



## Model Evaluation and Validation: Data, Diagnostics and Tool Upgrades

S. Hristova-Veleva<sup>1,2</sup>, Z. Haddad<sup>1,2</sup>, J. Steward<sup>2</sup>, B. Stiles<sup>1</sup>

H. Su<sup>1</sup>, L. Wu<sup>1</sup>, B. Lambrigtsen<sup>1</sup>, S. Tanelli<sup>1</sup>

T. Vukicevic<sup>3</sup>, T. Greenwald<sup>4</sup>, Gopal<sup>3</sup>

P. P. Li<sup>1</sup>, F. J. Turk<sup>1</sup>, B. Knosp<sup>1</sup>, Q. Vu<sup>1</sup>, W. Poulsen<sup>1</sup>, T.-P. Shen<sup>1</sup>

<sup>1</sup> JPL

<sup>2</sup> UCLA | JIFRESSE

<sup>3</sup> NOAA, AOML, HRD

<sup>4</sup> CIMSS / UW-Madison

August 10th, 2012



# Outline

- **New Data**
  - TCIS – 11 year data records
  - GRIP and HS3 NRT portals for data interrogation
- **Diagnostics**
  - Use of instrument simulators
  - Analysis of:
    - 2D fields
    - Vertical structures
    - Composites
    - Principal components
- **Tools – Upgrades and new development**
  - **the HWSS**
    - Slant path
    - Antenna convolution
  - **AIST project**



# 1. Observational Data for model validation

Funded by NASA's Hurricane Science Research Program

# DATA:

## Tropical Cyclone Data Archive

- First phase released May 2012
- **Satellite depictions of hurricanes over the globe**
- **12-year record (1999-2010)**
- **offers both data and imagery**, making it a unique source to support hurricane research.

## GRIP Portal – NRT in 2010, Atlantic

- **Integrates model forecasts with satellite and airborne observations from a variety of instruments and platforms**, providing good spatial and temporal context for the high-resolution, but limited in space and time, airborne observations.
- essential knowledge for the experiment design, flight planning, and a **very rich information source in the analysis stage of the experiment.**
- **Allows interrogation of a large number of atmospheric and ocean variables** to better understand the large-scale and storm-scale processes associated with hurricane genesis, track and intensity changes.

**Jet Propulsion Laboratory**  
California Institute of Technology

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**JPL Tropical Cyclone Information System**

Home | Team/Collaborations | Feedback | Data Archive | GRIP Portal

### Welcome to the JPL Tropical Cyclone Information System

The JPL Tropical Cyclone Information System (TCIS) was developed to support hurricane research. It has two components: a 12-year global archive of multi-satellite hurricane observations and, what was a near real-time portal, that supported the 2010 NASA Genesis and Rapid Intensification Processes (GRIP) hurricane field campaign. Together, data and visualizations from the near-real time system and data archive can be used to study hurricane process, validate and improve models, and assist in developing new algorithms and data assimilation techniques.

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/IR (right).

### Tropical Cyclone Data Archive

The long-term goal for the TCIS data archive is to create a comprehensive tropical cyclone database of satellite observations, in-situ measurements, and models. The first phase of the TCIS archival database, released in May 2012, contains the satellite depictions of hurricanes over the globe during the period 1999-2010. It offers both data and imagery, making it a unique source to support hurricane research.

### GRIP Data Portal

The near real-time (NRT) web portal, developed to facilitate the GRIP field campaign, integrates model forecasts with satellite observations from a variety of instruments and platforms. The unique features of the portal allow users to interrogate a large number of atmospheric and ocean variables to better understand the large-scale and storm-scale processes associated with hurricane genesis, track and intensity changes. By including a diverse set of satellite observations and model forecasts, it provides a good spatial and temporal context for the high-resolution, but limited in space and time, airborne observations. Such knowledge is essential for the experiment design, providing critical input for the flight planning and serving as a very rich source of information in the analysis stage of the airborne experiment.

<http://grip.jpl.nasa.gov>

**Acknowledgments:** The development JPL Tropical Cyclone Information System was sponsored by NASA's Hurricane Science Research Program managed by Dr. Ramesh Kakar, Weather Focus Area Leader within the Earth Science Division, NASA Headquarters in Washington, D.C.

The inclusion of specific products was also supported by several other projects (CloudSAT, QuikSCAT, MLS, AIRS, HURSAT). The NRT GRIP portal was developed with contributions from the Marshall Space Flight Center, NRL, NPS and the science teams of the PREDICT (NSF) and IFEX (NOAA) field experiments which had similar to GRIP's goals and ran highly coordinated missions.

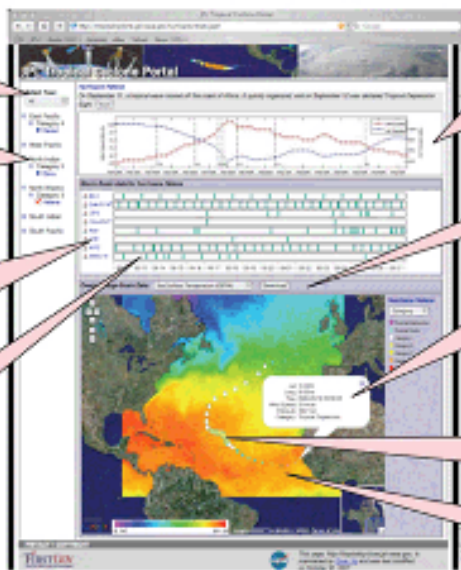
Webmaster: Qunq Yu  
JPL Clearance: CL#03-3460



# DATA: Tropical Cyclone Data Archive

## Guidelines / Help

The Portal Main Page



Select one year or all years to display

Hurricanes list ordered by basins and categories

Click to download all the available data for a specific instrument

Storm Level Observation data sorted by time with clickable green bars

Hurricane Timeline Intensity, Wind Speed and Air Pressure

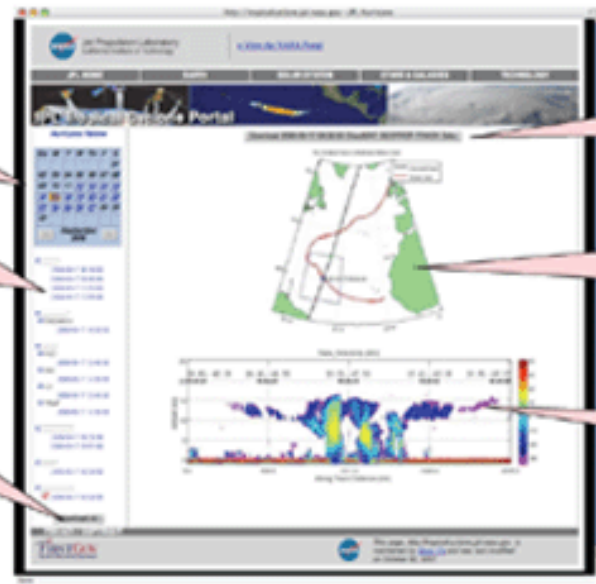
Pulldown menu for large scale overlay

Mouse over popup for detailed storm information

Storm track with circle color representing the intensity

Google map with large scale overlay

The Storm-level Data Page



Select another date

List all the data available for the selected date

Download all the data for the selected date

Download the dataset for the plots displayed

The storm track, the satellite orbit and the subregion for the plot

Cloudsat Reflectivity plot



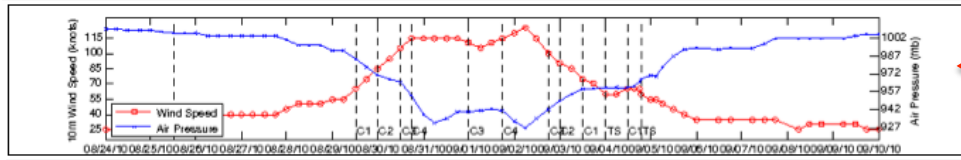
# DATA

## JPL Tropical Cyclone Information System

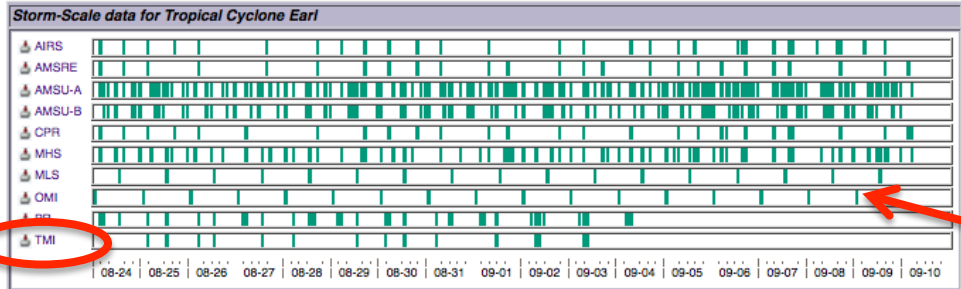
Home Team/Collaborations Feedback Data Archive GRIP Portal

Select Year 2010 Tropical Cyclone Earl Get Tracks

- East Pacific
- West Pacific
- North Indian
- North Atlantic
  - Category 4
    - Danielle
    - Earl
    - Igor
    - Julia
  - Category 3
    - Karl
  - Category 2
    - TMI
  - Category 1
    - Alex
    - Paula
    - Richard
    - Tomas
  - Tropical Storm
    - Bonnie
    - Colin
    - Fiona
    - Gaston
    - Hermine
    - Matthew
    - Nicole
    - Unnamed1
- South Indian
- South Pacific



← Timeline



View and download Storm-scale data

Earl, 2010

Download all data from this Instrument (TMI)

**Tropical Cyclone Earl**

Su	M	T	W	Th	F	S
		01	02	03	04	05
06	07	08	09	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

August 2010

At hour: 18:00:00

- AMSU-A TPW-8hr
- G1SST SST-24hr
- Multi 65H-6hr
- AIRS CAPE
- AIRS LI
- ASCAT Wind

**Download**

Legends: [Category](#) [Wind Speed](#)

Download Selected large-scale data from this day





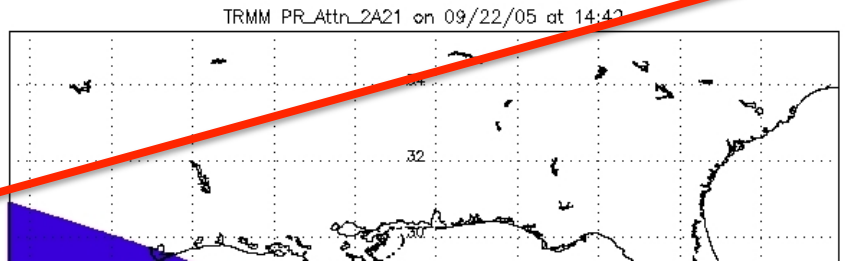
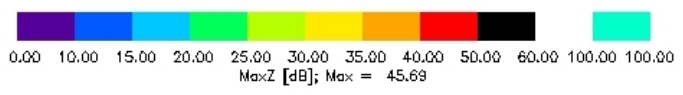
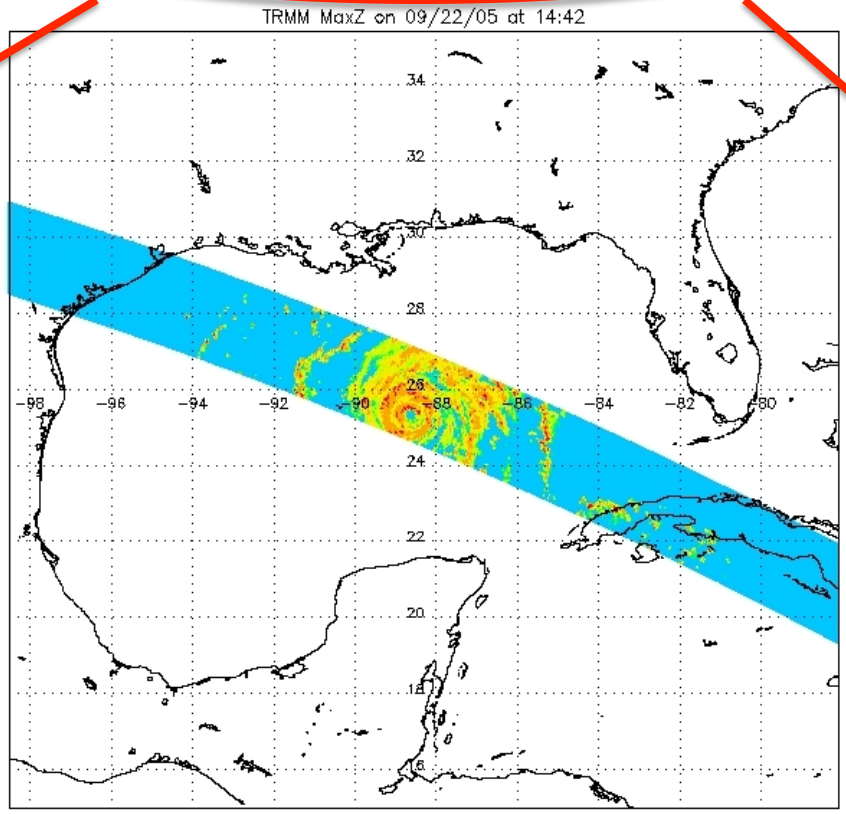
**Tropical Cyclone Rita**

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

September 2005

- MLS
- SeaWINDS
- GPS-RO
- OMI
- AIRS
- PR
  - TRMM
  - MaxZ-PIA-RR-RT
    - 2005-09-22 08:10:00
    - 2005-09-22 14:42:00
- TMI
- AMSRE
- AMSU-A
- SSMI
- GEO

Download 2005-09-22 14:42:00 PR MaxZ-PIA-RR-RT Data



Download All

Download NetCDF

At this time

All data on this day



## JPL Tropical Cyclone Information System

Home

Project

Feedback

Data Portal

Analysis Tool

### Tropical Cyclone Rita

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

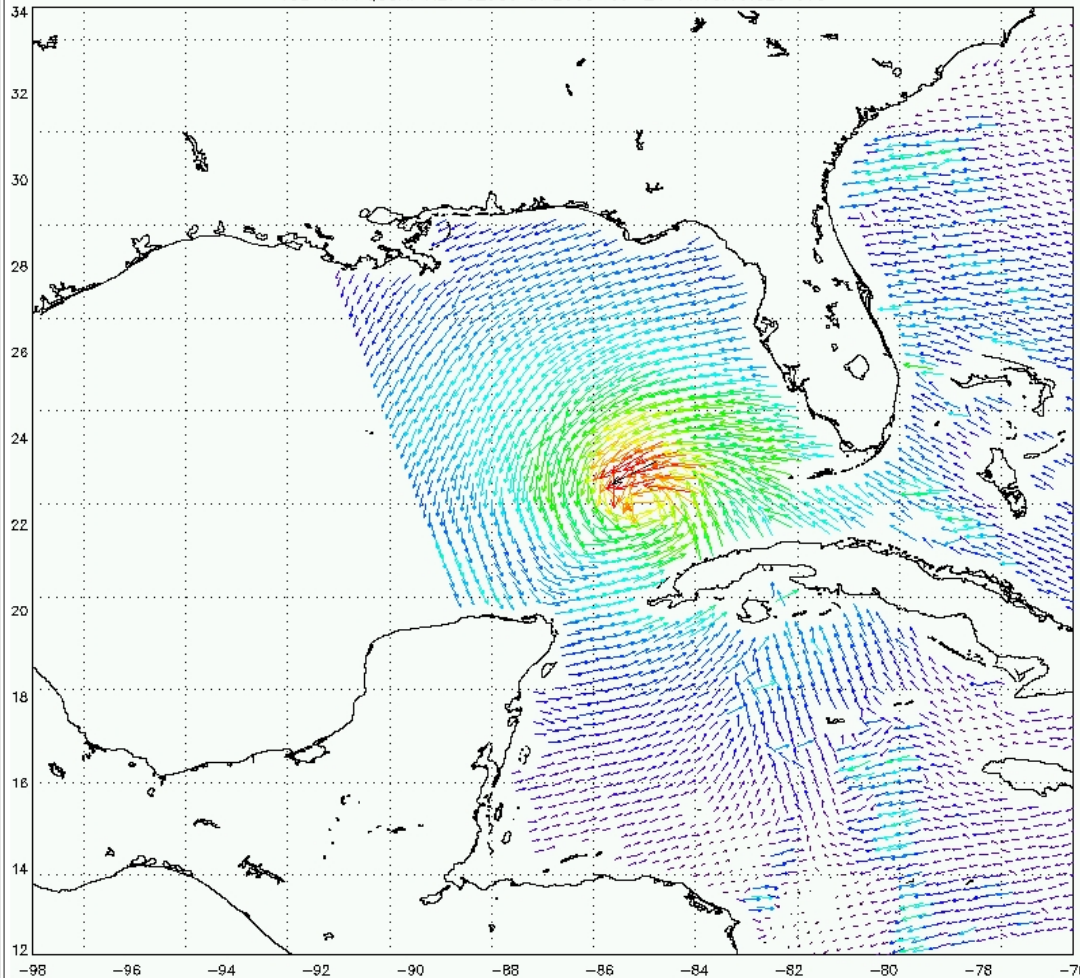
September 2005

- MLS
- SeaWINDS
  - QuikScat
  - WIND
    - 2005-09-21 11:05:00
    - 2005-09-21 23:28:00
- GPS-RO
- OMI
- AIRS
- PR
- TMI
- AMSRE
- AMSU-A
- SSMI
- GEO

Download All

Download 2005-09-21 11:05:00 SeaWINDS WIND Data

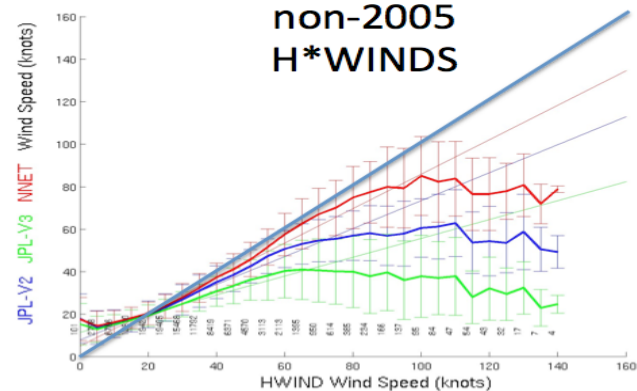
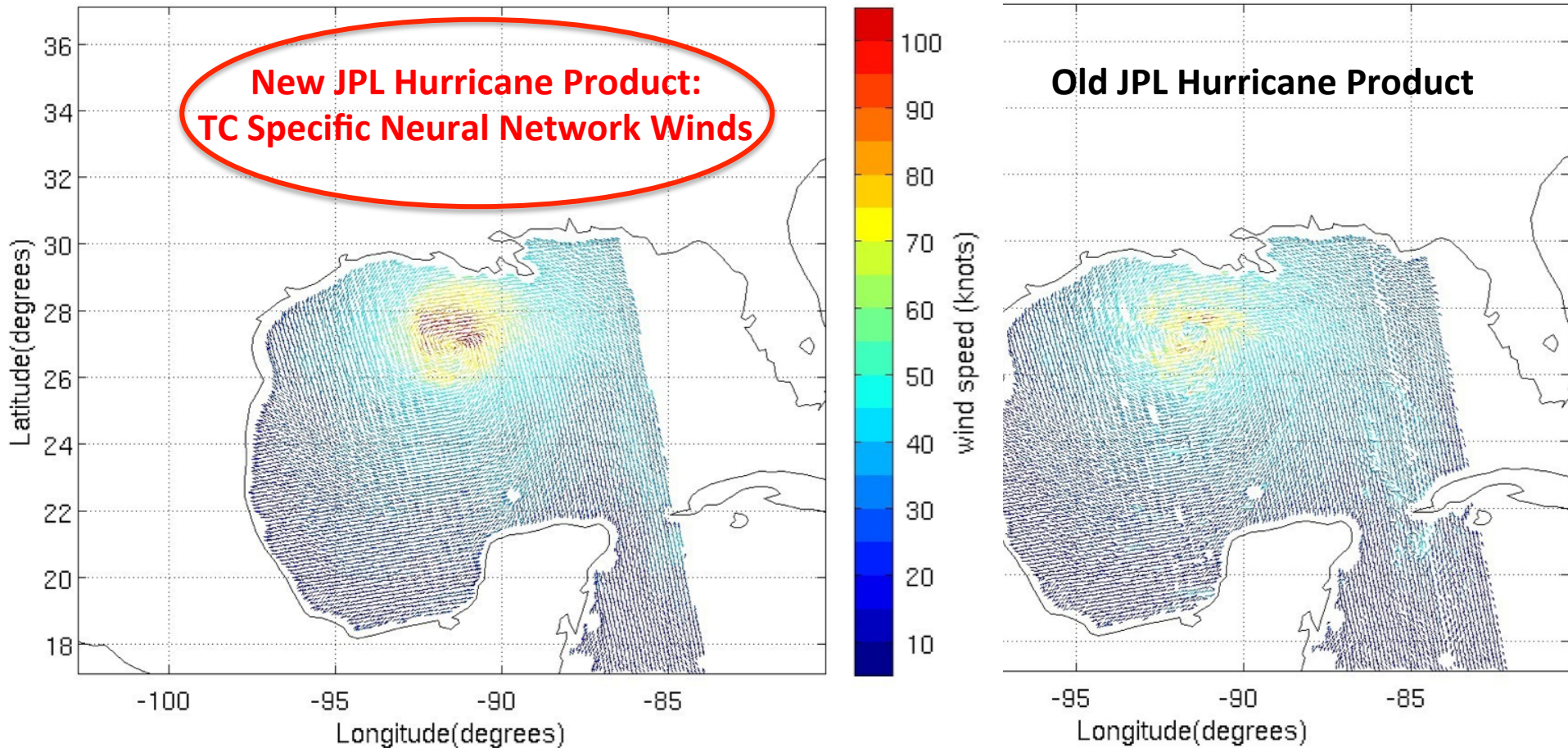
18L-RITA QSCAT REV 32586 at 2005-09-21 11:05:10.825 UTC





# DATA

Scatterometer winds: Hurricane Rita, September 23, 2005



**The Neural Net winds show only slight negative bias vs. H\*WINDS up to 80 knots**

**The old JPL-V2 winds start to saturate at 40 knots.**

**B. Stiles, R. Danielson, W. L. Poulsen, M. J. Brennan, and S. M. Hristova-Veleva, 2012: "Multiple Scatterometer Hurricane Winds Ten years of optimized QuikSCAT cyclone winds validated against best track speeds, H\*WIND and SFMR, and initial OceanSAT-2 cyclone winds", 2012 IOVWST, Utrecht, ND**



# The 12-year Global Data Archive

- **Advantages:**
  - Offers imagery AND digital data
  - One of only three places where you can get easy access:
    - organized by storm (year and basin) – no need to search
    - no need to login (not password protected), order and wait
  - Contains more data than the websites at JAXA and HURSAT
  - It is organized and has an image to go with each set of data so you know what you are getting
  - All data are in netcdf
  - Offers subsets (2000x2000km) centered on the storm, reducing the volume of data!!!

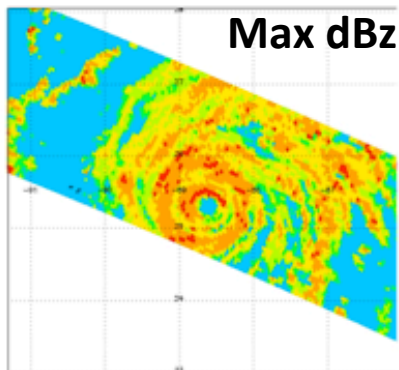


## 2. Model diagnostics and evaluation

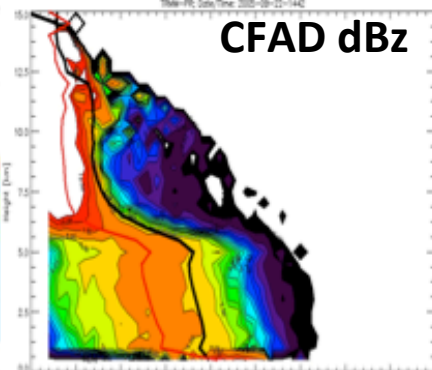


# JPL Research using the TCIS Data Archive: MODEL EVALUATION – the Microphysics

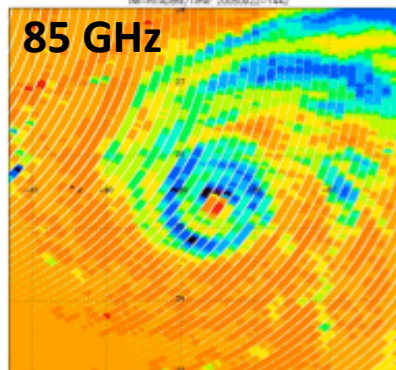
TRMM



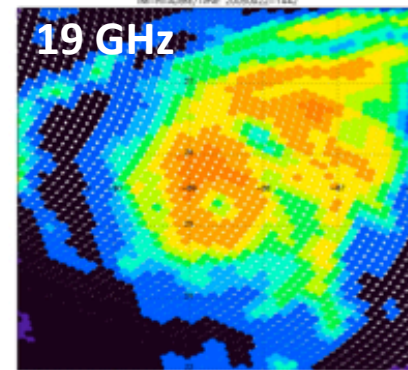
Max dBz



CFAD dBz

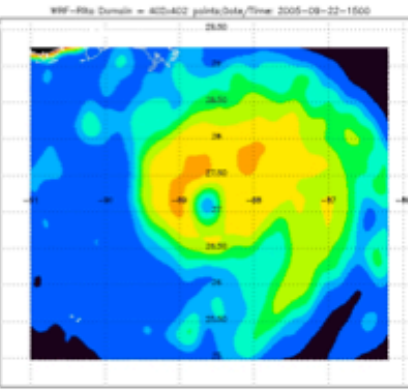
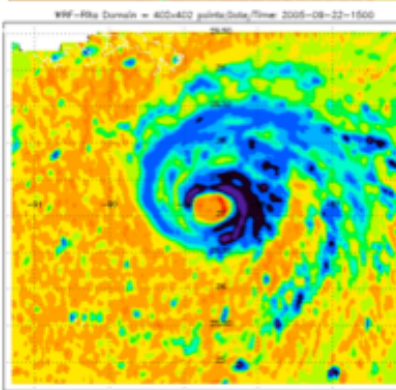
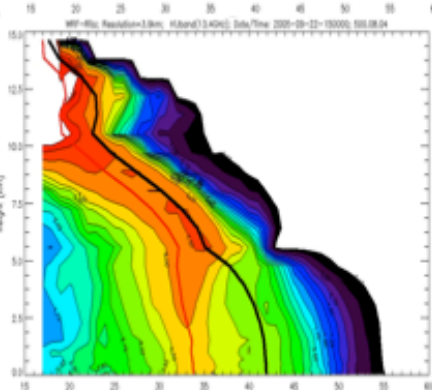
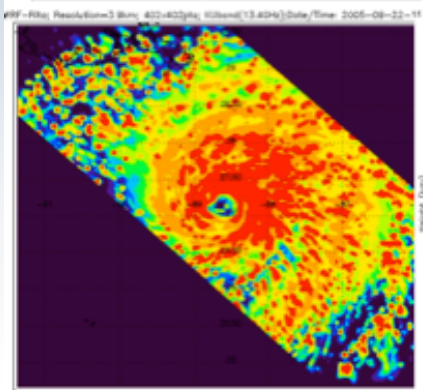


85 GHz

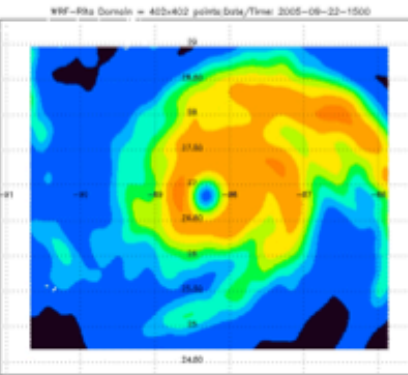
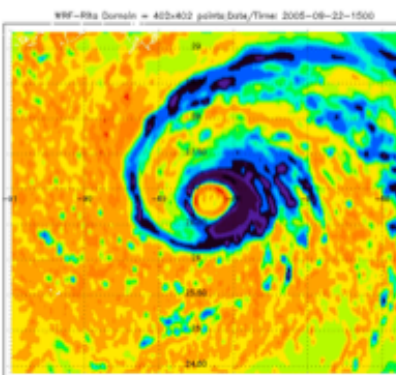
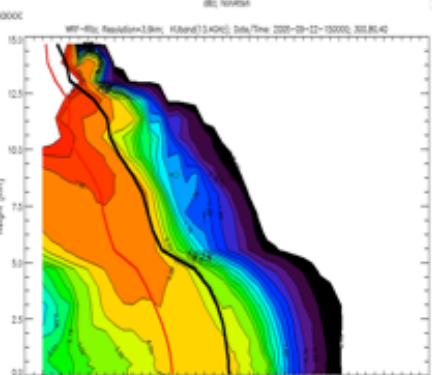
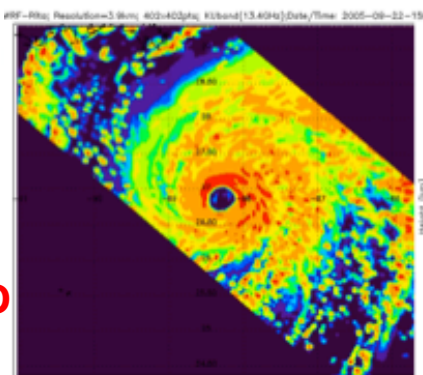


19 GHz

WRF  
WSM3



WRF  
WSM6  
New PSD





# Evaluating the Impact of Using the Hurricane EnKF Data Assimilation System (HEDAS)

(Developed at NOAA's Hurricane Research Division)

## HEDAS ANALYSIS

We compare three cases:

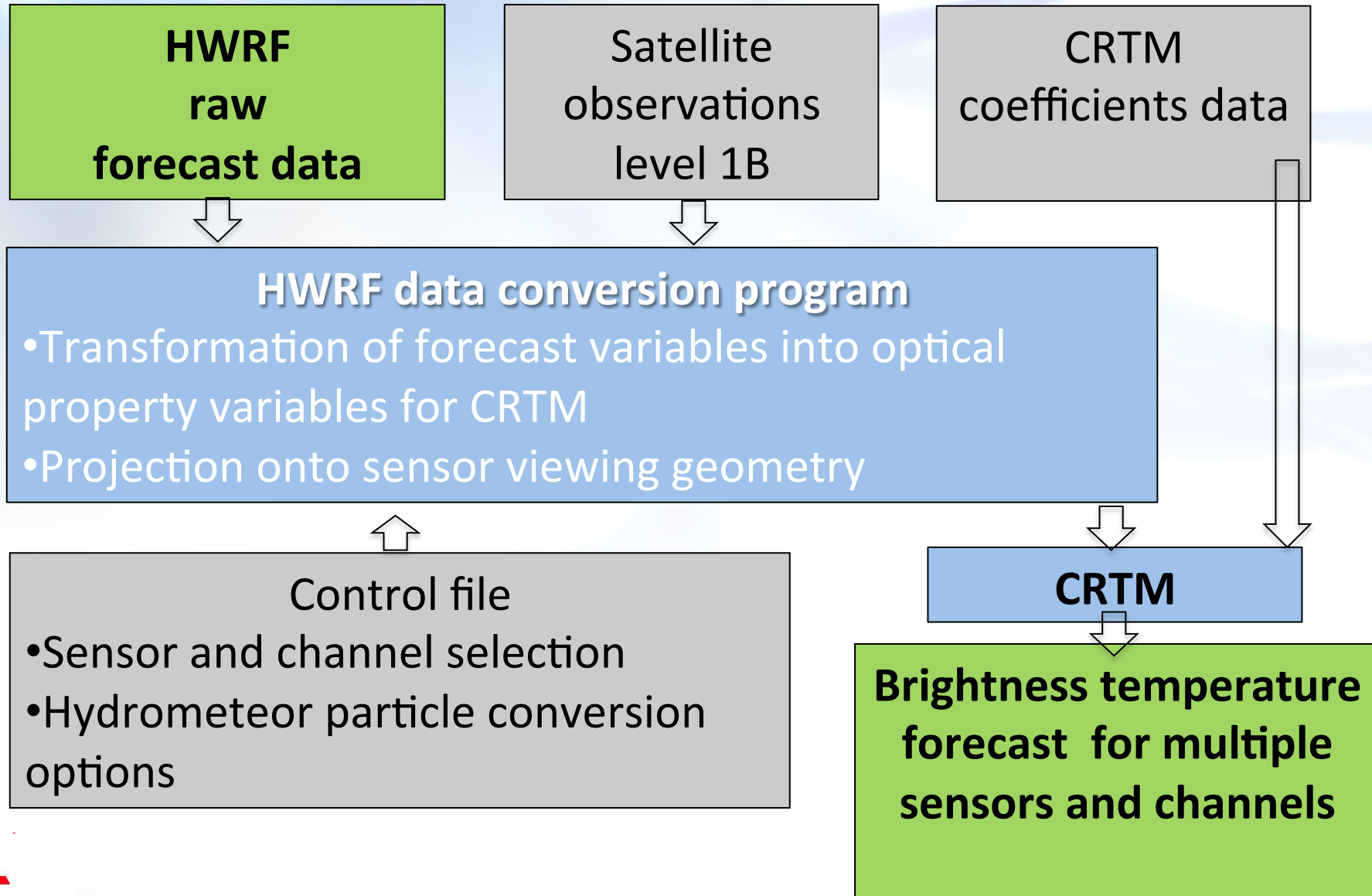
1. HWRF 2h forecast without data assimilation - noDA
2. HEDAS analysis after assimilating airborne data (no Doppler) - h3nd
3. As in 2 but also assimilating Doppler data - h3vk



# Hurricane WRF Satellite Simulator (HWSS)

T. Greenwald (CIMSS/UW) and T. Vukicevic (HRD/NOAA)

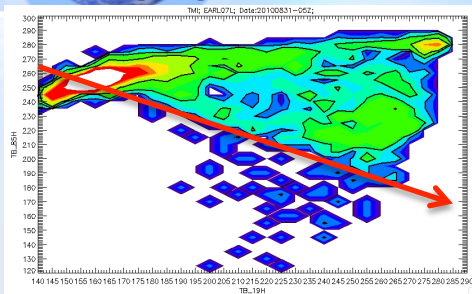
JHT supported project



# Statistical Comparison – Joint PDFs

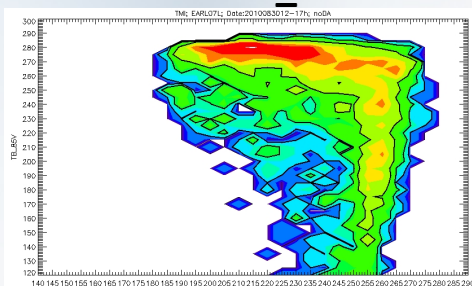
2010-08-31; At TMI resolution – 85H vs 19H

OBSERVED

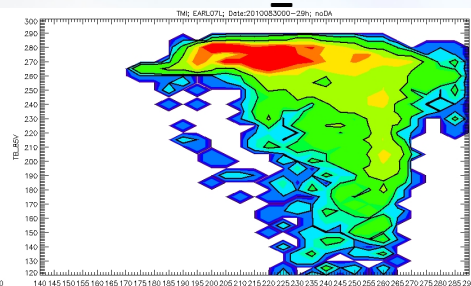


- The statistical relationship between the 19 GHz TBs and the 85 GHz TB presents information on the vertical structure of the storm

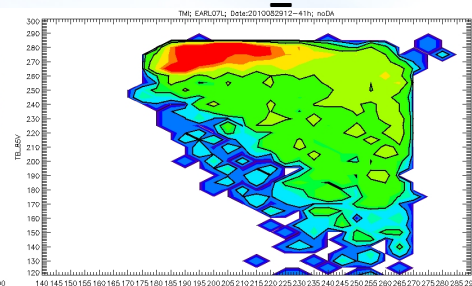
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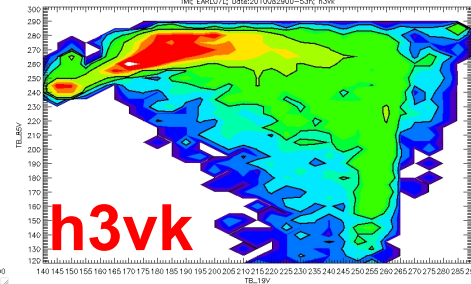
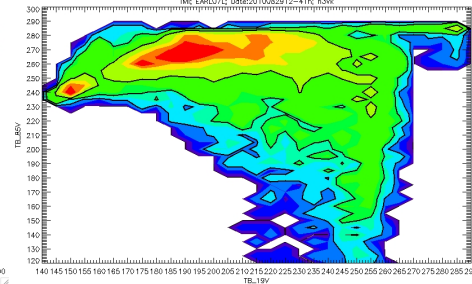
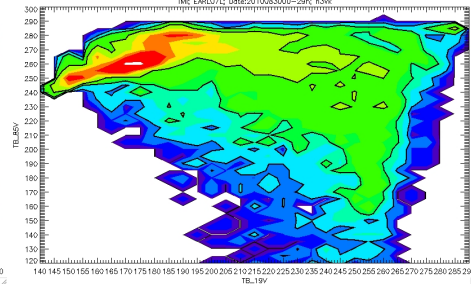
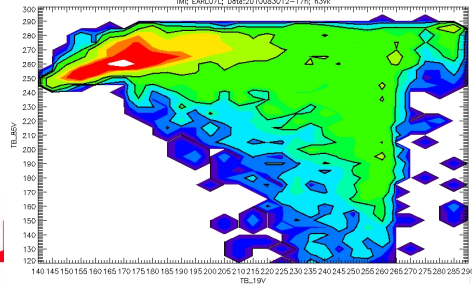
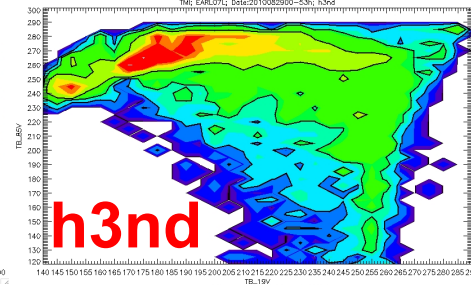
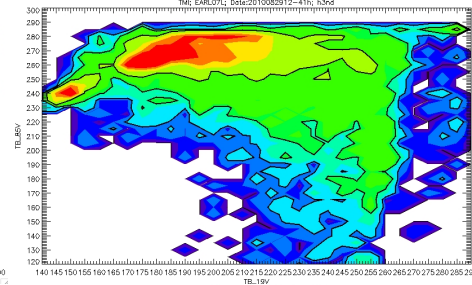
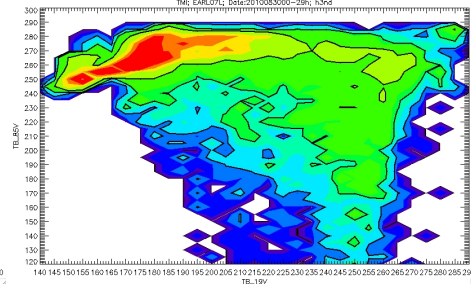
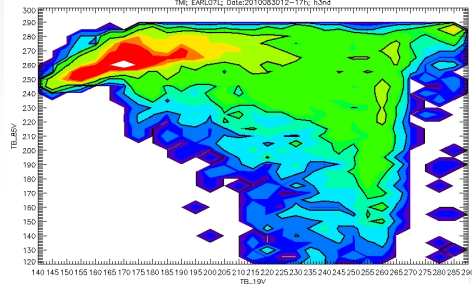
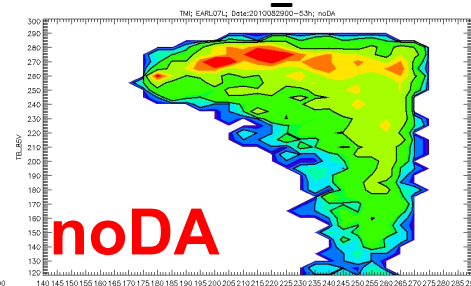
2010-08-30\_00Z 29h



2010-08-29\_12Z 41h



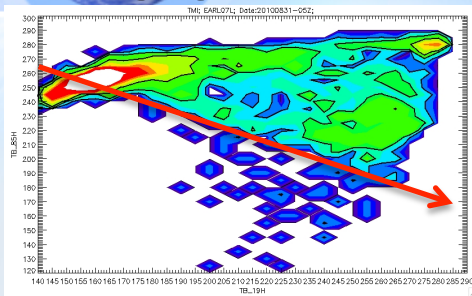
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# Statistical Comparison – Joint PDFs

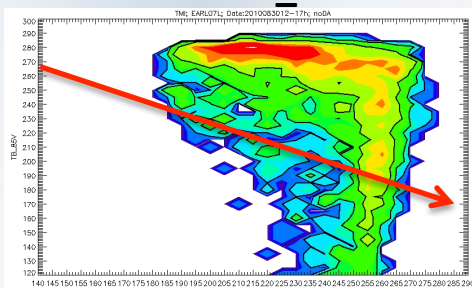
2010-08-31; At TMI resolution – 85H vs 19H

OBSERVED

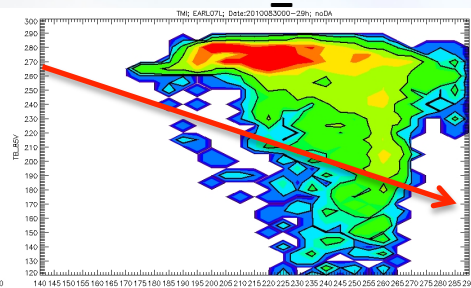


- The statistical relationship between the 19 GHz TBs and the 85 GHz TB presents information on the vertical structure of the storm

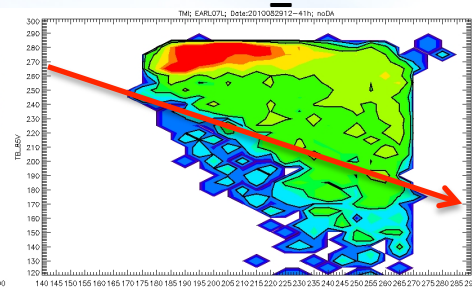
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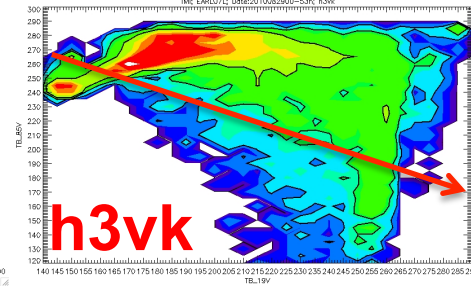
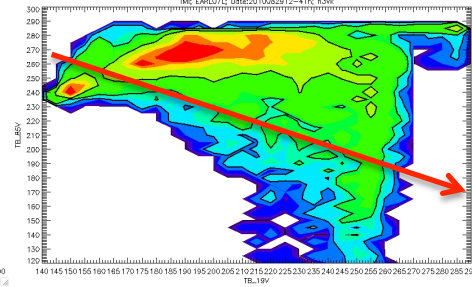
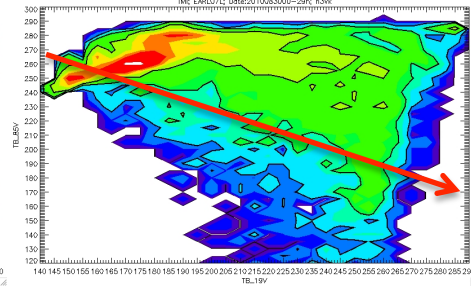
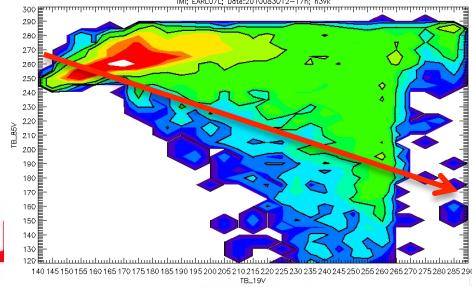
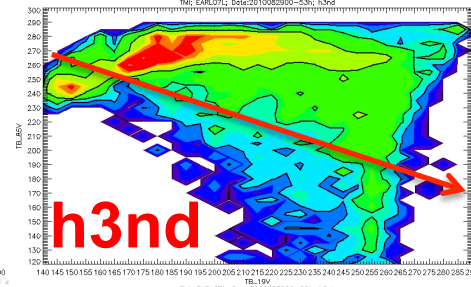
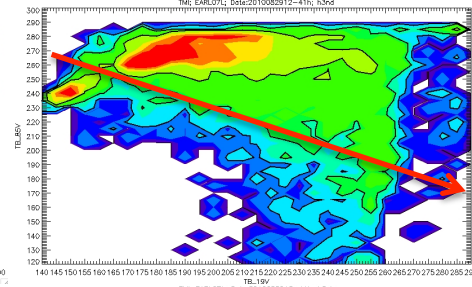
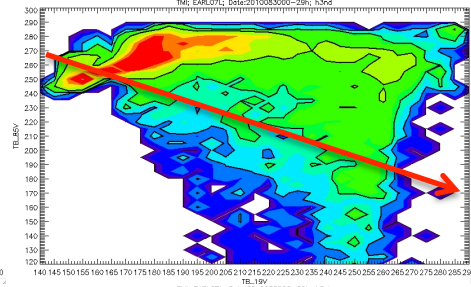
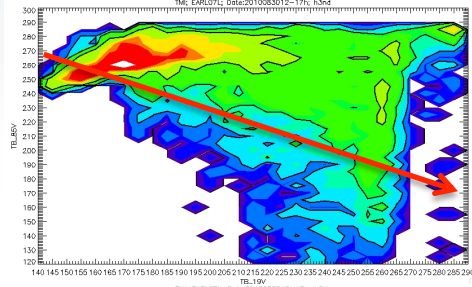
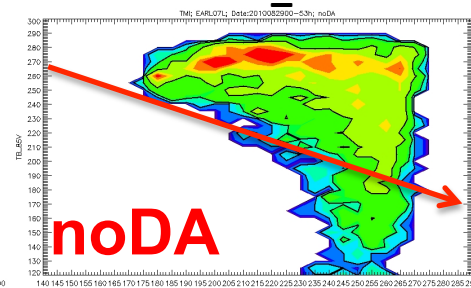
2010-08-30\_00Z 29h



2010-08-29\_12Z 41h



2010-08-29\_00Z 53h

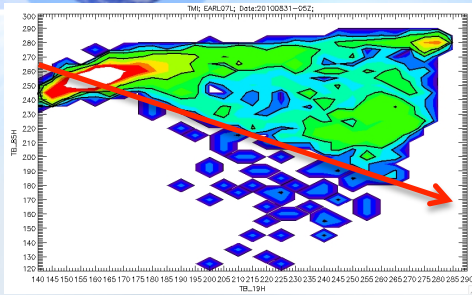




# Statistical Comparison – Joint PDFs

2010-08-31; At TMI resolution – 85H vs 19H

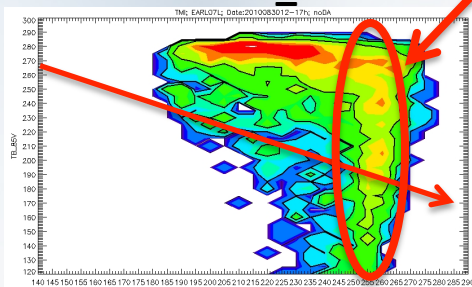
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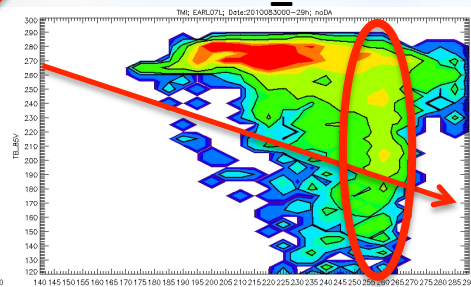
- The statistical relationship between the 19 GHz TBs and the 85 GHz TB presents information on the vertical structure of the storm

- The vertical branch indicates too much scattering

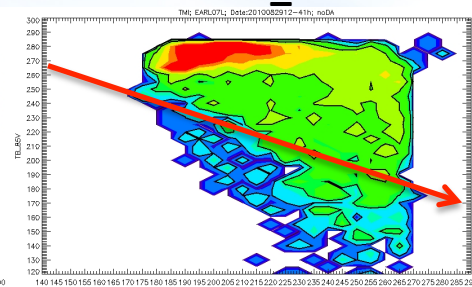
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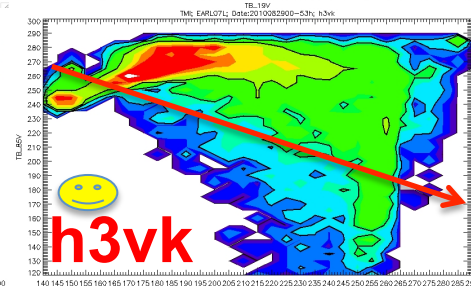
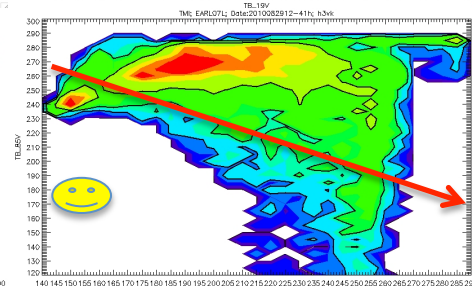
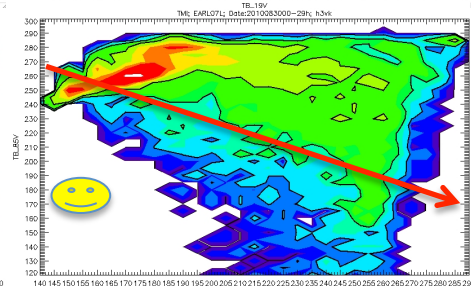
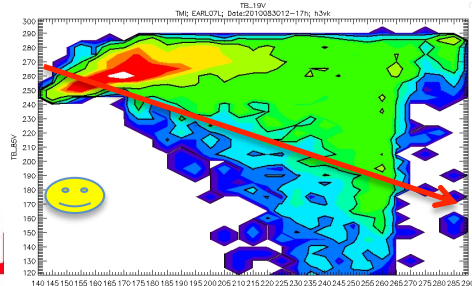
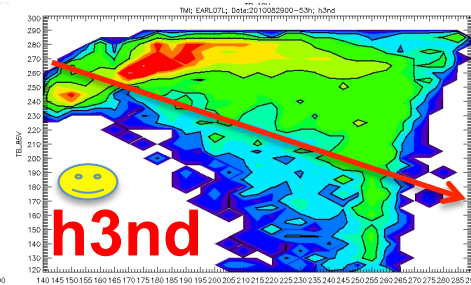
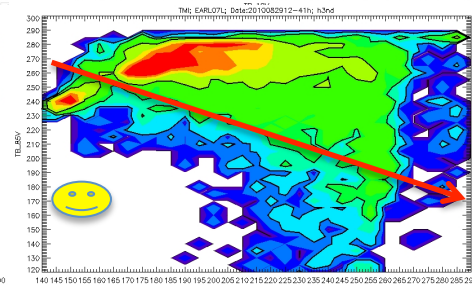
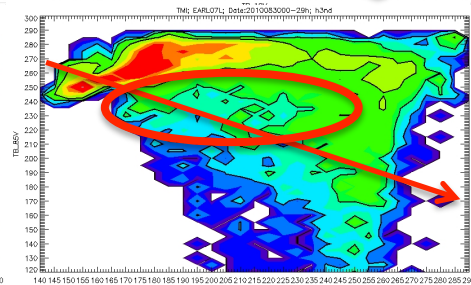
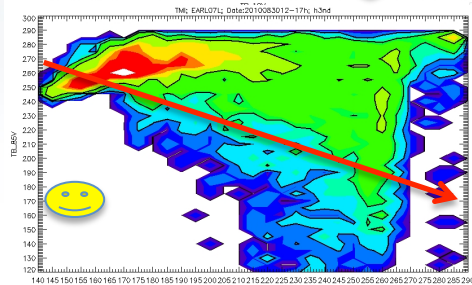
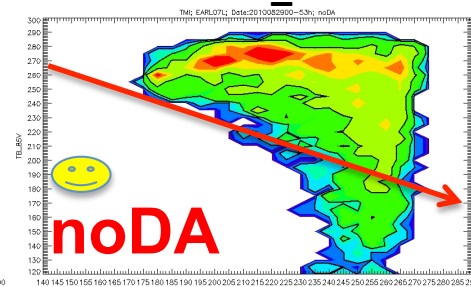
2010-08-30\_00Z 29h



2010-08-29\_12Z 41h



2010-08-29\_00Z 53h





# Research using the TCIS Data Archive:

## TCIS Data Archive: Climatology – Environmental Humidity and TC Intensity and Change

### Using AIRS temperature and humidity

#### DATA

198 North Atlantic Ocean TCs from 09/2002 to 11/2010 based on NHC Best Track Data

74 Cat 1-5 hurricanes (37%)

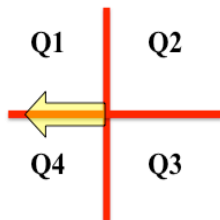
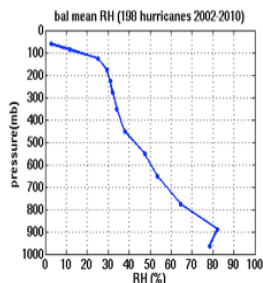
36 Cat 3-5 hurricanes (18%)

10 Cat 5 hurricanes (5%)

AIRS Level 2 Relative Humidity (filtered by *pgood*)

#### Approach

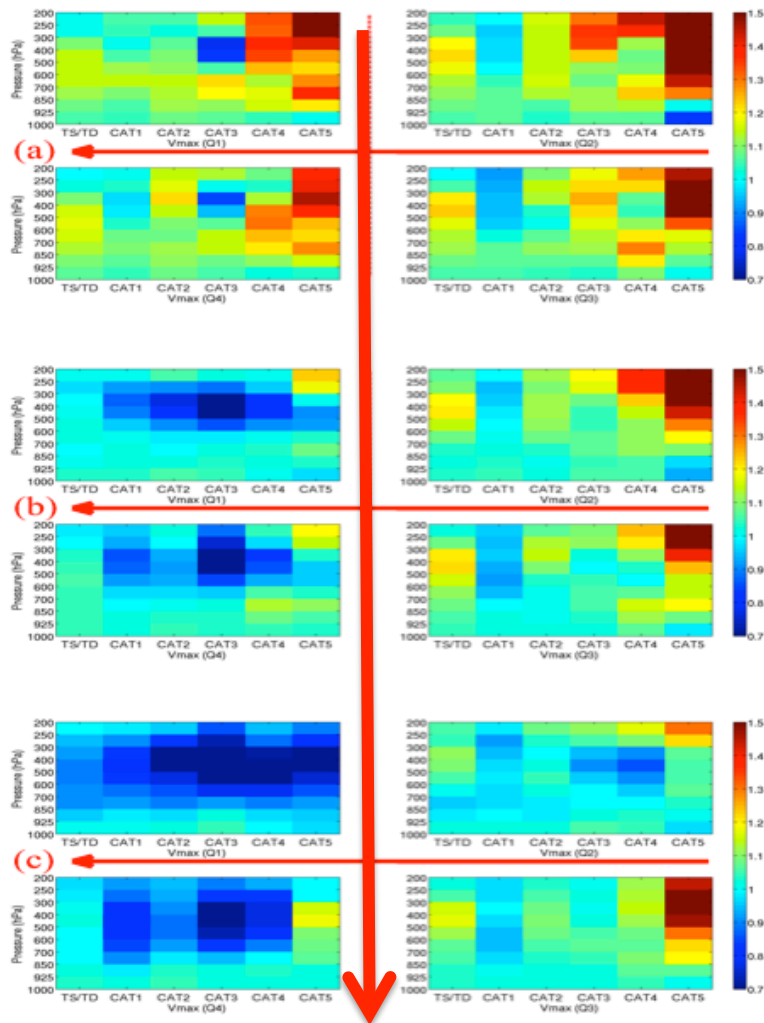
To sort RH by the radial distance to the storm center, separated by four quadrants relative to storm movement, and composite RH as a function of storm intensity and intensification rate



Range  
200-400km

Range  
400-600km

Range  
600-800km



Longtao Wu<sup>1,2</sup>, Hui Su<sup>1</sup>, Robert G. Fovell<sup>3</sup>, Bin Wang<sup>4</sup>, Janice T. Shen<sup>1</sup>, Brian H. Kahn<sup>1</sup>, Svetla M. Hristova-Veleva<sup>1</sup>, Bjorn H. Lambriksen<sup>1</sup>, Eric J. Fetzer<sup>1</sup>, Jonathan H. Jiang<sup>1</sup>, 2012: "Relationship of Environmental Relative Humidity with Tropical Cyclone Intensity and Intensification Rate over North Atlantic", *to be submitted*

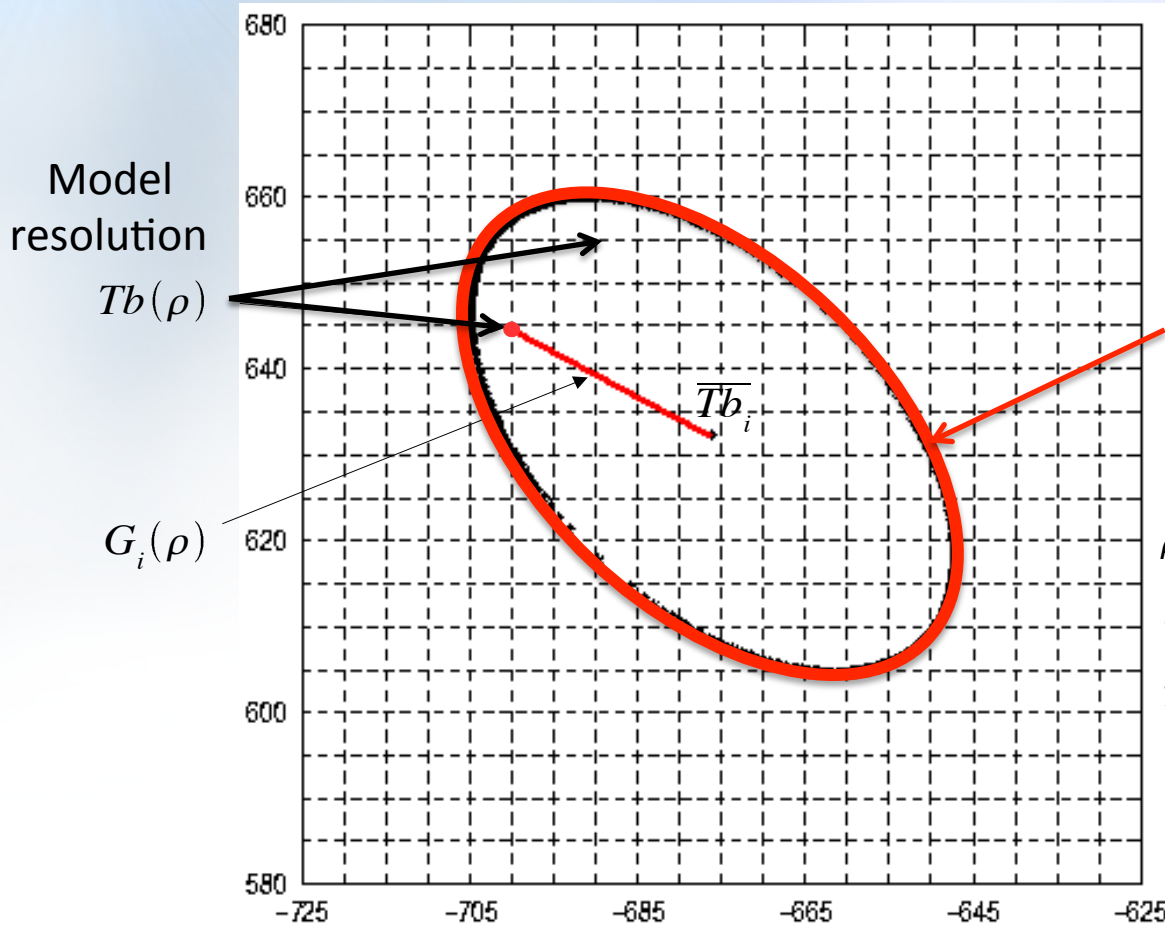


# 3. Tools – upgrades and new development



# Simulating the Satellite Resolution

## Resampling ...



**Satellite resolution**

$$\overline{Tb}_i = \int Tb(\rho) G_i(\rho) dA$$

where

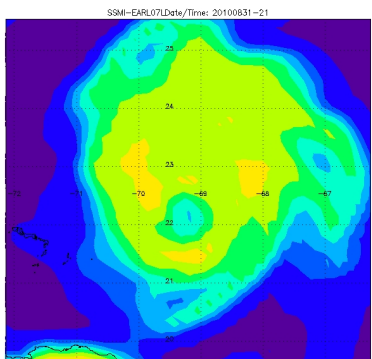
$\rho$  indicates a particular location

$G_i(\rho)$  – antenna gain pattern

$Tb(\rho)$  – brightness temperature  
at location  $\rho$

# 37 GHz H pol – September 01 2010 - Resolution

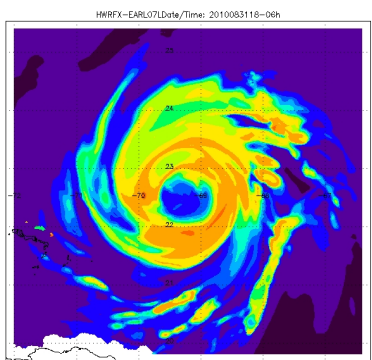
Observed



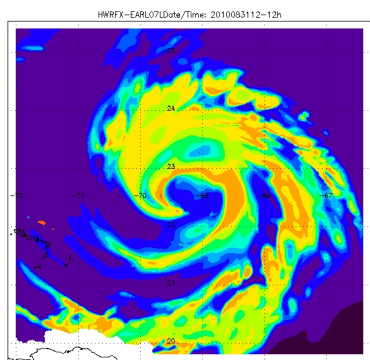
- **Observed**
- **HWRFX – at the model resolution**
- **HWRFX – antenna-convolved to simulate brightness temperatures at the satellite resolution (37GHz - 27.5 x45.0km)**



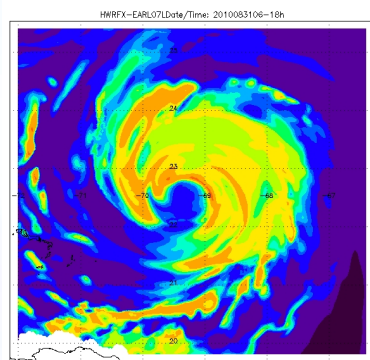
06h



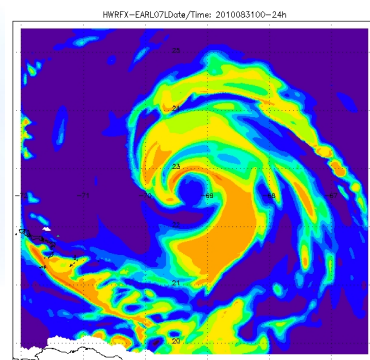
12h



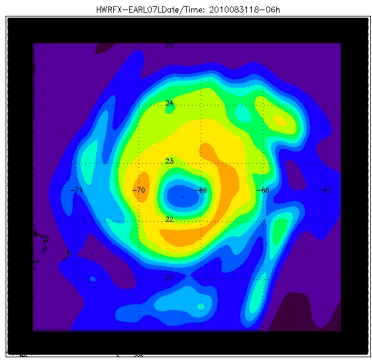
18h



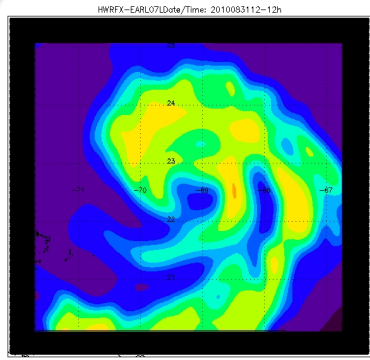
24h



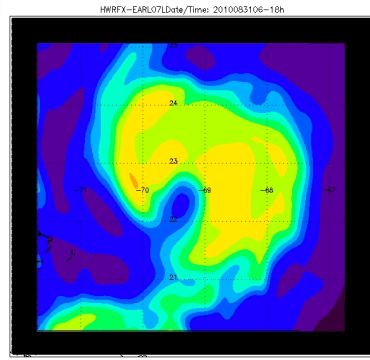
06h



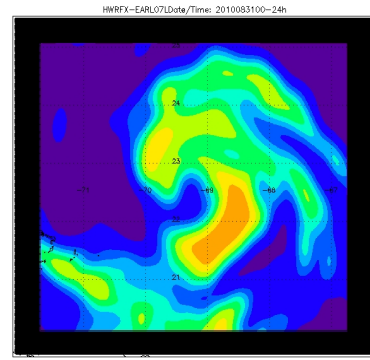
12h



18h



24h





# 10 GHz H pol – August 31 2010 - Resolution

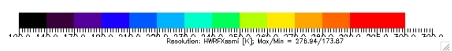
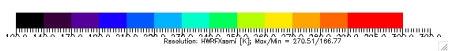
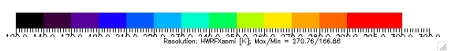
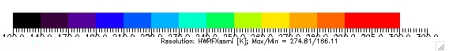
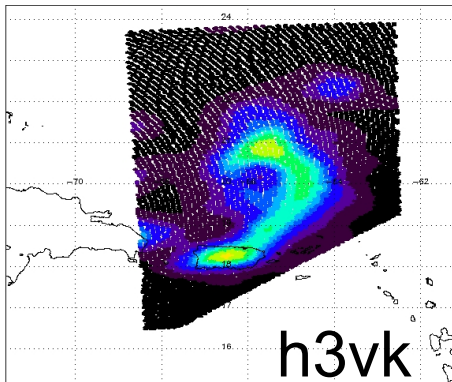
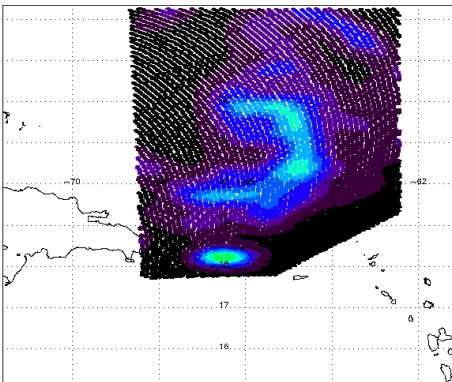
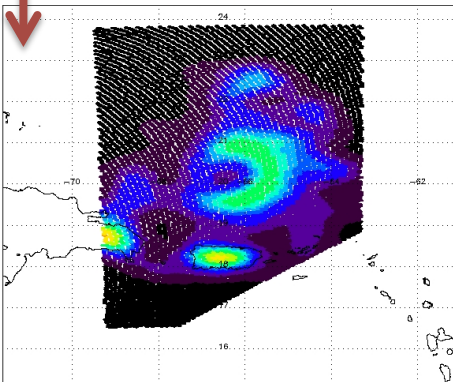
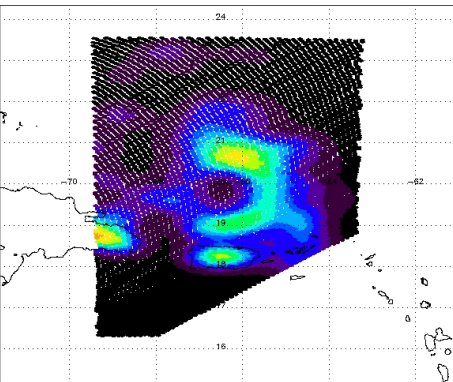
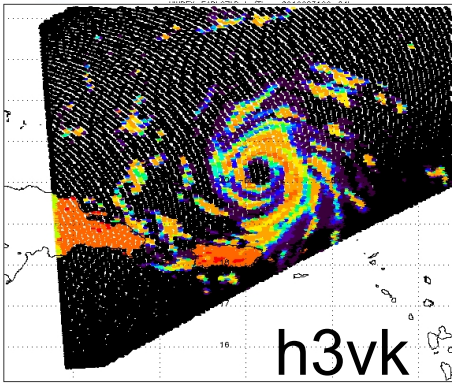
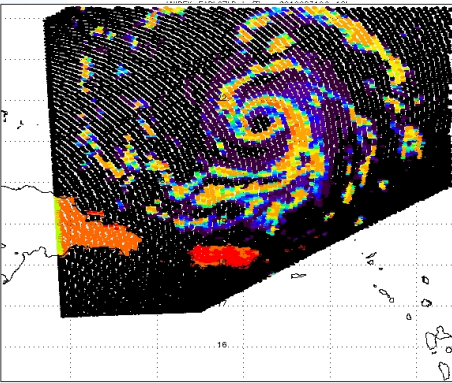
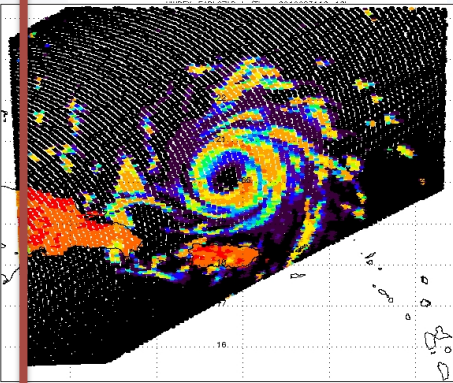
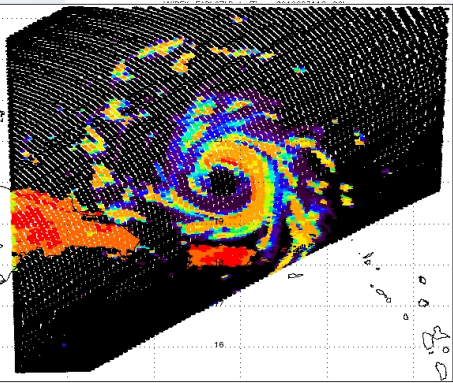
- HWRFX – at the model resolution
- HWRFX – antenna-convolved to simulate brightness temperatures at the satellite resolution (10GHz - 60 x45.0km)

2010-08-30\_12Z 17h

2010-08-30\_00Z 29h

2010-08-29\_12Z 41h

2010-08-29\_00Z 53h



# Fusion of hurricane models and observations: Developing the technology to improve the forecasts

PI: Svetla Hristova-Veleva / JPL

## Approach:

Integration of the ISSARS instrument simulator with operational hurricane forecast models and incorporation of simulated satellite observables into the existing database of satellite and airborne observations.

Development of a set of advanced analysis tools

Development of data immersion to enable real-time interaction with the models, and visualization of highly complex systems

## Objective

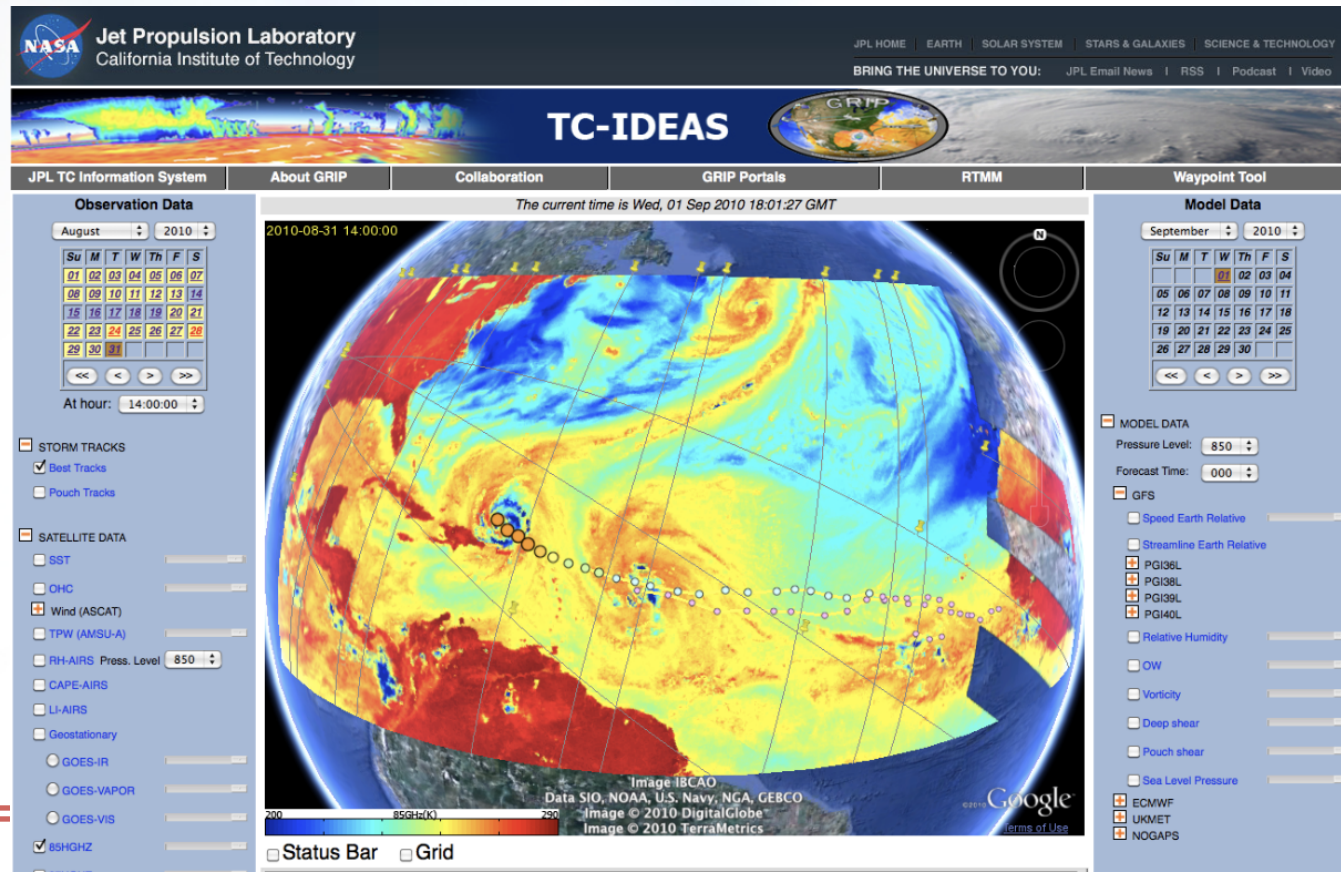
To develop the technology to provide the fusion of observations and operational model simulations to help improve the understanding and forecasting of the hurricane processes.

Specifically,

- To develop processing techniques to enable multi-source data fusion across hurricane forecast models, satellite data, and *in-situ* sensors,
- To develop tools to manage the validation and assessment of model comparisons to more easily evaluate the performance of different numerical models,
- To develop interactive visualization techniques to enable analysis of highly complex systems.

## In collaboration with:

R. Rogers, S. Gopalakrishnan,  
F. Marks, T. Vukicevic - HRD/AOML  
V. Tallapragada - NOAA/EMC





# We will build on

## The GRIP/HS3 JPL PORTAL

- A near real-time (NRT) web portal
- Integrates large-scale model forecasts with satellite observations from a variety of instruments and platforms.
- The unique features of the portal allow users to interrogate a large number of atmospheric and ocean variables to better understand the large-scale and storm-scale processes associated with hurricane genesis, track and intensity changes.
- By including a diverse set of satellite observations and model forecasts, it provides a good spatial and temporal context for the high-resolution, but limited in space and time, airborne observations.
- Such knowledge is essential for the experiment design, providing critical input for the flight planning and serving as a very rich source of information in the analysis stage of the airborne experiment



# The JPL GRIP Portal – [grip.jpl.nasa.gov](http://grip.jpl.nasa.gov)

Hurricane Earl of 2010 – Bringing together model flow with satellite observations of precipitation, providing the context for the airborne observations

## TC-IDEAS



JPL TC Information System

About GRIP

Collaboration

GRIP Mission Page

NASA Hurricanes

### Observation Data

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 19:00:00

STORM TRACKS

SATELLITE DATA

SST

OHC

Wind (ASCAT)

TPW (AMSU-A)

RH-AIRS Press. Level 850

CAPE-AIRS

LI-AIRS

Geostationary

GOES-IR

GOES-VAPOR

GOES-VIS

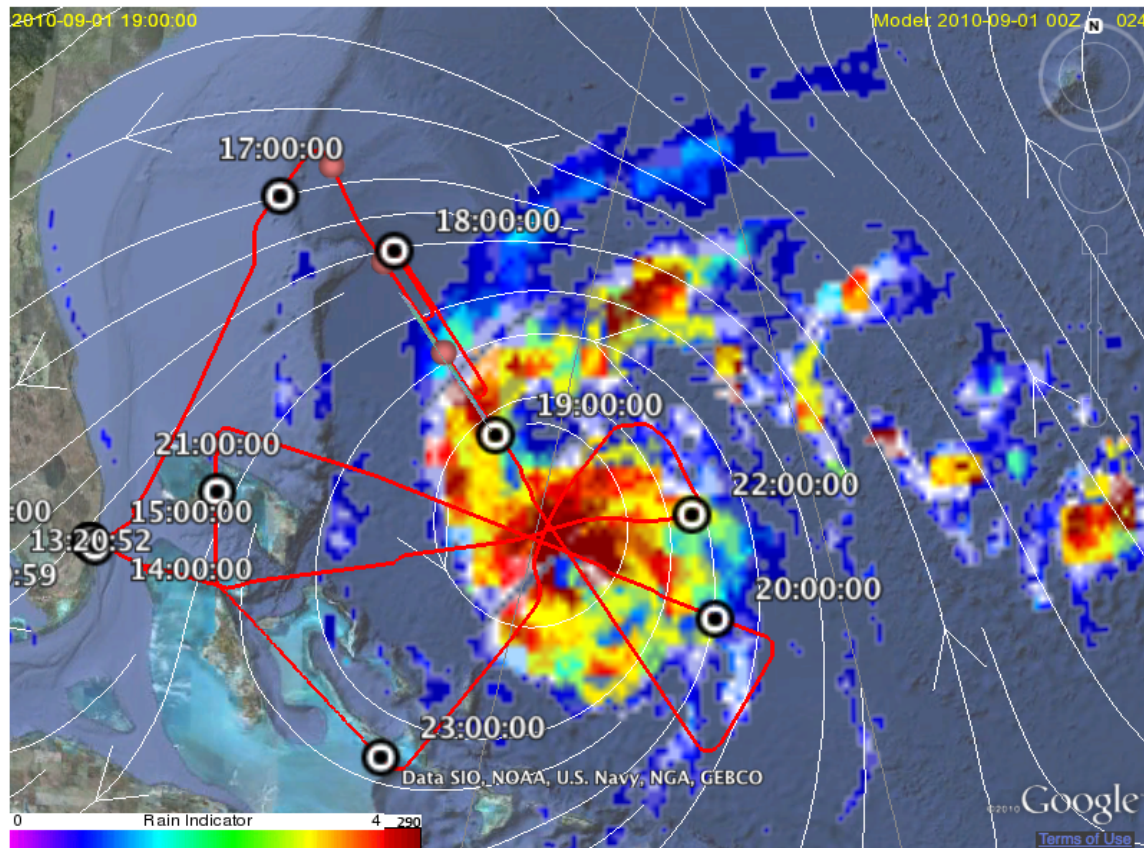
85GHZ

37GHZ

Rain

TRMM PR Nadir

The current time is Wed, 01 Jun 2011 07:04:25 GMT



Status Bar  Grid

Animation:  Observation Data  Model Data

### Model Data

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

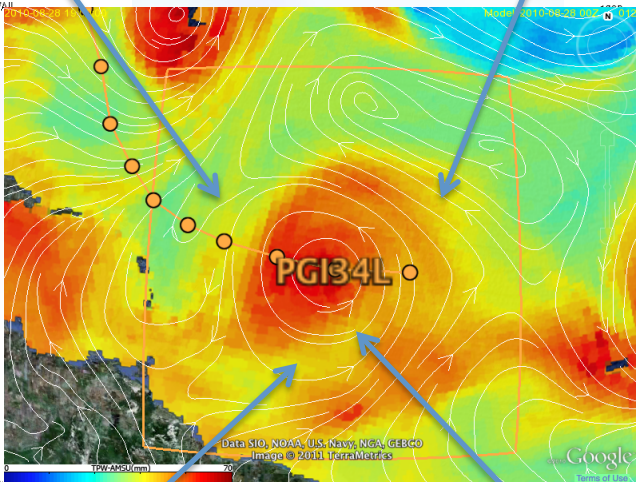
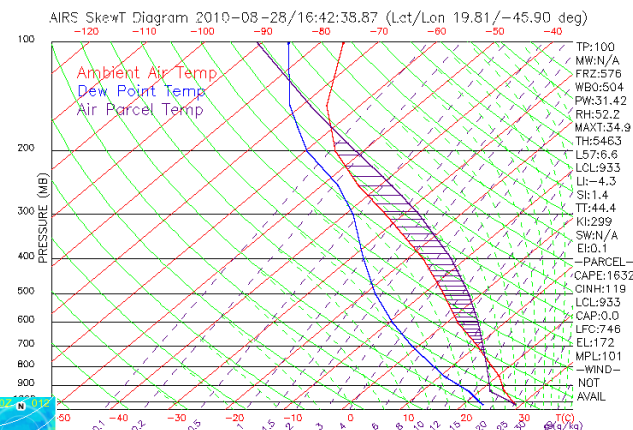
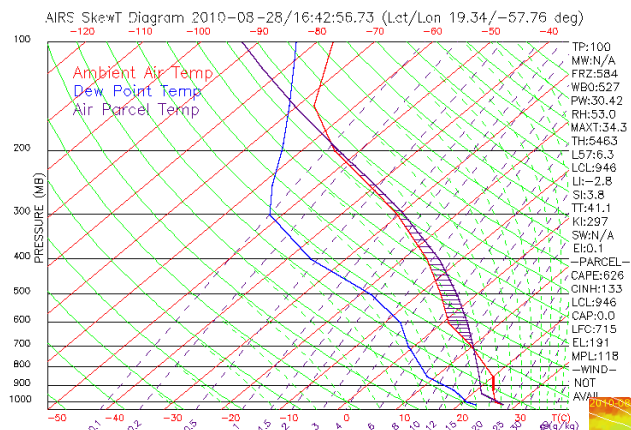
At hour: 19:00:00

- MODEL DATA
  - Pressure Level: 850
  - Forecast Time: 024
- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PG136L
  - PG138L
  - PG139L
  - PG140L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS

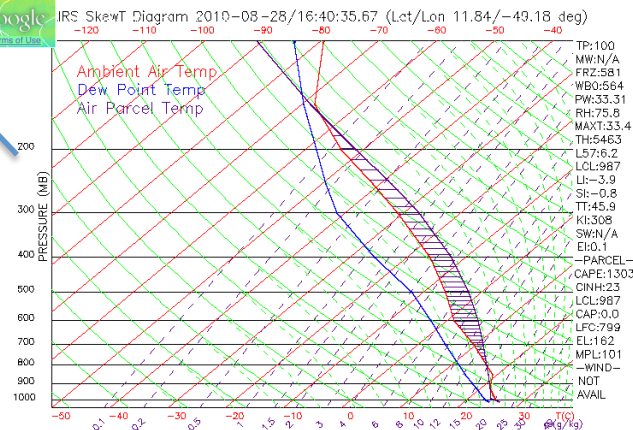
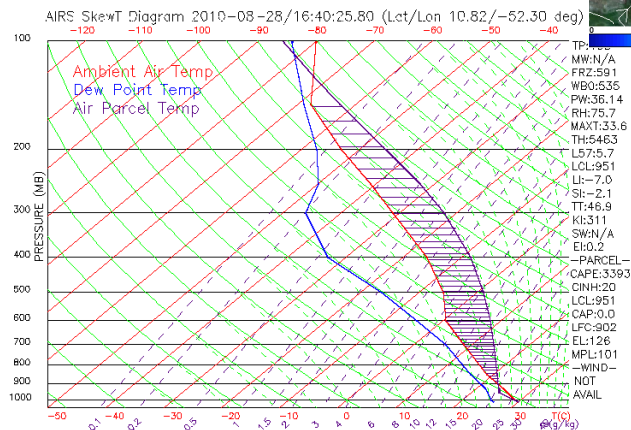
# NRT Satellite Data – Use during the campaign



## Hurricane Earl; Aug. 28, 2010 19Z



1. TPW from AMSU
2. Soundings from AIRS
3. Pouch-relative flow from ECMWF

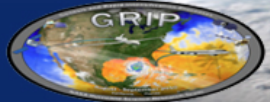




# Multi-frequency active observations TRMM-PR, CloudSAT and CALIPSO



## TC-IDEAS



- JPL TC Information System
- About GRIP
- Collaboration
- GRIP Mission Page
- NASA Hurricanes

The current time is Tue, 07 Jun 2011 07:03:33 GMT

### Observation Data

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

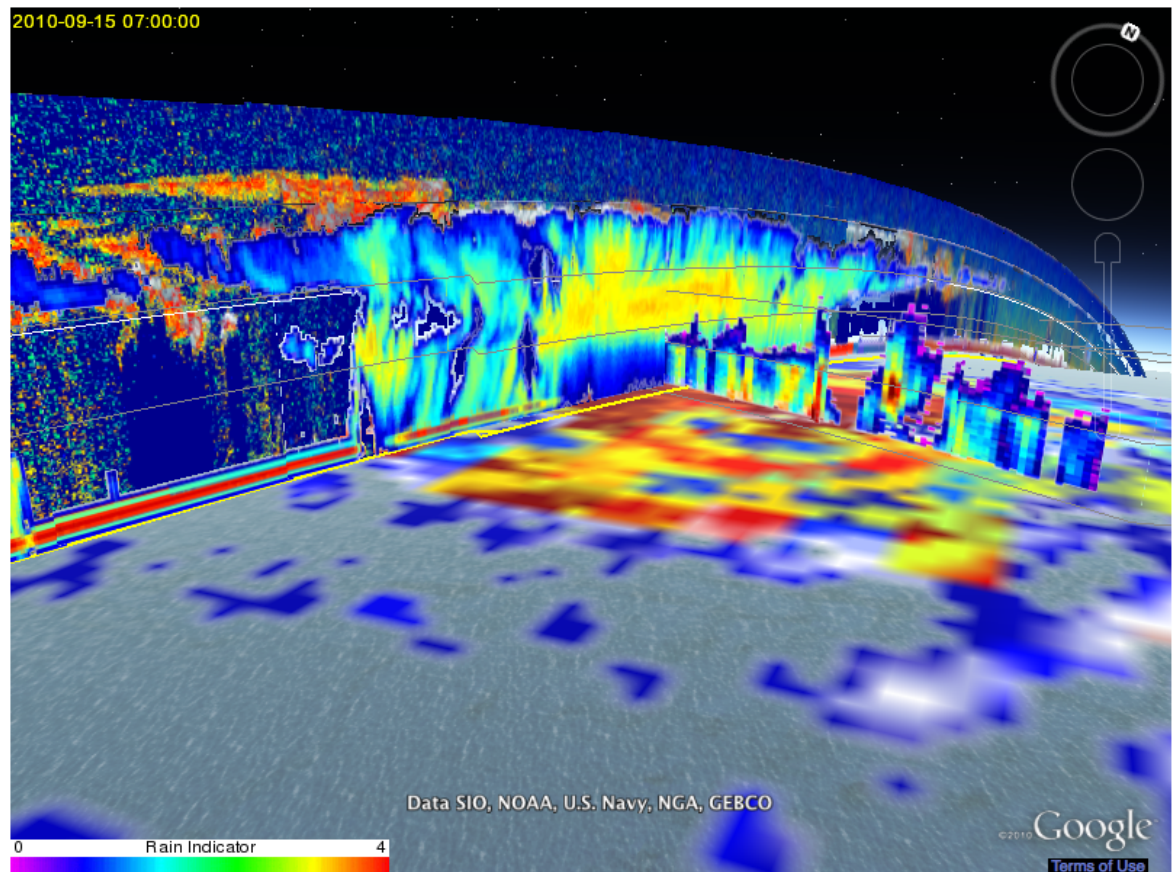
At hour: 07:00:00

### STORM TRACKS

- Best Tracks
- Pouch Tracks
  - PGI41L
  - PGI43L
  - PGI44L
  - PGI45L

### SATELLITE DATA

- SST
- OHC
- Wind (ASCAT)
- TPW (AMSU-A)
- RH-AIRS Press. Level: 850
- CAPE-AIRS
- LI-AIRS
- Geostationary



### Model Data

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

- MODEL DATA
  - Pressure Level: 850
  - Forecast Time: 000
- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PGI41L
  - PGI43L
  - PGI44L
  - PGI45L
  - PGI46L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET



# Karl, just after genesis - 14<sup>th</sup> September 2010, 22Z

## Bringing together model flow 37 GHz obs, airborne tracks and dropsonde data- providing the context for the airborne observations



JPL TCIS Data Archive

About GRIP

Collaboration

GRIP Mission Page

NASA Hurricanes

**Observation Data**

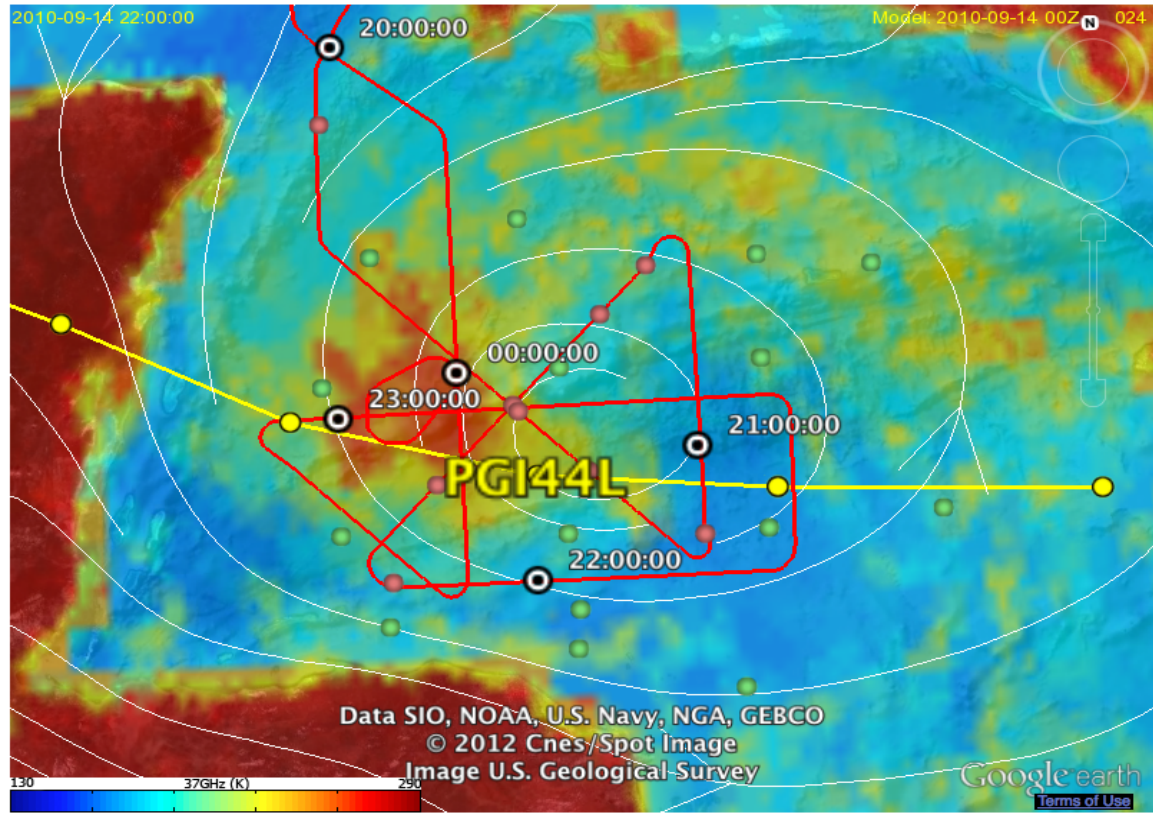
September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 22:00:00

- STORM TRACKS
  - Best Tracks
  - Pouch Tracks
- SATELLITE DATA
- AIRBORNE DATA
  - HAMS Channel: 01
  - HAMS Reflectivity
  - APR2: Zku
  - Dropsonde
  - NOAA: N42RF
  - Lase
  - Daily DC8-Flight track
  - Daily Global Hawk track
  - Hourly Global Hawk track

The current time is Mon, 07 May 2012 18:23:15 GMT



**Model Data**

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

- MODEL DATA
  - Pressure Level: 925
  - Forecast Time: 024
- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PGI41L
  - PGI43L
  - PGI44L
  - Speed comoving
  - Streamline comoving
  - PGI45L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS

Status Bar  Grid

Animation:  Observation Data  Model Data



# Karl, just after genesis - 14<sup>th</sup> September 2010, 22Z

## Bringing together model flow 37 GHz obs, airborne tracks and dropsonde data- providing the context for the airborne observations

### TC-IDEAS



JPL TCIS Data Archive

About GRIP

Collaboration

GRIP Mission Page

NASA Hurricanes

#### Observation Data

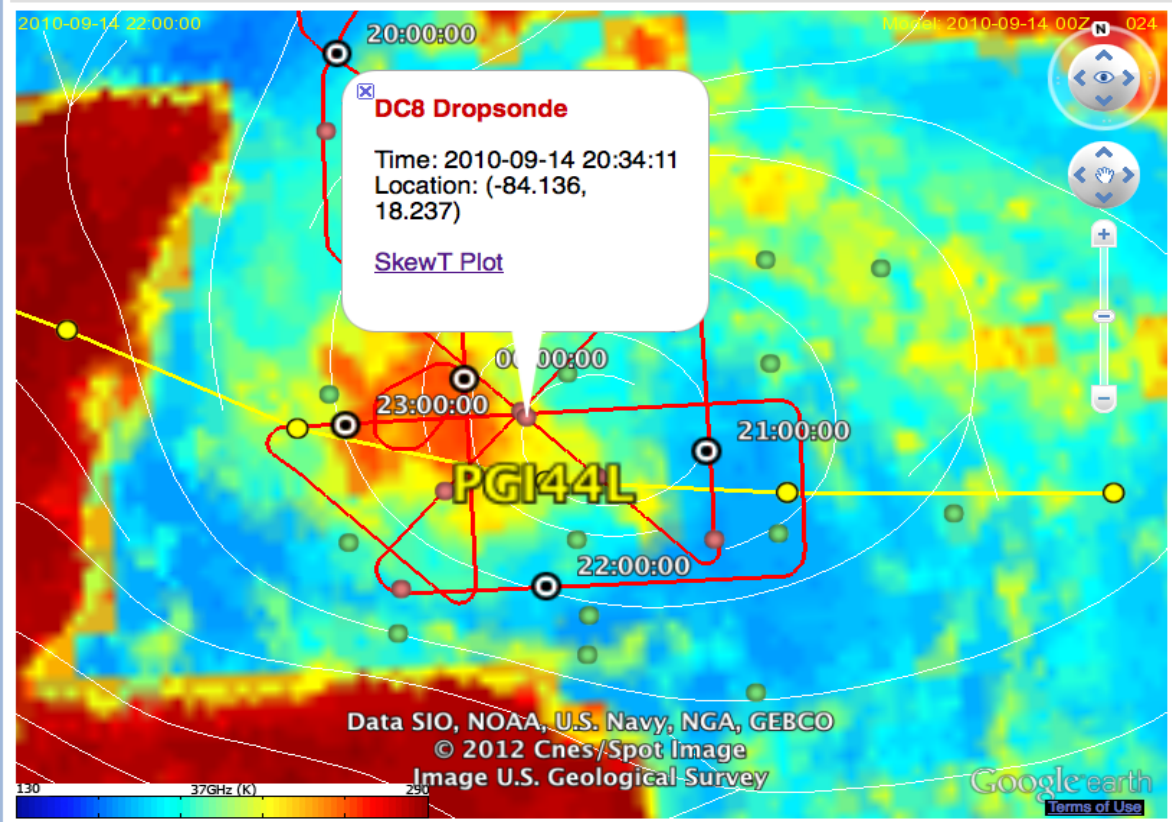
September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 22:00:00

- STORM TRACKS
  - Best Tracks
  - Pouch Tracks
- SATELLITE DATA
- AIRBORNE DATA
  - HAMS Channel: 01
  - HAMS Reflectivity
  - APR2: Zku
  - Dropsonde
  - NOAA: N42RF
  - Lase
  - Daily DC8-Flight track
  - Daily Global Hawk track
  - Hourly Global Hawk track

The current time is Mon, 07 May 2012 18:08:34 GMT



#### Model Data

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

- MODEL DATA
  - Pressure Level: 925
  - Forecast Time: 024
- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PGI41L
  - PGI43L
  - PGI44L
  - Speed comoving
  - Streamline comoving
  - PGI45L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS



# Karl, just after genesis - 14<sup>th</sup> September 2010, 22Z

## Bringing together model flow 37 GHz obs, airborne tracks and dropsonde data- providing the context for the airborne observations



### TC-IDEAS



- JPL TCIS Data Archive
- About GRIP
- Collaboration
- GRIP Mission Page
- NASA Hurricanes

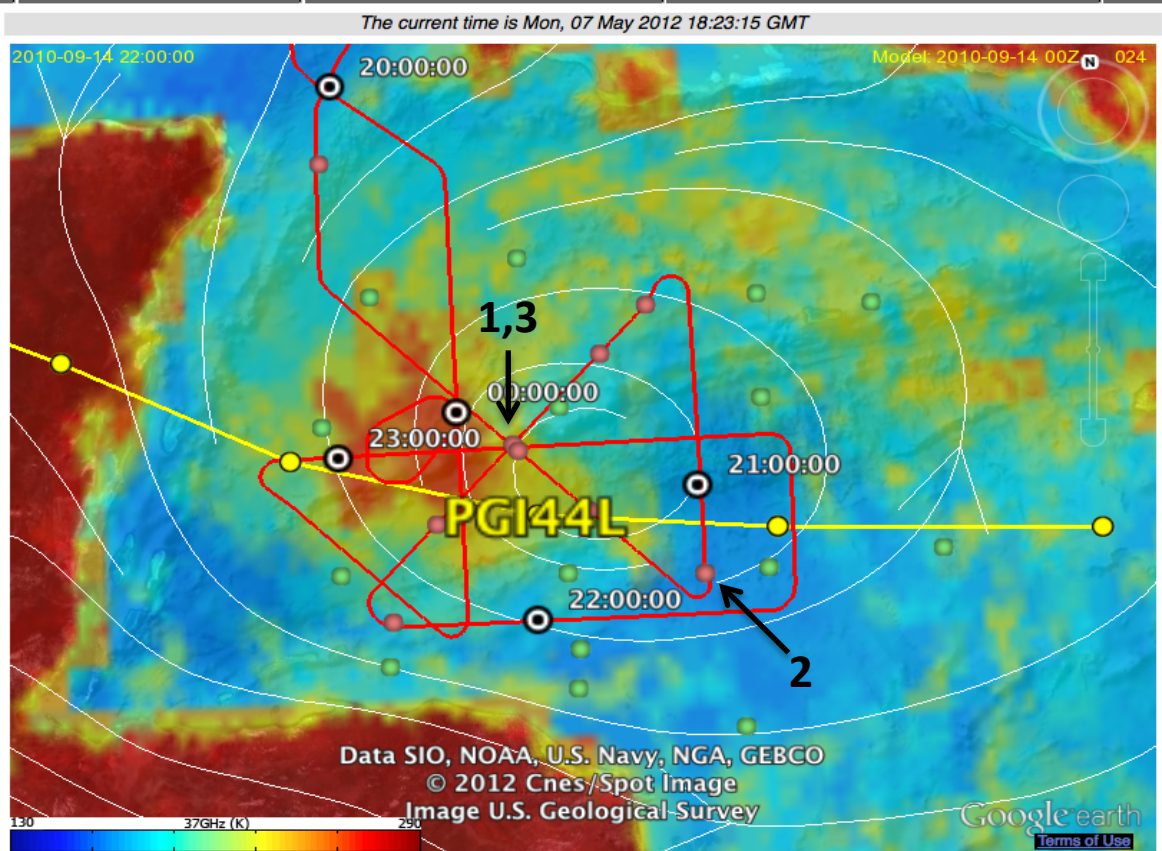
**Observation Data**

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 22:00:00

- STORM TRACKS
  - Best Tracks
  - Pouch Tracks
- SATELLITE DATA
- AIRBORNE DATA
  - HAMS Channel: 01
  - HAMS Reflectivity
  - APR2: Zku
  - Dropsonde
  - NOAA: N42RF
  - Lase
  - Daily DC8-Flight track
  - Daily Global Hawk track
  - Hourly Global Hawk track



**Model Data**

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

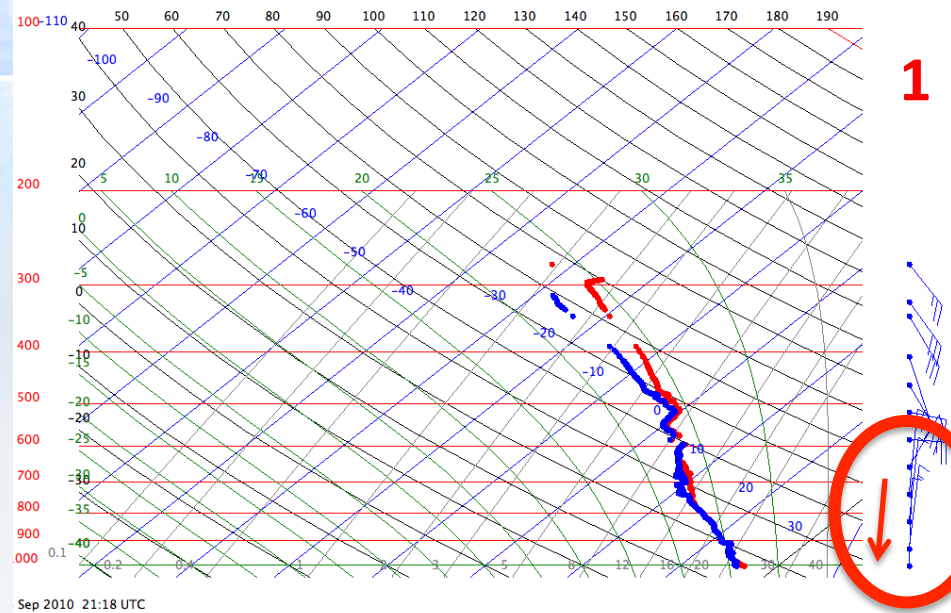
- MODEL DATA
  - Pressure Level: 925
  - Forecast Time: 024
- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PGI41L
  - PGI43L
  - PGI44L
  - Speed comoving
  - Streamline comoving
  - PGI45L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS

- Status Bar
- Grid
- Save snapshot
- Load snapshot
- Download

Animation:  Observation Data  Model Data

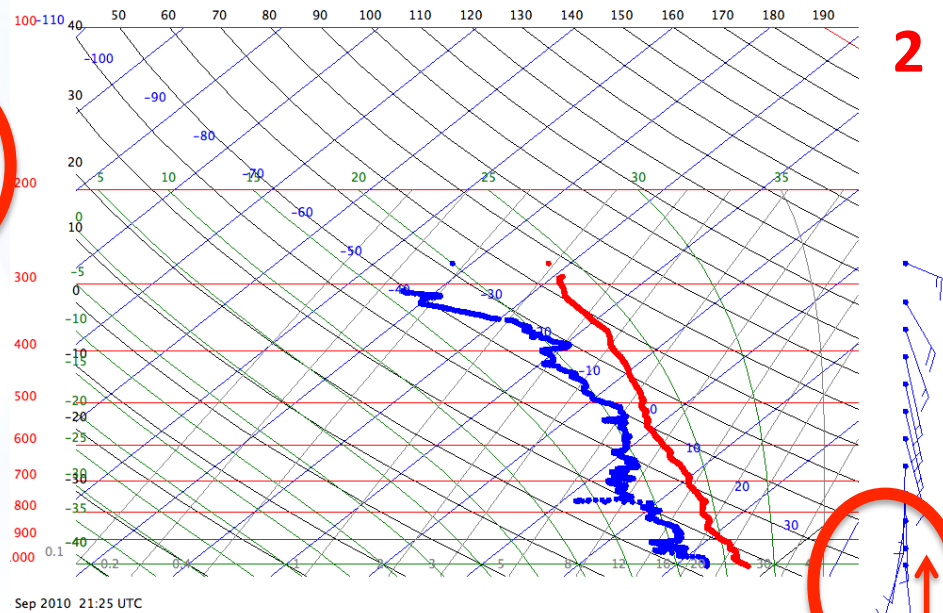
# 14<sup>th</sup> September 2010, 20-22 Z

D20100914\_203411\_P\_4 102045092 GRIP, RF11 NASA DC8, N817NA  
N18.2368 W84.1357



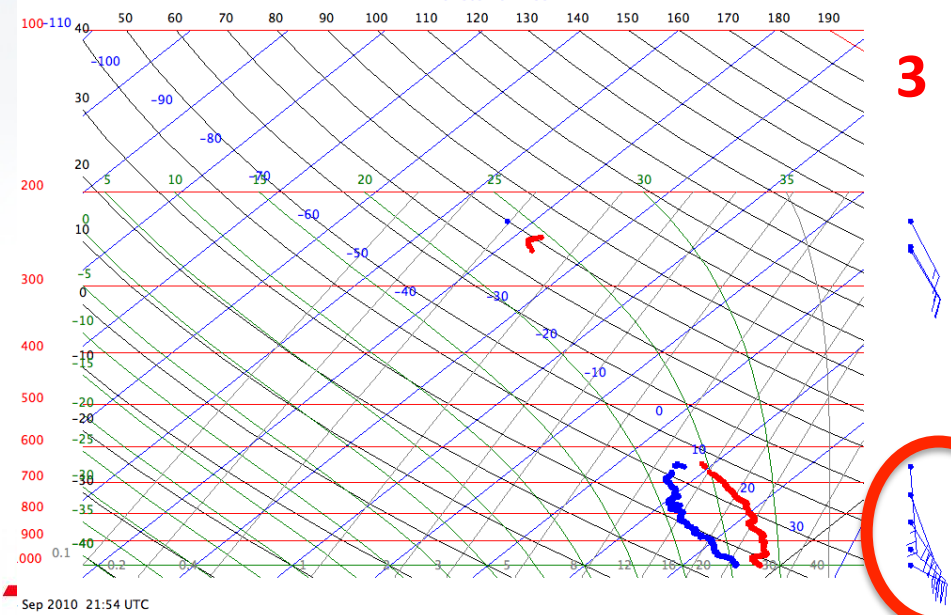
1

D20100914\_205327\_P\_2 102115238 GRIP, RF11 NASA DC8, N817NA  
N17.0139 W82.5156



2

D20100914\_213155\_P\_1 102115256 GRIP, RF11 NASA DC8, N817NA  
N18.2969 W84.1798



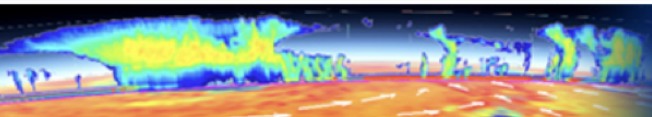
3





# The 3D structure of the storm 17<sup>th</sup> September 2010, 07Z

Untitled74



## TC-IDEAS



JPL TC Information System

About GRIP

Collaboration

GRIP Mission Page

NASA Hurricanes

### Observation Data

The current time is Thu, 19 Jan 2012 07:14:51 GMT

### Model Data

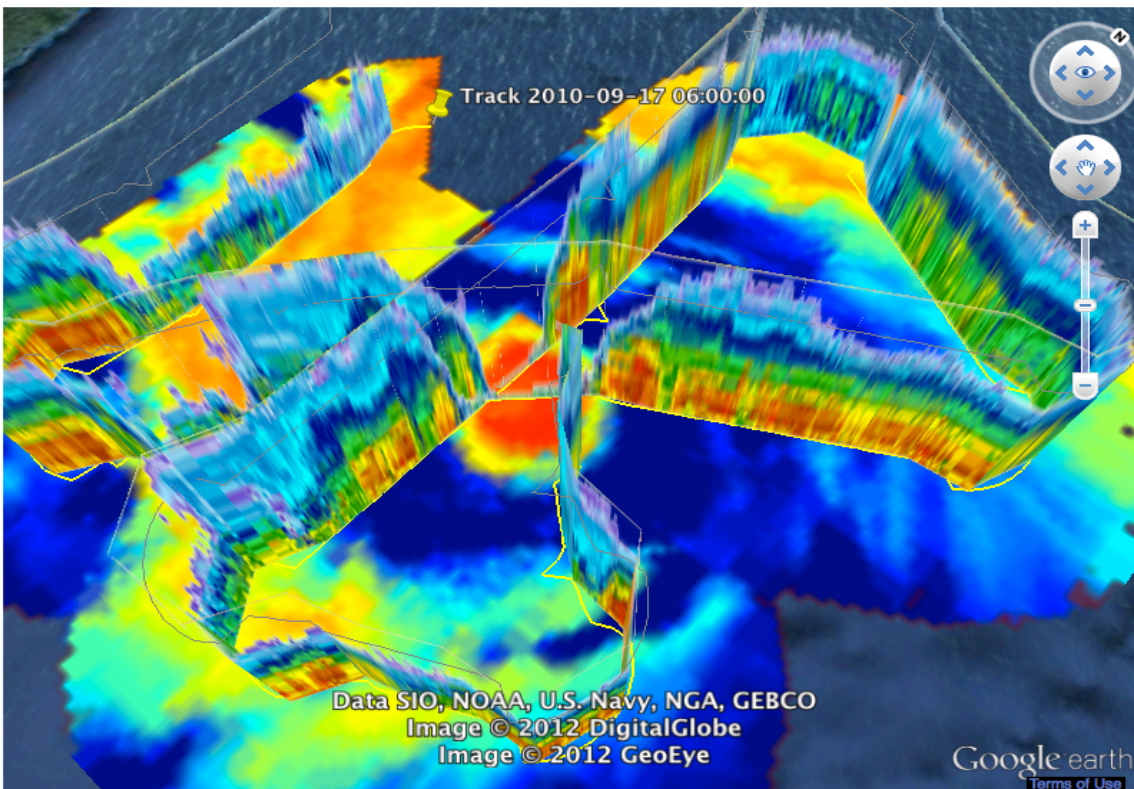
September 2010

September 2010

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 07:00:00



Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image © 2012 DigitalGlobe  
Image © 2012 GeoEye

Google earth  
Terms of Use

- GOES-IR
- GOES-VAPOR
- GOES-VIS
- 85GHZ
- 37GHZ
- Rain
- TRMM PR Nadir
- CloudSat
- CALIPSO
- MLS
- AOT (MODIS)
- Satellite Winds (CIMSS)

- MODEL DATA
  - Pressure Level: 850
  - Forecast Time: 000
- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PGI41L
  - PGI43L
  - PGI44L
  - PGI45L
  - PGI46L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS

Status Bar  Grid

Save snapshot

Load snapshot

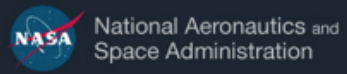
Download





# Investigate, share the scenes, get the data

## 02<sup>th</sup> September 2010, 19Z Earl



### NASA Airborne Science Data



#### Visualization Portal

The current time is Tue, 08 May 2012 18:33:18 GMT

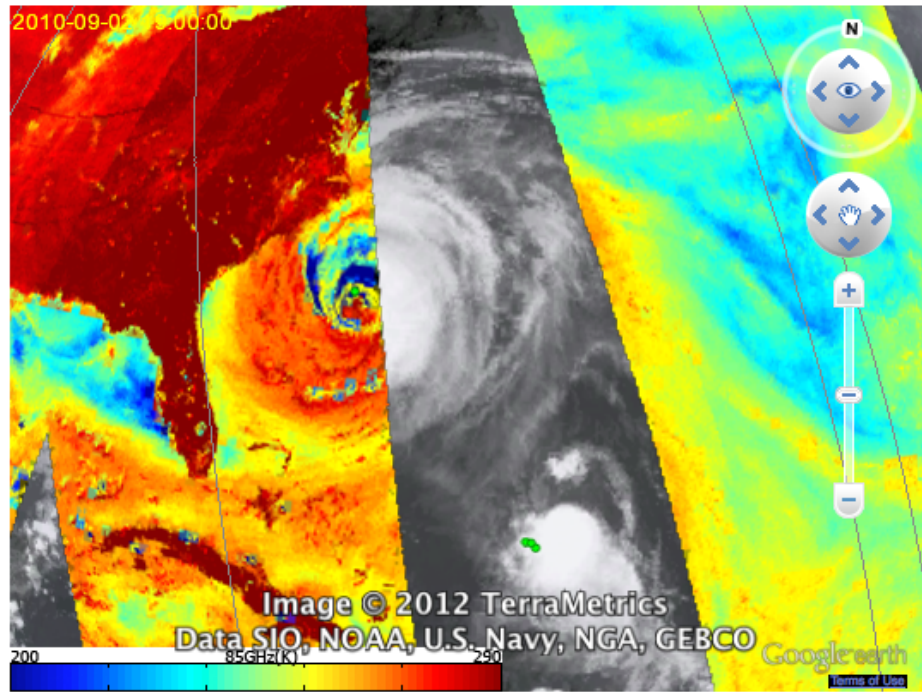
#### Observation Data

Septembe 20

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 19:00:00

- STORM TRACKS
  - Best Tracks
  - Pouch Tracks
  - PG136L
  - PG138L
  - PG139L
  - PG140L
- SATELLITE DATA
  - SST
  - DHC
  - Wind (ASCAT)
  - TPW (AMSU-A)
  - RH-AIRS Press. Level 850
  - CAPE-AIRS
  - LI-AIRS
  - Geostationary
    - GOES-IR
    - GOES-VAPOR
    - GOES-VIS
    - 85GHZ
    - 37GHZ



#### Model Data

Septembe 20

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

#### MODEL DATA

Pressure Level: 850

Forecast Time: 000

- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PG141L
  - PG143L
  - PG144L
  - PG145L
  - PG146L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS

Status Bar  Grid

Animation:  Observation Data  Model Data

Select a time range to animate: (from 2010-09-02 00:00:00 to 2010-09-03 00:00:00)

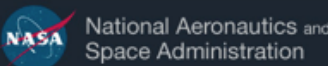
Start 2010-09-02 19:00:00 End 2010-09-03 19:00:00 Animation Step 1 hour





# Investigate, share the scenes, get the data

## 02<sup>th</sup> September 2010, 19Z Earl



### NASA Airborne Science Data

NADS Home Visualization Portal

The current time is Tue, 08 May 2012 16:28:35 GMT

2010-09-02 19:00:00

Image © 2012 TerraMetrics

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Animation:  Observation Data  Model Data

Select a time range to animate: (from 2010-09-02 00:00:00 to 2010-09-03 00:00:00)

Start 2010-09-02 19:00:00 End 2010-09-03 19:00:00 Animation Step 1 hour

Observation Data: September 20, 19:00:00

Model Data: September 20, 850 Pressure Level, 024 Forecast Time

AIRBORNE DATA:  HAMSR Channel 09,  HAMSR Reflectivity,  APR2,  Dropsonde,  NOAA,  Lase,  Daily DC8-Flight track,  Daily Global Hawk track,  Hourly Global Hawk tracks

MODEL DATA:  GFS,  Speed Earth Relative,  Streamline Earth Relative,  PGI41L,  PGI43L,  PGI44L,  PGI45L,  Relative Humidity,  OW,  Vorticity,  Deep shear,  Pouch shear,  Sea Level Pressure,  ECMWF,  UKMET,  NOGAPS

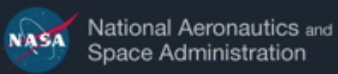
85 GHz Tb  
HAMSR – chan. 9





# Investigate, share the scenes, get the data

## 02<sup>th</sup> September 2010, 19Z Earl



### NASA Airborne Science Data

NADS Home Visualization Portal

The current time is Tue, 08 May 2012 18:27:08 GMT

2010-09-02 19:00:00

Image © 2012 TerraMetrics

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

At hour: 19:00:00

GDES-VAPDR  
 GDES-VIS  
 85GHZ  
 37GHZ  
 Rain  
 TRMM PR Cu  
 CloudSat  
 CALIPSO  
 MLS  
 AOT (MODIS)  
 Satellite Winds (CIMSS)

AIRBORNE DATA  
 HAMSR Channel 09  
 HAMSR Reflectivity  
 APR2 Zku  
 Dropsonde  
 NOAA N42RF  
 Lase  
 Daily DC8-Flight track  
 Daily Global Hawk track  
 Hourly Global Hawk track

MODEL DATA  
 Pressure Level: 850  
 Forecast Time: 024  
 GFS  
 Speed Earth Relative  
 Streamline Earth Relative  
 PGH41L  
 PGH43L  
 PGH44L  
 PGH45L  
 Relative Humidity  
 OW  
 Vorticity  
 Deep shear  
 Pouch shear  
 Sea Level Pressure  
 ECMWF  
 UKMET  
 NOGAPS

Animation:  Observation Data  Model Data

Select a time range to animate: (from 2010-09-02 00:00:00 to 2010-09-03 00:00:00)

Start 2010-09-02 19:00:00 End 2010-09-03 19:00:00 Animation Step 1 hour

Buttons: Status Bar, Grid, Save snapshot, Load snapshot, Download

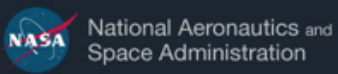
85 GHz Tb  
 HAMSR – chan. 9  
 HAMSR – dBz





# Investigate, share the scenes, get the data

## 02<sup>th</sup> September 2010, 19Z Earl



### NASA Airborne Science Data

Visualization Portal

The current time is Tue, 08 May 2012 16:23:29 GMT

2010-09-02 19:00:00

Image © 2012 TerraMetrics

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

Animation:  Observation Data  Model Data

Select a time range to animate: (from 2010-09-02 00:00:00 to 2010-09-03 00:00:00)

Start 2010-09-02 19:00:00 End 2010-09-03 19:00:00 Animation Step 1 hour

Observation Data

September 20

Su	M	T	W	Th	F	S
		01	02	03	04	
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

At hour: 19:00:00

- Wind (ASCAT)
  - Wind Vector
  - Wind Speed
- TPW (AMSU-A)
- RH-AIRS Press. Level 850
- CAPE-AIRS
- LI-AIRS
- Geostationary
- GOES-IR
- GOES-VAPOR
- GOES-VIS
- 85GHZ
- 37GHZ
- Rain
- TRMM PR Cu
- CloudSat
- CALIPSO
- MLS
- AOT (MODIS)
- Satellite Winds (CIMSS)

MODEL DATA

Pressure Level: 850

Forecast Time: 024

- GFS
  - Speed Earth Relative
  - Streamline Earth Relative
  - PGH41L
  - PGH43L
  - PGH44L
  - PGH45L
  - Relative Humidity
  - OW
  - Vorticity
  - Deep shear
  - Pouch shear
  - Sea Level Pressure
- ECMWF
- UKMET
- NOGAPS

85 GHz Tb  
 HAMSR – chan. 9  
 HAMSR – dBz  
 ASCAT - winds



[NASD Home](#)



# NASA Airborne Science Data

Data Access Home → Browse Across Types

## Cross Product Type Search

[Browse By Type](#) [Browse Across Types](#)

Filter:  =

Exclusive:

Filename	=	MULTI_COMPOSITE_L1_85H_20100903_0000.nc	<input type="button" value="Remove"/>
Filename	=	ASCAT_MetOp-A_L2_Wind_20100903_0000.nc	<input type="button" value="Remove"/>
Filename	=	HAMSR_GHAWK_L1B_20100902_1900.nc	<input type="button" value="Remove"/>

To see these filters again, go to:  
[http://acce.jpl.nasa.gov/missions/NASD/browse/typesearch/1/Filename/MULTI\\_COMPOSITE\\_L1\\_85H\\_20100903\\_0000.nc/Filename/ASCAT\\_MetOp-A\\_L2\\_Wind\\_20100903\\_0000.nc/Filename/HAMSR\\_GHAWK\\_L1B\\_20100902\\_1900.nc/](http://acce.jpl.nasa.gov/missions/NASD/browse/typesearch/1/Filename/MULTI_COMPOSITE_L1_85H_20100903_0000.nc/Filename/ASCAT_MetOp-A_L2_Wind_20100903_0000.nc/Filename/HAMSR_GHAWK_L1B_20100902_1900.nc/)

Page 1 of 1 (Products 1 to 3, out of 3)

Product Name	ProductType	StartDateTime	CAS.ProductReceivedTime
MULTI_COMPOSITE_L1_85H_20100903_0000	MULTI_85H_L1	2010-09-03T00:00:00.000Z	2012-02-28T13:23:39.4
HAMSR_GHAWK_L1B_20100902_1900	HAMSR_L1B	2010-09-02T19:00:00.000Z	2012-02-28T13:31:30.4
ASCAT_MetOp-A_L2_Wind_20100903_0000	ASCAT_Wind_L2	2010-09-03T00:00:00.000Z	2012-02-28T13:23:15.4

[NASD Home](#)



# NASA Airborne Science Data

Data Access Home → Browse By Type → HAMSR\_L1B → Products → 94229ed5-6253-11e1-af2f-734eed206005

## Product Metadata: HAMSR\_GHAWK\_L1B\_20100902\_1900

CAS.ProductId	94229ed5-6253-11e1-af2f-734eed206005
CAS.ProductName	HAMSR_GHAWK_L1B_20100902_1900
CAS.ProductReceivedTime	2012-02-28T13:31:30.494-08:00
FileLocation	/usr/local/acce/nasd/services/.../archive/GRIP/HAMSR_L1B/HAMSR_GHAWK_L1B_20100902_1900
Filename	HAMSR_GHAWK_L1B_20100902_1900.nc
InstrumentId	HAMSR
MimeType	application/octet-stream application octet-stream
PlatformId	GHAWK
ProductStructure	Flat
ProductType	HAMSR_L1B
ProjectId	GRIP
StartDateTime	2010-09-02T19:00:00.000Z

### Download this Product:

HAMSR\_GHAWK\_L1B\_20100902\_1900.nc  
42.4 MB  
Mime Type: application/octet-stream  
[save](#)





# NEW FEATURES

- Option to save the scene
  - selected data
  - viewing geometry
- Data accesses
  - Displayed datasets can be downloaded in netcdf!!
- **Advantages**
  - Visualization facilitates exploration of multiparameter, multi-instrument observations
  - **“Snapshot” save** allows easy sharing and recollection
  - **“Download” button** gives you an immediate access to the digital data of interest
  - Digital data are stored in an unified format -netcdf

# Summary



- **New Data**

- TCIS – 11 year data records
- GRIP and HS3 NRT portals for data interrogation

- **Diagnostics**

- Use of instrument simulators
- Analysis of:
  - 2D fields
  - Vertical structures
  - Composites
  - Principal components

- **Tools – Upgrades and new development**

- **the HWSS**

- Antenna convolution and Slant Path

- **New AIST project – just starting up**

- Integration of the ISSARS and HWSS instrument simulators with operational hurricane forecast models and incorporation of simulated satellite observables into the existing database of satellite and airborne observations.
- Development of a set of advanced analysis tools



# Summary

## Advantages of the JPL TCIS:

### – The Tropical Cyclone Data Archive

- No need to query, find storms and discover – it is all there, organized and easy to obtain
- It is global and covers 12 years of satellite observations
- Imagery and digital data
- Unified format - netcdf

### – GRIP/HS3 Portal

- Can go back in time!! Not just in NRT!
- Google Earth Visualization allows overlay and interrogation of multi - parameter data
- Offers model and multi-instrument data (satellite, airborne and in-situ)
- New capability – save snapshots, download data





# References:

- Hristova-Veleva, S. M., Y. Chao, A. Chau, Z. Haddad, B. Knosp, B. Lambrigtsen, P. Li, J. Martin, W. L. Poulsen, E. Rodriguez, B. Stiles, S. Tanelli, J. Turk, D. Vane, Q. Vu, 2010: “Impact of microphysical assumptions on the intensity and the structure of simulated hurricanes: Can satellite observations help determine the optimal set of microphysical assumptions?”, AMS, 29<sup>th</sup> Conference on Hurricanes and Tropical Meteorology, May 2010, Tucson, AZ
- Hristova-Veleva, S. M., J. Steward, T. Vukicevic, Z. Haddad, S. Aberson, S. Gopalakrishnan, T. Quirino, F. J. Turk, P. P. Li, B. Knosp, B. Lambrigtsen, S. Durden, S. Tanelli, 2012: “The Experimental HWRF-HEDAS system: Using satellite observations to evaluate the model and to assess the impact of data assimilation”, AMS, 30<sup>th</sup> Conference on Hurricanes and Tropical Meteorology, April 2012, Ponte Vedra Beach, FL
- Stiles, B., R. Danielson, W. L. Poulsen, M. J. Brennan, and S. M. Hristova-Veleva, 2012: Multiple Scatterometer Hurricane Winds Ten years of optimized QuikSCAT cyclone winds validated against best track speeds, H\*WIND and SFMR, and initial OceanSAT-2 cyclone winds, 2012 IOVWST, Utrecht, ND
- Wu, L., Hui Su, R. G. Fovell, B. Wang, J. T. Shen, B. H. Kahn, S. M. Hristova-Veleva, B. H. Lambrigtsen, E. J. Fetzer, J. H. Jiang, 2012: “Relationship of Environmental Relative Humidity with Tropical Cyclone Intensity and Intensification Rate over North Atlantic”, *submitted*



# Backup



# The people on our team...

- BRIAN KNOSP - Database development and data repository retrievals
- P PEGGY LI - Google Earth display integration, Plot development
- FRANCIS (Joe) TURK - Data repository retrievals and plot development
- WILLIAM (Lee) POULSEN - Hurricane track display development, scatterometer winds
- QUOC VU - Website creation
- STEPHEN LICATA - Data plot development
- TSAE-PYNG (Janice) SHEN - Data plot development

## Project development, concept, and design

SVETLA HRISTOVA-VELEVA, BJORN LAMBRIGTSEN,  
YI CHAO, SIMONE TANELLI, HUI SU, ZIAD HADDAD, DEB VANE

[svetla.veleva@jpl.nasa.gov](mailto:svetla.veleva@jpl.nasa.gov)



# The JPL Tropical Cyclone Information System (TCIS)

**Funded by the Hurricane Science Research Program**

## Collaborations

- **Satellite projects – CloudSAT, QuikSCAT, AIRS, MLS – JPL/NASA**
- **HURSAT** - NCDC/NOAA
- **NPS** - Naval Postgraduate School, Monterey, CA
- **CIMSS** - Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin-Madison
- **NRL** - U.S. Naval Research Laboratory, Washington, D.C.
- **RSMAS** - The Rosenstiel School of Marine and Atmospheric Science
- **HRD** - Hurricane Research Division/AOML/NOAA
- **NCAR** - National Center for Atmospheric Research, Boulder, CO
- **MSFC** - NASA's Marshall Space Flight Center, Huntsville, AL



# The JPL Tropical Cyclone Information System (TCIS)

<http://tropicalcyclone.jpl.nasa.gov>

## ***Objective of the TCIS***

To provide a one-stop place that facilitates fusion of multi-parameter, multi-instrument observations (satellite, airborne and in-situ) and model output, relevant to both the large-scale and the storm-scale hurricane processes, in the atmosphere and in the ocean.

## ***Goal:***

- help understand the physical processes that determine hurricane genesis, intensity, track and impact on large-scale environment
- help improve hurricane forecast accuracy by facilitating validation and improvement of hurricane models through comparison with observations and development of new data assimilation techniques
- enable studies aimed at developing new algorithms, sensor systems and missions.



# The 12-year Global Data Archive

- A wide variety of data types
- **Organized by year, basin, storm**
  - no need to search!!!
- **DATA and imagery**
- **Large-scale and storm scale**



# The 12-year Global Data Archive

- A wide variety of data types
- **Organized by year, basin, storm**
  - no need to search!!!
- **DATA and imagery**
- **Large-scale and storm scale**
  - **Large-scale (over the ocean basins; +2 days on either side)**
    - SST
    - Scatterometer winds
    - TPW
    - Thermodynamic atmospheric structure from AIRS



# The 12-year Global Data Archive

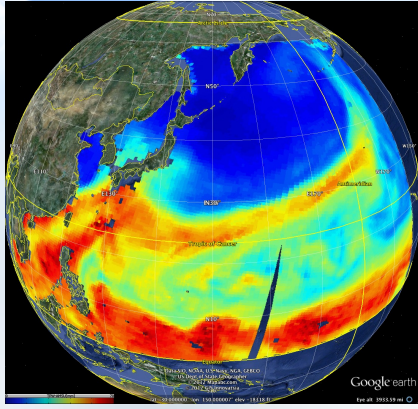
- A wide variety of data types
- **Organized by year, basin, storm**
  - no need to search!!!
- **DATA and imagery**
- **Large-scale and storm scale**
  - **Large-scale (over the ocean basins; +2 days on either side)**
    - SST
    - Scatterometer winds
    - TPW
    - Thermodynamic atmospheric structure from AIRS
  - **Storm scale**
    - Geostationary IR: GOES, MTSAT, FY2, Meteosat, MSG (HURSAT Version 5)
    - Multi-frequency brightness temperatures from TRMM-TMI, AMSR-E, SSM/I
    - full set of radar observations from TRMM-PR and CloudSAT
    - QuikSCAT surface winds
    - MLS, OMI



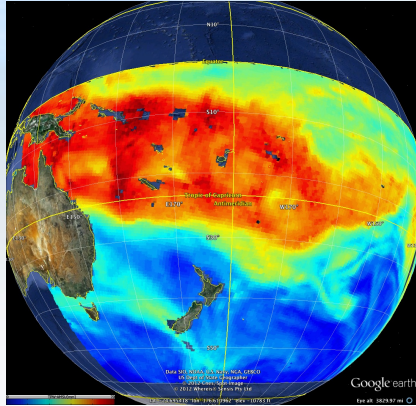


# Basin Scale Domains

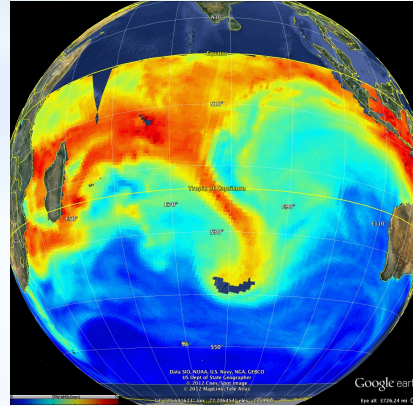
## Example -TPW



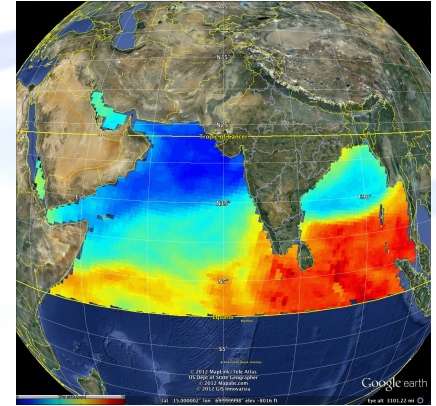
West Pacific



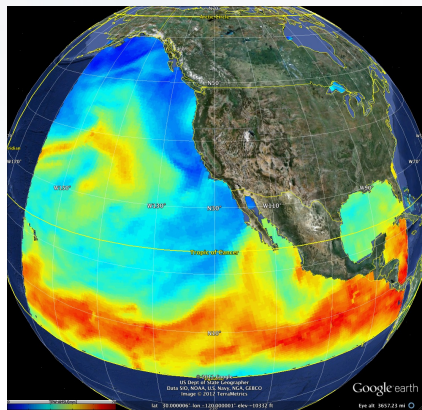
South Pacific



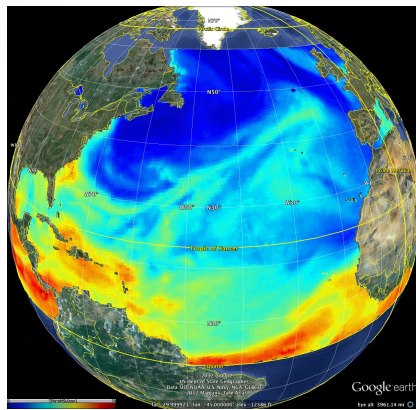
South Indian



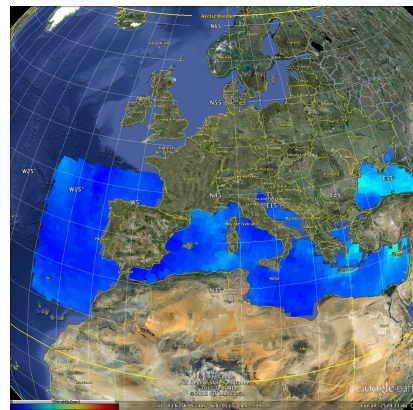
North Indian



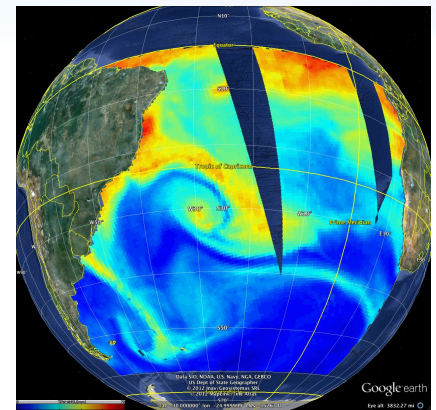
East Pacific



North Atlantic



Mediterranean Sea



South Atlantic

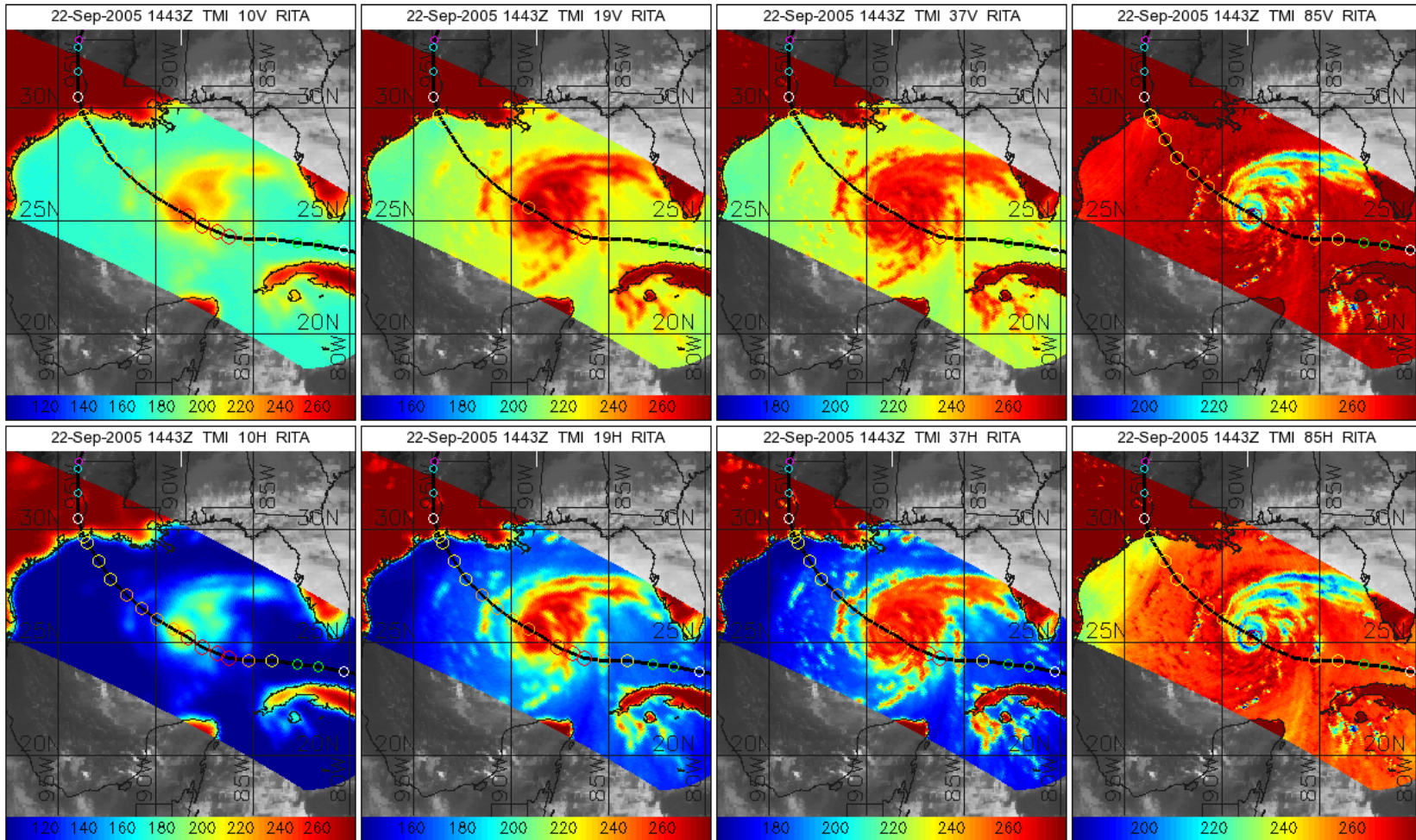
## Tropical Cyclone Rita

Download 2005-09-22 14:43:00 TMI BRIGHTNESS Data

Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

September 2005

- MLS
- SeaWINDS
- GPS-RO
- OMI
- AIRS
- PR
- TMI
- TRMM
- BRIGHTNESS
  - 2005-09-22 08:11:00
  - 2005-09-22 14:43:00
- RR
- AMSRE
- AMSU-A
- SSMI
- GEO



Data extracted over surrounding region and stored in netCDF, with a quicklook image.  
 Corresponding channels from (AMSR-E, SSMI, TMI), (AMSU-B,MHS) and AMSU-A mapped to same color scale, regardless of satellite



# JPL Tropical Cyclone Information System

- [Home](#)
- [Project](#)
- [Feedback](#)
- [Data Portal](#)
- [Analysis Tool](#)

## Tropical Cyclone Rita

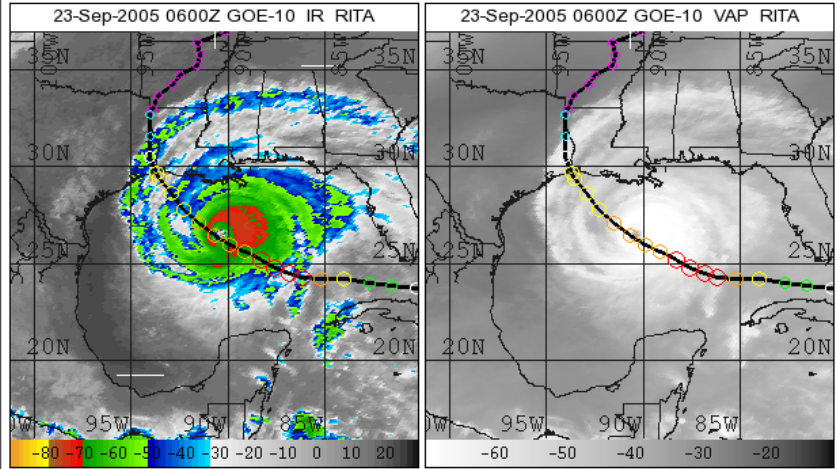
Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

- MLS
- SeaWINDS
- GPS-RO
- OMI
- AIRS
- PR
- TMI
- AMSRE
- AMSU-A
- SSMI
- GEO
  - GOE12
  - GOE10
- BRIGHTNESS

2005-09-23 06:00:00

[Download All](#)

Download 2005-09-23 06:00:00 GEO BRIGHTNESS Data





# NEW FEATURES

- Option to save the scene
  - selected data
  - viewing geometry
- Data accesses
  - Displayed datasets can be downloaded in netcdf!!
- Advantages
  - Visualization facilitates exploration of multiparameter, multi-instrument observations
  - “Snapshot” save allows easy sharing and recollection
  - “Download” button gives you an immediate access to the digital data of interest
  - Digital data are stored in an unified format -netcdf