National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

NASA Sounder Science Teem Meeting – Greenbelt – October 13-16, 2015

SHOUT Field Campaigns

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Jet Propulsion Laboratory, California Institute of Technology

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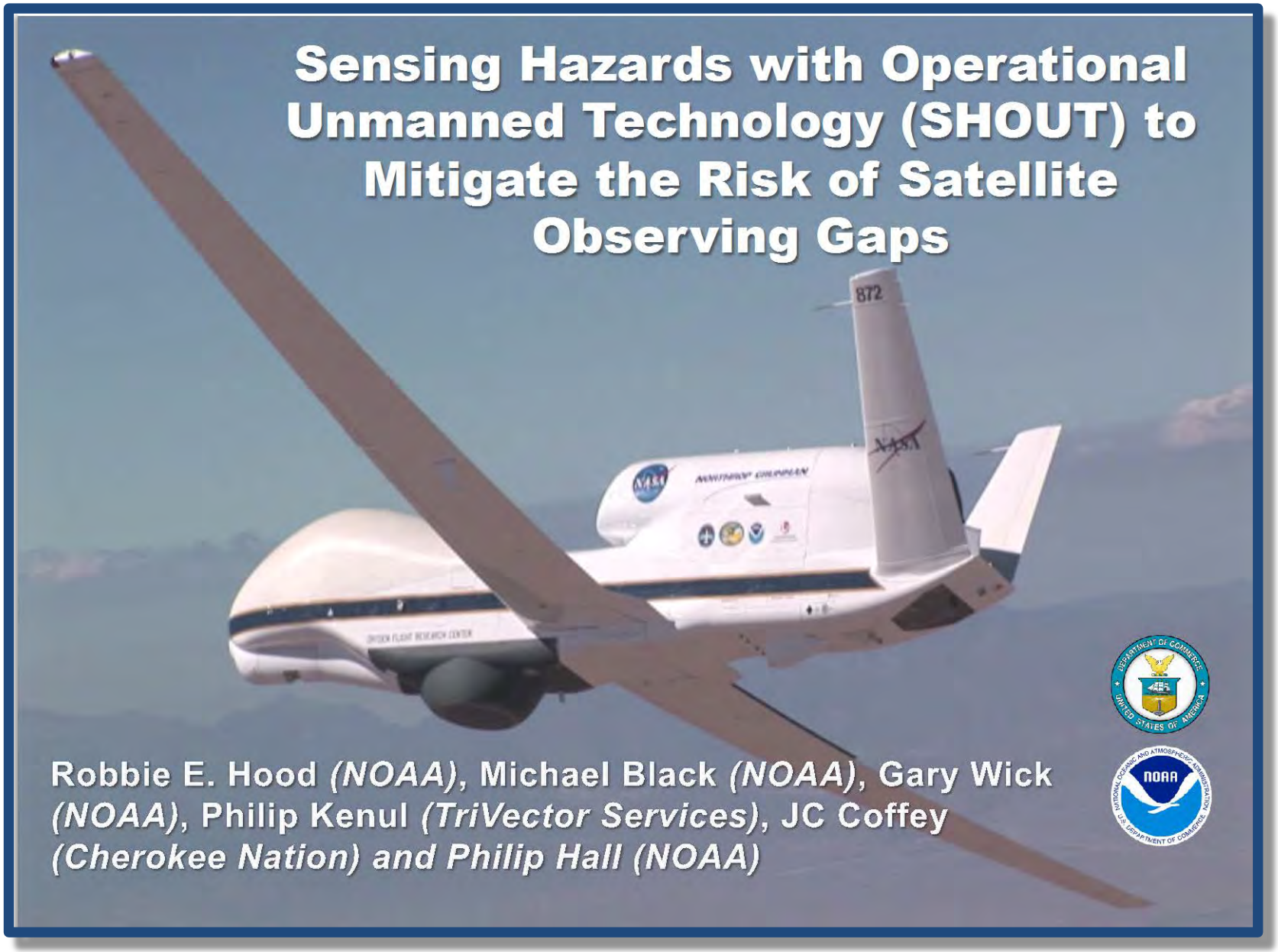

Targeted Observations → Forecasts

Project Objectives

Overall Goal

- Demonstrate and test prototype UAS concept of operations that could be used to mitigate the risk of diminished high impact weather forecasts and warnings in the case of polar-orbiting satellite observing gaps

Objective 1

- Conduct data impact studies
  - Observing System Experiments (OSE) using data from UAS field missions
  - Observing System Simulation Experiments (OSSE) using simulated UAS data

Objective 2

- Evaluate cost and operational benefit through detailed analysis of life-cycle operational costs and constraints

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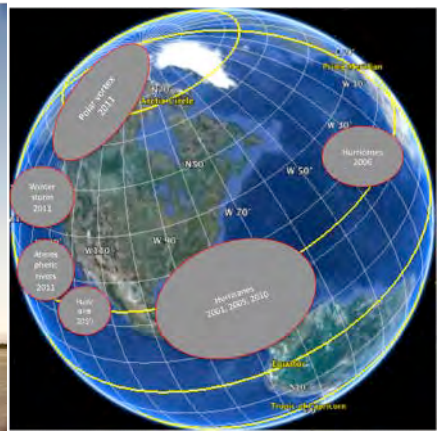
HAMSR Overview

High Altitude MMIC Sounding Radiometer

- Built under IIP-98 in 2001
- Pre-ATMS prototype
- Currently most accurate/sensitive MW sounder
  - Upgraded under AITT in 2010
- Flies on multiple platforms
  - Global Hawk
  - ER-2
  - DC-8
- Data transmitted from Global Hawk in R/T
  - Products displayed in R/T
  - V. useful for situational awareness

Now on the Global Hawk



Flown in many regions

Measurements

- Observations under all weather conditions
- Thermodynamic state of atmosphere
  - T(z), q(z), CLW
- Precipitation
- Convective structure
  - Reflectivity from hydrometeors
- Applications:
  - Hurricanes
  - Atmospheric rivers
  - Storms

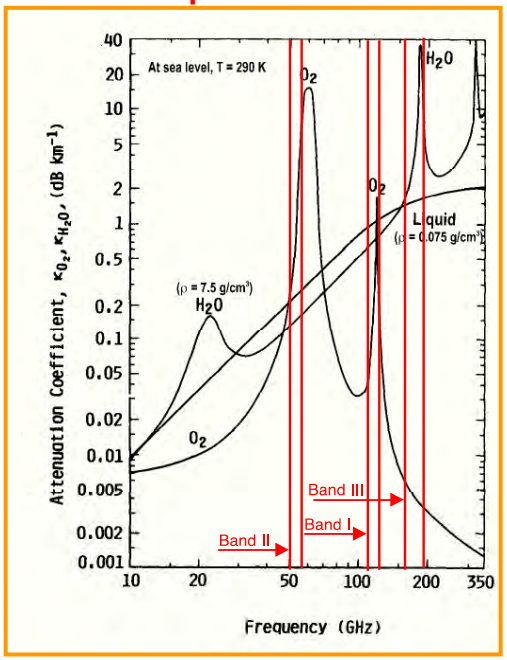
Past and current campaigns

- CAMEX-4/Florida: Hurricanes **2001**
- TCSP/Costa Rica: Hurricanes **2005**
- NAMMA/Cape Verde: Hurricanes **2006**
- GRIP/California: Hurricanes **2010**
- WISPAR/California: **2011**
  - Atmospheric rivers
  - Pacific winter storms
  - Arctic science
- HS3/Virginia: Hurricanes **2011-2015**
- CalWater2/California: Atmospheric rivers **2015**
- SHOUT/CA, VA: Severe weather **2015-2016**
  - Hurricanes (NATL, EPAC)
  - Atmospheric rivers
  - Pacific & arctic winter storms

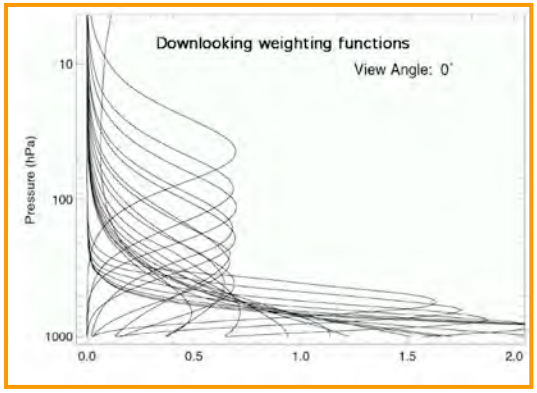
HAMSR Measurement Specs

HAMSR provides a 3D picture of the thermodynamic environment, convective structure & precipitation

Three spectral bands



Weighting functions



Direct measurements:

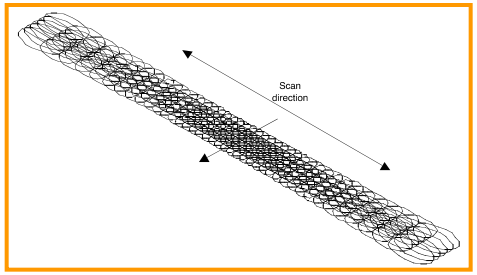
- **Brightness temperatures**
  - 25 channels
  - ~ 0.5 K cal. accuracy
- **Derived vertical profiles:**
  - Surface to aircraft altitude
  - 1-2 km vertical resolution
  - 1-2 km horizontal resolution
  - Super-critical sampling
- **Temperature profiles**
  - Dual bands (50 & 118 GHz)
- **Water vapor profiles**
  - More accurate than AMSU-B
- **Liquid water profiles**
  - 3 bands ⇒ V. profile
- **Reflectivity profiles**
  - Experimental product

25 channels

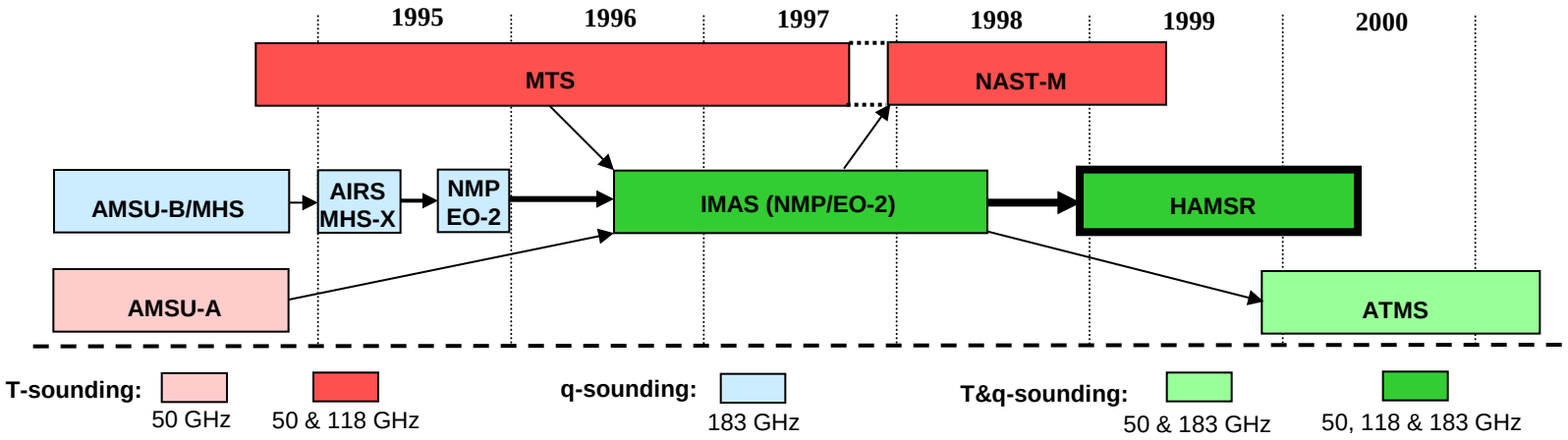
Chan #	Center freq. [GHz]	Offset [GHz]	Bandwidth [MHz]	Wt-func. Peak [mb or mm]
I-1	118.75	-5.500	1500	Sfc/[30 mm]
I-2	"	-3.500	1000	Surface
I-3	"	-2.550	500	Surface
I-4	"	-2.050	500	1000 mb
I-5	"	-1.600	400	750 mb
I-6	"	-1.200	400	400 mb
I-7	"	±0.800	2x400	250 mb
I-8	"	±0.450	2x300	150 mb
I-9	"	±0.235	2x130	80 mb
I-10	"	±0.120	2x100	40 mb
⇒ II-1	50.30	0	180	Sfc/[100 mm] ⇐
II-2	51.76	0	400	Surface
⇒ II-3	52.80	0	400	1000 mb ⇐
⇒ II-4	53.596	±0.115	2x170	750 mb ⇐
⇒ II-5	54.40	0	400	400 mb ⇐
⇒ II-6	54.94	0	400	250 mb ⇐
⇒ II-7	55.50	0	330	150 mb ⇐
⇒ II-8	56.02 56.67	0	270 330	90 mb ⇐
⇒ III-1	183.31	-17.0	4000	[11 mm] ⇐
III-2	"	±10.0	2x3000	[6.8 mm]
⇒ III-3	"	±7.0	2x2000	[4.2 mm] ⇐
III-4	"	±4.5	2x2000	[2.4 mm]
⇒ III-5	"	±3.0	2x1000	[1.2 mm] ⇐
III-6	"	±1.8	2x1000	[0.6 mm]
⇒ III-7	"	±1.0	2x500	[0.3 mm] ⇐

⇒: Identical to AMSU ⇒: Equivalent to AMSU

Cross-track scanner



Context and Pedigree of HAMSR

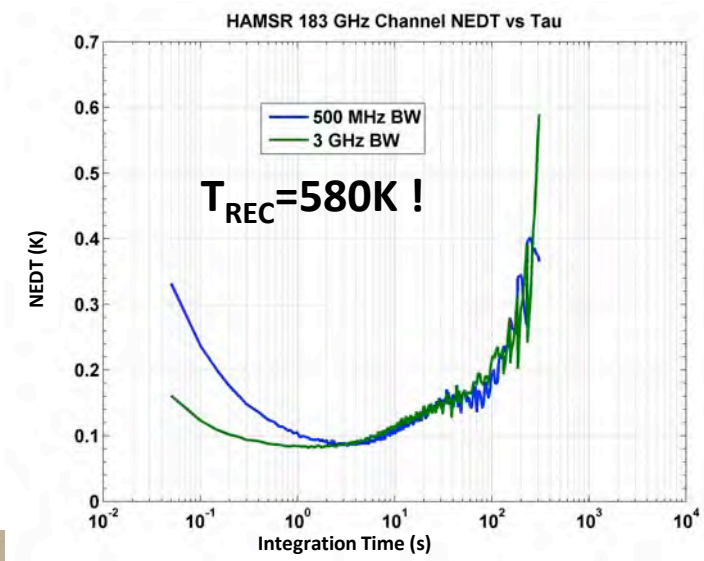


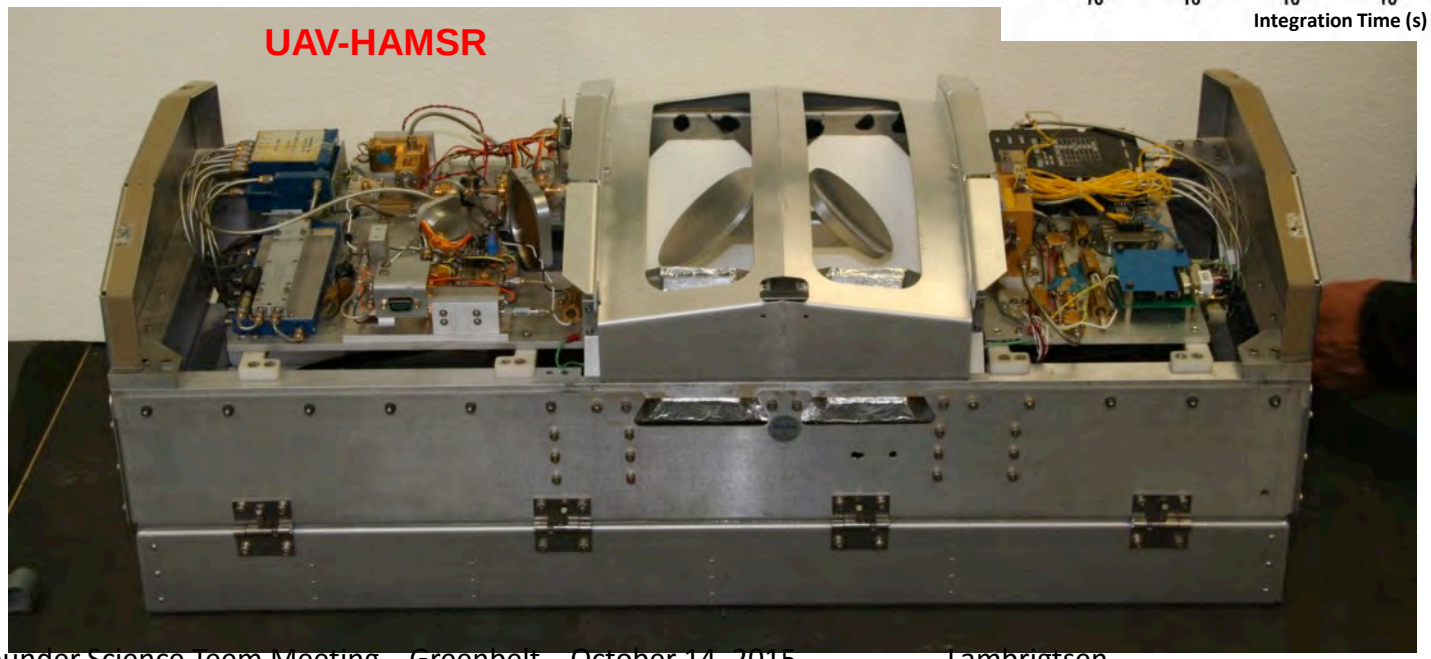
- HAMSR carries the IMAS development effort to maturity
  - Dual-band T-sounding + q-sounding in single package
  - New MMIC receiver technology; Small instrument
- ATMS is also based on IMAS
  - Single-band T-sounding + q-sounding
- NAST-M implements IMAS T-sounding
  - Dual-band T-sounding — No q-sounding (added later)

Developed under IIP (1998-2001) Upgraded under AITT (2008-2009)

- New 183-GHz receiver (from GeoSTAR)
- Upgraded
  - power
  - thermal
  - scanning system
- ***Reconfigured for Global Hawk***
- Developed R/T data link
  - R/T processing system

Breakthrough receiver performance





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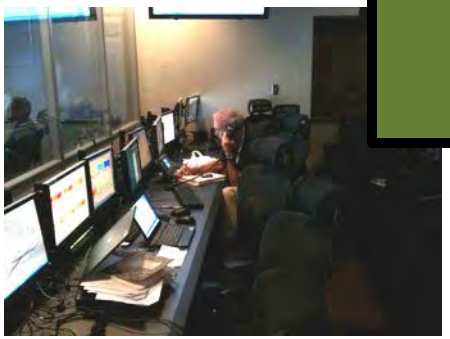
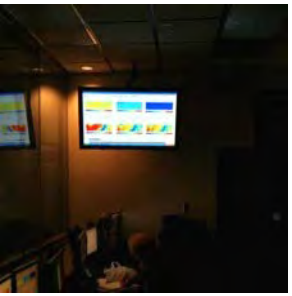
HAMSR real-time data system

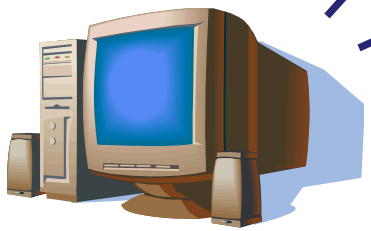
Commanding

Data downlink

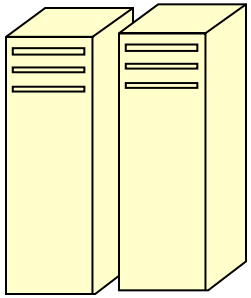


GHOC

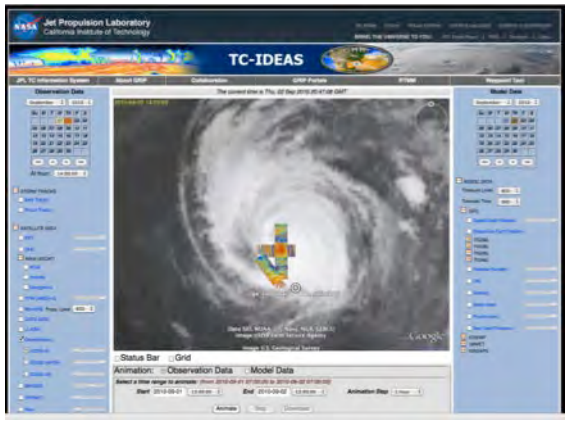




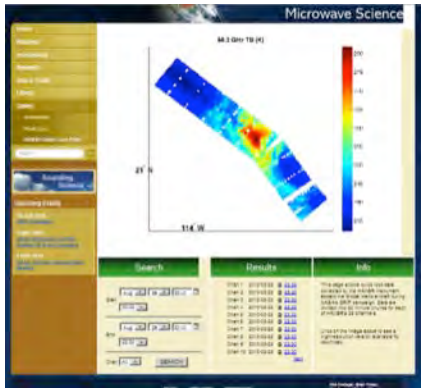
HAMSR ground data processor



netCDF L1B files

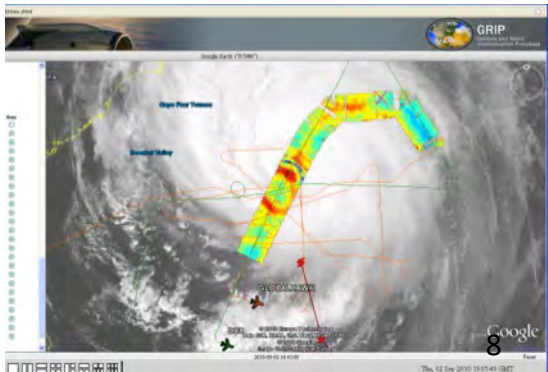


JPL Hurricane Portal



HAMSR website quick look images

Mission server



The JPL Tropical Cyclone Information System

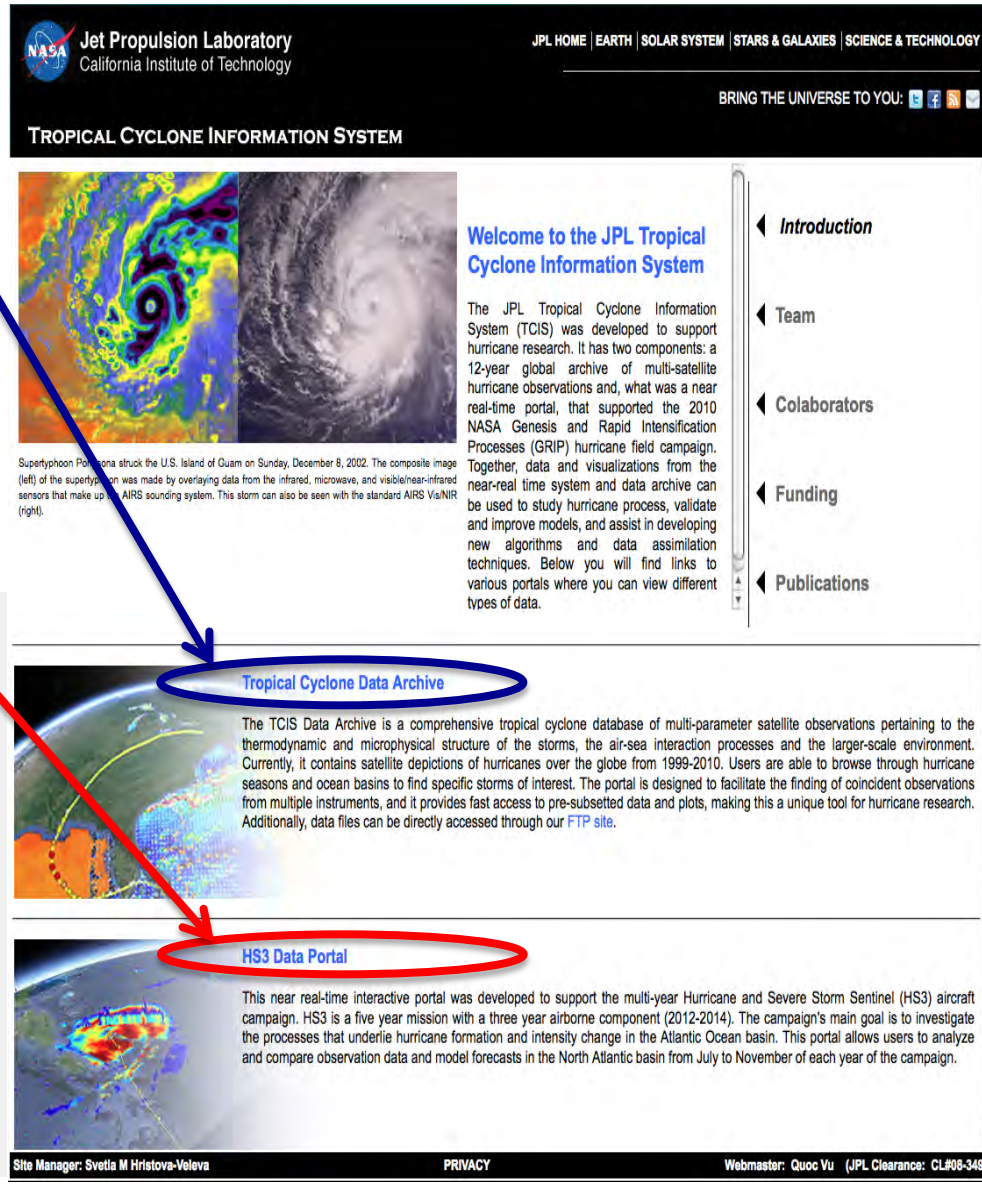
http://tropicalcyclone.jpl.nasa.gov or http://hurricanewatch.jpl.nasa.gov

Tropical Cyclone Data Archive

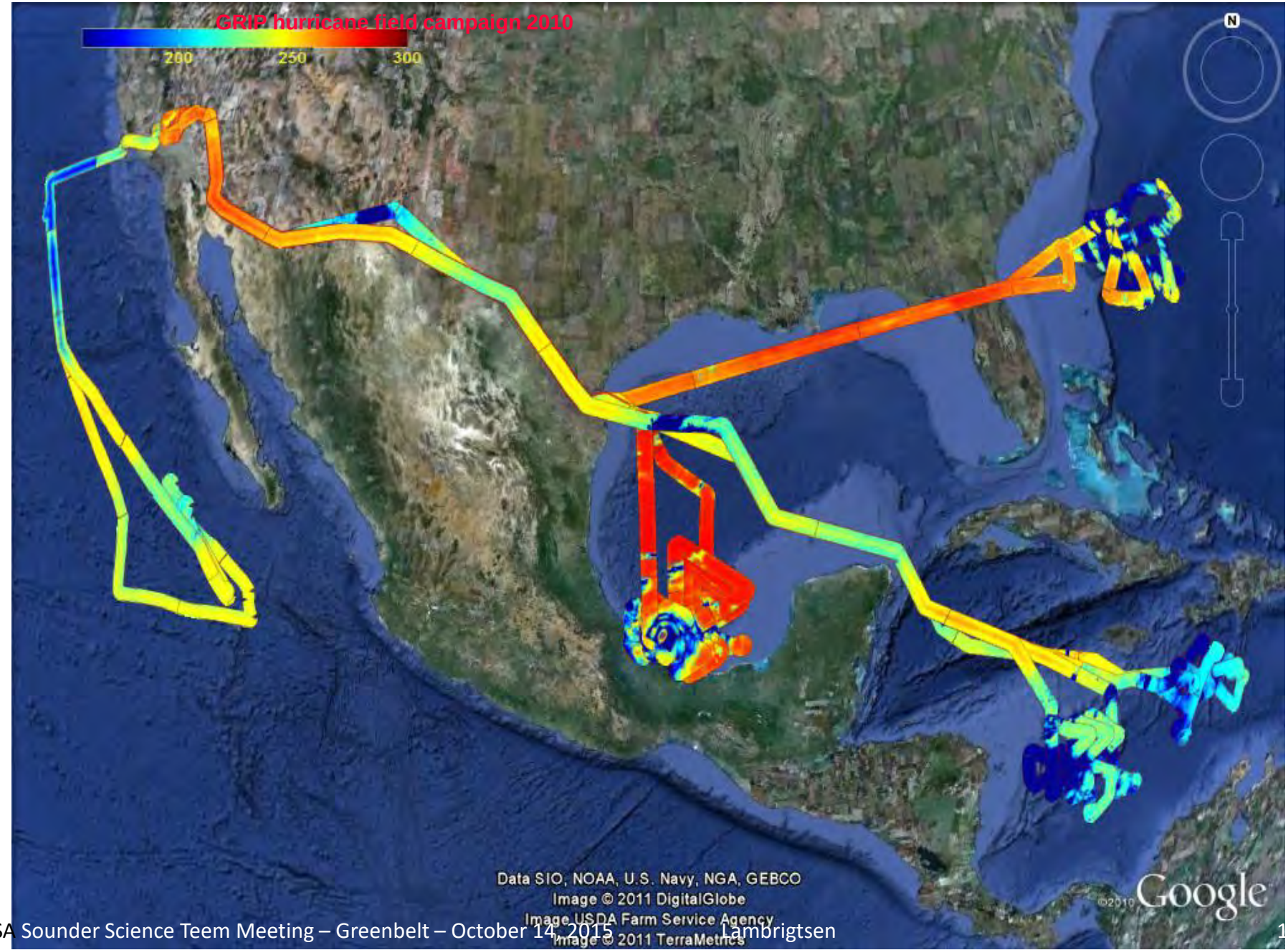
- Satellite depiction of hurricanes over the globe
- 12-year record (1999-2010)
- offers both data and imagery, making it a unique source to support:
  - hurricane research
  - forecast improvement
  - algorithm development
  - instrument design

HS3 – Interactive NRT Atlantic portal

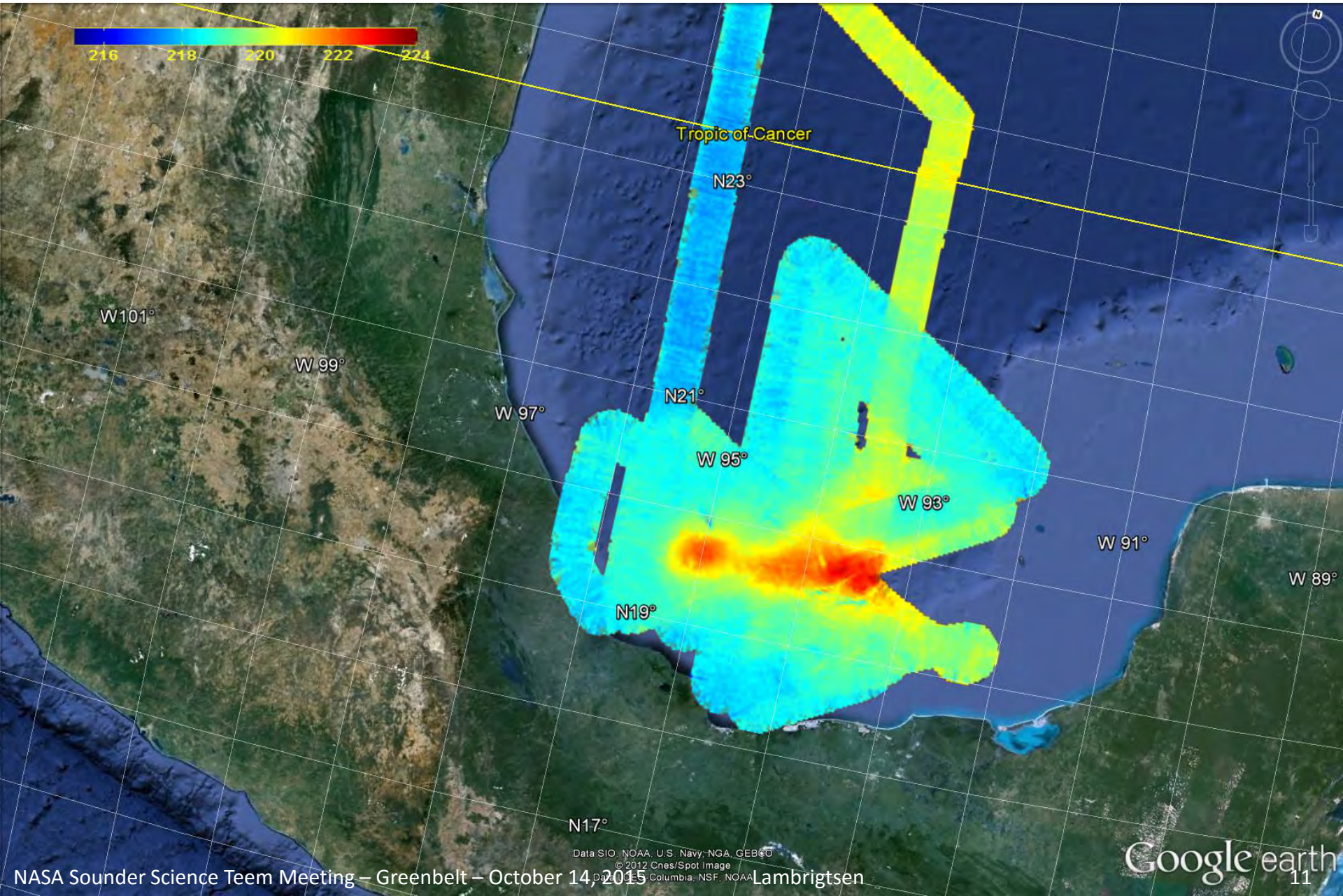
- Integrates model forecasts with satellite and airborne observations from a variety of instruments and platforms, allowing for easy model/observations comparisons.
- Allows interrogation of a large number of atmospheric and ocean variables to better understand the large-scale and storm-scale processes associated with hurricane genesis, track and intensity changes.
- Very rich information source during the analysis stages of the field campaigns.



Hurricanes (GRIP, 2010)



Hurricane Karl Flight



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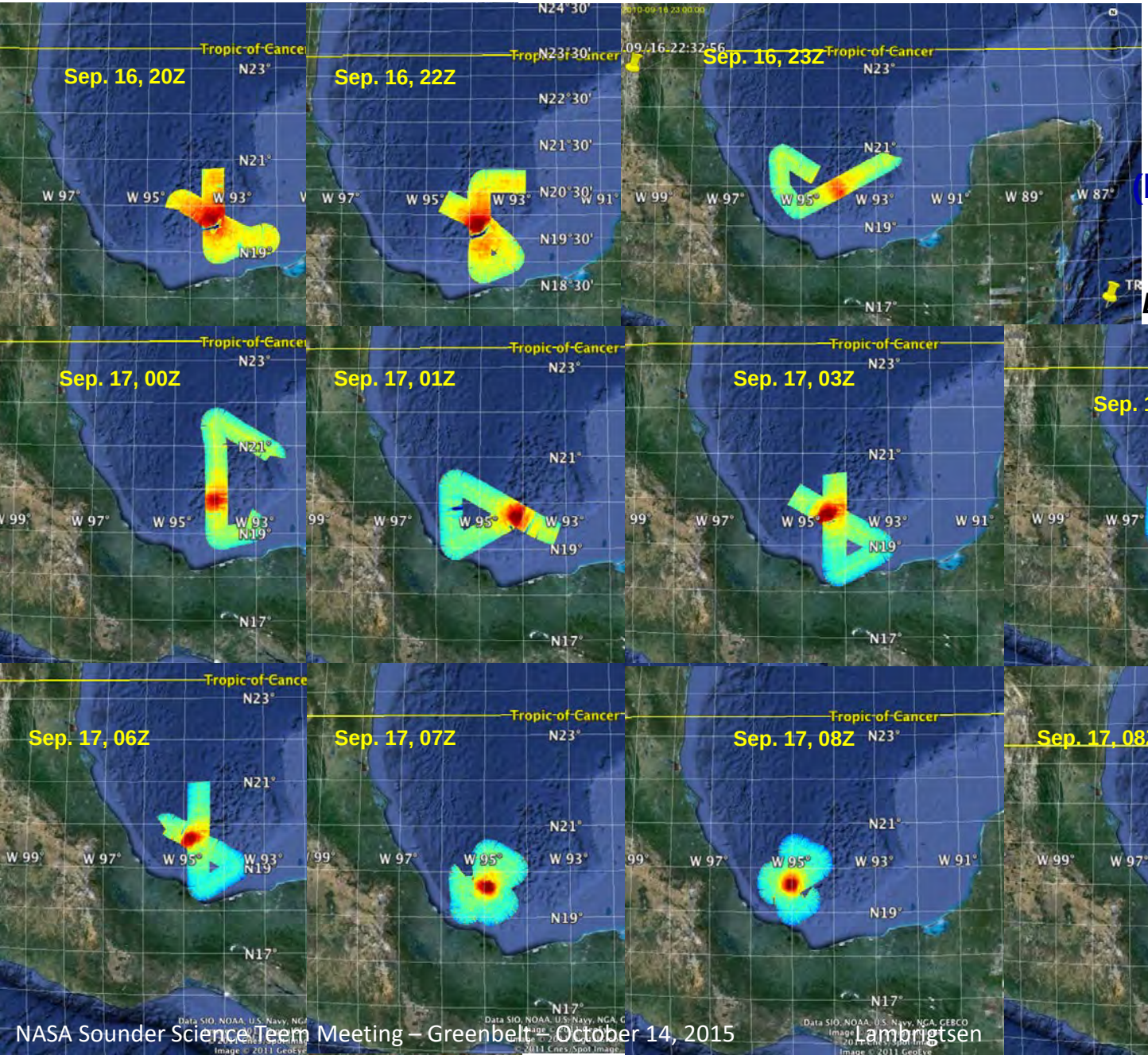
20 Eye Overpasses: A New record

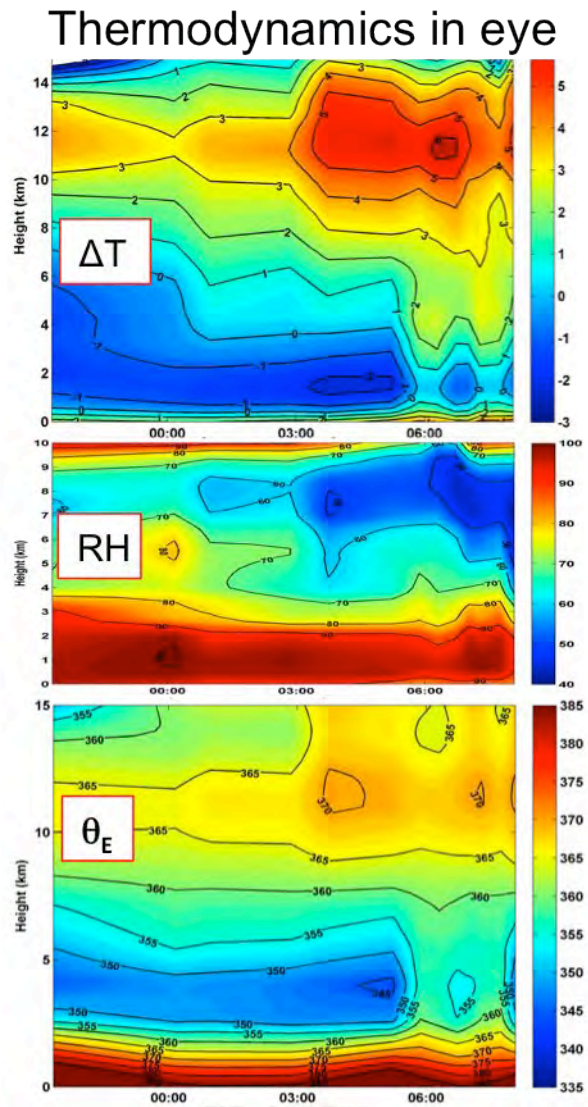


Warm core evolution as seen by HAMSR (brightness temperatures Channel 6

B. Lambrigtsen & S. Brown

Evolution of Warm Core During RI

Hurricane Karl during Rapid Intensification

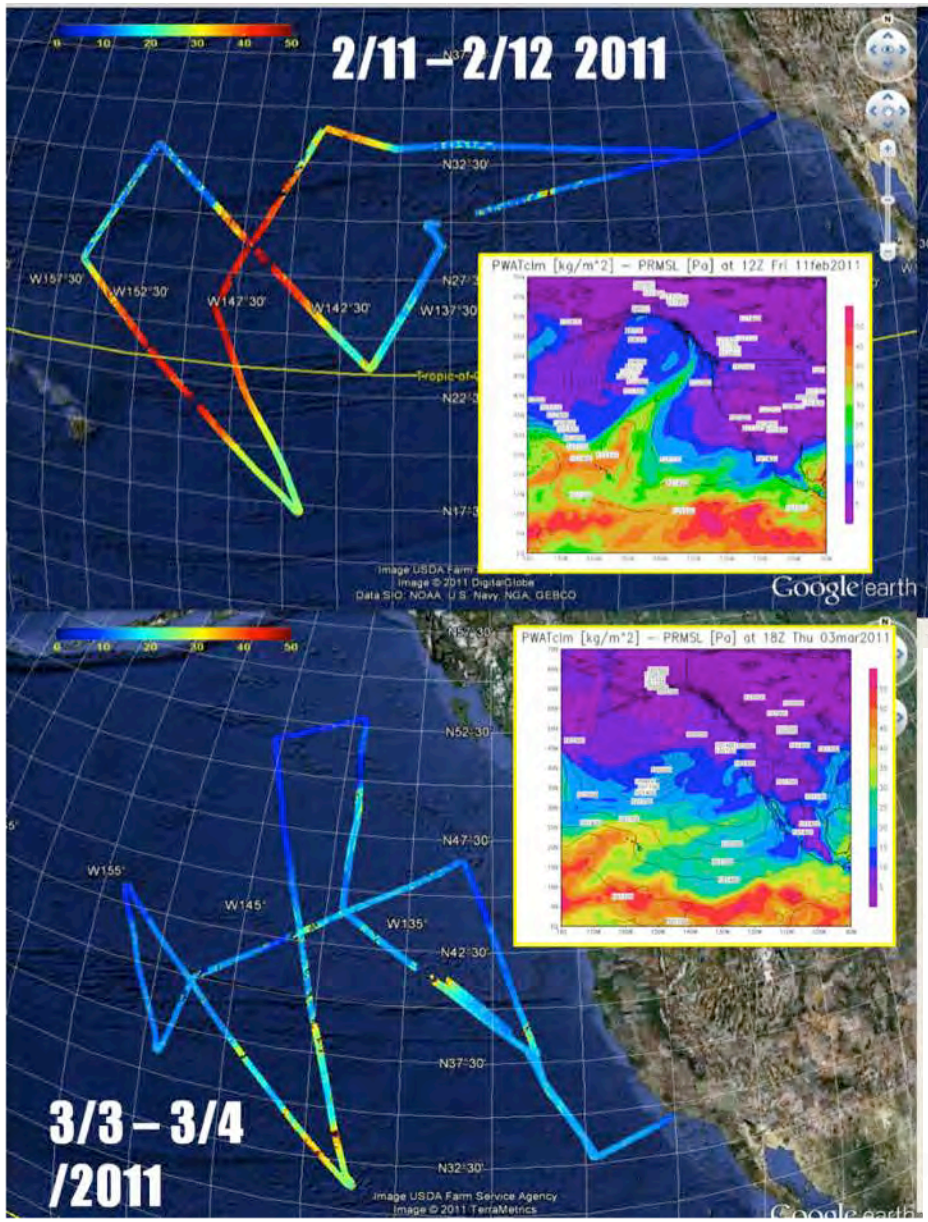


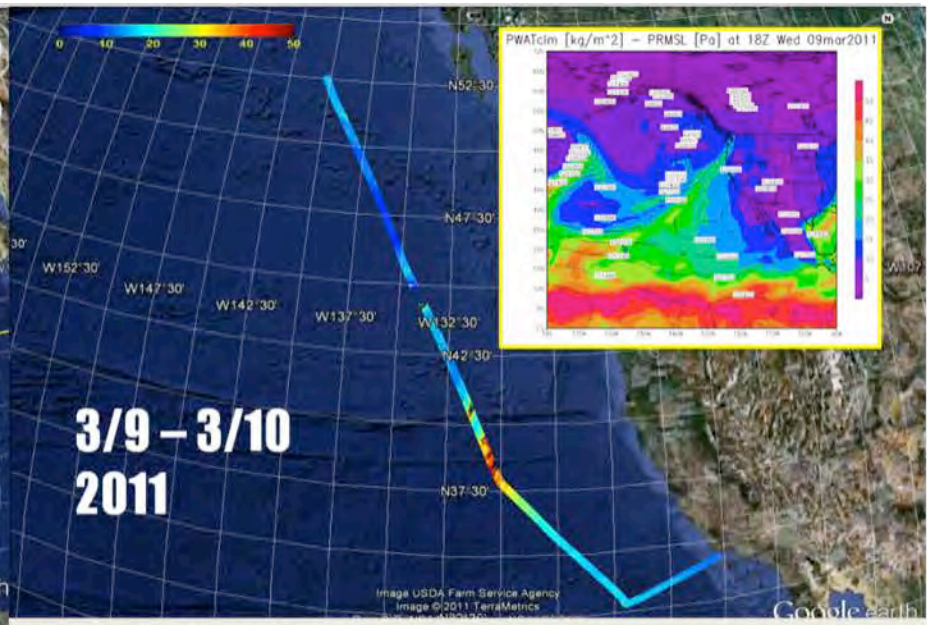
Warm anomaly propagates to lower levels as the storm intensifies with the peak warm anomaly increasing by ~2-3C

Decreasing RH in upper troposphere while air below the inversion layer remained near saturation

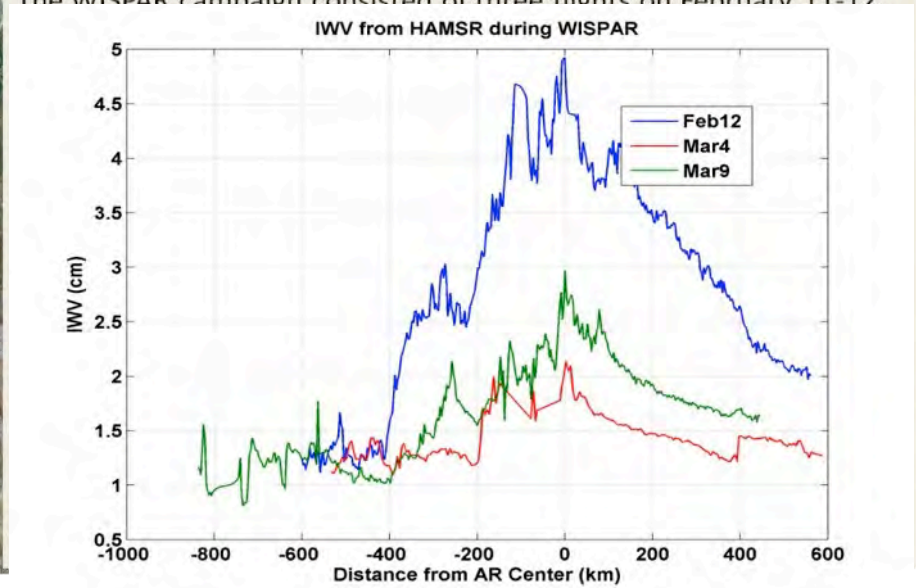
Evolution near the end of the flight may be influenced by proximity of land

Atmospheric Rivers (WISPAR, 2011)

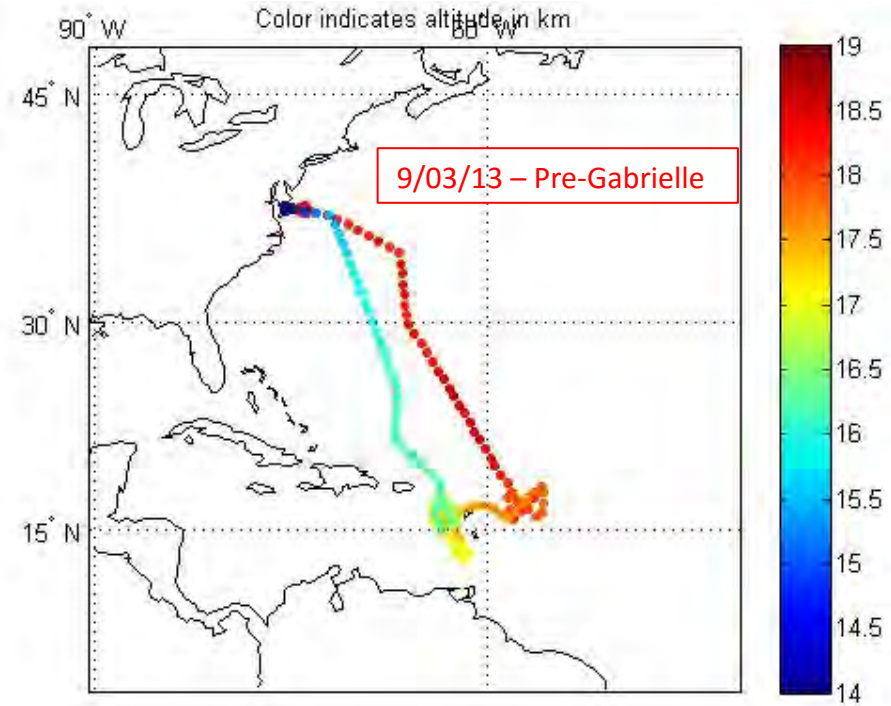


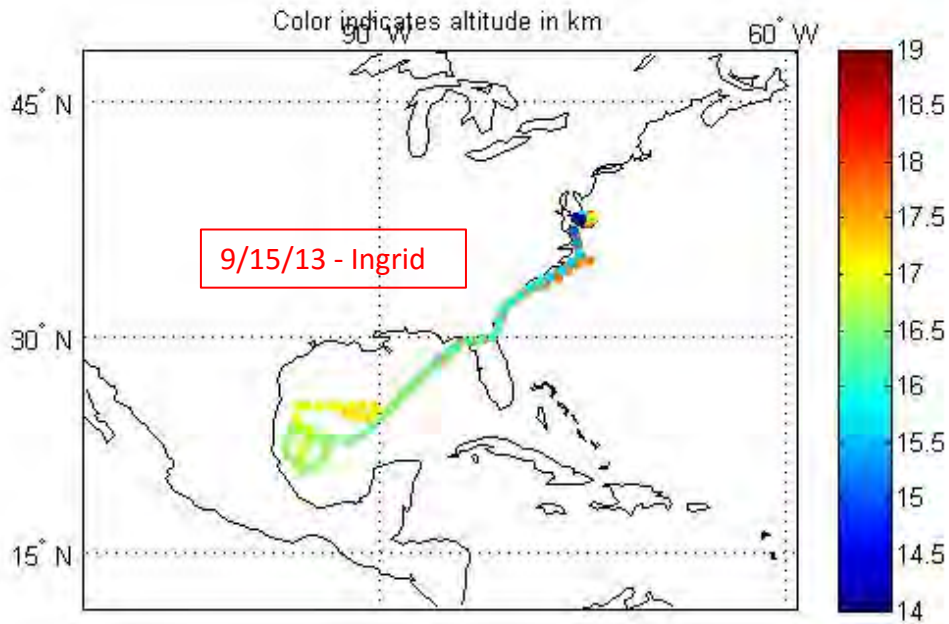


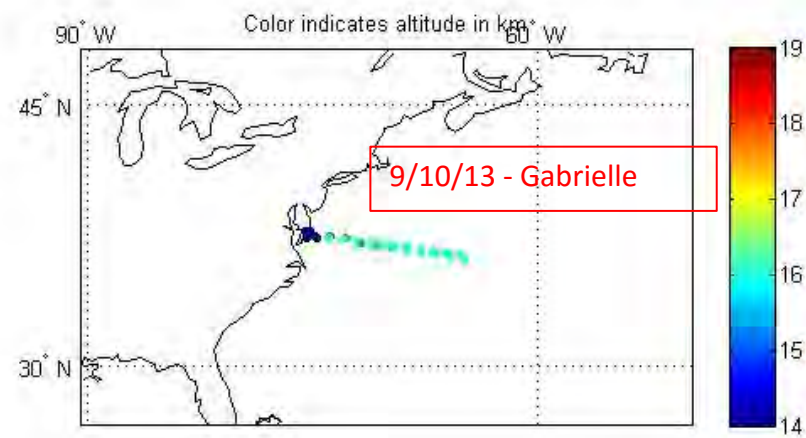
The WISPAR campaign consisted of three flights on February 11-12

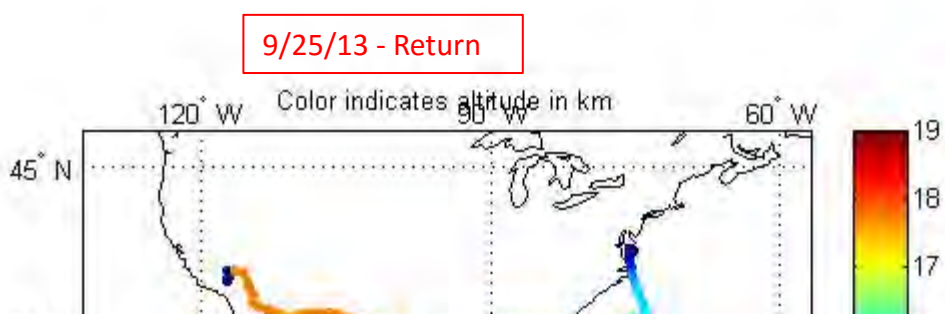


More Hurricanes (HS3, 2012-2014)





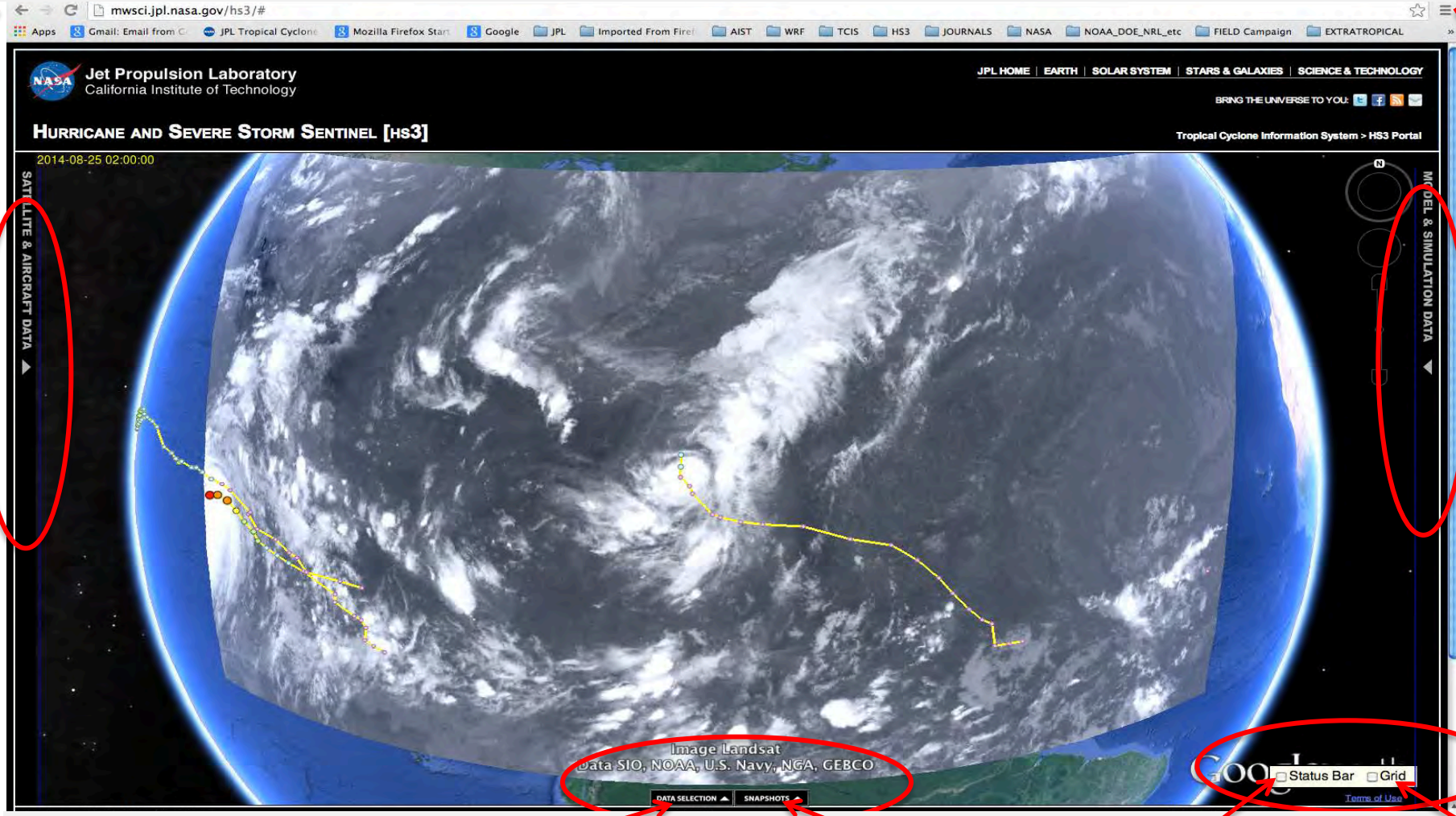




HS3 Portal (NRT version of JPL Portal)

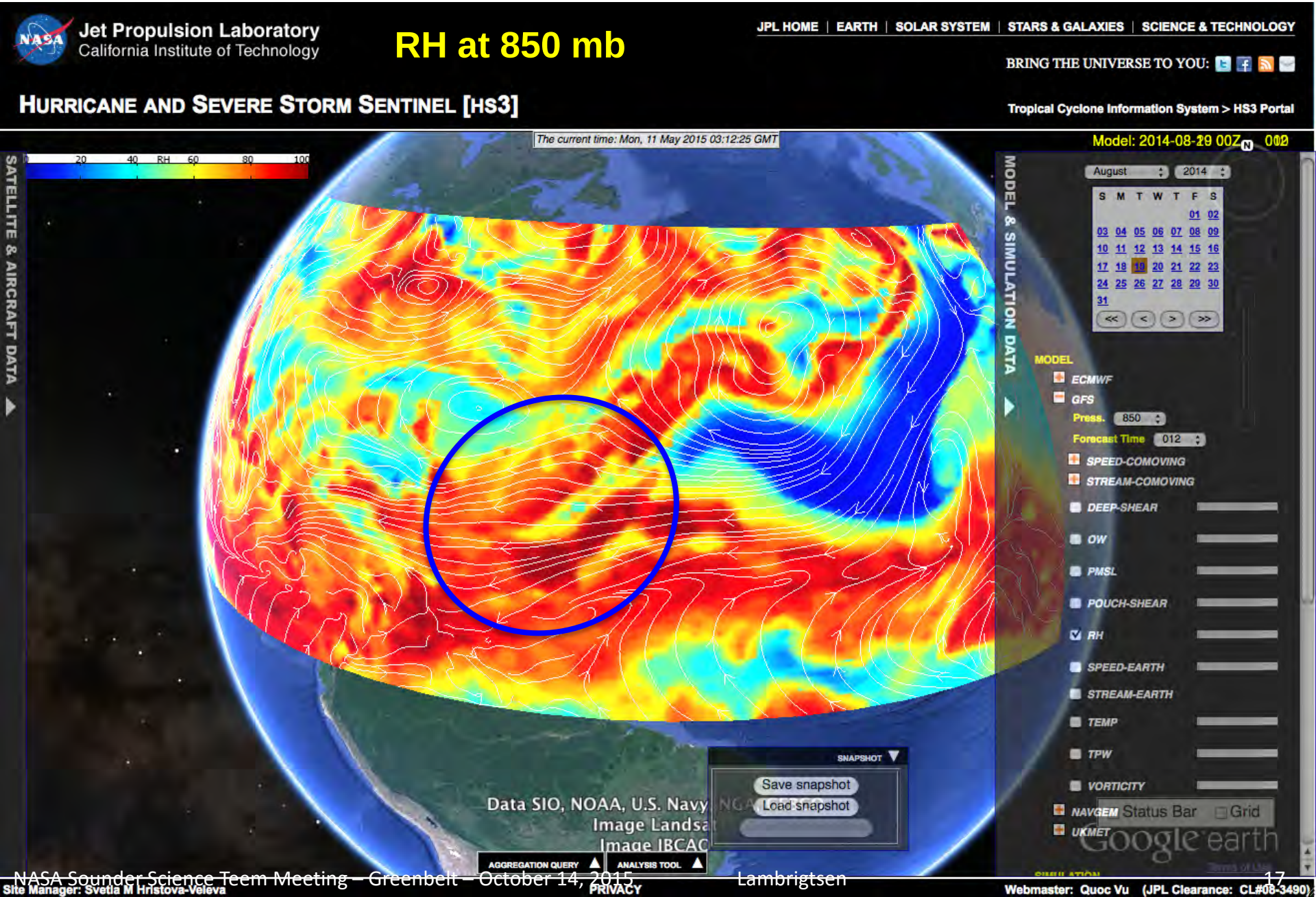
Two Calendar-driven menus (click on the triangles on the two sides):

- Observations **- Model data**

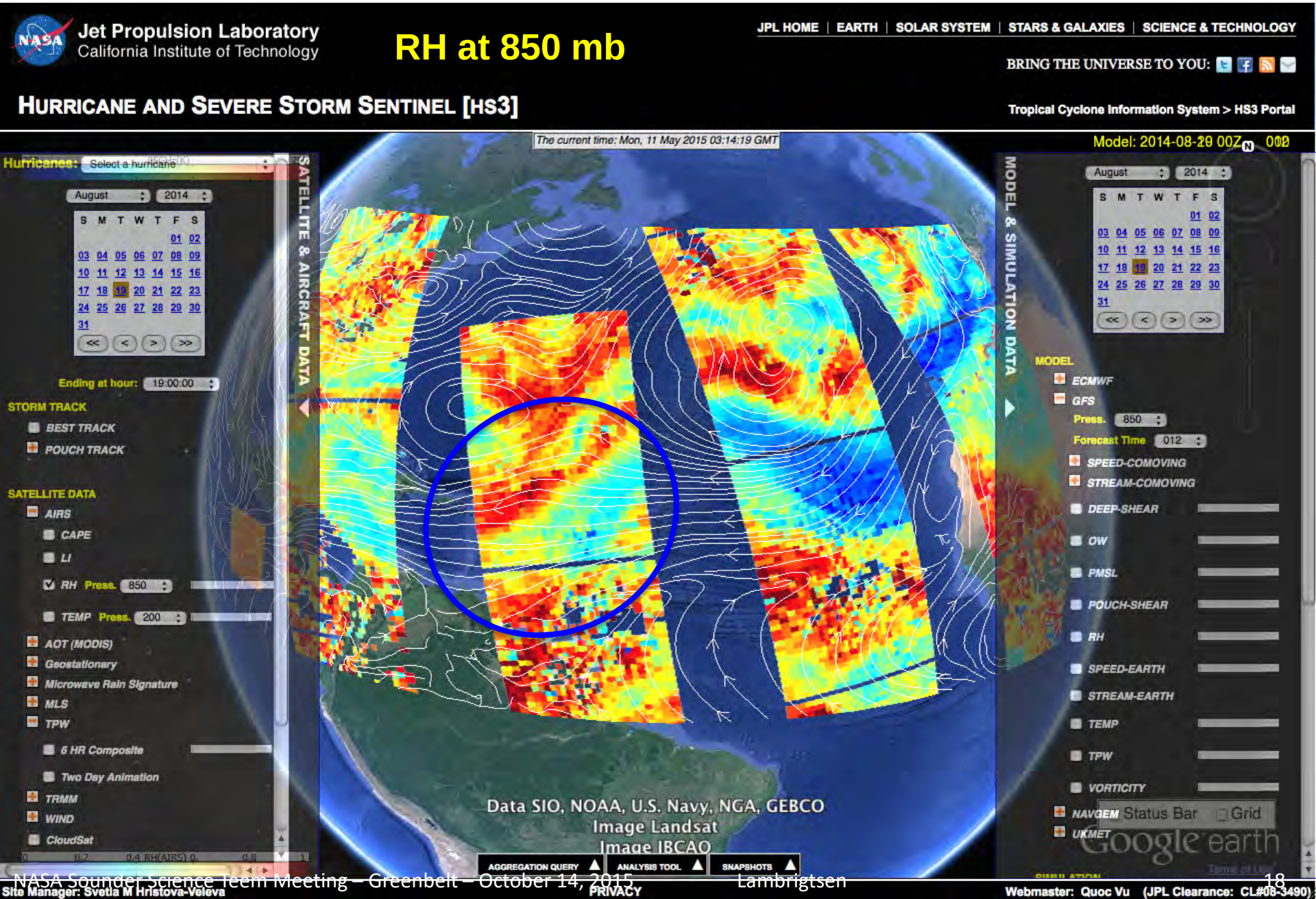


Analysis Tools **Save a view** **Overlay Grid**
Find lat/lon of a point

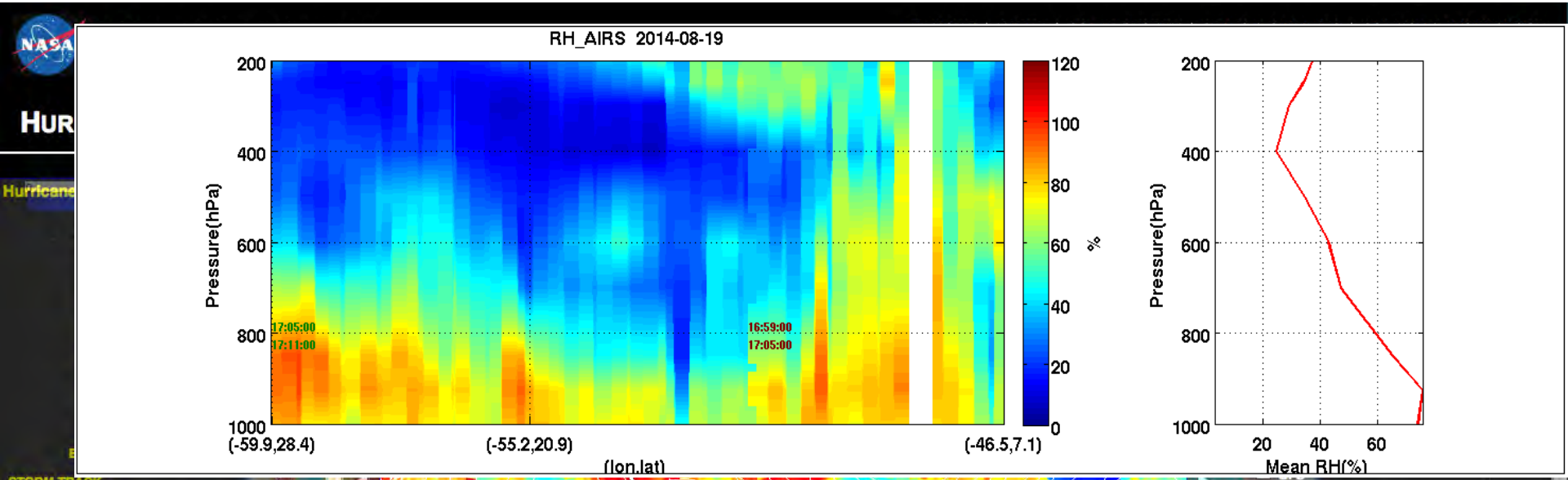
Forecast Analysis: GFS

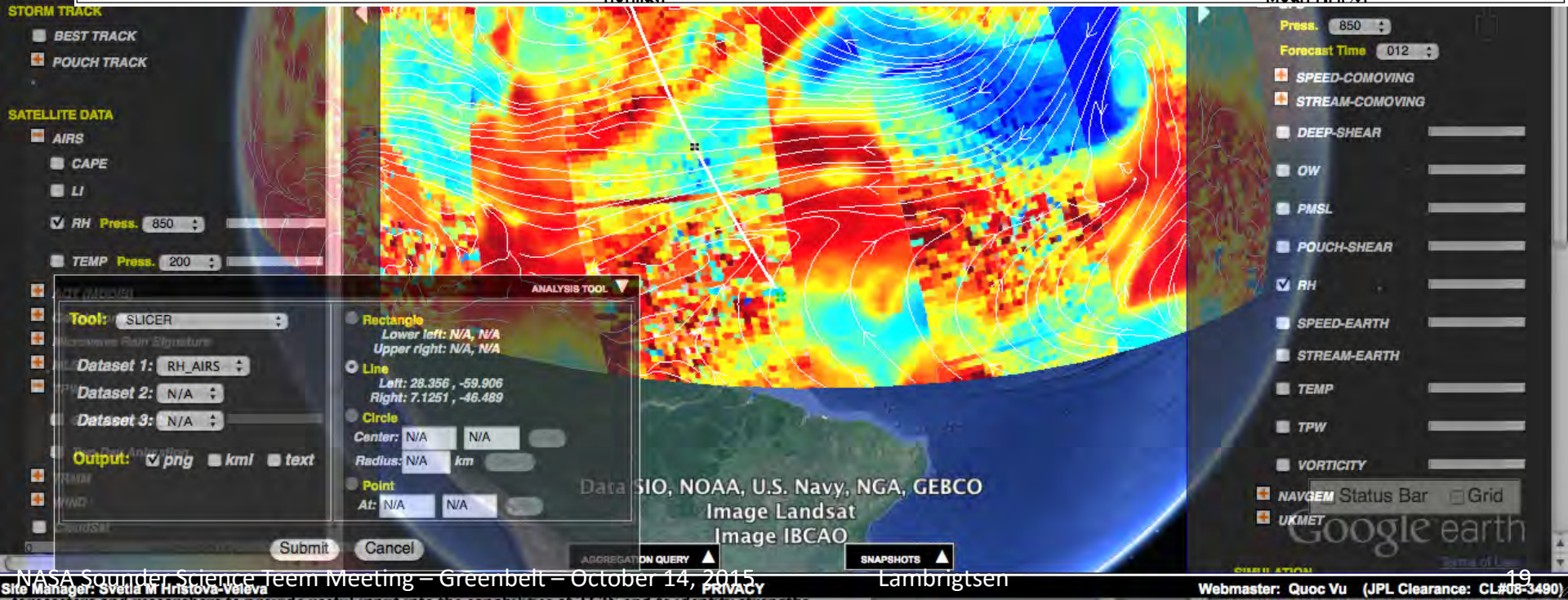


Satellite Observations: AIRS



The "Slicer" Tool – Vertical Profiles





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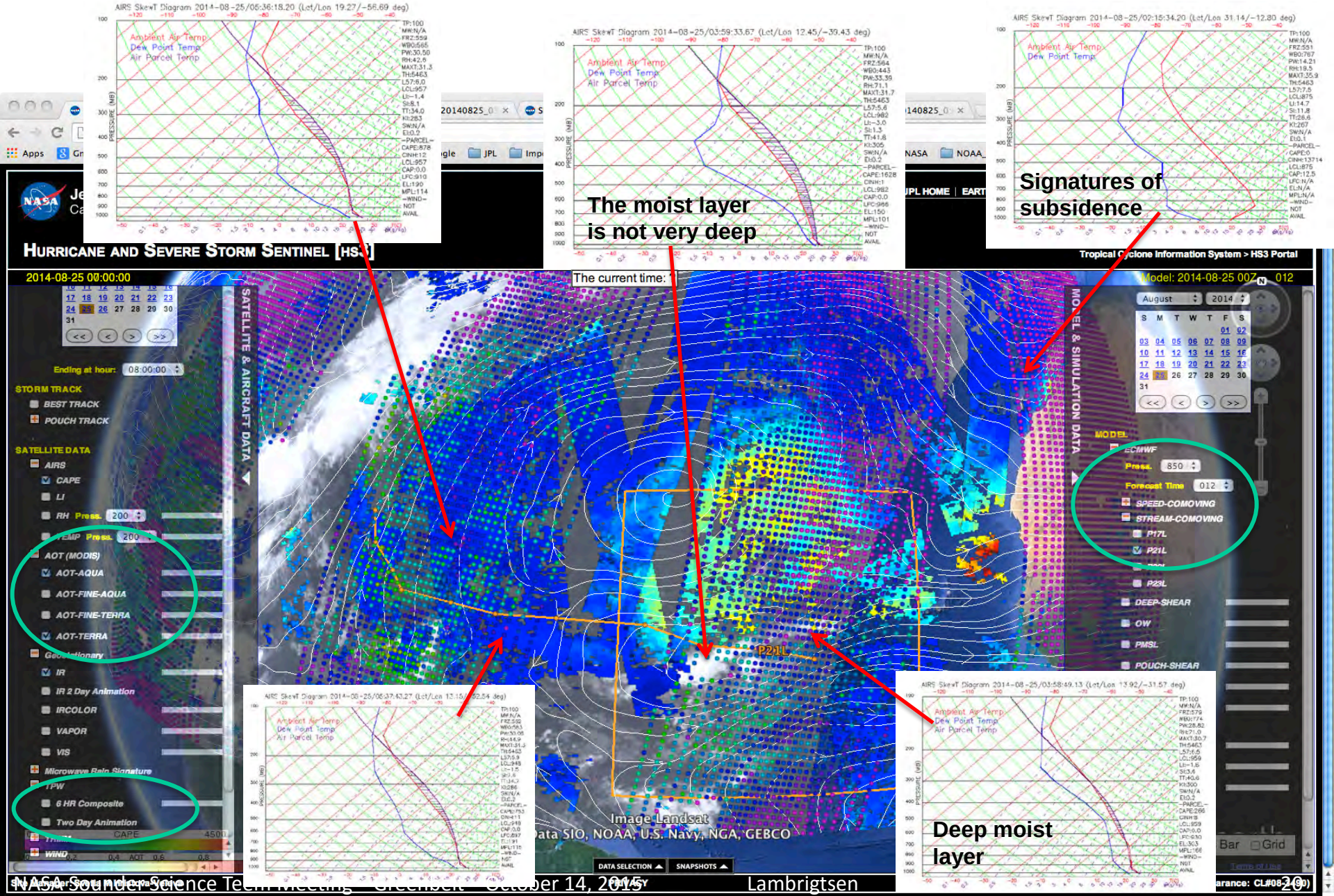
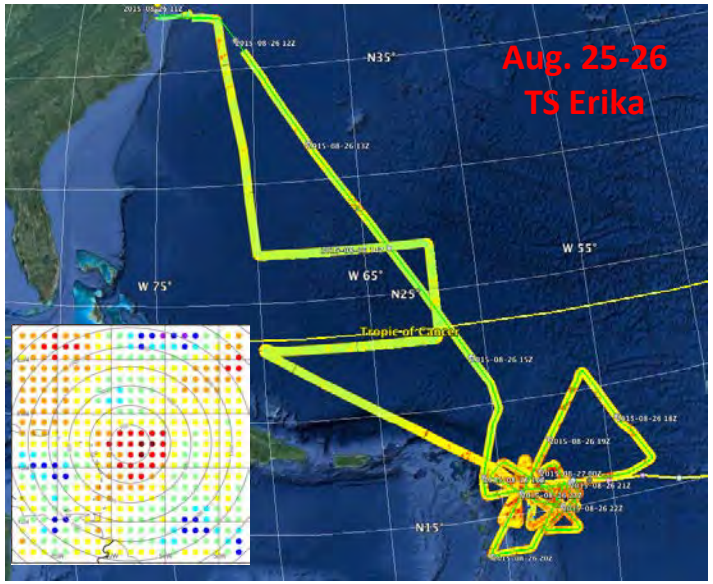
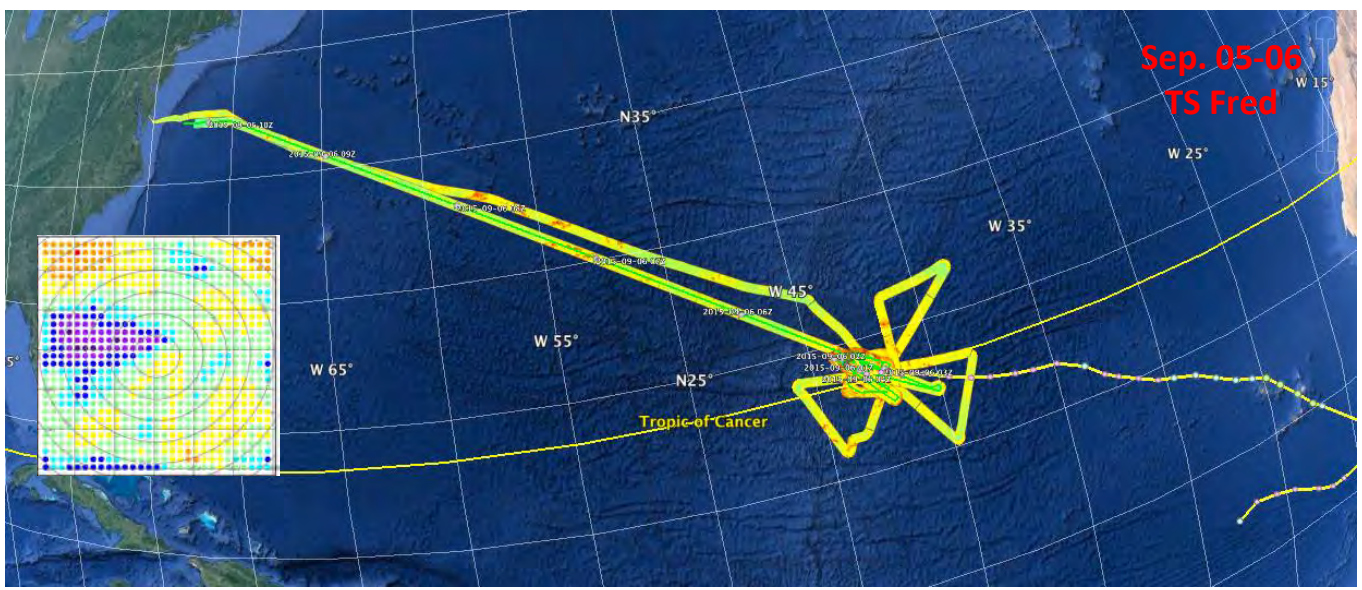
Skew-T from AIRS, AOT from MODIS



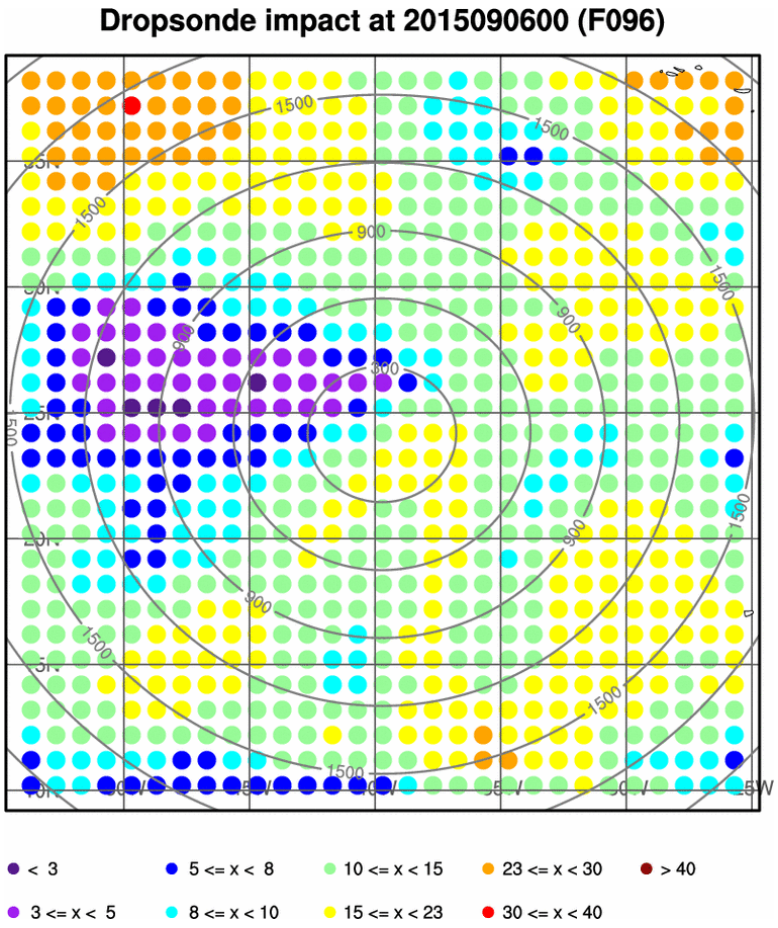
SHOUT Flights (2015)

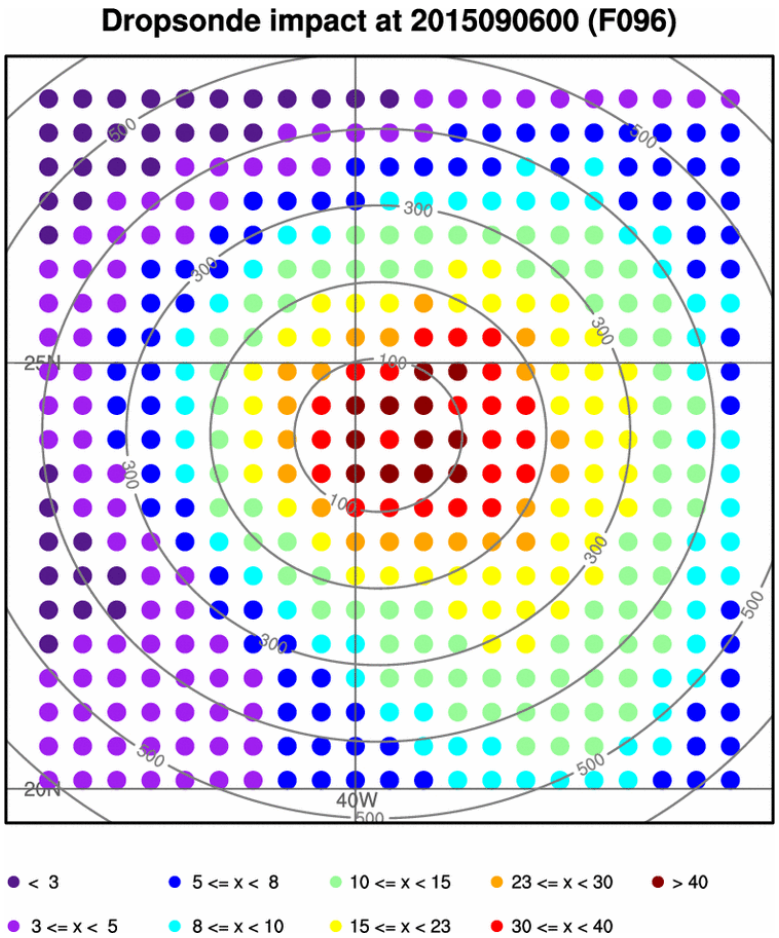




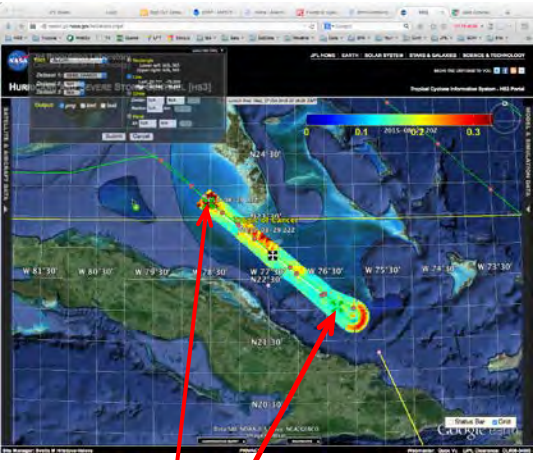
Flight Planning for Forecast Impact

- Predicted forecast impact from dropsondes, based on HWRF
- Results in maps of recommended coverage regions
- Example TS Fred: Track forecast (left); Intensity forecast (right)

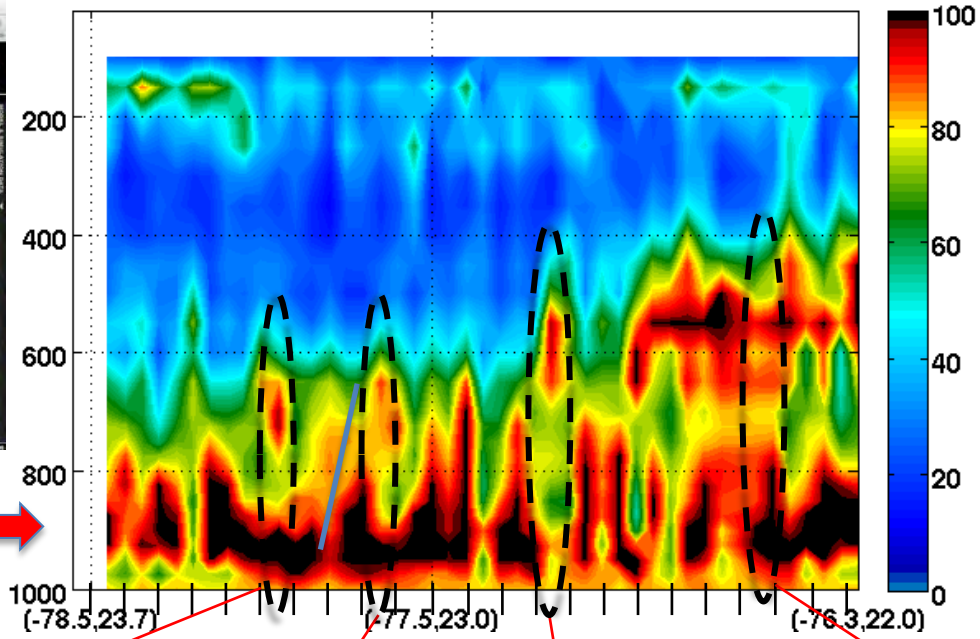


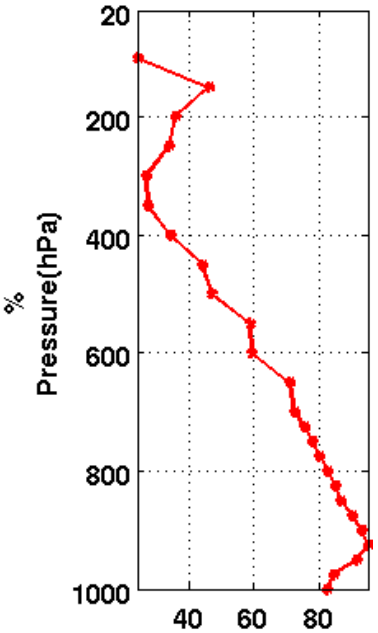


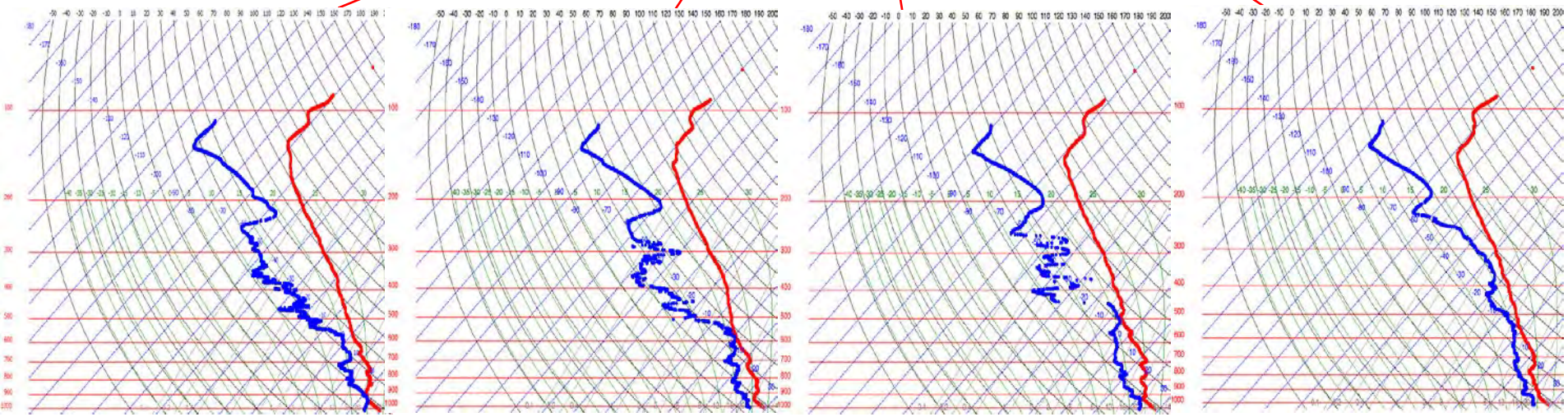
HAMSR vs. Dropsondes (Erika #2)



Slicing tool between these end points

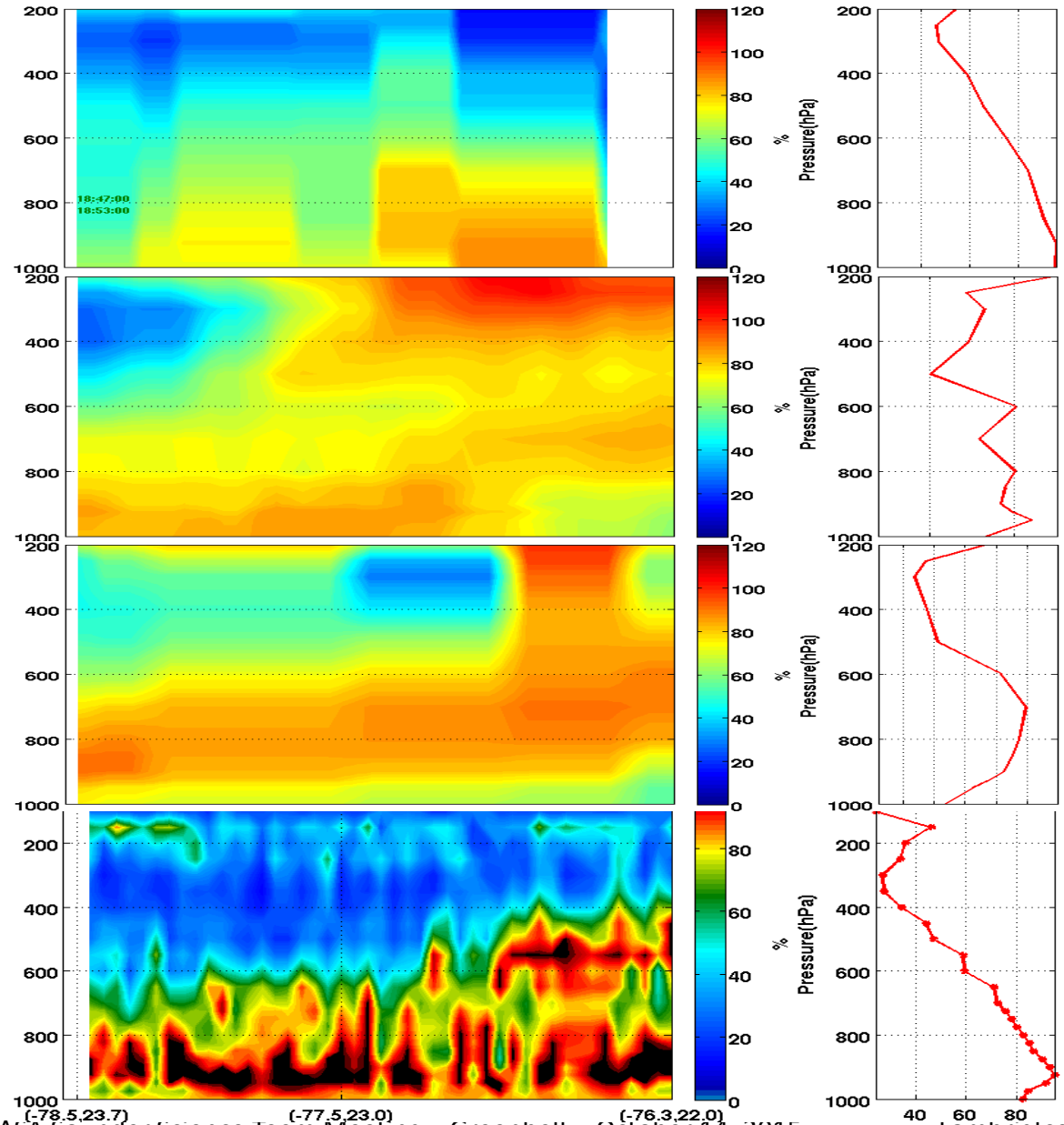






AIRS-ECMWF-GFS-HAMSR RH-comparisons

Erika #2, 8/29 ~ 22Z



AIRS (19Z) does pretty well: gets BL moist layer and UT dry layer

ECMWF (24Z) gets BL moist layer but misses much of UT dry layer

GFS (24Z) misses most of BL moist layer, gets UT dry layer fairly well

HAMSR (22Z) agrees well with DSs; penetrates further than AIRS

Summary

- Campaign was only partly successful
  - Due to a lack of TCs (both in NATL and later in EPAC)
- Dropsondes were assimilated operationally
  - Forecast impact TBD
  - SHOUT Project will conduct OSEs to measure impact
- HAMSR not assimilated
  - But is the most reliable sensor
  - SHOUT Project will conduct OSSEs and OSEs
- Other sensors also not assimilated
  - HIWRAP: Doppler wind/rain radar
  - LIP: Lightning detector
- Success of Targeted Observations is TBD
  - There are plenty of skeptics
  - But THORPEX demonstrated success
- Will it be needed?
  - Maybe, if there is a gap SNPP-JPSS1-JPSS2…

Next…

1. Possible West Coast campaign this coming winter: TBD
   - Focused on El Nino and atmospheric rivers
2. Probable NATL follow-on campaign next summer
   - Focused on TCs