Fusion of satellite and model data to study hurricanes and improve forecasts: The JPL Tropical Cyclone Information System and Near Real Time Portal.

S. Hristova-Veleva, P. P. Li , F. J. Turk, B. Knosp , Q. Vu
B. Lambrigtsen, Y. Chao, Z. Haddad, D. Vane,
H. Su, S. Tanelli

Jet Propulsion Laboratory, California Institute of Technology

August 2nd, 2011

The JPL Tropical Cyclone Information System - a satellite database and analysis tools to study hurricanes

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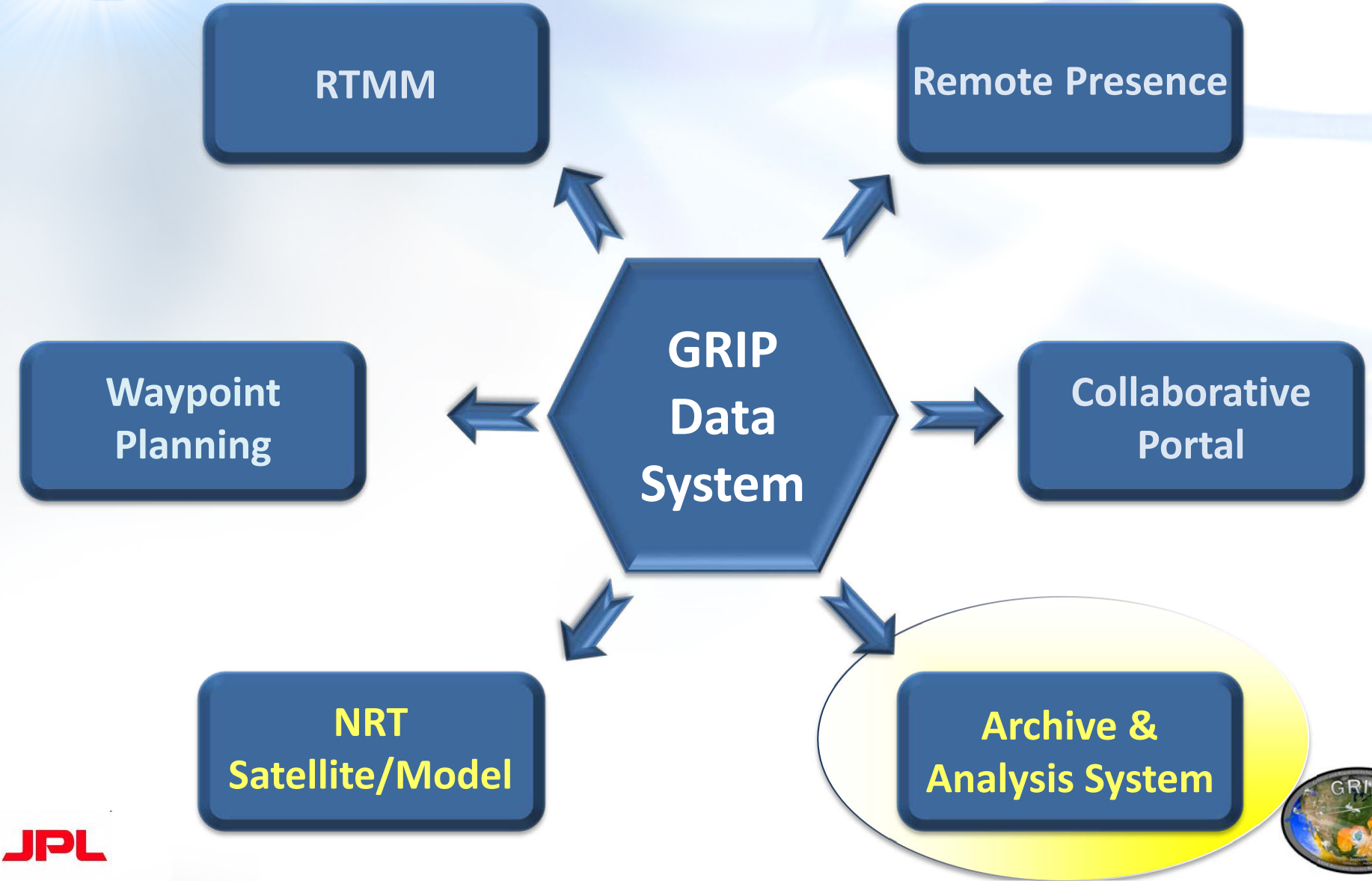
H. Su, S. Tanelli

Jet Propulsion Laboratory, California Institute of Technology

M. Goodman, H. Conover (and team) - MSFC

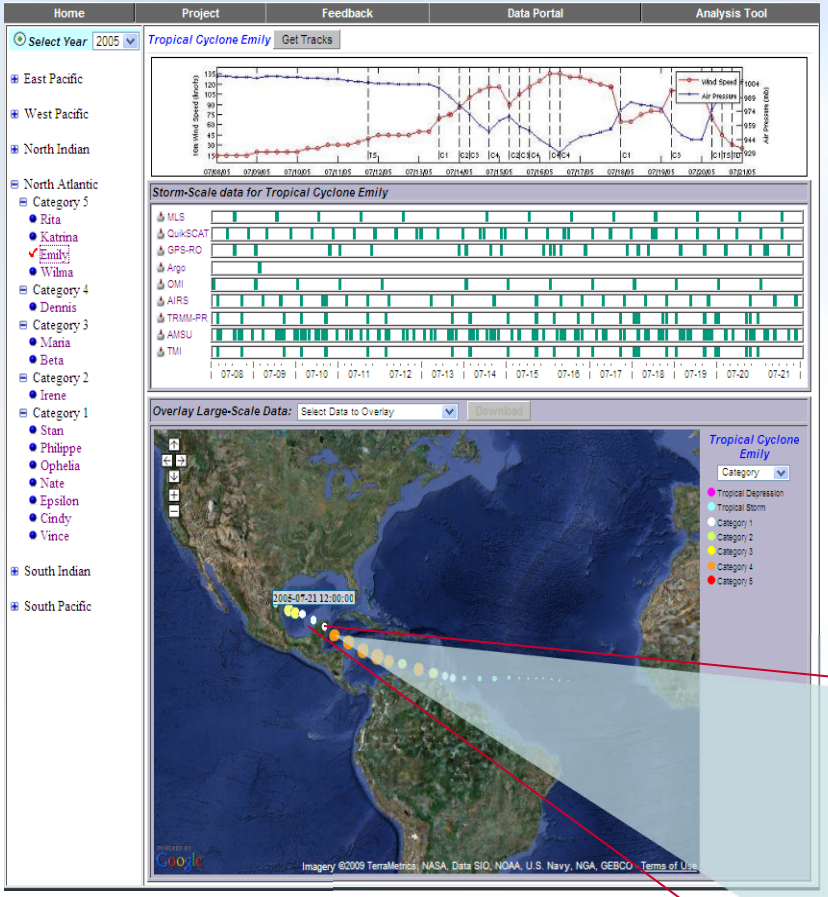
August 2nd, 2011

Joint NASA JPL and MSFC Project



Tropical Cyclone – Integrated Data Exchange and Analysis System (TC-IDEAS)

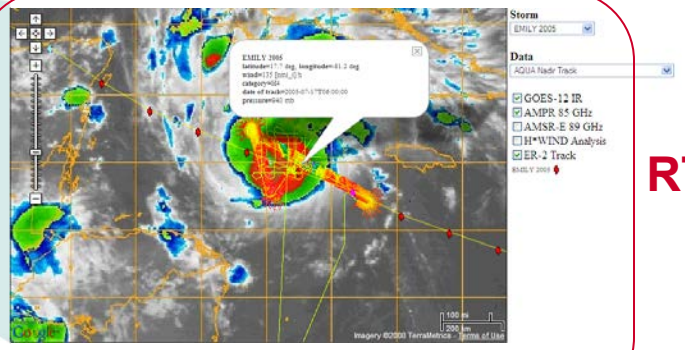
Joint NASA Jet Propulsion Lab and Marshall Space Flight Center Project
Funded by the Hurricane Science Research Program



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

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

- supporting both research and field campaigns (incorporating RTMM)
- 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 over GOES IR

RTMM

TC-IDEAS –
Historical database and analysis

http://tropicalcyclone.jpl.nasa.gov

- **Data Portal**
  - **Data organized by year, basin, storm**
  - **DATA and imagery**
  - **A wider variety of data types (MLS, OMI, ARGO floats, Ocean Heat Potential, Multi-frequency brightness temperatures, full set of radar observations, retrieved precipitation parameters, Aerosol Optical Depth)**
- **Analysis System**
  - Will communicate with satellite and airborne data
  - Space and time sub-sectioning and aggregation
  - Stability, Skew-T, EOFs, WRF simulations, instrument simulators

2 main components
In the current
JPL TCIS

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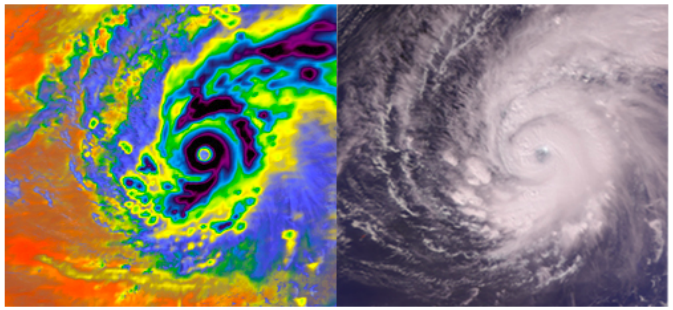
Welcome to the JPL Tropical Cyclone Information System

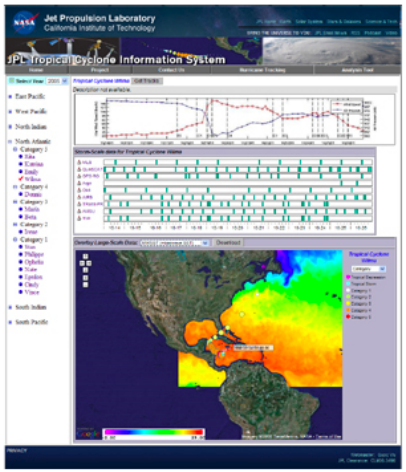
The JPL Tropical Cyclone Information System (TCIS) brings together satellite and in situ data sets from various sources to help you find information for a particular tropical cyclone over the world ocean. Currently, we have populated the entire 2005 and we will add data from other years in the future. 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).

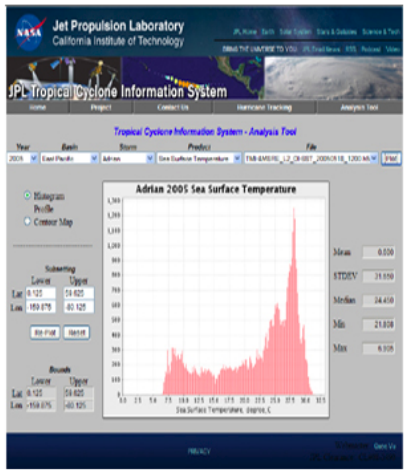
Tropical Cyclone Data Portal

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



Data Analysis Tool

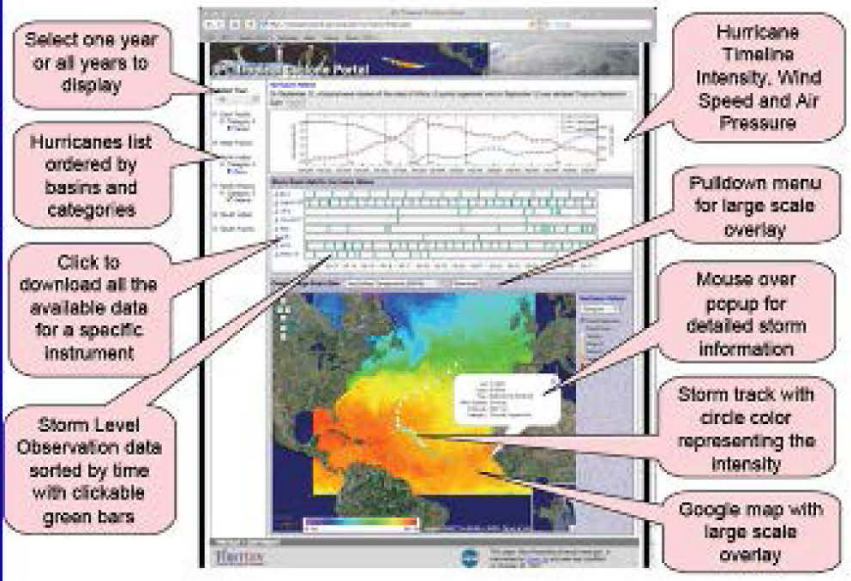
This tool will let you analyze data associated with a storm. You can plot histograms, maps, and profiles for many different data sets and products.



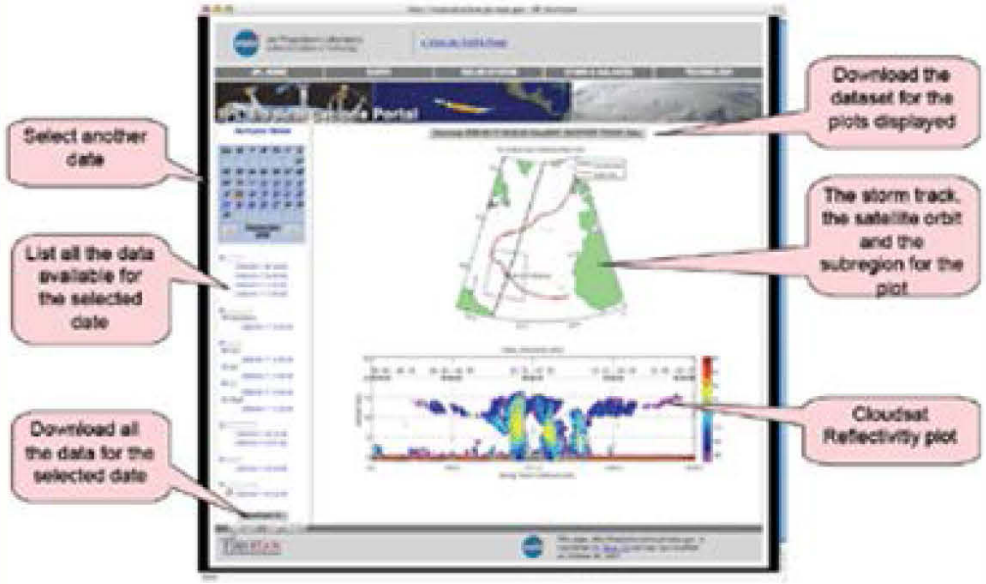
PRIVACY

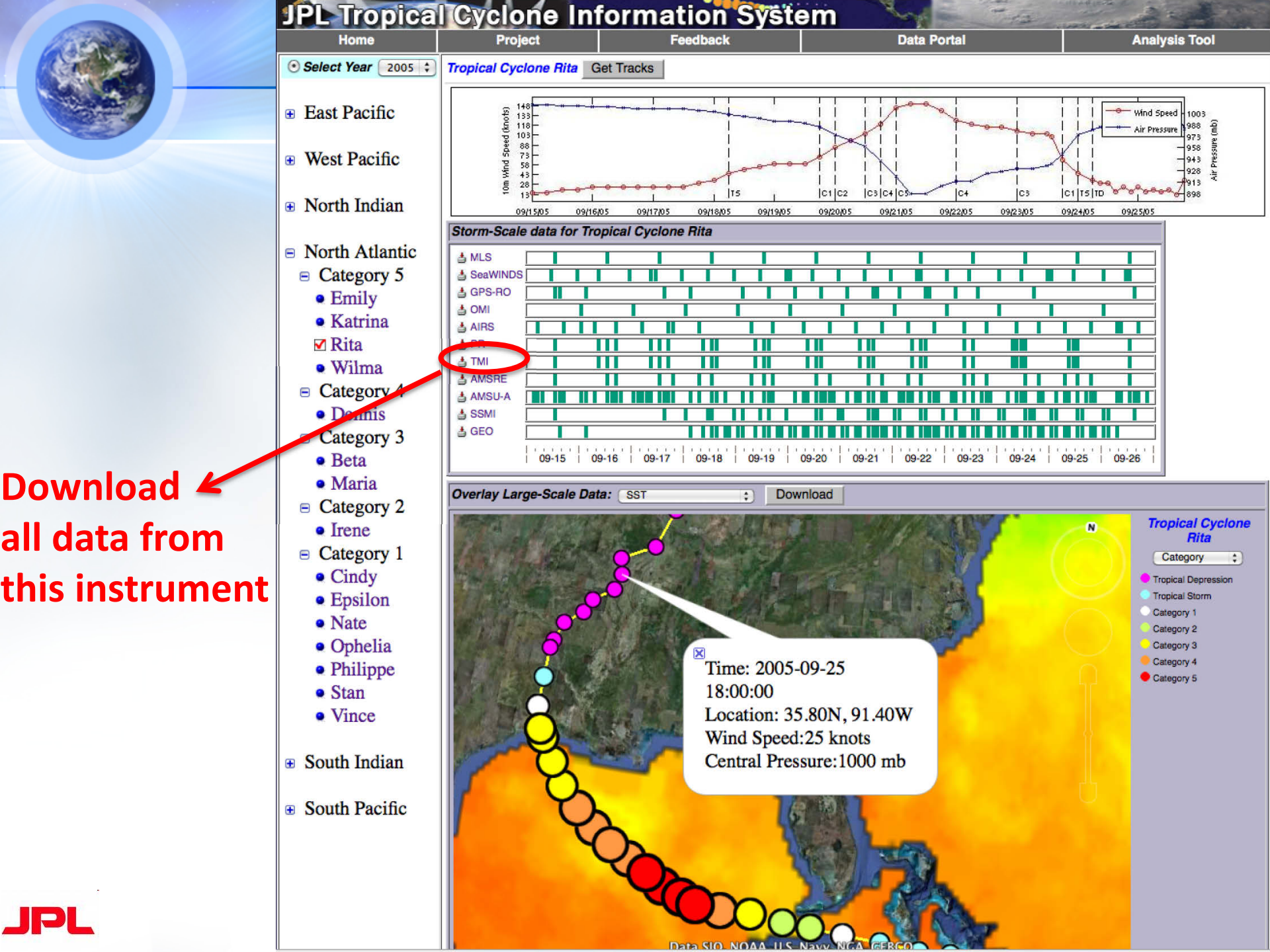
Webmaster: Quoc Vu
JPL Clearance: CL#08-3490

The Portal Main Page



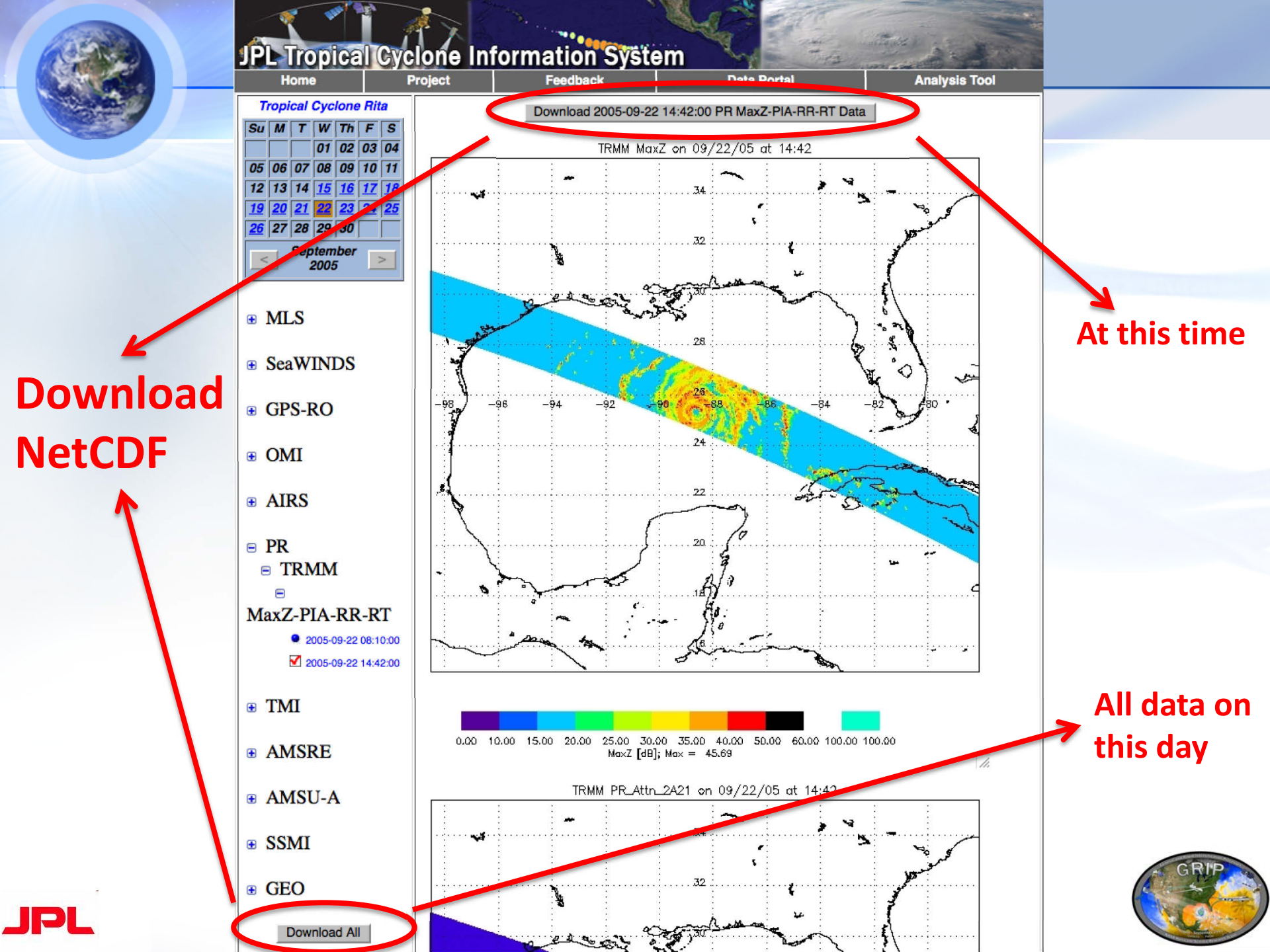
The Storm-level Data Page





Download all data from this instrument

JPL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Analysis Tool
Tropical Cyclone Rita
Download 2005-09-22 14:42:00 PR MaxZ-PIA-RR-RT Data
TRMM MaxZ on 09/22/05 at 14:42
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 All
0.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 50.00 60.00 100.00 100.00
MaxZ [dB]; Max = 45.69
TRMM PR_Attn_2A21 on 09/22/05 at 14:42
Download NetCDF
At this time
All data on this day
JPL
GRIP

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Tropical Cyclone Rita

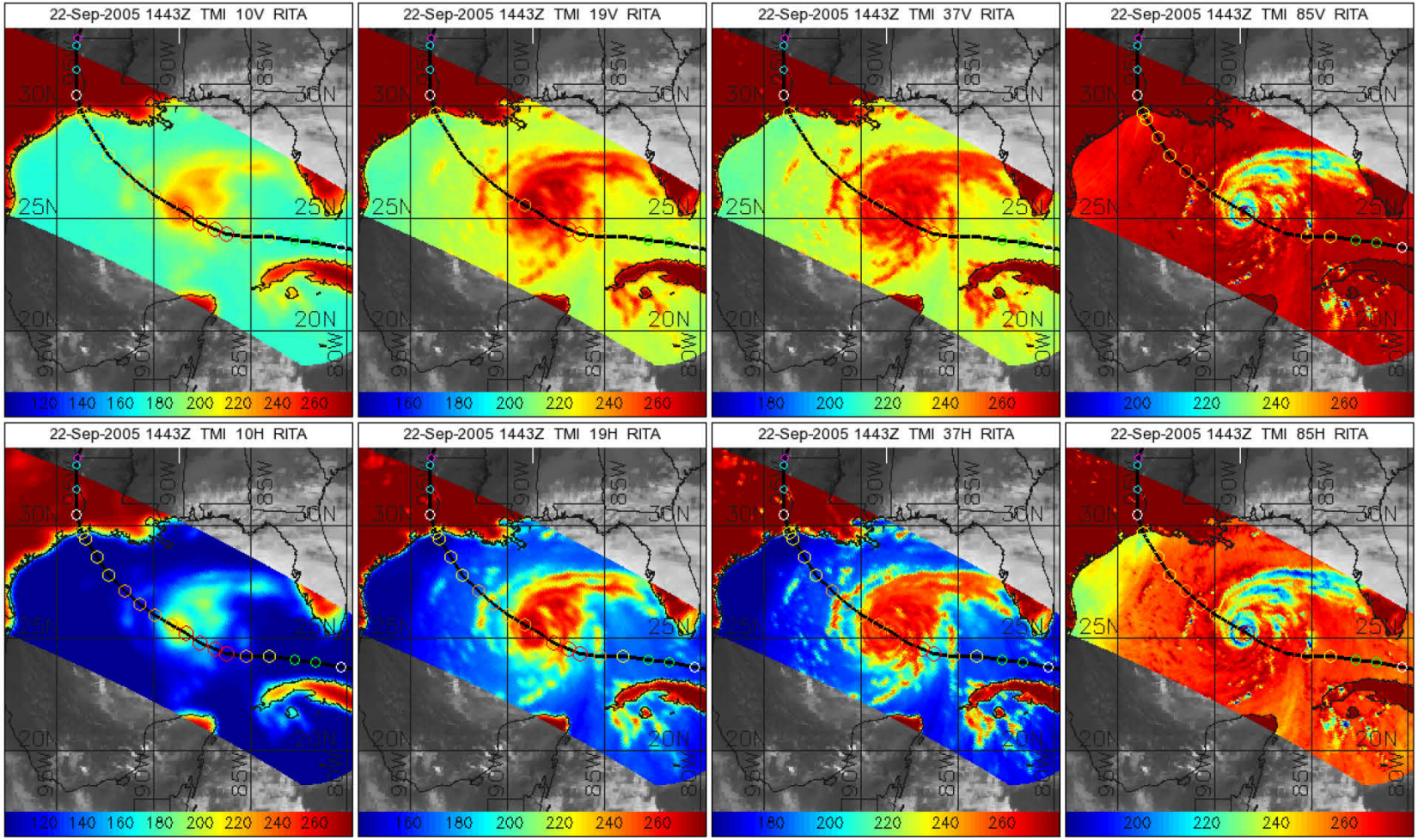
Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

< September 2005 >

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

Download All

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



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Tropical Cyclone Rita

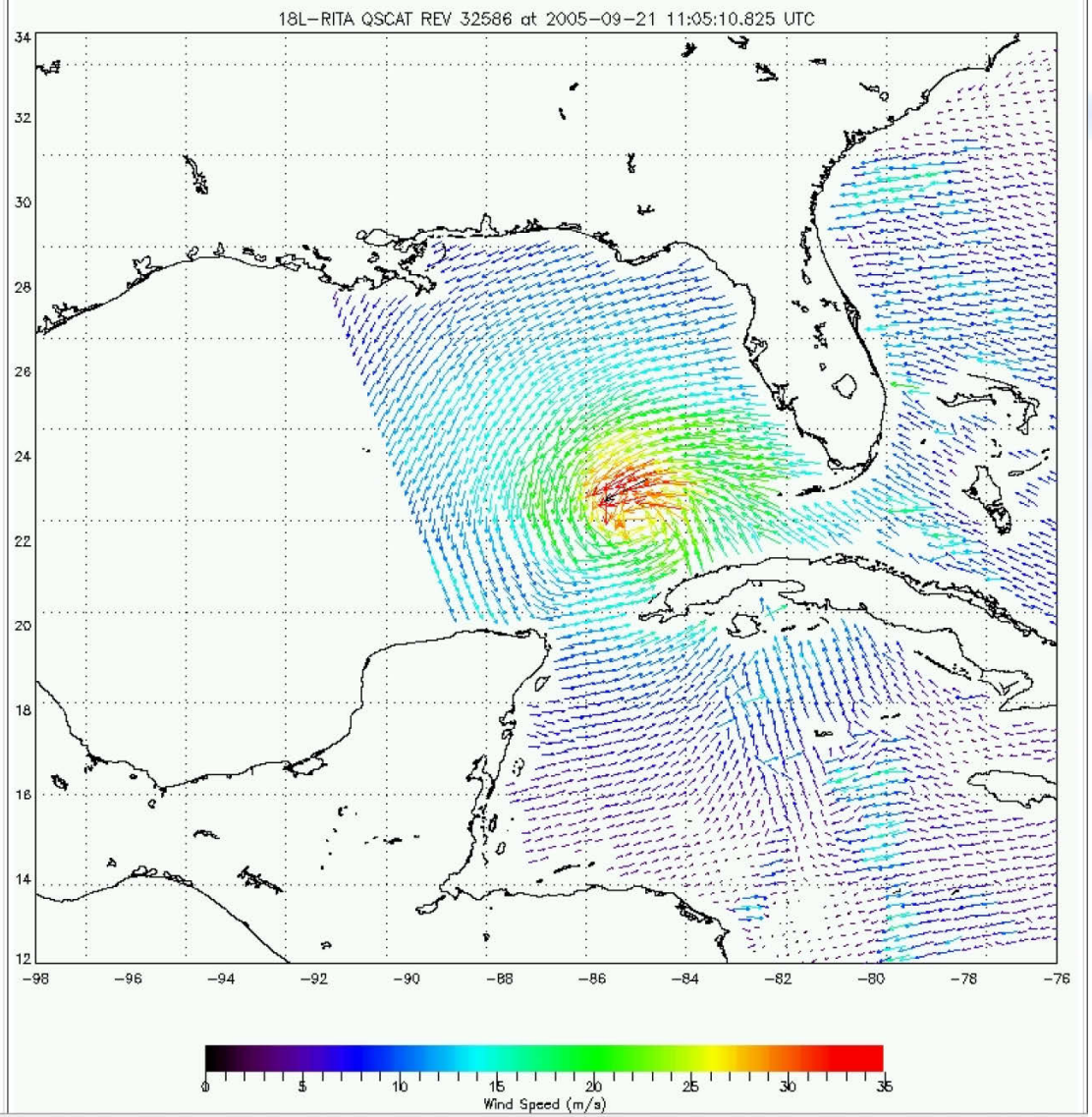
Su	M	T	W	Th	F	S
			01	02	03	04
05	06	07	08	09	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

< 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



JPL Tropical Cyclone Information System

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		

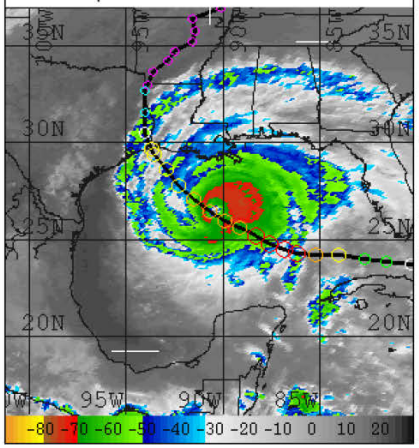
< September 2005 >

- MLS
- SeaWINDS
- GPS-RO
- OMI
- AIRS
- PR
- TMI
- AMSRE
- AMSU-A
- SSMI
- GEO
  - GOE12
  - GOE10
    - BRIGHTNESS
      - 2005-09-23 06:00:00

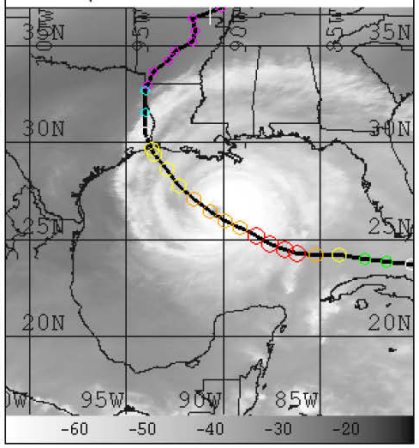
Download All

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

23-Sep-2005 0600Z GOE-10 IR RITA



23-Sep-2005 0600Z GOE-10 VAP RITA



New Features

- The large scale – GE
  - Available
    - SST; TPW; 85 GHz; AIRS (Skew-T)
  - Coming
    - 37 GHz, Rain Indicator, AOT, IR, OHC
    - Model: ECMWF; GFS
- Format - netcdf

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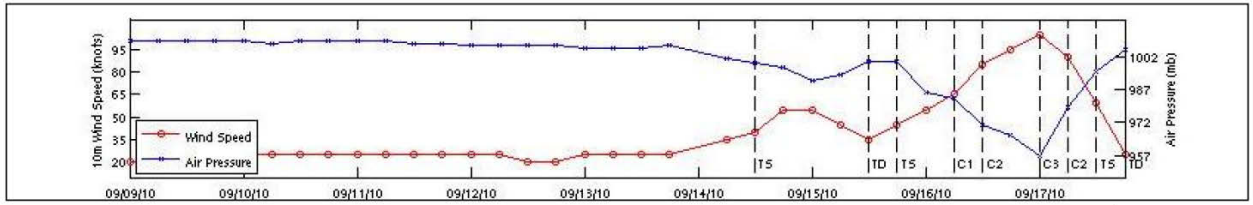
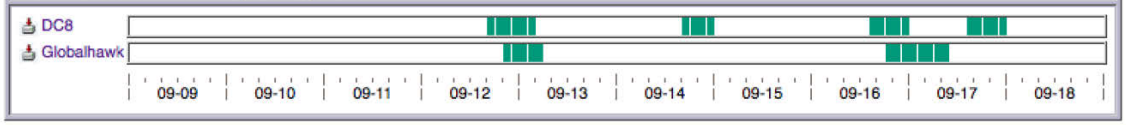
Select Year 2010

- East Pacific
- West Pacific
- North Indian
- North Atlantic
  - Category 5
    - Igor
  - Category 4
    - Danielle
    - Earl
    - Julia
  - Category 3
    - ☑ Karl
  - Category 2
    - Alex
    - Paula
    - Tomas
  - Category 1
    - Lisa
    - Otto
    - Richard
    - Shary
- South Indian
- South Pacific

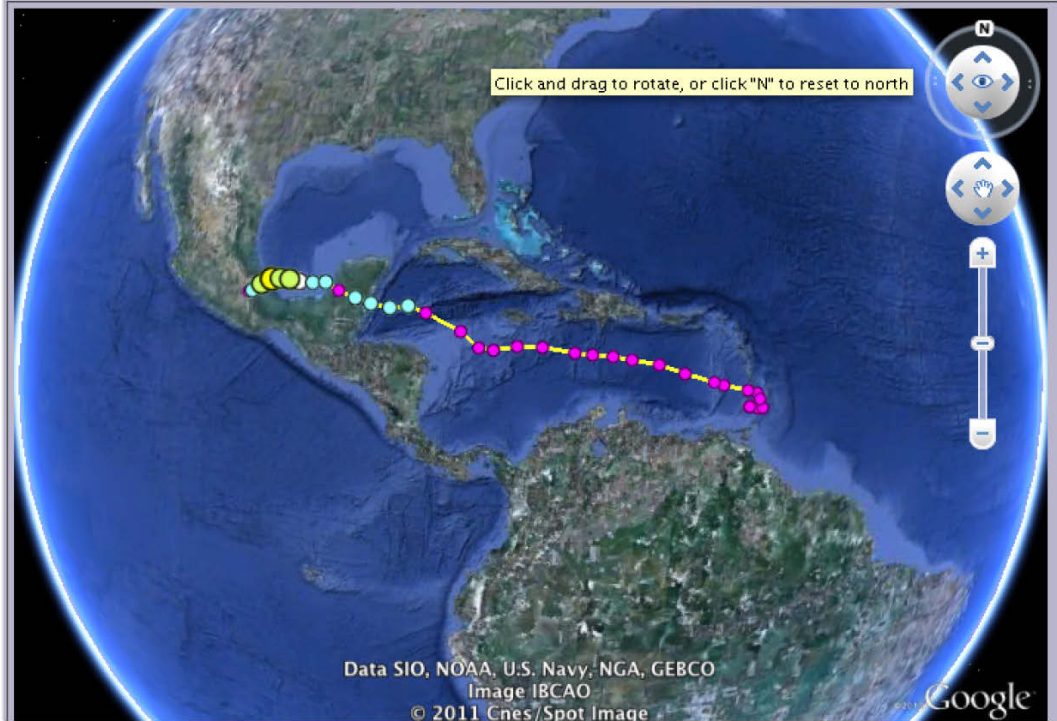
Tropical Cyclone Karl Get Tracks



Storm-Scale data for Tropical Cyclone Karl



Overlay Large-Scale Data: Select Data to Overlay | Download



Tropical Cyclone Karl

Category

- Tropical Depression
- Tropical Storm
- Category 1
- Category 2
- Category 3
- Category 4
- Category 5

JPL

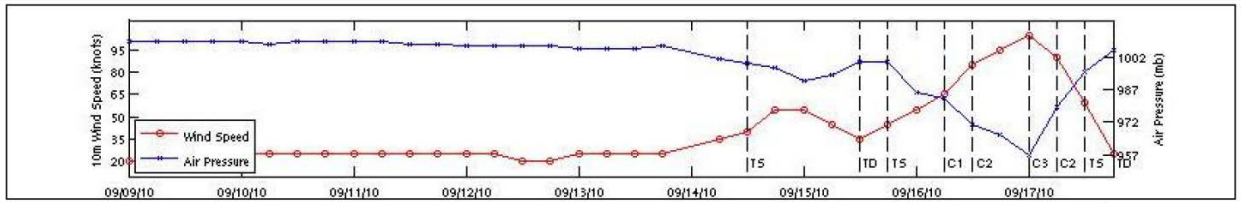
GRIP

JPL Tropical Cyclone Information System

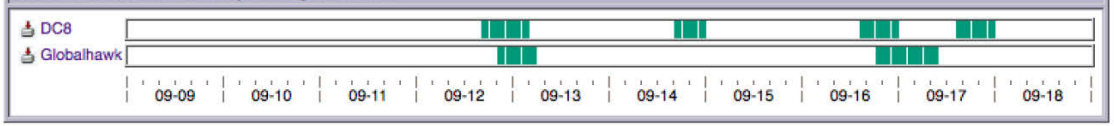
Select Year 2010

- East Pacific
- West Pacific
- North Indian
- North Atlantic
  - Category 5
    - Igor
  - Category 4
    - Danielle
    - Earl
    - Julia
  - Category 3
    - Karl
  - Category 2
    - Alex
    - Paula
    - Tomas
  - Category 1
    - Lisa
    - Otto
    - Richard
    - Shary
- South Indian
- South Pacific

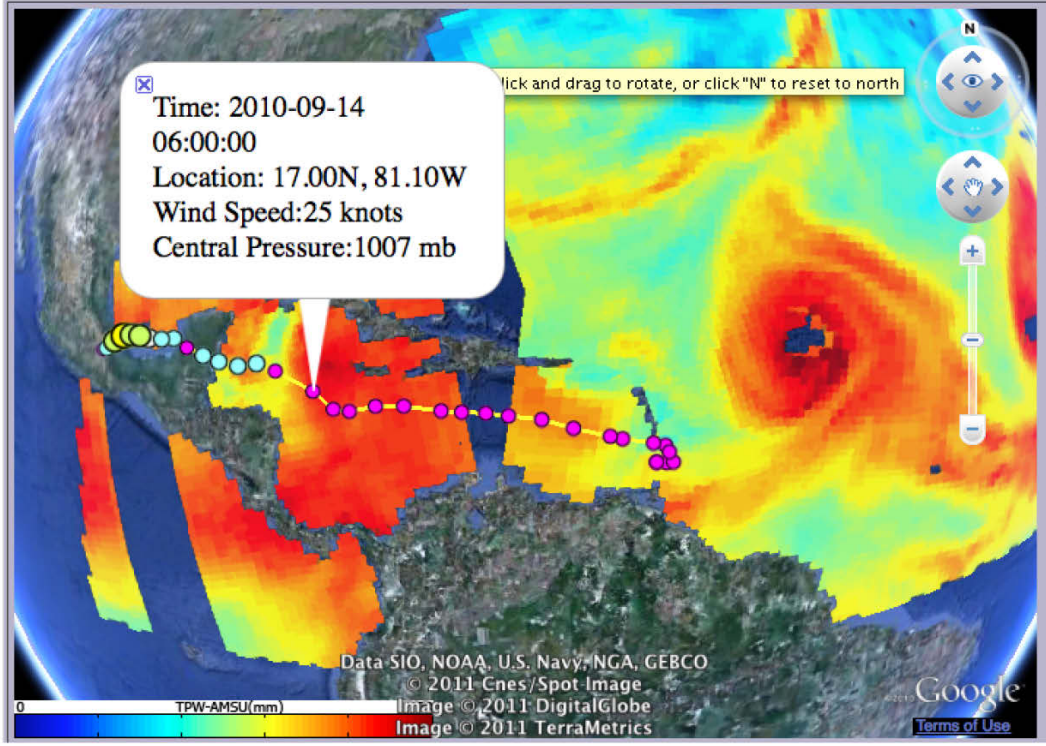
Tropical Cyclone Karl Get Tracks



Storm-Scale data for Tropical Cyclone Karl



Overlay Large-Scale Data: TPW-6hr Download



Tropical Cyclone Karl

Category

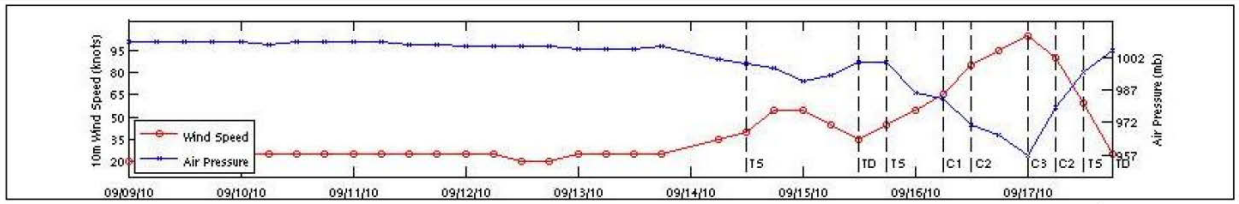
- Tropical Depression
- Tropical Storm
- Category 1
- Category 2
- Category 3
- Category 4
- Category 5

JPL Tropical Cyclone Information System

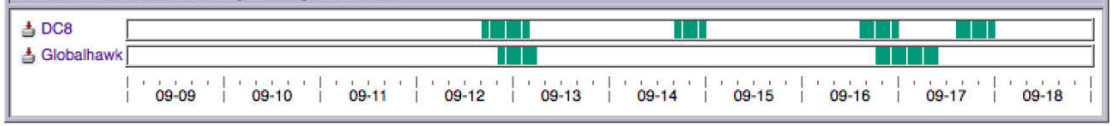
Select Year 2010

- East Pacific
- West Pacific
- North Indian
- North Atlantic
  - Category 5
    - Igor
  - Category 4
    - Danielle
    - Earl
    - Julia
  - Category 3
    - Karl
  - Category 2
    - Alex
    - Paula
    - Tomas
  - Category 1
    - Lisa
    - Otto
    - Richard
    - Shary
- South Indian
- South Pacific

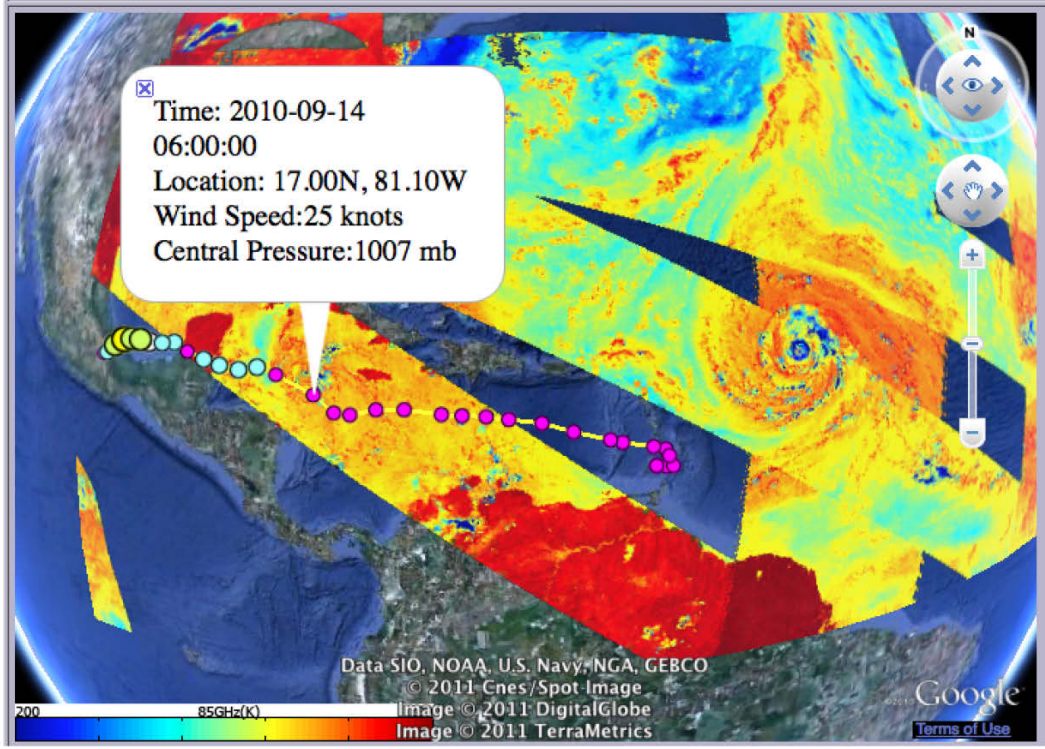
Tropical Cyclone Karl Get Tracks



Storm-Scale data for Tropical Cyclone Karl



Overlay Large-Scale Data: 85H-6hr Download

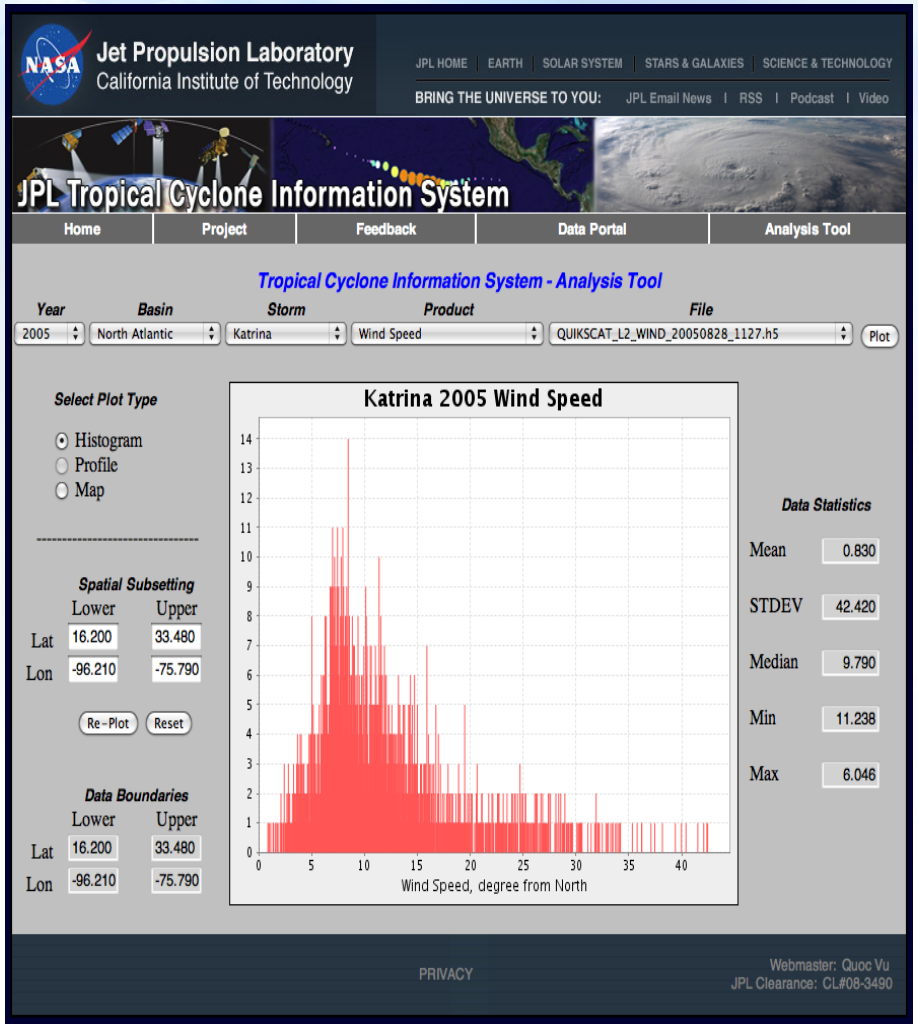


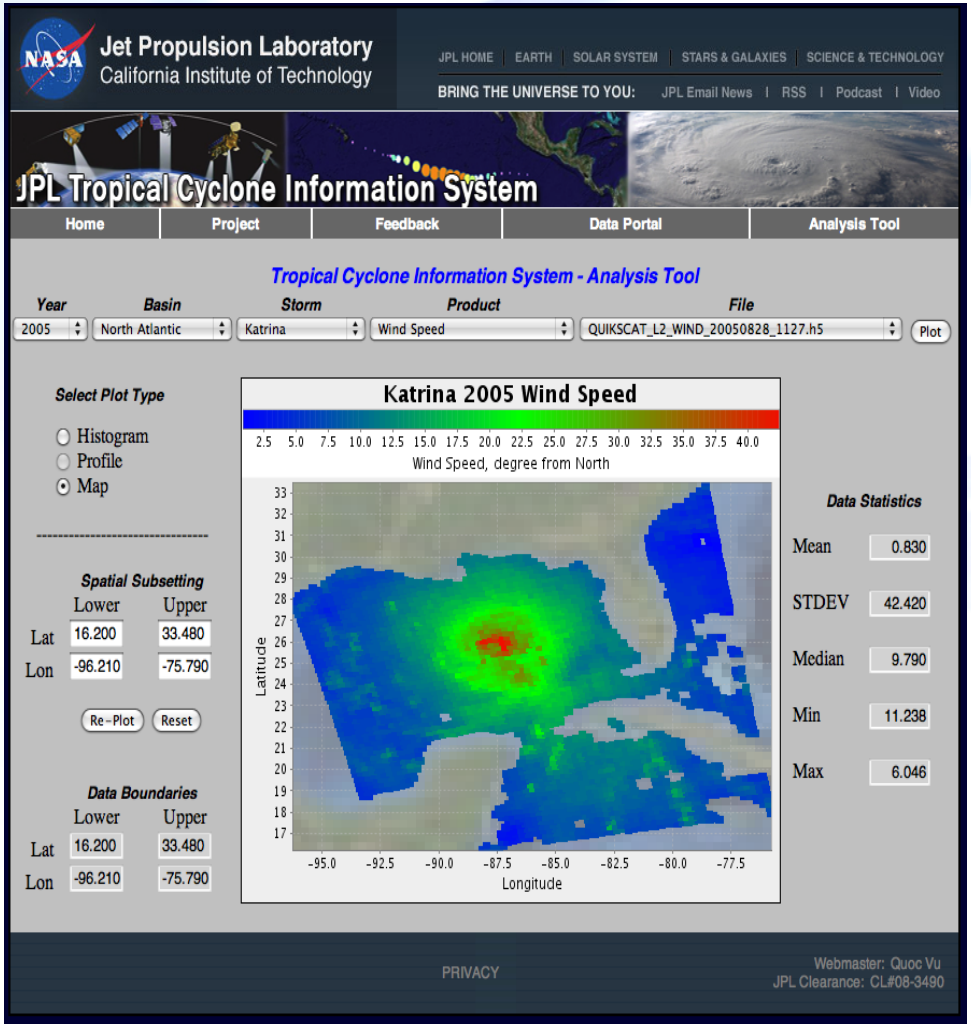
Tropical Cyclone Karl

Category

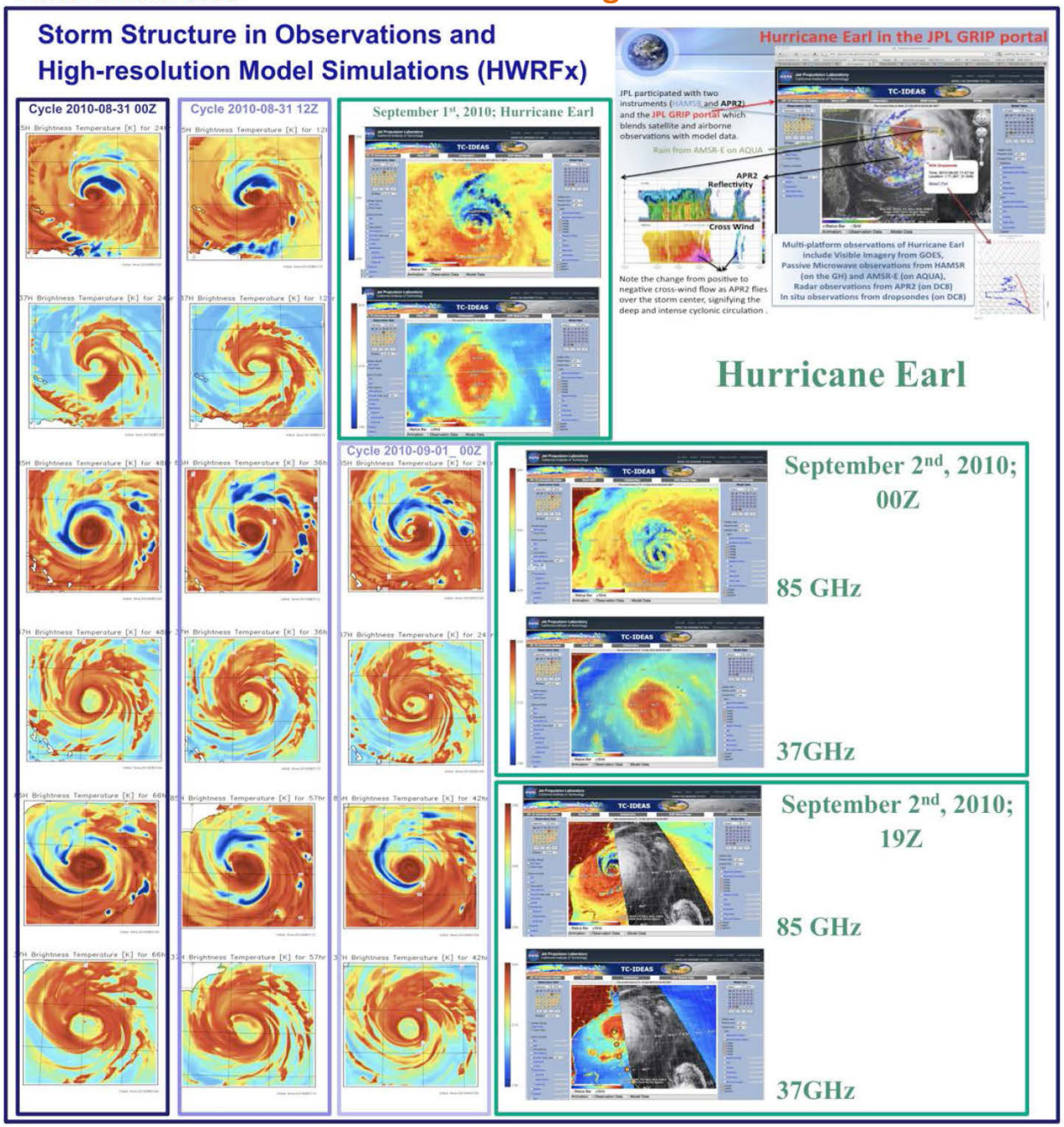
- Tropical Depression
- Tropical Storm
- Category 1
- Category 2
- Category 3
- Category 4
- Category 5

Analysis Tools – Current Status
Single Parameter Statistics





Poster # A41B-0086 - 2010 Fall AGU meeting – Hristova-Veleva et al.



RESEARCH

MODEL VALIDATION

- **Collaboration with NOAA's Hurricane Research Division**
- Used the JPL GRIP portal to identified a number of cases to use for the evaluation of different hurricane forecasts.
- Focus on evaluating the HRD's forecast of hurricane Earl.
- 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 (the brightness temperatures at 37 and 89 GHz).
- Found some deficiencies, even though the model was capable in depicting the precipitation structure and its evolution

Beyond the image comparison …

- In this study we again used the **HWRFX model forecast** of the thermodynamic and hydrometeor fields to forward simulate satellite observables **(brightness temperatures computed at HRD)**

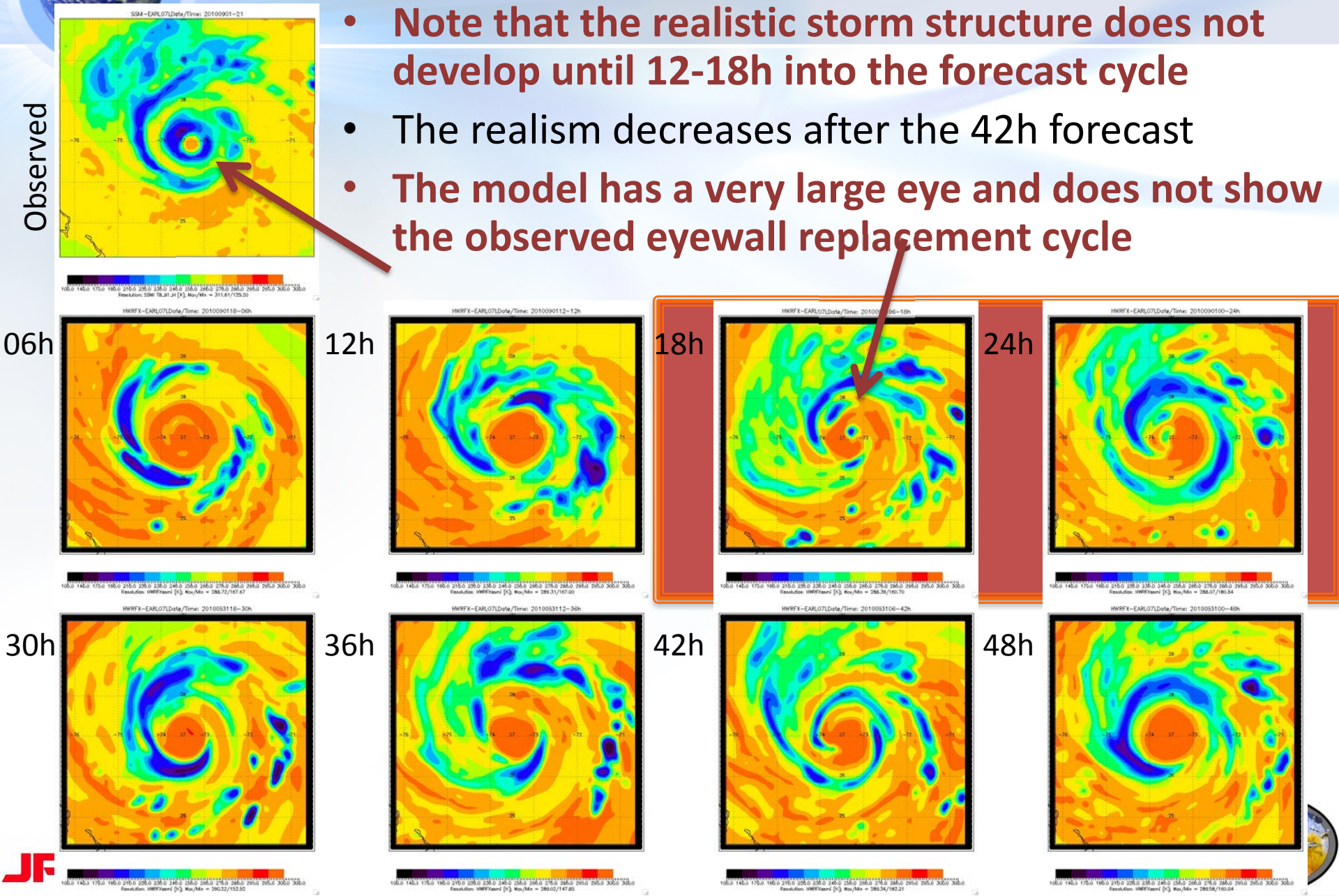
- We use the digital data to evaluate the model forecast. We consider the impact of:

  - **Satellite sampling**
  - **Resolution of the satellite data**
  - **Physics-induced biases**

STRUCTURE

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

- **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**



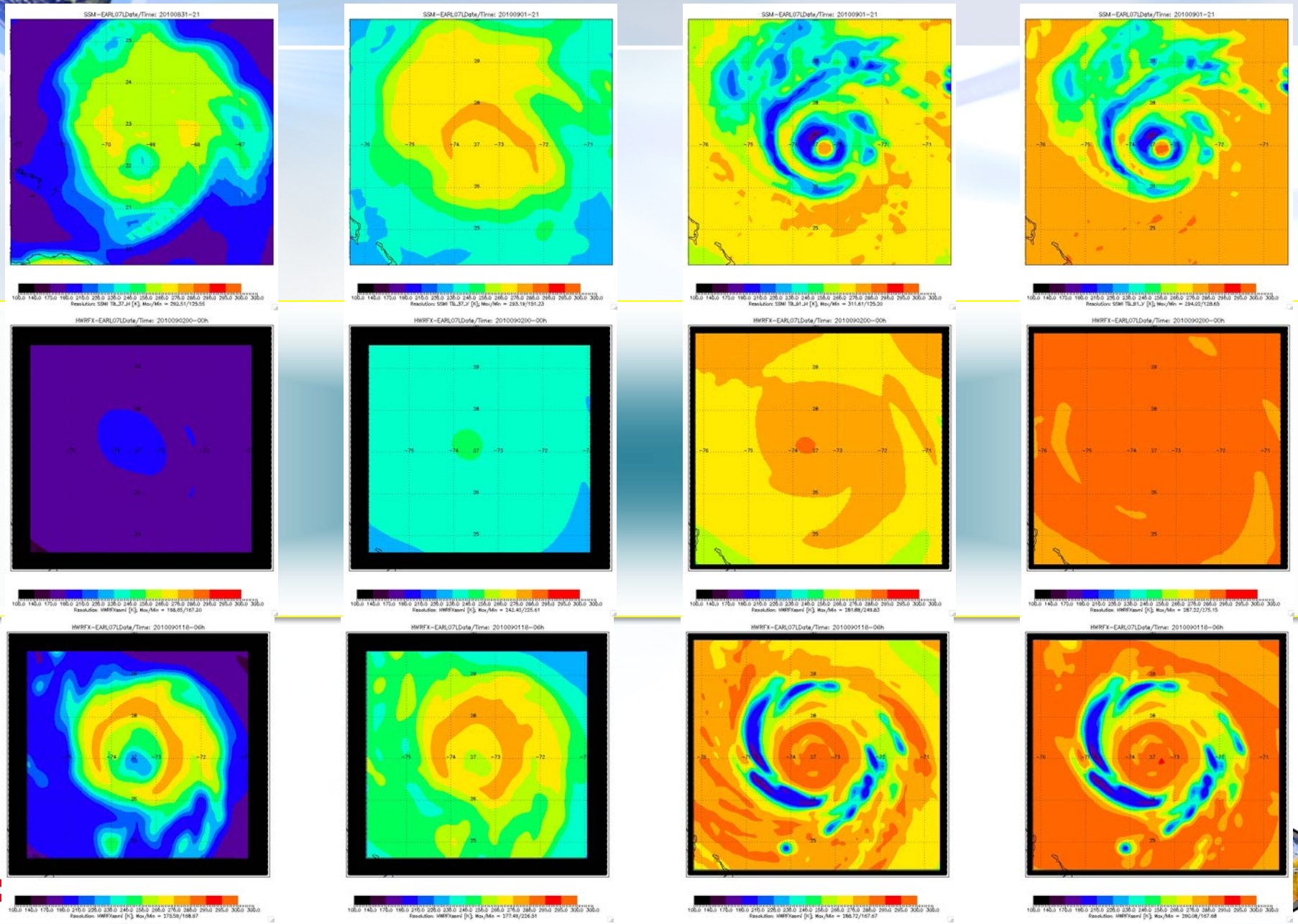
Evaluating the initial conditions

37H 37V 85H 85V

OBSERVED

ANALYSIS

06h Forecast



Summary

1. The long spin-up time might be the result of sub-optimal initial conditions which do not contain the observed precipitation structures.

2. During the model initialization we should make every effort to assimilate the microwave satellite information inside the precipitating hurricane core in order to incorporate:

   – **the precipitation-related thermodynamics**
   – **the important vortex asymmetries**