
# Identification of small ice cloud particles using infrared radiometric observations during SPartICus

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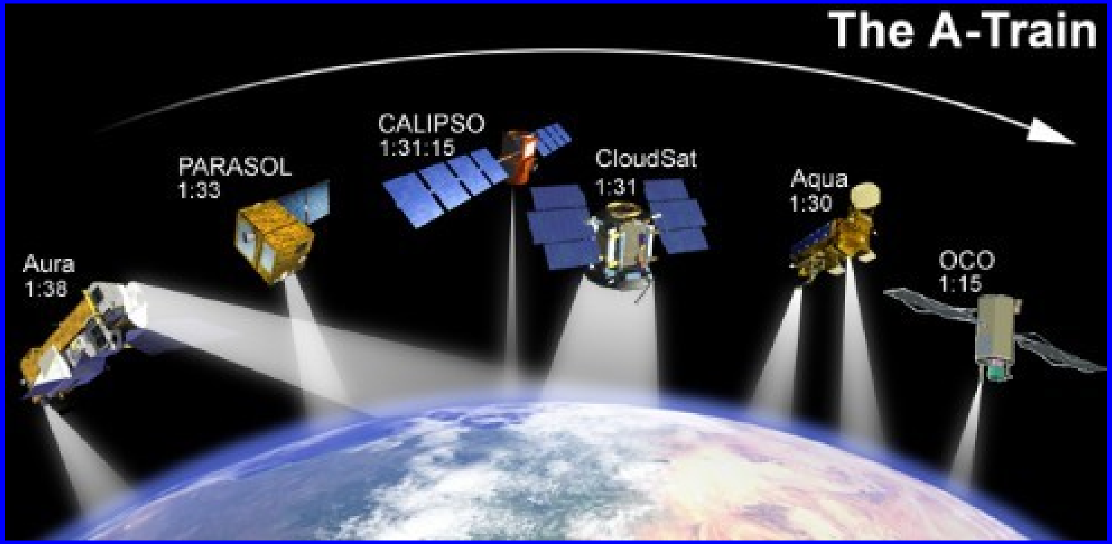
# Motivation

- Cirrus clouds play an important role in the regulation of climate




- Very different estimates of ice cloud properties for different techniques


- Different in-situ instrumentation yielded vastly different estimates of ice cloud particle size

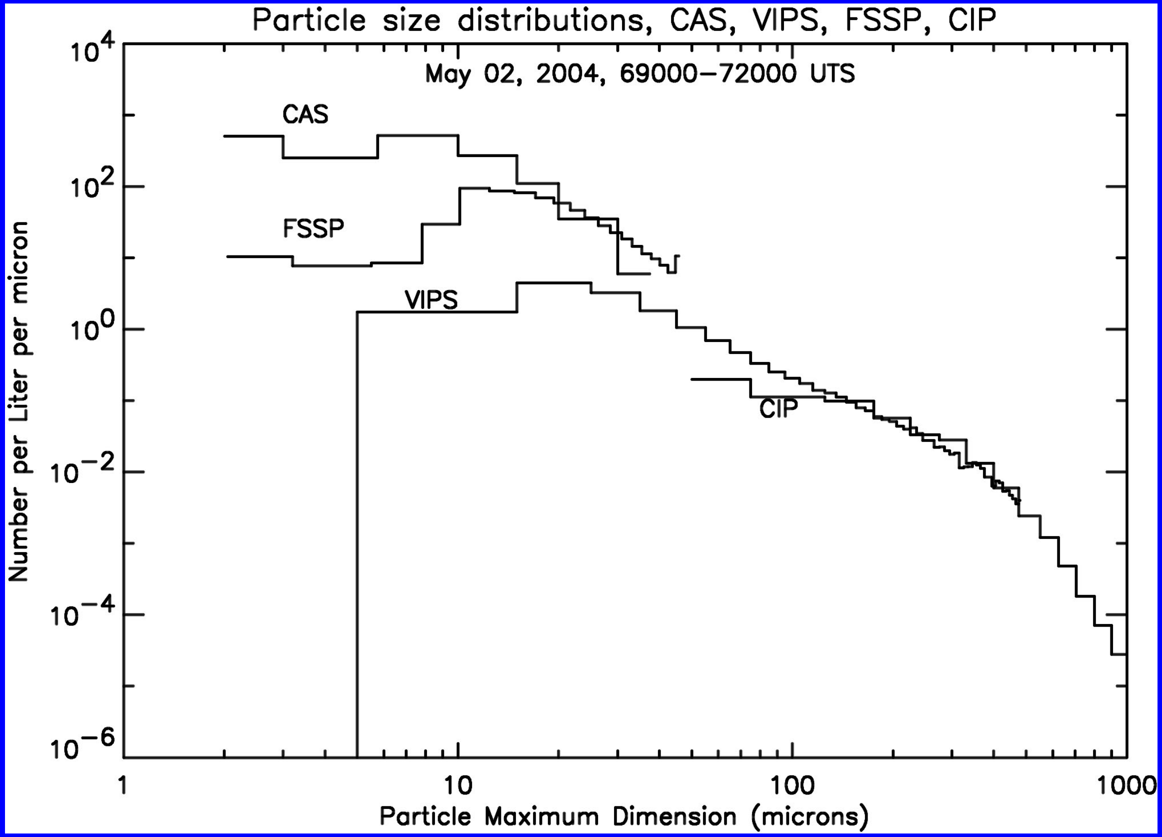



Figure from Andrew Heymsfield, MidCiX Workshop (2005)

# Probe Ice Particle Shattering

- In-situ measurements complicated by the possibility that ice particles may shatter during measurement

- Are observed small ice particles (< 20 μm) the result natural of cloud processes?

- Develop and apply passive remote sensing technique as a constraint on in-situ measurements from SPartICus

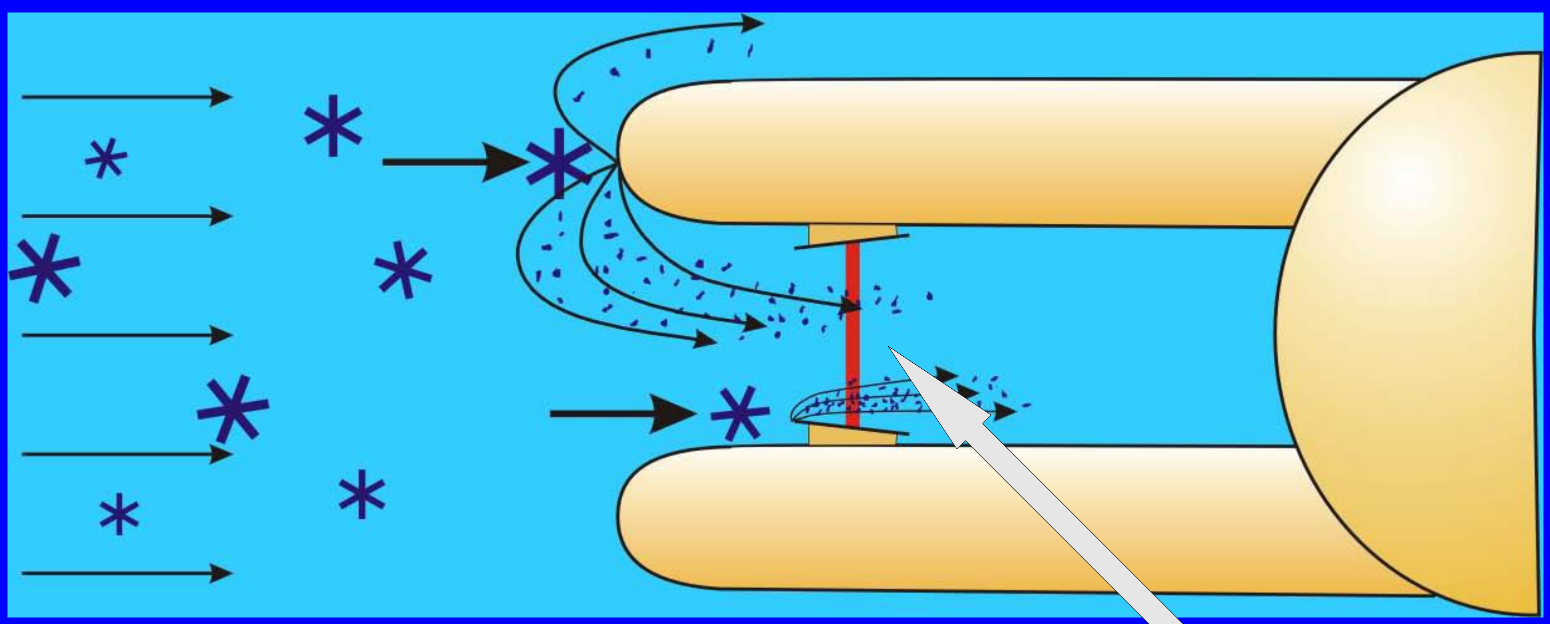


Figure from Alexei Koralev,
ARM Instrumentation Workshop (2008)

Probe Sample Volume

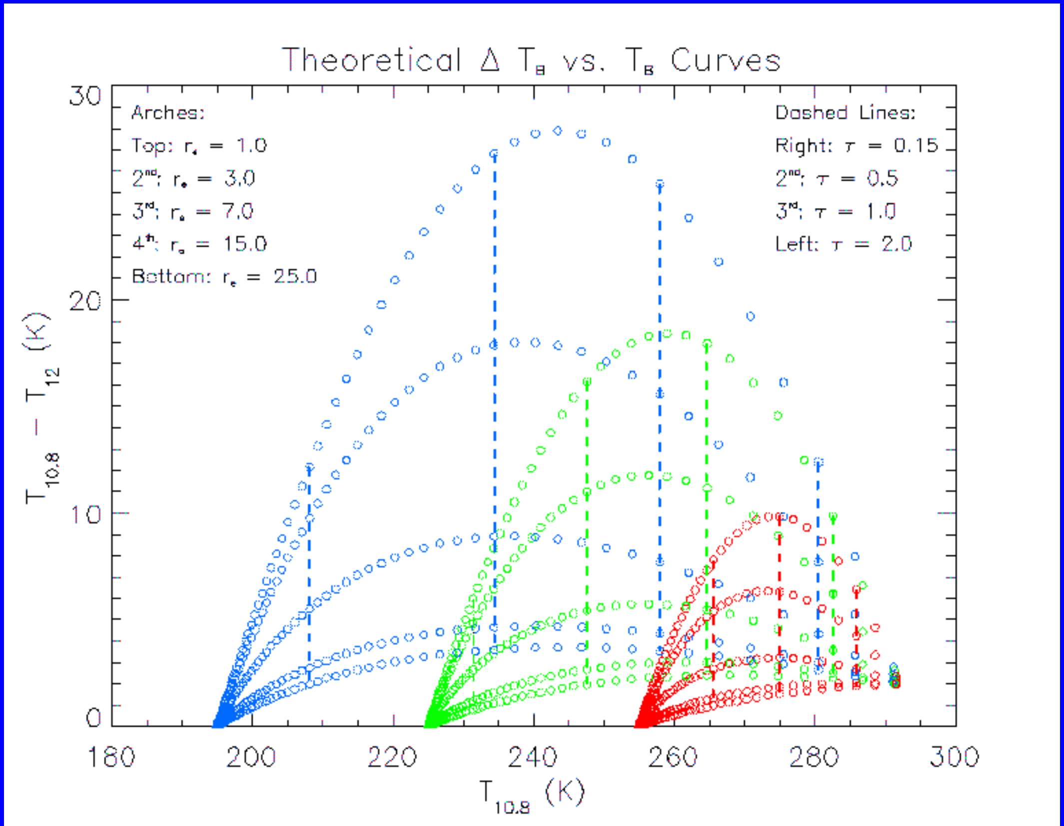
# How Best to Identify Small Particles?

- Choose non-invasive satellite technique to counter possible effects of shattering

- Information content considerations suggest 'split-window' technique is most accurate for thin clouds

- Based upon spectral variation of absorption by ice cloud particles across the window region

- Sensitivity range limited to thin clouds and reasonably small effective radii (< 30 μm)



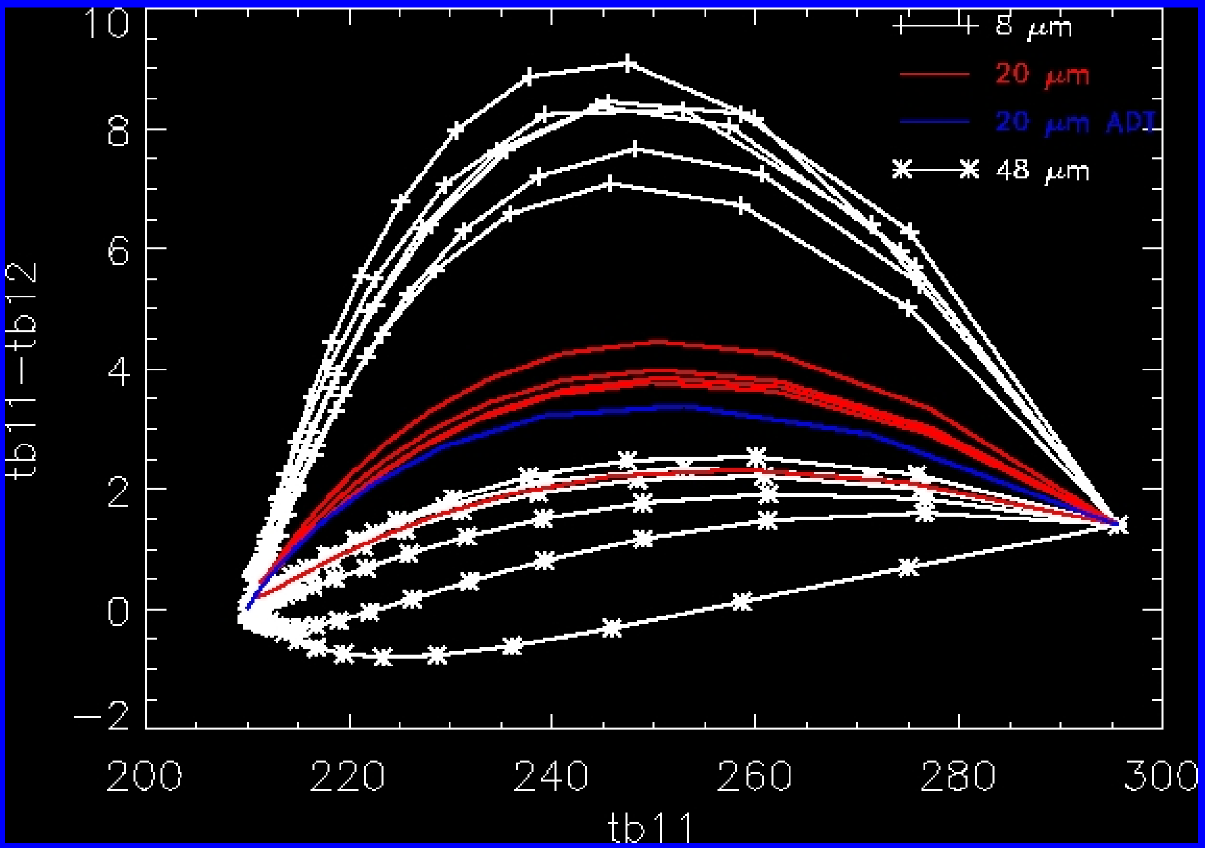
# Infrared Retrievals

## -Find infrared radiometric signatures that could only be associated with 'small' based upon expected uncertainties

Particle size, crystal habit, PSD, optical depth, cloud temp, and atmospheric temp and RH profiles all define shape of arches

- Regardless of assumptions, a sufficiently large (11.0 μm – 12.0 μm) brightness temperature difference guarantees a small particle

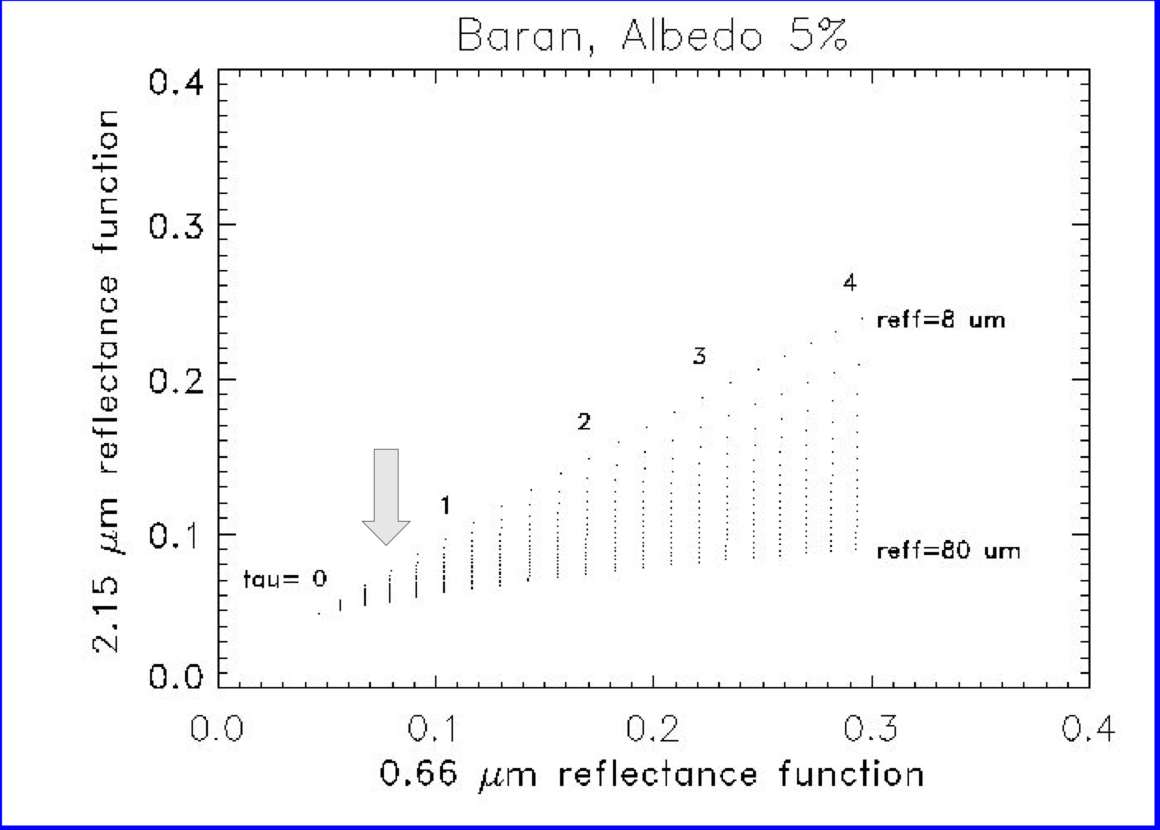
- Difference of 4K conservatively correlates to a particle smaller than 20 μm



# Difficulties with visible, near-infrared approach

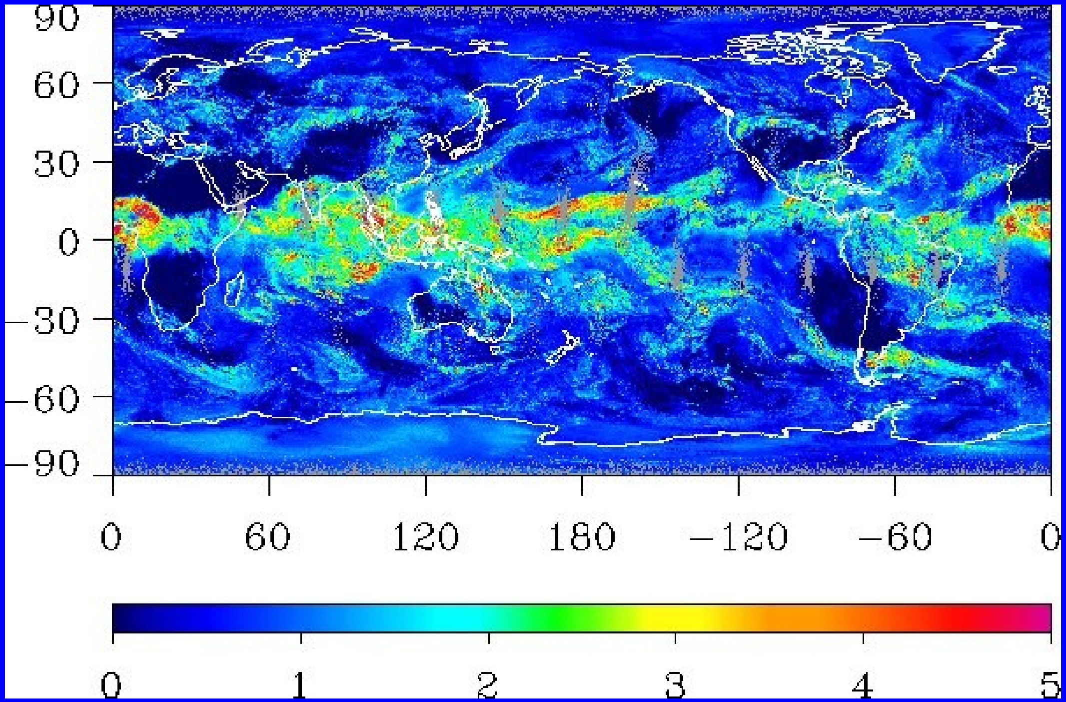
- MODIS operational technique based upon visible/ near-infrared measurements is heavily dependent upon specific ice crystal habit and surface albedo assumptions
  - For thin clouds, small changes in observed reflectances can result in large changes in retrieved effective radii.

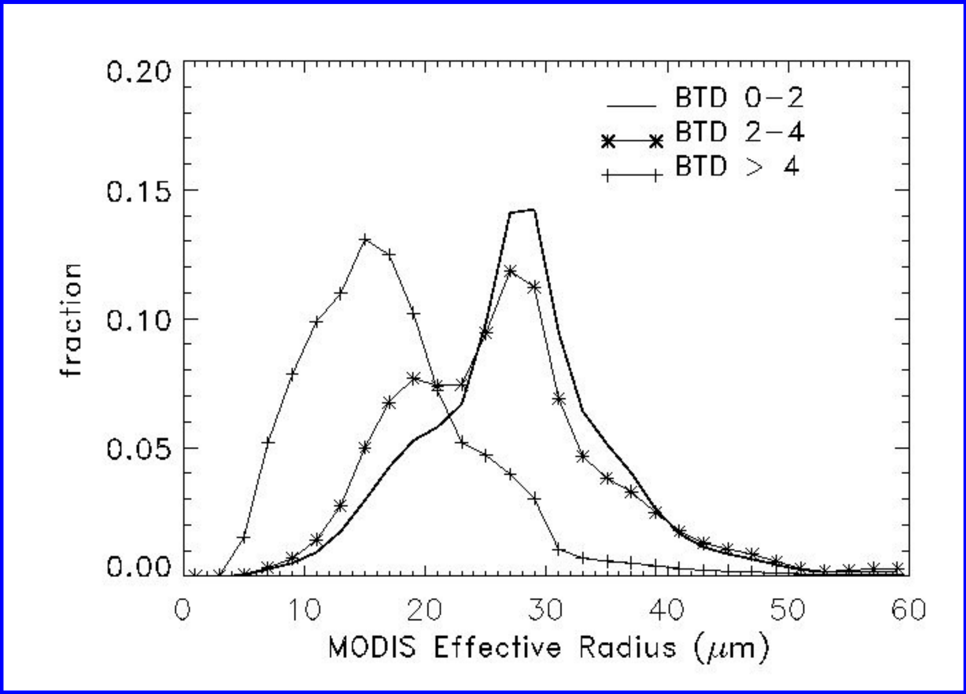
- Sample sensitivity calculation for optical depth 0.6
- 1% 'error' in absolute reflectance causes retrieved effective radius to shift from 8 µm to 40 µm
- 0.5% 'error' in absolute reflectance causes retrieved effective radius to shift from 20 µm to 40 µm



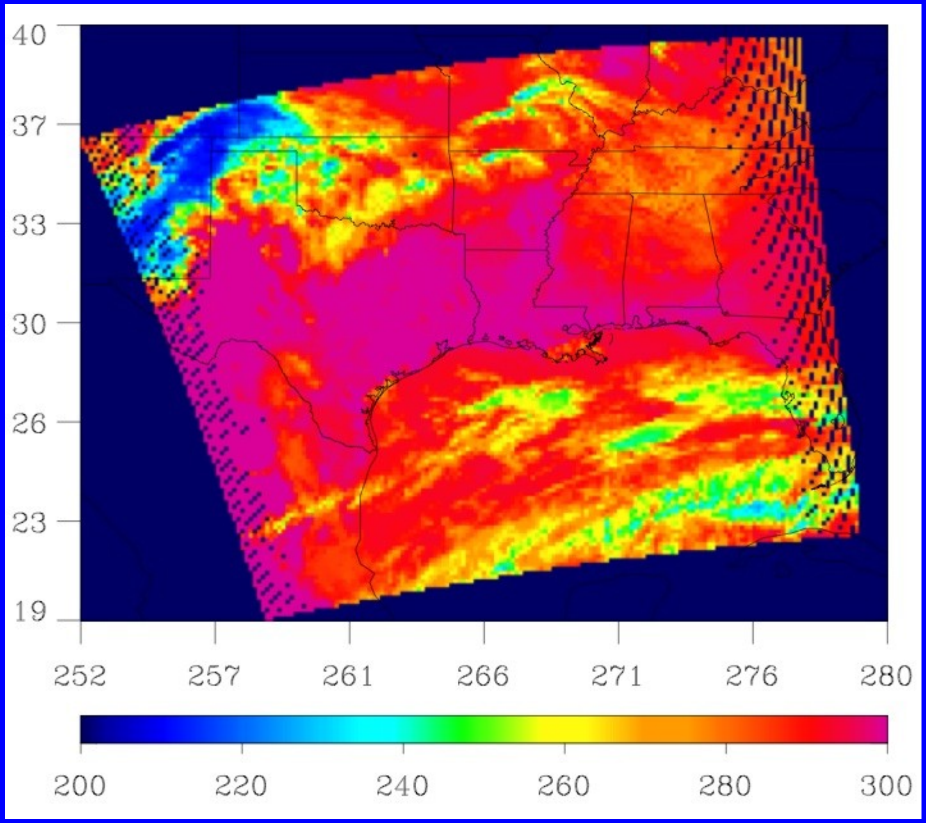
# Split-Window applied to MODIS observations

- Restrict thresh hold retrieval to thin, single-layer cirrus clouds
- ~ 15-20% of cirrus clouds composed of small ice crystals less than 20 μm

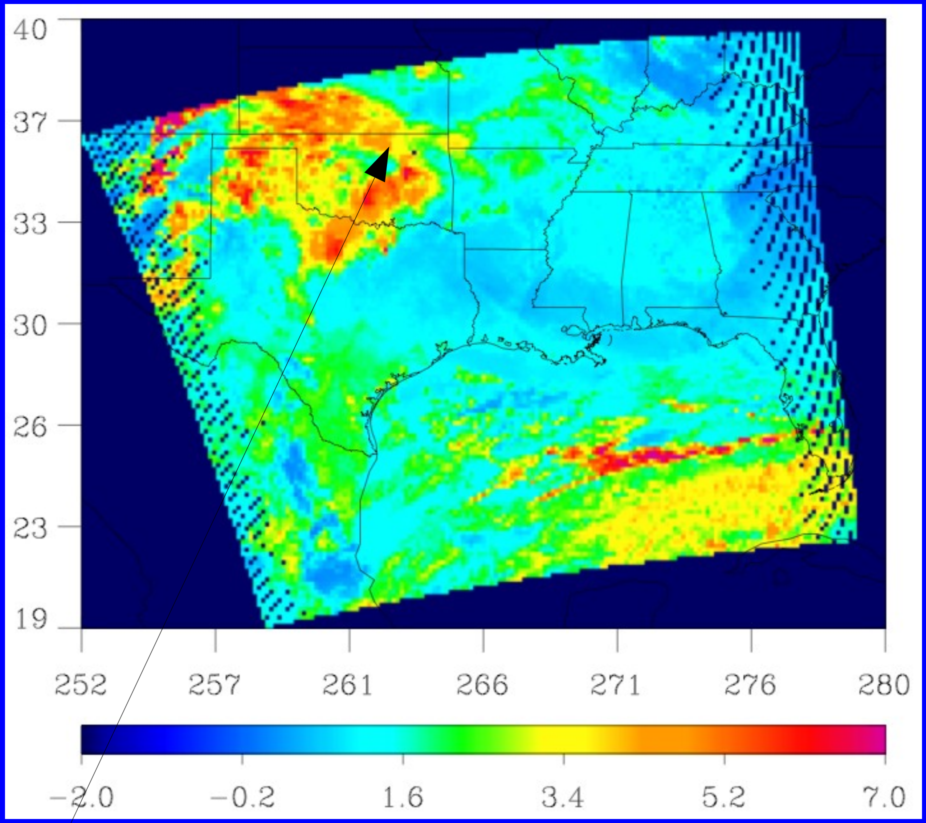


# SPartICus April 28- Small Crystal Case




11 µm Brightness Temp (K)



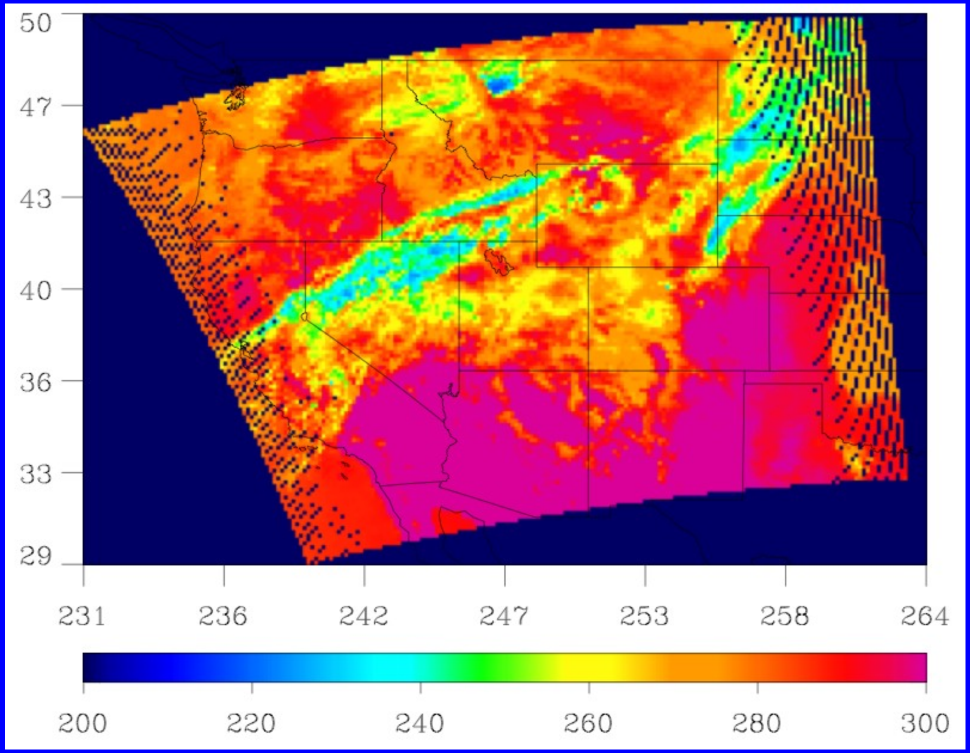

11-12 µm BTD (K)

Plane Location in Oklahoma

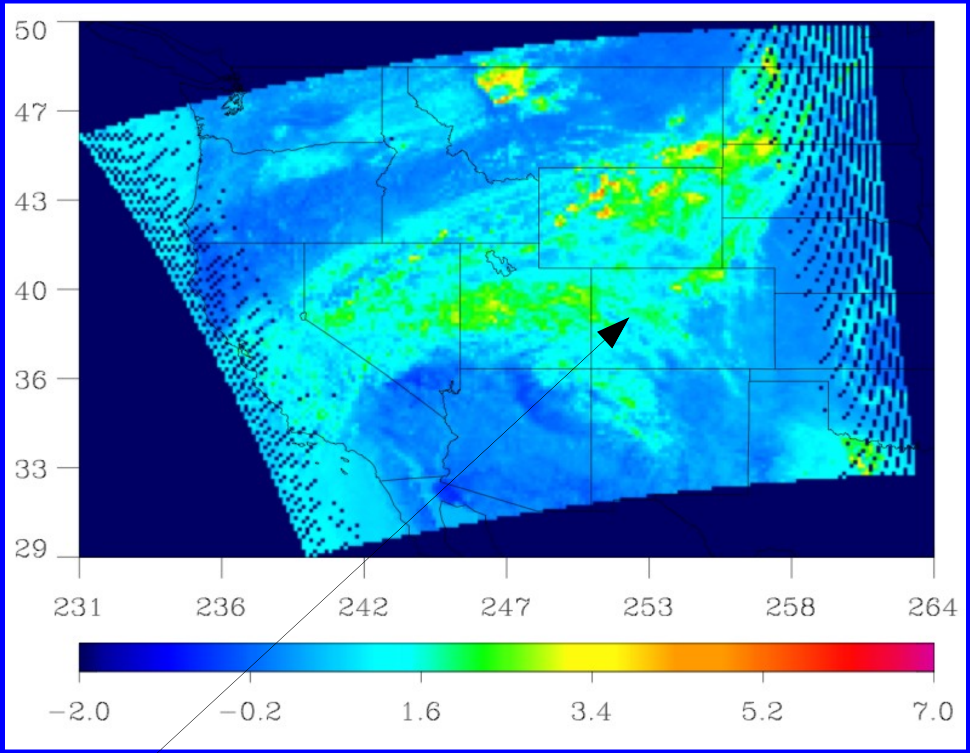
High brightness temperature differences (>4K) for thin cirrus suggest small ice particles < 20 µm

2D-S measurements suggest 17 µm effective radii

# SPartICus March 17- Large Crystal Case




11 µm Brightness Temp (K)




11-12 µm BTD (K)

Plane Location in western Colorado

Low brightness temperature differences (~2K) for thin cirrus suggest large ice particles

2D-S measurements suggest 38 µm effective radii

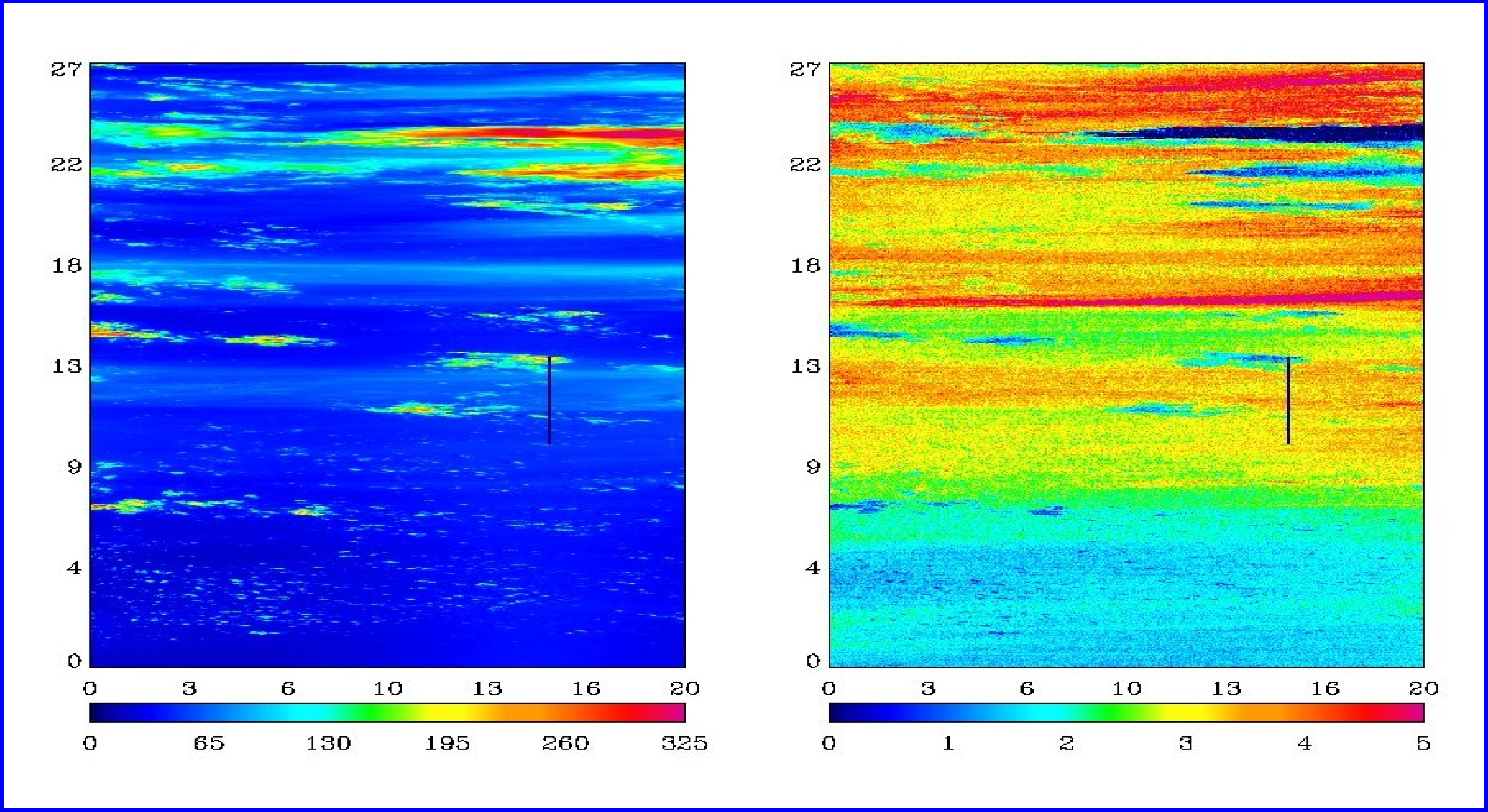
# CRYSTAL-FACE Case 1: July 26 off Honduras

<u>Radiances</u> versus <u>In-situ</u>

- MAS on NASA ER-2

-CAPS/ CIN on NASA WB-57

Garrett et al. (2003) and Roskovensky et al. (2004) observed effective radii smaller than 10 μm for this flight leg.



# Conclusions

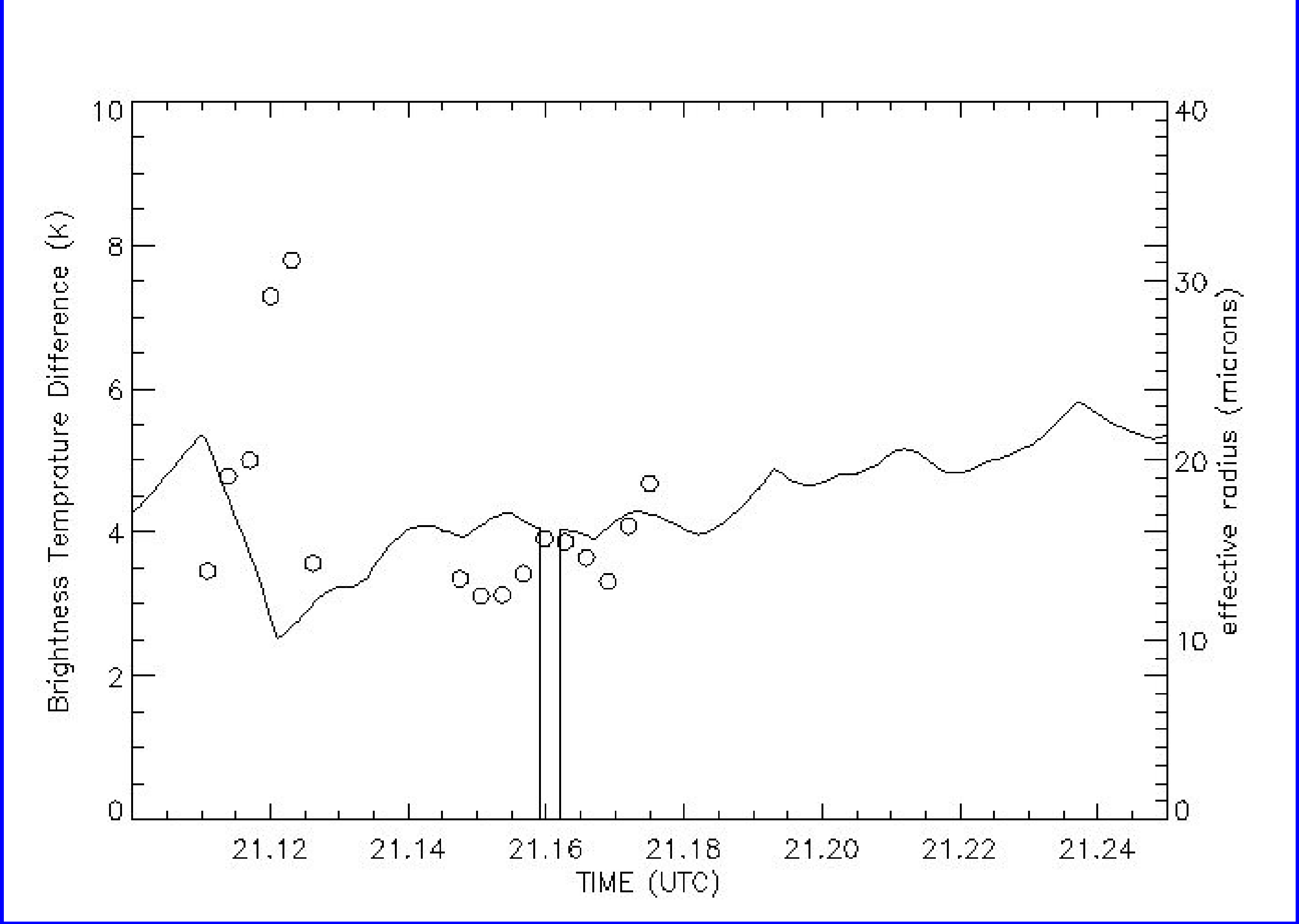

- Infrared split-window technique can be used to identify ice clouds composed predominately of small ice crystals
- Results from SPartICus find good agreement between BTD threshold technique and 2D-S instrument
- The existence of small particles less than 20μm cannot be discounted solely due to probe particle shattering arguments

# CRYSTAL-FACE Case 2 July 21 off Florida

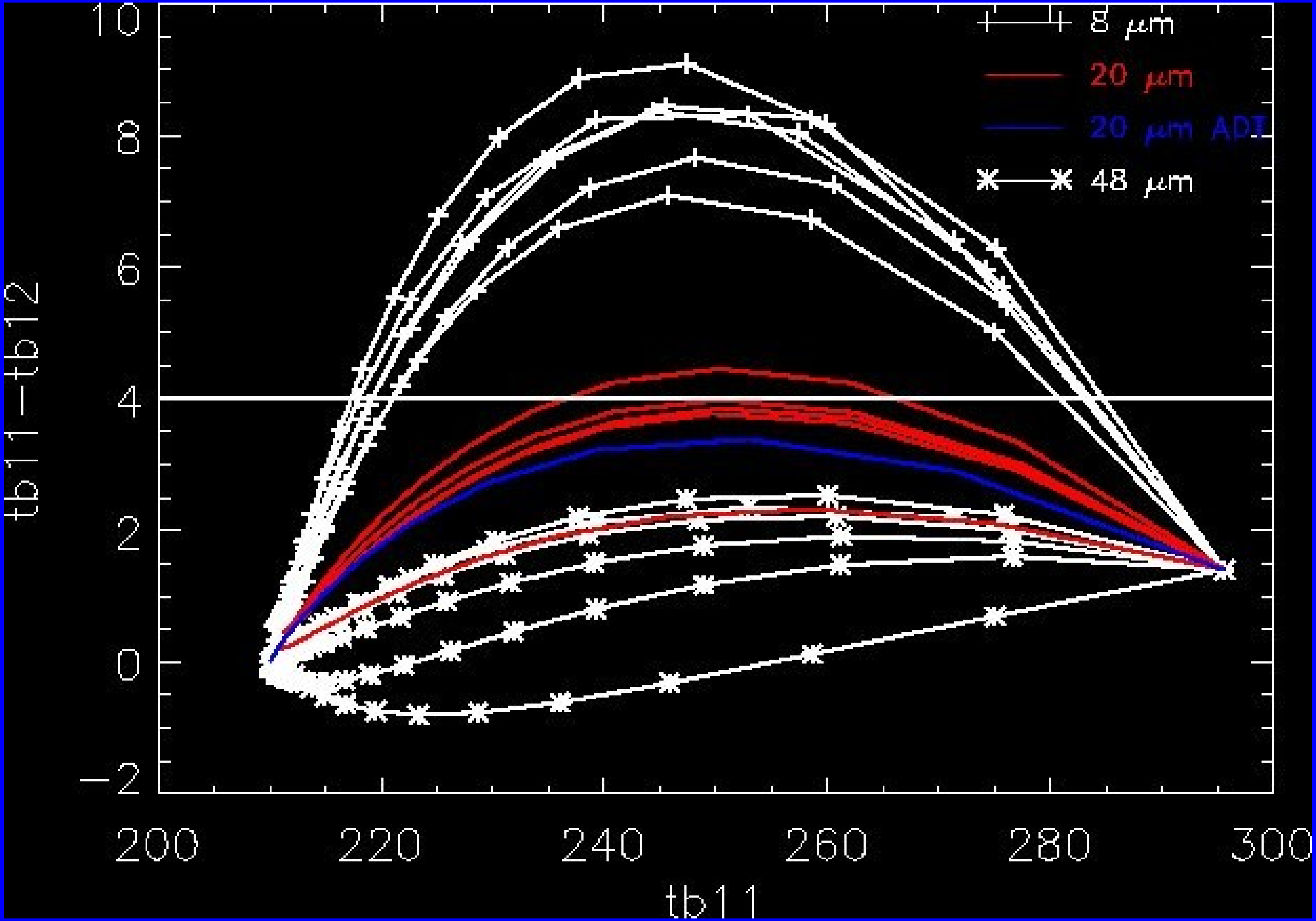
<u>Radiances Obs</u> versus <u>In-situ Obs</u>

GOES-8 CIN and CVI

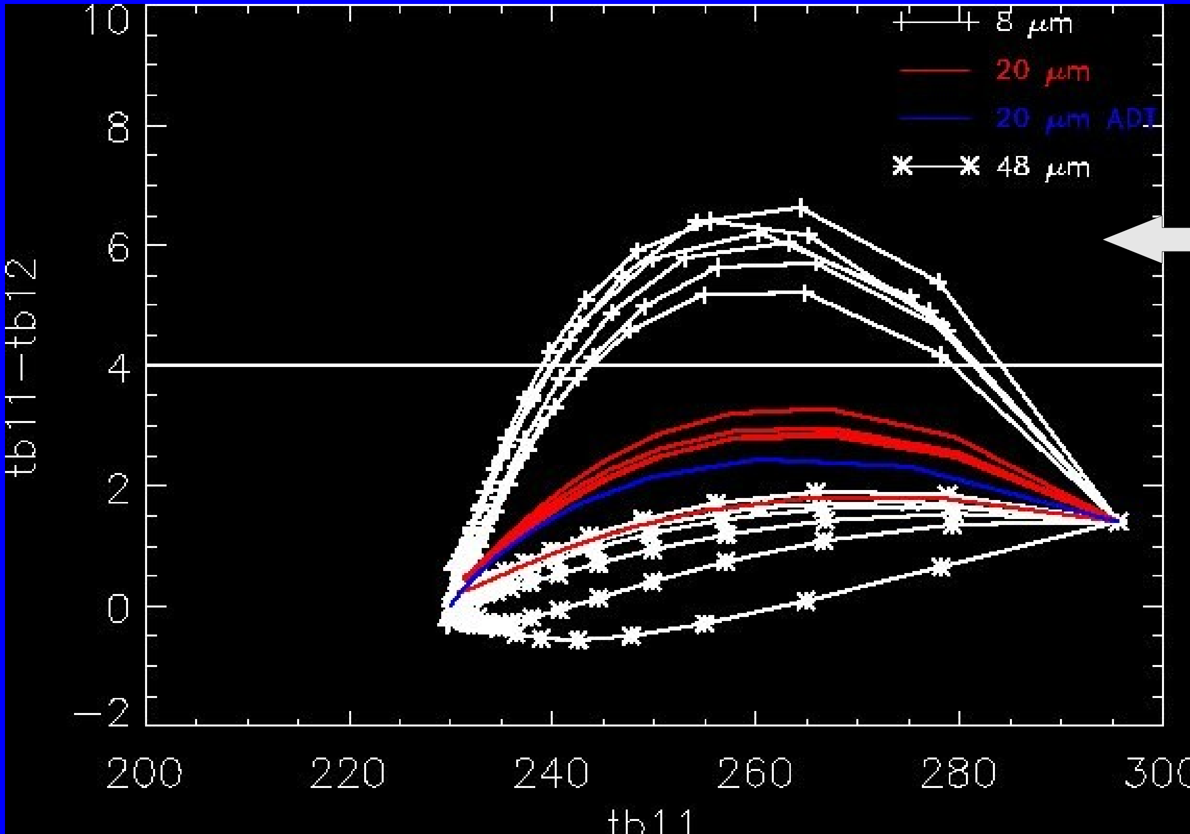
- Garrett et al., 2005 found radii less than 20 μm



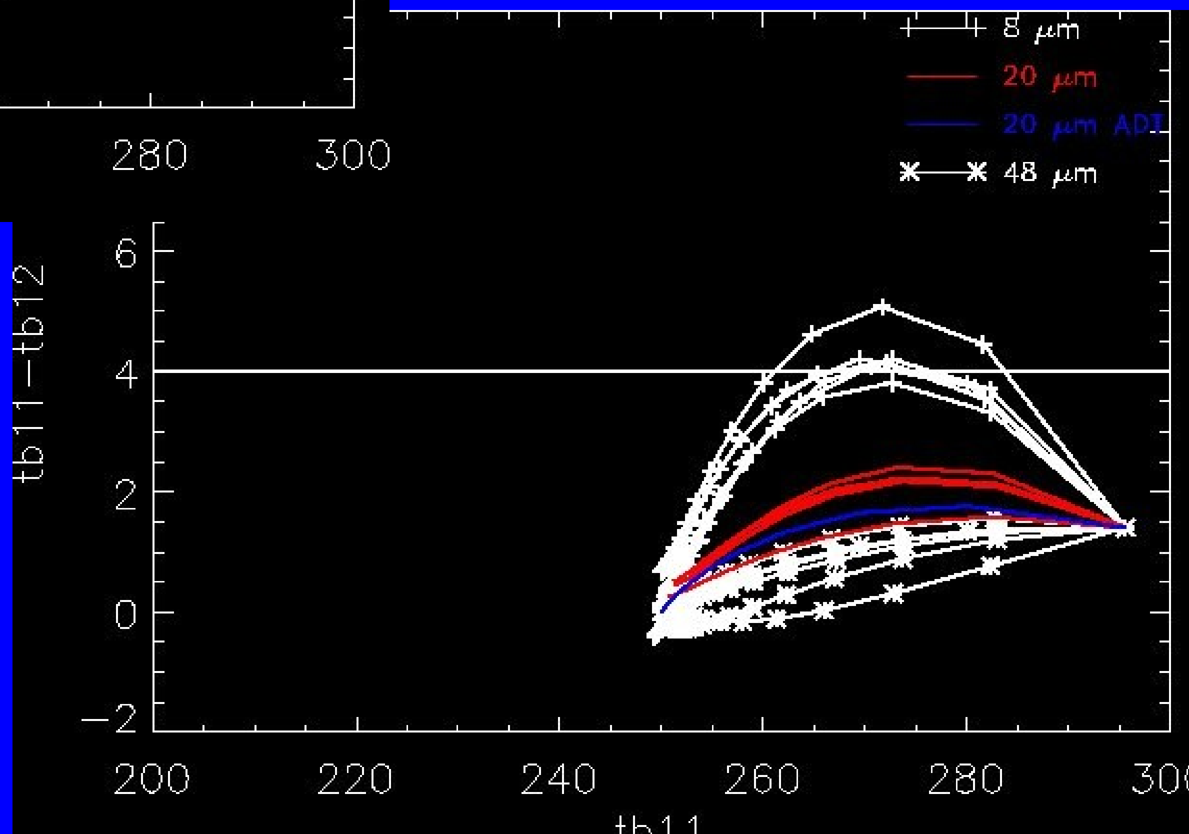
# Extra Slides



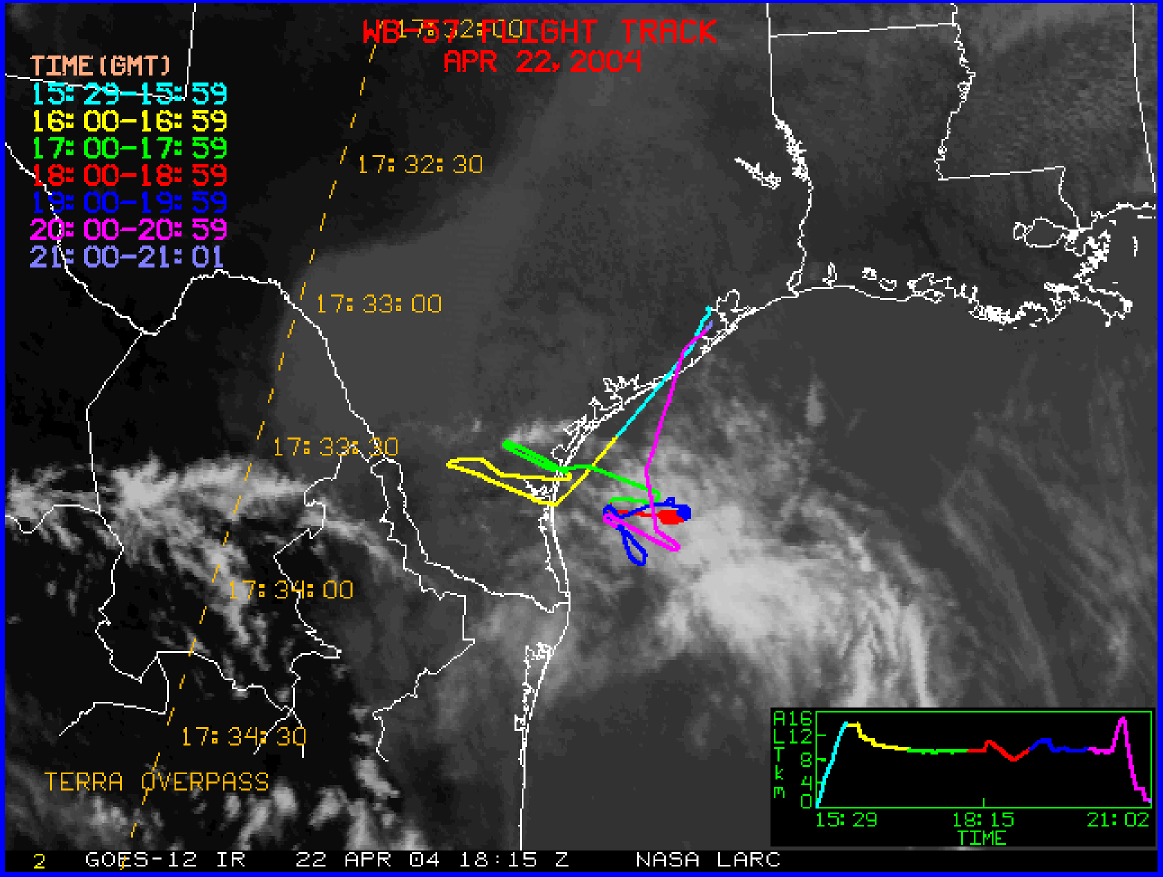

- Cloud temperature 210K

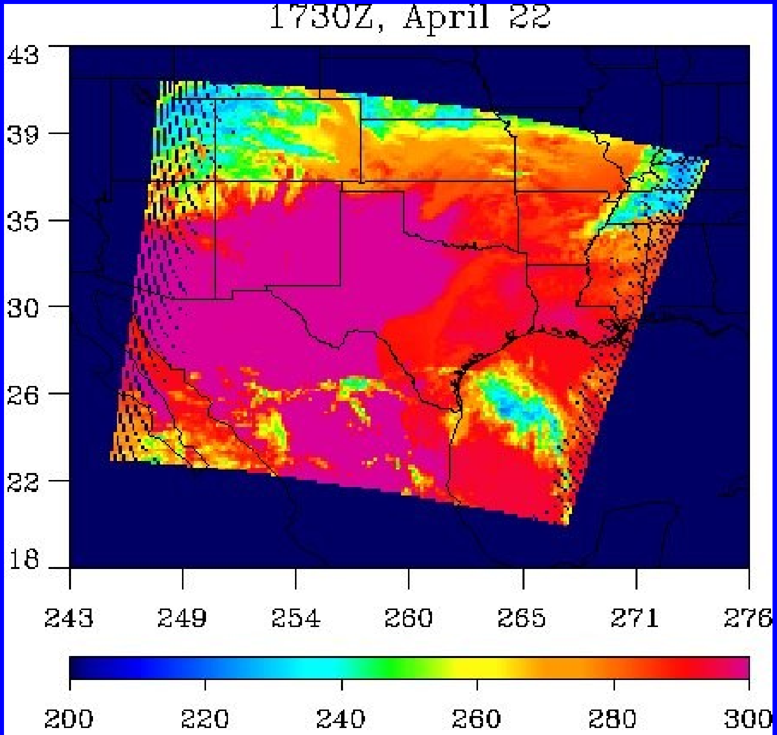


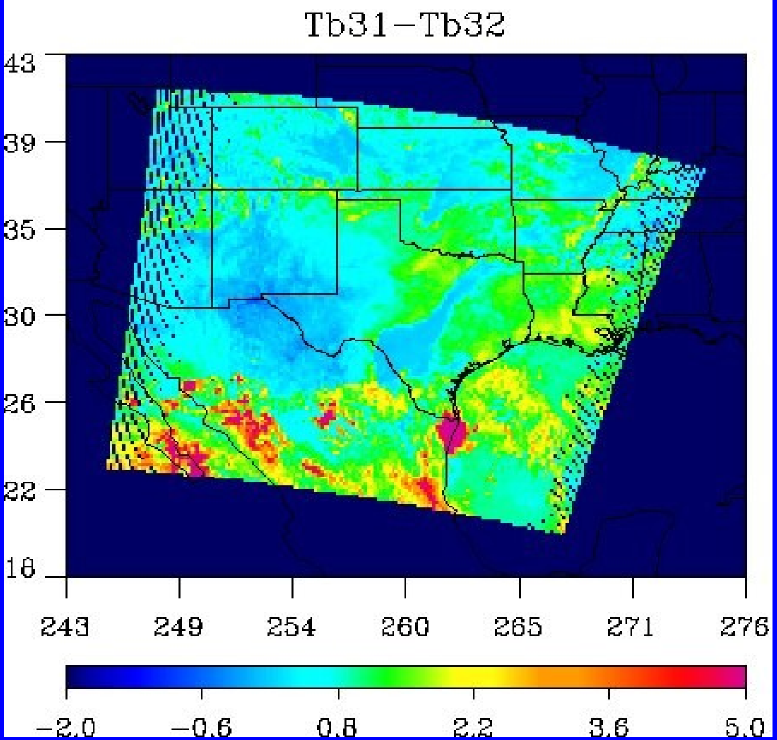

Cloud Temperature
230K and 250 K



# April 22 flight path and MODIS infrared obs



# MODIS thin cloud case

- Find cloud cluster where MODIS effective radius product is > 30 μm but infrared brightness temperature differences are large
  - Warm ocean Surface, 28° solar zenith angle

| Assumptions | Radii Average |
|---|---|
| MODIS product | 41 μm |
| Columns 4% albedo | 18 μm |
| Baran 4% albedo | 28 μm |
| Baran 6% albedo | 45 μm |