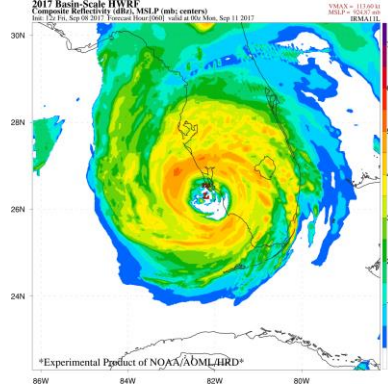


Preliminary Evaluation of Hurricanes Harvey and Irma in the 2017 Basin-Scale HWRF

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

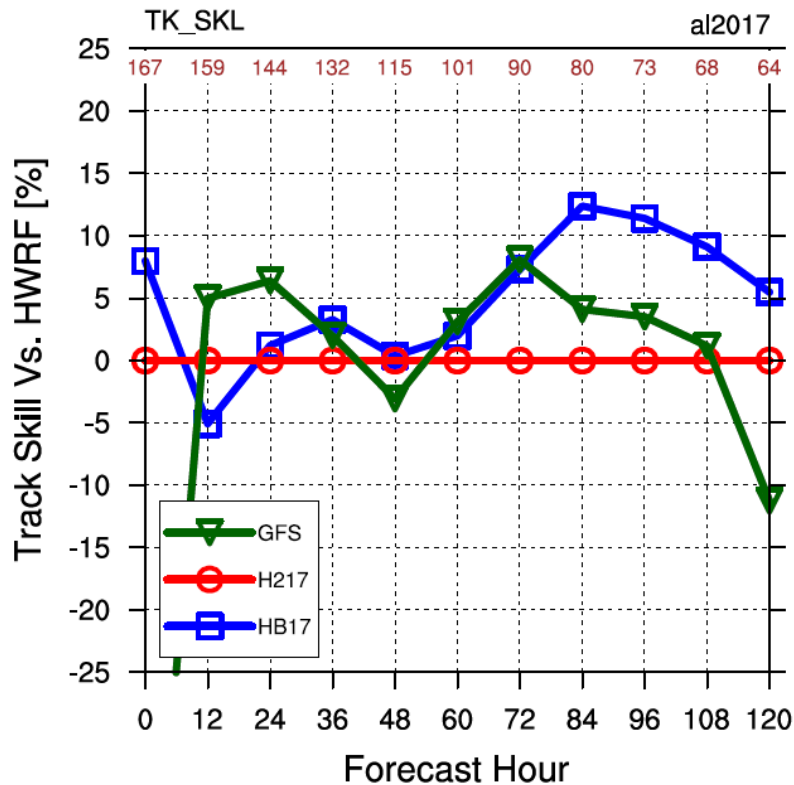
HB17
2017 Basin-Scale HWRF
Left column

H217
2017 Operational HWRF
Right column

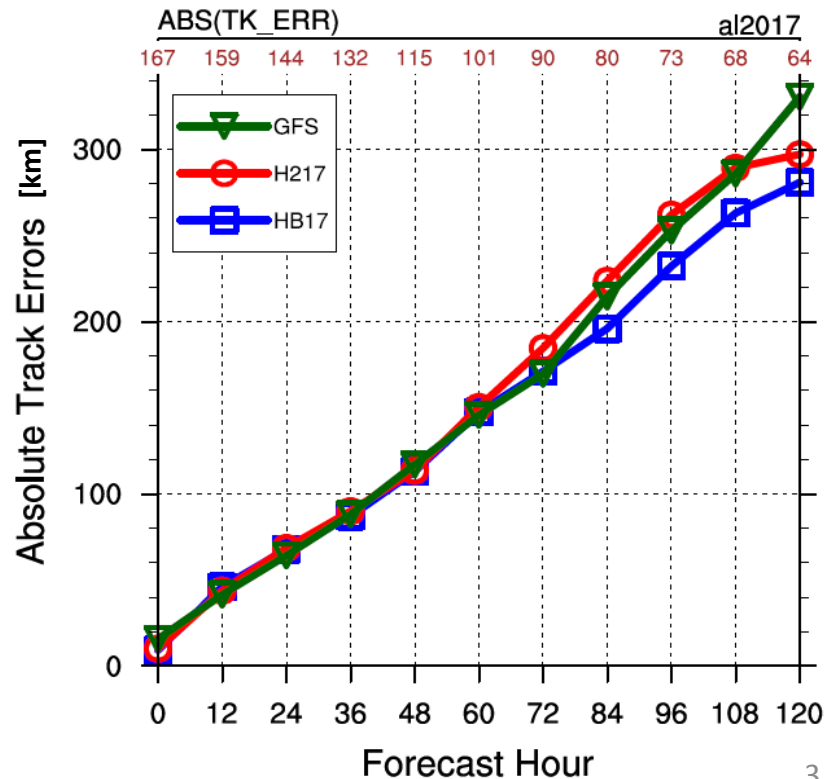
Differences are BOLDED

2017 Verification for the Atlantic Basin

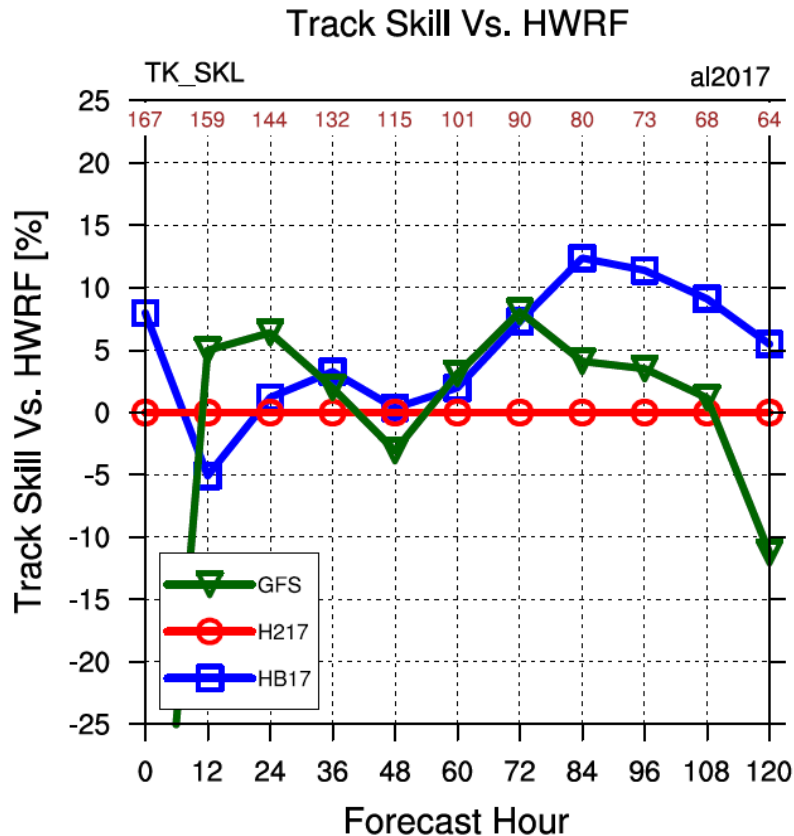
Track Skill Vs. HWRF



Absolute Track Errors



2017 Verification – Atlantic Basin

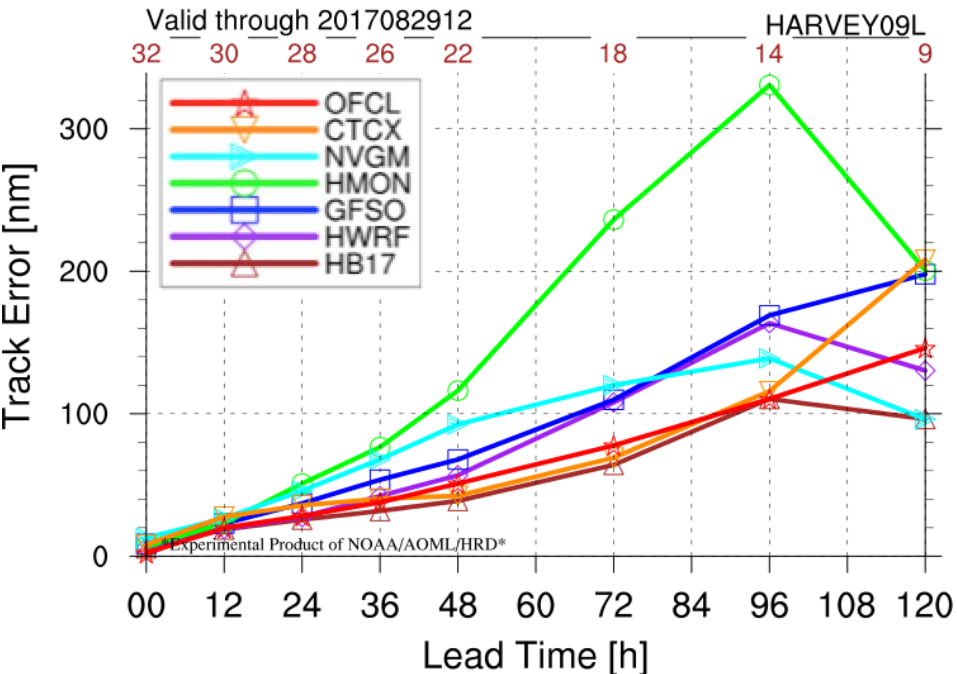


- Calculate % improvement relative to **H217**
- **HB17** excels at long lead times > 72h
 - 10% improvement over **H217** at 84 h and 96 h
 - Improvement over **H217** at every lead time except for 12 h
- Track was the primary focus with Basin-Scale HWRF
 - TC-TC interactions
 - TC-environment interactions

Hurricane Harvey (09L)

Preliminary Verification

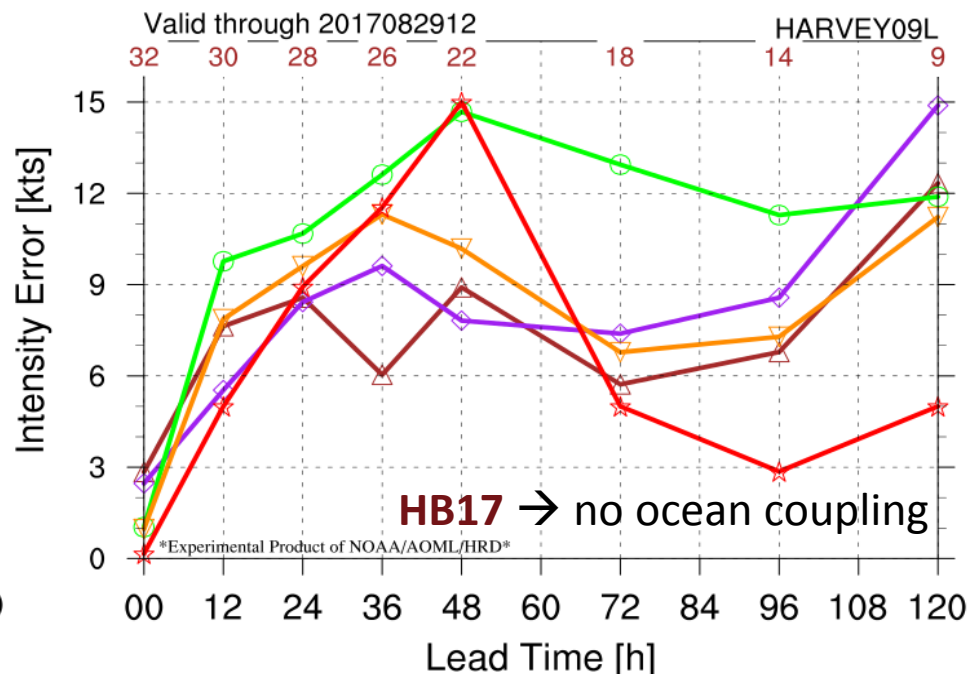
LATE TRACK ERROR



HB17 produced the best **Track Forecasts**

CTCX & **OFCL** were good too

LATE INTENSITY ERROR (absolute)



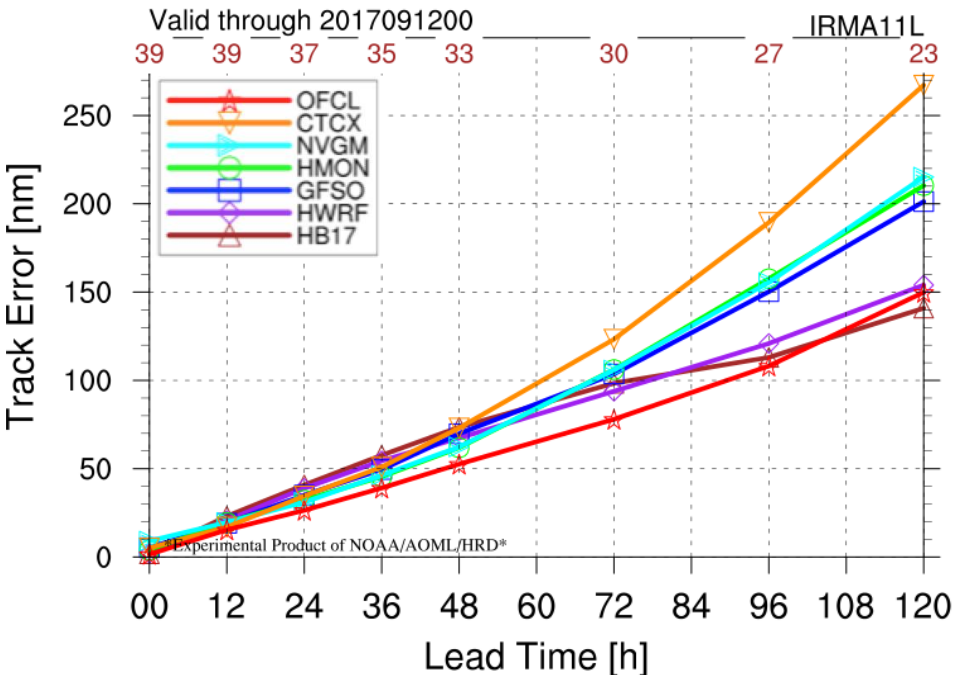
HB17 produced low **Intensity Error**

HWRF & **OFCL** were good too

Hurricane Irma (11L)

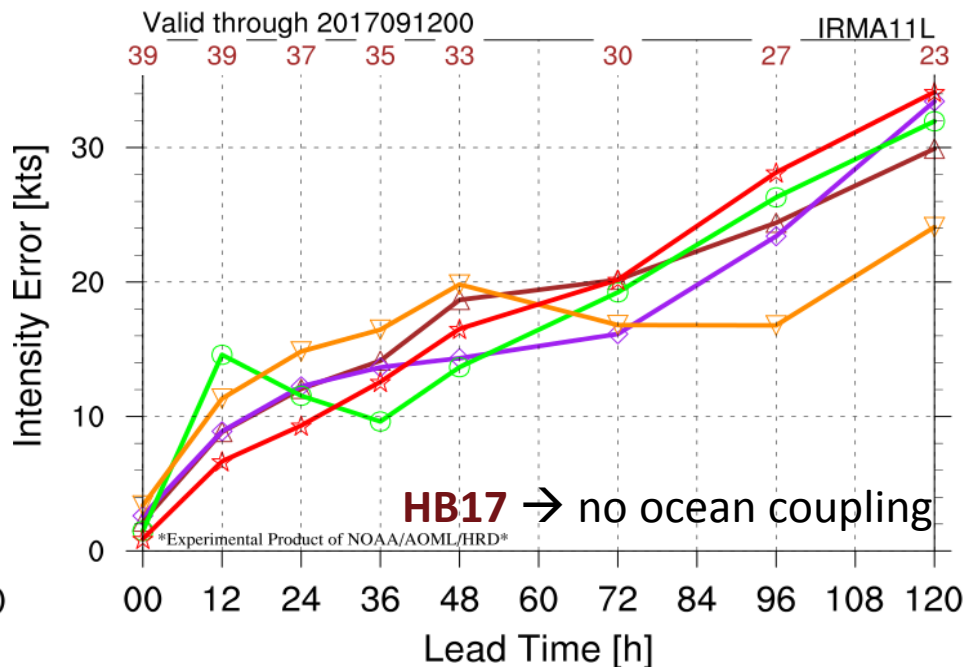
Preliminary Verification

LATE TRACK ERROR



HB17 produced the good **Track Forecasts**
OFCL was the best, **HWRF** was good too

LATE INTENSITY ERROR (absolute)

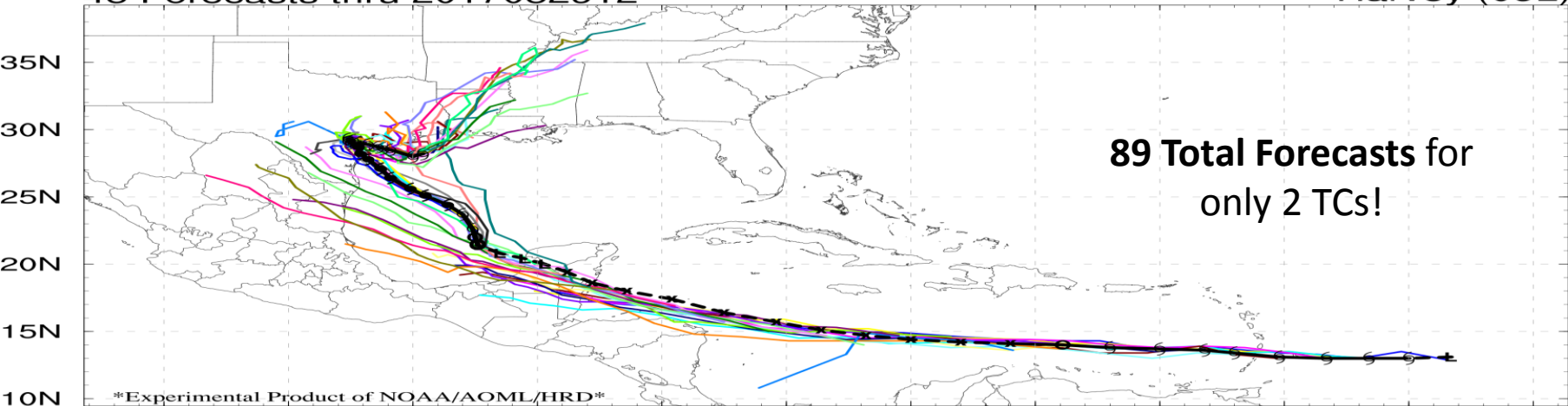


HB17 produced reasonable **Intensity Error**
HWRF & **CTCX** were good too

HB17 Lifetime Track Forecasts

48 Forecasts thru 2017082912

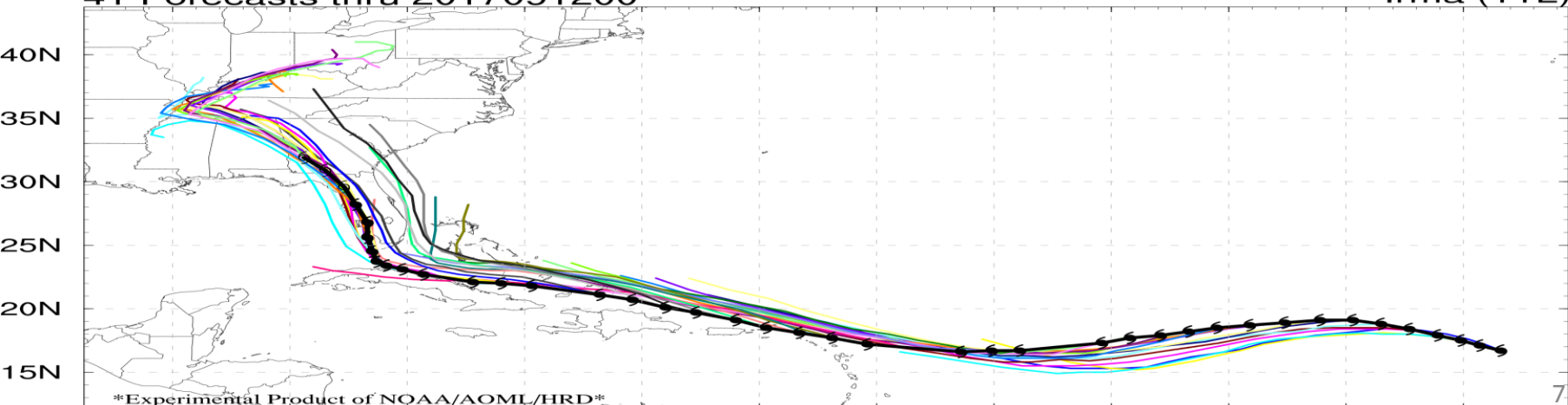
Harvey (09L)



HB17 Lifetime Track Forecasts

41 Forecasts thru 2017091200

Irma (11L)



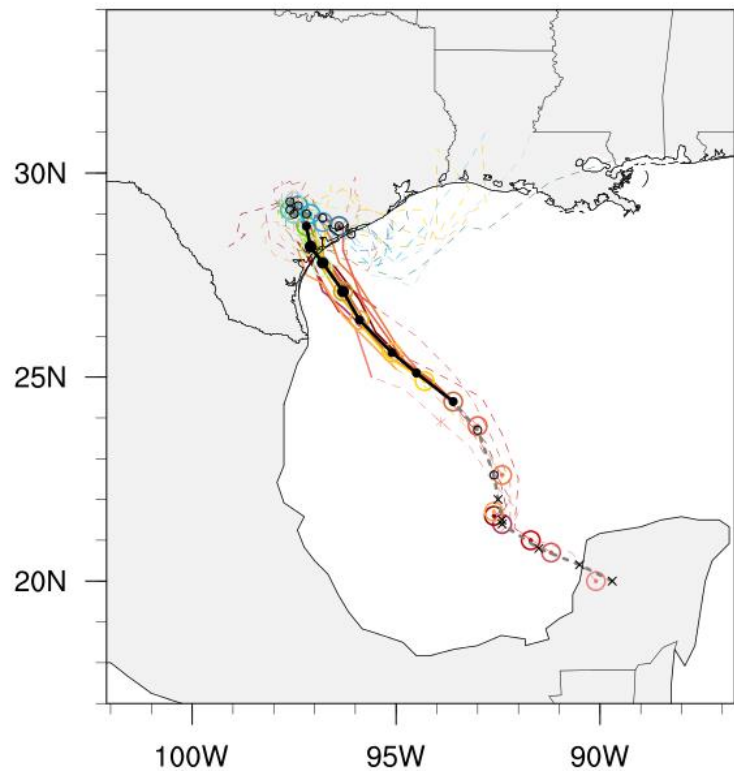
Hurricane Harvey in HB17

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

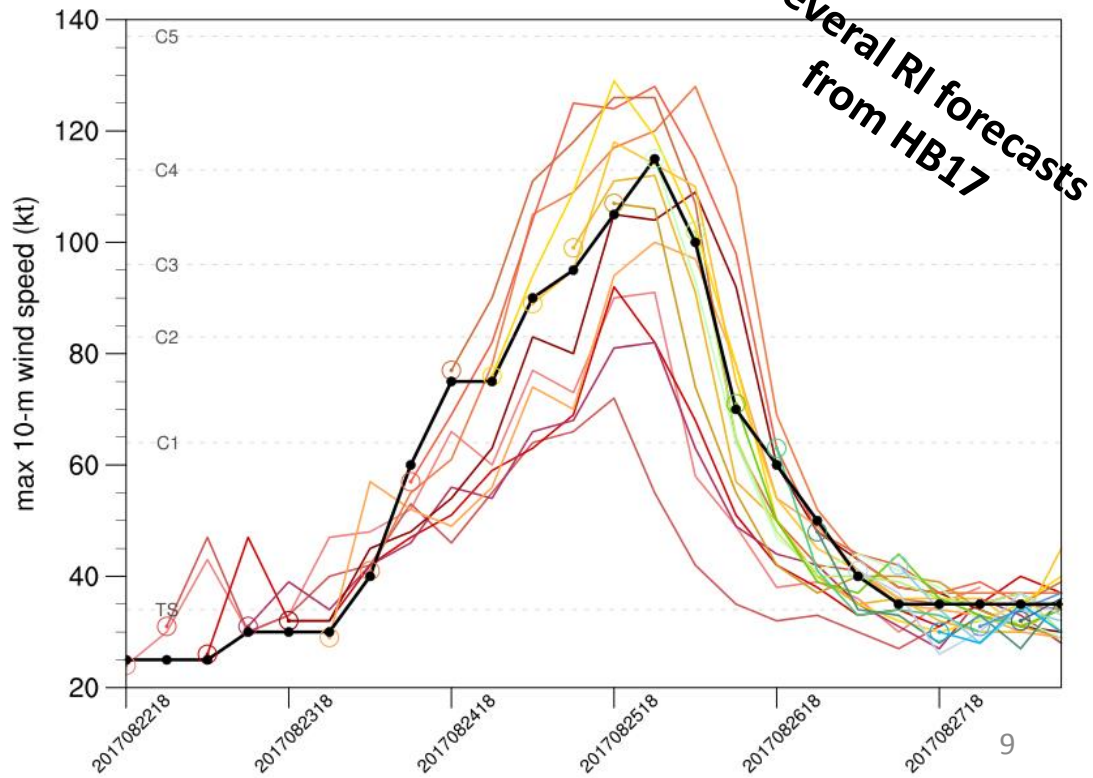
Hurricane Harvey in HB17

Rapid Intensification

09L Harvey

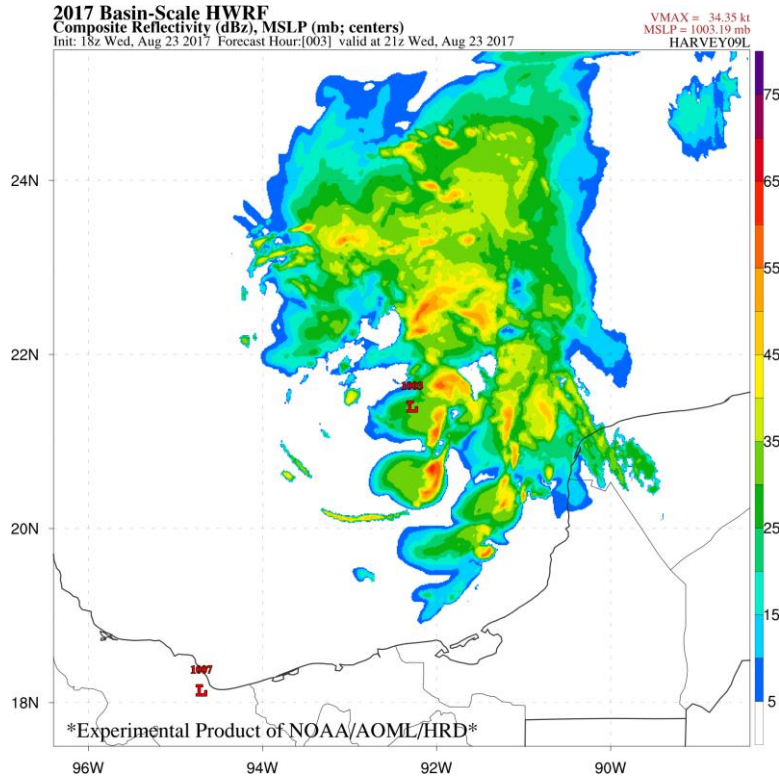


09L Harvey



Hurricane Harvey in HB17

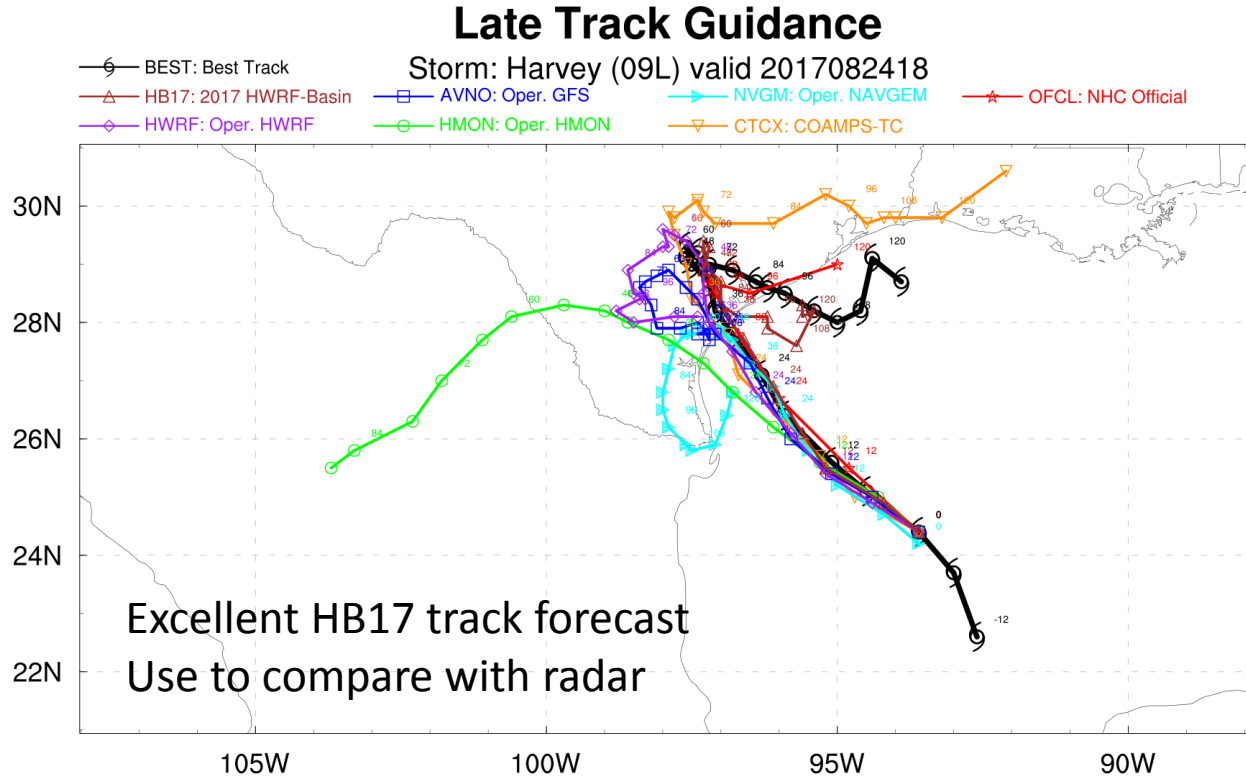
Rapid Intensification



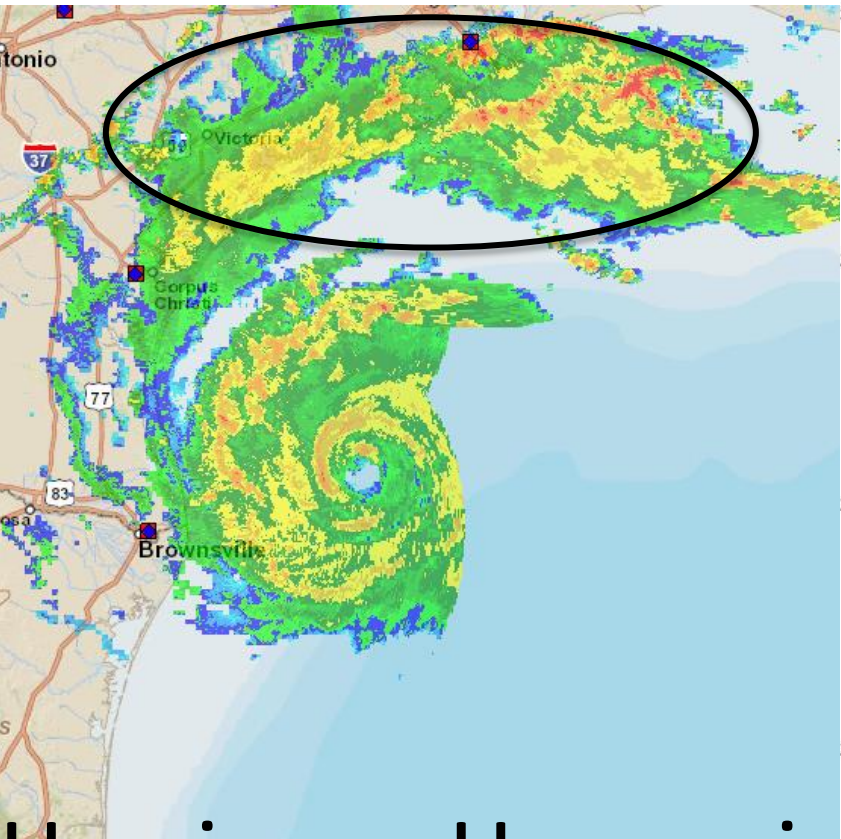
- Center “jumps” north early on in response to deep convection
- Rapid development of the inner core
- Evidence of double eyewalls and ERC
- The eye grows just before landfall in response to ERC
- Several rainbands near Houston

Hurricane Harvey in HB17

Radar Comparisons

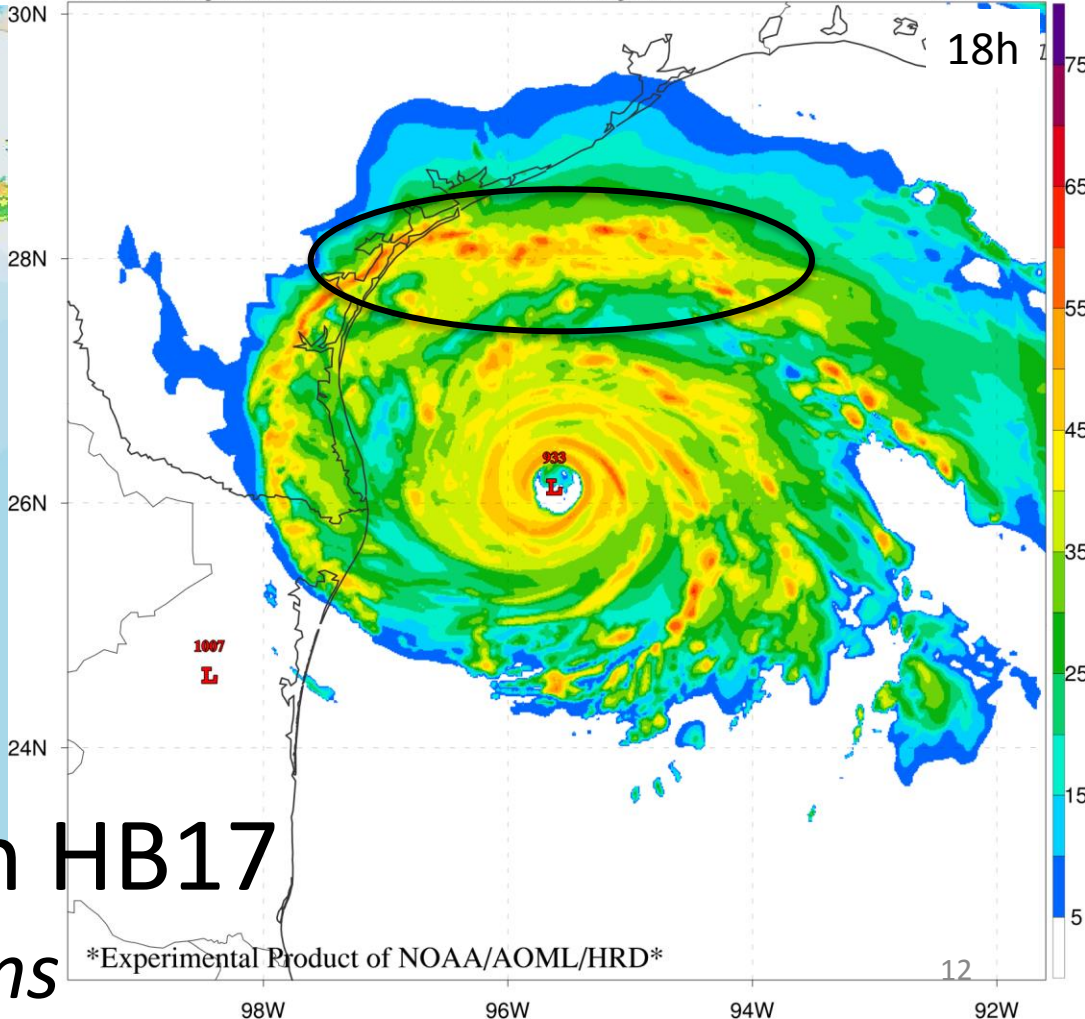


NEXRAD: 12z Fri., Aug. 25 2017



2017 Basin-Scale HWRF
Composite Reflectivity (dBz), MSLP (mb; centers)
Init: 18z Thu, Aug 24 2017 Forecast Hour:[018] valid at 12z Fri, Aug 25 2017

VMAX = 118.43 kt
MSLP = 932.80 mb
HARVEY09L

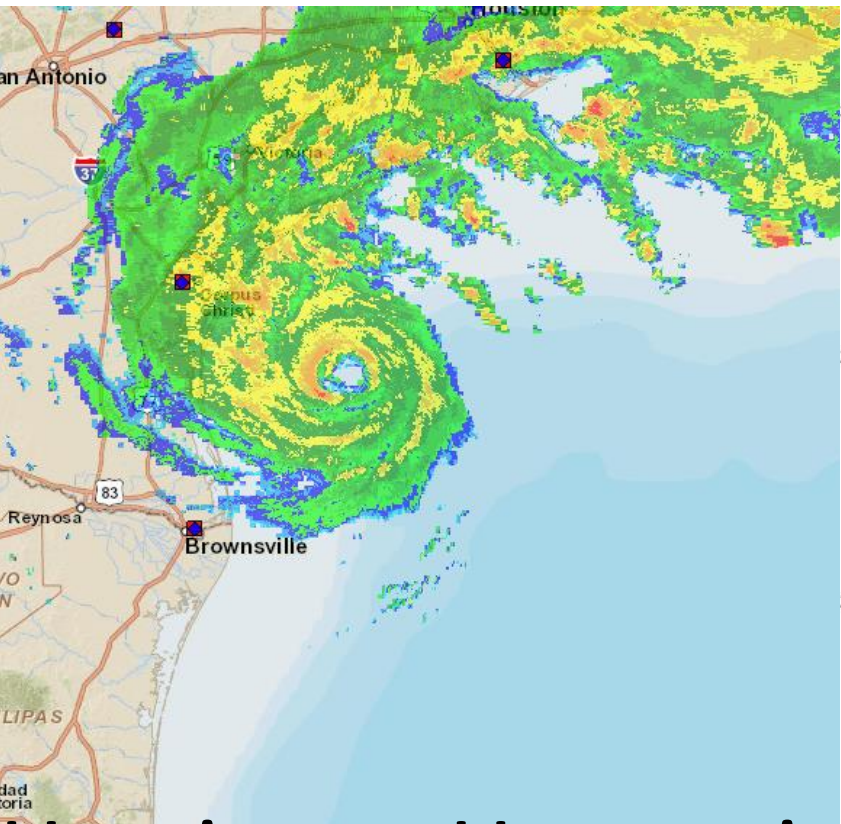


Hurricane Harvey in HB17
Radar Comparisons

Experimental Product of NOAA/AOML/HRD

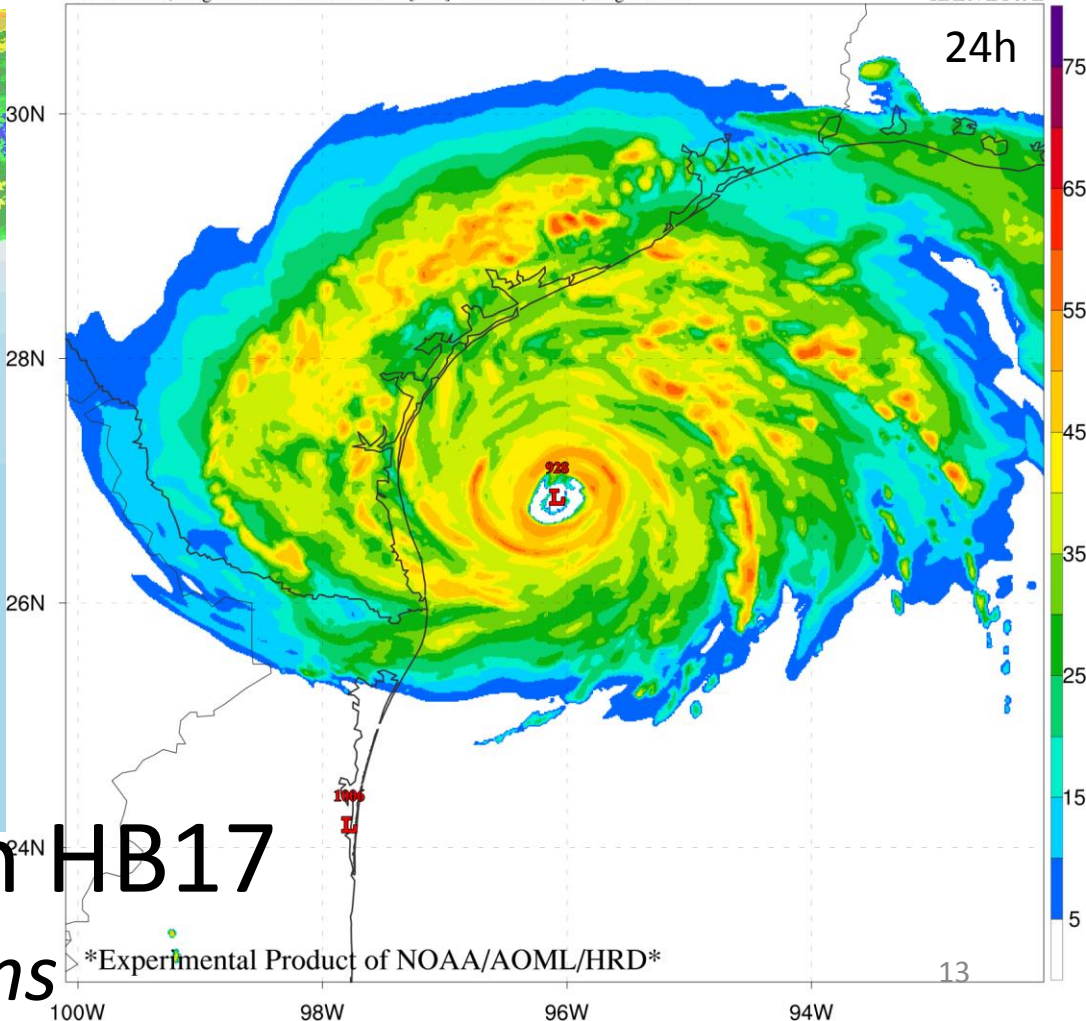
12

NEXRAD: 18z Fri., Aug. 25 2017



2017 Basin-Scale HWRP
Composite Reflectivity (dBz), MSLP (mb; centers)
Init: 18z Thu, Aug 24 2017 Forecast Hour:[024] valid at 18z Fri, Aug 25 2017

VMAX = 126.26 kt
MSLP = 927.33 mb
HARVEY09L



Hurricane Harvey in HB17
Radar Comparisons

NEXRAD: 00z Sat., Aug. 26 2017



2017 Basin-Scale HWRF

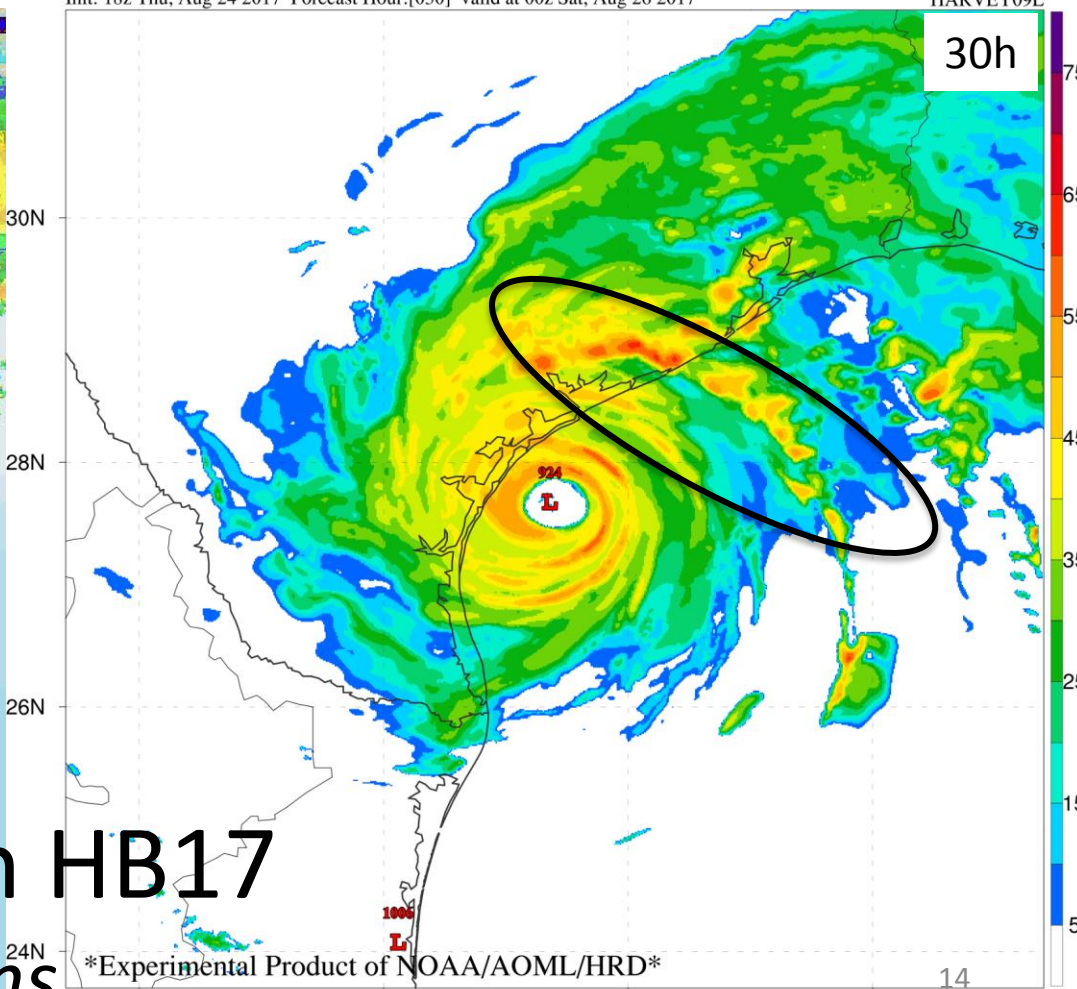
Composite Reflectivity (dBz), MSLP (mb; centers)

Init: 18z Thu, Aug 24 2017 Forecast Hour:[030] valid at 00z Sat, Aug 26 2017

VMAX = 126.29 kt

MSLP = 923.44 mb

HARVEY09L



Hurricane Harvey in HB17

Radar Comparisons

NEXRAD: 06z Sat., Aug. 26 2017



2017 Basin-Scale HWRP

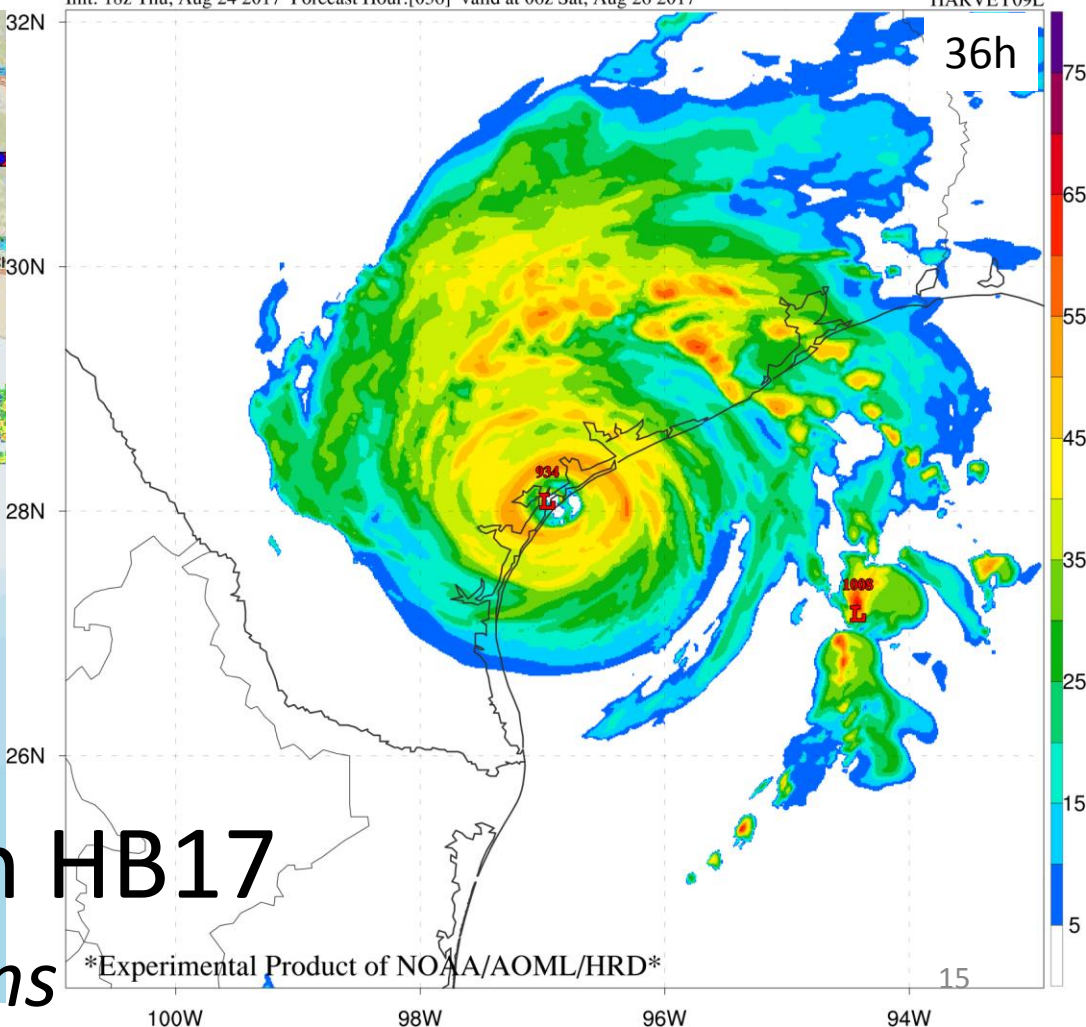
Composite Reflectivity (dBz), MSLP (mb; centers)

Init: 18z Thu, Aug 24 2017 Forecast Hour:[036] valid at 06z Sat, Aug 26 2017

VMAX = 107.39 kt

MSLP = 933.83 mb

HARVEY09L



Hurricane Harvey in HB17

Radar Comparisons

Experimental Product of NOAA/AOML/HRD

Hurricane Harvey in HB17

Rainfall

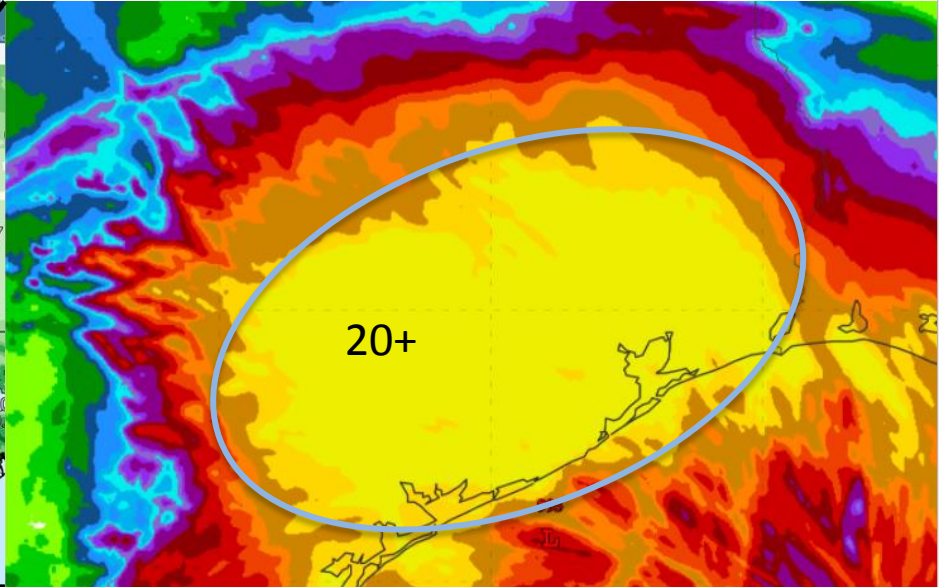
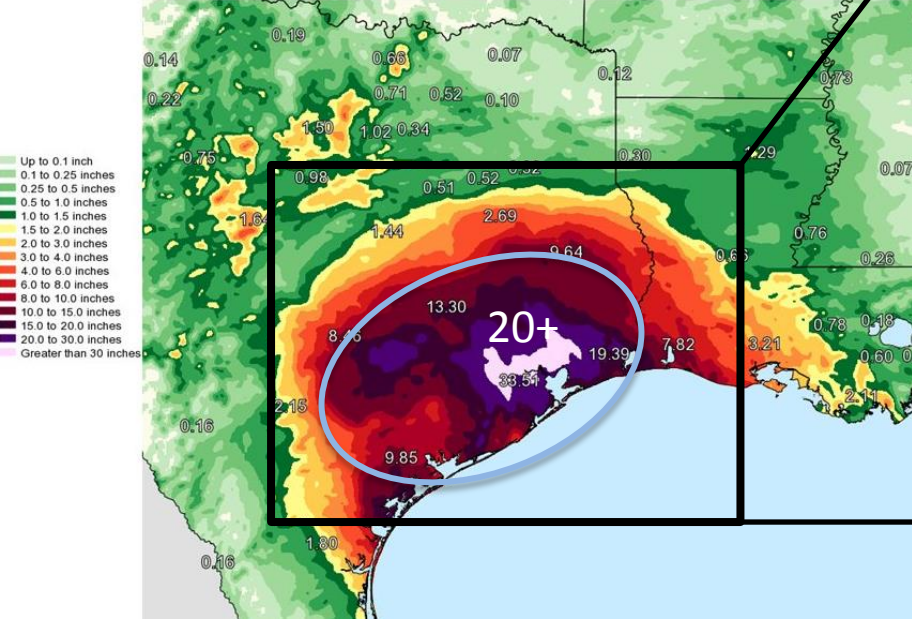
Observed

Model

Note: different color scale

Observed Precipitation

Valid Ending Monday August 28th, 2017 at 7 AM CDT



Source: NWS

HB17's good tracks result in reasonable rainfall forecasts


Hurricane Harvey in HB17

Severe Weather & Tornadoes

SPC Storm Reports for 08/25/17

Map updated at 1208Z on 08/29/17

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

 **TORNADO REPORTS.. (9)**
WIND REPORTS/HI..... (11/0)
HAIL REPORTS/LG..... (6/0)
TOTAL REPORTS..... (26)

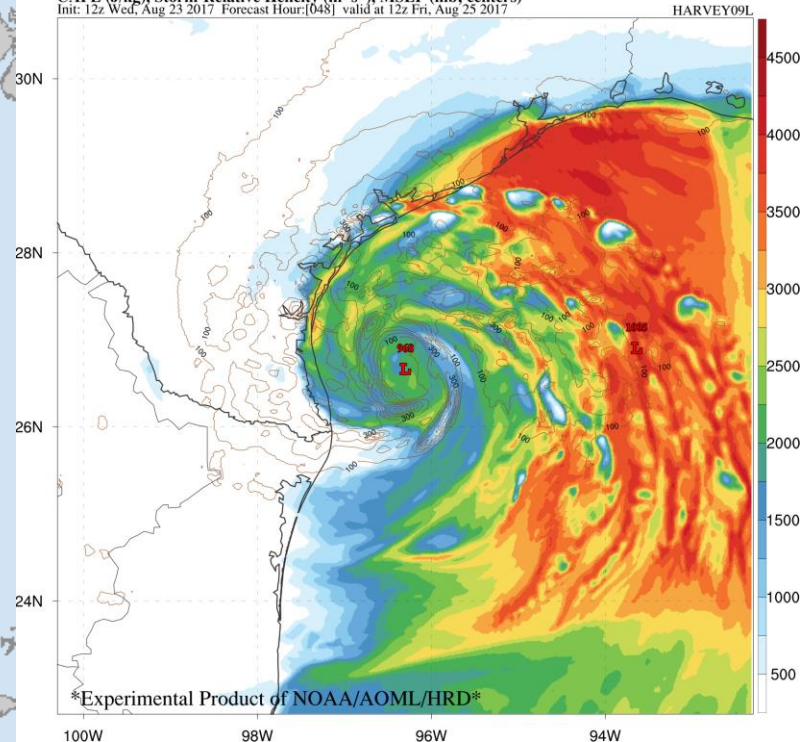
National Weather Service
Storm Prediction Center
Norman, Oklahoma



■ High Wind Report (65KT +)
■ Large Hail Report (2" dia. +)

PRELIMINARY DATA ONLY

2017 Basin-Scale HWRP
CAPE (J/kg), Storm-Relative Helicity ($m^2 s^{-2}$), MSLP (mb; centers)
Init: 12z Wed, Aug 23 2017 Forecast Hour:[048] valid at 12z Fri, Aug 25 2017

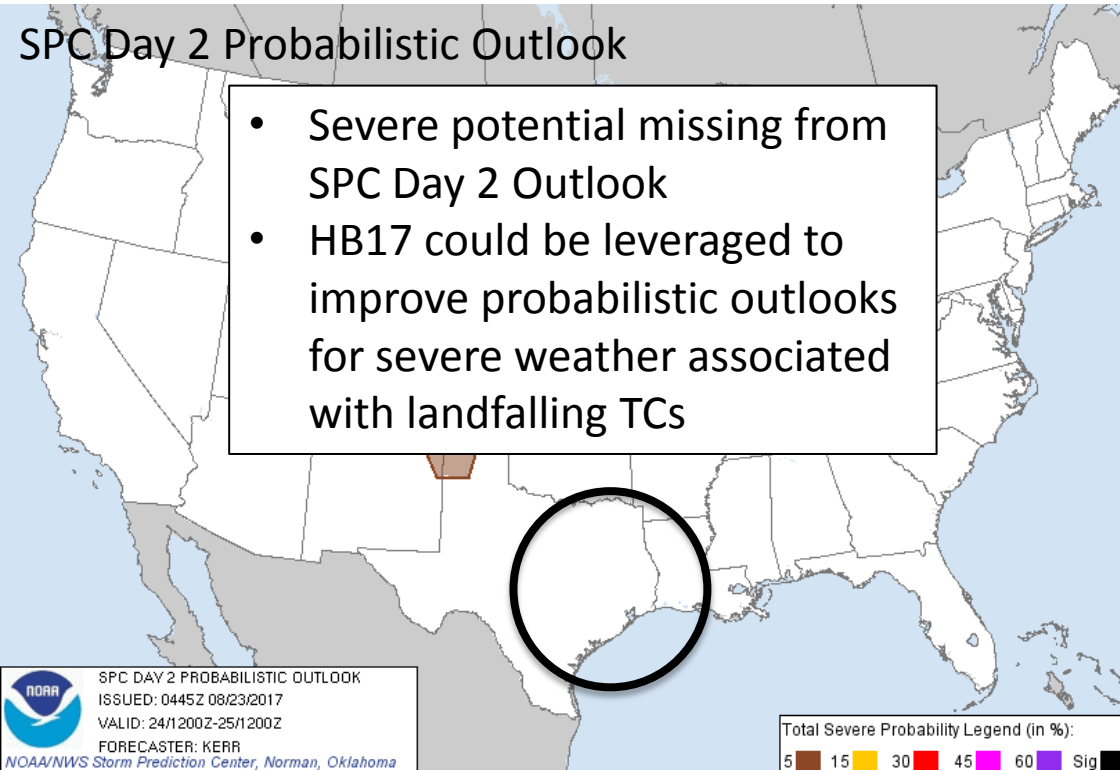


Hurricane Harvey in HB17

Severe Weather & Tornadoes

SPC Day 2 Probabilistic Outlook

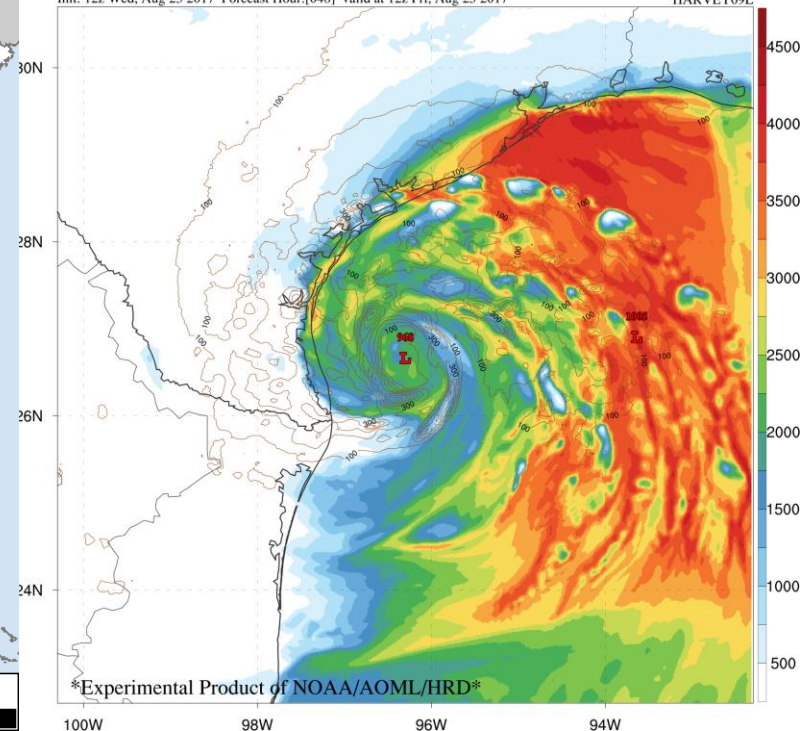
- Severe potential missing from SPC Day 2 Outlook
- HB17 could be leveraged to improve probabilistic outlooks for severe weather associated with landfalling TCs



2017 Basin-Scale HWRF

CAPE (J/kg), Storm-Relative Helicity ($m^2 s^{-2}$), MSLP (mb; centers)
Init: 12z Wed, Aug 23 2017 Forecast Hour:[048] valid at 12z Fri, Aug 25 2017

VMAX = 68.21 kt
MSLP = 968.29 mb
HARVEY09L

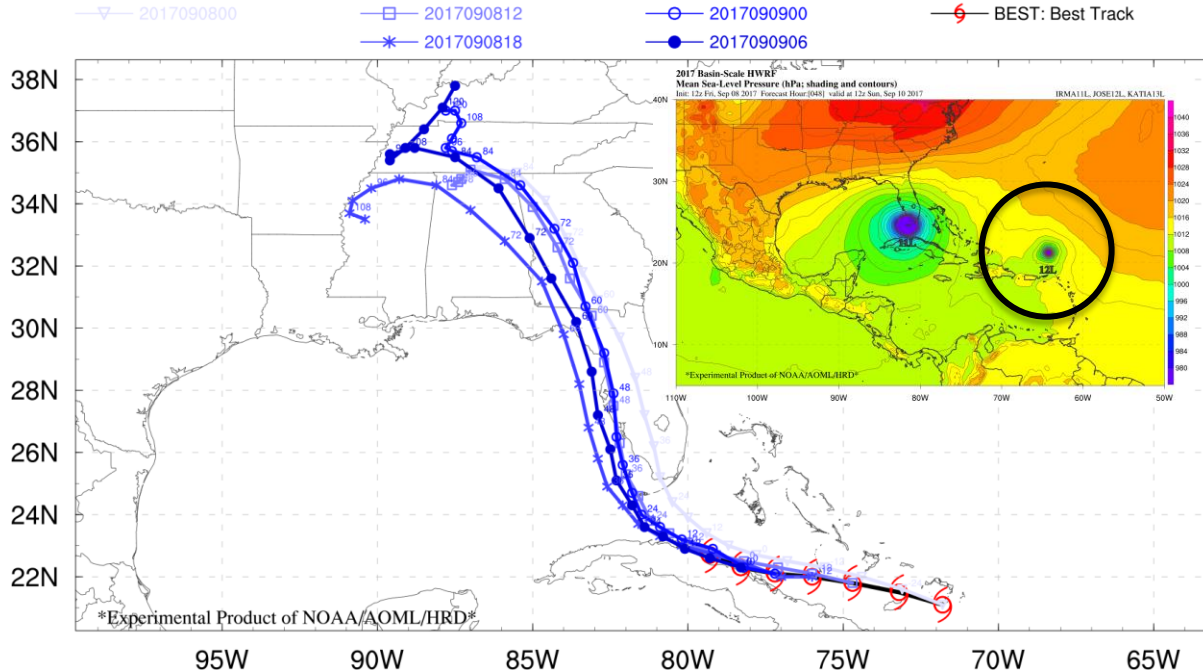


Hurricane Irma in HB17

Track Forecast Progression

HB17 Late Track Trend

Irma (11L) valid on 2017090906



Forecasts were consistently good throughout Irma's lifetime

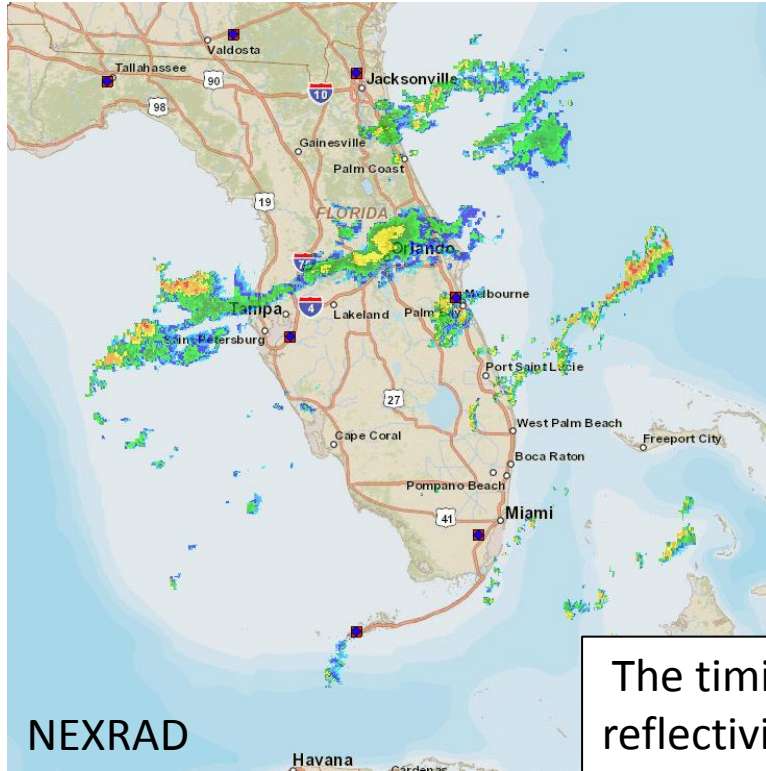
HB17 tracks shift West beginning cycle 2017090812

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



2017 Basin-Scale HWRF

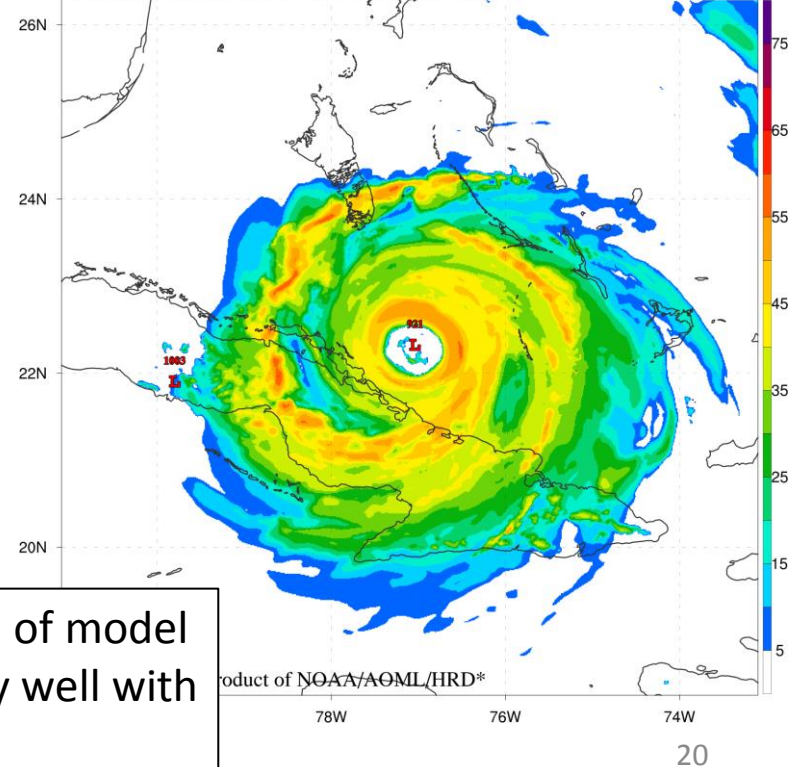
Composite Reflectivity (dBz), MSLP (mb; centers)

Init: 12z Fri, Sep 08 2017 Forecast Hour:[012] valid at 00z Sat, Sep 09 2017

VMAX = 137.78 kt

MSLP = 921.10 mb

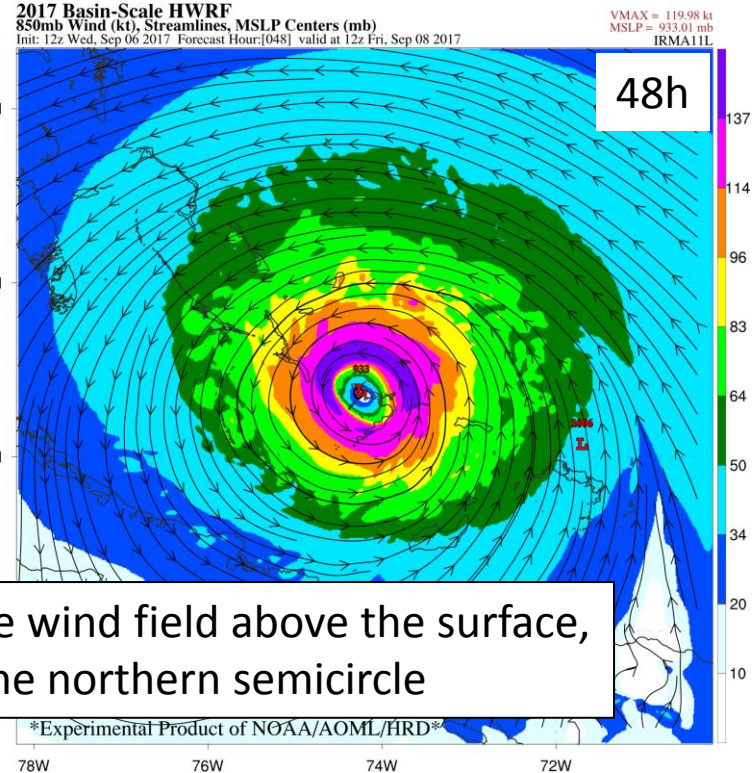
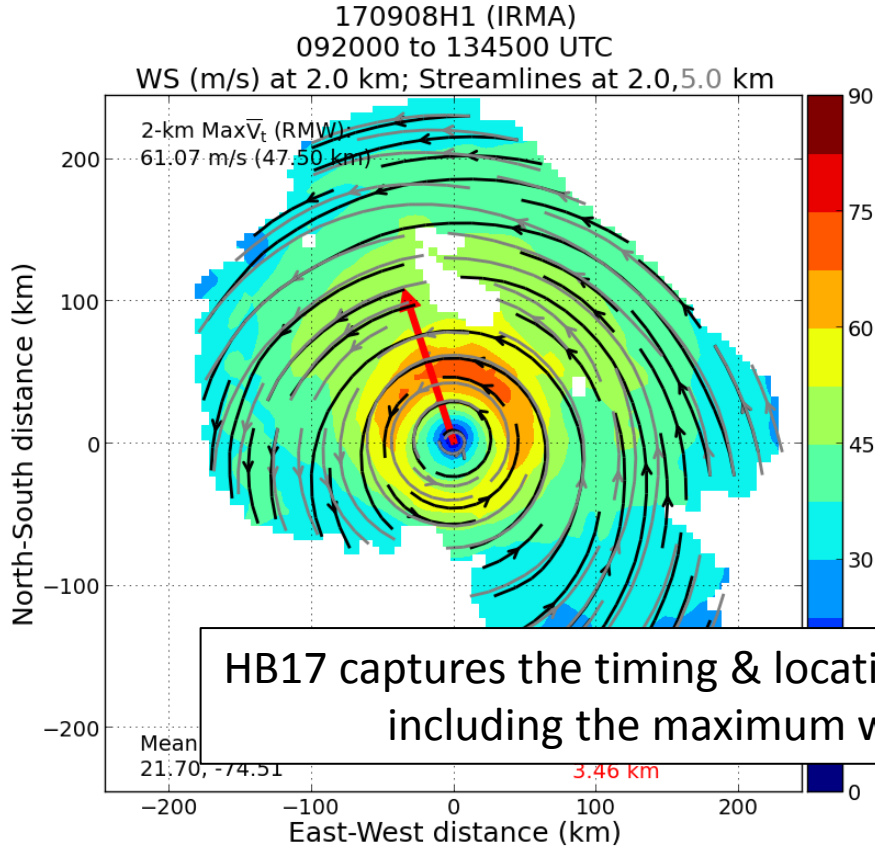
IRMA11L



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

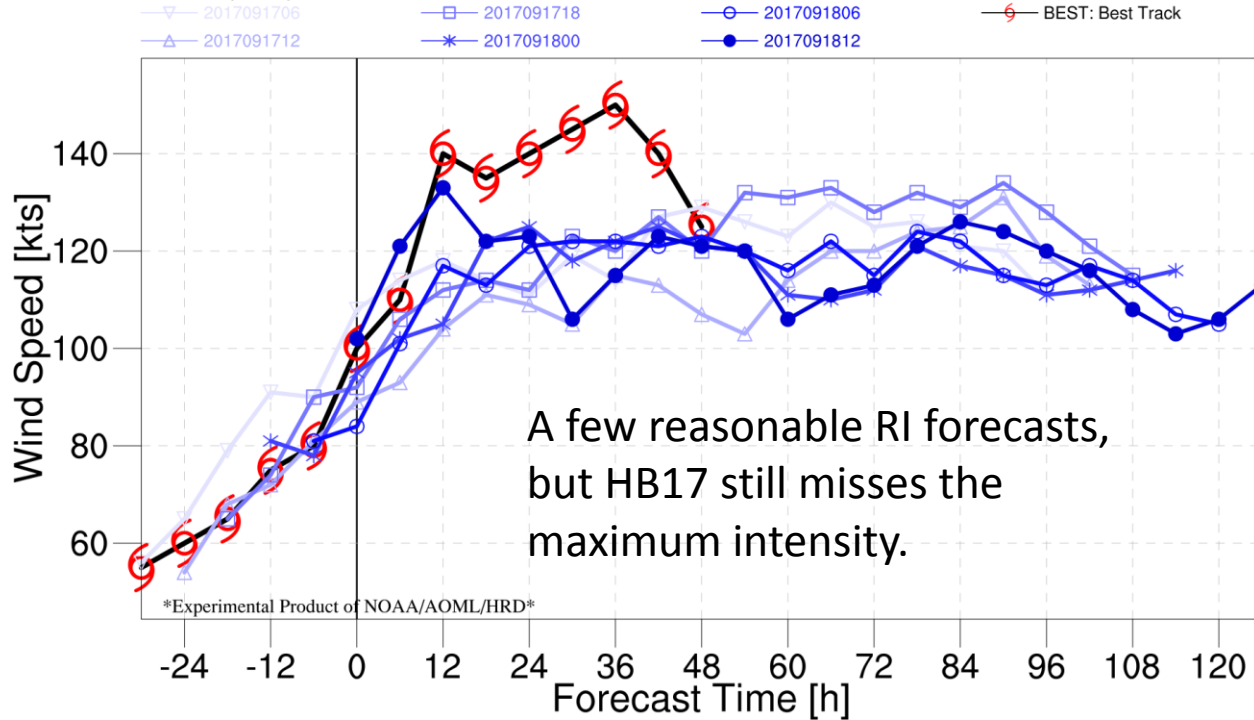
- HB17 performed very well for Hurricane Harvey and Hurricane Irma
 - Low track errors for Hurricane Harvey
 - Low 120 h track error for Hurricane Irma
- Initial evaluation show the potential utility of HB17 forecasts for a variety of applications
 - Rapid Intensification, Rainfall, Severe Weather, Vortex 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

HB17 Late Intensity Trend

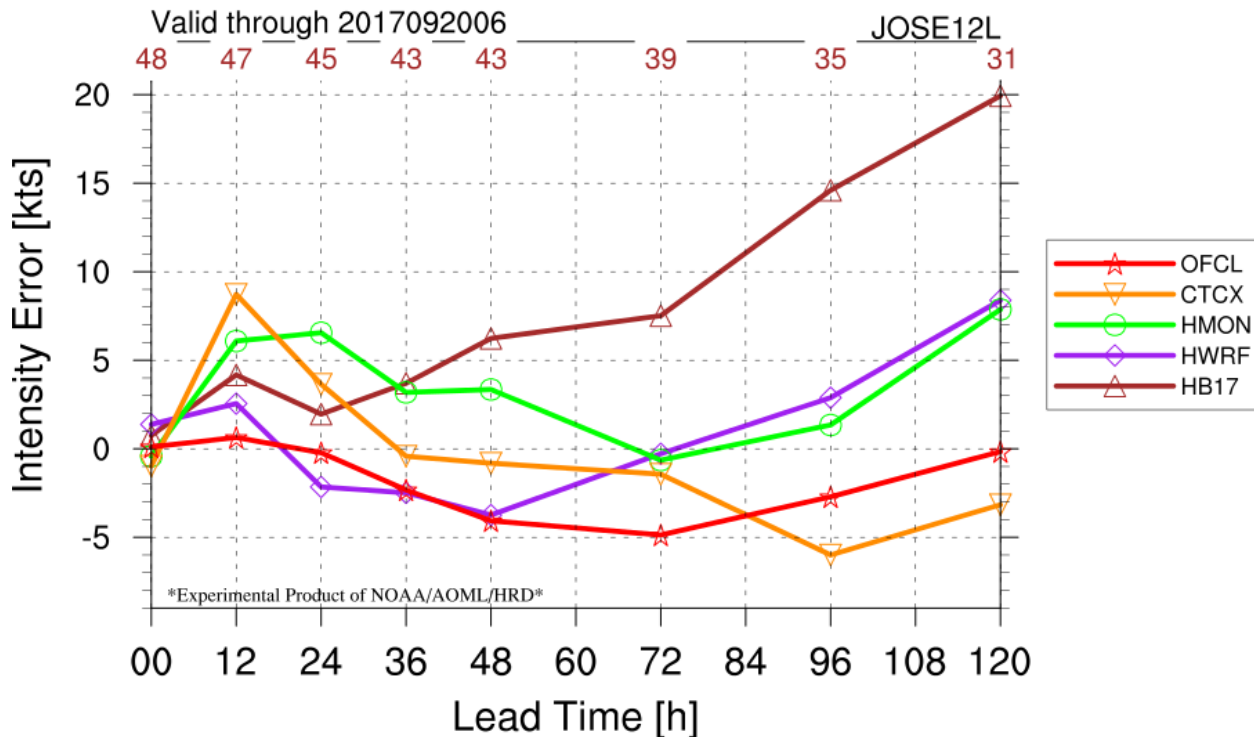
Maria (15L) initialized on 2017091812



Hurricane Jose in HB17

Positive Intensity Bias

LATE INTENSITY ERROR (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?

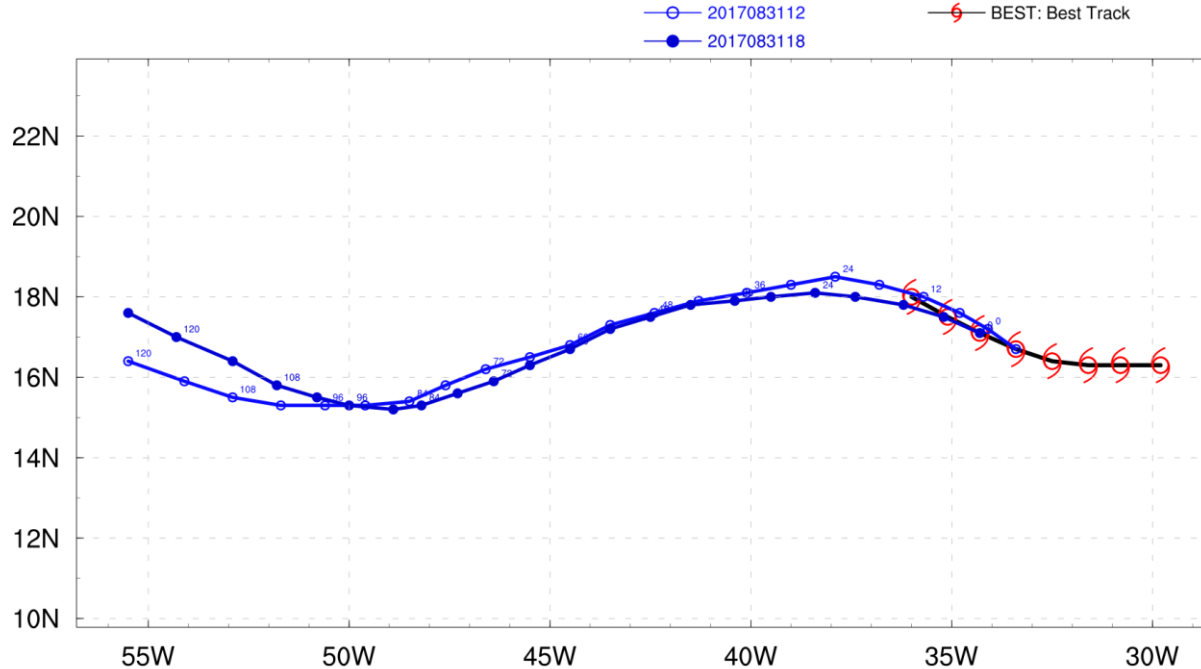
Extra Slides

Hurricane Irma in HB17

Track Forecast Progression

HB17 Late Track Trend

Irma (11L) valid on 2017083118

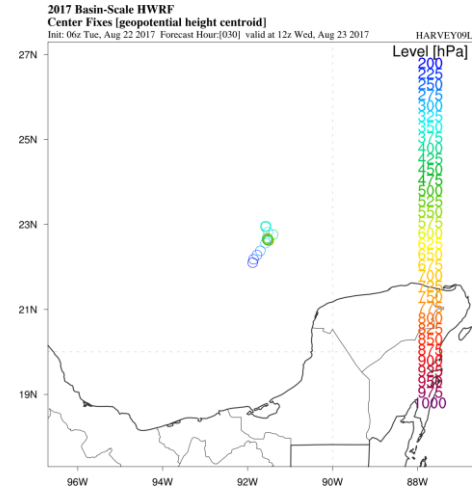
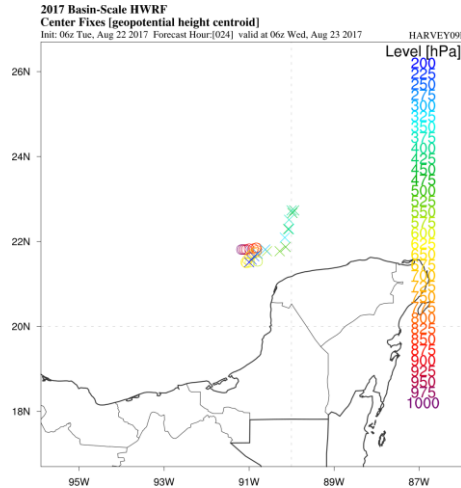
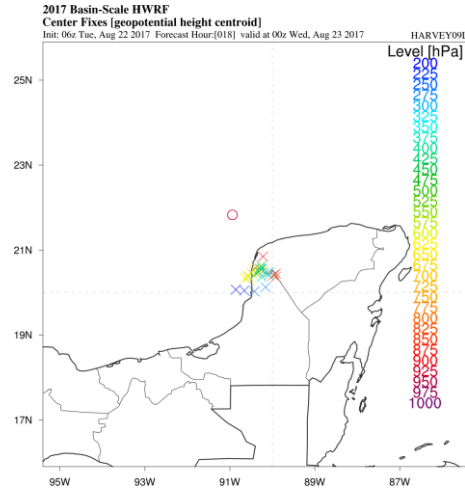
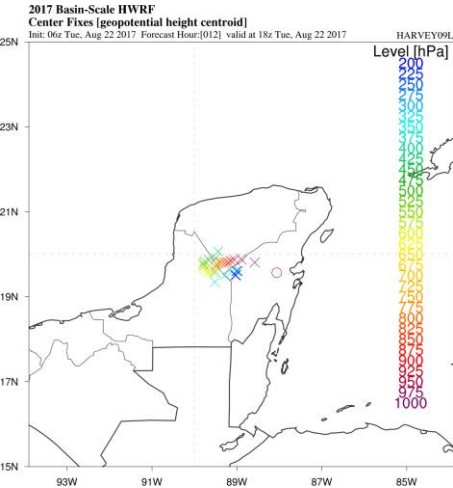


Forecasts were consistently good throughout Irma's lifetime

HB17 tracks shift West beginning cycle 2017090812

Hurricane Harvey in HB17

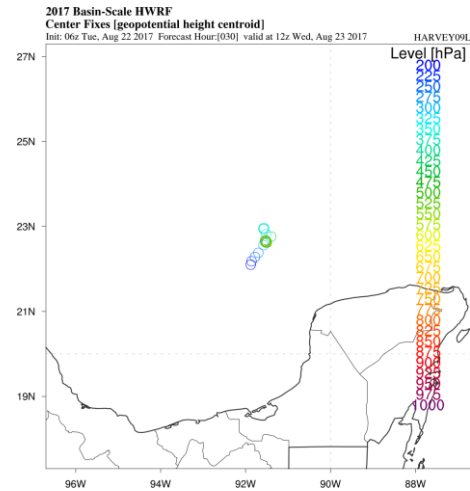
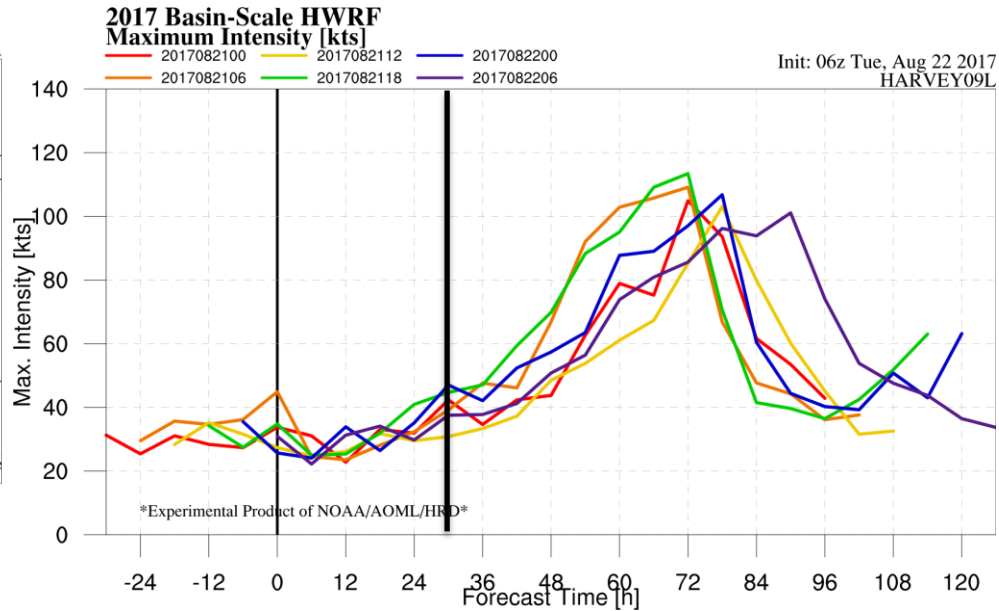
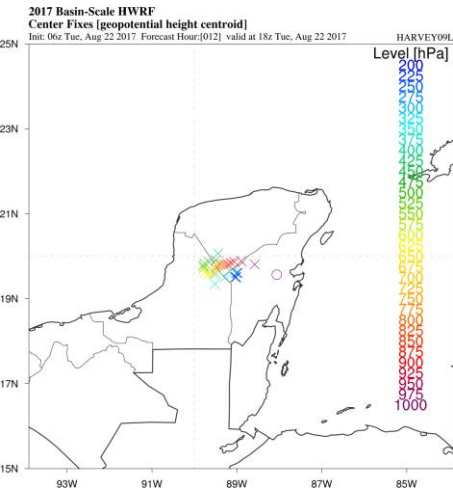
Vortex Tilt/Alignment



1. Calculate the geopotential height centroid at every level in a $10^{\circ} \times 10^{\circ}$ 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

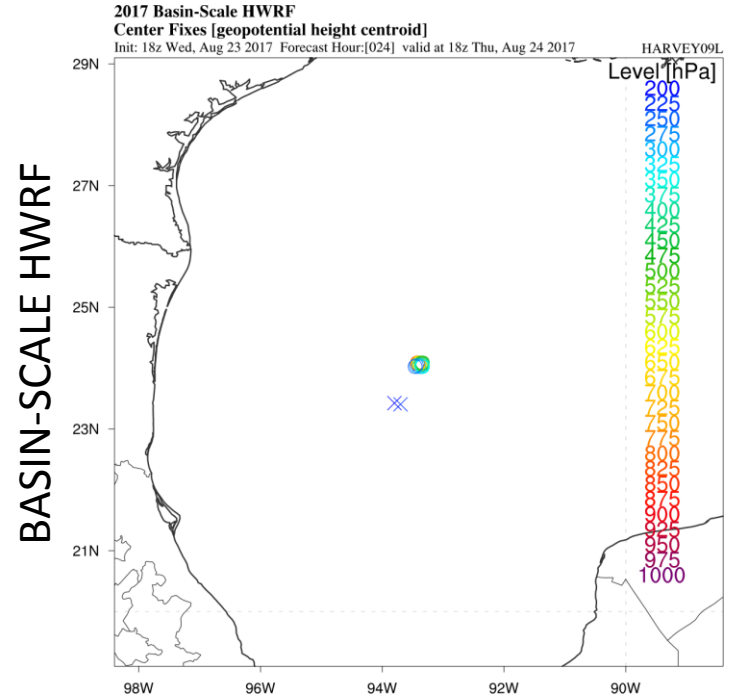
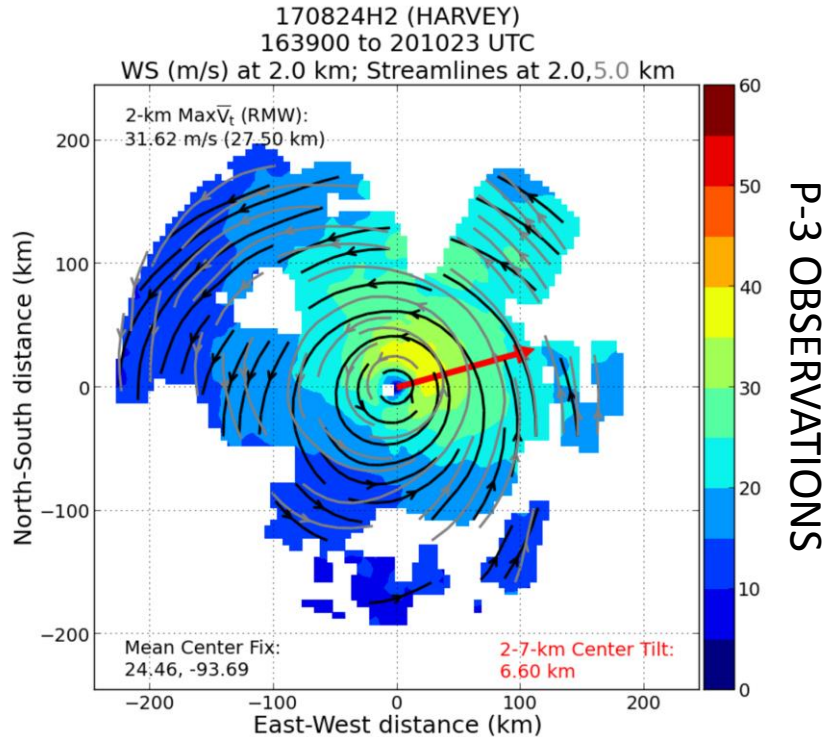
Vortex Tilt/Alignment



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

Hurricane Harvey in HB17

Vortex Tilt/Alignment – P-3 Comparison

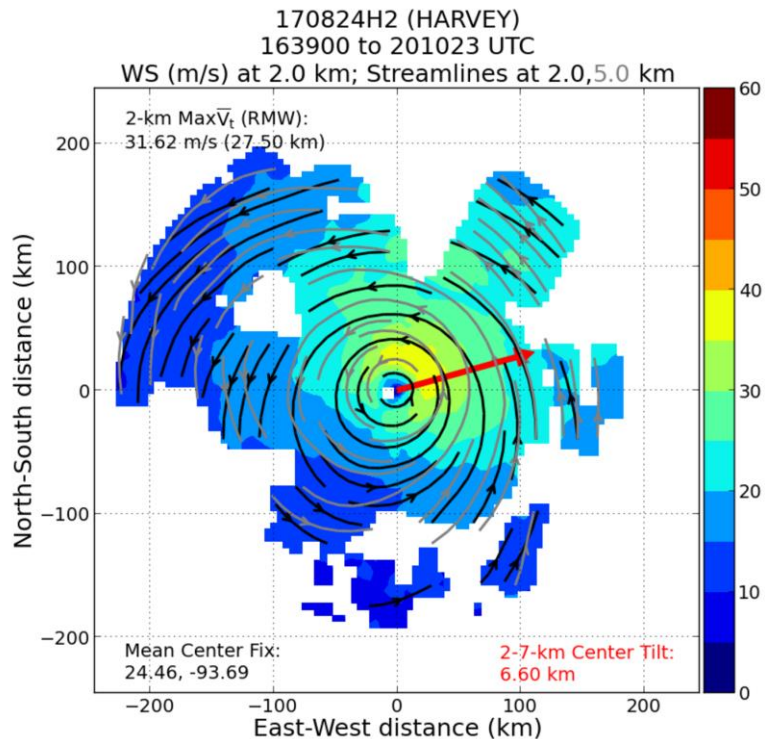


- Red arrow shows the tilt direction
- Harvey is showing a tilt to the ENE

HB17 vortex is generally well-aligned,
consistent with observations

Hurricane Harvey in HB17

Vortex Tilt/Alignment – P-3 Comparison



2017 Basin-Scale HWRP

Center Fixes [geopotential height centroid]

Init: 18z Wed, Aug 23 2017 Forecast Hour:[024] valid at 18z Thu, Aug 24 2017



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

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