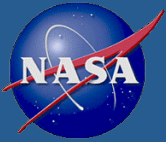


Impact of microphysical parameterizations on the structure and intensity of simulated hurricanes:

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

S. Hristova-Veleva, A. Chau, Z. Haddad,
B. Knosp, B. Lambrigtsen, P. Li,
E. Rodriguez, T.-P. Shen, B. Stiles, H. Su, J. Turk, Q. Vu

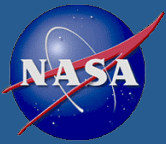
Jet Propulsion Laboratory, California Institute of Technology



Motivation



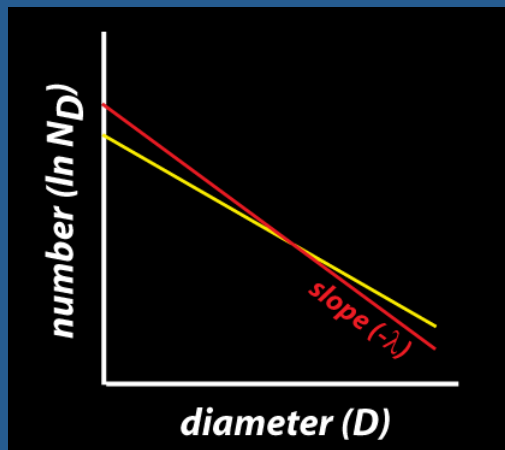
- Need to improve hurricane forecast models
- Inner-core dynamics are important - need to properly reflect small scale complex processes
 - high-resolution models
 - realistic physical parameterizations



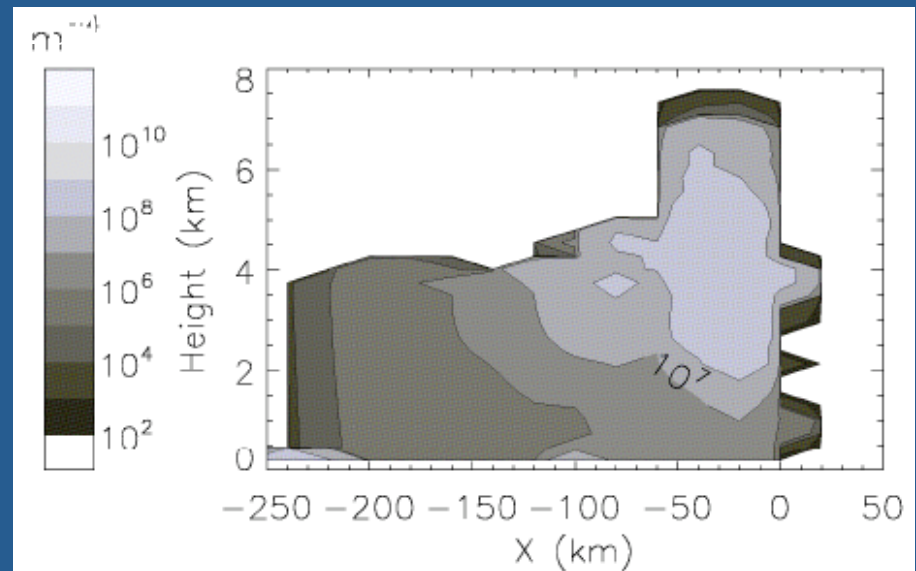
Motivation

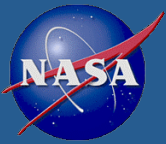


- Focus on microphysics
 - latent heating that accompanies the hydrometeor production during the convective process strongly impacts storm intensity and size
 - Cloud radiative impact
 - significant uncertainty in PSD assumptions



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

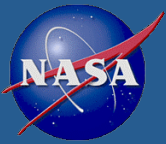




How to Evaluate the Models



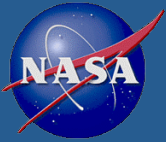
- In situ microphysical observations to distinguish between different modeling approaches and improve on the most promising ones.
- These point measurements cannot adequately reflect the space and time correlations characteristic of the convective processes.
- An alternative approach to evaluating microphysical 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**



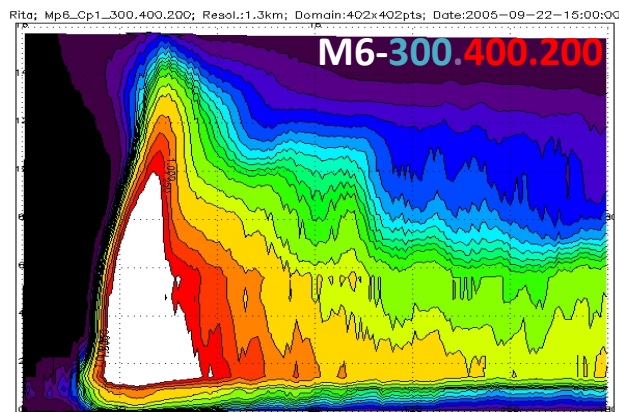
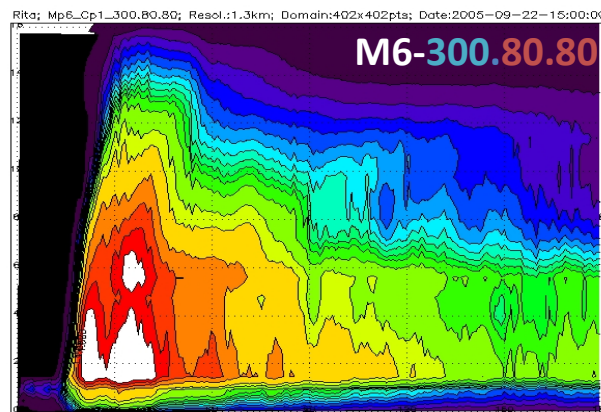
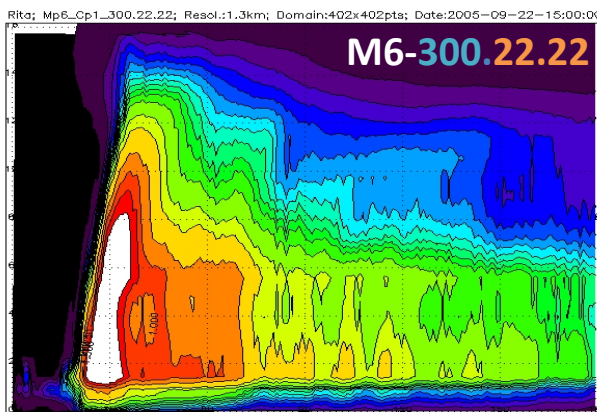
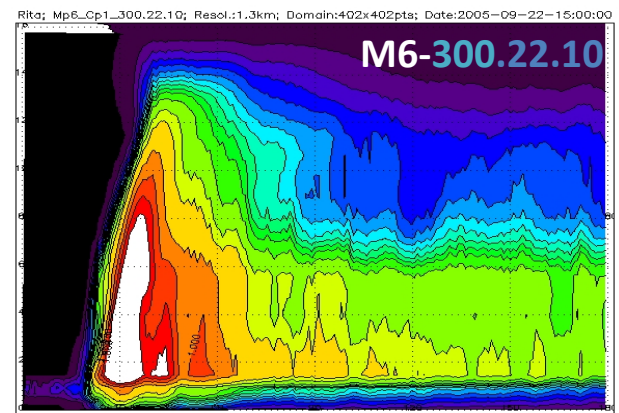
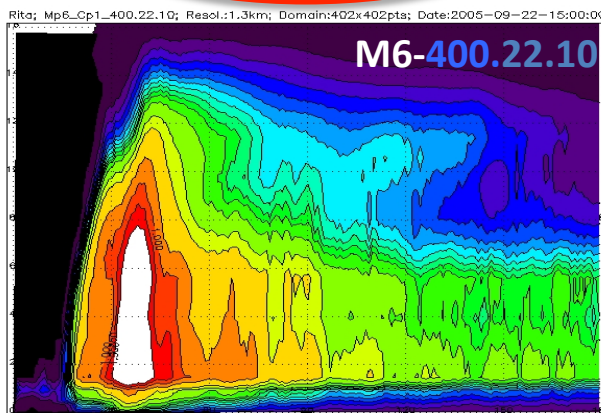
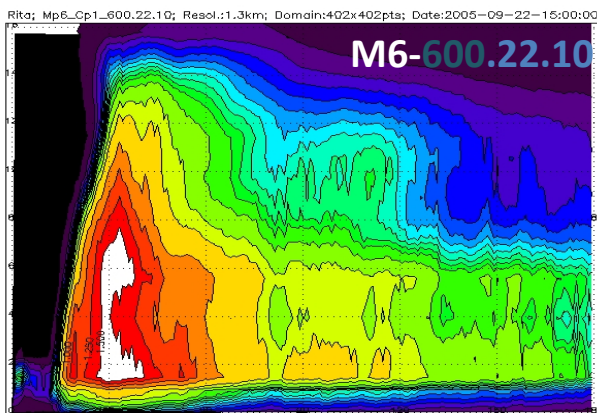
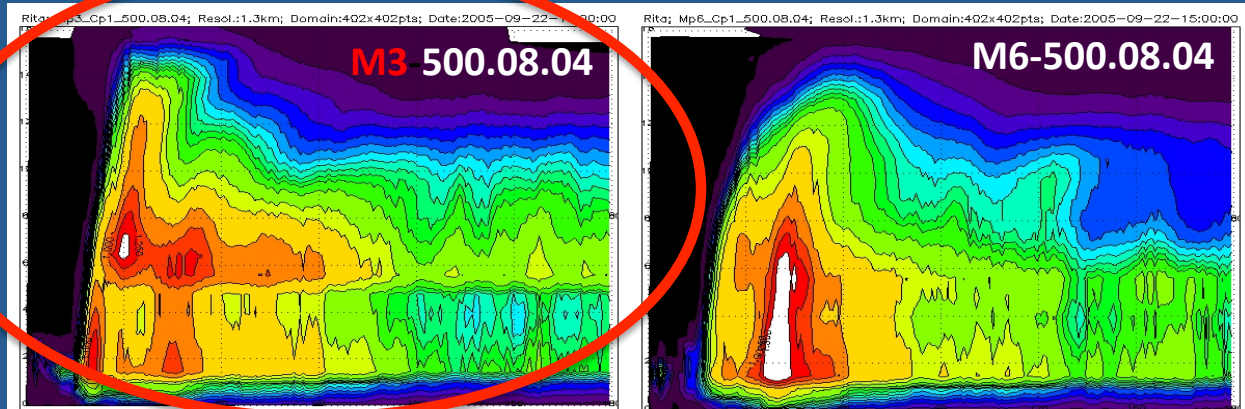
Approach

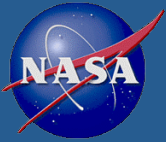


- WRF high-resolution ensemble simulations
 - Hurricane Rita (2005); GFDL initial/boundary
 - Two microphysical schemes (WSM3 and WSM6)
 - seven different Particle Size Distribution (PSD) assumptions within one of the microphysical schemes (WSM6)
- **Simulation of radiometric signatures**
 - **Radar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

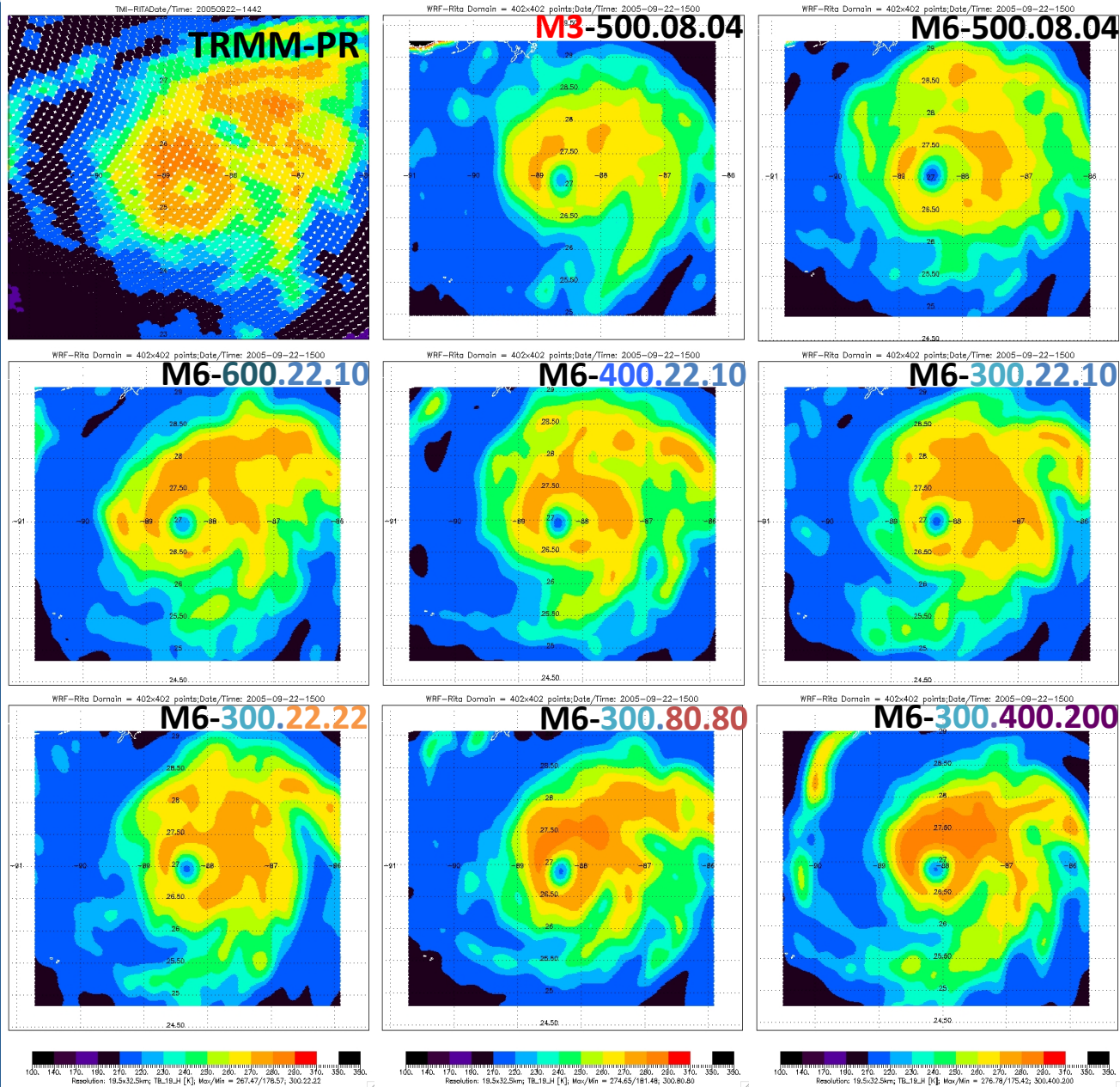


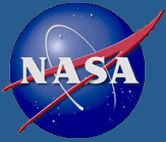
Condensate - Azimuth Averages



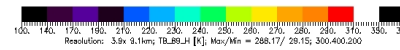
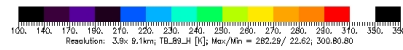
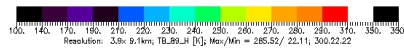
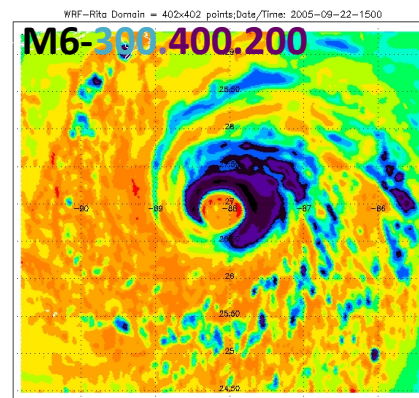
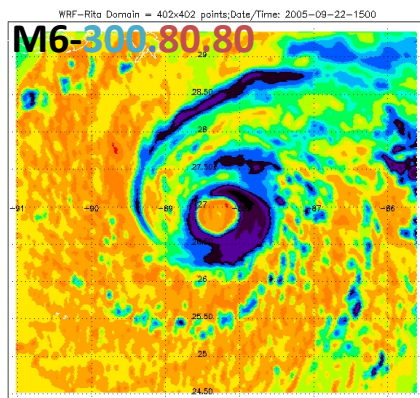
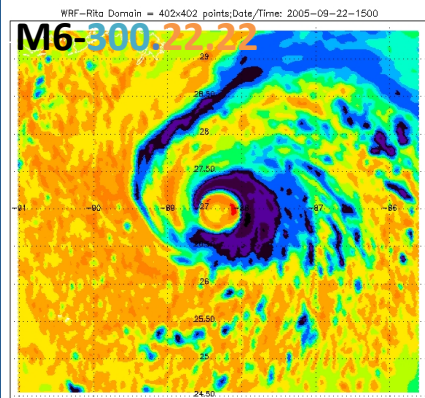
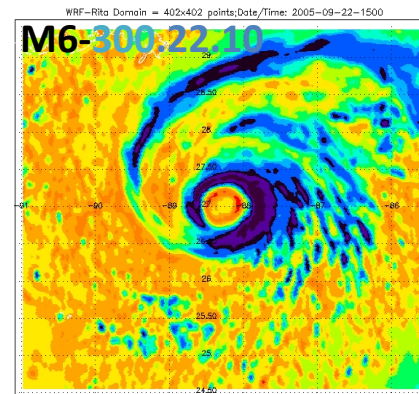
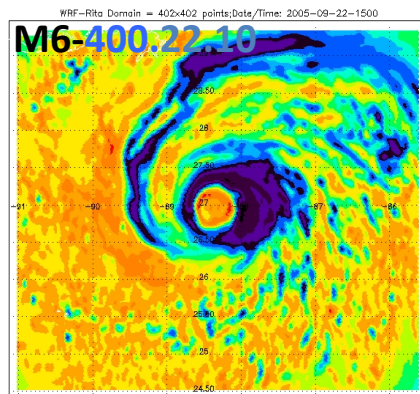
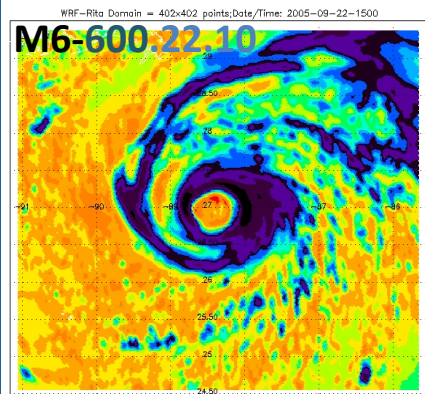
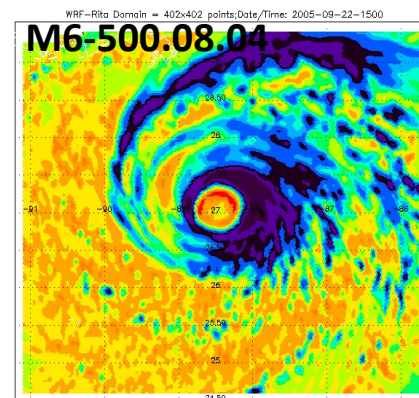
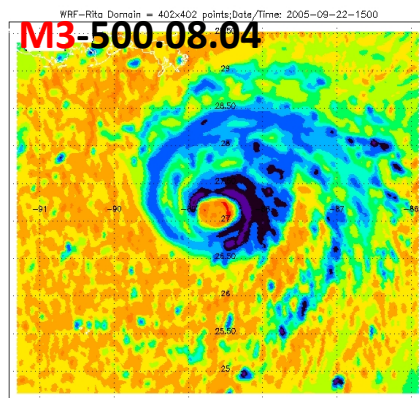
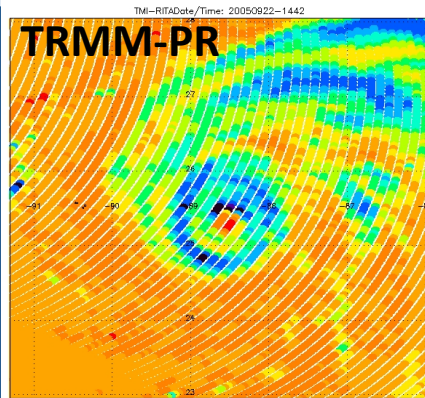


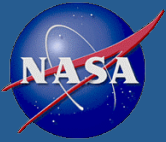
Brightness Temperature-19 GHz H



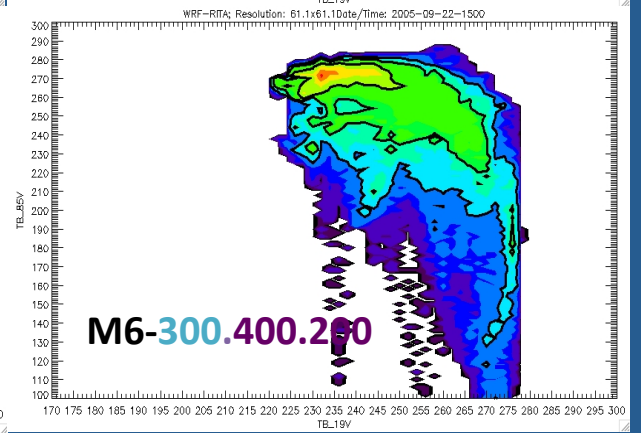
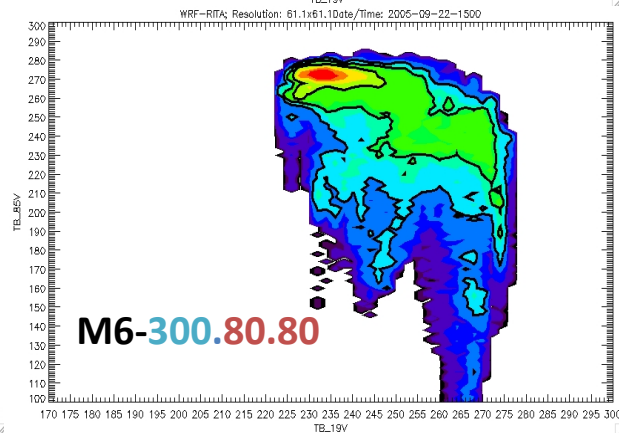
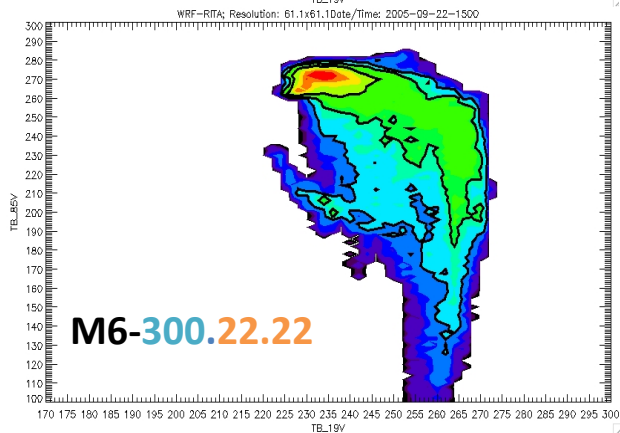
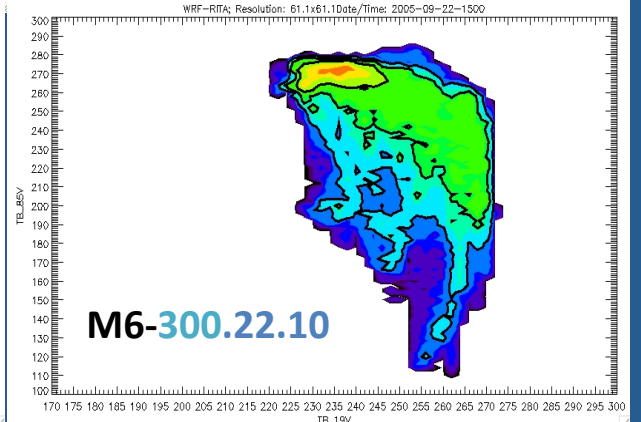
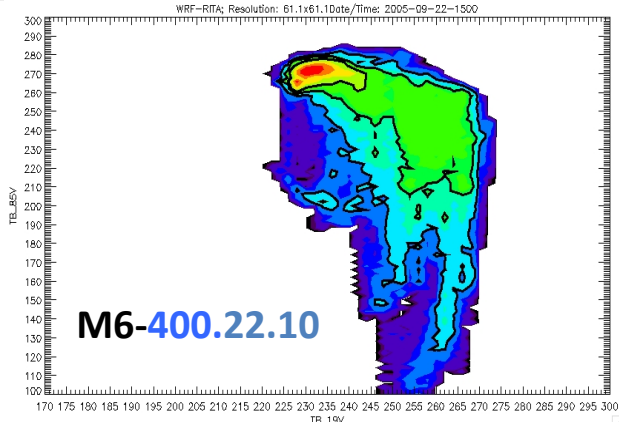
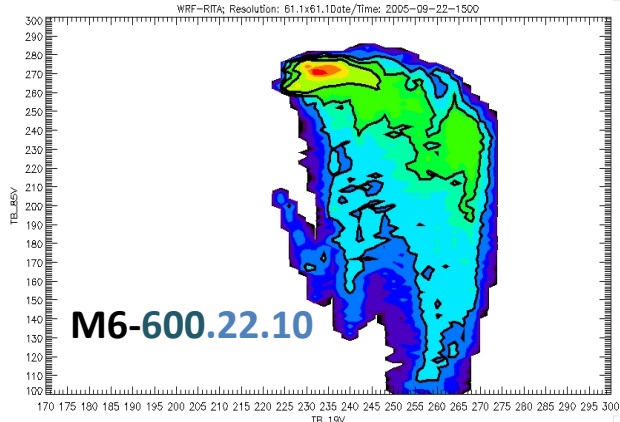
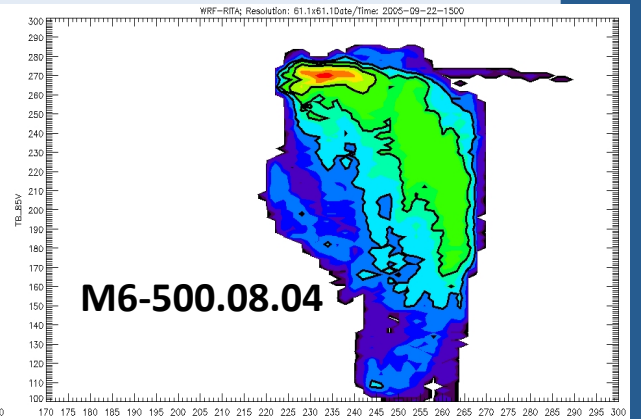
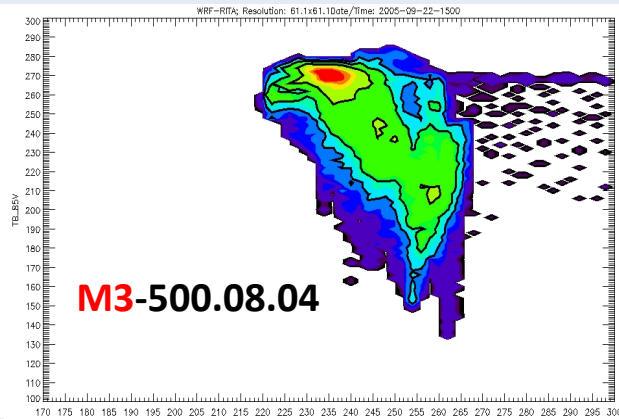
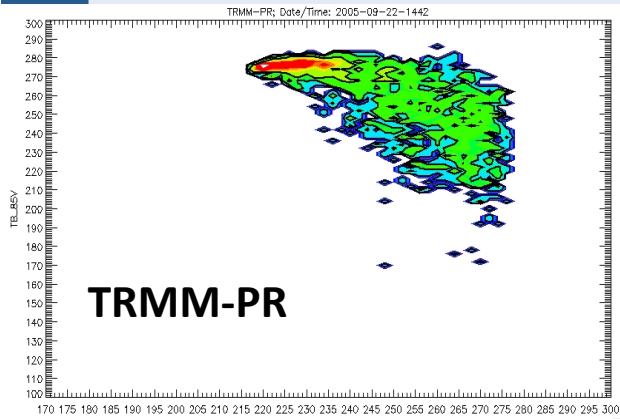


Brightness Temperature-85 GHz H

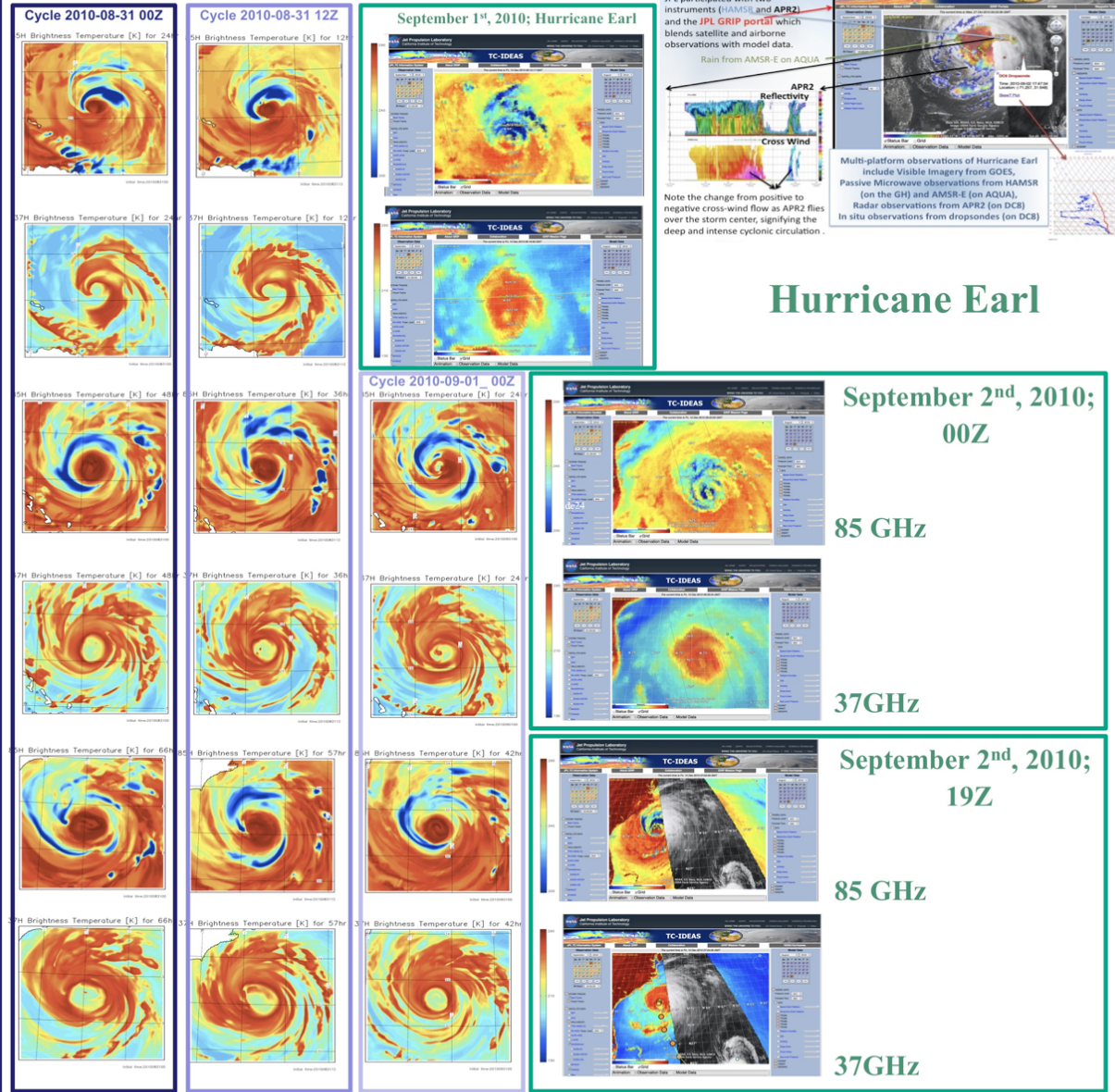




PDF of the relation 85V-19V



Storm Structure in Observations and High-resolution Model Simulations (HWRFx)

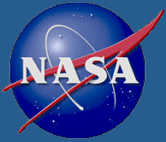


- Used the JPL GRIP portal to identified a number of cases to use for the evaluation of different hurricane forecasts.

- Focused on evaluating the 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.

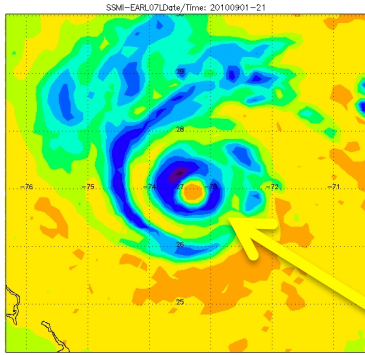


HWRFX STRUCTURE of Earl



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

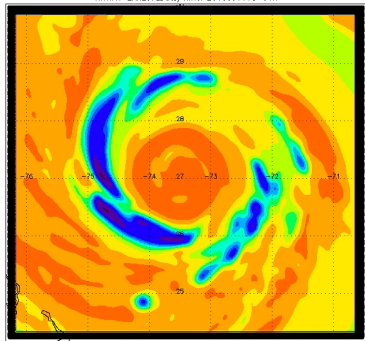
Observed



SSM-EARL07Date/Time: 20100901-21
Resolution: SSM TLR/L14 [K] Max/Min = 316.1/175.0

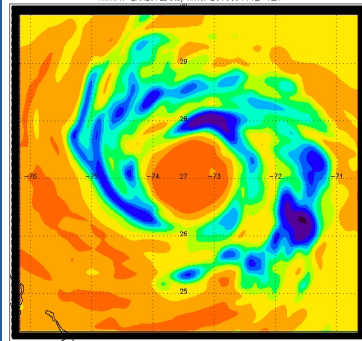
- Note that the realistic storm structure does not develop until 12-18h into the forecast cycle
- The realism decreases after the 42h forecast
- The model has a very large eye and does not show the observed eyewall replacement cycle

06h



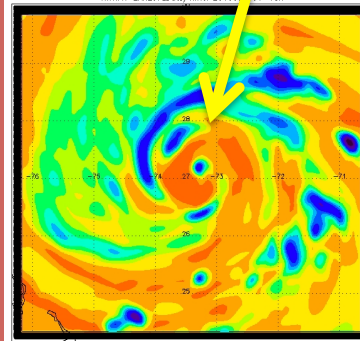
HWRFX-EARL07Date/Time: 2010090106-06h
Resolution: HWRFXarr2 [K] Max/Min = 285.72/167.67

12h



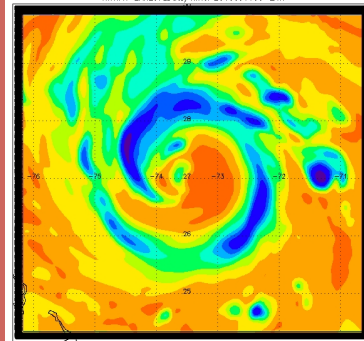
HWRFX-EARL07Date/Time: 2010090112-12h
Resolution: HWRFXarr2 [K] Max/Min = 289.51/167.00

18h



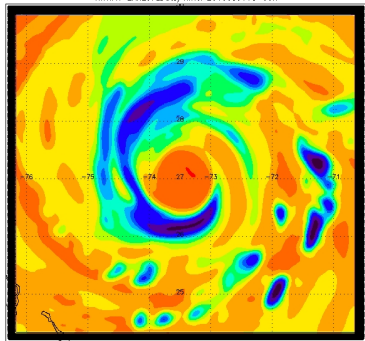
HWRFX-EARL07Date/Time: 2010090118-18h
Resolution: HWRFXarr2 [K] Max/Min = 288.39/166.76

24h



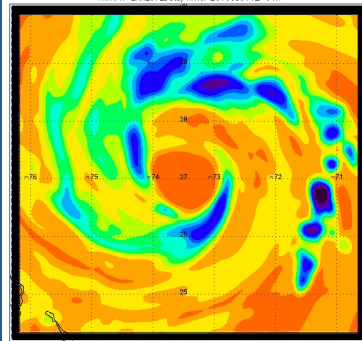
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Resolution: HWRFXarr2 [K] Max/Min = 288.07/166.54

30h



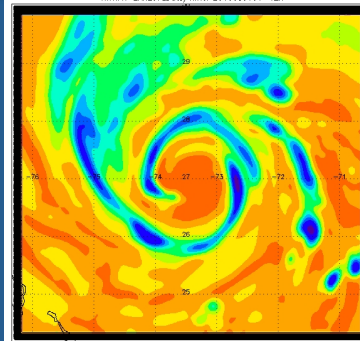
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Resolution: HWRFXarr2 [K] Max/Min = 290.32/152.52

36h



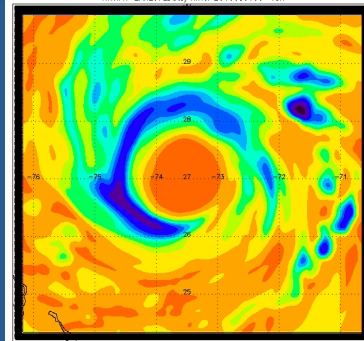
HWRFX-EARL07Date/Time: 2010083112-36h
Resolution: HWRFXarr2 [K] Max/Min = 289.02/147.85

42h

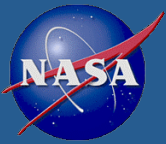


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Resolution: HWRFXarr2 [K] Max/Min = 289.34/162.21

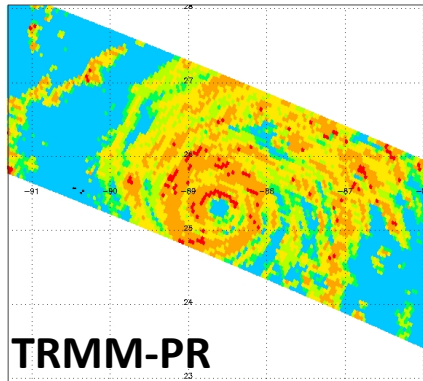
48h



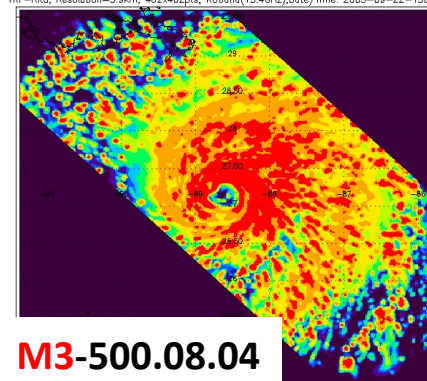
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Resolution: HWRFXarr2 [K] Max/Min = 289.58/160.04



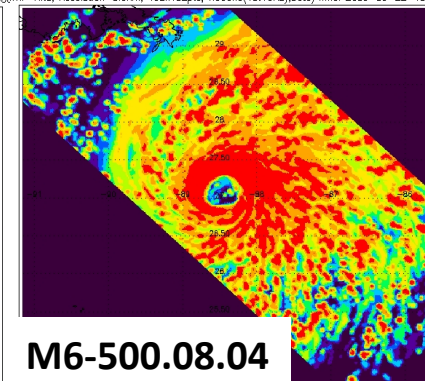
Maximum Attenuated Reflectivity



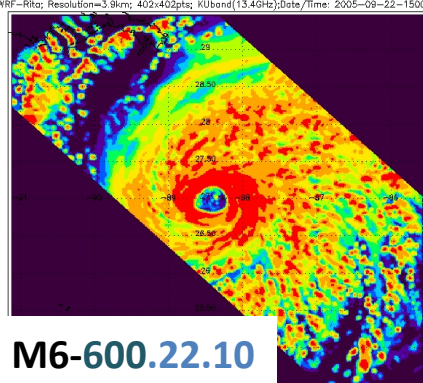
TRMM-PR



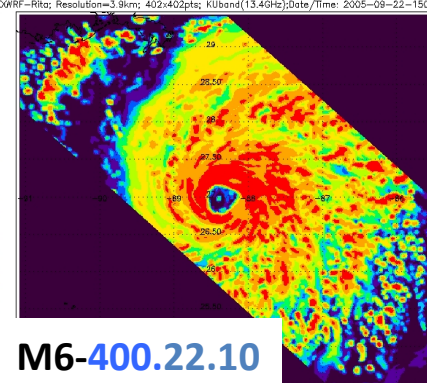
M3-500.08.04



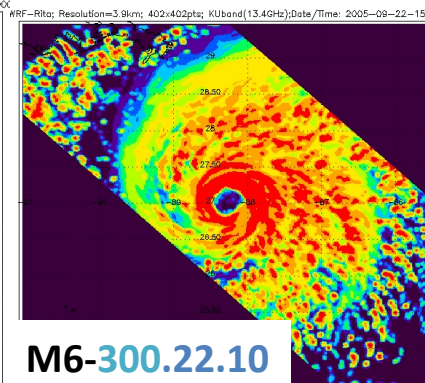
M6-500.08.04



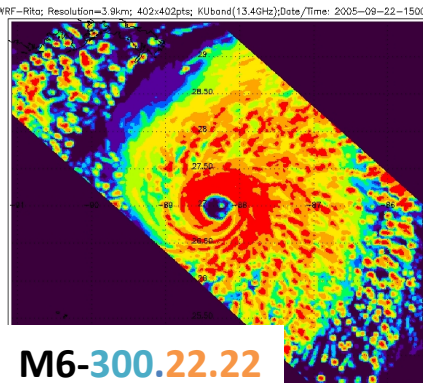
M6-600.22.10



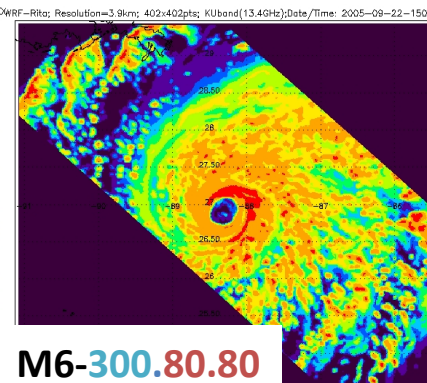
M6-400.22.10



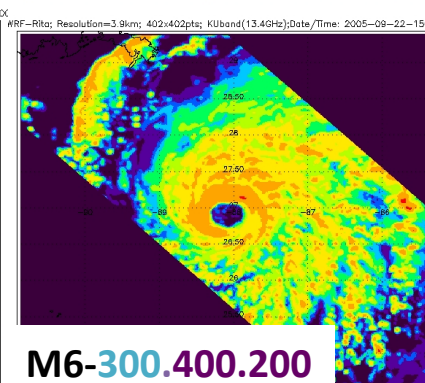
M6-300.22.10



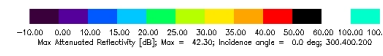
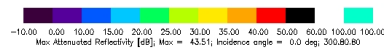
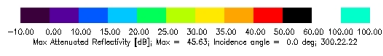
M6-300.22.22

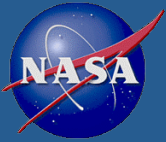


M6-300.80.80



M6-300.400.200

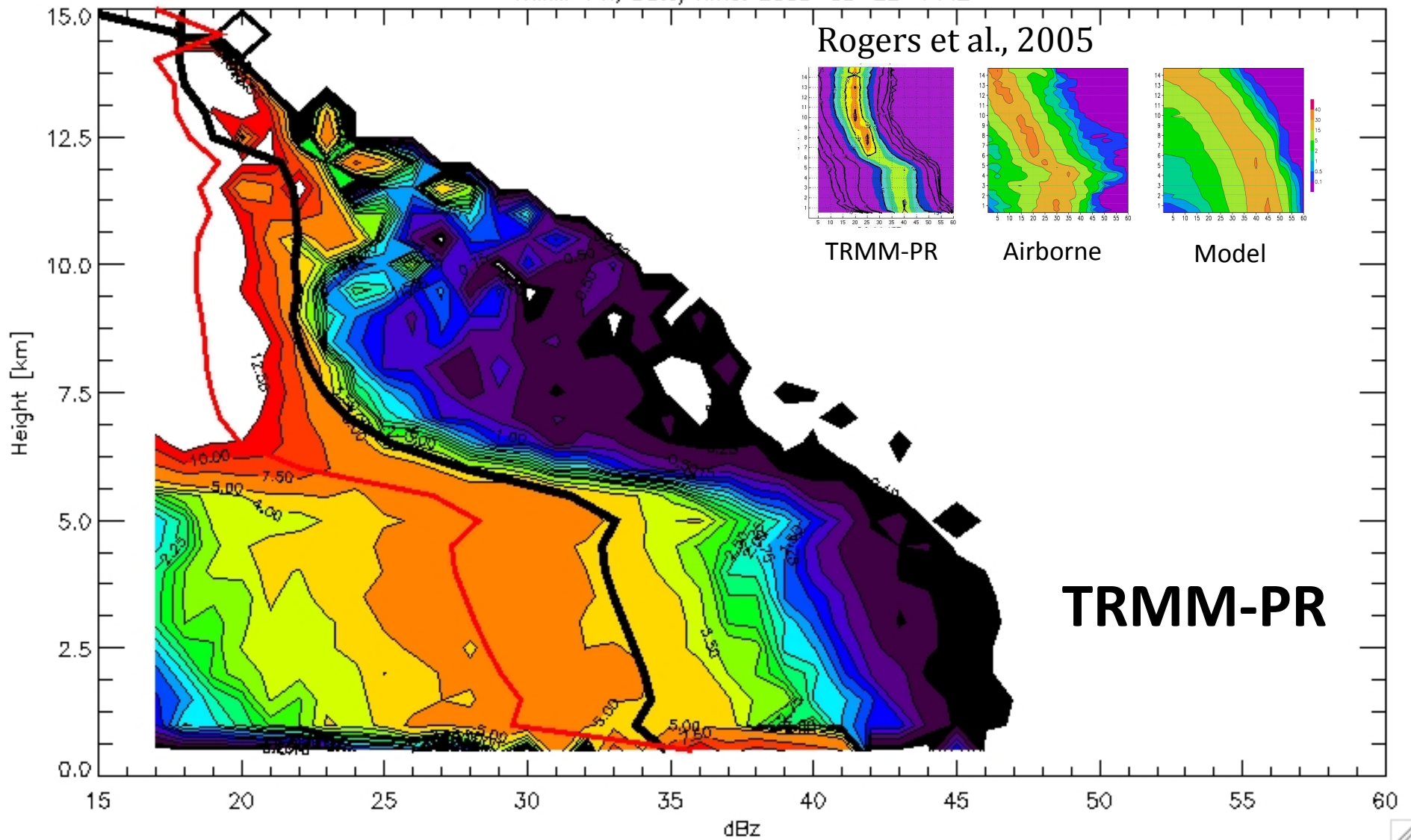


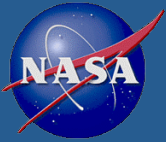


CFADs (Yuter and Houze 1994)

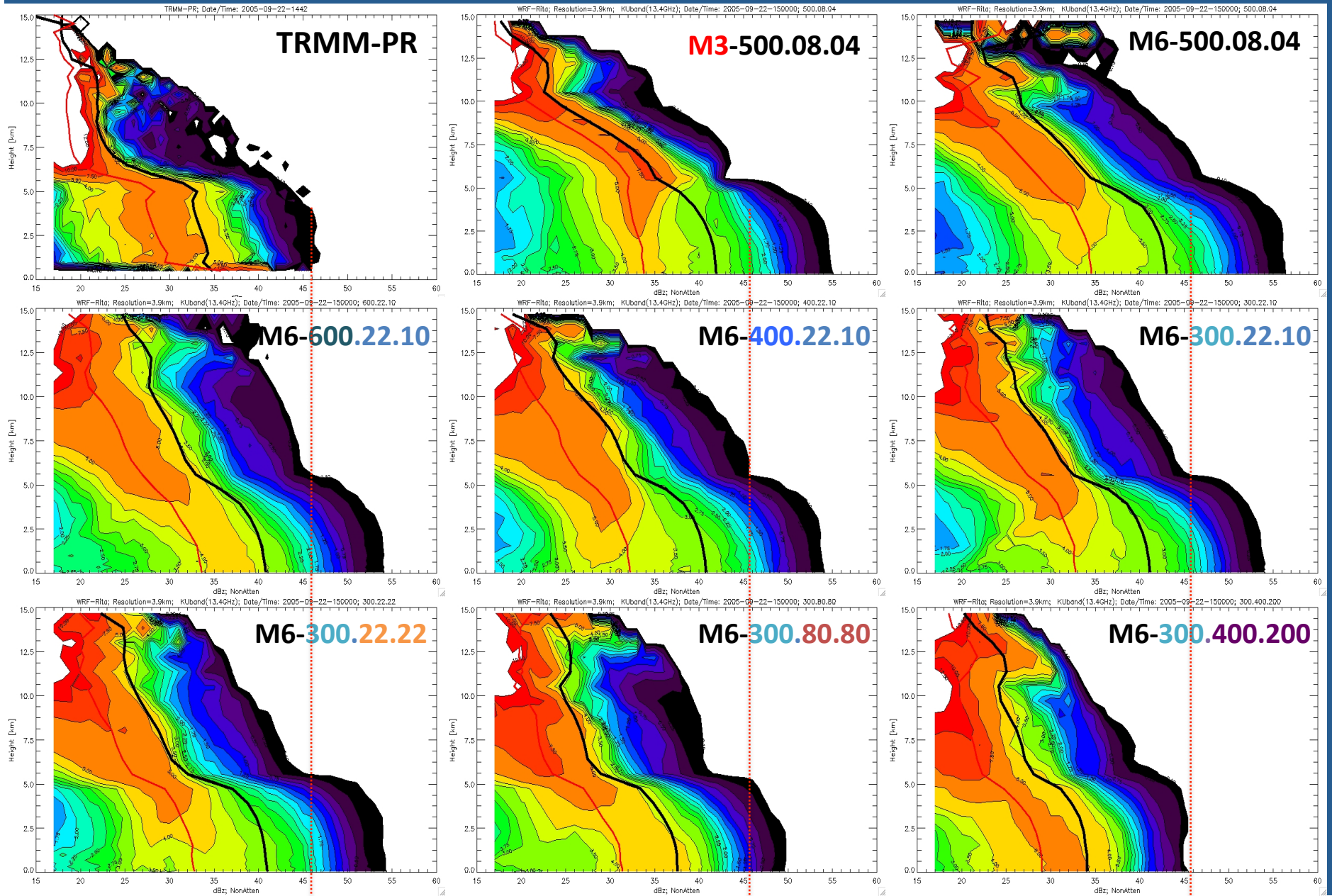


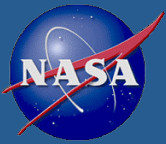
TRMM-PR; Date/Time: 2005-09-22-1442





CFADs

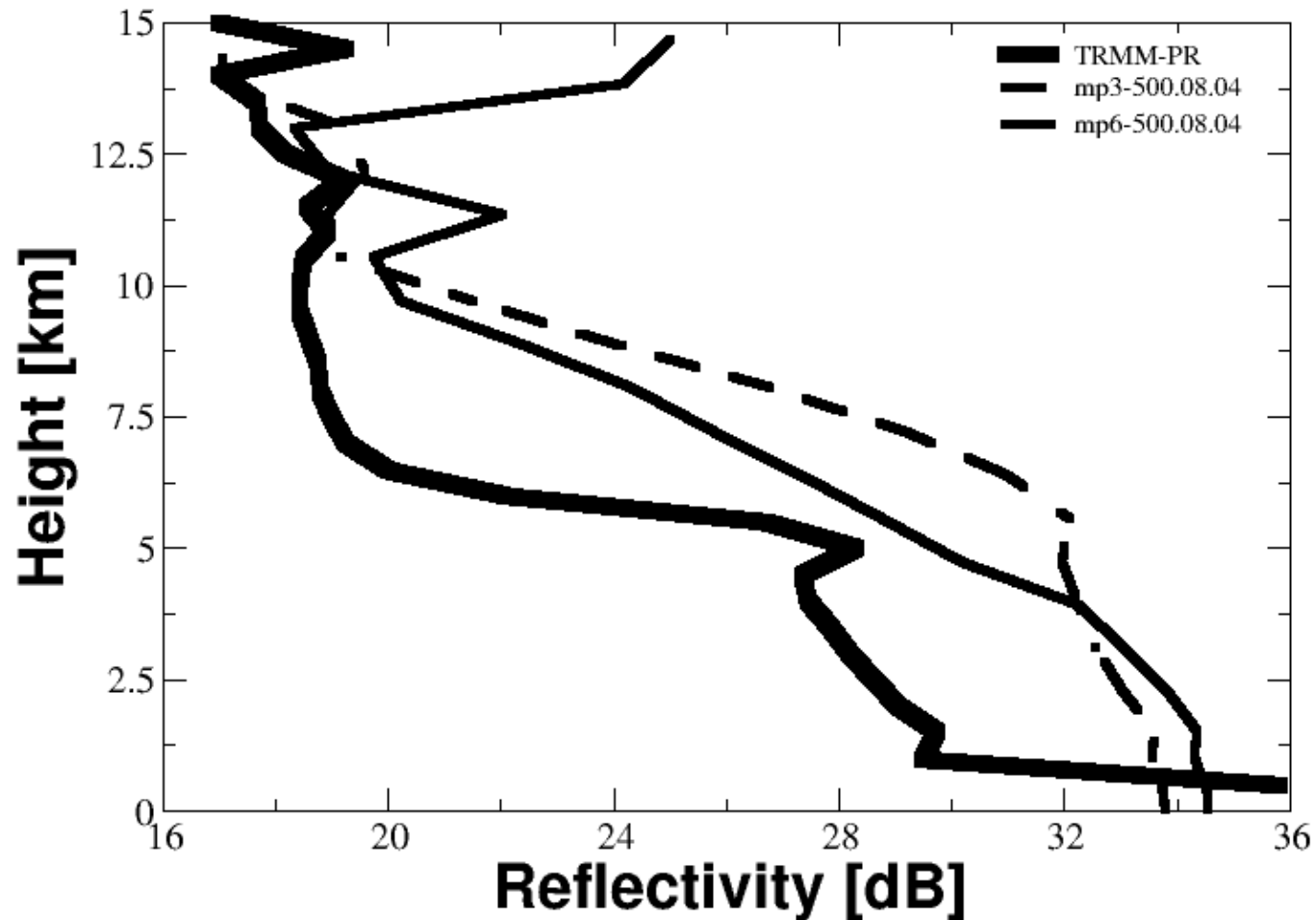


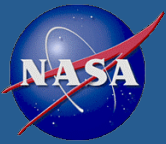


MODE of the Reflectivity



Vertical Profile of the Reflectivity Distribution Mode

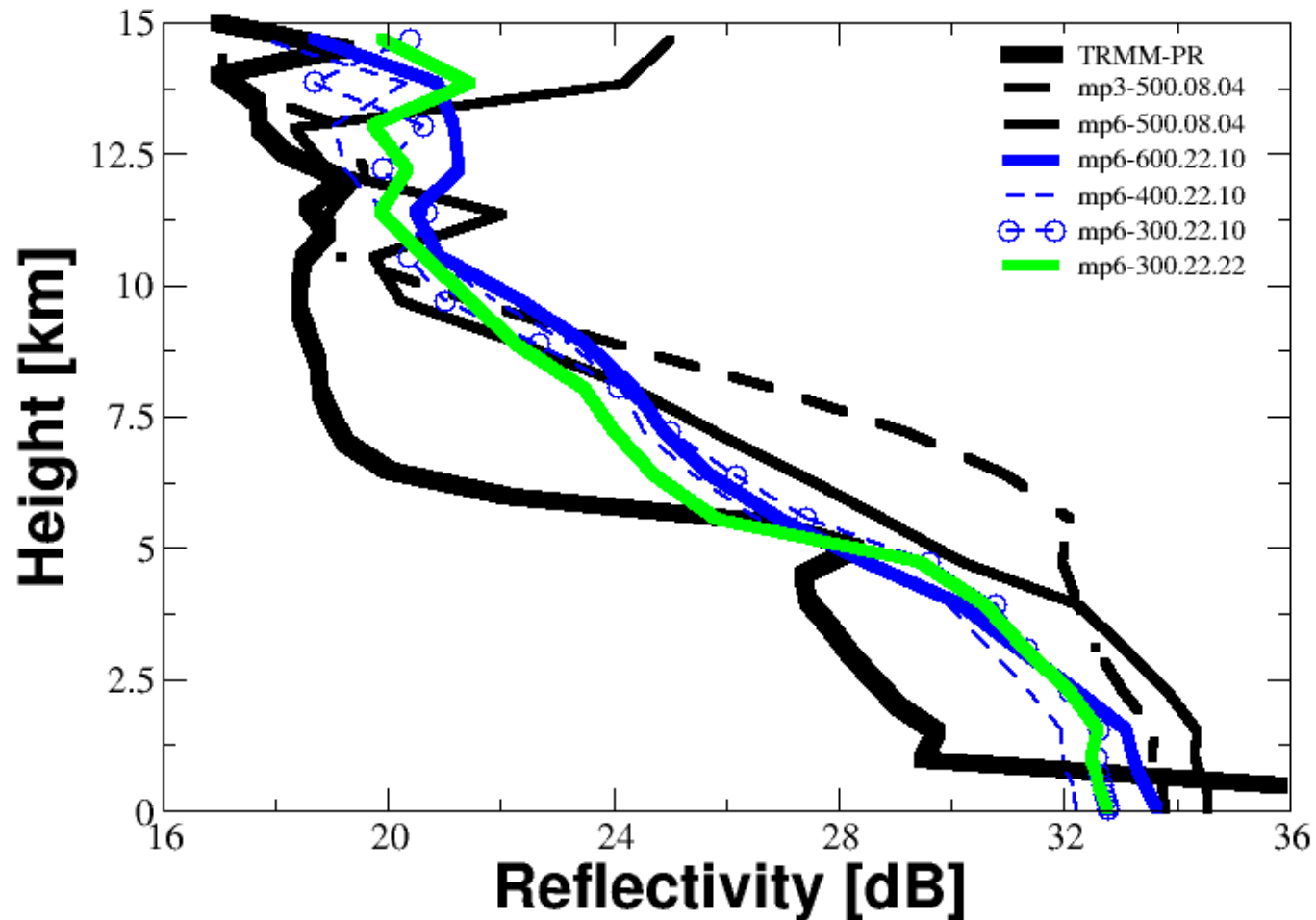


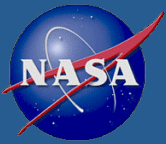


MODE of the Reflectivity



Vertical Profile of the Reflectivity Distribution Mode

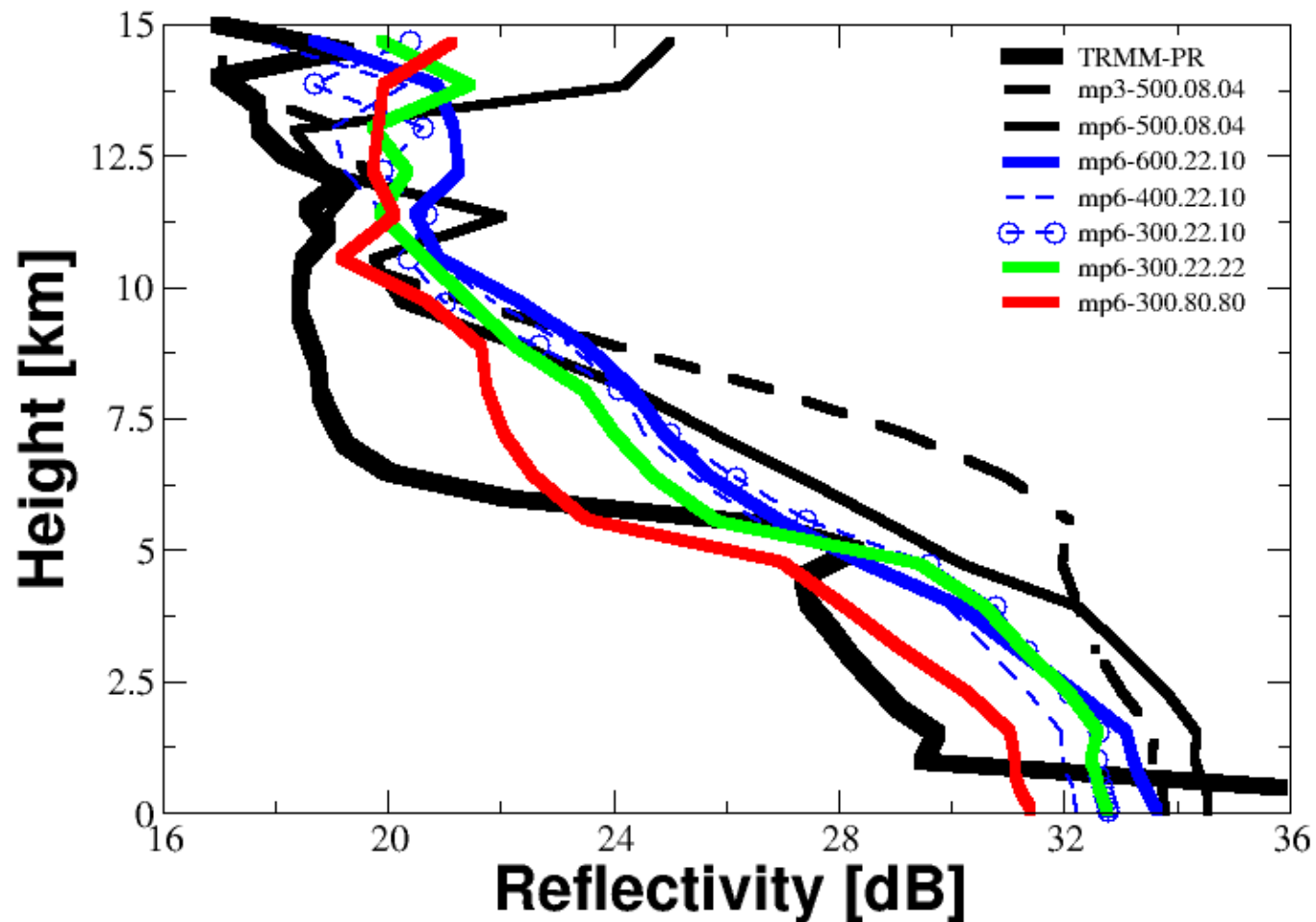


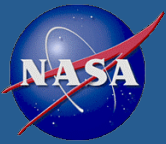


MODE of the Reflectivity



Vertical Profile of the Reflectivity Distribution Mode

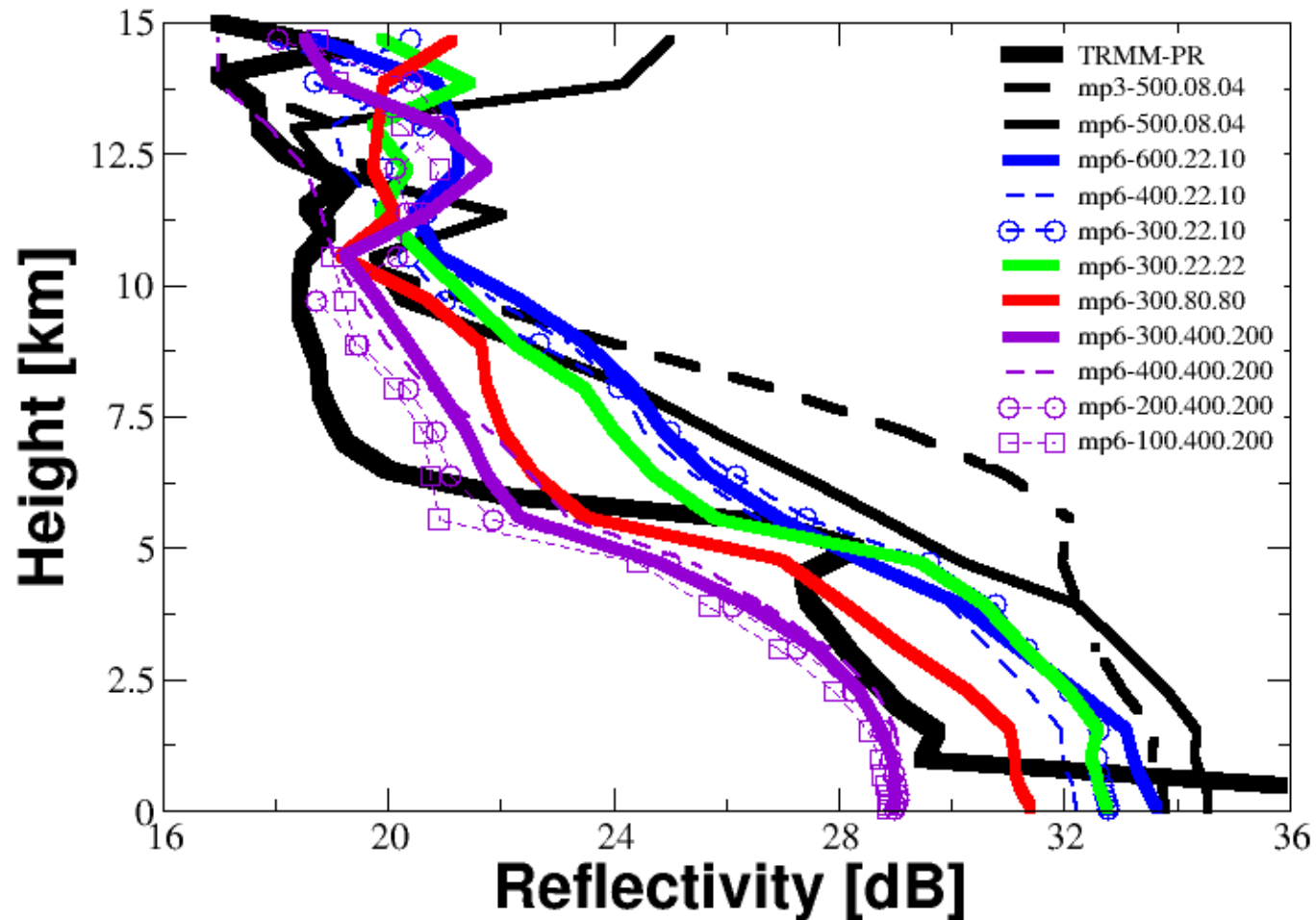


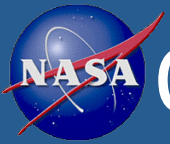


MODE of the Reflectivity



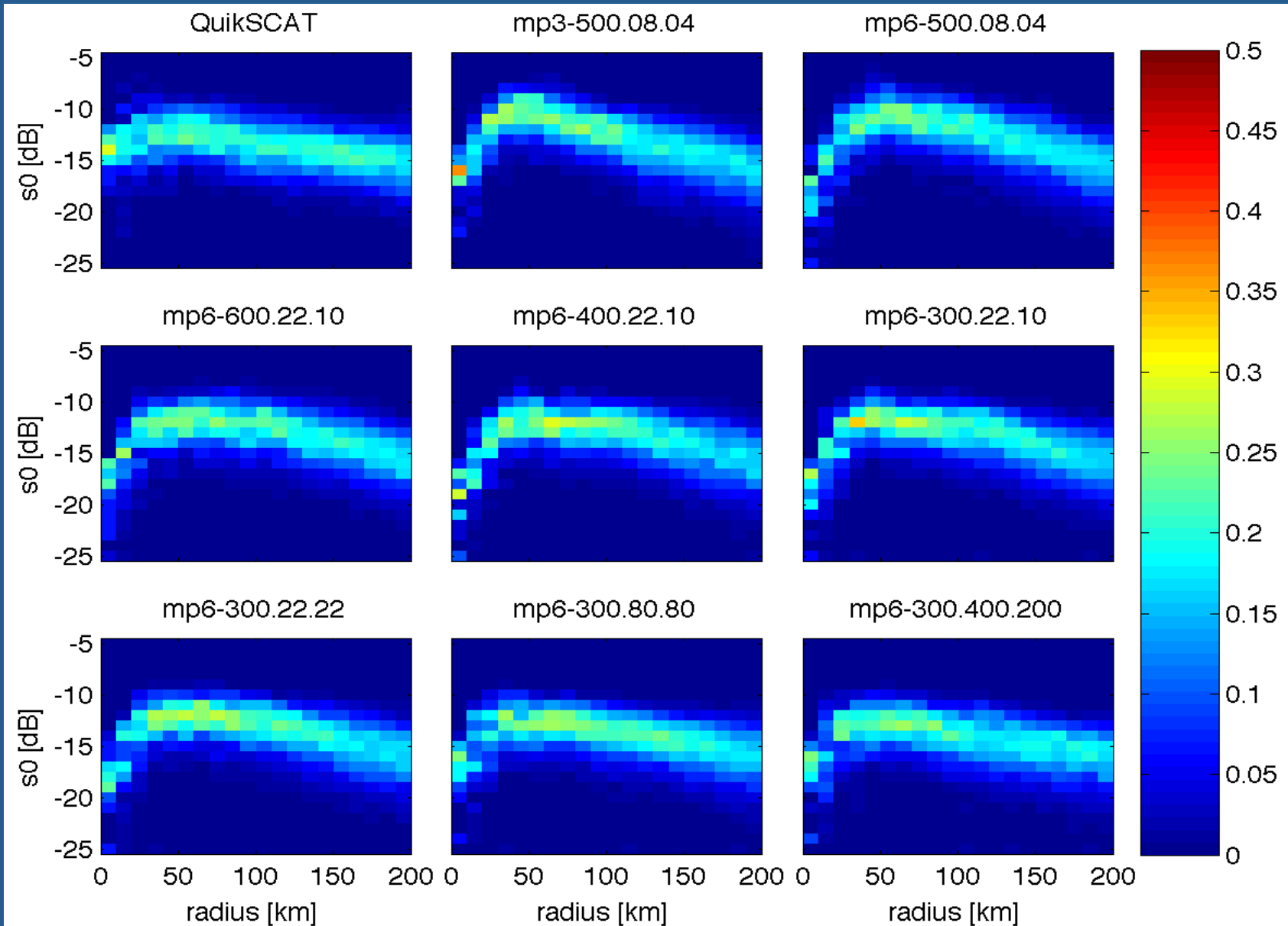
Vertical Profile of the Reflectivity Distribution Mode

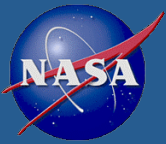




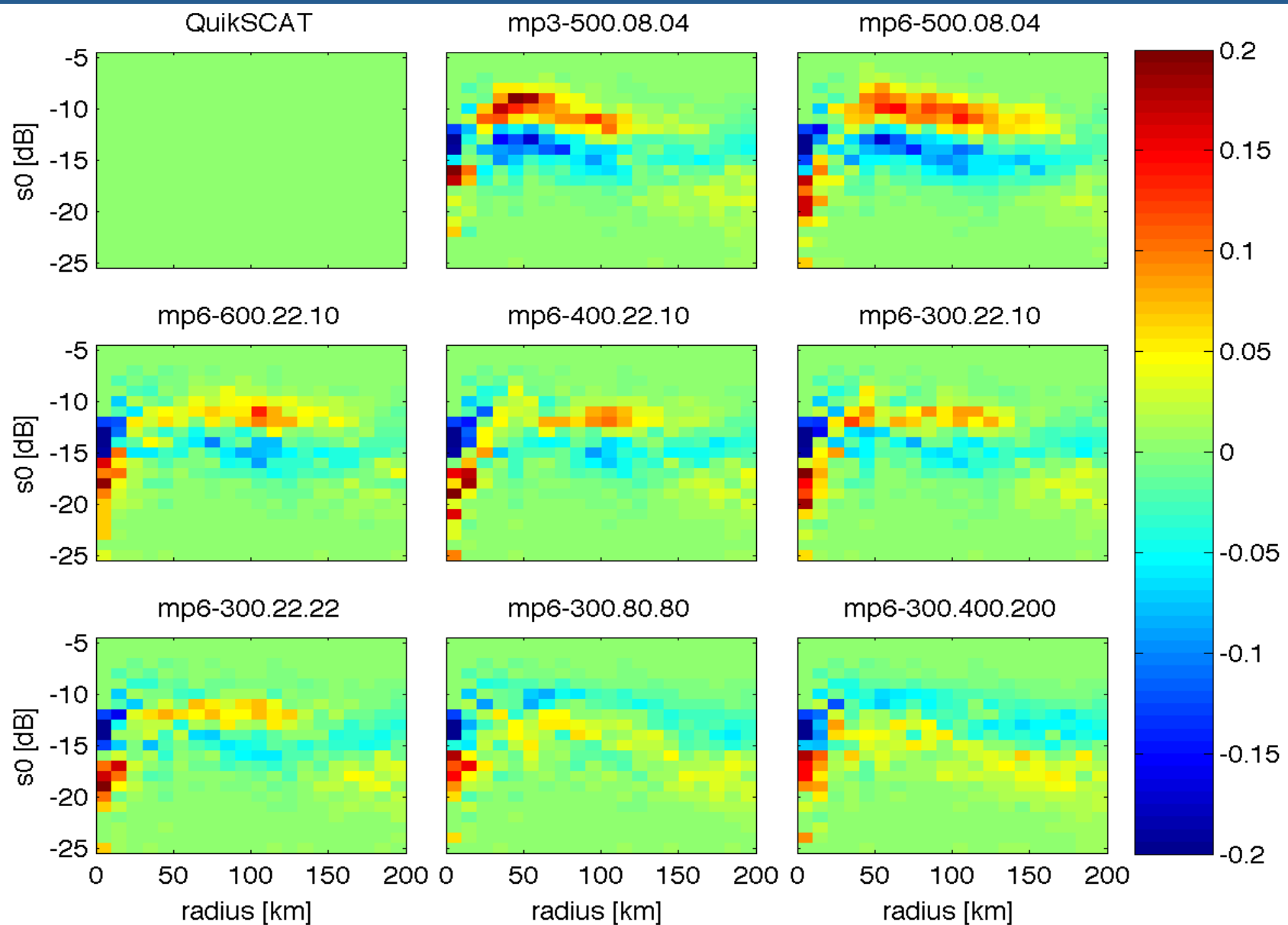
QuikSCAT

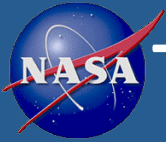
$$\sigma^o_{measured} = Attn(\sigma^o_{wind} + \sigma^o_{Splash}) + \sigma^o_{Rain}$$





PDF difference

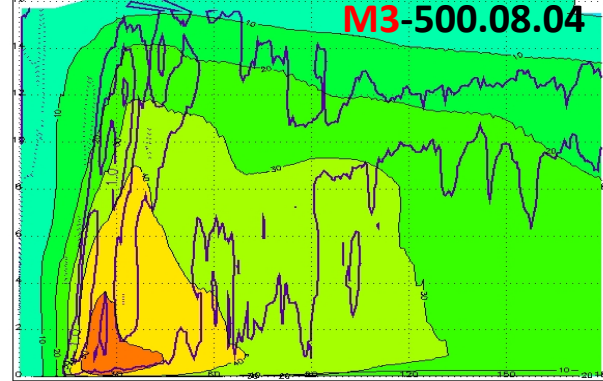




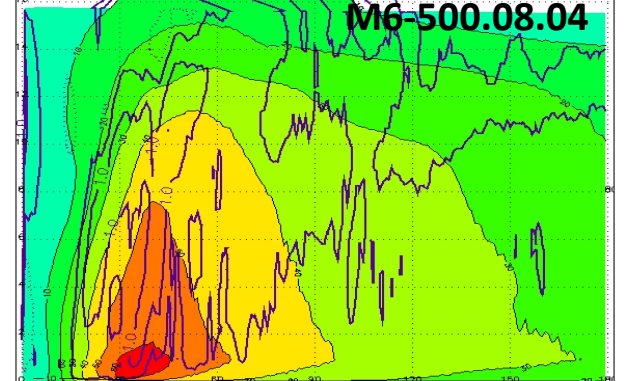
Tangential Flow - Azimuth Averages



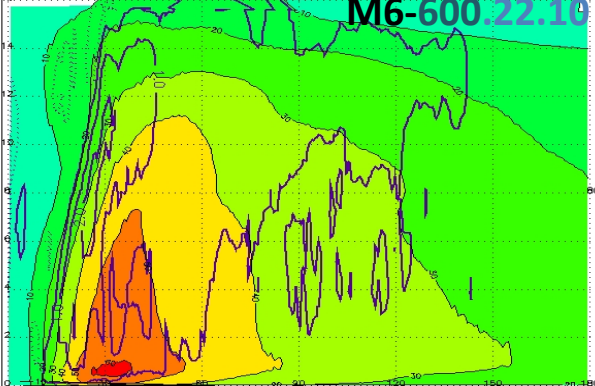
Rita; Mp3_Cp1_500.08.04; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00



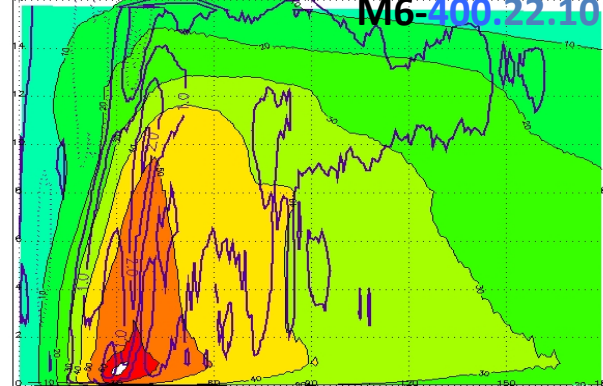
Rita; Mp6_Cp1_500.08.04; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00



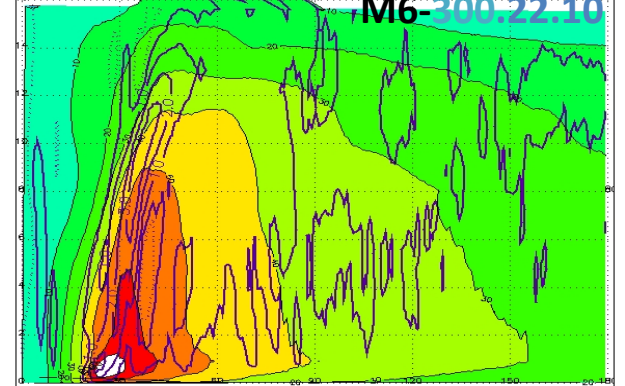
Rita; Mp6_Cp1_600.22.10; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00



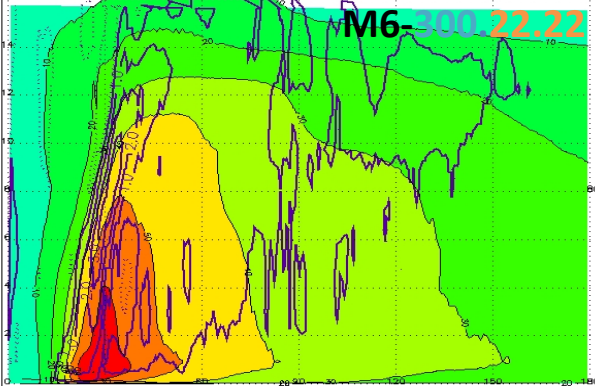
Rita; Mp6_Cp1_400.22.10; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00



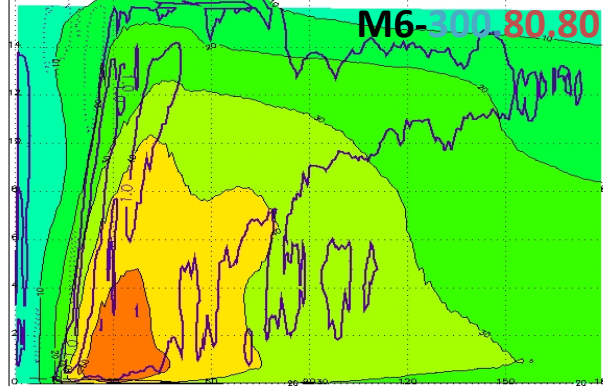
Rita; Mp6_Cp1_300.22.10; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00



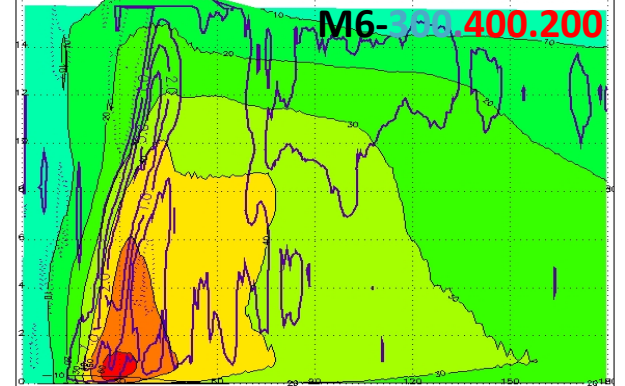
Rita; Mp6_Cp1_300.22.22; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00

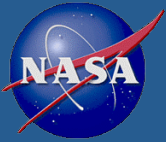


Rita; Mp6_Cp1_300.80.80; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00

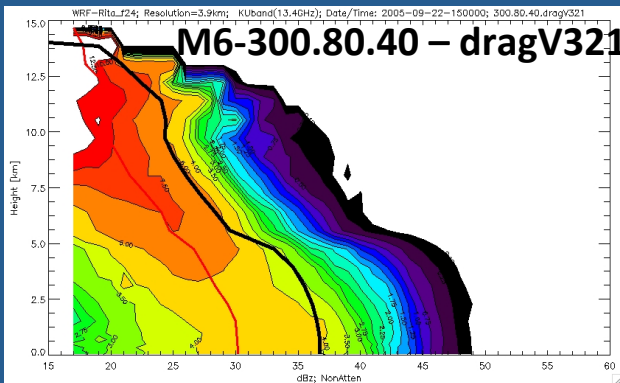
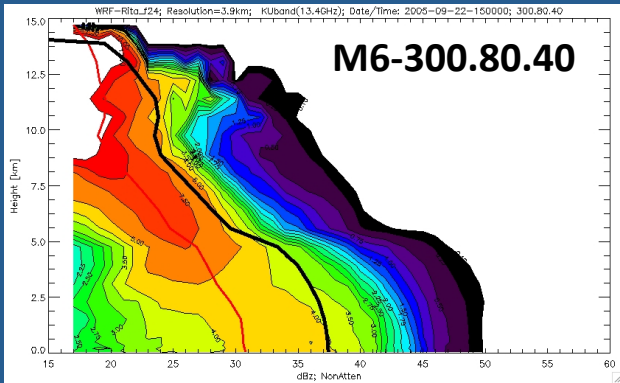


Rita; Mp6_Cp1_300.400.200; Resol.:1.3km; Domain:402x402pts; Date:2005-09-22-15:00:00

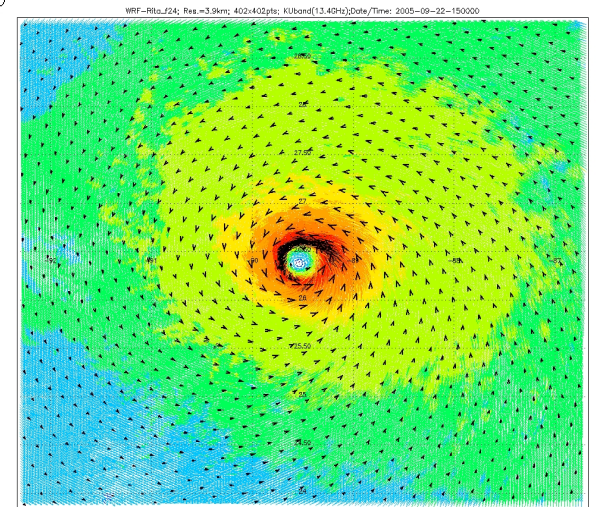
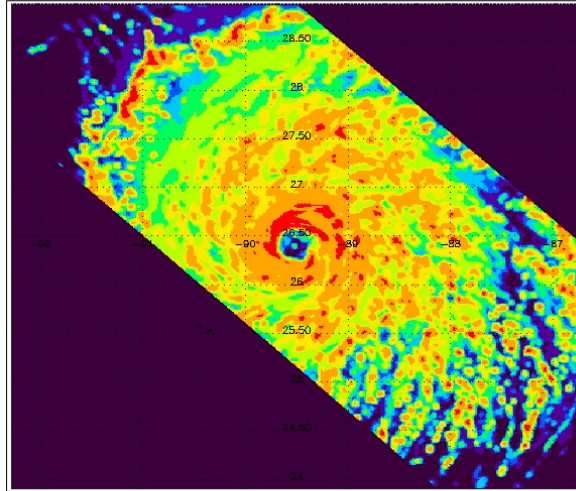




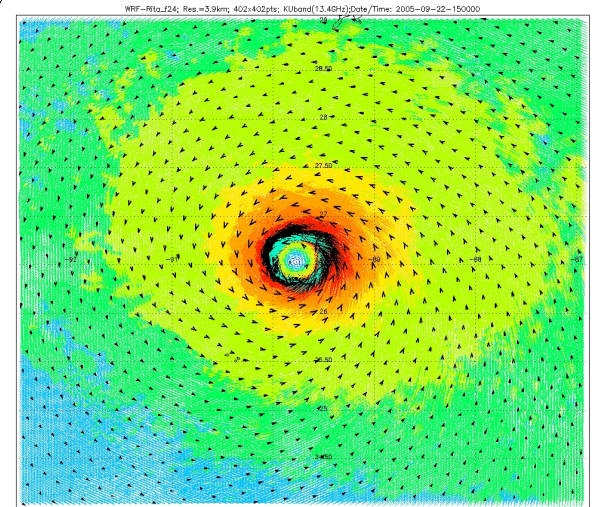
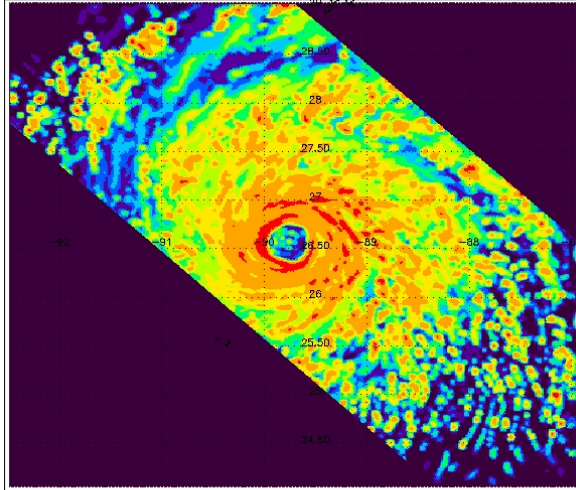
f24



WRF-Rita_f24; Res.=3.9km; 402x402pts; KUbant(13.4GHz);Date/Time: 2005-09-22-150000



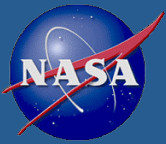
WRF-Rita_f24; Res.=3.9km; 402x402pts; KUbant(13.4GHz);Date/Time: 2005-09-22-150000



< 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 = 42.86; incidence angle = 0.0 deg; 300.80.40.dragV321

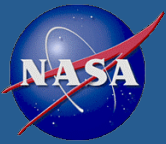
< 0.00 0.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 50.00 60.00 100.00 >100.00



Summary



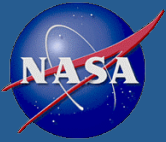
- Assuming hydrometeor distributions with larger number of smaller particles results in model simulations with radiometric signatures that compare more closely to observations.
- Intensity forecast is negatively impacted
 - Does not mean we should go back to current assumptions
 - Other physics might 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>

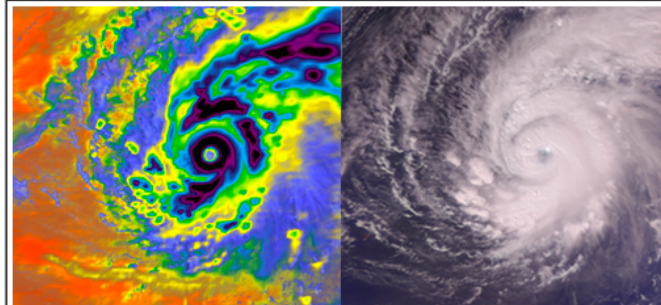


JPL Tropical Cyclone Information System

Home | Project | Feedback | Data Portal | Analysis Tool

Welcome to the 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.

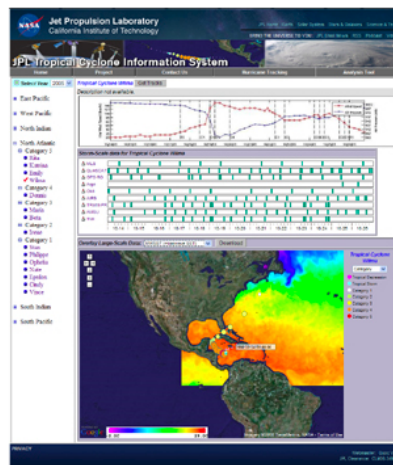


Supertyphoon Pongsona struck the U.S. Island of Guam on Sunday, December 8, 2002. The composite image (left) of the supertyphoon was made by overlaying data from the infrared, microwave, and visible/near-infrared sensors that make up the AIRS sounding system. This storm can also be seen with the standard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

2 main components
In the current
JPL iTCIS

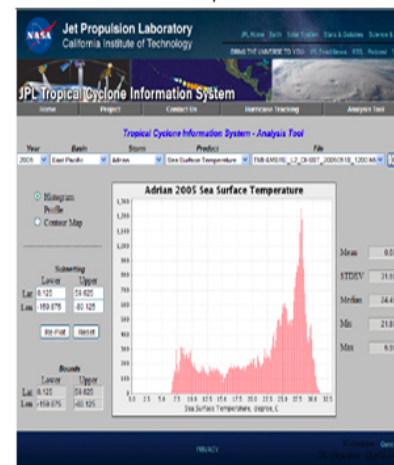
Tropical Cyclone Data Portal

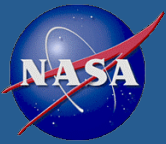
Here you can search for specific storms in 2005 and directly access data and plots associated with that storm.



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.



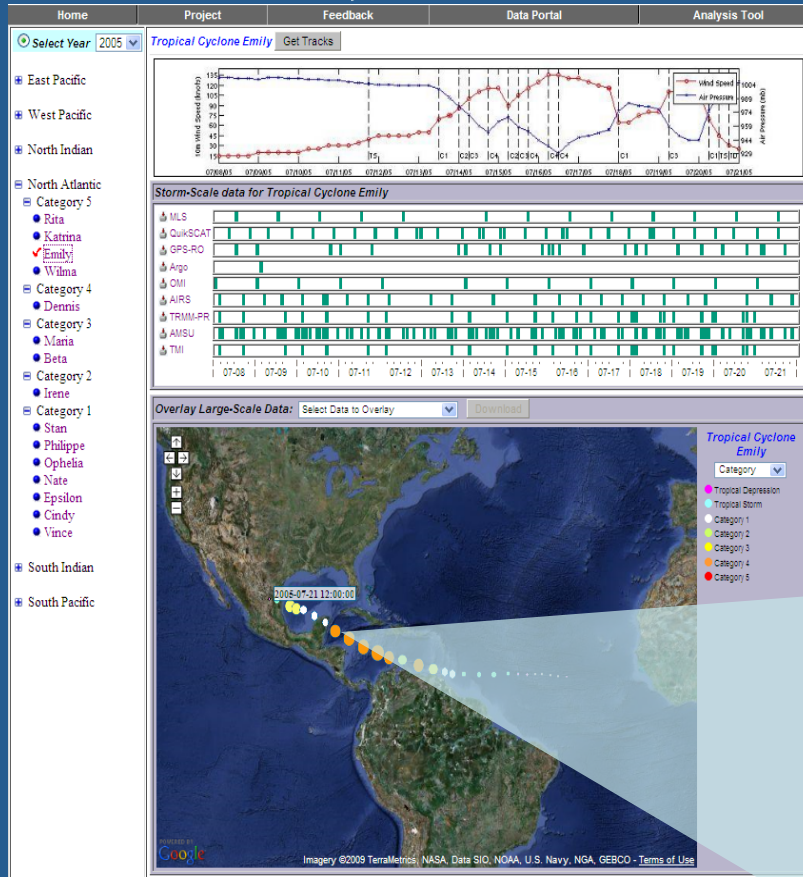


Tropical Cyclone – Integrated Data Exchange and Analysis System (TC-IDEAS) – being developed as Part of the HSRP



Joint NASA Jet Propulsion Lab and Marshall Space Flight Center Project

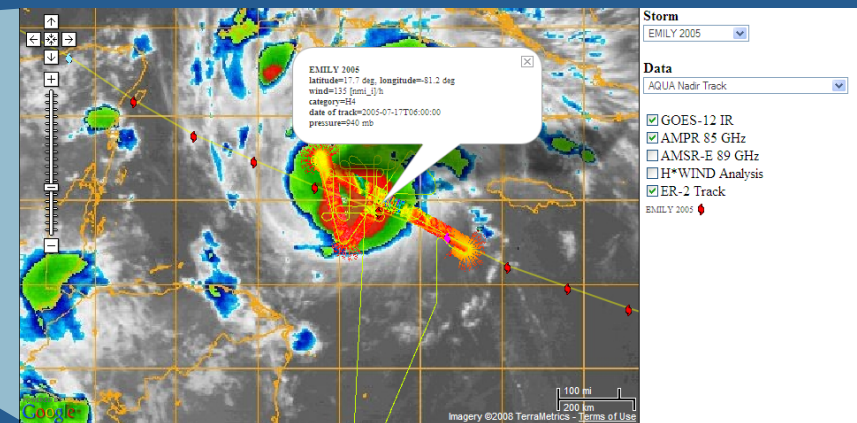
The JPL TCIS



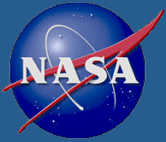
Select by basin, name, or category with corresponding data availability timelines

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



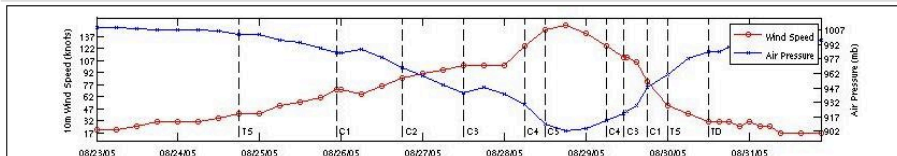
JPL Tropical Cyclone Information System

Home Project Feedback Data Portal Analysis Tool

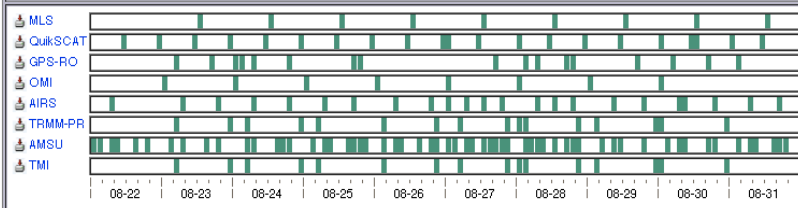
Select Year 2005

Tropical Cyclone Katrina Get Tracks

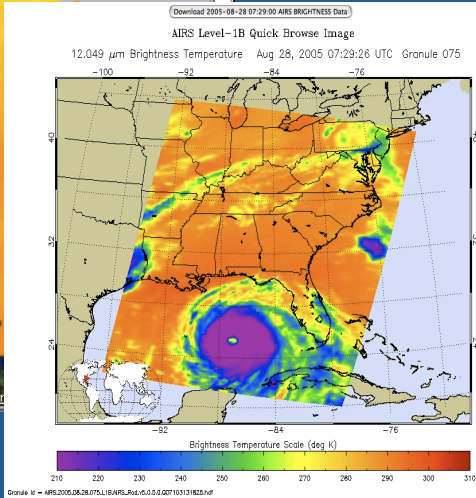
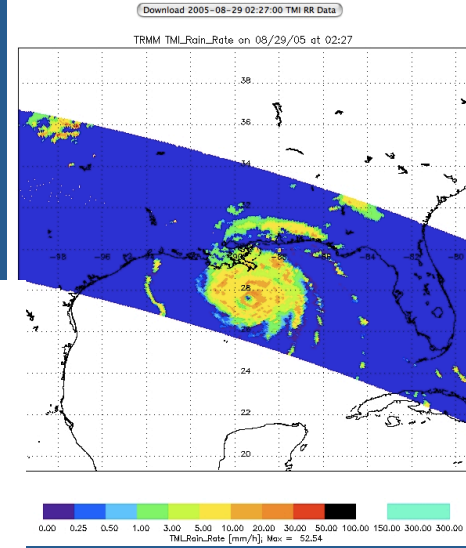
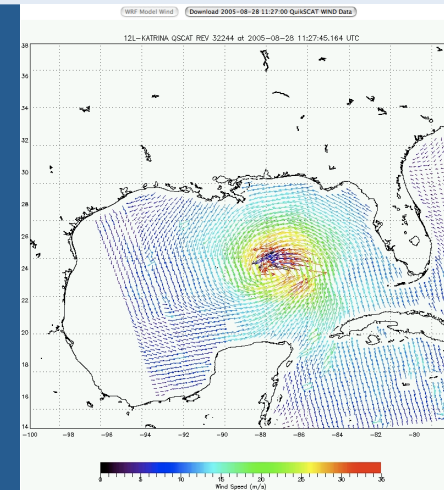
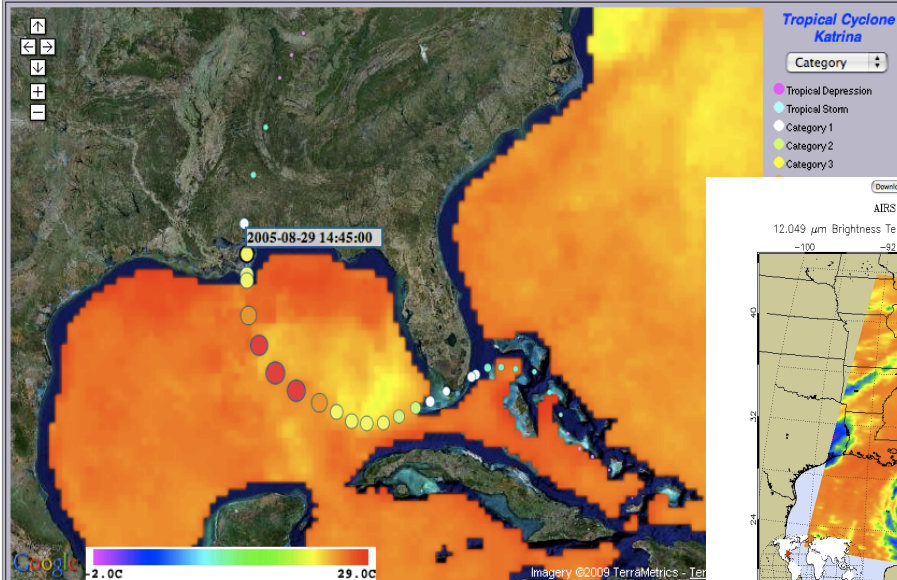
- East Pacific
- West Pacific
- North Indian
- North Atlantic
 - Category 5
 - Rita
 - Katrina
 - Emily
 - Wilma
 - Category 4
 - Dennis
 - Category 3
 - Maria
 - Beta
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 - Stan
 - Philippe
 - Ophelia
 - Nate
 - Epsilon
 - Cindy
 - Vince
- South Indian
- South Pacific

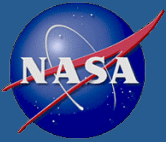


Storm-Scale data for Tropical Cyclone Katrina



Overlay Large-Scale Data: MWSST (microwave SST) Download





Analysis Tools – CURRENT STATUS



Single Parameter Statistics

NASA Jet Propulsion Laboratory
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Tropical Cyclone Information System - Analysis Tool

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

Select Plot Type

Histogram
 Profile
 Map

Spatial Subsetting

Lower	Upper
Lat 16.200	33.480
Lon -96.210	-75.790

Re-Plot | Reset

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

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

NASA Jet Propulsion Laboratory
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Tropical Cyclone Information System - Analysis Tool

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

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Lat 16.200	33.480
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Re-Plot | Reset

Data Boundaries

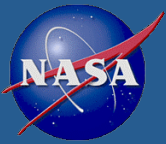
Lower	Upper
Lat 16.200	33.480
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Katrina 2005 Wind Speed

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Mean	0.830
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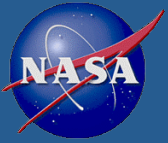
Webmaster: Quoc Vu
JPL Clearance: CL#08-3490



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”**

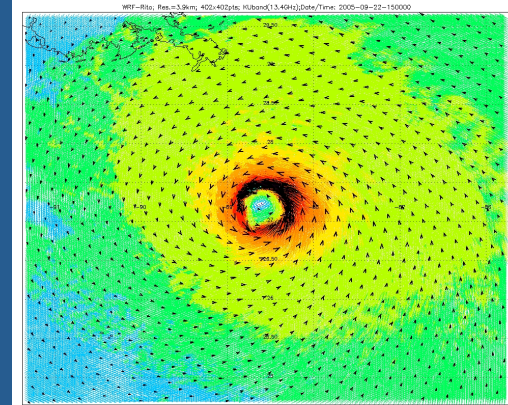
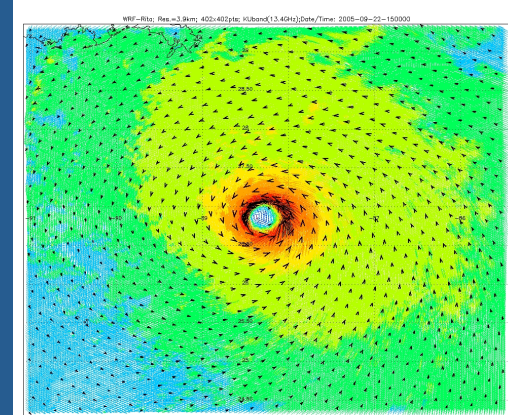
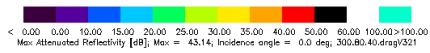
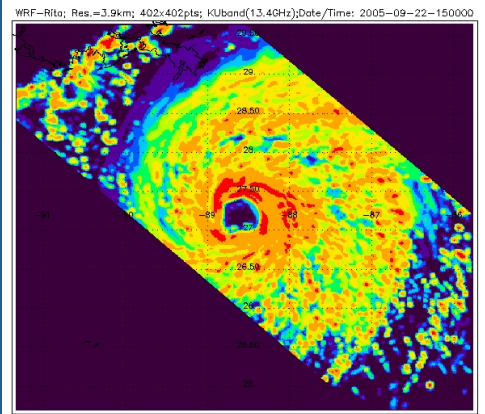
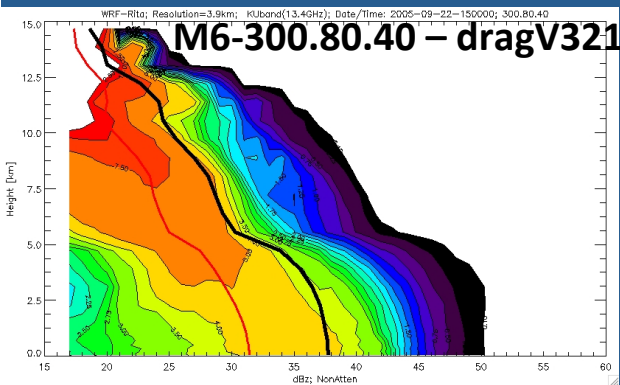
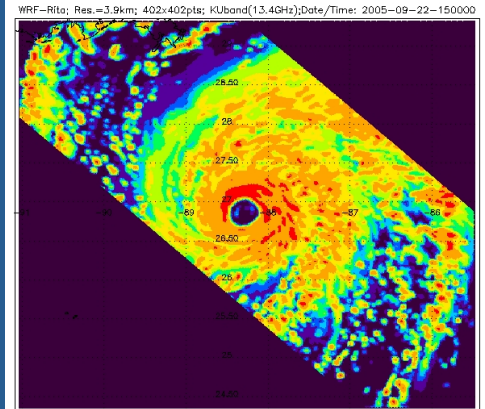
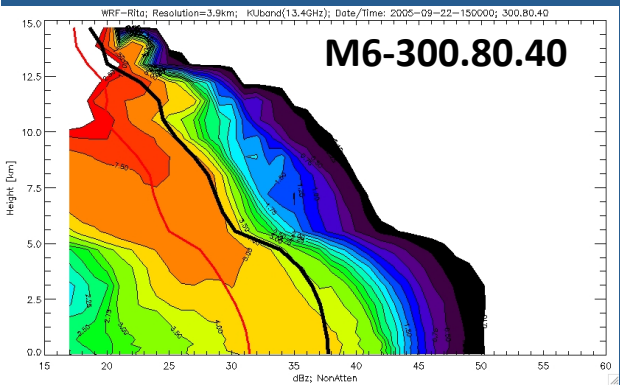
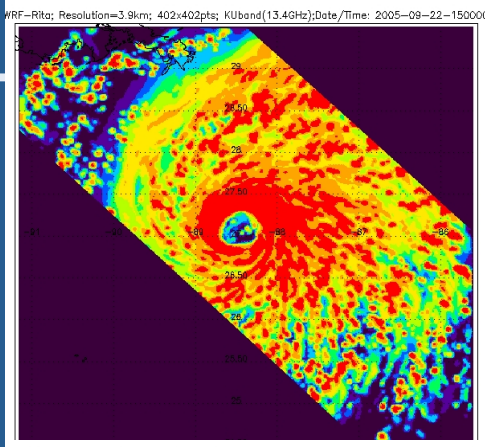
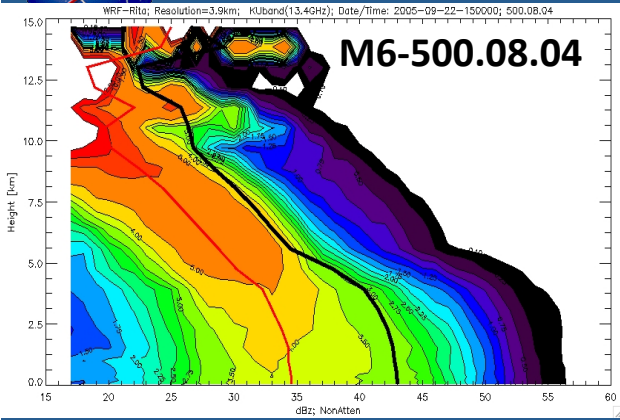


BACKUP





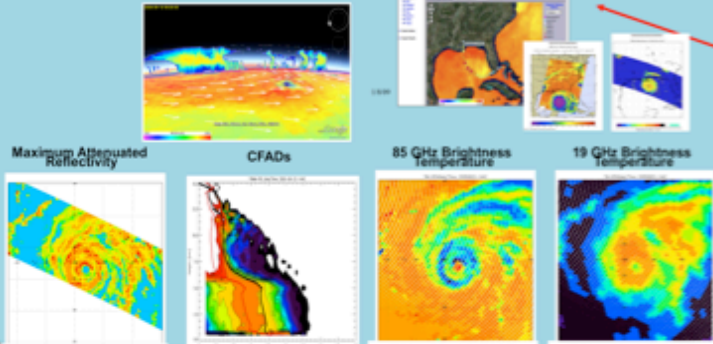
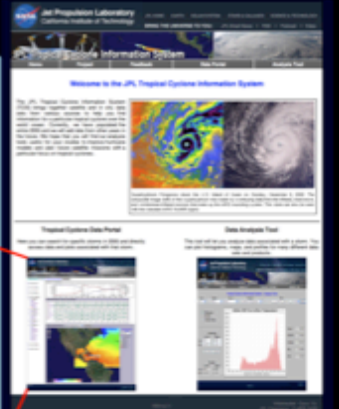
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TC-IDEAS

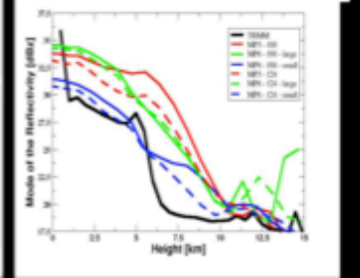
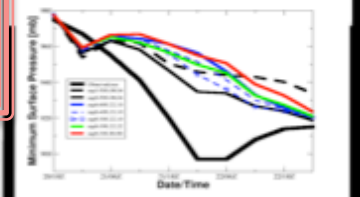
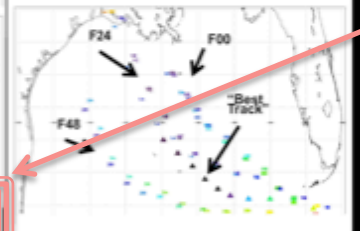
funded by NASA's
Hurricane Science
Research Program

<http://tropicalcyclone.jpl.nasa.gov>
TOPICAL CYCLONE DATA PORTAL

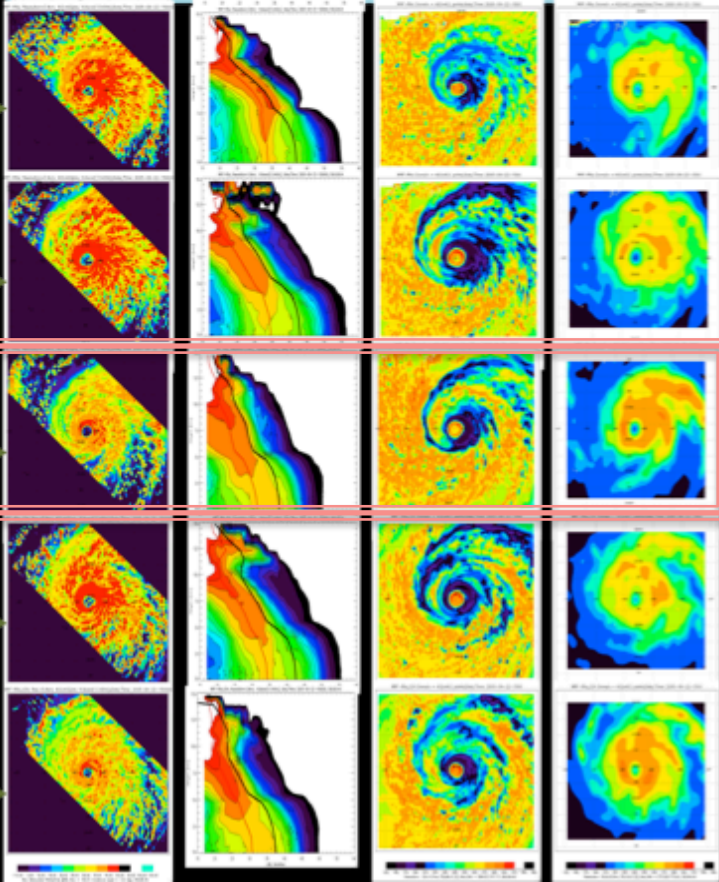


Simulation of radiometric signatures
- Radar Reflectivity and Attenuation
- Microwave Brightness Temperatures
- Surface Backscattering Cross-section

Comparison to Observations
TRMM-PR, TRMM-TMI, QuikSCAT



WSM3
Larger Particles (500.08)
WSM6
Larger Particles (500.08.04)
**WSM6
Smaller Particles (300.80.40)**
WSM6
Larger Particles (500.08.04)
WSM6
Smaller Particles (300.80.40)

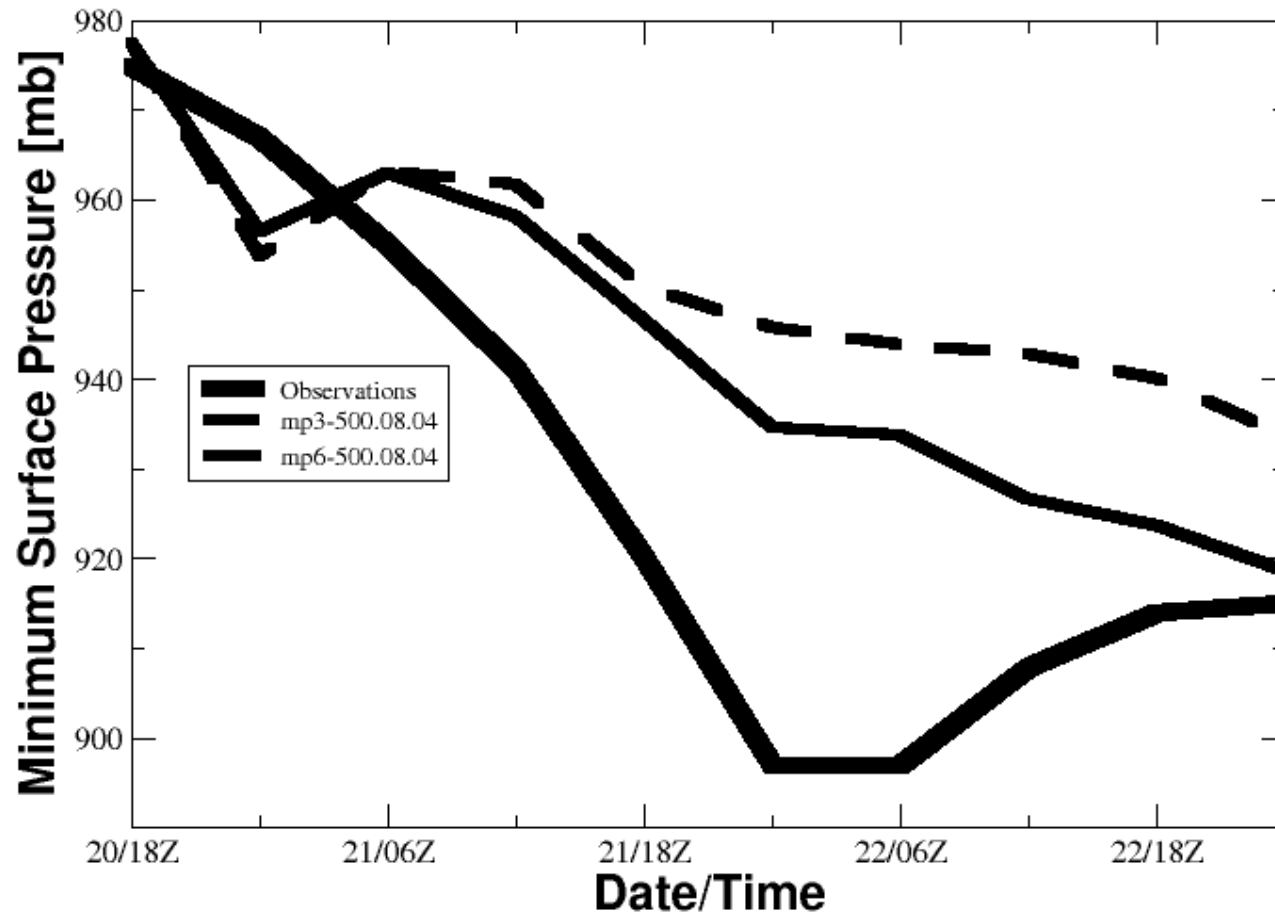
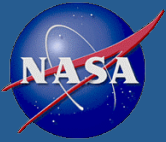


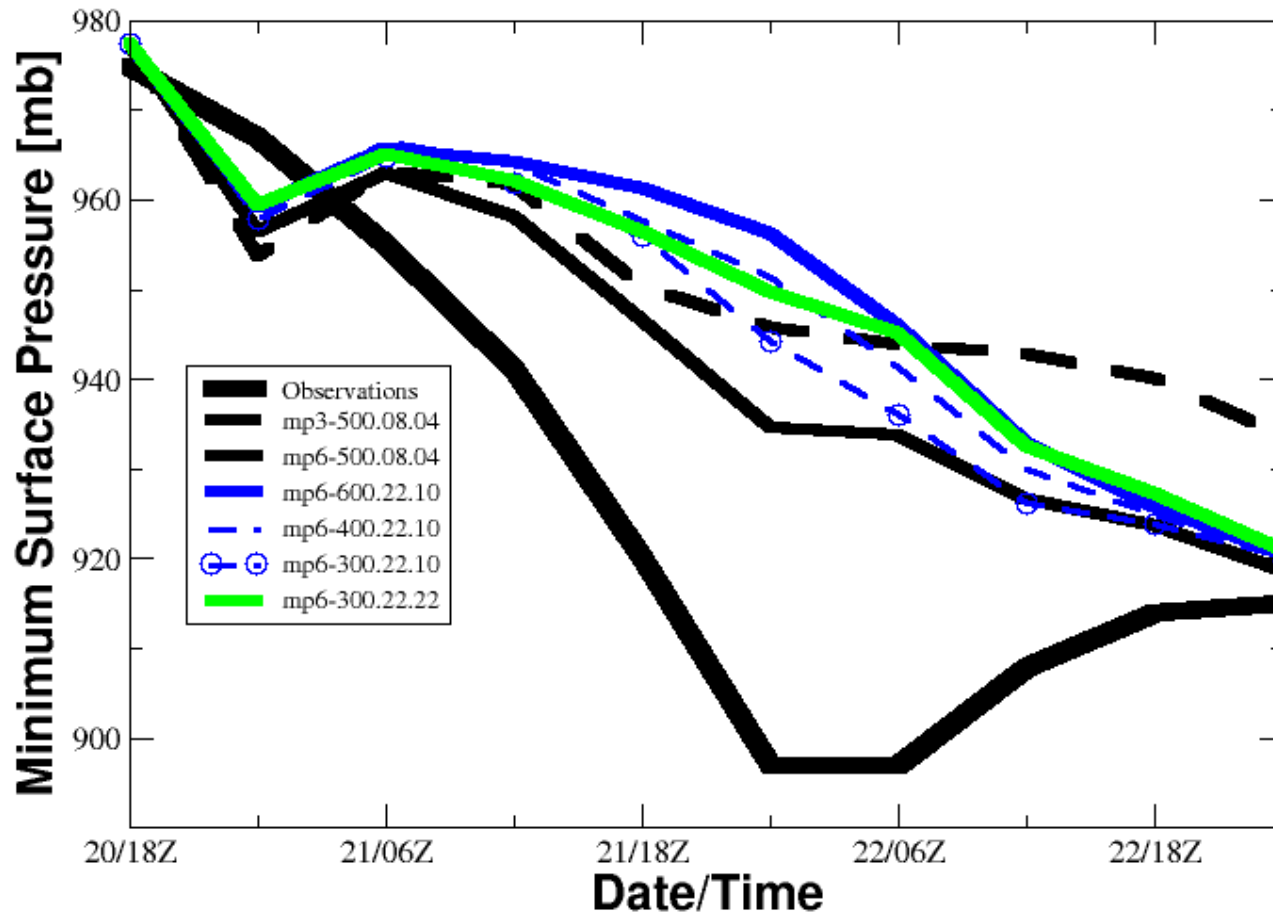
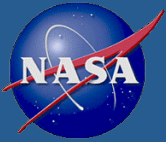
RESEARCH JPL

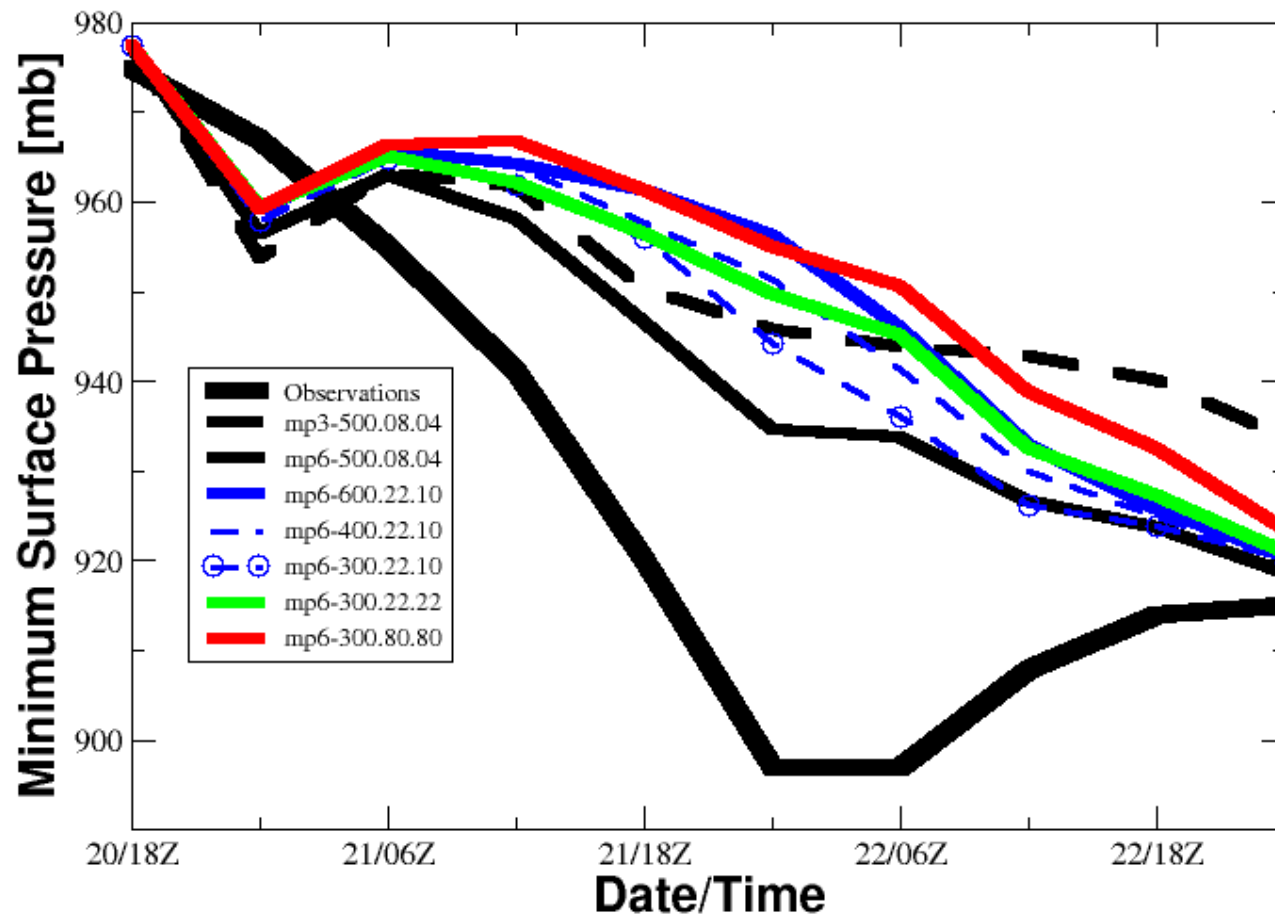
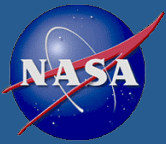
MODEL

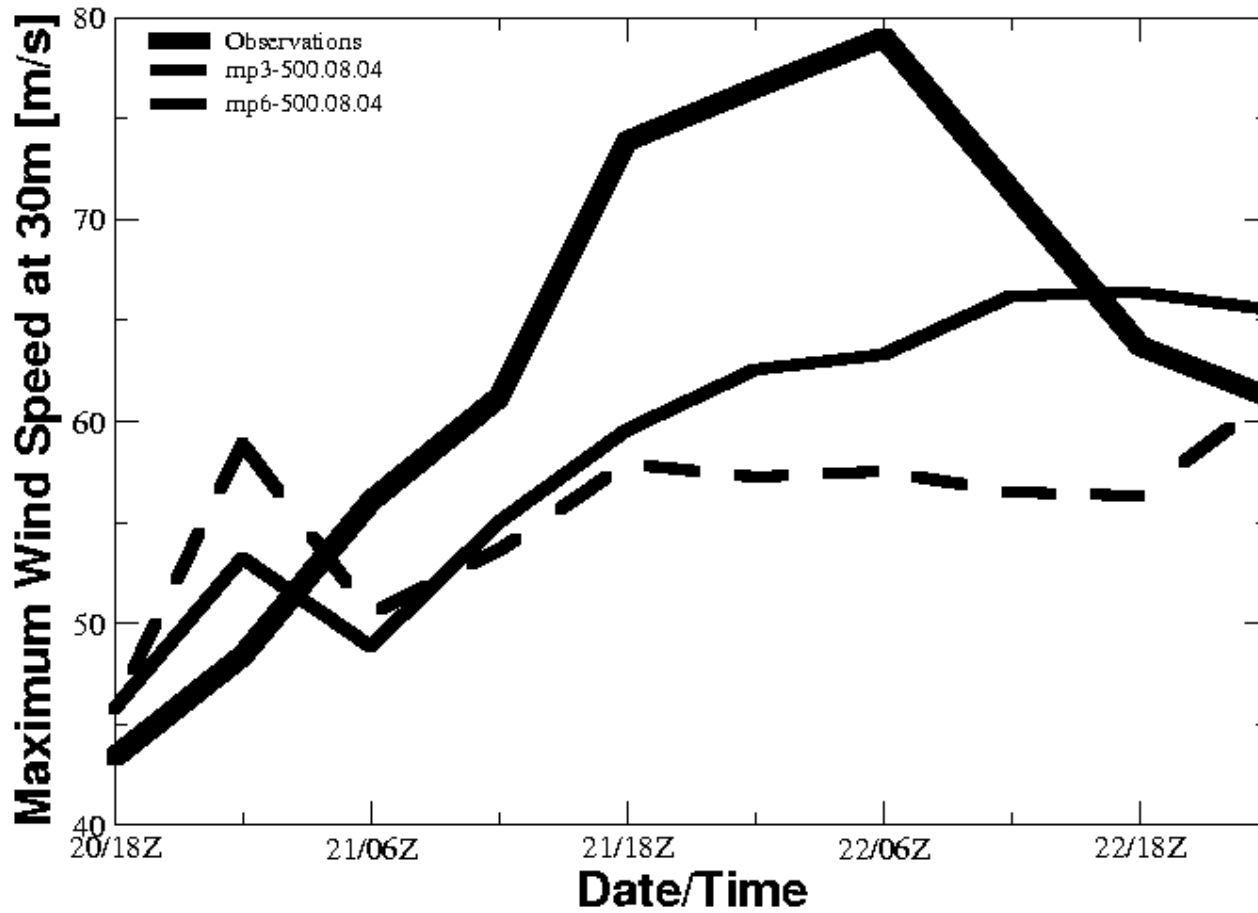
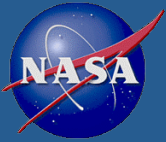
IMPROVEMENTS

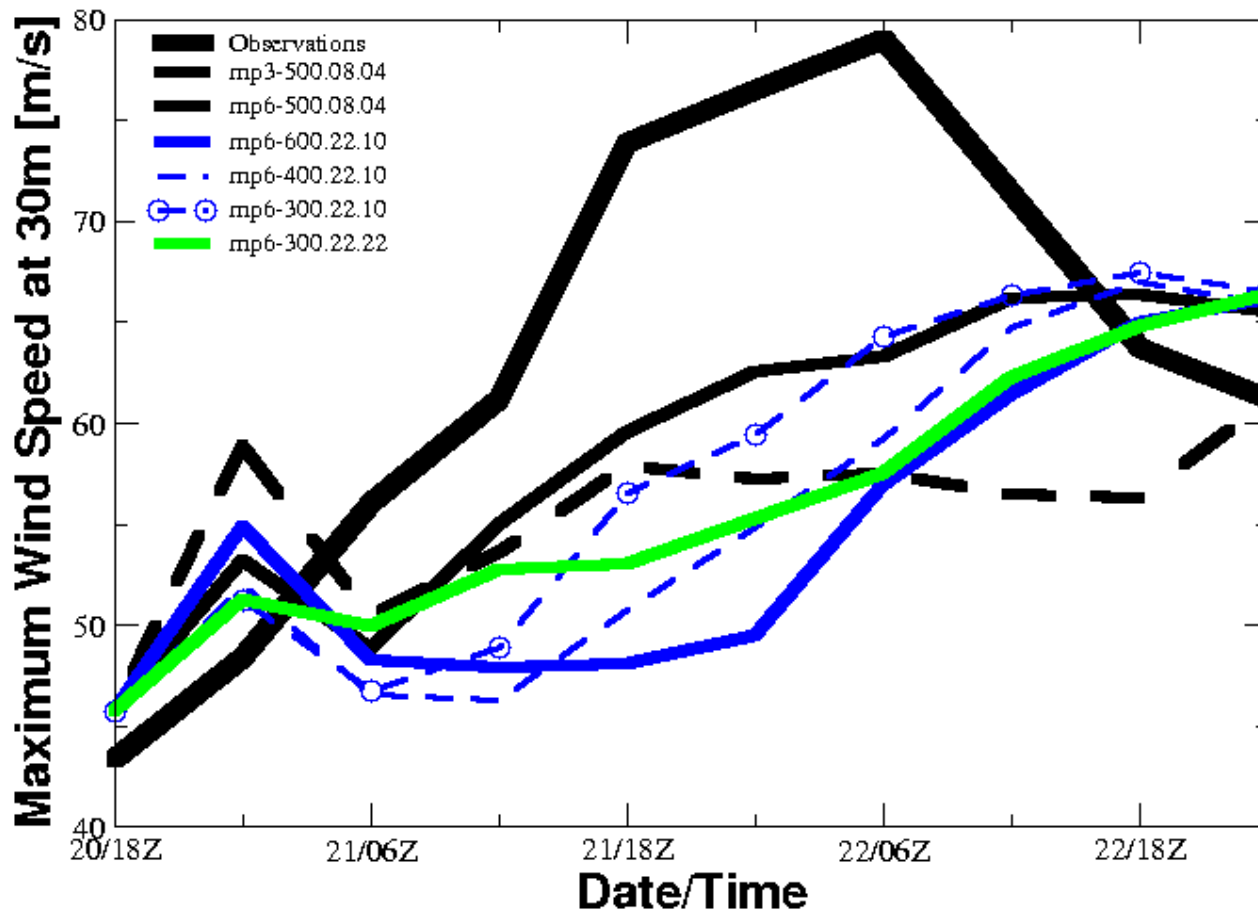
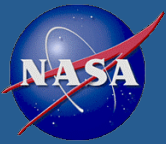
- Using instrument simulators and multiparameter satellite observations we can discriminate between model forecasts using different microphysical assumptions.
- Assuming hydrometeor distributions with smaller particles results in model forecasts with radiometric signatures that are closer to observations.
- 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

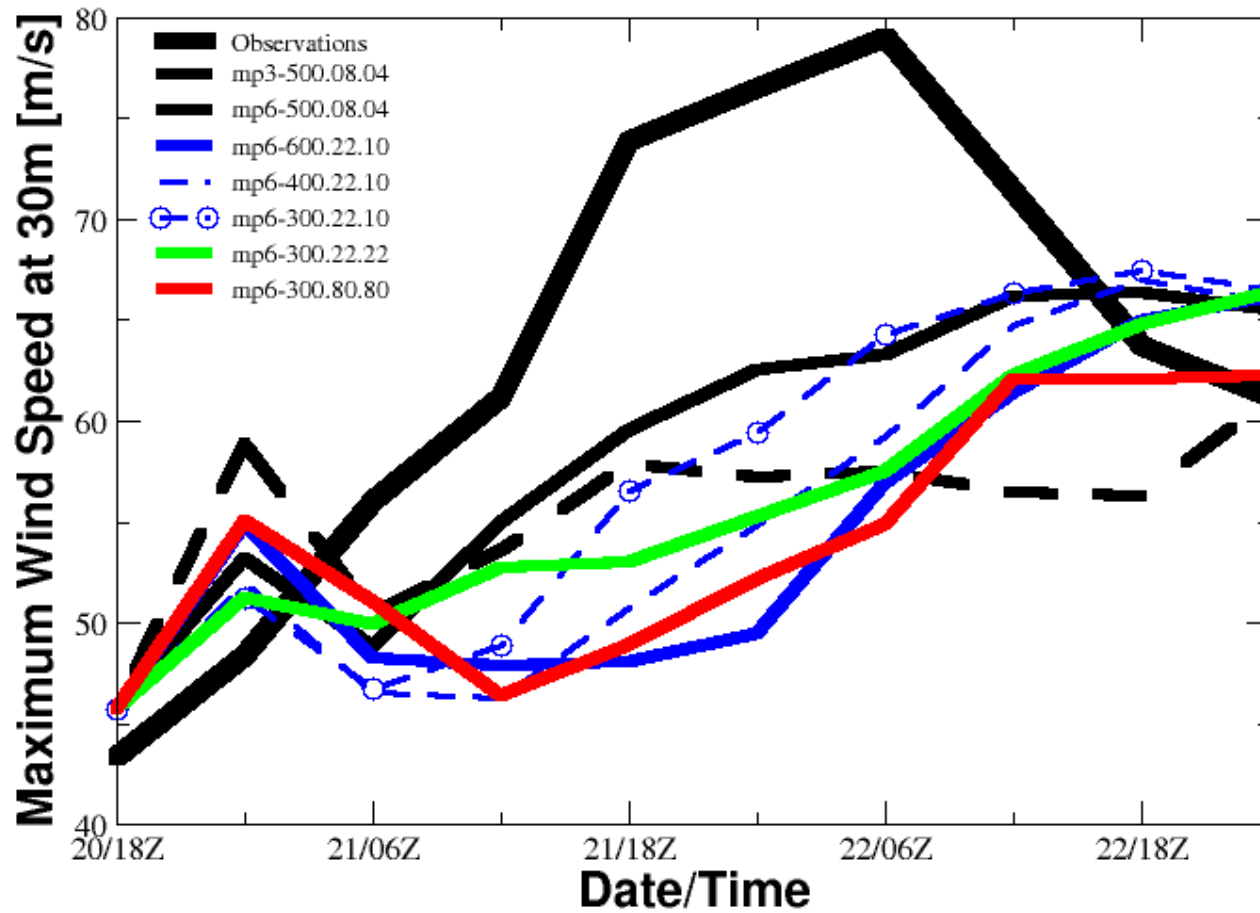
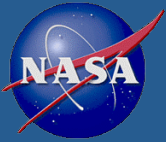


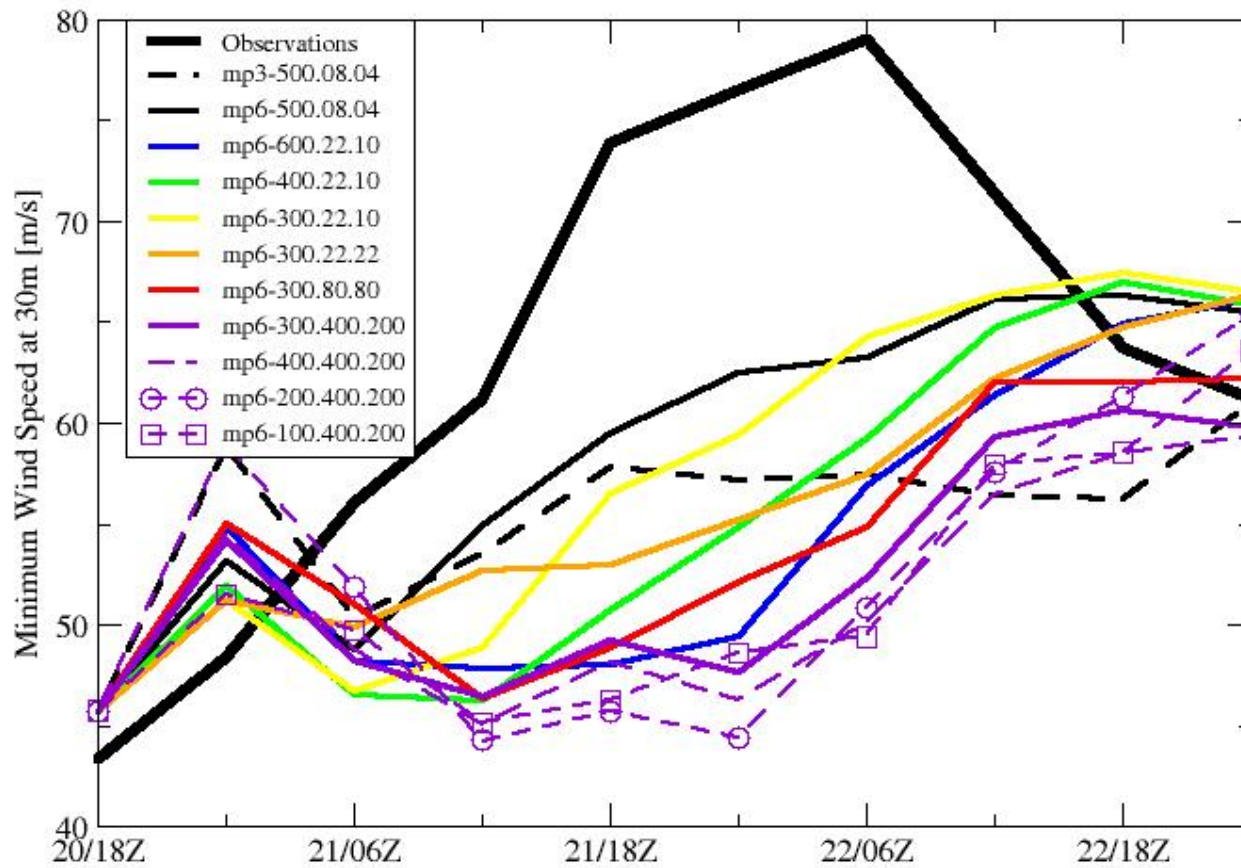


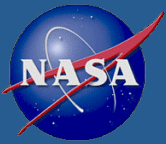




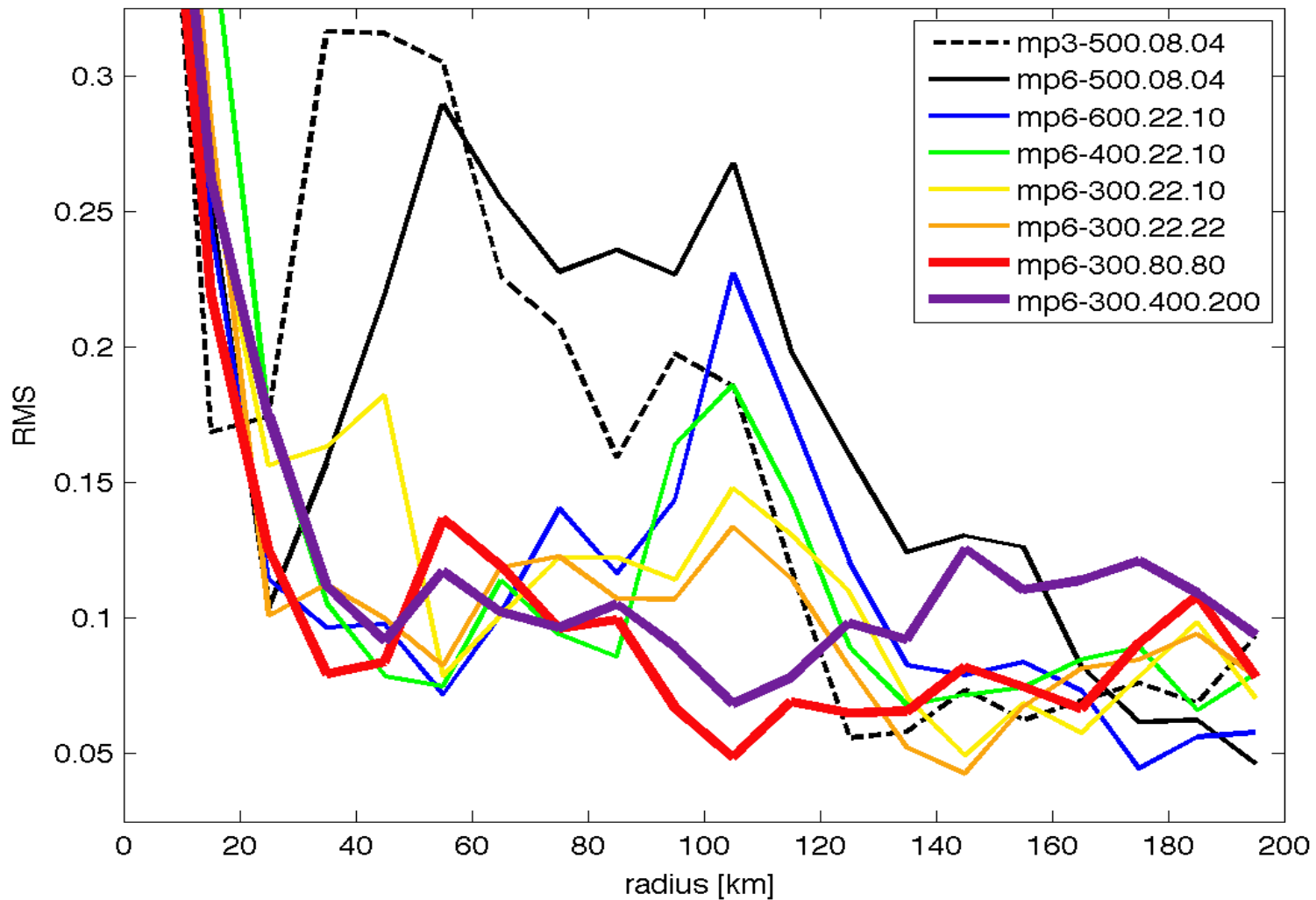


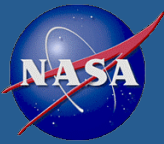






RMS of the range-dependent PDFs





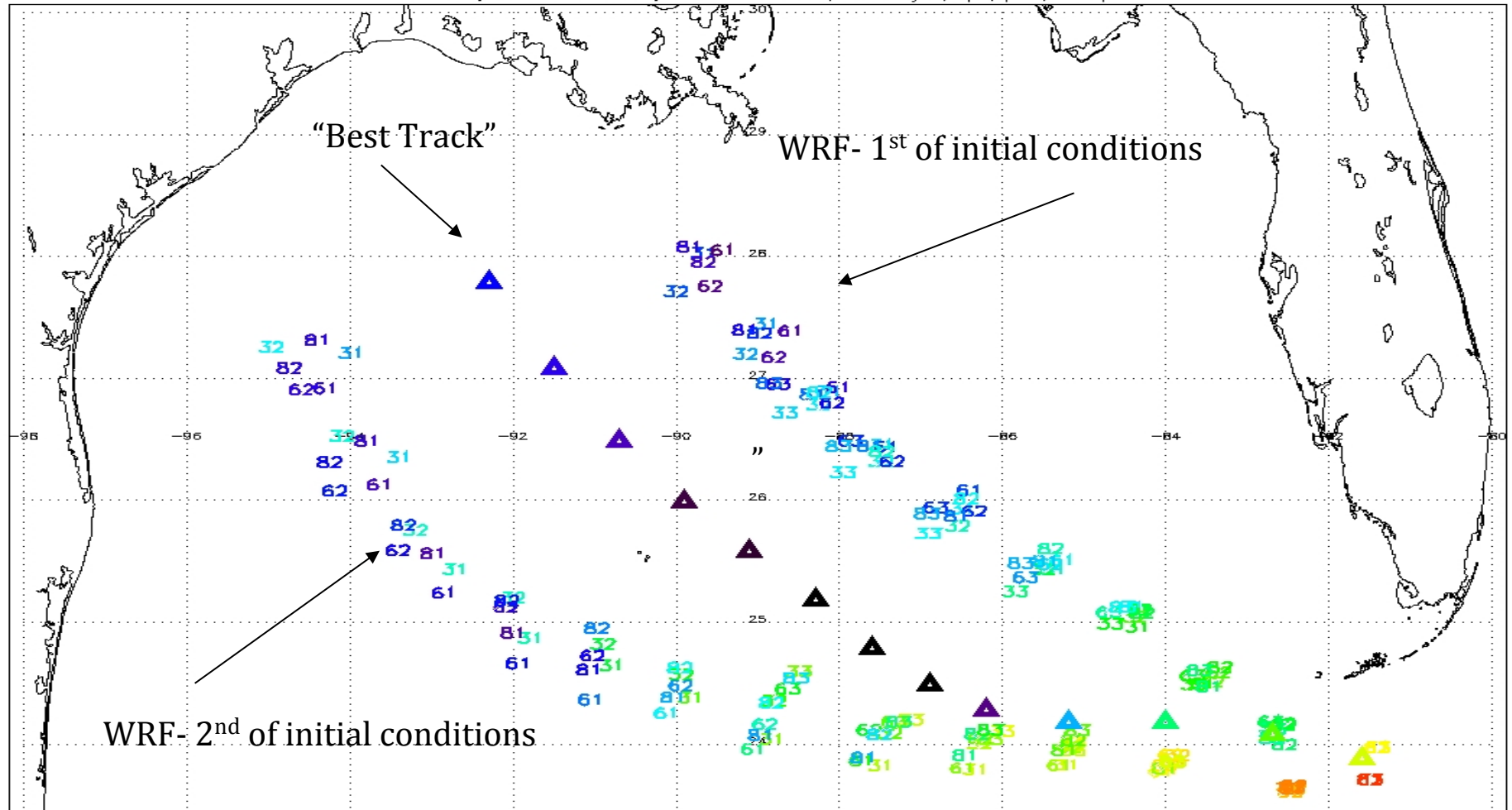
31 - microphysics 3; convective scheme 1
32 - microphysics 3; convective scheme 2
33 - microphysics 3; convective scheme 3

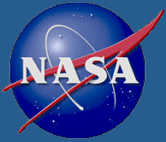
61 - micro. 6; conv. 1
62 - micro. 6; conv. 2
63 - micro. 6; conv. 3

81 - micro. 8; conv. 1
82 - micro. 8; conv. 2
83 - micro. 8; conv. 3

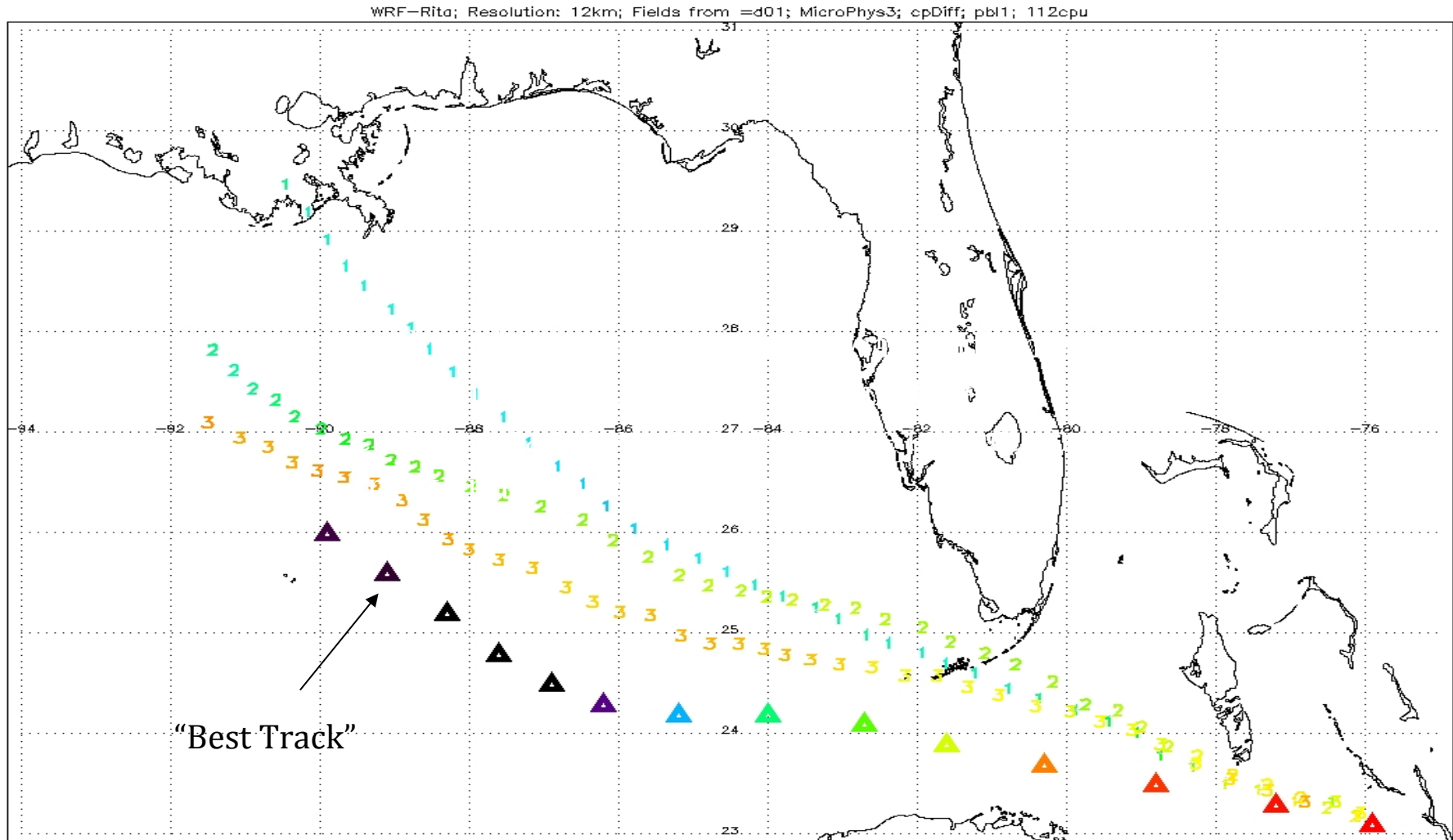


WRF-Rita; Resolution: 1.3km; Fields from =dQ3; MicroPhys3; cp1; pb1; 112cpu





Impact of cumulus parameterization.



"Best Track"



