Satellite Data Analysis For CPEX

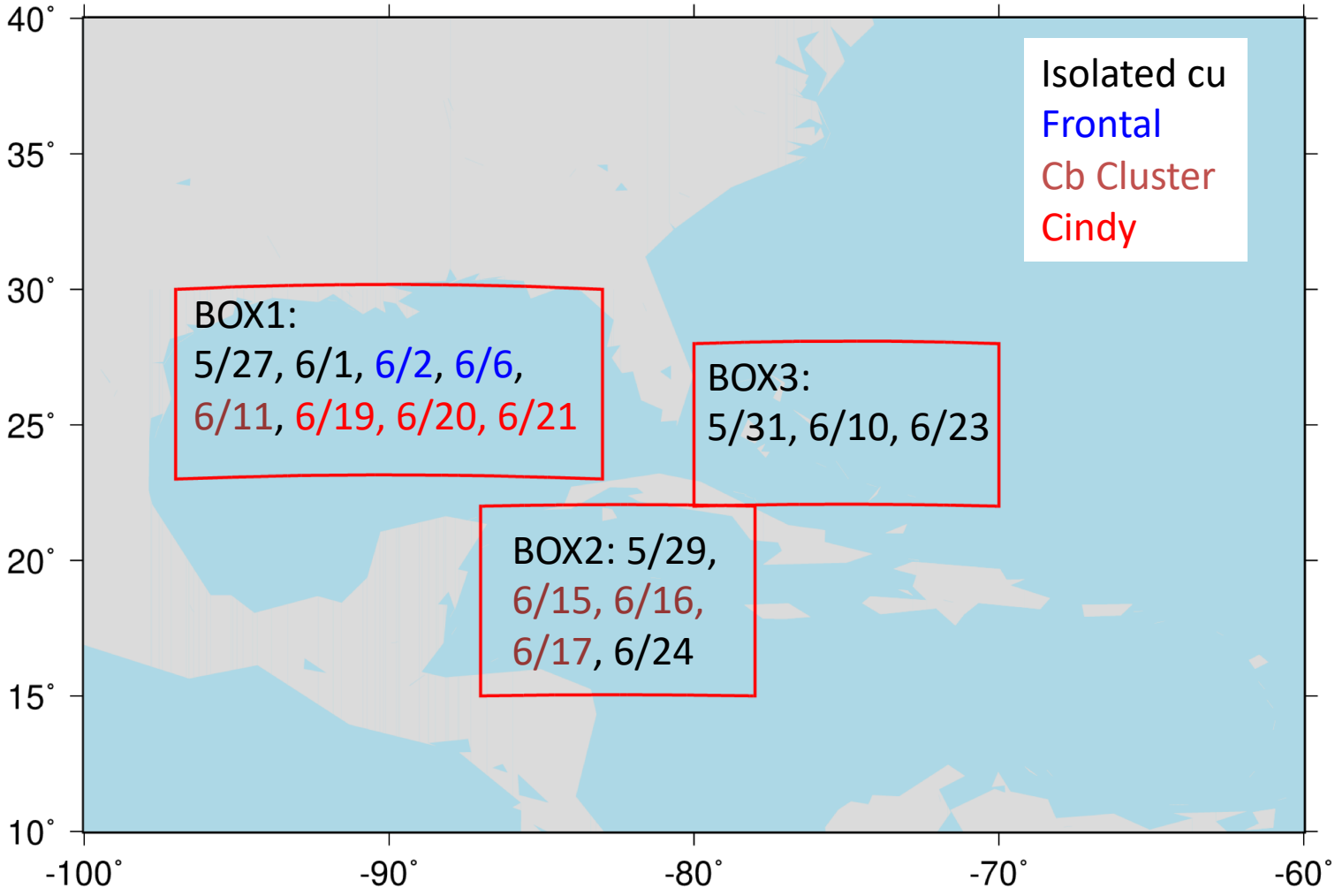
Guosheng Liu
Florida State University

CPEX Related Research

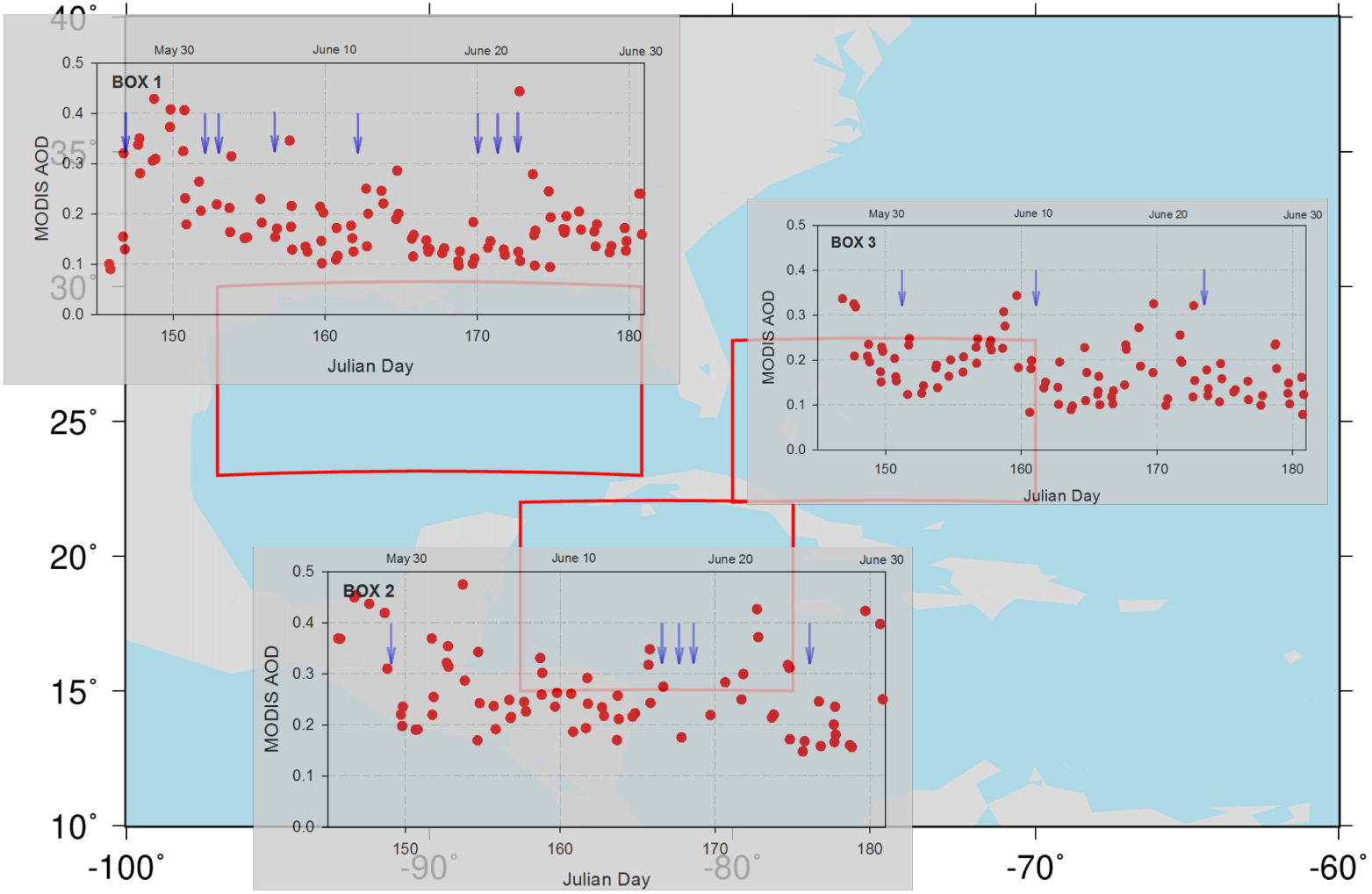
- Satellite Data Synergy
  - Temporal continuity
  - Broadening spatial coverage
  - Compare satellite wind with DAWN wind
- Satellite Data Analysis
  - Cloud Classification – ice vs liquid
  - Cloud “age” within a cluster vs. large-scale environment
  - Warm Clouds – precipitation initiation

Data Synergy

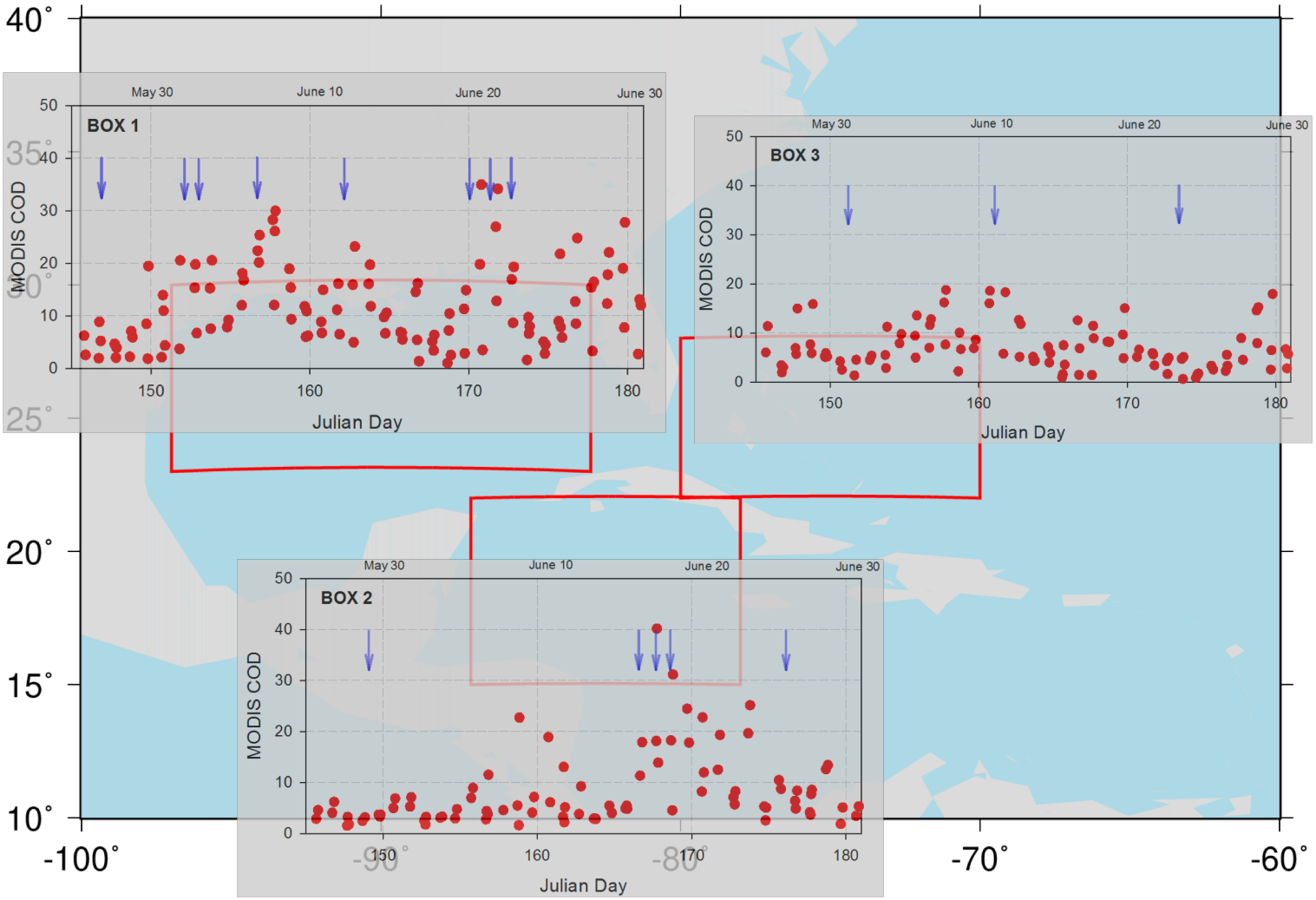
CPEX Flights



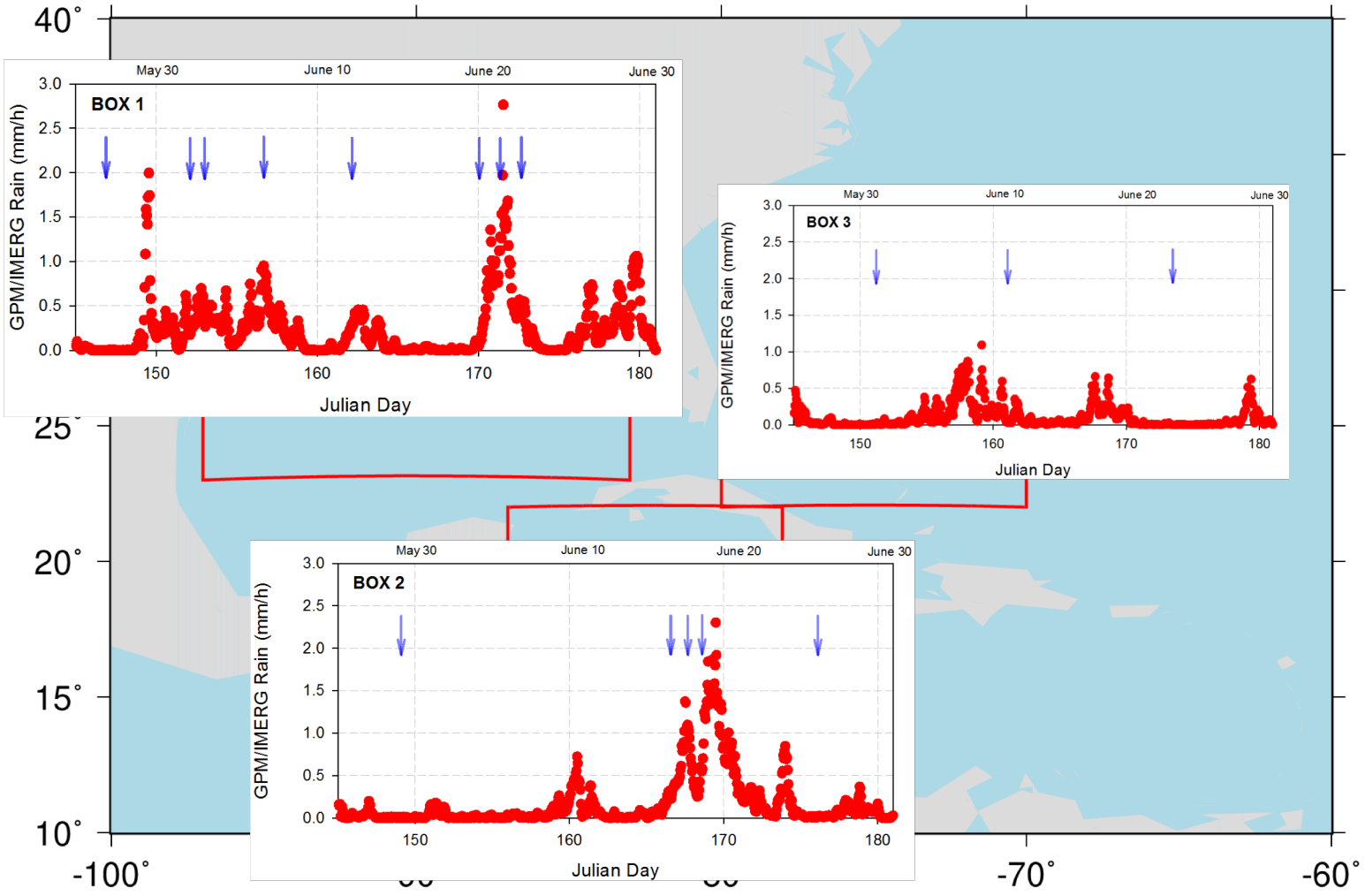
Aerosols


BOX 1
BOX 2
BOX 3
MODIS AOD
Julian Day
May 30
June 10
June 20
June 30
150
160
170
180
0.0
0.1
0.2
0.3
0.4
0.5
40˚
35˚
30˚
25˚
20˚
15˚
10˚
-100˚
-90˚
-80˚
-70˚
-60˚

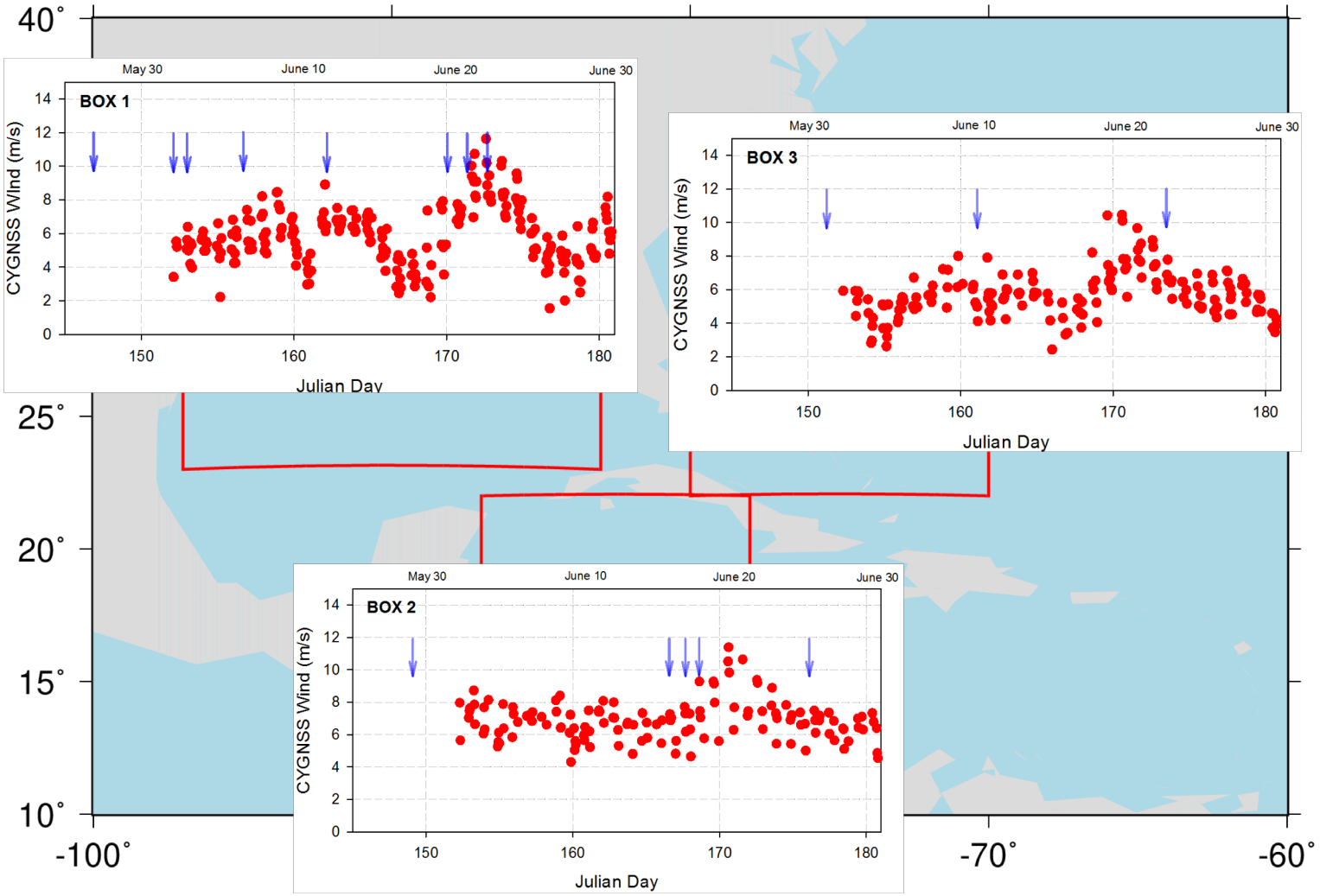
Clouds


40˚
35˚
30˚
25˚
20˚
15˚
10˚
-100˚
-90˚
-80˚
-70˚
-60˚
BOX 1
May 30
June 10
June 20
June 30
MODIS COD
Julian Day
BOX 3
BOX 2

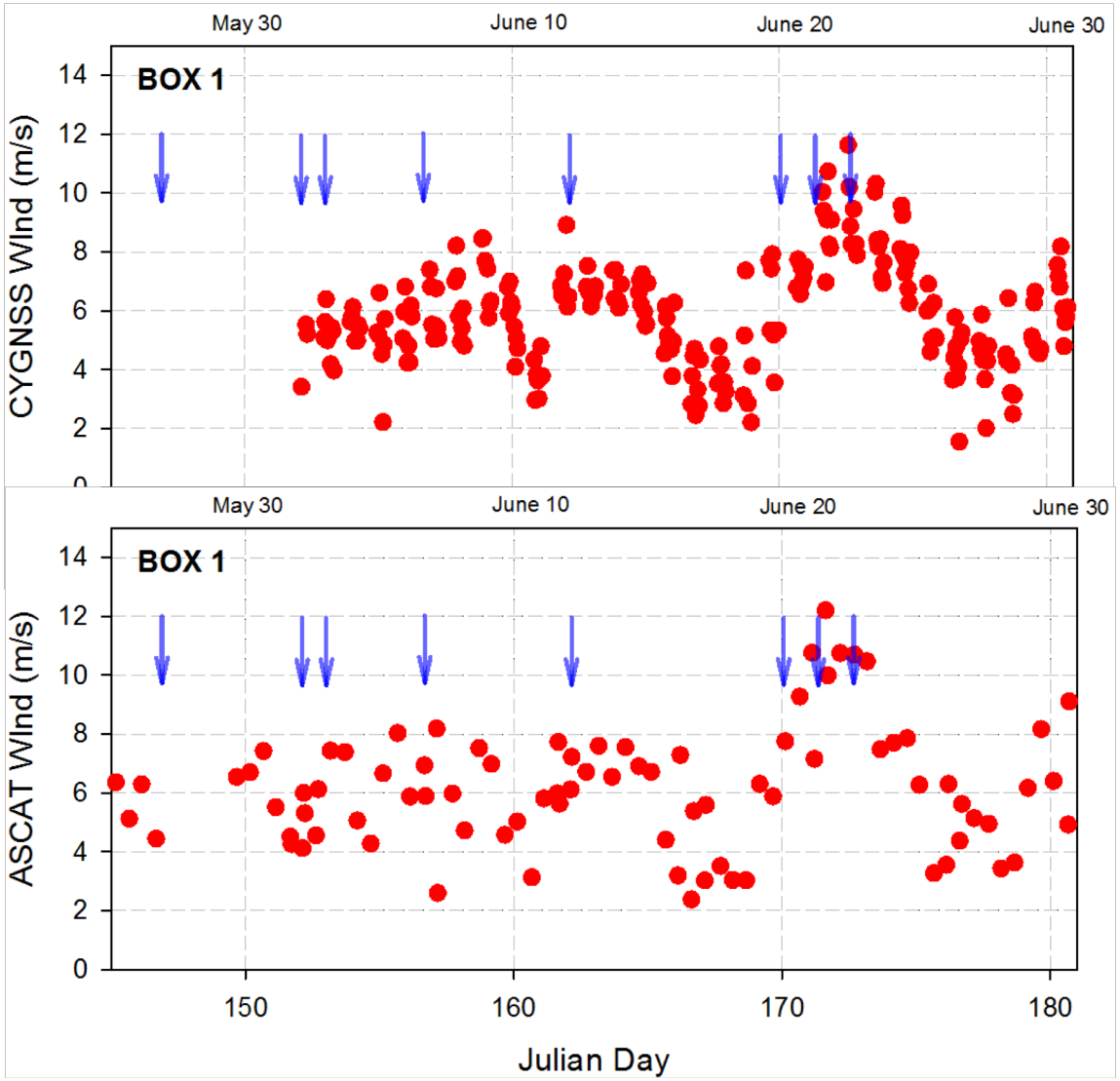
Rain


40˚
25˚
20˚
15˚
10˚
-100˚
-70˚
-60˚
May 30
June 10
June 20
June 30
BOX 1
GPM/IMERG Rain (mm/h)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
150
160
170
180
Julian Day
BOX 3
BOX 2

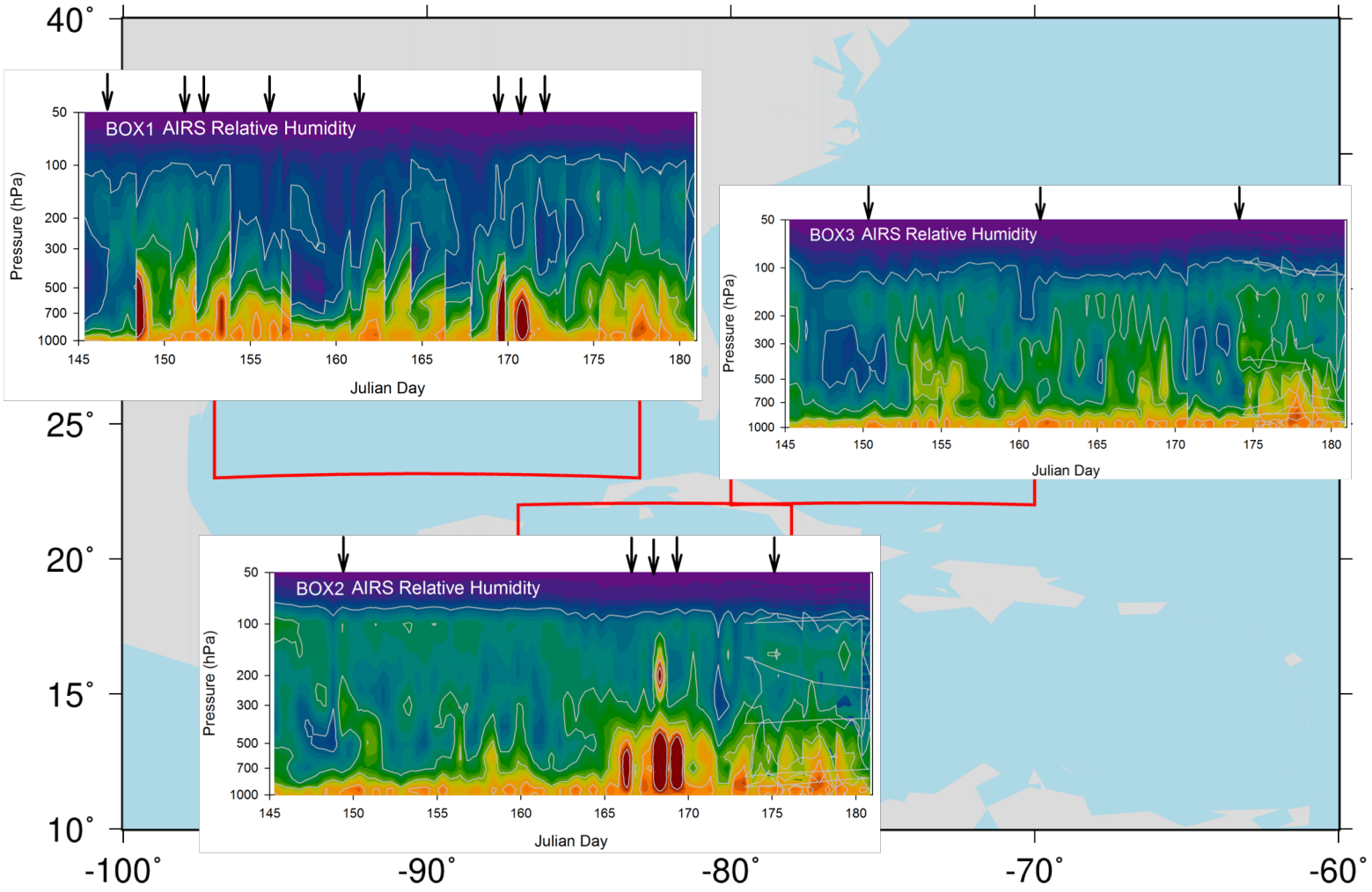
Wind - CYGNSS

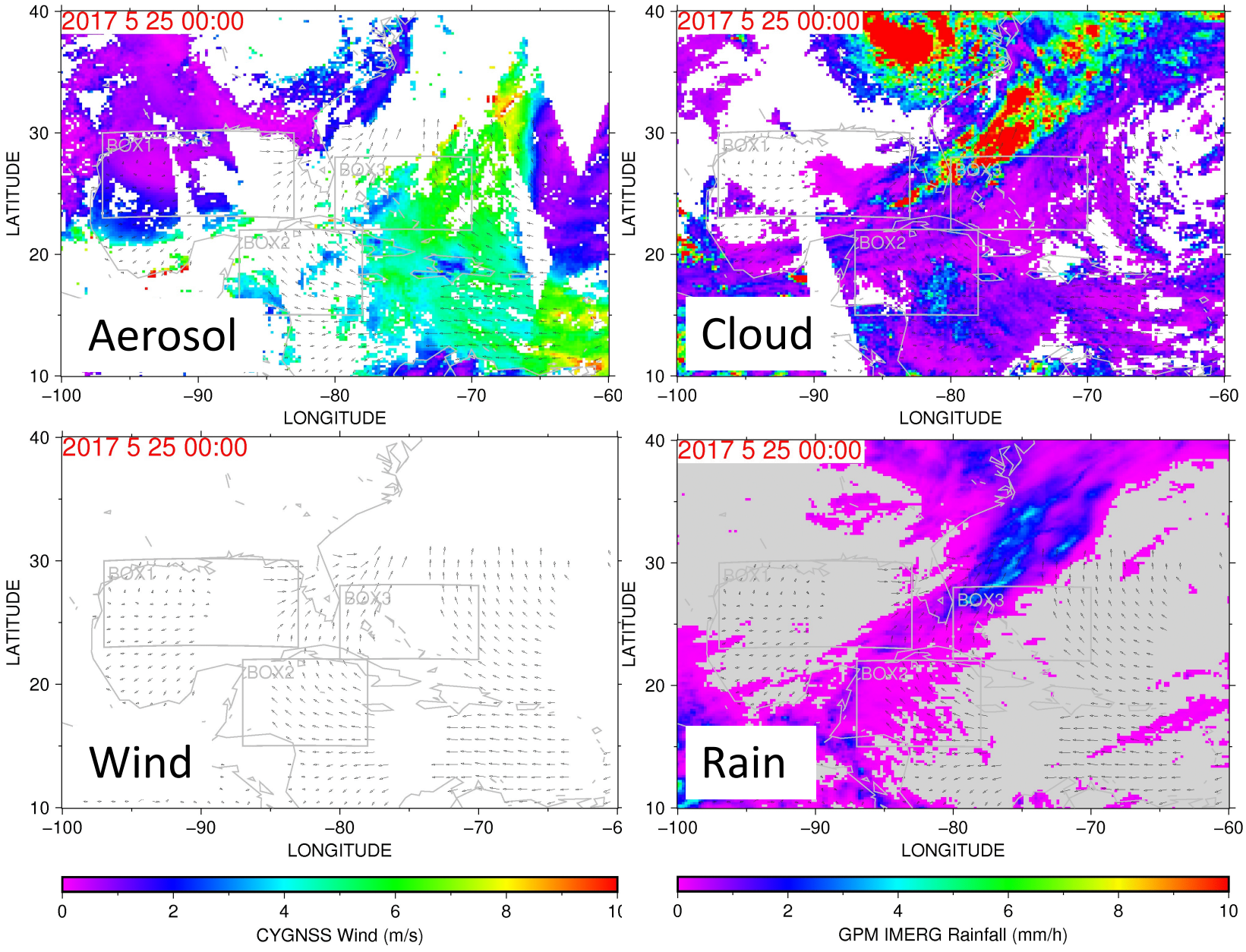

40˚
25˚
20˚
15˚
10˚
-100˚
-70˚
-60˚
BOX 1
May 30
June 10
June 20
June 30
CYGNSS Wind (m/s)
Julian Day
BOX 3
BOX 2

Compare ASCAT and CYGNSS in BOX1



AIRS – Relative Humidity




2017 5 25 00:00
Aerosol
Cloud
Wind
Rain
BOX1
BOX2
BOX3
LATITUDE
LONGITUDE
40
30
20
10
−100
−90
−80
−70
−60
0
2
4
6
8
10
CYGNSS Wind (m/s)
GPM IMERG Rainfall (mm/h)

Data Archive

http://cpex.met.fsu.edu

Satellite Products | Docs&Tools | Images

Satellite Data During CPEX

Retrieved Environmental Variables

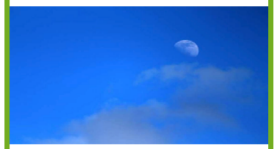
Aerosol Data

Cloud Data

Rain Data

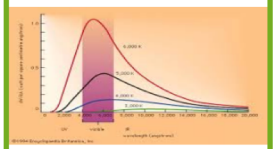
Surface Wind Data

Sounding Data



Original Radiances

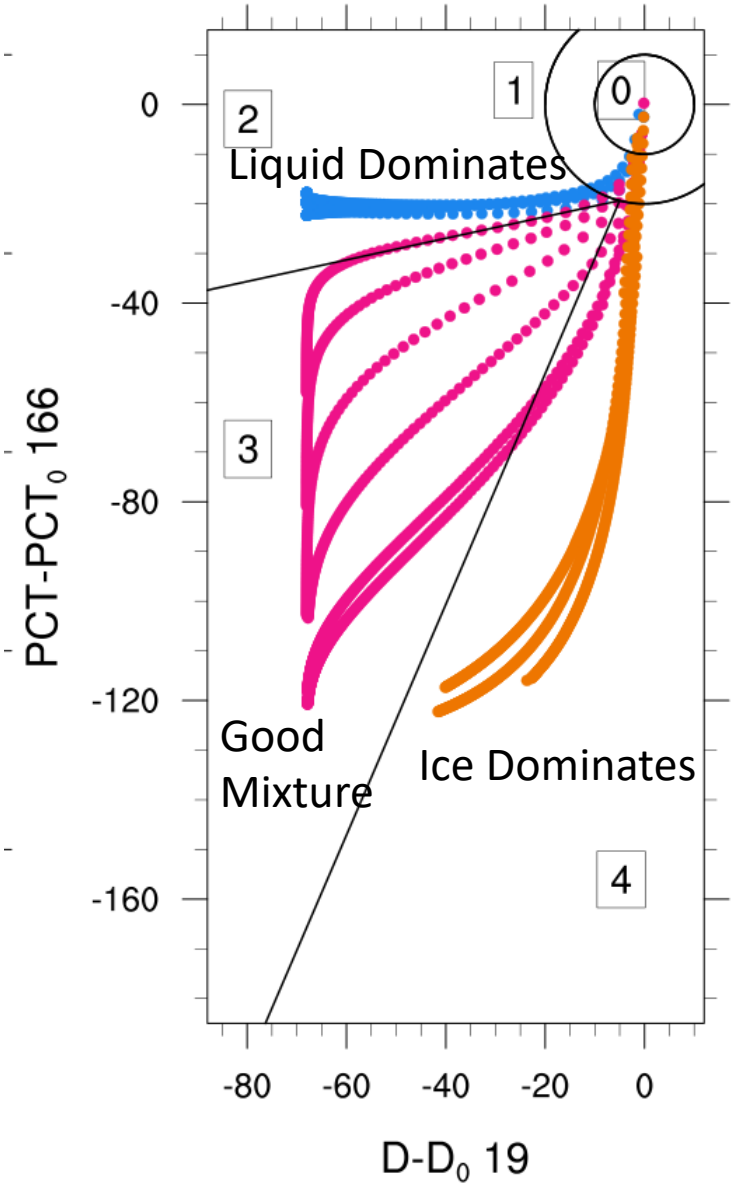
Microwave TBs



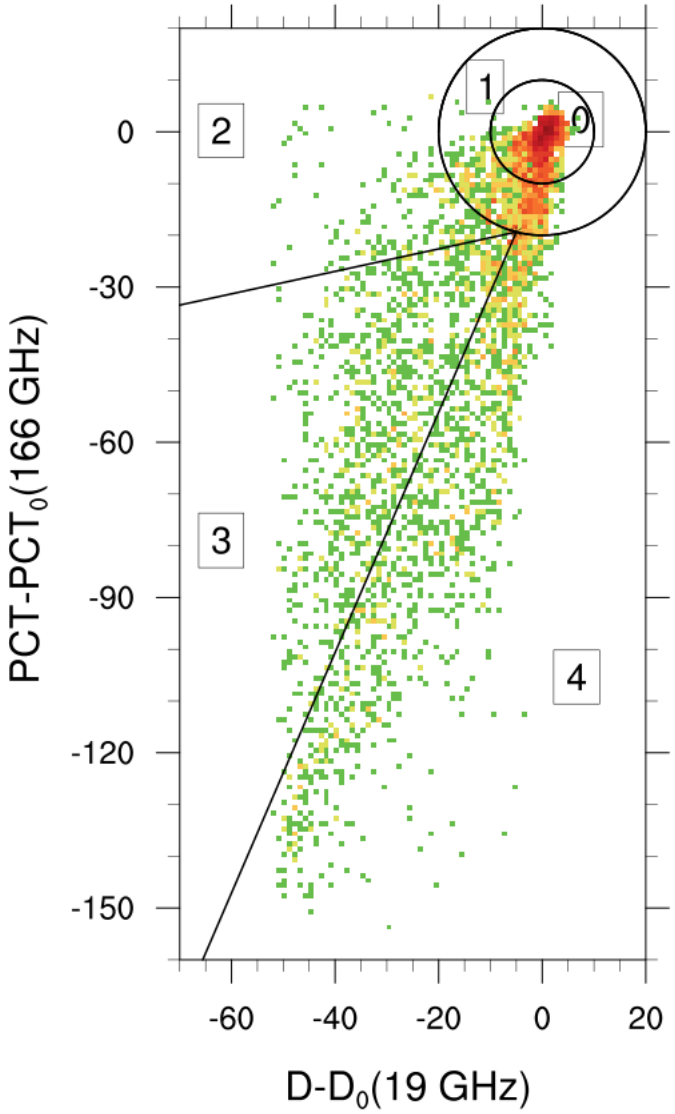
Data Analysis

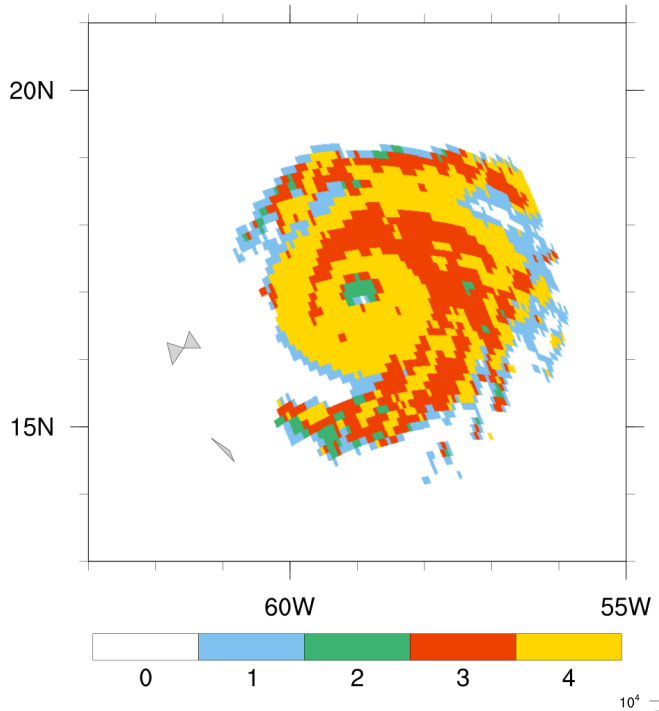
Ice vs. Liquid in Clouds/Precipitation

- Low-freq Microwave: liquid signal
  - GMI 19 GHz D=TBv-TBh
- High-freq Microwave: ice signal
  - GMI 166 GHz PCT=(1+α)TBv-αTBh

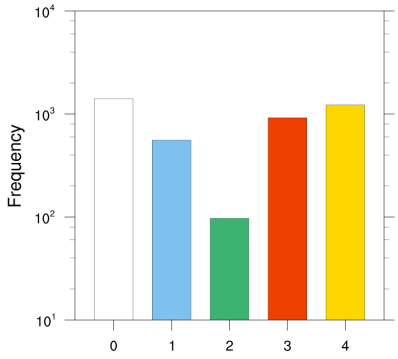


Classification of Clouds –Irma

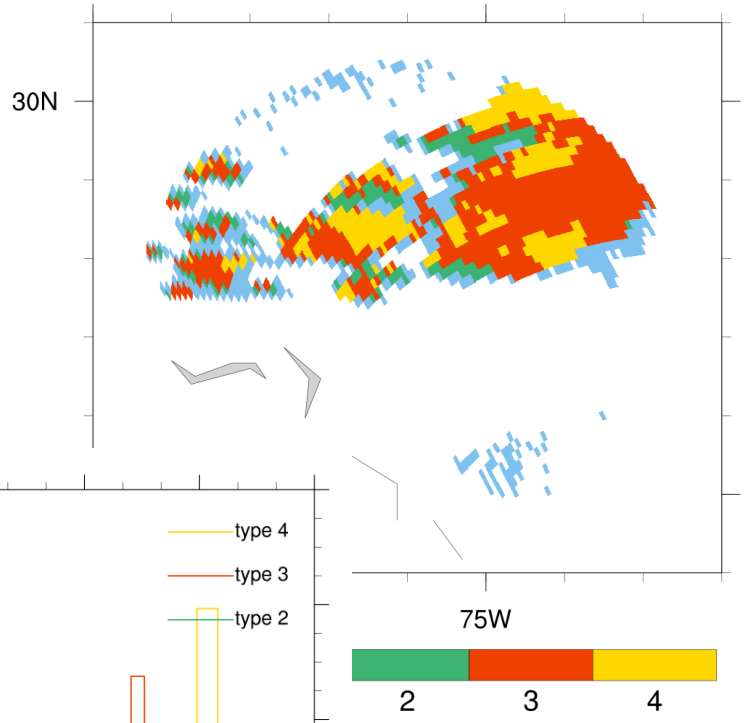


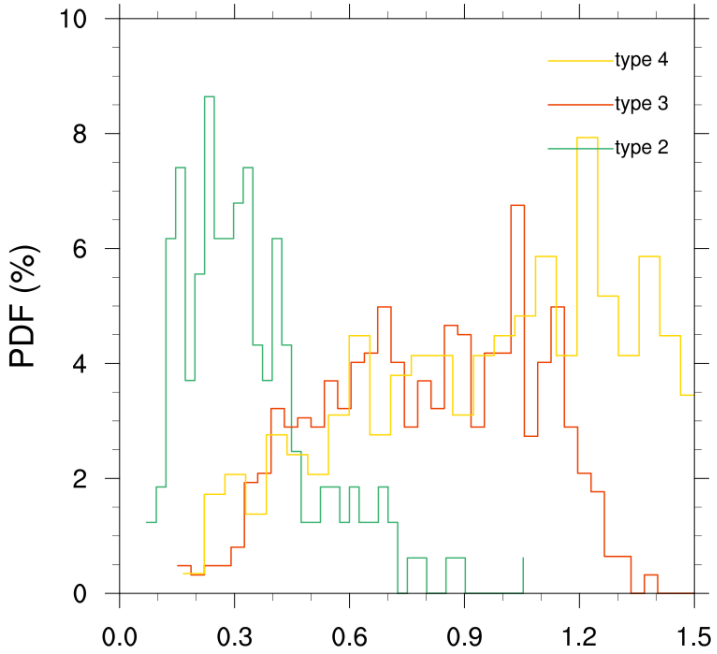


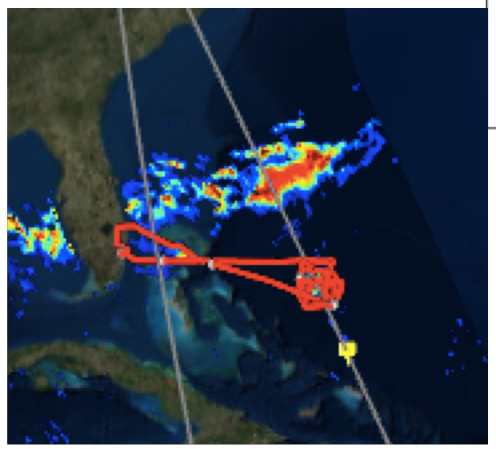
9.5 Irma

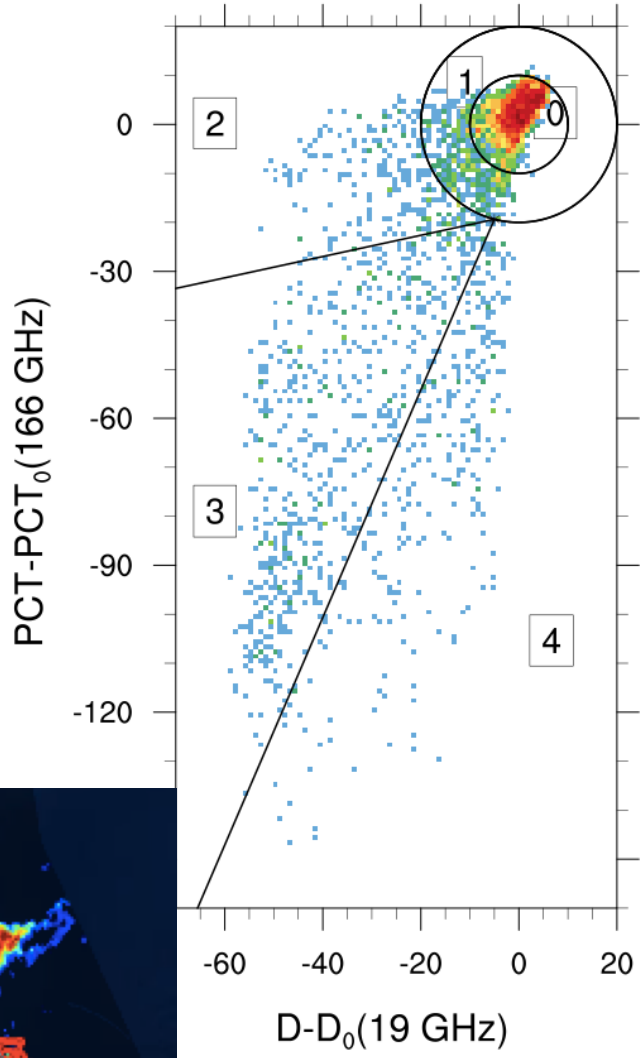


6/10 Case



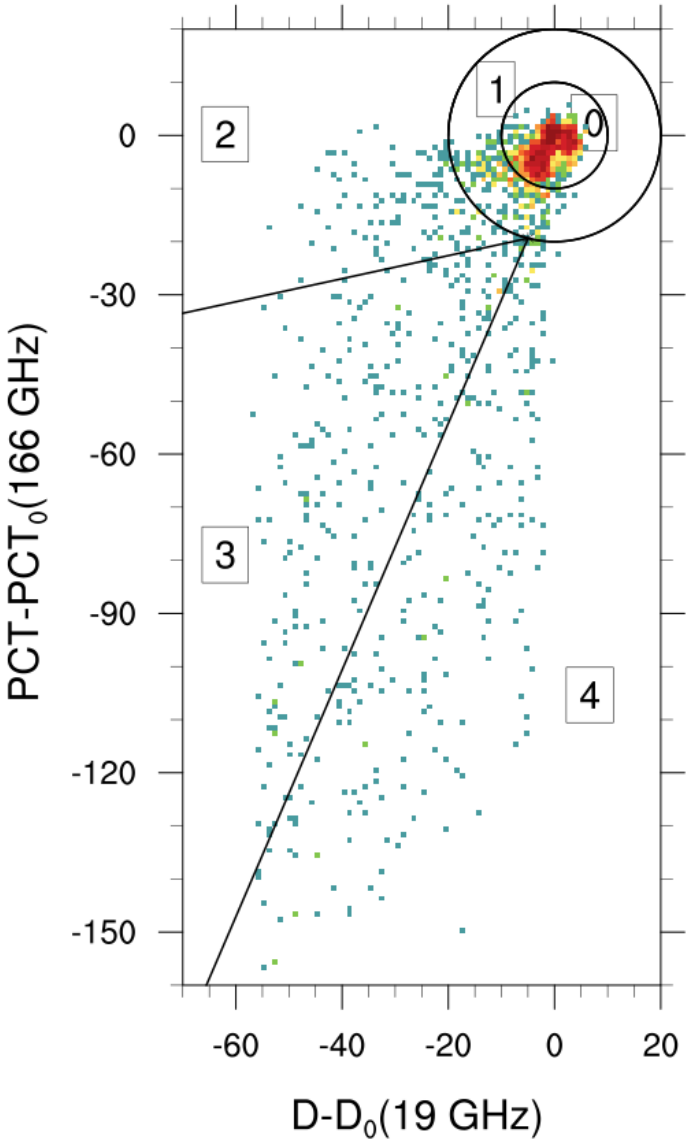


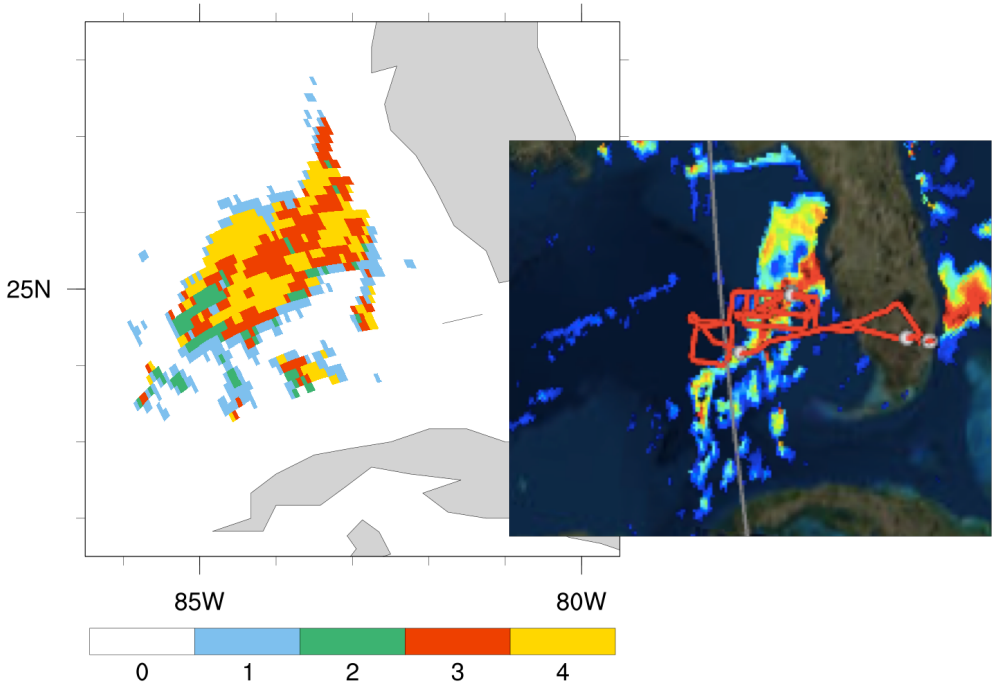




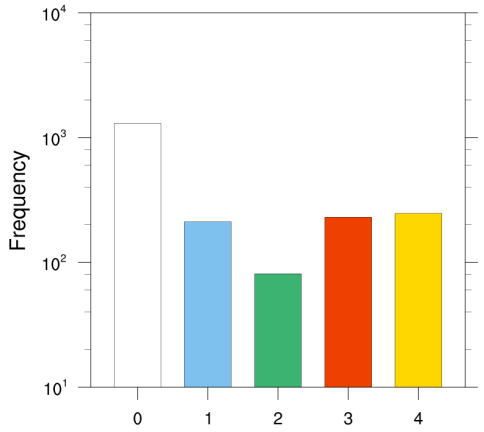
Ice to Liquid Ratio from GPM combined

June 6 – Frontal Clouds in the Gulf

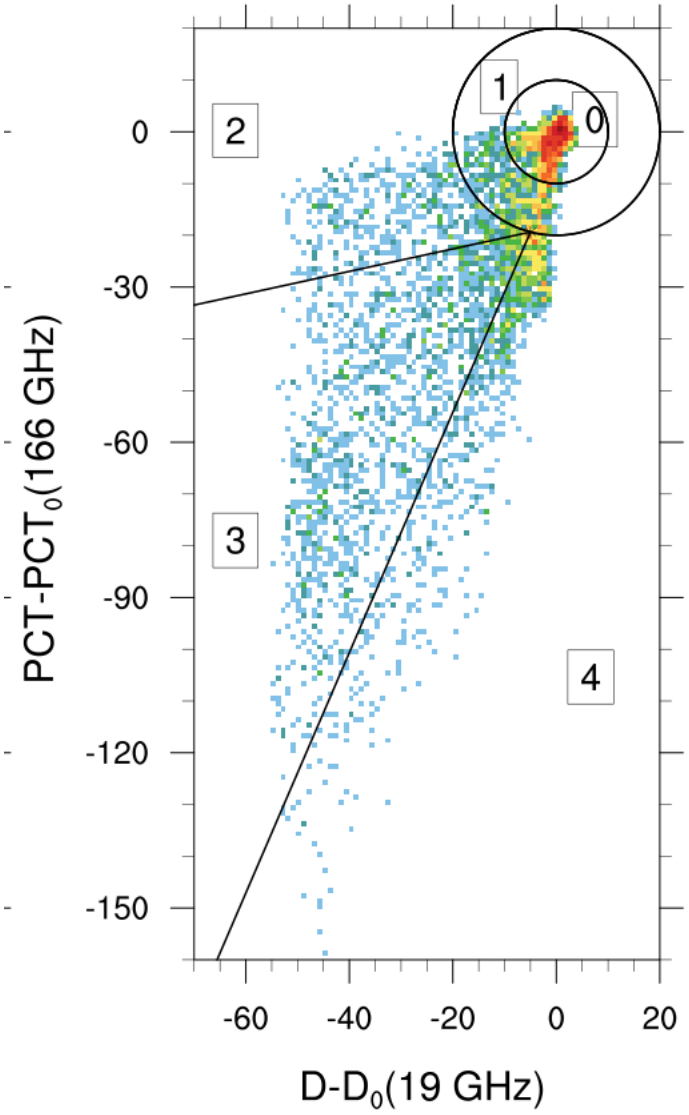


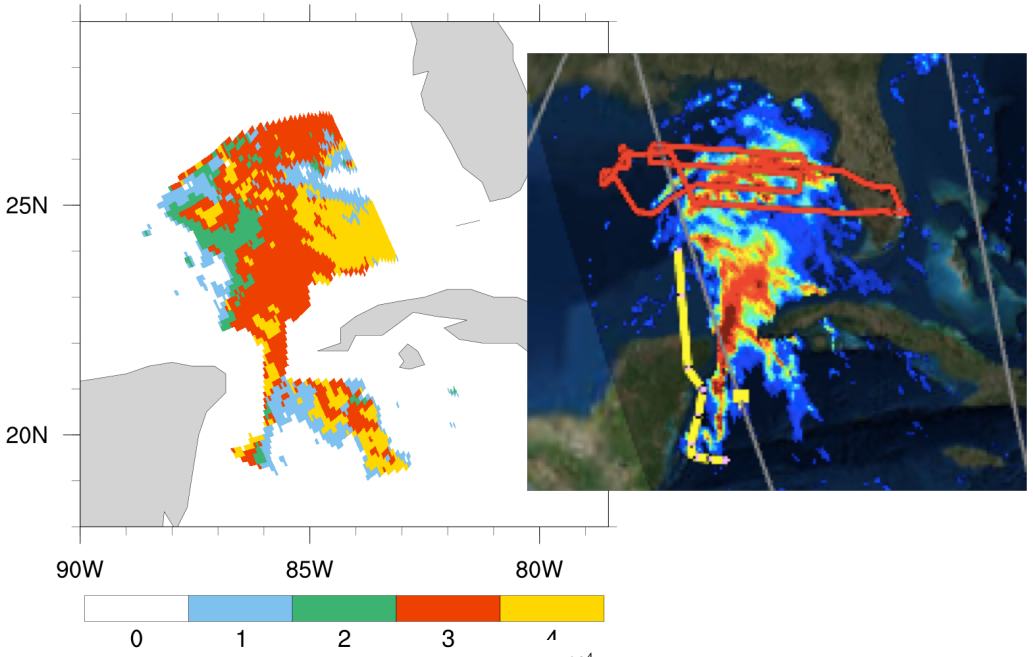


6/6 Flight



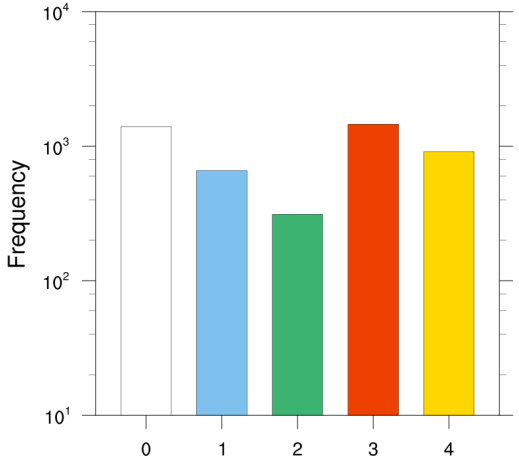
June 19 – Pre-Cindy



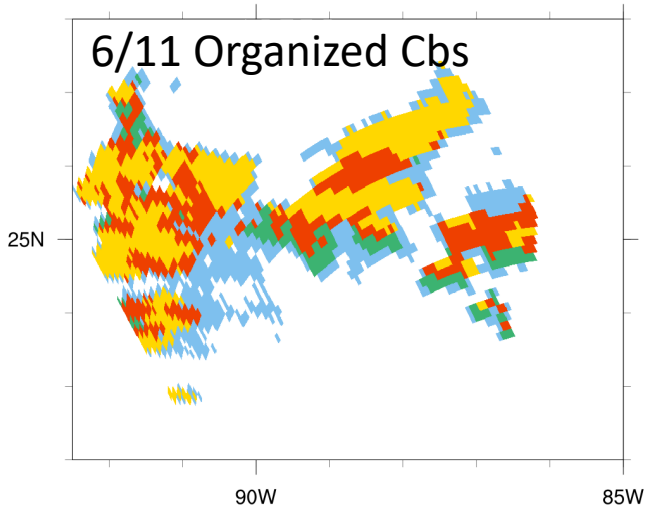


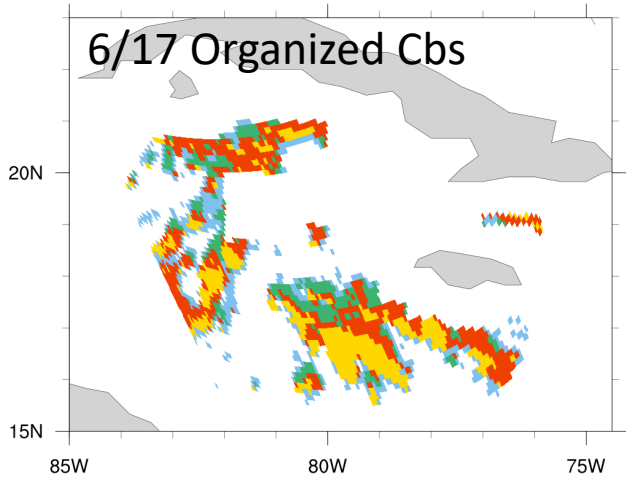
6/19 Flight

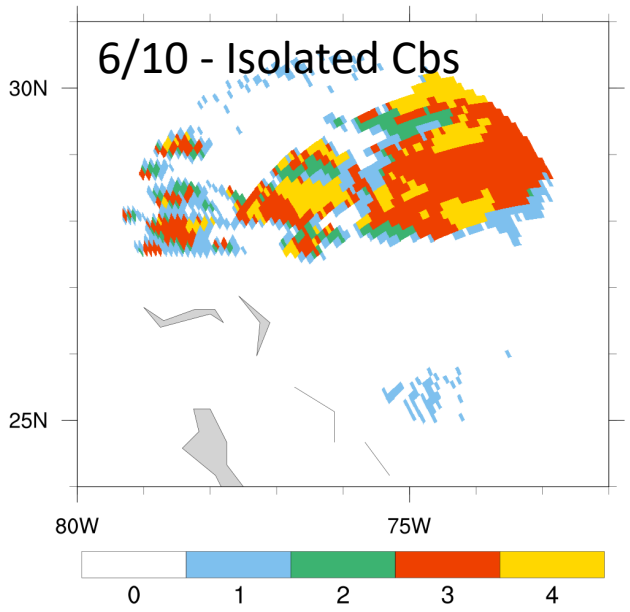
[GFS]

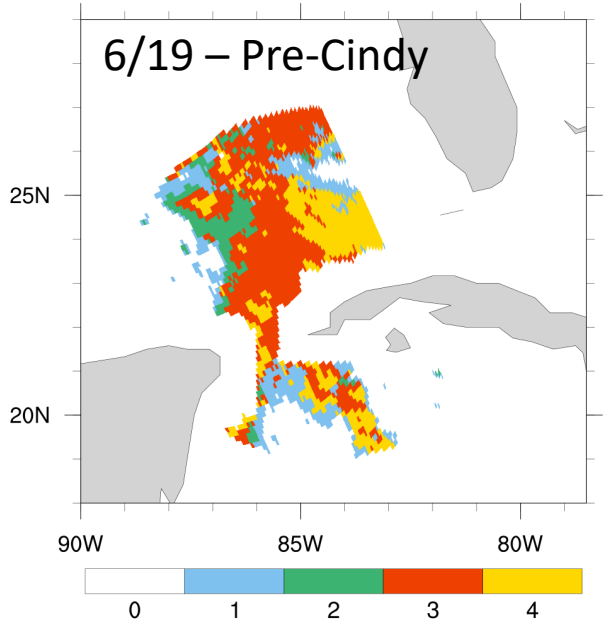


“Age” of cells within a cluster?



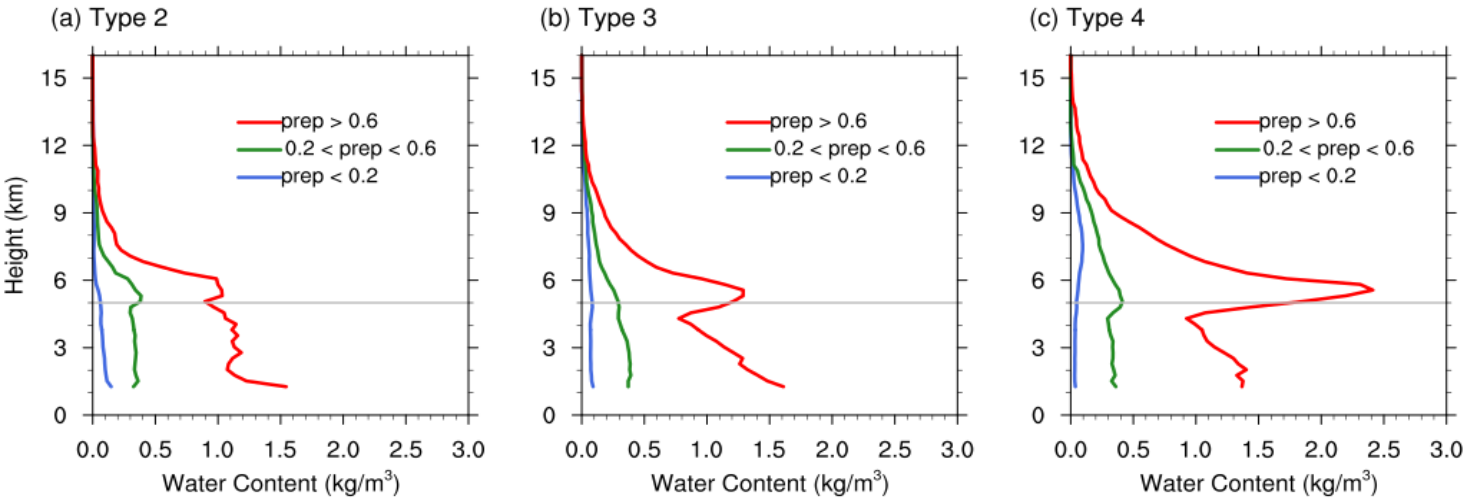




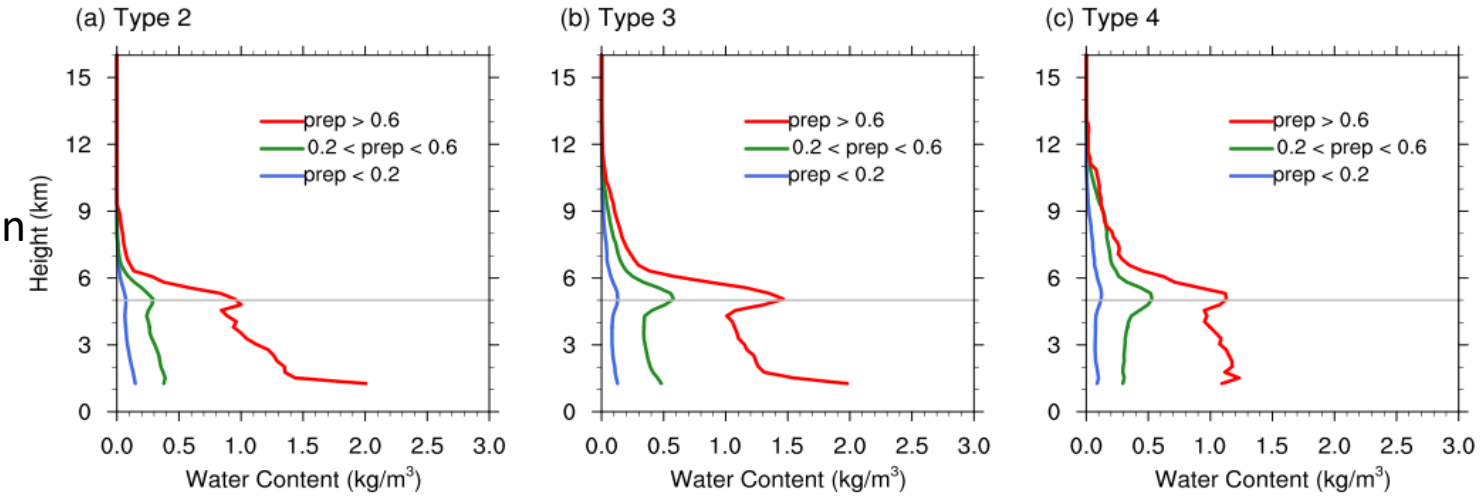


Vertical Structures

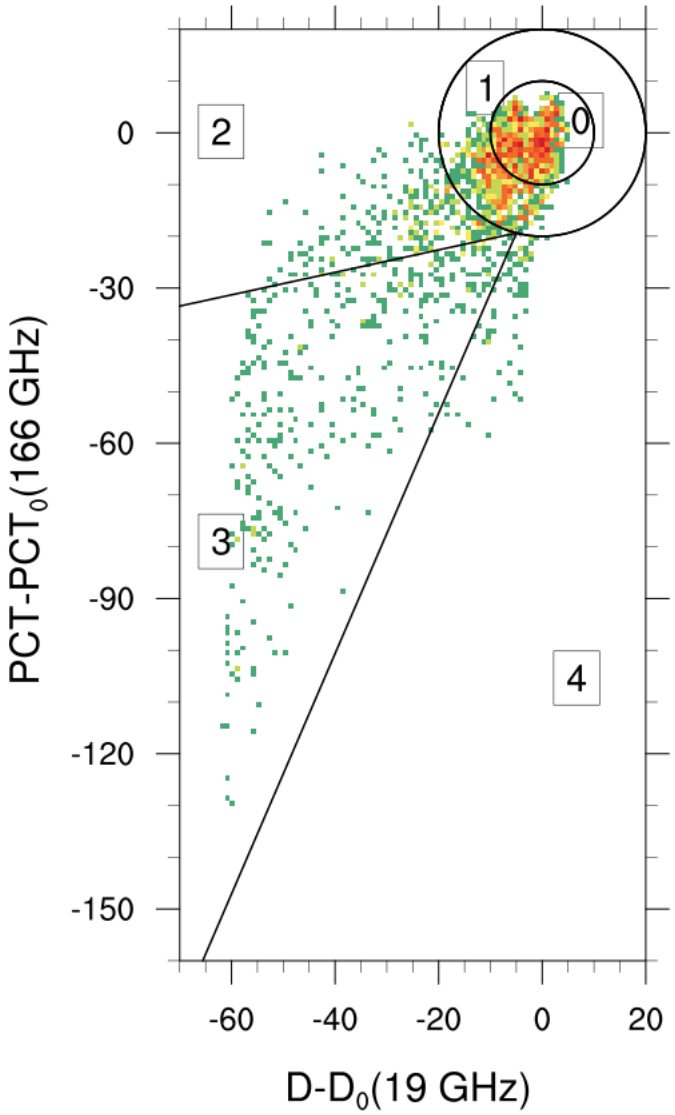
6/6 Front:

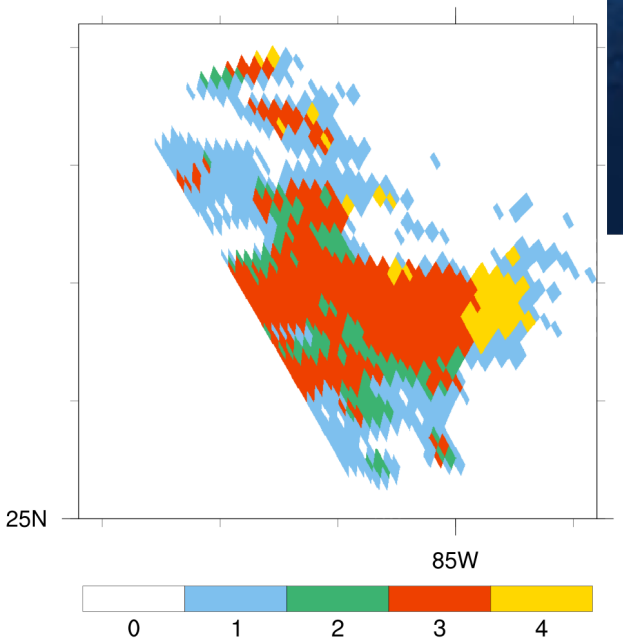


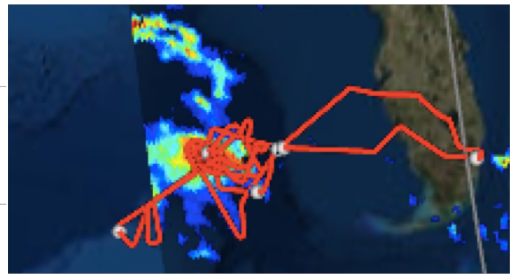
6/19 Convection before Cindy:



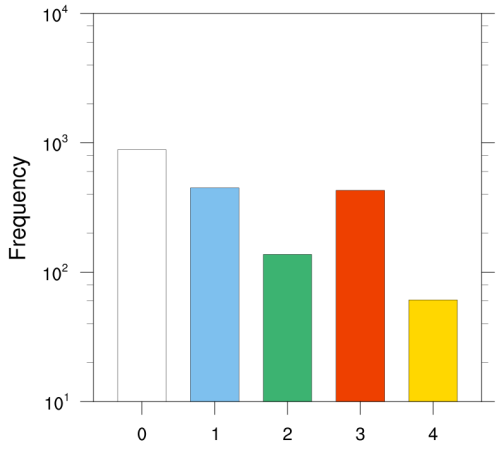
June 1 – Isolated Cbs







6/1 Flight



Works to Do Next

- Satellite Data Synergy – Support Science Team
  - Compare satellite vs DWAN winds
- Liquid-vs-Ice cloud classification to understand cloud-type variation relative to position-within-a-cluster, developing-stage of cells, large-scale environment
- Adapt this methodology to HAMSR (~50 vs. ~183 GHz), so see more details for individual cells
- Use airborne Radar & MW data, analyze precip onset in cu/cb cells, understand how the onset vary with environment

How much liquid must have to initiate precipitation in warm clouds?

- Radar reflectivity profile to figure out precipitation onset
- Microwave radiometer to figure out liquid water
- How precipitation onset is related to aerosol/large-scale environment?

Observed vertical distribution of warm clouds (Rogers&Yau, Wallace&Hobbs)

Adiabatic liquid water content: liquid water almost linearly increase with height above cloud base.

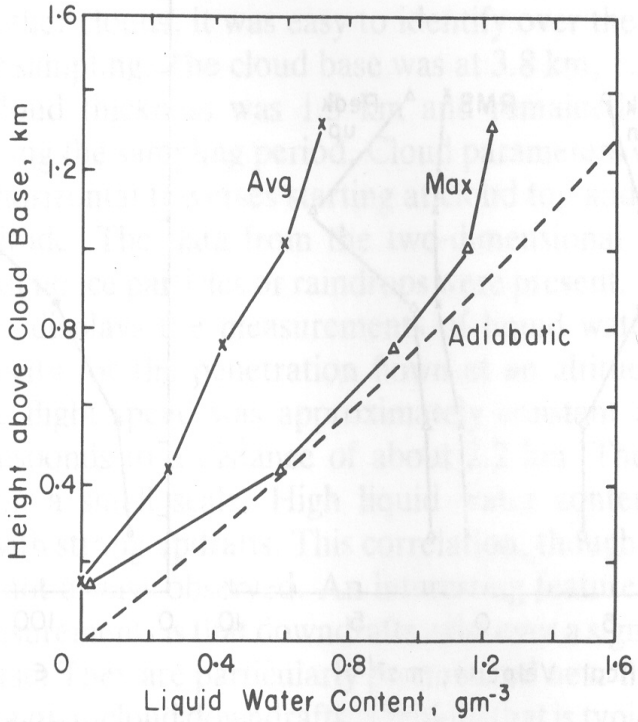
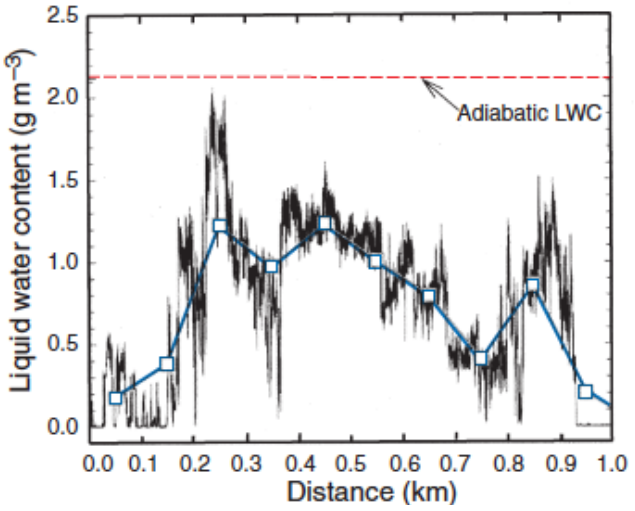
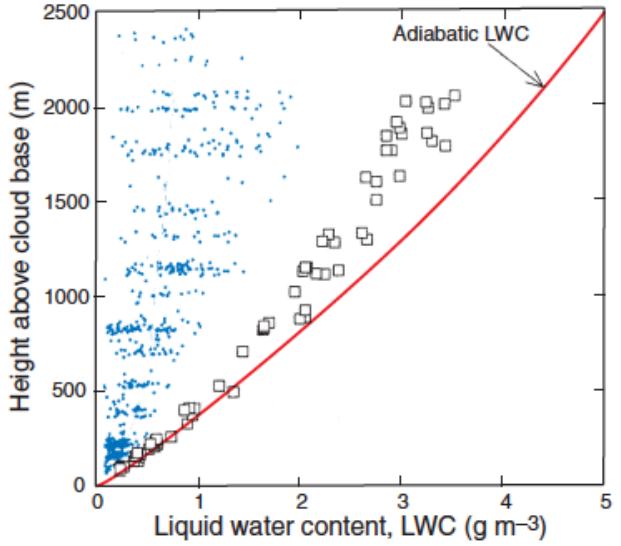
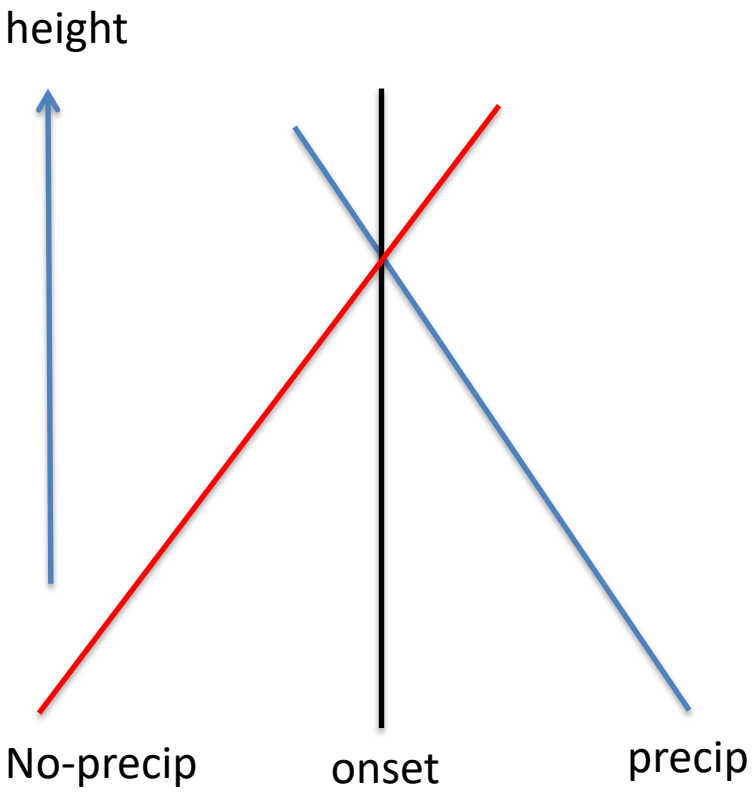


FIG. 5.6. Maximum, average, and adiabatic liquid water contents plotted against height above cloud base. (Adapted from Schemenauer *et al.*, 1980.)





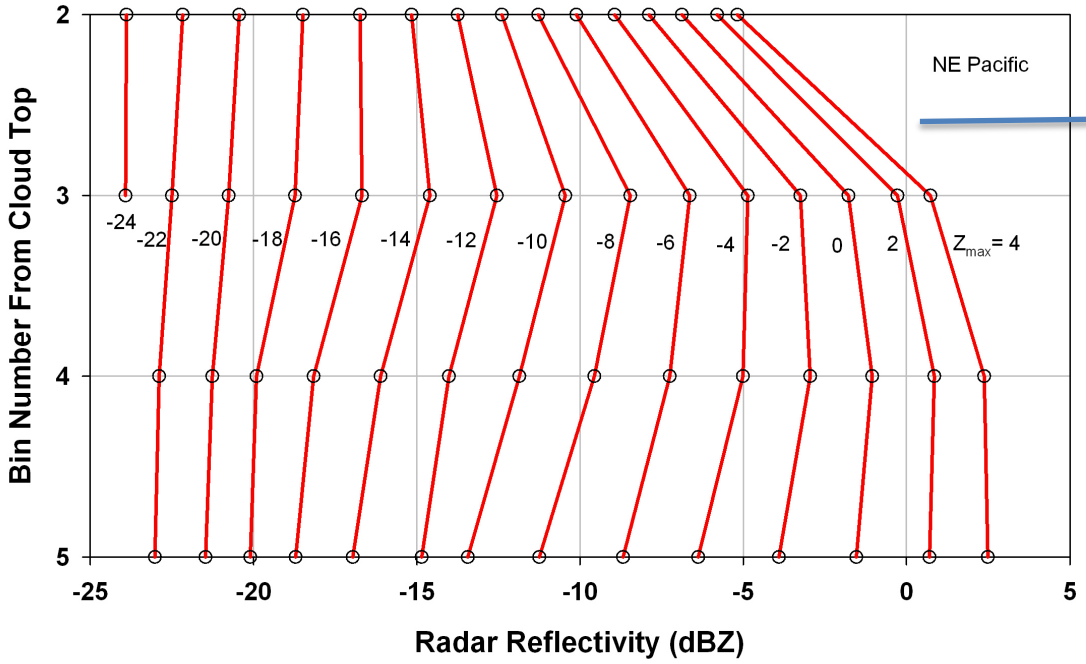
Working Assumption

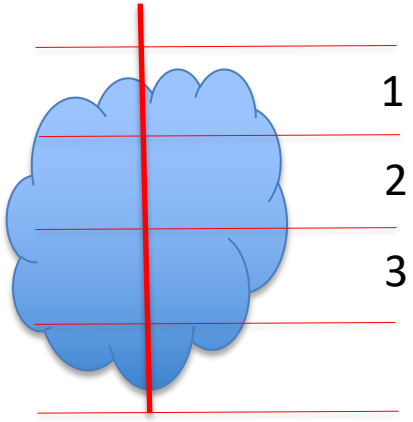


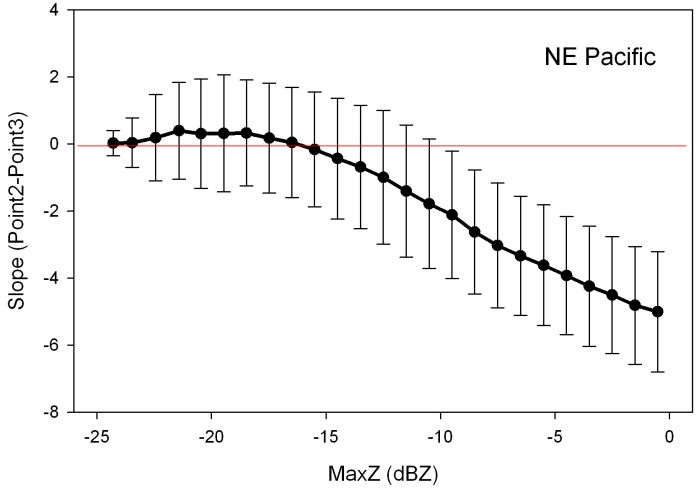
- Non-precip clouds: dBZ increases with height
- Precip clouds: dBZ decreases, at least near the top, with height

That is, vertical profile of radar reflectivity changes from top-heavy to bottom-heavy when precip starts

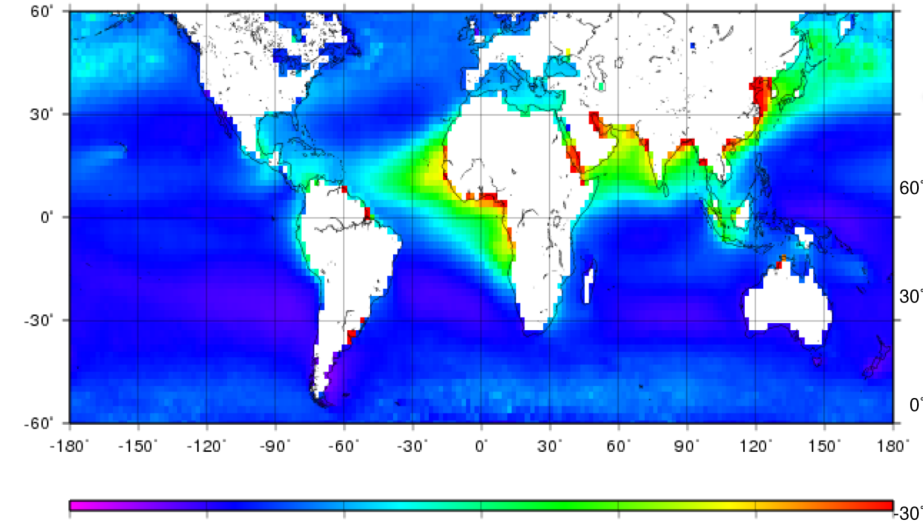
Vertical Profiles of CloudSat CPR warm clouds only, N.E. Pacific



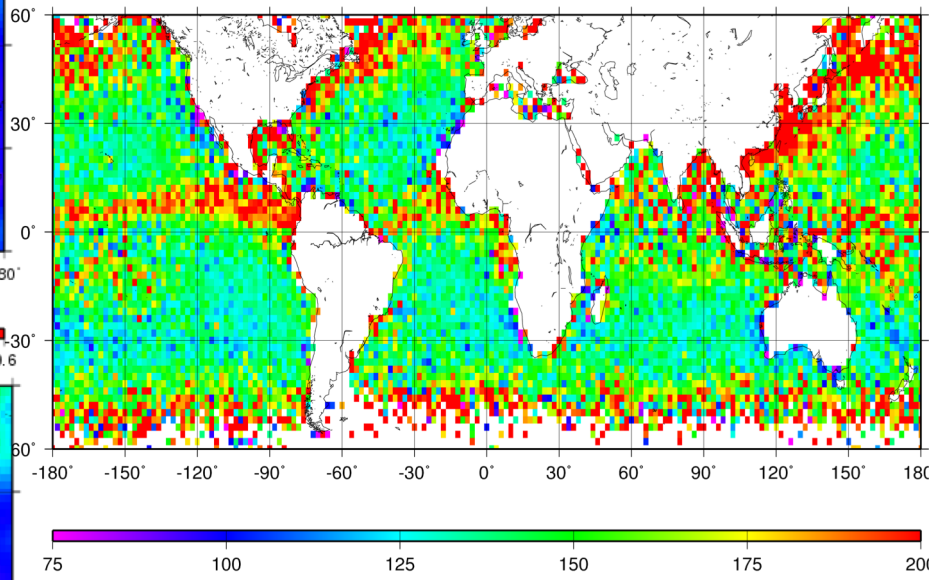




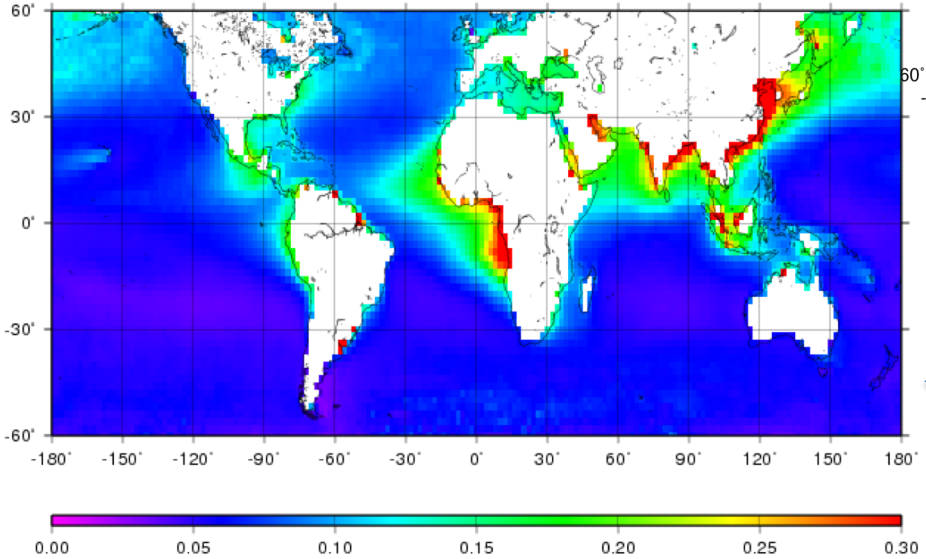
MODIS Aerosol Optical Depth vs. AMSR-E/2 Liquid Water Path at Drizzle Onset



← Aerosol Optical Depth (all aerosols)



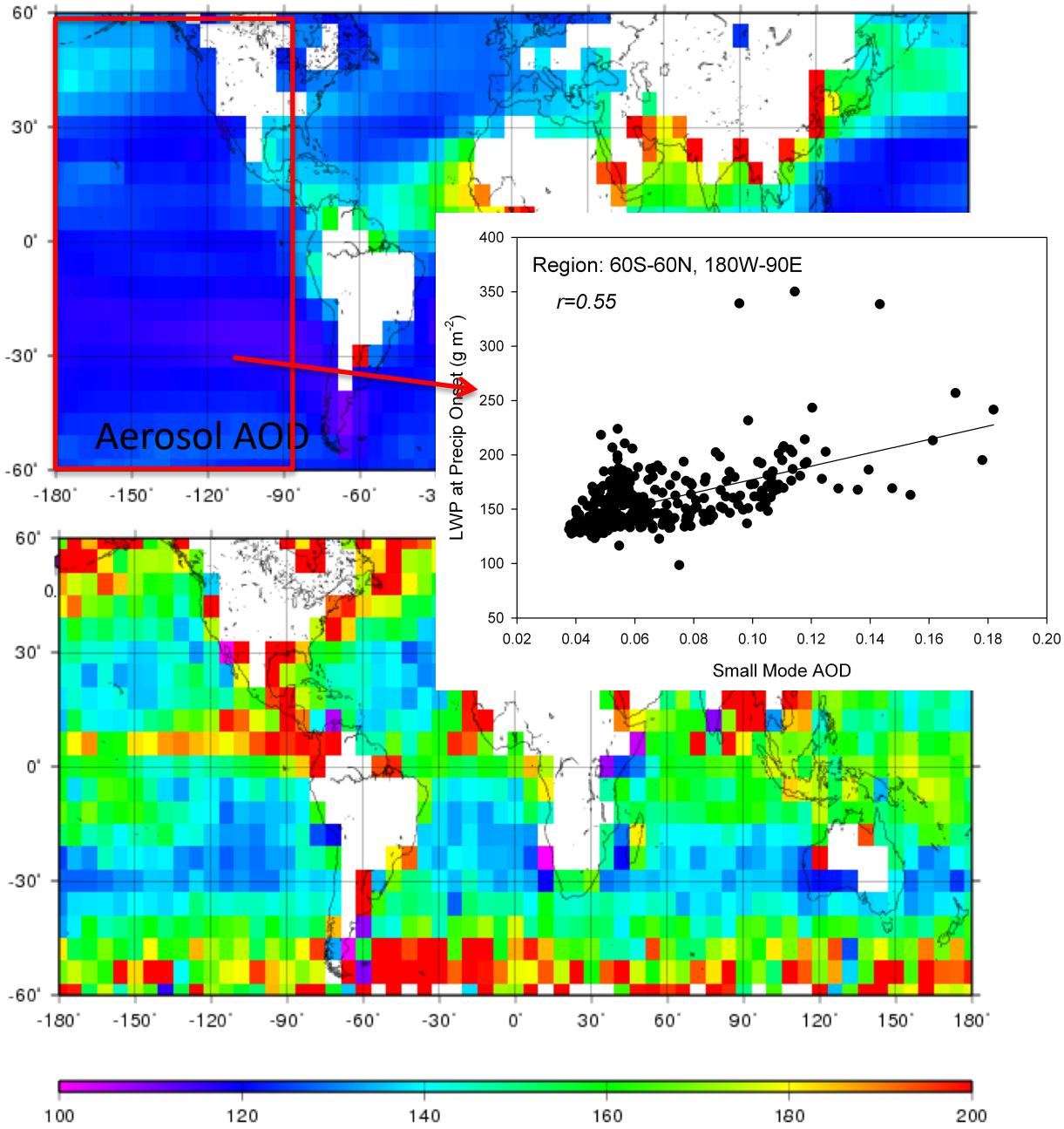
LWP @ Drizzle Onset (g m^{-2})



← Aerosol Optical Depth (small aerosols)

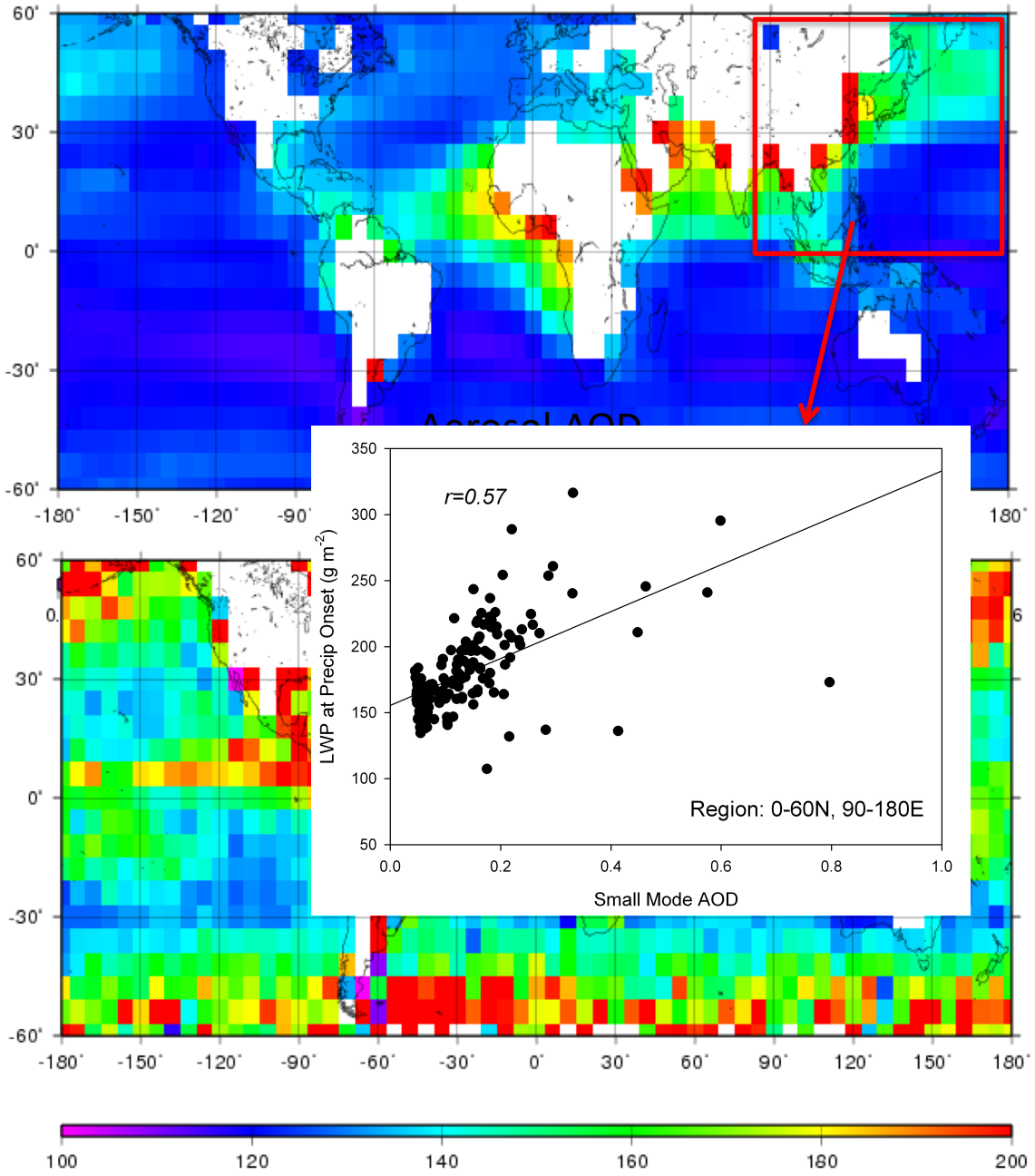
Annual Means

Pattern comparison

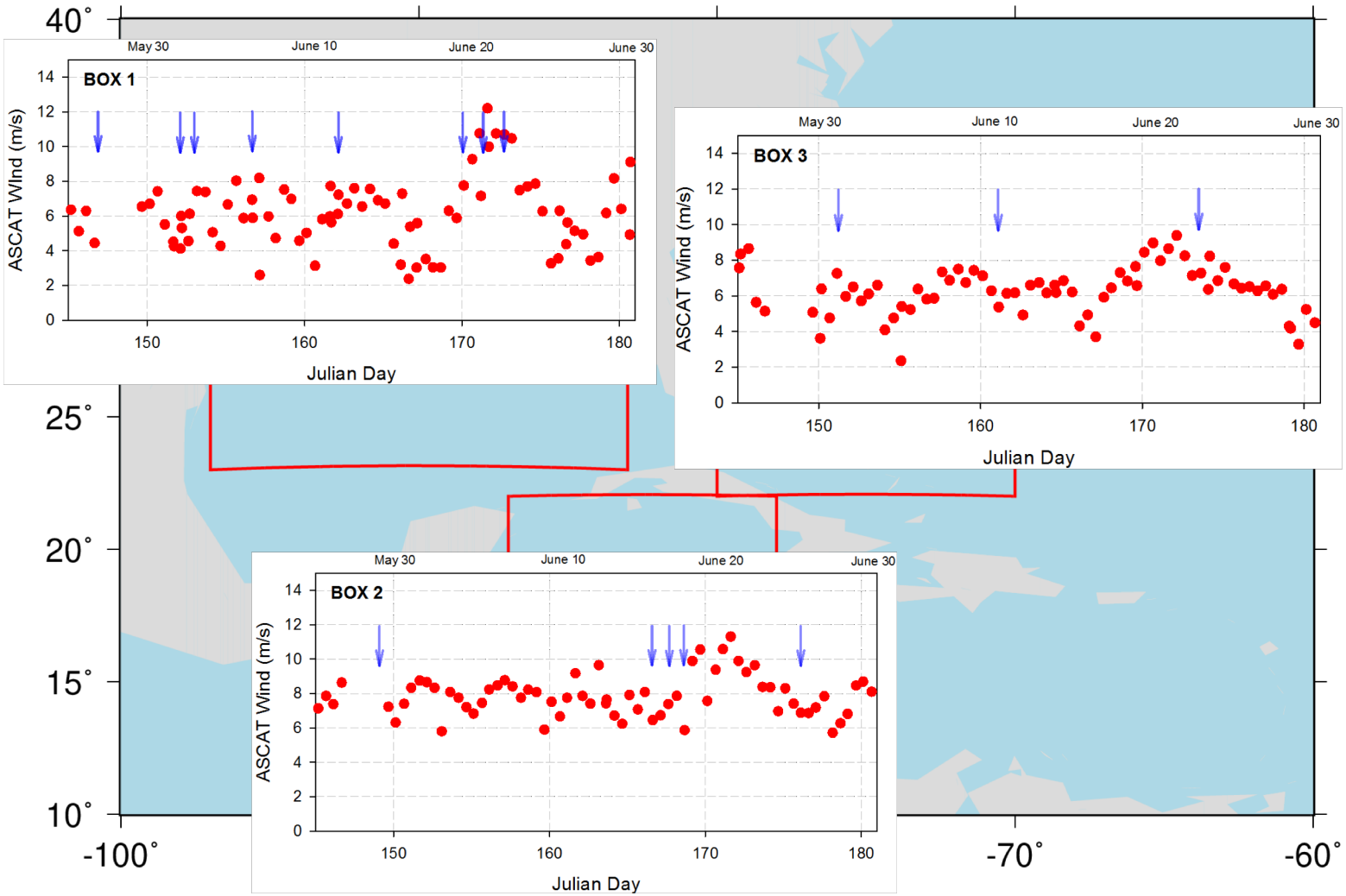


Pattern comparison

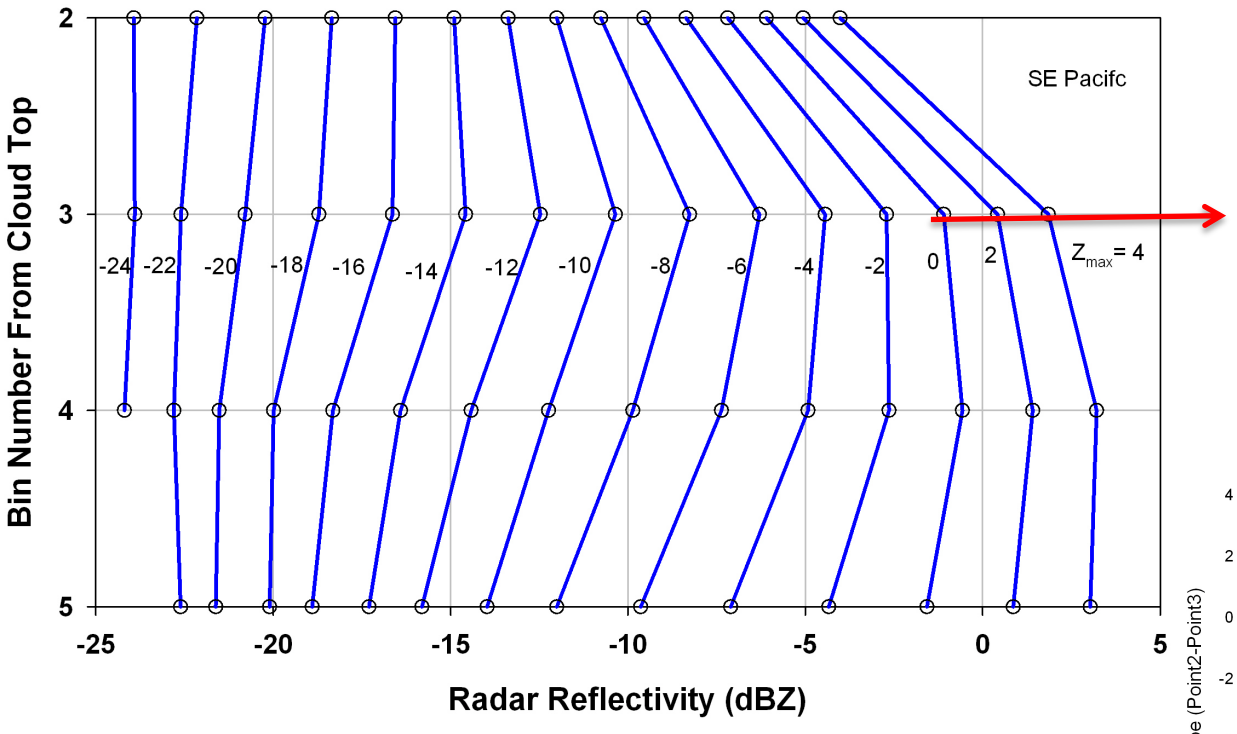
LWP @ onset

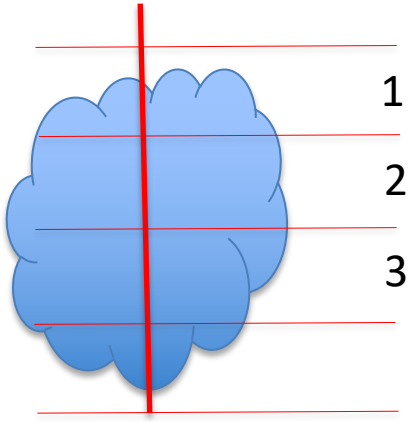


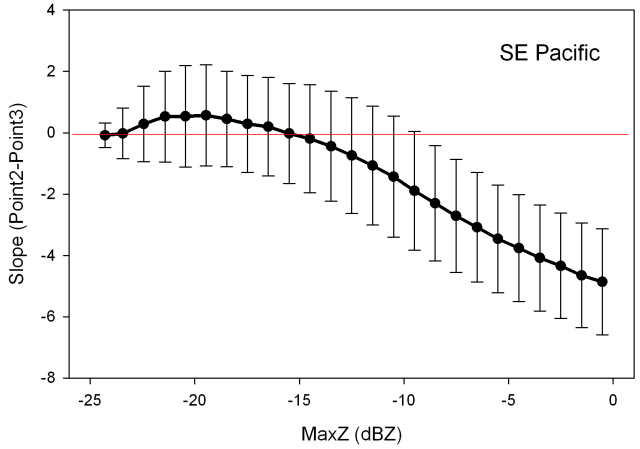
Wind -ASCAT


40˚
25˚
20˚
15˚
10˚
-100˚
-70˚
-60˚
May 30
June 10
June 20
June 30
BOX 1
ASCAT Wind (m/s)
Julian Day
BOX 3
ASCAT Wind (m/s)
Julian Day
BOX 2
ASCAT Wind (m/s)
Julian Day

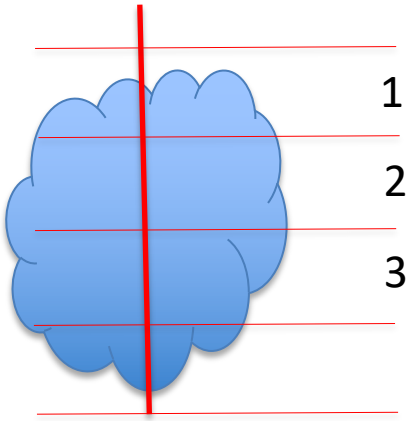
Vertical Profiles of CloudSat CPR warm clouds only, S.E. Pacific

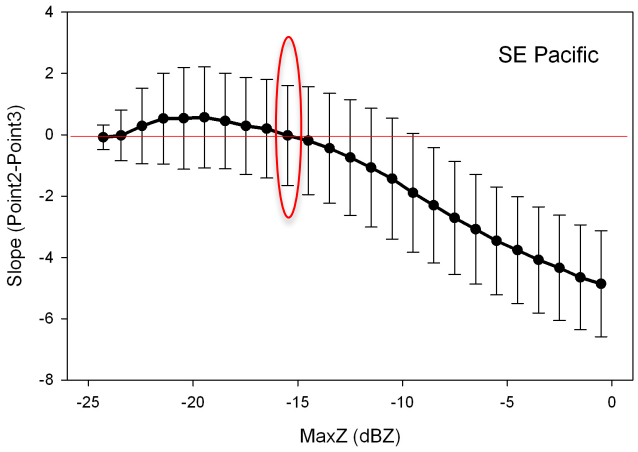






Determine LWP at drizzle onset





1. Find pixels with Slope23 ~ 0 dBZ (-0.2 to 0.2)

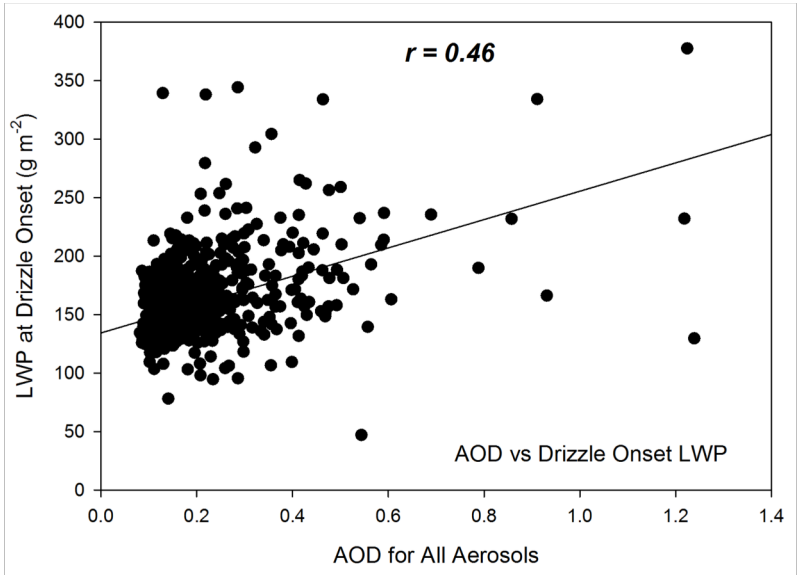
2. Collocate AMSR-E/2 pixel, find its LWP

3. Average over time (monthly, seasonally, annually) and area (1°x1°, 2°x2°,…)

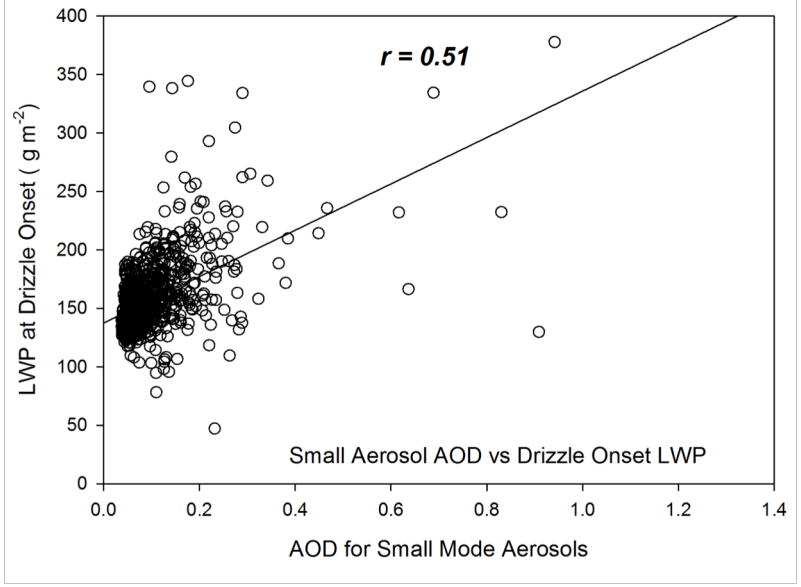
4. Find aerosol (AOD) in the same time & spatial scale, look for correlations

Correlations: AOD vs. LWP_onset

All Aerosols



Small Mode Aerosols only

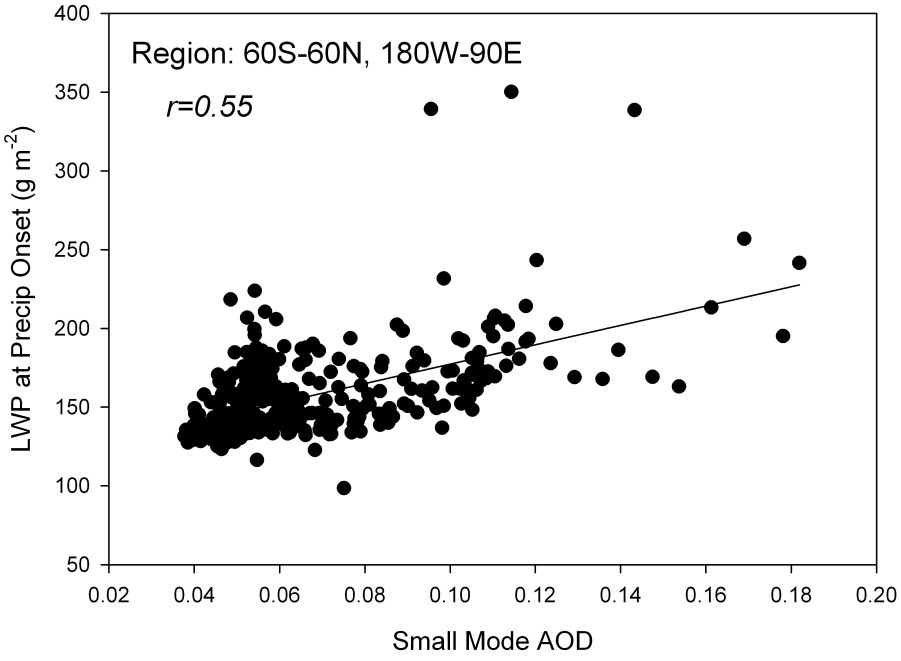


- ocean only data
- averaged over 5x5 degree
- 45S – 45N Latitudes
- 2006 – 2010

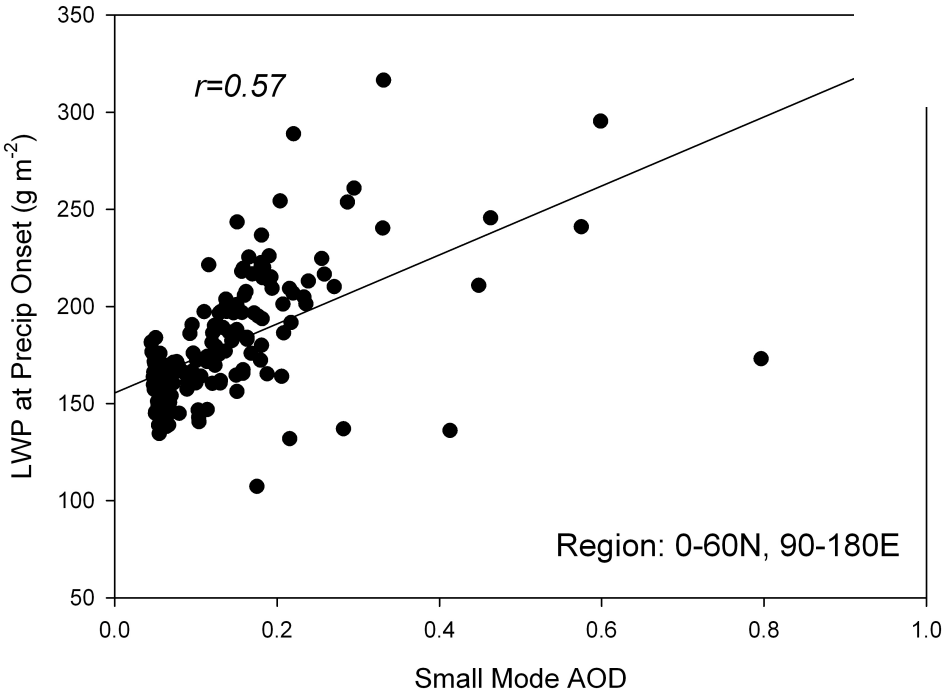
- AOD – MODIS (Terra&Aqua)
- LWP – Wentz (NSIDC)

Just part of globe

West Portion (clean)



East Portion (polluted)



Better correlation if confine data within a smaller region

GPM/IMERG Rain