



Impact of microphysical parameterizations on the structure and intensity of simulated hurricanes:

Using satellite data to determine the
parameterizations that produce most realistic
storms.

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Motivation

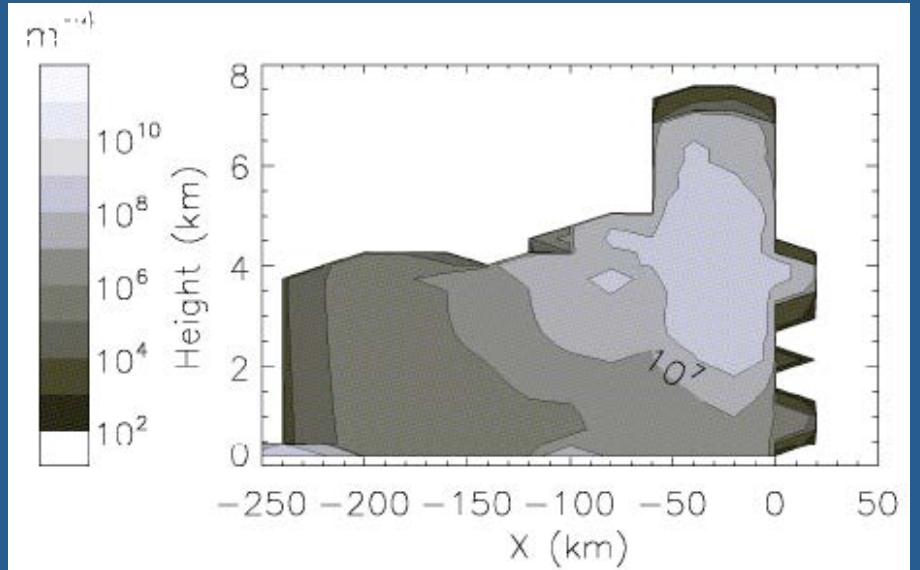
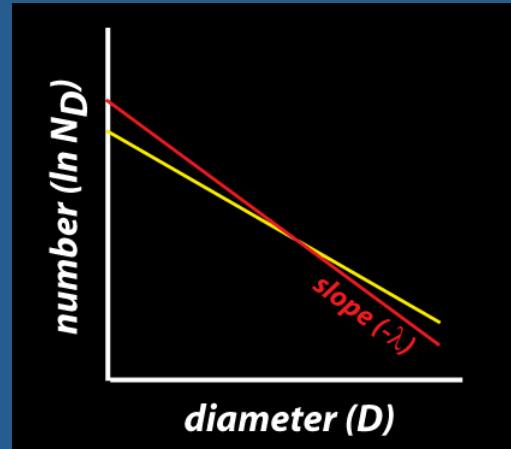


- Need to improve hurricane forecast models
- Inner-core dynamics are important - need to properly reflect small scale complex processes
 - high-resolution models
 - realistic physical parameterizations

Motivation

- Focus on microphysics
 - latent heating that accompanies the hydrometeor production during the convective process strongly impacts storm intensity and size
 - Cloud radiative impact
 - significant uncertainty in PSD assumptions

Rain Intercept parameter, N_{or} , predicted in a two-moment scheme (Morrison et al,





How to Evaluate the Models



- In situ microphysical observations to distinguish between different modeling approaches and improve on the most promising ones.
- These point measurements cannot adequately reflect the space and time correlations characteristic of the convective processes.
- An alternative approach to evaluating microphysical assumptions is to use multi-parameter remote sensing observations.
- In doing so, we could compare modeled to retrieved geophysical parameters. The satellite retrievals, however, carry their own uncertainty.
- To increase the fidelity of the evaluation results, we should
 - bring model and observations into a common analysis system
 - use instrument simulators to produce satellite observables from the model fields and compare to the observed.
 - Improve model forecast through data assimilation that also uses the instrument simulators

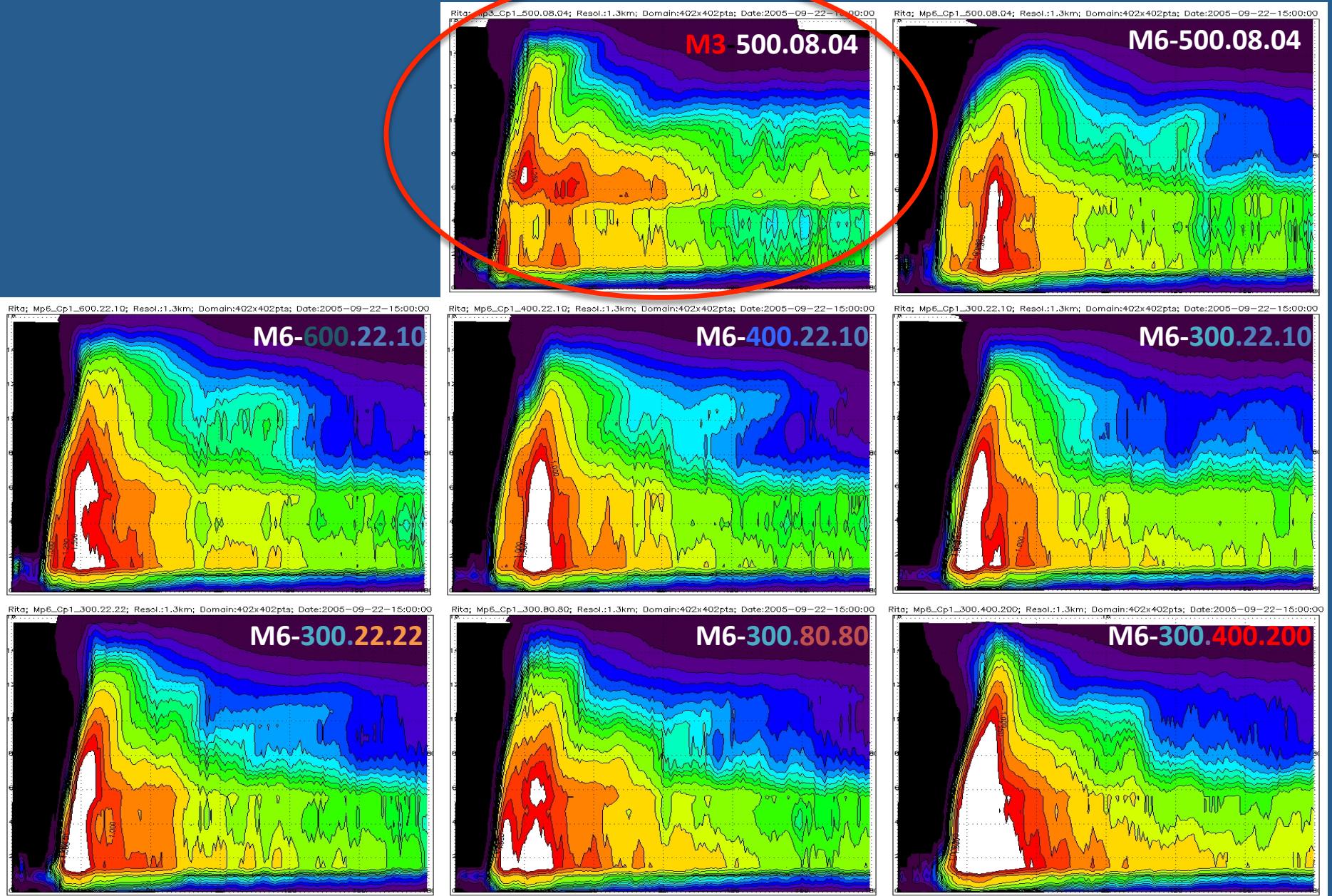


Approach

- WRF high-resolution ensemble simulations
 - Hurricane Rita (2005); GFDL initial/boundary
 - Two microphysical schemes (WSM3 and WSM6)
 - seven different Particle Size Distribution (PSD) assumptions within one of the microphysical schemes (WSM6)
- **Simulation of radiometric signatures**
 - Radar Reflectivity and Attenuation
 - Microwave Brightness Temperatures
 - Surface Backscattering Cross-section
- Comparison to Observations
 - **TRMM-PR; TRMM-TMI; QuikSCAT**



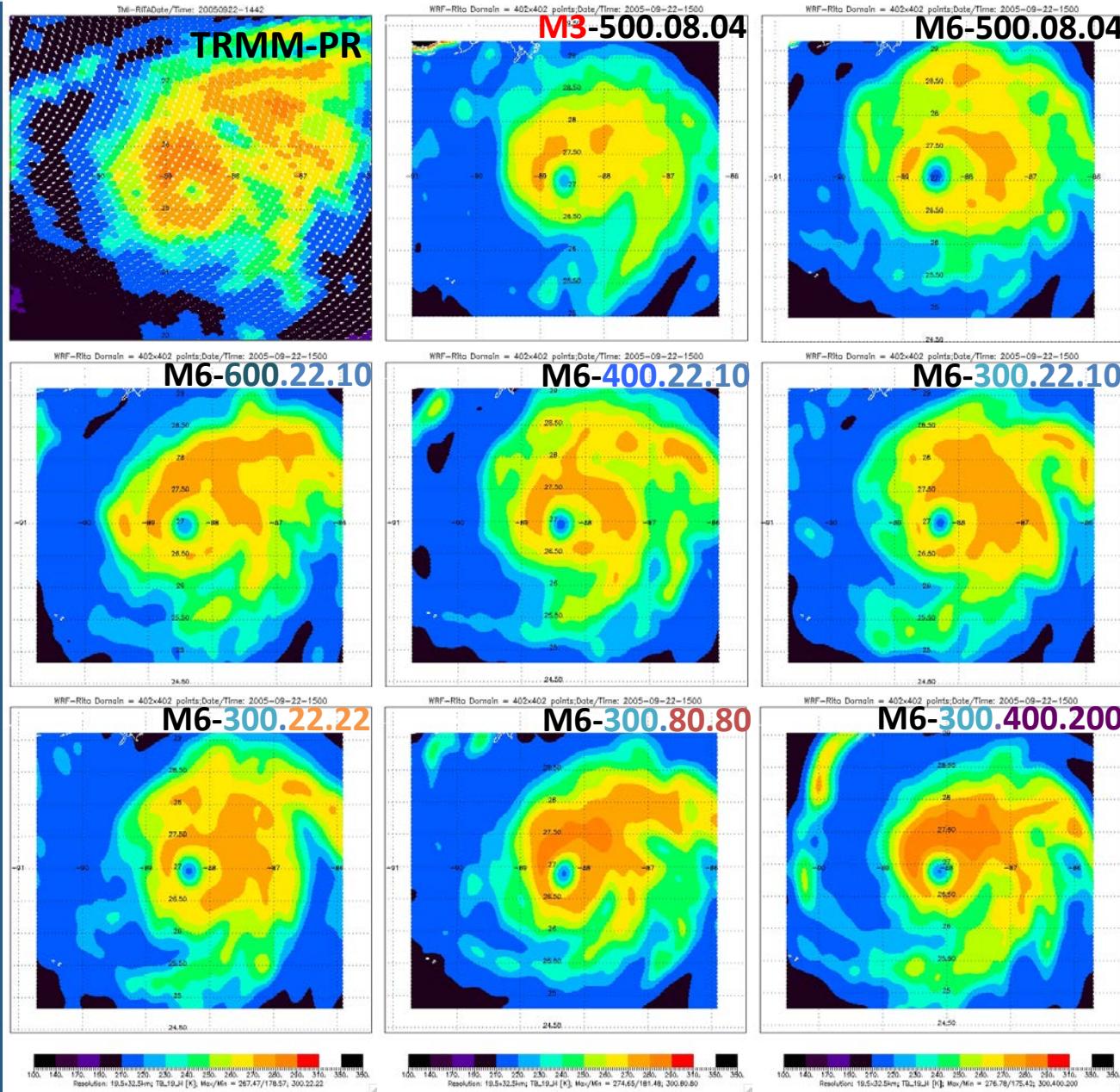
Condensate - Azimuth Averages





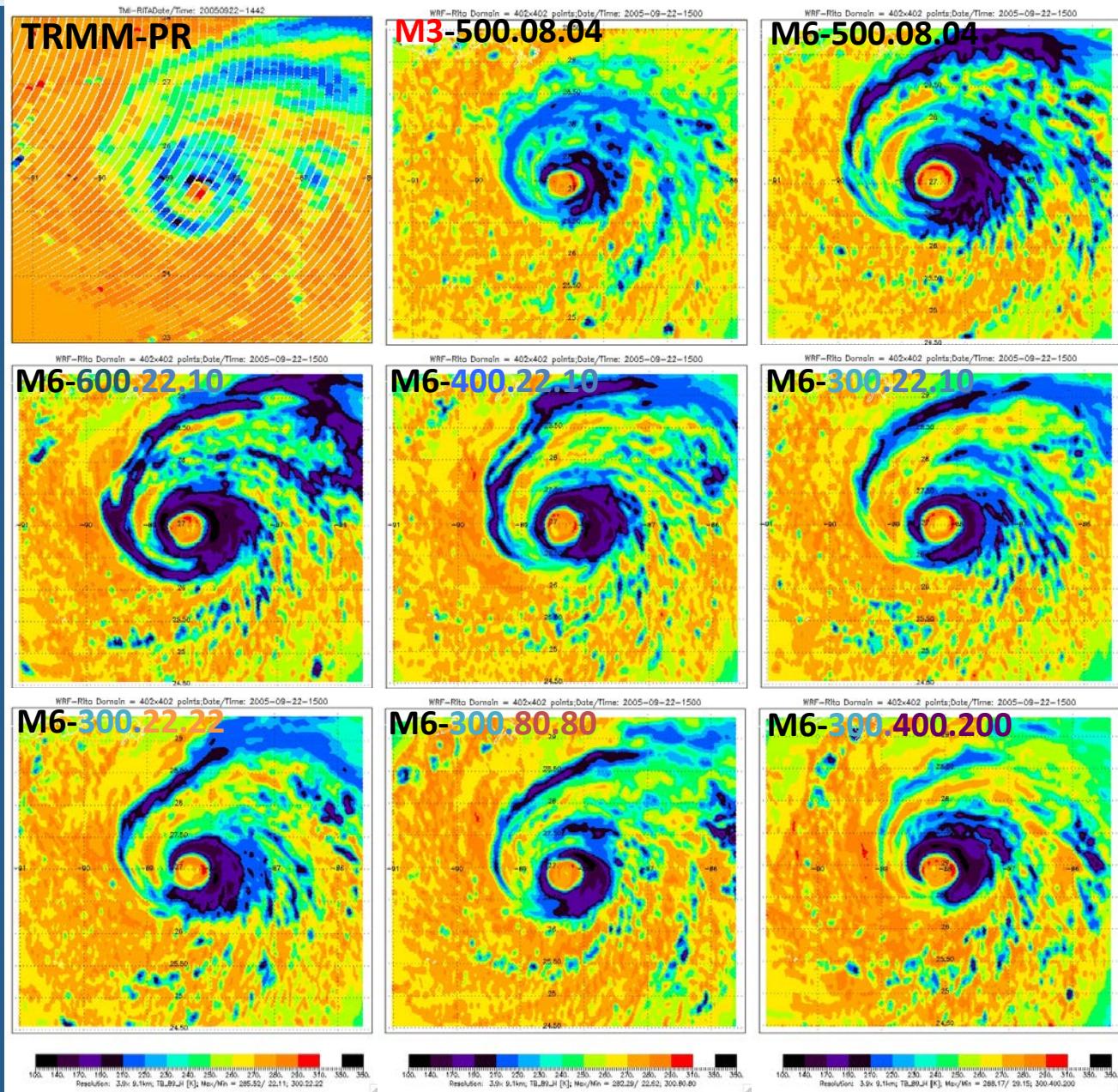
Brightness Temperature-19 GHz H

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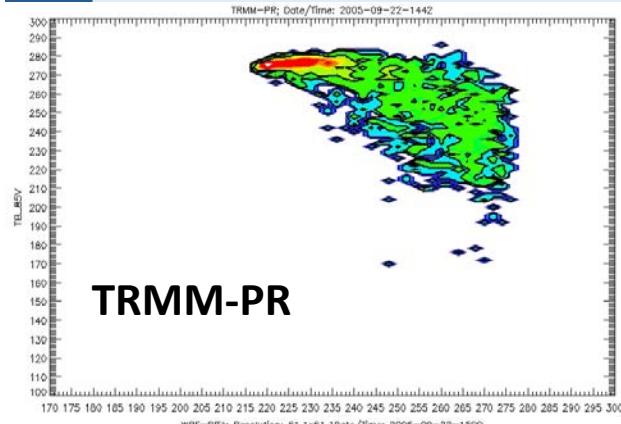


Brightness Temperature-85 GHz H

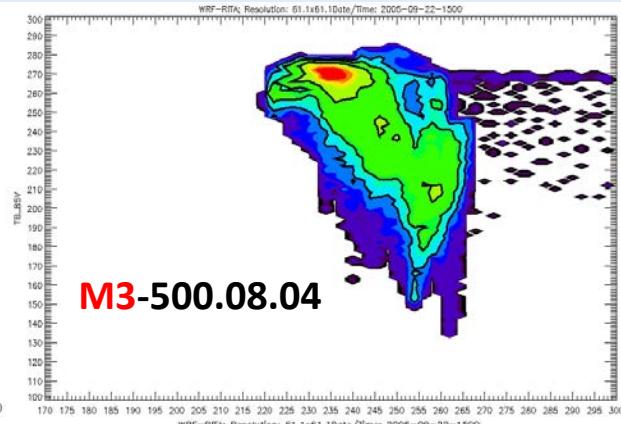




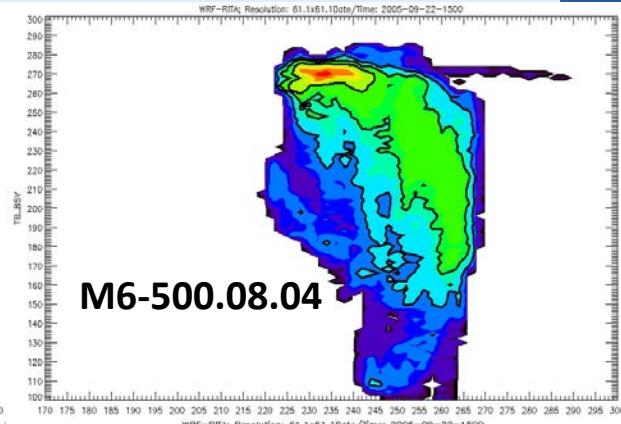
PDF of the relation 85V-19V



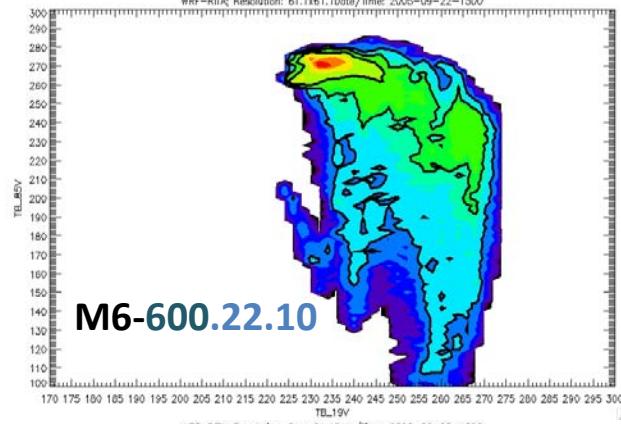
TRMM-PR



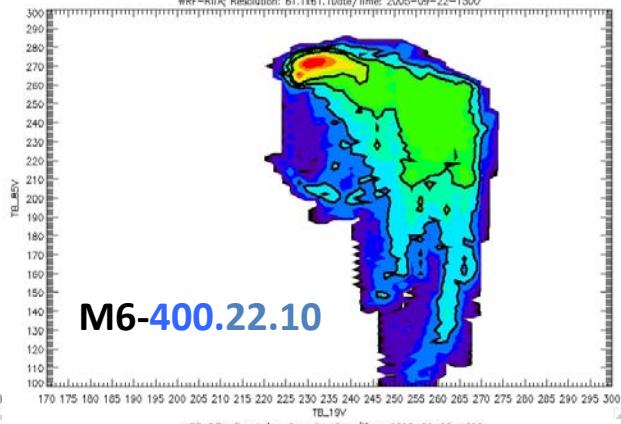
M3-500.08.04



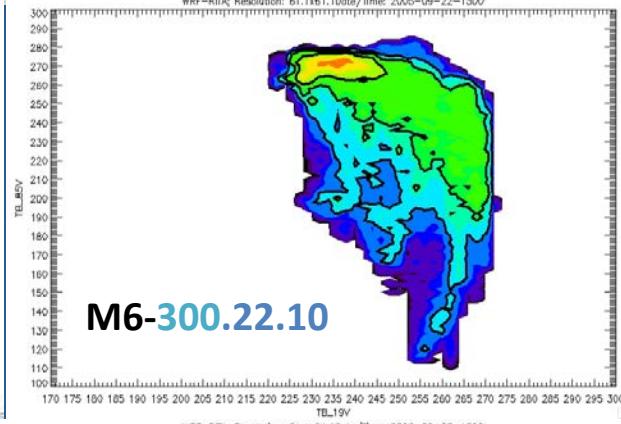
M6-500.08.04



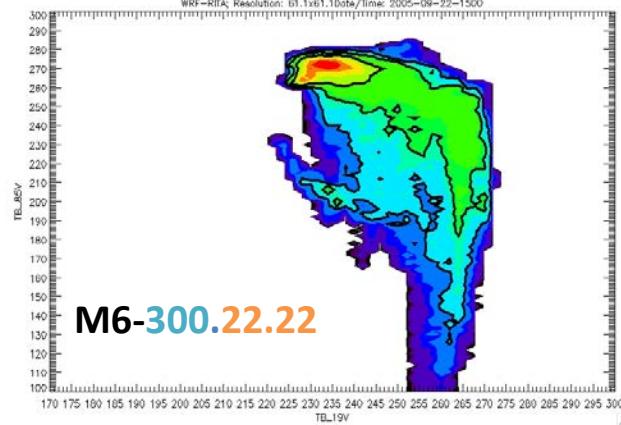
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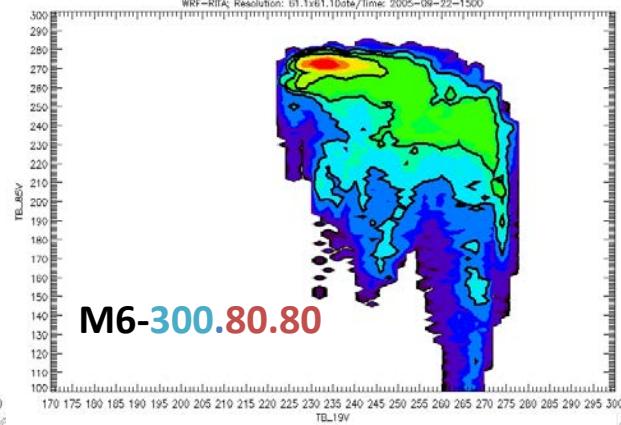
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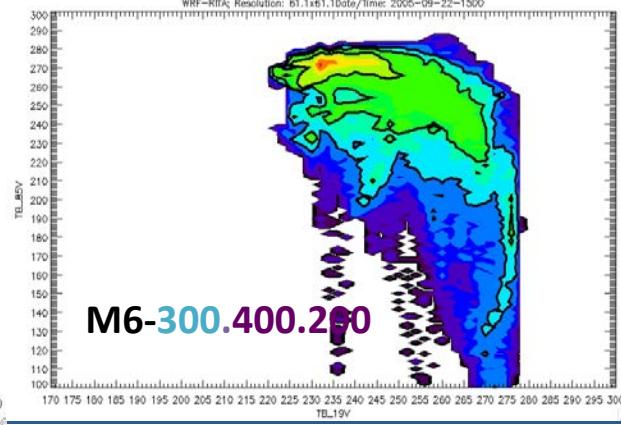
M6-300.22.10



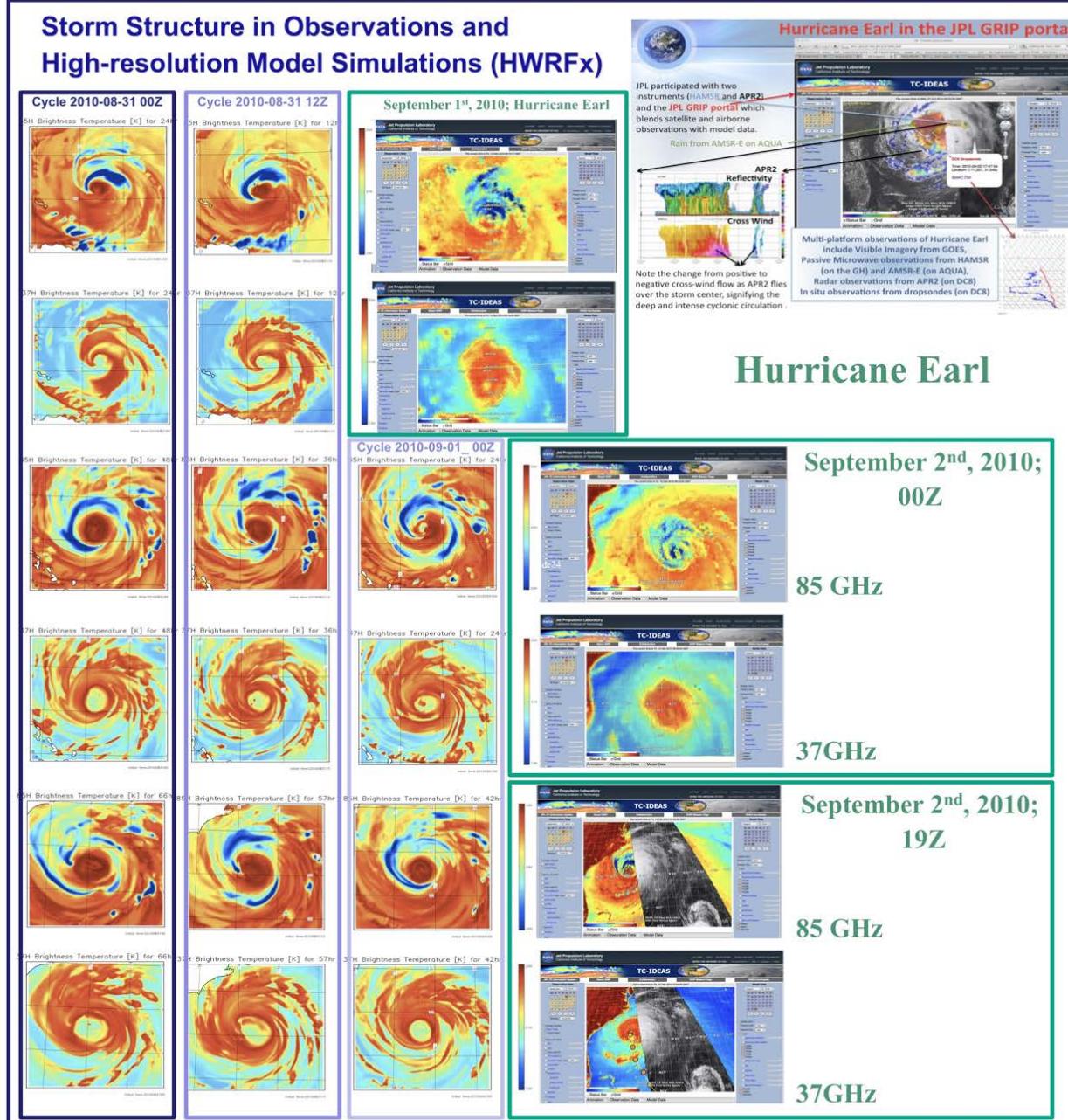
M6-300.22.22



M6-300.80.80



M6-300.400.200



- Used the JPL GRIP portal to identified a number of cases to use for the evaluation of different hurricane forecasts.
- Focused on evaluating the Experimental version of HWRF (HWRFX) in forecasting **hurricane Earl**.
- In a previous study, used the model forecast of the thermodynamic and hydrometeor fields to **forward simulate satellite observables (HRD)**.
- Compared the structure of the **observed and forecasted storms** (from the brightness temperatures at 37 and 89 GHz channels). Found that the model was highly capable in depicting the 2D structure of the precipitation field and its evolution.

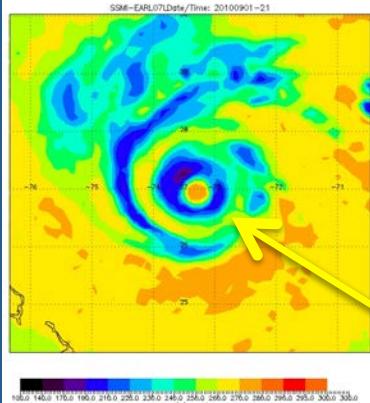


HWRFx STRUCTURE of Earl

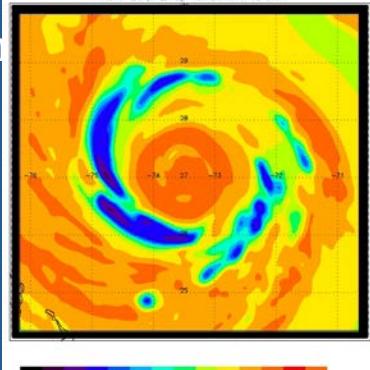
JPL

85/91 GHz H pol (sat. resolution) – 02 Sept. 2010

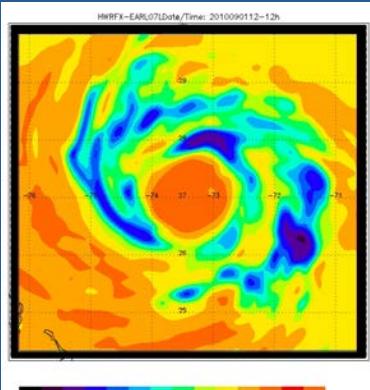
Observed



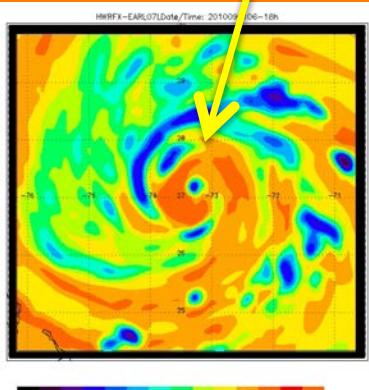
06h



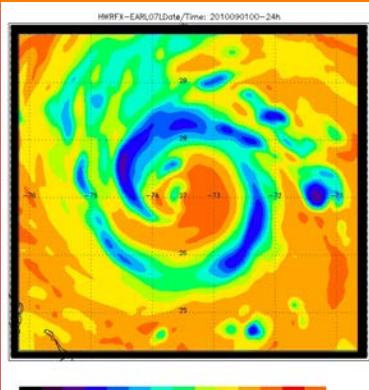
12h



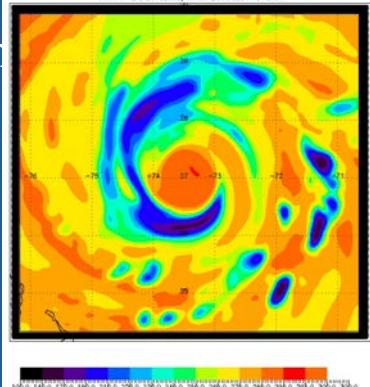
18h



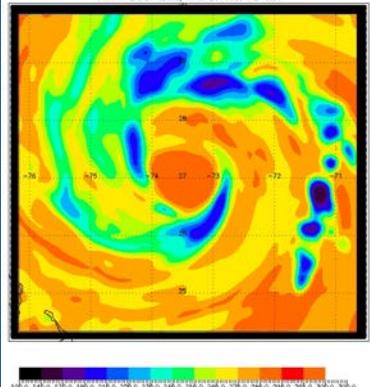
24h



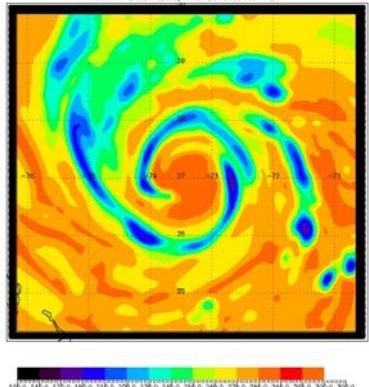
30h



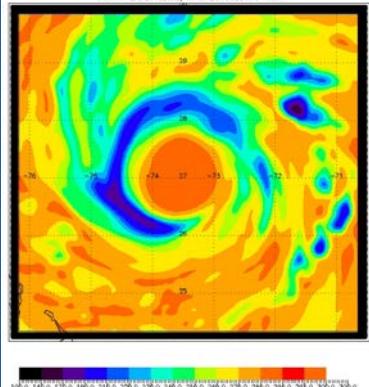
36h



42h



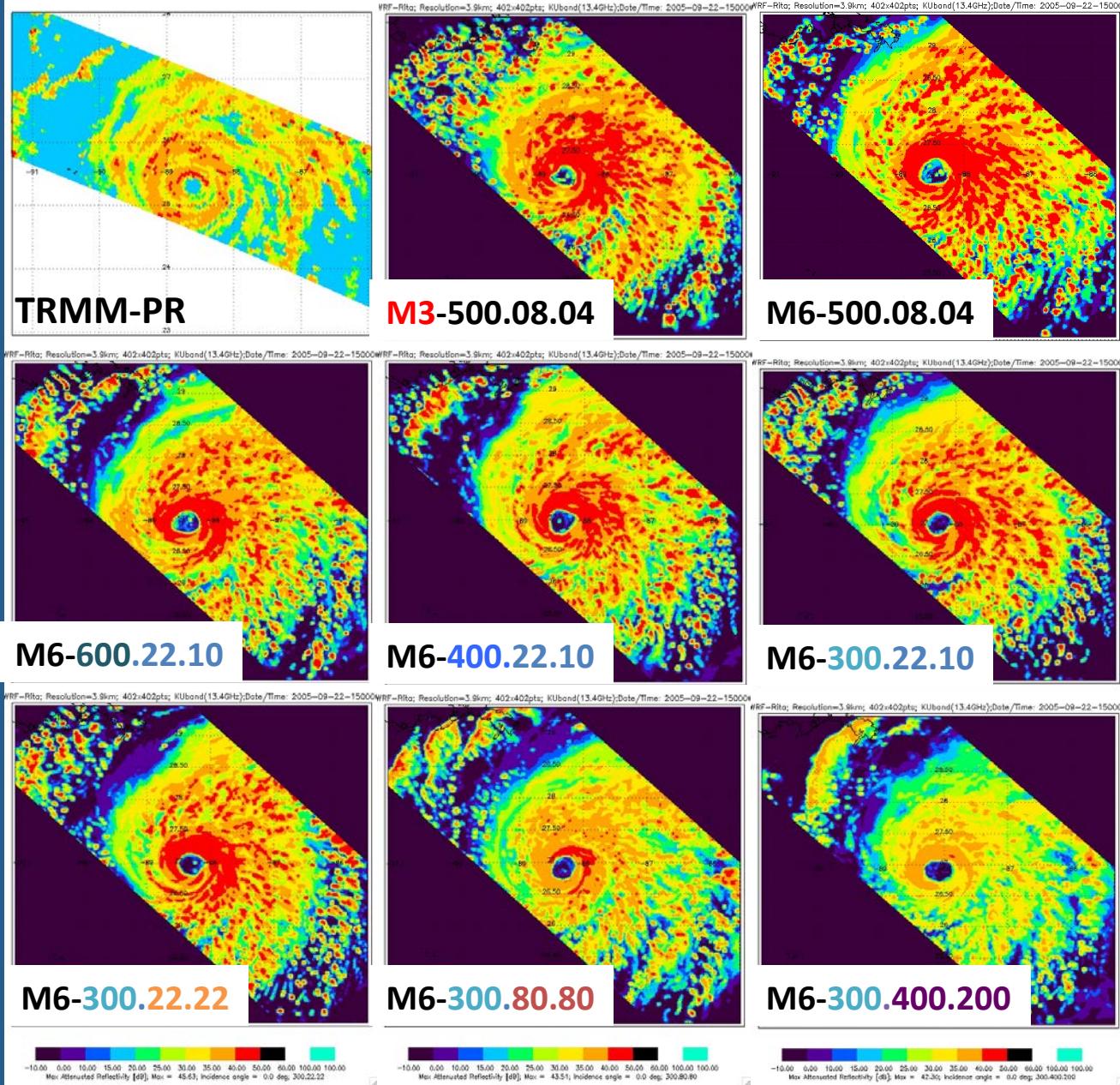
48h



- Note that the realistic storm structure does not develop until 12-18h into the forecast cycle
- The realism decreases after the 42h forecast
- The model has a very large eye and does not show the observed eyewall replacement cycle



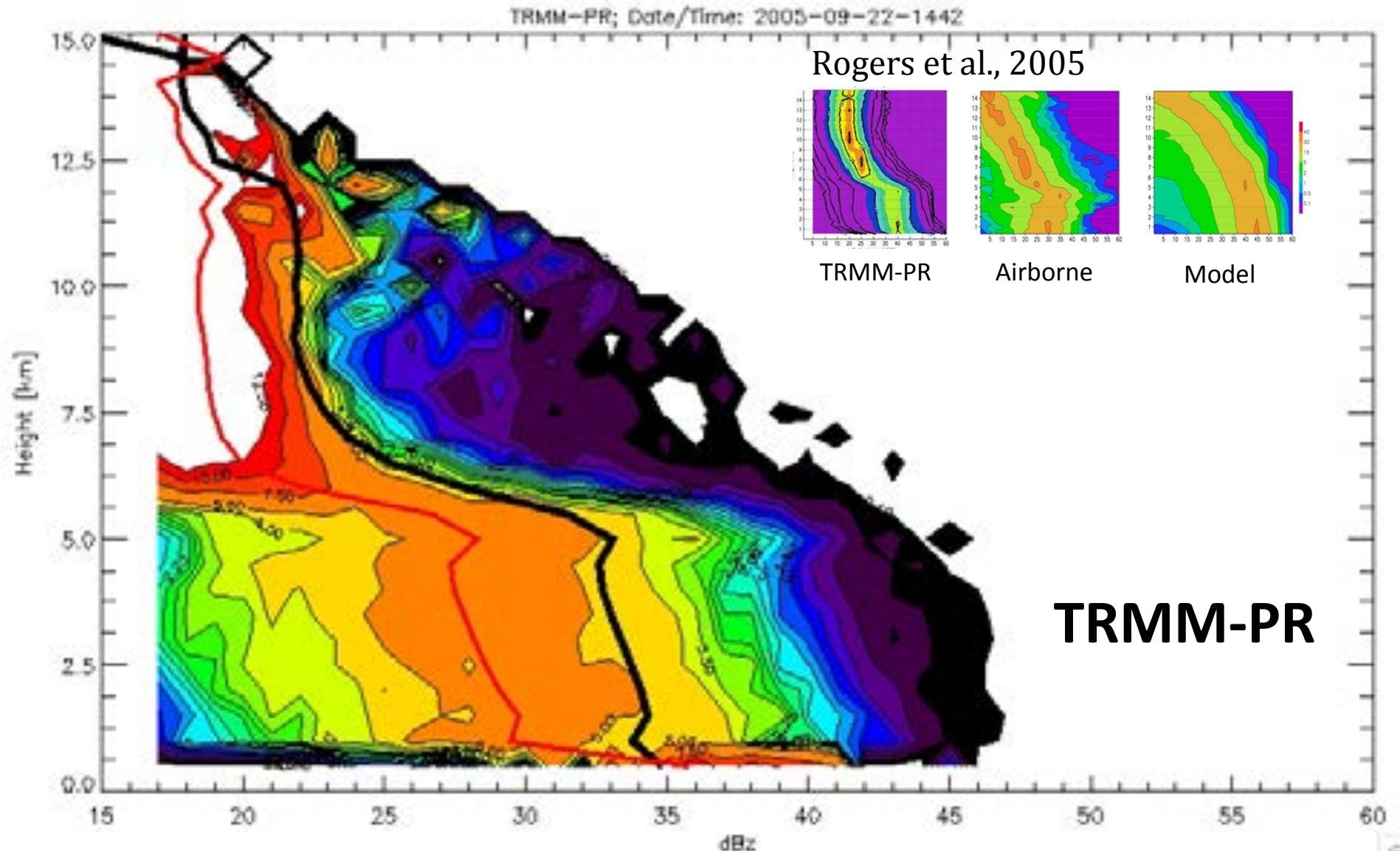
Maximum Attenuated Reflectivity





CFADs (Yuter and Houze 1994)

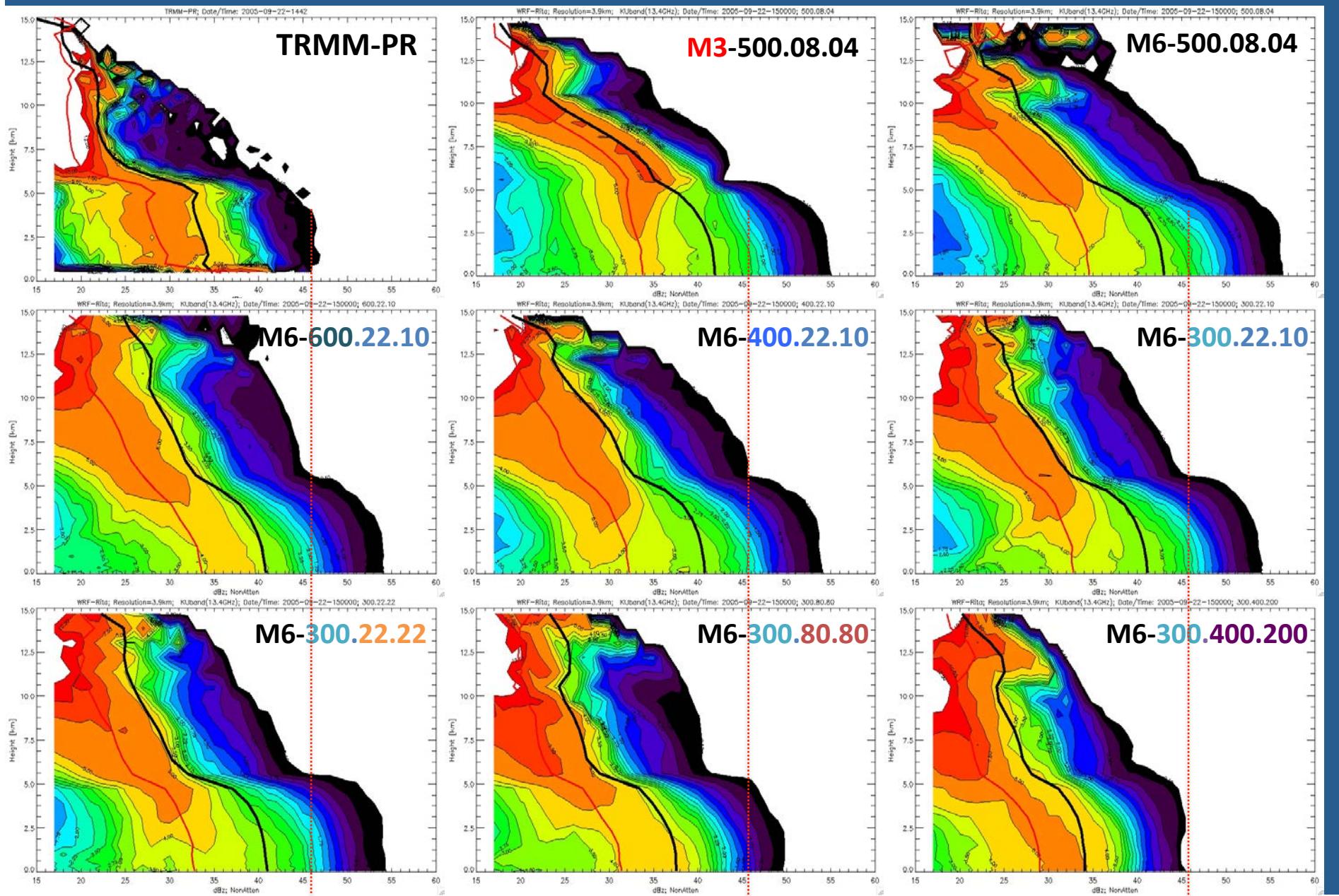
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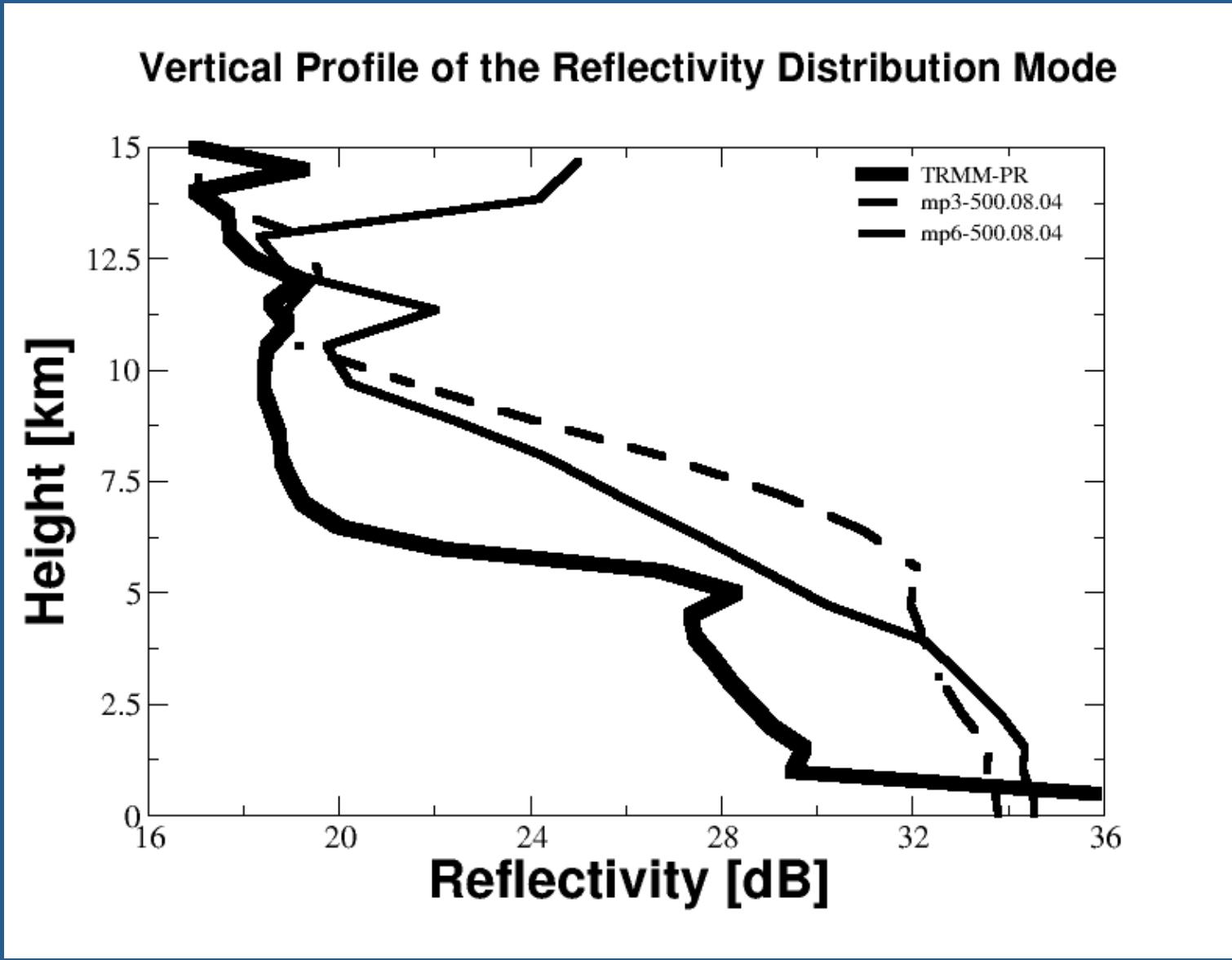
CFADs



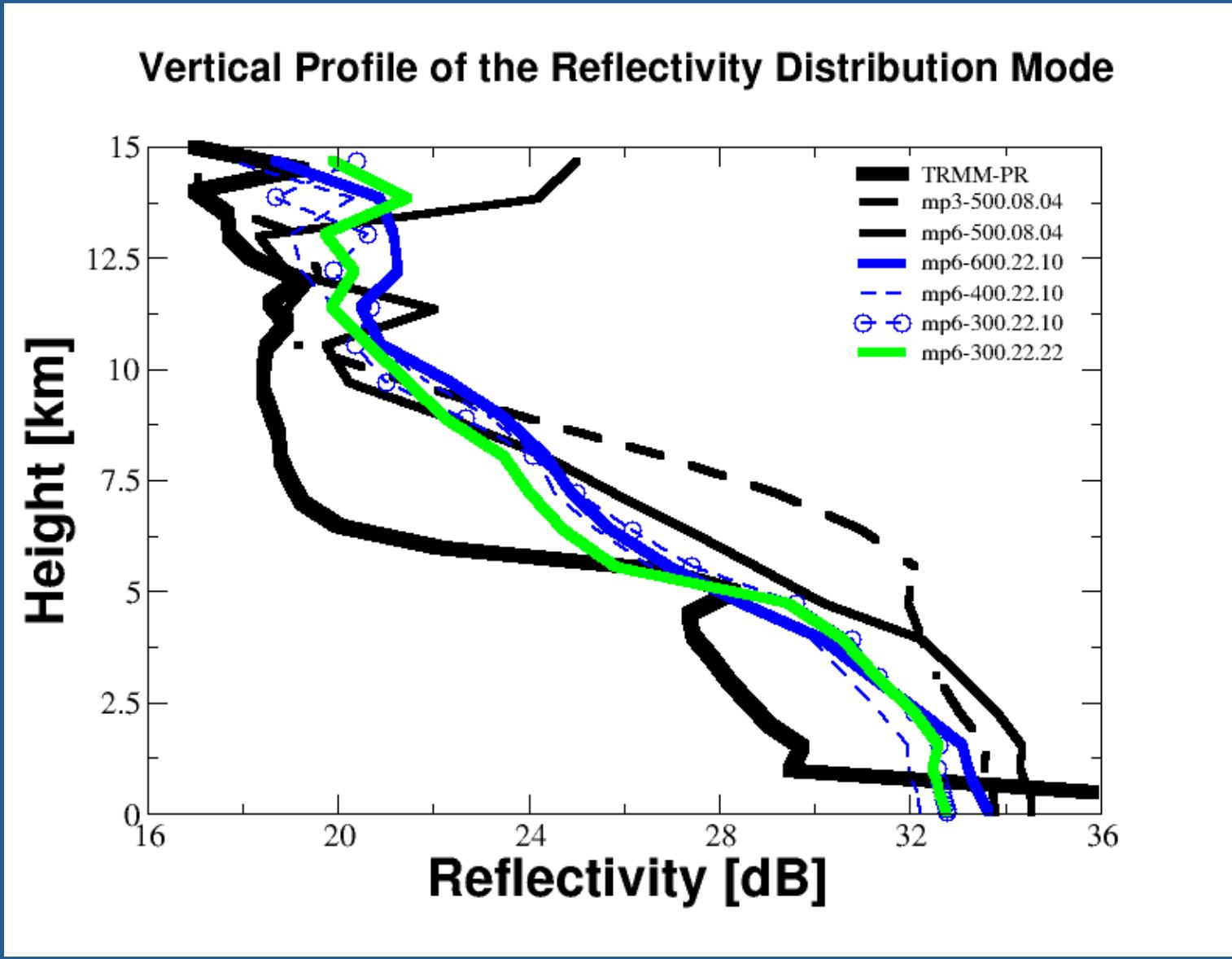


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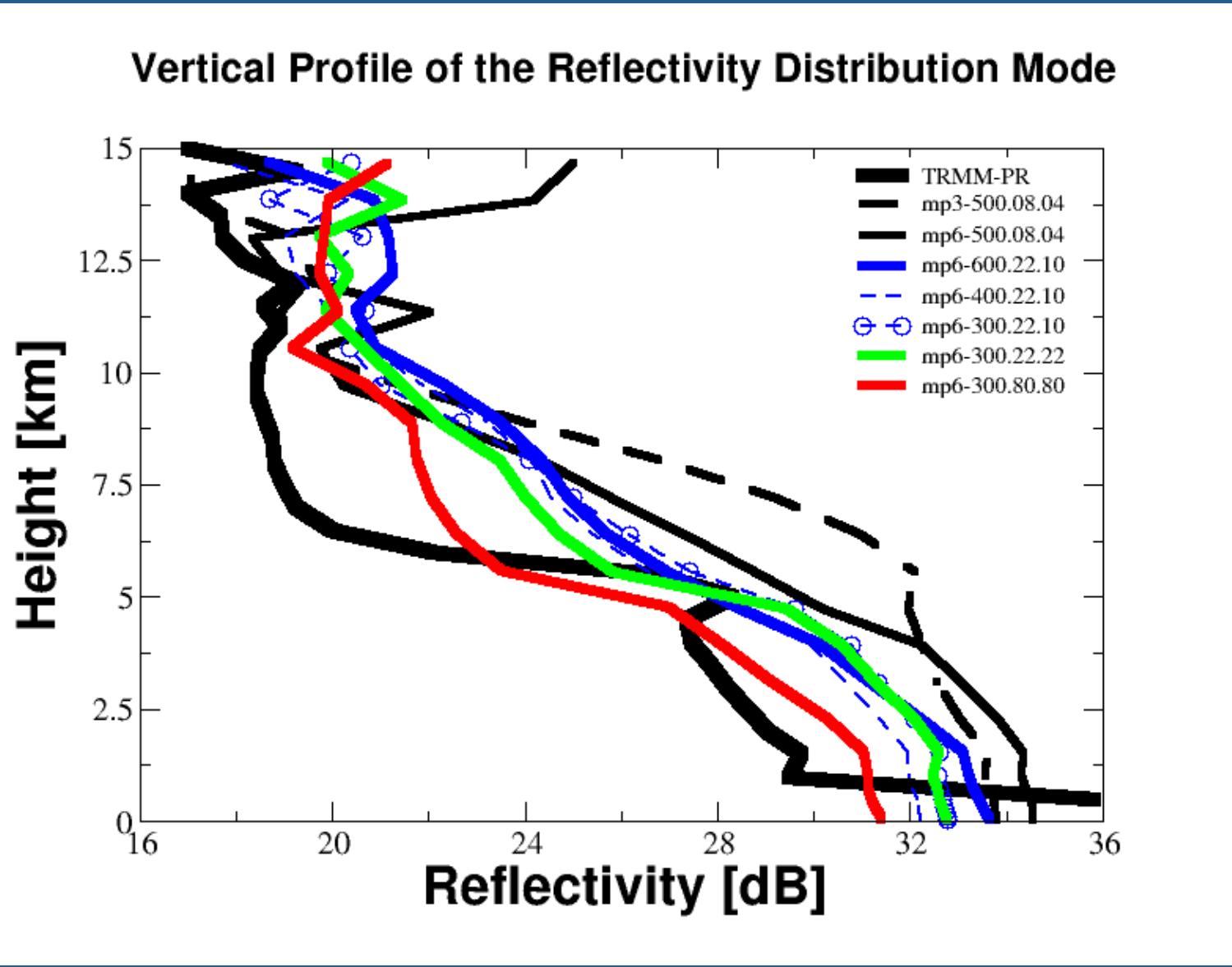
MODE of the Reflectivity



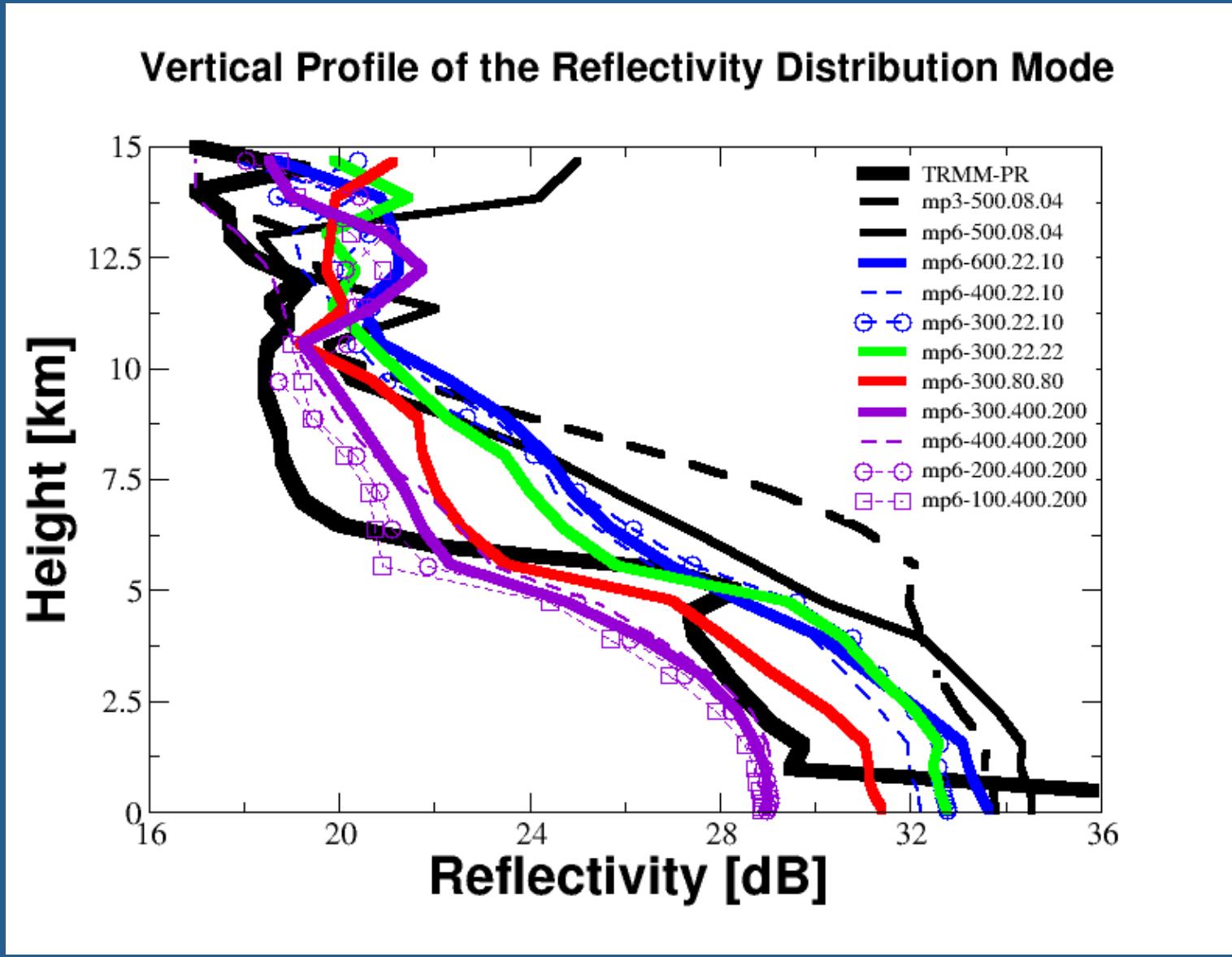
MODE of the Reflectivity



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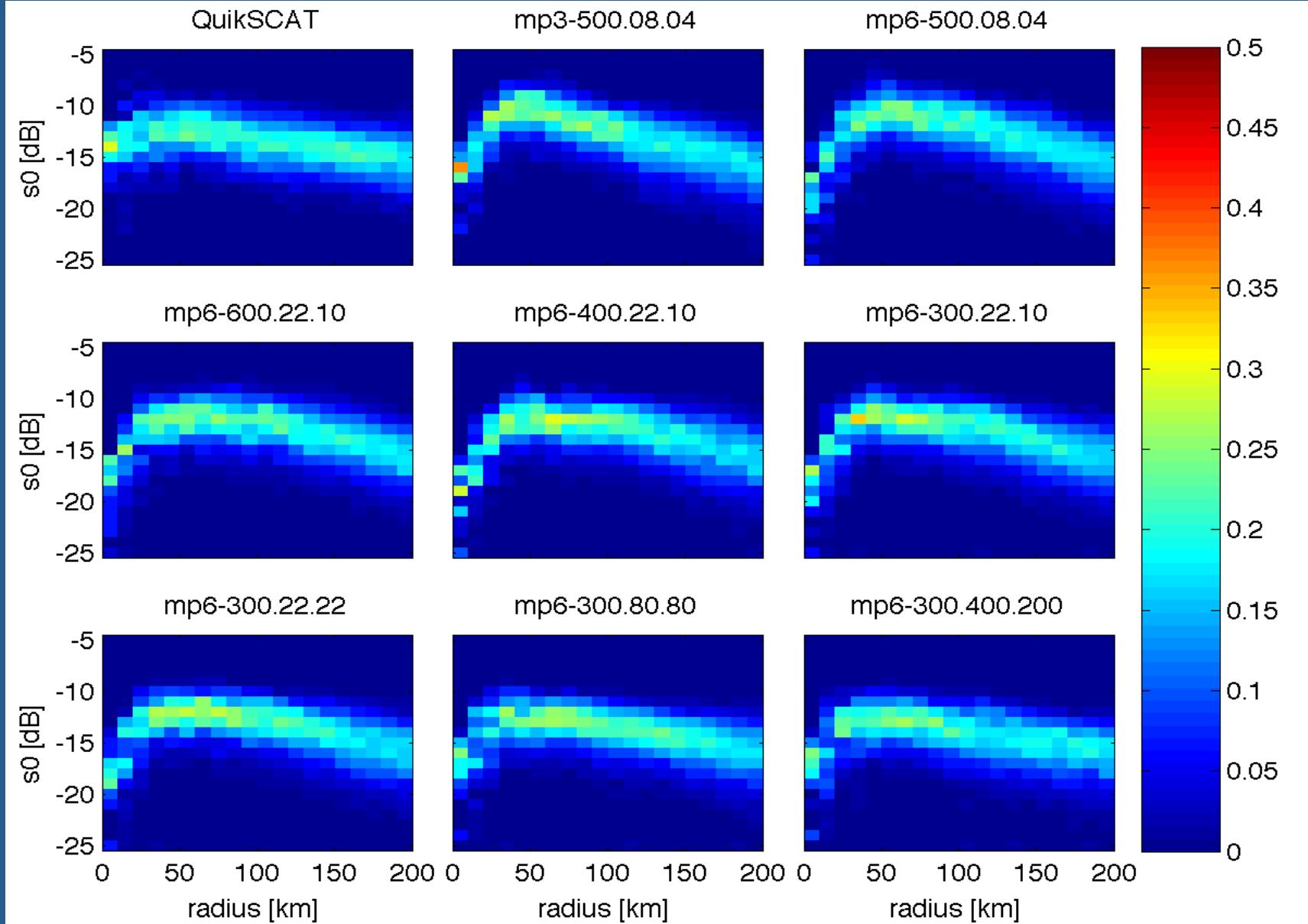




QuikSCAT

$$\sigma^o_{measured} = Attn(\sigma^0_{wind} + \sigma^0_{Splash}) + \sigma^0_{Rain}$$

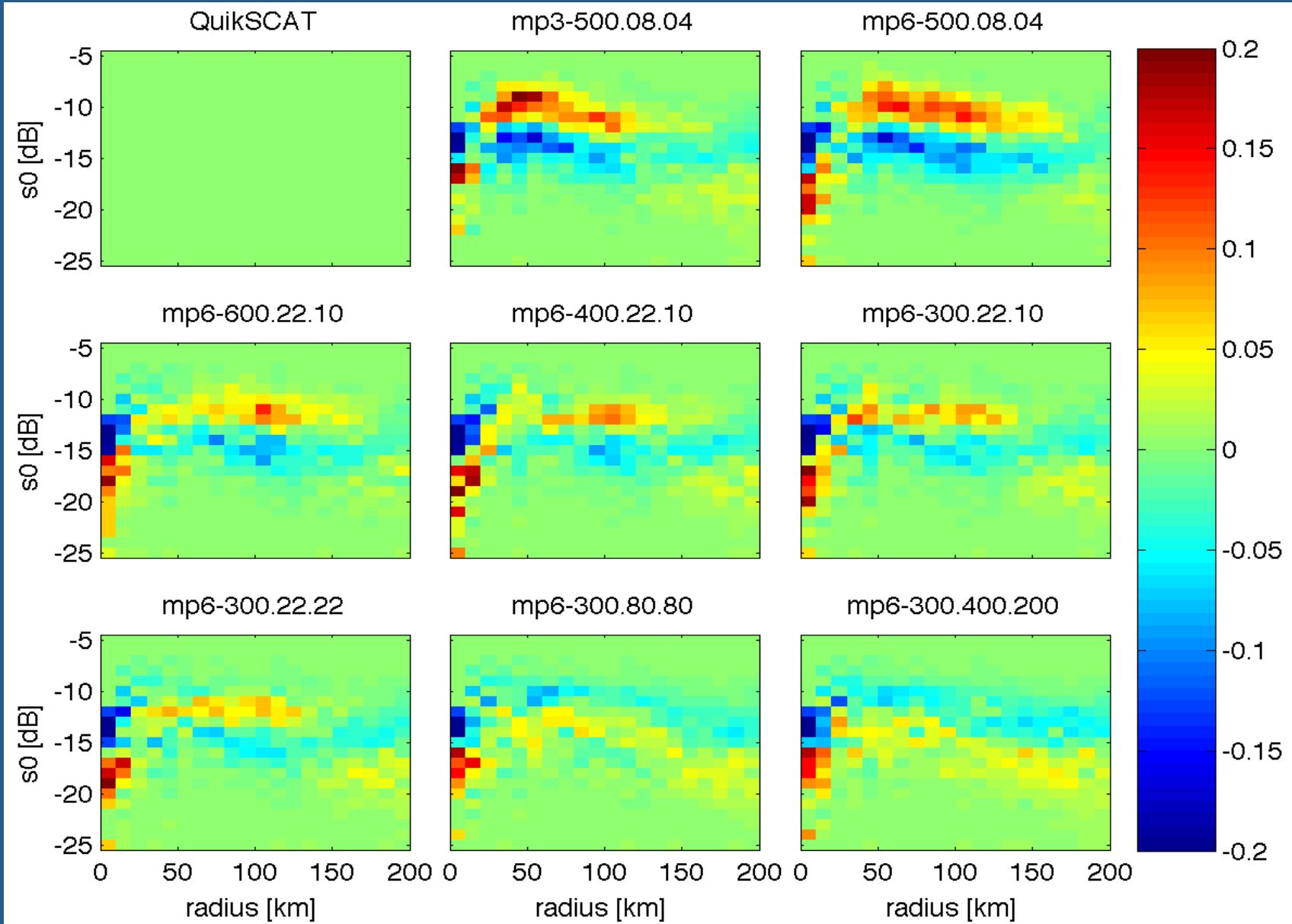
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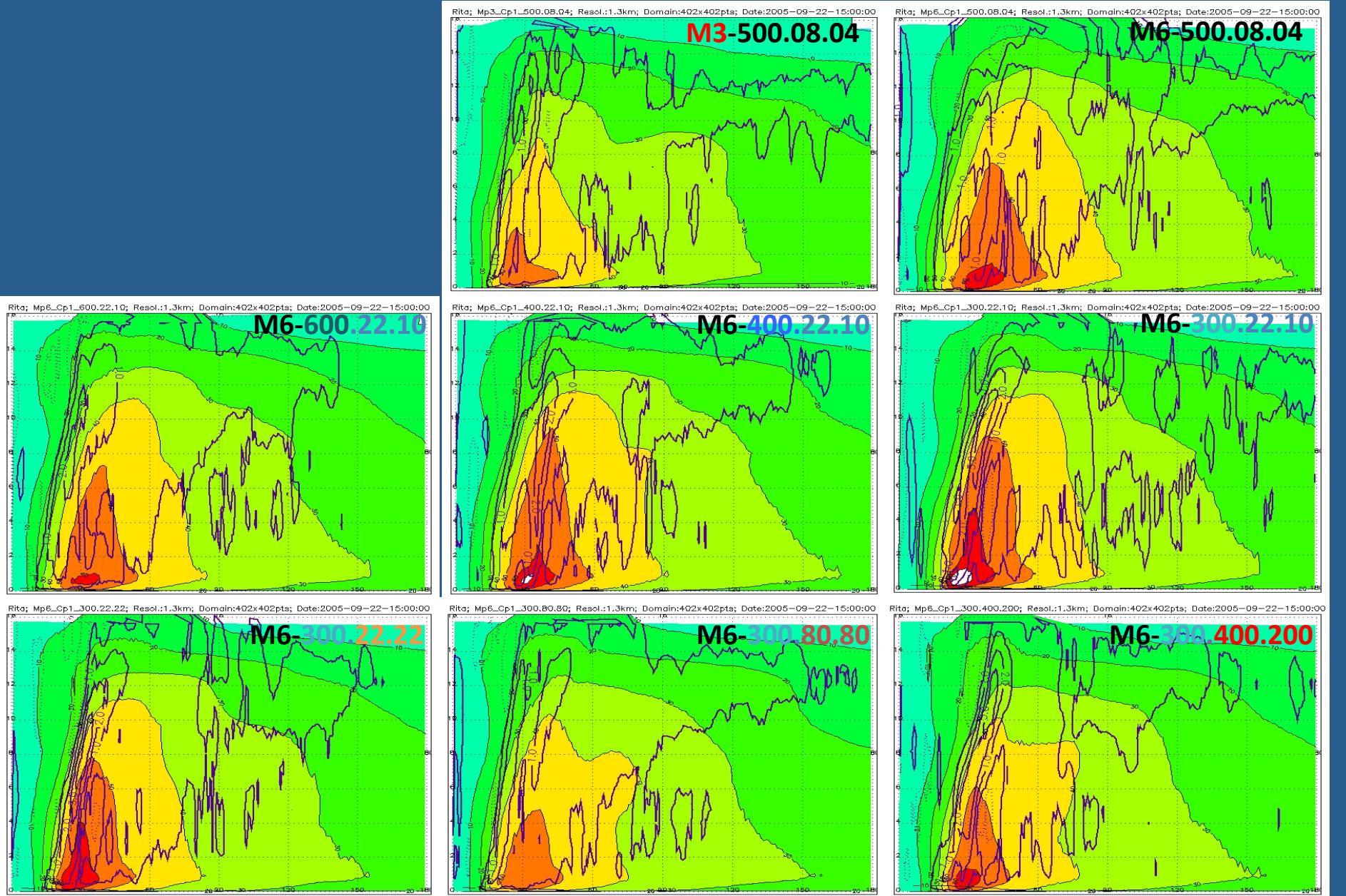
PDF difference





Tangential Flow - Azimuth Averages

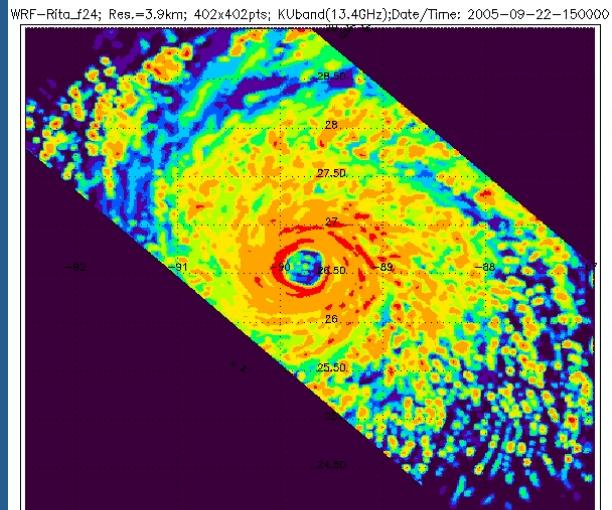
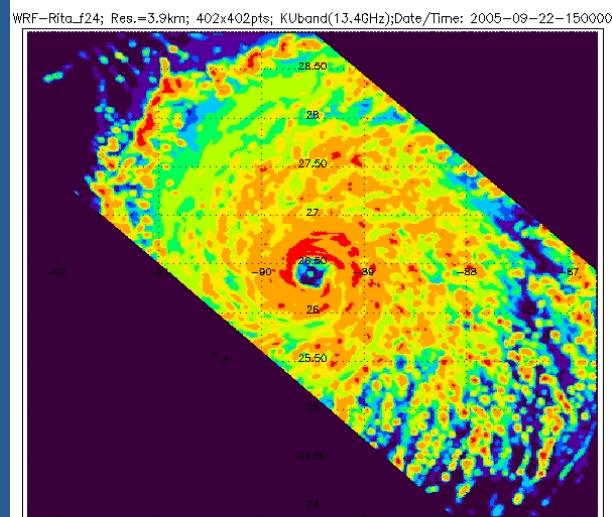
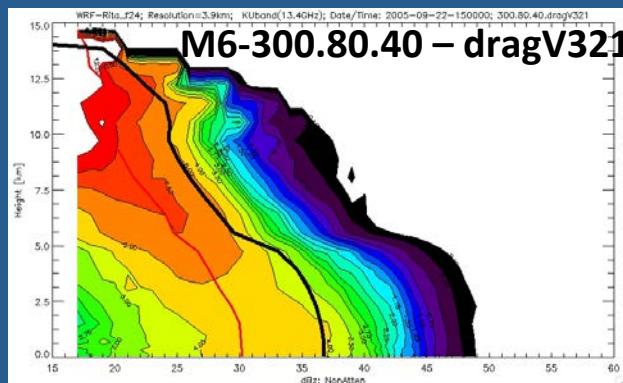
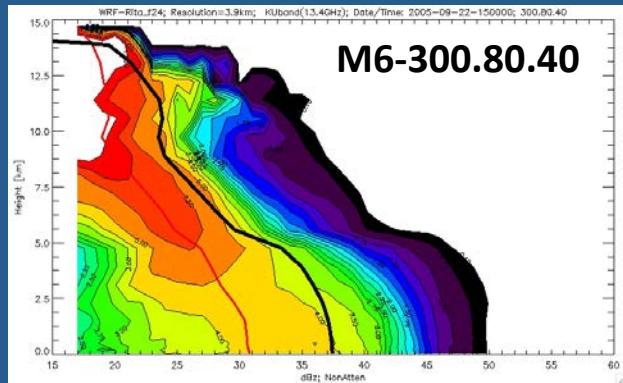
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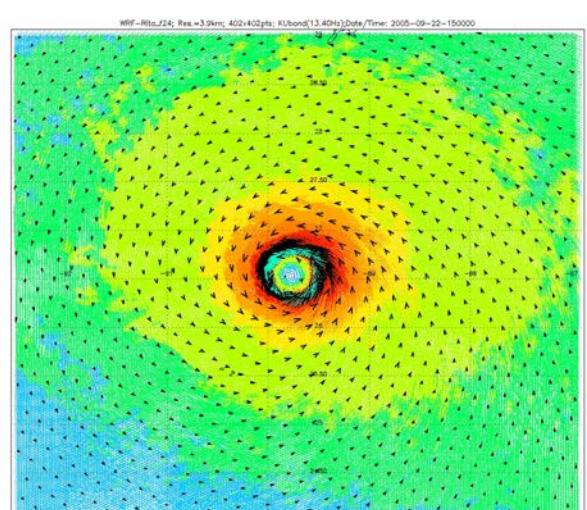
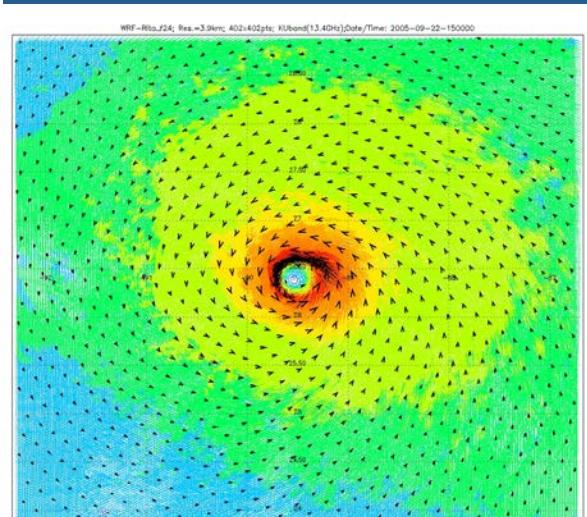


f24

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< 0.00 0.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 50.00 60.00 100.00 >100.00
Max Attenuated Reflectivity [dB]; Max = 42.96; Incidence angle = 0.0 deg; 300.80.40.dragV321



< 0.00 0.00 3.00 7.00 14.00 20.00 35.00 45.00 45.00 55.00 60.00 70.00 > 70.00
Wind Speed [m/s]; Max = 43.77 at 20.00 m/s



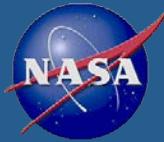
Summary

- Assuming hydrometeor distributions with larger number of smaller particles results in model simulations with radiometric signatures that compare more closely to observations.
- Intensity forecast is negatively impacted
 - Does not mean we should go back to current assumptions
 - Other physics might help
- Will have impact on hurricane forecasting in two ways:
 - providing guidance as to the optimal set of physical parameterizations to be used
 - improving the data assimilation outcome by designing model forecasts whose radiometric signatures are close to the observed ones, thus increasing the relative importance of the observations during the assimilation.



Summary

- Using instrument simulators and multiparameter satellite observations we can discriminate between WRF model simulations using different microphysical assumptions.
- To facilitate the research we are developing the TCIS (Tropical Cyclone Information System) as part of the NASA TC-IDEAS
- <http://tropicalcyclone.jpl.nasa.gov>



2 main components
In the current
JPL iTCIS

JPL Tropical Cyclone Information System

The JPL Tropical Cyclone Information System (TCIS) brings together satellite and in situ data sets from various sources to help you find information for a particular tropical cyclone over the world ocean. Currently, we have populated the entire 2005 and we will add data from other years in the future. We hope that you will find our analysis tools useful for your studies to improve hurricane models and plan future satellite missions with a particular focus on tropical cyclones.

Welcome to the JPL Tropical Cyclone Information System

Supertyphoon Pongsana struck the U.S. Island of Guam on Sunday, December 8, 2002. The composite image (left) of the supertyphoon was made by overlaying data from the infrared, microwave, and visible/near-infrared sensors that make up the AIRS sounding system. This storm can also be seen with the standard AIRS Vis/NIR (right).

Tropical Cyclone Data Portal

Here you can search for specific storms in 2005 and directly access data and plots associated with that storm.

Data Analysis Tool

This tool will let you analyze data associated with a storm. You can plot histograms, maps, and profiles for many different data sets and products.

PRIVACY

Webmaster: Quoc Vu
JPL Clearance: CL#08-3490

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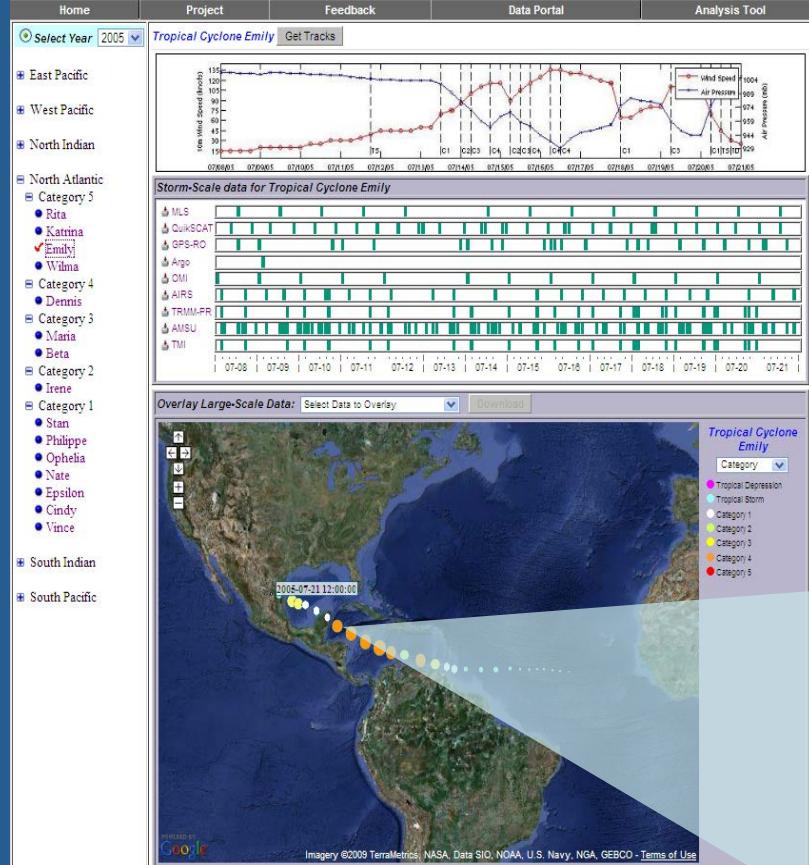


Tropical Cyclone – Integrated Data Exchange and Analysis System (TC-IDEAS) – being developed as Part of the HSRP



Joint NASA Jet Propulsion Lab and Marshall Space Flight Center Project

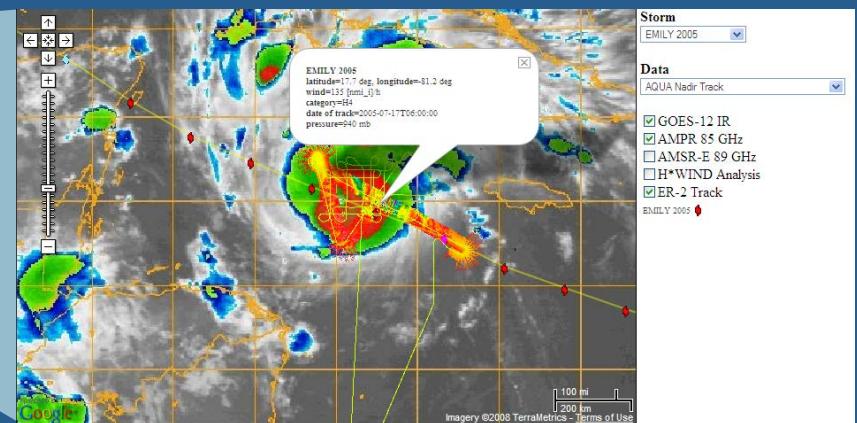
The JPL TCIS



Select by basin, name, or category with corresponding data availability timelines

Objective: To provide fusion of multi-parameter hurricane observations (satellite, airborne and *in-situ*) and model simulations with the purpose of:

- supporting both research and field campaigns
- understanding the physical processes
- improving hurricane forecast by facilitating model validation and data assimilation
- enabling the development of new algorithms, sensors and missions.

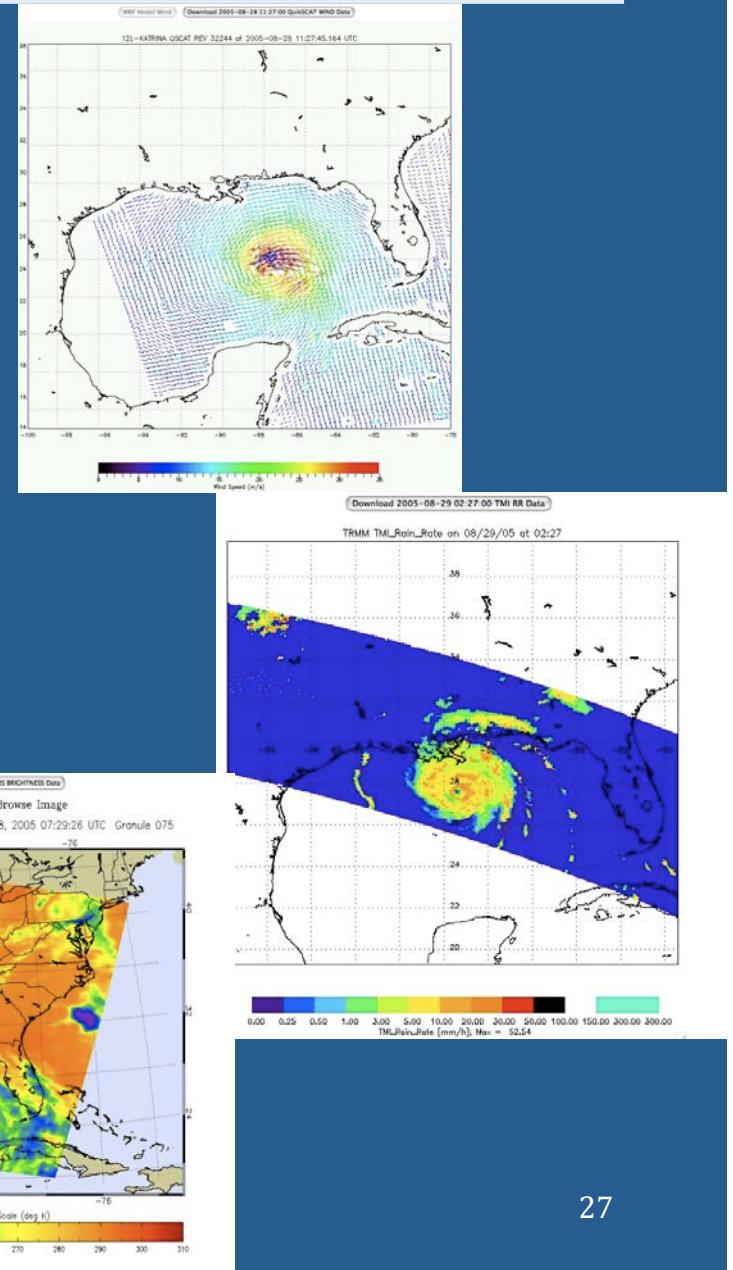
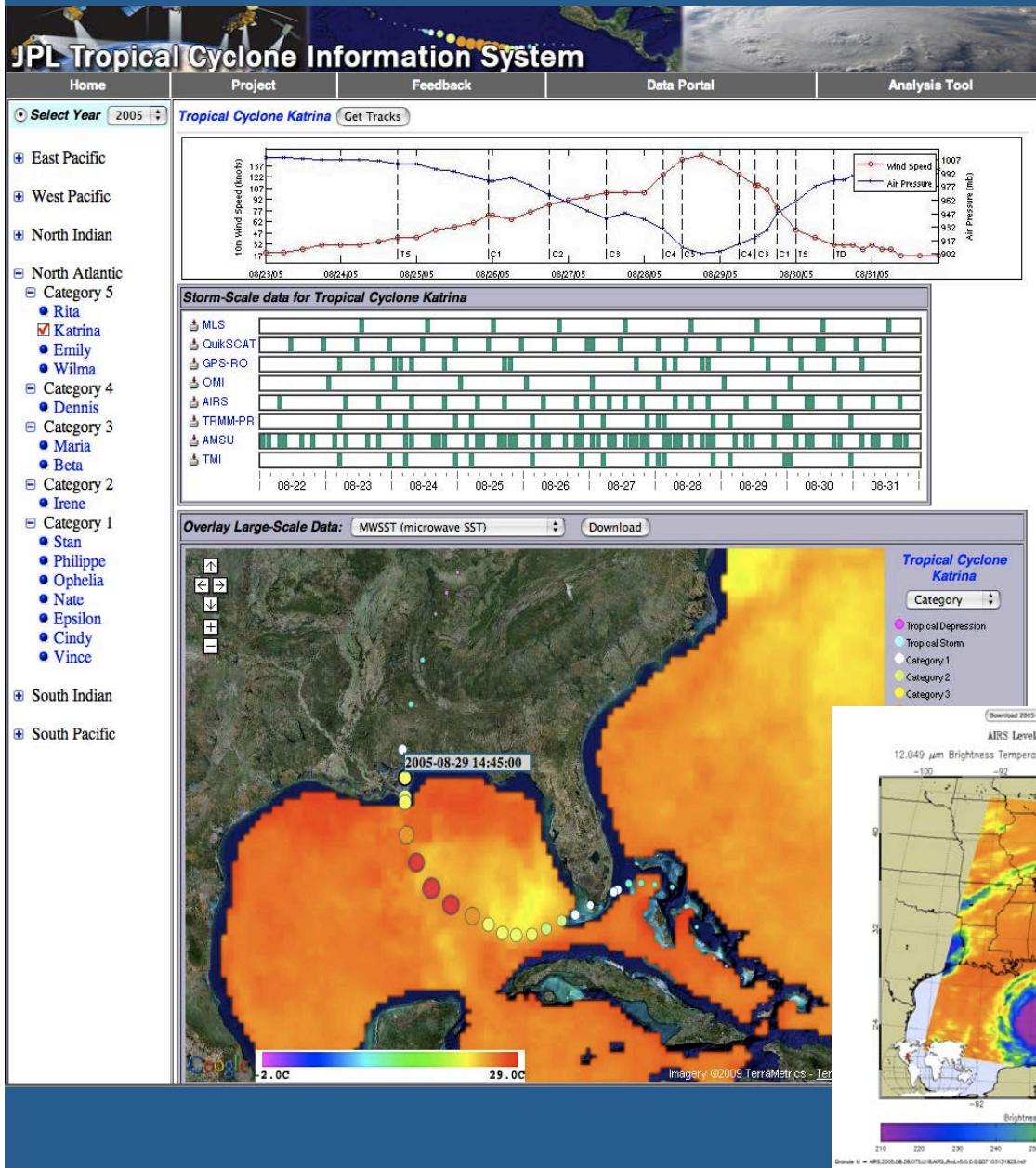


ER-2 / AMPR data overlaid on GOES IR



TOPICAL CYCLONE DATA PORTAL

JPL





Analysis Tools – CURRENT STATUS



Single Parameter Statistics

JPL Tropical Cyclone Information System

Home Project Feedback Data Portal Analysis Tool

Tropical Cyclone Information System - Analysis Tool

Year	Basin	Storm	Product	File
2005	North Atlantic	Katrina	Wind Speed	QUIKSCAT_L2_WIND_20050828_1127.h5

Select Plot Type

Histogram
 Profile
 Map

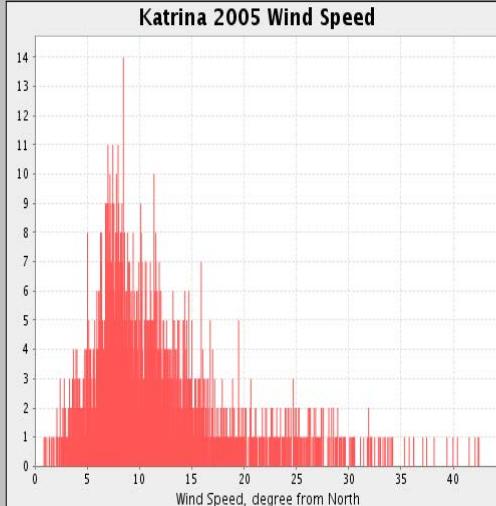
Spatial Subsetting

Lower	Upper
Lat 16.200	33.480
Lon -96.210	-75.790

Data Boundaries

Lower	Upper
Lat 16.200	33.480
Lon -96.210	-75.790

Katrina 2005 Wind Speed



Data Statistics

Mean	0.830
STDEV	42.420
Median	9.790
Min	11.238
Max	6.046

PRIVACY Webmaster: Quoc Vu JPL Clearance: CL#08-3490

JPL Tropical Cyclone Information System

Home Project Feedback Data Portal Analysis Tool

Tropical Cyclone Information System - Analysis Tool

Year	Basin	Storm	Product	File
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Select Plot Type

Histogram
 Profile
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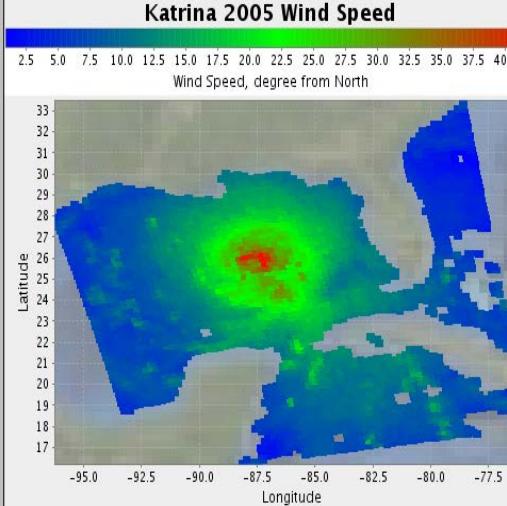
Spatial Subsetting

Lower	Upper
Lat 16.200	33.480
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Katrina 2005 Wind Speed



Data Statistics

Mean	0.830
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Max	6.046

PRIVACY Webmaster: Quoc Vu JPL Clearance: CL#08-3490



Analysis Tools – COMING UP

- Data subsetting and aggregation
- Convective/Stratiform separation
- EOFs CFADs
- **Incorporating Instrument simulators developed under ISSARS (PI Simone Tanelli) – “Instrument Simulator Suite for Atmospheric Remote Sensing from Spaceborne Platforms”**

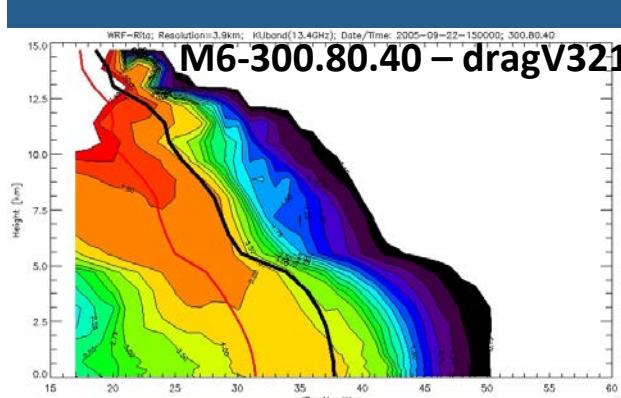
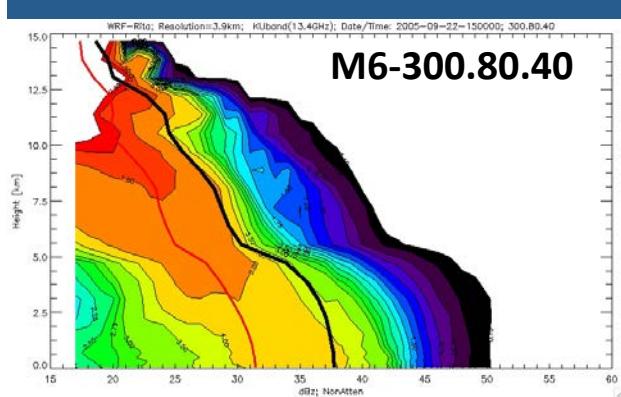
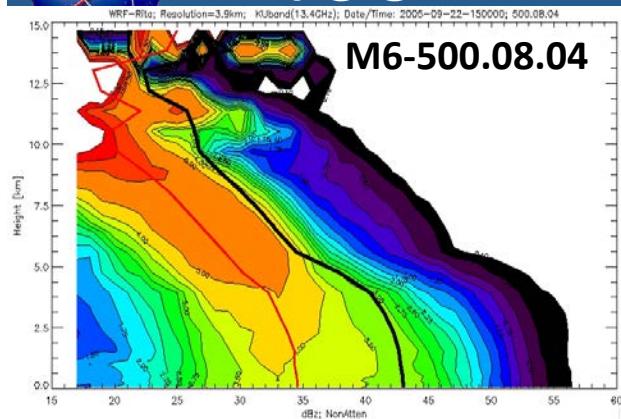


BACKUP

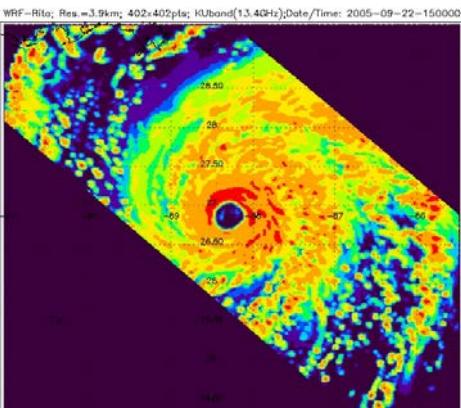
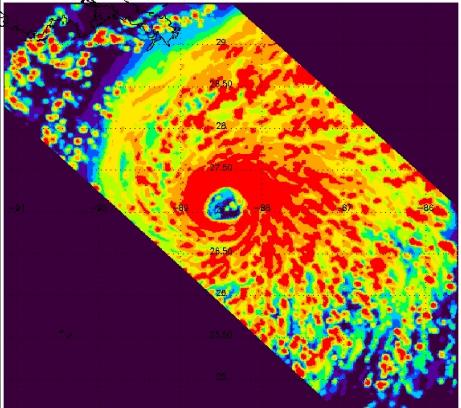




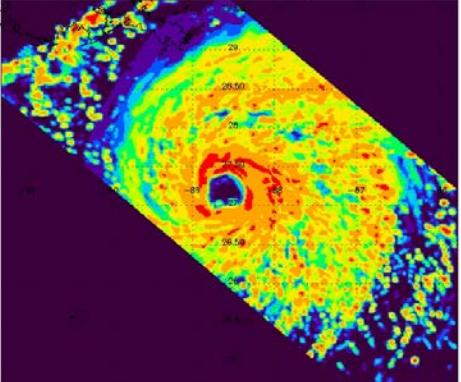
f00



WRF-Rita; Resolution=3.9km; 402x402pts; KuBand(13.4GHz); Date/Time: 2005-09-22-150000



WRF-Rita; Res.=3.9km; 402x402pts; KuBand(13.4GHz); Date/Time: 2005-09-22-150000

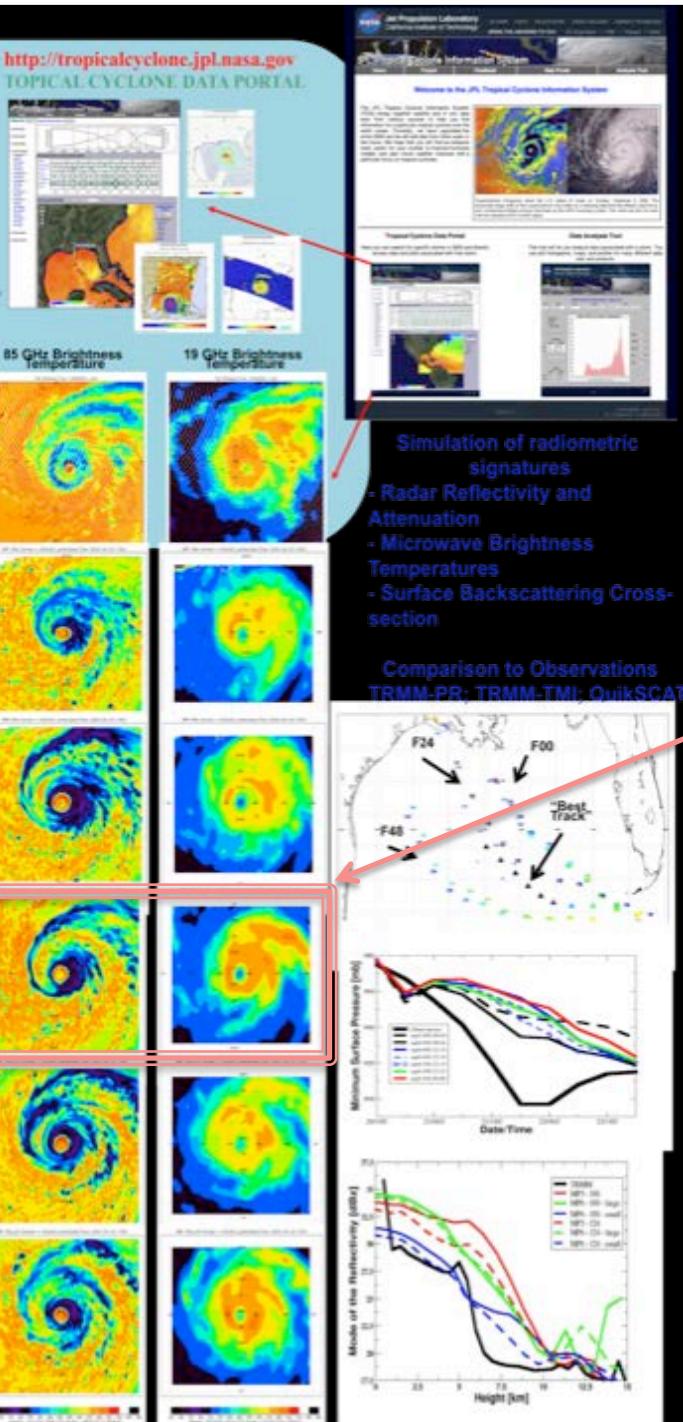


< 0.00 10.00 20.00 30.00 40.00 50.00 60.00 70.00 >100.00
Max Attenuated Reflectivity [dB] Max = 43.14; Incidence angle = 0.0 deg; 300.80.40-dragV321

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TC-IDEAS

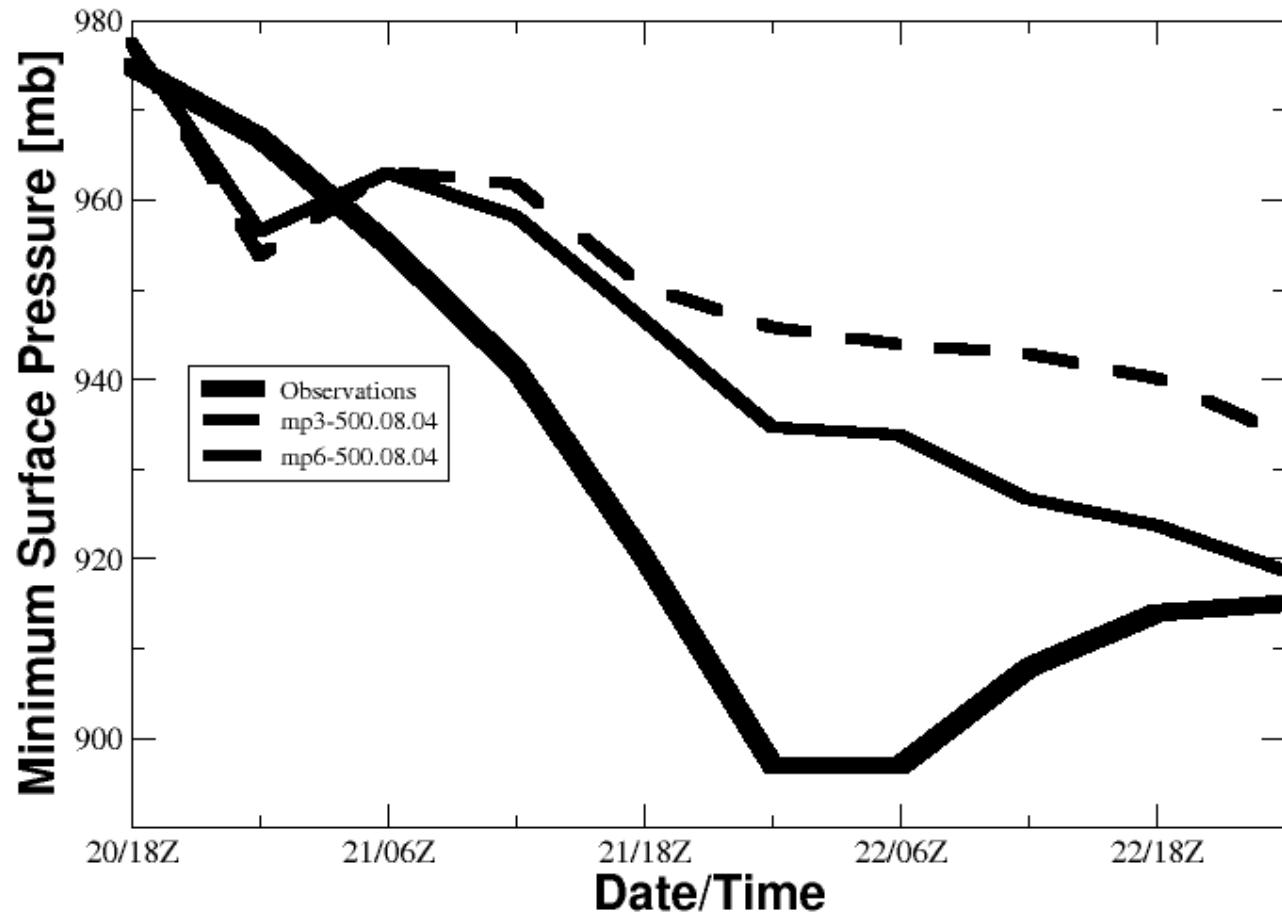
funded by NASA's
Hurricane Science
Research Program

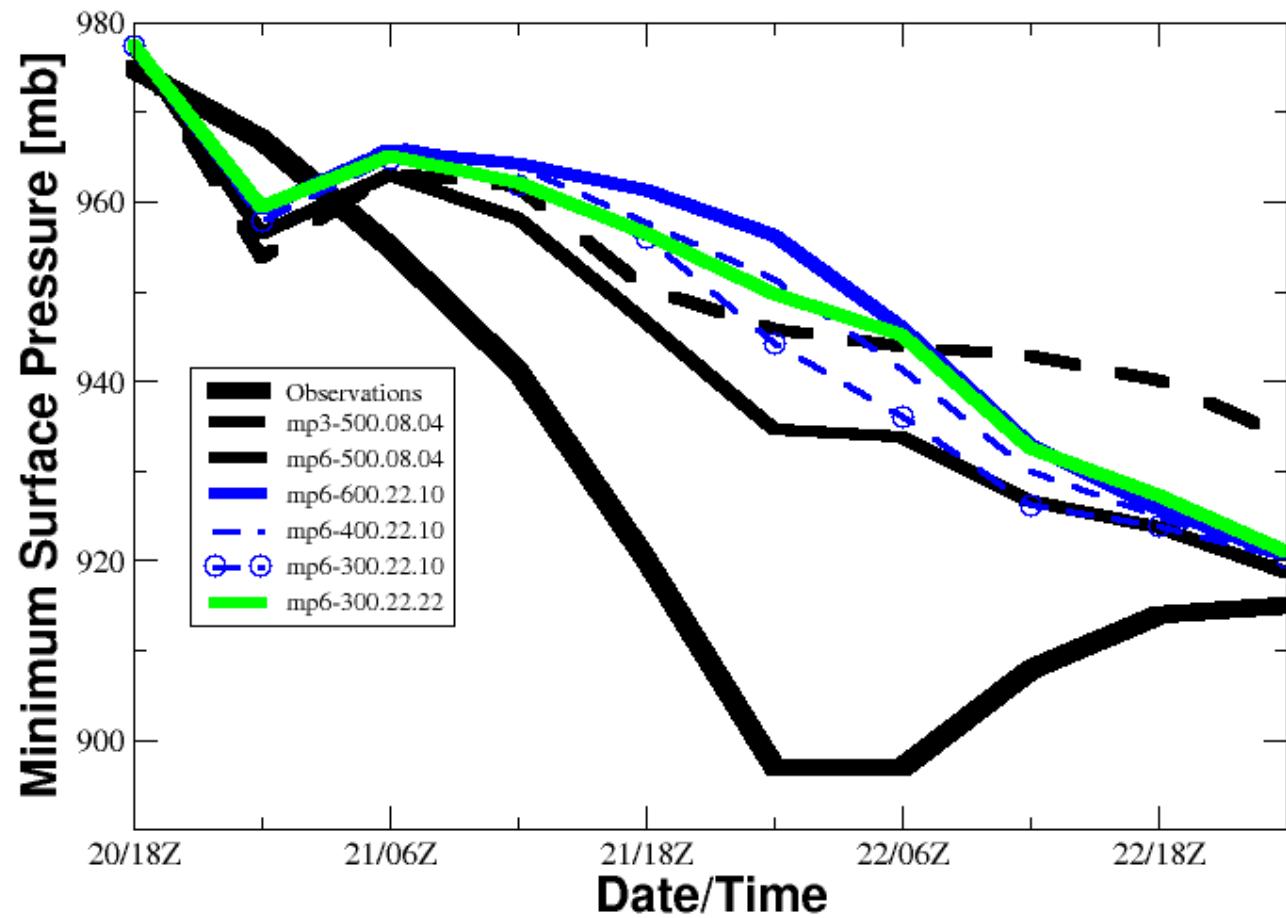


RESEARCH JPL

MODEL IMPROVEMENTS

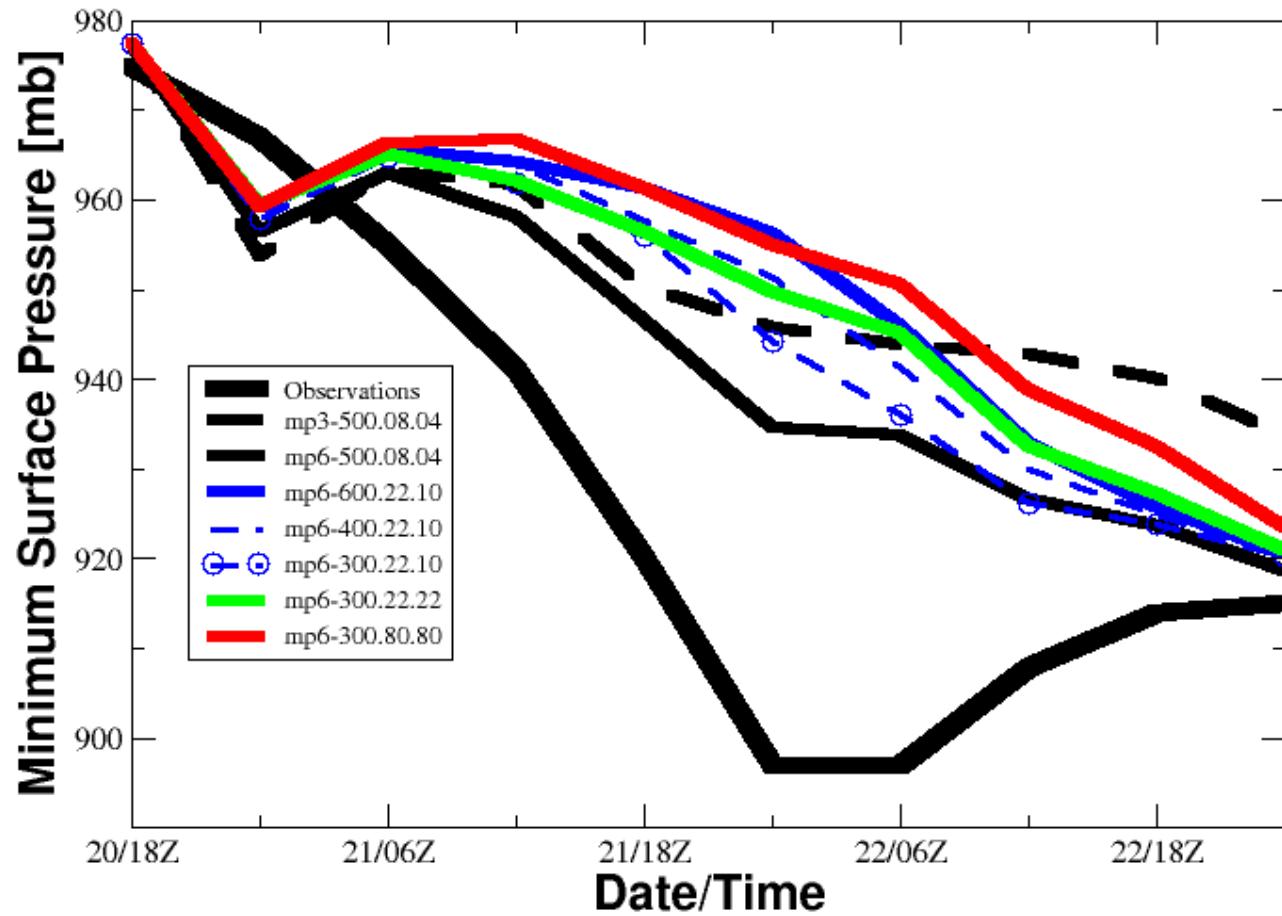
- Using instrument simulators and multiparameter satellite observations we can discriminate between model forecasts using different microphysical assumptions.
- Assuming hydrometeor distributions with smaller particles results in model forecasts with radiometric signatures that are closer to observations.
- Will have impact in two ways:
 - providing guidance on the optimal set of physical parameterizations
 - improving the data assimilation outcome by designing model forecasts whose radiometric signatures are close to the observed ones, increasing the relative importance of the observations during the assimilation.
- Improved understanding of the PSD characteristics will lead to decrease in the uncertainty of satellite retrievals of precipitation

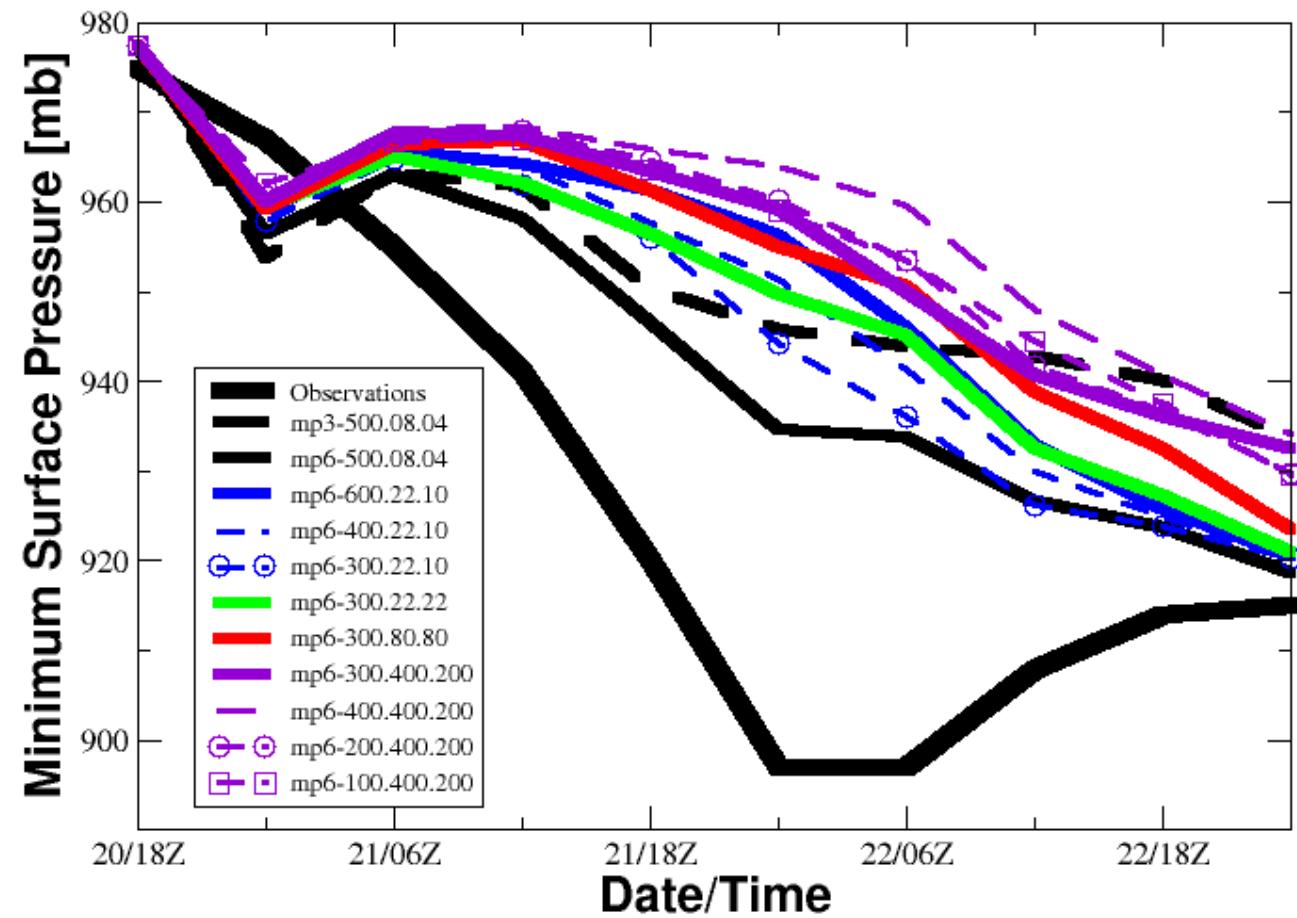


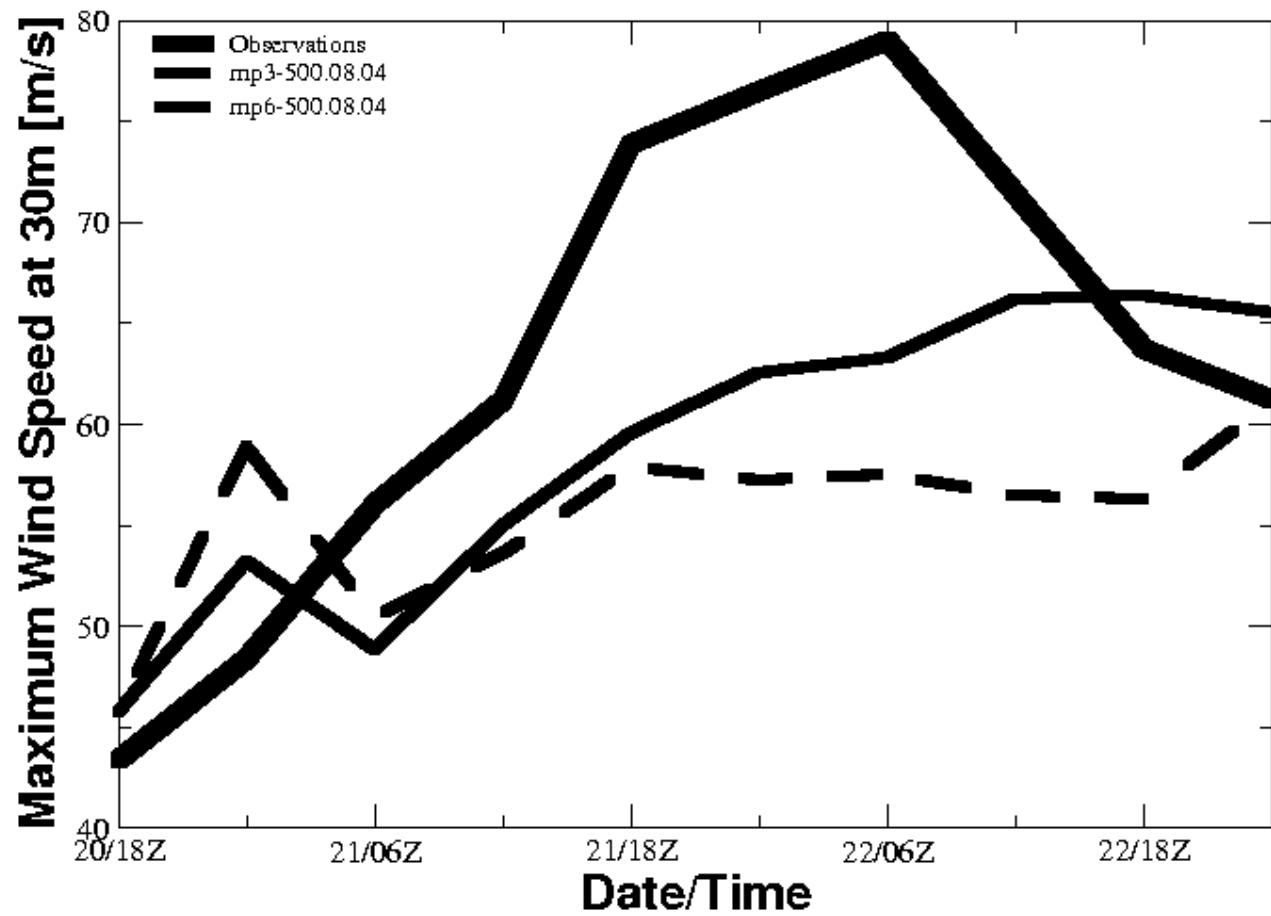


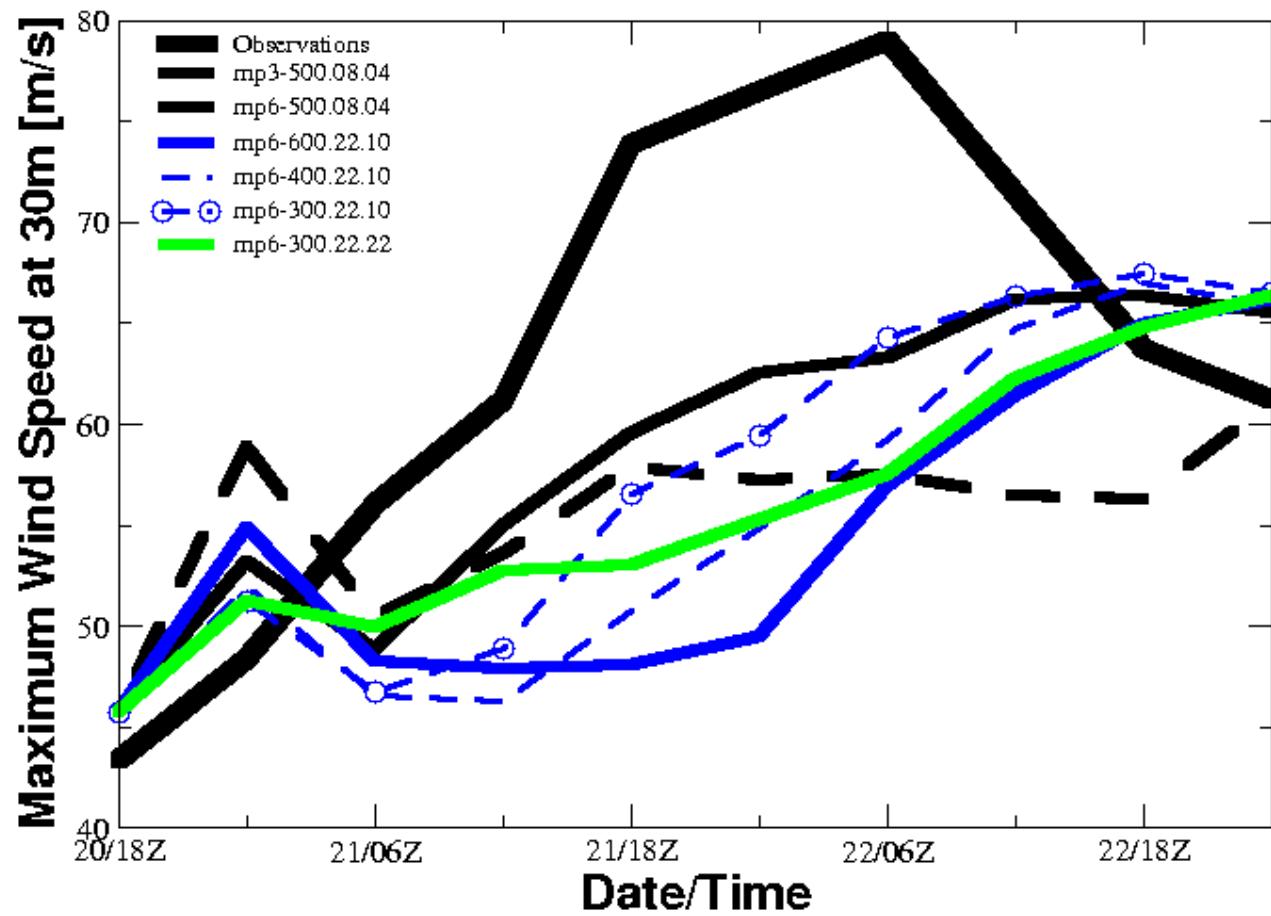


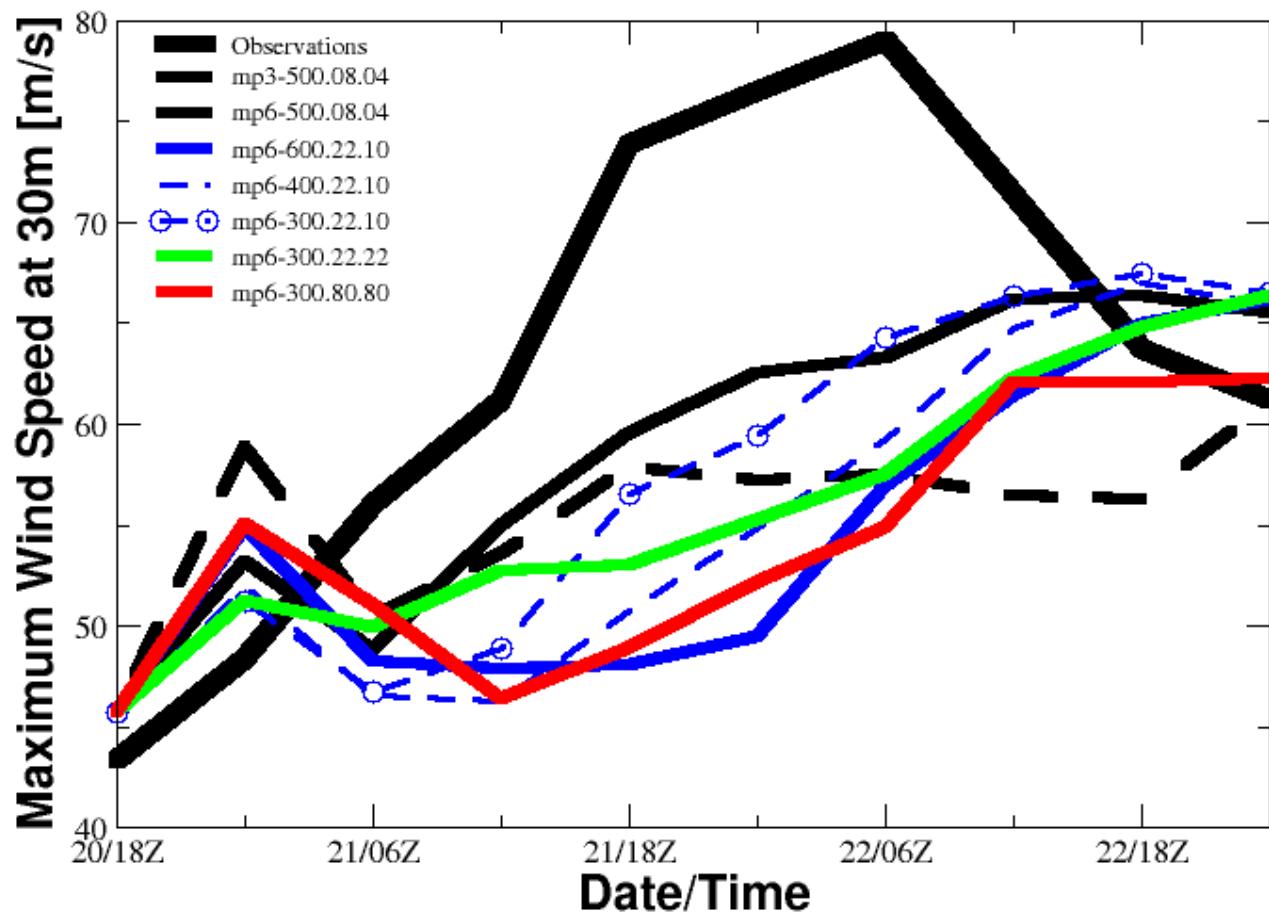
JPL

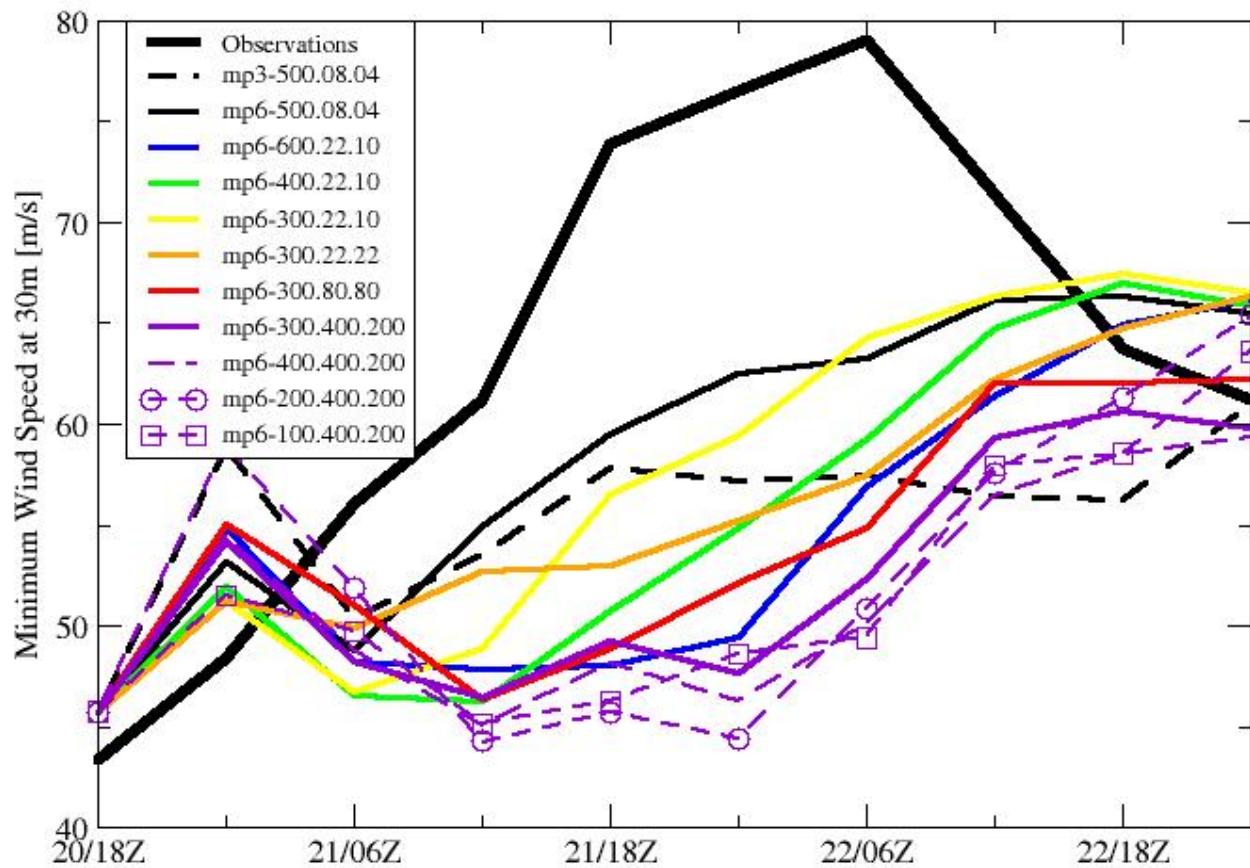








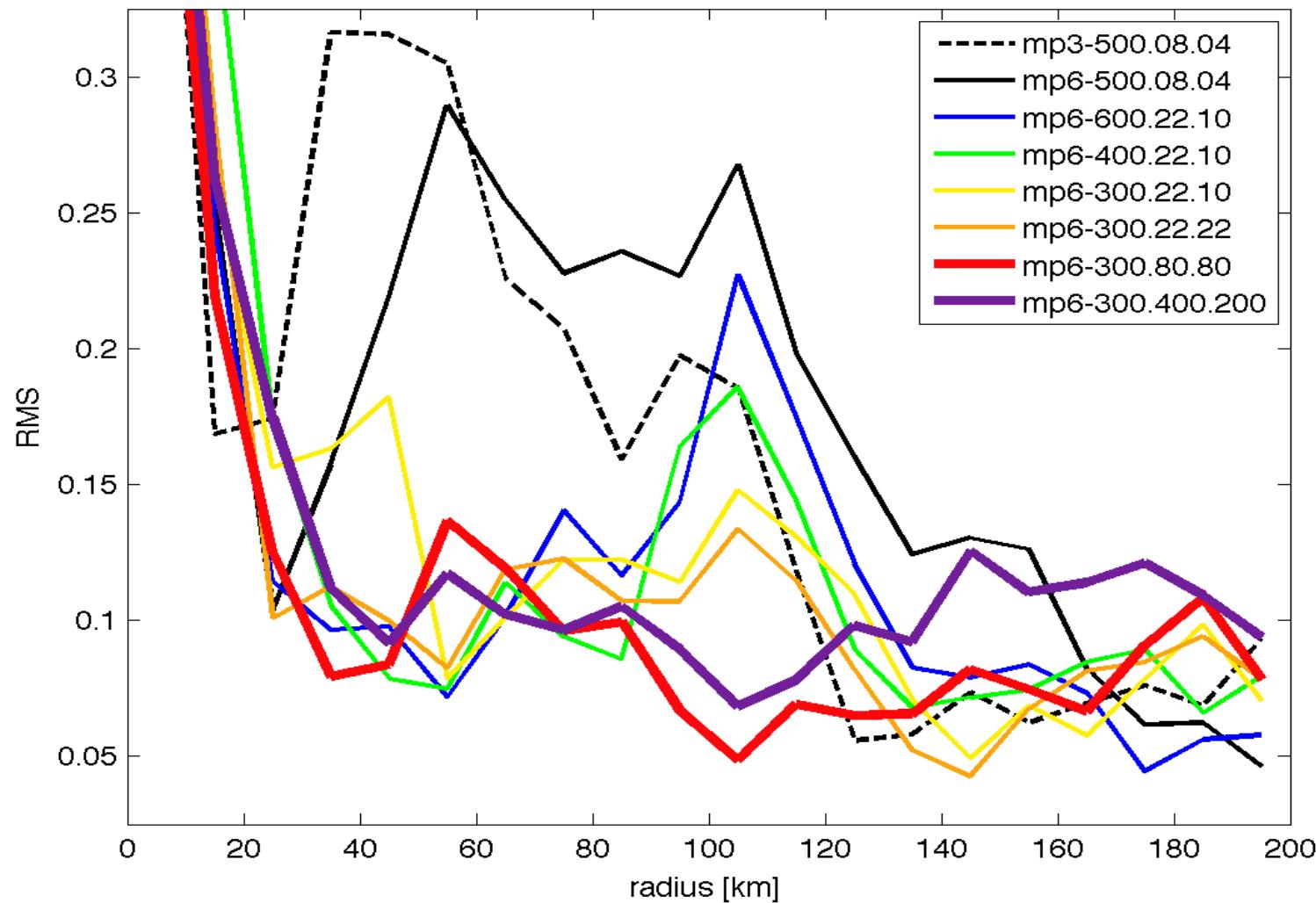






RMS of the range-dependent PDFs

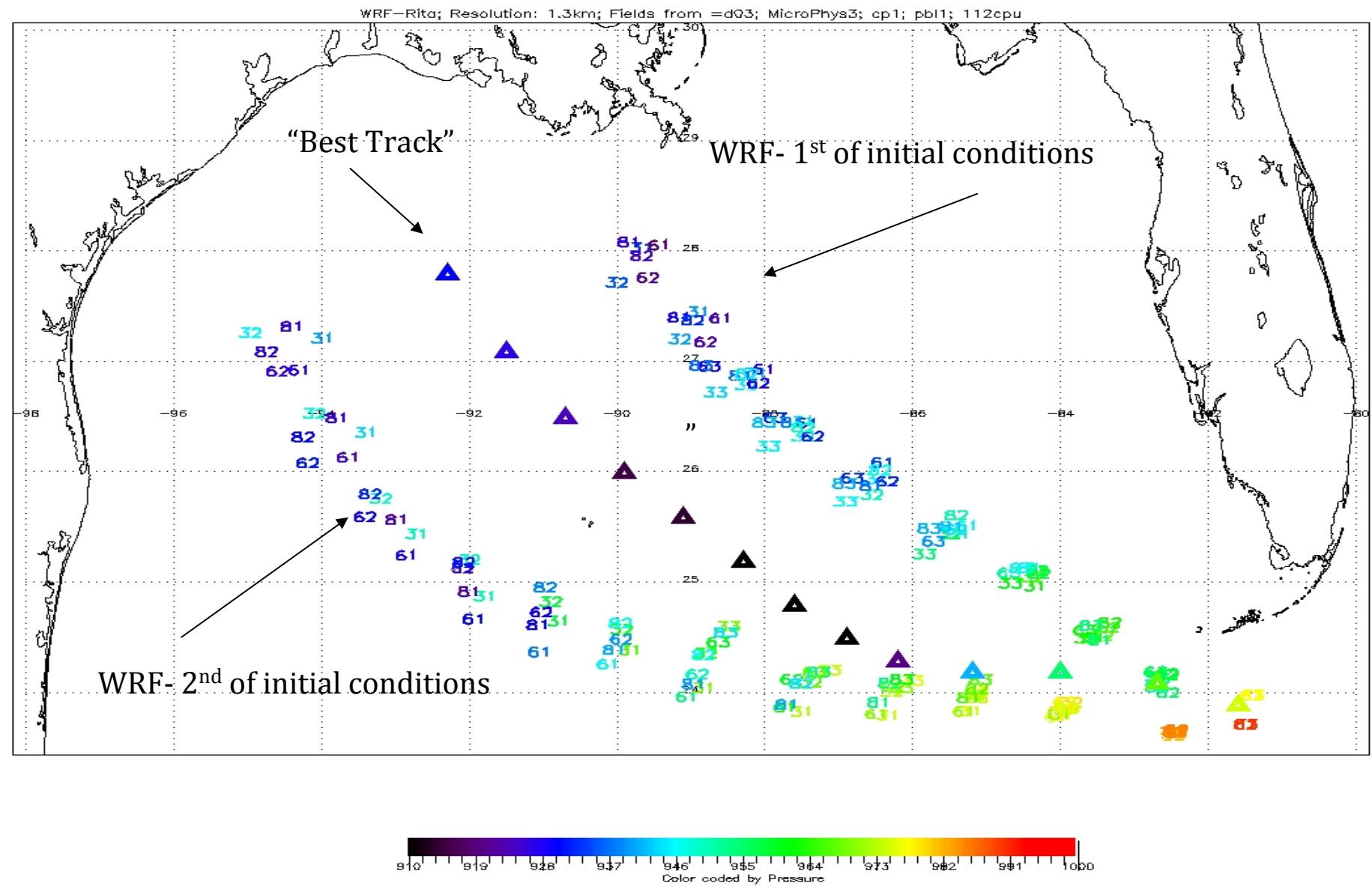
JPL





31 - microphysics 3; convective scheme 1
32 - microphysics 3; convective scheme 2
33 - microphysics 3; convective scheme 3

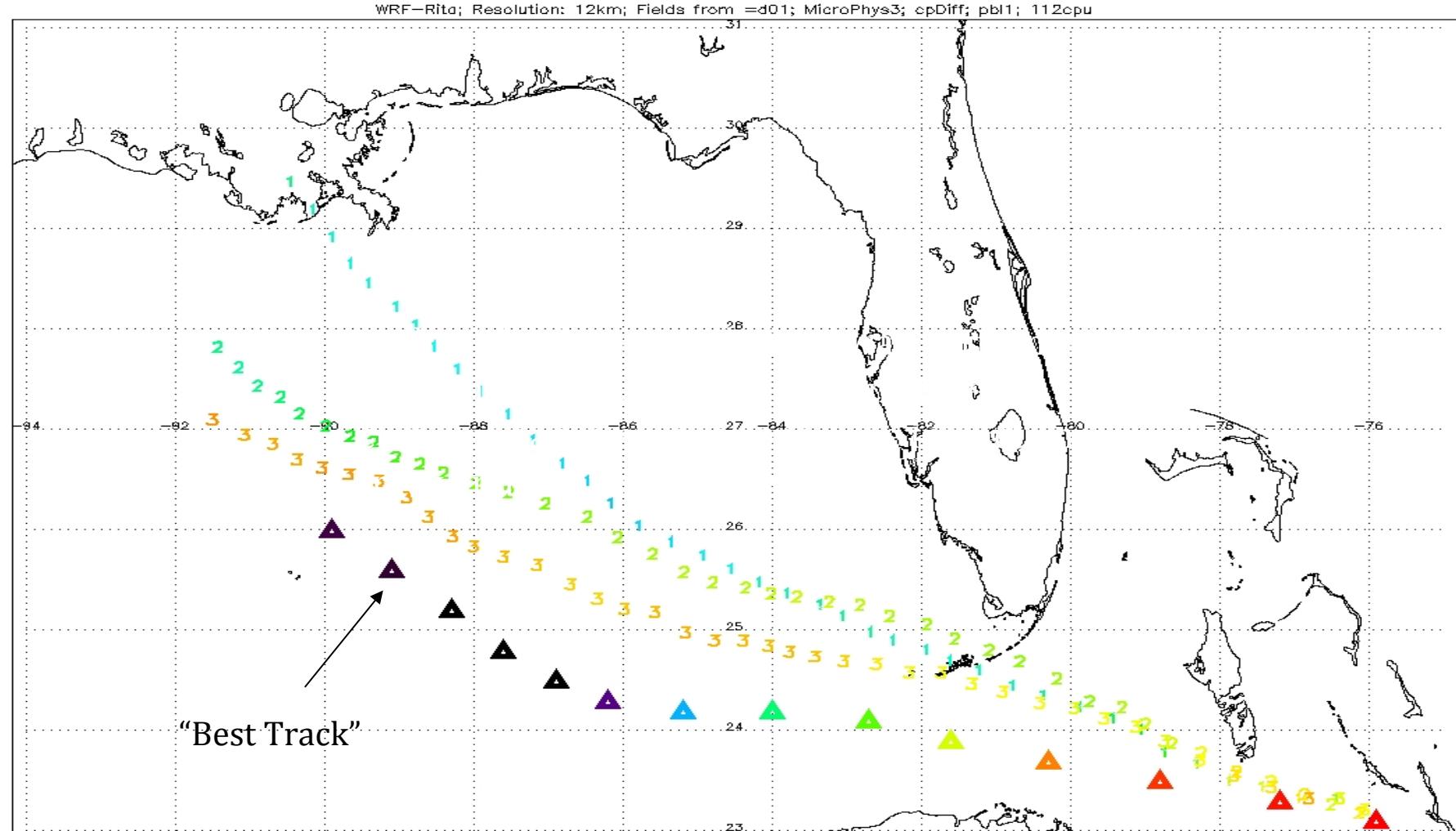
61 - micro. 6; conv. 1
62 - micro. 6; conv. 2
63 - micro. 6; conv. 3
81 - micro. 8; conv. 1
82 - micro. 8; conv. 2
83 - micro. 8; conv. 3





Impact of cumulus parameterization.

JPL





JPL