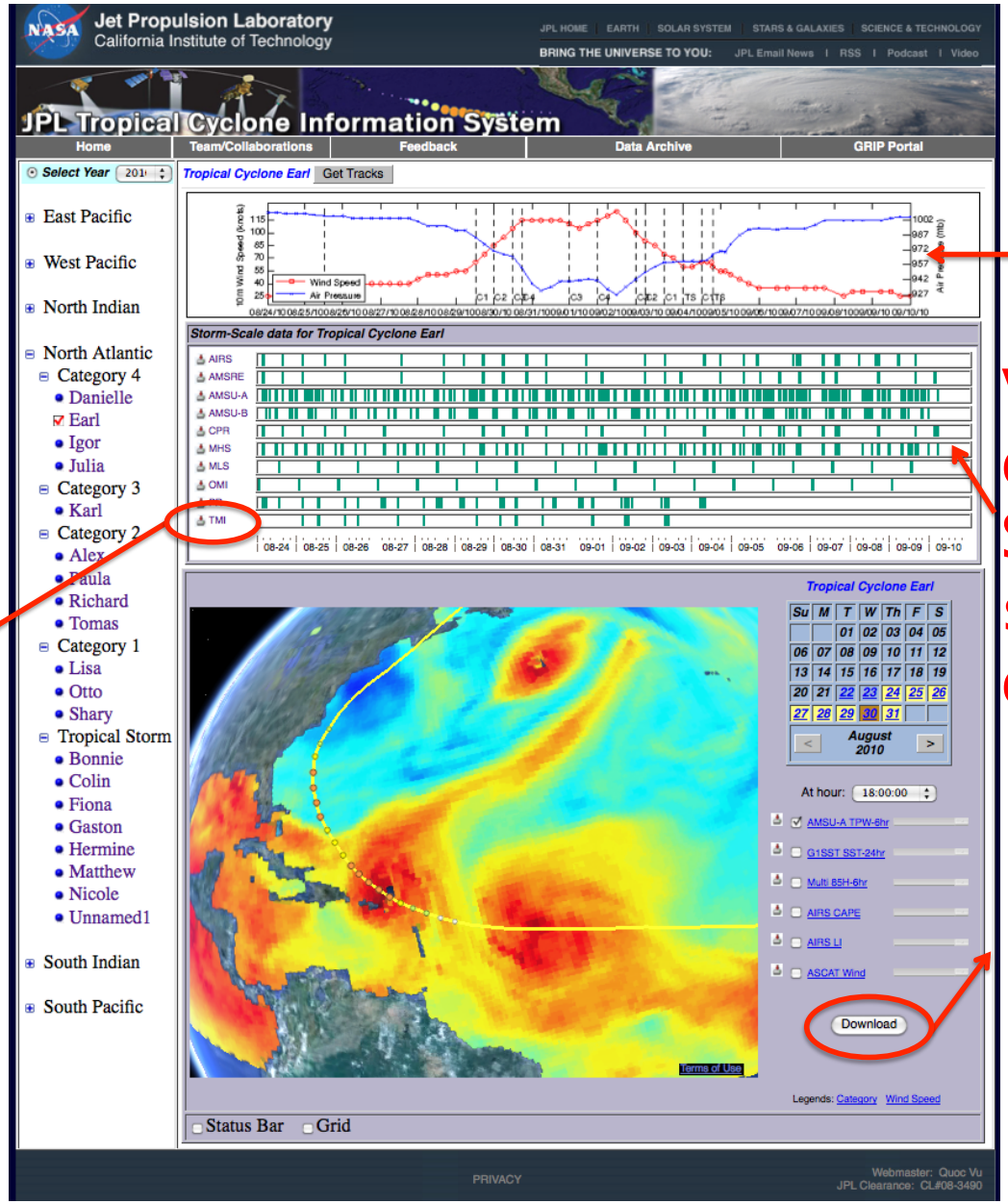
Aircraft observations

JPL TCIS – The Tropical Cyclone Data Archive

http://tropicalcyclone.jpl.nasa.gov

- Satellite/aircraft depictions of hurricanes over the globe
- 12-year record (1999-2010)
- Offers both data and imagery, making it a unique source to support hurricane research.



Timeline

View and download Storm-scale data

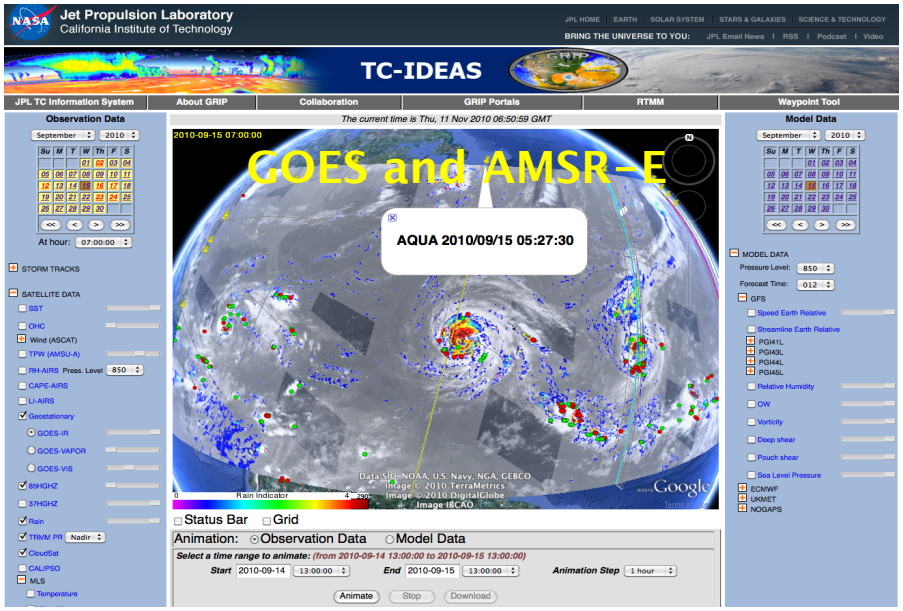
Download Selected large-scale data

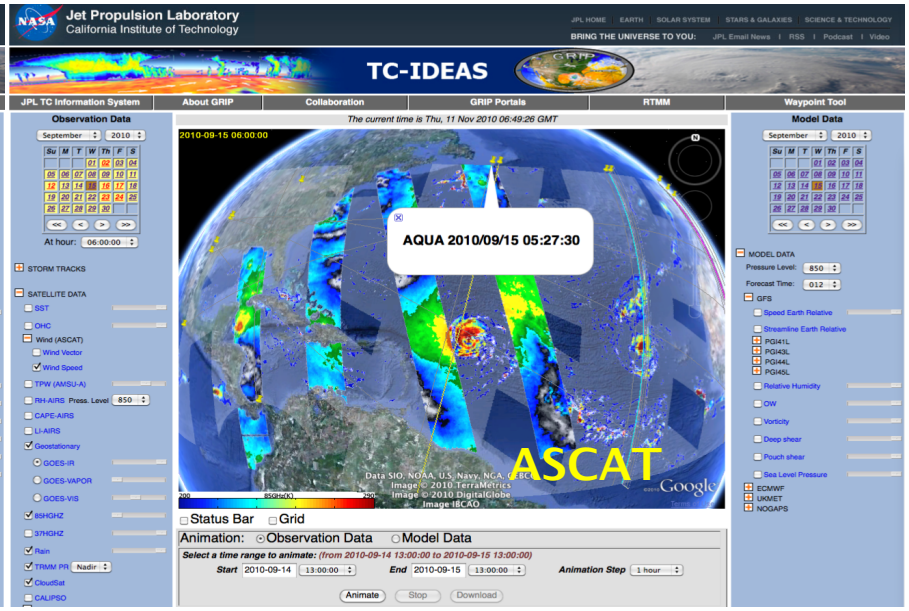
Download all data from this Instrument (TMI)

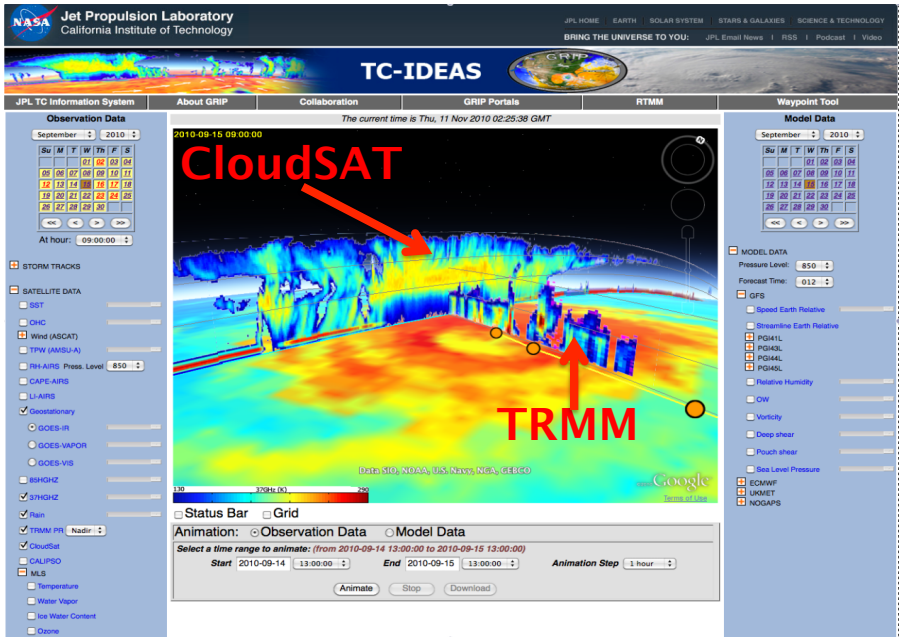
Earl 2010

GRIP Portal – NRT in 2010, Atlantic

http://grip.jpl.nasa.gov Satellite Observations





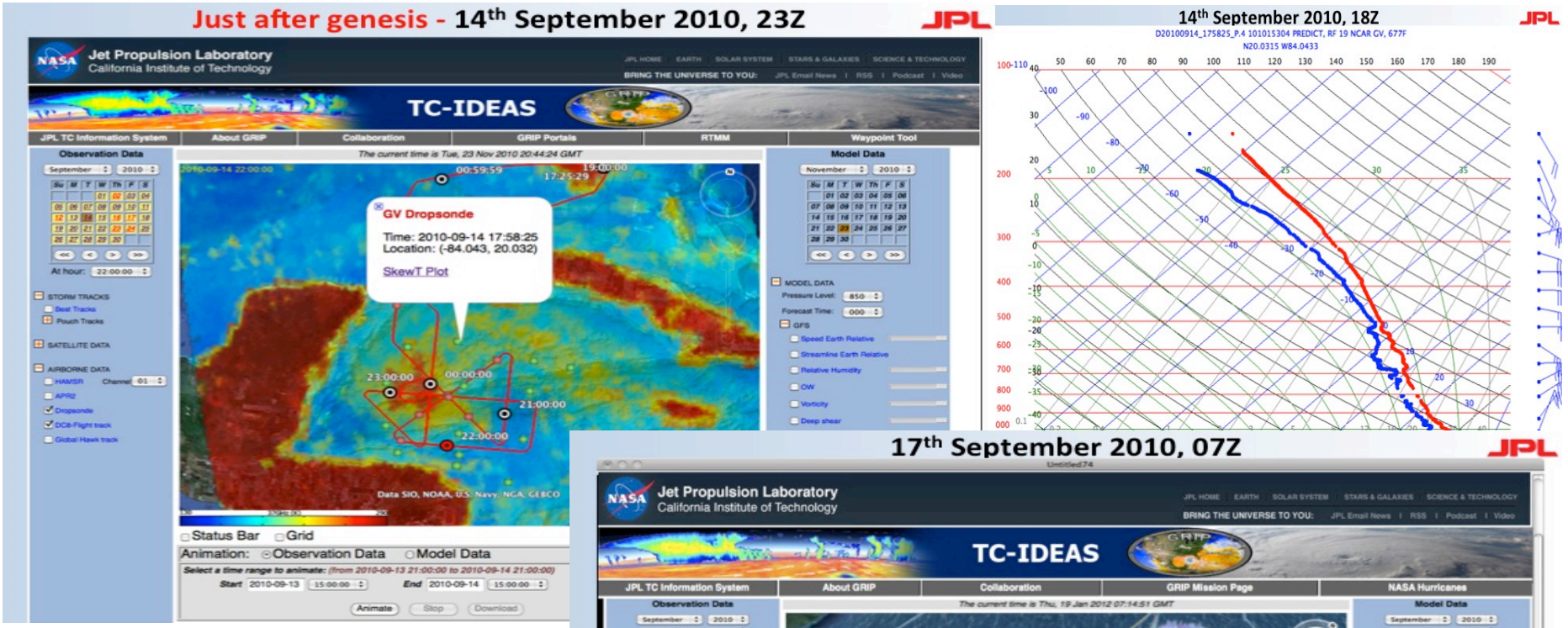


Hurricane Igor as seen in the JPL GRIP portal on September 15, 2010. **Top left panel** shows two overlays – the **IR** brightness temperatures in the background and the **rain index** (foreground, in color), **computed from multi-channel passive microwave observations**. The thin lines indicate the nadir tracks for different satellite and provide information on the particular satellite and time of overpass. **Top-right panel** shows similarly the overlays of the rain indicator and the **ASCAT**-derived surface wind speed, revealing the large spatial extent of the hurricane winds. **Bottom panel** reveals the 3D structure of the precipitation as depicted by vertical cross-sections of reflectivity observed by **TRMM and CloudSAT**, illustrating their complementary nature.

GRIP Portal – NRT in 2010, Atlantic

http://grip.jpl.nasa.gov

Airborne Observations



Hurricane Karl:

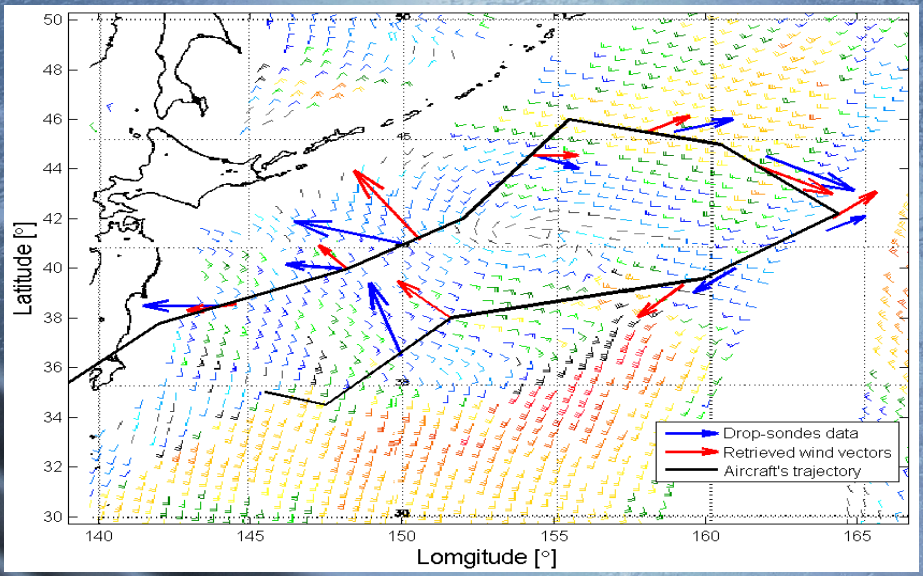
Genesis and Rapid Intensification from
-satellite,
-airborne and
-in-situ observations

NOAA's W-band radar for airborne observations of sea spray

- Construction is underway for the repacked radar to be housed inside a pressurized Pod for use in NOAA's P3 research aircraft
- An integration and flight test plan for the sea spray studies has been approved with NOAA flight operations
- Preliminary ground testing is scheduled for the fall of 2012 with final integration and flights set for mid 2013
- The new dual use construction will allow for easy re-configuration for future flights as well as shipboard deployments

WIND VECTOR RETRIEVAL FROM GPS OCEAN--SCATTERED SIGNALS IN THE NOAA AIRBORNE EXPERIMENT

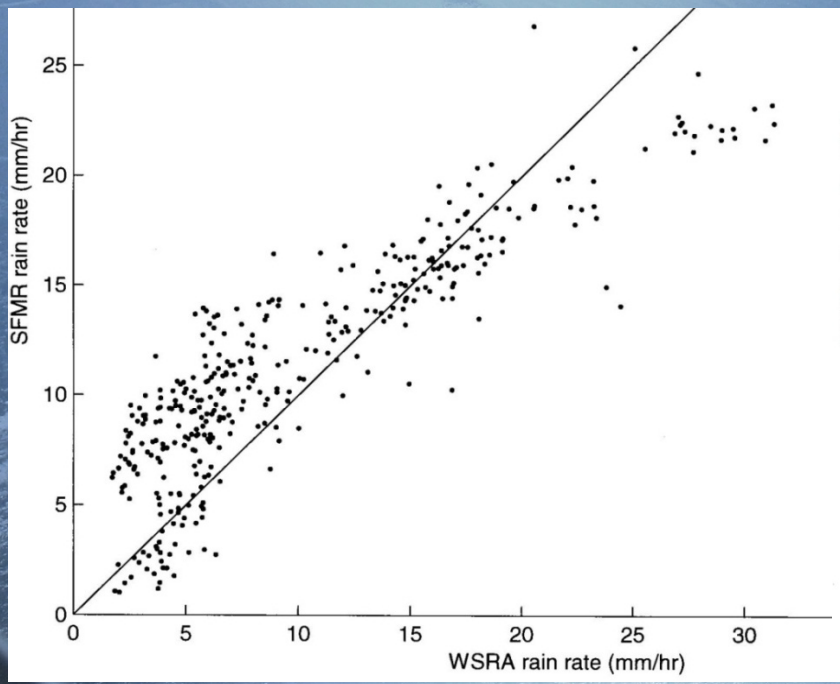
- A skewness angle of the Delay-Doppler Map (DDM) was proposed as a parameter describing the DDM asymmetry. It maintains sensitivity to wind direction and receiver's flying direction while remaining insensitive to the other DDM parameters.
- The skewness angle was accurately modeled by an analytical expression as a function of wind direction and receiver's flying direction.
- This model was successfully validated using experimental data from the January 24, 2010 flight on NOAA G-IV in the Northern-Pacific Ocean.
- The retrieved wind directions and speeds were assembled into wind vectors for various segments of the flight track and compared with the satellite data.
- The main limitation of the proposed technique appears to be a noisy reflected signal due to insufficiently high SNR of the measurements with a low-gain down-looking antenna.

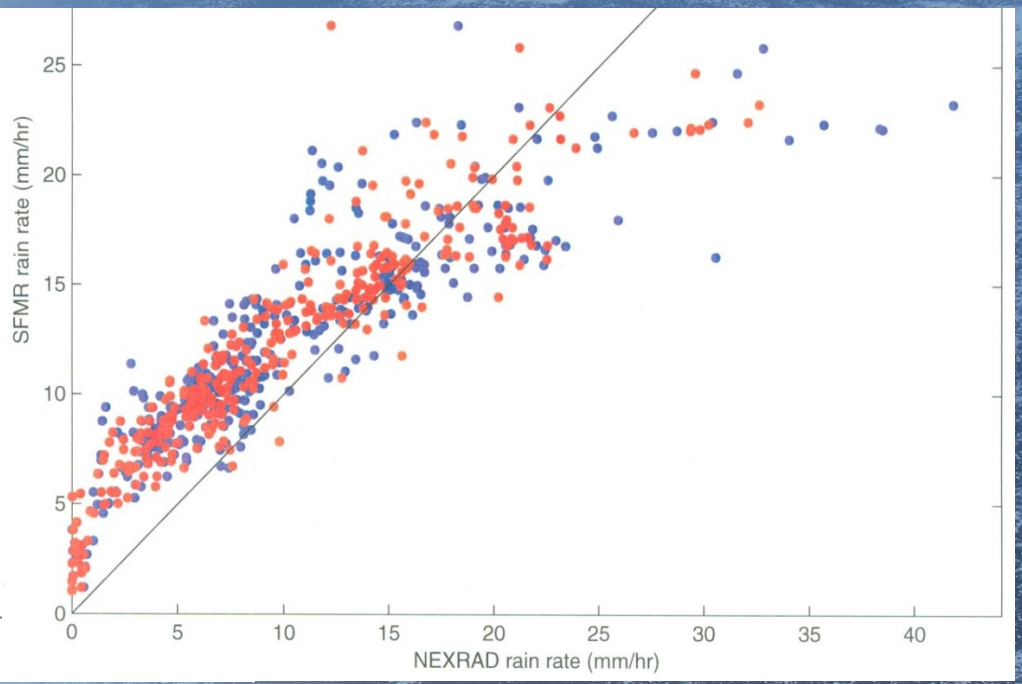


An example of retrieved wind vectors overlayed on a satellite wind map showing an anticyclonic circulation over which the aircraft was flying.

The aircraft track is in the counterclockwise direction.

Compared to WSRA and NEXRAD, SFMR tends to be low at high rain rates and high at low rain rates in wind speeds below hurricane force. An improved SFMR model function is under development (Eric Uhlhorn, private communication, 2012).

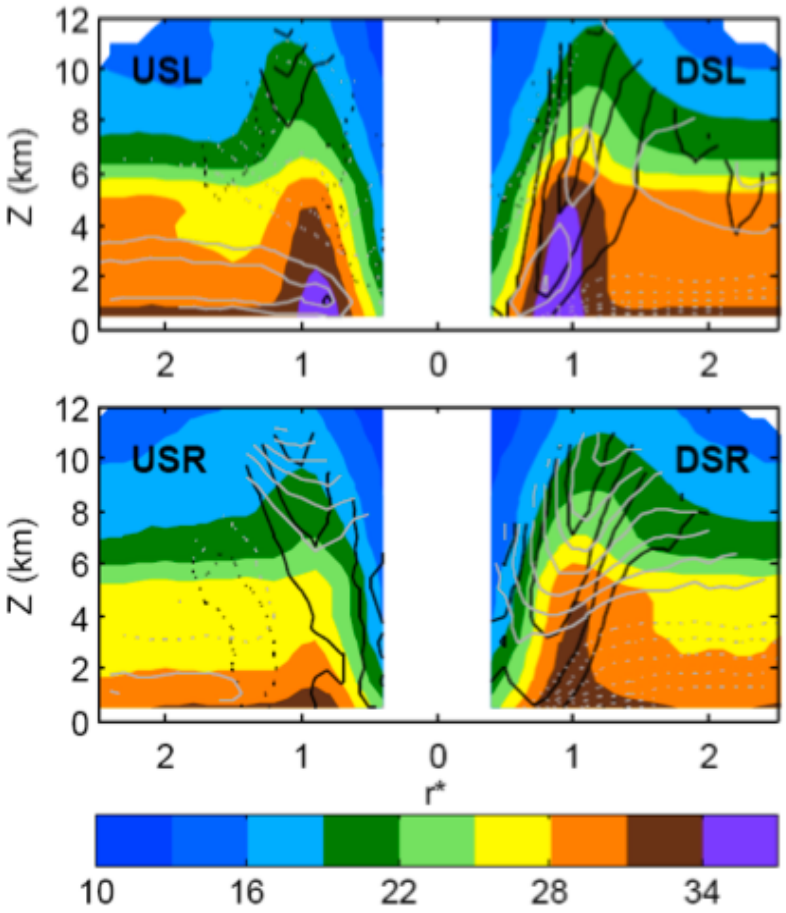




In a multi-case approach to investigating asymmetric hurricane structure, Doppler analyses are composited relative to the SHIPS shear direction

(P. Reasor, R. Rogers, and S. Lorsolo)

Composite analyses of observed shear-relative reflectivity, wind, vortex tilt, local shear, vorticity and divergence serve as an essential reference for similar model-based diagnostic analyses.



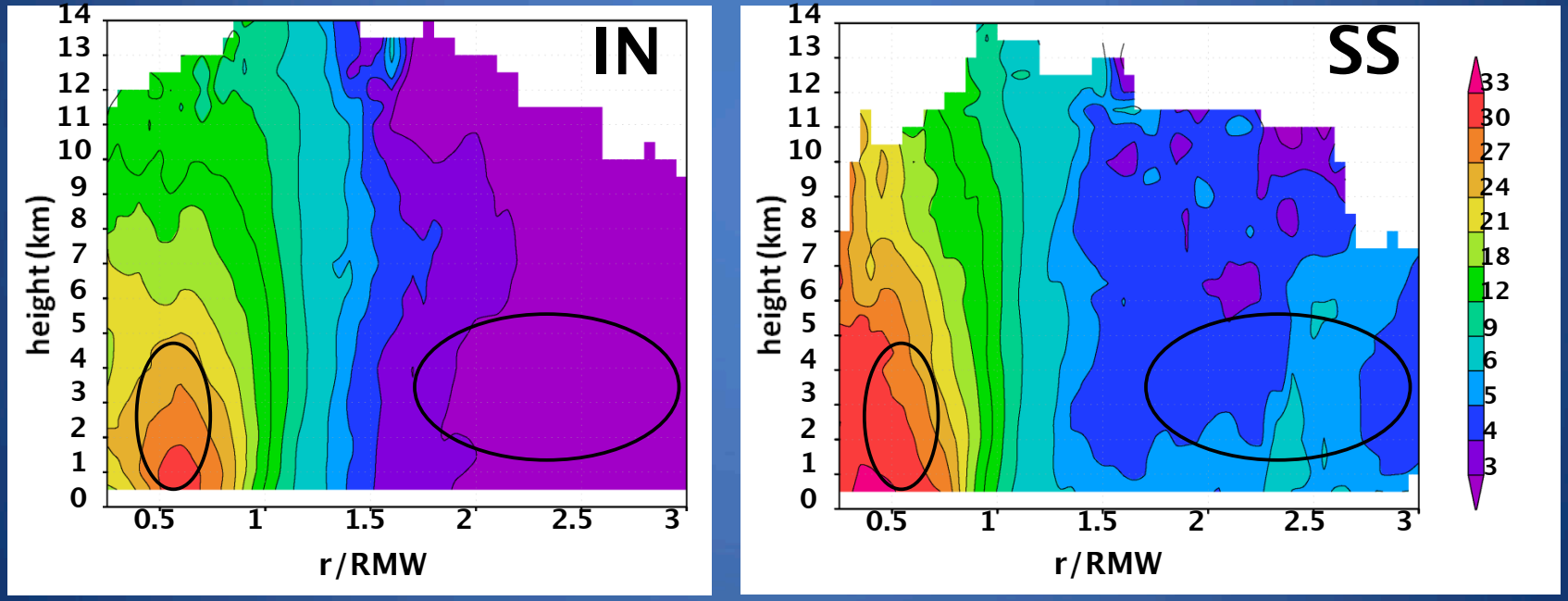
Shown: Quadrant averages of shear-relative reflectivity (dBZ, shaded), radial wind speed (1 ms^{-1}, gray), and vertical wind speed (0.5 ms^{-1}, black) with radius scaled by radius of maximum wind speed.

Note: Largest low- to mid-level ascent found downshear, and maximum precipitation found downshear-left (DSL).

Relationship between TC inner-core structure and intensification

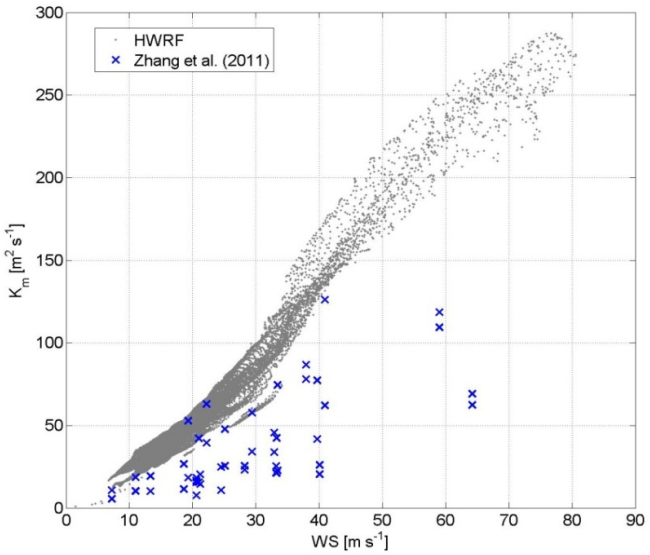
Axisymmetric vortex structure from airborne Doppler radar composites of intensifying (IN) and steady-state (SS) TCs

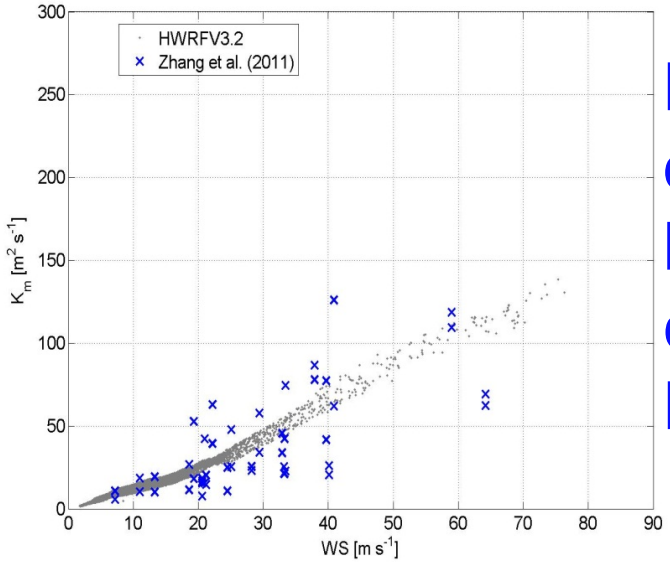
Vertical vorticity (x 10^{-4} s^{-1})



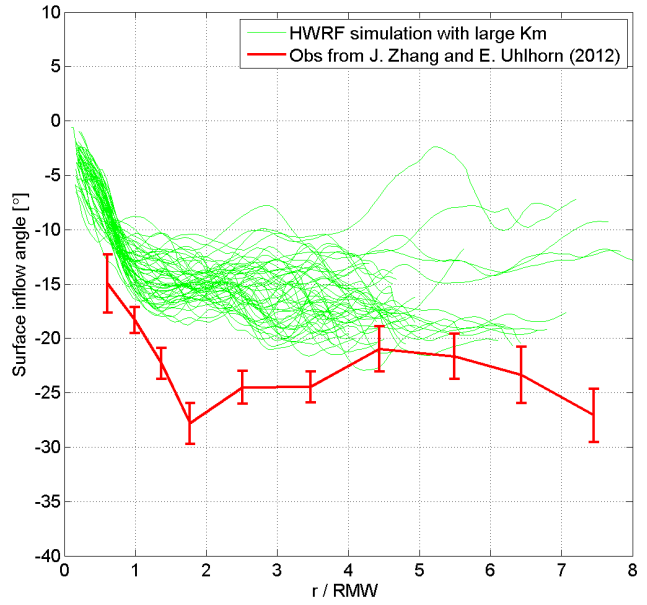
IN cases show (significant at 95% confidence level):

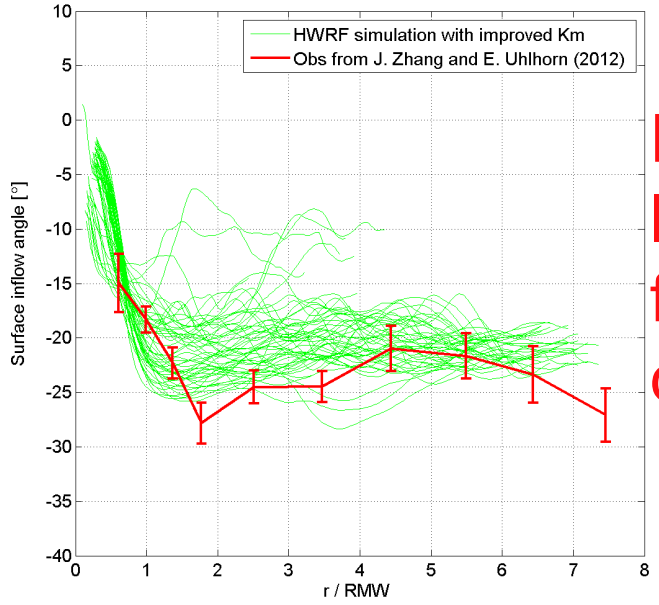
- ring-like vorticity structure inside eyewall
- low vorticity outside the core





Blue is dropwindsonde-based calculations of K_m



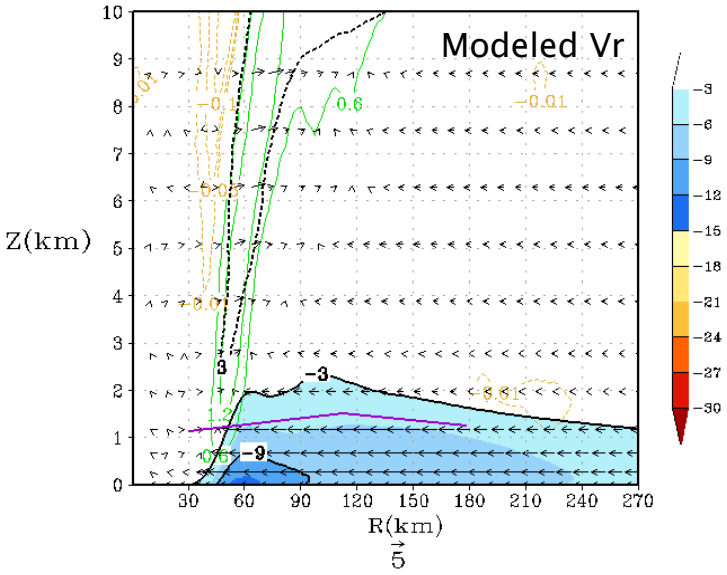


Red is boundary-layer inflow angle from dropwindsondes

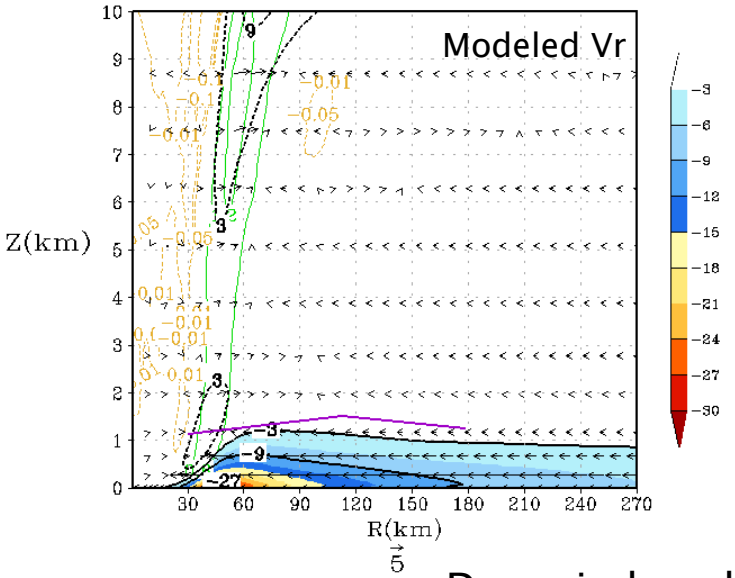
The simulated inflow angle is much closer to observations using HWRF with improved vertical eddy diffusivity (K_m) than that without correction.

Using HRD's aircraft observations to improve and validate PBL physics (Gopalakrishnan et al. 2012 JAS)

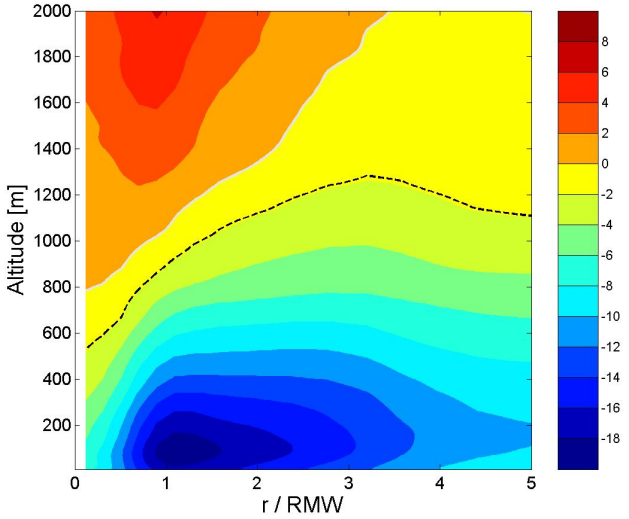
Original K_m in HWRF



Observation-based modification of K_m in HWRF



Dropwindsonde V_r

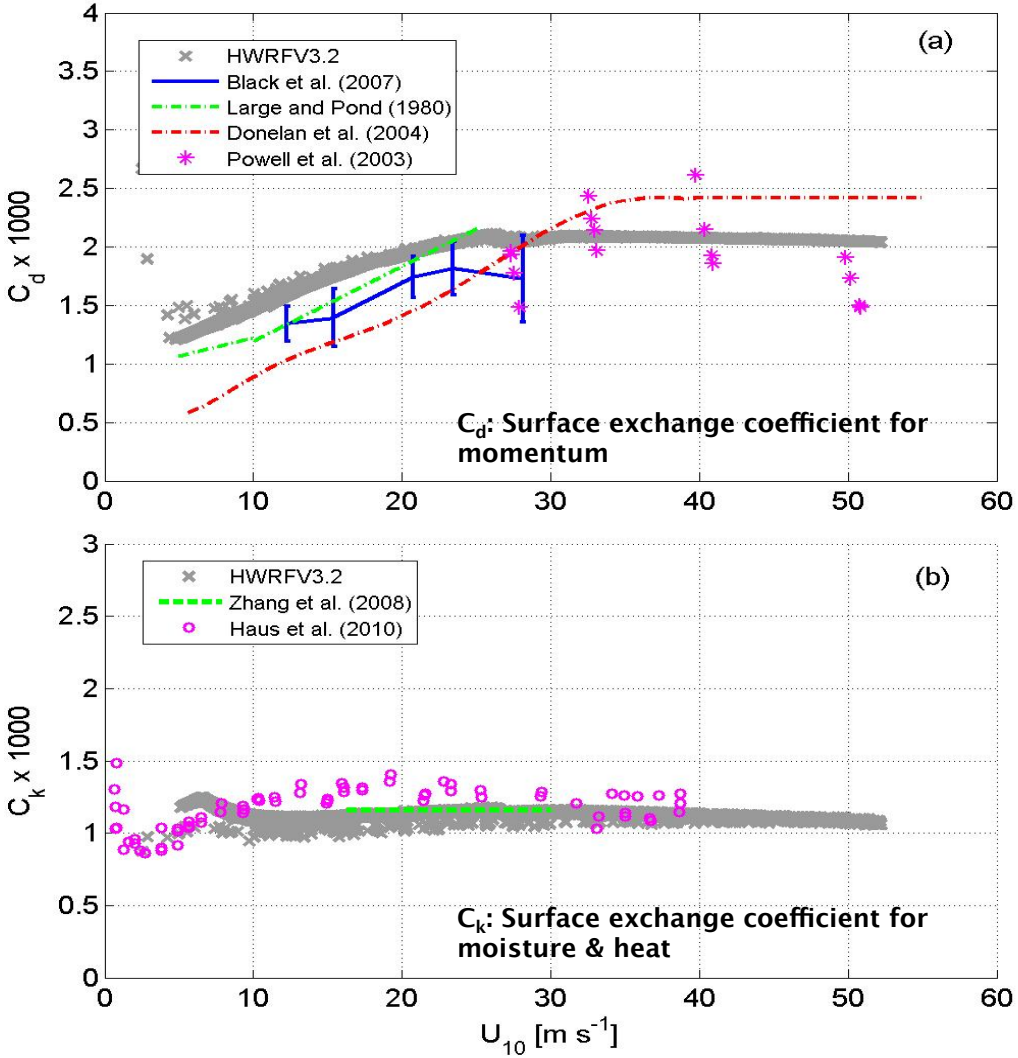


- depth of inflow layer consistent with dropwindsonde composites
- strong peak radial inflow with more accurate K_m

The purple line in the upper two panels is the inflow-layer depth from the composite analysis using data from hundreds of dropwindsondes (Jun Zhang et al. 2011b MWR).

Using HRD's aircraft observations to improve hurricane model surface-layer physics

(Gopalakrishnan et al. 2012 JAS)



Direct flux observation-based estimates of C_d and C_k from CBLAST:
Black et al. (2007)
J. Zhang et al. (2008)

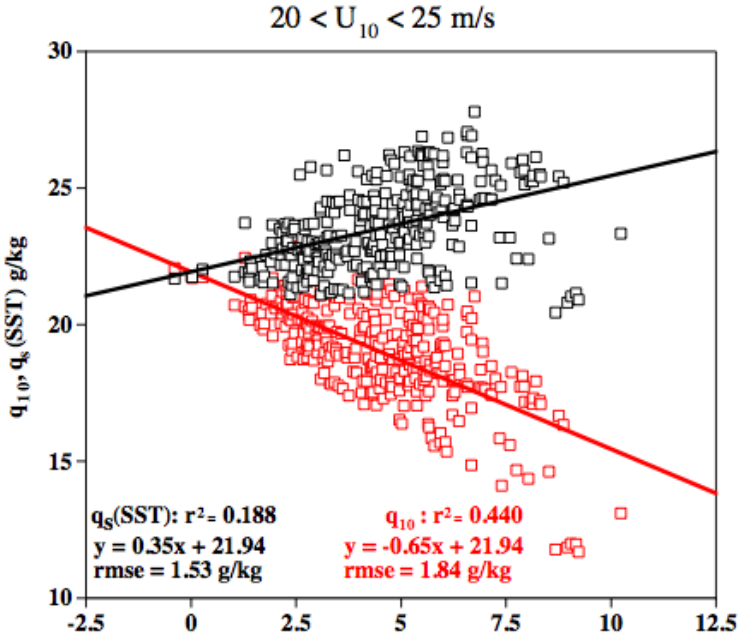
Dropwindsonde-based estimates of C_d:
Powell et al. (2003)

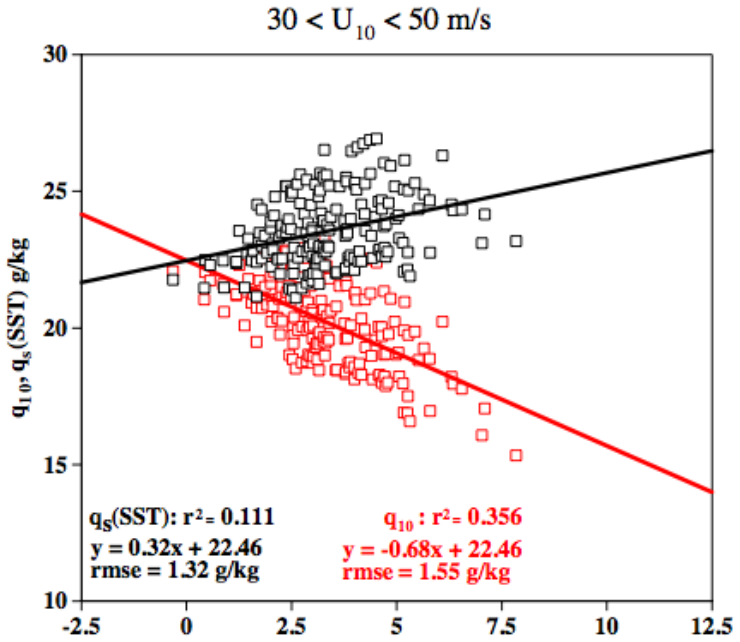
Gopalakrishnan et al. 2011

What is the dominant thermodynamic factor impacting TC surface moisture flux?

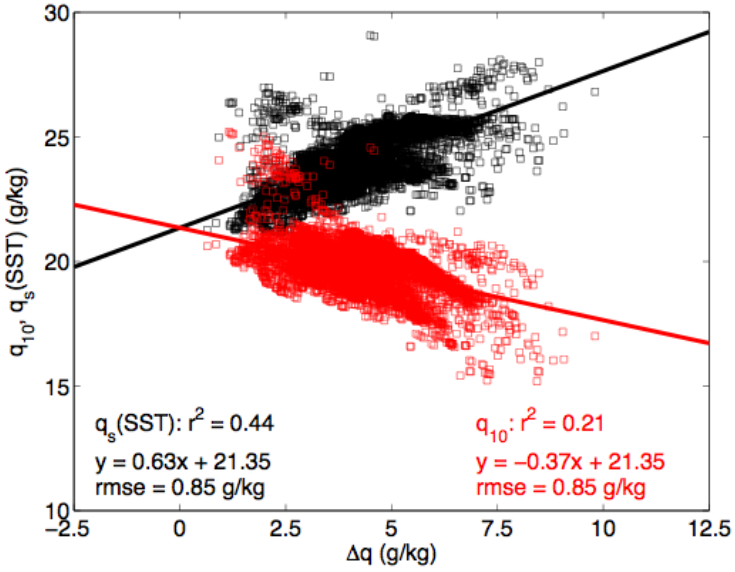
Ocean (q_s(SST))…or…Atmosphere (q_{10})

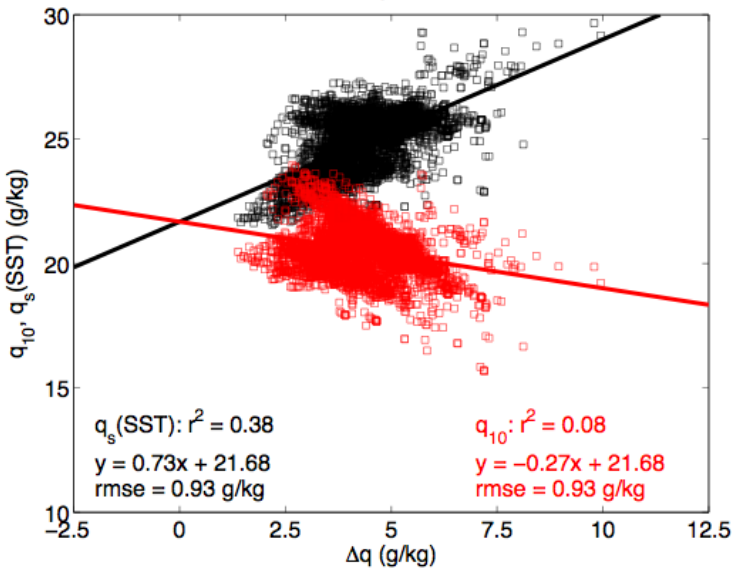
TCBD
(observations)





HWRF
V3.2

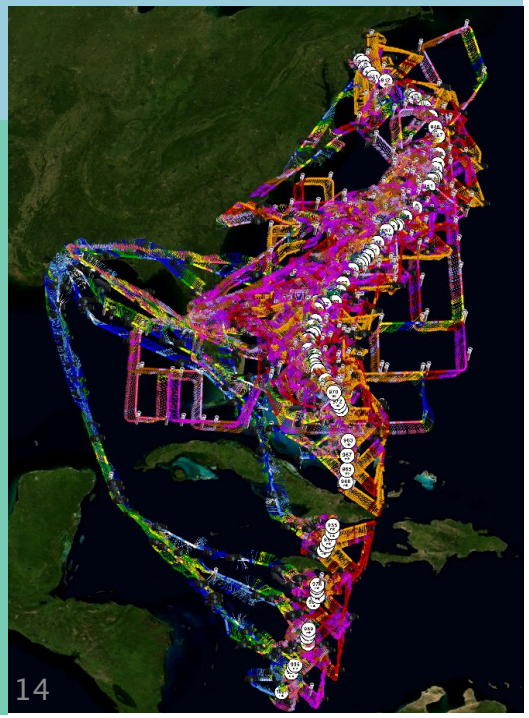




2012 IFEX Field Campaign Recap

- 22 P-3 missions (Isaac, Leslie, Rafael, and Sandy)
- 9 G-IV missions (Isaac, Leslie, and Sandy)
- ~258 flight hours flown (includes ferry flights)
- ~62 radar analyses transmitted in real-time
- ~140 AXBTs launched
- ~786 GPS dropwindsondes launched

Sandy 2012 flights (all)



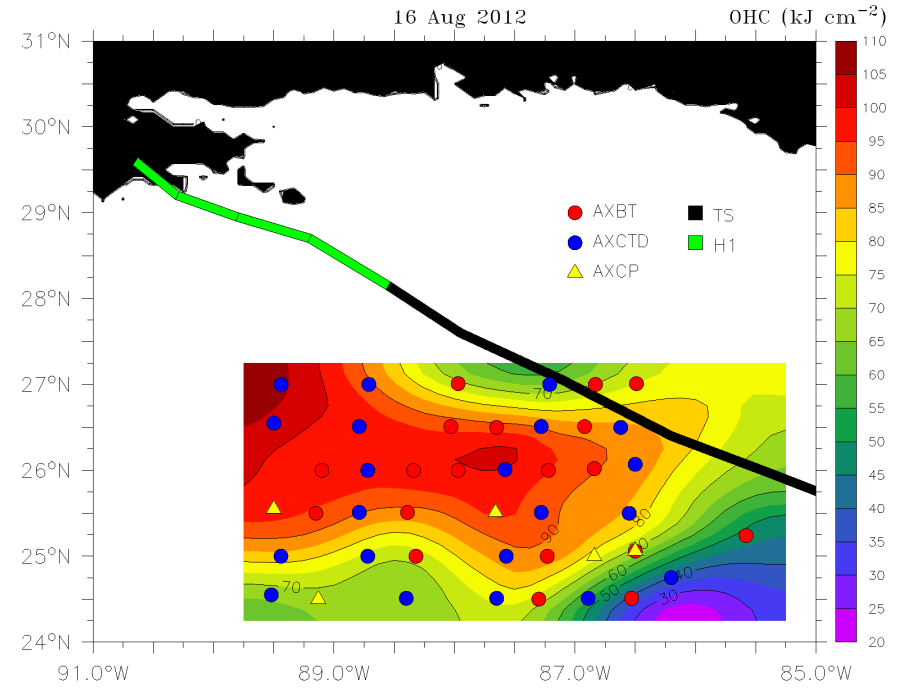
- Highlights

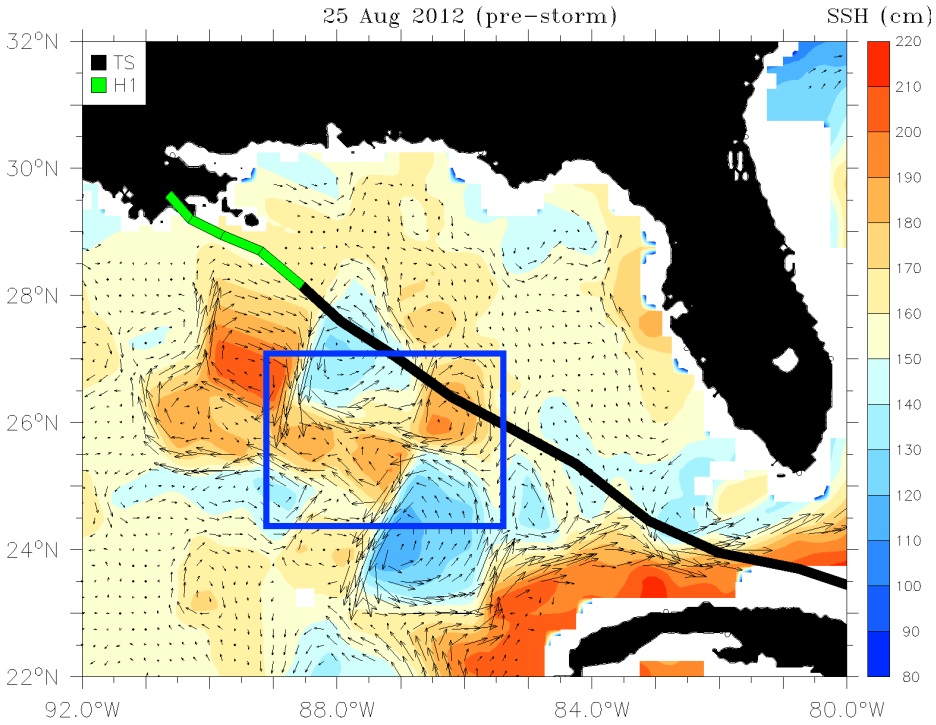
- 1 P3 and G-IV
- Tail Doppler Radar missions (P-3 & G-IV)
- Ocean Heat Content missions
- Landfall mission
- WSRA and IWRAP instruments on P-3
- HFIP and VIP visitors

Pre-storm

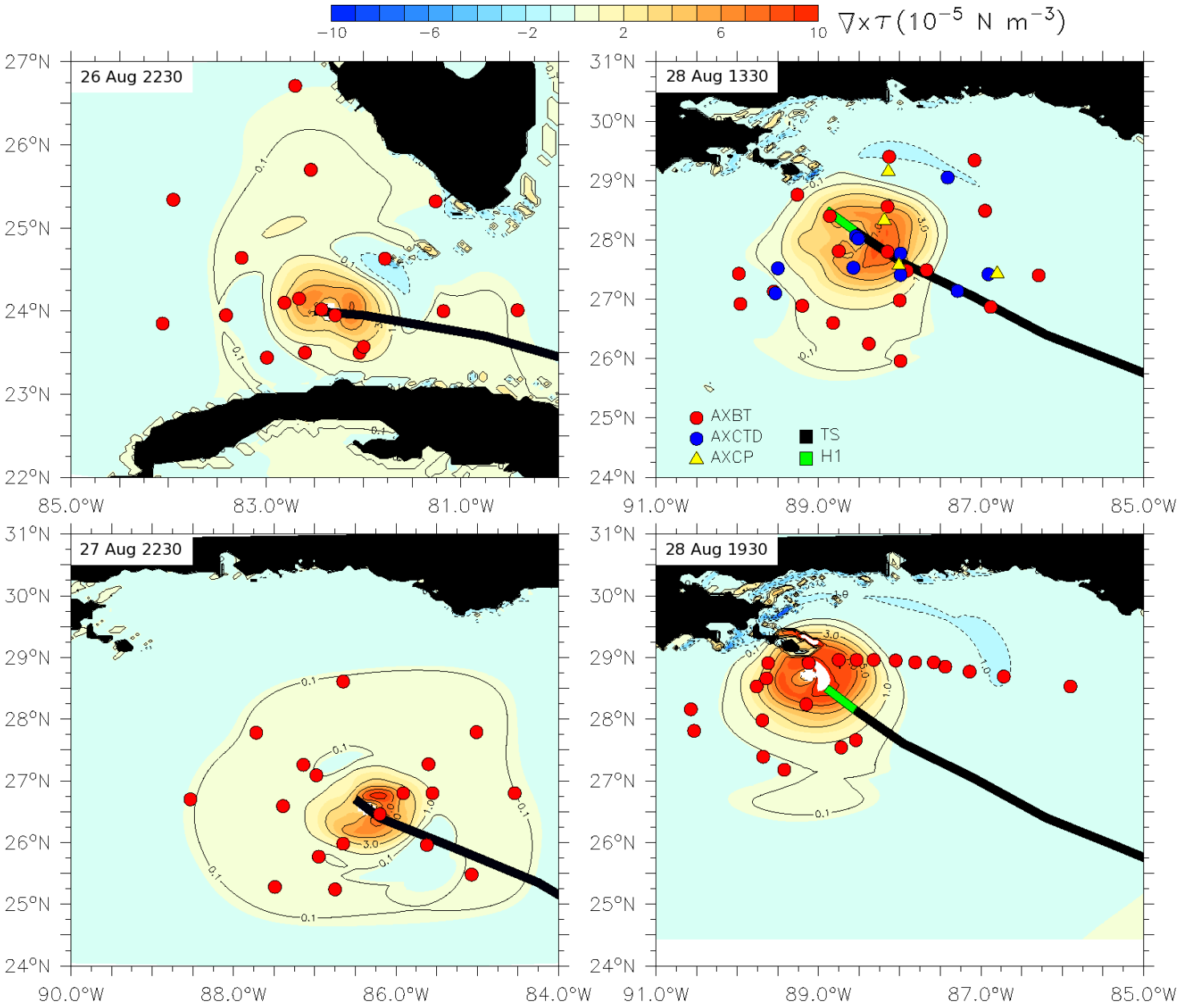
- **High levels of oceanic heat content (OHC) were measured 9 days before Isaac. Successful probes during the P3 flight: 19 AXBT, 21 AXCTD, 5 AXCP, 8 dropwindsondes.**

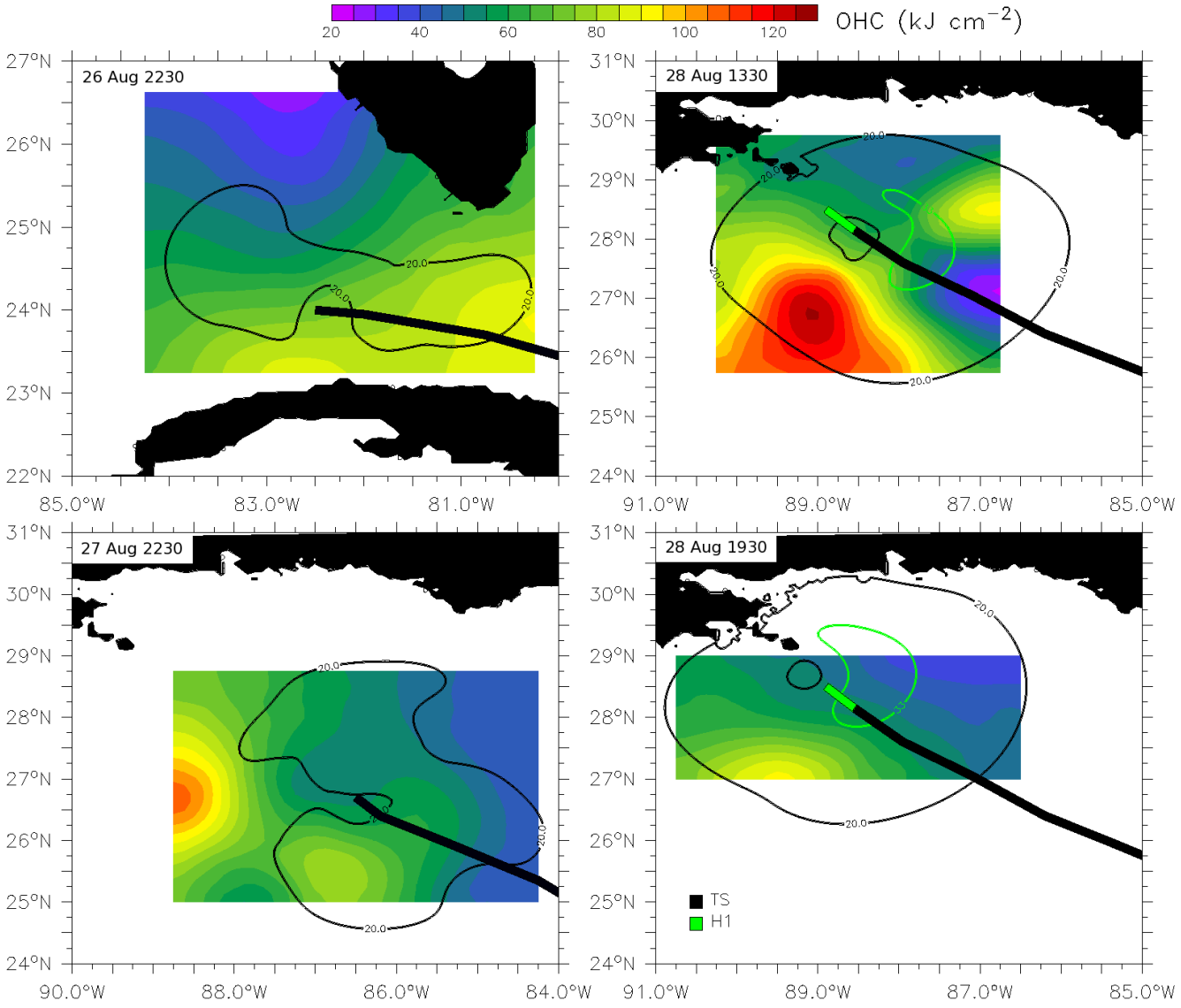
- **Altimeter-based surface geostrophic currents during the day that Isaac moved into the Gulf of Mexico.**





Expendable probes deployed during in-storm flights in Isaac

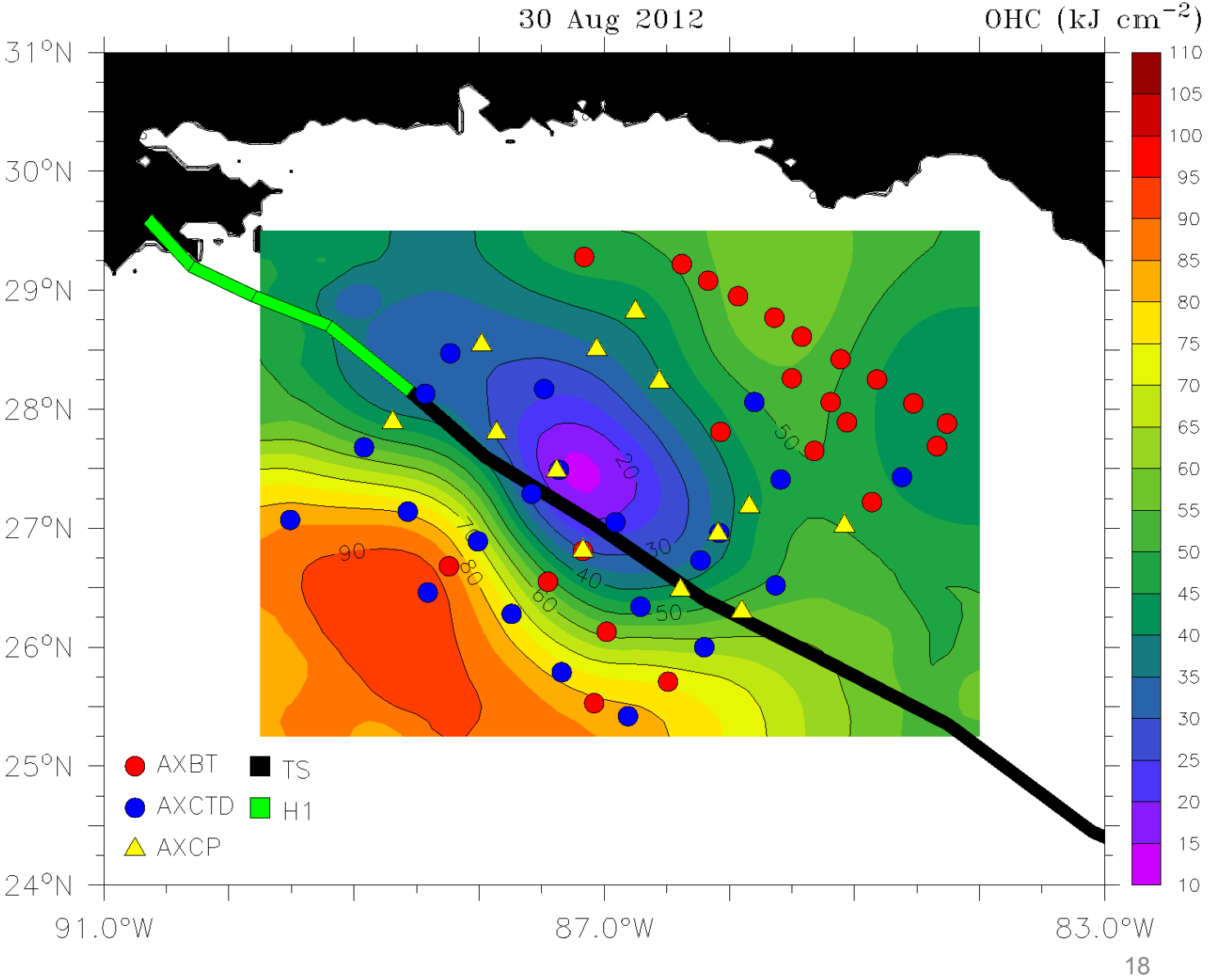




Intensification to hurricane status over OHC gradients.

Stronger hurricane winds occurred across OHC gradients.

Expandable probes deployed during the post-storm flight



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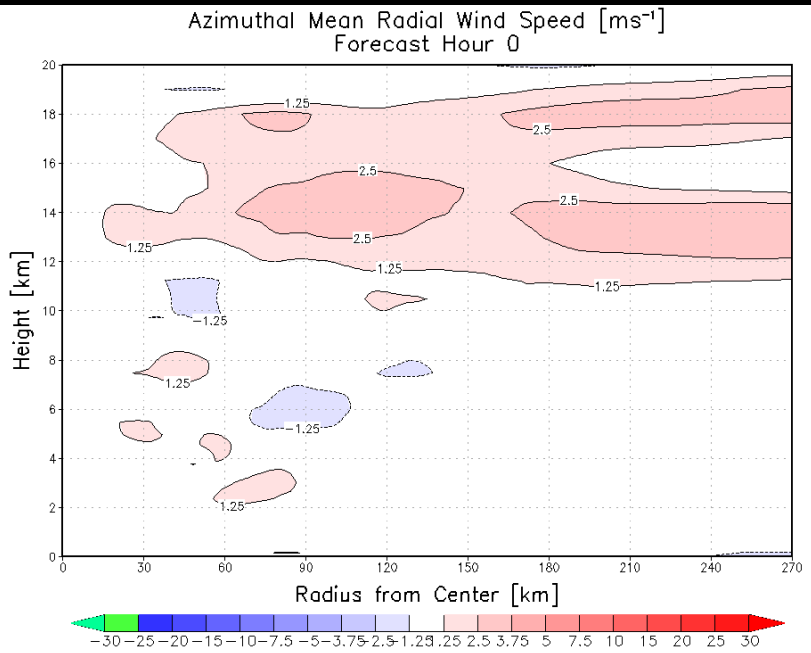

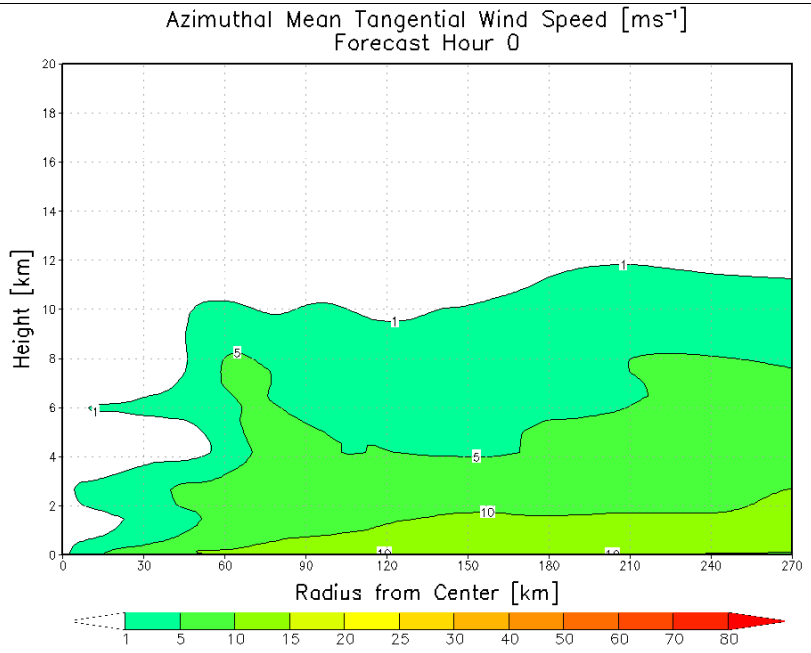

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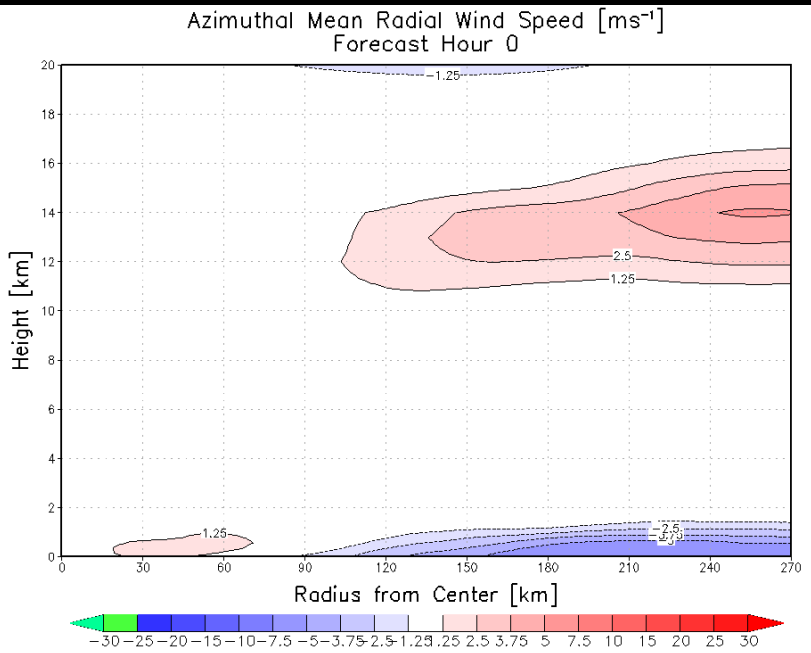

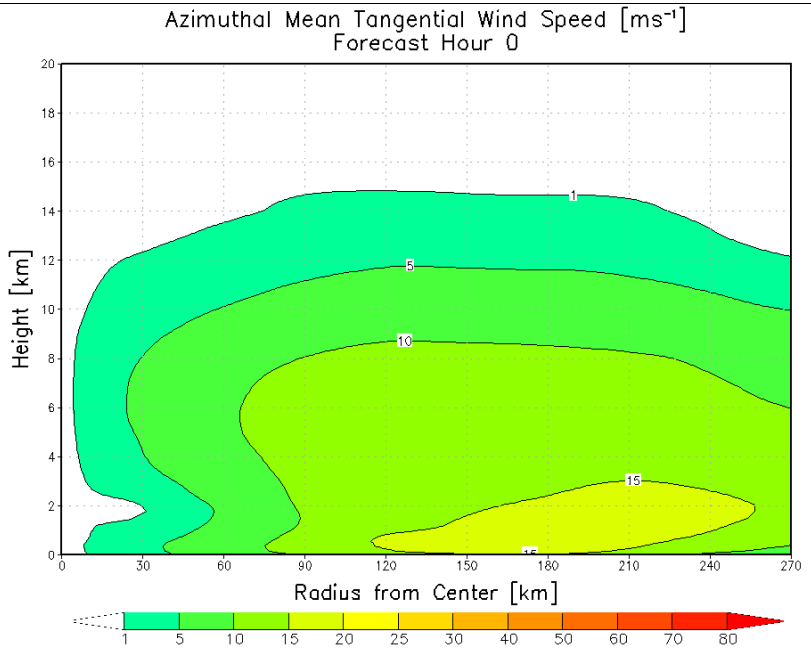

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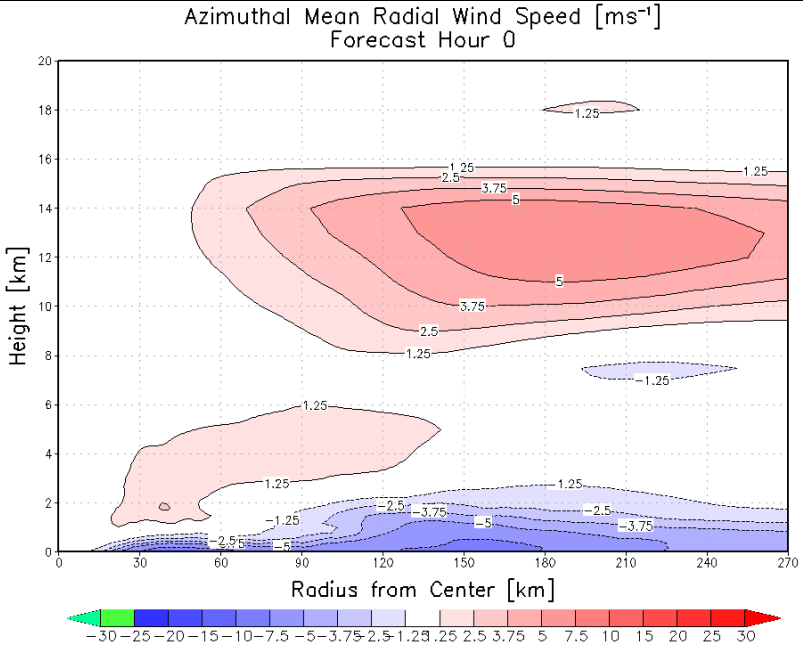

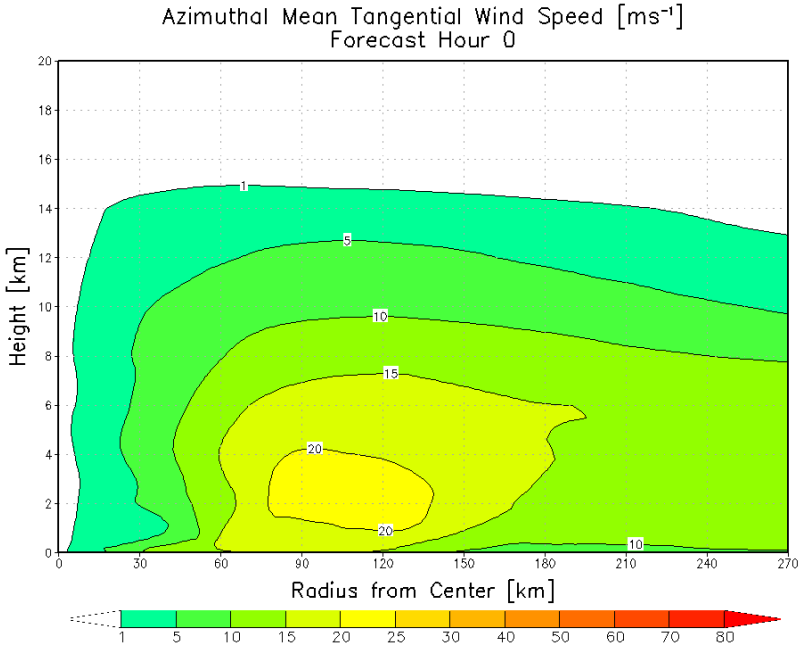

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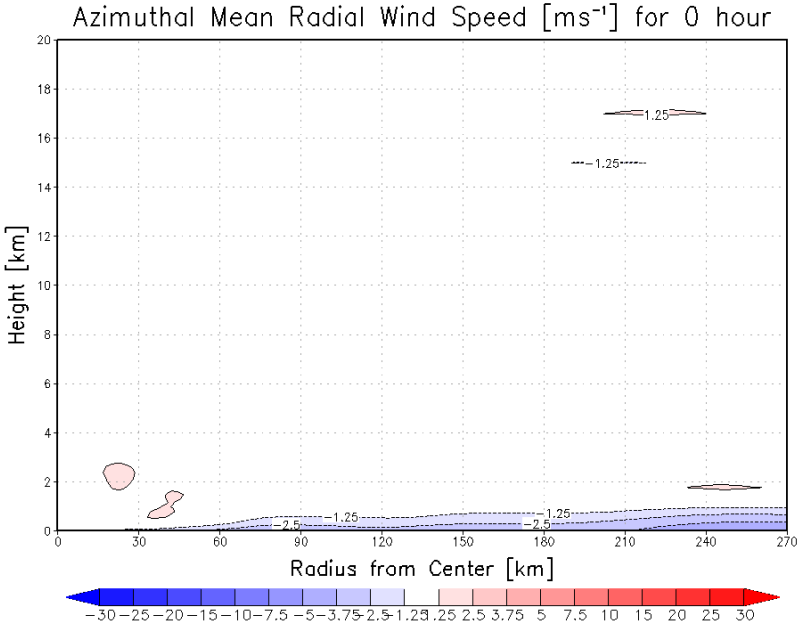

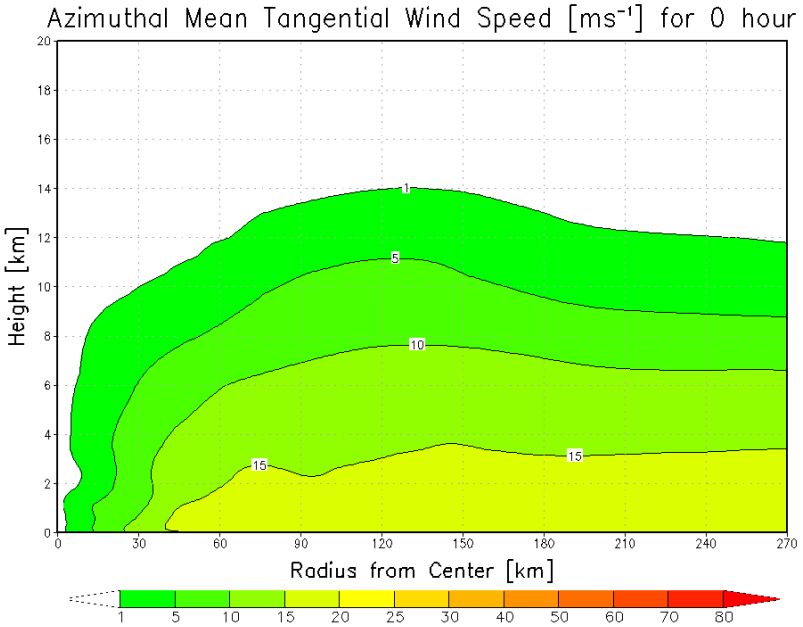

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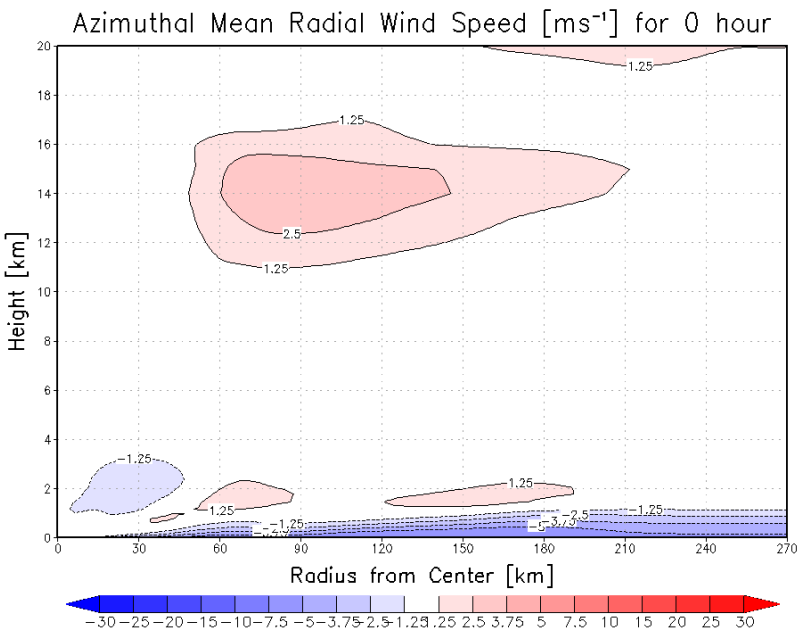
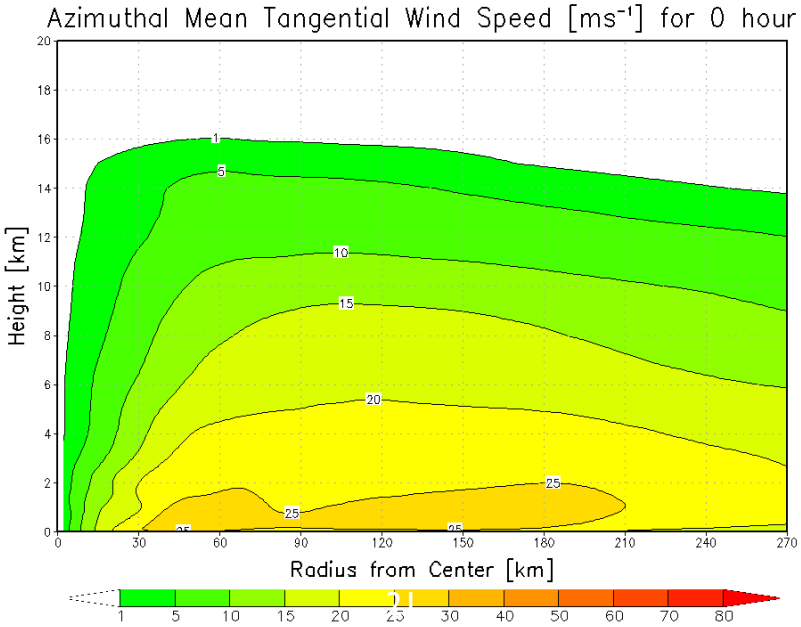
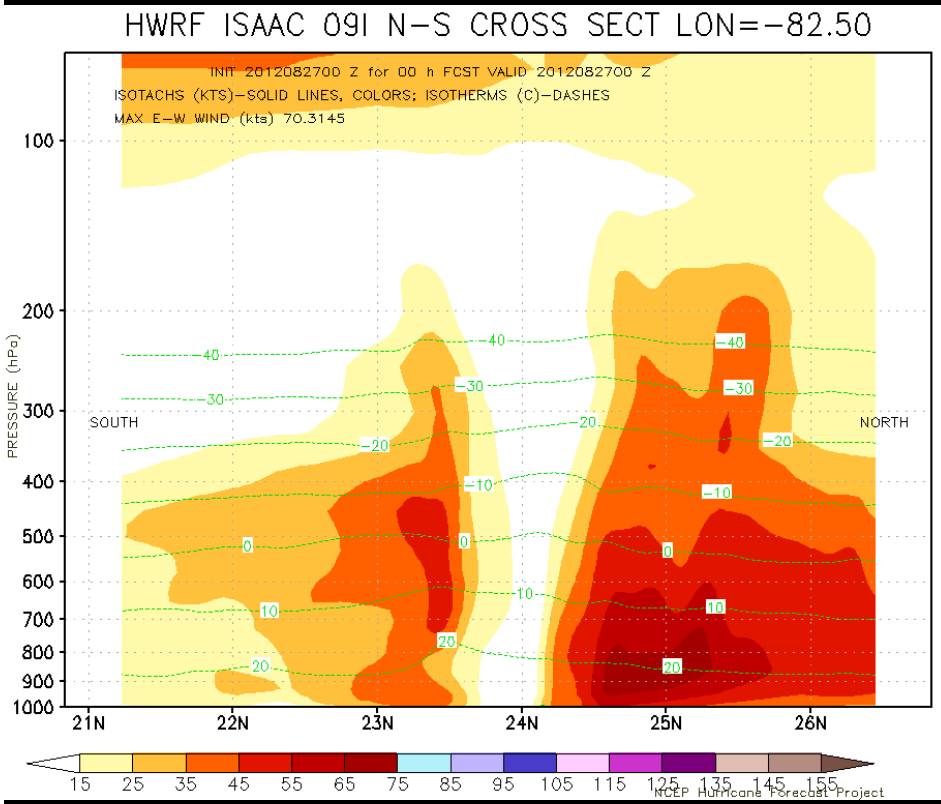
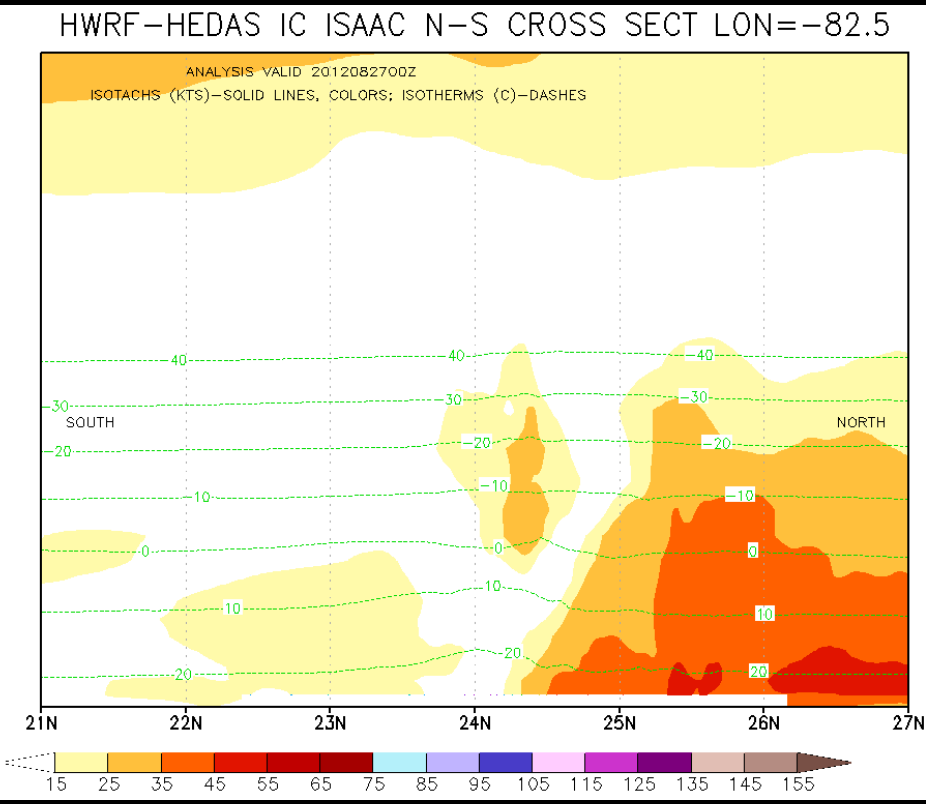

Azimuthal Mean Radial Wind Speed [ms⁻¹] for 0 hour
Height [km]
Radius from Center [km]
−30 −25 −20 −15 −10 −7.5 −5 −3.75 −2.5 −1.25 1.25 2.5 3.75 5 7.5 10 15 20 25 30


Azimuthal Mean Tangential Wind Speed [ms⁻¹] for 0 hour
Height [km]
Radius from Center [km]
1 5 10 15 20 25 30 40 50 60 70 80


HWRF ISAAC 09I N-S CROSS SECT LON=-82.50
INIT 2012082700 Z for 00 h FCST VALID 2012082700 Z
ISOTACHS (KTS)-SOLID LINES, COLORS; ISOTHERMS (C)-DASHES
MAX E-W WIND (kts) 70.3145
PRESSURE (hPa)
SOUTH
NORTH
21N
22N
23N
24N
25N
26N
15 25 35 45 55 65 75 85 95 105 115 125 135 145 155
NCEP Hurricane Forecast Project


HWRF-HEDAS IC ISAAC N-S CROSS SECT LON=-82.5
ANALYSIS VALID 2012082700Z
ISOTACHS (KTS)-SOLID LINES, COLORS; ISOTHERMS (C)-DASHES
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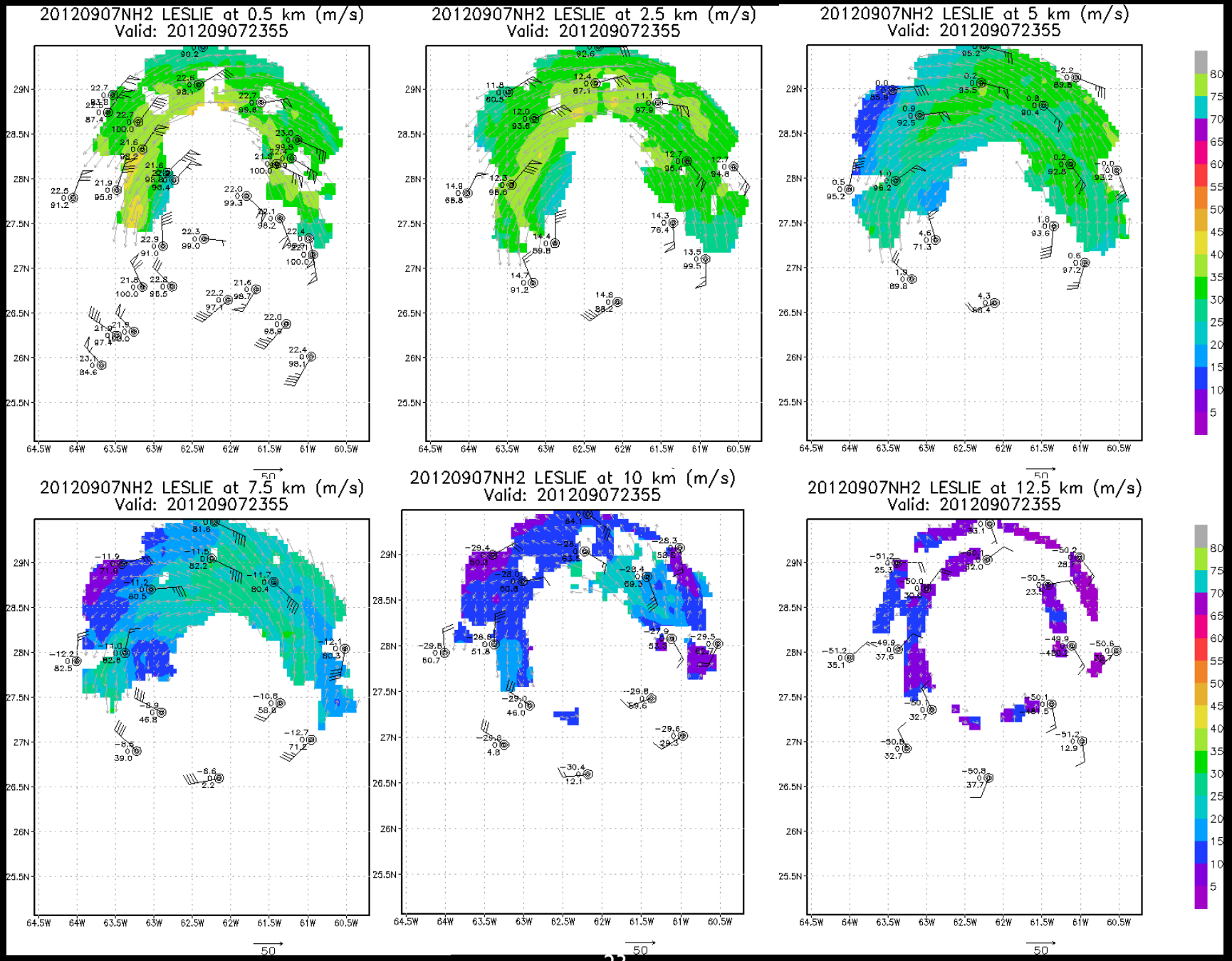
NORTH
21N
22N
23N
24N
25N
26N
27N
15 25 35 45 55 65 75 85 95 105 115 125 135 145 155


20120907NH2 LESLIE at 0.5 km (m/s)
Valid: 201209072355
20120907NH2 LESLIE at 2.5 km (m/s)
Valid: 201209072355
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Valid: 201209072355
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Valid: 201209072355
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Valid: 201209072355
20120907NH2 LESLIE at 12.5 km (m/s)
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27.5N
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26.5N
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62W
61.5W
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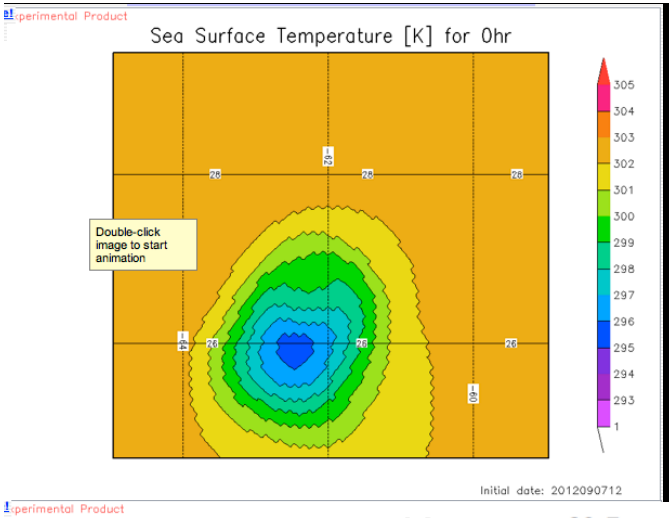
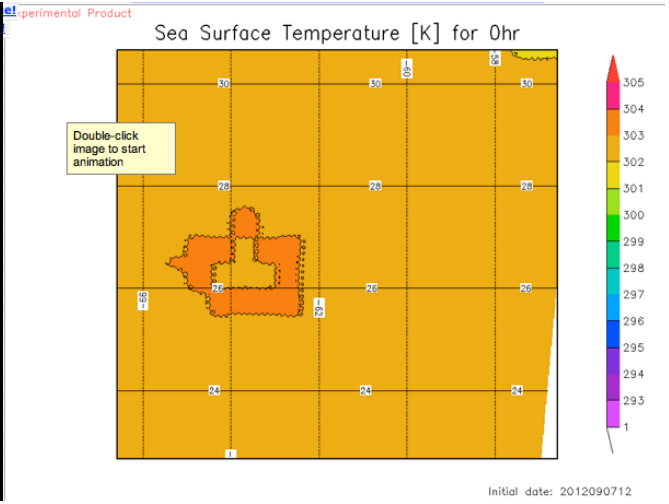
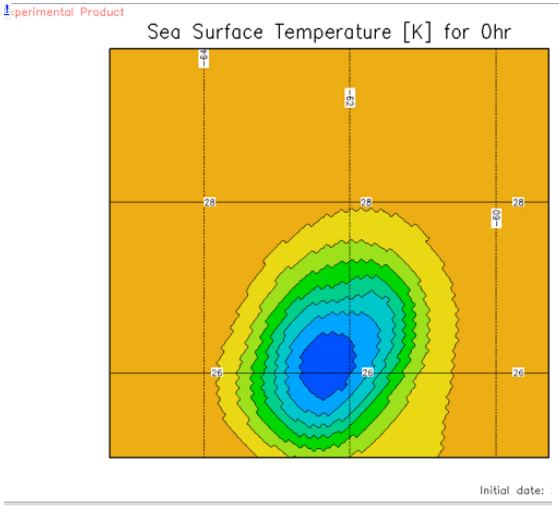
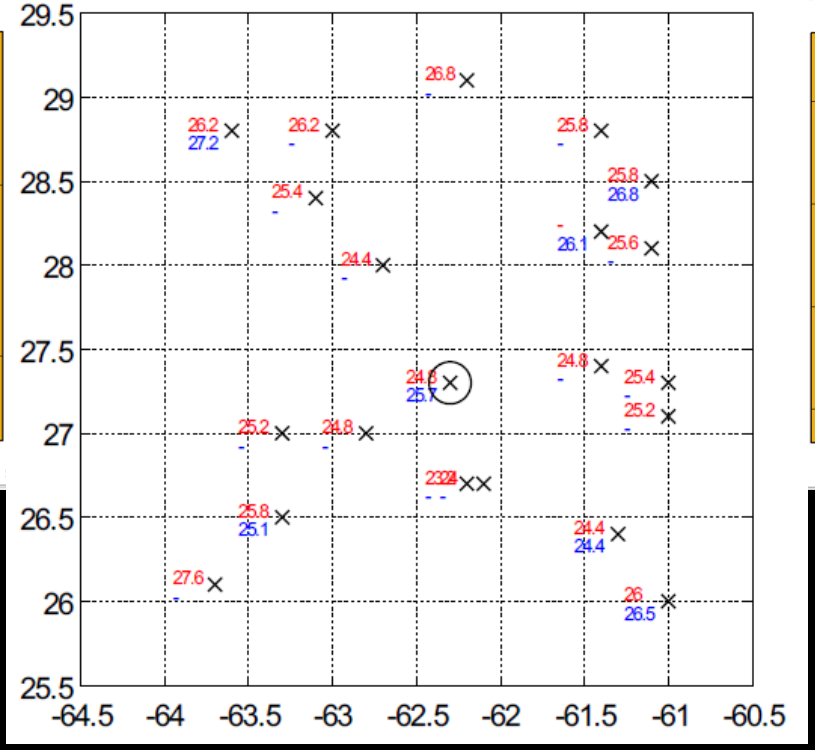
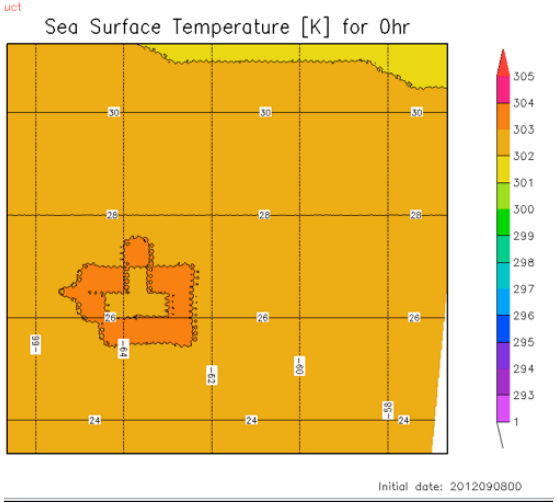










HWRF SST

GFS SST

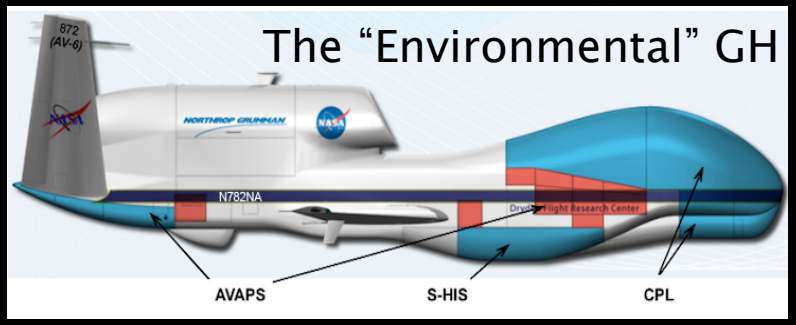
AXBTs

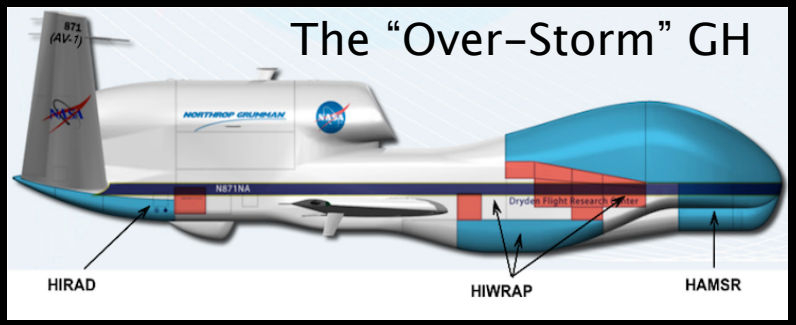
HS3 Explores Nadine

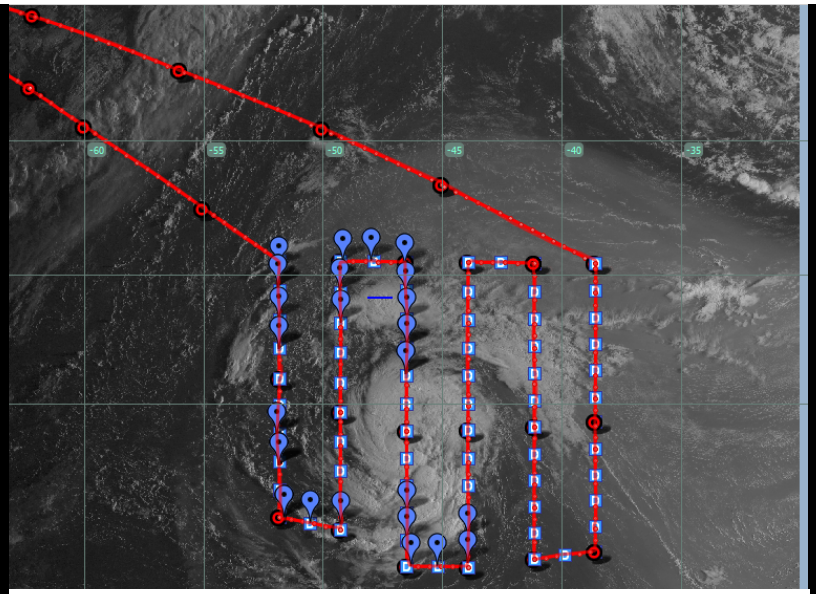
Target: Nadine

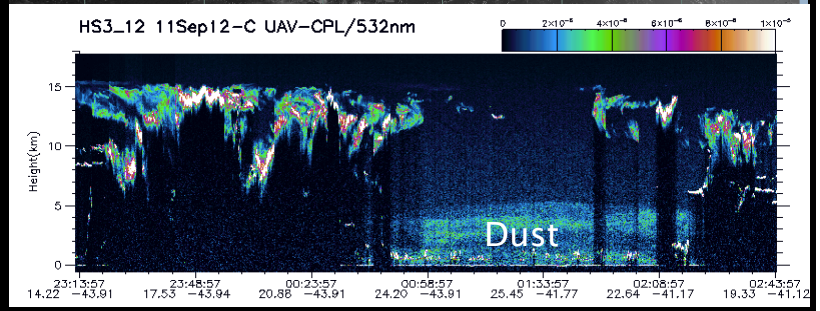
Goal: Examine whether SAL air is getting into Nadine's circulation and perhaps slowing its development

Goal: To investigate how wind shear affects storm structure and intensification



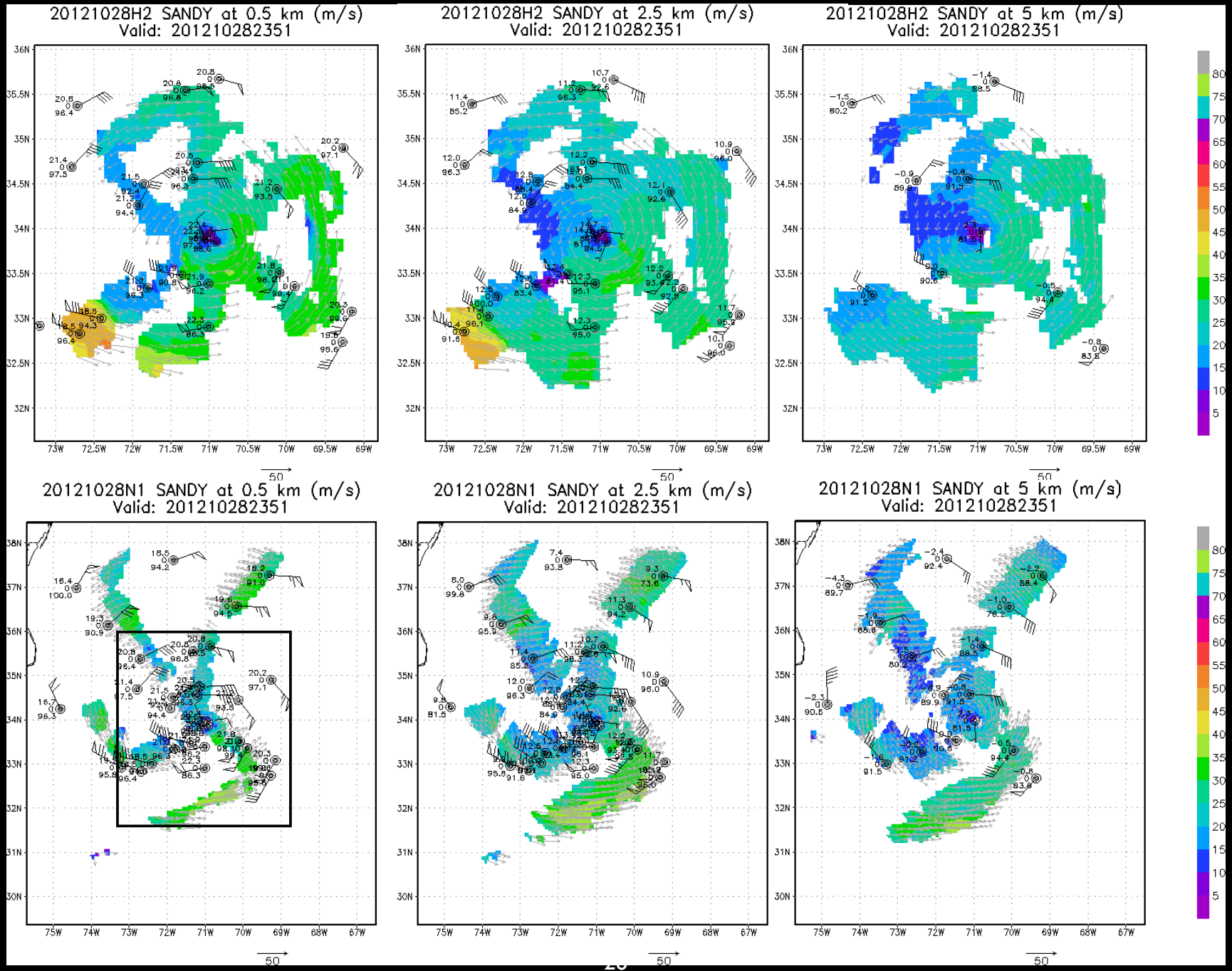






Sample data from the Cloud Physics Lidar

NASA Hurricane and Severe Storm Sentinel HS3


20121028H2 SANDY at 0.5 km (m/s)
Valid: 201210282351
20121028H2 SANDY at 2.5 km (m/s)
Valid: 201210282351
20121028H2 SANDY at 5 km (m/s)
Valid: 201210282351
20121028N1 SANDY at 0.5 km (m/s)
Valid: 201210282351
20121028N1 SANDY at 2.5 km (m/s)
Valid: 201210282351
20121028N1 SANDY at 5 km (m/s)
Valid: 201210282351
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70
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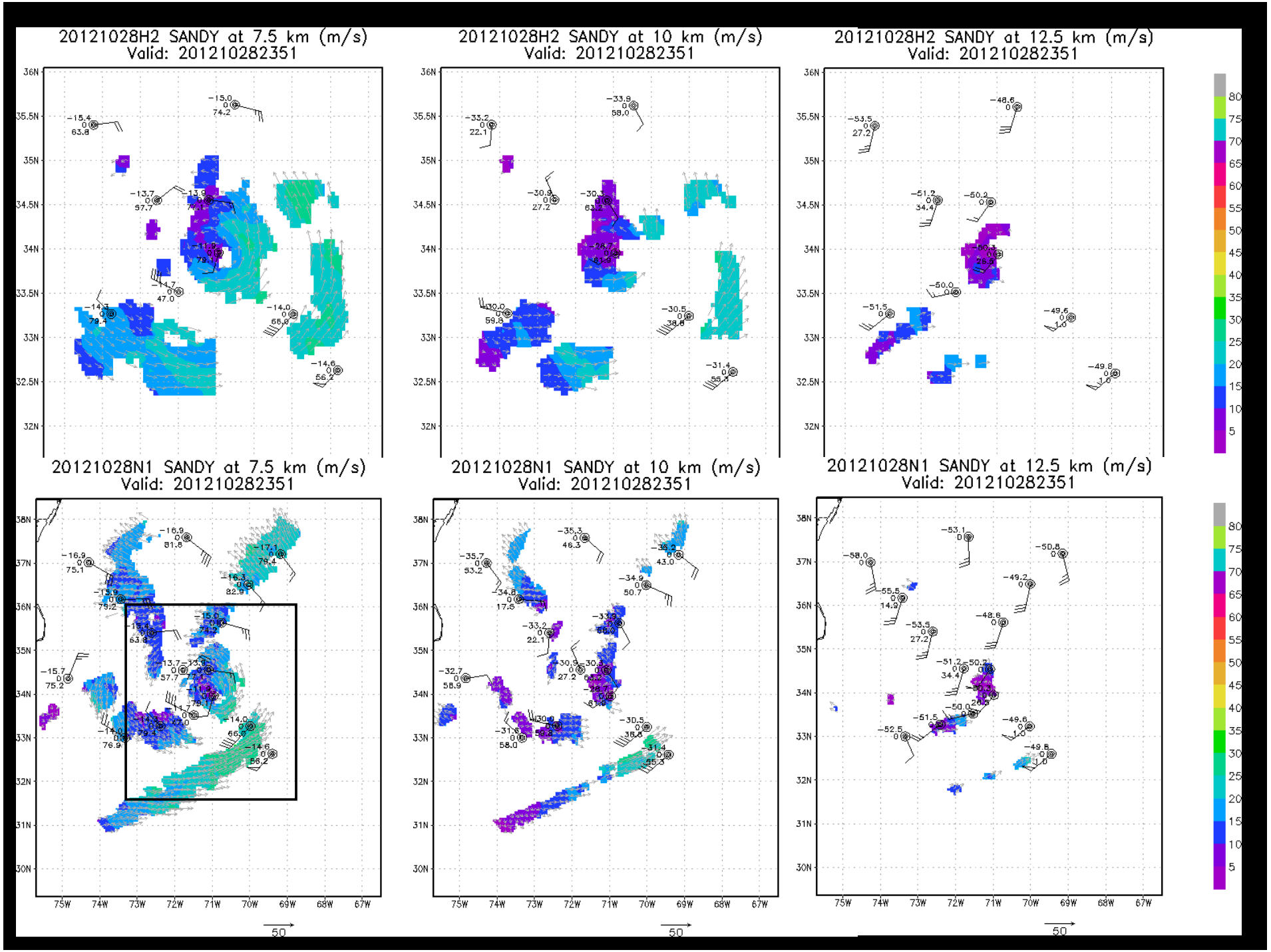
5
50


20121028H2 SANDY at 7.5 km (m/s)
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20121028H2 SANDY at 10 km (m/s)
Valid: 201210282351
20121028H2 SANDY at 12.5 km (m/s)
Valid: 201210282351
20121028N1 SANDY at 7.5 km (m/s)
Valid: 201210282351
20121028N1 SANDY at 10 km (m/s)
Valid: 201210282351
20121028N1 SANDY at 12.5 km (m/s)
Valid: 201210282351
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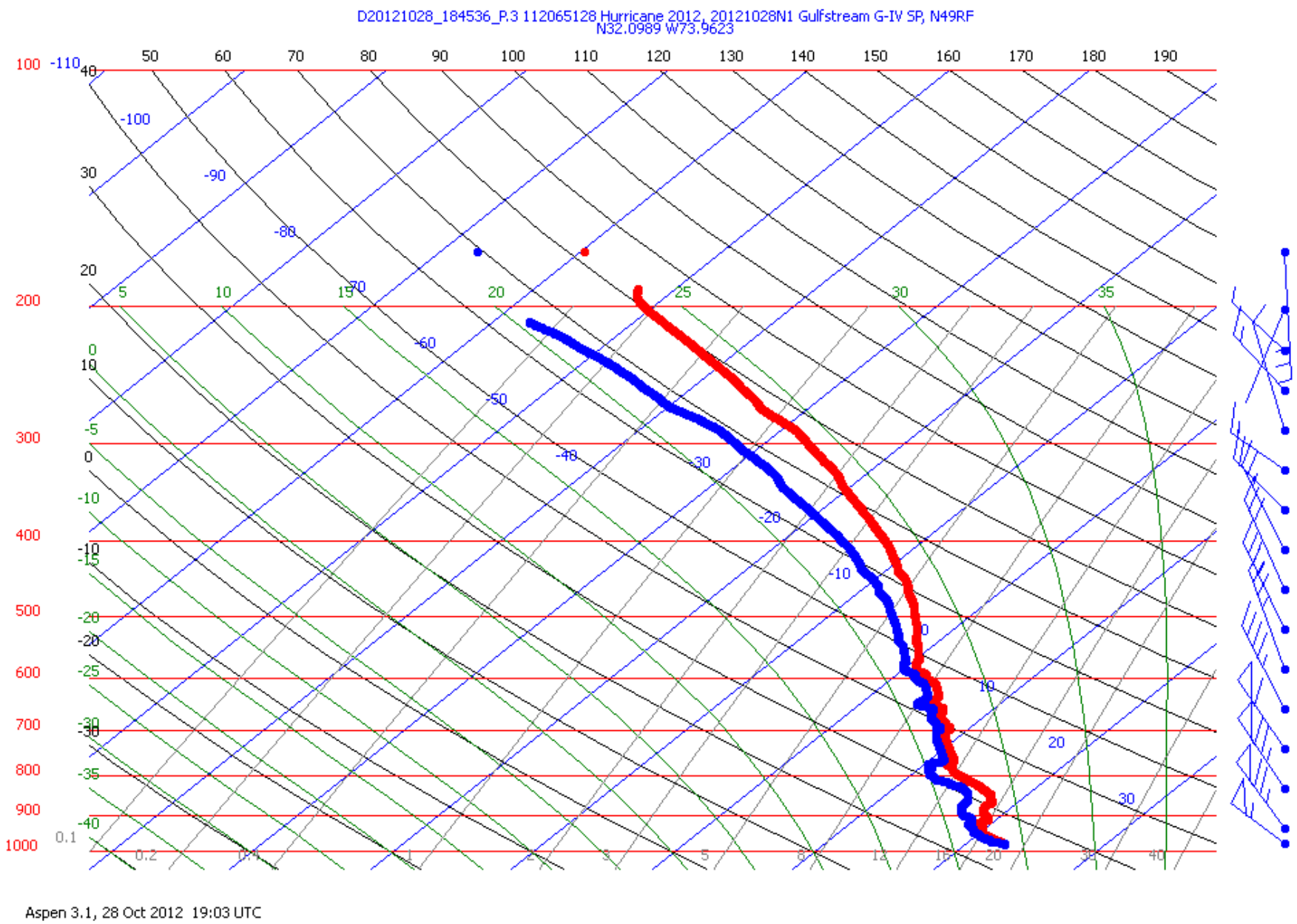
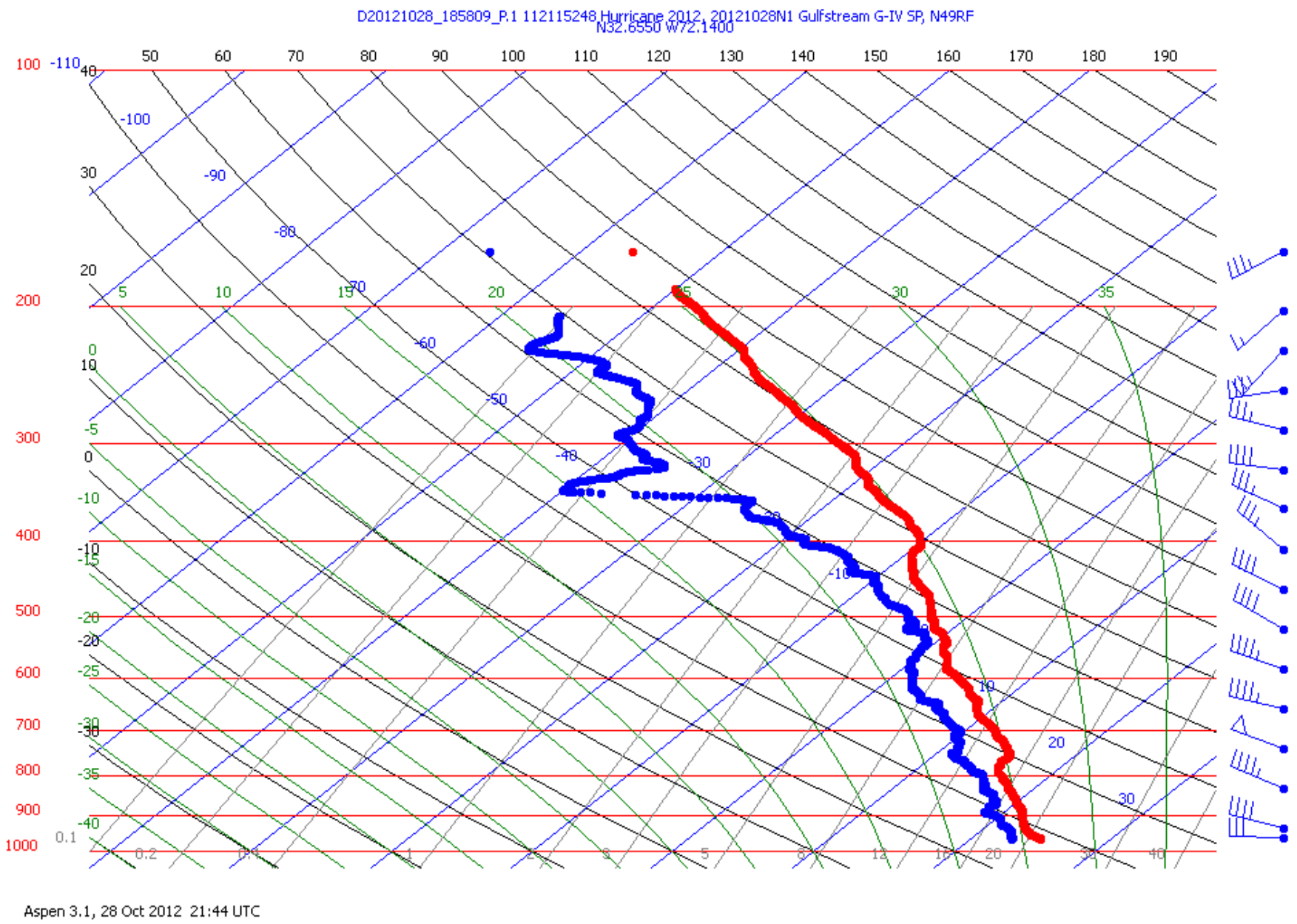
50

SW


D20121028_184536_P.3 112065128 Hurricane 2012, 20121028N1 Gulfstream G-IV SP, N49RF
N32.0989 W73.9623
Aspen 3.1, 28 Oct 2012 19:03 UTC

Center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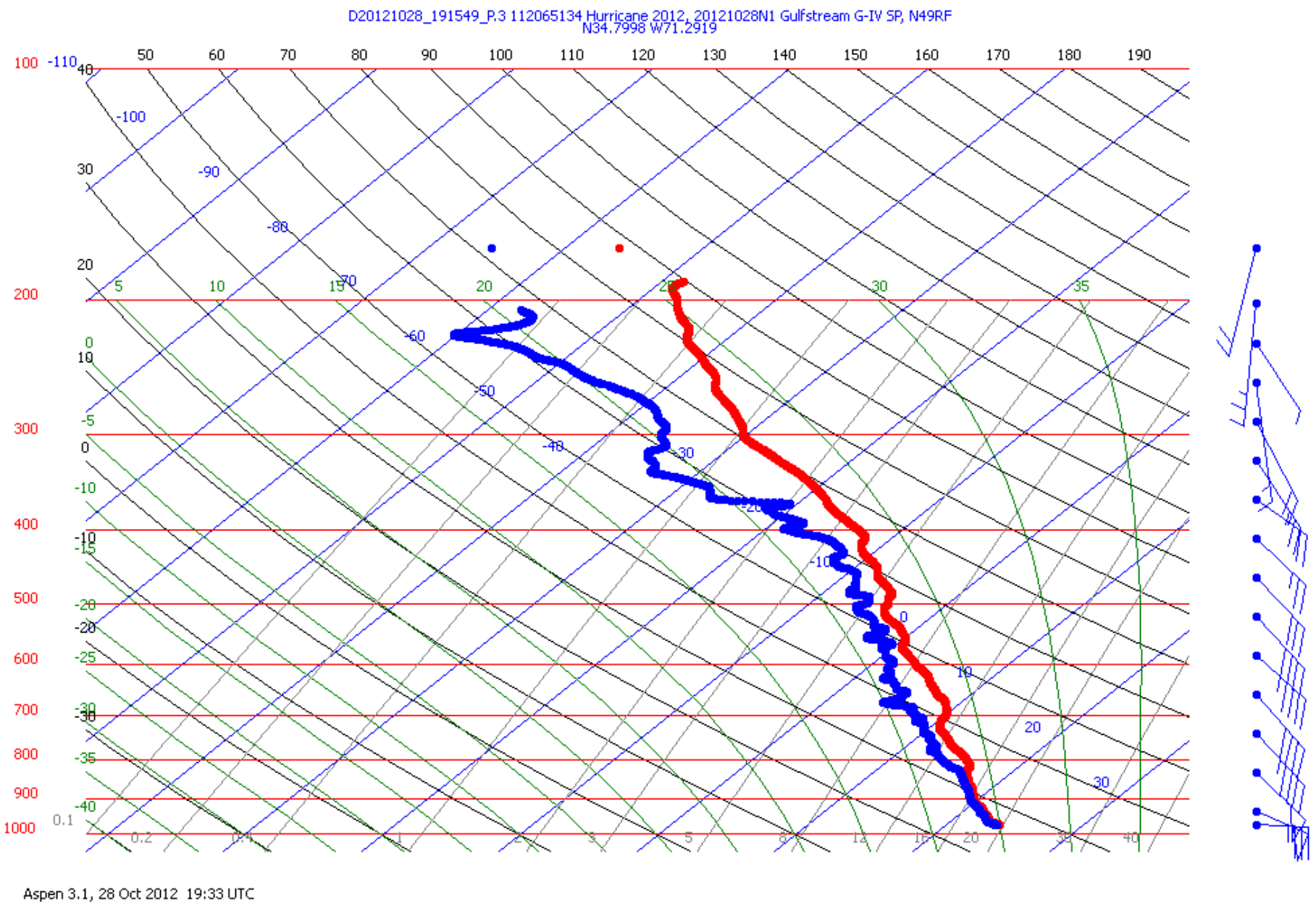
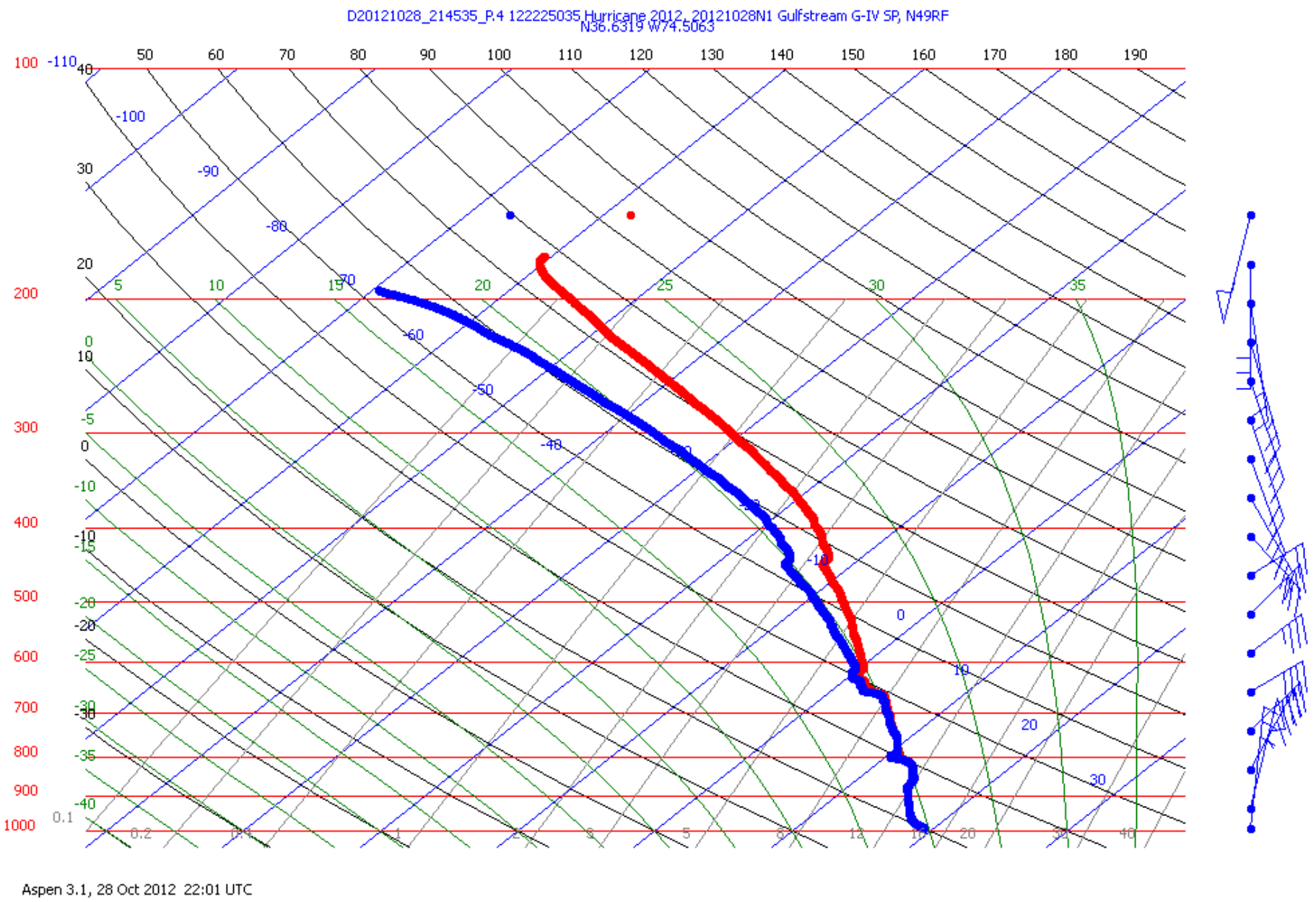
N32.6550 W72.1400
Aspen 3.1, 28 Oct 2012 21:44 UTC


D20121028_191549_P.3 112065134 Hurricane 2012, 20121028N1 Gulfstream G-IV SP, N49RF
N34.7998 W71.2919
Aspen 3.1, 28 Oct 2012 19:33 UTC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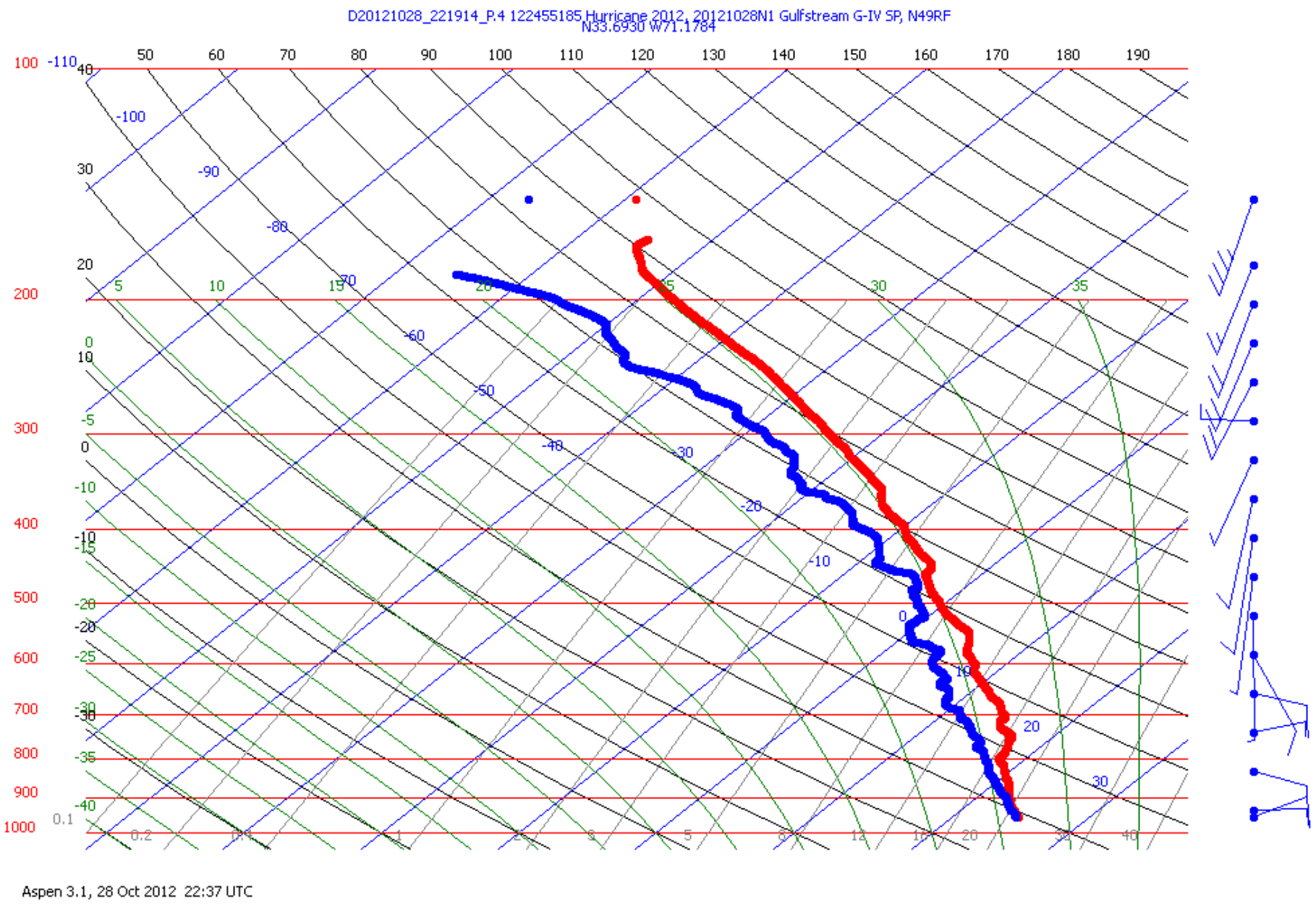
Aspen 3.1, 28 Oct 2012 22:01 UTC

Center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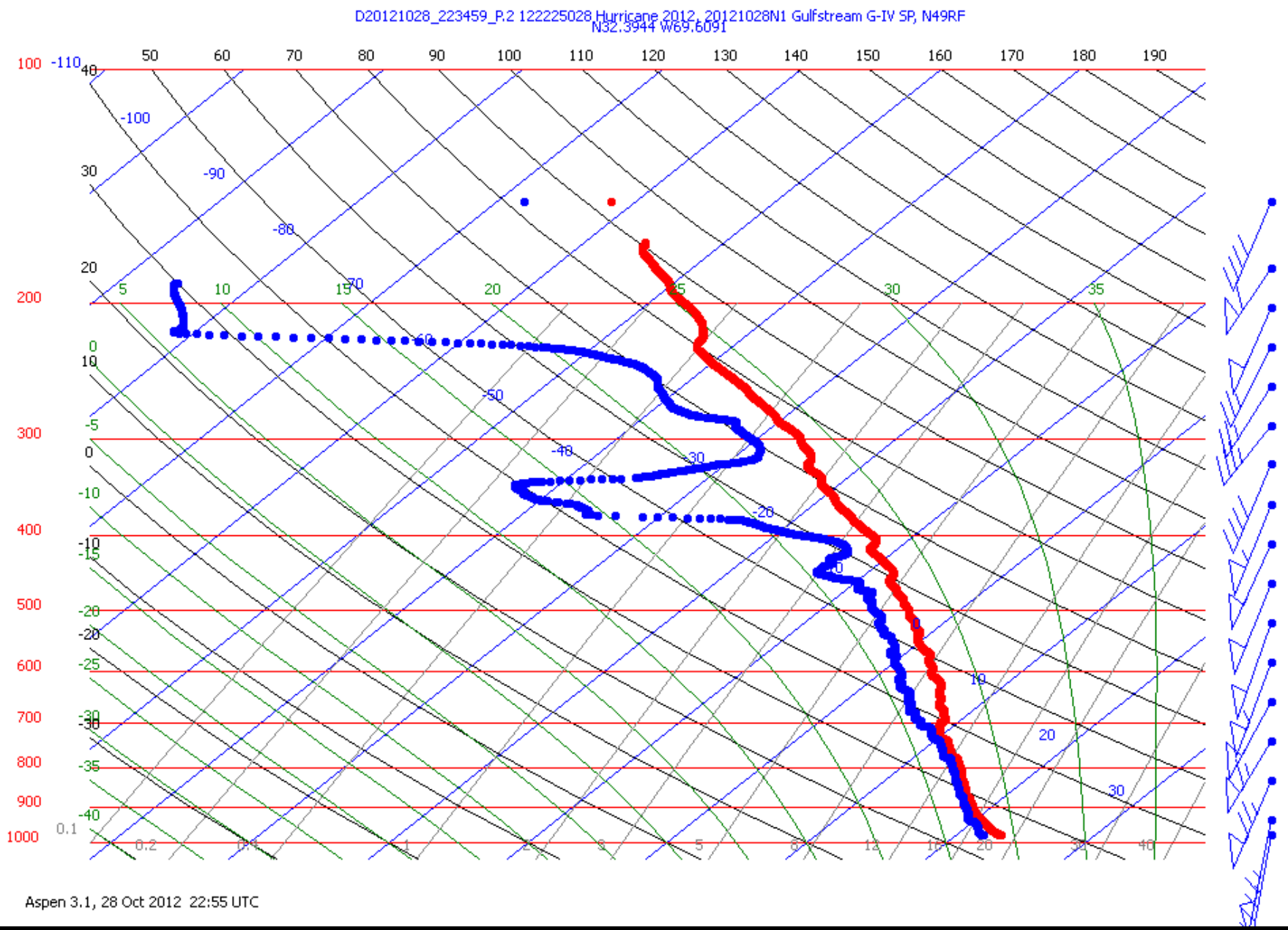
Aspen 3.1, 28 Oct 2012 22:37 UTC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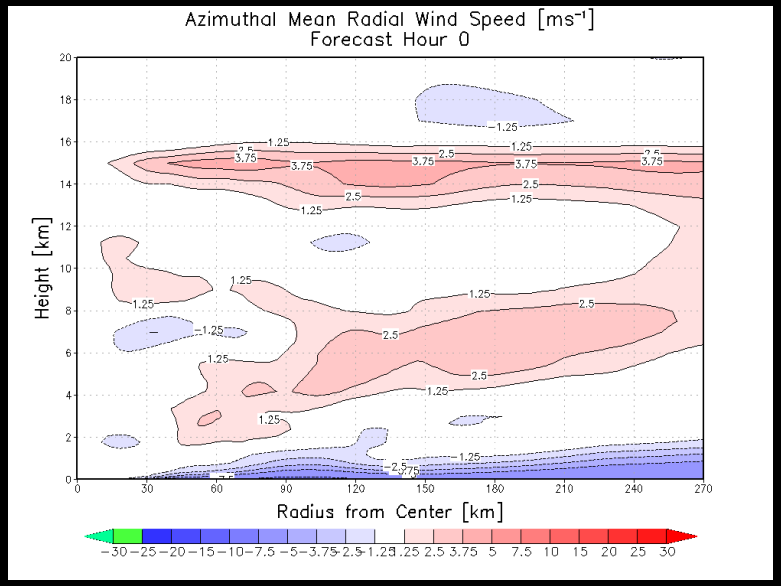
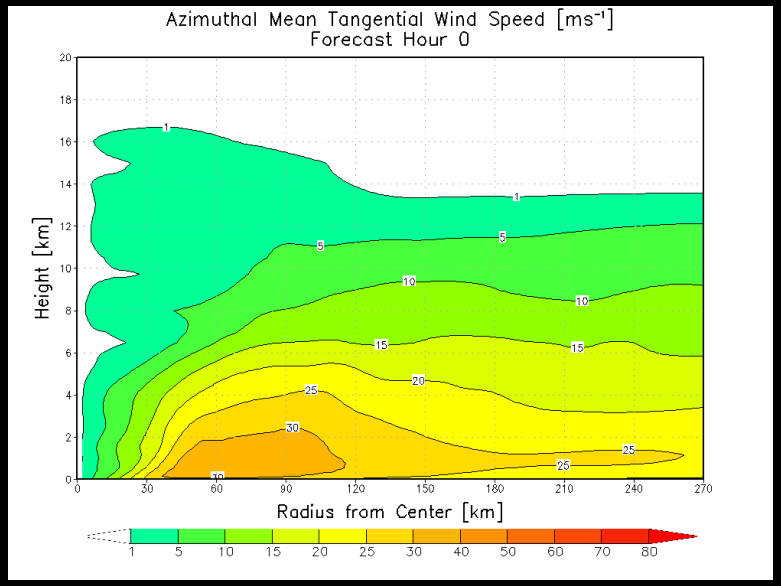
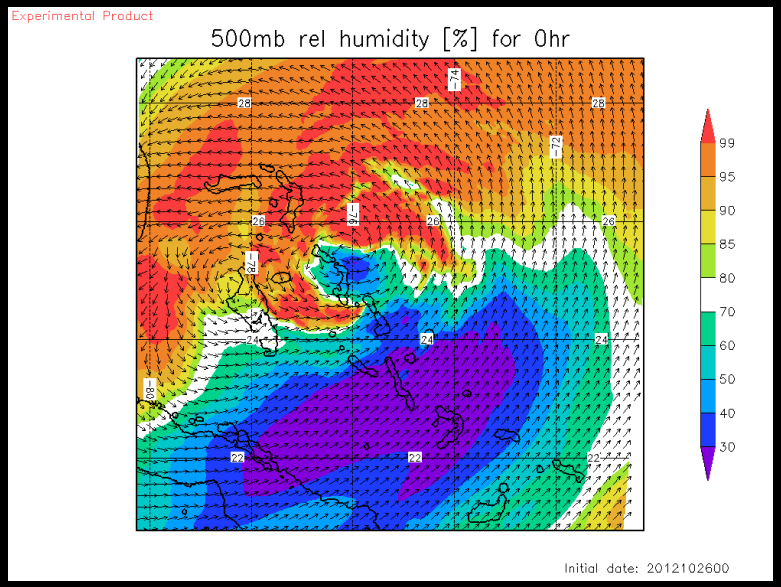

Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
−30 −25 −20 −15 −10 −7.5 −5 −3.75 −2.5 −1.25 1.25 2.5 3.75 5 7.5 10 15 20 25 30


Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
1 5 10 15 20 25 30 40 50 60 70 80

2012102600


Experimental Product
500mb rel humidity [%] for 0hr
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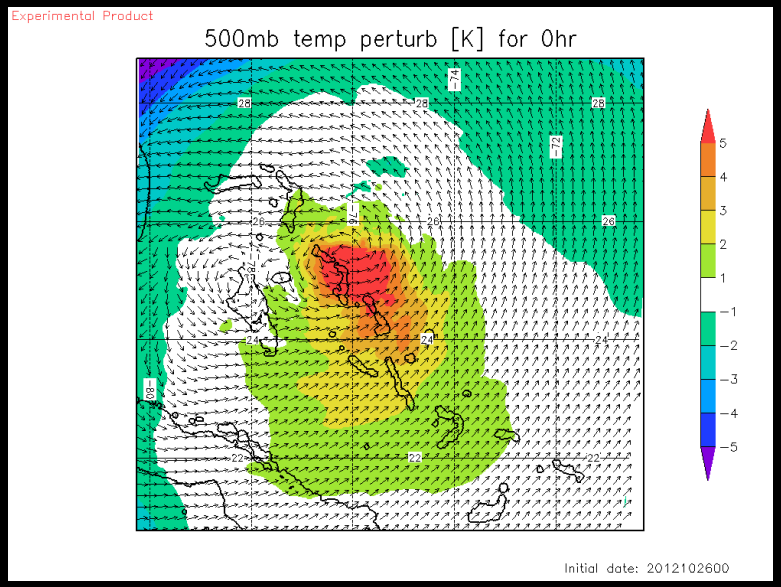
Initial date: 2012102600


Experimental Product
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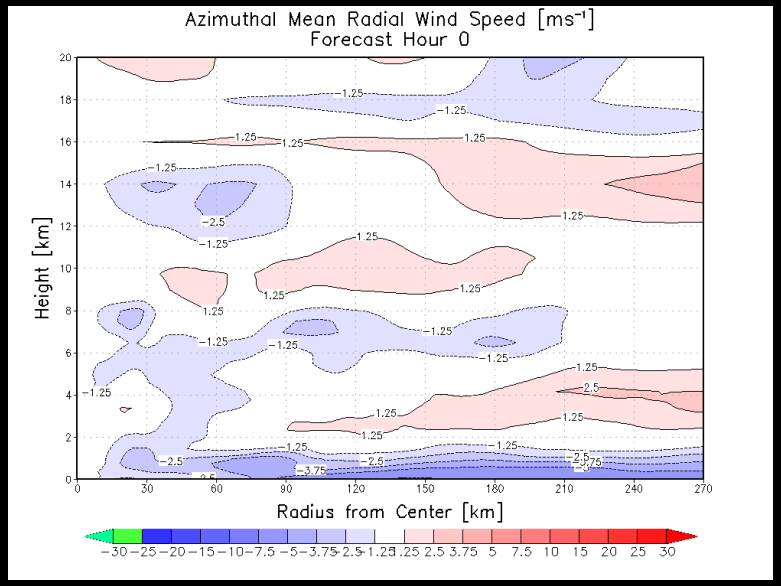
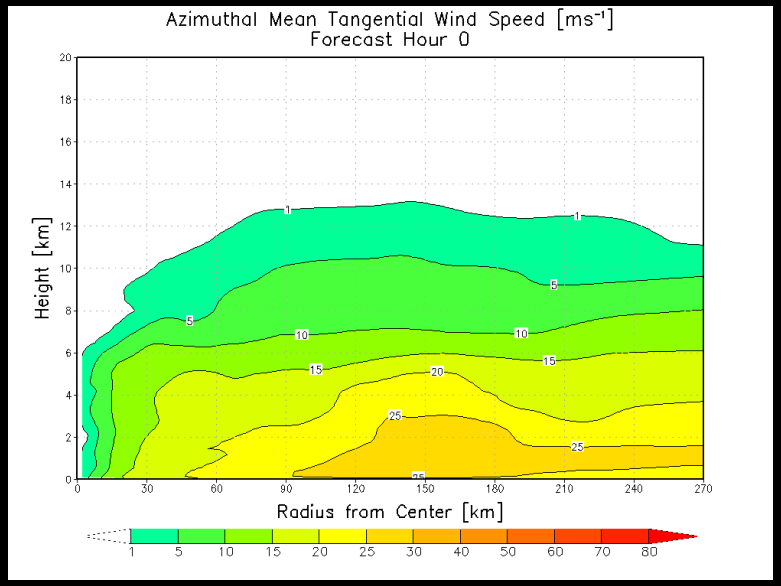
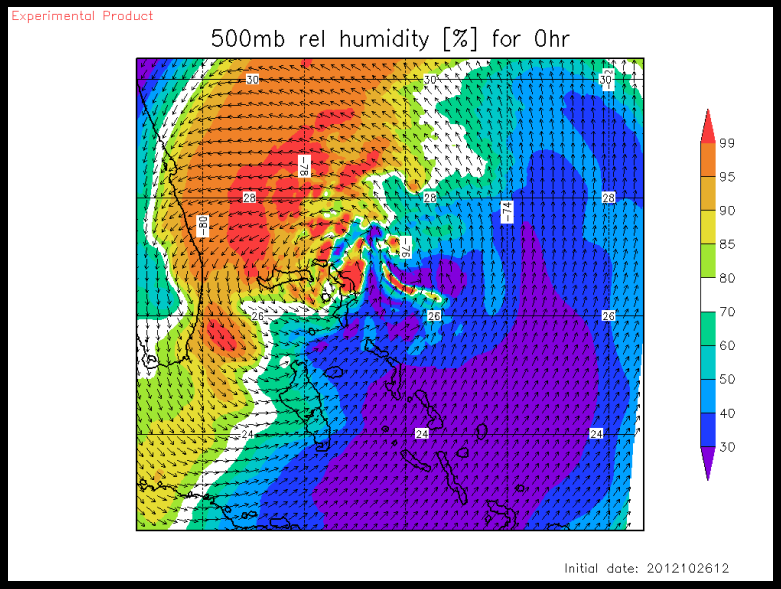
Initial date: 2012102600


Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
−30 −25 −20 −15 −10 −7.5 −5 −3.75 −2.5 −1.25 1.25 2.5 3.75 5 7.5 10 15 20 25 30


Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
1 5 10 15 20 25 30 40 50 60 70 80

2012102612


Experimental Product
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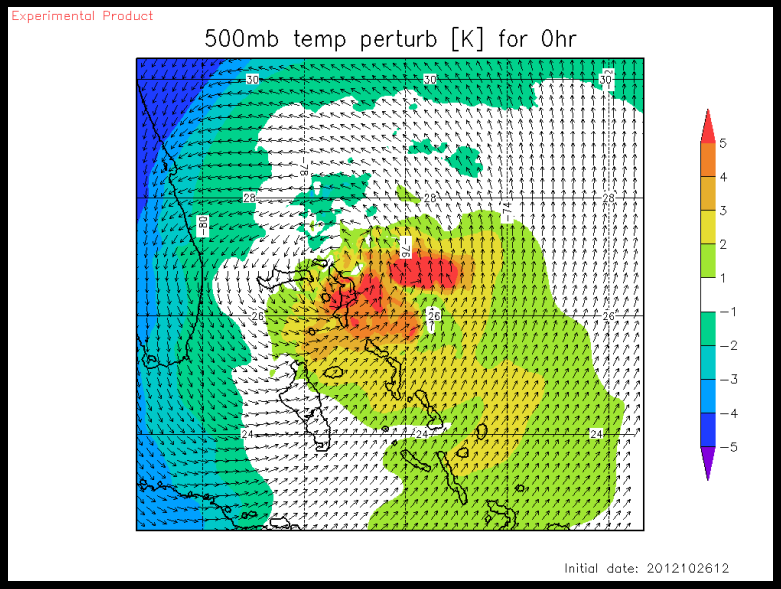
Initial date: 2012102612


Experimental Product
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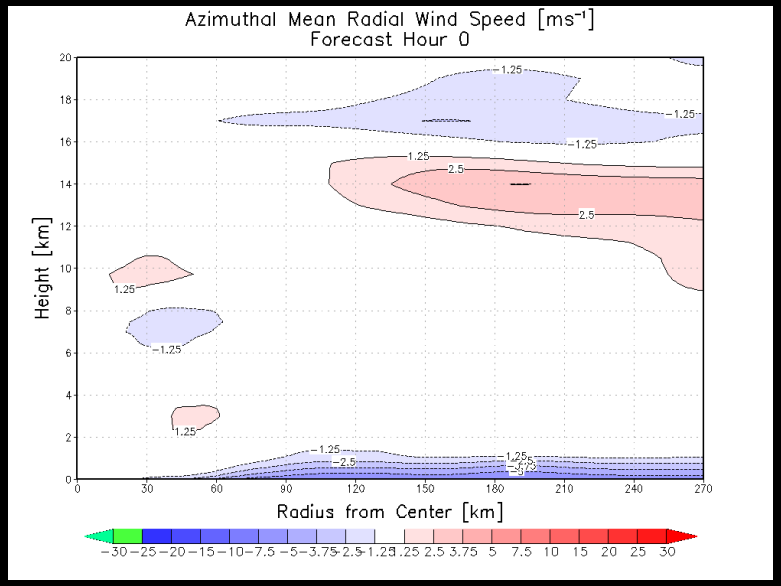
Initial date: 2012102612


Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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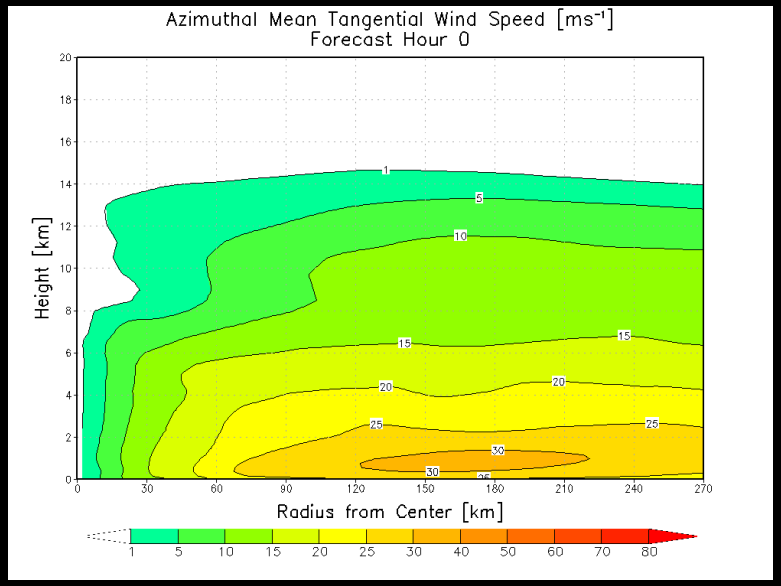
Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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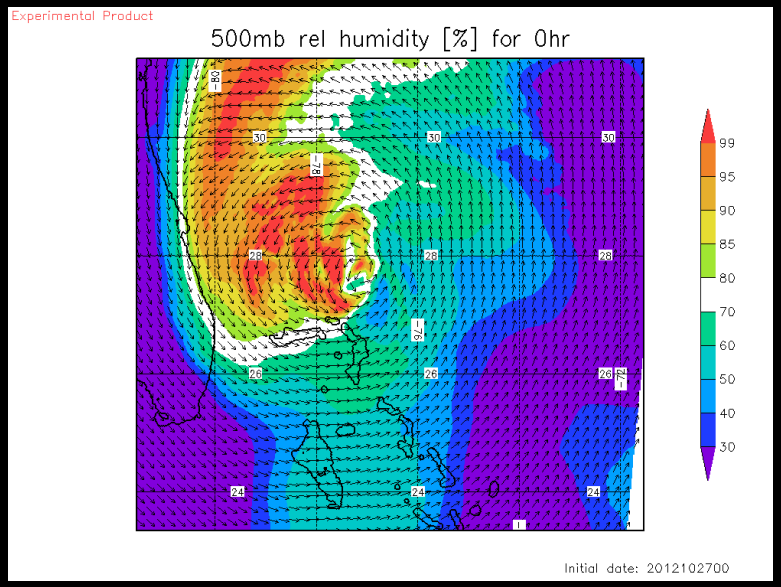
2012102700


Experimental Product
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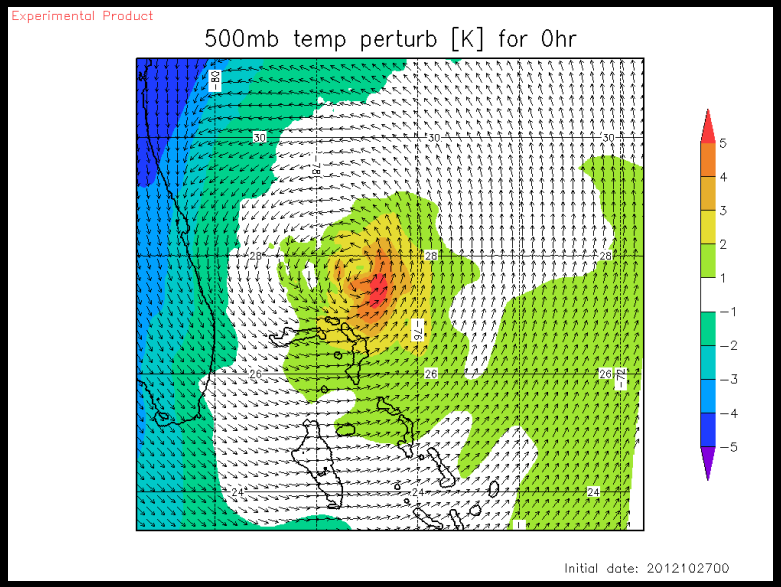
Initial date: 2012102700


Experimental Product
500mb temp perturb [K] for 0hr
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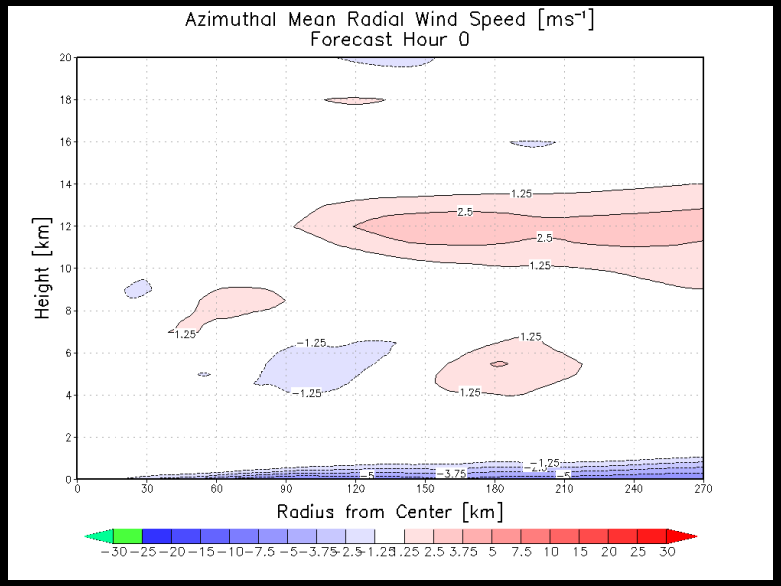
Initial date: 2012102700


Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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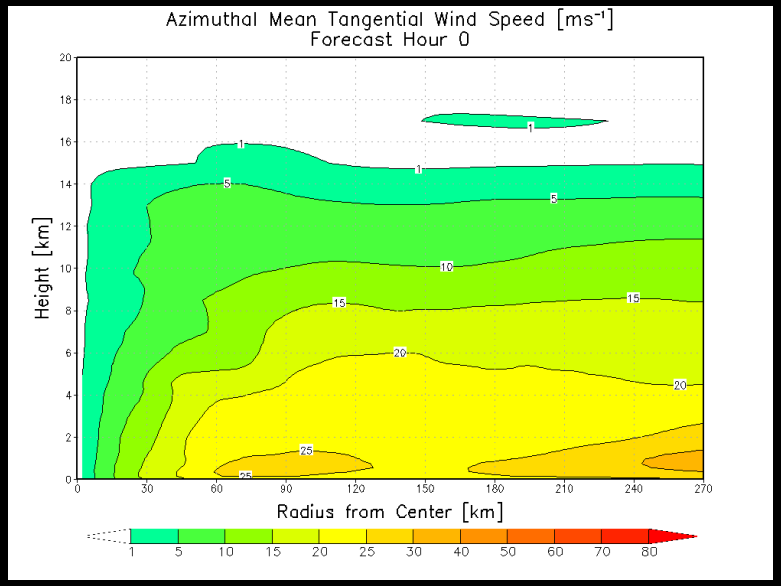
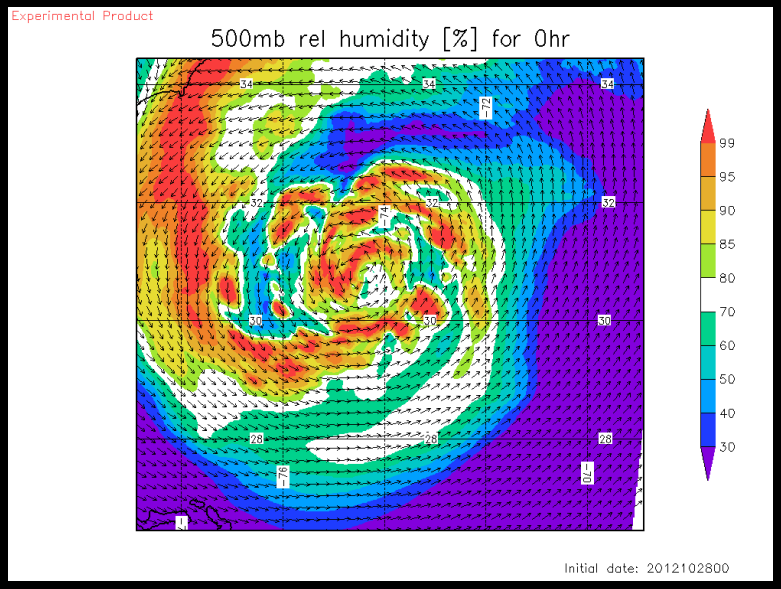

Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
1 5 10 15 20 25 30 40 50 60 70 80

2012102800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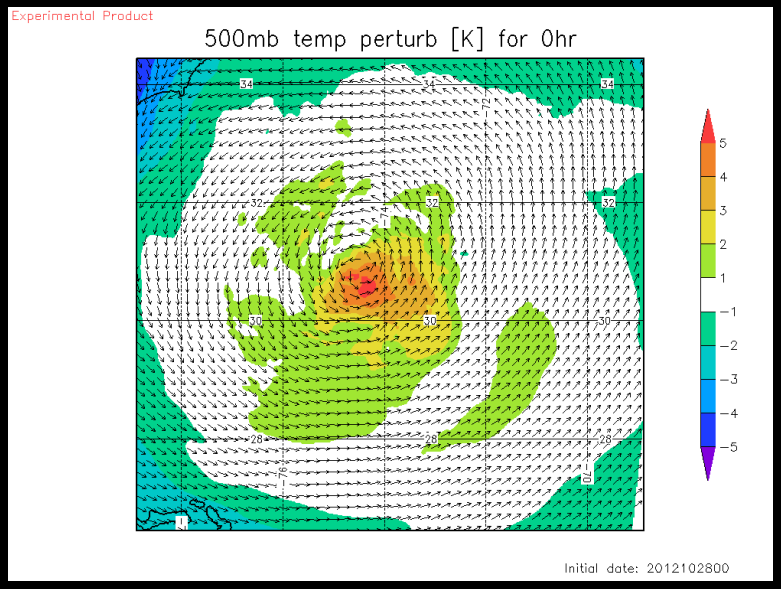
Initial date: 2012102800


Experimental Product
500mb temp perturb [K] for 0hr
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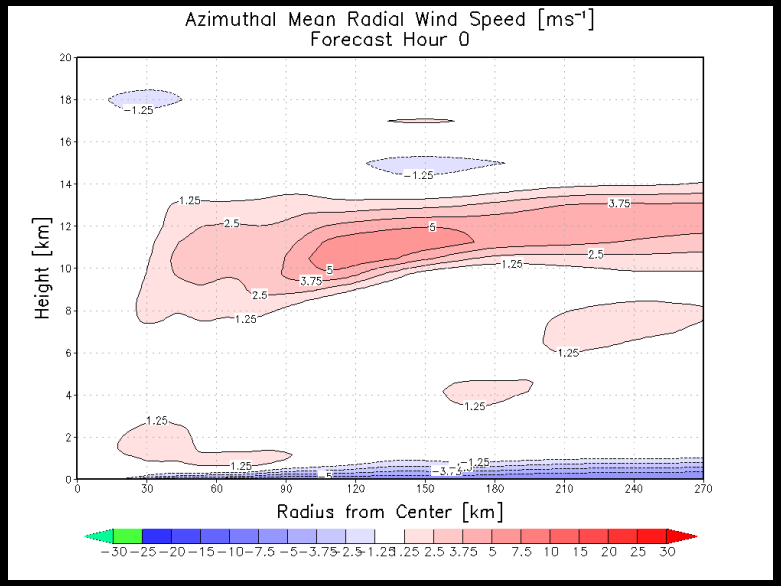
Initial date: 2012102800


Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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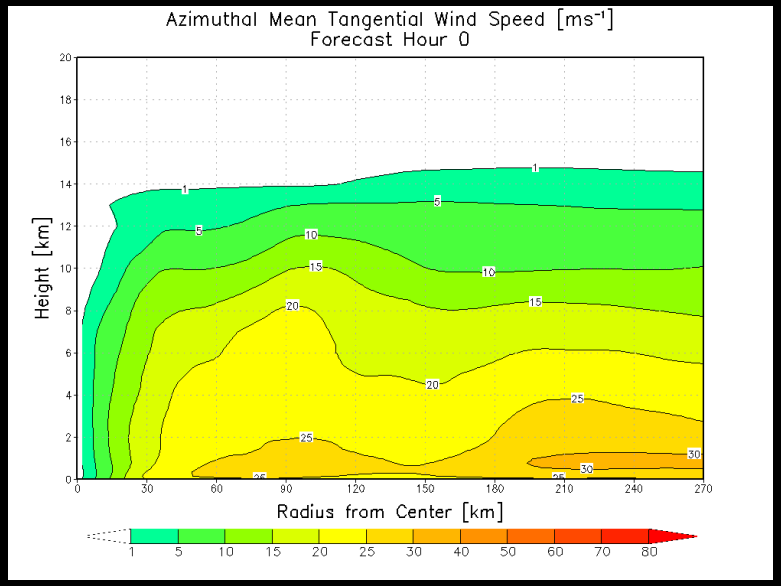
Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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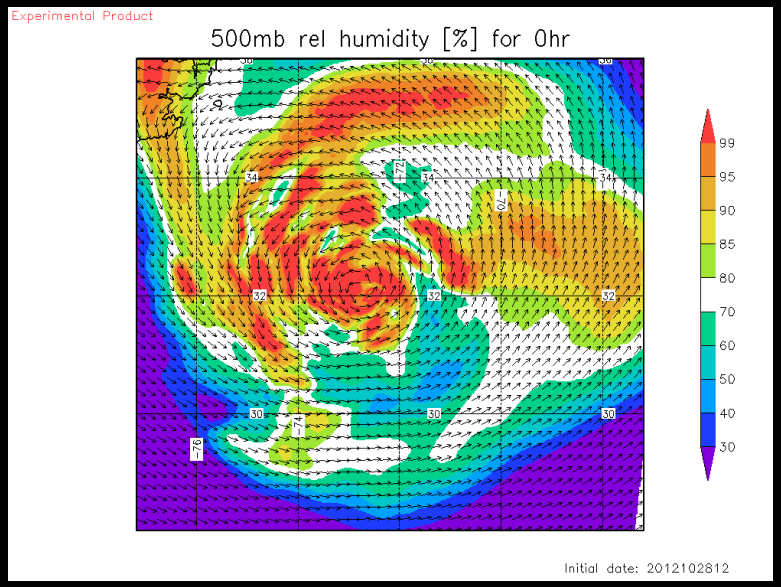
2012102812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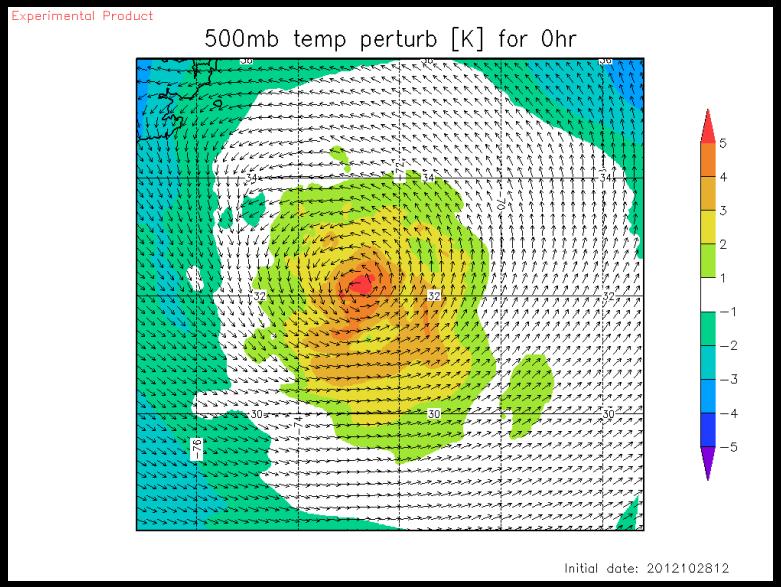
Initial date: 2012102812


Experimental Product
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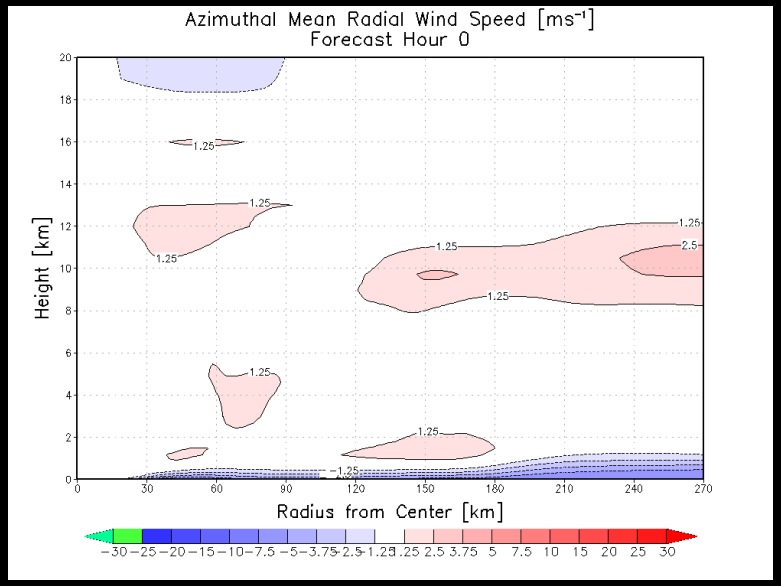
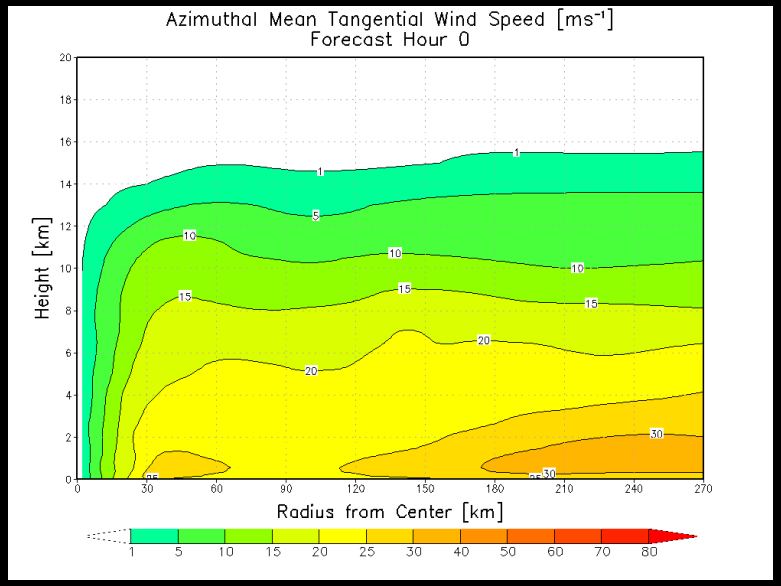
Initial date: 2012102812


Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
−30 −25 −20 −15 −10 −7.5 −5 −3.75 −2.5 −1.25 1.25 2.5 3.75 5 7.5 10 15 20 25 30


Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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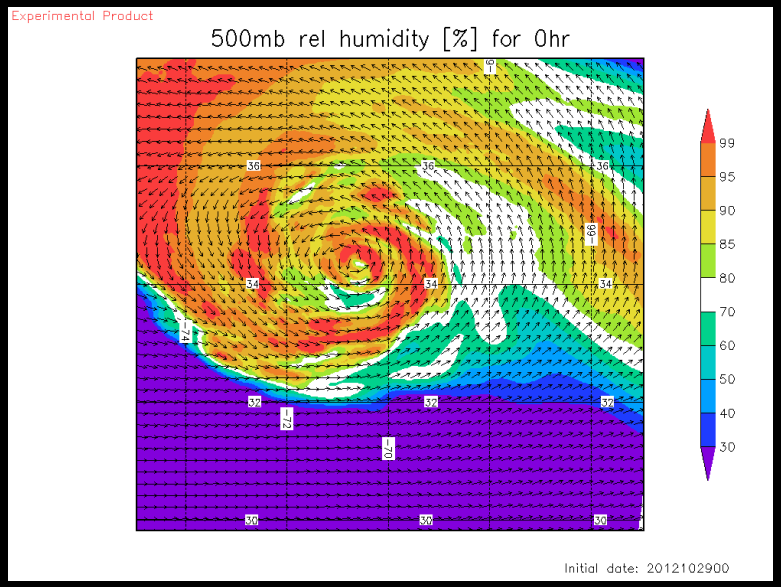
2012102900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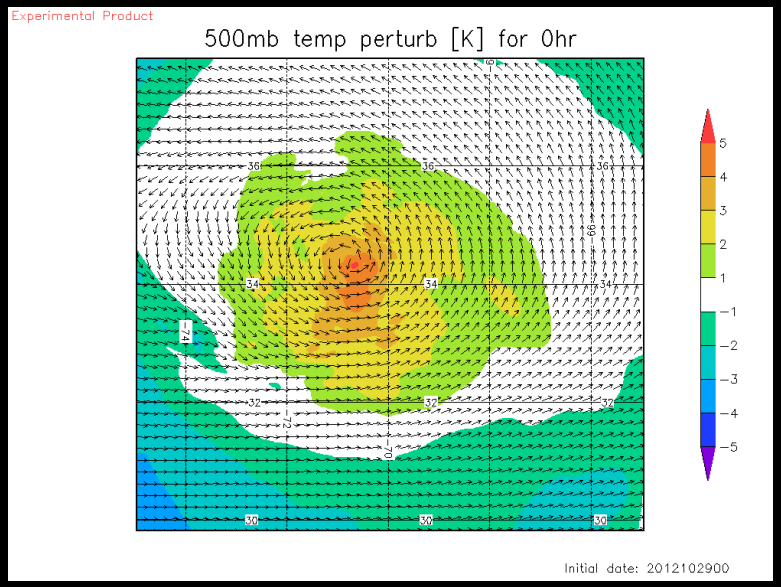
Initial date: 2012102900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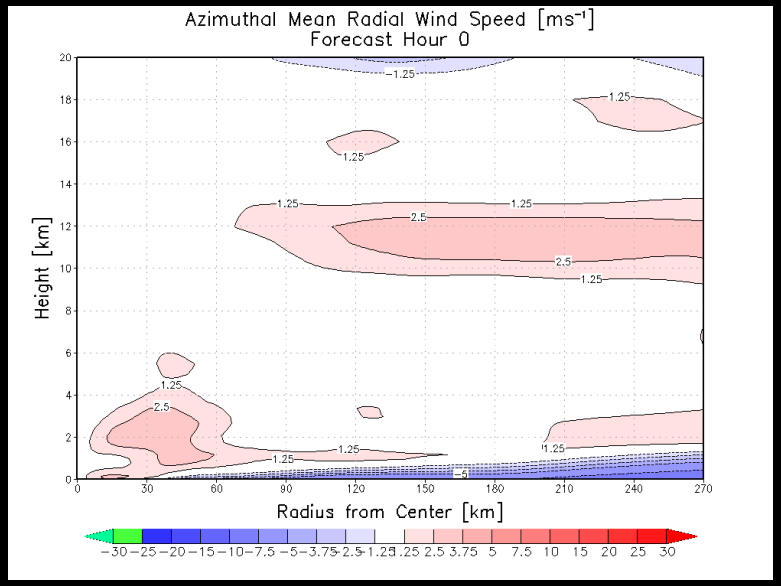
Initial date: 2012102900


Azimuthal Mean Radial Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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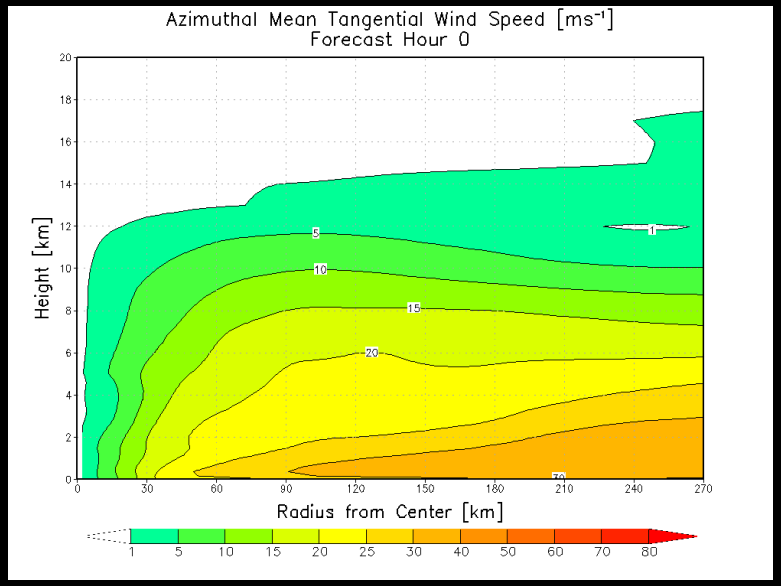
Azimuthal Mean Tangential Wind Speed [ms⁻¹]
Forecast Hour 0
Height [km]
Radius from Center [km]
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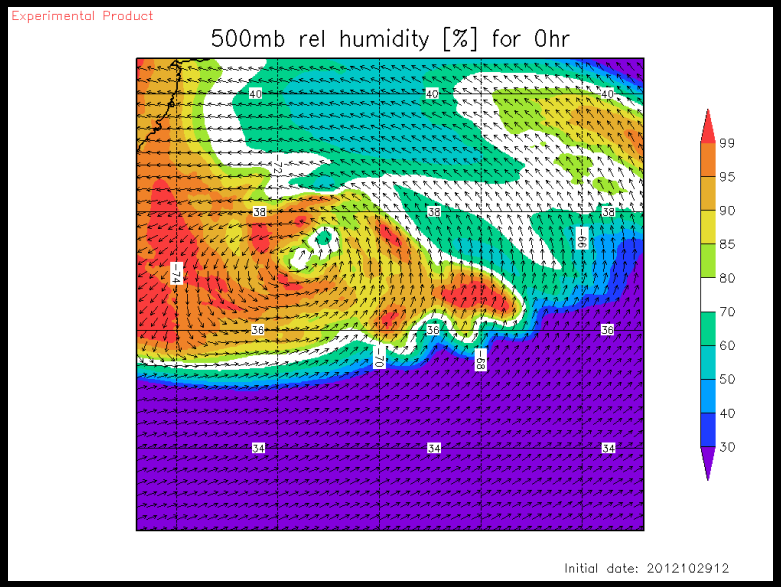
2012102912


Experimental Product
500mb rel humidity [%] for 0hr
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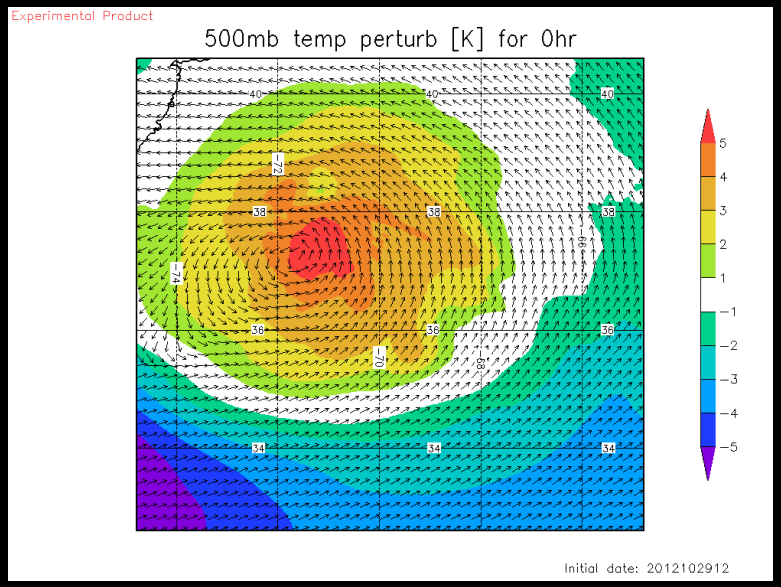
Initial date: 2012102912


Experimental Product
500mb temp perturb [K] for 0hr
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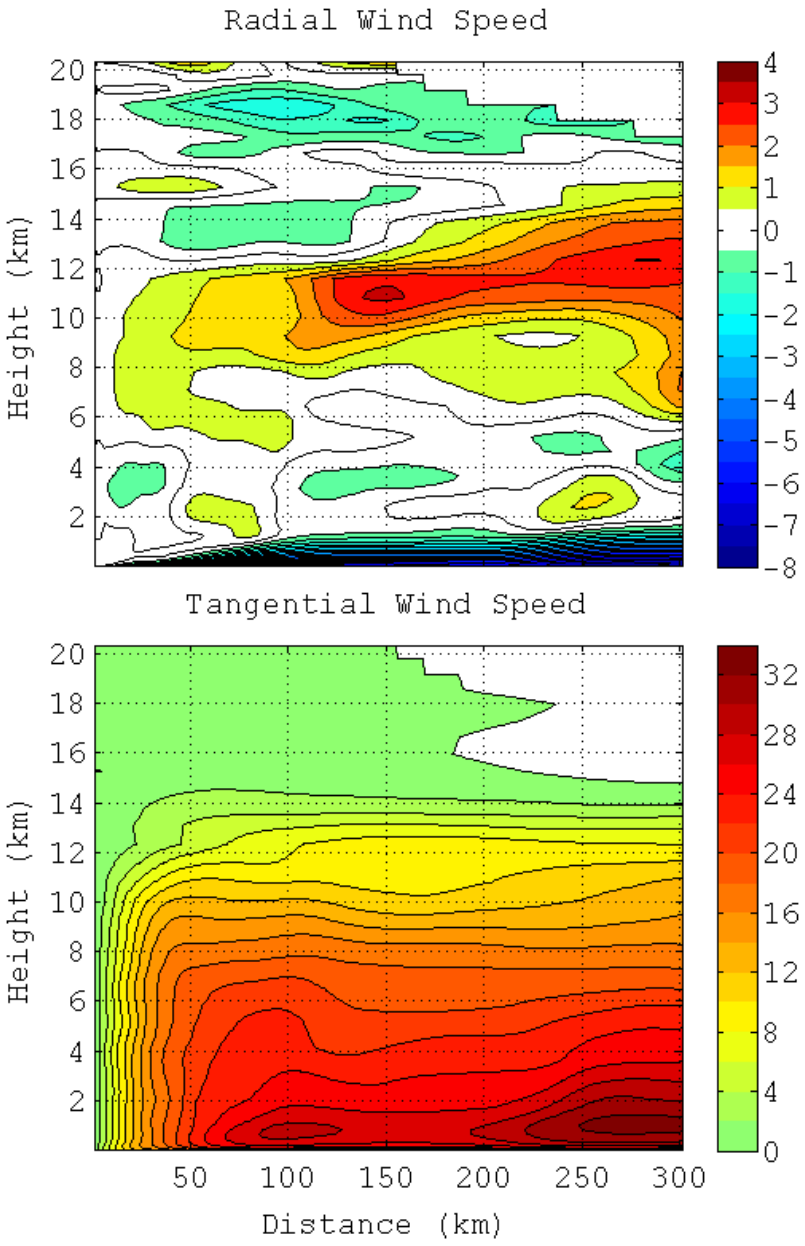
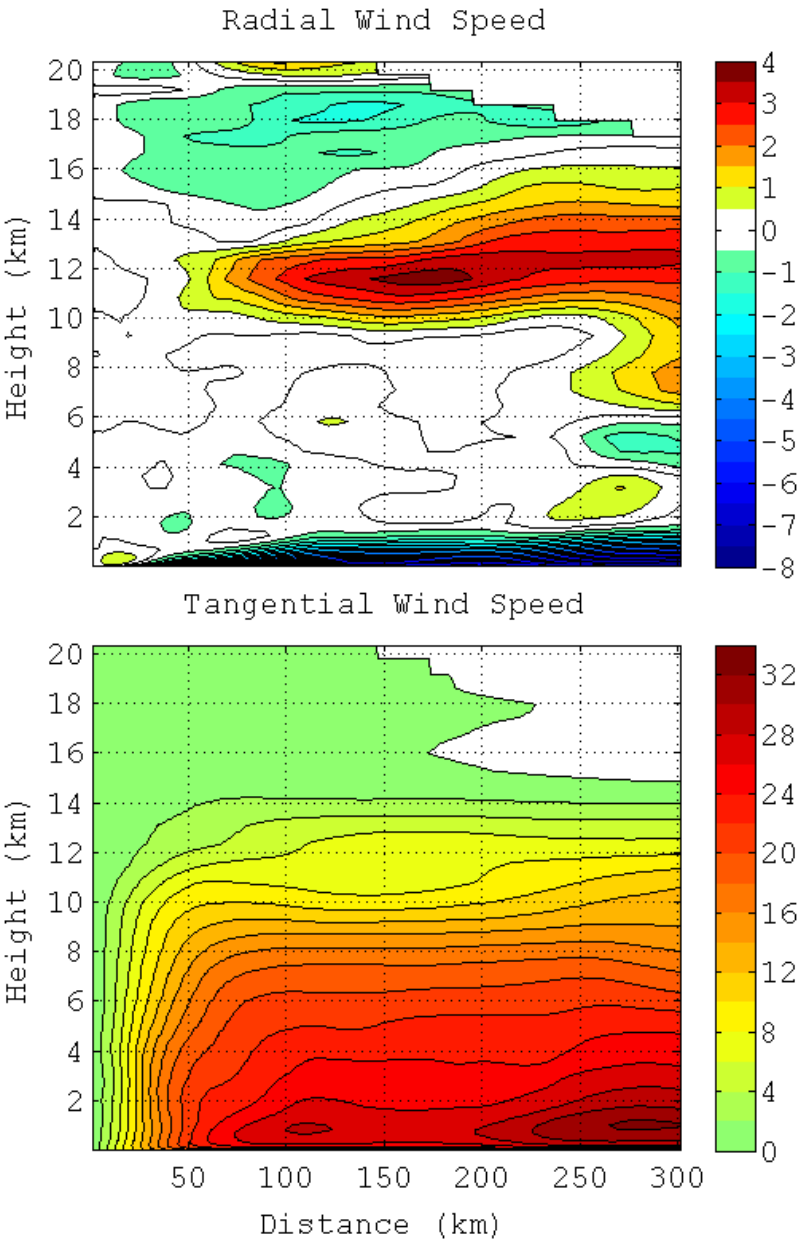
Initial date: 2012102912

G-IV Doppler radar

HEDAS analysis
with G-IV Doppler Radar data



HEDAS analysis
HDOBS and dropwindsonde only



HFIP Visiting Scientist
Ryan Torn - University at Albany
Yongzuo Li - Oklahoma
Dave Zelinsky - NHC
Stacie Stewart - NHC

Other visiting dignitaries and scientists participated during Isaac and Sandy flights