The Hurricane Rainband and Intensity Change Experiment (RAINEX): Observations and Modeling of Katrina and Rita

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In the eye of Katrina
Factors Controlling Intensity Change

- Inner core (eye and eyewall) dynamics
- Environmental conditions, including vertical wind shear, moisture distribution, and sea surface temperature (upper ocean heat content), etc.
RAINEX Science Objectives

- Use airborne observations to examine simultaneously the dynamic and thermodynamic *structures* of hurricane inner core and outer rainband regions where the positive potential vorticity associated with deep convective cores are located.

- Use numerical model to investigate the *interactions* of the rainbands and primary hurricane vortex circulation and their role in hurricane intensity change.
How Hurricanes Gain Strength

1. Hurricane begins as a tropical storm
2. Eyewall forms as storm intensifies
3. Concentric eyewalls appear as the hurricane is the most intense
4. Inner eyewall breaks down and storm weakens

Collecting Data
Parachuting instruments called dropsondes are released from airplanes and record:
- air pressure
- temperature
- altitude
- humidity
and more...

Analyzing Data
Gathered data will be used to develop models to better predict hurricane intensity.
Simplified RAINEX Data Flow

IOP: August-September 2005
High-Resolution Multi-nested Vortex-Following Numerical Models at University of Miami:

- UM/RSMAS Coupled Atmos-Wave-Ocean Model
- Weather Research and Forecast (WRF) Model

Mini ensemble MM5 and WRF forecasts using GFS, NOGAPS, CMC, and GFDL forecast fields as initial and lateral boundary conditions.
Intensity of Hurricane Katrina (2005)

- Wind Speed (kts)
- Pressure (mb)

- Category 5
- Category 4
- Category 3
- Category 2
- Category 1

Time (Hours after 00 UTC August 24)

- 8/27
- 8/28
Eyewall Replacement in Hurricane Rita (2005)

N43 flight-level wind in Rita

Observed

MM5 simulation of Hurricane Rita at 1200 UTC 22 SEP 2005

WRF simulation of Hurricane Rita at 0600 UTC 22 SEP 2005

Radar Reflectivity
Effect of vertical wind shear on Hurricane Rita structure and intensity

Model 5-day forecast
Conclusions

- RAINEX conducted 9 multi-aircraft missions in Hurricanes Katrina, Ophelia, and Rita, and collected data in all stages from Tropical Depression to Category 5 hurricanes.

- RAINEX provided an unique, comprehensive dataset for evaluating and improving high-resolution models.

- High-resolution (~1 km, resolving the inner core and rainbands) forecasts in real-time are extremely valuable for mission planning and overall understanding of the storm structure, evolution, and intensity change.

- Accurate initial and lateral boundary conditions for high-res models are needed.
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Hurricane

Rita MM5 simulation Rain Rate (mm hr⁻¹)

Rita MM5 simulation (5km) Rain Rate (mm hr⁻¹)
Hurricane Internal Dynamics

- Inner core and rainband interactions
- Concentric eyewalls and eyewall replacement cycle

Environment $\rightarrow$ Rainbands $\leftrightarrow$ Inner Core

- Vertical wind shear
- Moisture distribution

Hurricane Rainband and Intensity Change Experiment (RAINEX)
Houze et al. (2006, BAMS)
RAINEX is the first experiment using three-Doppler-aircraft flying in hurricanes.

Approach:

- Use airborne Doppler radar to observe both eyewall and rainband internal vorticity structures simultaneously.
- Use intensive dropsondes for thermodynamic environment of hurricane rainbands and eyewall to support both analysis and modeling/forecasting.
- Use model to determine how the vorticity features evolve and storm intensity changes.