

# NASA GRIP 2010

## Overview of research flights

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on behalf of the Science Team

# What did we do during hurricane season 2010?

- NSF/NCAR PREDICT (PRE-Depression Investigation of Cloud Systems of the Tropics)
- NASA GRIP (Genesis and Rapid Intensification Processes)
- NOAA IFEX (Intensity Forecasting Experiment)

GOALS: Remarkably Similar.....*Not a coincidence!*



# Mission and Science Overview: Summary of GRIP Science Objectives



- **Genesis:** Distinguish the role of the larger-scale environment vs. meso-convective processes near the putative developing center.
- **Rapid Intensification:** Relative role of environmental vs. inner core processes? Is RI predictable?
- **Test-bed:** Evaluate candidate technologies for remote sensing from aircraft and from satellites. Wind lidar, high frequency passive microwave, dual-frequency radars, Global Hawk itself.



# Scientific Accomplishments

- Tropical cyclone genesis
  - Tropical Storm Gaston—null case for development
  - Hurricane Karl—unprecedented multiday coverage from first detection through genesis
- Rapid Intensification
  - Hurricane Earl—documentation of rapid intensification as well as weakening stage of a previously large Category 4 storm
  - Hurricane Karl—observations of rapid intensification from storm stage to Category 3 and landfall

# Aircraft Hours in GRIP



| <b>Storm</b>         | <b>GH</b>    | <b>DC-8</b>  | <b>WB-57</b> | <b>NOAA</b> | <b>NSF</b> | <b>AF</b> |
|----------------------|--------------|--------------|--------------|-------------|------------|-----------|
| Frank                | 15.3         | 0            | 0            | N           | N          | N         |
| Earl                 | 24.2         | 39.3         | 10.9         | Y           | Y          | Y         |
| Gaston               | 0            | 14.5         | 0            | N           | Y          | N         |
| Karl                 | 48.5         | 40.2         | 17.5         | Y           | Y          | Y         |
| Matthew              | 25.1         | 17.8         | 0            | Y           | Y          | Y         |
| Other Sci            | 0            | 12.2         | 0            | NA          | NA         | NA        |
| Transit/test flights | 8.6          | 14.9         | 0            | NA          | NA         | NA        |
| <b>TOTAL</b>         | <b>121.7</b> | <b>138.9</b> | <b>28.4</b>  |             |            |           |

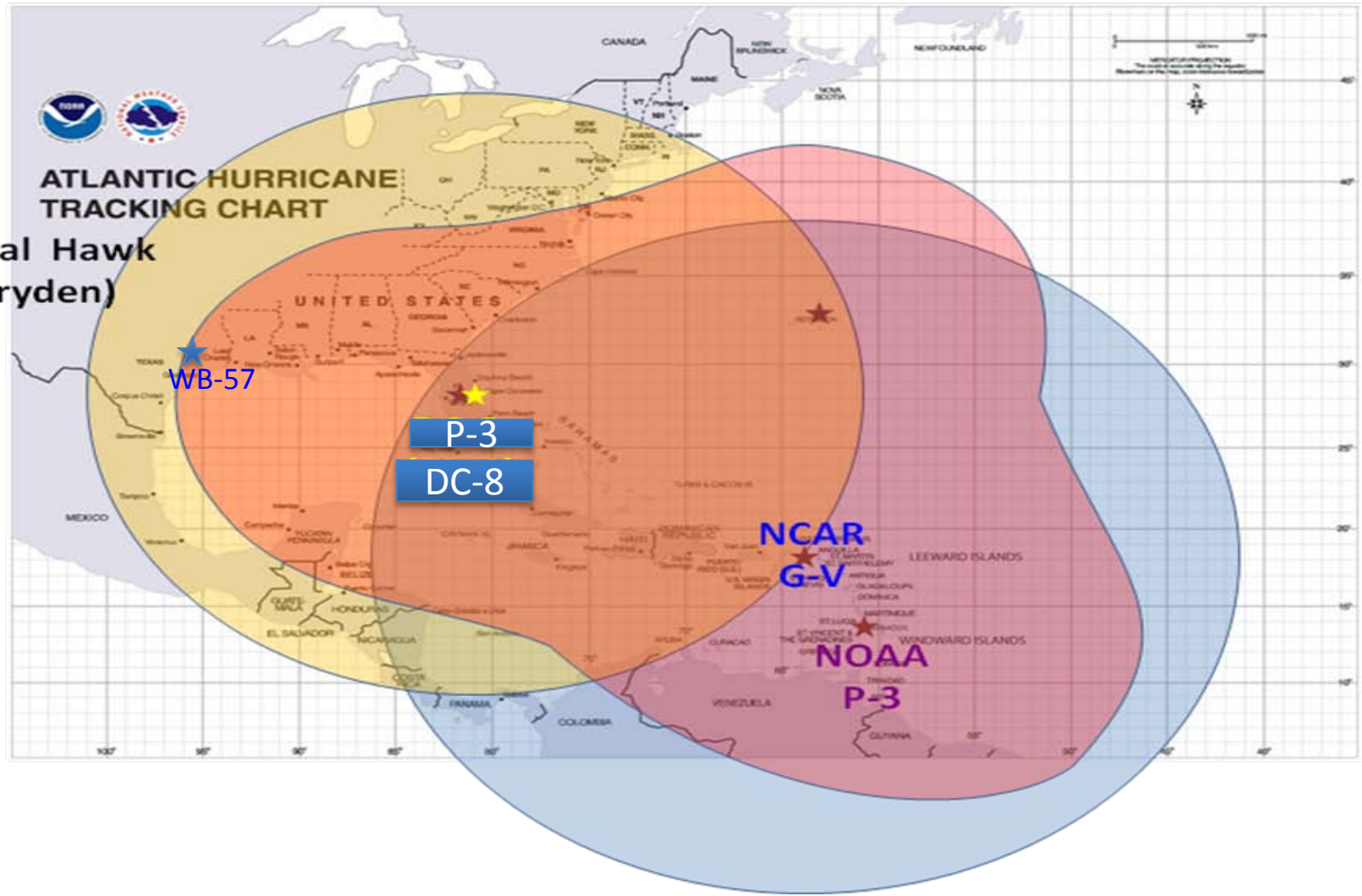


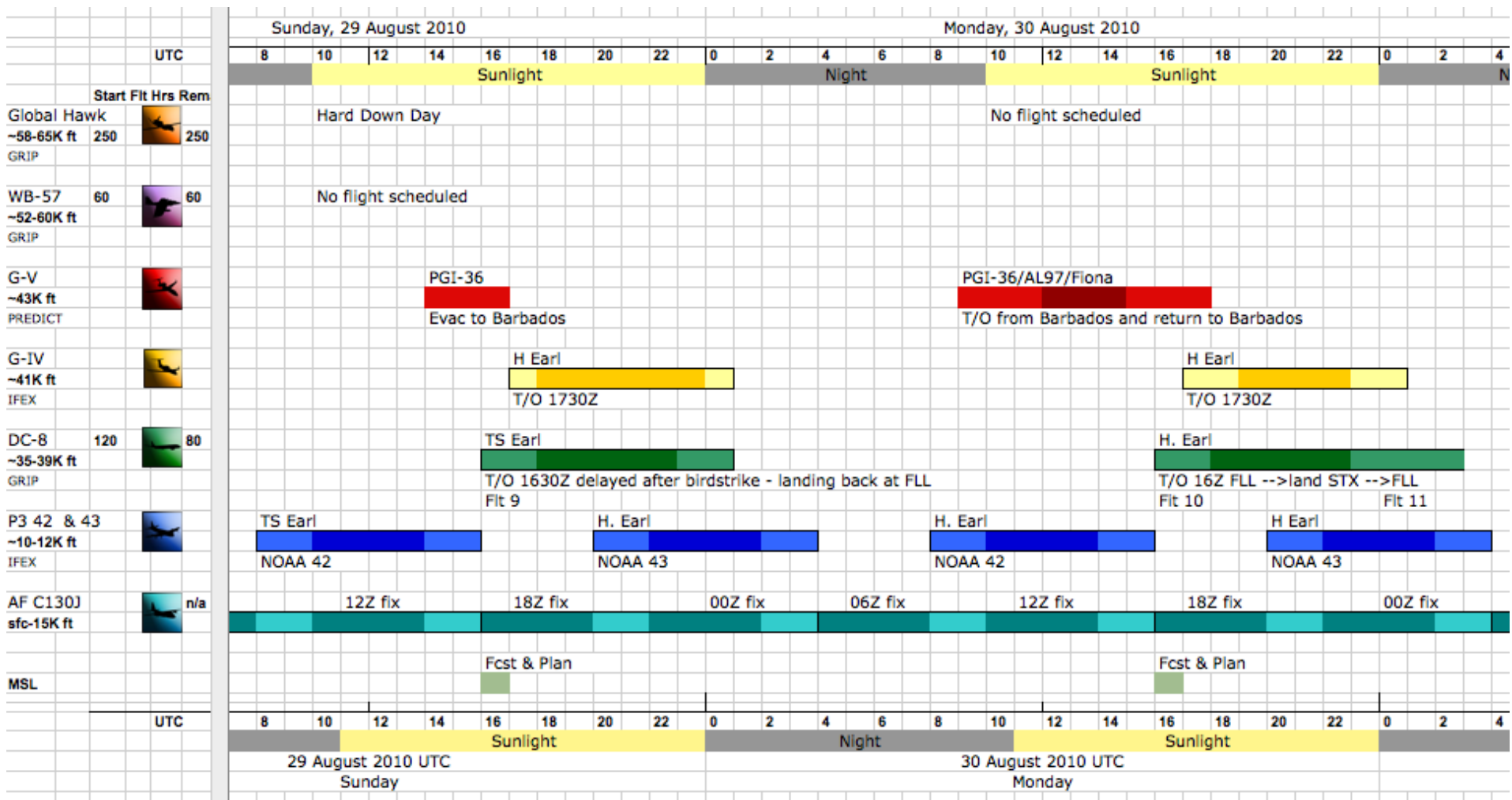
# GRIP Hurricane Mission

Genesis and Rapid Intensification Processes



## PREDICT/GRIP/IFEX Domains





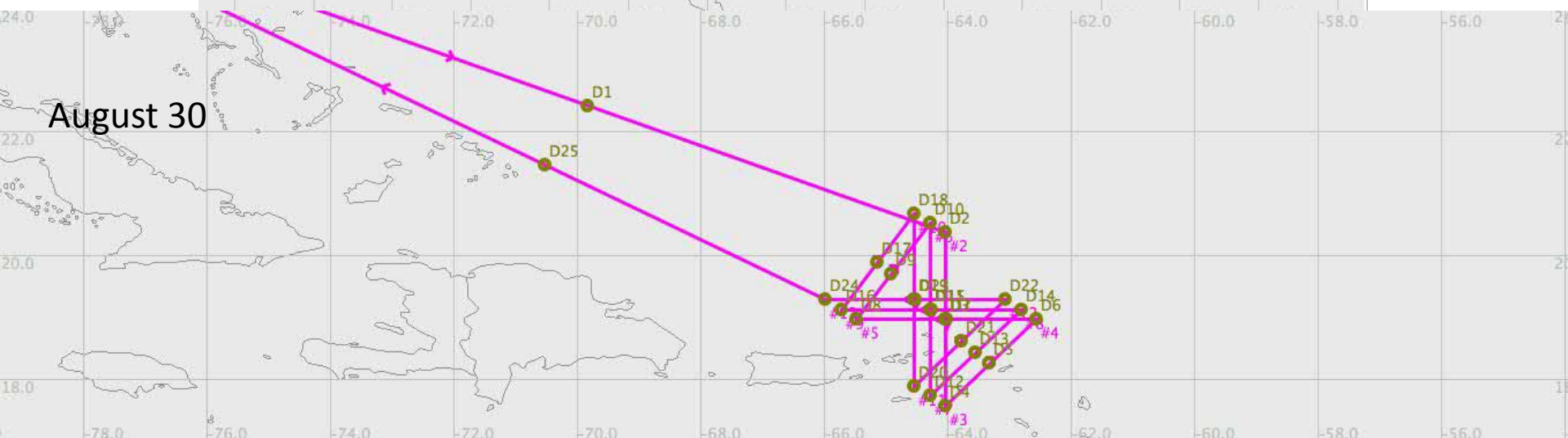
All flights into Earl during rapid intensification, 29-31 August 2010



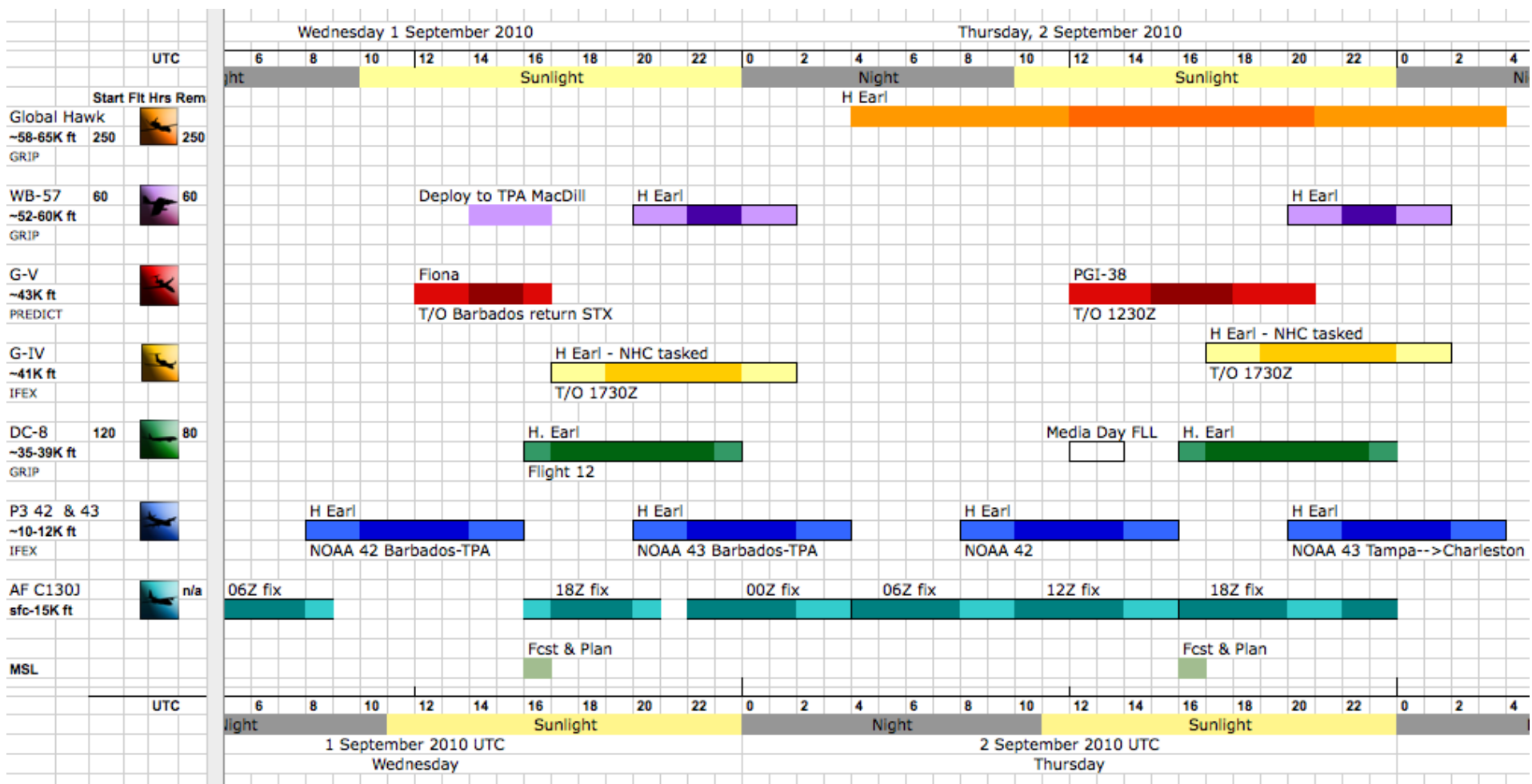


# Hurricane Earl Flights

## August 29-30



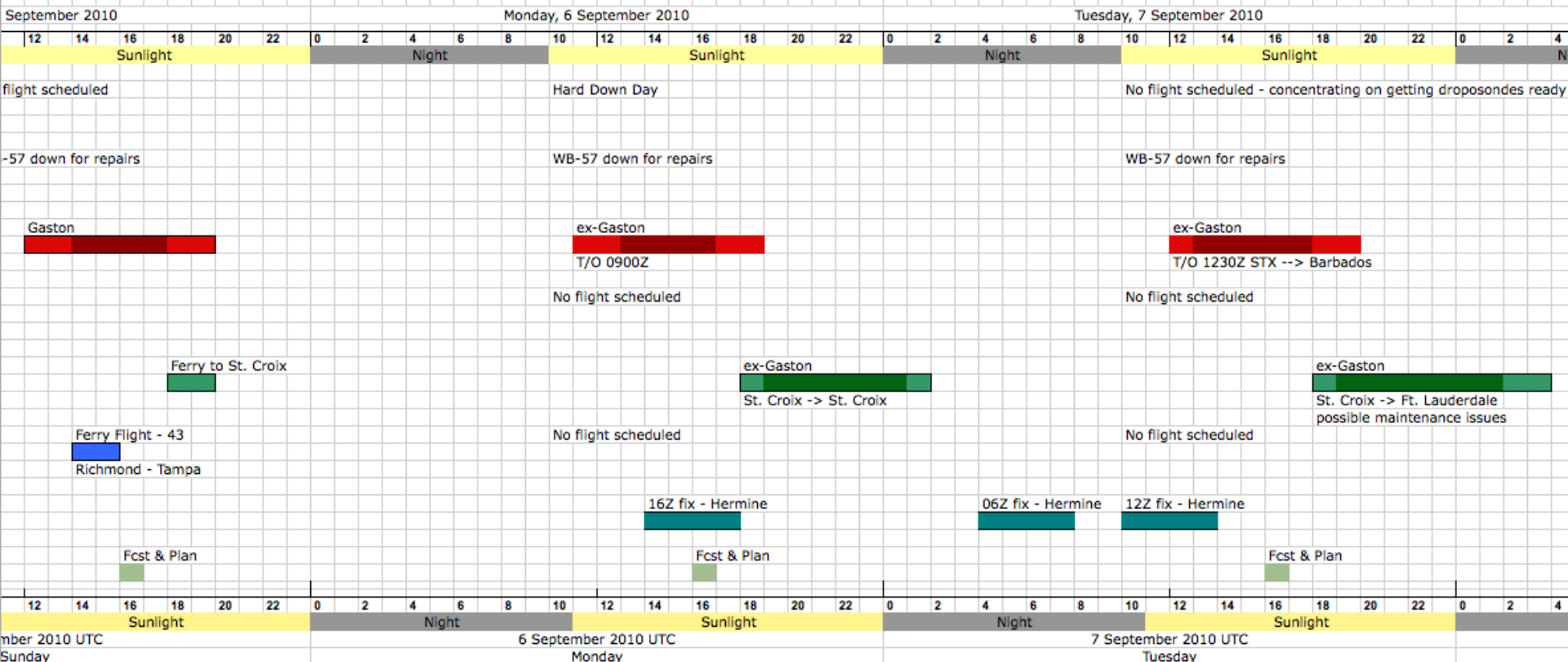




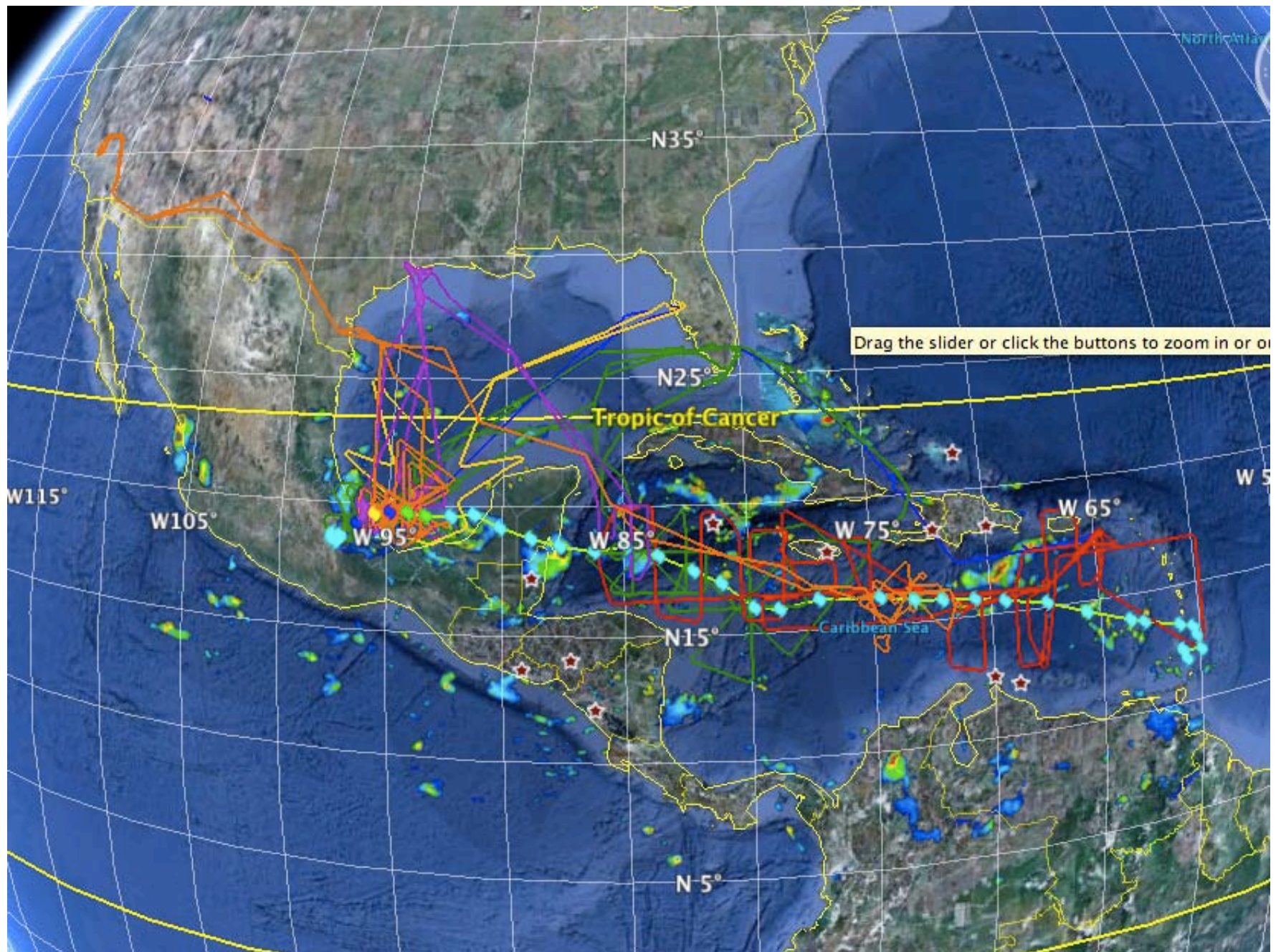
All flights into Hurricane Earl, 1-3 September 2010

# GRIP-IFEX-PREDICT All Aircraft Flight Schedule

# GRIP-IFEX-PREDICT All Aircraft Flight Schedule



All flights into ex-Gaston, 5-7 September 2010

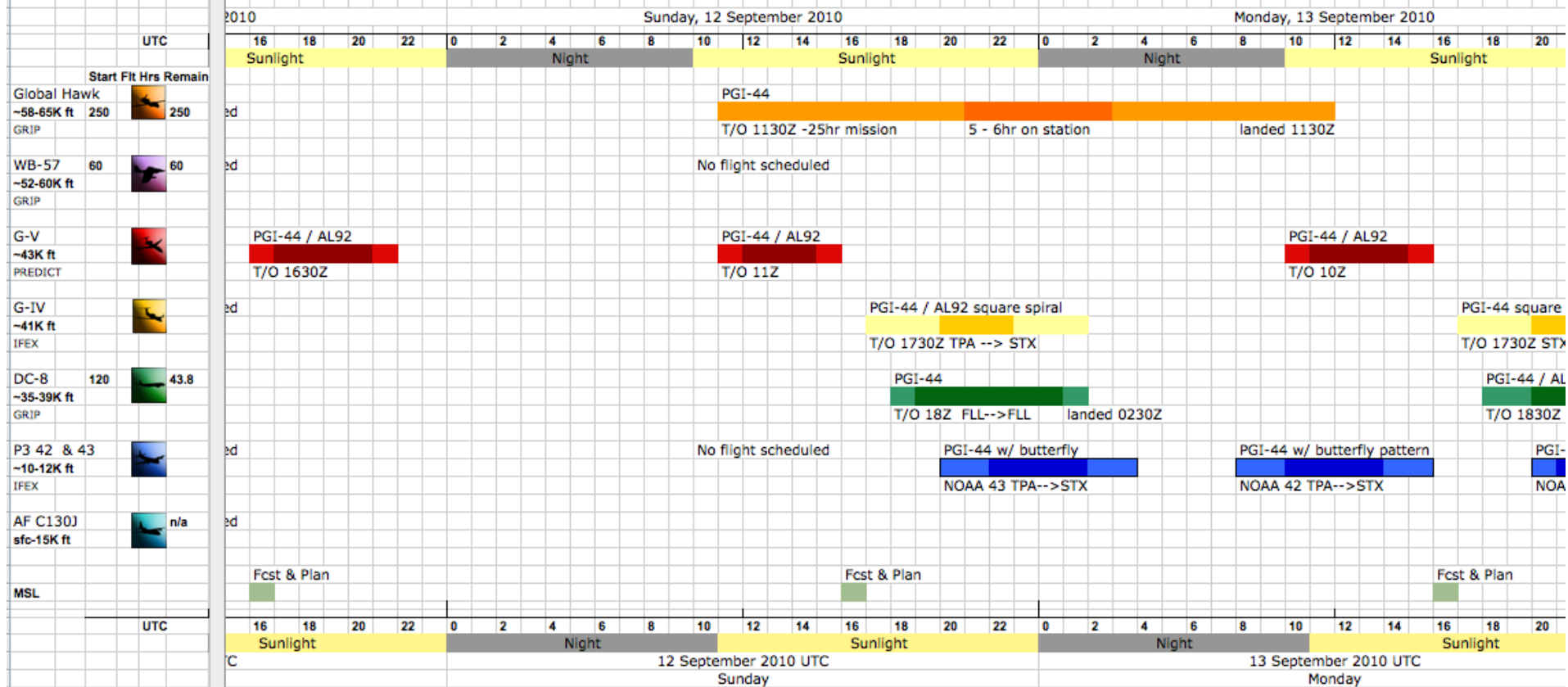


This made all the planning worthwhile! Karl 2010: All Flight tracks (almost) Sept 11-17 *Courtesy Scott Braun*



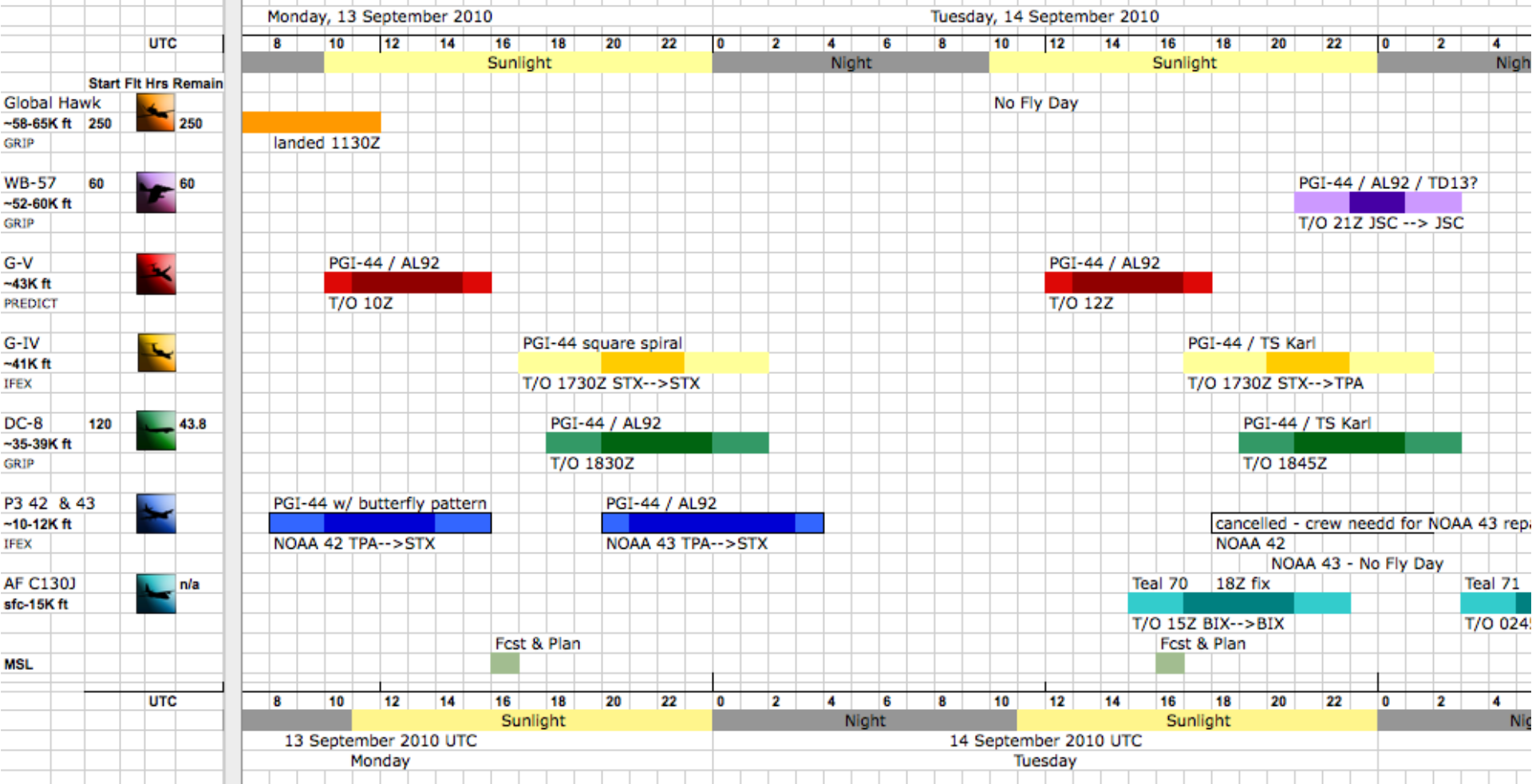
# Flight Schedule

## GRIP-IFEX-PREDICT All Aircraft Flight Schedule



All flights into pre-Karl, 11 – 13 September 2010

# GRIP-IFEX-PREDICT All Aircraft Flight Schedule

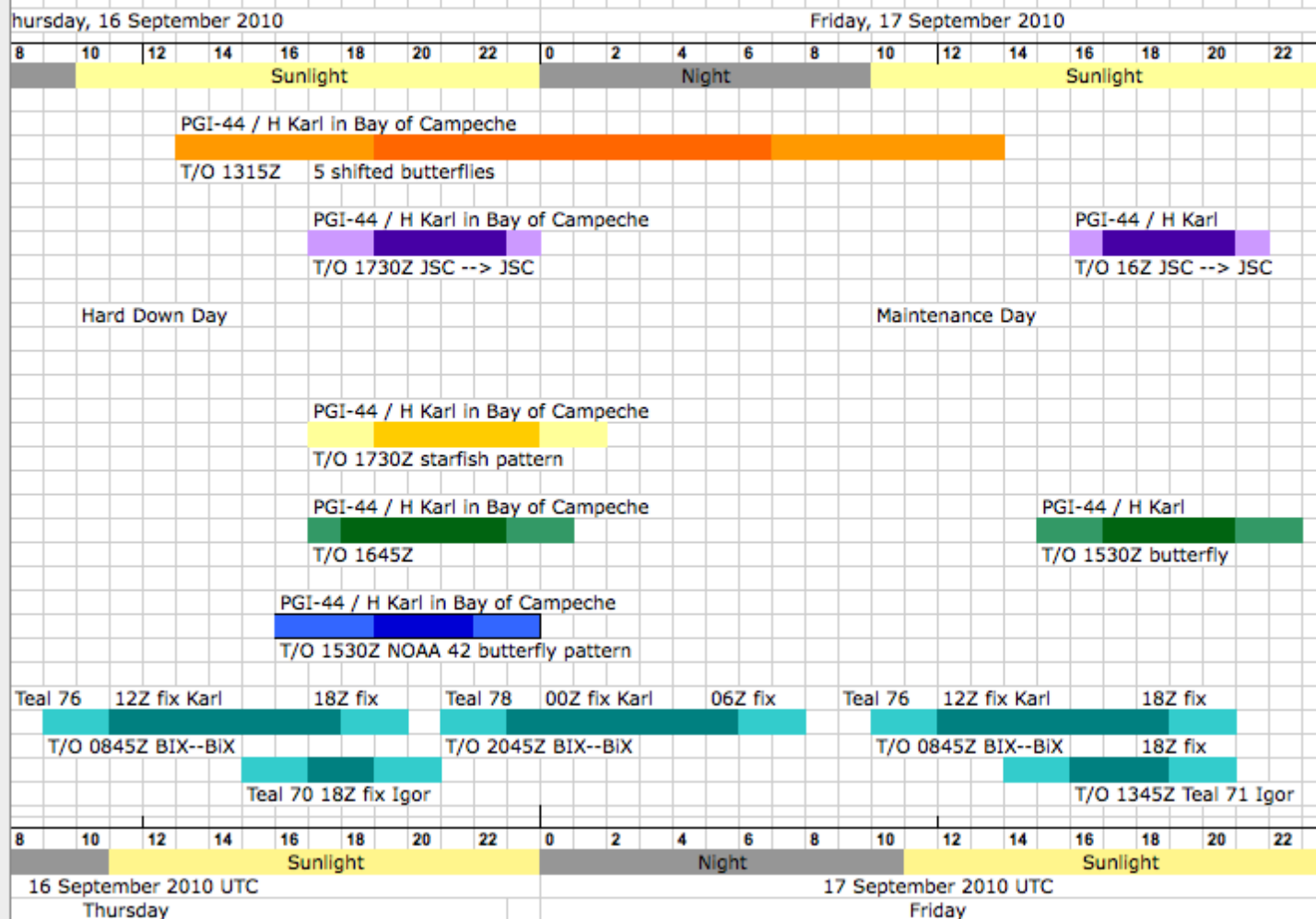
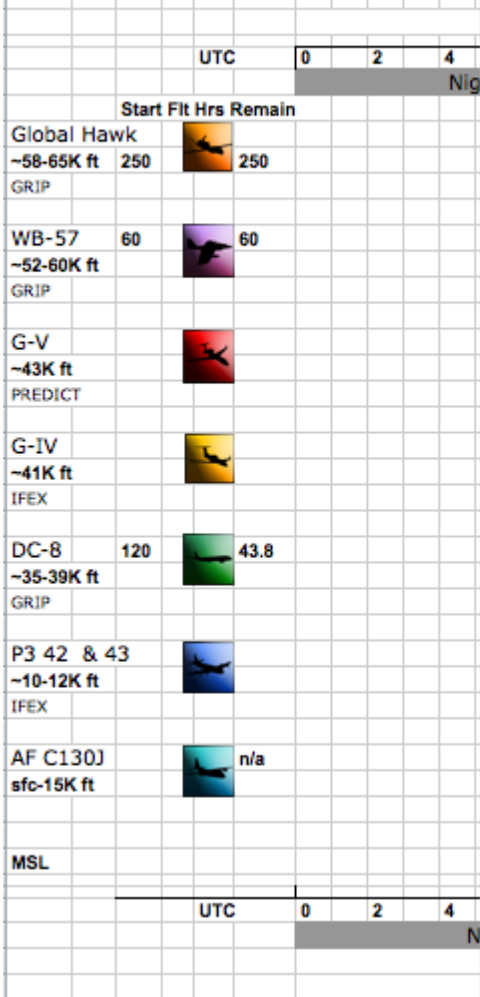


All flights into pre-Karl and TS Karl, 13 – 14 September 2010

# GRIP-IFEX-

# GRIP-IFEX-PREDICT All Aircraft Flight Schedule

# GRIP-IFEX-PREDICT All Aircraft



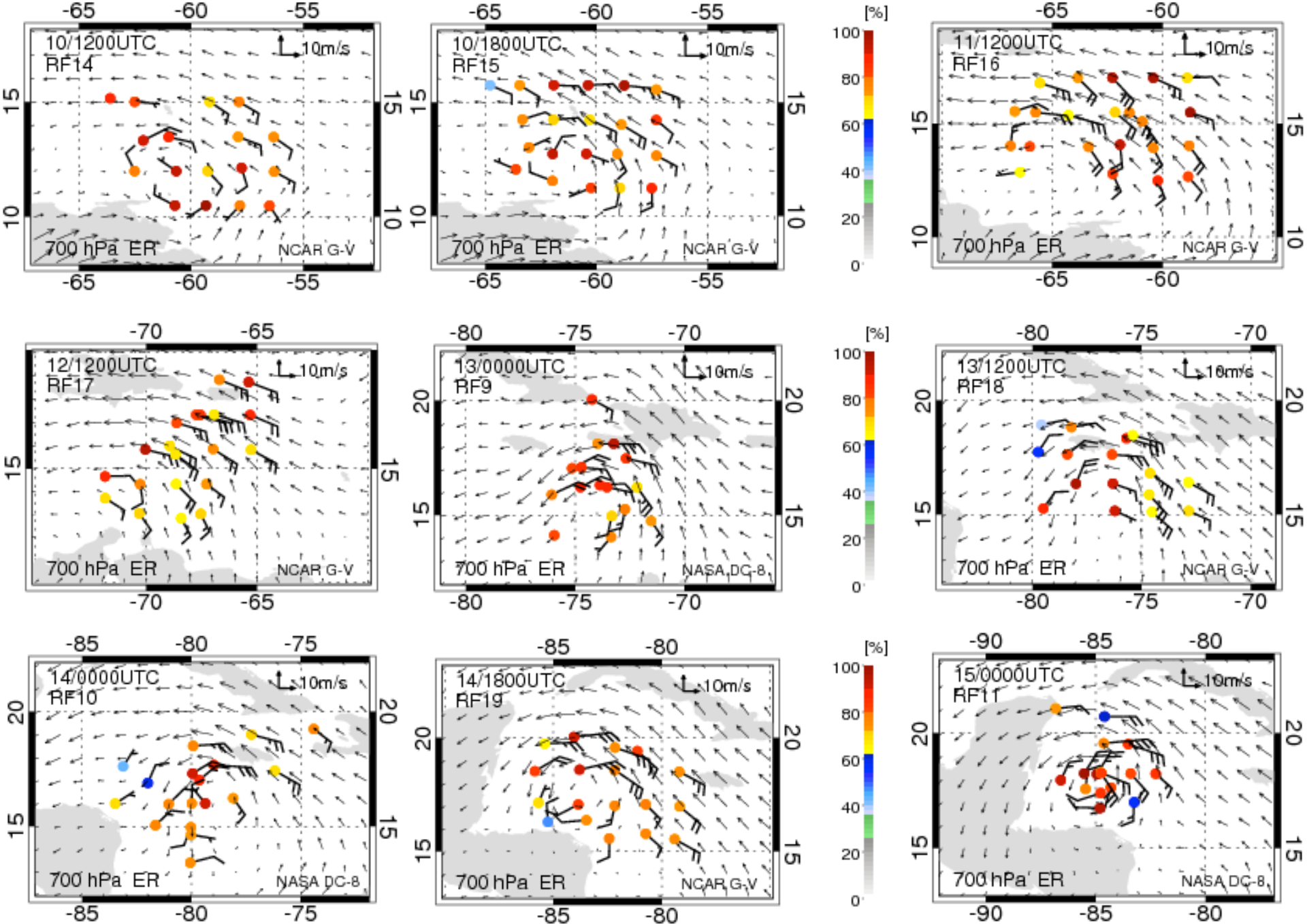
All flights into Hurricane Karl, 16 – 17 September 2010

Major Science Questions: Why did Karl take so long to form?

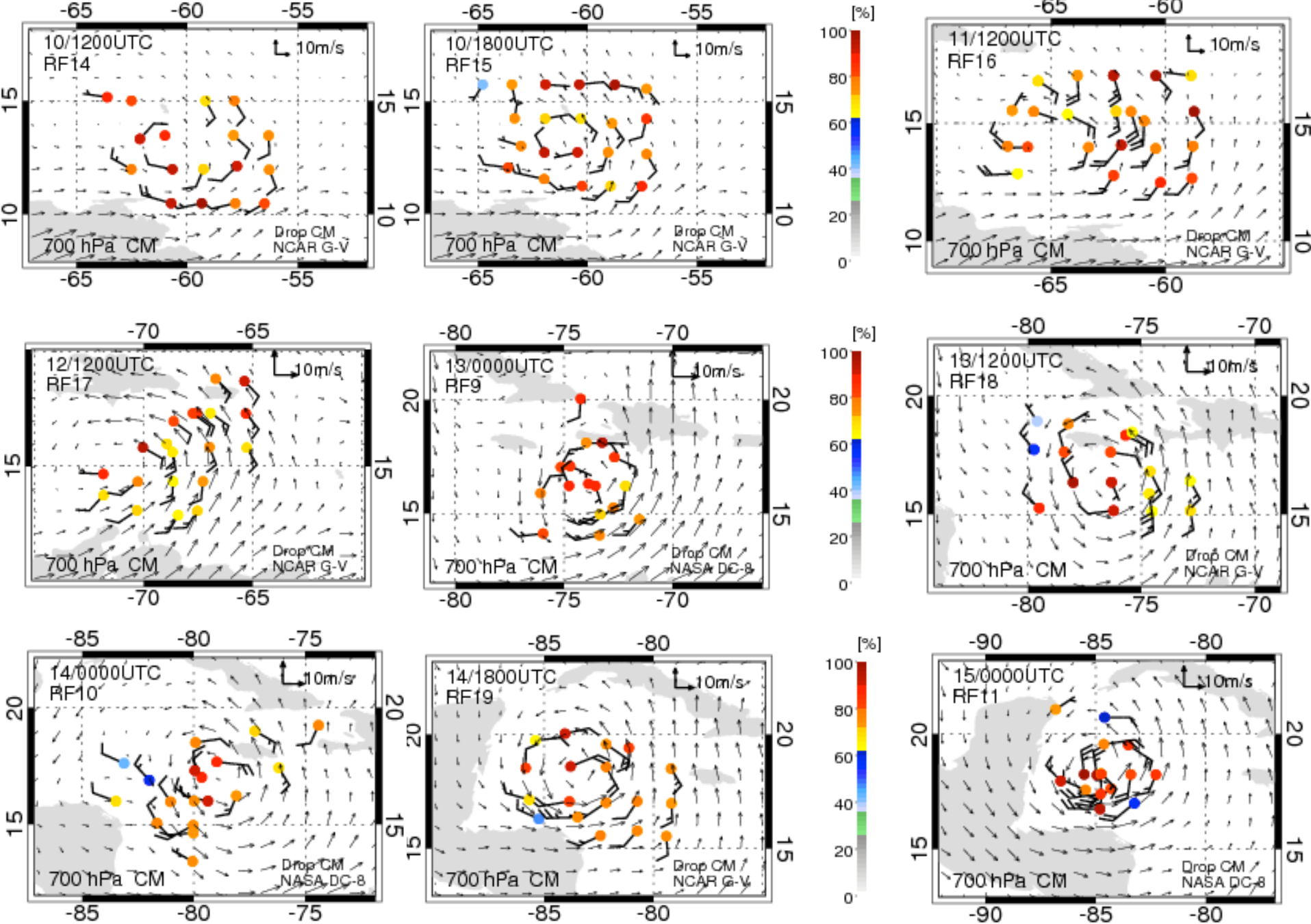
What was the time evolution of inner core moistening? Did the convective bursts help?

**STAY TUNED: WORK IS JUST GETTING STARTED**





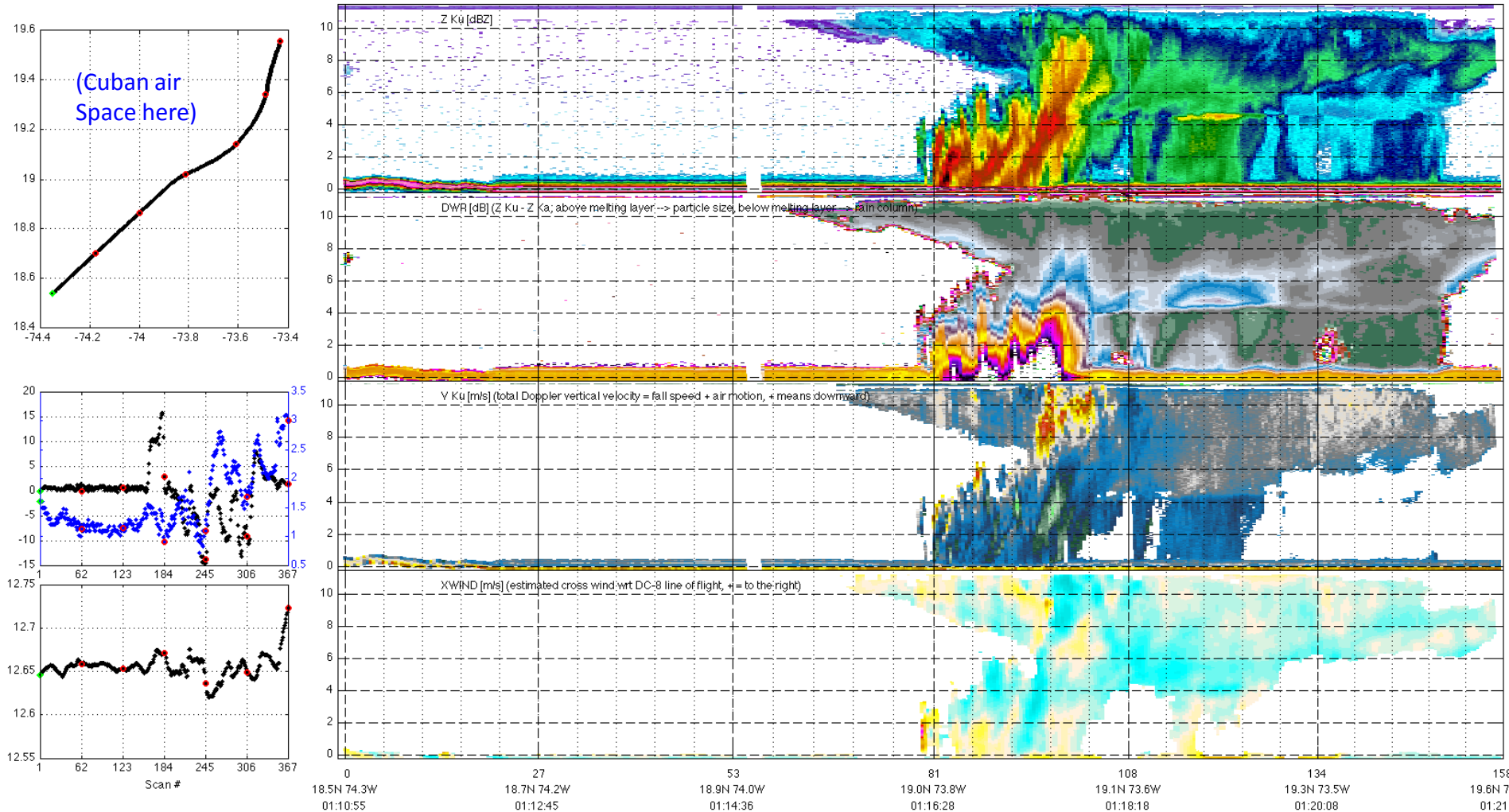
*Courtesy Jon Zawislak*



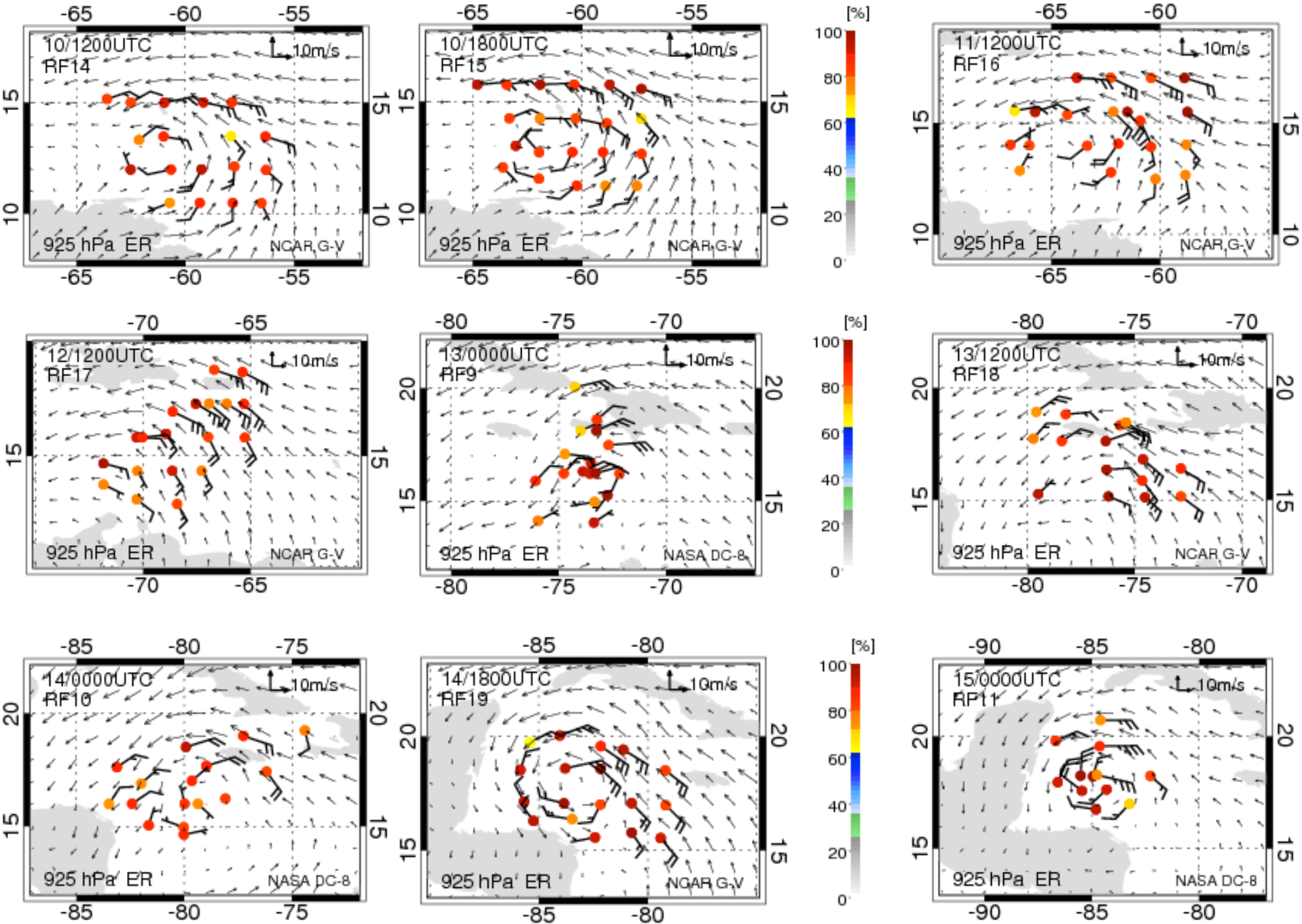
Courtesy Jon Zawislak

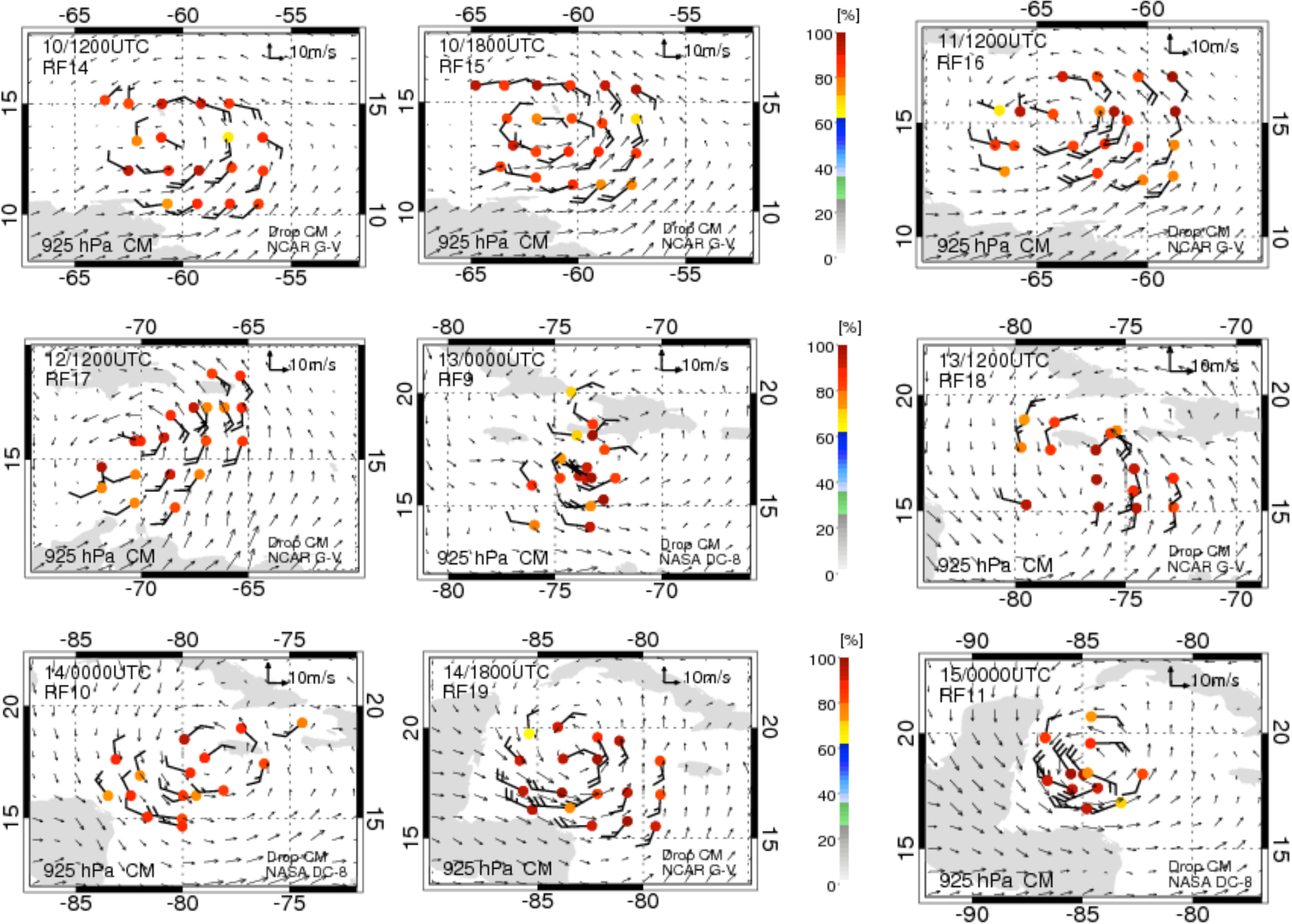
Example of great data obtained by APR-2 when the DC-8 pilot preferred penetration of an active thunderstorm/MCS complex over Haiti to entering Cuban air space

*Courtesy Simone Tanelli and APR-2 team from JPL*



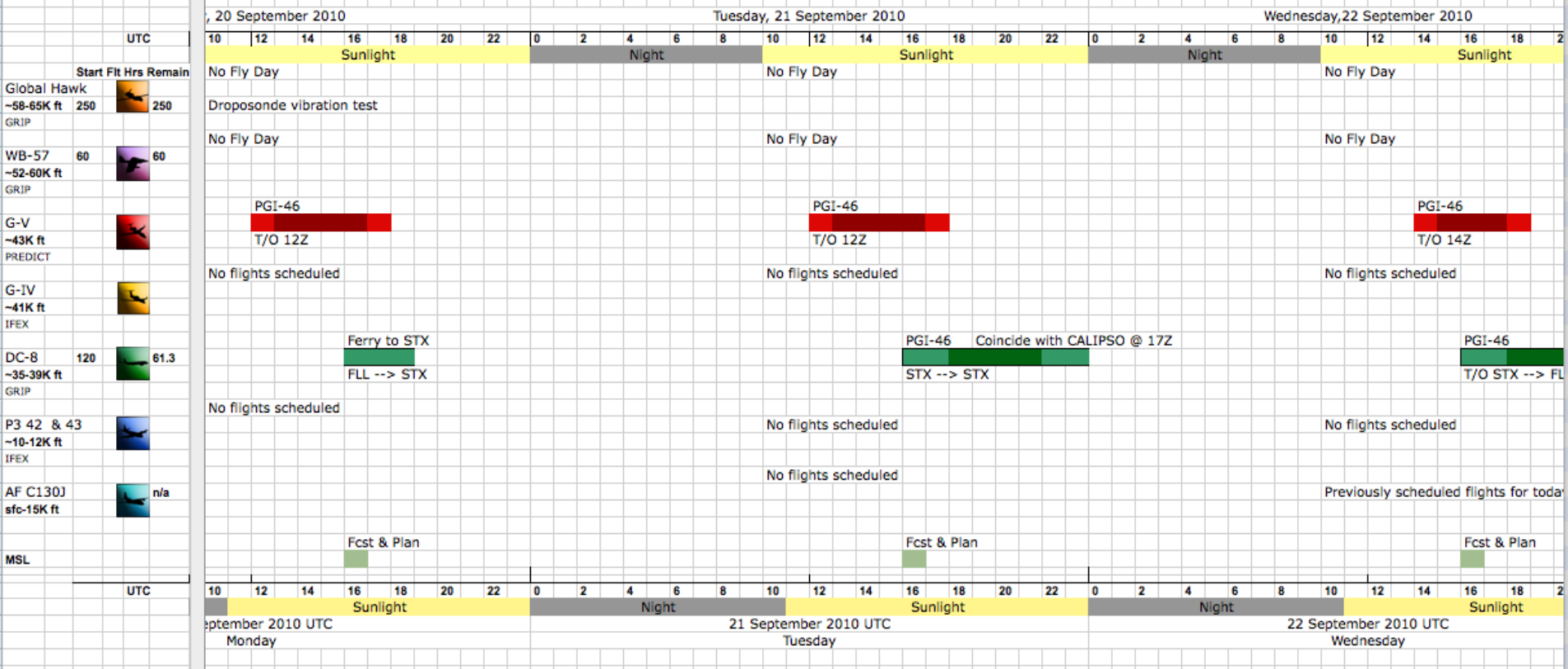






# GRIP-IFEX-PREDICT All Aircraft Flight Schedule

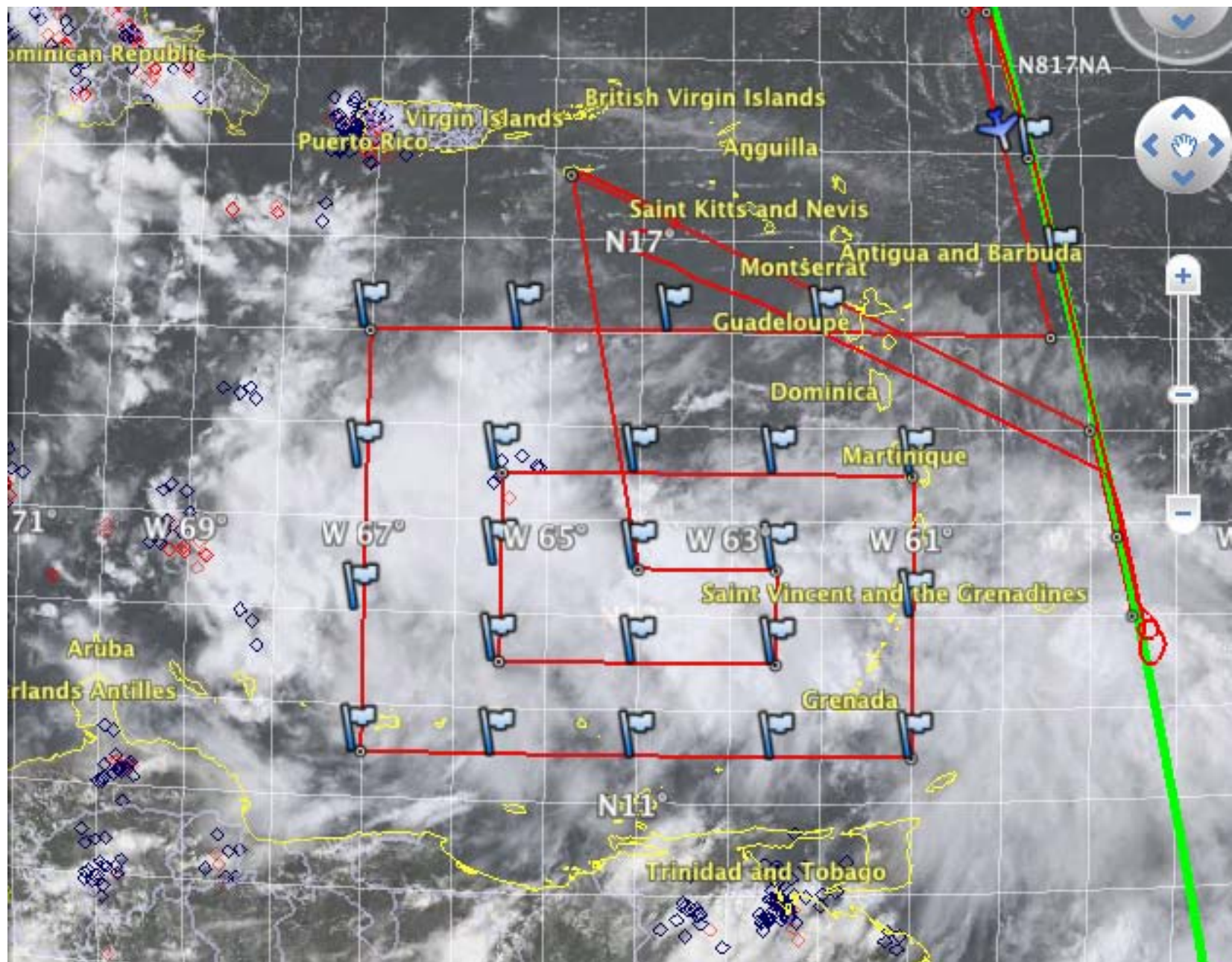
GRIP-IFEX-PREDICT All

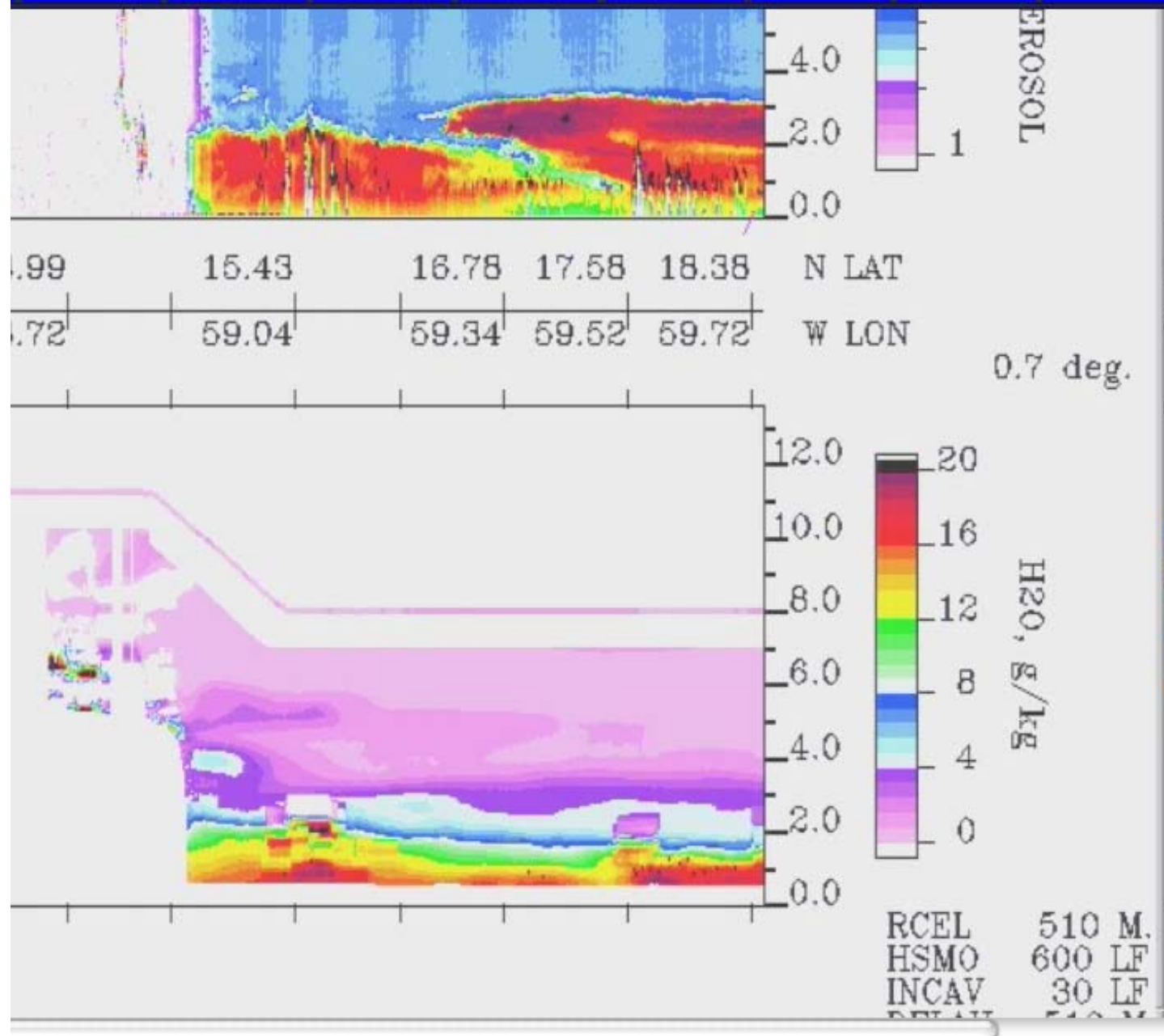


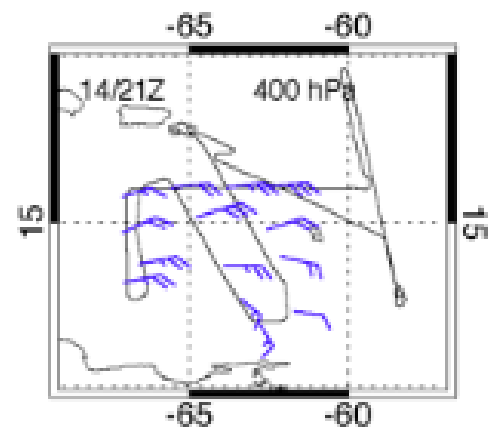
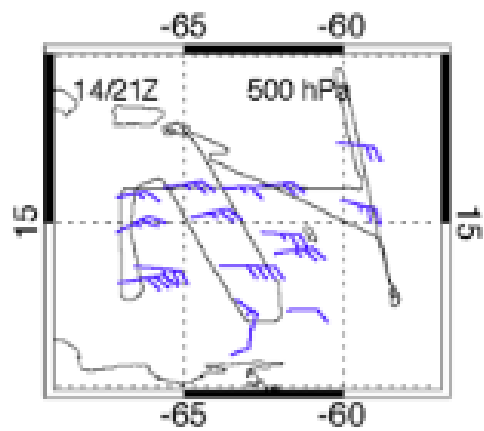
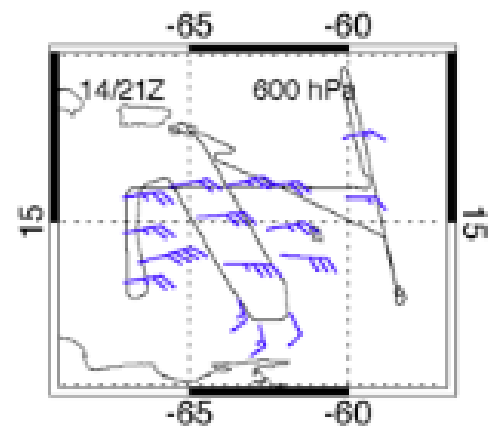
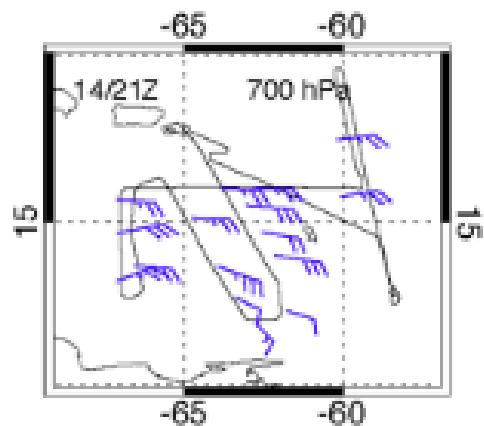
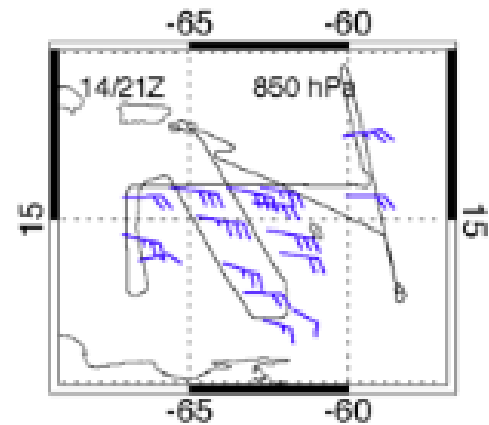
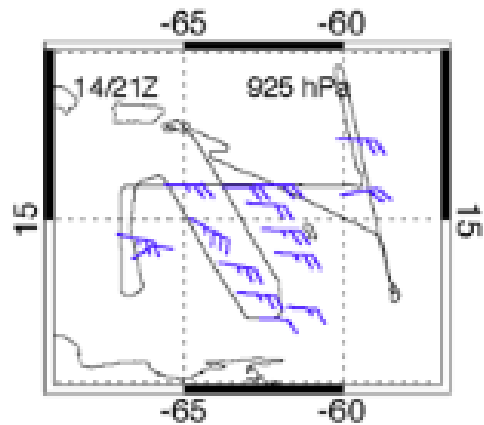
All flights into pre-Matthew, 20-22 September 2010



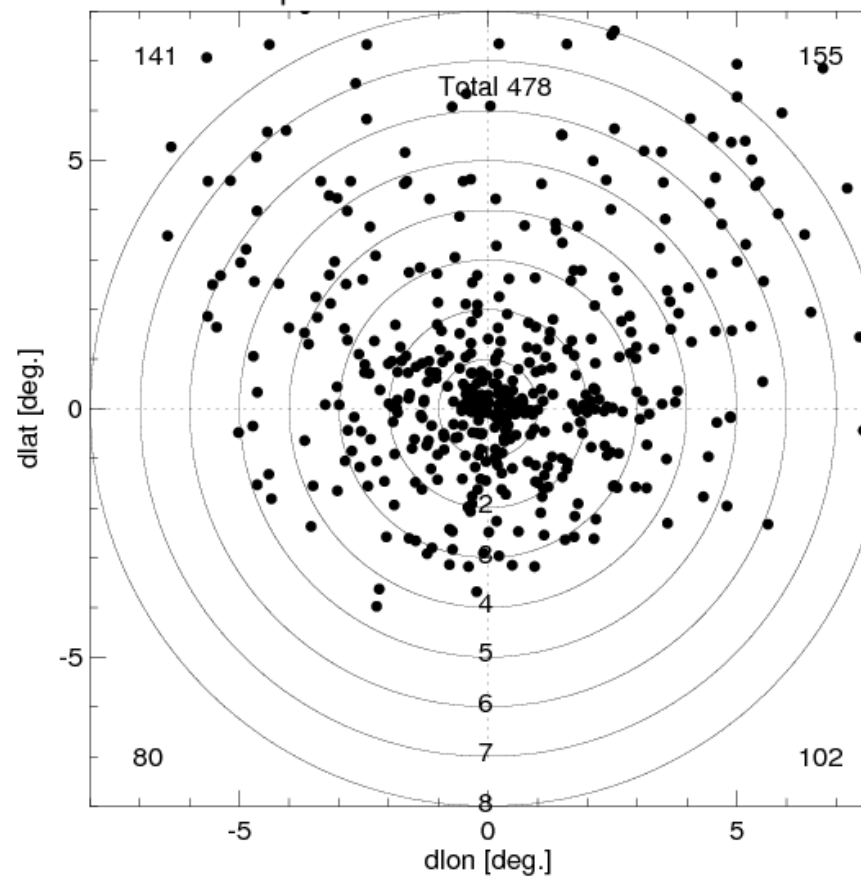




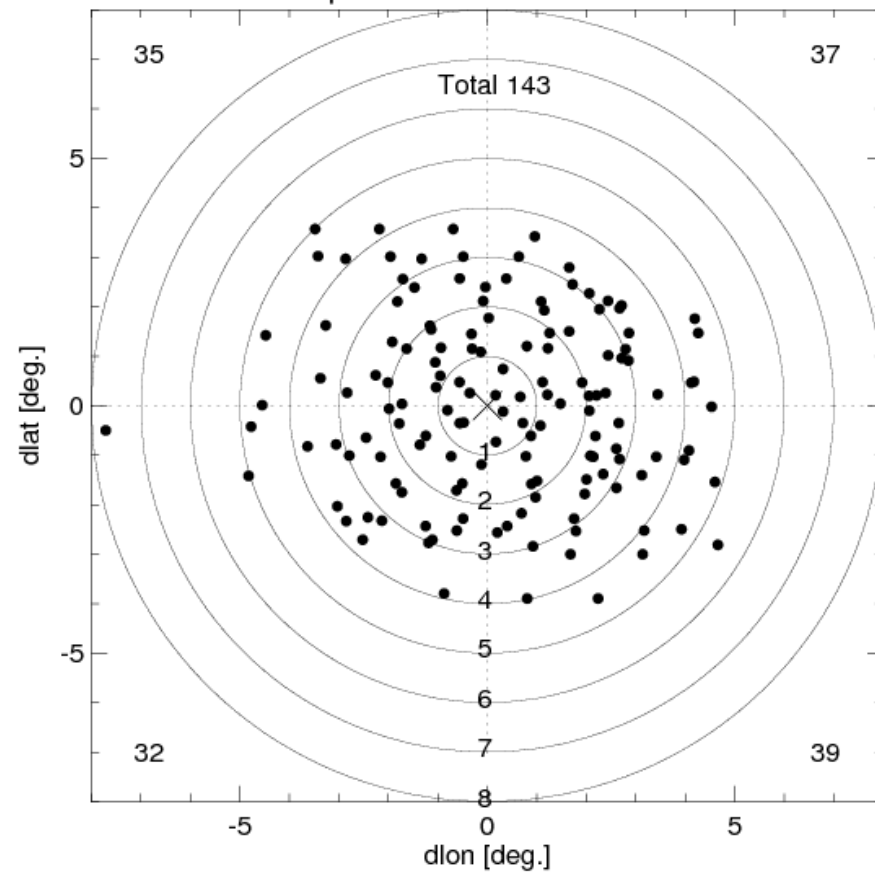




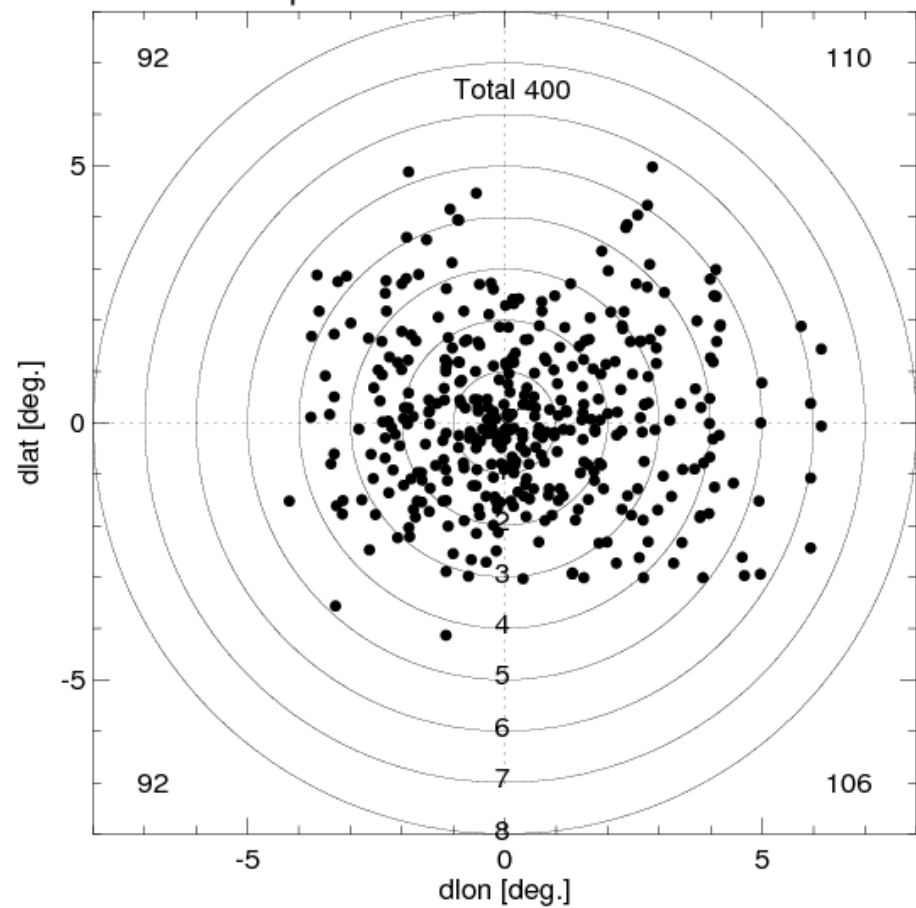
Earl Drop Locations Relative to 850 hPa VM



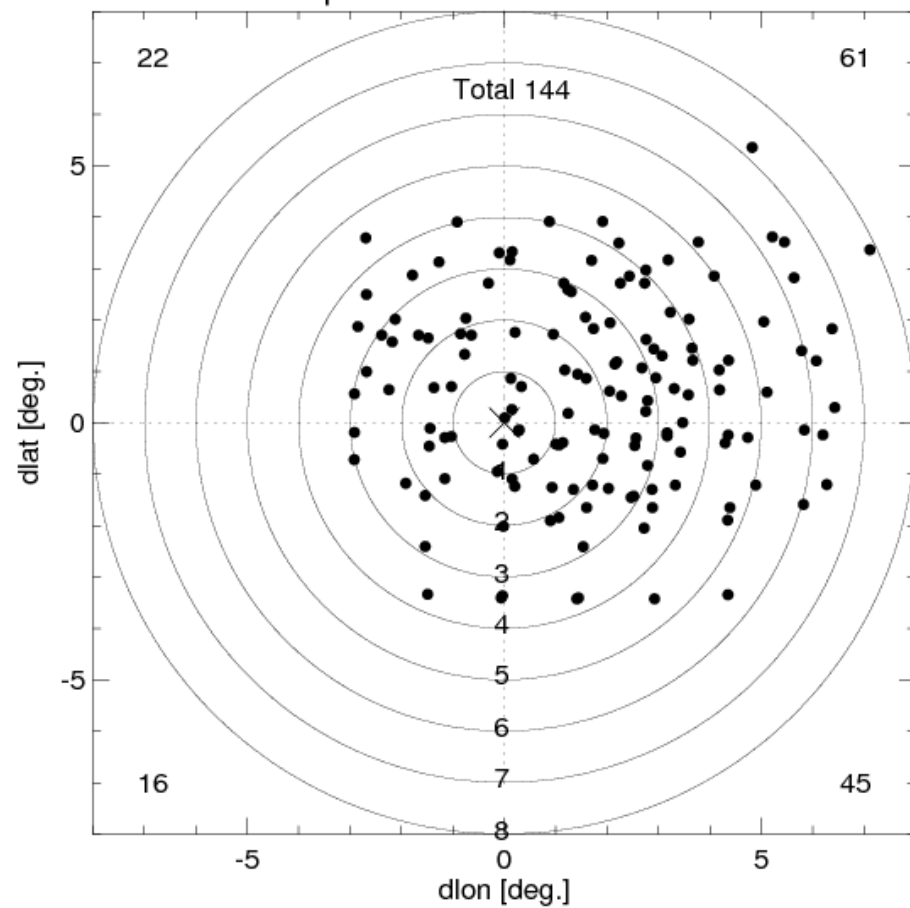
ex-Gaston Drop Locations Relative to 850 hPa VM



Karl Drop Locations Relative to 850 hPa VM



Matthew Drop Locations Relative to 850 hPa VM



Now it's time to get to work!





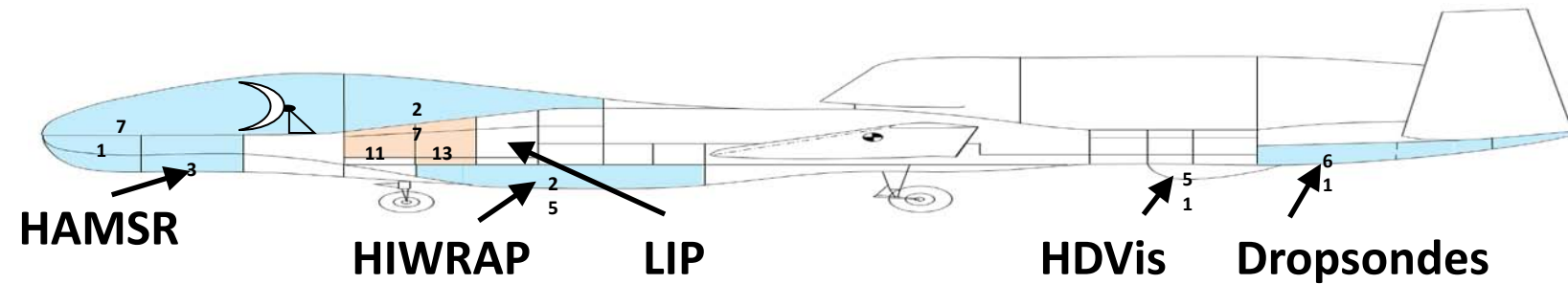


# GRIP Hurricane Mission

Genesis and Rapid Intensification Processes



## GLOBAL HAWK



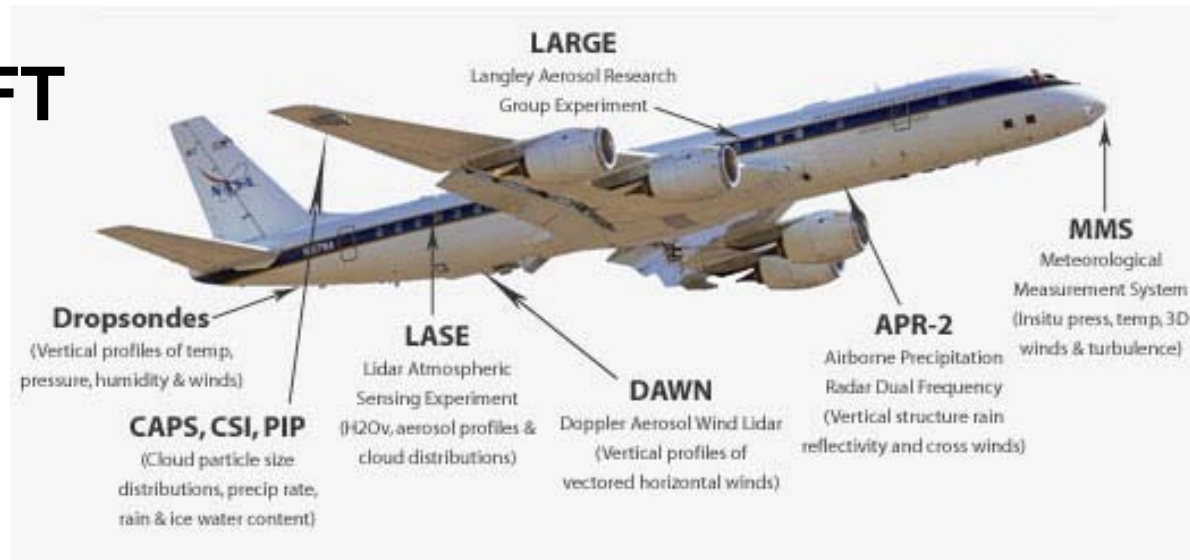


## GRIP Hurricane Mission

Genesis and Rapid Intensification Processes



## DC-8 AIRCRAFT



## WB-57 AIRCRAFT

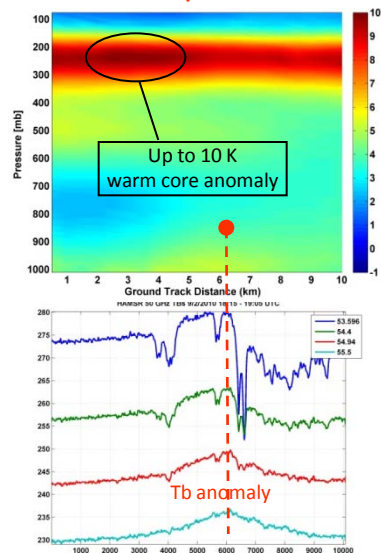


PREDICT planning meeting, Nov 2009 at HRD, together with IFEX and GRIP people

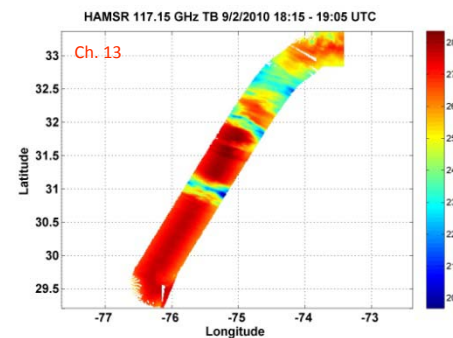
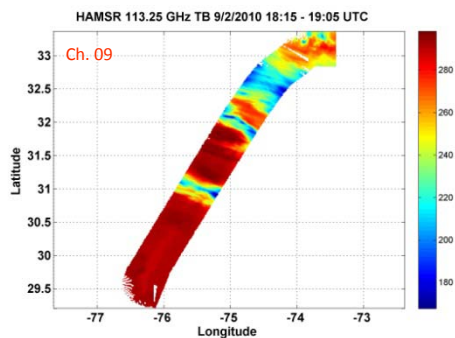
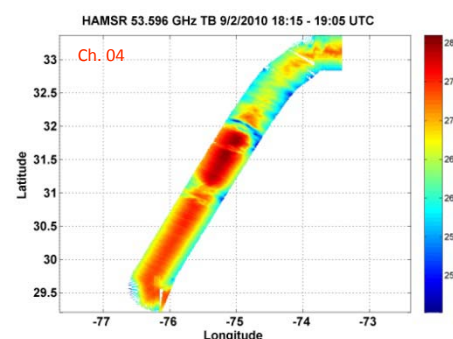
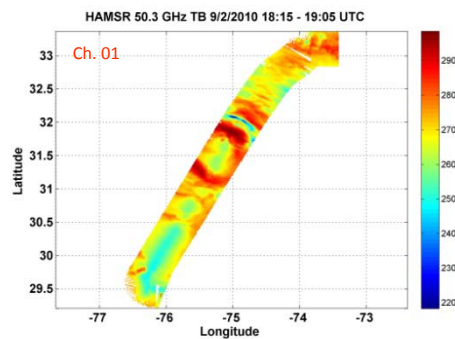
# HAMSR @ Earl, 9/2/2010, 1815-1905 UTC

(All retrievals are preliminary)

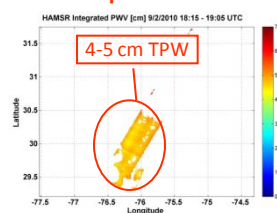
## Temperature



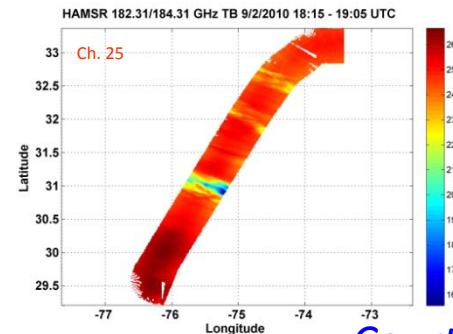
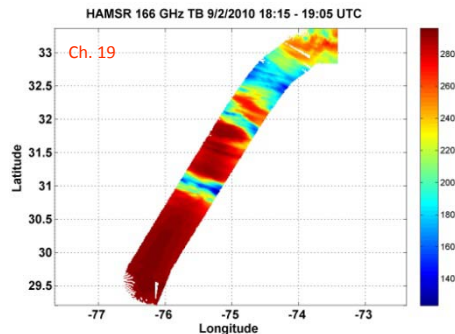
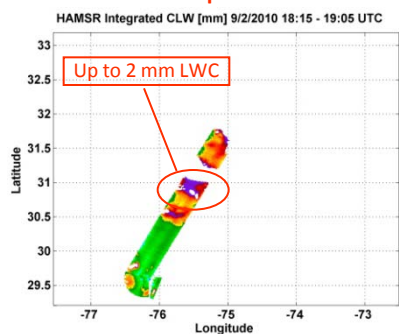
## Brightness temperatures



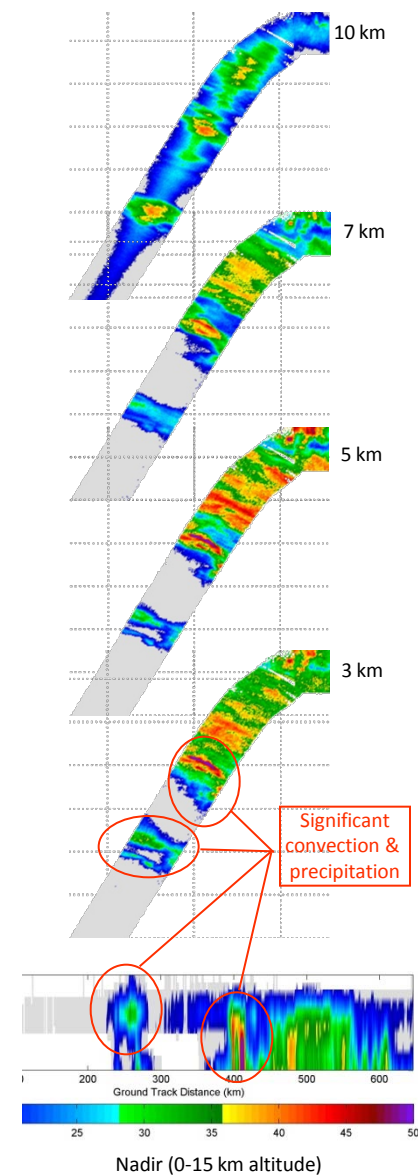
## Precipitable water



## Cloud liquid water



## Reflectivity (experimental)

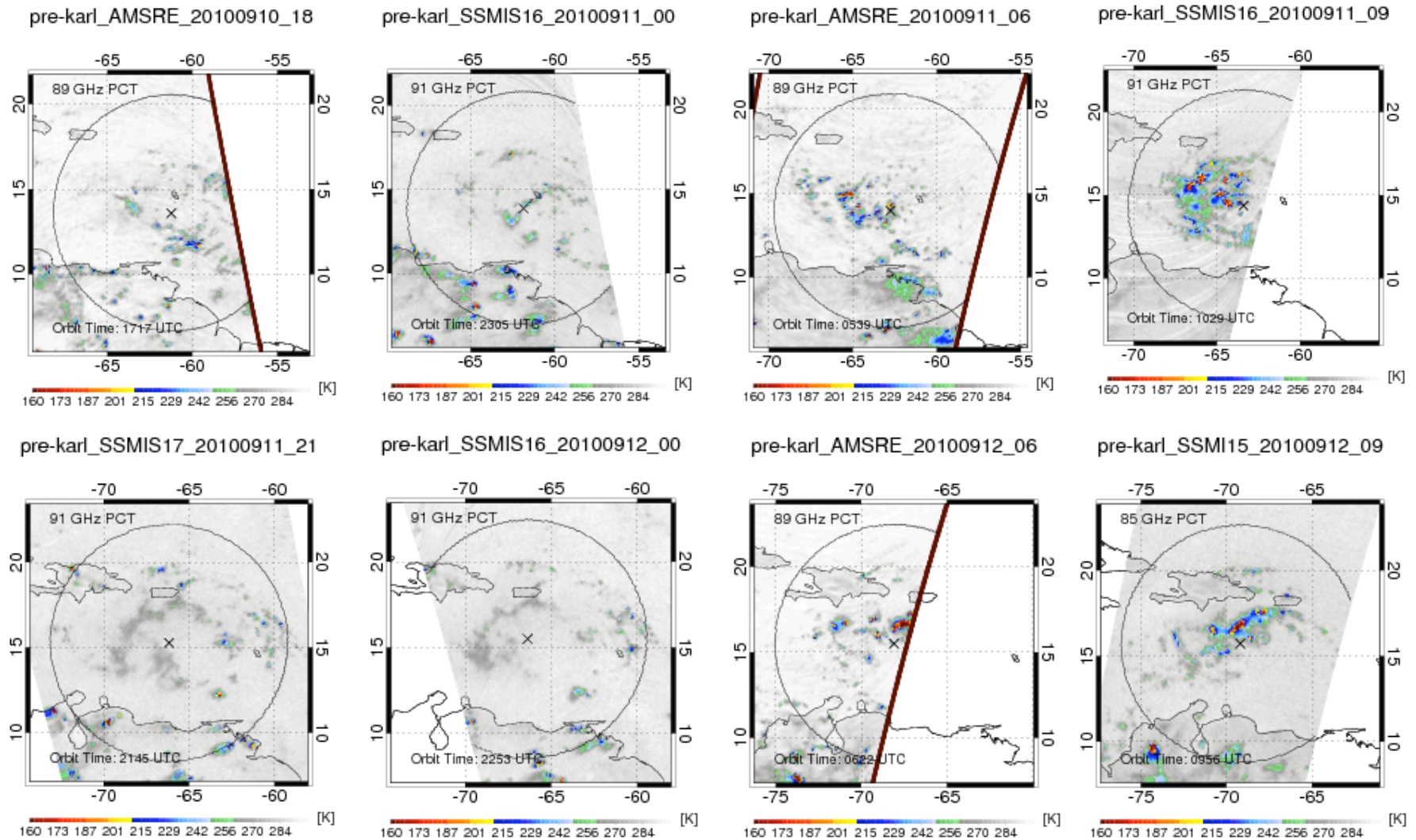


Courtesy Bjorn Lambrigtsen



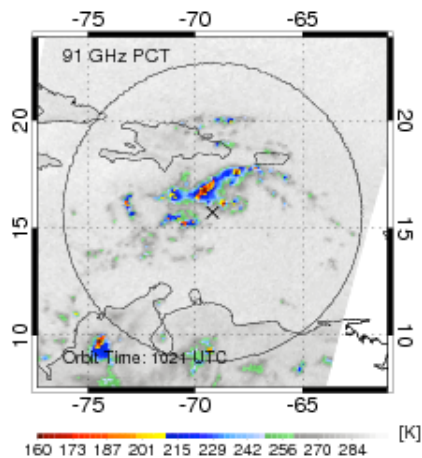
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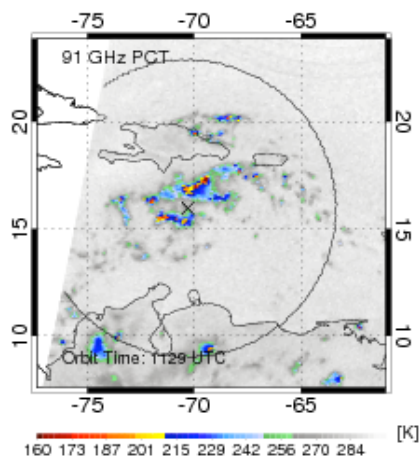


*Courtesy Jon Zawislak*

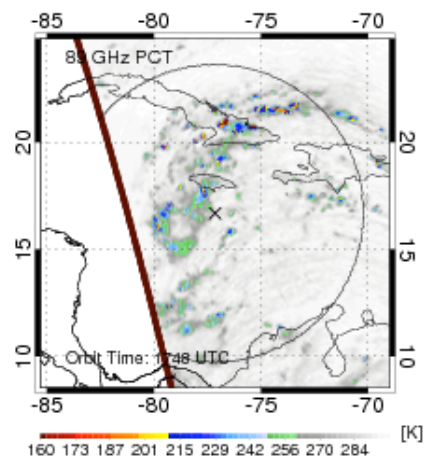
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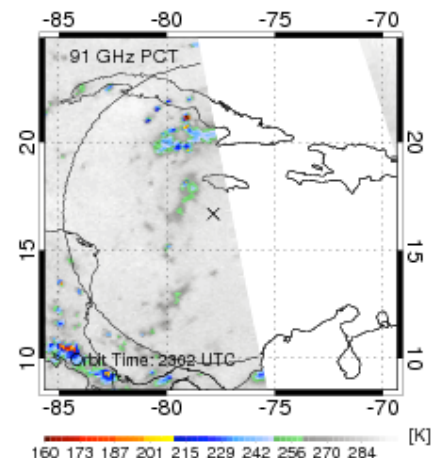
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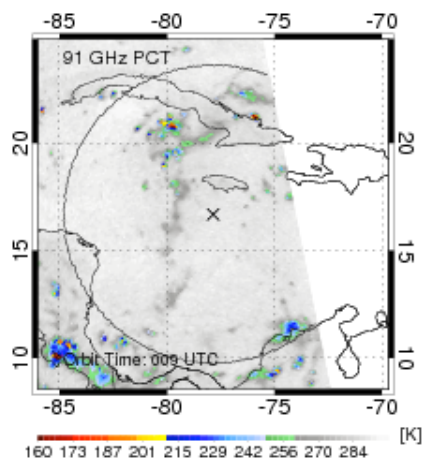
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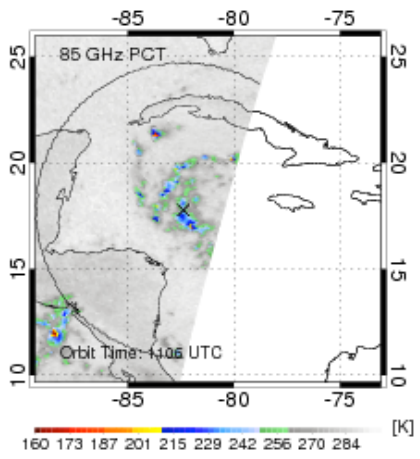
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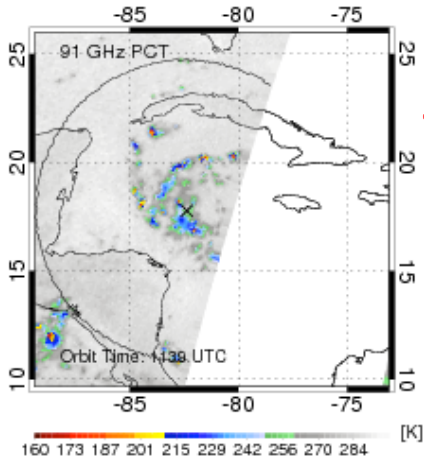
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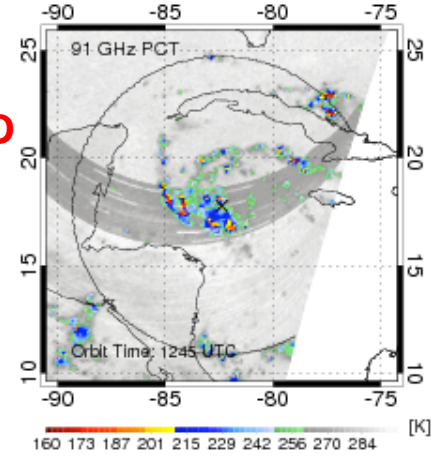
pre-karl\_SSMI15\_20100914\_12



pre-karl\_SSMIS17\_20100914\_12



pre-karl\_SSMIS16\_20100914\_12



*Courtesy Jon Zawislak*