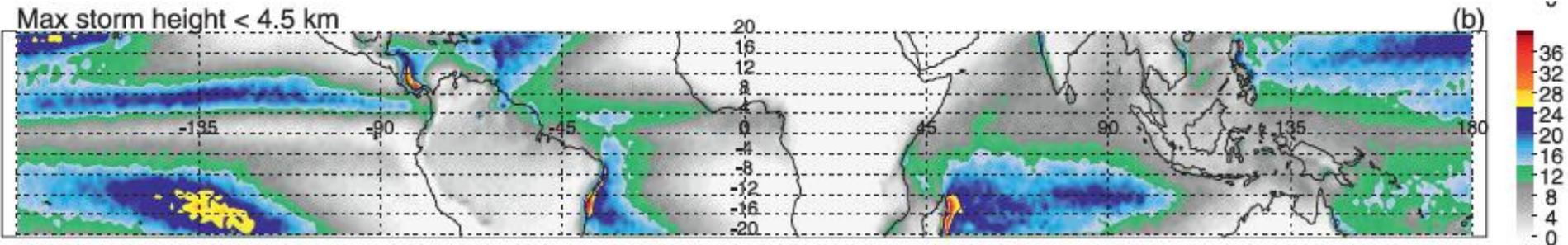
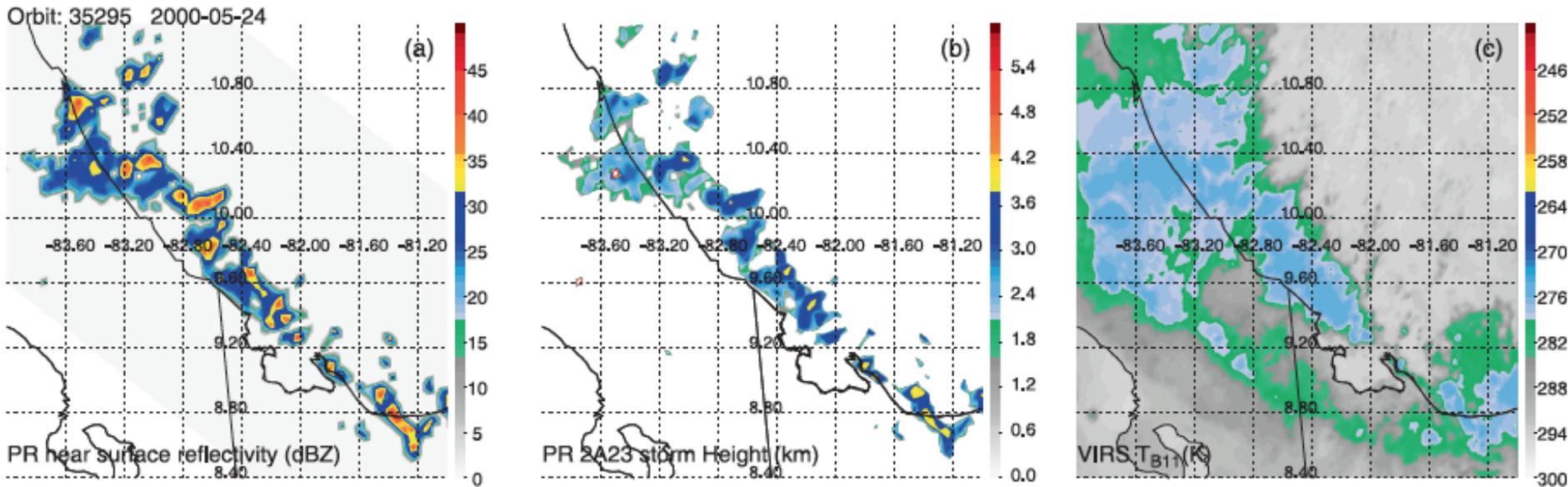


**Infrared TB**



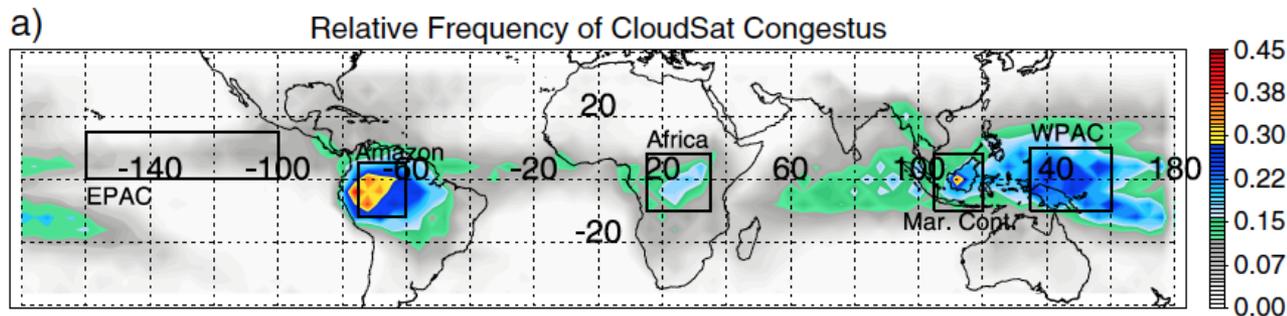
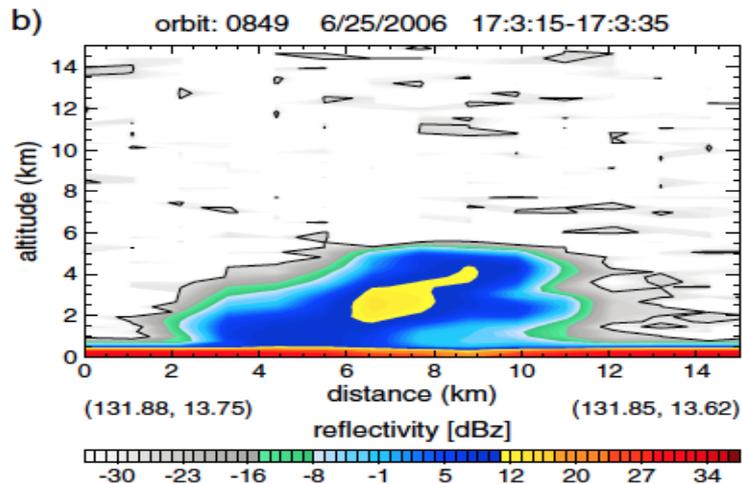
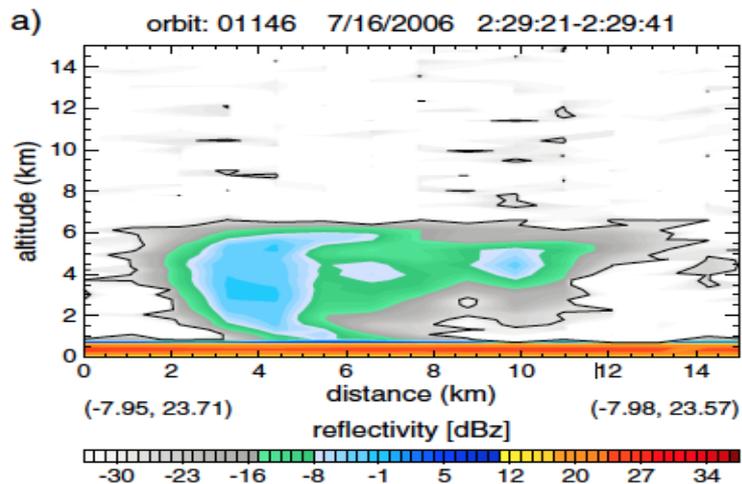
**Radar vertical structure**

# Where are the shallow precipitation systems in tropics (TRMM)?

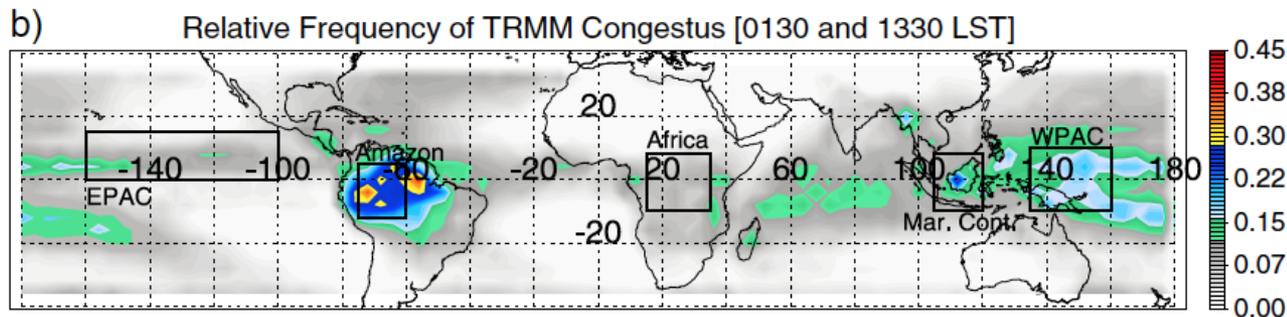


TRMM radar echo top < 4.5 km

# Where are the congestus in tropics and subtropics (CloudSat)?



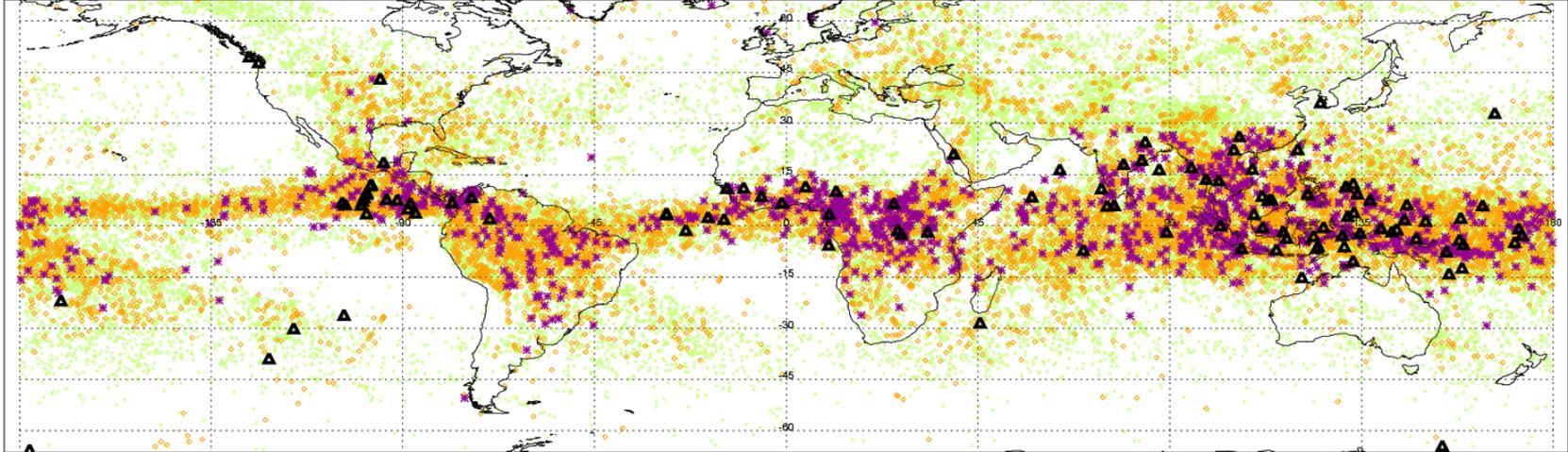
CloudSat  
echo top in 5-8 km  
Bottom < 1.5 km  
Maximum echo > -5 dBZ



TRMM  
TB11 in 235-273 K  
With surface precipitation

# Where are the strongest storms on Earth (GPM)?

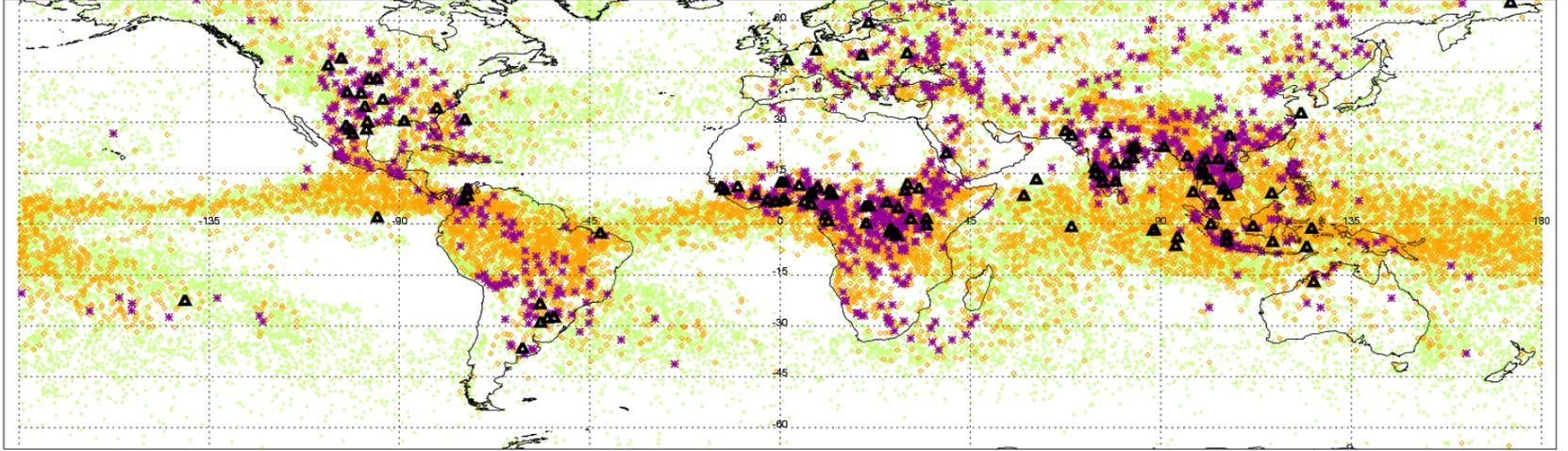
03/2014-06/2014 GPM PF 20 dBZ echo top height (km)



Deep convection indicated by 20 dBZ echo top

90.22% (553666 PFs)	7.84% (48124 PFs)	1.73% (10643 PFs)	0.1810% (1111 PFs)	0.0181% (111 PFs)
0.2 - 6	6.8 - 10	10.8 - 15	15.5 - 17	17.8 - 18

03/2014-06/2014 GPM PF 40 dBZ echo top height (km)

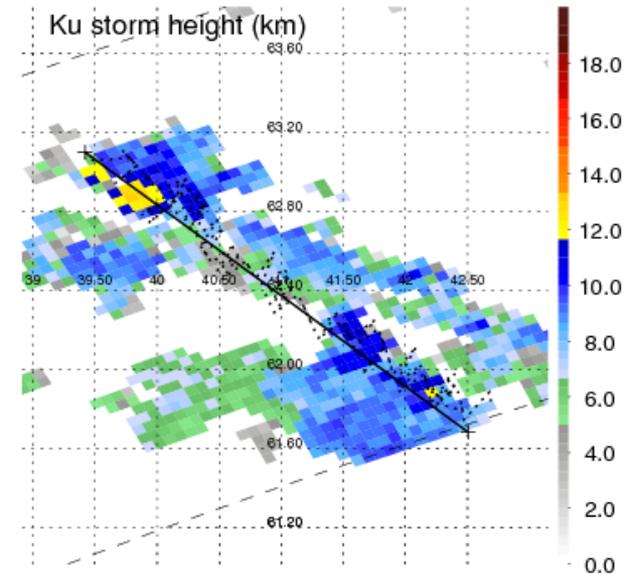
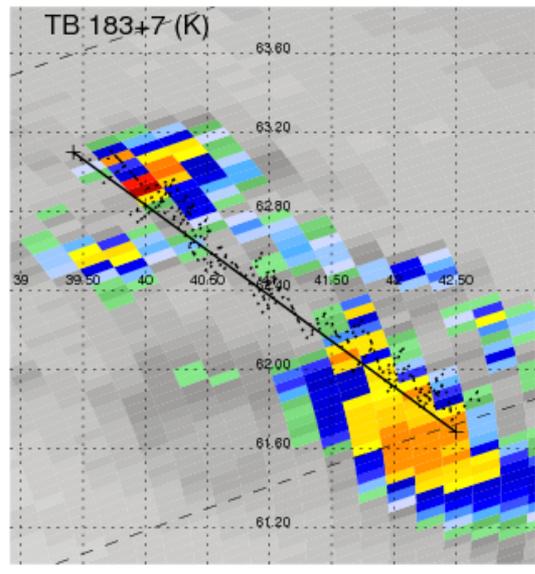
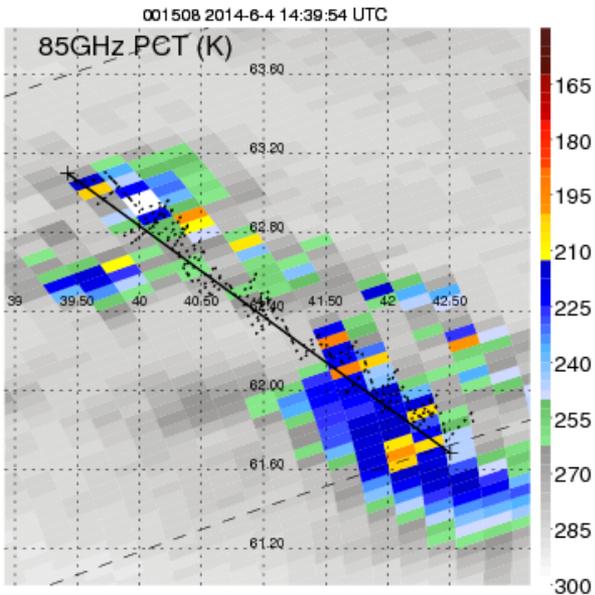
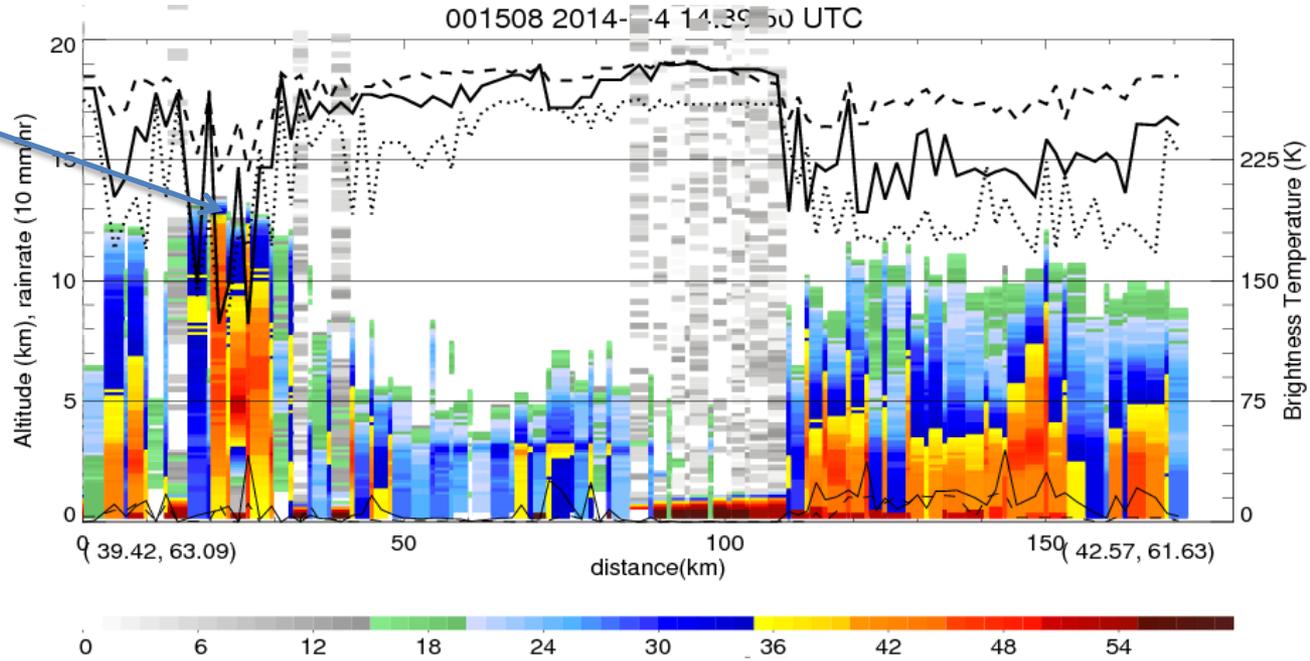


Intense storms Indicated by 40 dBZ echo top

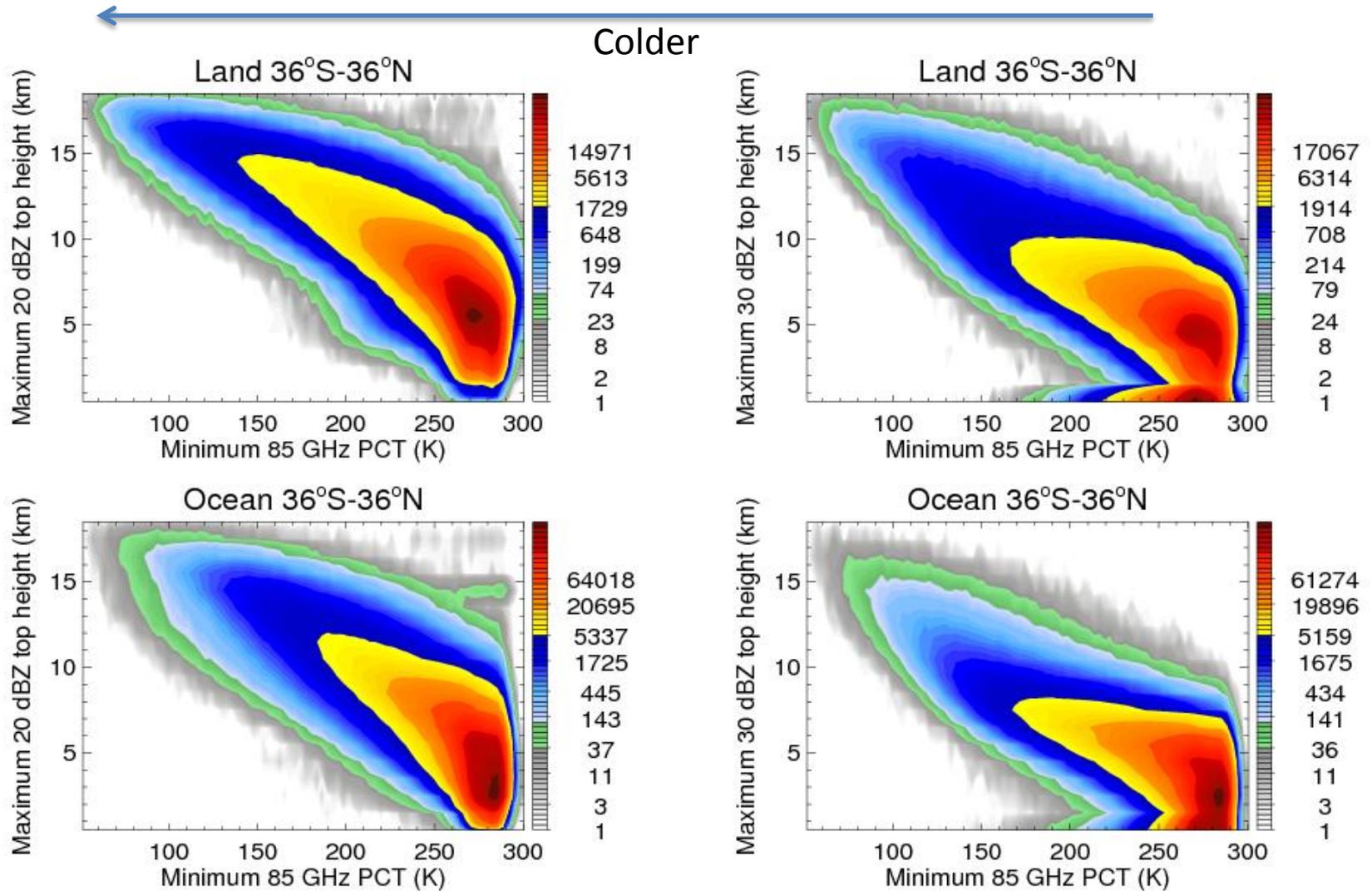
90.00% (552305 PFs)	8.01% (49129 PFs)	1.80% (11038 PFs)	0.1736% (1065 PFs)	0.0192% (118 PFs)
0.0 - 2	2.0 - 5	5.2 - 8	8.5 - 13	13.1 - 17

# An intense storm over Russia at 62° N from the GPM

40 dBZ at  
13 km

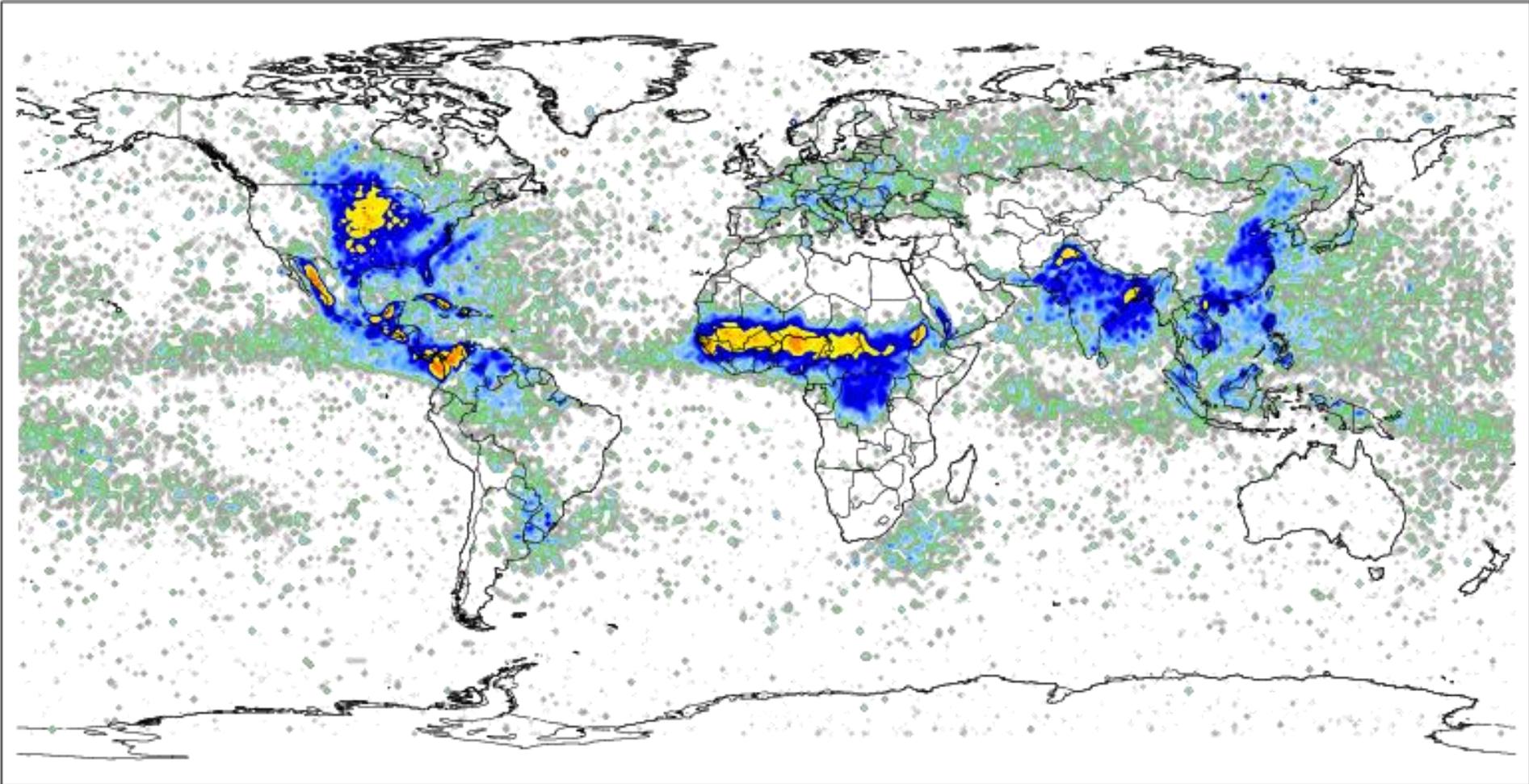


# There are more passive microwave observations



Colder 85 GHz TB ←→ deeper storm

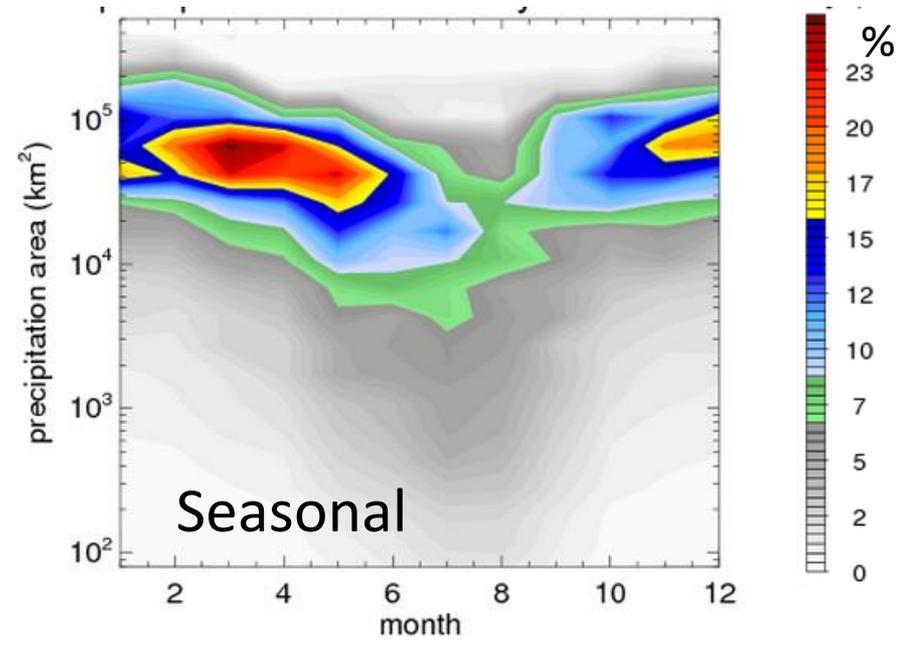
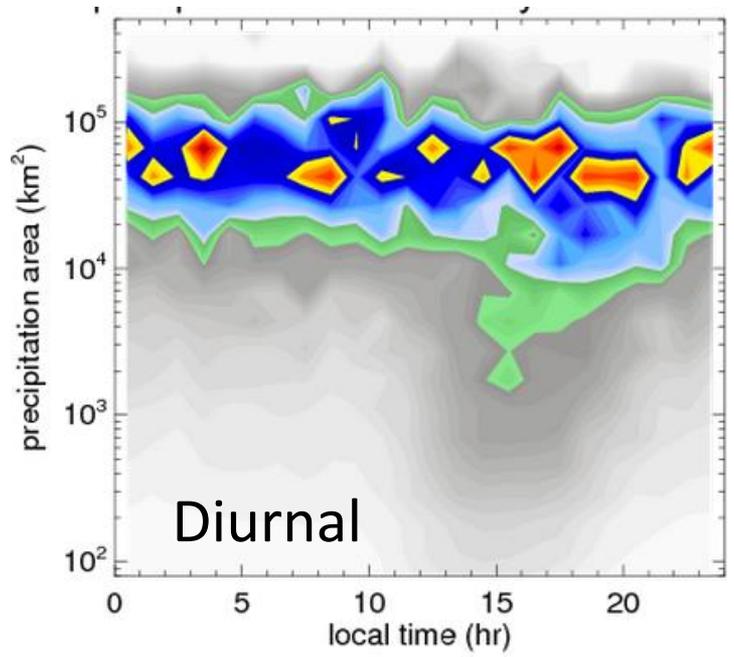
Occurrence of 85 GHz PCT < 150 K from SSM/I (F08-F15) in JJA (%)



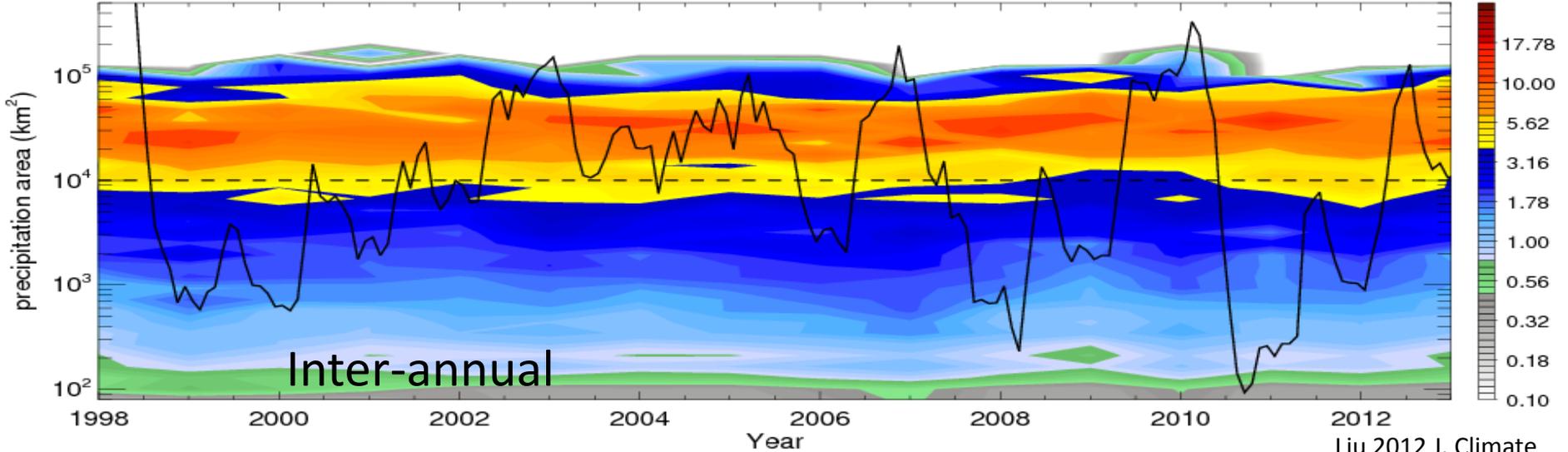
## More than just show where they are

- 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
- ...

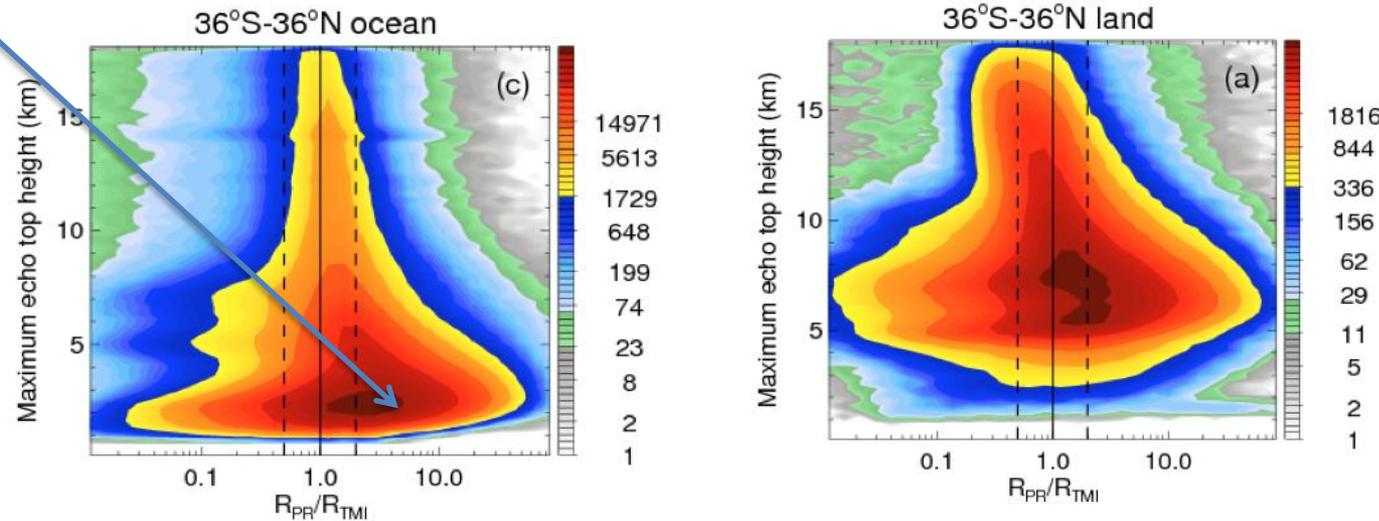
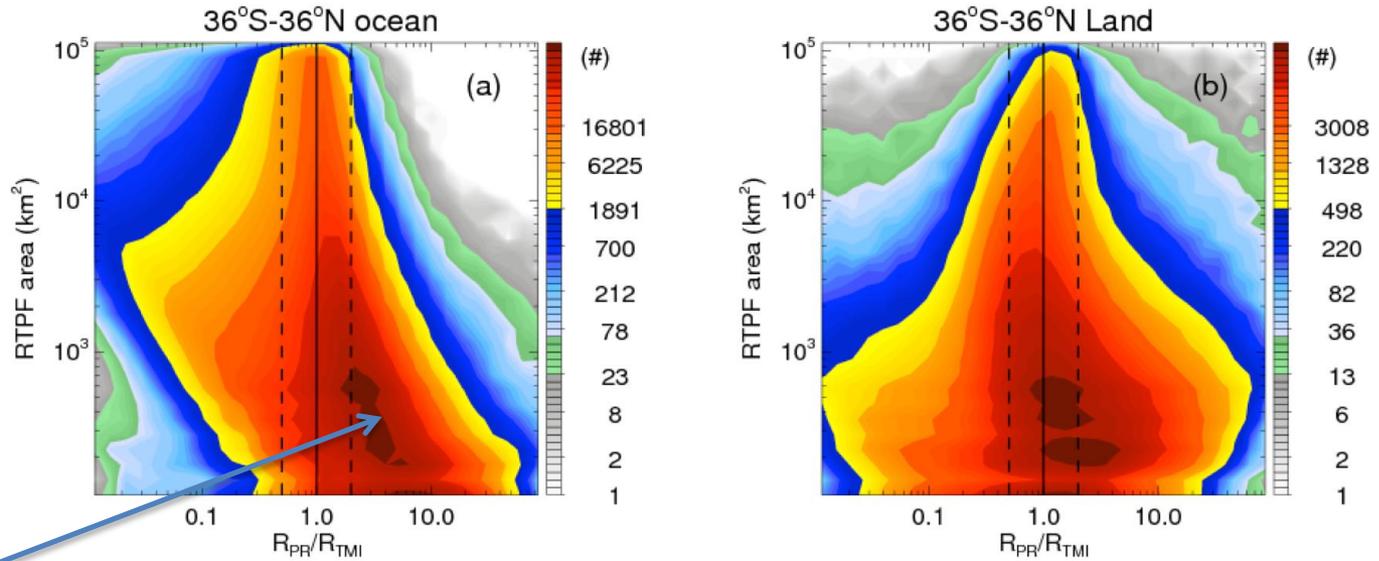
# Variation of precipitation and storms at different time scales



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



# Precipitation retrieval uncertainty analysis

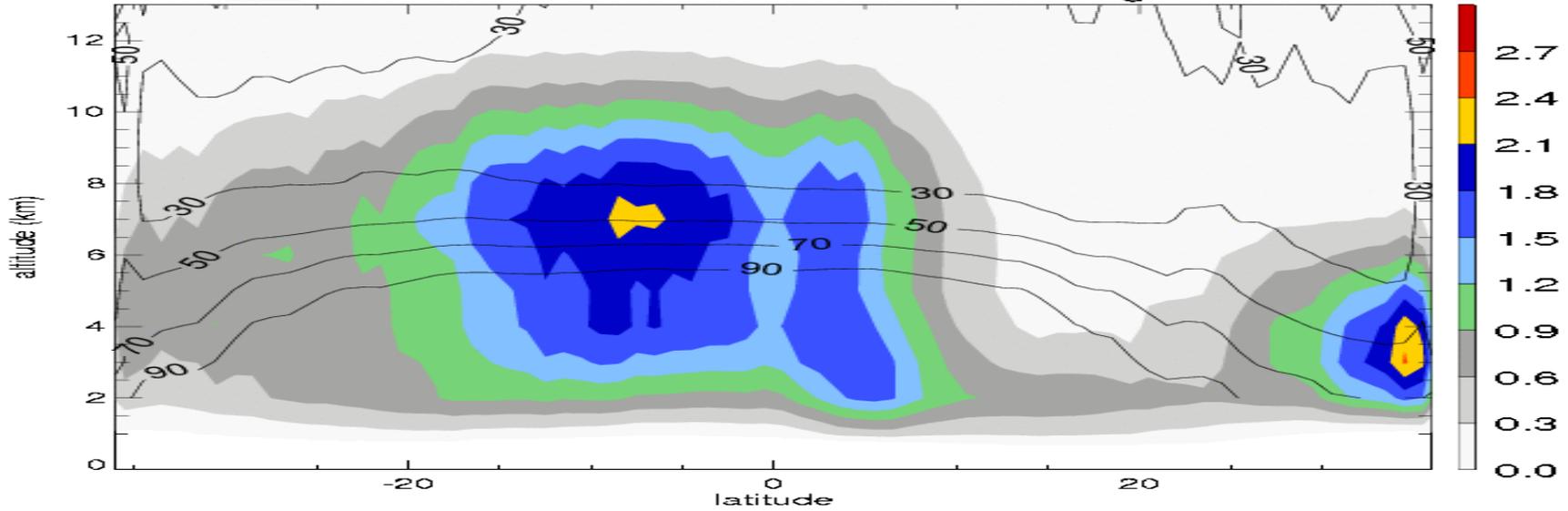


Radar vs. Passive microwave retrievals

Radar sees more rain in small and shallow systems over ocean

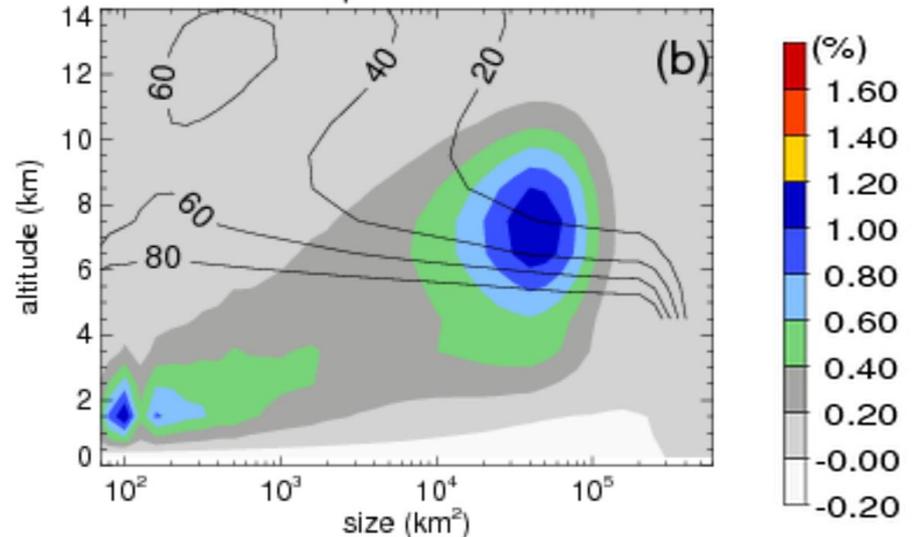
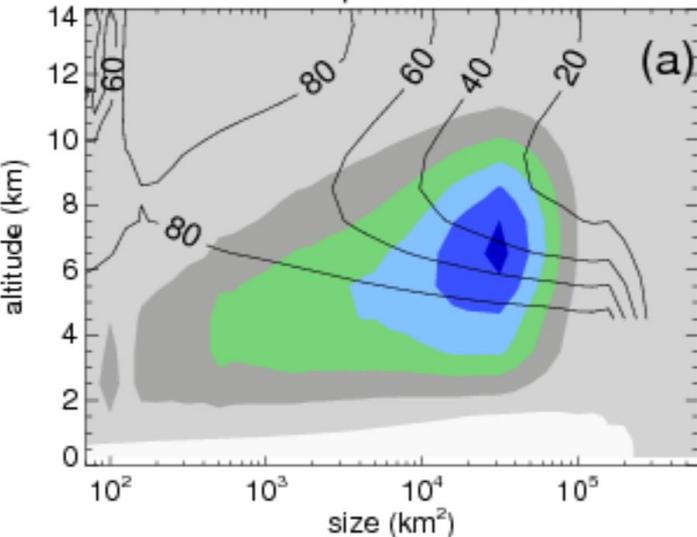
# Latent heating contribution from various types of precipitation systems and implications to the climate modeling

01. TRMM PR zonal mean latent heating rate



Tropical land

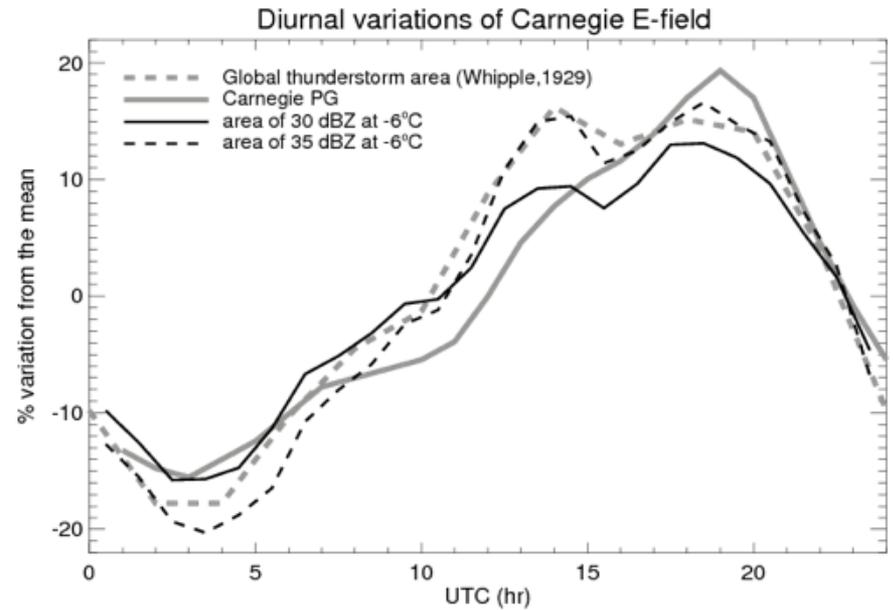
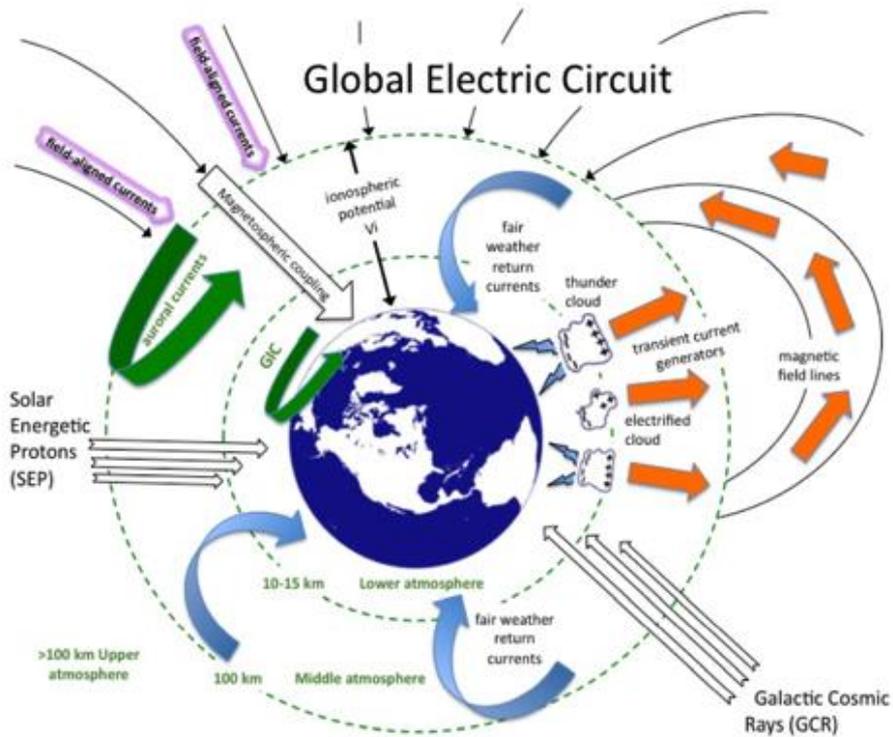
Tropical ocean



Color: LH contribution

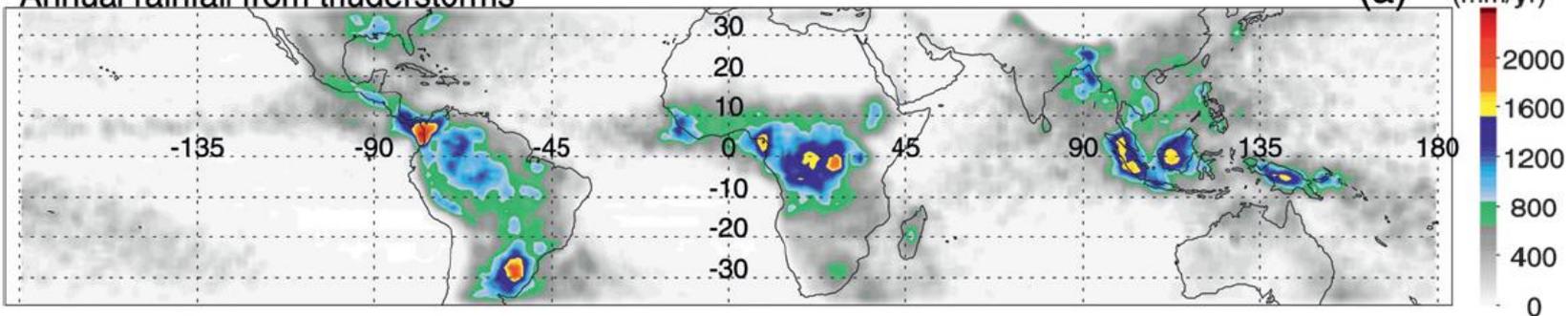
Contours: convective fraction

# Relationship between thunderstorms and the global electric circuit

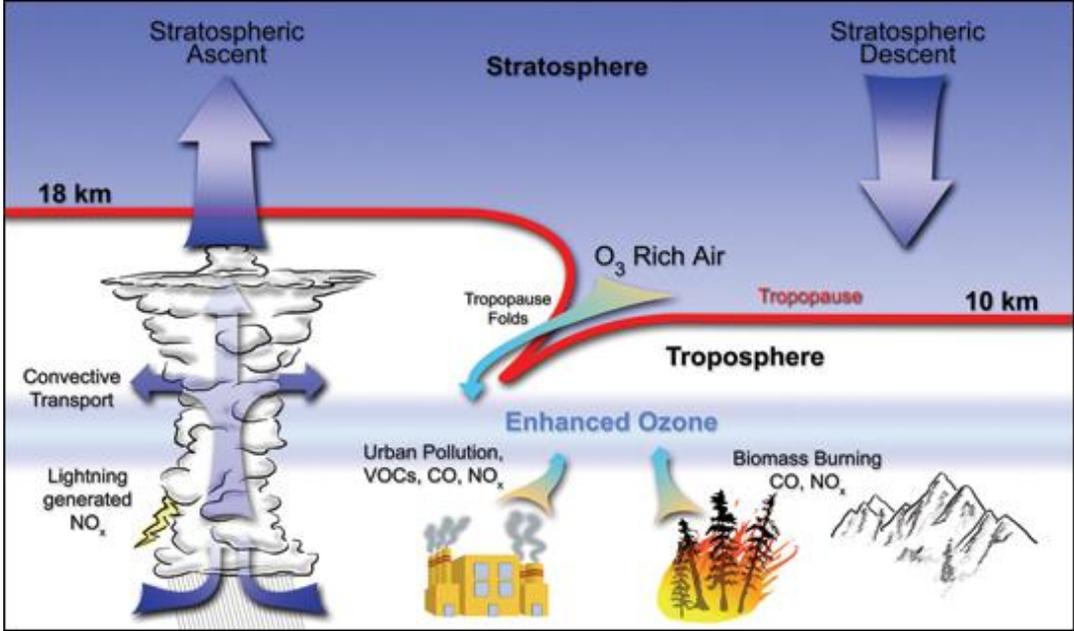


Annual rainfall from thunderstorms

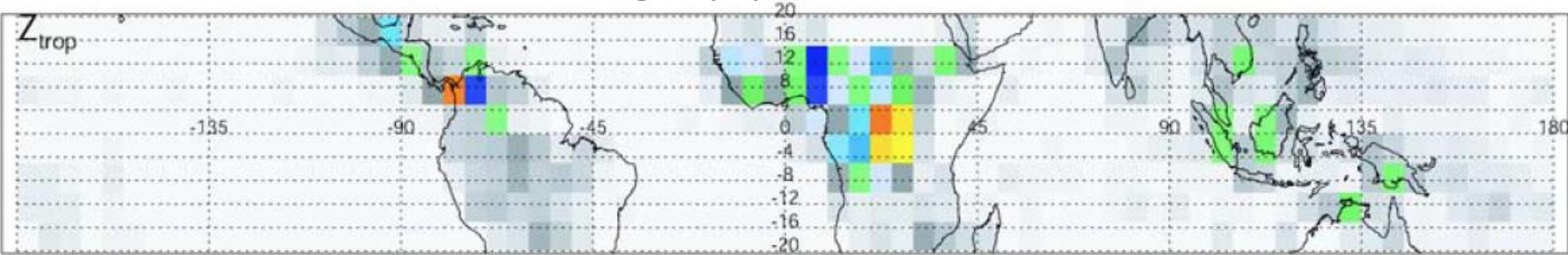
(a) (mm/yr)



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



Area of radar echo overshooting tropopause

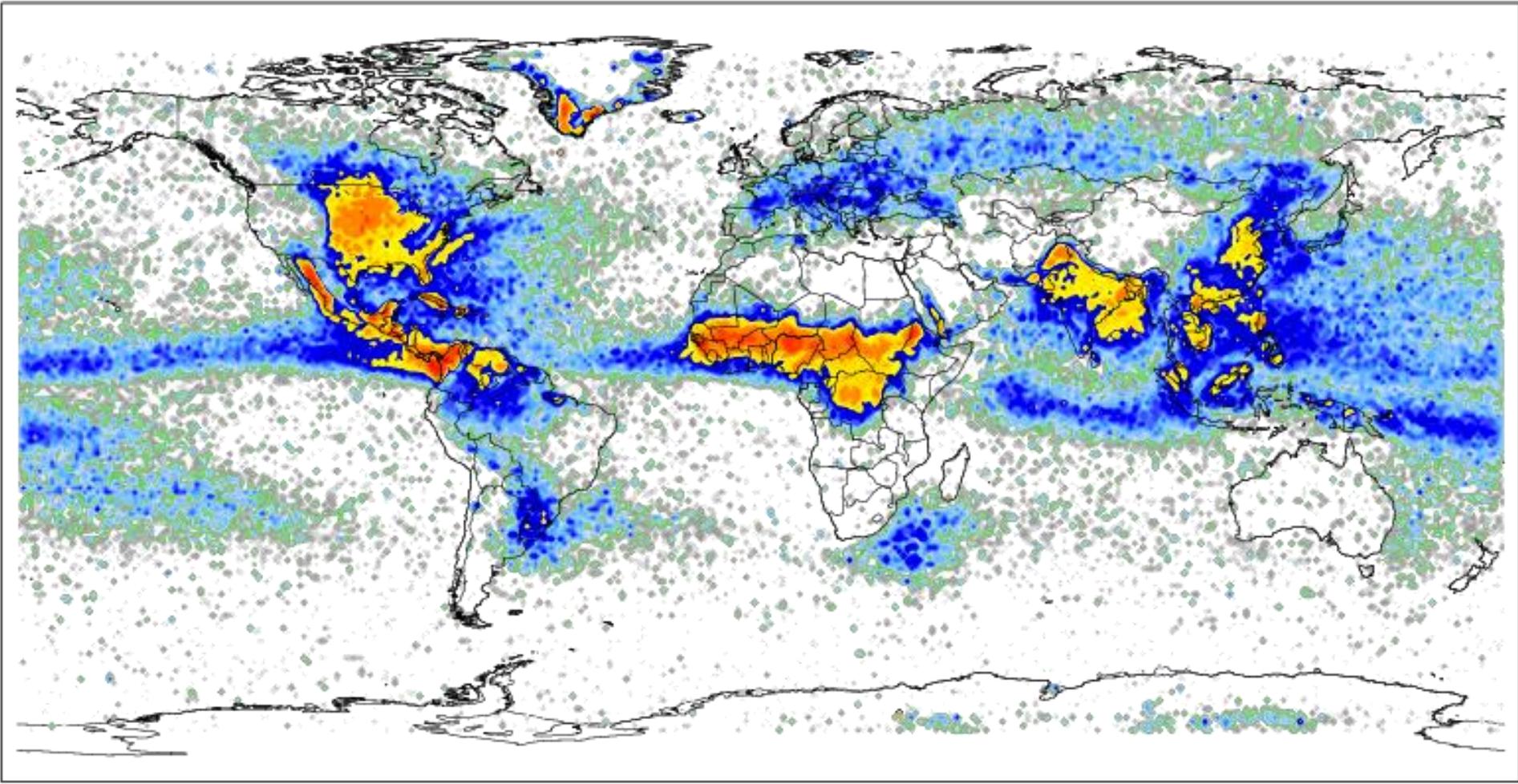


# Summary

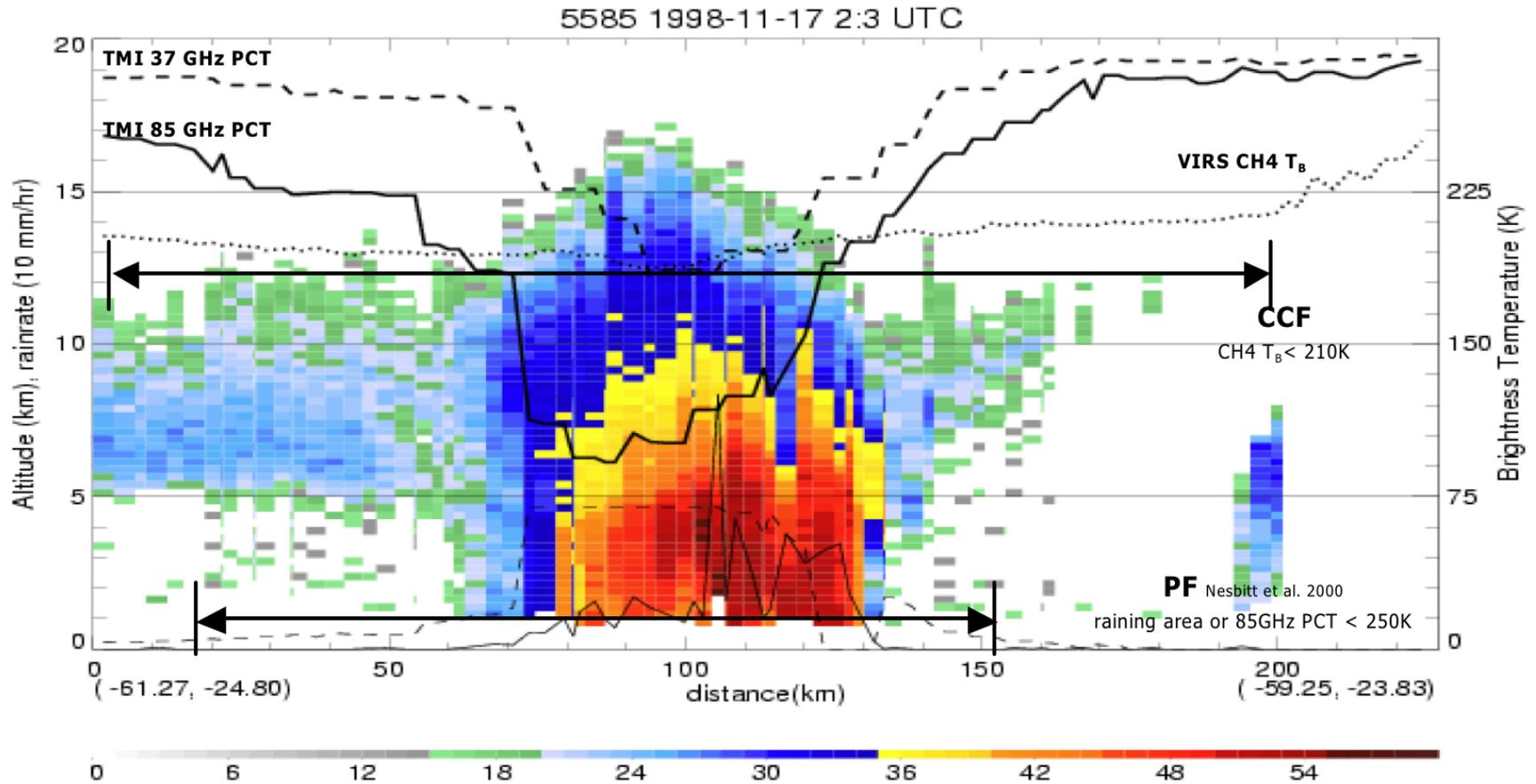
- In the era of the explosion of information, event based data analysis method could greatly improve the accessing and assessment of large volume of satellite data.
- There are MANY important scientific questions that need to be addressed from the perspective of different types of weather/convective 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 (%)

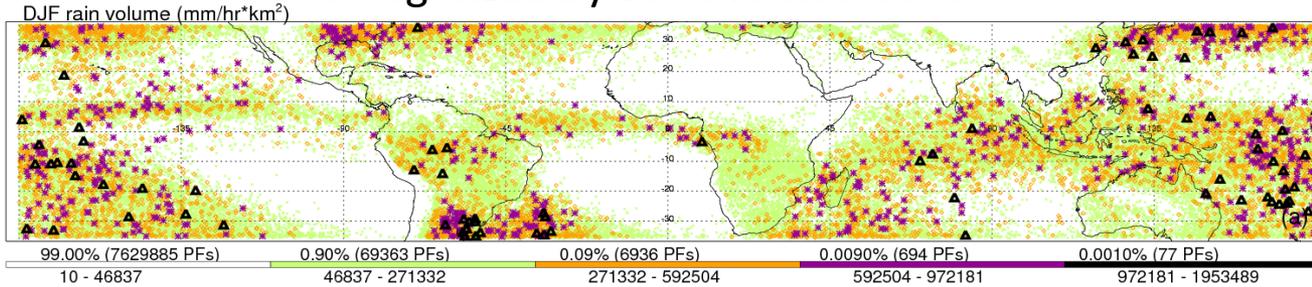


# Vertical view of a storm

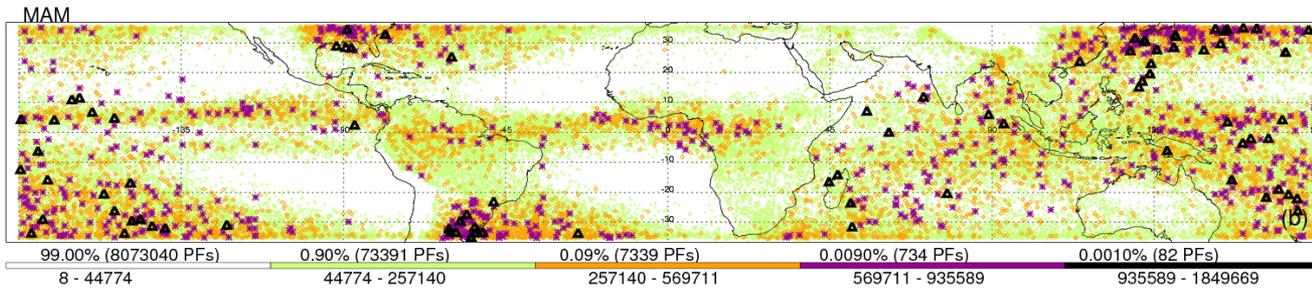


# Where are the rainiest systems on Earth?

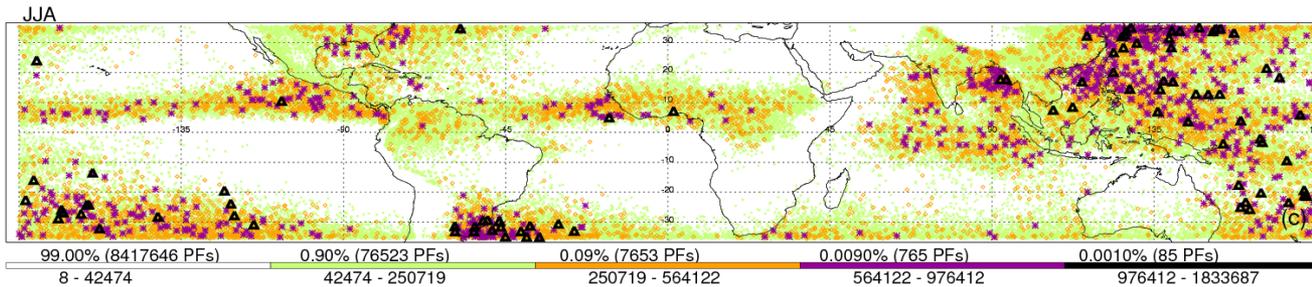
## Categorized by volumetric rainfall



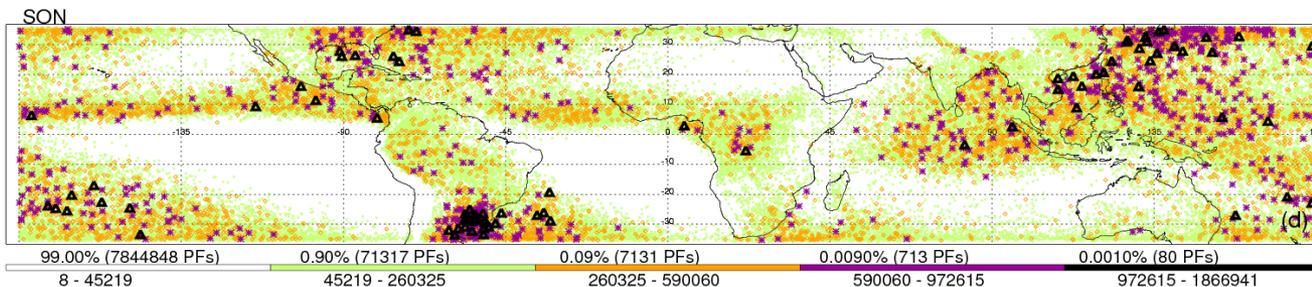
DJF



MAM



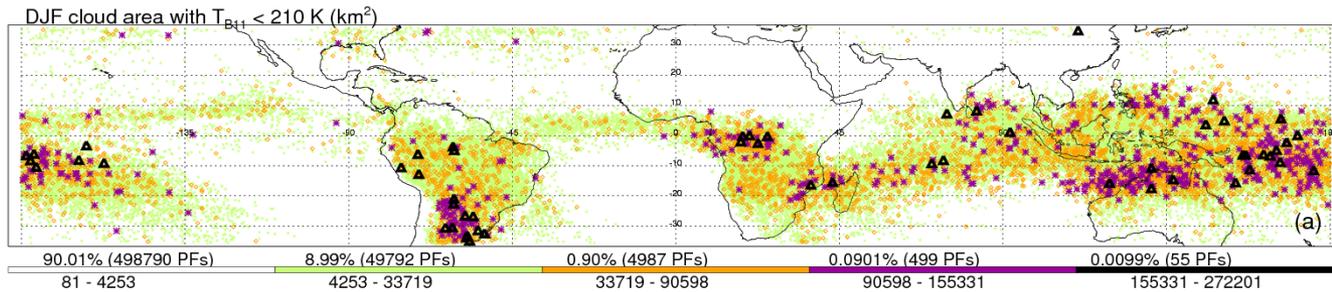
JJA



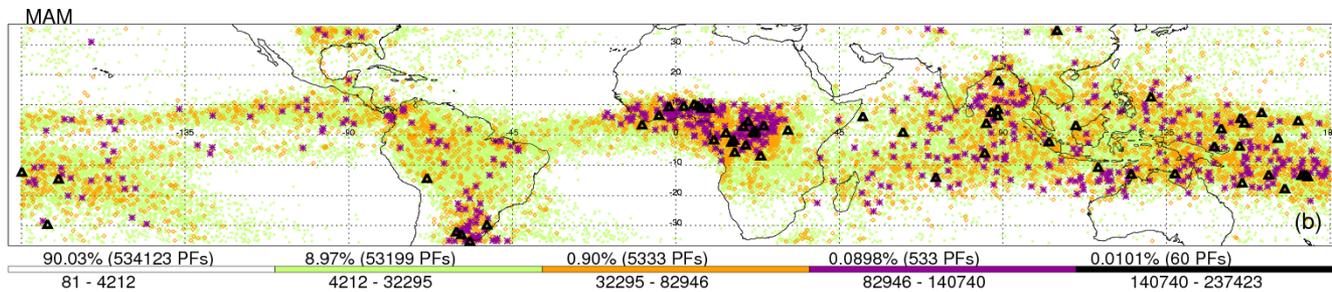
SON

# Where are the large area of cold clouds?

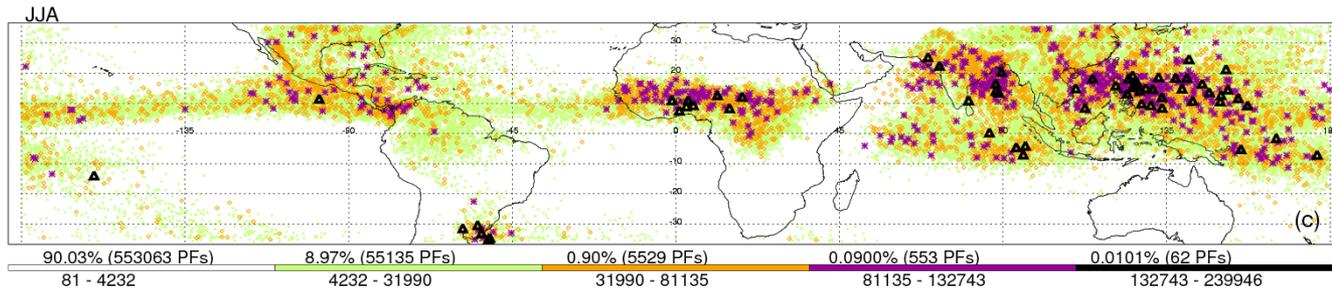
clouds with infrared TB < 210 K (~13.5 km in tropics)



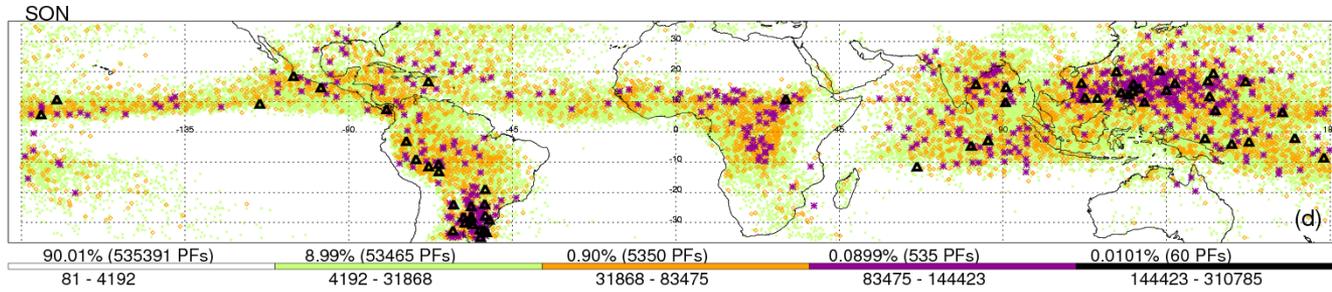
DJF



MAM



JJA



SON

# Where are the thunderstorms

Categorized by flash counts per storm

DJF

MAM

JJA

SON

