

New era for observing and understanding atmospheric moist processes

Graeme Stephens

- **CloudSat successfully launched April 28, 2006**
- **Operationally collected data since June, 2 (>98% all data since has been processed)**
- **Products released at end of January**
- **2year funded mission, seeking an extension for further 3 years**





Perhaps we are now in the golden age of Earth Observation

CloudSat Mission science goals

- Measure vertical structure of clouds, quantify their ice and water contents as a step toward improved weather prediction and understanding of climate

*What are the functions of clouds?
How do clouds structure the climate?*

What is the impact of clouds on the climate system?

What is the impact of clouds on the climate system?

- Quantify the relationship between cloud microphysics and radiative heating by clouds

*Do clouds heat or cool the Earth?
Do the radiative effects of clouds depend on their vertical structure?*

- Evaluate cloud information from existing satellites

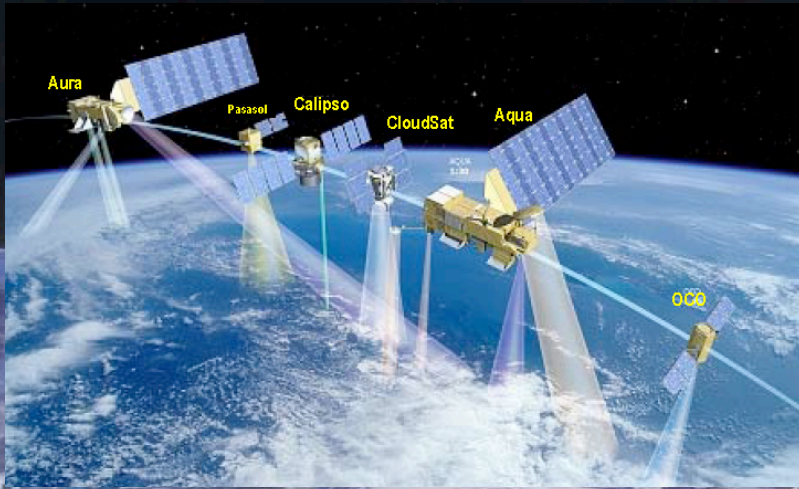
- Improve our understanding of precipitation

To what extent are the properties above (water, ice, precipitation, vertical structure) influenced by aerosol?

• Products

- Geometrical profiles = Radar profiles
= Hydrometeor profiles
- Cloud incidence
- Cloud type
- Cloud physics = water content profiles
- Cloud contribution to atmospheric radiative heating - derived from geometric profiles, cloud physics, T,q analysis
- Precipitation incidence
- Quantitative precipitation

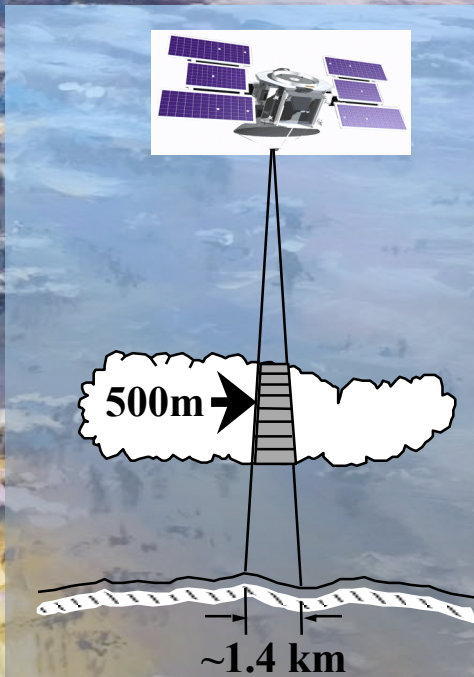
Two components to the mission design




1. Formation with the A-Train

2. The Cloud Profiling Radar (CPR)

- Nadir pointing, 94 GHz radar
- $3.3\mu\text{s}$ pulse \rightarrow 480m vertical res, over-sampled at $\sim 240\text{m}$
- 1.4 km horizontal res.
- Sensitivity ~ -28 dBZ (-31 dBZ)
- Dynamic Range: 80 dB



CloudSat Data Processing Center (DPC)



CLOUDSAT DATA PROCESSING CENTER
A NASA EARTH SYSTEM SCIENCE PATHFINDER MISSION

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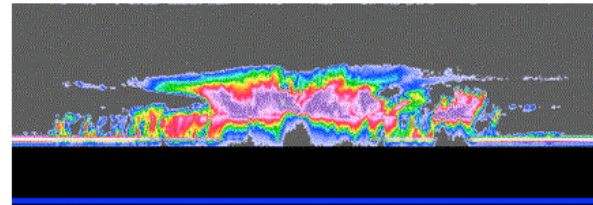
Links

CloudSat Flies Over Hurricane Daniel

On 23 July 2006, the CloudSat orbit coincided with the position of Hurricane Daniel, whose winds were over 100 mph at the time. This image represents a slice through the hurricane very close to the eye. The red purple areas indicate large amounts of cloud water. The blue areas along the top of the clouds indicate cloud ice. The wavy blue line at the bottom indicates heavy precipitation likely exceeding 30 mm/hr (1.18 inches/hr). For a comparison of this image to the MODIS satellite image of the hurricane, click on the image.

For more images like this one, see our new [Case Studies page!](#)







DPC News

See interesting CloudSat overpasses on our new [Case Studies page!](#)


Science Team members: [click here for account creation instructions.](#)

Partners

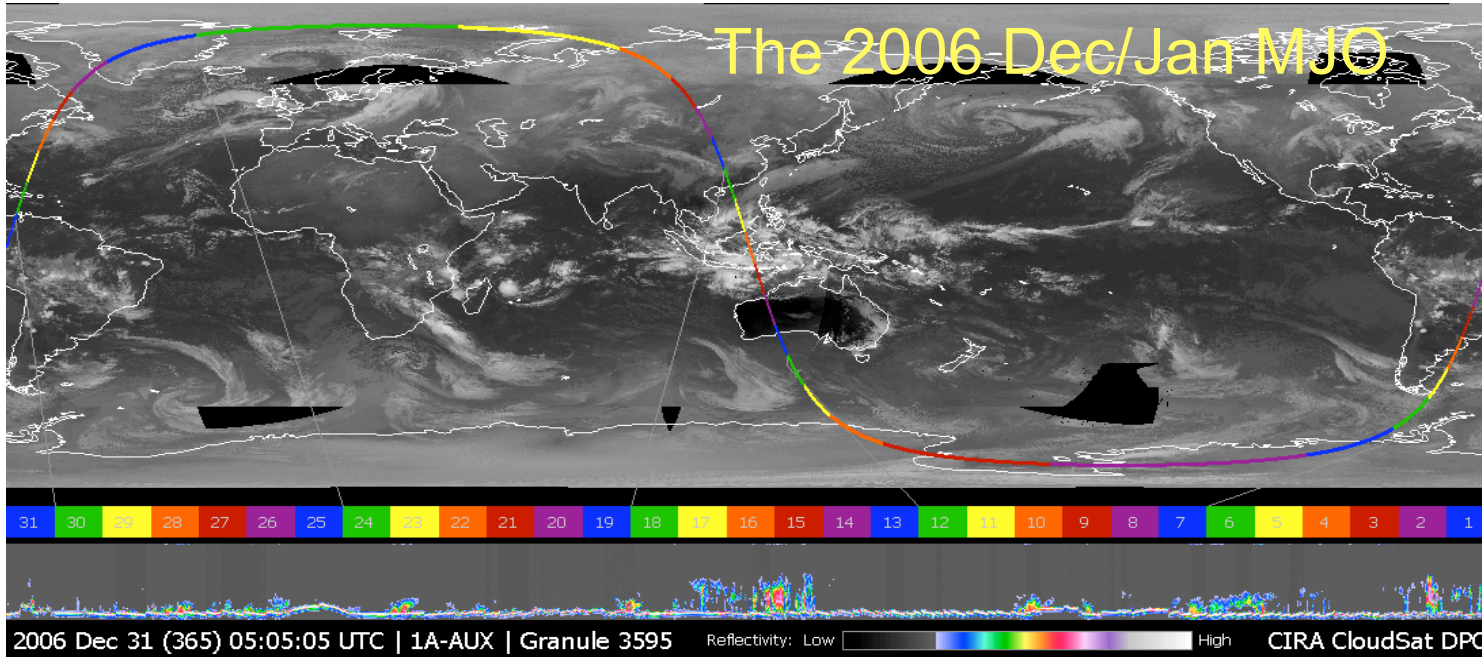
CloudSat's radar was turned on at approximately 14:44 UTC on June 2nd. Data have been collected since and are being evaluated during an approximate two-month checkout period, after which time products will be released to the CloudSat Science team and then to the general science community. Check back for updates on the release schedule.

Data not yet available. [Click here to learn about the data products.](#)

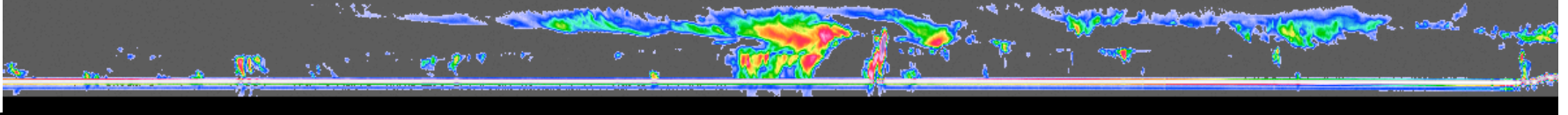


<http://www.cloudsat.cira.colostate.edu>

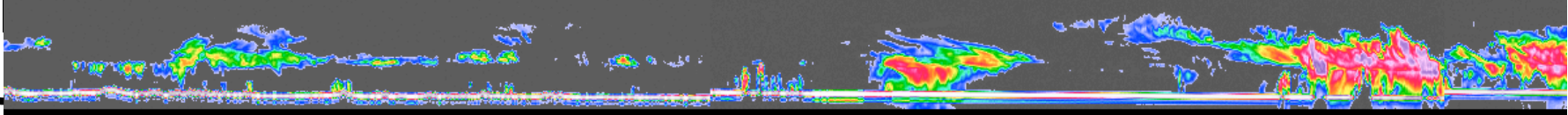
The 2006 Dec/Jan MJO



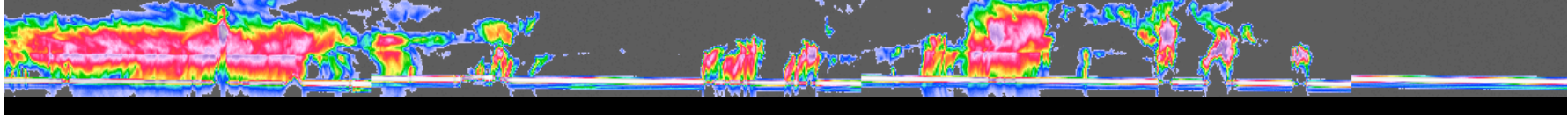
17



16



15



2006 Dec 31 (365) 05:05:05 UTC | 1A-AUX | Granule 3595 15 Time 05:52:56 05:49:44 | Lat -6.1 -17.6 | Lon 118.6 121.1 CIRA CloudSat DPC

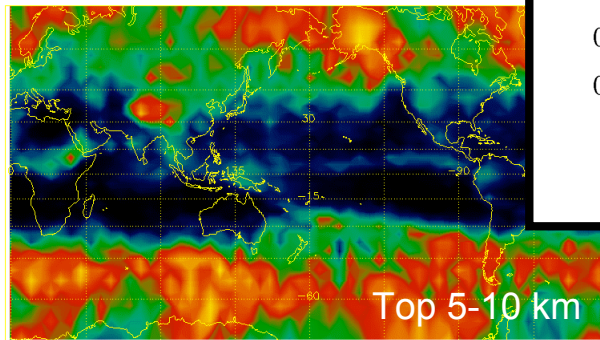
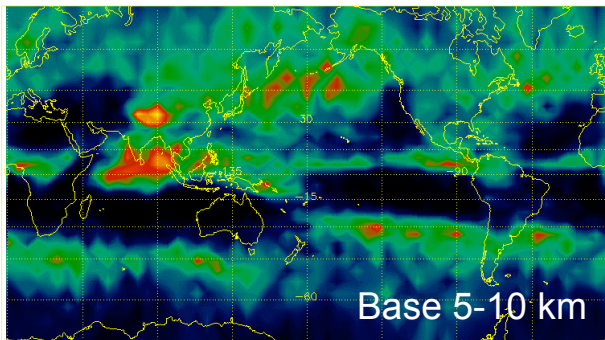
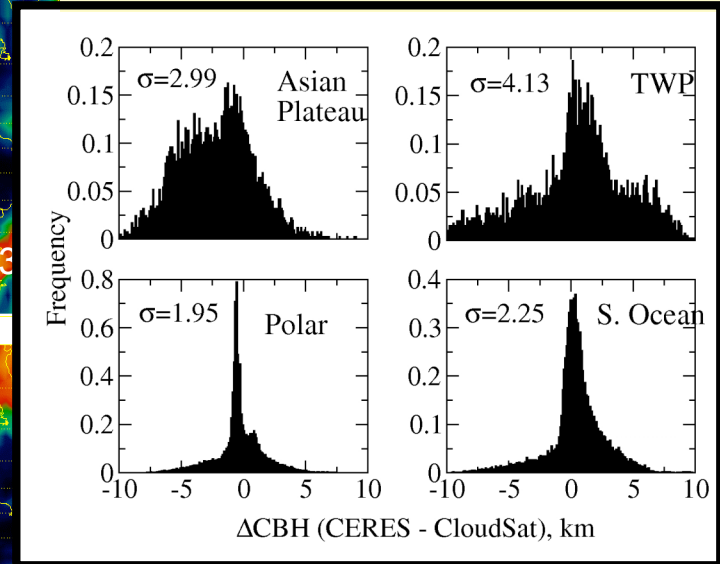
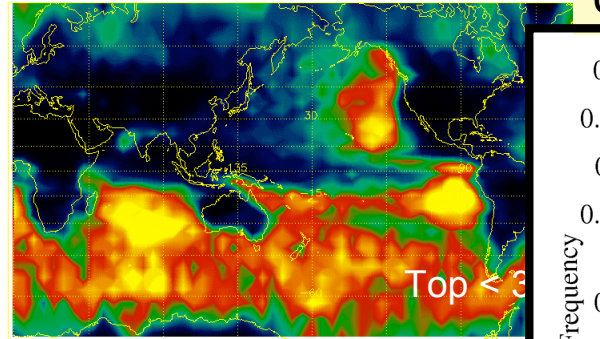
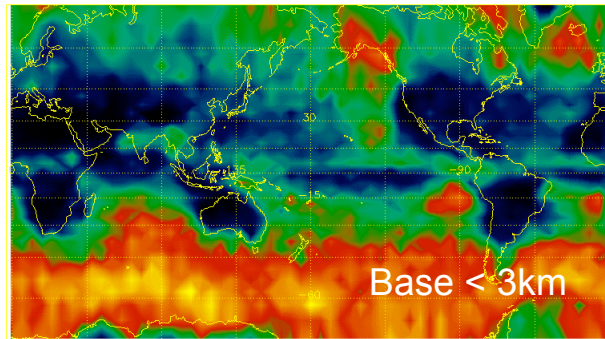
1400

30 km

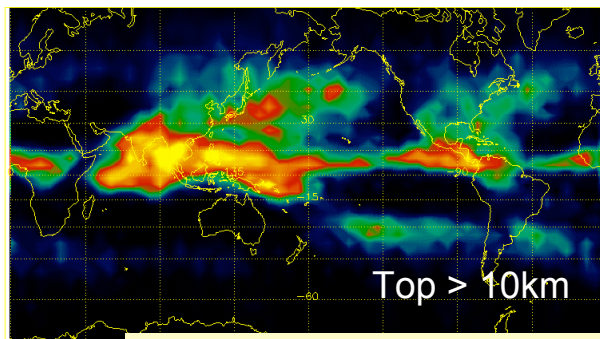
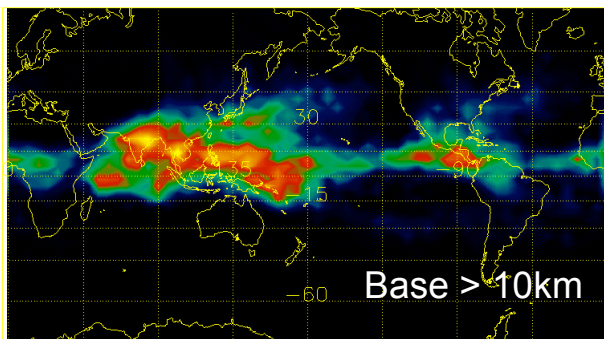
Example of cloud structure statistics (JJA)

- *2B geoprof*

Cloud base differences from other satellite products



rms differences 2-4 km



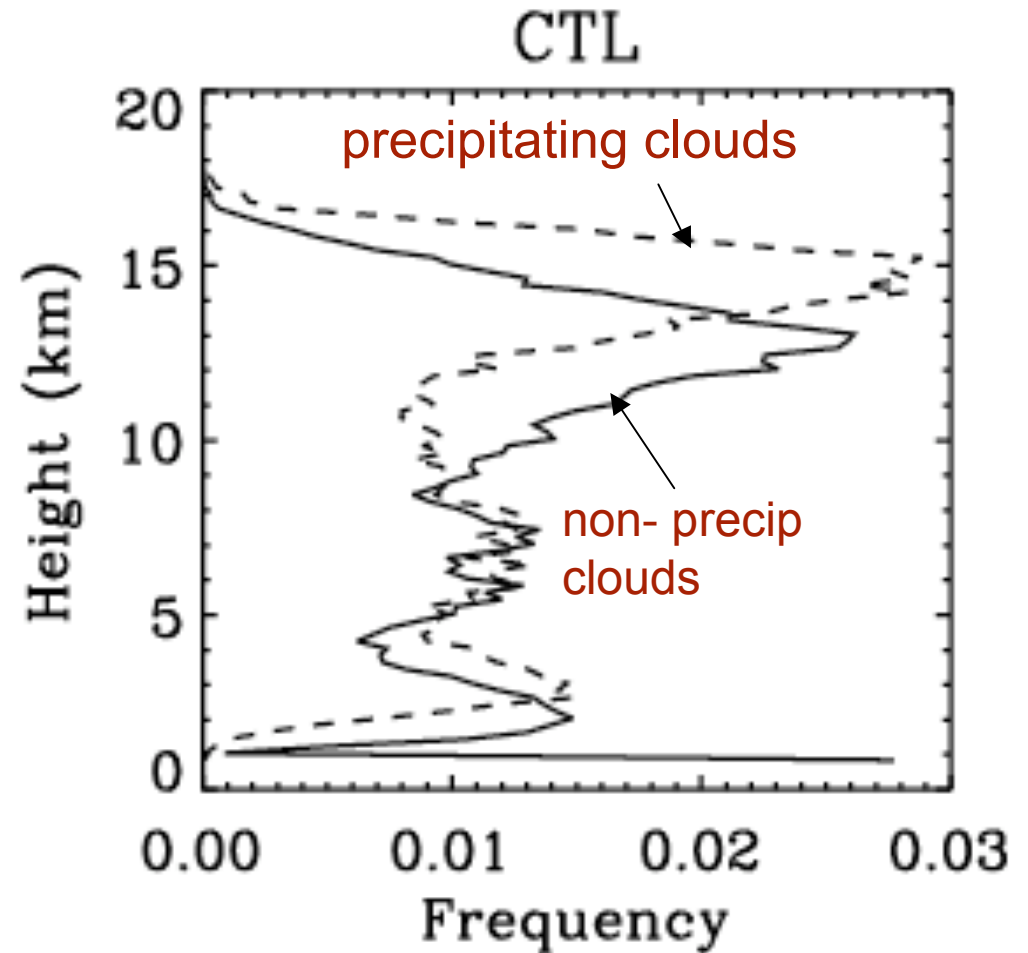
Mace et al, 2007

Composite vertical profile for west pac, JJA

Minimum cloud top heights distributions

Of note:

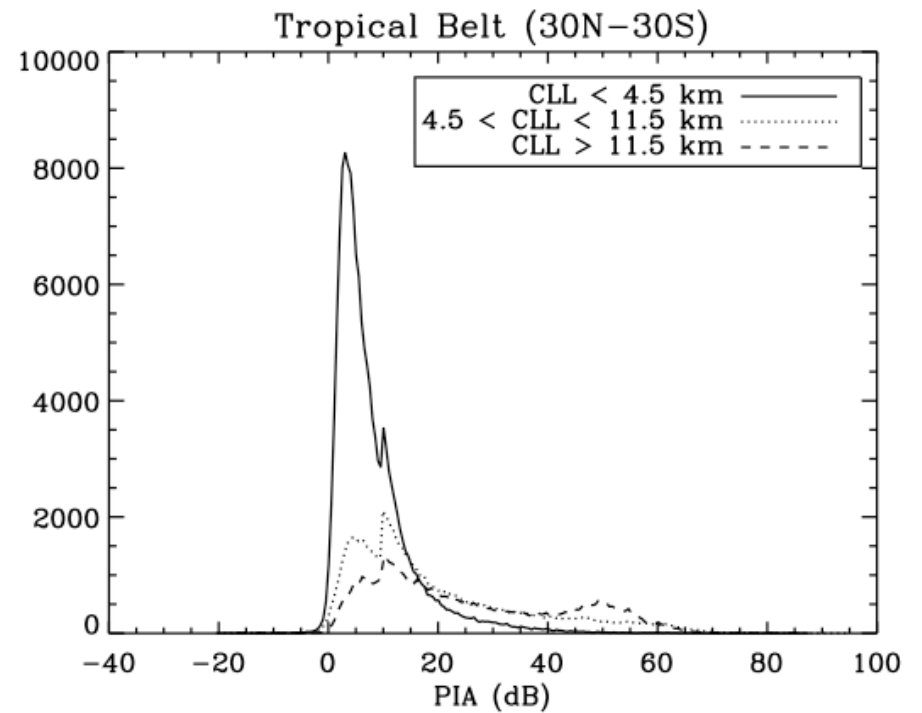
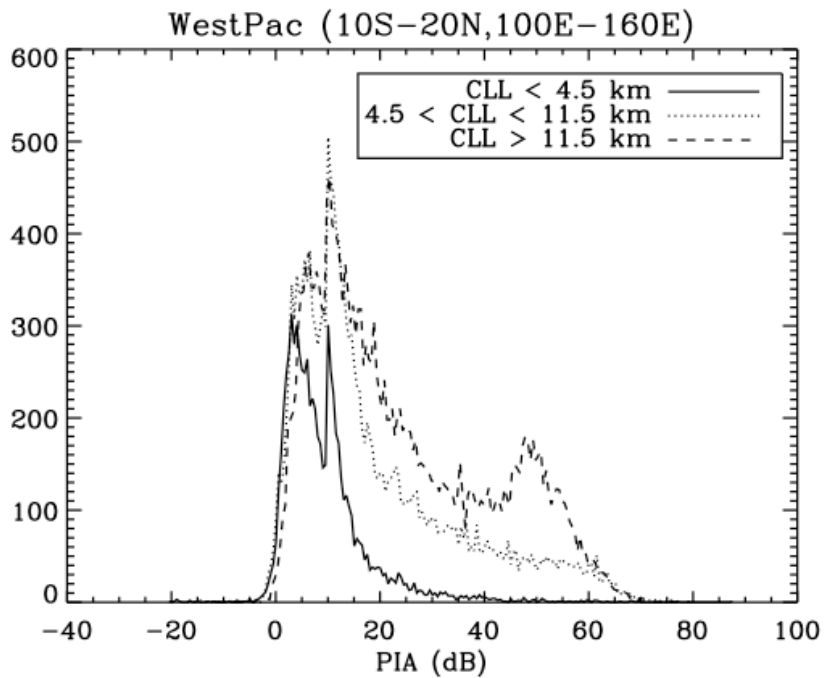
- Trimodality (quadra-modal) heights
- precipitating clouds are deeper than non precipitating clouds



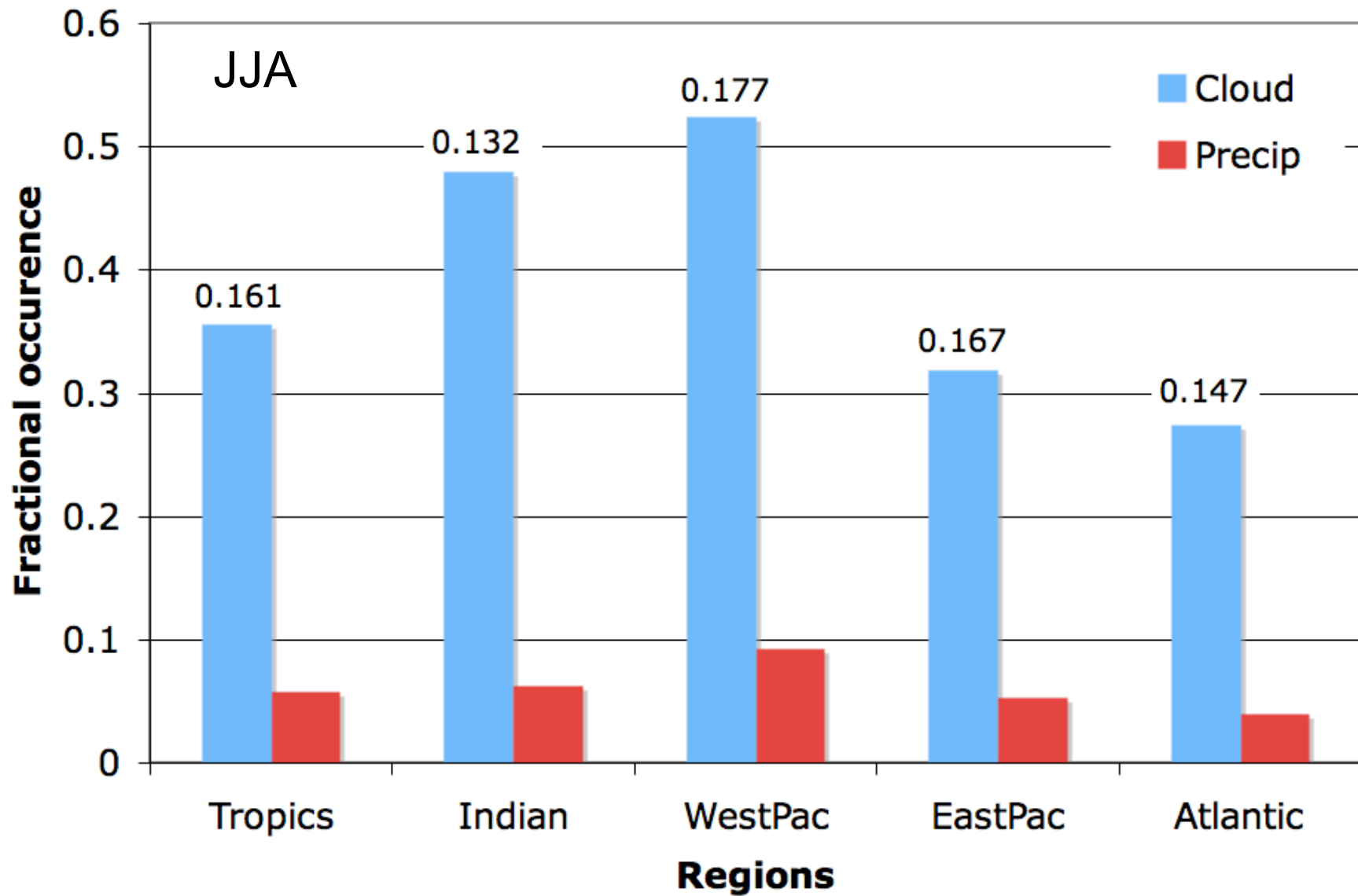
Revealing the trimodality of tropical precipitation

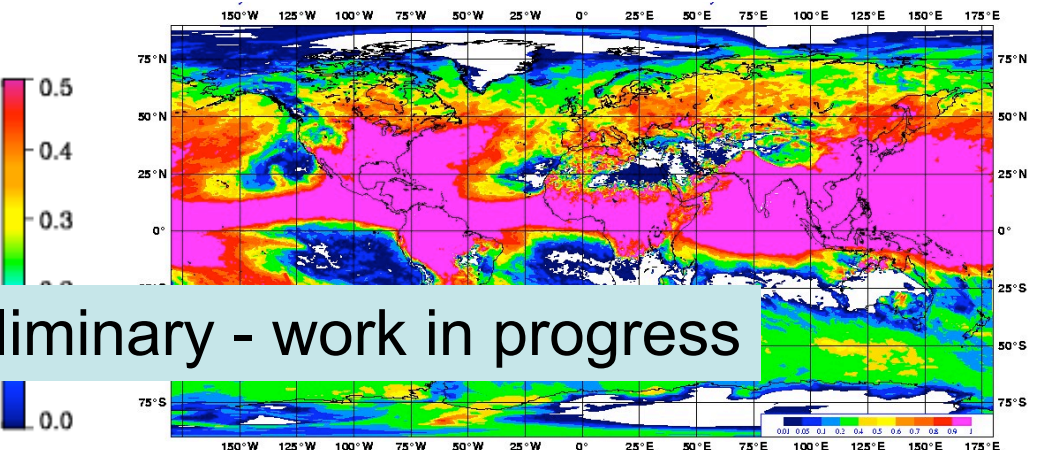
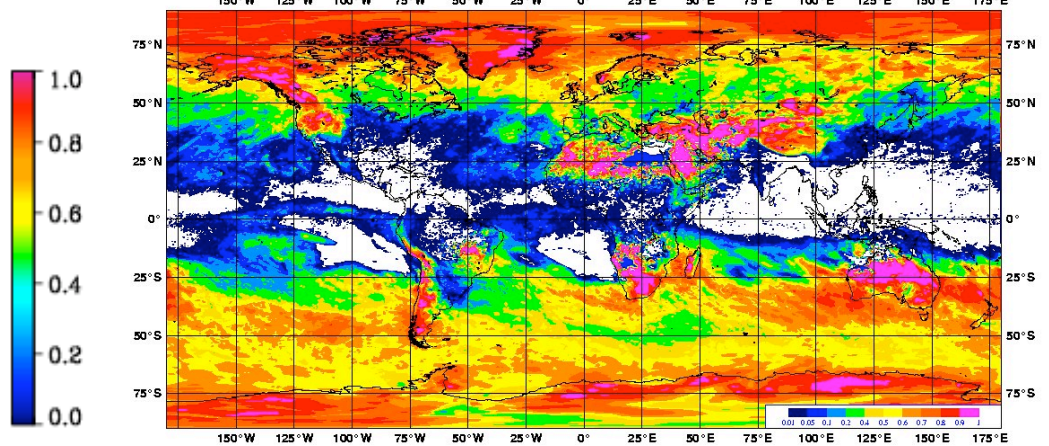
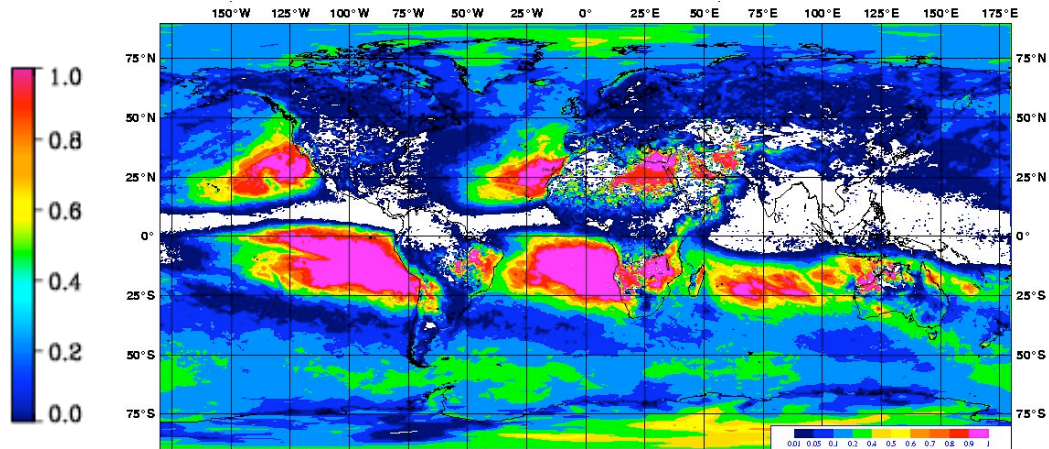
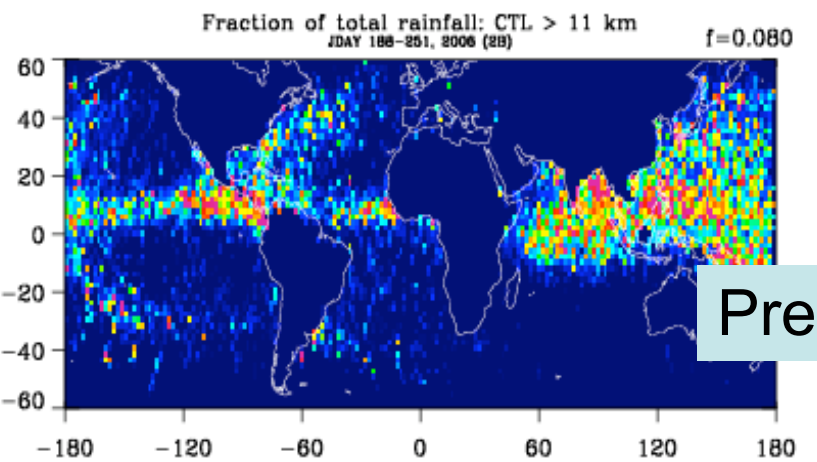
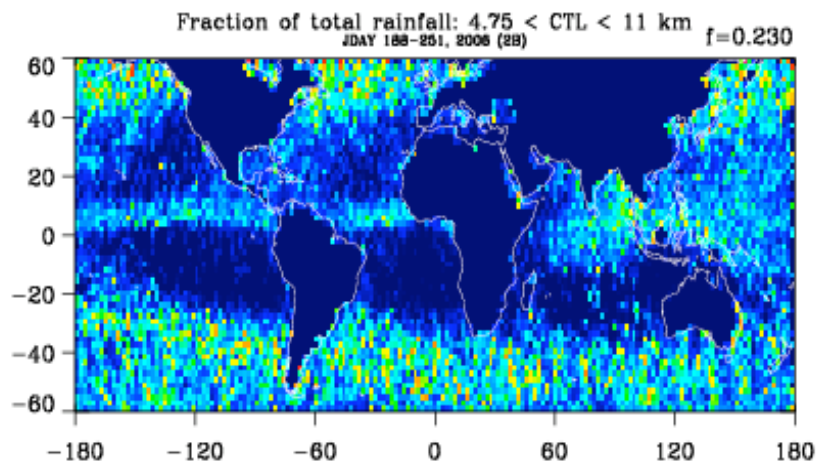
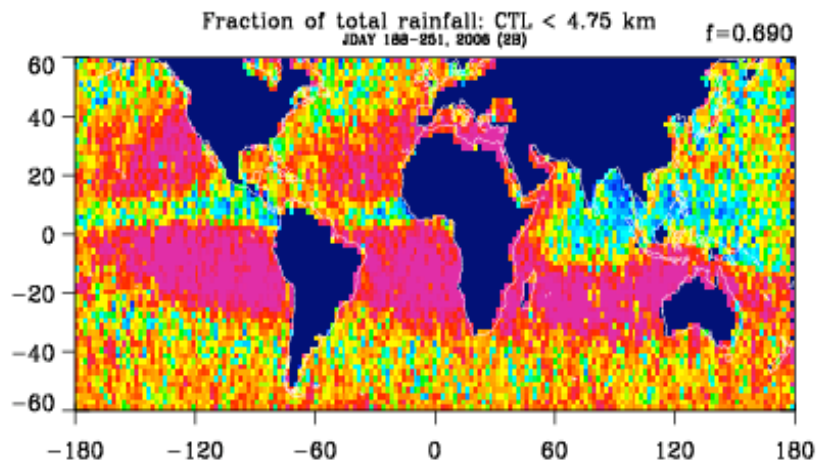
Approximate Precip Rate (mm hr^{-1})

0.0 1.8 4.4 7.5 11.2



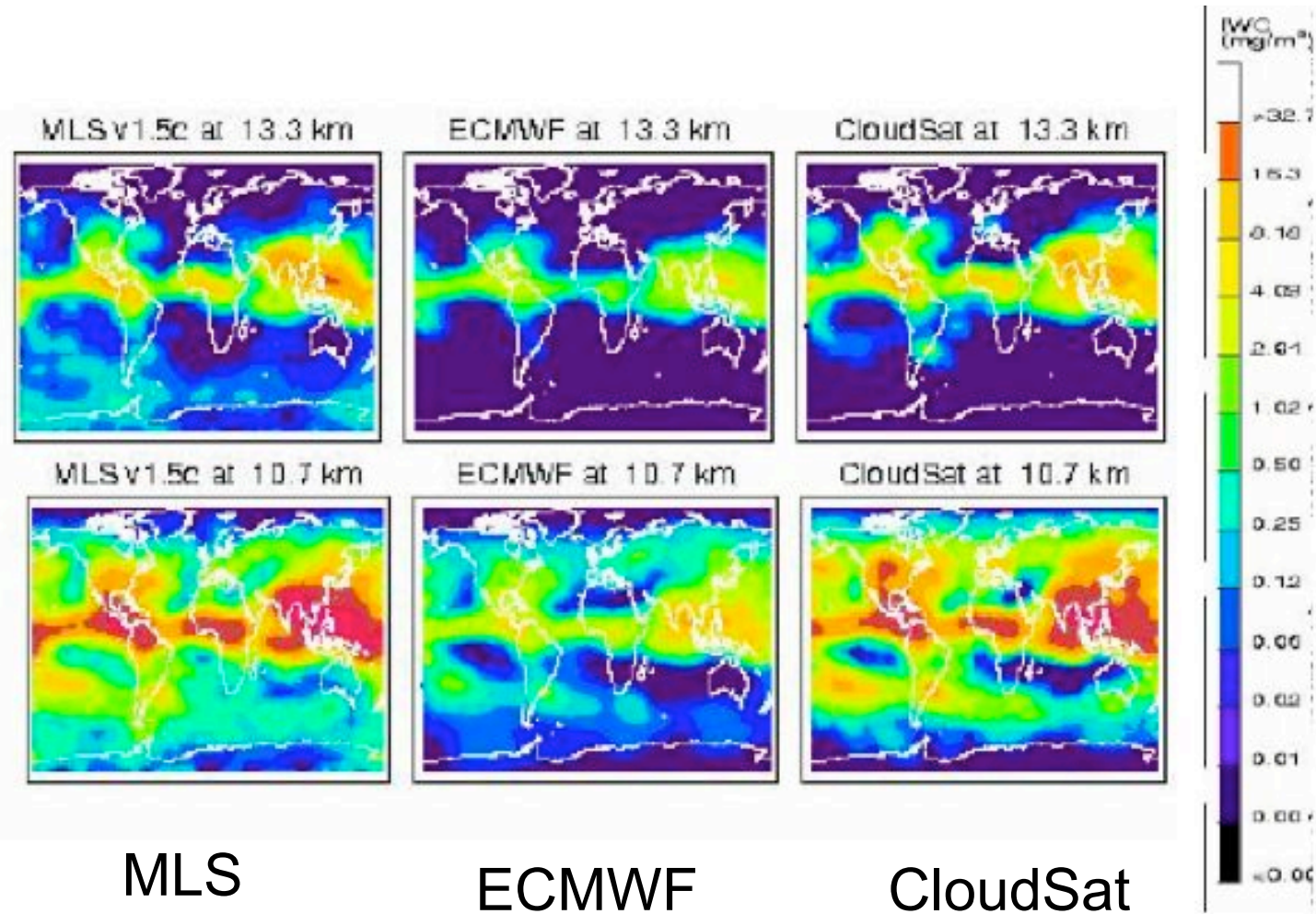
Frequency of Occurrence of Clouds and Precipitation





Preliminary - work in progress

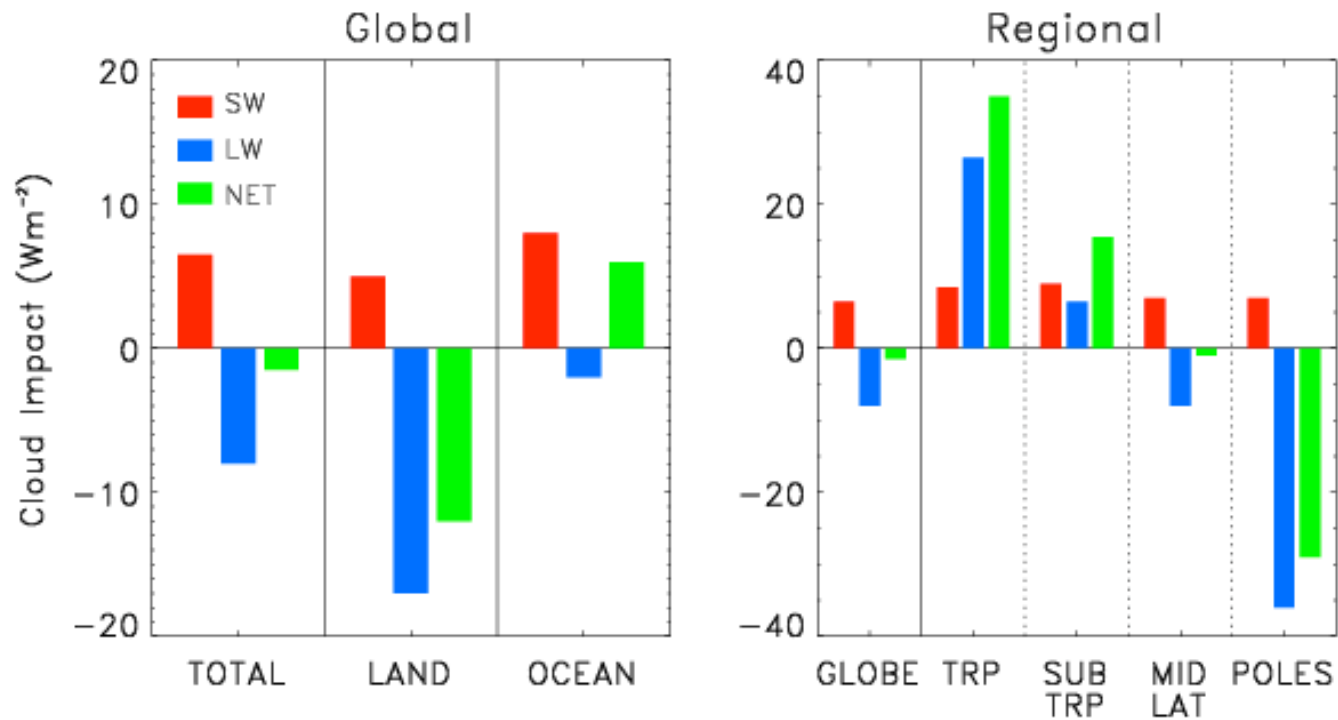
Cloud Ice water content (*2B-CWC*) - modelers last line of defense against measured TOA fluxes¹



¹ Tony DelGenio

Cloud 'Impact' on Radiative heating of atmosphere

2b-fluxhr product



Preliminary, one month of data

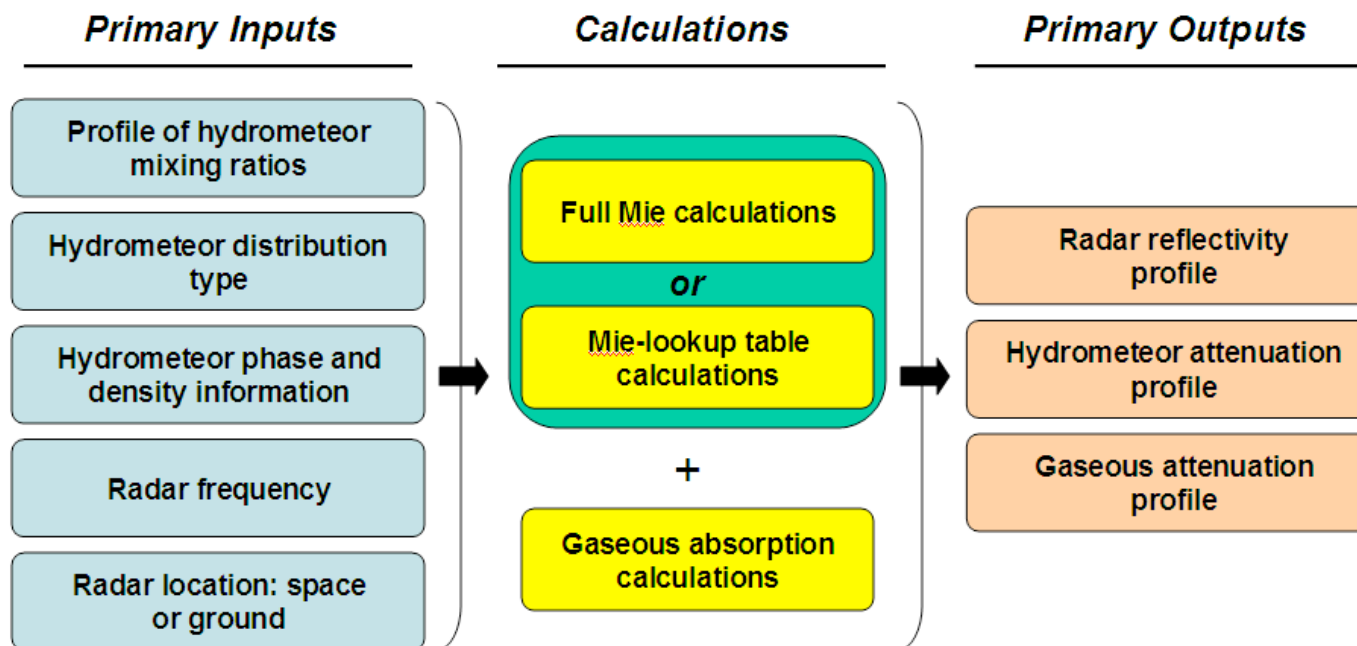
Clouds over global land areas radiatively cool

Clouds over global oceans radiatively heat

?????

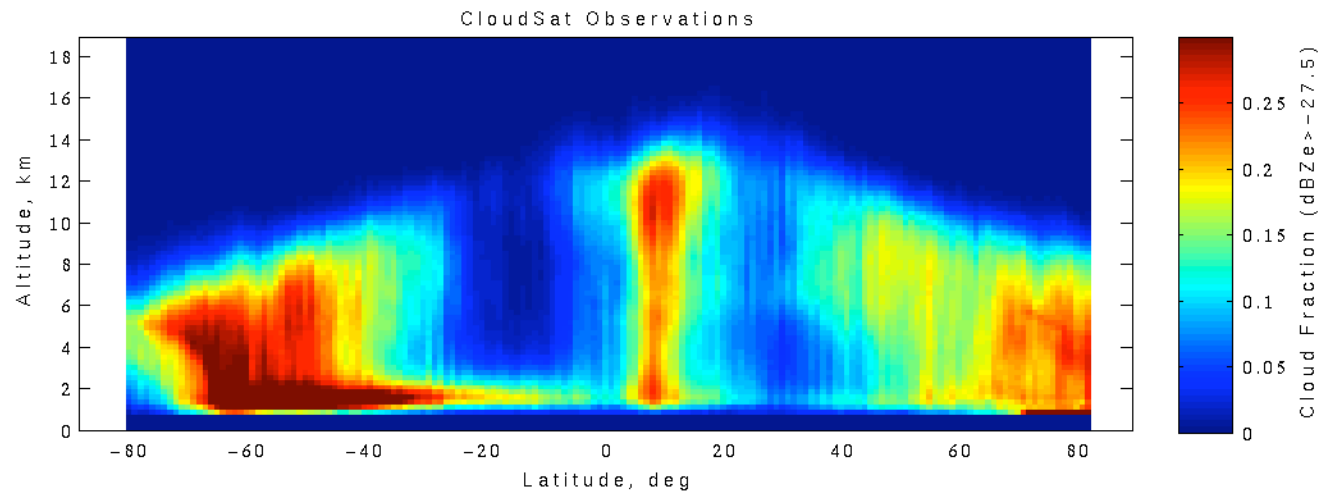
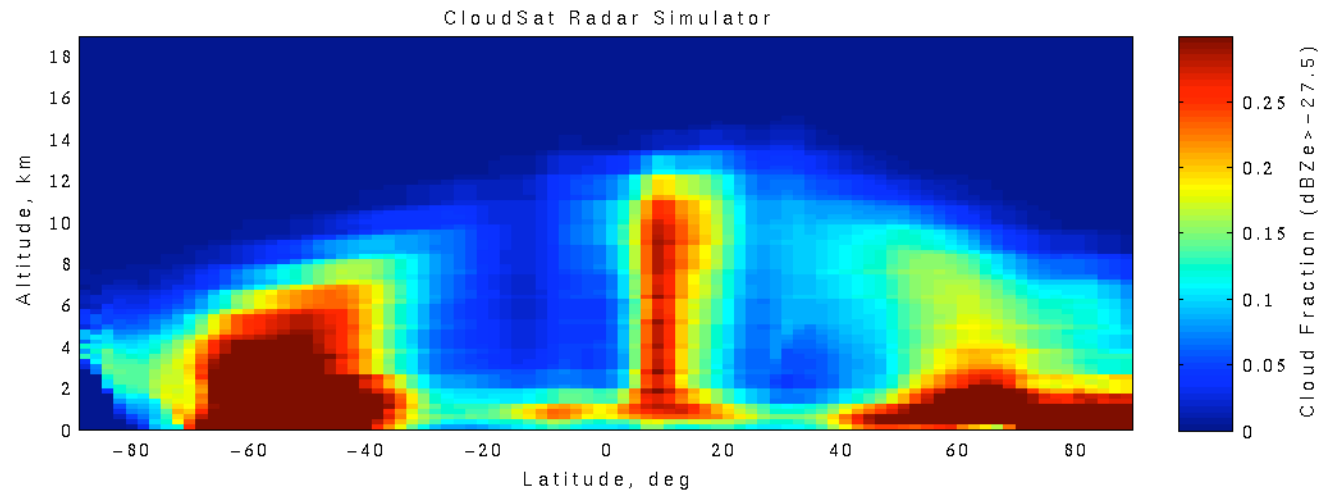
CloudSat simulator activity

- CloudSat simulator (Quickbeam)
 - Emulates observations (in the spirit of ISCCP simulator)
 - Requires Cloud **and** Precipitation as input
 - Has been integrated into certain versions of global models
 - Being adapted to more 'conventional' low-resolution models.

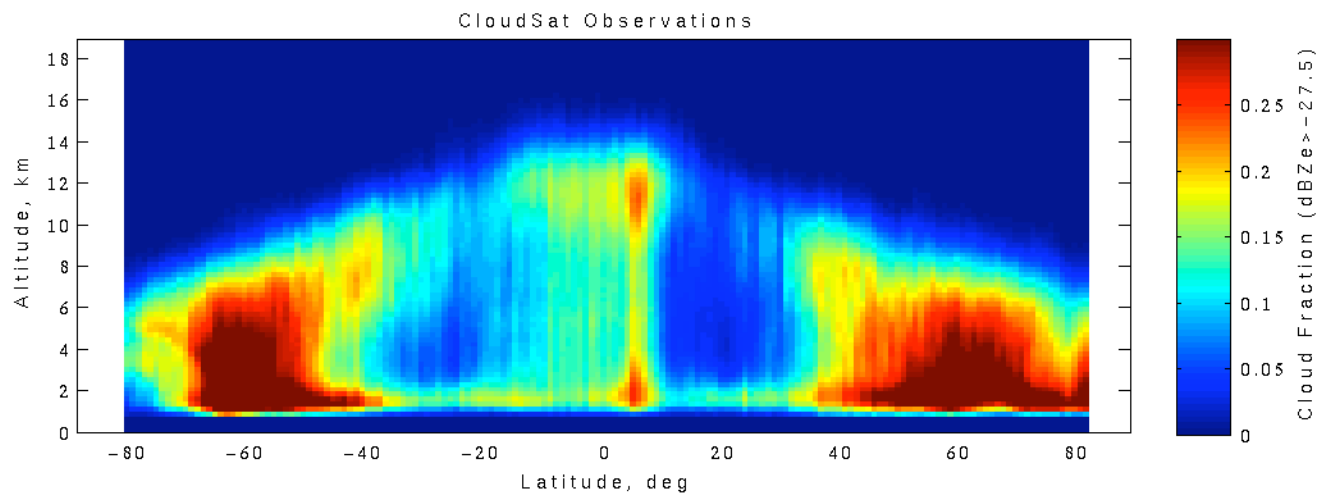
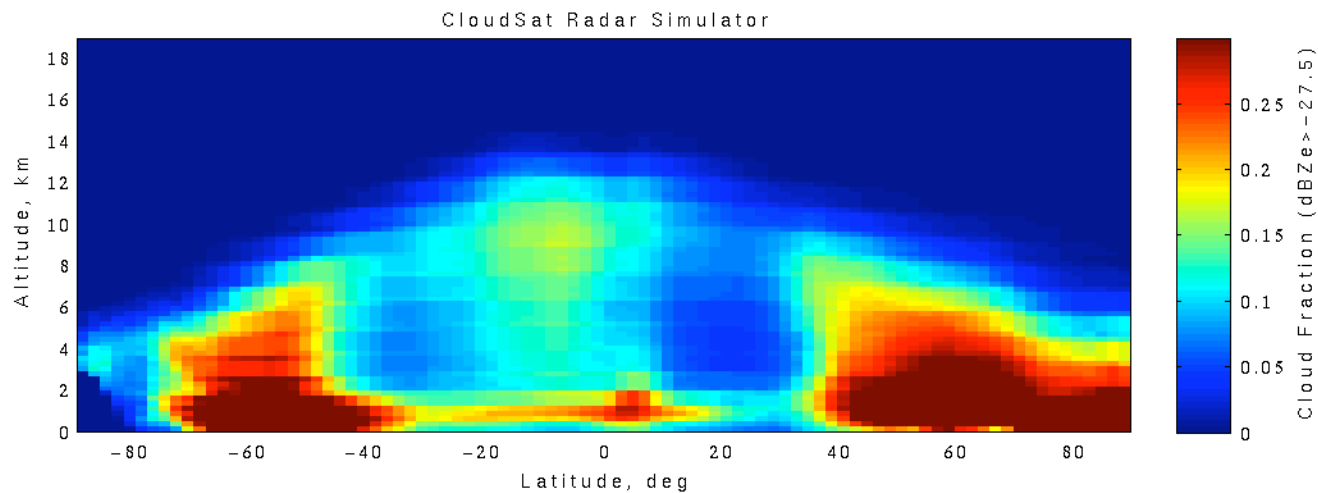


Haynes et al., 2007

July



December

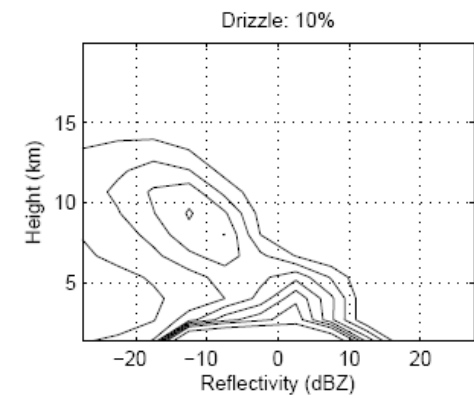
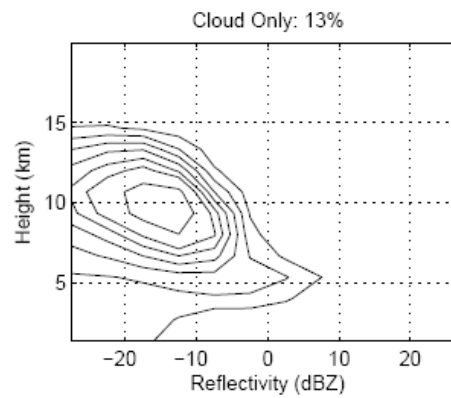
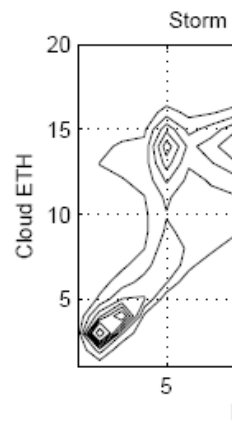
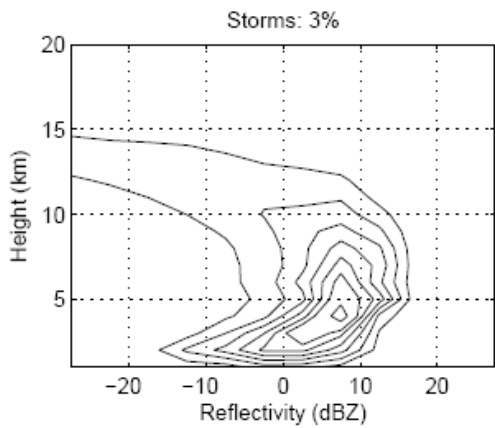
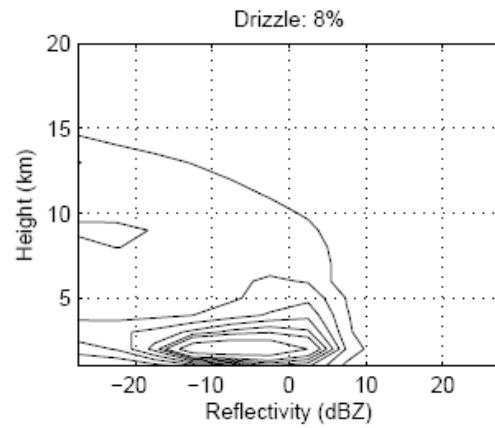
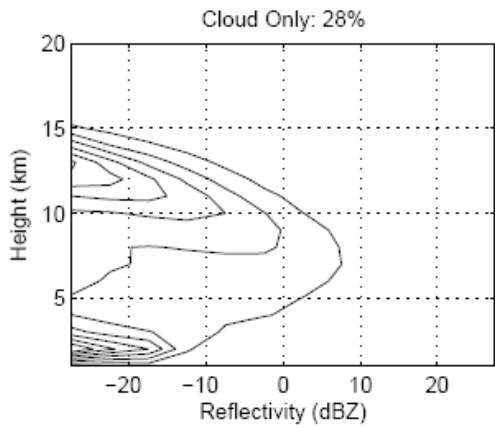


Summary

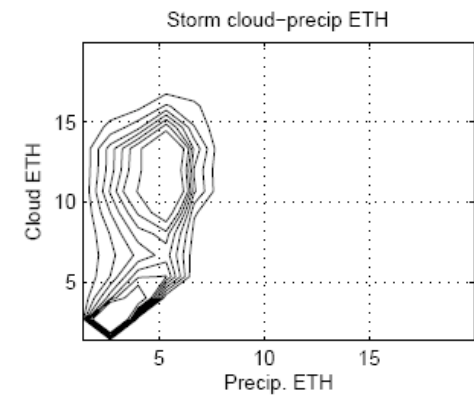
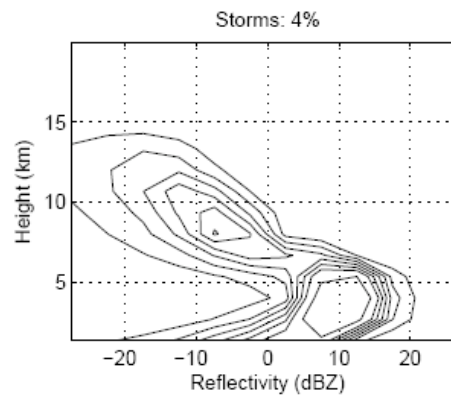
We are gathering new important insights on moist processes - such as insights on

- global precipitation efficiency,
- cloud structures in relation to storm types
- warm-rain auto-conversion
- influence of clouds on atmospheric and surface energetics

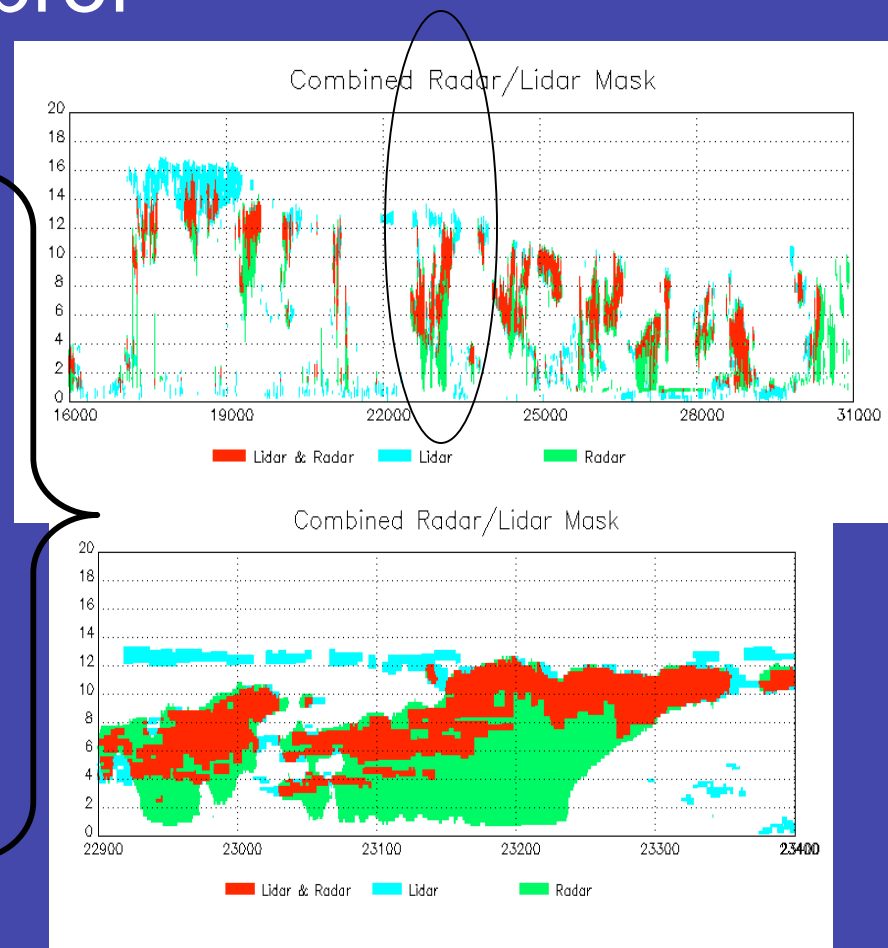
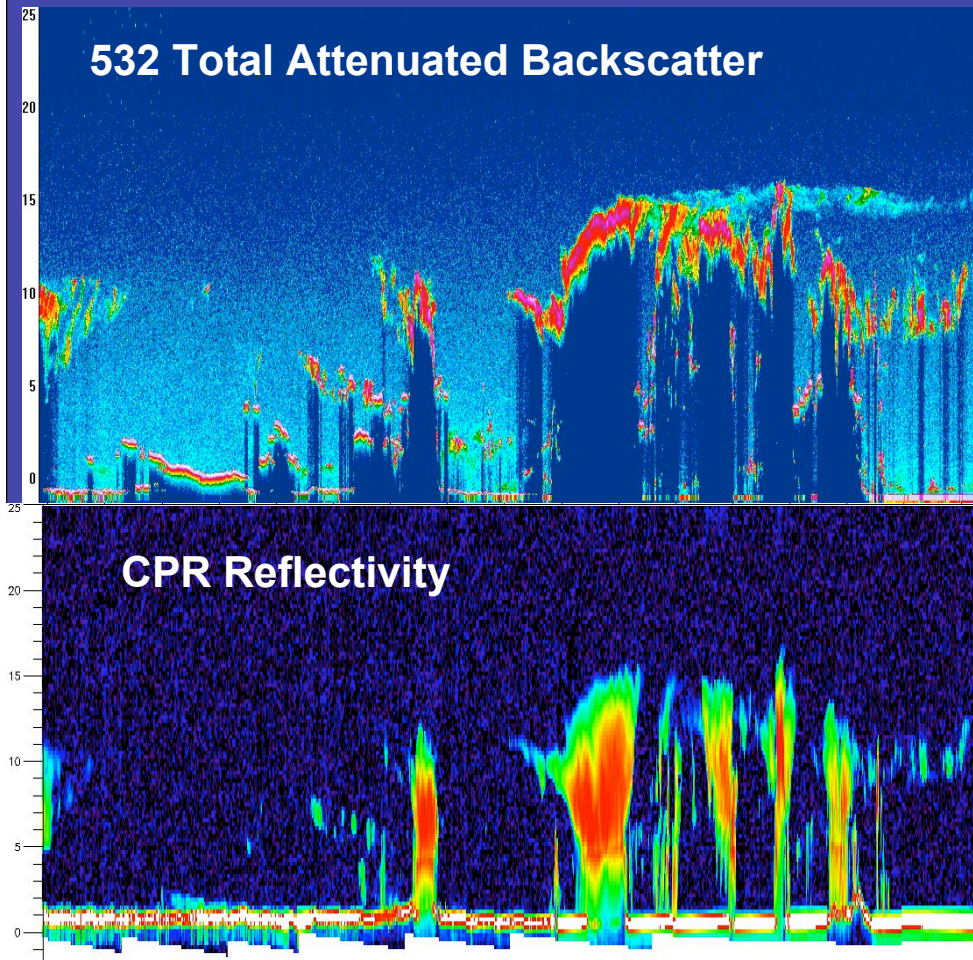
While comparison with models is revealing, we are keen to see the knowledge gained being converted to quantitative-process centric metrics as defined by these new observations.



	No Zi > 10 dBZ	Zi > 10 dBZ	No Zi > -30 dBZ
Low-level dBZ < -10	Cloud only (CO) 0.574		Clear 0.307
Low-level dBZ > -10	Drizzle 0.013	Storm Classes (A, B, C, D, E) 0.106	



Preliminary steps toward the CloudSat radar/lidar geoprof

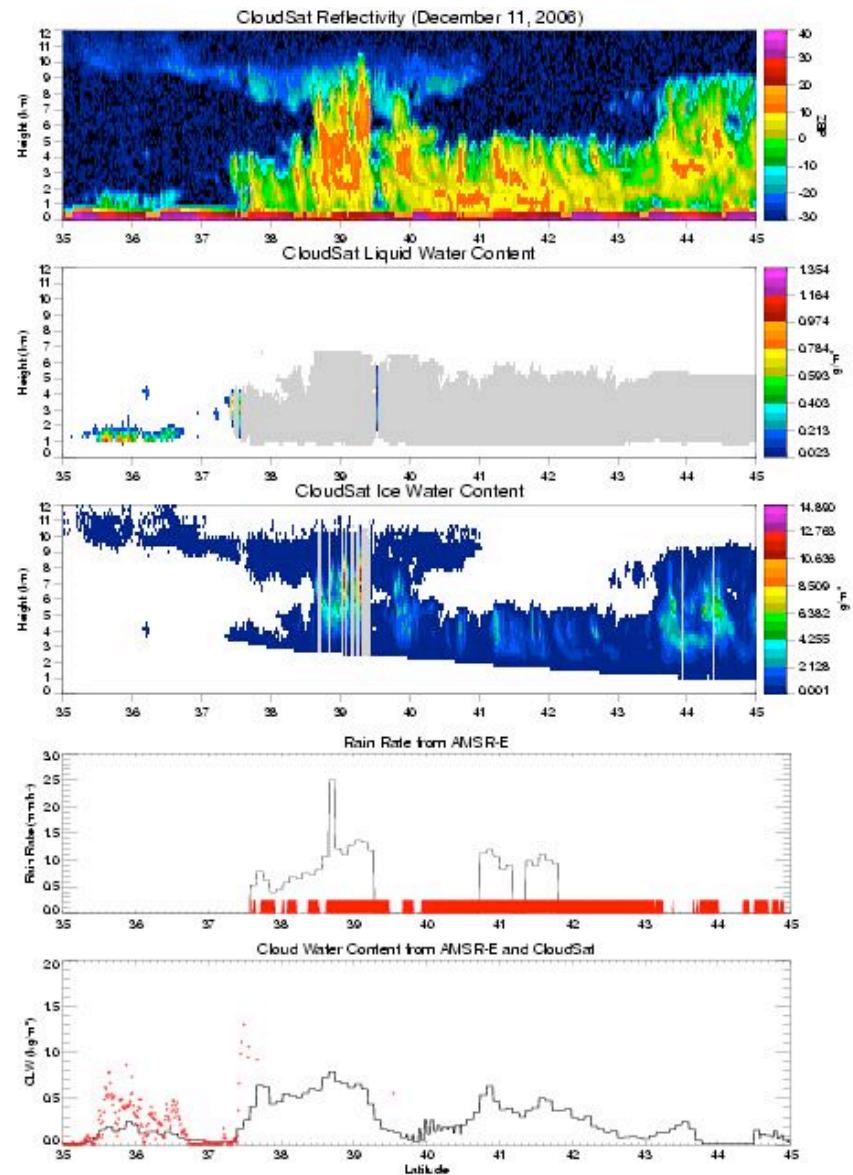


Preliminary example for portion of an orbit

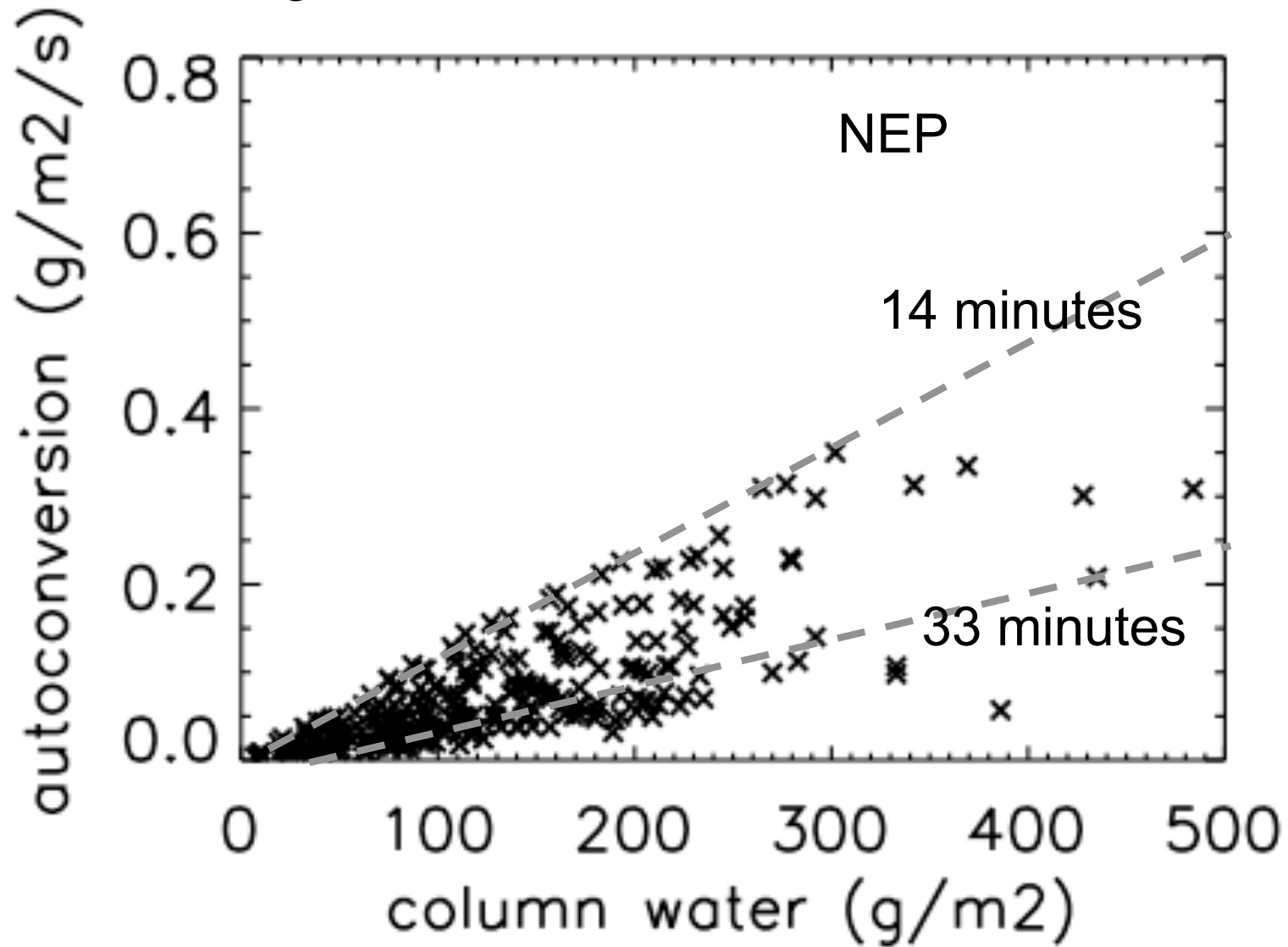
Courtesy Jay Mace

A case study example
of comparison
between CloudSat and
AMSRE -

passive microwave
methods are missing
significant fractions of
light precipitation



Using matched CloudSat radar, MODIS data



Stephens and Haynes, 2007