

Recent History- CAMEX 3, 4, TCSP, NAMMA.
Types of flights, instruments carried

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Previous NASA TC Related Field Experiments

Campaign		Location	Date	Objectives	Storms	A/C
Tropical Ocean Global Atmosphere	TOGA-COARE	Townsville, Australia	Jan 1993	Tropical convection	Oliver (1)	DC-8 ER-2 P3s
Convection and Moisture Experiment - 3	CAMEX-3	Patrick AFB, FL	Aug - Sept 1998	TC, TRMM validation, water vapor	Georges (2), Earl (1), Danielle (2), Bonnie (4),	DC-8 ER-2 Citation P3s
Convection and Moisture Experiment - 4	CAMEX-4	Jacksonville NAS, FL	Aug - Sept 2001	TC (track, intensity, landfall), convection	Chantal (1), Gabrielle (2), Erin (1), Humberto (3)	DC-8 ER-2 P3s
Tropical Cloud Systems and Processes	TCSP	San Jose, CR	July 2005	TC (genesis, structure, moisture,..)	Dennis (3), Emily (1), Gert (3), pre-Eugene (2)	ER-2 P3s
NASA AMMA	NAMMA	Sal, Cape Verde	June 2006	TC genesis, SAL impacts	Pre-Ernesto (2), Debbie (1), pre-Gordon (2), pre-Helene (1)	DC-8

TCSP Objectives

Improve understanding and prediction of tropical cyclone genesis, intensity, motion, rainfall potential and landfall impacts by remote and in situ sensing of three phases of water from spaceborne and airborne platforms

Satellite and aircraft remote sensor data assimilation and validation studies pertaining to development of tropical cyclones

ER-2 emphasis

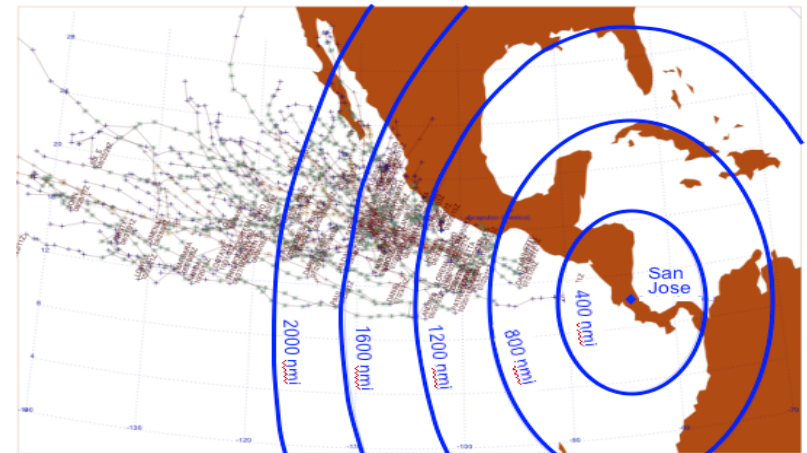
- **Genesis**
- **Microphysics**
- **Convective Burst**
- **Boundary layer conditions**
- **Large area sampling**

Aerosonde

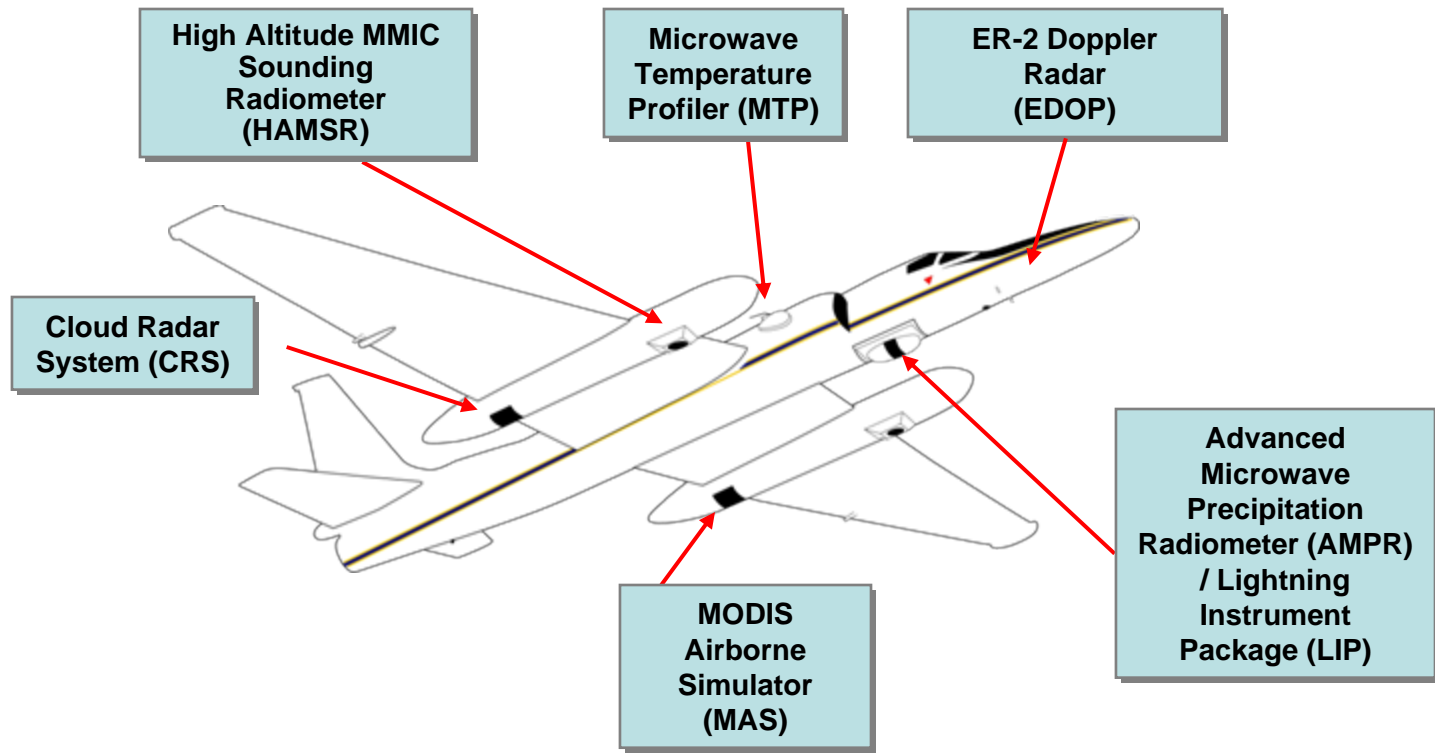
Cyclogenesis in East Pacific

All storms 2000-2004

Rings: ER-2 range out of San Jose, Costa Rica

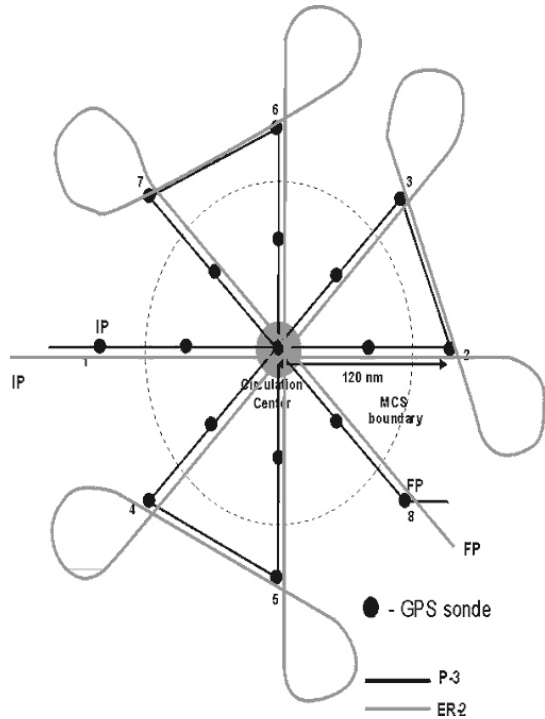


NASA ER-2 Instrument Payload for TCSP

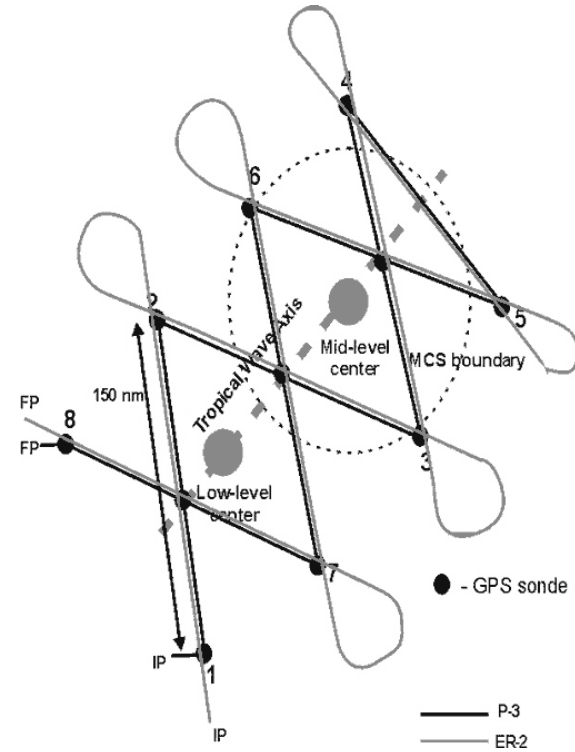


- Advanced Microwave Precipitation Radiometer (AMPR)
 - Precipitation structures*
- Cloud Radar System (CRS)
 - Ice content and vertical velocities*
- ER-2 Doppler Radar (EDOP)
 - Rate rates, ice content, vertical velocities*
- High Altitude MMIC Sounding Radiometer (HAMSR)
 - Temperature and humidity profiles*
- Lightning Instrument Package (LIP)
 - Total lightning count & rates, storm electrical current, storm charge structure*
- MODIS Airborne Simulator (MAS)
 - Visible and infrared imagery*
- Microwave Temperature Profiler (MTP)
 - Temperature profiles and tropopause height*

Example Flight Patterns



Vortex survey pattern

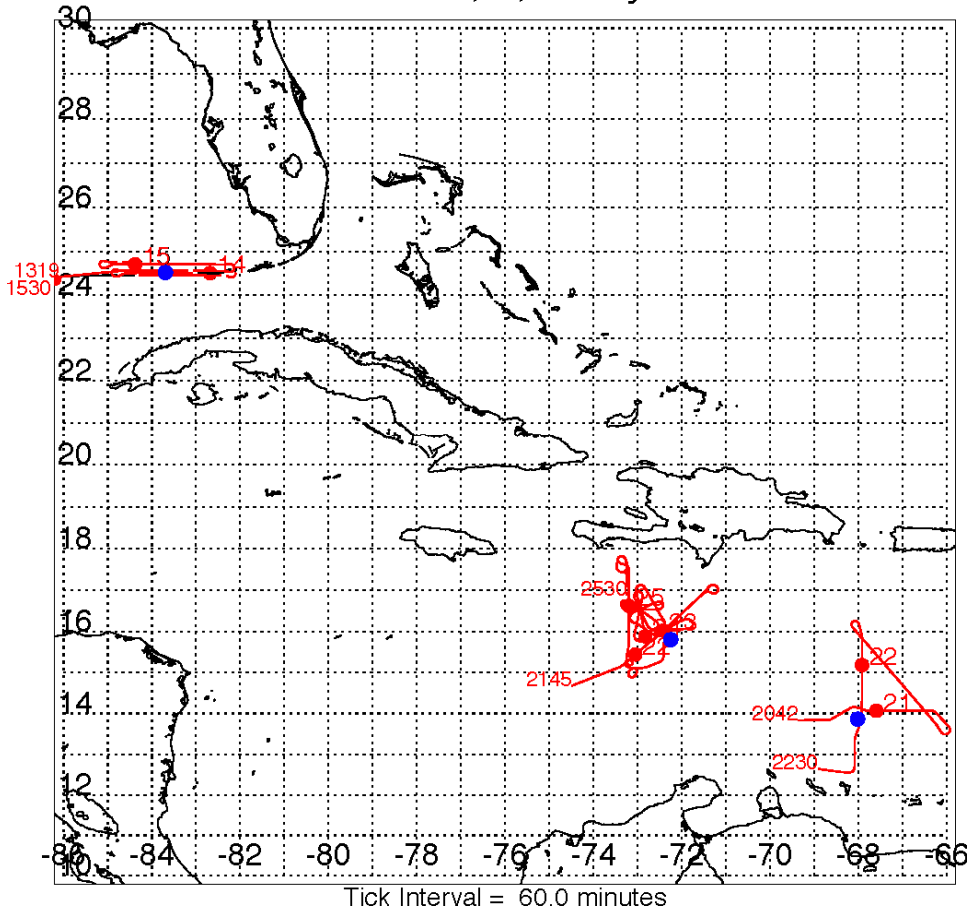


Diamond pattern

Modules: Convection/ Hot tower, Microphysics, Remote sounder, Calibration (for sounder)

Hurricane Dennis (2005)

Dennis 5, 6, 9 July 2005

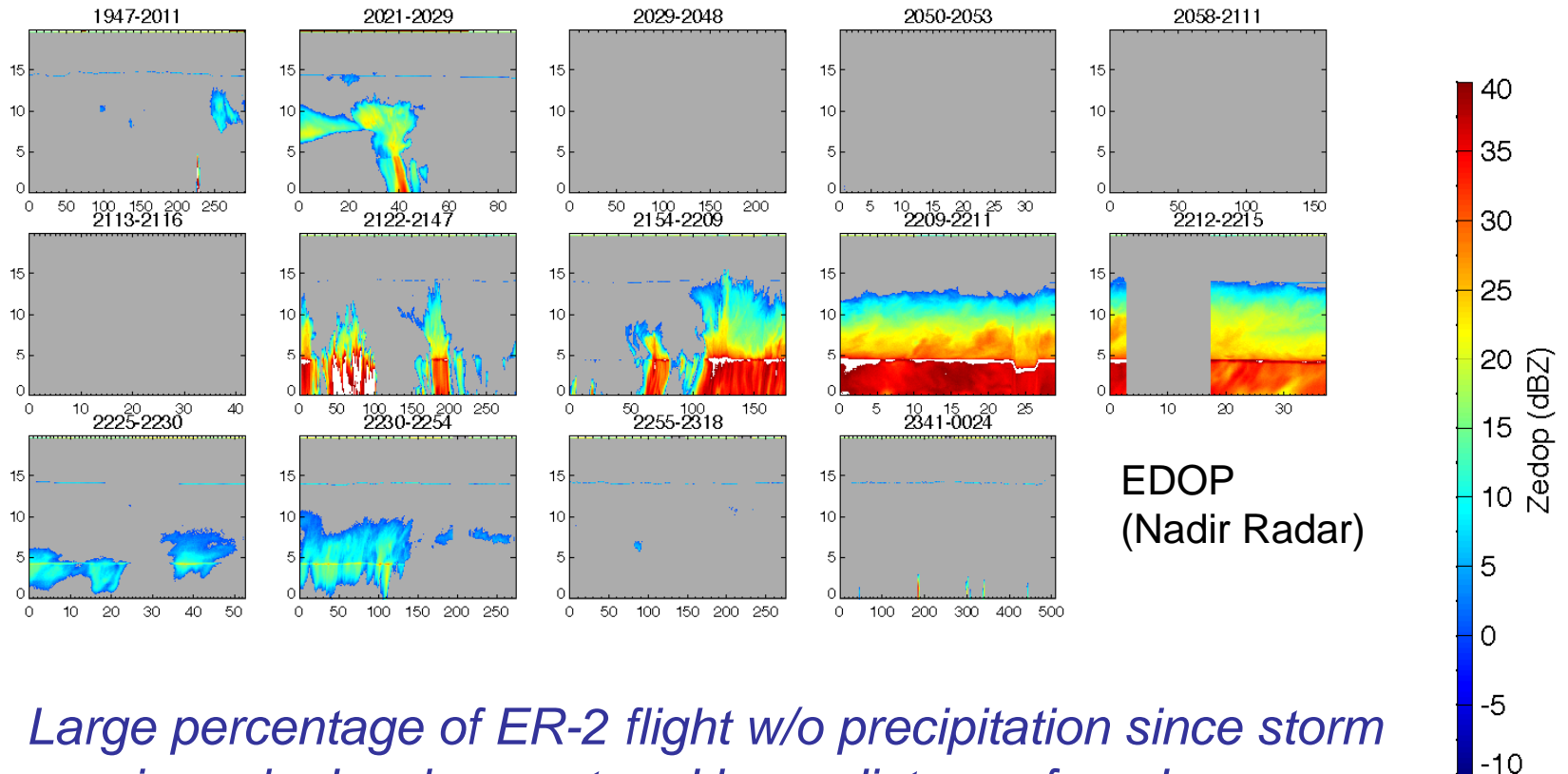


- Evolution from TD to hurricane
- ER-2 flew Figure 4's on 5, 6 July, and E-W legs on 9 July 2005
- Coordination with NOAA P3's on 5, 6 July; Key West 88D used to coordinate plane on 9 July 2005

-> *Flight clearance problems around Cuba*

TD #4 (Dennis) 5 July 2006

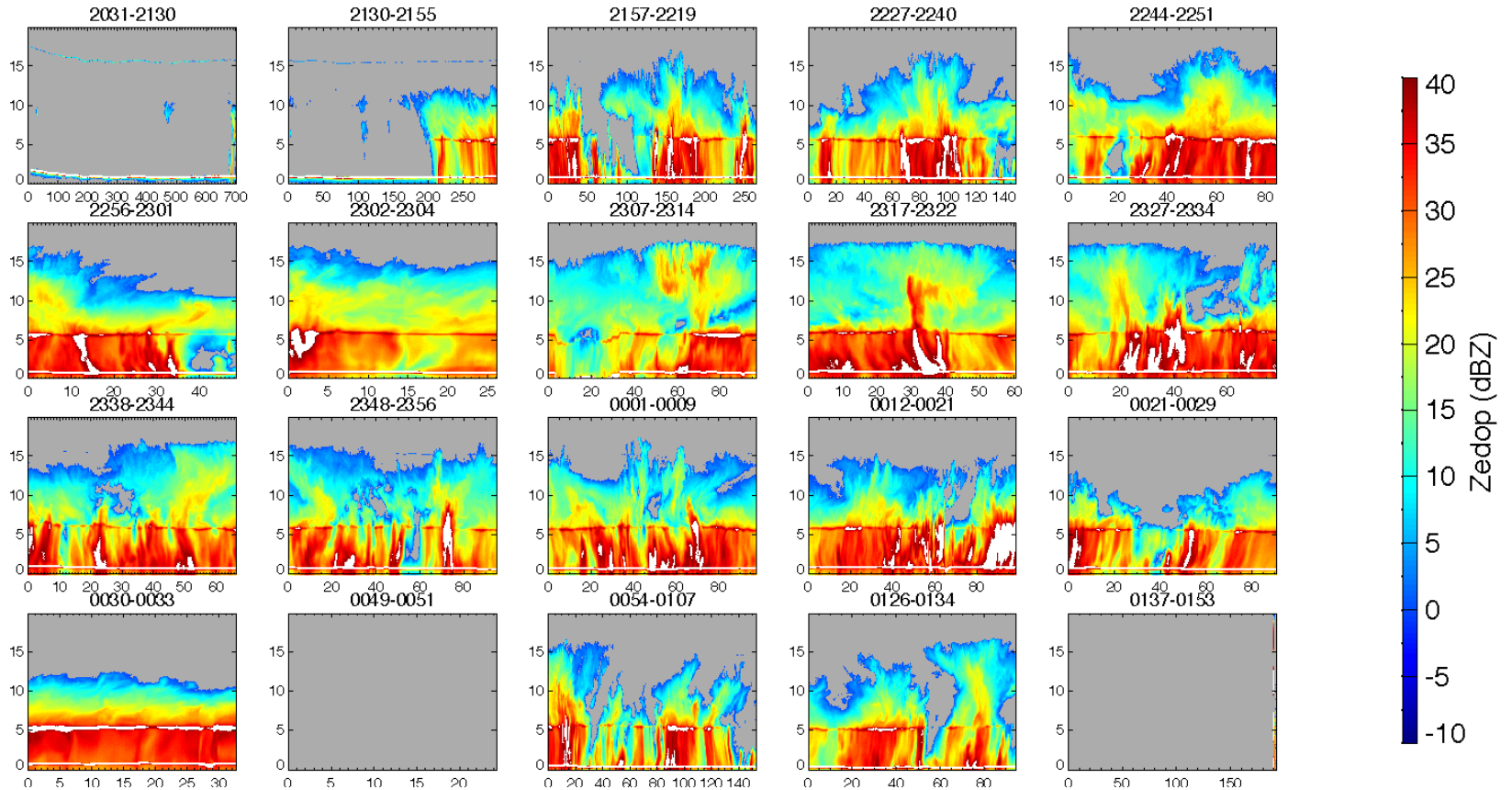
edop_050705



Large percentage of ER-2 flight w/o precipitation since storm was in early development and large distance from base allowed only 2 passes across center.

Tropical Storm Dennis 6 July 2006

edop_050706



2nd Dennis flight had significantly more cloud and higher cloud tops.

NAMMA / Science Objectives

African easterly waves (AEWs) - developers and non-developers

Control of TC intensity by large-scale wave vs. smaller-scale convective systems that erupt periodically within the wave

Role of the Saharan Air Layer (SAL) in the fate of the AEWs and TCs

Characteristic vertical distribution, microphysical and optical properties and composition of the African dust, and in what specific ways does the dust affect cloud microphysics and cloud dynamics

DC-8 Instruments

2D-S (stereo) probe (2D-S)

- Cloud particle sizing and imaging

Dual-Frequency Airborne Precipitation Radar (APR-2)

- 14/35-GHz dual-frequency Doppler radar

Cloud Particle Imager (CPI)

- Cloud particle sizing and imaging

Cloud Aerosol and Precipitation Spectrometer (CAPS)

- Optical array imaging probe and scattering spectrometer

Carbon monoxide By Attenuation of Laser Transmission (COBALT)

- in-situ laser absorption spectrometer

Counterflow Virtual Impactor (CVI)

- In-situ Droplet Impactor

Diode Laser Hygrometer (DLH)

- in-situ Diode Laser Absorption Spectrometer

High Altit. Monolithic Microwave Integrated Circuit Sounding Radiometer (HAMSR)

- Microwave radiometer

Langley Aerosol Research Group Experiment (LARGE)

- In situ aerosol sensors

Lidar Atmospheric Sensing Experiment (LASE)

- Lidar (water vapor, aerosol, dust)

Meteorological Measurement System (MMS)

- In situ DC-8 measurements

Emphasis:
Microphysics
Dust
Precipitation

Pre-Debby 23 August 2006

NAMMA Mission 2006/08/23

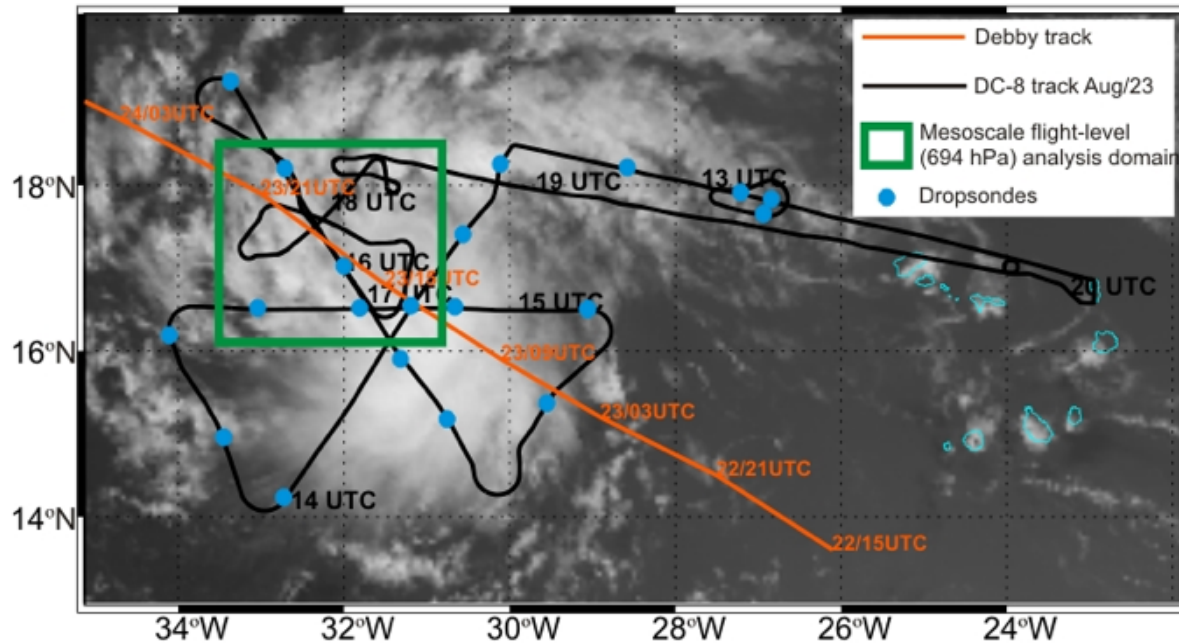


Figure 6. DC -8 flight track on 23 August. The longer legs passing near the storm center (1320 – 1630 UTC) obtained remote sensing and dropwindsonde data from 237 hPa before descending to near 700 hPa to obtain detailed in situ data across the storm core. The best track for Debby from 22-24 August is in red.

Issues to Think About

- Tropical cyclone focus: genesis, rapid intensification, warm core, hot towers, wave development, etc.
- Sampling: widespread environment vs. inner core region, flight altitudes, etc.
- Multiple aircraft and whether they are stacked
- End data use: data analysis though compositing, data assimilation, etc.

New Measurement Capabilities -NASA Technology Investments

Global Hawk:

Temperature & moisture sounding (radiometer)

Precipitation structure (radar and radiometer)

Horizontal winds in precipitation (radar)

Ocean surface winds (radar and radiometer)

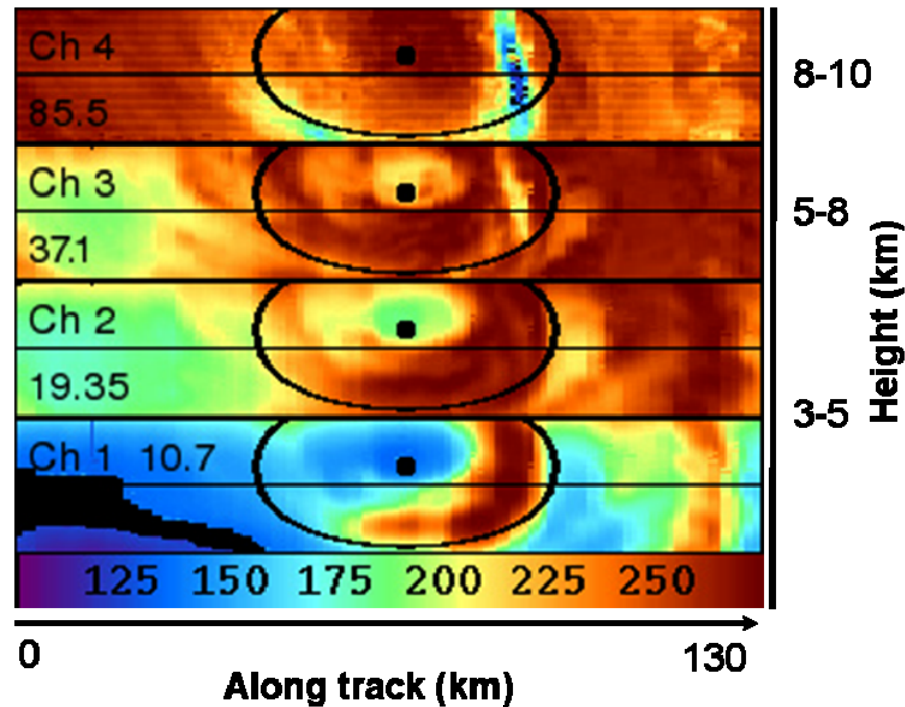
DC-8:

Horizontal and LOS winds in clear regions (lidar)

ER-2:

Horizontal winds in precip (radar)

Scanning Radiometer (AMPR) Hurricane Dennis (9 July 2005)

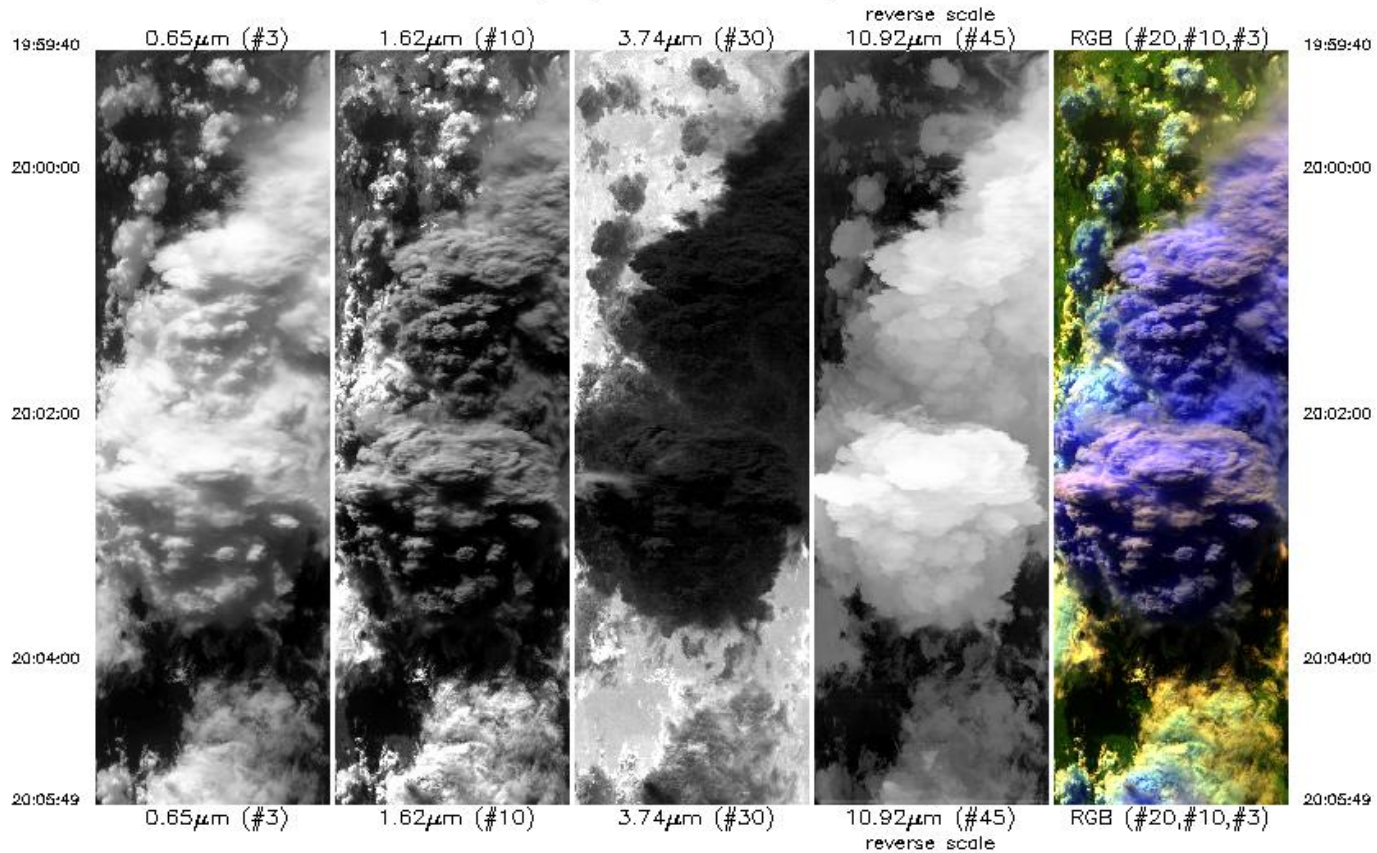


Guimond et al (2009)

Figure 7. Zoomed in view of the AMPR T_{BS} for channel 1 (10 GHz), 2 (19 GHz), 3 (37 GHz) and 4 (85 GHz) during the third ER-2 overpass (Fig. 6c) between 1421-1433 UTC 9 July 2005. The thin black line through the center of each swath is the track of the ER-2, the circle is the mean RMW (25 km) for this time period and the dot is the estimated storm center (using the method of Willoughby and Chelmow 1982). The approximate heights for each channel (Spencer et al. 1994) and along track distances are labeled on the figure. Note that the RMW is elliptically shaped, since in AMPR scan coordinates the along-track and across-track pixel resolutions are different.

MODIS Airborne Simulator Vis/IR Imagery

MODIS Airborne Simulator Browse Imagery
TRMM-Brazil Campaign - 26 Jan 1999
Flight #99-032 Track #10



Aircraft Heading = 99.7°
Solar Zenith = 53.5°
GPS Altitude = 19618. m (MSL)