GOES-13 All-sky infrared radiance impacts on Hurricane Joaquin (2015) prediction with PSU-EnKF

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Background

- Emanuel and Zhang (2016 and 2017, JAS) found that, in the first few days, intensity error mainly comes from the initial intensity error. Initial intensity error does not only stand for position and intensity, but also inner core moisture, which is a dominant factor in causing intensity forecast error (Hurricane Joaquin).

- Robert et al (2017 JAS, in review) studied Hurricane Joaquin based on the ensemble forecast initiated at 12Z29 Sep; the track spread came between the 600~900km area from the initial position while the initial intensity error inside of 300km was the dominant source leading to the intensity spread.

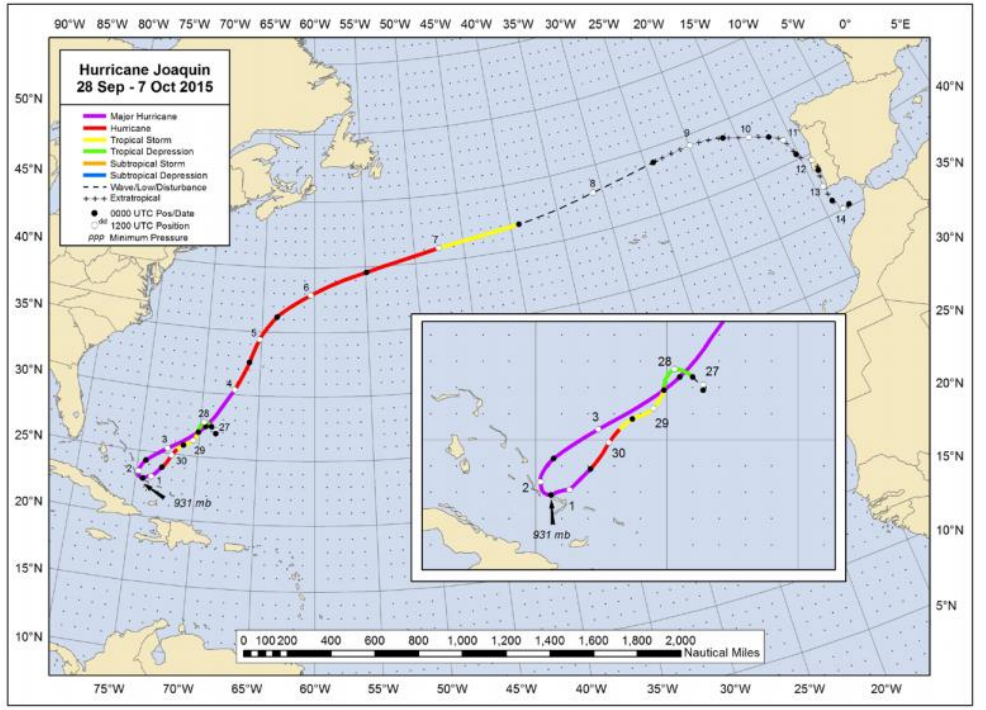
- Inner core observational information of hurricanes is rarely obtained. Satellite data is the most integral observation.

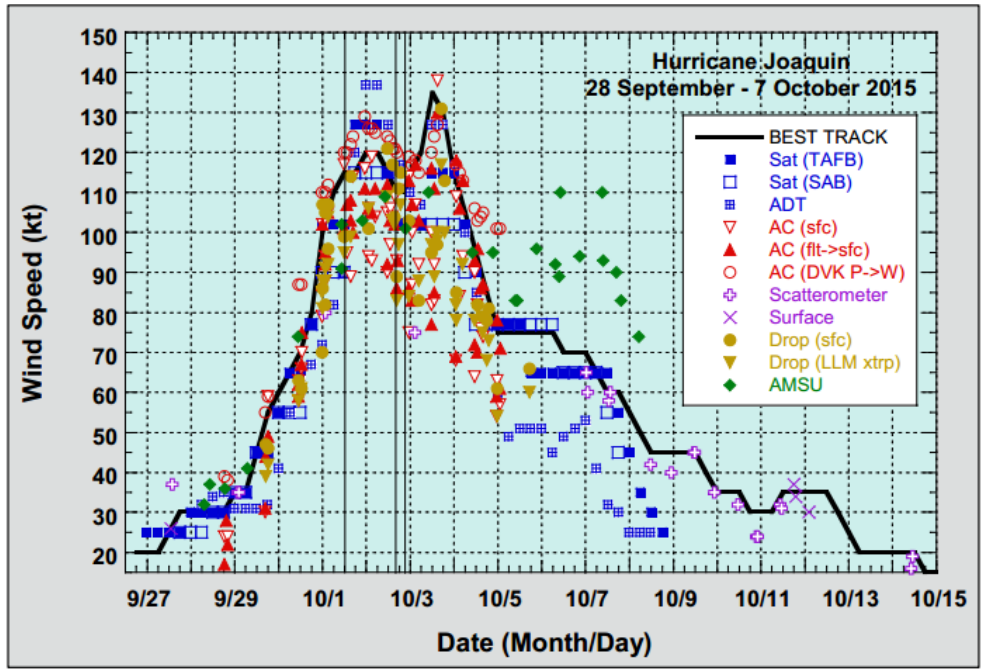
Case Overview

NOAA GOES-EAST VISIBLE SATELLITE IMAGE (TRUE-COLOR BACKGROUND) OF HURRICANE JOAQUIN AT 1900 UTC 1 OCTOBER WHILE IT WAS CENTERED NEAR THE CENTRAL AND SOUTHEASTERN BAHAMAS

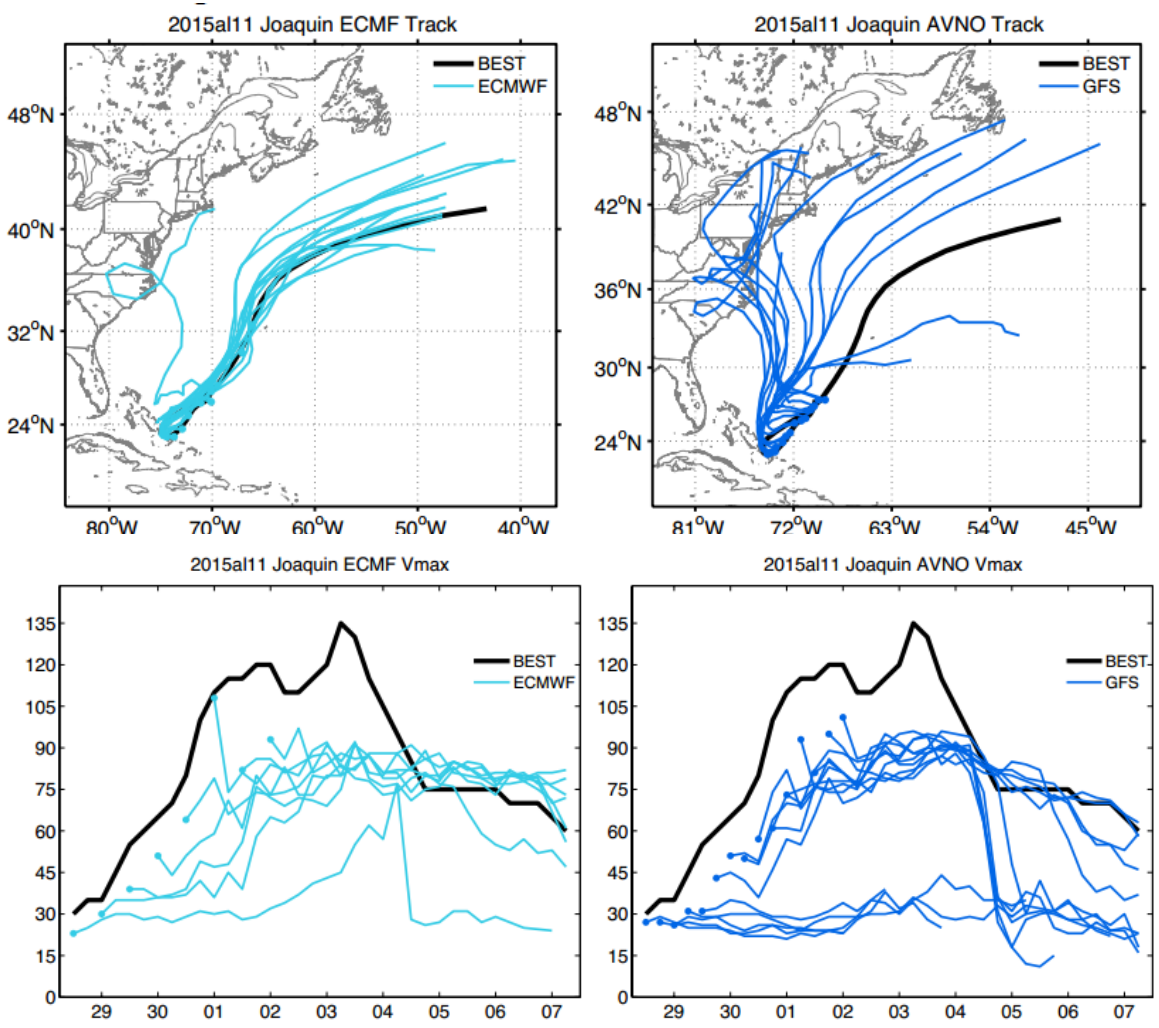
Joaquin was a category 4 hurricane (on the Saffir-Simpson Hurricane Wind Scale) whose strong winds and storm surge devastated Crooked Island, Acklins, Long Island, Rum Cay, and San Salvador in the central and southeastern Bahamas. Joaquin took the lives of 34 people—all at sea—including the 33 crewmembers of the cargo ship *El Faro*, which sunk during the storm northeast of Crooked Island. Joaquin is the strongest October hurricane known to have affected the Bahamas since 1866 and the strongest Atlantic hurricane of non-tropical origin in the satellite era.

Source: http://www.nhc.noaa.gov/data/tcr/AL112015_Joaquin.pdf





Operational forecasts



Satellite Obs

GOES-13 Imager:

- Geostationary orbit; altitude 35786km; 75W;

5 channels:

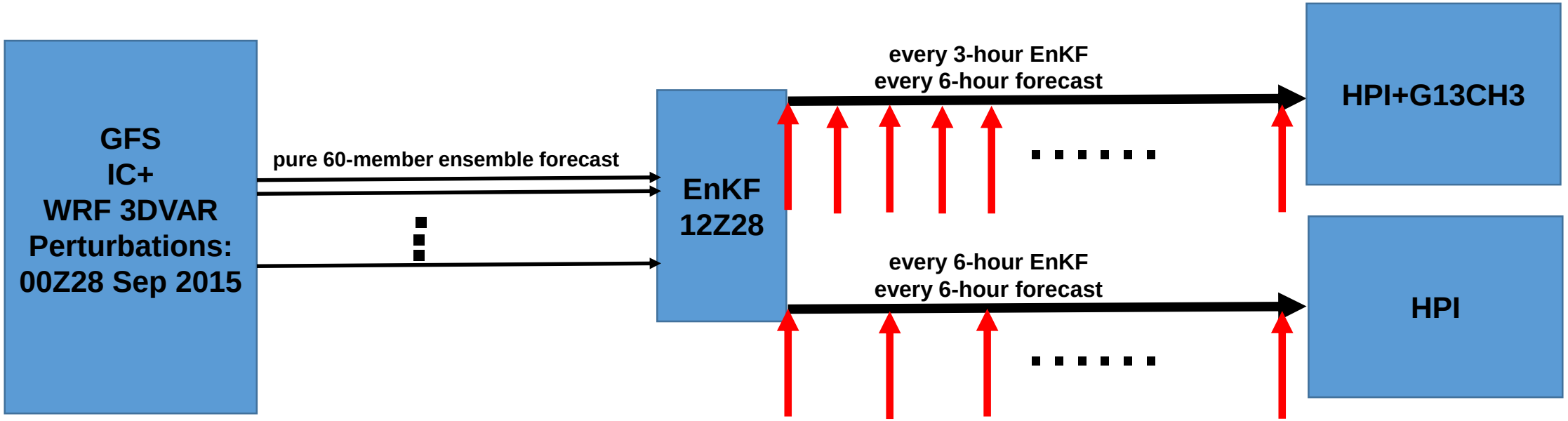
- Visible channel: 0.65μm (0.55-0.75, 1km resolution)
- Infrared channel: 3.90μm (3.80-4.00); 6.55μm (5.80-7.30, 4km, water vapor channel); 10.70μm (10.2-11.2); 13.35μm (13.0-13.7)

DA system:

- PSU realtime WRF-EnKF system

Experimental set-up

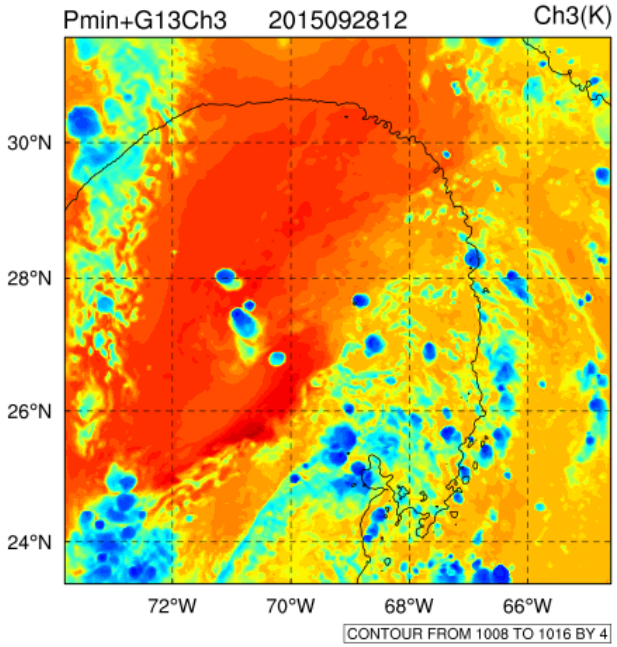
- 12-hour free ensemble forecasts from 09/28/00/2015
- DA initiates from 09/28/12, every 3-hour til 10/04/12, with and without GOES-13 infrared radiance data (Channel 3)
- Do 5 days deterministic forecasts every 6-hour



Schematic flowchart for the EnKF experiments

Simulation vs. CH3

G13CH3+HPI



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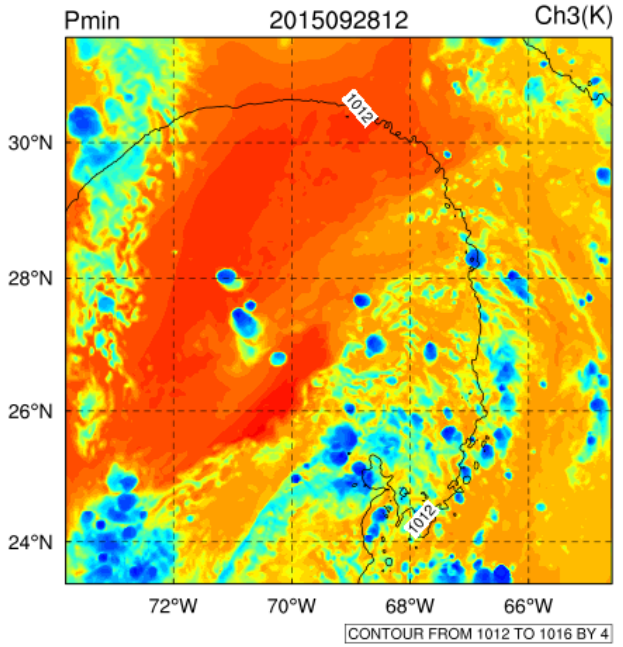

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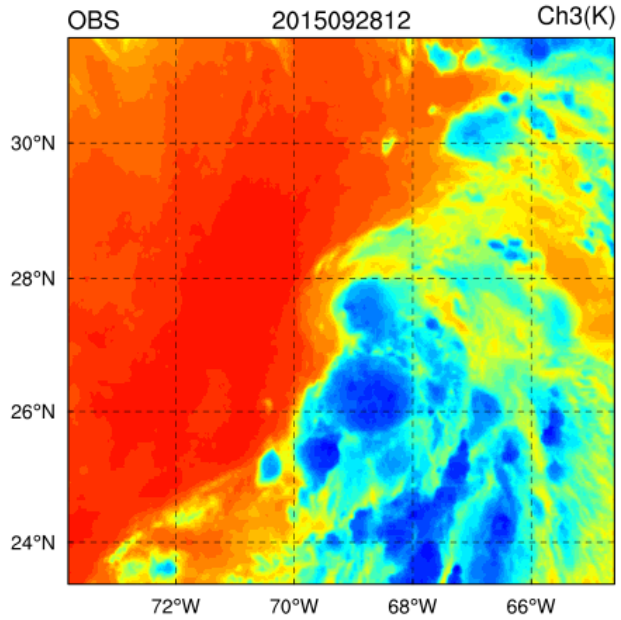

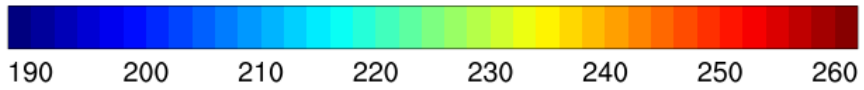

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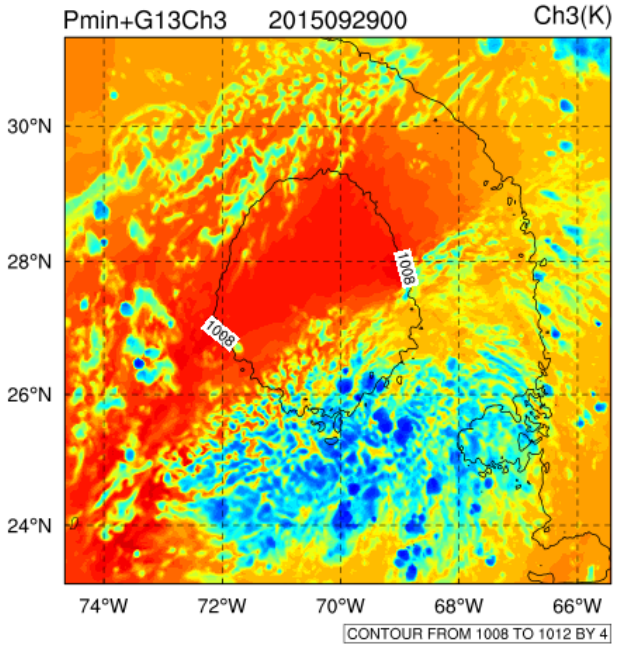

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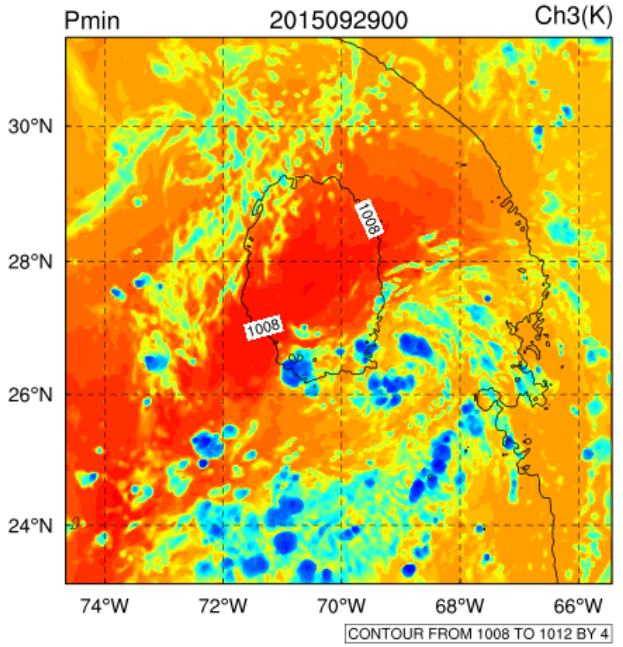

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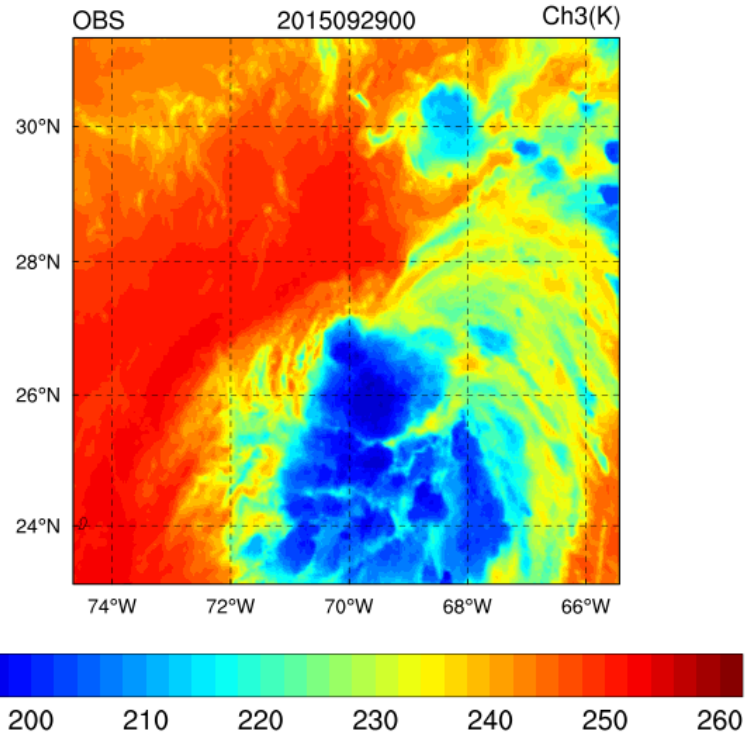

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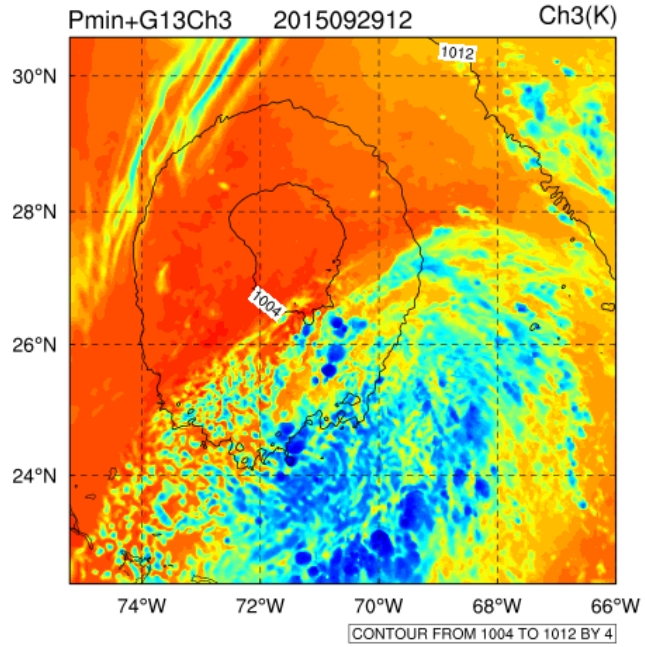

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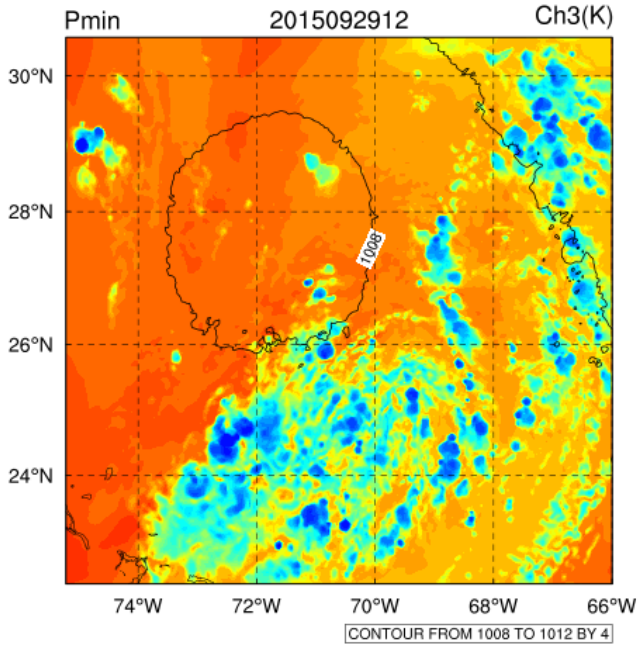

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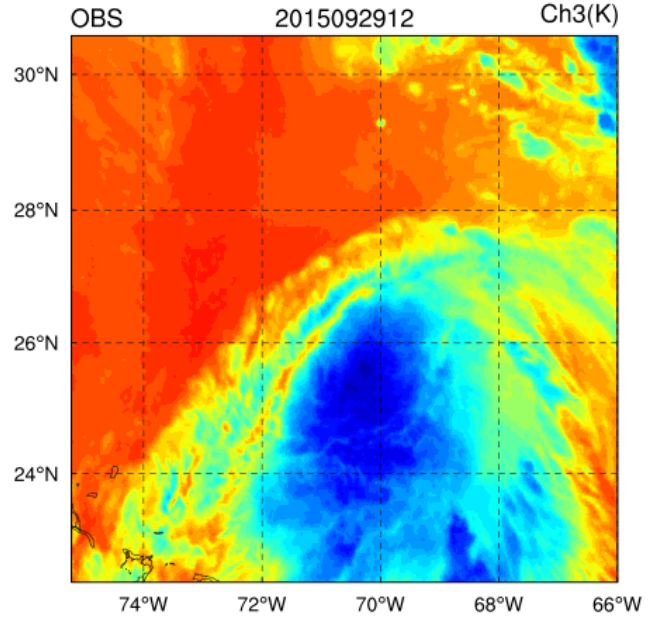

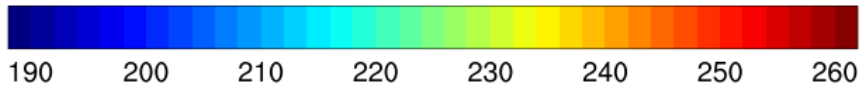

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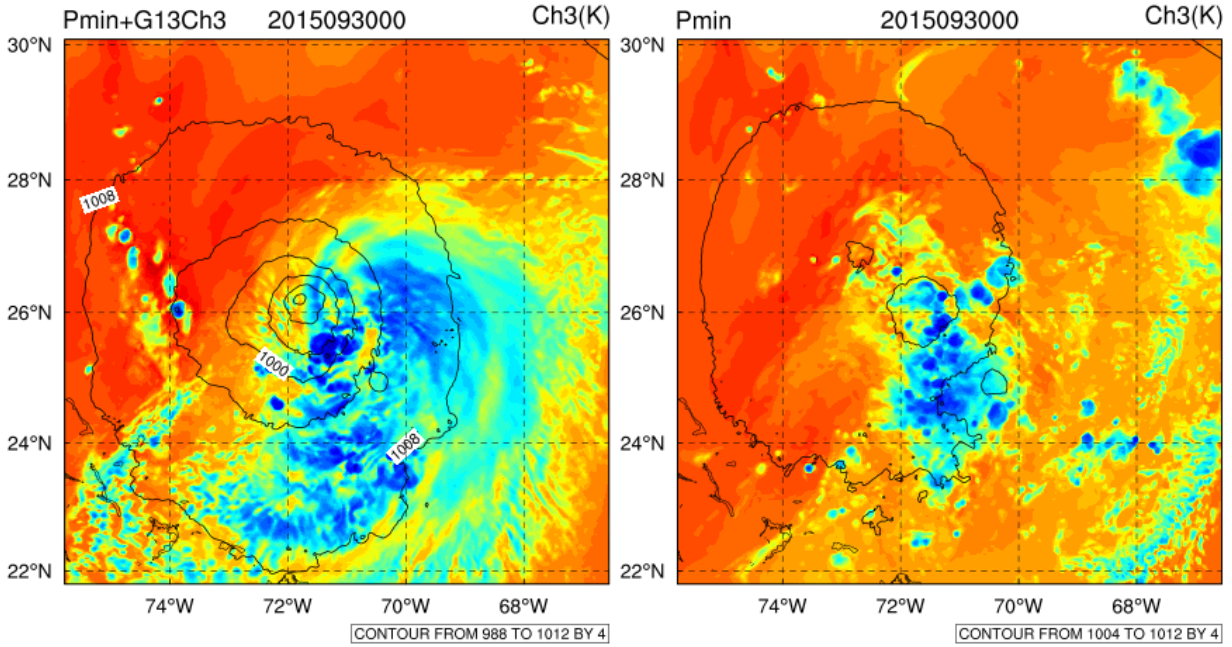

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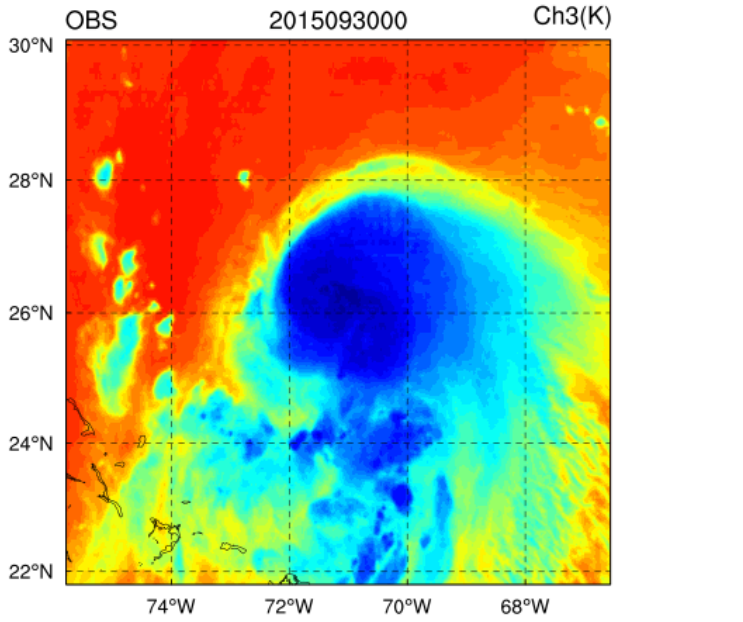

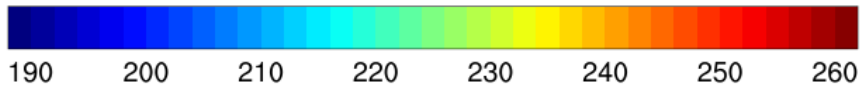

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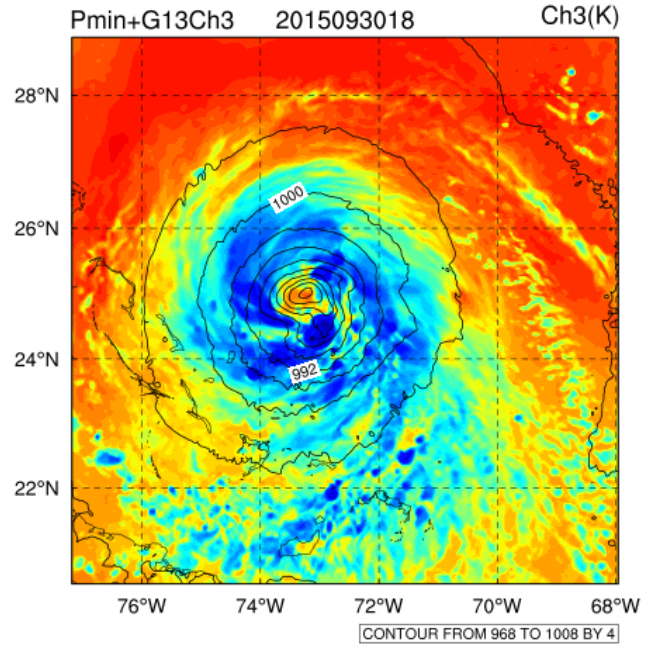

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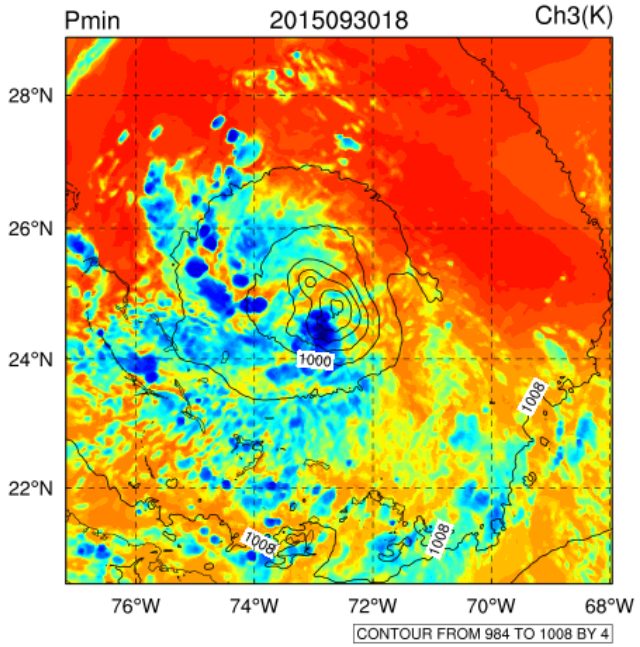

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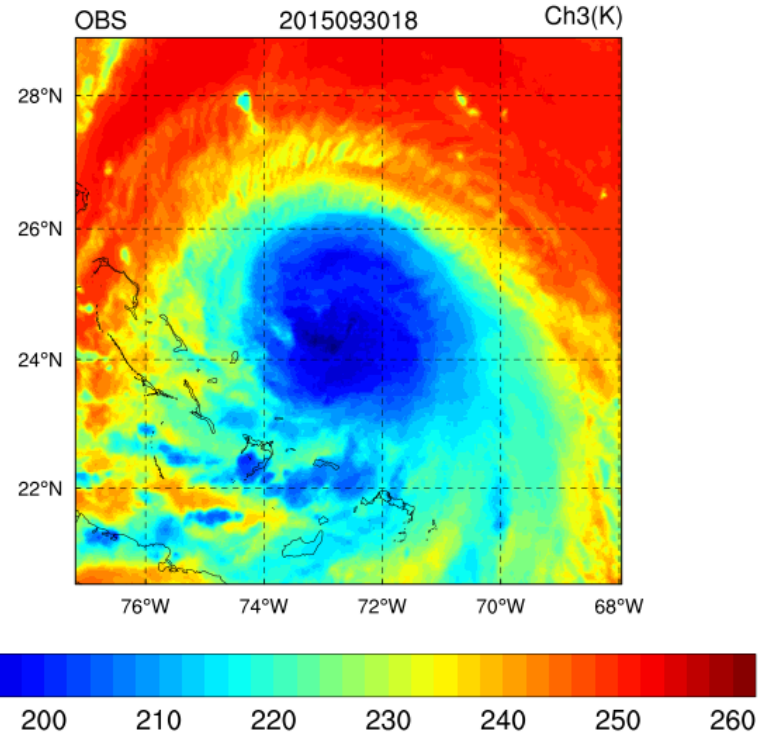

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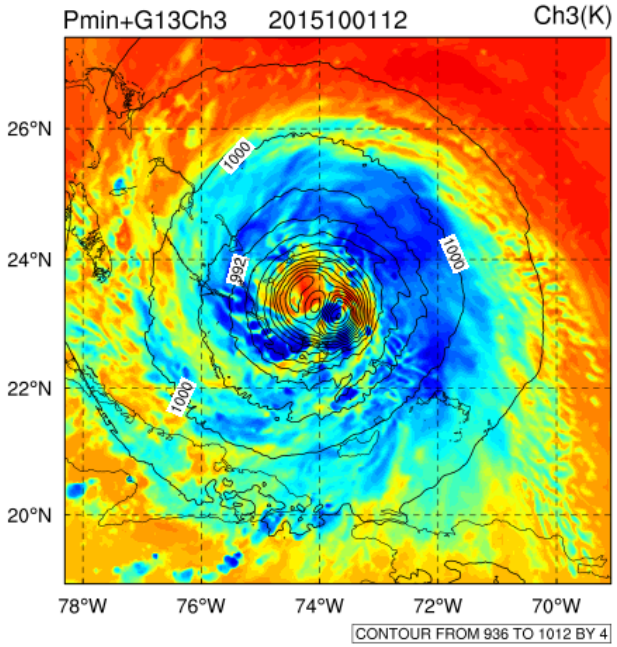

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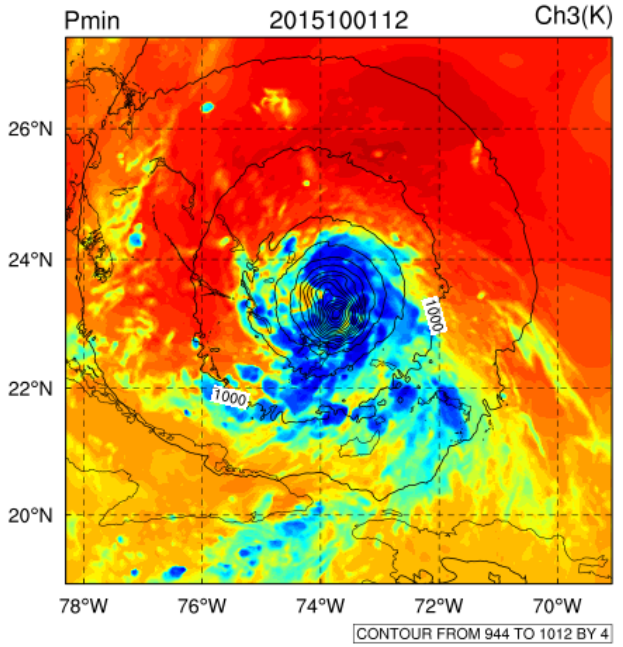

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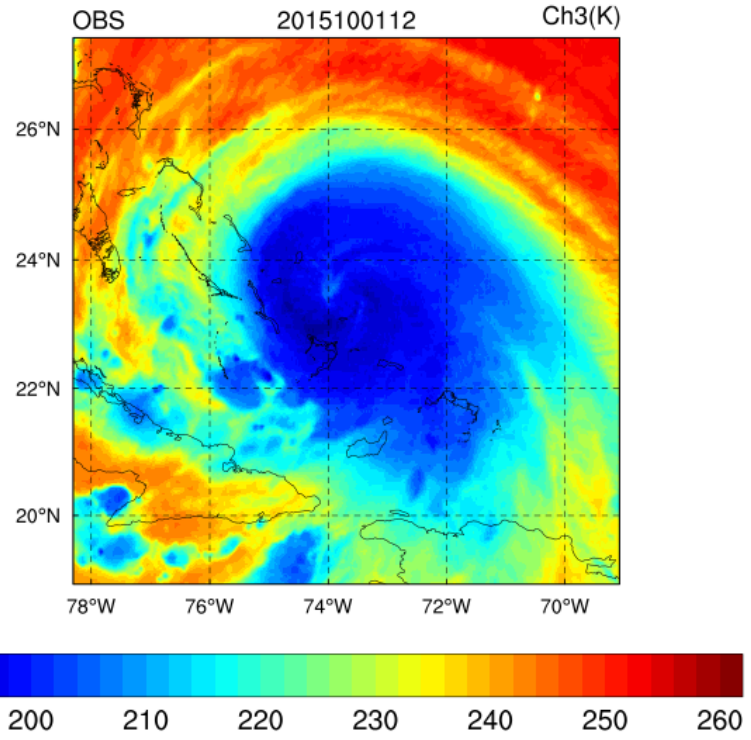

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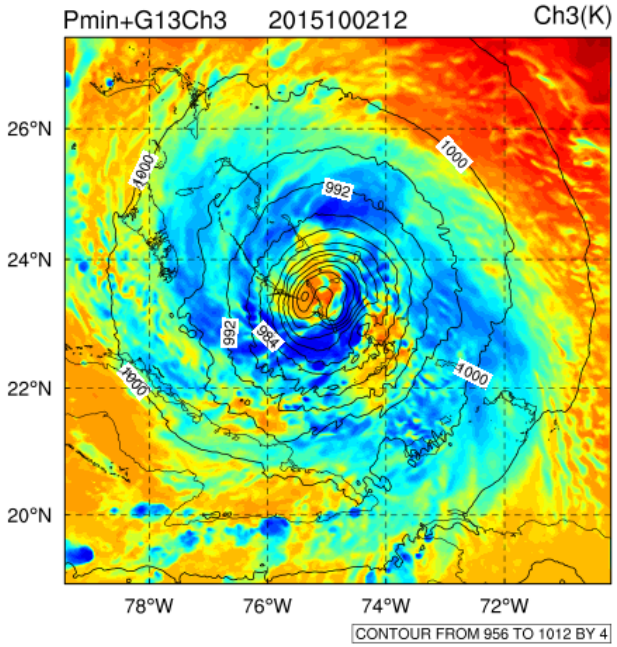

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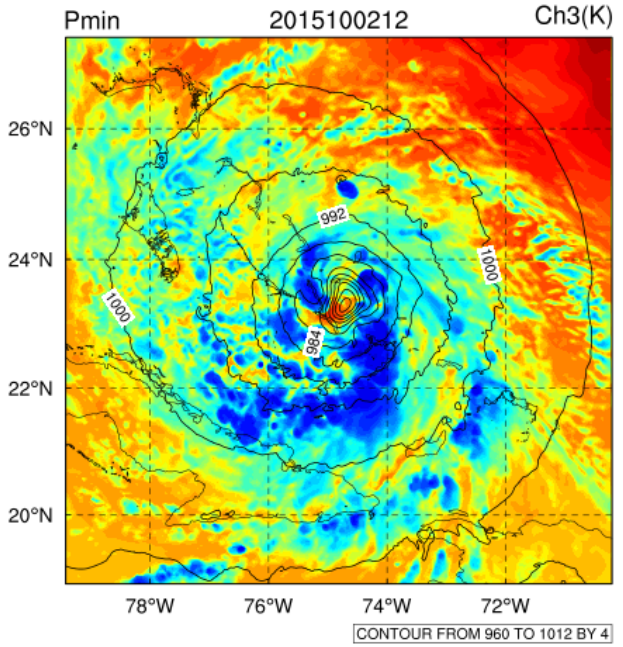

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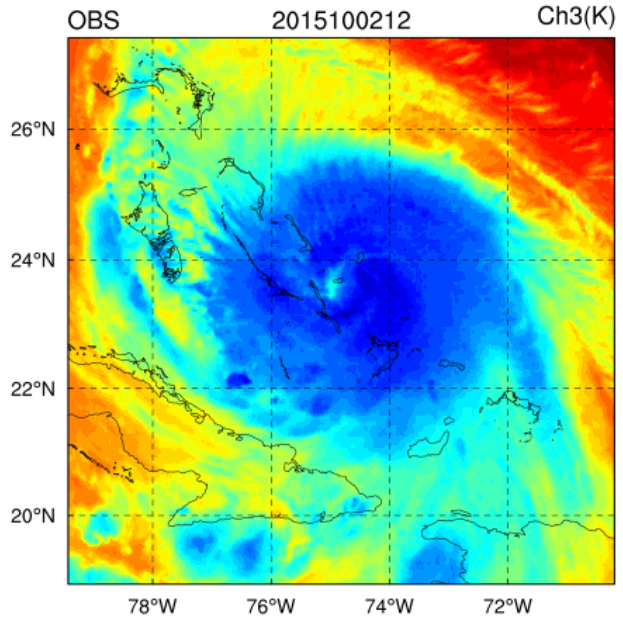

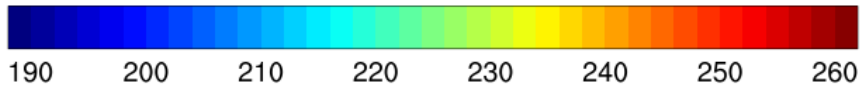

Simulation vs. CH4

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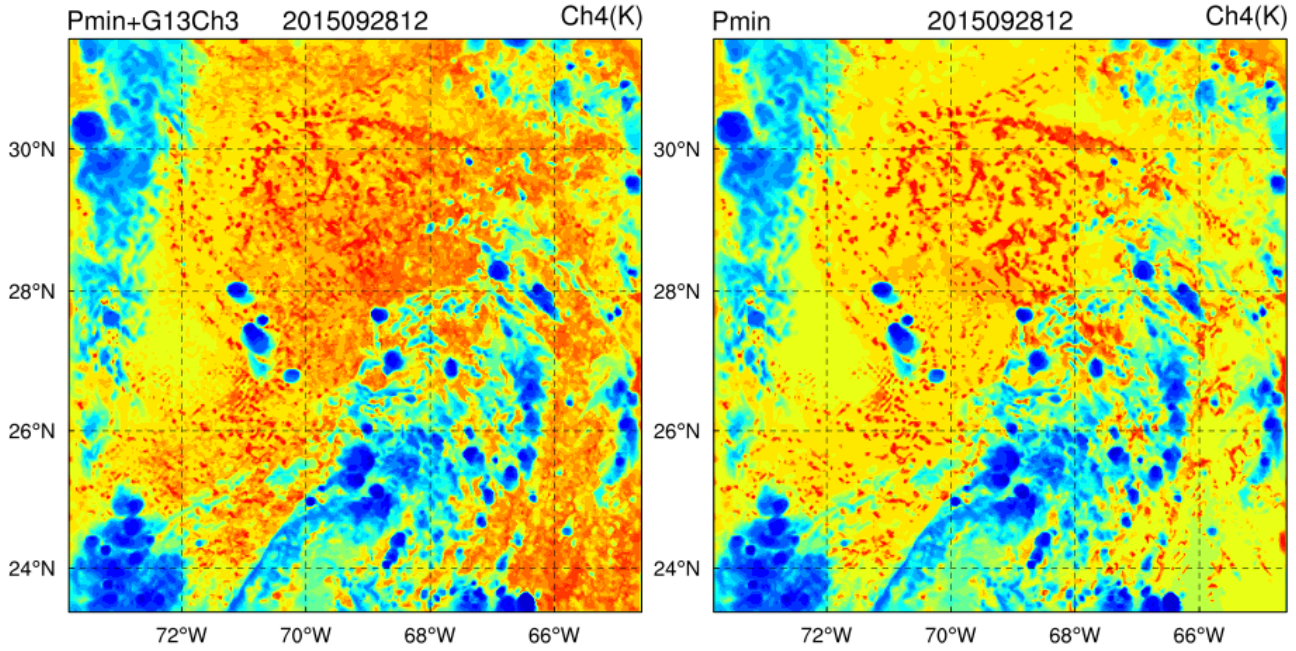

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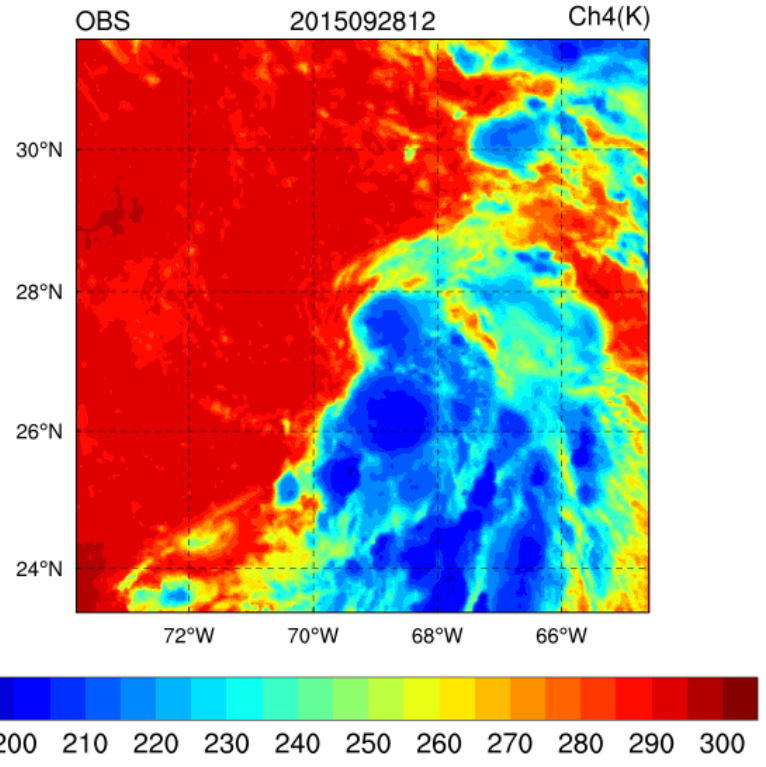

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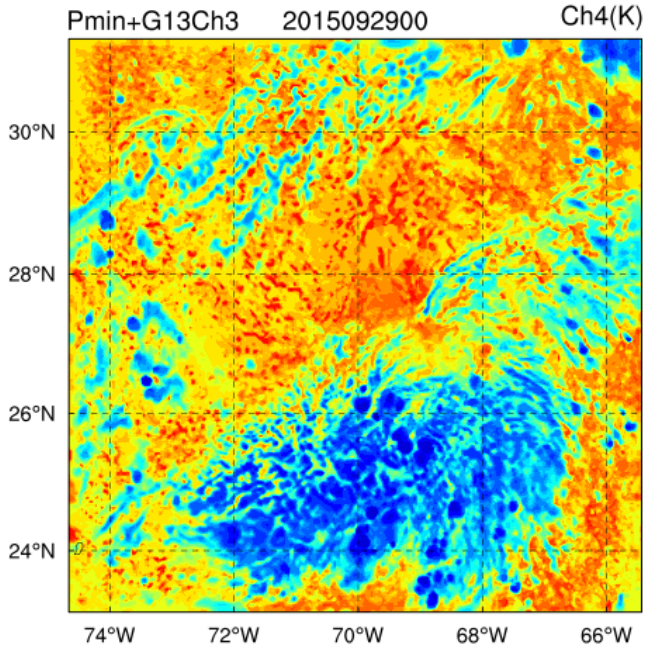

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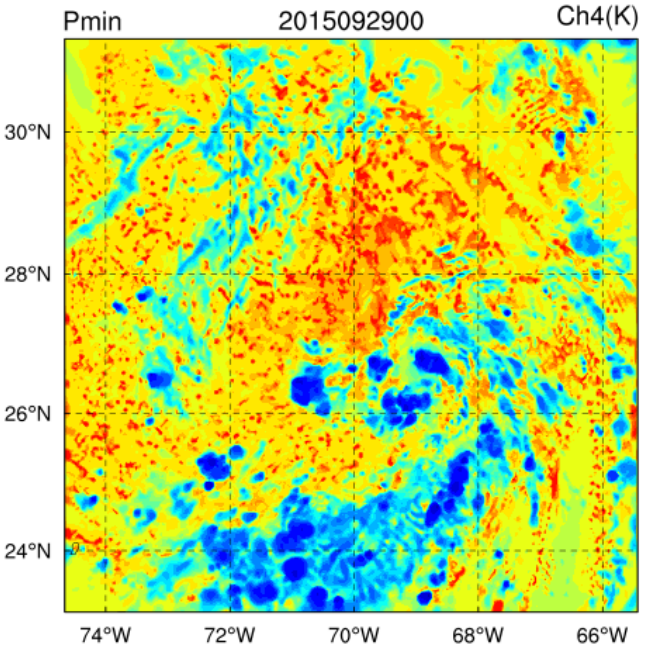

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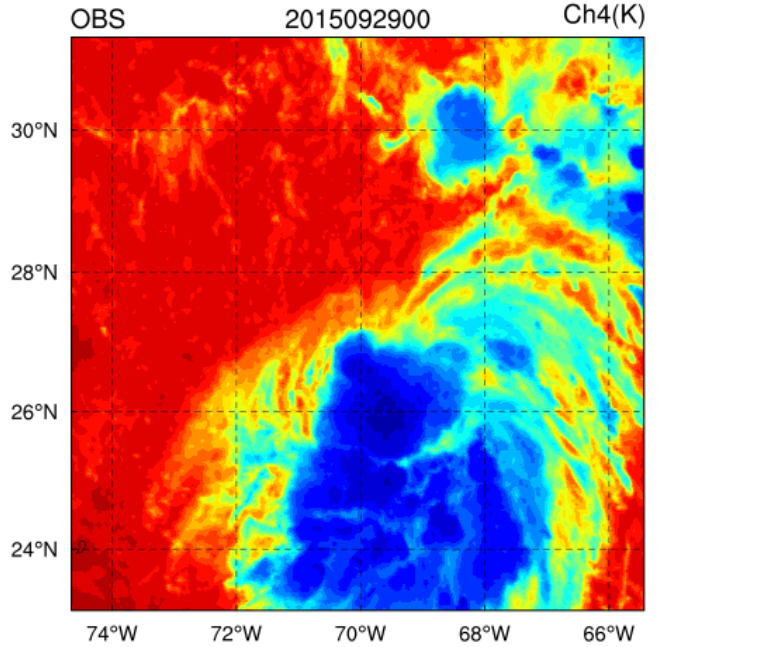

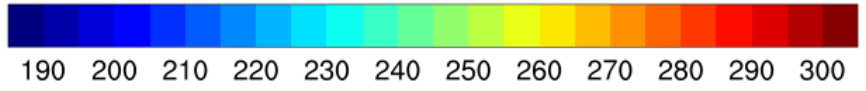

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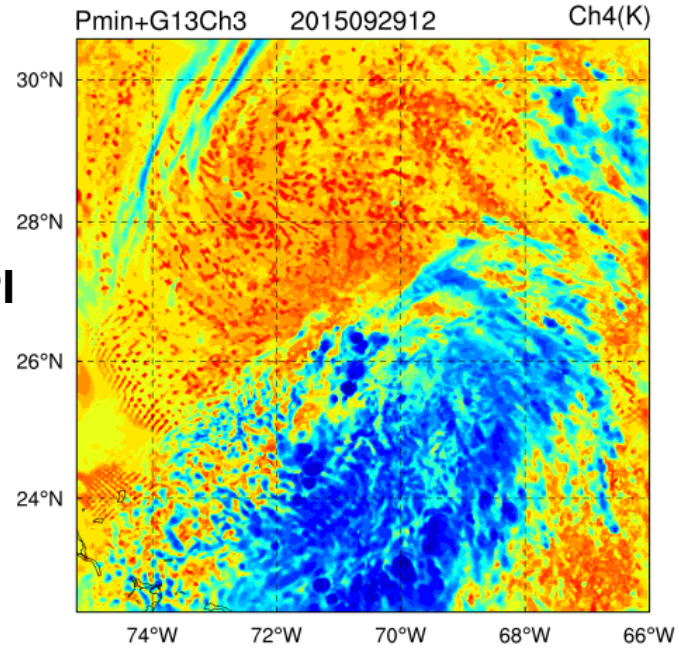

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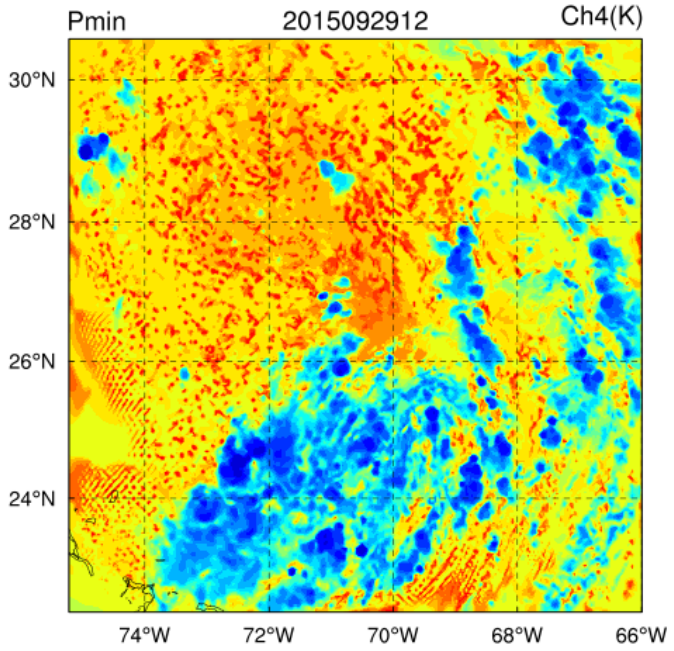

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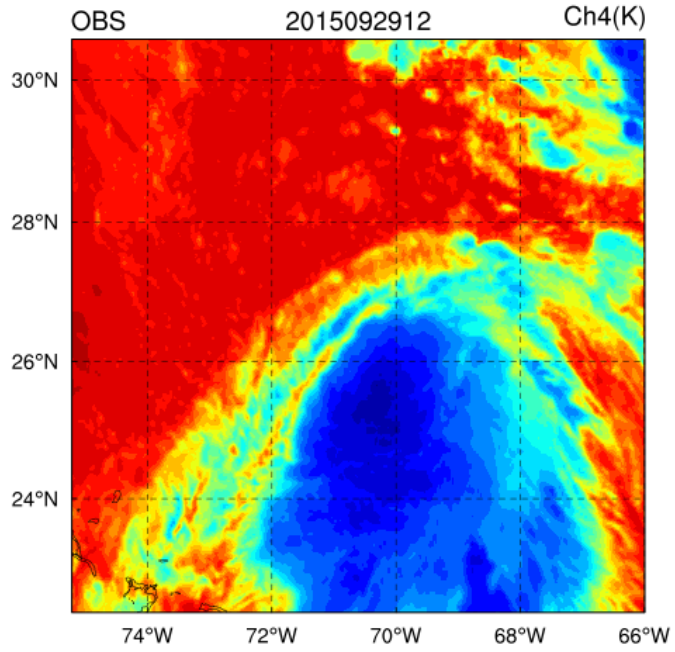

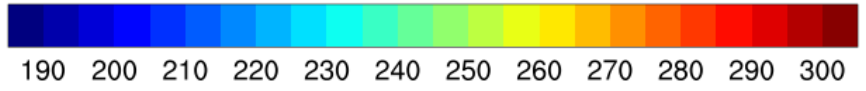

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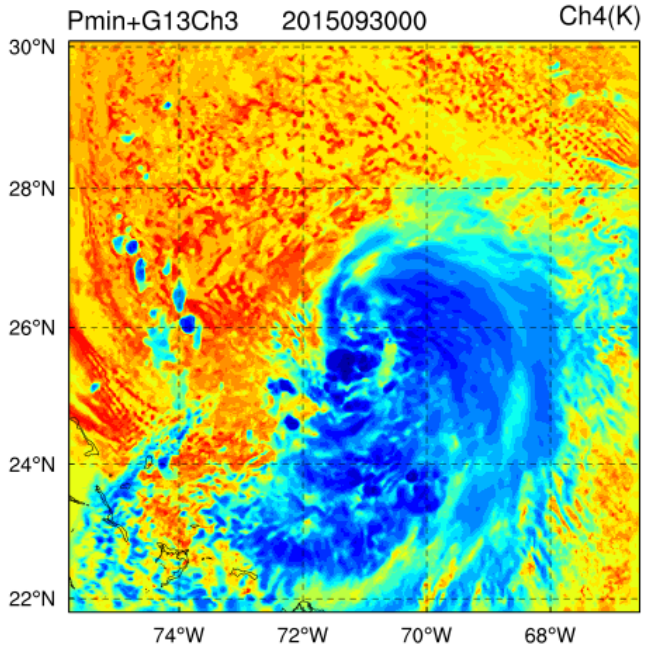

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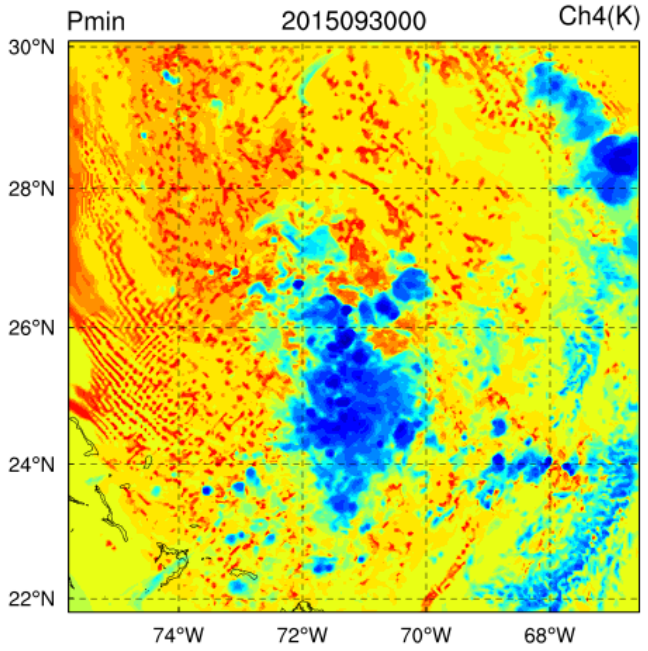

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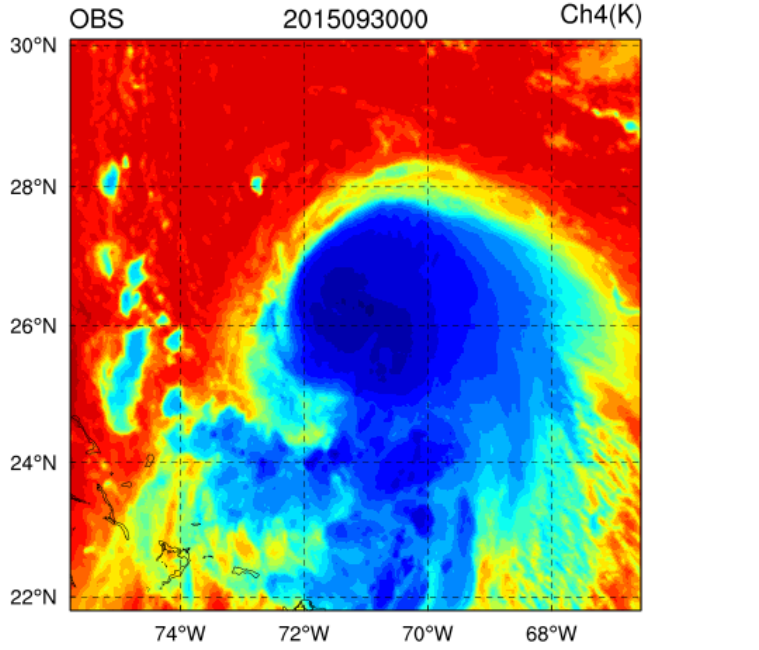

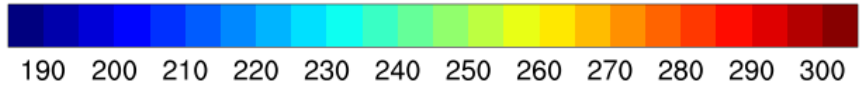

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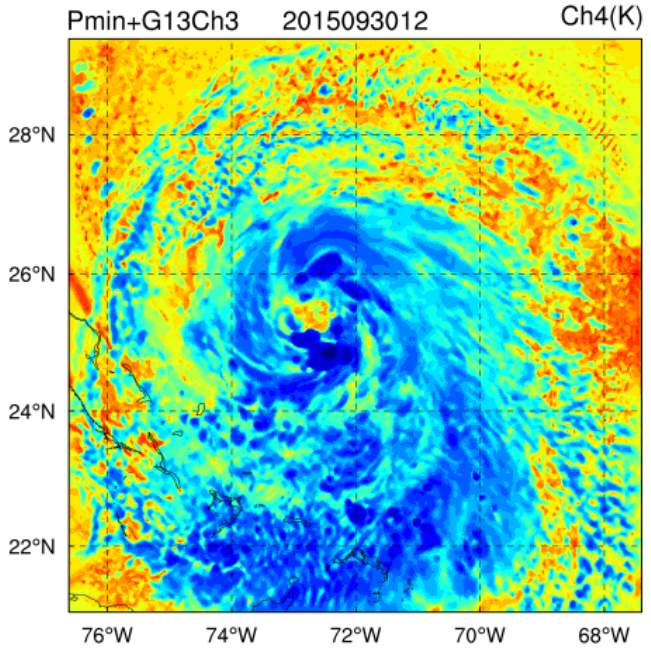

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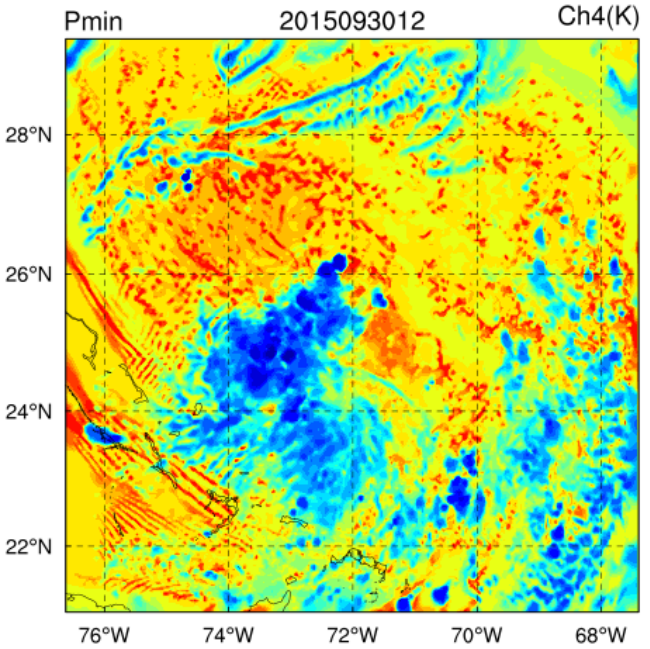

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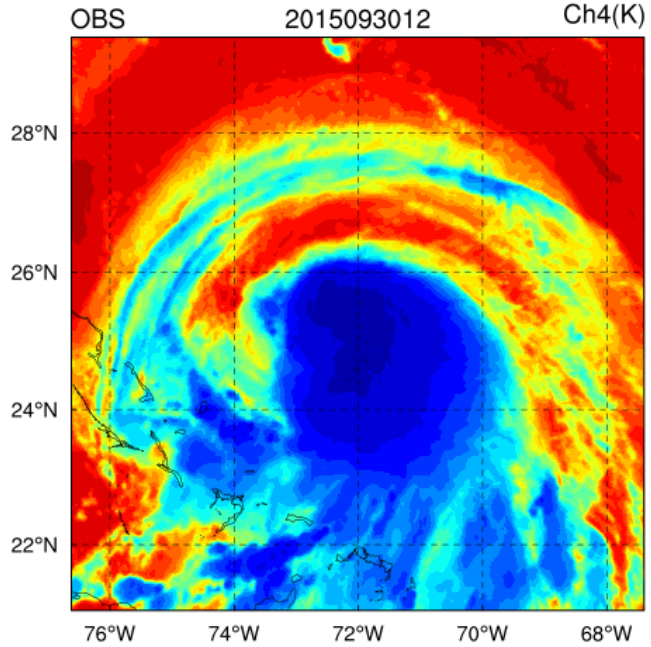

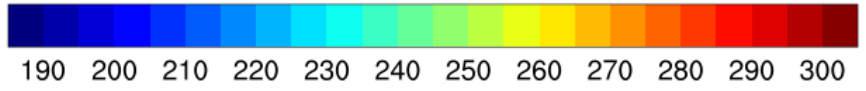

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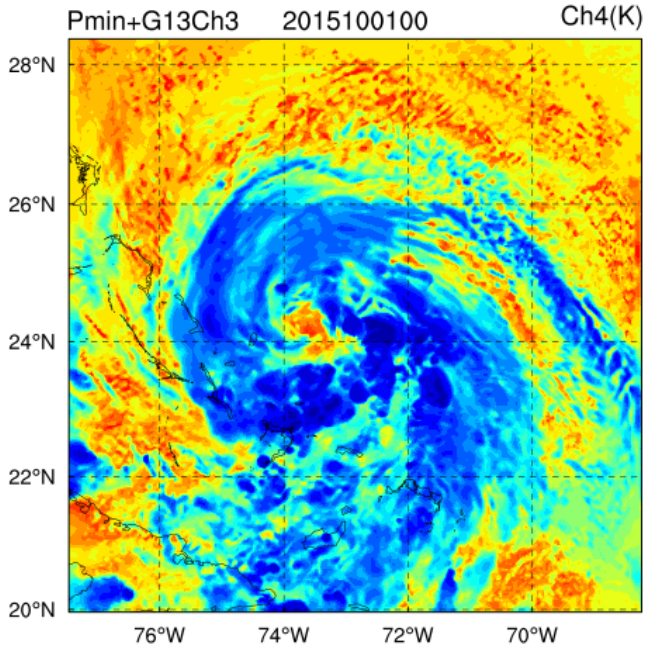

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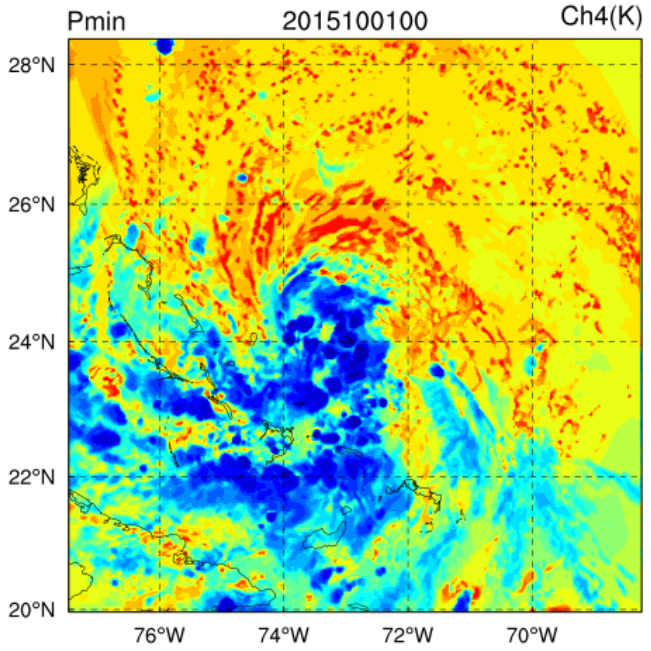

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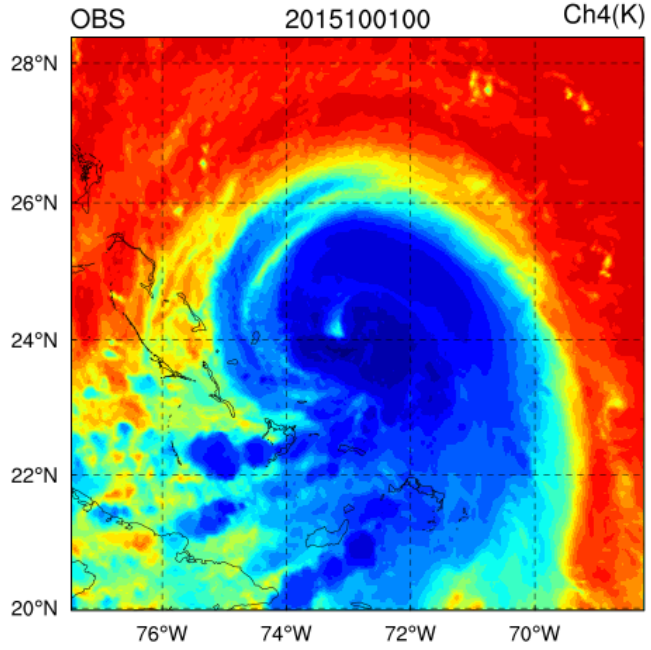

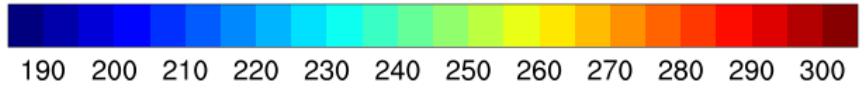

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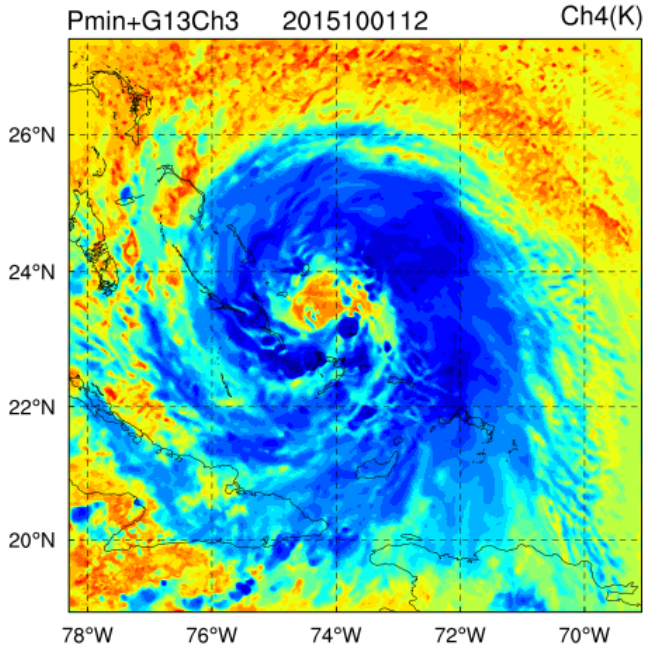

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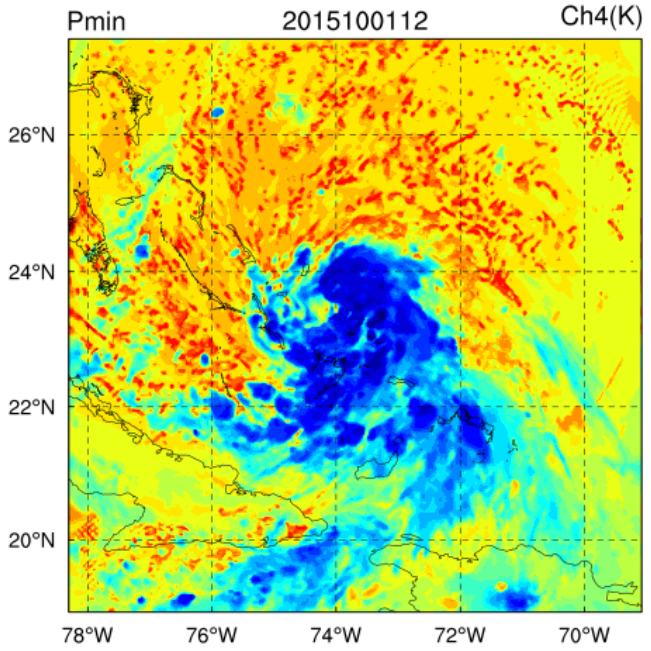

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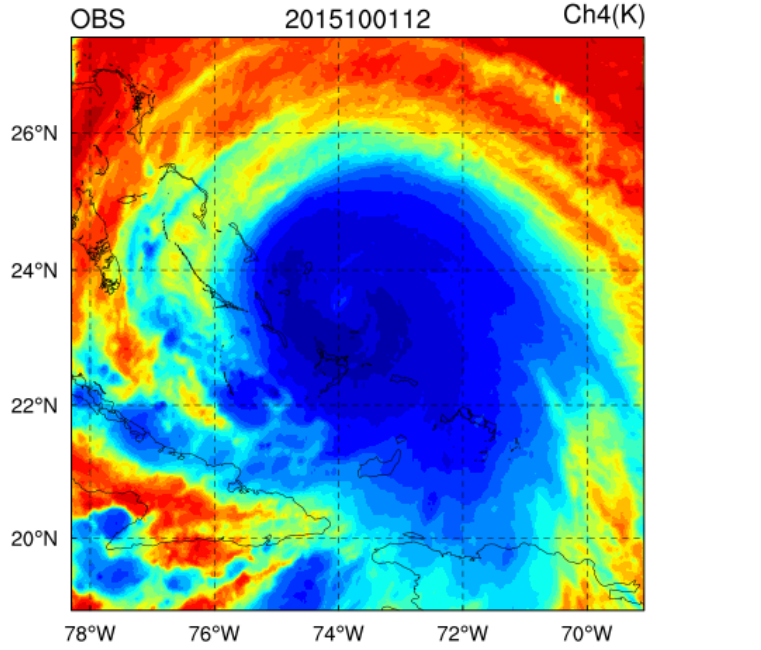
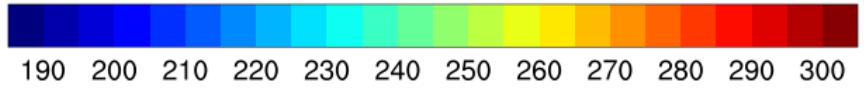
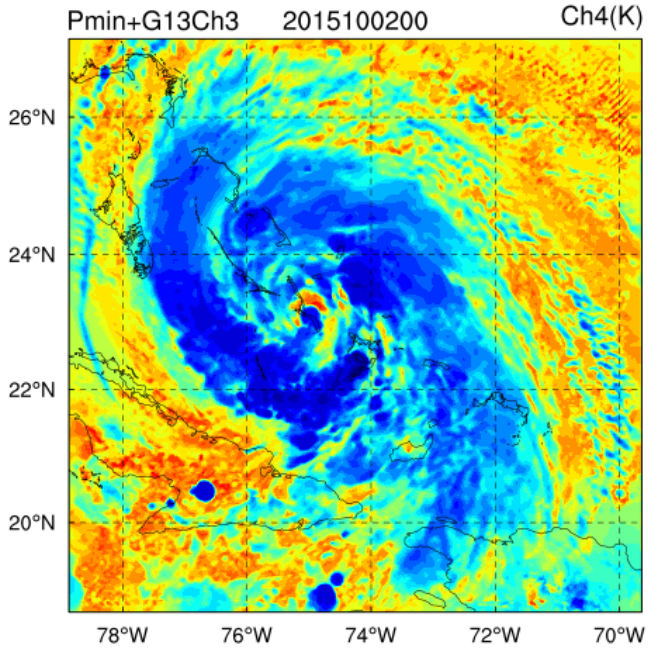


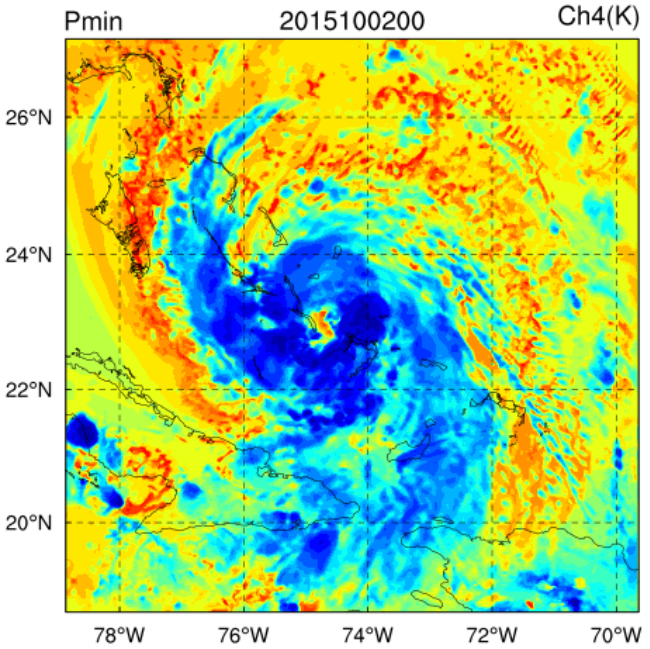


Simulation vs. CH4

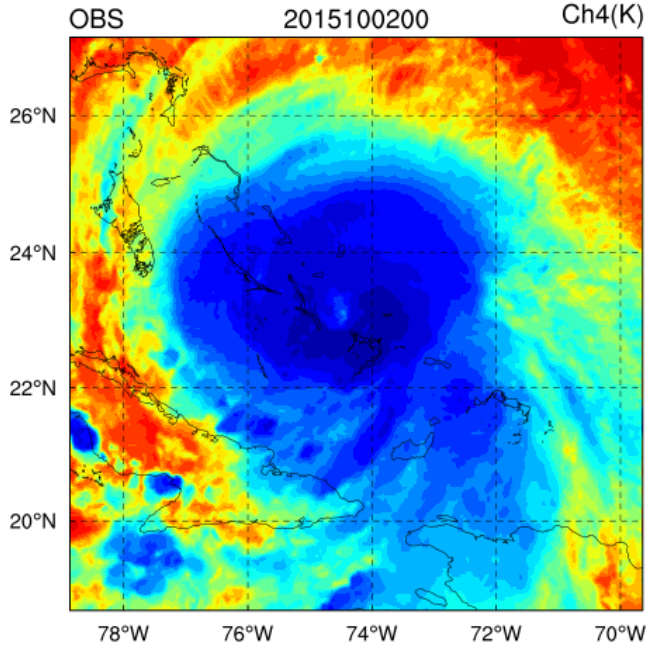
G13CH3+HPI

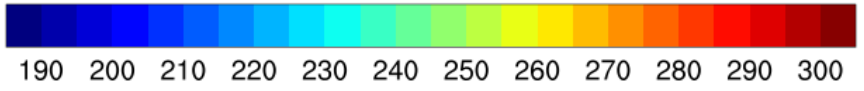


HPI



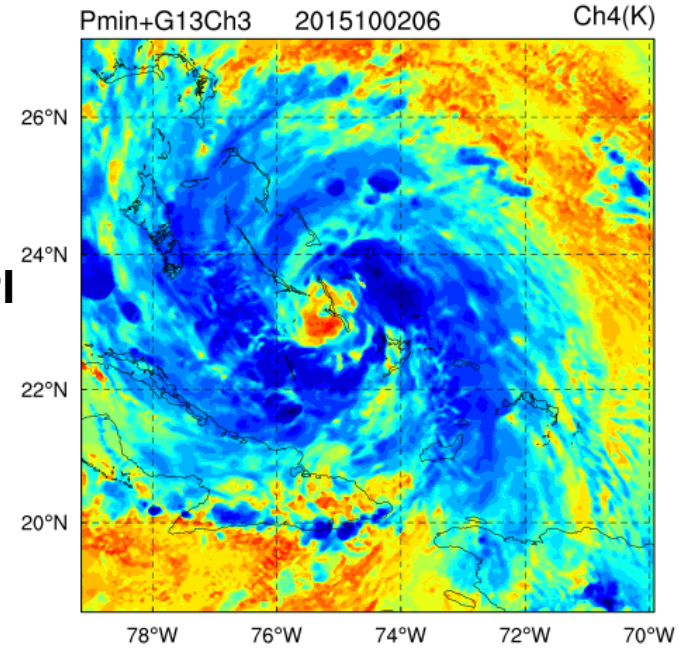
OBS_CH4



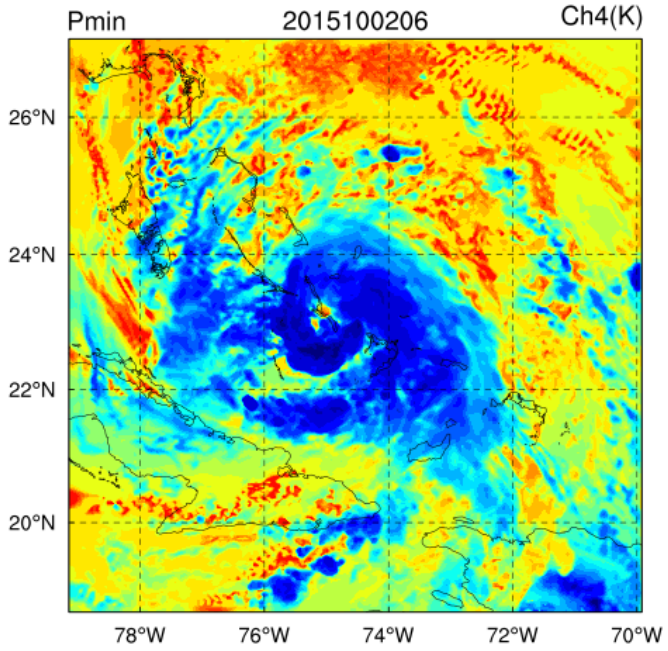


Simulation vs. CH4

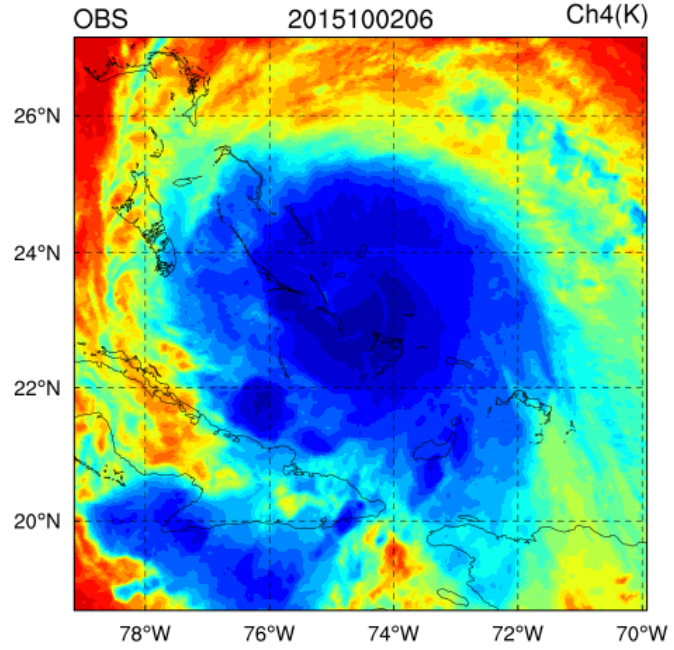
G13CH3+HPI

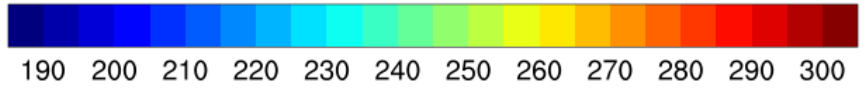


HPI

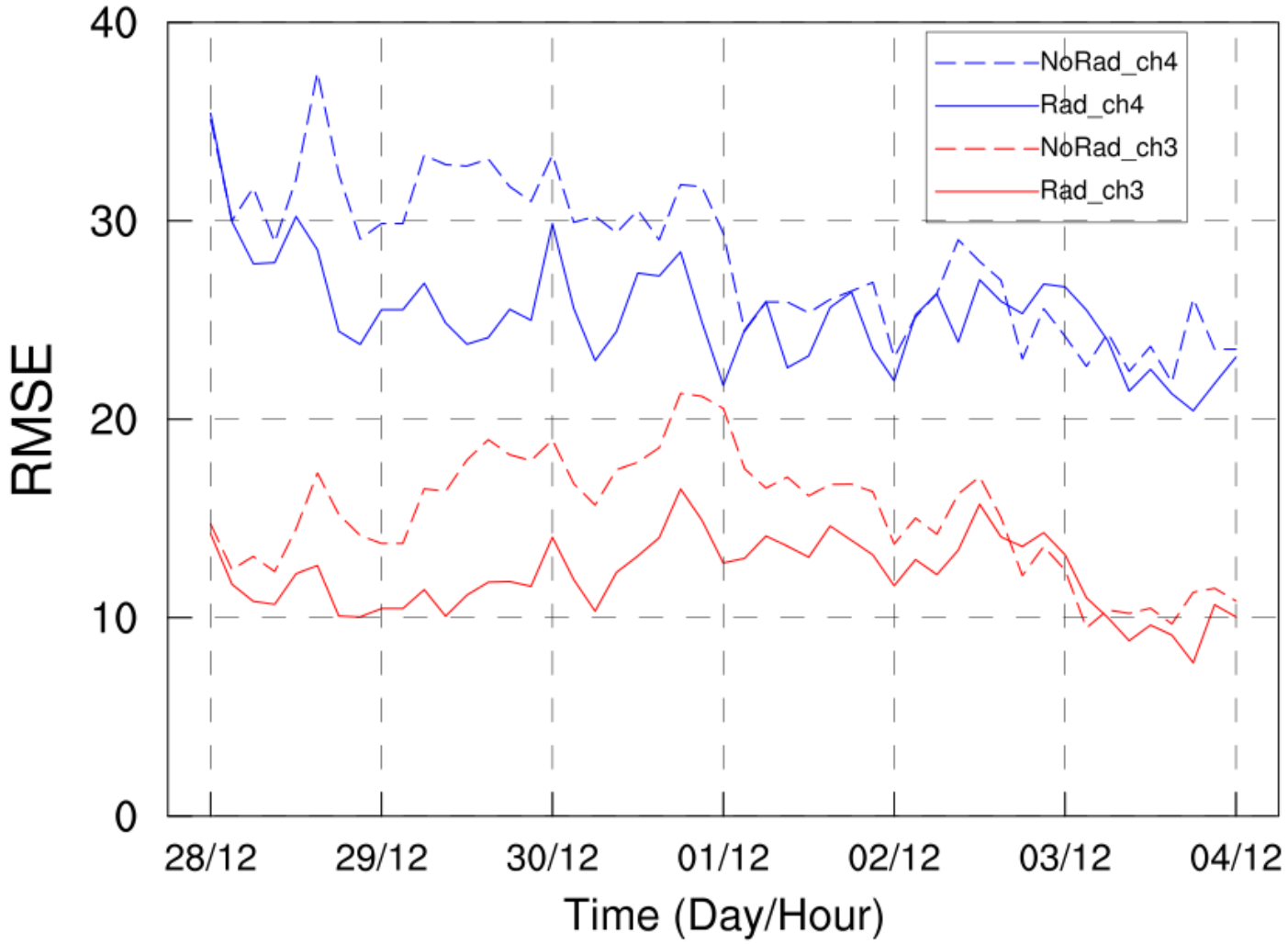


OBS_CH4



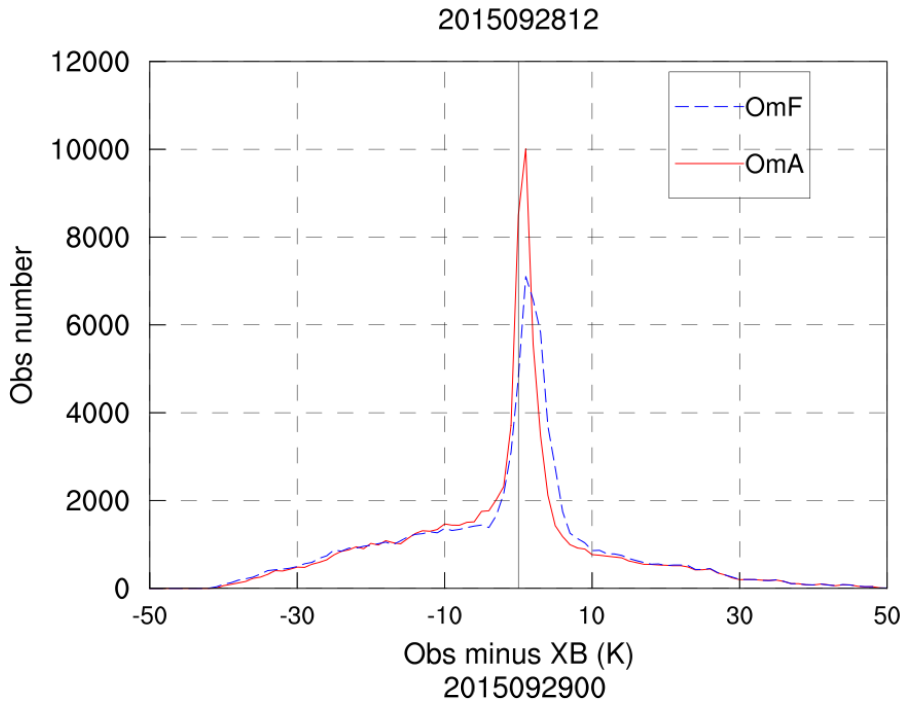


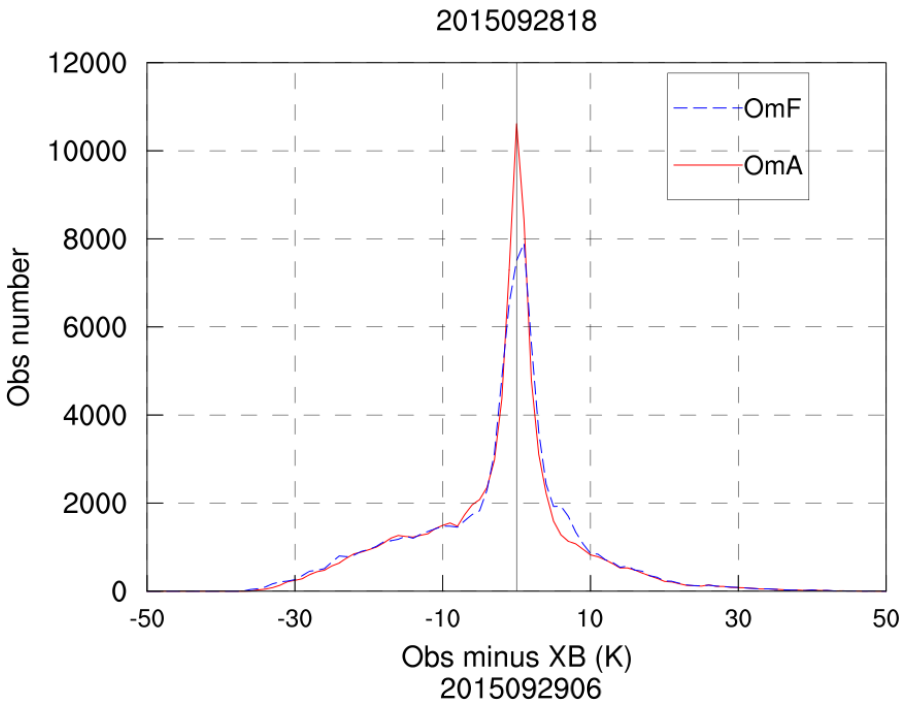
RMSE averaged over D03 with channel 3 and 4

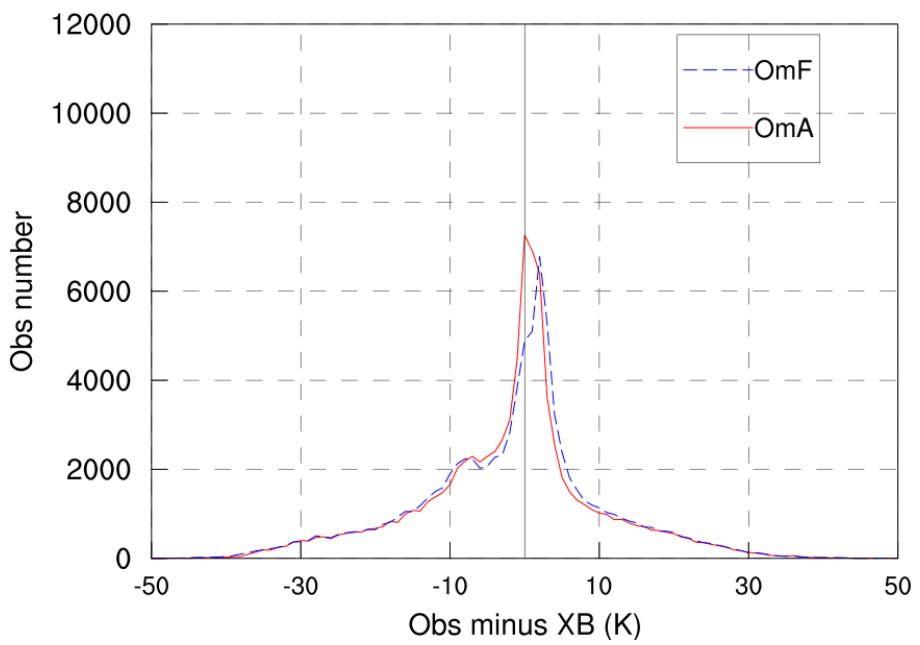


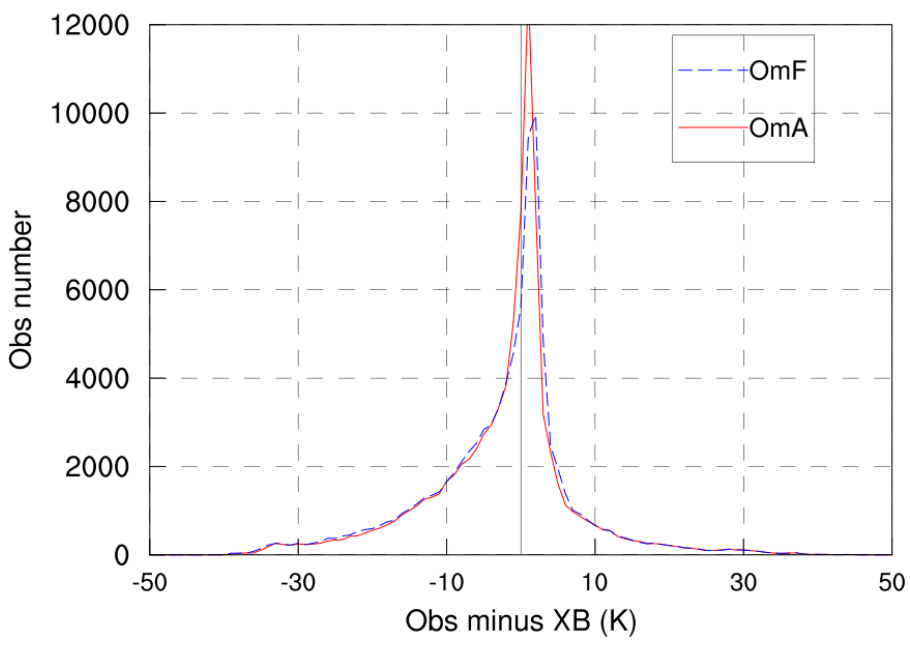
OmF means observation minus prior; OmA means observation minus posterior.

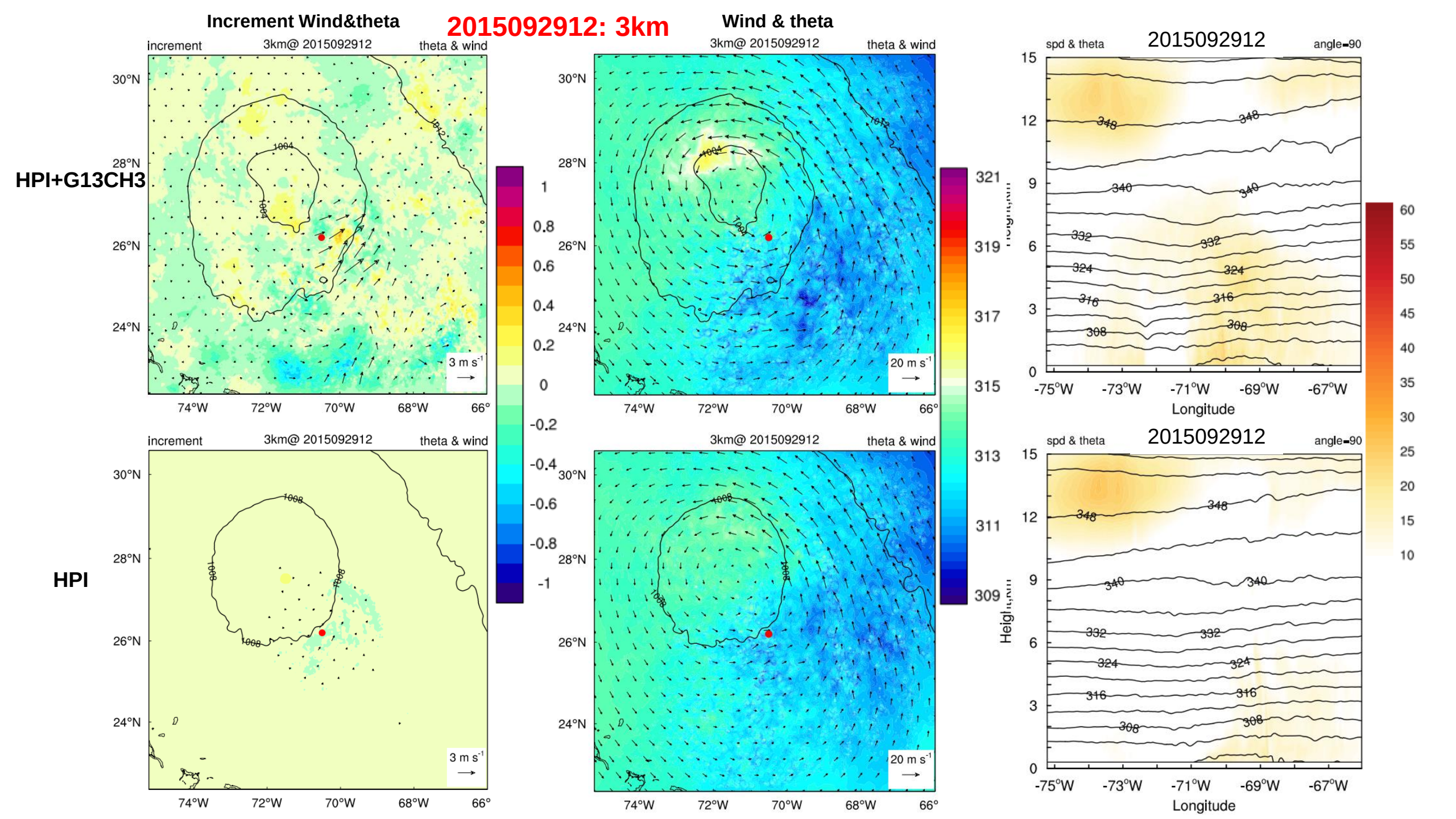
Only for experiment HPI+G13CH3







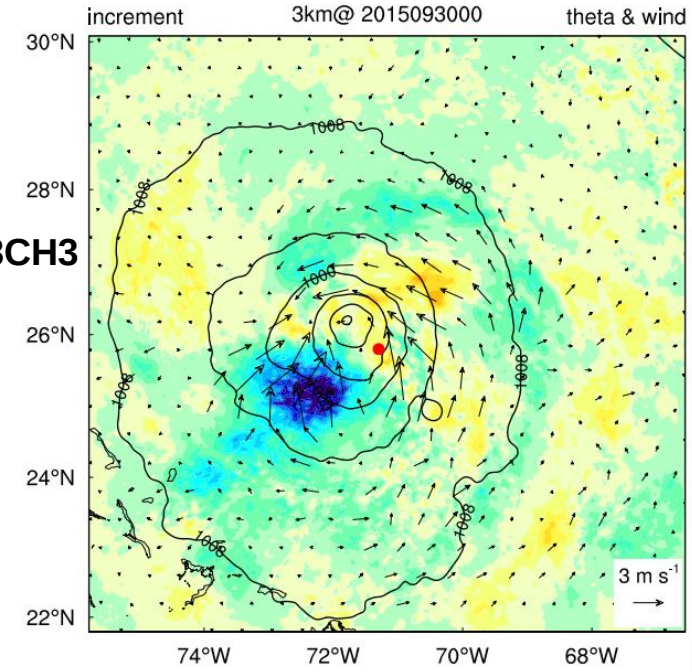


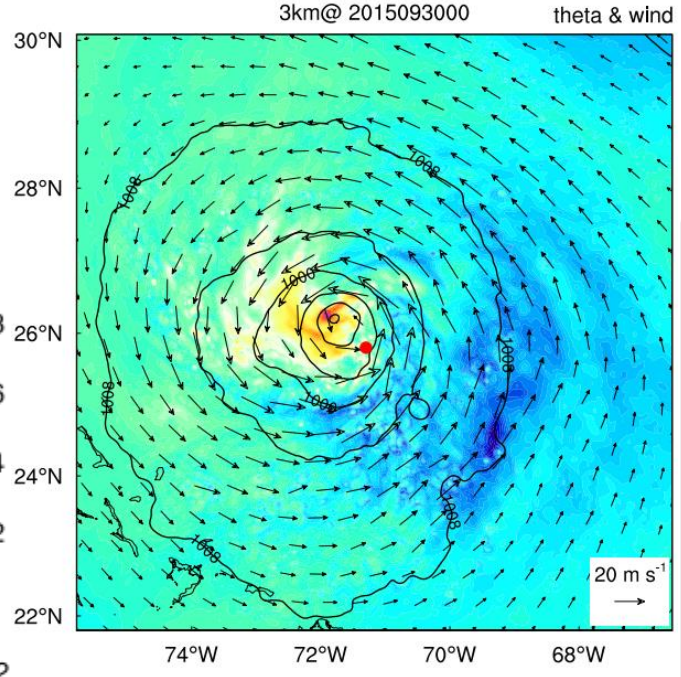

Increment Wind&theta
2015092912: 3km
Wind & theta
HPI+G13CH3
HPI
increment
3km@ 2015092912
theta & wind
spd & theta
angle=90
2015092912
3 m s-1
20 m s-1
30°N
28°N
26°N
24°N
74°W
72°W
70°W
68°W
66°
-75°W
-73°W
-71°W
-69°W
-67°W
Longitude
Height,hPa

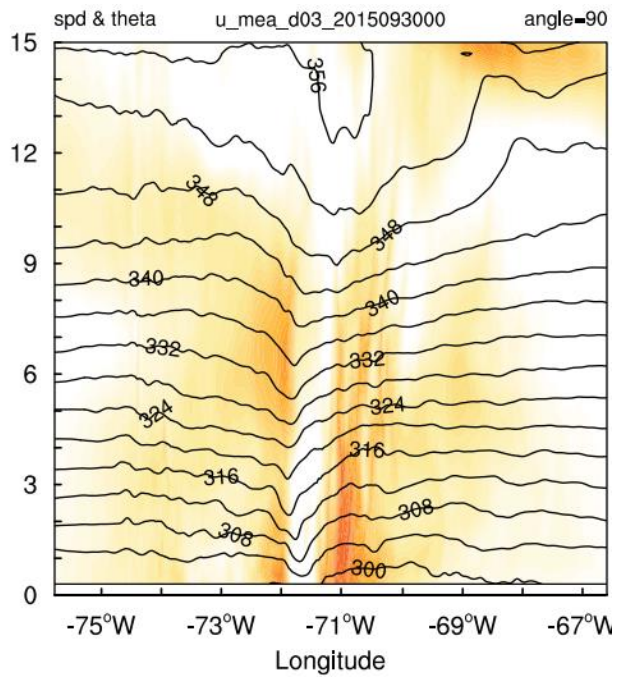
2015093000: 3km

Increment Wind&theta | **Wind & theta**

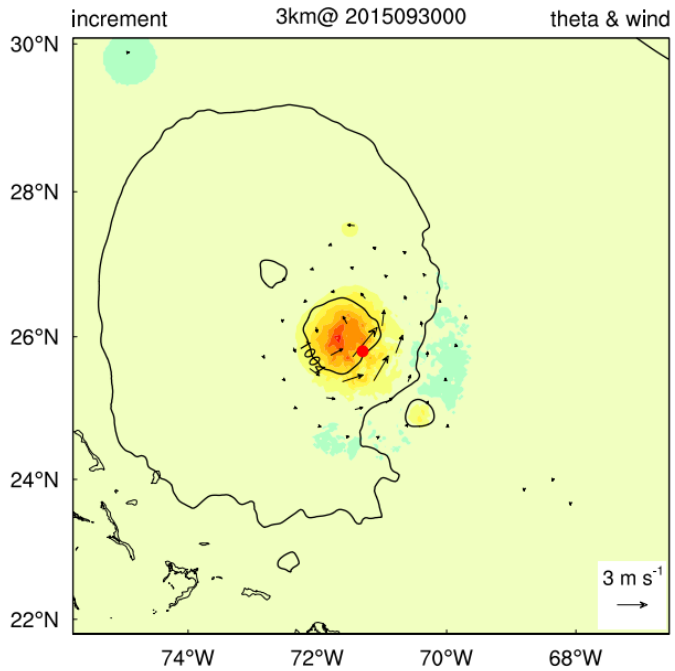
HPI+G13CH3

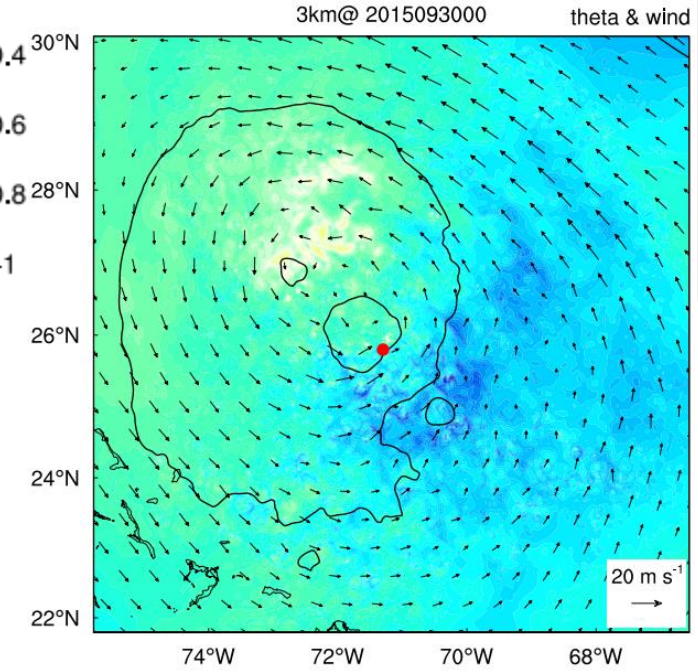


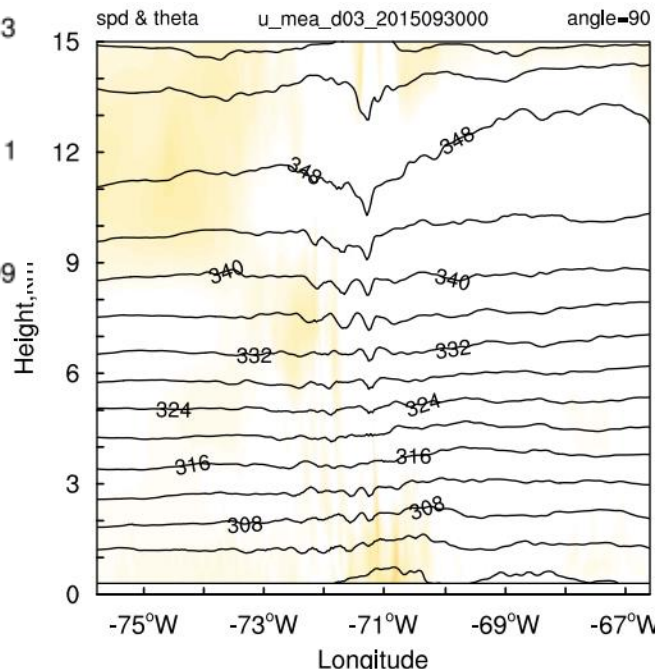




HPI







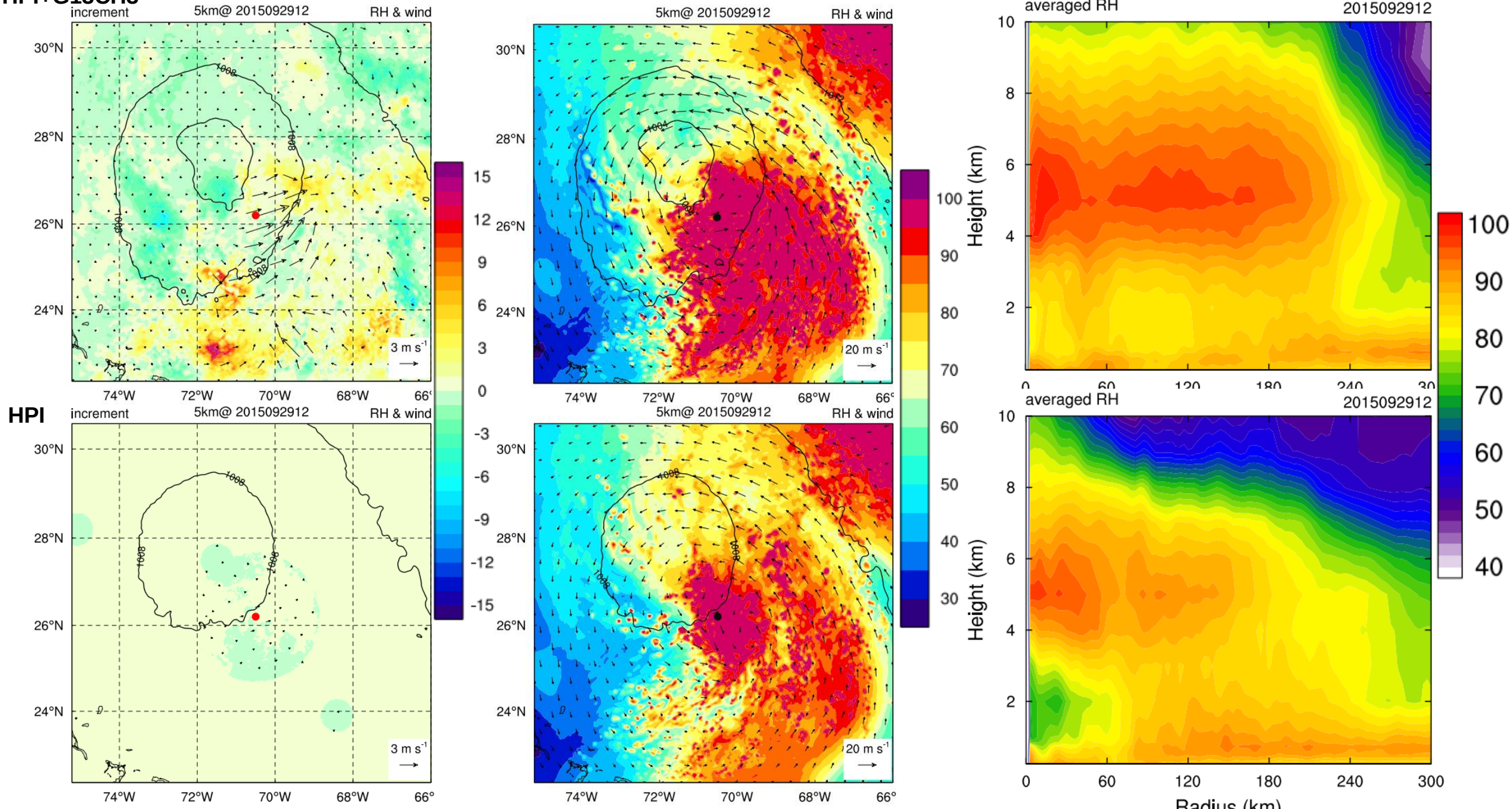
HPI+G13CH3

Increment RH&Wind

2015092912: 5km

Relative humidity&Wind

Azimuthally averaged RH



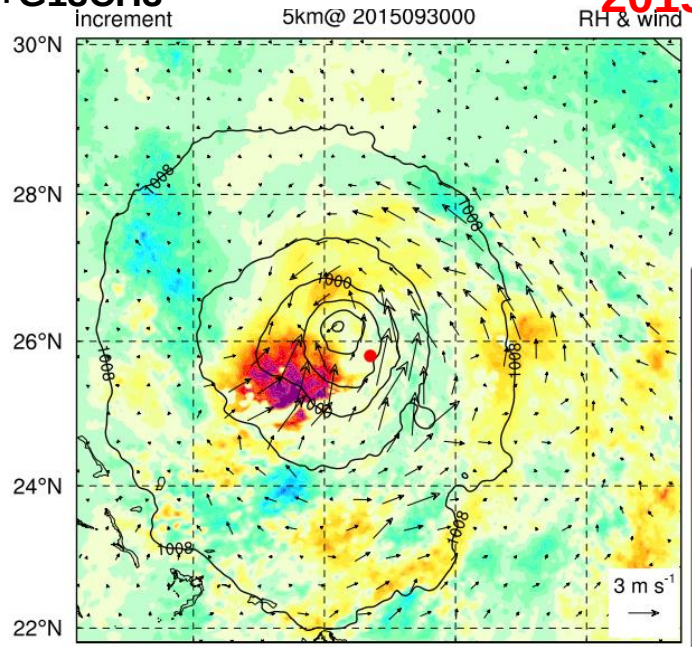
HPI+G13CH3

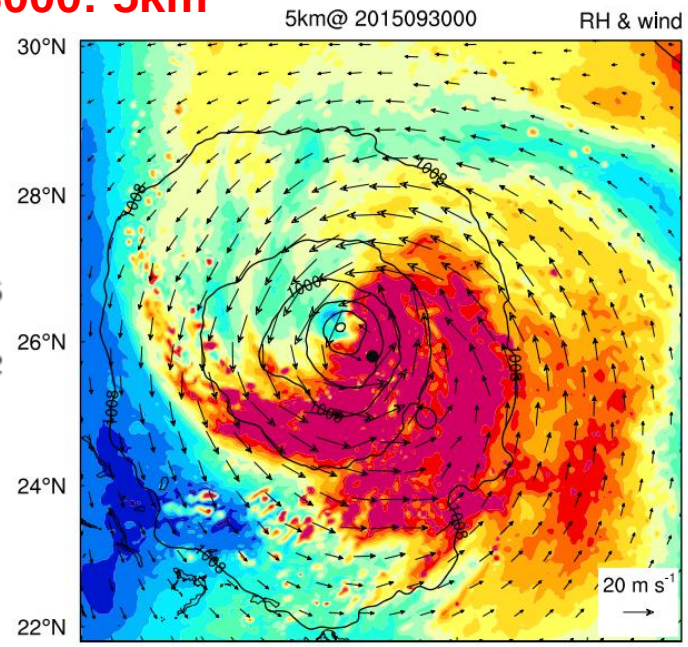
Increment RH&Wind

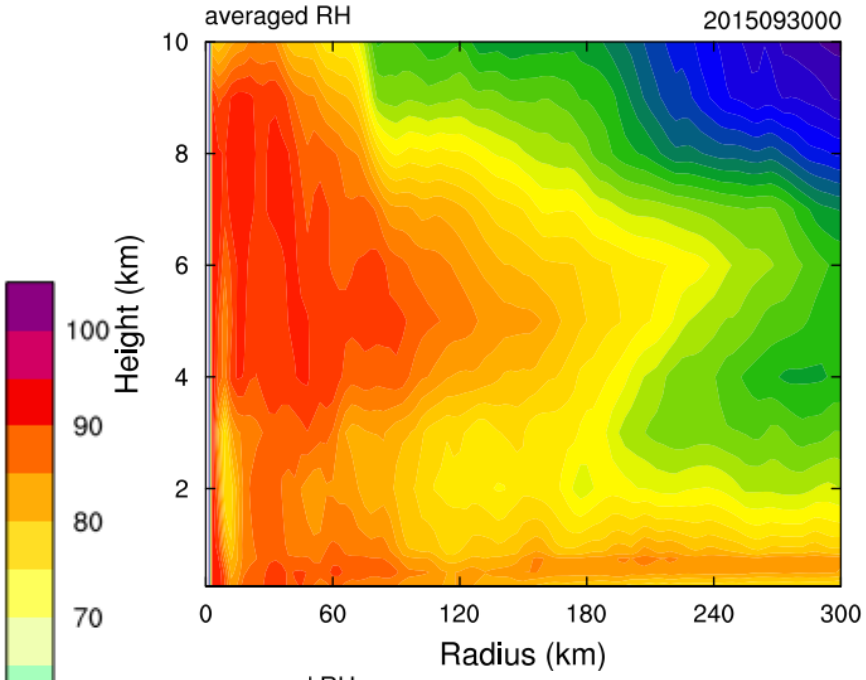
2015093000: 5km

Relative humidity&Wind

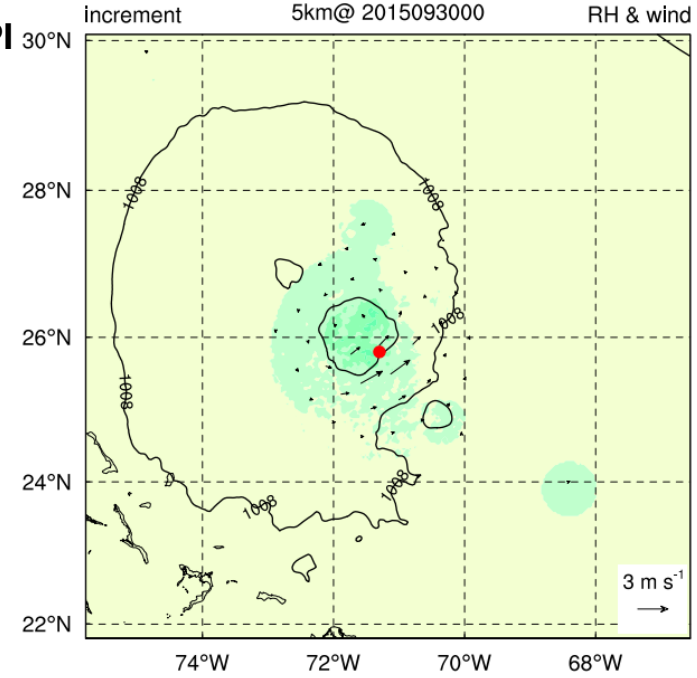
Azimuthally averaged RH

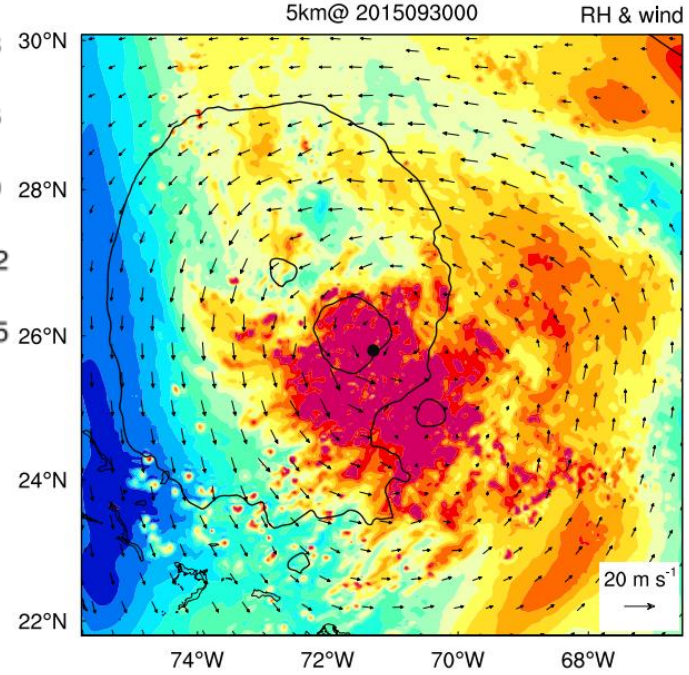


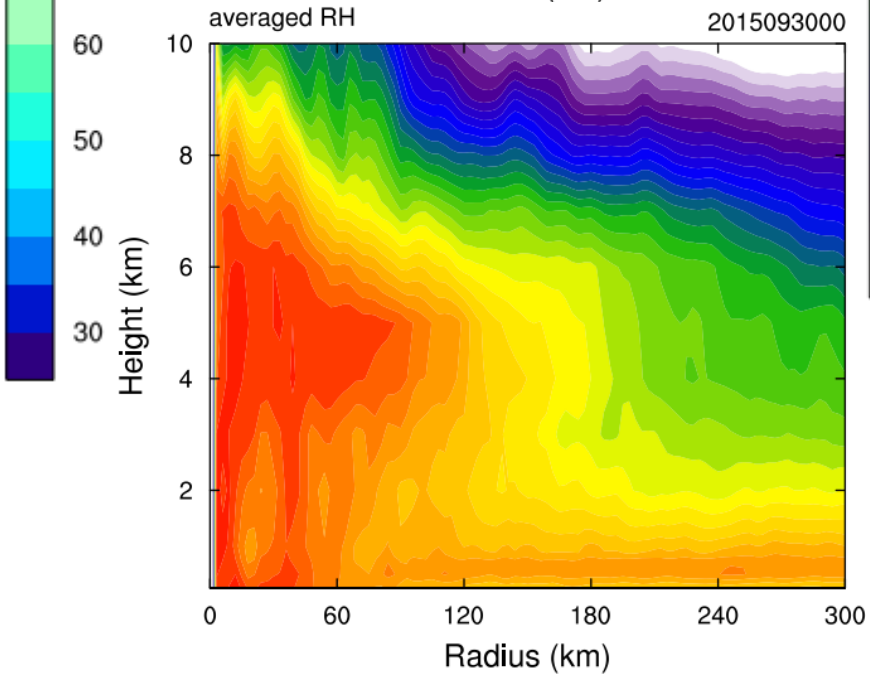


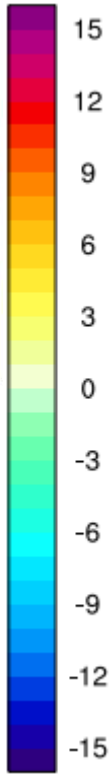


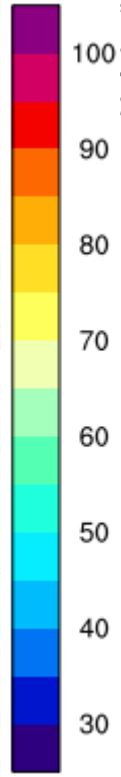
HPI

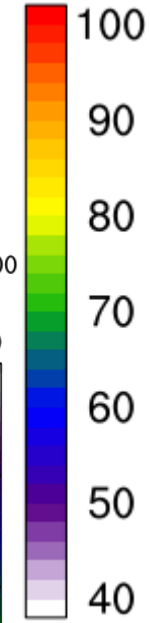




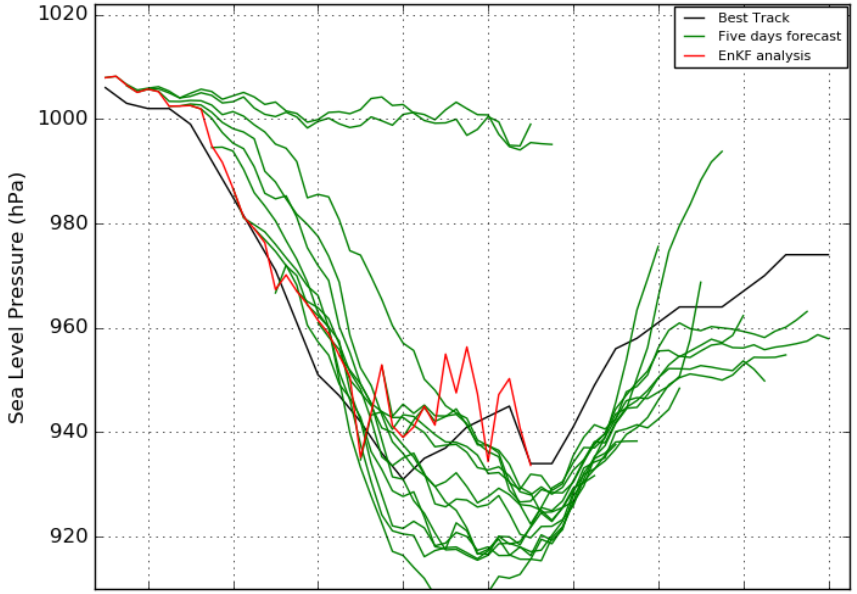


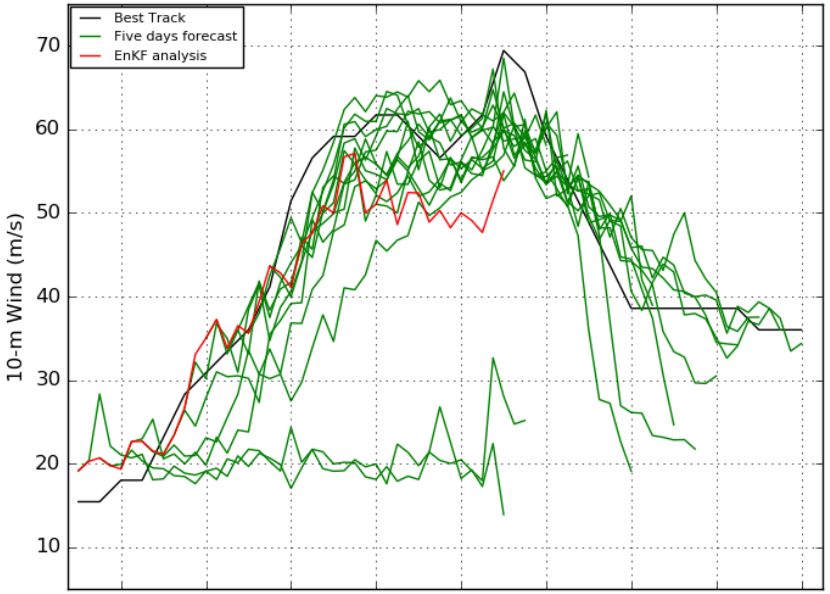




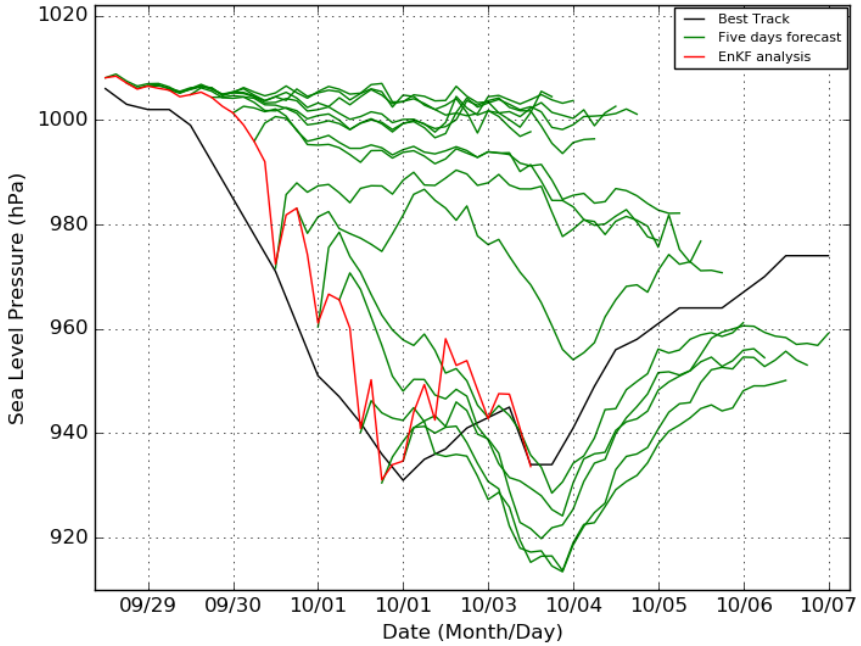


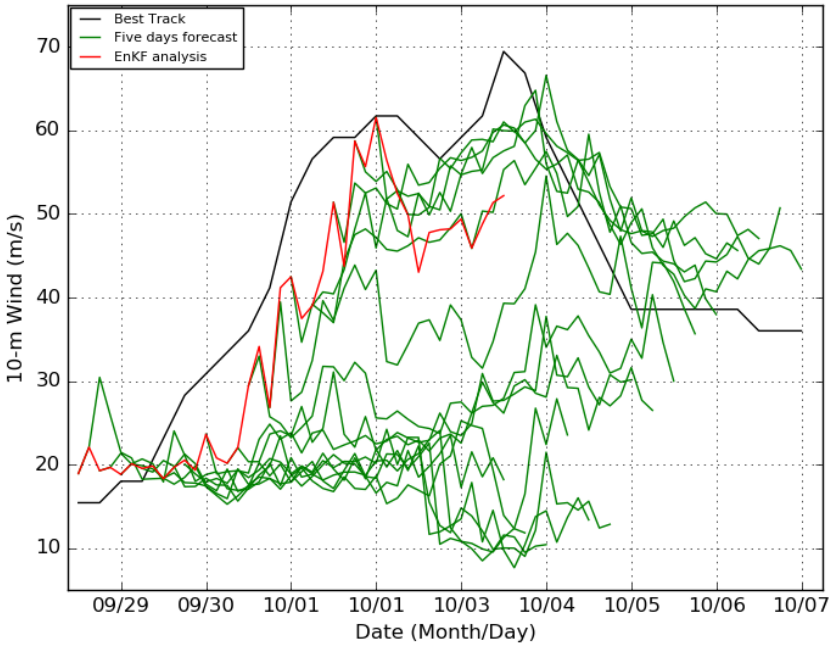
HPI + G13CH3





HPI





Conclusion

- ✓ Radiance data is able to improve the inner core structure of hurricanes and obtain a more realistic hurricane.
- ✓ With the radiance data assimilated into the initial condition, the intensity forecast can be improved significantly.
- ✓ More analyses that compare with other observations (airborne or/and dropsonde) will be done.