Science Mission Directorate

NASA's Hurricane Research Program

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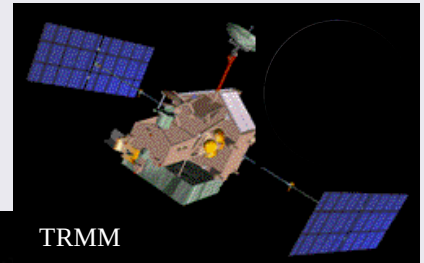
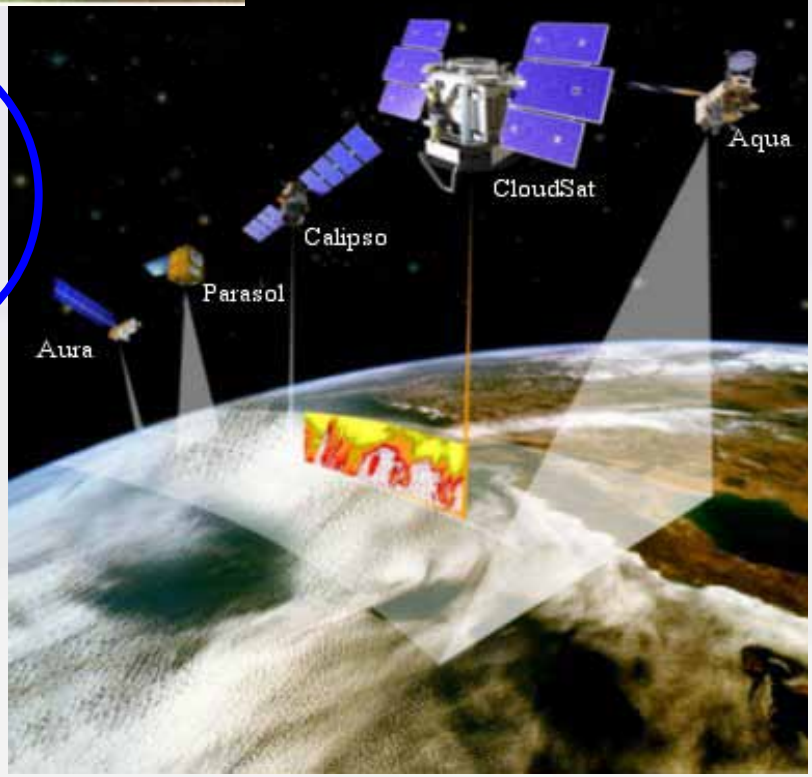
RESEARCH SYNERGY



Models

Aircraft

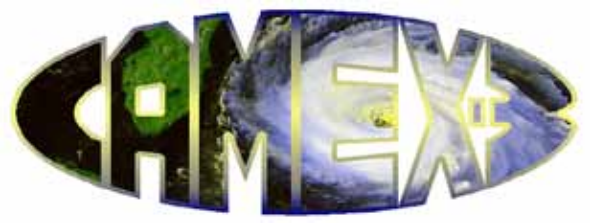
Satellite



A Three-Pronged Approach

NASA's Heritage of Hurricane Research Field Programs

- Joint partnership with NOAA HRD
- Blending of *in situ* and satellite data sets
- Improved parameterization of models
- Data assimilation to improve models
- Technology testbed (i.e. ER-2 dropsonde, Aerosonde)



CAMEX-3 (1998)

- Inner core dynamics
- Synoptic flow environment
- Landfalling intensity change
- Genesis environment

CAMEX-4 (2001)

- Rapid intensification
- Storm movement
- Structure and dynamics
- Scale interactions
- Remote sensing techniques

TCSP (2005)

- Genesis in EPAC, GOMEX, ATL
- Rapid intensification
- Easterly wave dynamics
- Satellite cal/val

NASA ER-2:
Virtual Satellite

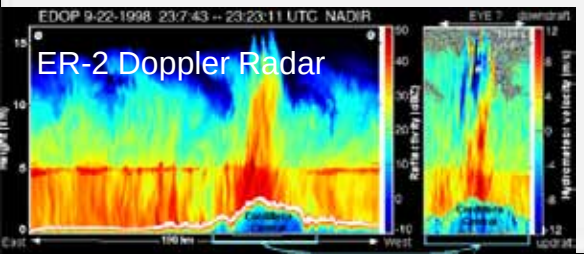
Advanced Microwave
Precipitation Radiometer

MODIS

Lightning
Imaging Sensor

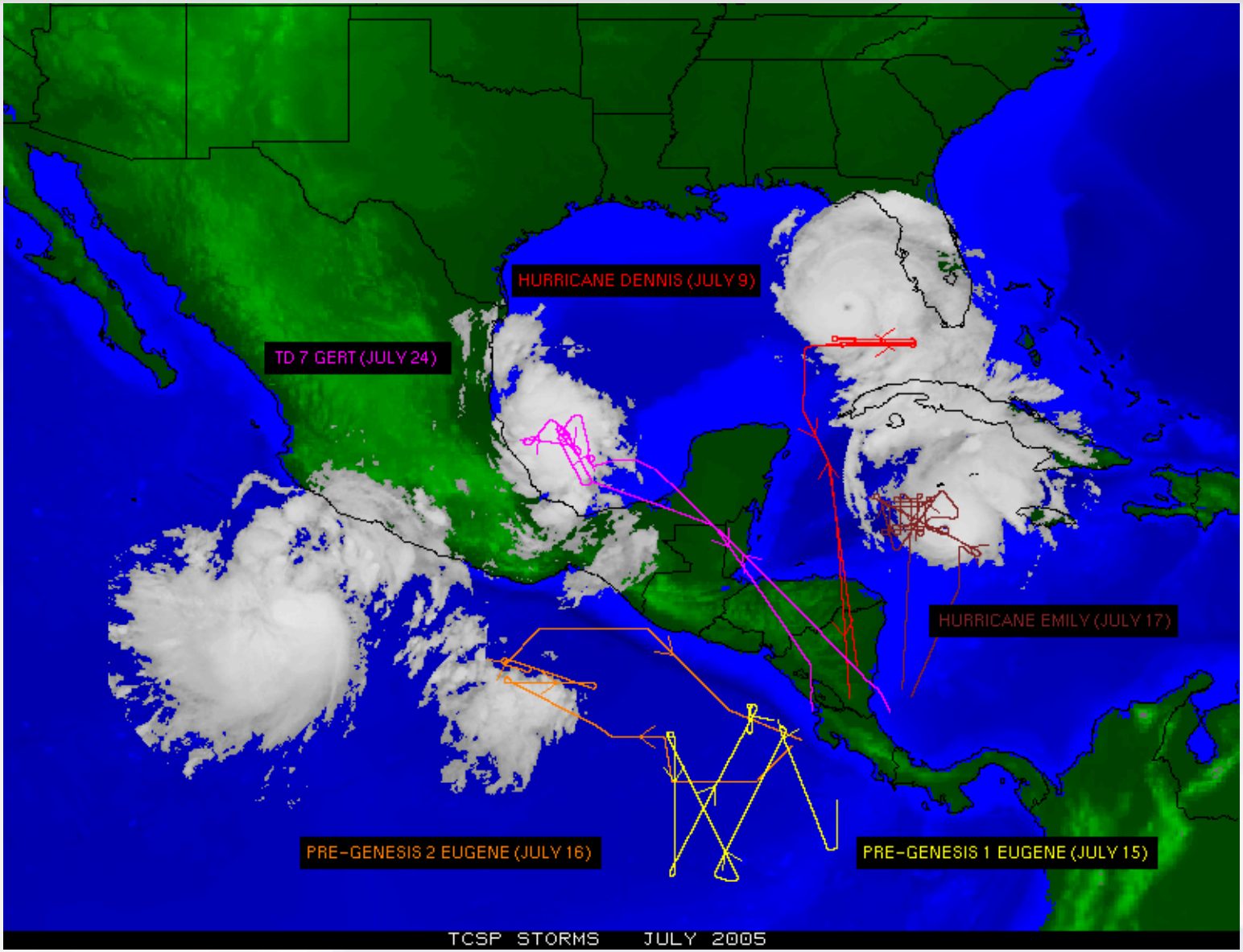
TRMM
Microwave
Imager

Precipitation
Radar

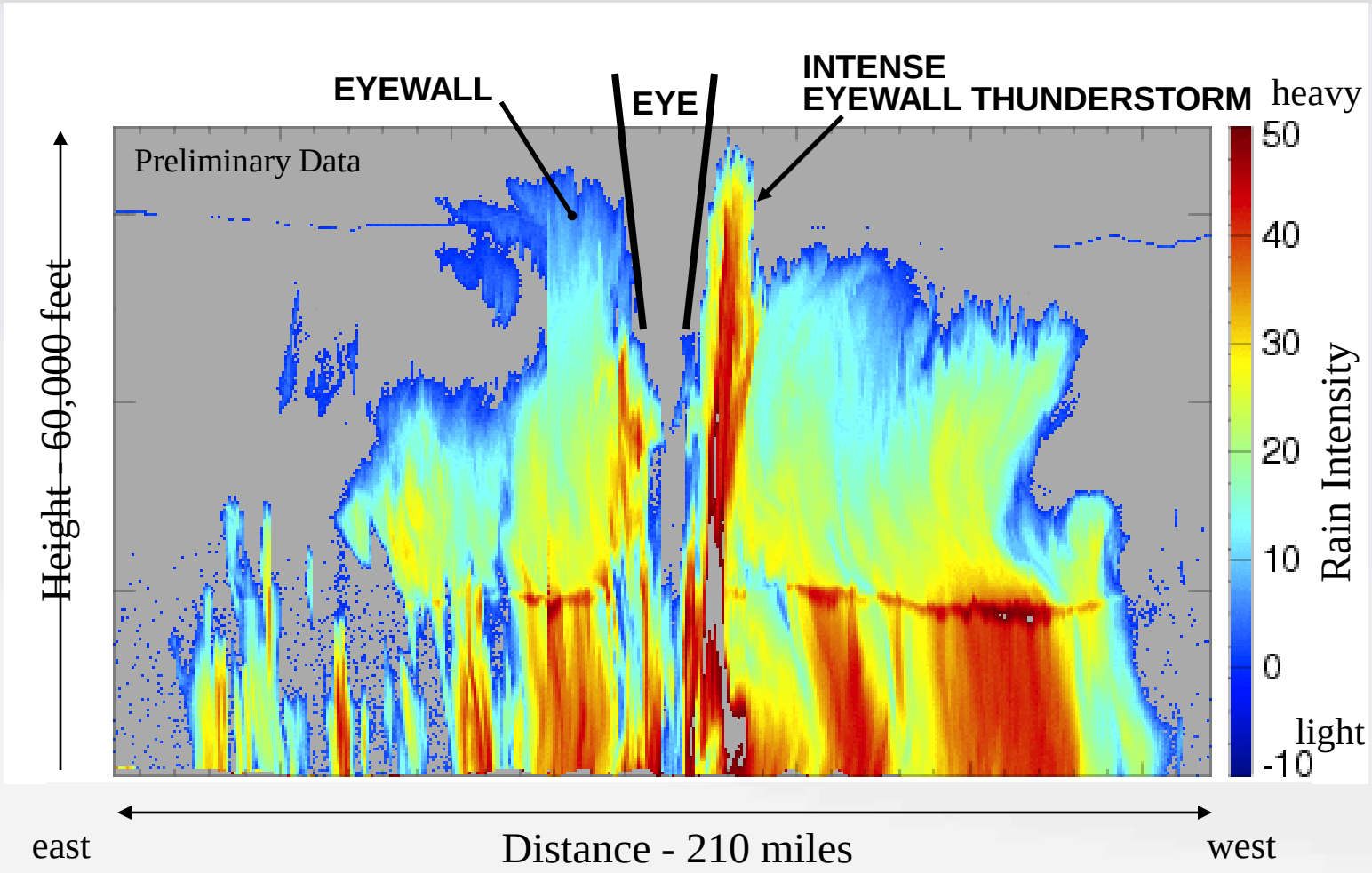


AMSR-E

TCSP Tropical Cyclone Missions



ER-2 Doppler Radar (EDOP) Views Detailed Super-Anatomy Of Intense Hurricane Emily During NASA's TCSP Experiment



- High impact (strong category) storm during US landfall
- Strongest hurricane ever overflown by a NASA research aircraft
- Deepest "hot tower" ever imaged by the ER-2 airborne Doppler radar

NASA/NOAA/Aerosonde Partnership

NASA: Provided project management support, airfield, restricted area access, airspace coordination, payload engineering review as well as flight and ground safety review/oversight.

NOAA: Provided science analysis funding to the PI who also made the data available in real-time to National Hurricane Center forecasters.

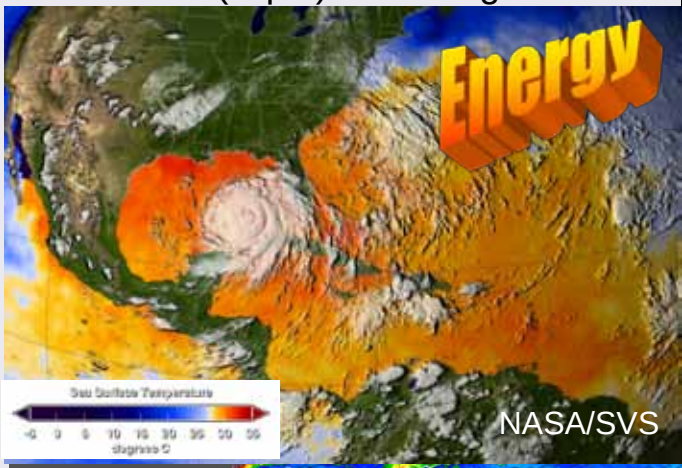
Aerosonde: Provided the aircraft, manpower for maintenance and operations, and made the data available to the PI at the Hurricane Research Division in real-time.

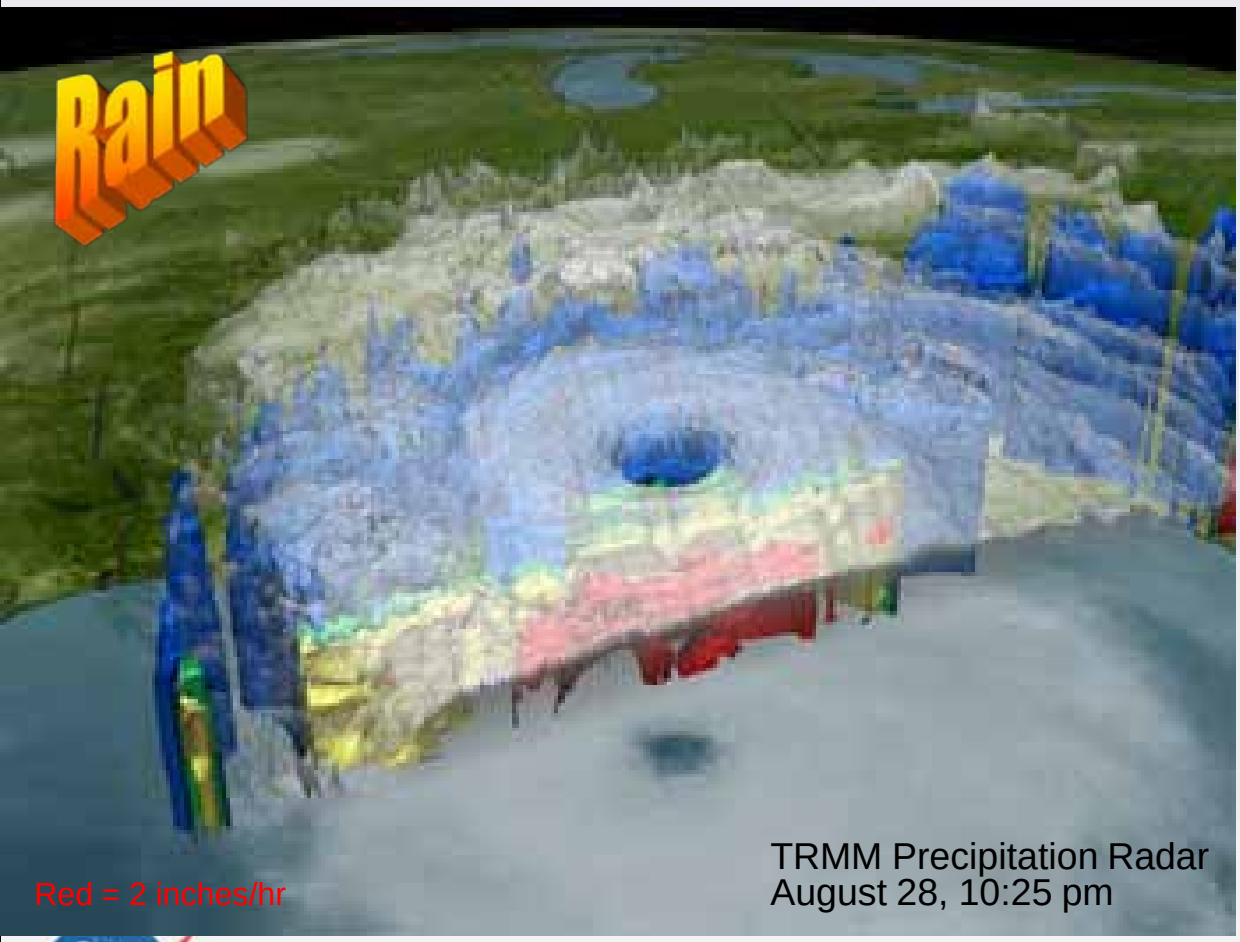
NASA Satellites contributing to Hurricane Research

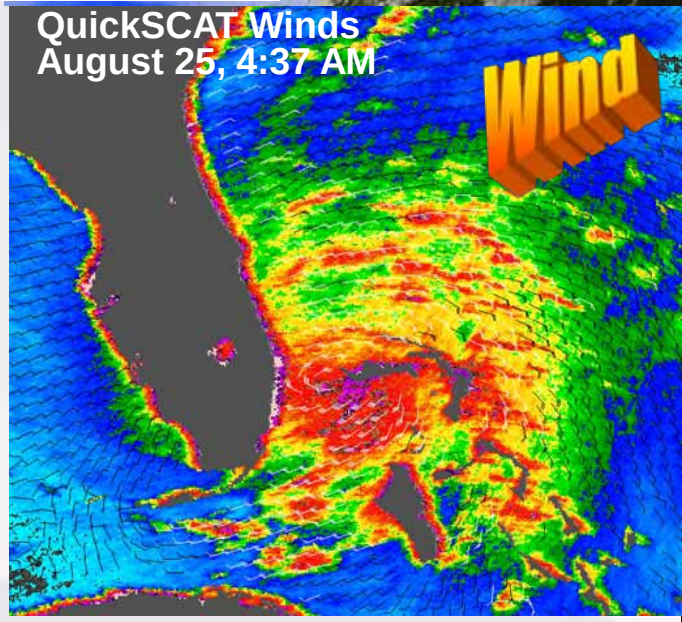
Satellite	Measurement
TRMM	Precipitation Rates, 3-D Precipitation Structure, SST
Aqua	Temperature, Moisture, SST, Precipitation, Flood Extent
QuickSCAT	Ocean Vector Winds
Multiple Satellites	Rain Accumulation
TOPEX, Jason	Tropical Cyclone Heat Potential
Landsat 7	Flood Extent

NASA Satellites Observe the Birth and Intensification of Hurricane Katrina

AMSR-E (Aqua) SSTs August 15-27







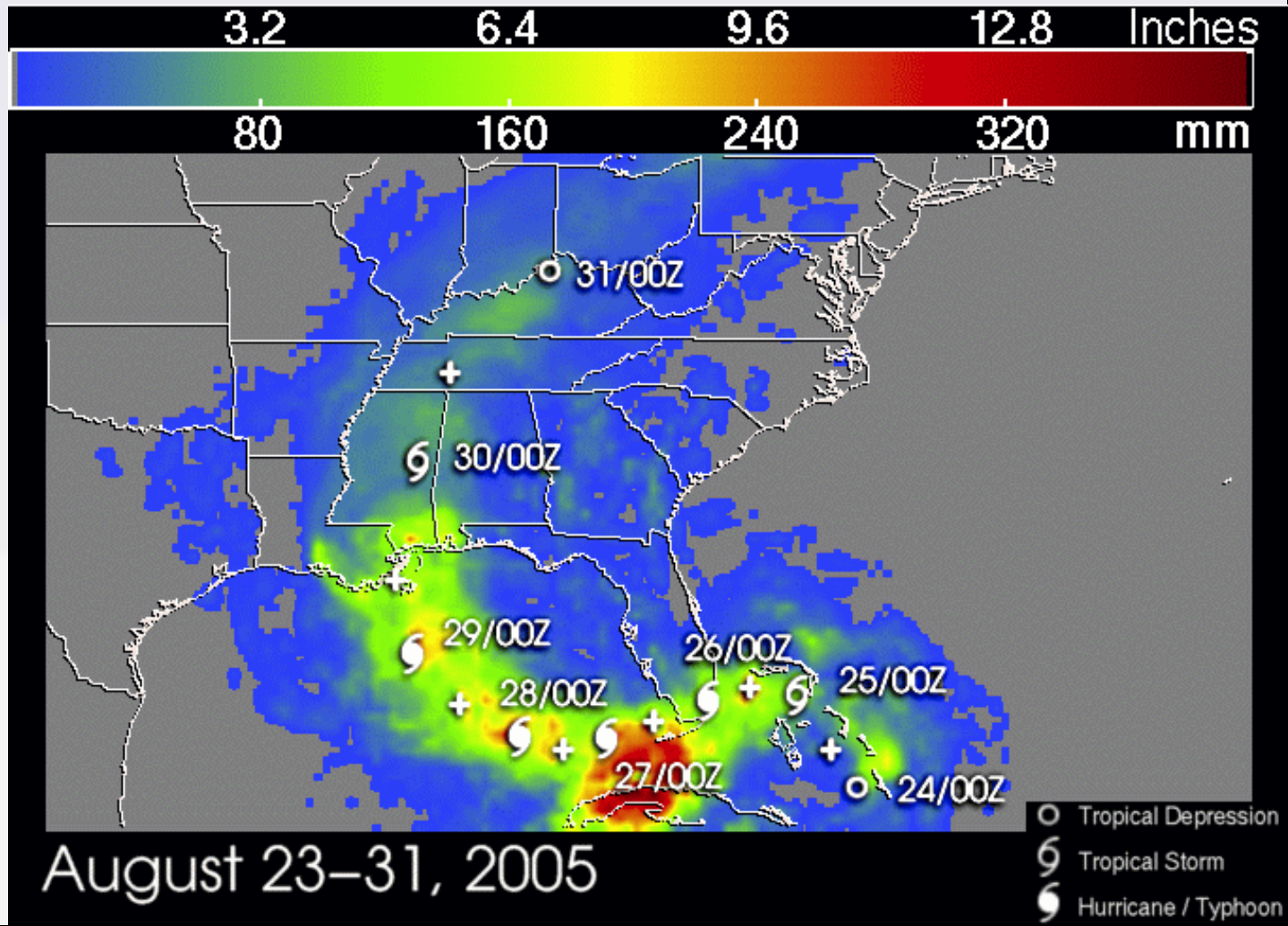
QuickSCAT Science Team, JPL

A Look Inside Katrina's Rain Bands

The Precipitation Radar aboard NASA's TRMM satellite can measure rain rates over time (see movie below) as well as vertical structure within severe storms (see 3-D slight at right). The movie spans Aug. 23-31, while the 3-D snapshot shows Katrina on Aug. 28, 2005, while it was still a Category 5 storm.

NASA Multi-Satellite Precipitation Analysis (MPA) of Hurricane Katrina's Rain Accumulation

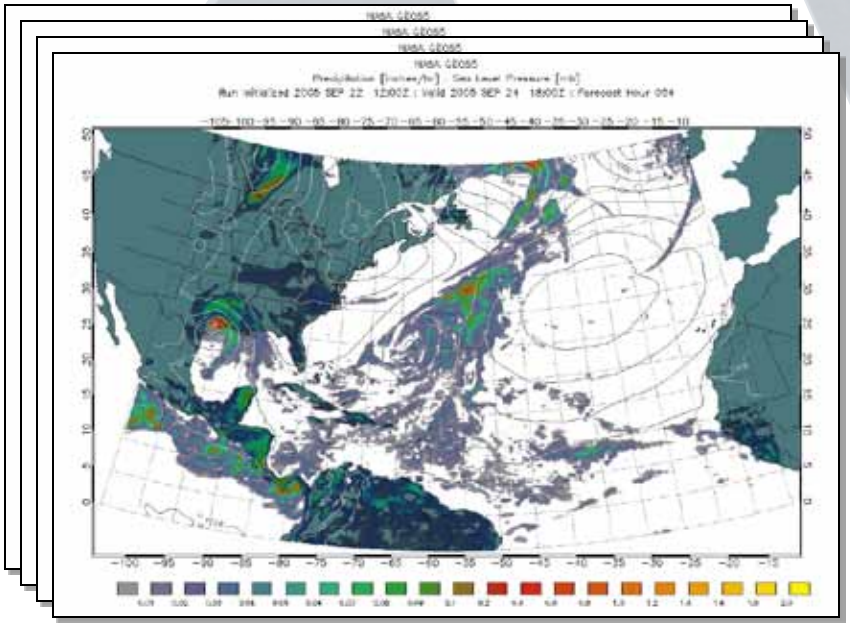
- Rain history of Katrina from genesis over Bahamas to her extratropical transition over the Ohio Valley
- Heaviest rains fell as the storm was Cat 1 during and after landfall over south Florida
- Rain swath widened dramatically as the storm intensified to Cat 5
- Rapid forward speed limited inland rain accumulations
- Rain swath traces a broad arc around the western flank of the Atlantic subtropical ridge



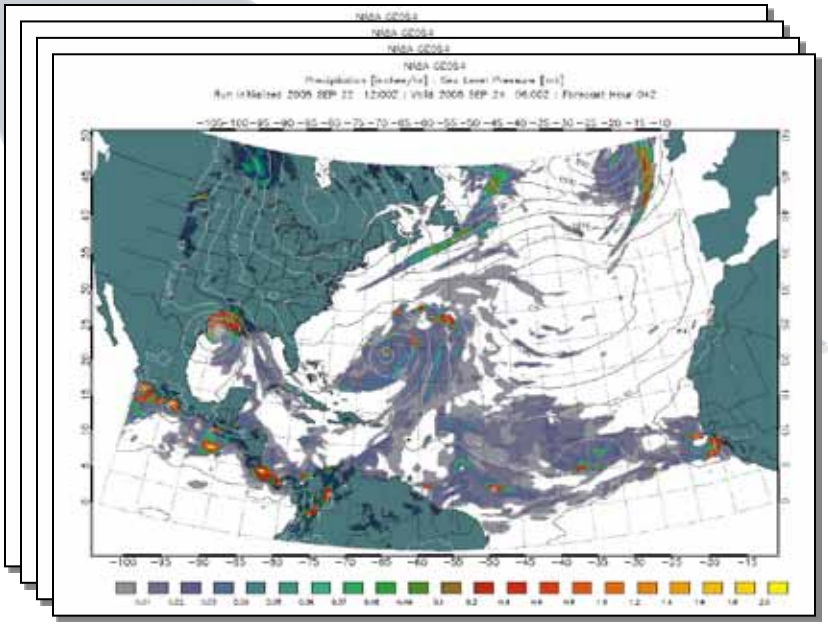
Overarching Goals - MAP '05

- *Understand capabilities for NASA models to predict tropical cyclones & other extreme weather events (GEOS4 & new GEOS5)*
- *Contribute NASA models to the Florida State University hurricane "Superensemble" to test their impact*
- *Deliver output directly to National Hurricane Center for offline evaluation*
- *Exploit Project Columbia capabilities to deliver model output at unprecedented horizontal resolution (1/4 x 1/4°) while meeting NOAA operational delivery schedules*

GEOS4: Existing Model

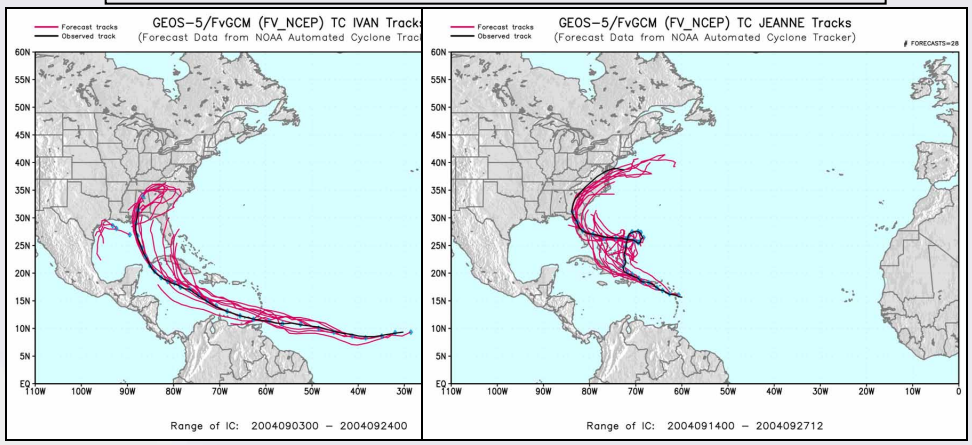


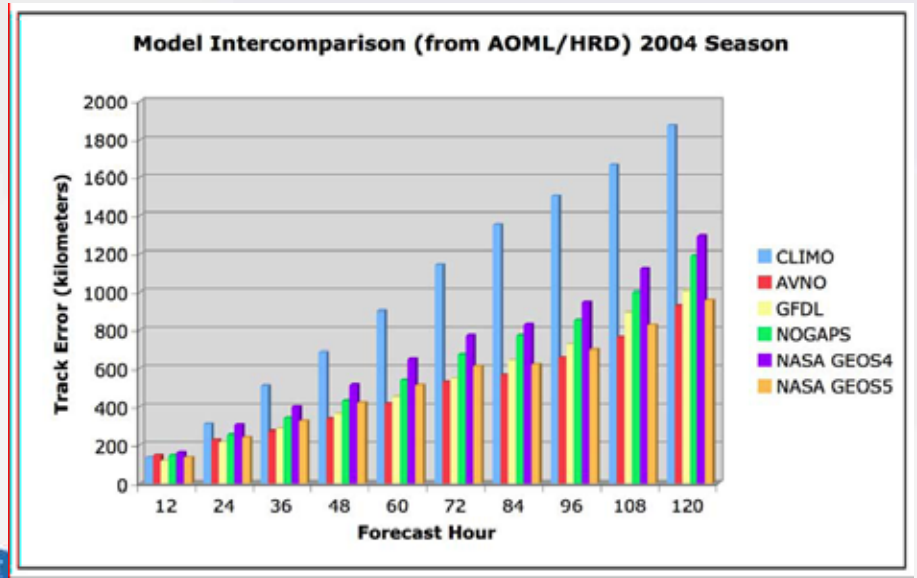
GEOS5: Model in Beta Testing



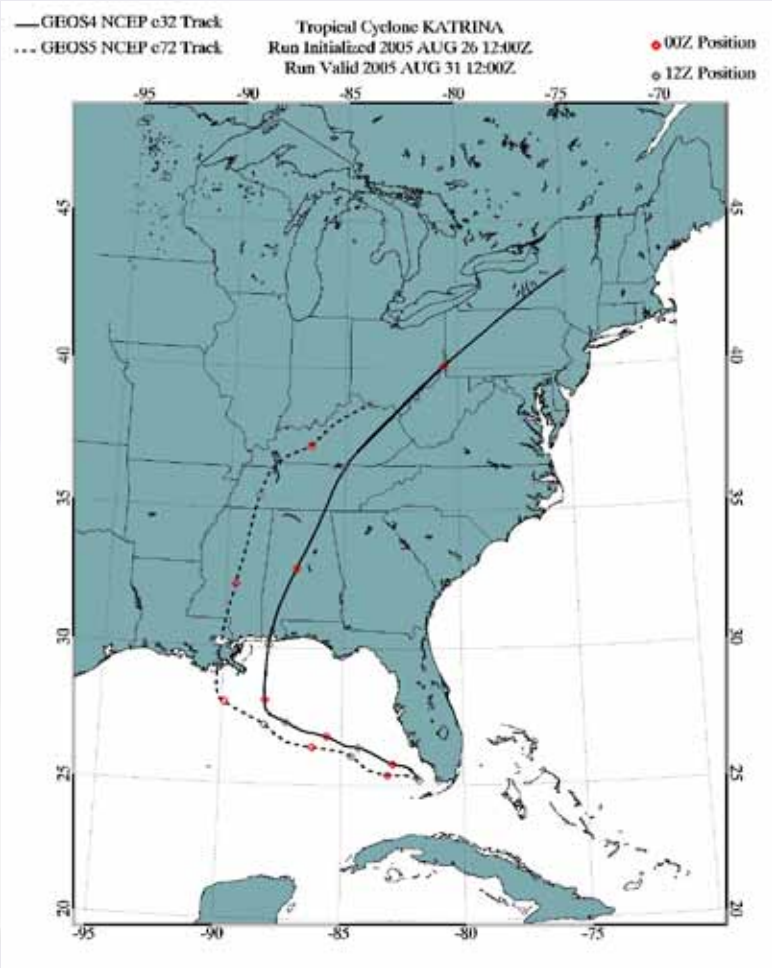
GEOS5: Encouraging Results

Sample Training Runs for FY04 hurricane cases





GEOS-5 shows early forecast of New Orleans landfall for Katrina



Flooding in New Orleans

The false-color Landsat 7 image below shows an 80% flooded downtown New Orleans on Sept. 7, shortly after officials began pumping water back into Lake Pontchartrain.

The image above shows New Orleans on Sept. 15, after much of the floodwater had been pumped out. Officials estimated 380 cubic meters of water per second were pumped back into the lake.

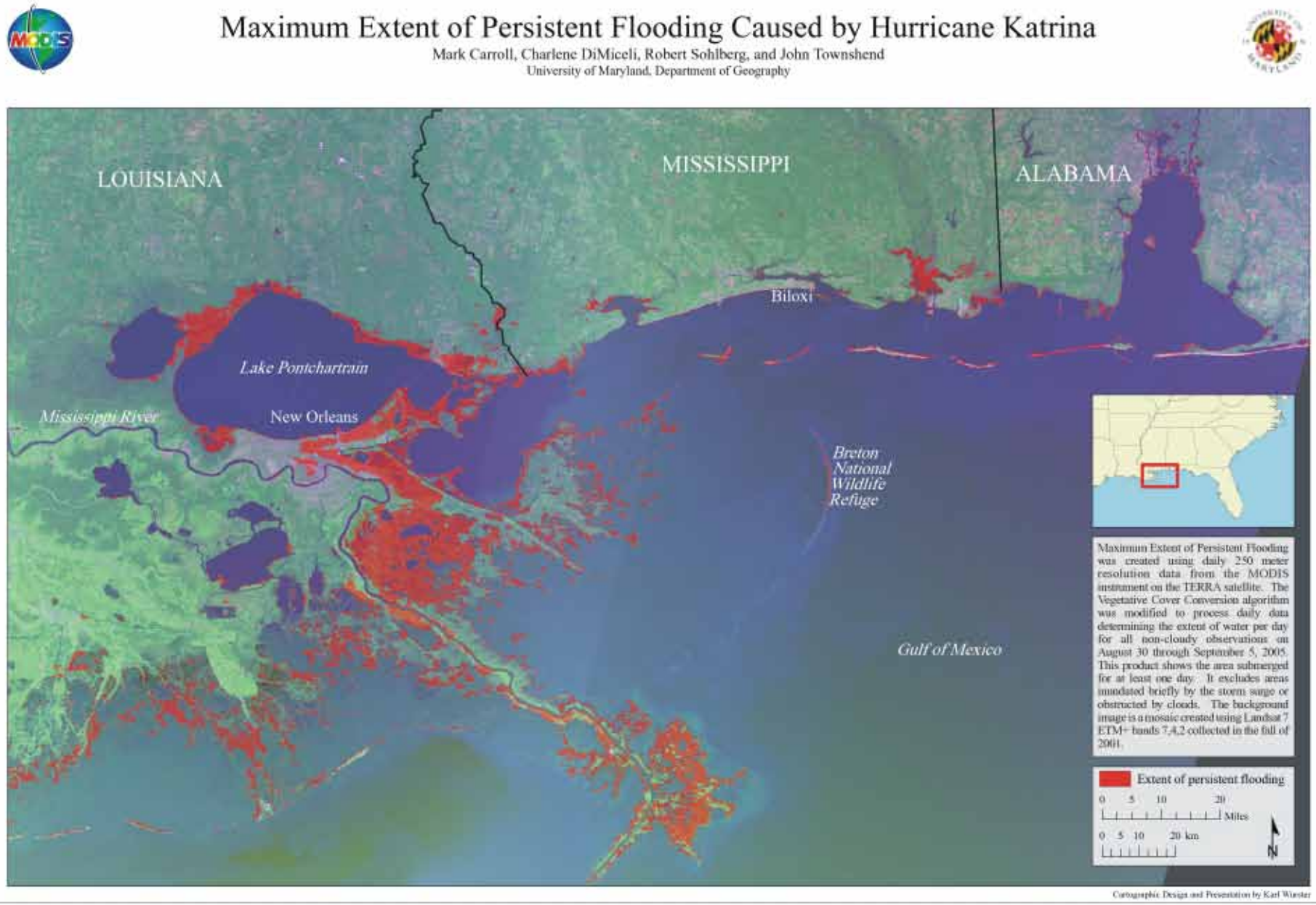
Flood Assessment

August 30, 2005

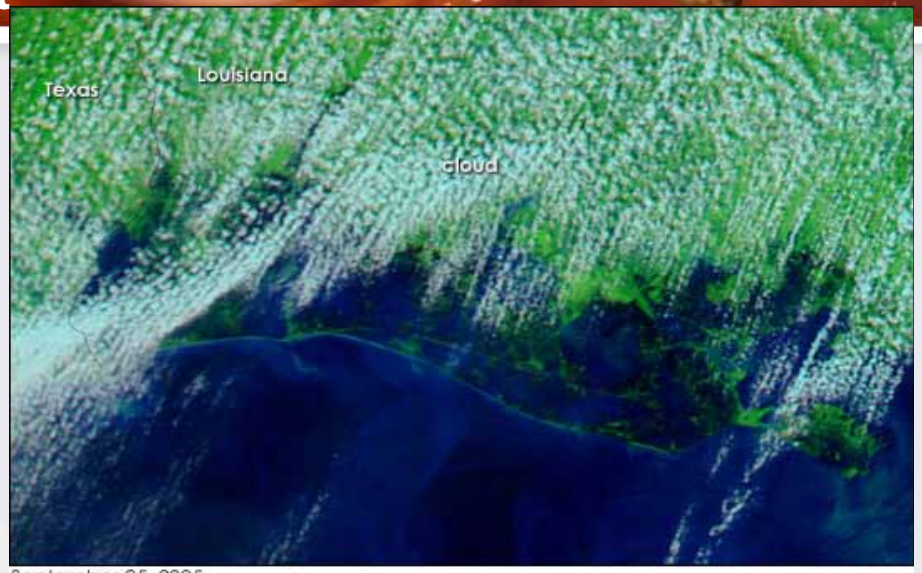
August 27, 2005

Flood Extent of Katrina-Using NASA Satellite Data

MODIS - Katrina Flood Extent

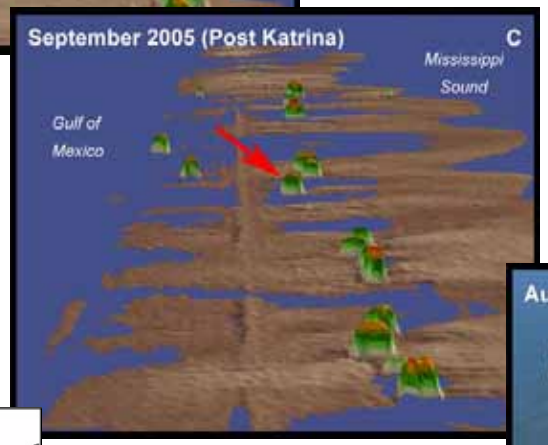


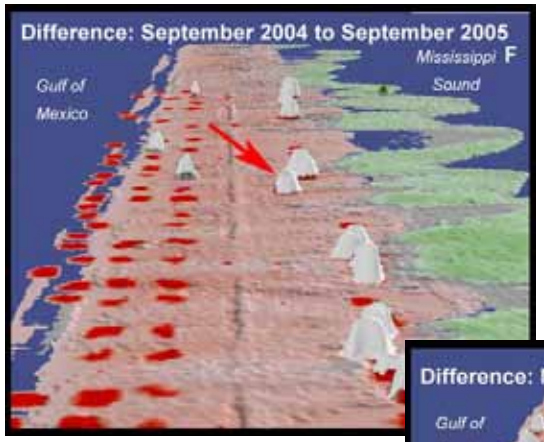
Aqua MODIS Images of Gulf Coast Before and After Rita

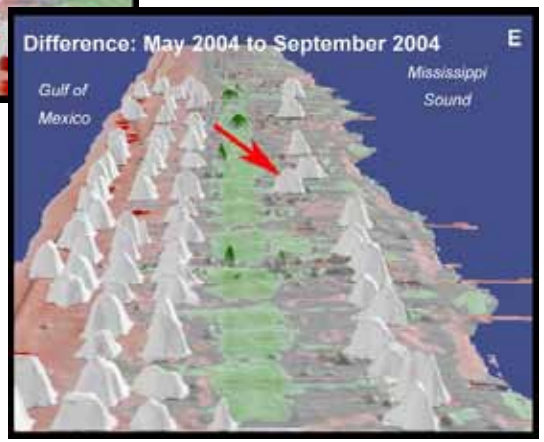


September 25, 2005

September 21, 2005

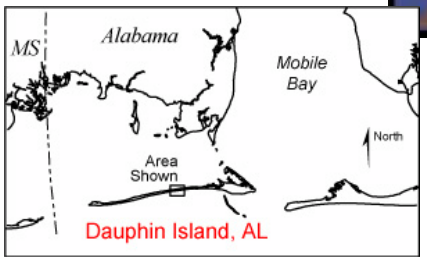


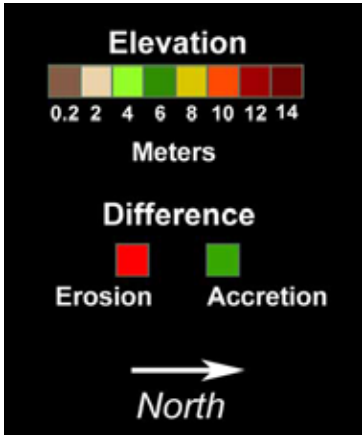




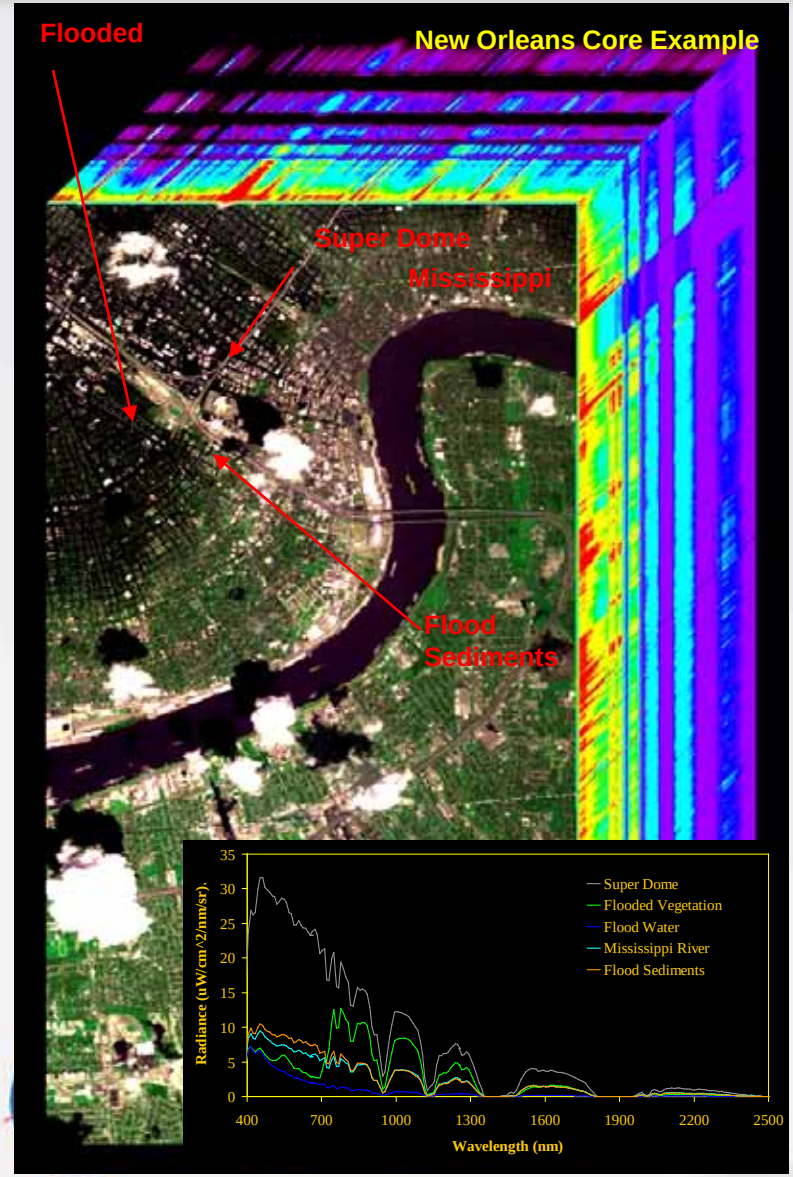
Dauphin Island Prospective:

Lidar measurements from NASA instrumented aircraft showing erosion & deposition on barrier island





AVIRIS Measurements in Support of Katrina Response



- MEASURMENTS

- 62 flight lines over 6 days of New Orleans and Biloxi.
- 10 m spatial and full spectrum 370 to 2510 nm @ 10 nm.

High uniformity, calibration accuracy, precision (SNR)

- OBJECTIVE

Impact of flood and devastation assess via NASA advanced imaging spectroscopy

Example: Flood water composition, particulate distribution, oil contamination, methane leaks, environmental damage, fires,

- ANALYSIS STATUS

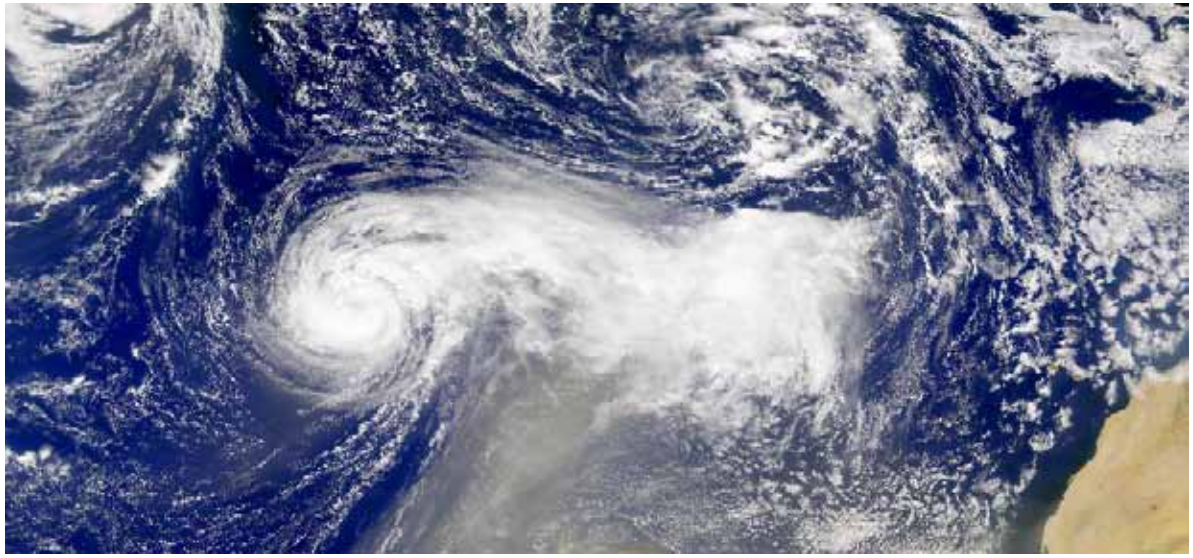
Calibrated radiance being produced

Inversion from radiance to reflectance in process

Spectroscopic analysis to follow

ESS Planned Hurricane Field Campaign: NAMMA-06

- Out of Africa: African Easterly Waves are the progenitors of many late-season, strong category hurricanes that strike the U.S.
- Leverages off AMMA SOP-3 and will be based in Cape Verde
- Multidisciplinary approach involving Weather, Water & Energy, Composition foci
- Partnering with European consortium, NOAA HRD
- NAMMA-06 science in line with CCSP objectives
- Platforms to include DC-8, Aerosonde, TOGA & NPOL radars, micropulse lidars



African SAL: Impact on tropical cyclogenesis - hypothesize to be a hurricane suppressant, in an ocean marginally suitable for hurricane generation; examine SAL impact on microphyiscs, thermodynamic instability, shear,airmass dessication

Planning Activities

- Satellites
  - GPM (delayed)
  - NPP (delayed)
  - Wind Lidar (roadmap plan)
    - 4 IIP proposals selected

Models
- Improving GEOS5 parameterization and data assimilation techniques

Field Experiments
- NAMMA06
- Joint NASA/NOAA plans for UAV flights
- Collaboration with NOAA, NSF and DOD perhaps under the THORPEX umbrella