Clouds with Low Optical Water Depths (CLOWD)

Retrieval Algorithm Intercomparison using BBHRP

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Algorithm Participants

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Participants

- Dave Turner – MIXCRA, MWRRET
- Sasha Marshak and Christine Chiu – 2NFOV
- Chuck Long – Radiative Flux Analysis
- Qilong Min – MFRSR
- Mandy Khaiyer and Pat Minnis – VISST (satellite based)

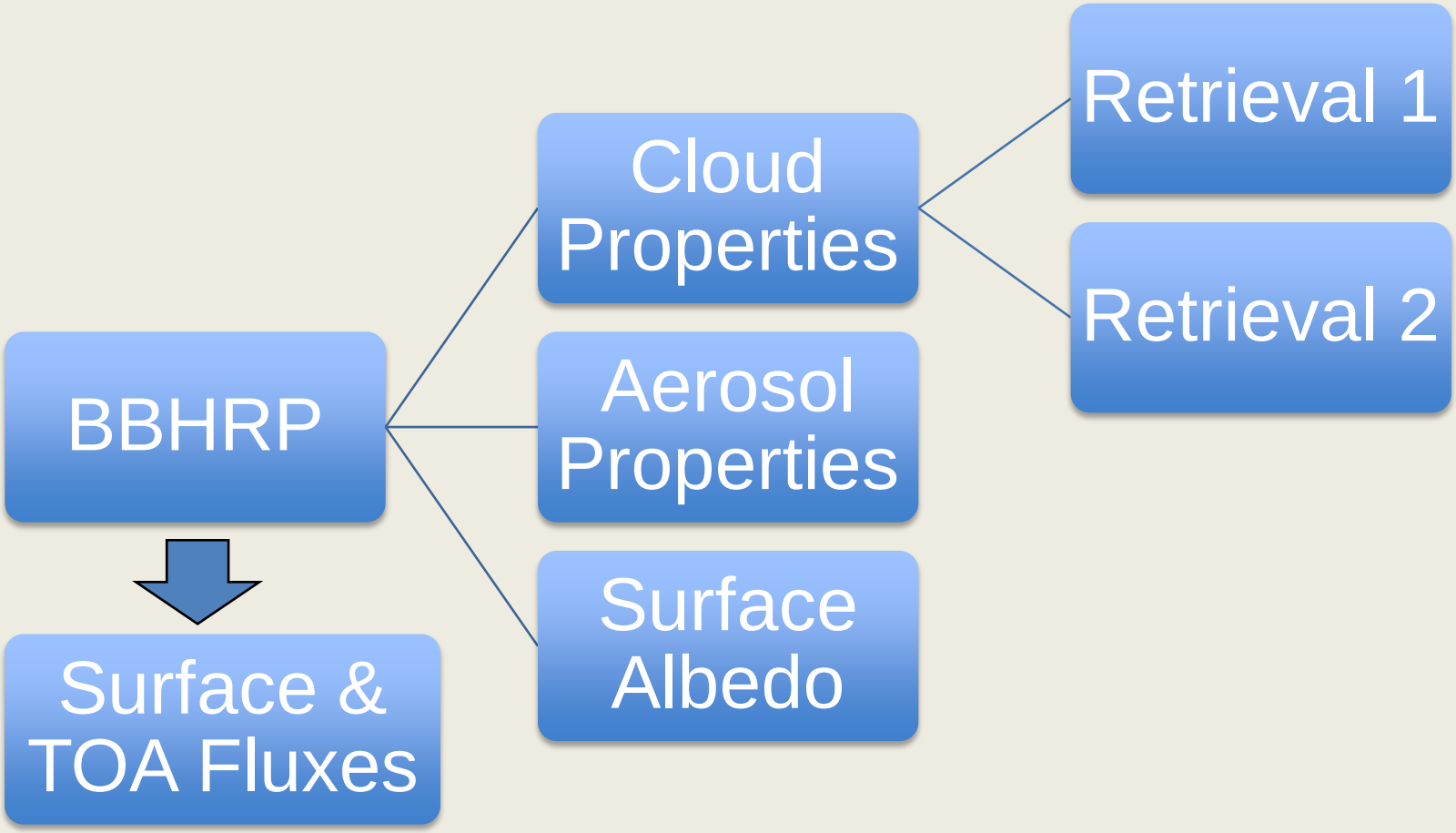
Overview

- CLOWD – Clouds with Low Optical Water Depths
  - LWP<100 g m^{-2}
  - Over 50% of liquid water clouds at SGP are CLOWD's (Marchand et al. 2003)
  - ~80% in the Arctic (Shupe and Intrieri 2004)
  - ~90% of nonprecipitating liquid clouds at Nauru (McFarlane and Evans 2004)
- BBHRP (Broadband Heating Rate Profiles)
  - Radiative transfer algorithm RRTM
  - Use BBHRP framework to vet algorithms for a CLOWD VAP or Cloud Properties Best Estimate
  - Series of surface and TOA radiative flux closure exercises

Overview

- Past intercomparisons
  - Turner et al. BAMS (2007) Case studies
- Next Steps
  - Develop statistical dataset of low LWP clouds (<100 g/m^2) for different CLOWD types
  - Pt. Reyes July-Aug 2005 (Stratiform clouds, i.e., single-layer and plane-parallel-ish)

Analysis Steps



BBHRP Inputs

- **Surface Spectral Albedo**
  - Compute broadband albedo to capture day-to-day variations
  - Use MODIS spectral albedo measured over Pt. Reyes to characterize spectral variations
  - Use “matching” high-resolution spectral albedo from SGP to help “map” to RRTM bands
  - Scale RRTM albedo using measured broadband albedo
- **Cloud boundaries derived from radar and lidar data**
- **Assume no aerosols**

Retrieval Algorithms

Retrieval	Participant	Spectrum	Optical Depth	LWP	Effective Radius
MFRSR	Min	Visible	X		X
2NFOV	Marshak/Chiu	Visible	X		
RadFlux	Long	Visible	X		
MIXCRA	Turner	Infrared	X	X	X
MWR-RET	Turner	Microwave		X	
VISST	Minnis/Khaiyer	Infrared and solar (satellite)	X		X

Microphysical Properties

- If no r_{eff} is submitted:
  - Maritime clouds mean r_{eff}~7.0 microns
  - Normalized height $H=(z-z_b)/(z_t-z_b)$
  - $R_{eff}=3.75H+5.0$ (r_{eff}=5 at base and 8.75 at top)
  - Slope and size range from Miles et al. (2000) for maritime clouds
- If only Optical Depth is submitted, use r_{eff} at cloud top and compute LWP:

$$LWP = \frac{5}{9}\rho_w \tau\, r_{eff}$$

- For all cases, LWP is vertically distributed assuming

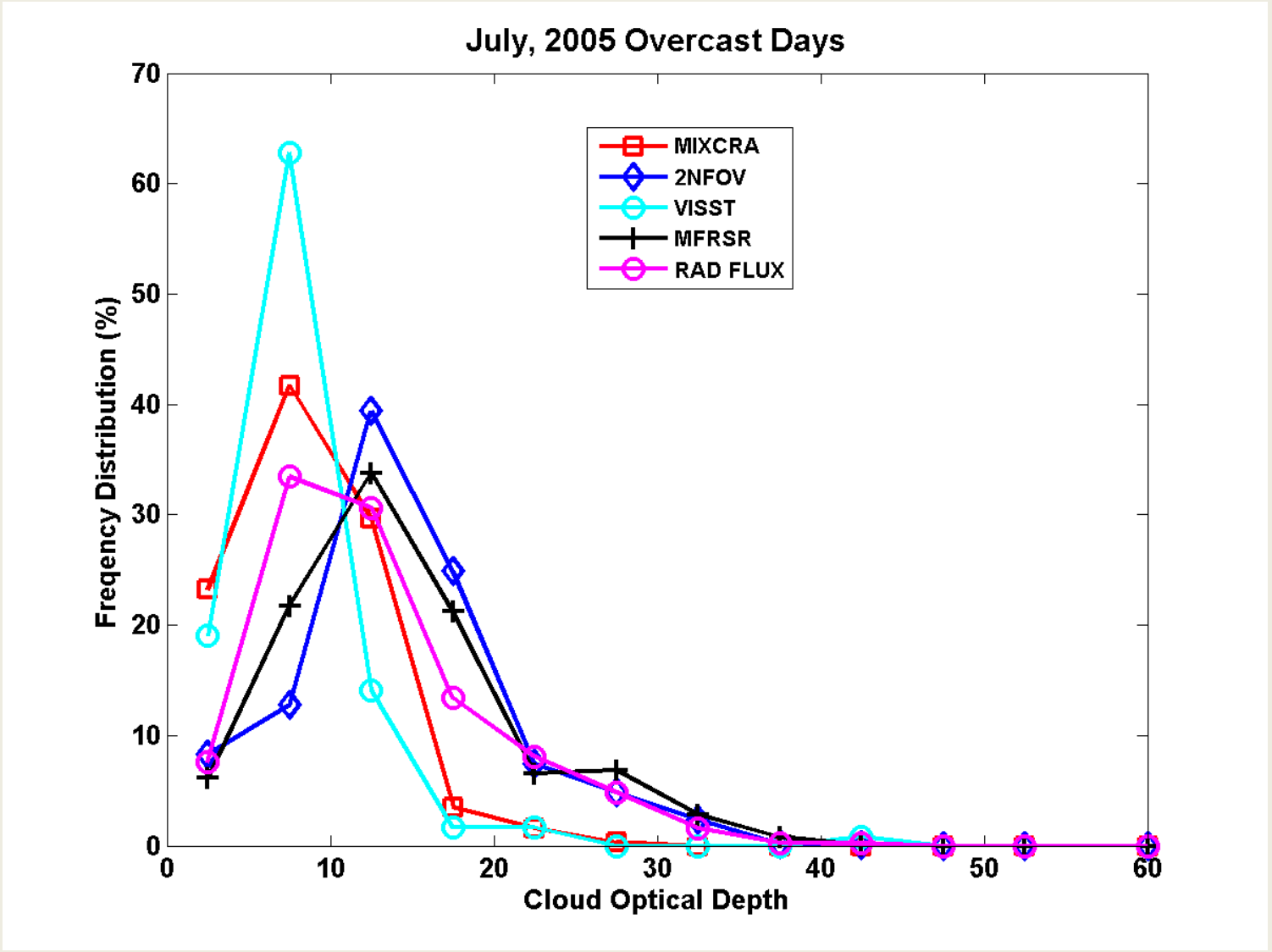
$$LWP = \int_0^h q_L dz = \frac{1}{2} f_{ad}\Gamma_{ad} h^2$$

$$LWC(z) = f_{ad}\Gamma_{ad} z$$

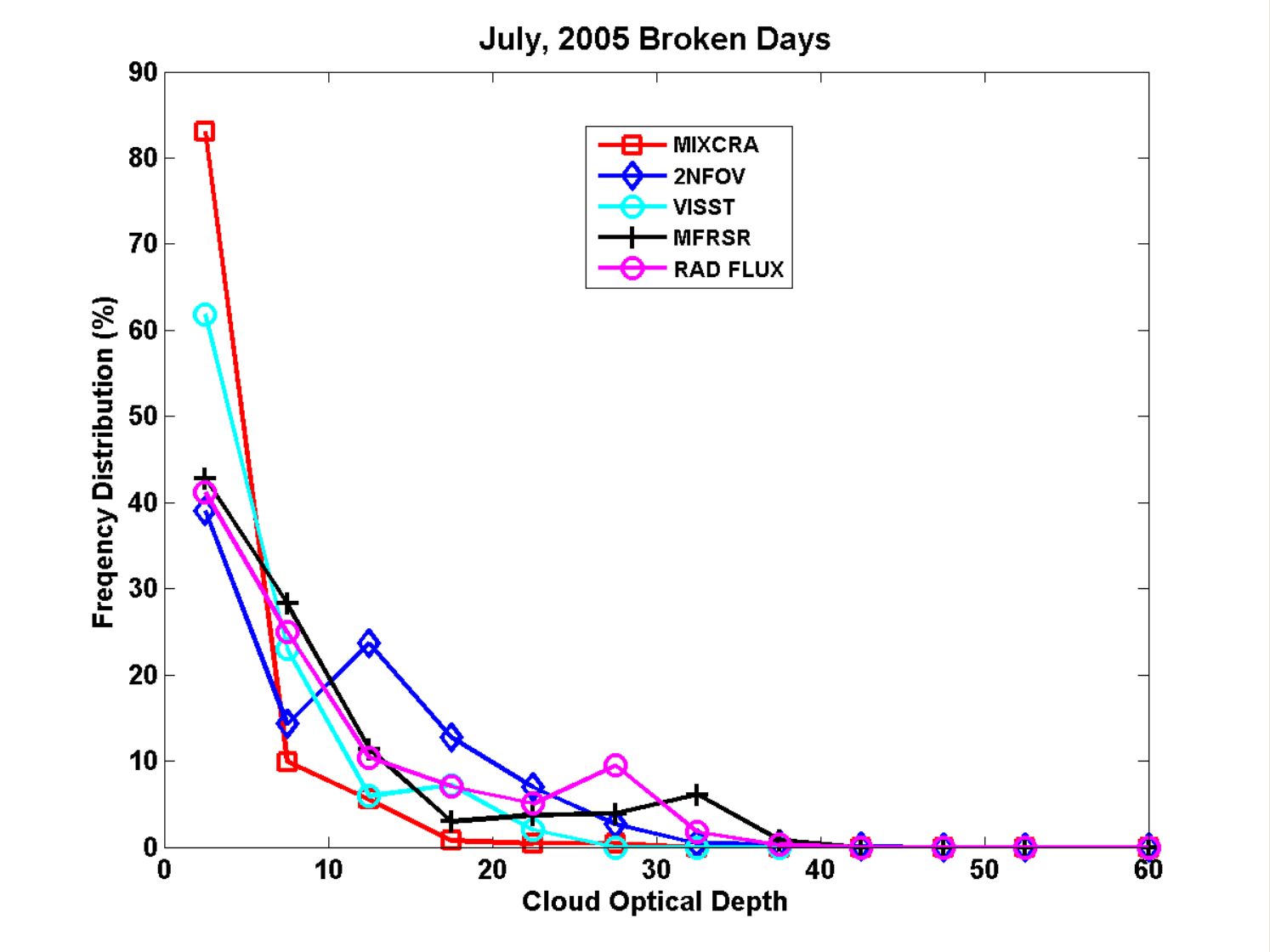
Evaluation

- Retrieved Microphysical Properties
  - Optical Depth
  - LWP
- Surface Flux Closure
  - Shortwave Flux Closure
  - Longwave Flux Closure
  - Segregate by Overcast and Broken Days
- TOA Albedo

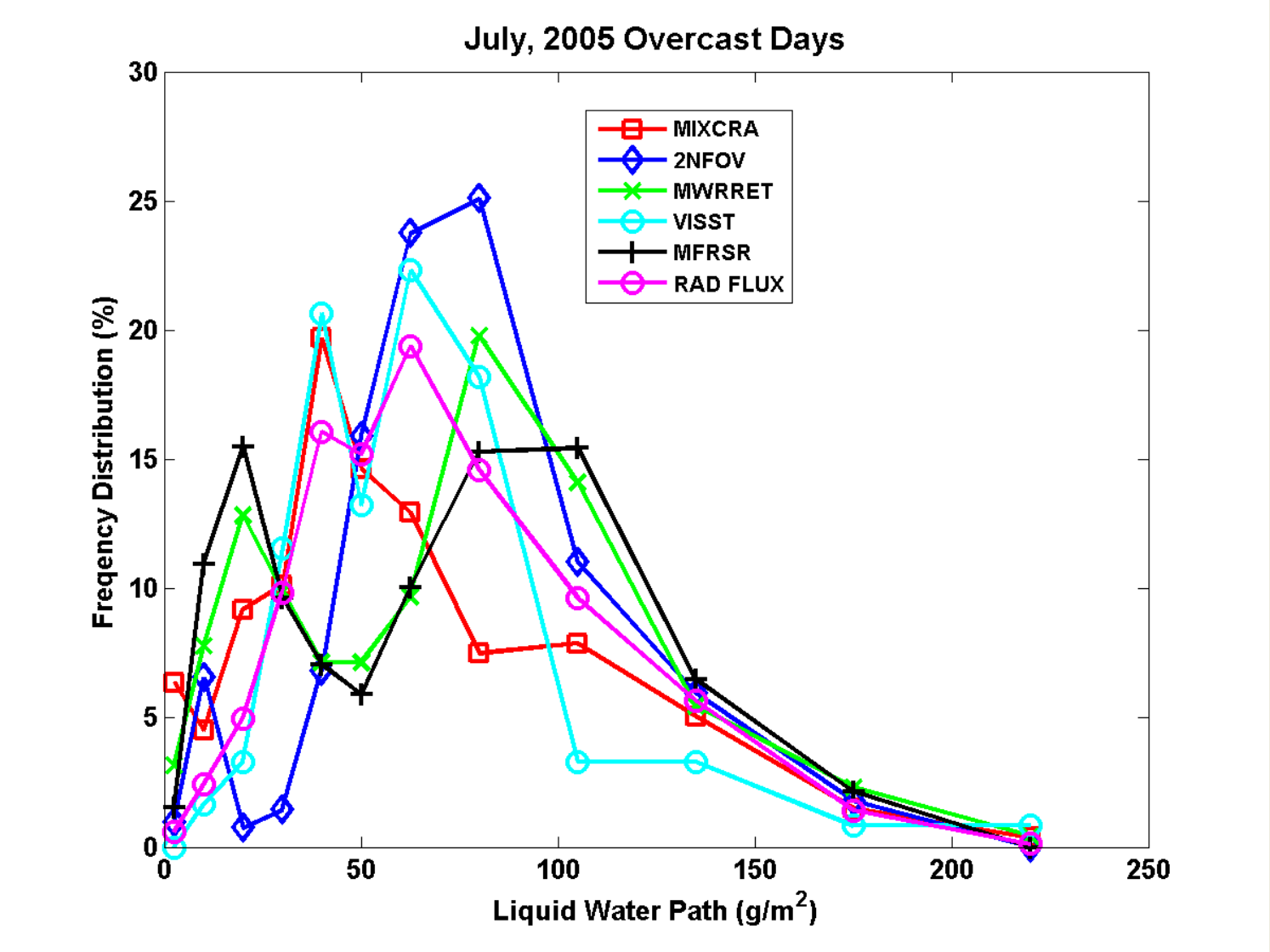
Cloud Optical Depth - Overcast



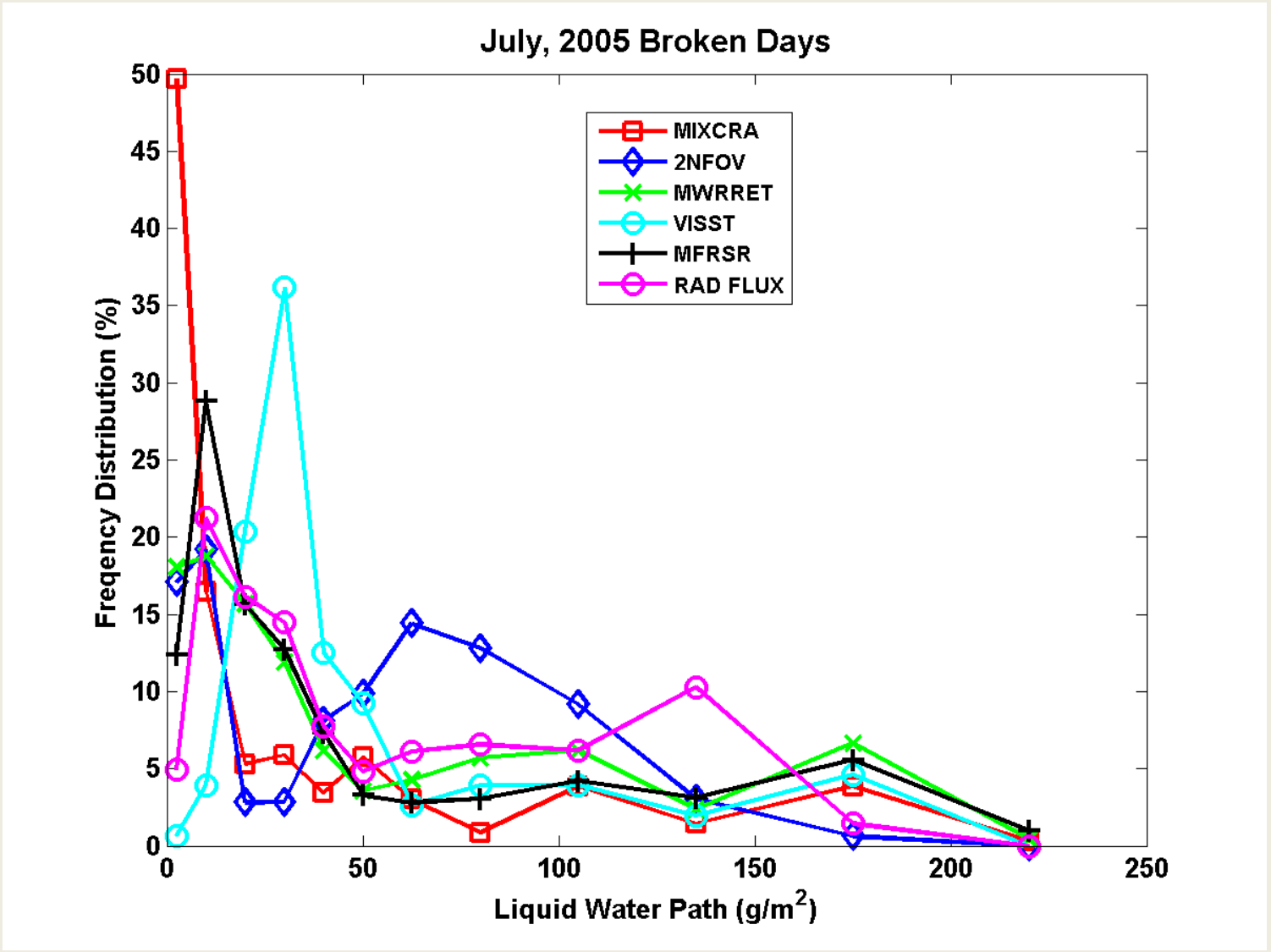
Cloud Optical Depth - Broken



LWP - Overcast



LWP - Broken


July, 2005 Broken Days
MIXCRA
2NFOV
MWRRET
VISST
MFRSR
RAD FLUX
Freqency Distribution (%)
Liquid Water Path (g/m2)
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250

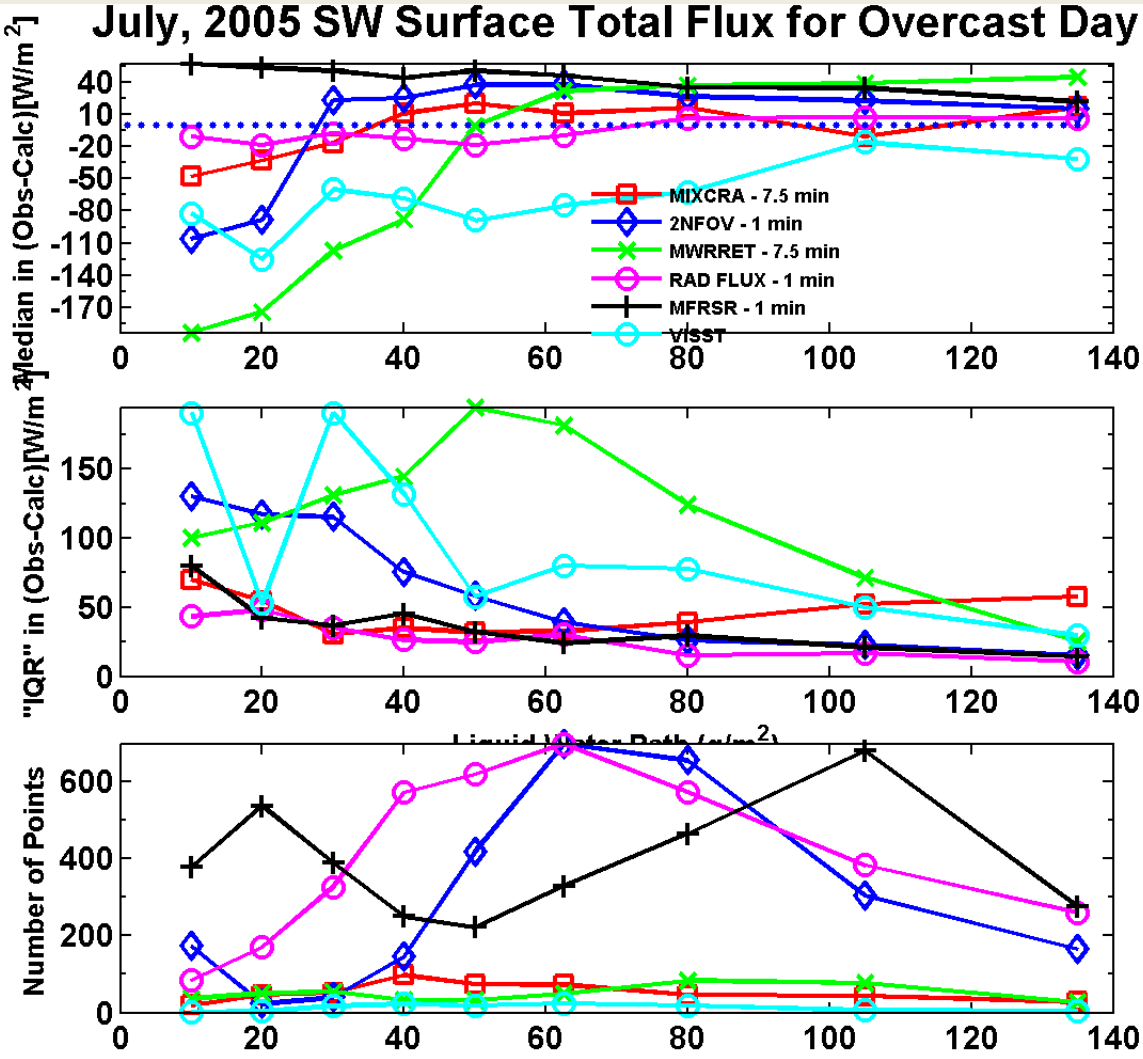
Shortwave Total Flux – Overcast

Atmospheric Radiation Measurement

Median Flux Residual

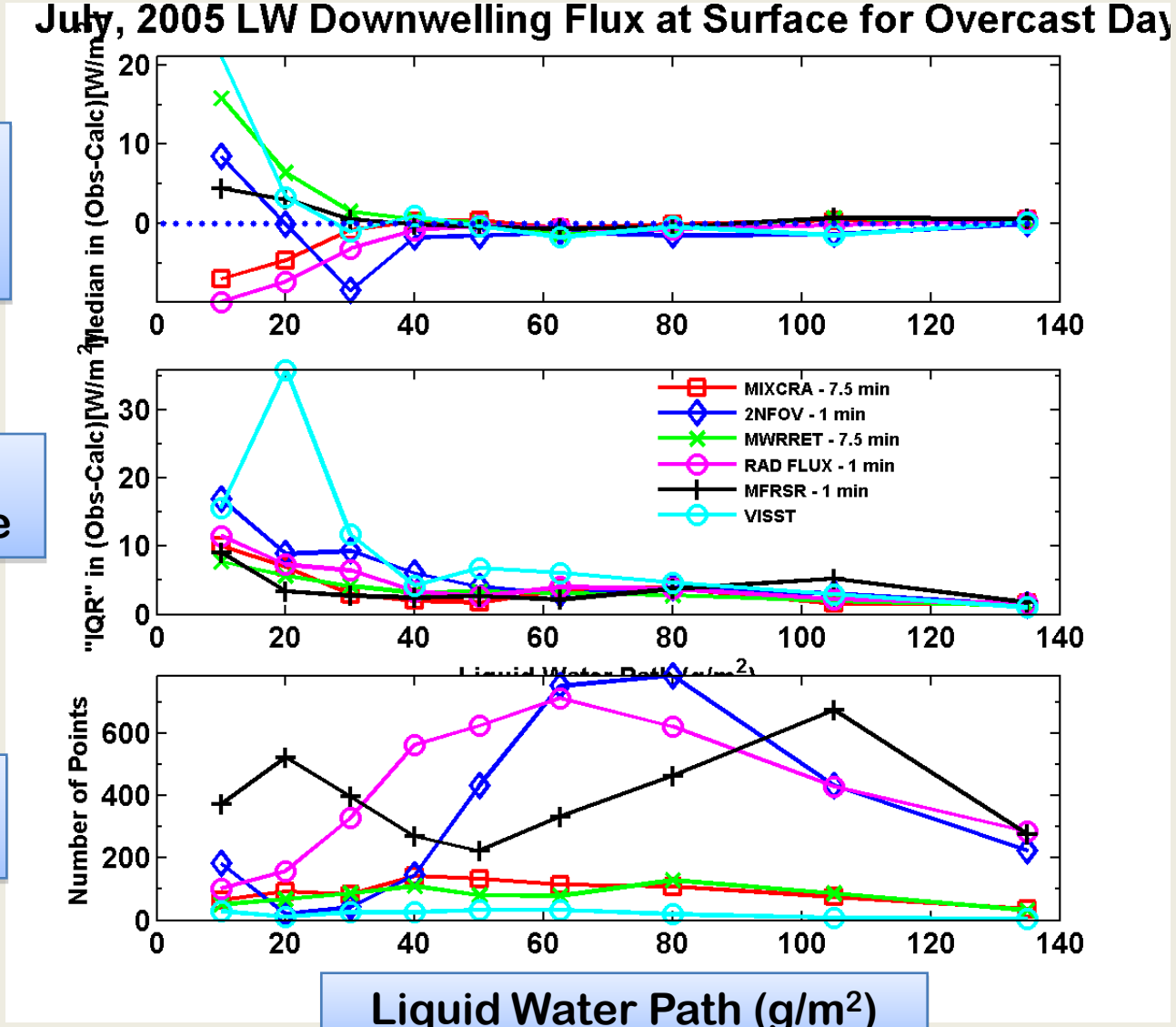
75th-25th Interquartile

Number of Points



Longwave Flux – Overcast

Atmospheric Radiation Measurement



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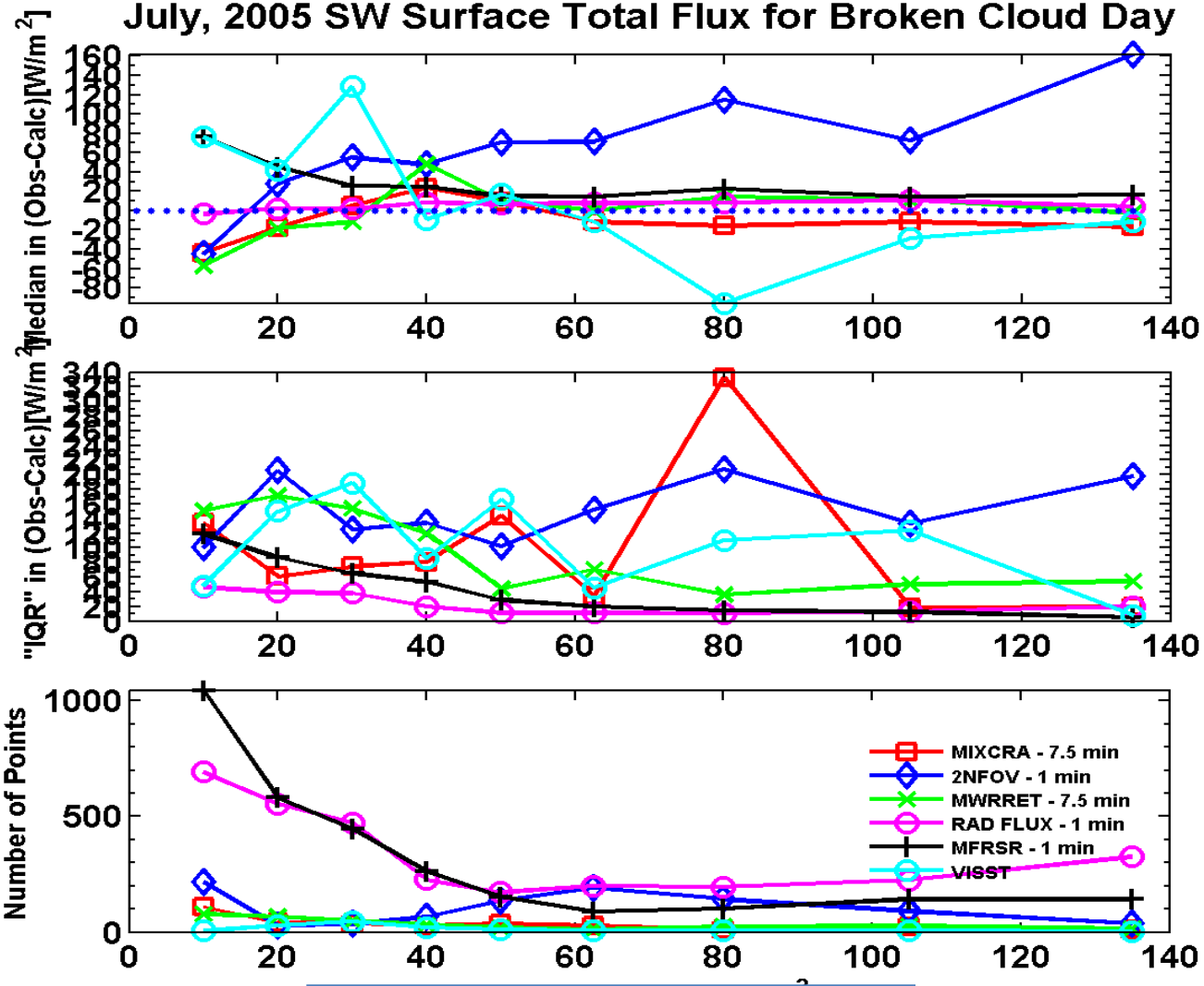

Longwave Flux - Broken

Atmospheric Radiation Measurement

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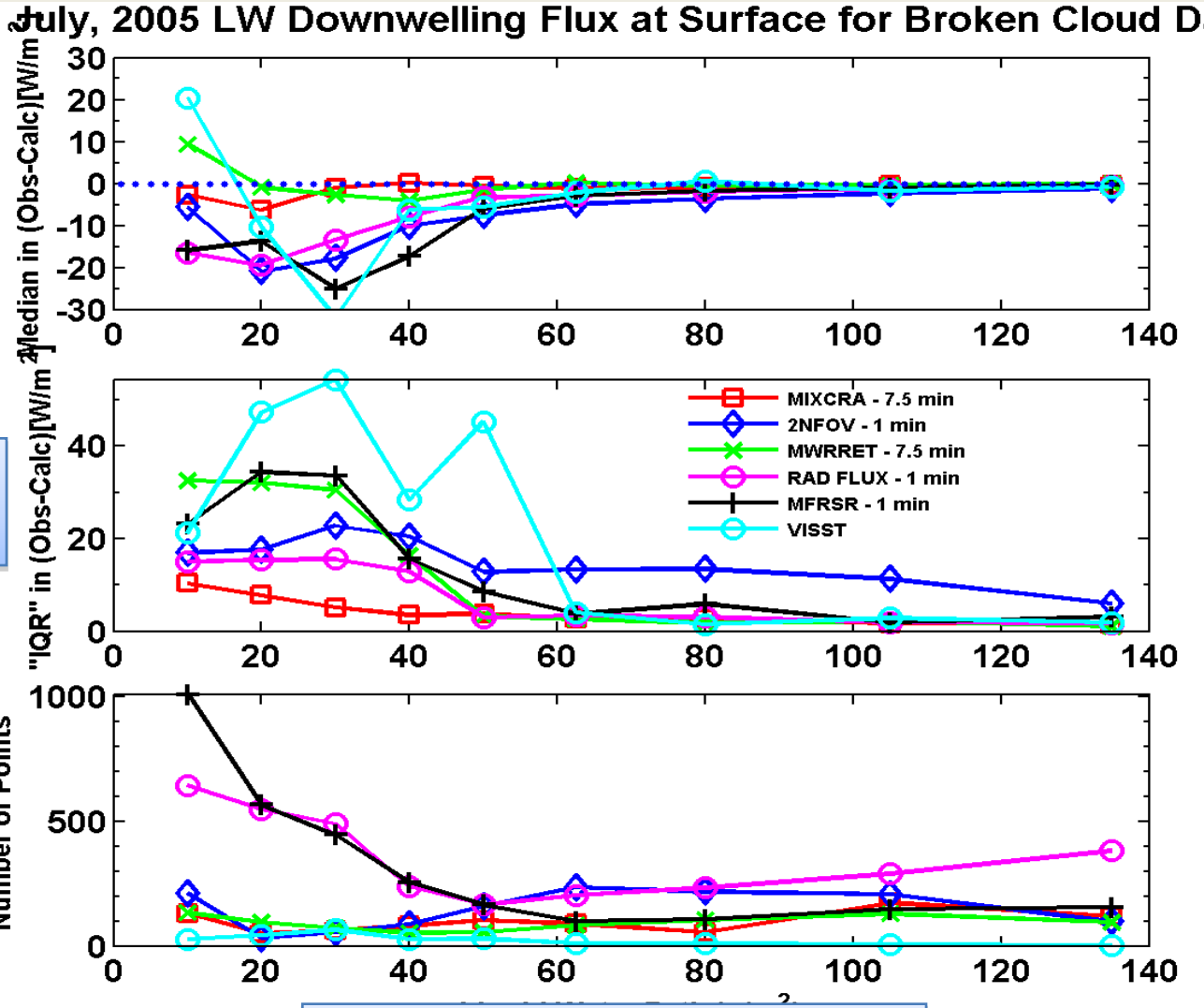
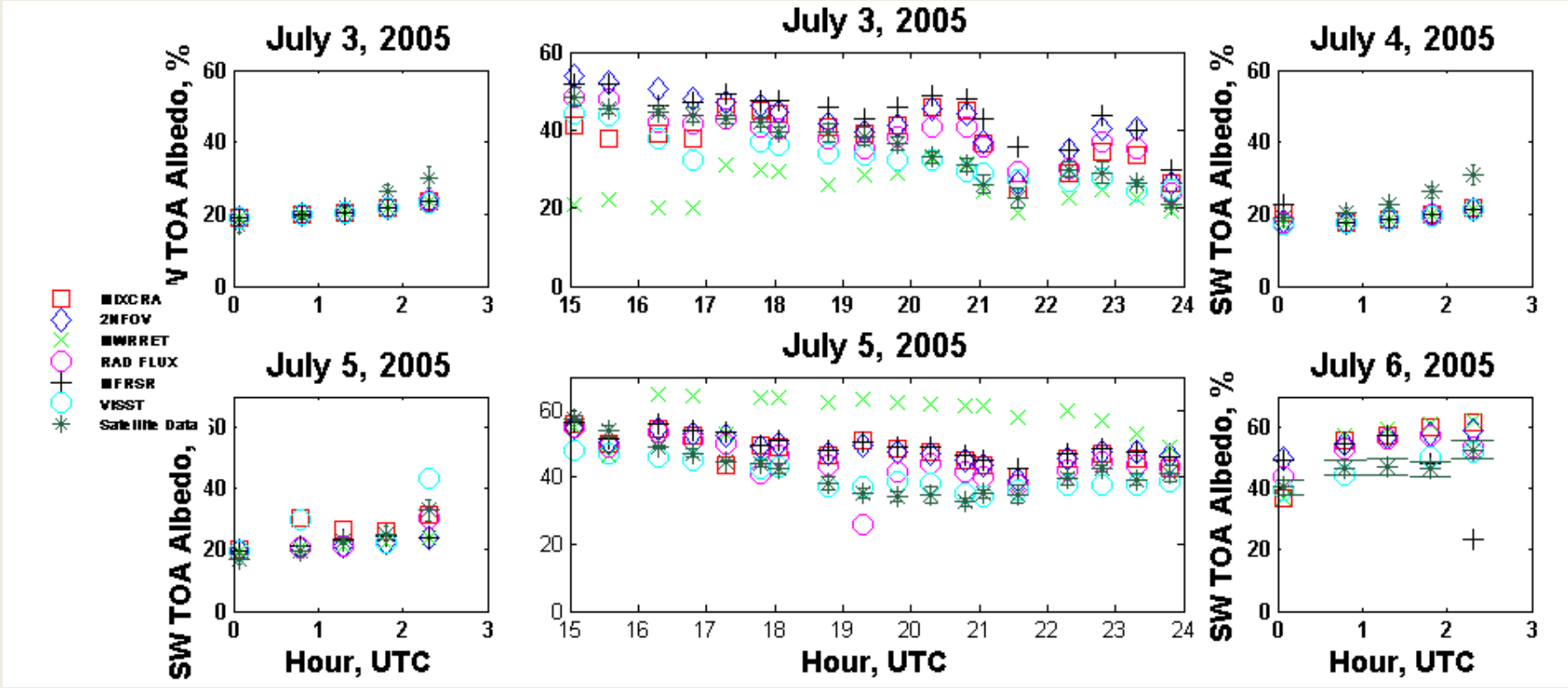
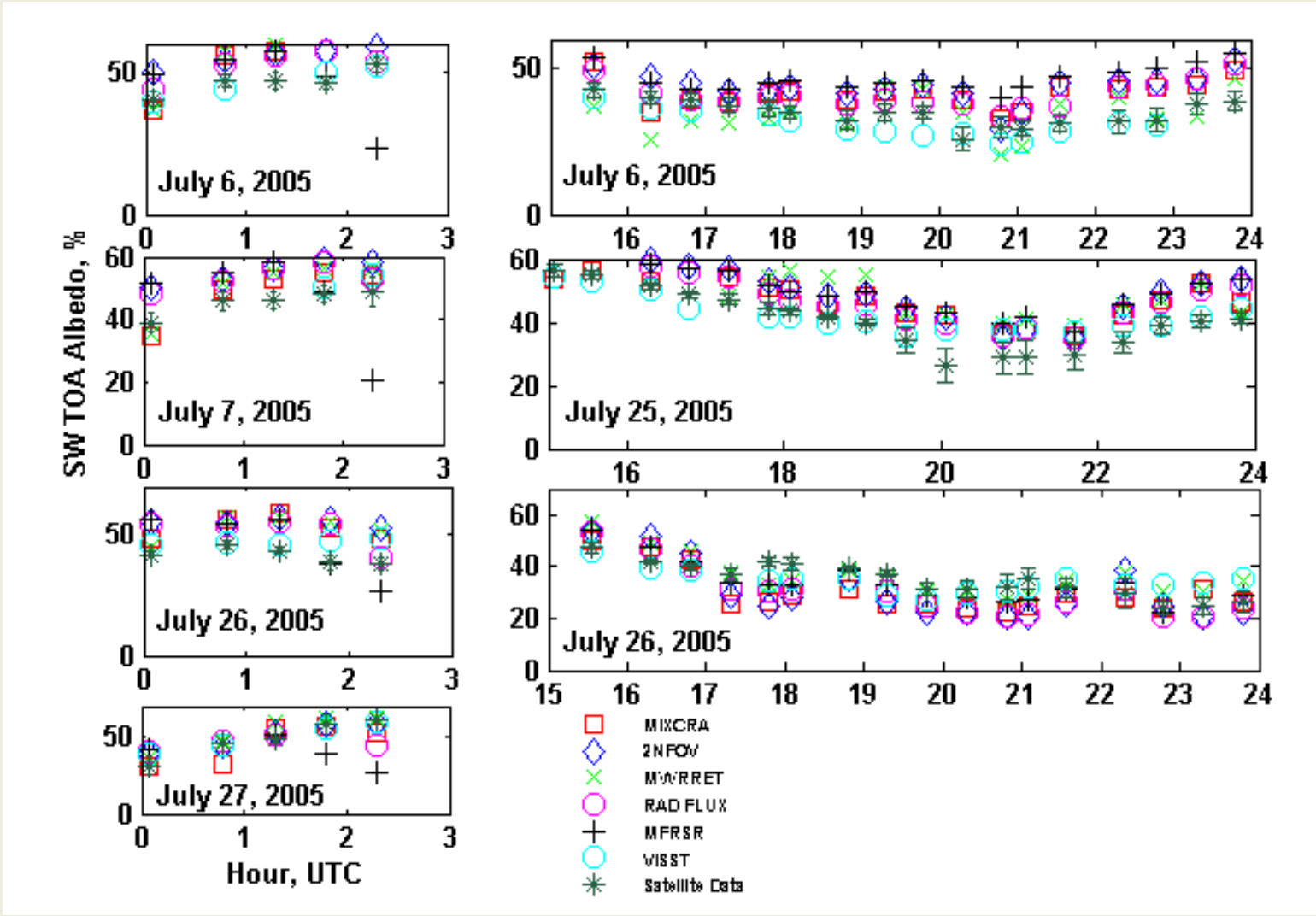


TOA Albedo for Overcast Days

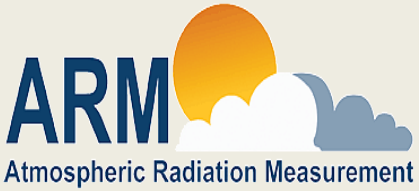


TOA Albedo for Overcast Days

ARM
Atmospheric Radiation Measurement



Discussion



- Most uncertainty lies below 25 W/m^2
- What metrics do we use to vet these algorithms?
- How should we move forward from here?
- Are there other sensitivities that we need to do?
  - Surface albedo
  - Effective radius