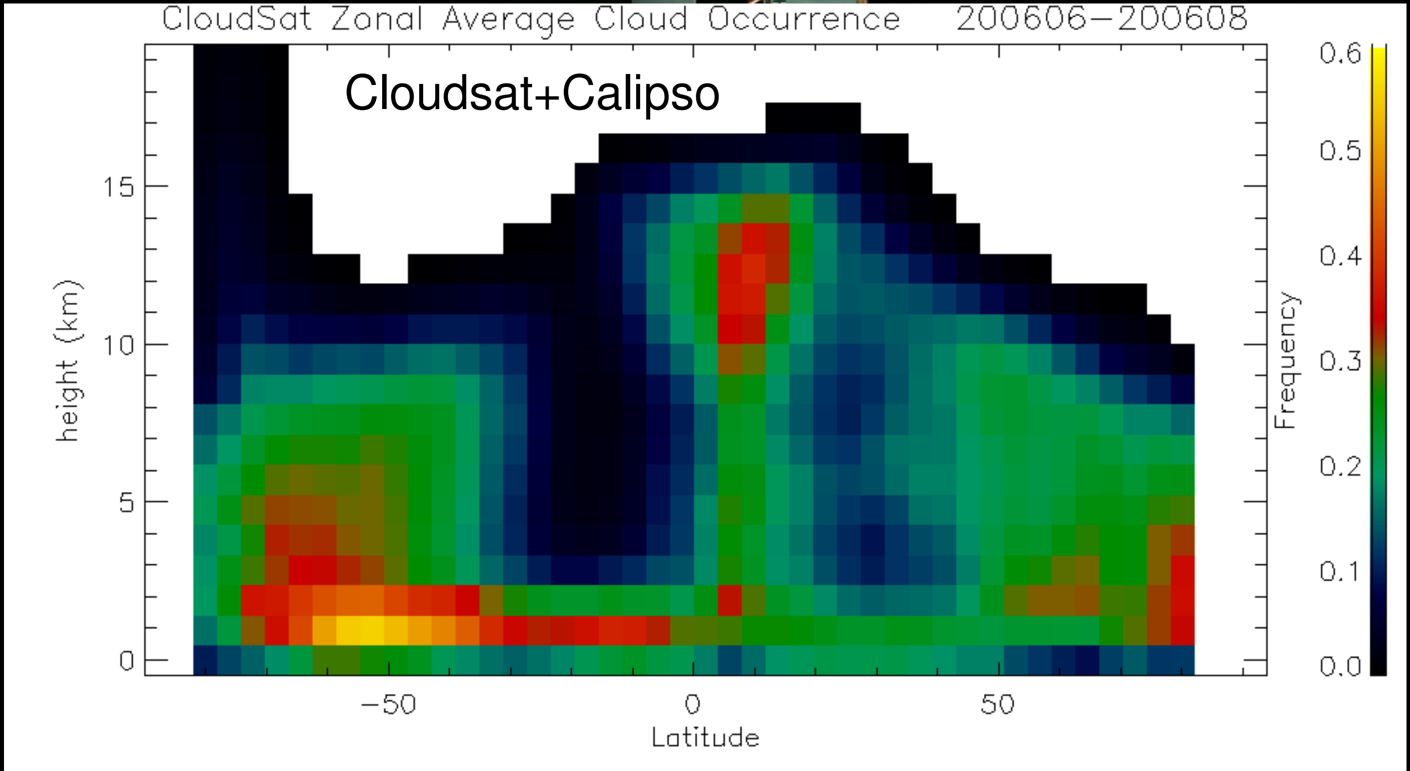
CloudSat Objectives for TC4



Relevant 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 climatic processes*
  - *What are the fundamental vertical structures of global clouds*
  - ***How do structure & properties differ in the presence of precipitation?***
  - *What fraction of clouds of Earth precipitate?*
  - ***What is the mass of ice suspended in the atmosphere?***
- *Quantify the relationship between cloud profiles and the radiative heating by clouds*
  - ***Do clouds heat or cool the atmosphere (relative to clear skies)?***
  - ***Do the radiative properties of precipitation and non-precipitating clouds differ?***

•Cloudsat Standard Data Products

•**Radar+Lidar Cloud Geometrical profile** - *Mace& Marchand*

•**Cloud physics** - LWC/IWC profiles – Richard *Austin*

•**Radiative heating** - derived from geometric profiles, cloud physics, T,q analysis

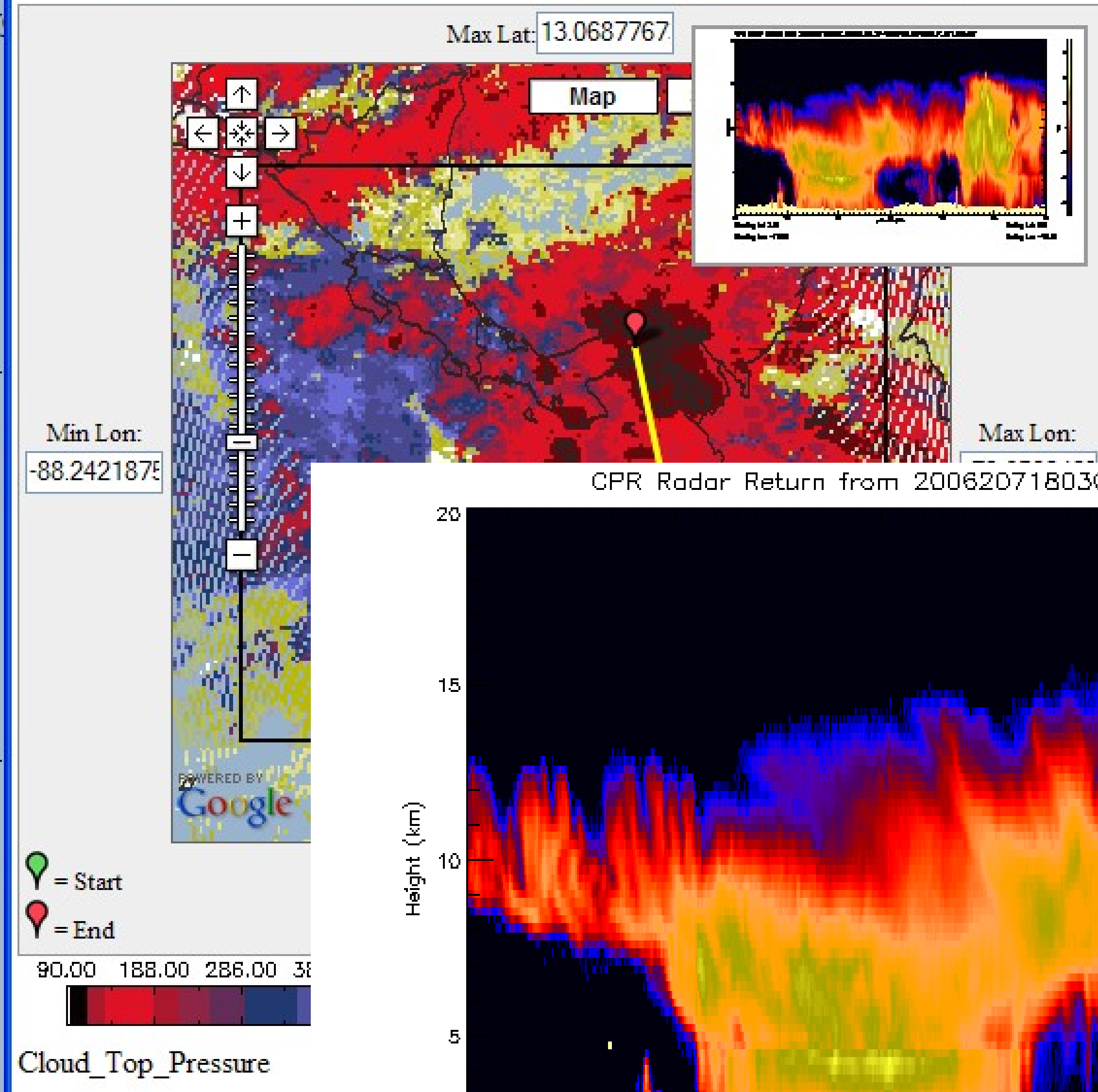
Tristan *L'Ecuye*r

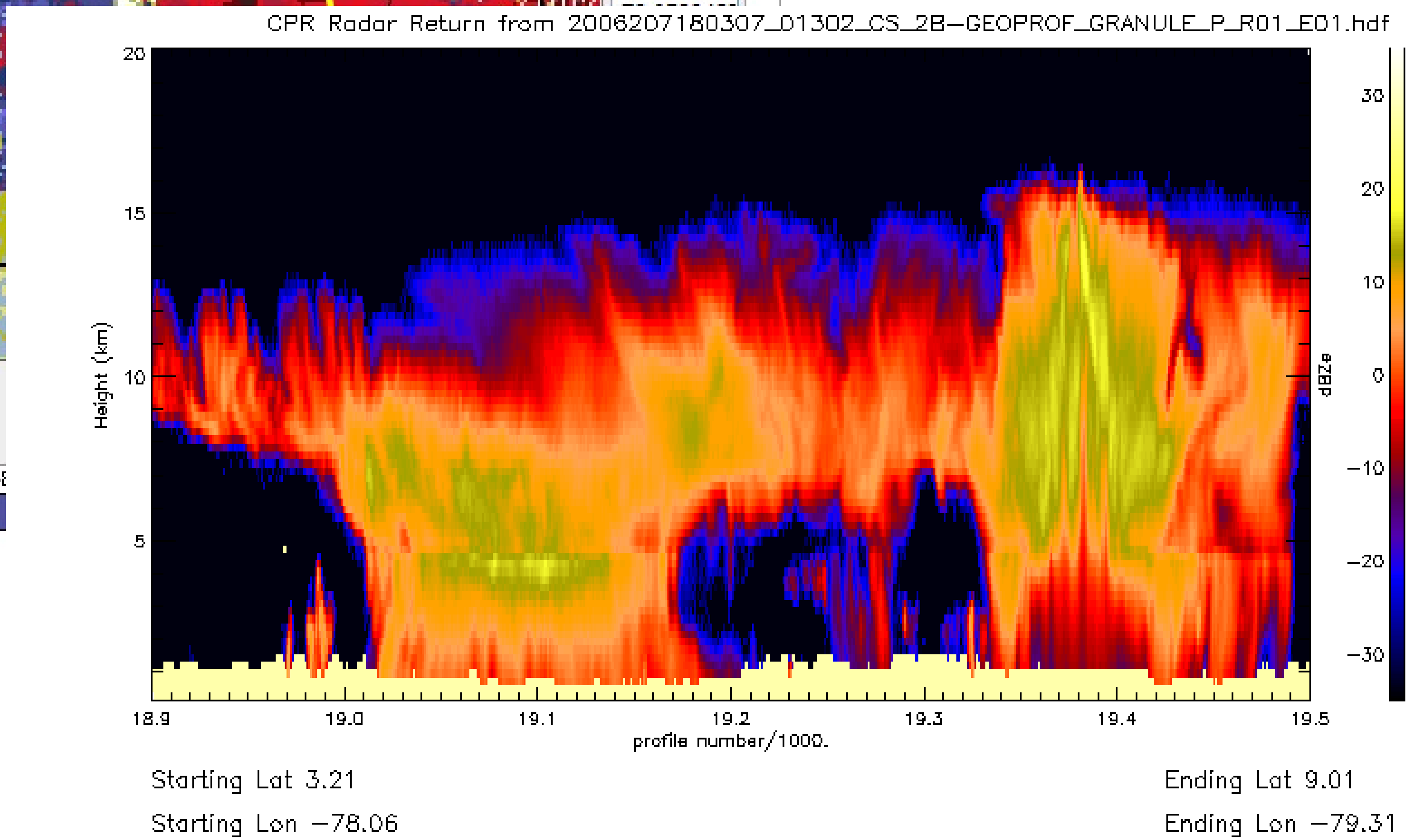
•**Precipitation incidence** *Wang, Haynes*

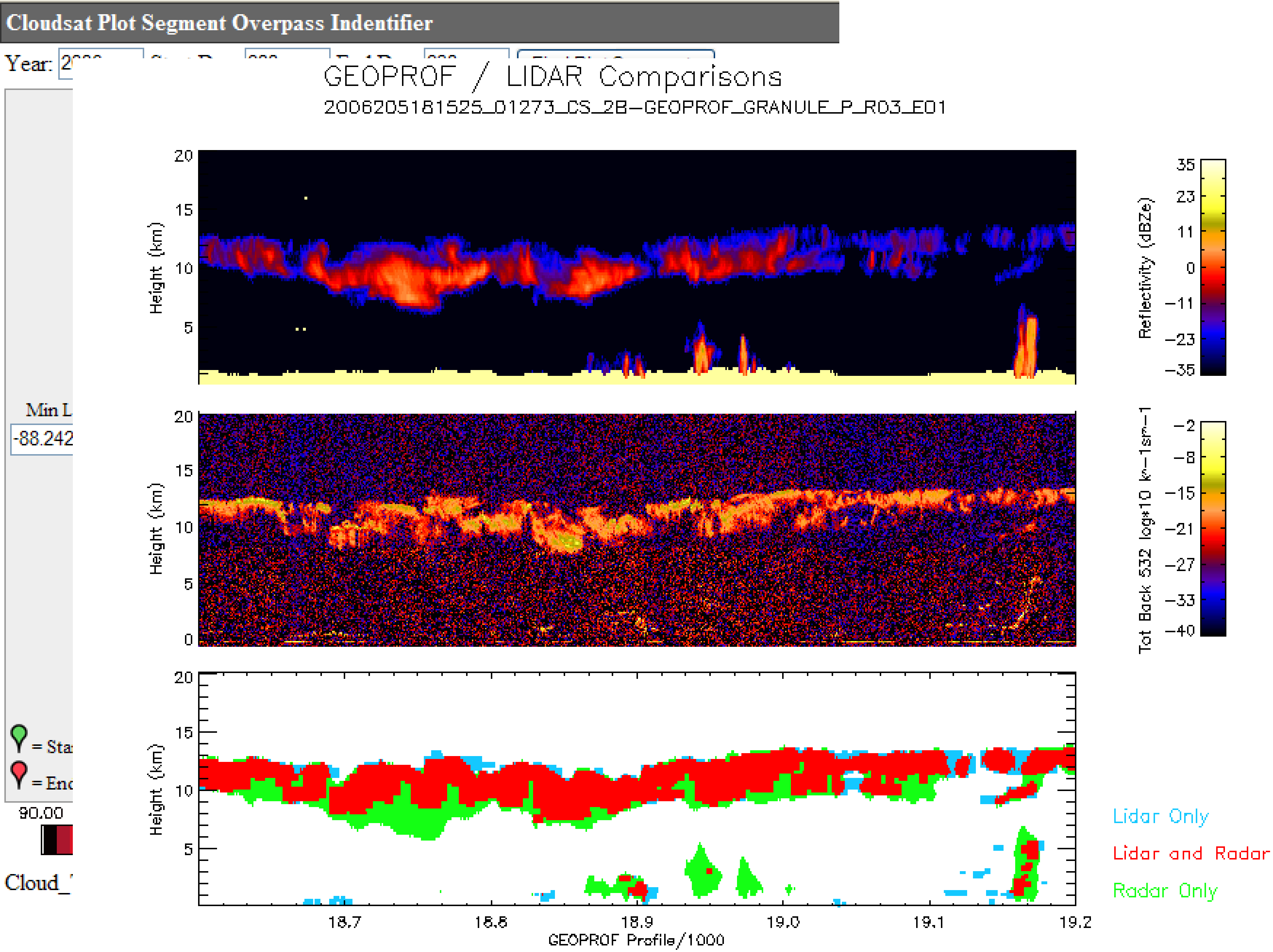
•***Quantitative precipitation*** *Mitrescu,*

Miller, Tristan L'Ecuyer

Heavy Convection over the Gulf of Panama – 26 July 2006






Cloudsat Plot Segment Overpass Indentifier
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Cloud_
GEOPROF / LIDAR Comparisons
2006205181525_01273_CS_2B-GEOPROF_GRANULE_P_R03_E01
Height (km)
Reflectivity (dBZe)
35
23
11
0
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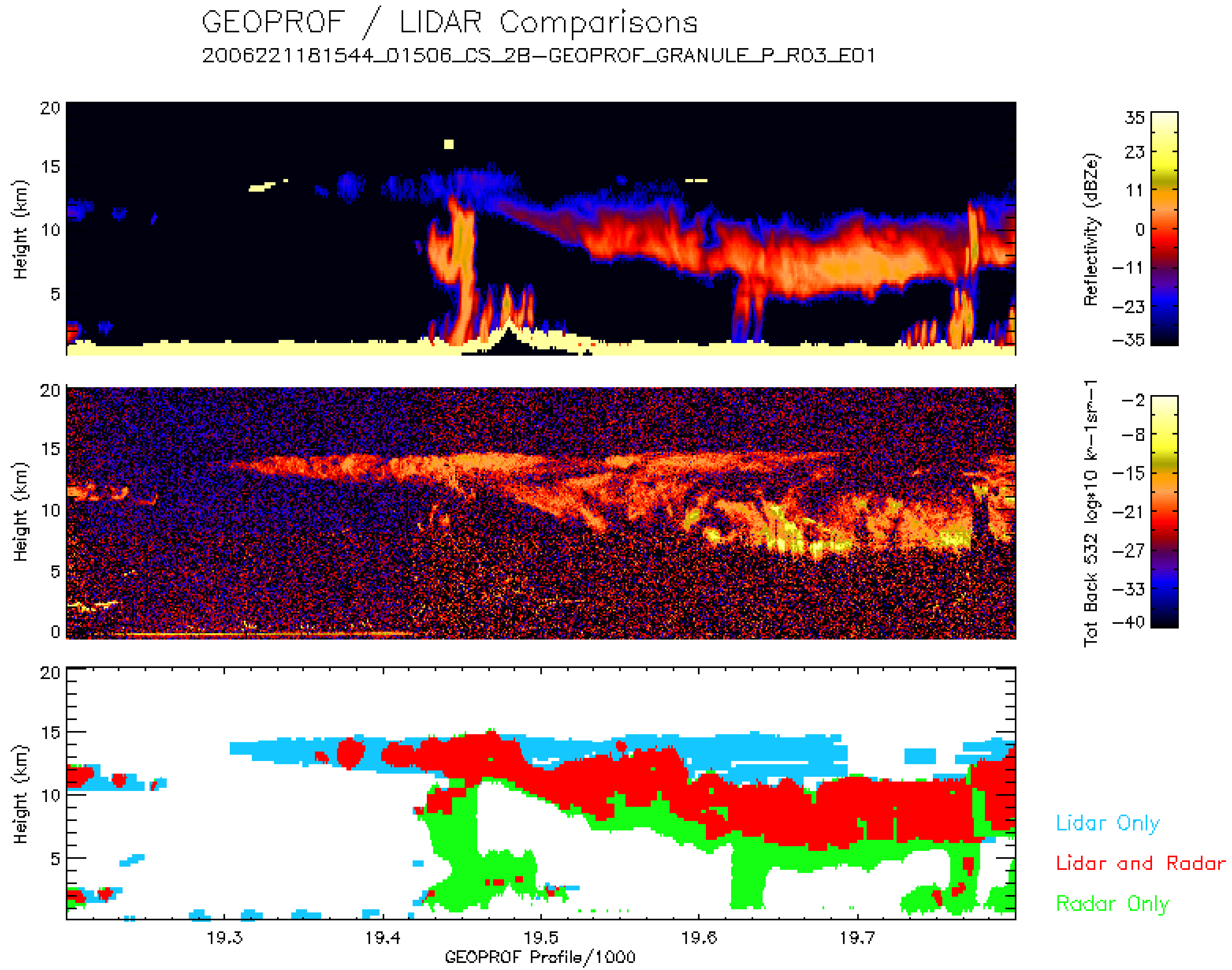
Tot Back 532 log*10 k^-1sr^-1
-2
-8
-15
-21
-27
-33
-40
Lidar Only
Lidar and Radar
Radar Only
18.7
18.8
18.9
19.0
19.1
19.2
GEOPROF Profile/1000



GEOPROF / LIDAR Comparisons
2006221181544_01506_CS_2B-GEOPROF_GRANULE_P_R03_E01
Height (km)
Reflectivity (dBZe)
35
23
11
0
-11
-23
-35
Tot Back 532 log*10 k^-1sr^-1
-2
-8
-15
-21
-27
-33
-40
19.3
19.4
19.5
19.6
19.7
GEOPROF Profile/1000
Lidar Only
Lidar and Radar
Radar Only

Two Primary Approaches to Validation

Fly under the satellites (Overpass Coordination)

- Advantages for intercomparison and calibration
- Necessary **but not the primary objective** for TC4

Use the ER2 as an A-Train+ Simulator *with* coordinated in situ aircraft (A-Train Simulation)

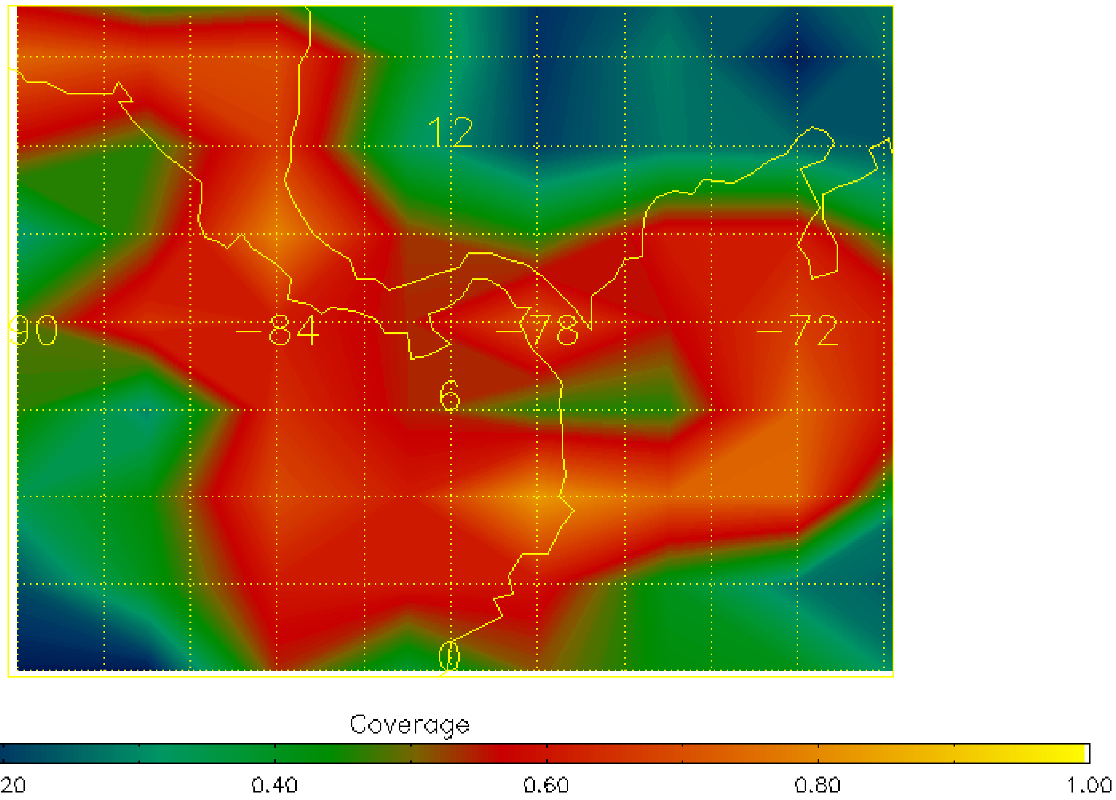
- Clear advantages for algorithm validation, algorithm development and ***learning*** something beyond algorithm issues
- This will be the most valuable approach to mission conduct during TC4
- Differences between the ER2 instruments and A-Train can be exploited –
  - Higher vertical and horizontal resolution,
  - narrower fields of view,
  - additional channels,
  - calibration

Geometrical Profile and Radar Calibration During TC4

Objectives:

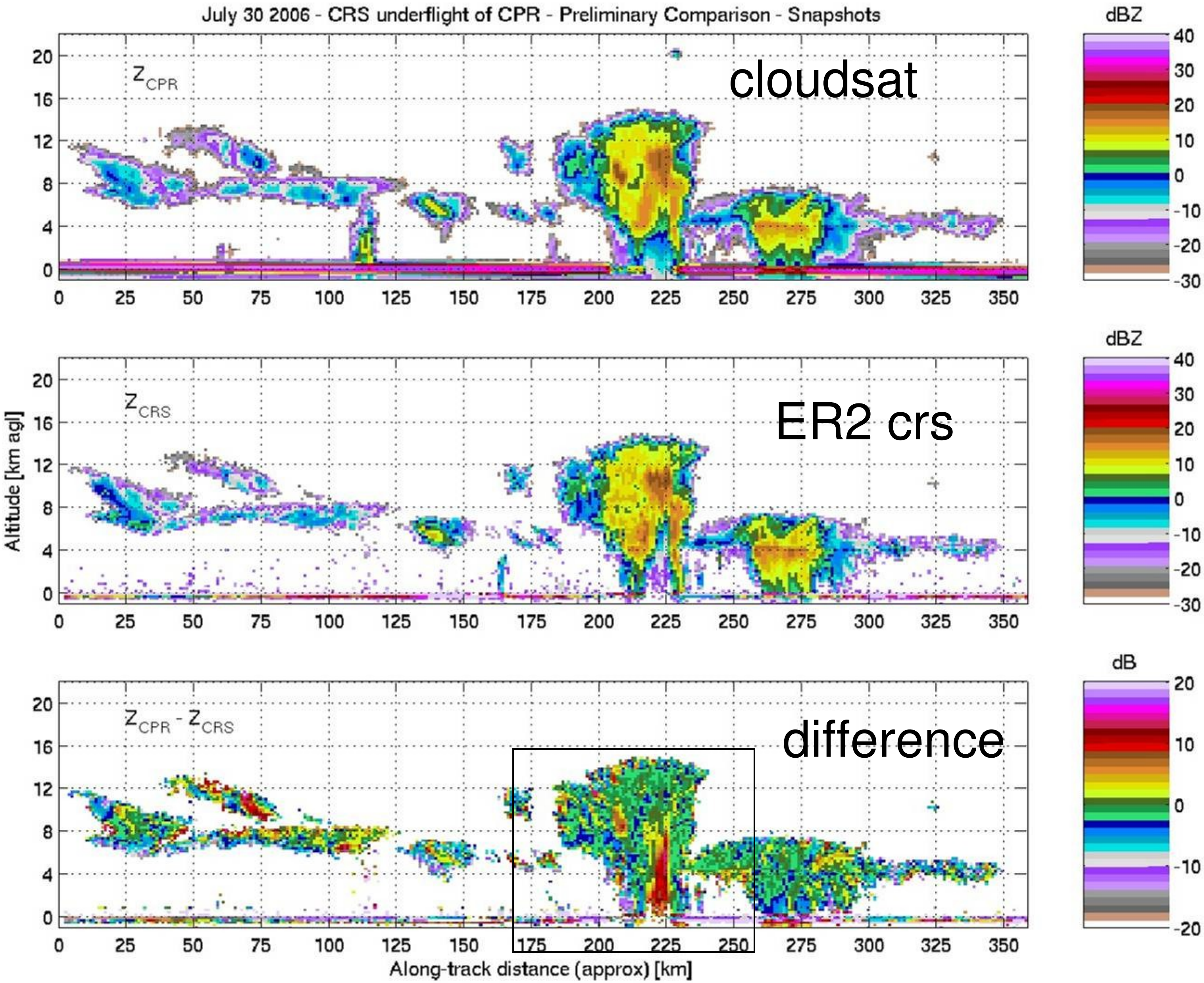
- Validation to ensure the combined product is capturing layers accurately.
- Establish CloudSat Radar Calibration through intercomparison with airborne radar (Ocean surface reflectance, direct comparison between airborne and space radars)

Radar-Lidar Coverage of Cloud base > 10 km – July-August 2006 →



Measurements needed: Overpass coordination with Cloudsat and Calipso with ER2 simulating A-Train while in situ aircraft porpoise within the region where the Radar and Lidar overlap (~Tau=3 region near cloud top)

CCVEX – Summer 2006

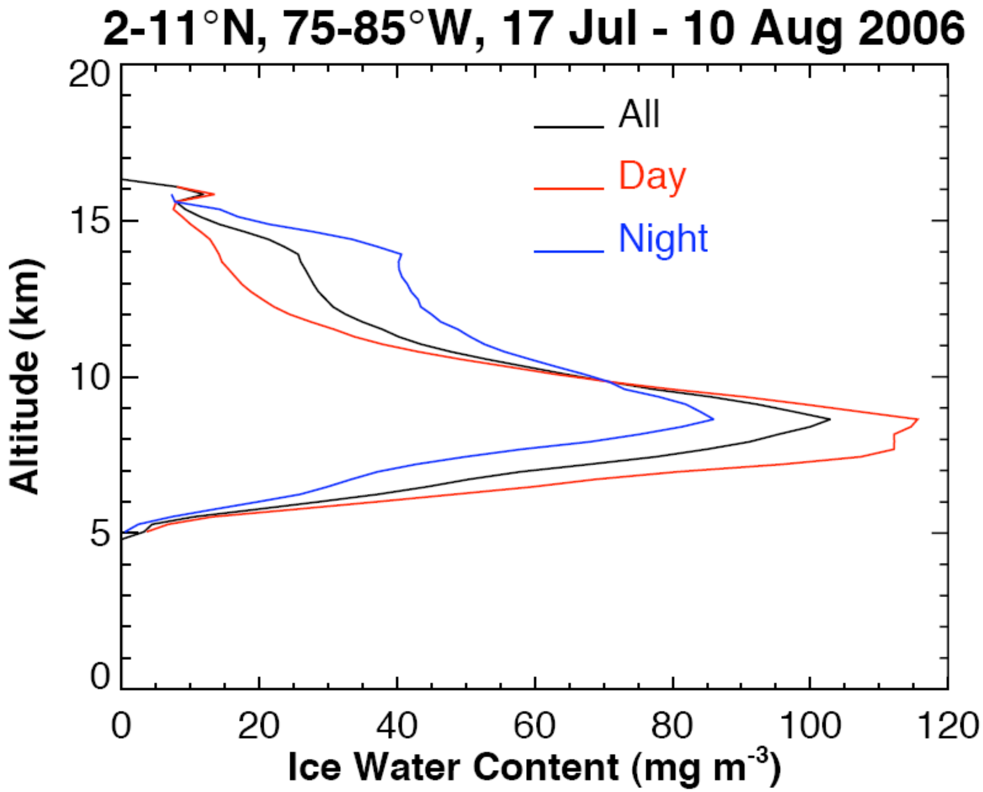


Calibration within 2dBZ

Multiple scattering in rain > 5mm/hr

Validation of CloudSat LWC/IWC Algorithms

CloudSat is producing liquid and ice water content retrievals from two algorithms using optimal estimation inversion approach (Radar Only, Radar-Optical Depth):



Validation of CloudSat LWC/IWC Algorithms

TC4 Validation Objectives:

1) Overpass Coordination:
   1) WB57 near cloud tops (tau=3).
   2) Big focus on regions where the DC8 can record heavy IWC>100 mg/m3. Coordination with overpasses will be very valuable.

3) A-Train simulation flights: Validation and Evaluation of algorithm assumptions:
   - Shape and dimensions of the particle size distributions in cirrus
   - Mass and Area-Dimensional relationships
   - Covariance of (a) measureables (radar reflectivity and extinction), (b) retrieved quantities (IWC and extinction), (c) Z-IWC as a function of PSD and Habit.

Establishing the validity of small ice particle measurements is critical.

Flight Scenarios:

Dedicated flights where ER2 and In Situ simulate A-Train in various genre of ice clouds (anvils, aged/ambient cirrus).

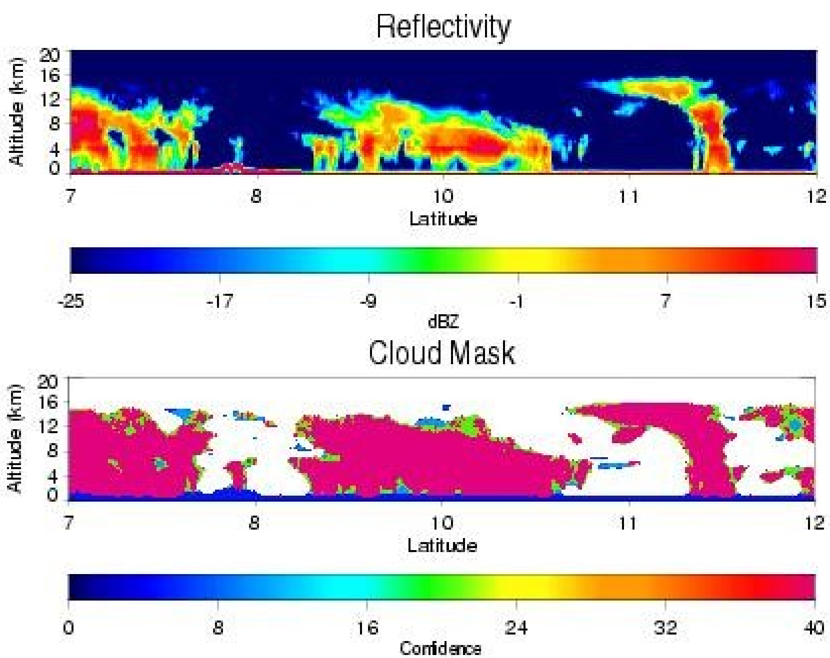
Flight profiles: spirals, level legs and ramps by in situ while ER2 sample along the same lines

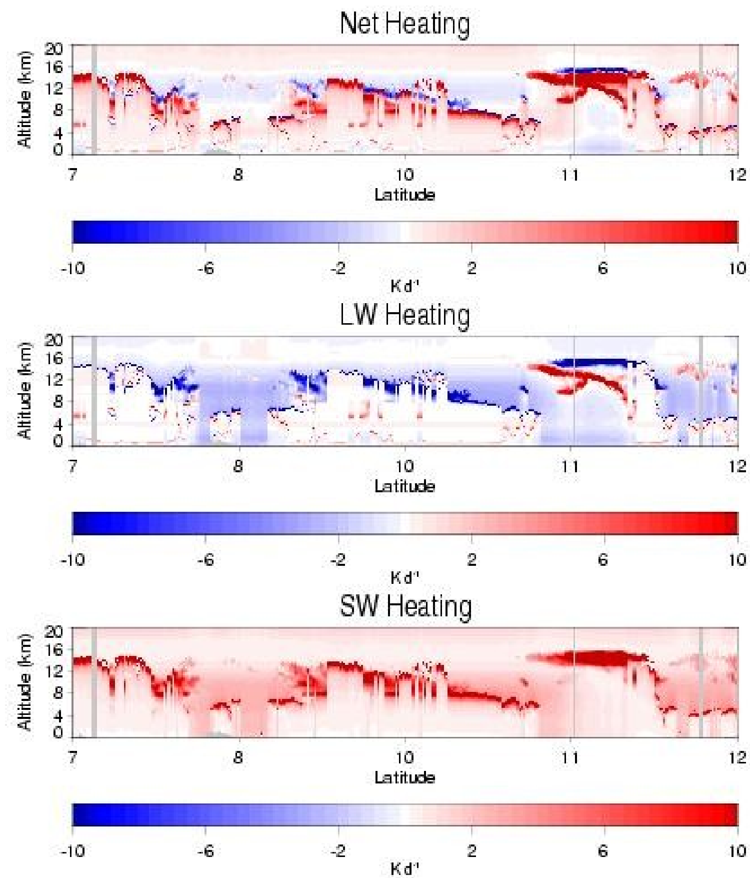
Statistical intercomparison between ER2 and in situ is focus not pixel comparison

Fluxes and Heating Rates

Product: Vertical profiles of upwelling and downwelling radiative fluxes and heating rates.

Key Parameters: Vertical profiles of cloud microphysics, temperature, and humidity.





Fluxes and Heating Rates

TC4 Validation Objectives: - major benefits from improved microphysics

1) Overpass Coordination:
    1) Daytime comparison between fluxes on ER2 and CERES

3) A-Train simulation flights: Validation and Evaluation of algorithm assumptions:
    - Comparison with net flux on ER2 using fluxes calculated with A-Train simulator instruments.

Flight Scenarios:

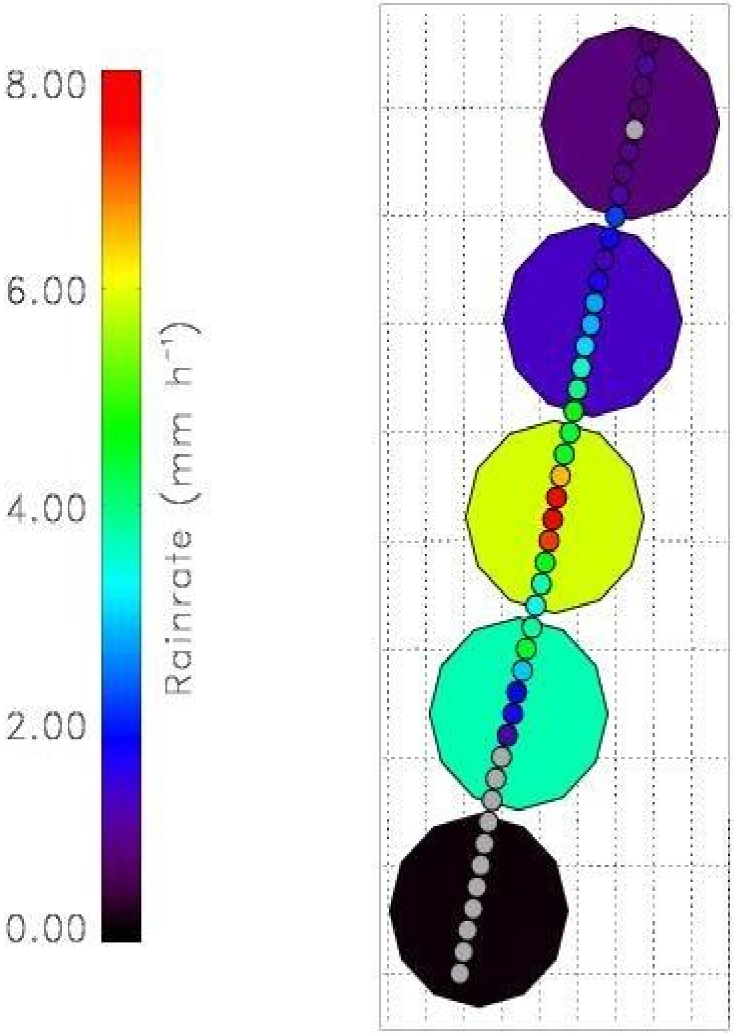
Dedicated flights where ER2 and In Situ simulate A-Train in various genre of ice clouds (anvils, aged/ambient cirrus).

Flight profiles: ER2 – level legs coordinated with WB57 Vertical profiles of cirrus to validate microphysics derived from A-Train simulator.

Precipitation

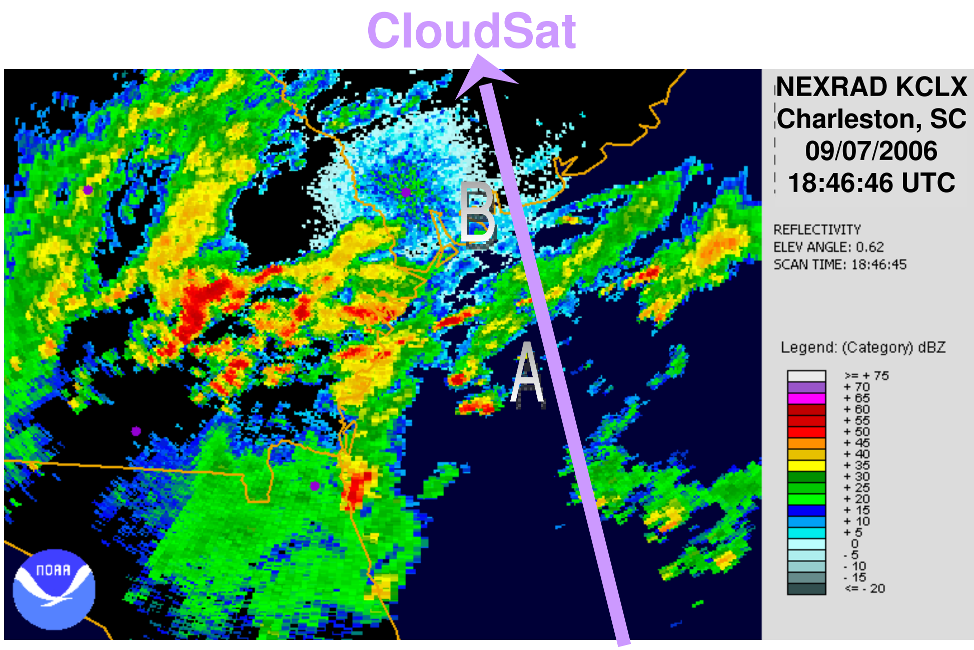
Product: Vertical profiles of precipitating LWC/IWC and surface precipitation rates.

Key Parameters: Particle size distribution, ice crystal shape and density, melting-layer properties, and clear-sky surface return.

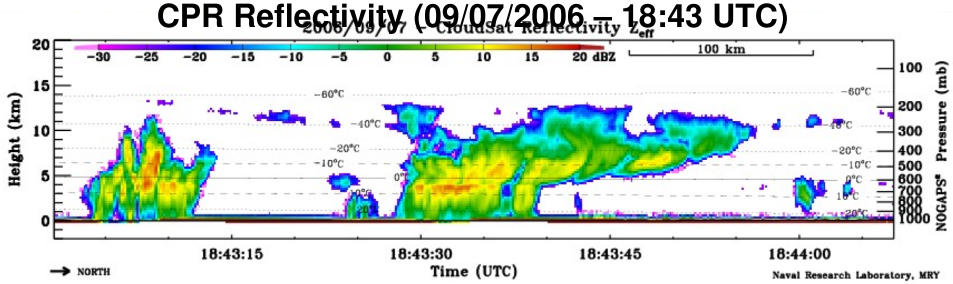


AMSR-E vs CloudSat Precip

Comparison with NEXRAD



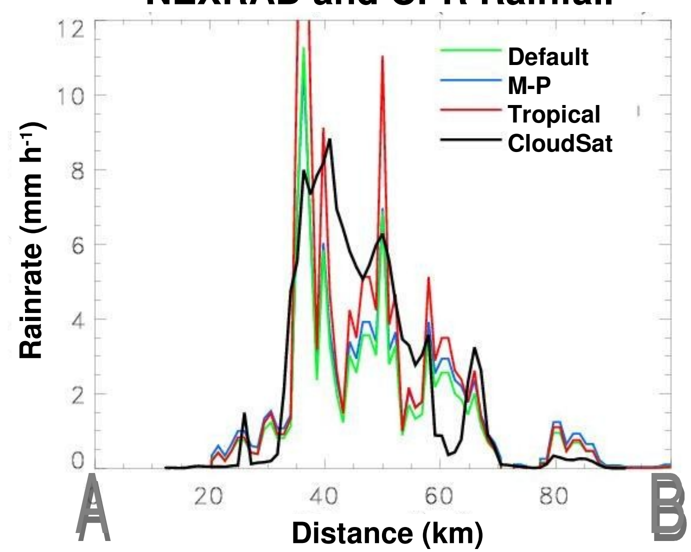
CPR Reflectivity (09/07/2006 – 18:43 UTC)



Validation Needs

- Raindrop size distribution
- Ice particle size distribution, density, and water fraction
- Dielectric properties of the melting layer

NEXRAD and CPR Rainfall



Precipitation

Validation Objectives:

Primary platform for this objective will be DC8

4. **flying under the ER2 in simulation mode and**
5. **In coordination with A-Train during overpasses.**

- **Observations from multiple sensors of the transition from cloud to rainfall**
- **Raindrop size distribution**
- **Ice particle size distribution, density, and water fraction**
- **Dielectric properties of the melting layer**

Note: For precipitation, complete simulator datasets are more important than satellite underflights since uncertainties in algorithm assumptions are expected to be very large.

Summary:

Cloudsat expects to benefit greatly from TC4.

- Multiple objectives (validation and science) can be addressed through A-Train simulation with in situ coordination with DC8 and WB57.

- So long as coordination is maintained between ER2 and in situ aircraft with appropriate cloud sampling, science goals **AND** validation goals can be met.

- Direct underflights of A-Train will also be beneficial **especially with DC8** for precip and heavy ice microphysics and melting layer region

Cloudsat Reflectivity o/ G. of Panama on 11 Aug. 2006