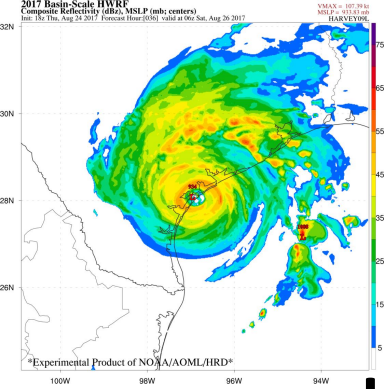
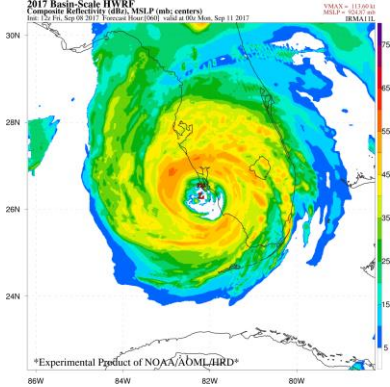




Preliminary Evaluation of Hurricanes Harvey and Irma in the 2017 Basin-Scale HWRF

Gus Alaka, Gopal, Xuejin Zhang, Laura Ko, Russell St. Fleur

September 20, 2017

Model Configuration

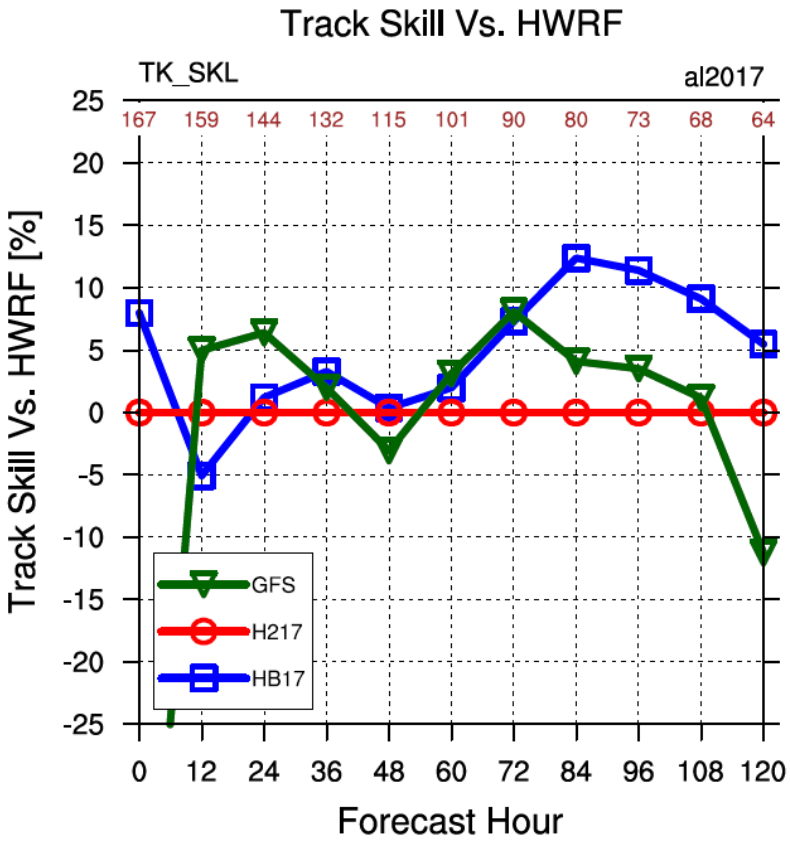
Configuration Options	HB17	H217
Domain	**18 km: 194.4° x 84.2° 06 km: 21.2° x 21.2° 02 km: 7.1° x 7.1°**	**18 km: 77.8° x 77.8° 06 km: 23.9° x 23.9° 02 km: 7.1° x 7.1°**
Model Top	10 hPa	10 hPa
Vertical Levels	75	75
Vortex Init.	at 2 km	At 2 km
Data Assimilation	**3DVAR DA**	**Hybrid DA**
Ocean Coupling	**NO**	**18-6 km: YES (POM) 2 km: Downscaled**
Multi-Storm	**YES (up to 3)**	**NO**
PHYSICS SCHEMES		
Microphysics	Ferrier-Aligo	Ferrier-Aligo
Radiation (LW,SW)	RRTMG	RRTMG
Surface Layer	GFDL	GFDL
PBL	GFS Hybrid-EDMF	GFS Hybrid-EDMF
Convection	Scale-Aware SAS	Scale-Aware SAS
Land Surface	Noah LSM	Noah LSM

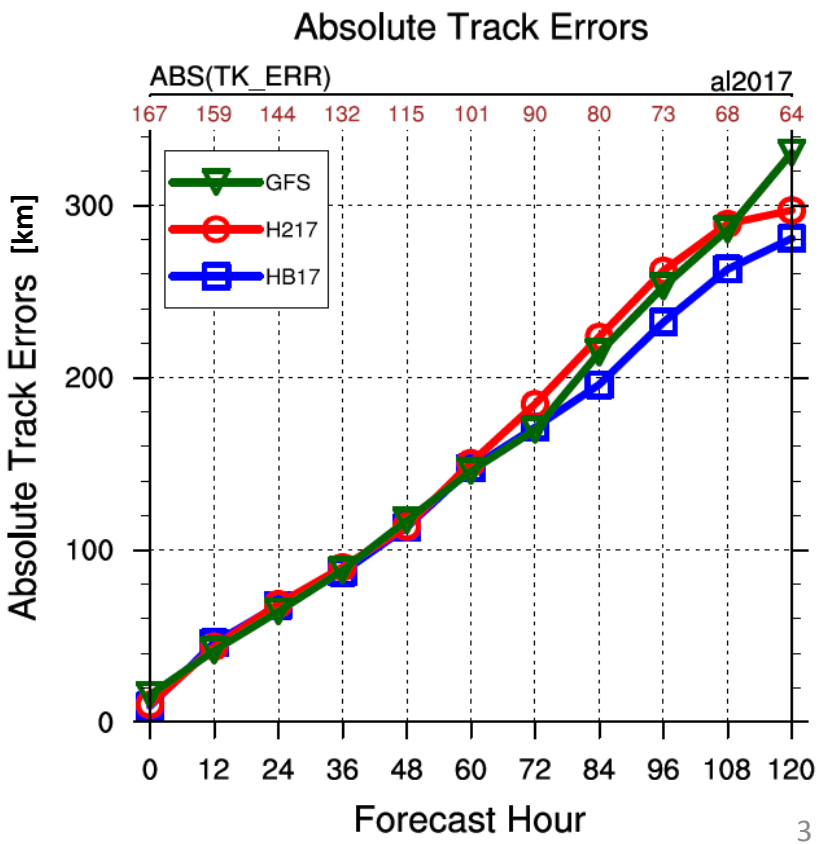
HB17
2017 Basin-Scale HWRF
Left column

H217
2017 Operational HWRF
Right column

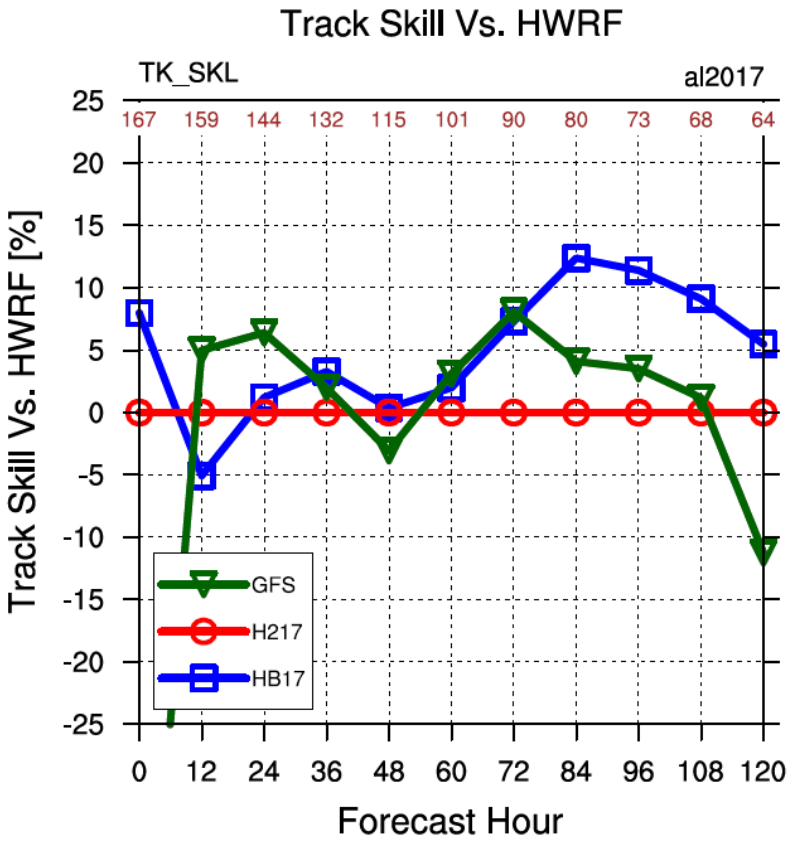
Differences are BOLDED

2017 Verification for the Atlantic Basin





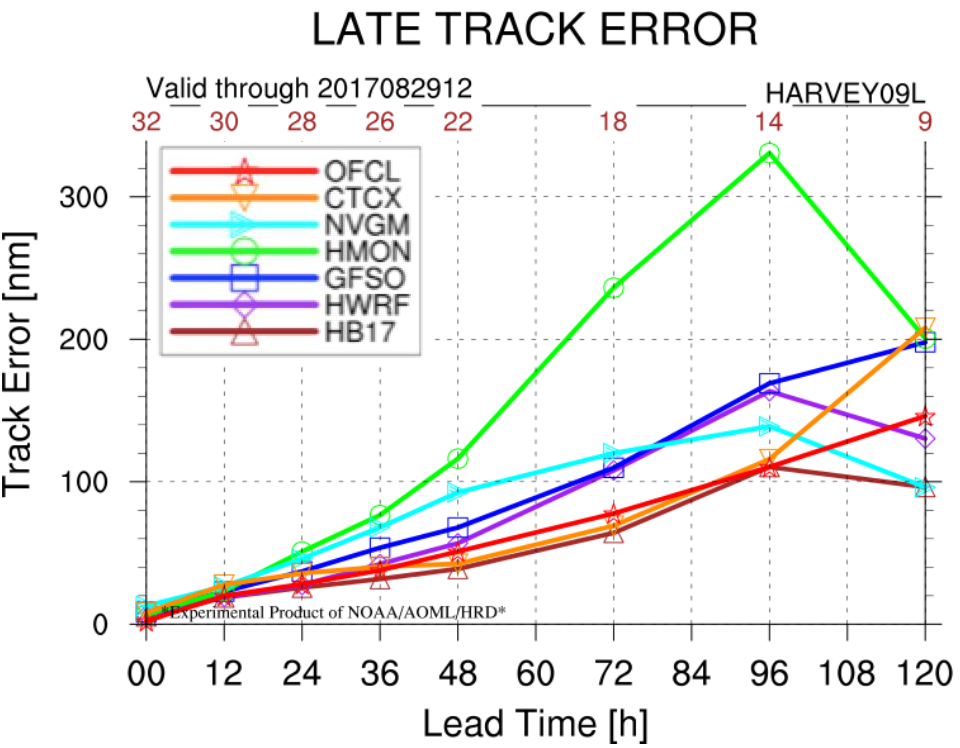
2017 Verification – Atlantic Basin



- Calculate % improvement relative to **H217**
- **HB17** excels at long lead times > 72h
  - 10% improvement over **H217** at 84 h and 96 h
  - Improvement over **H217** at every lead time except for 12 h
- Track was the primary focus with Basin-Scale HWRF
  - TC-TC interactions
  - TC-environment interactions

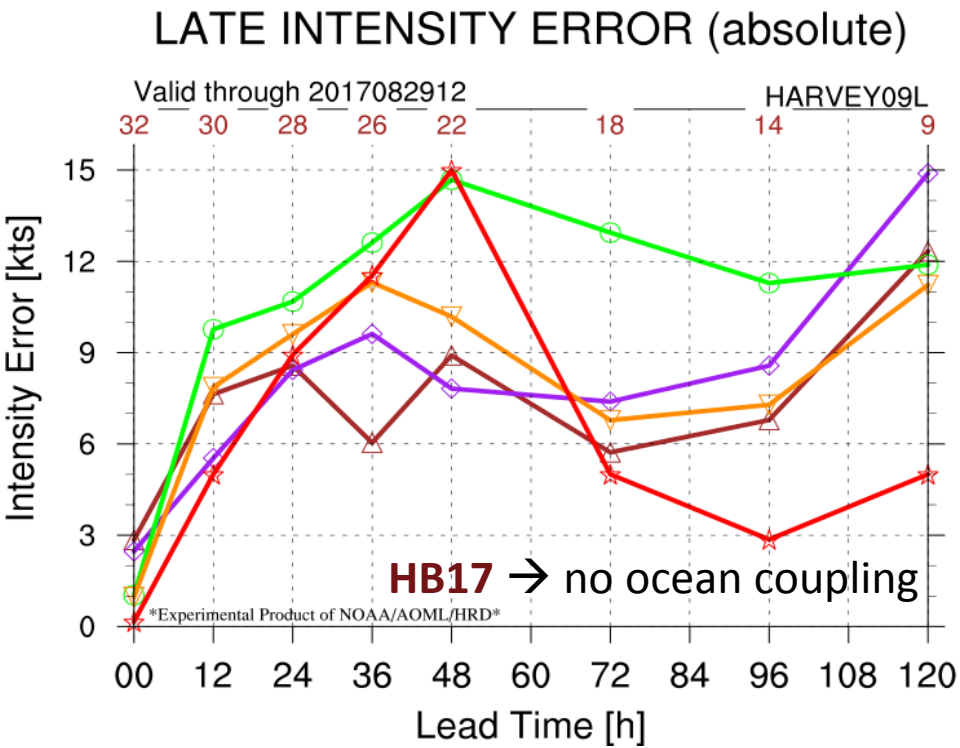
Hurricane Harvey (09L)

Preliminary Verification



HB17 produced the best **Track Forecasts**

CTCX & **OFCL** were good too

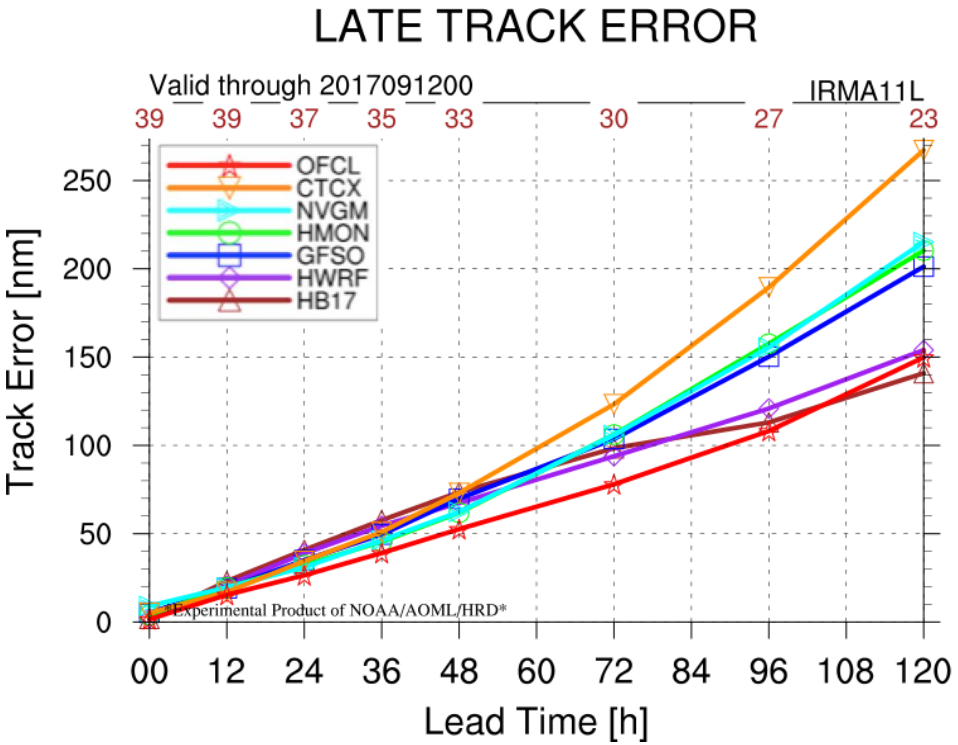


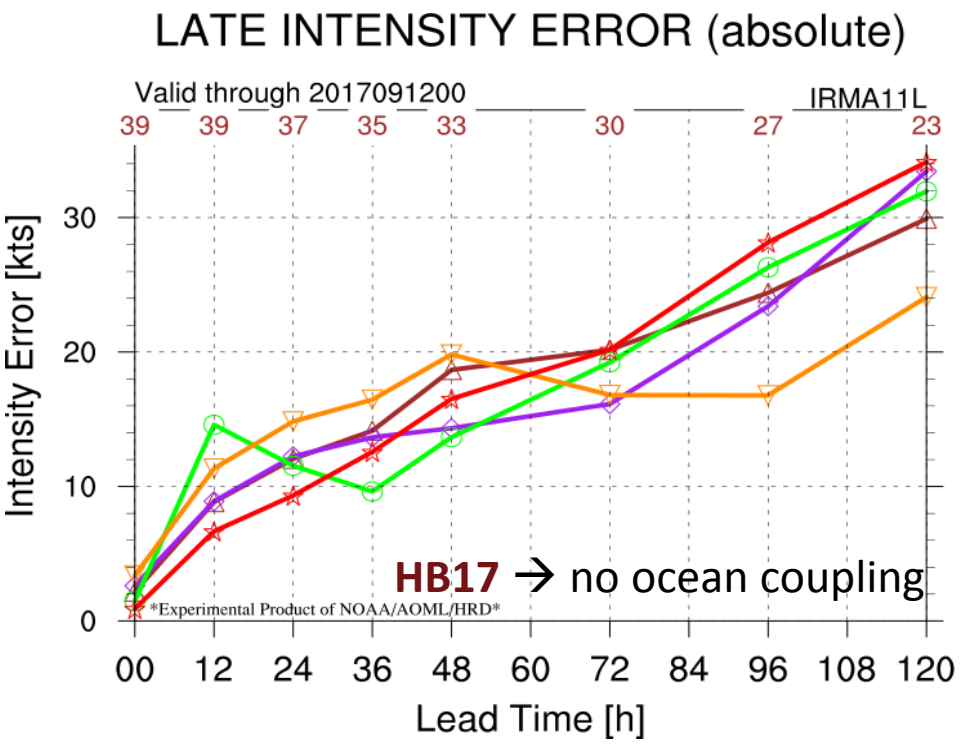
HB17 produced low **Intensity Error**

HWRF & **OFCL** were good too

Hurricane Irma (11L)

Preliminary Verification



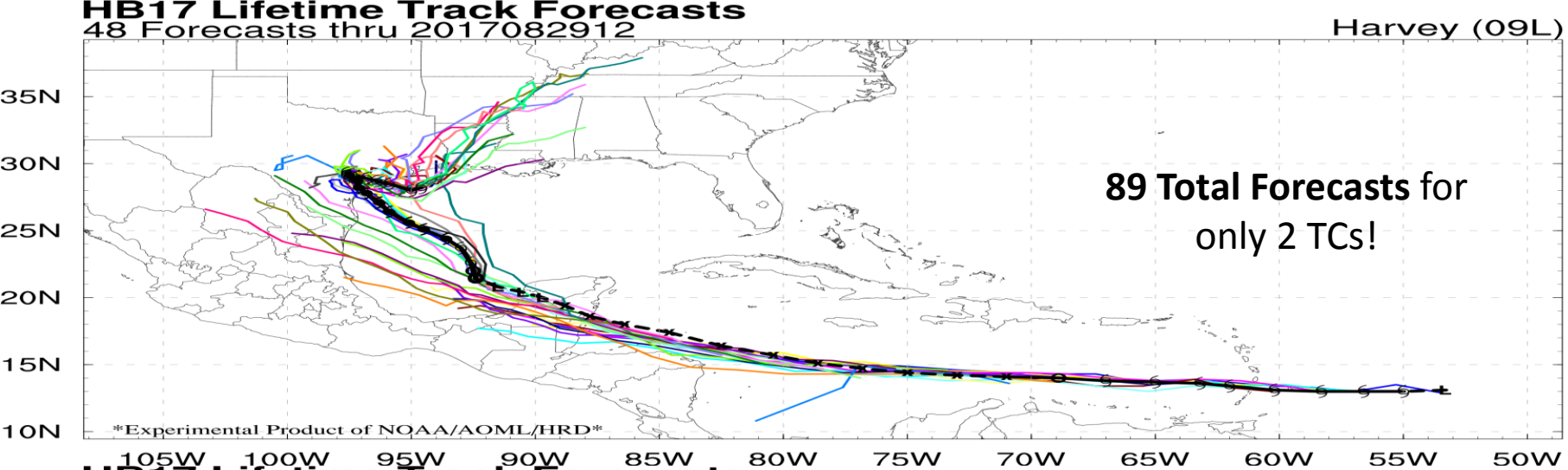


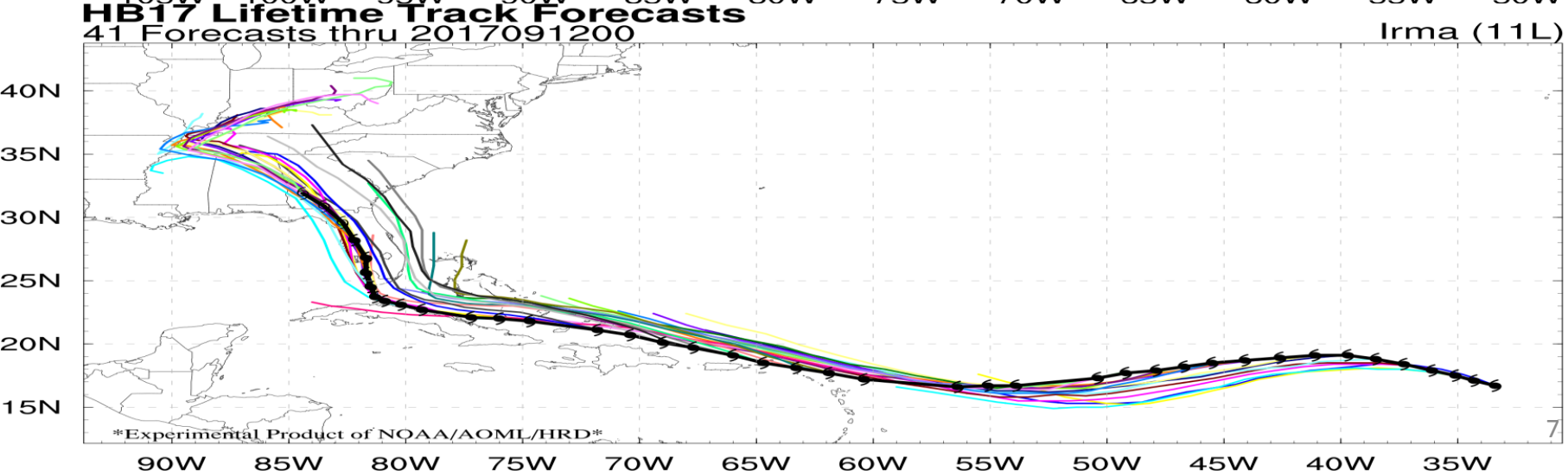
HB17 produced the good **Track Forecasts**

OFCL was the best, **HWRF** was good too

HB17 produced reasonable **Intensity Error**

HWRF & **CTCX** were good too


HB17 Lifetime Track Forecasts
48 Forecasts thru 2017082912
Harvey (09L)
89 Total Forecasts for only 2 TCs!
Experimental Product of NOAA/AOML/HRD
35N
30N
25N
20N
15N
10N
105W 100W 95W 90W 85W 80W 75W 70W 65W 60W 55W 50W
BEST

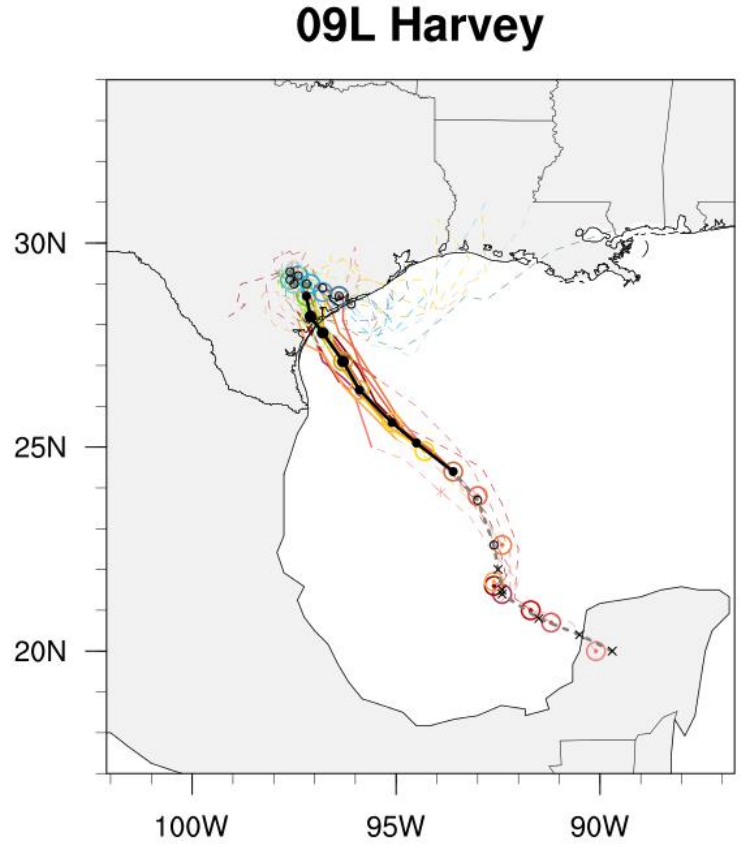

HB17 Lifetime Track Forecasts
41 Forecasts thru 2017091200
Irma (11L)
Experimental Product of NOAA/AOML/HRD
40N
35N
30N
25N
20N
15N
90W 85W 80W 75W 70W 65W 60W 55W 50W 45W 40W 35W
BEST

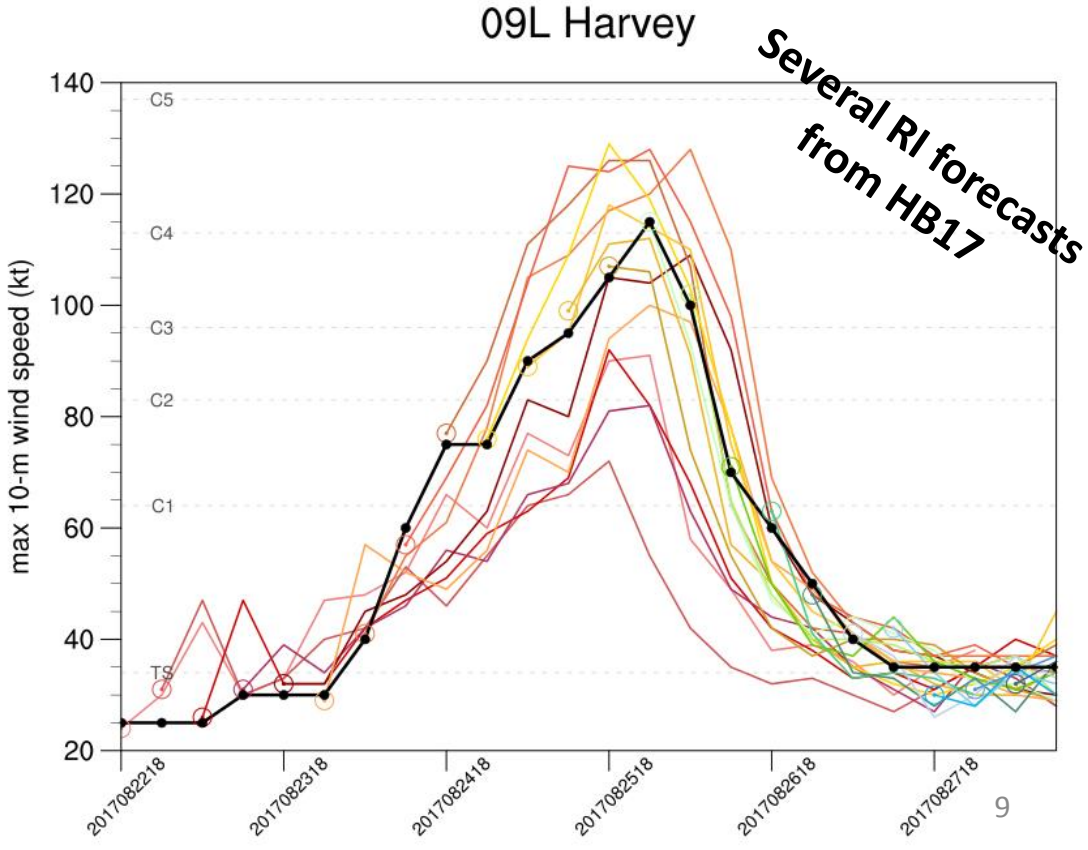
Hurricane Harvey in HB17

- Successes
  - *Real-time assimilation of TDR and HDOBs*
  - Rapid Intensification
  - Double eyewalls and eyewall replacement cycles
  - Rainfall
  - Severe weather threat

Hurricane Harvey in HB17

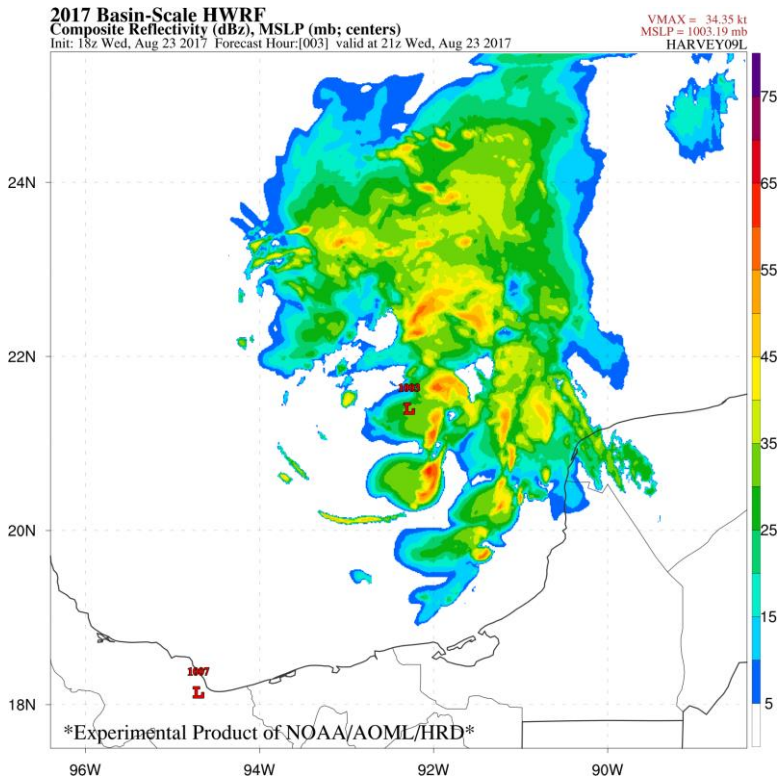
Rapid Intensification





Hurricane Harvey in HB17

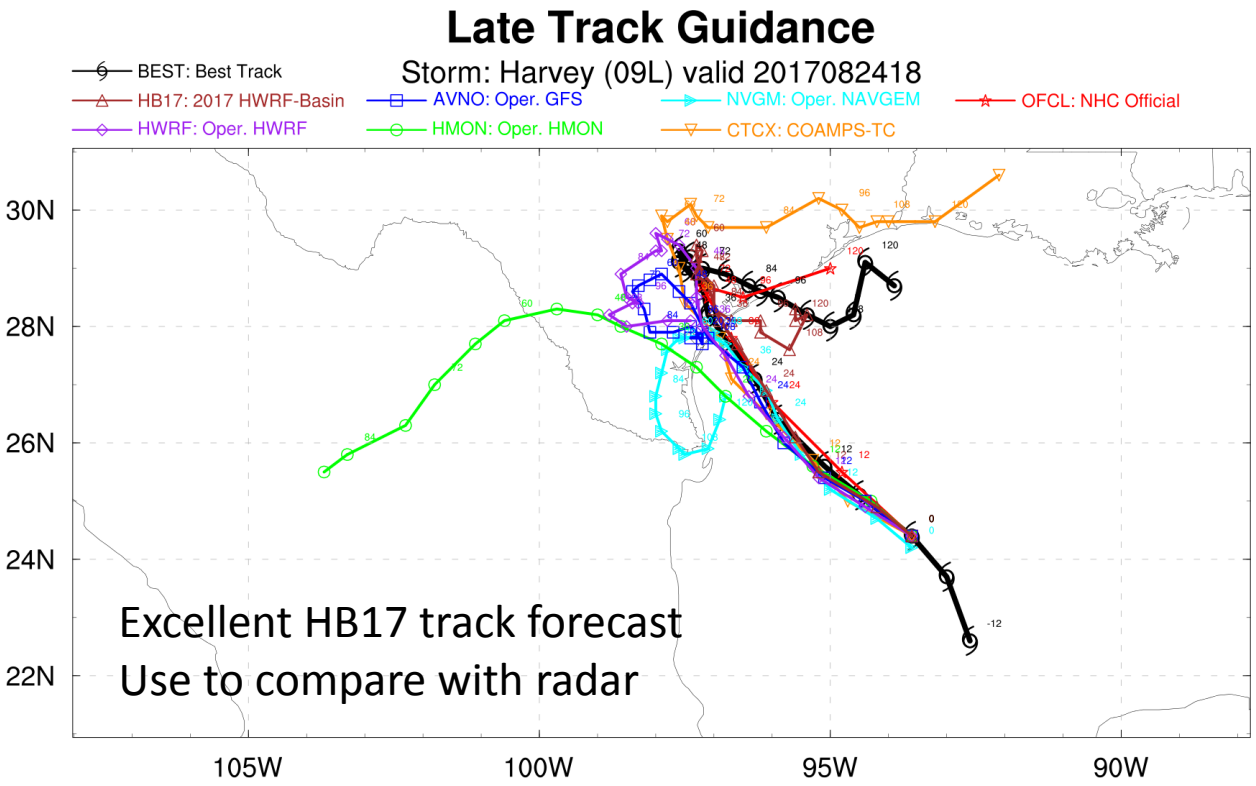
Rapid Intensification



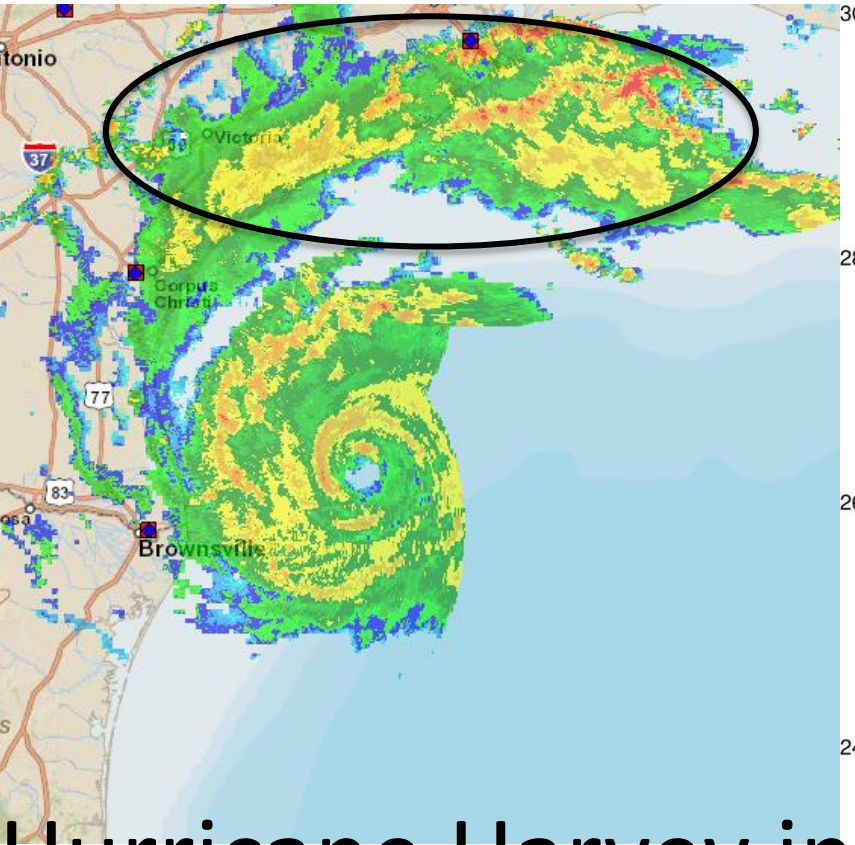
- Center “jumps” north early on in response to deep convection
- Rapid development of the inner core
- Evidence of double eyewalls and ERC
- The eye grows just before landfall in response to ERC
- Several rainbands near Houston

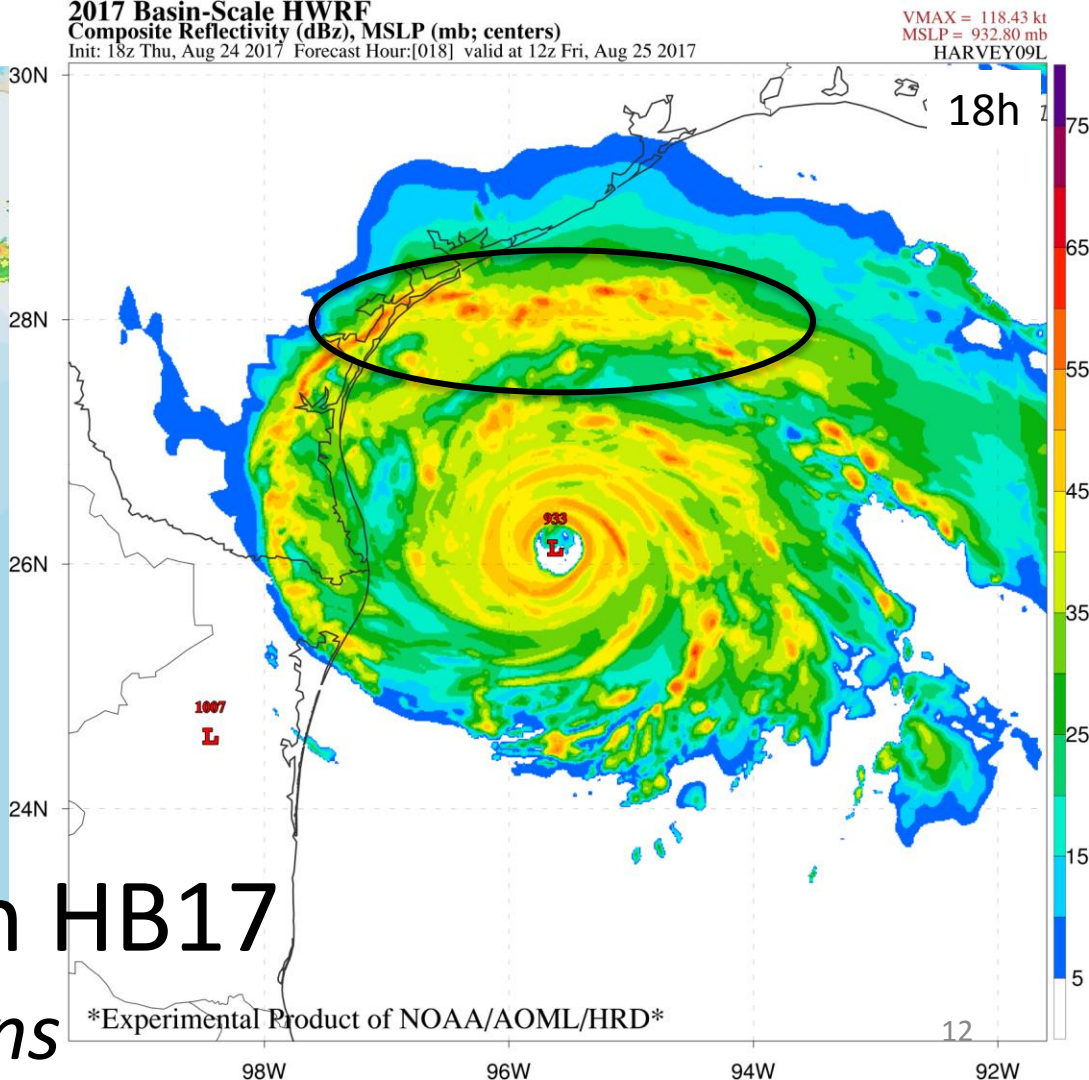
Hurricane Harvey in HB17

Radar Comparisons



NEXRAD: 12z Fri., Aug. 25 2017

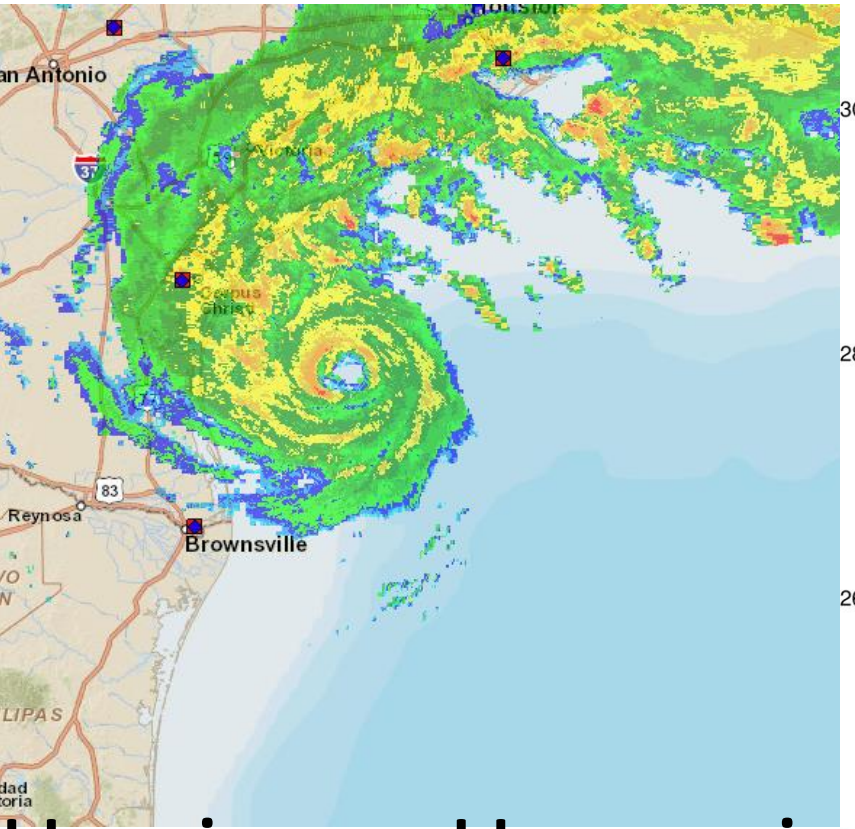


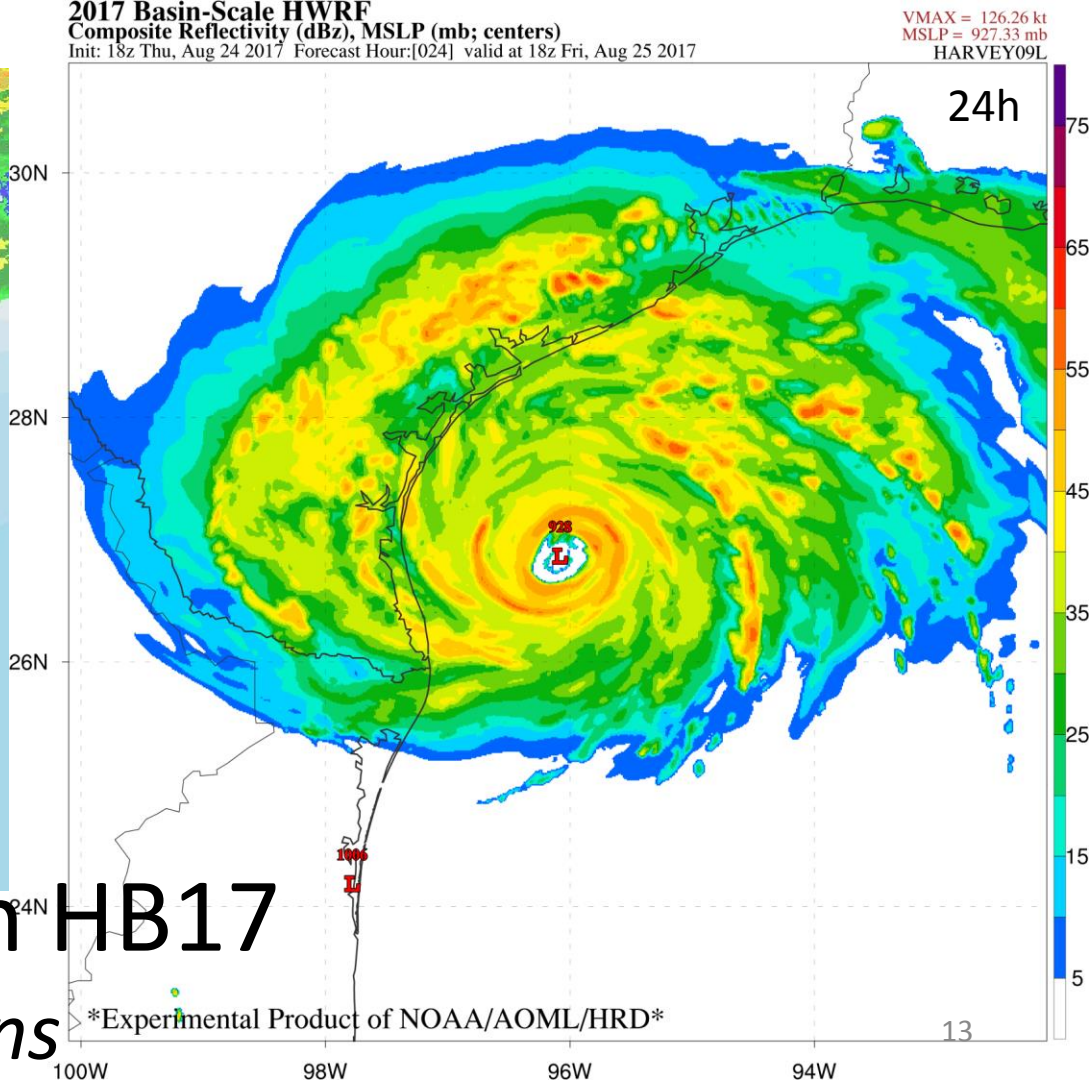


Hurricane Harvey in HB17

Radar Comparisons

NEXRAD: 18z Fri., Aug. 25 2017

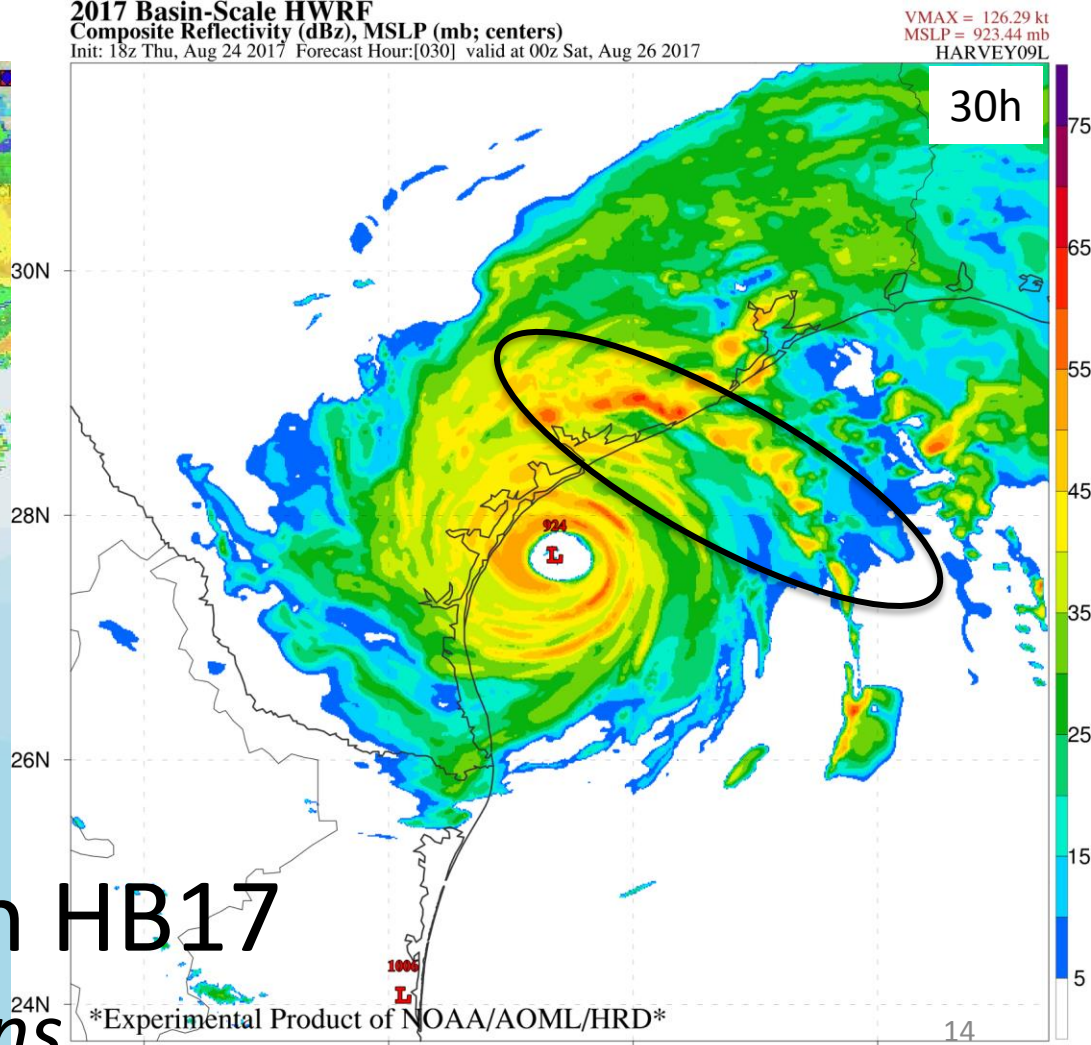




Hurricane Harvey in HB17

Radar Comparisons

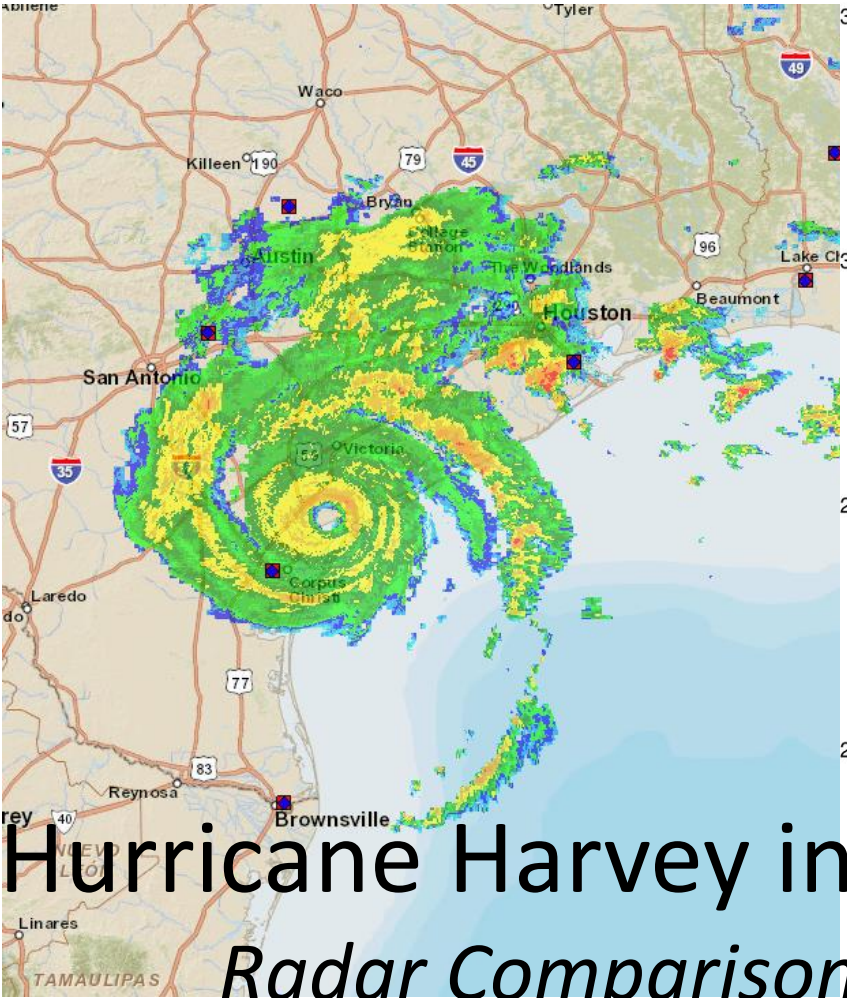
NEXRAD: 00z Sat., Aug. 26 2017

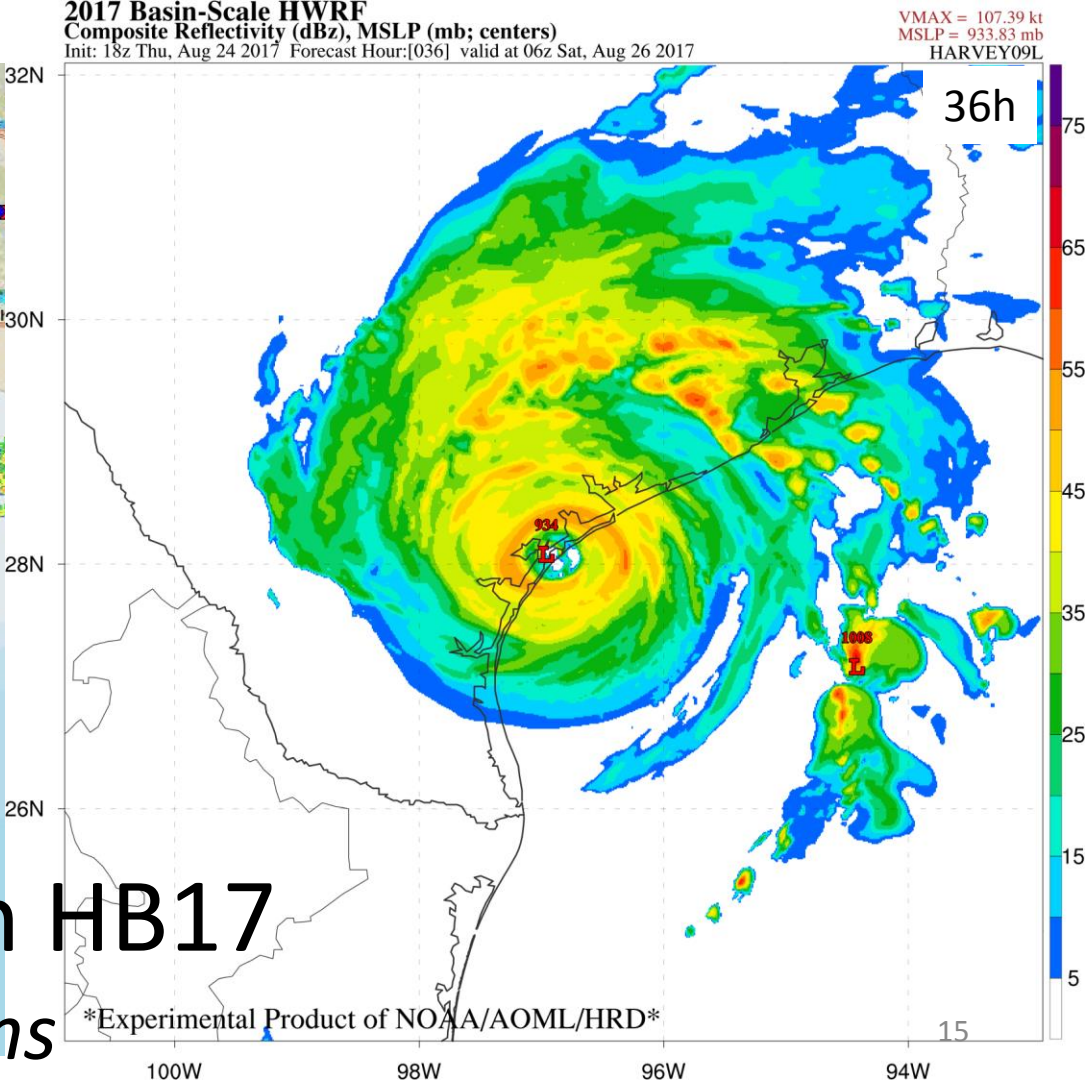


Hurricane Harvey in HB17

Radar Comparisons

NEXRAD: 06z Sat., Aug. 26 2017





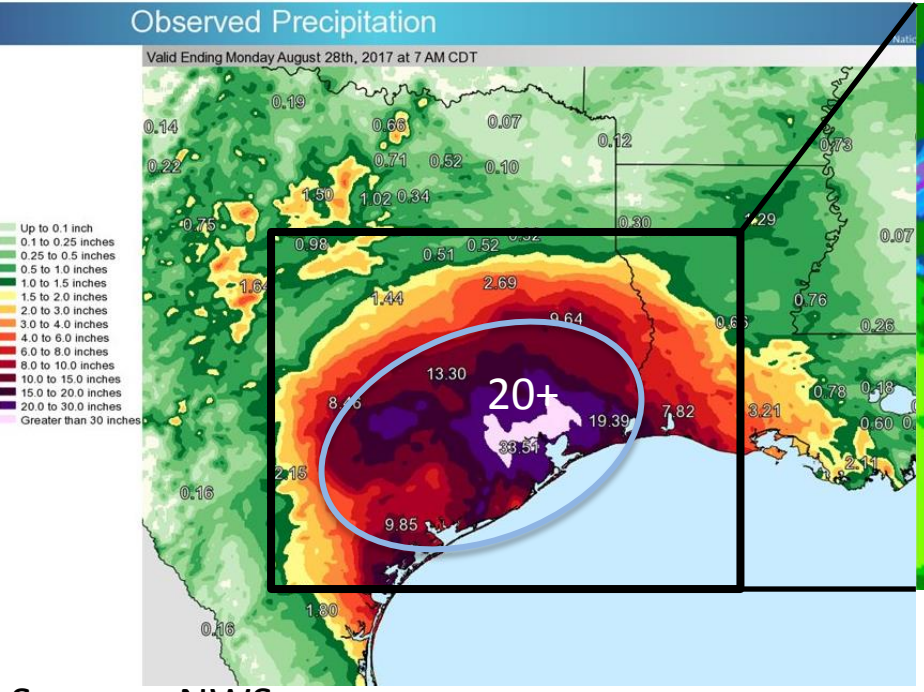
Hurricane Harvey in HB17

Radar Comparisons

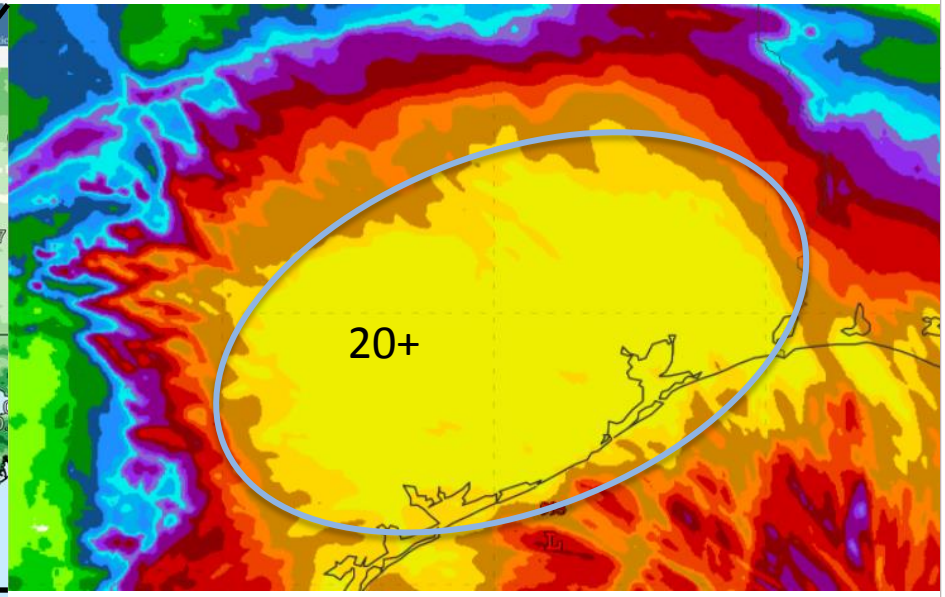
Hurricane Harvey in HB17

Rainfall

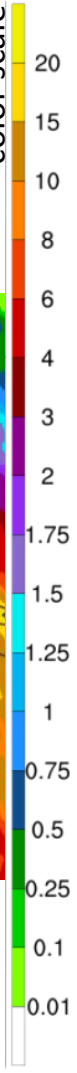
Observed



Model



Note: different color scale

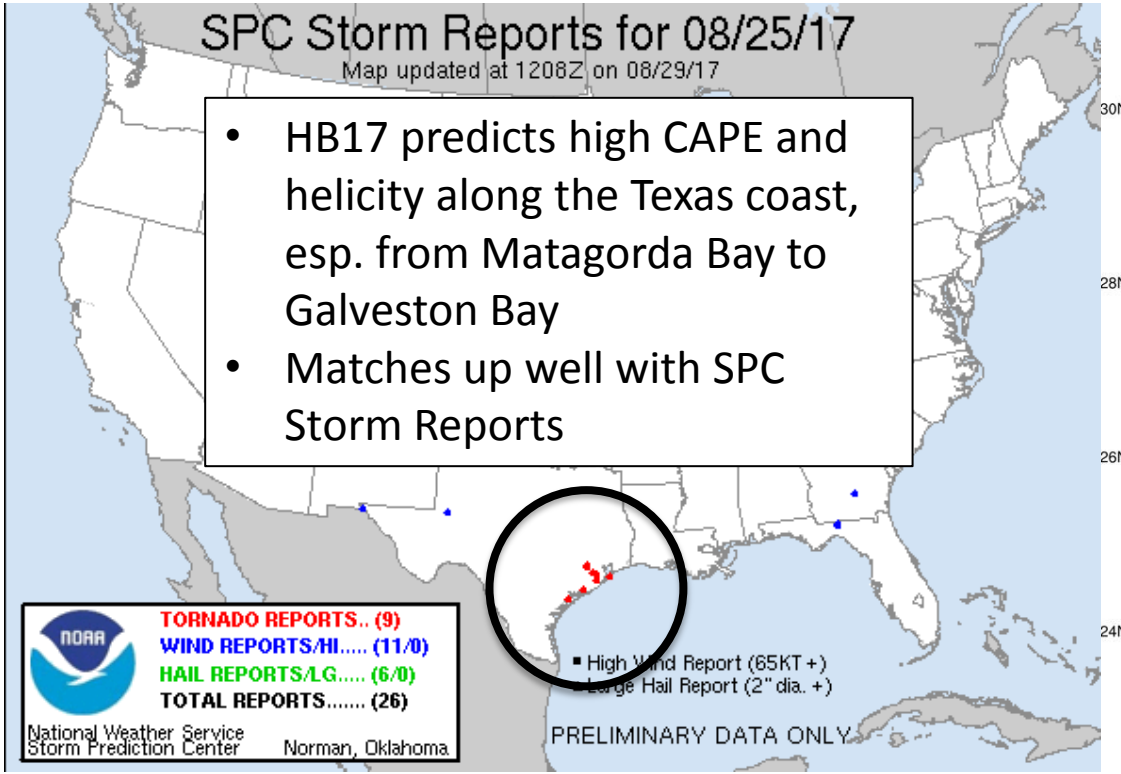


Source: NWS

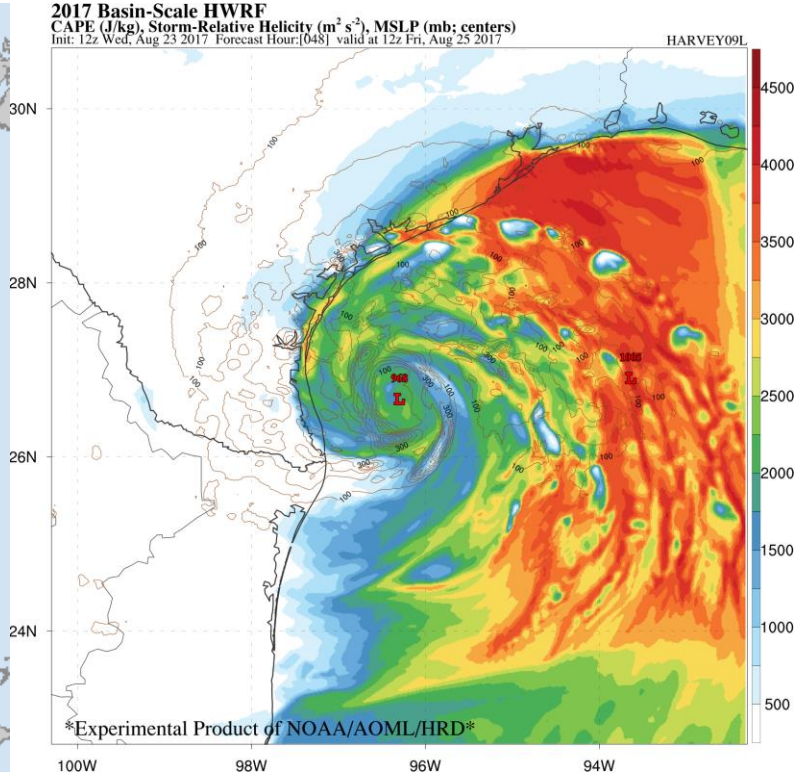
HB17's good tracks result in reasonable rainfall forecasts

Hurricane Harvey in HB17

Severe Weather & Tornadoes

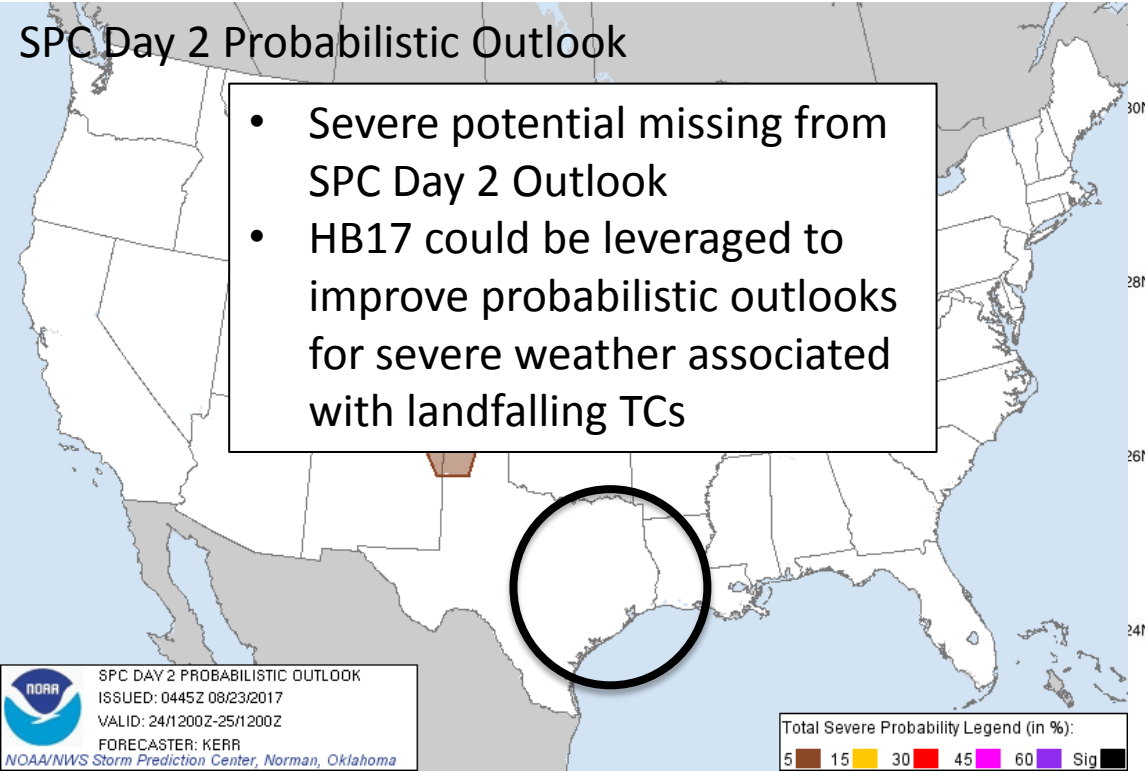


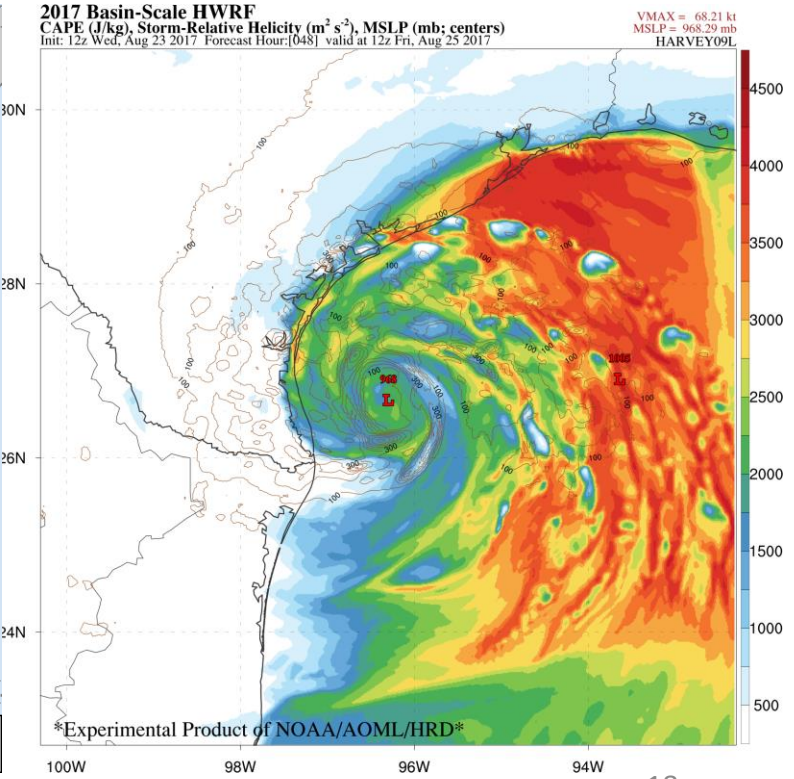
- HB17 predicts high CAPE and helicity along the Texas coast, esp. from Matagorda Bay to Galveston Bay
- Matches up well with SPC Storm Reports



Hurricane Harvey in HB17

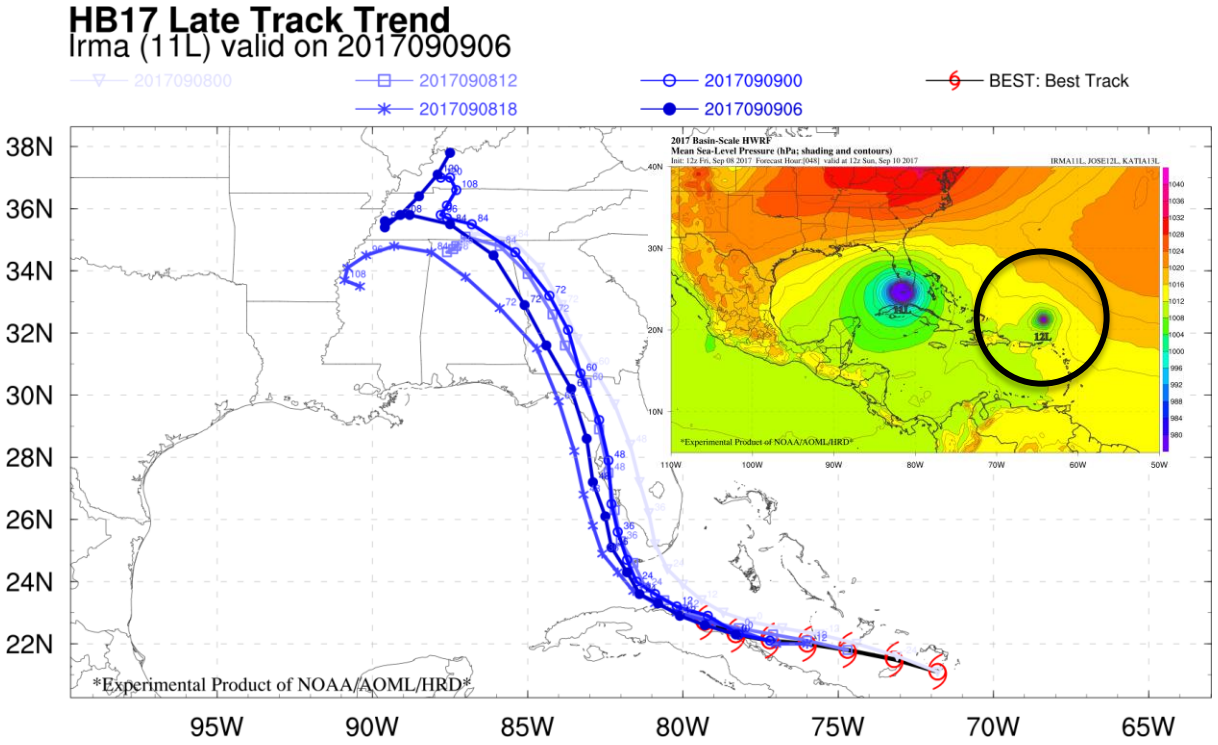
Severe Weather & Tornadoes





Hurricane Irma in HB17

Track Forecast Progression



Forecasts were consistently good throughout Irma's lifetime

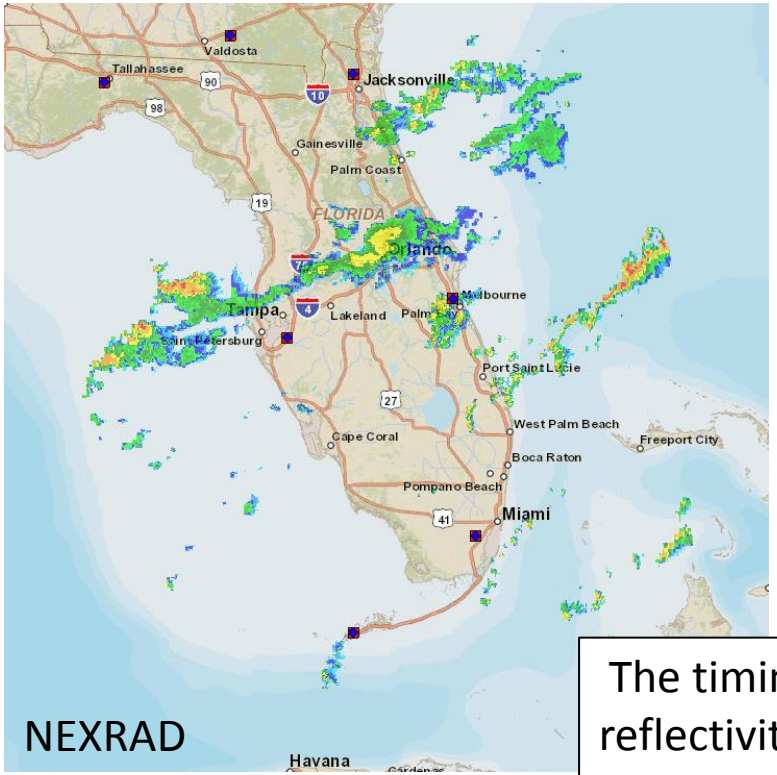
HB17 tracks shift West beginning cycle 2017090812

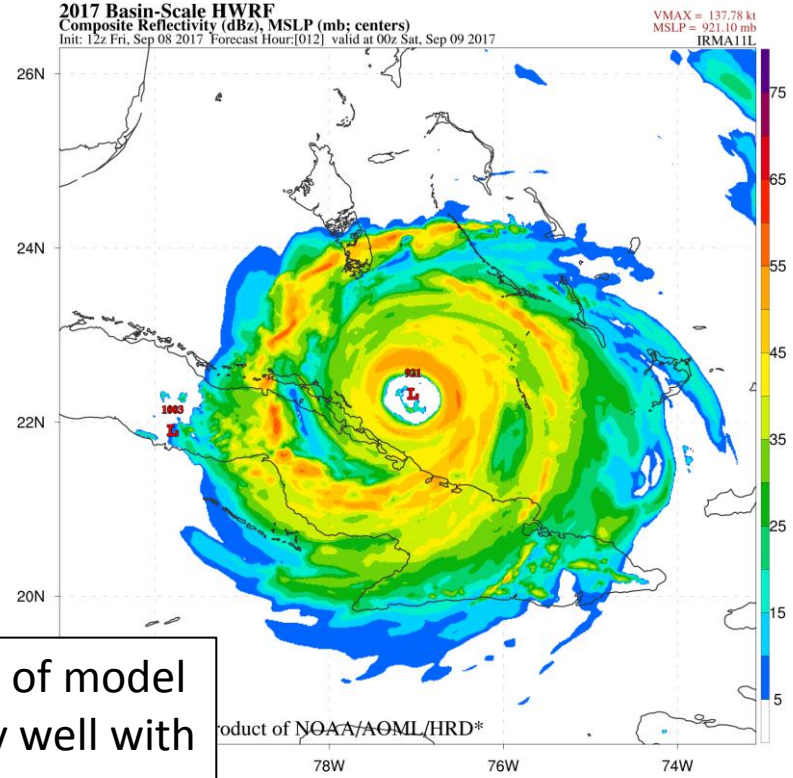
What is the impact of nearby Jose on Irma's track forecasts in HB17?

Hurricane Irma in HB17

Radar Comparisons

Initialize 12z Fri. Sep. 8 2017

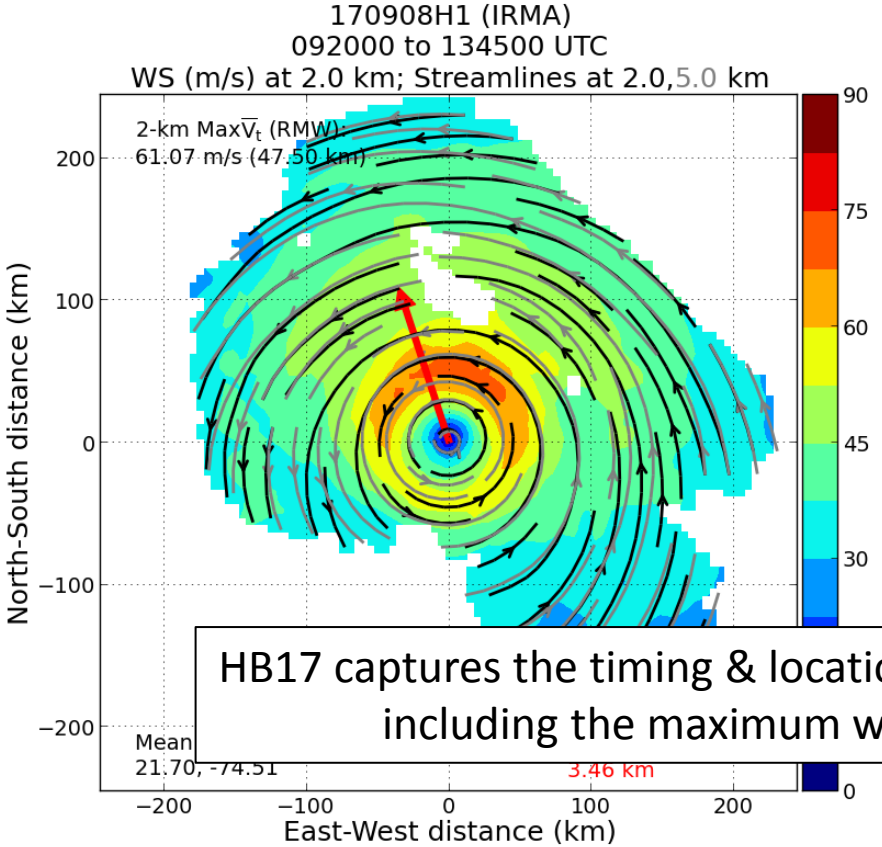


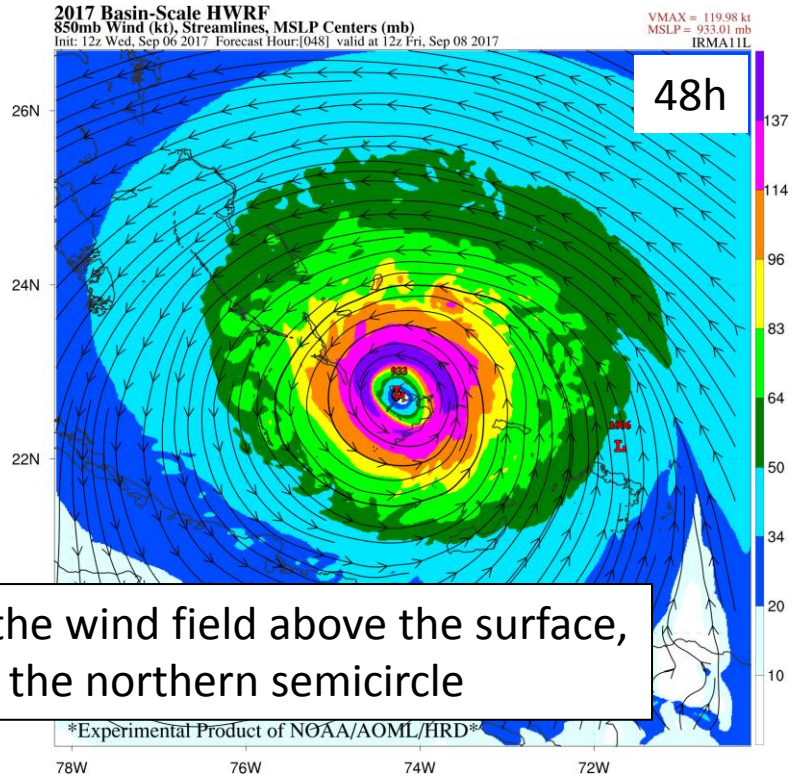


The timing and location of model reflectivity matches very well with NEXRAD data

Hurricane Irma in HB17

Radar Comparisons





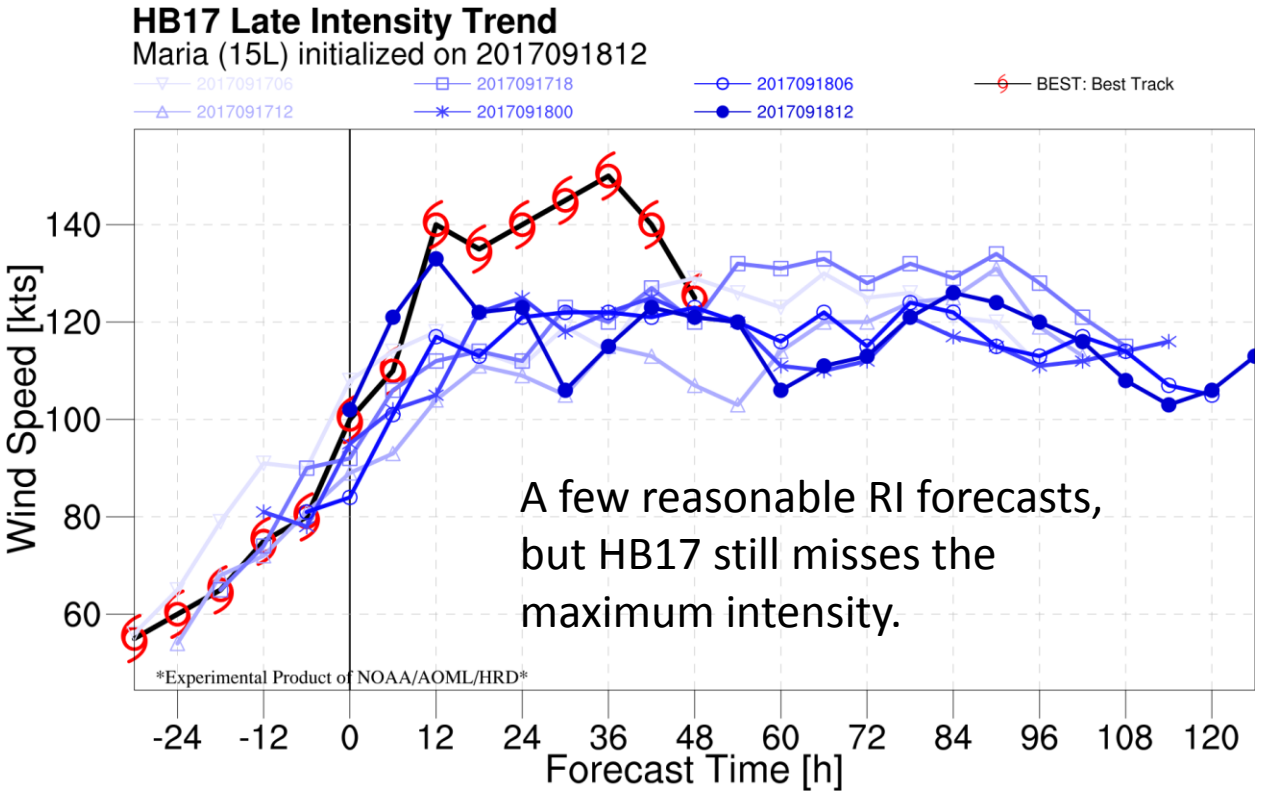
HB17 captures the timing & location of the wind field above the surface, including the maximum wind in the northern semicircle

Conclusions

- HB17 performed very well for Hurricane Harvey and Hurricane Irma
  - Low track errors for Hurricane Harvey
  - Low 120 h track error for Hurricane Irma
- Initial evaluation show the potential utility of HB17 forecasts for a variety of applications
  - Rapid Intensification, Rainfall, Severe Weather, Vortex Tilt
- Even without ocean coupling, intensity forecasts are reasonable for Harvey and Irma
  - Positive intensity bias for storms in NW Atlantic (Jose, Gert)
    - Related to positive SST bias in GFS?
  - We expect intensity to be on par with operational HWRF with addition of ocean coupling
- Sensitivity tests
  - What is the impact of TDR/HDOBs?
  - What is the impact of the multi-storm versus the big domain?
- We are continuing our evaluation with Maria…

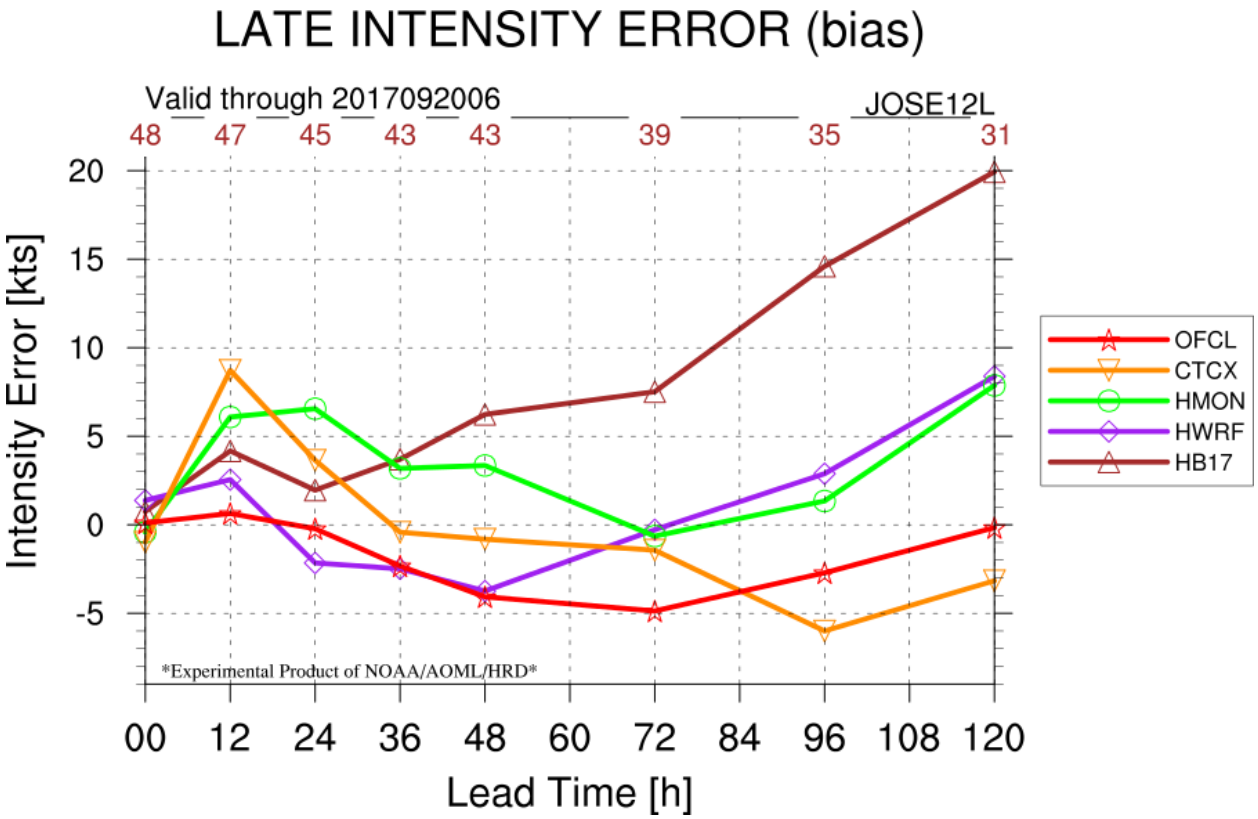
Hurricane Maria in HB17

Rapid Intensification



Hurricane Jose in HB17

Positive Intensity Bias



Positive intensity bias for Jose

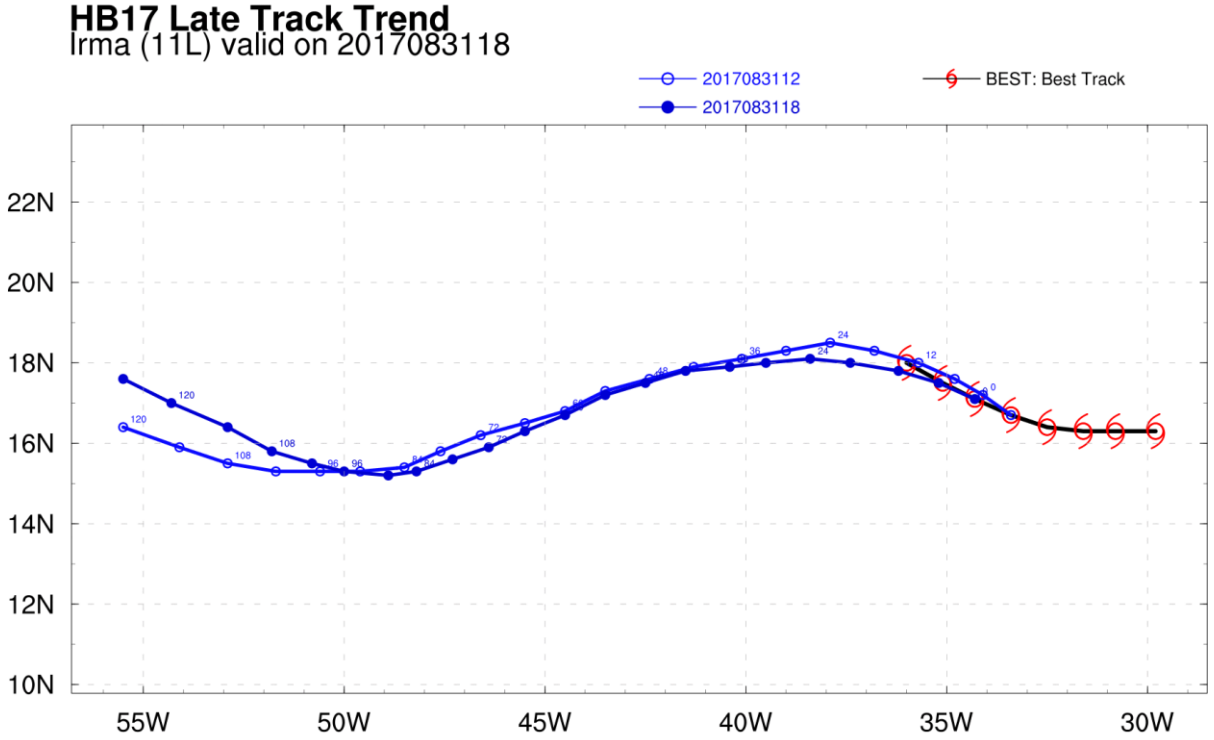
Jose stalled NE of the Bahamas and HB17 is not ocean-coupled. This means upwelling was not captured correctly

Warm bias in SST in this region? Gert, too?

Extra Slides

Hurricane Irma in HB17

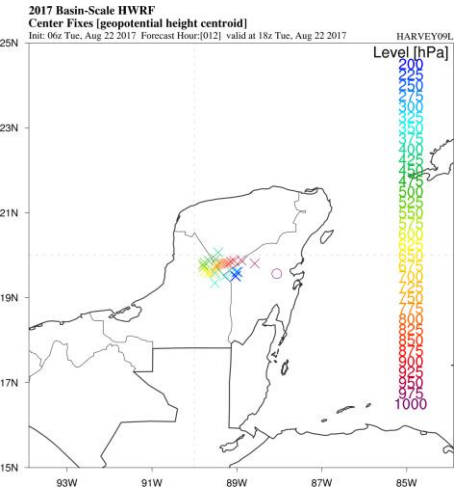
Track Forecast Progression

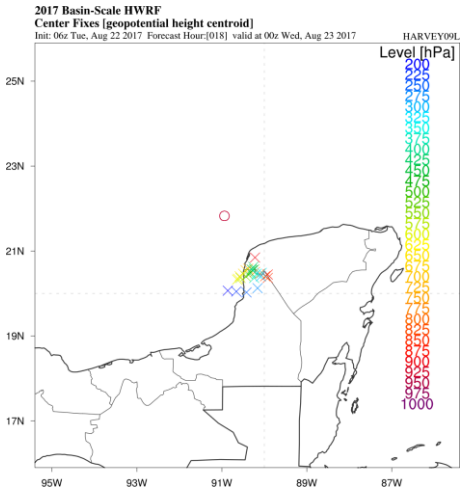


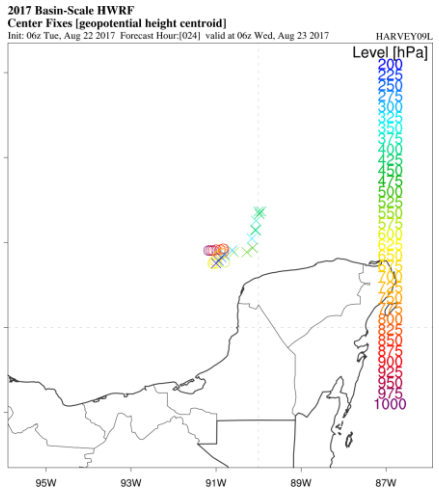
Forecasts were consistently good throughout Irma's lifetime

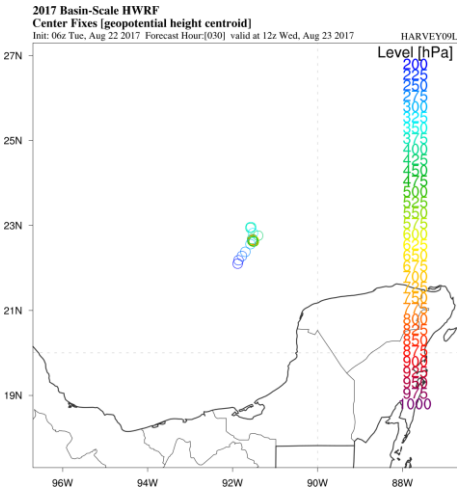
HB17 tracks shift West beginning cycle 2017090812

Hurricane Harvey in HB17
Vortex Tilt/Alignment





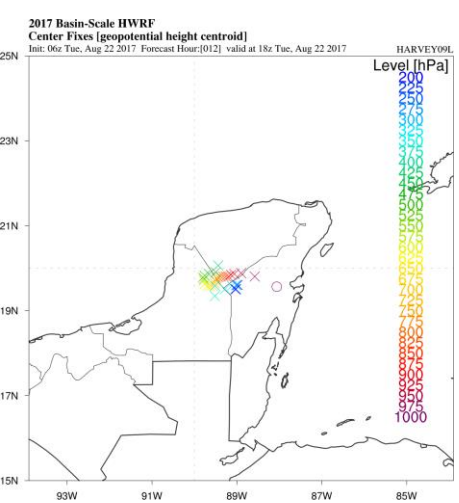


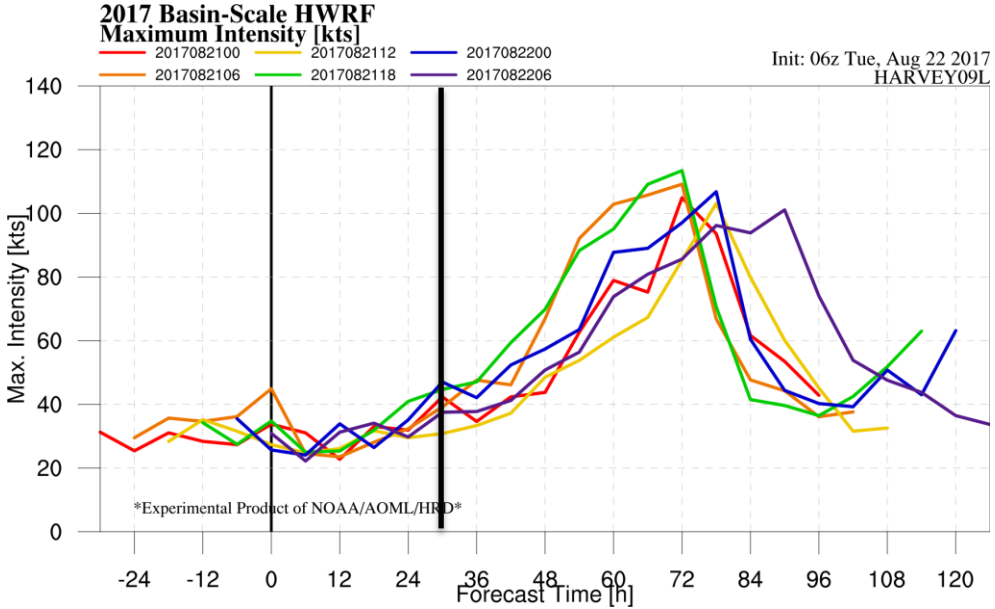


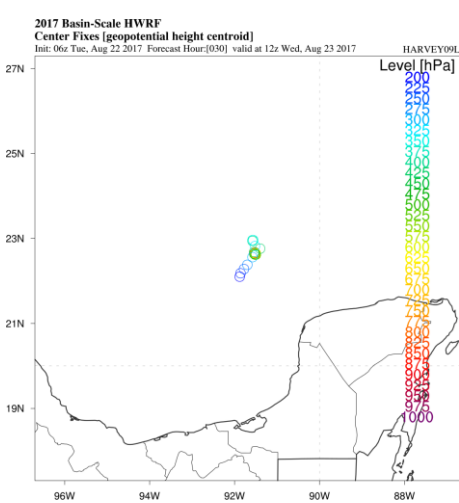
1. Calculate the geopotential height centroid at every level in a 10°x10° box centered on the ATCF center.
2. Start calculating from the surface, then upwards
3. Mark with “X” if not part of same vortex (subjective)

Hurricane Harvey in HB17

Vortex Tilt/Alignment



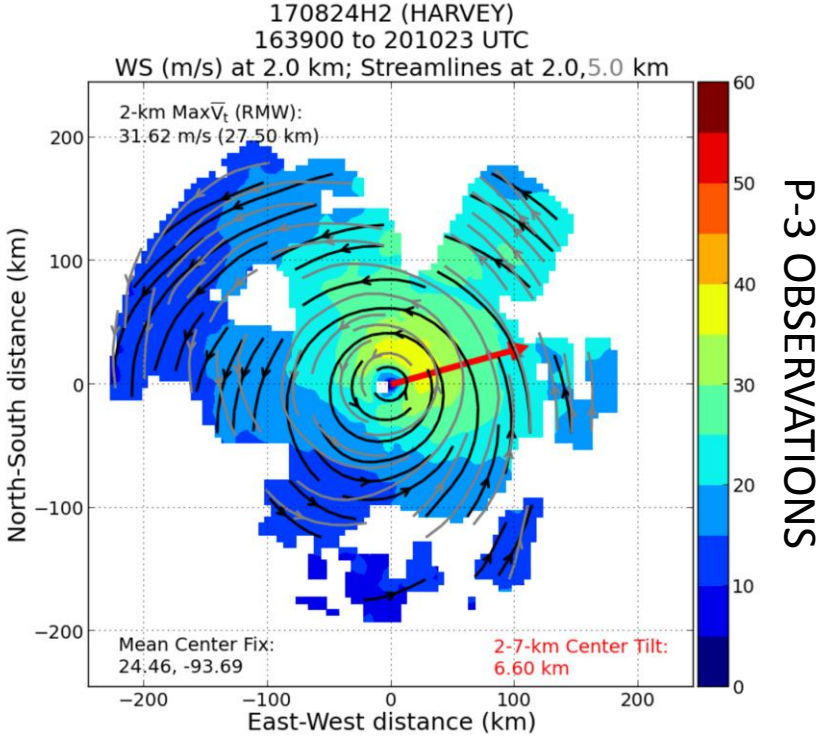


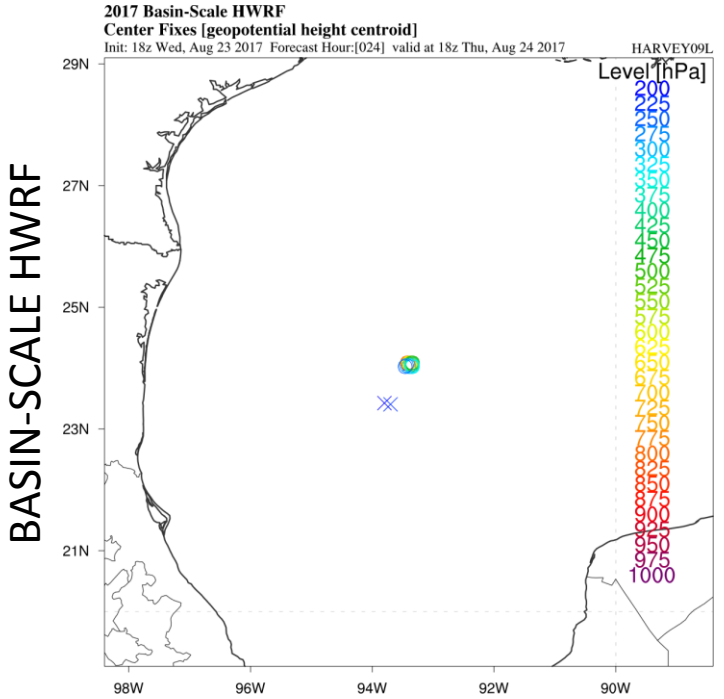


Harvey's vortex was aligning just before a period of rapid intensification

Hurricane Harvey in HB17

Vortex Tilt/Alignment – P-3 Comparison



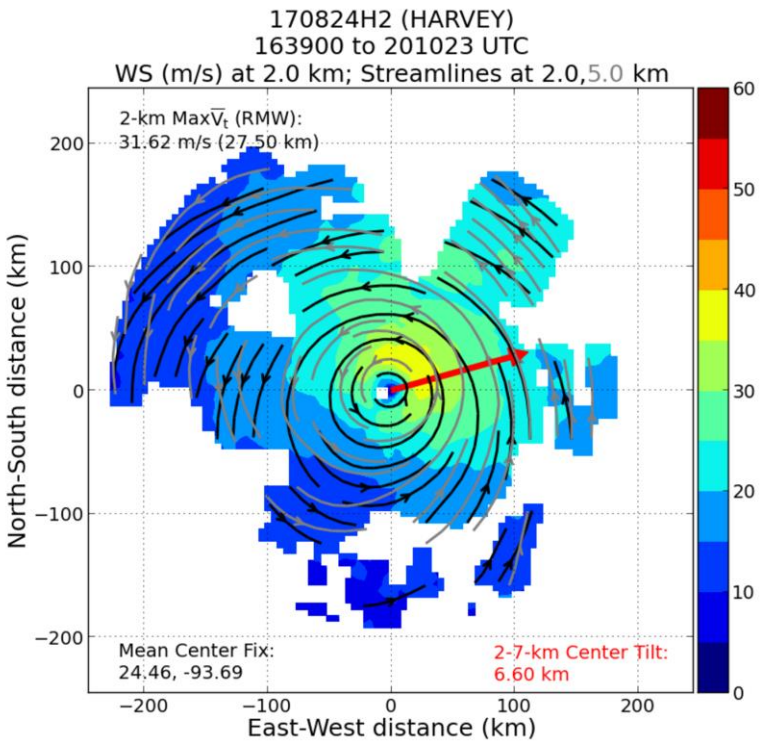


- Red arrow shows the tilt direction
- Harvey is showing a tilt to the ENE

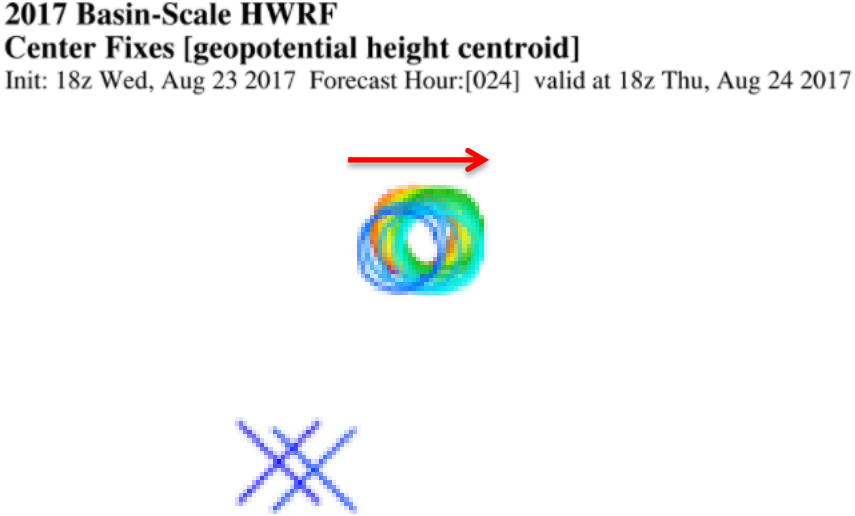
HB17 vortex is generally well-aligned, consistent with observations

Hurricane Harvey in HB17

Vortex Tilt/Alignment – P-3 Comparison



- Red arrow shows the tilt direction
- Harvey is showing a tilt to the ENE



…but, zooming in, we can even see evidence of a slight tilt to the E.