

# Recent COAMPS-TC Development and Future Plans

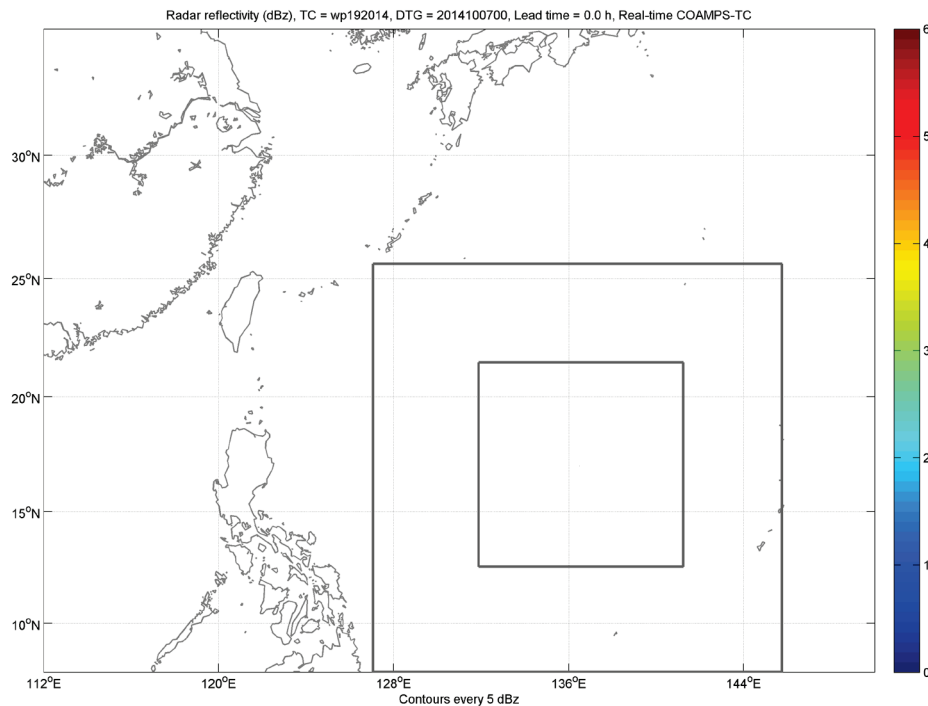
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Hao Jin, Yi Jin, Will Komaromi, Alex Reinecke, David Ryglicki,  
Dan Stern<sup>2</sup>, Shouping Wang**

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<sup>1</sup>SAIC, <sup>2</sup>UCAR

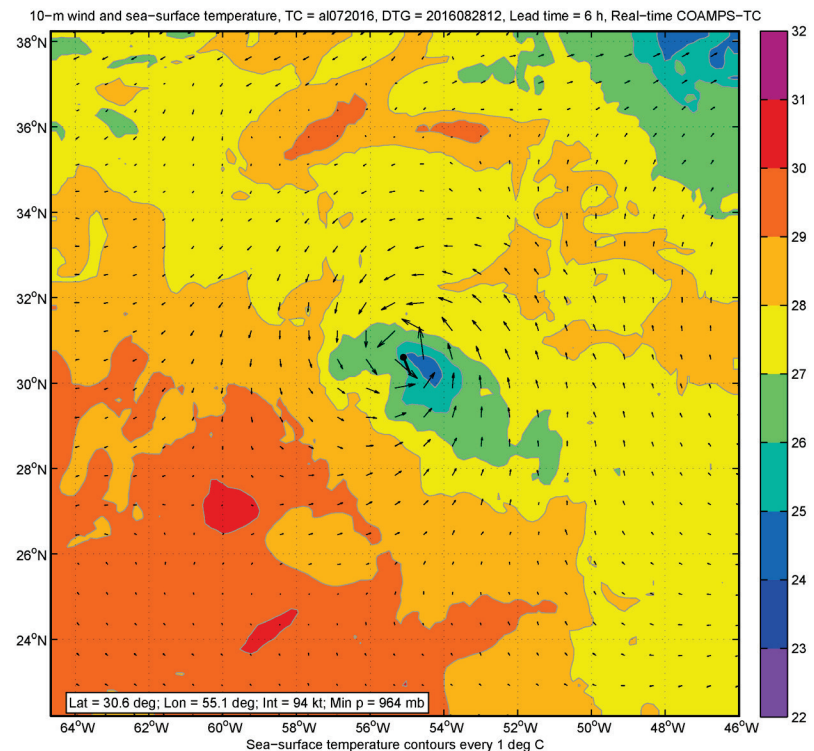
**Sponsors ONR, NRL, NOAA HFIP**

- **Analysis:** Cycling or no cycling: 3D-Var (NAVDAS), 4D-Var, EnKF DART
- **Atmos.:** Nonhydrostatic, moving nests, TC physics
- **Ocean:** 3D-Var (NCODA), ocean (NCOM), wave options (SWAN, WWIII)
- **Ops.:** 36-12-4km (2017); COTC (NAVGEM) & CTCX (GFS)
- **Ensemble:** 36-12-4km (2017); 11 member CTCX ensemble (w/ HWRF, HMON)

Vongfong (2014) Simulated Radar Reflectivity



Gaston (07L) (12Z 28 Aug 2016)



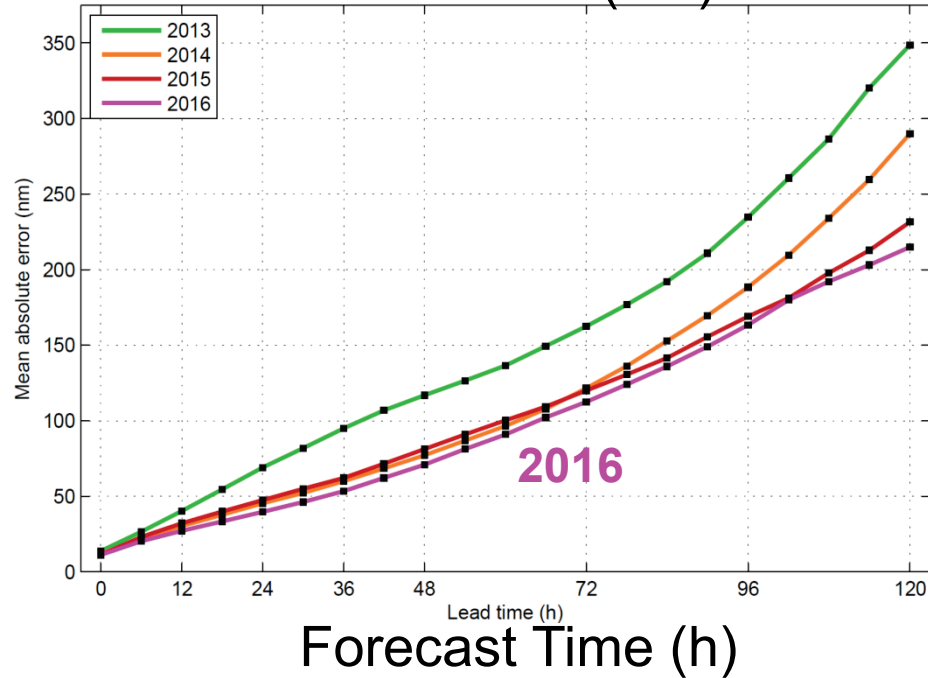


# COAMPS Performance History

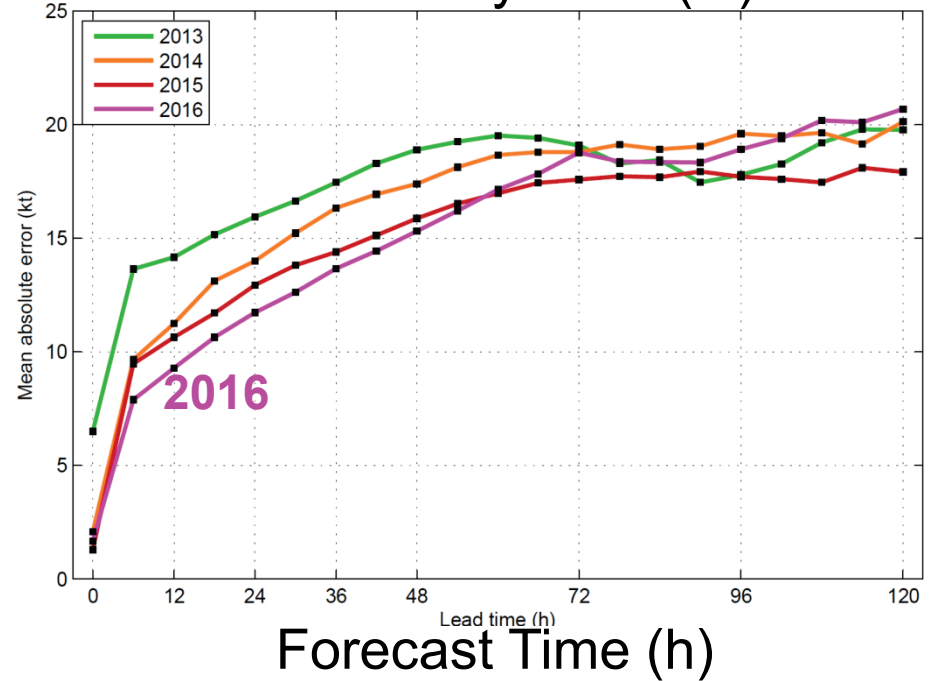
## 2013-2016 (AL/EP/CP/WP)



### Track Error (nm)



### Intensity Error (kt)

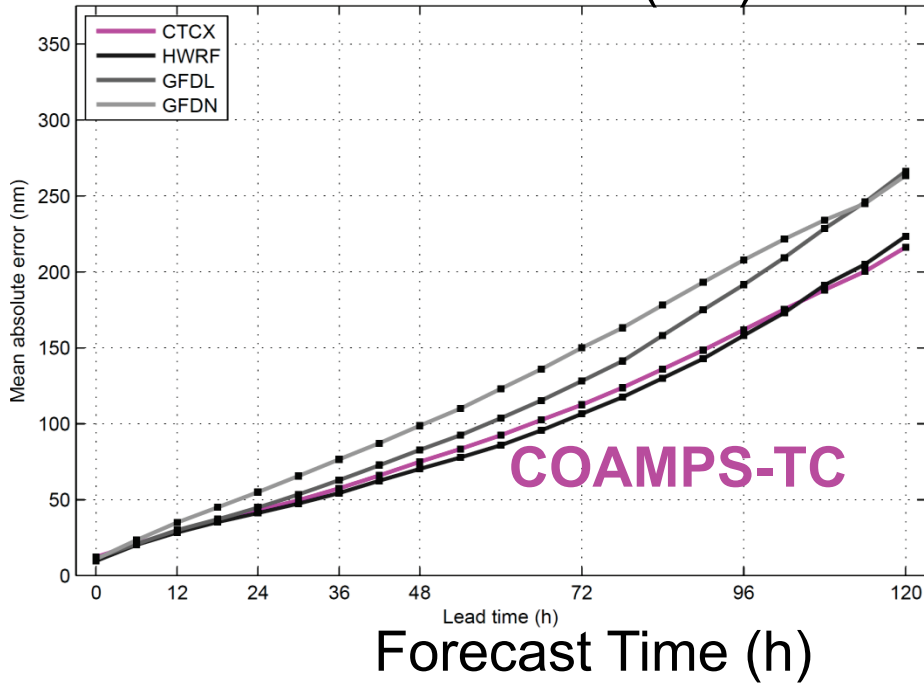


**Marked improvement in COAMPS-TC (CTCX) track and intensity forecasts over time (non-homogeneous sample)**

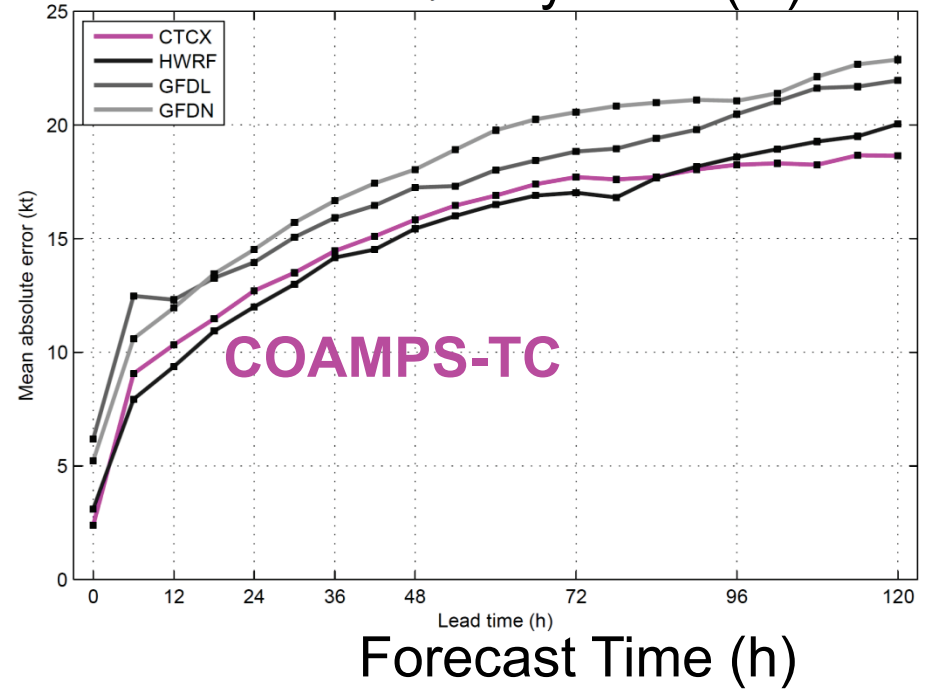
# COAMPS Operational Statistics

## 2015-2016

### Track Error (nm)



### Intensity Error (kt)



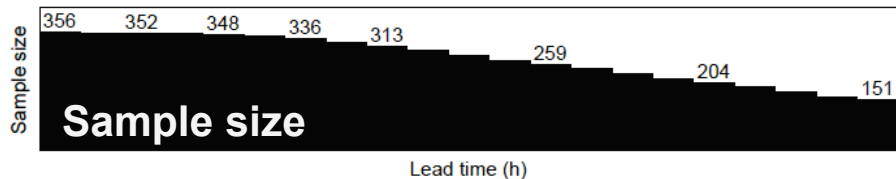
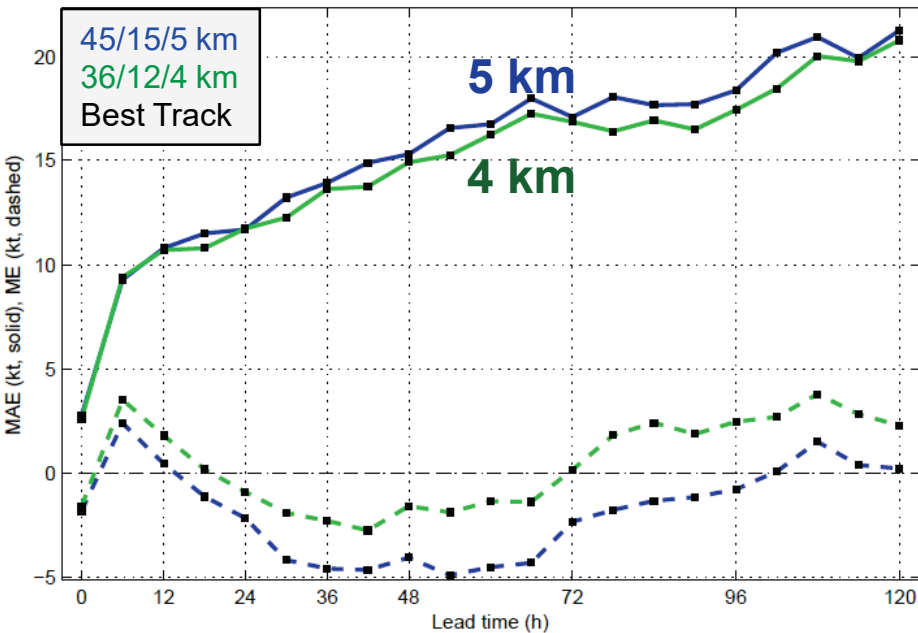
COAMPS-TC (CTCX) has performed very well compared with other leading models for the 2015-2016 time period (AL/EP/CP/WP)



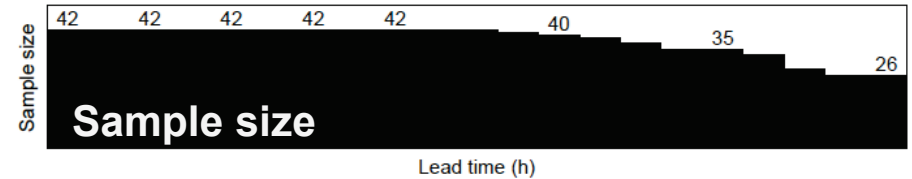
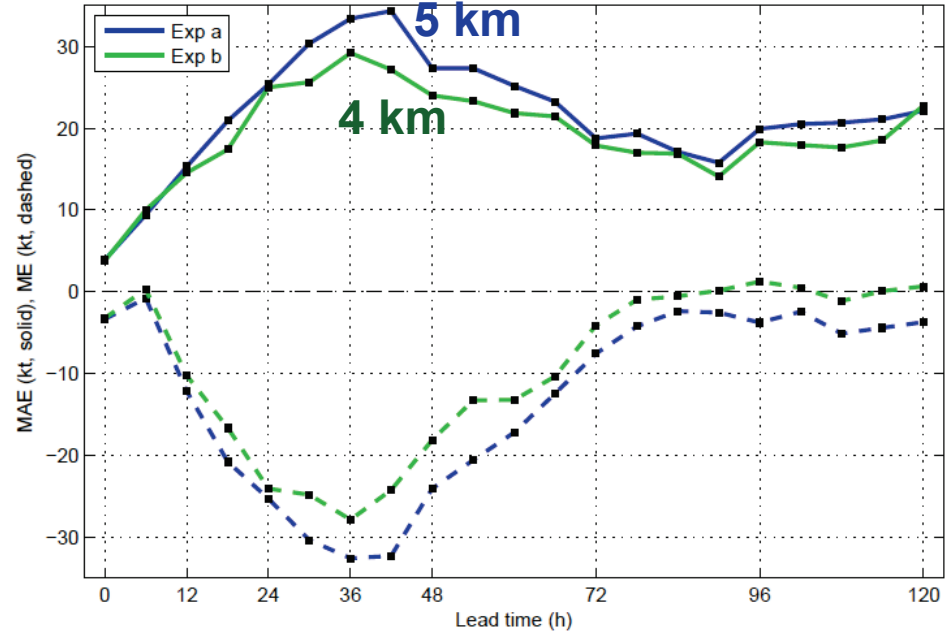
## Atlantic/EastPac/WestPac

## TCs observed to rapidly intensify (0-24 h)

Intensity MAE (solid) and ME (dashed)



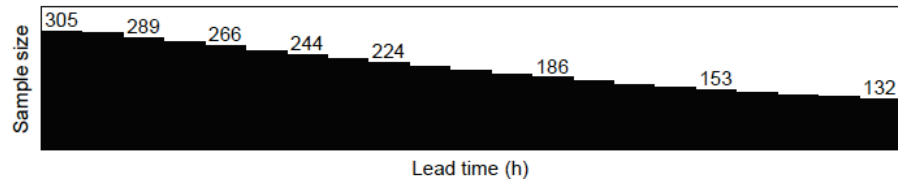
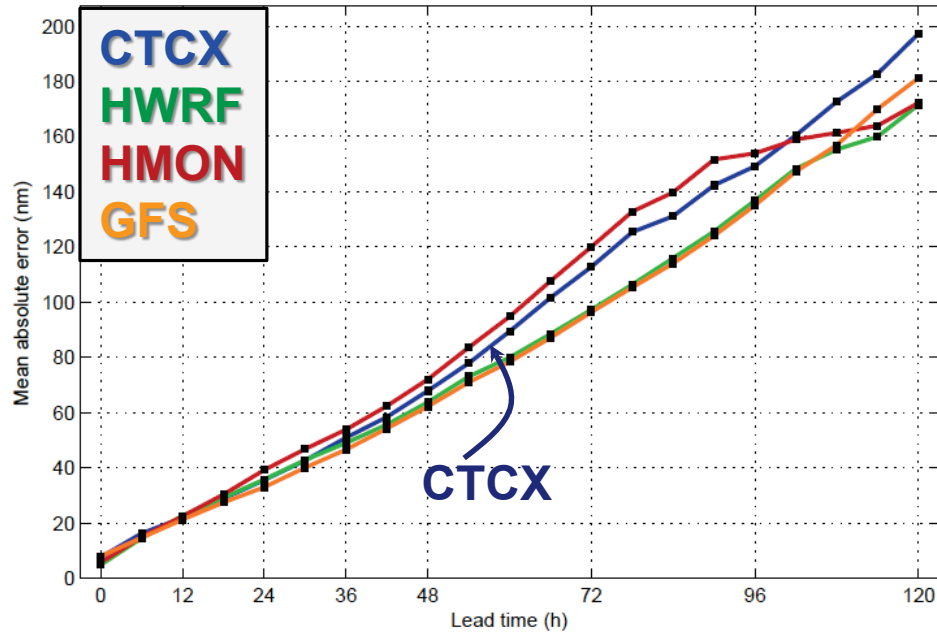
Intensity MAE (solid) and ME (dashed)



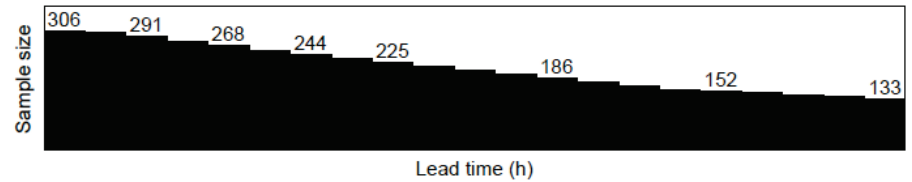
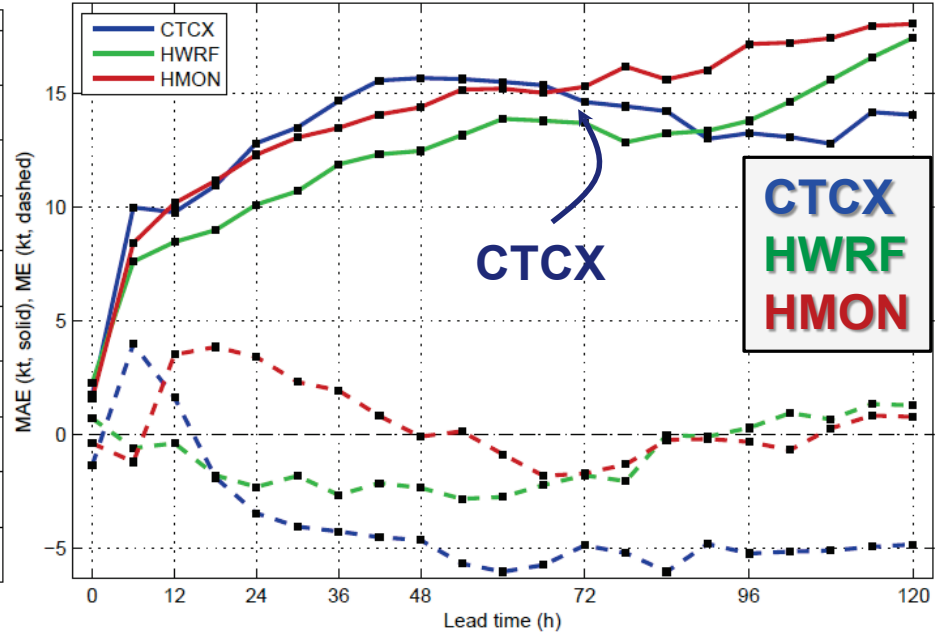
- 2017 version of COAMPS-TC with 4 km horizontal resolution.
- Intensity MAE is improved (5-10% improvement over 2016)
- Forecasts are particularly improved for TCs with observed RI

## Atlantic Basin

### Position Error



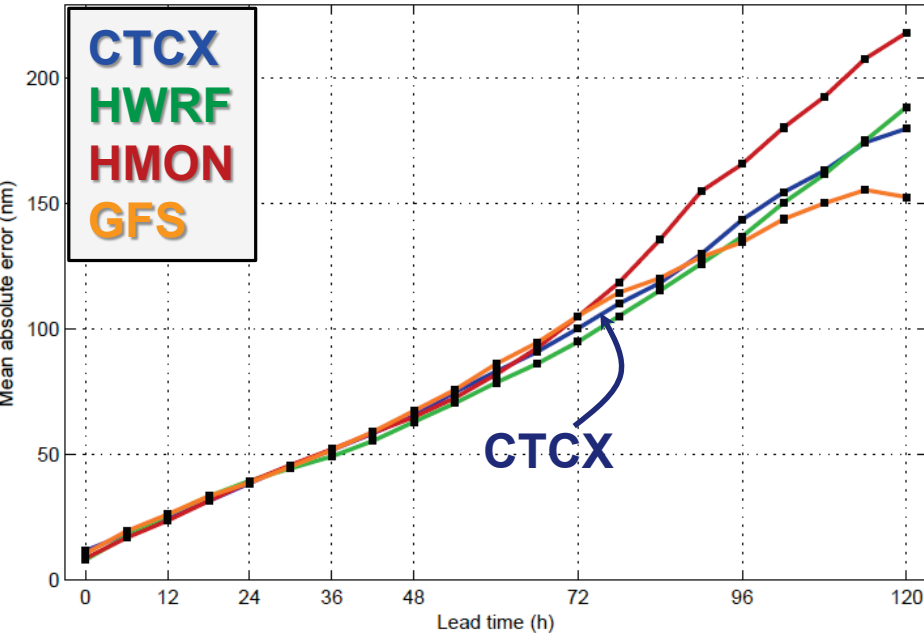
### Intensity Error & Bias



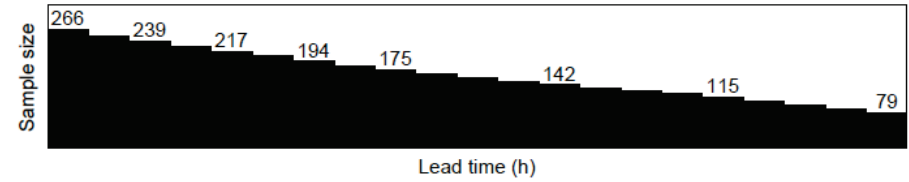
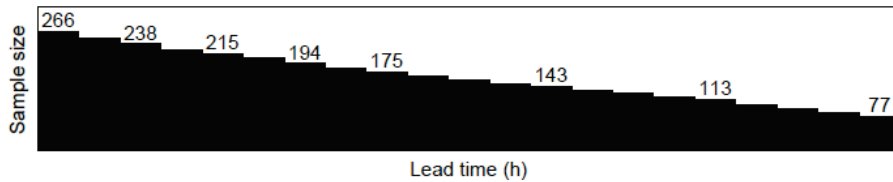
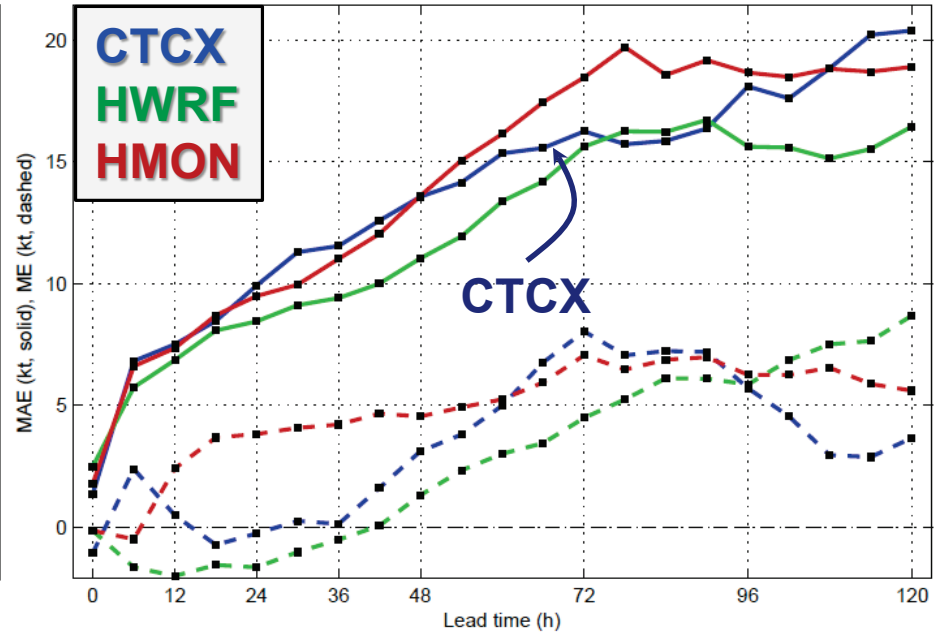
- CTCX (GFS based) track close to GFS & HWRF thru 48h; trailed 10-20 nm after 60h
- CTCX intensity had a worse spin-up problem (0-12h) in 2017 than 2016
- CTCX intensity top performer after 84h (despite bias)

## Eastern Pacific

**Position Error**



**Intensity Error & Bias**

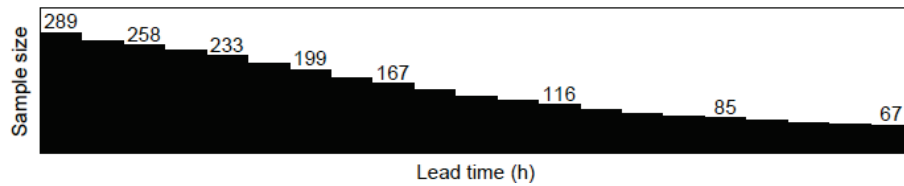
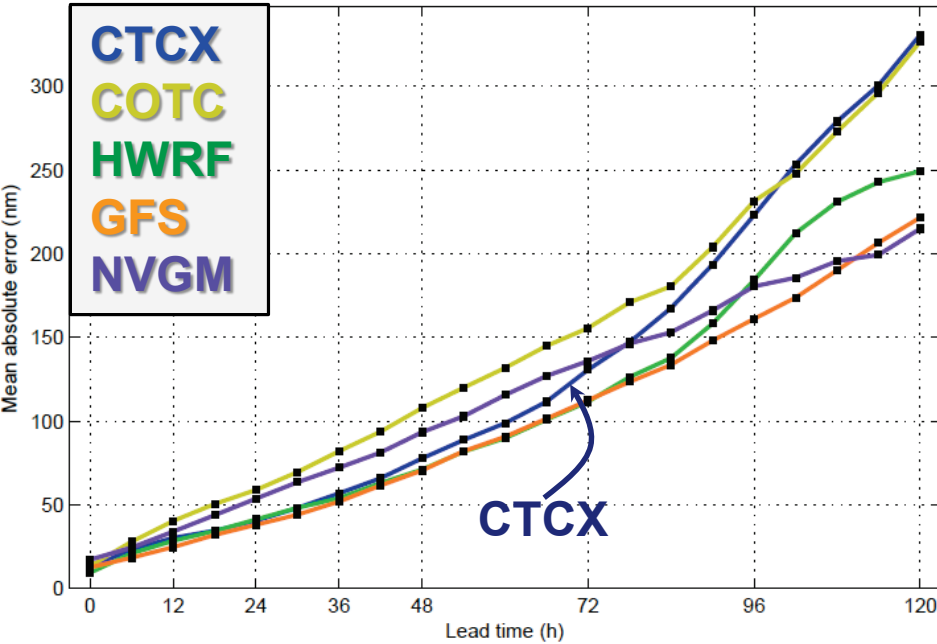


- CTCX (GFS based) track very close to HWRF thru 120h; trails GFS 20 nm after 96h
- CTCX intensity trailed HWRF by 1-2.5 kt through 72h

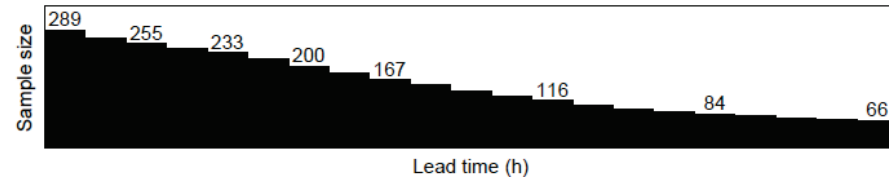
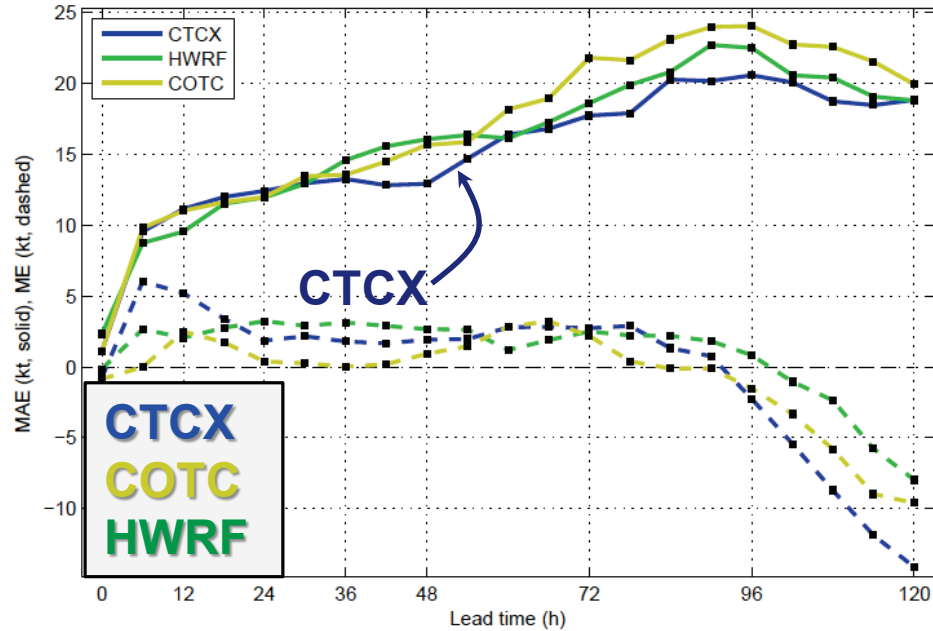


## Western Pacific

### Position Error



### Intensity Error & Bias



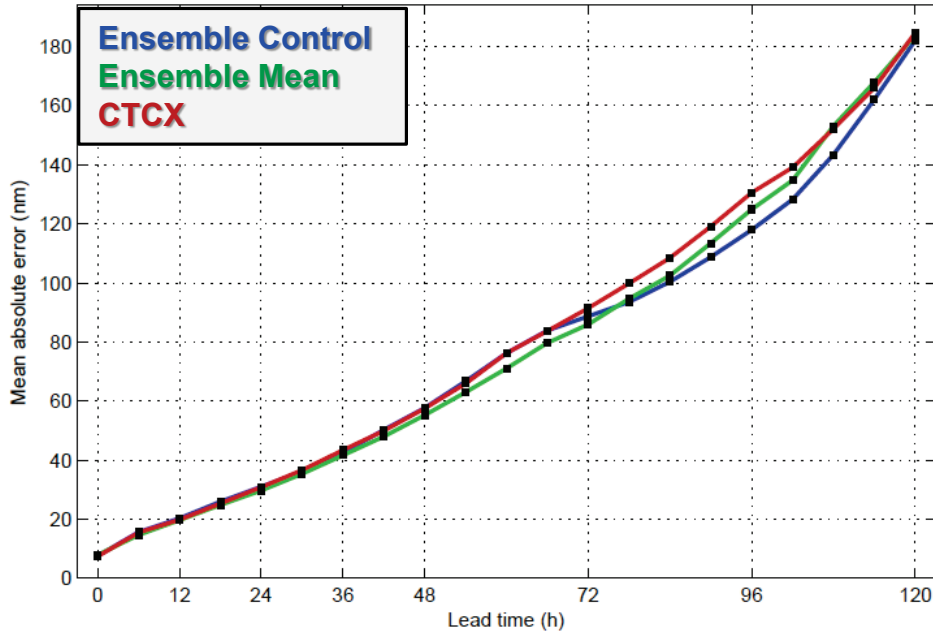
- CTCX (GFS based) track trails HWRF 10-25 nm after 48h, 70 nm at 120h (NE bias)
- COTC (NAVGEM based) track trails NAVGEM, CTCX
- CTCX generally top performer for intensity; COTC is close through 60h

# COAMPS-TC Ensemble System

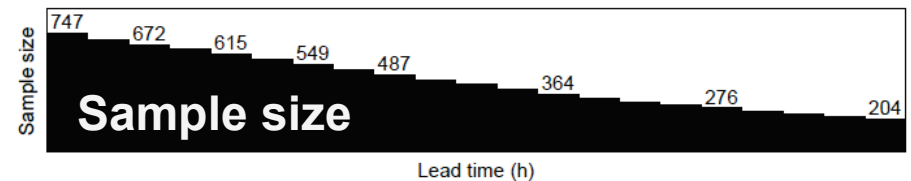
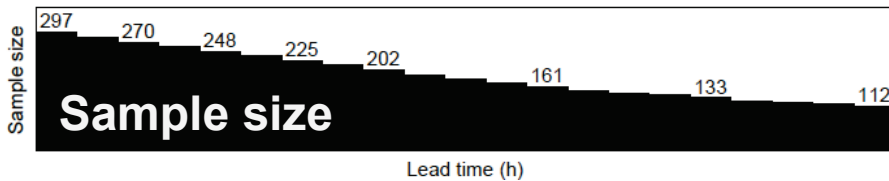
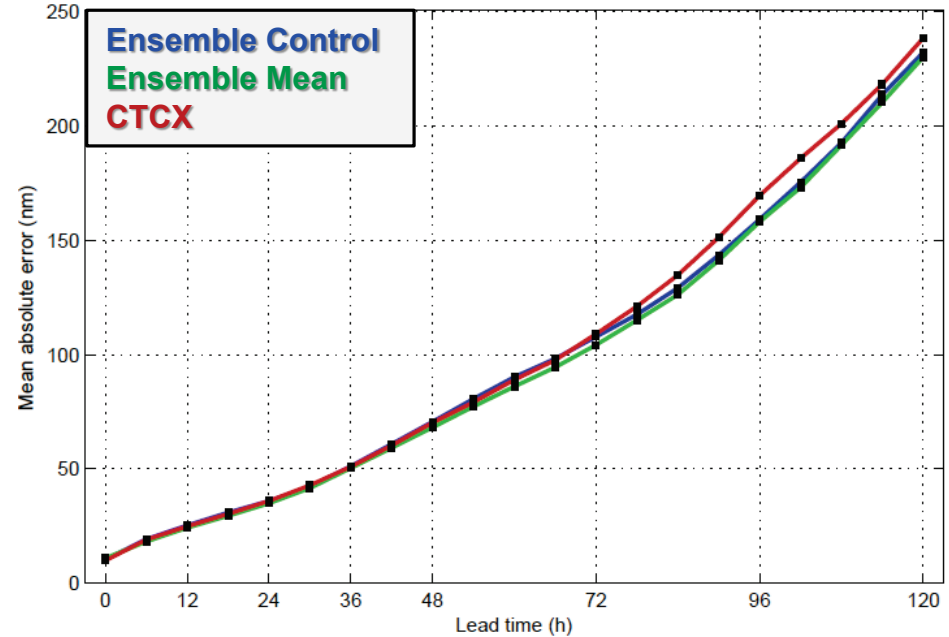
## 2017 Track Statistics

### Ensemble control vs Ensemble mean vs CTCX

**ATL Track MAE**



**ATL/EPAC/WPAC Track MAE**



- Ensemble mean outperforms CTCX
- Ensemble mean similar or better MAE w.r.t. control for most lead times

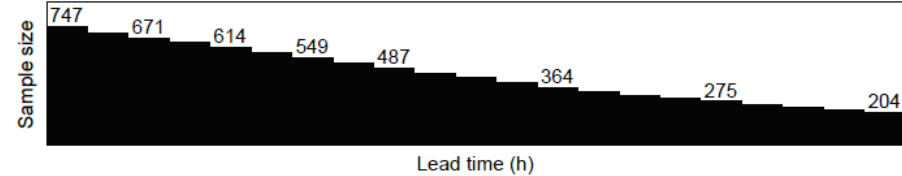
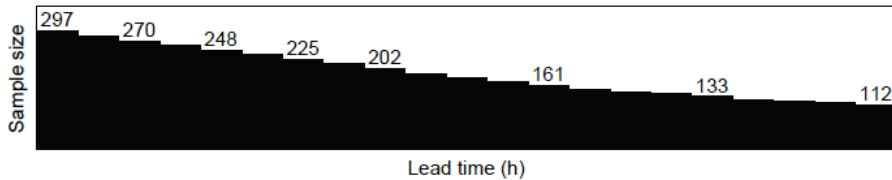
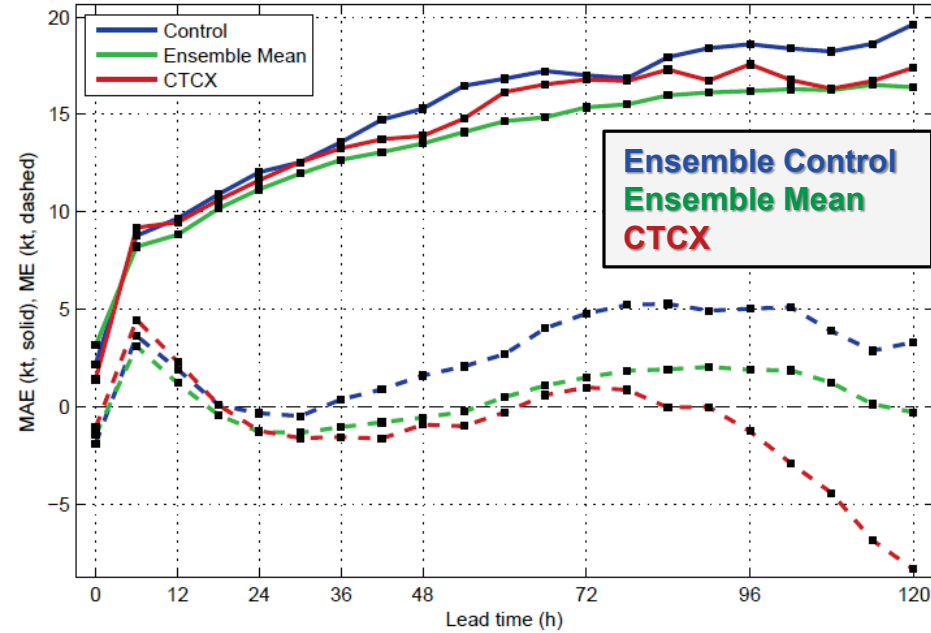
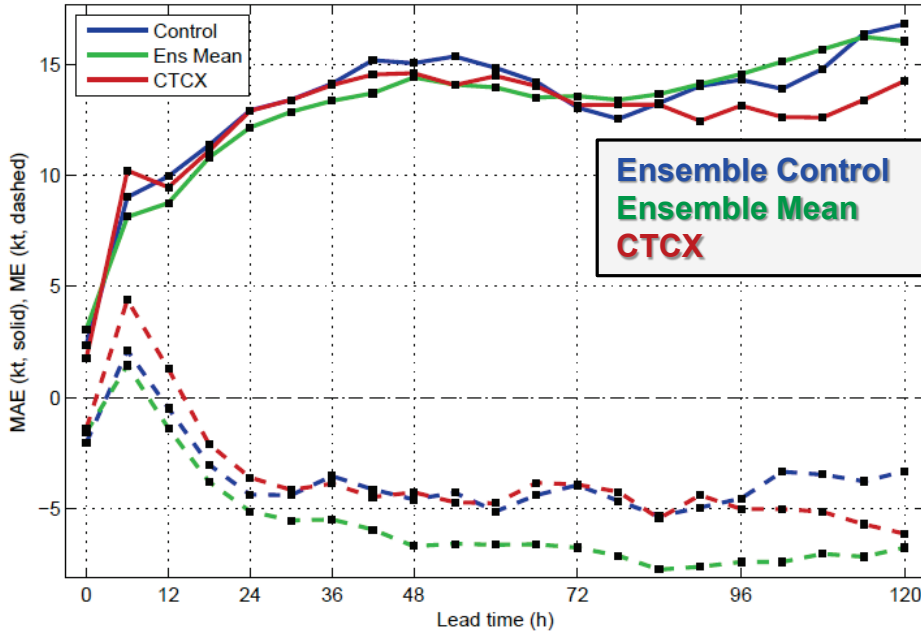
# COAMPS-TC Ensemble System

## 2017 Intensity Statistics

### Ensemble control vs Ensemble mean vs CTCX

**ATL Intensity**

**ATL/EPAC/WPAC Intensity**



Ensemble mean has a lower MAE than CTRL and CTCX through 72h (ATL) and 120h (ATL/EPAC/WPAC)

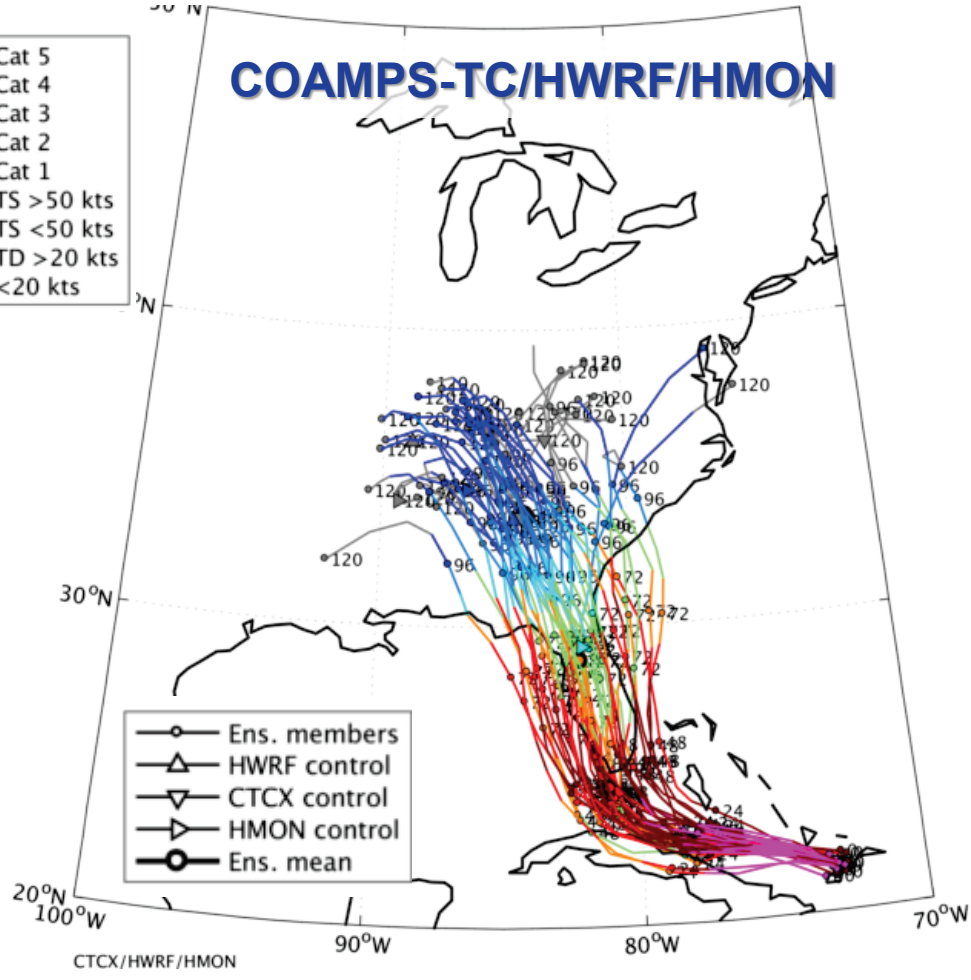
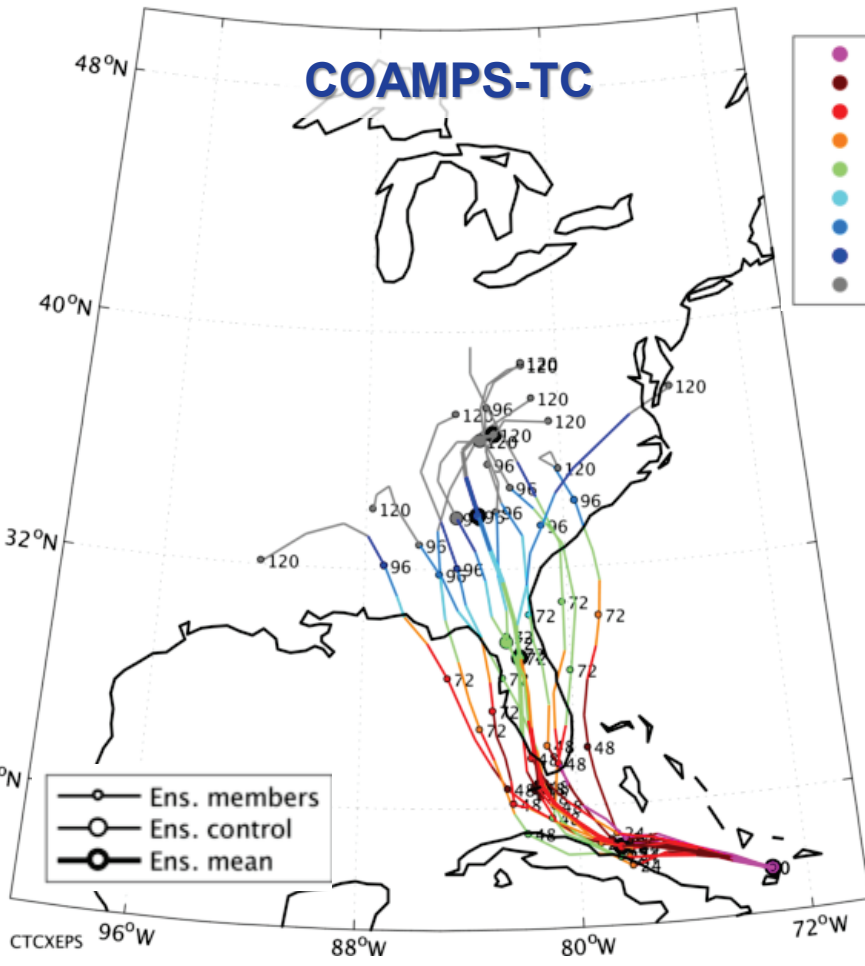


# COAMPS-TC Ensemble System

## 2017 Real-Time Products

Ensemble forecast products: Track colored by intensity

*Irma (11L), 2017090806 initial time (~54 h before FL Keys landfall)*



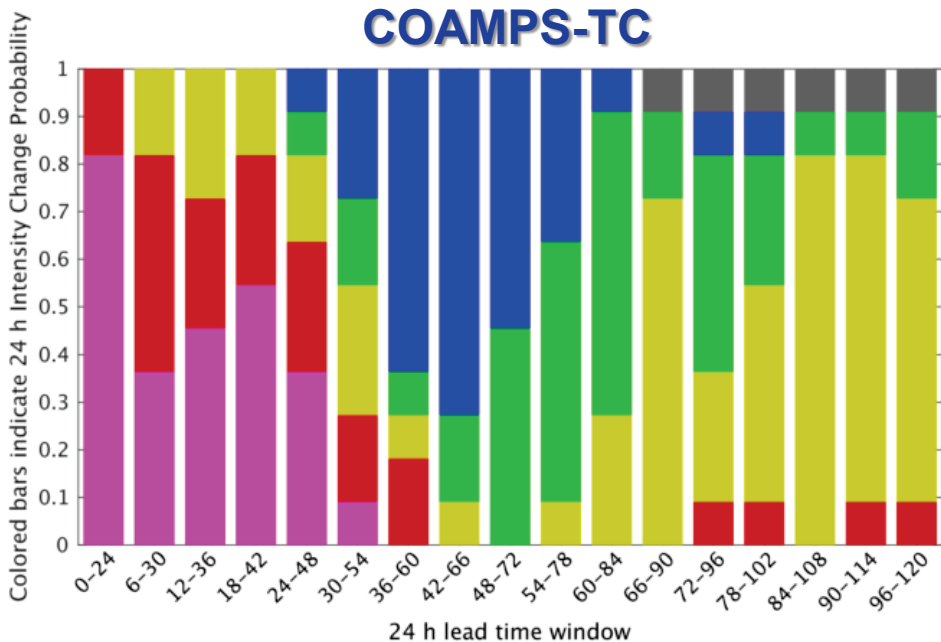
# COAMPS-TC Ensemble System

## 2017 Real-Time Products

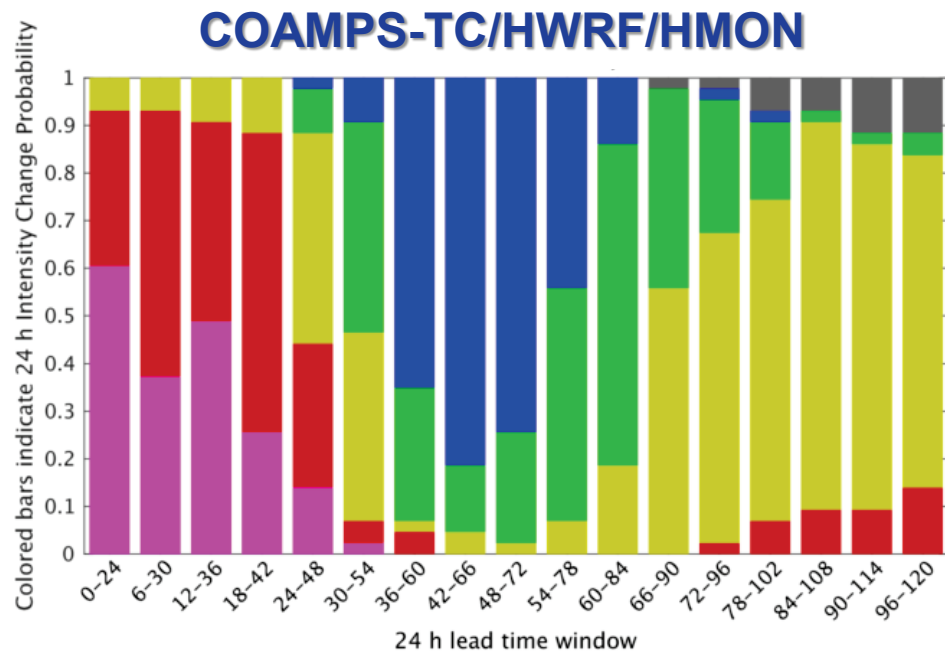


Ensemble forecast products: 24 h intensity change probabilities

*Harvey (09L), 2017082406 initial time (~48 h before TX landfall)*



$\Delta I \geq 30$  kt (Rapid Intensification)  
 $10 \text{ kt} \leq \Delta I < 30$  kt (Moderate Intensification)  
 $-10 \text{ kt} < \Delta I < 10$  kt (Steady Intensity)  
 $-30 \text{ kt} < \Delta I \leq -10$  kt (Moderate Weakening)  
 $\Delta I \leq -30$  kt (Rapid Weakening)  
 TC already dissipated or dissipates during window

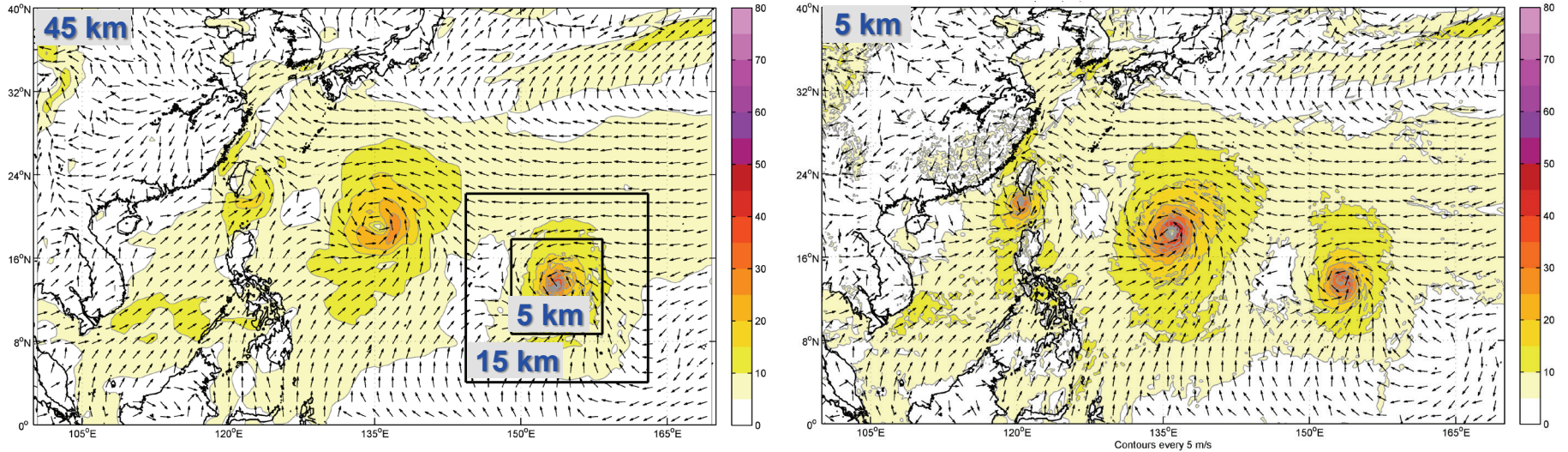


$\Delta I \geq 30$  kt (Rapid Intensification)  
 $10 \text{ kt} \leq \Delta I < 30$  kt (Moderate Intensification)  
 $-10 \text{ kt} < \Delta I < 10$  kt (Steady Intensity)  
 $-30 \text{ kt} < \Delta I \leq -10$  kt (Moderate Weakening)  
 $\Delta I \leq -30$  kt (Rapid Weakening)  
 TC already dissipated or dissipates during window

# COAMPS-TC

## Basin Scale COAMPS-TC

36-h forecast of 10-m winds  
Initial time: 2015070600

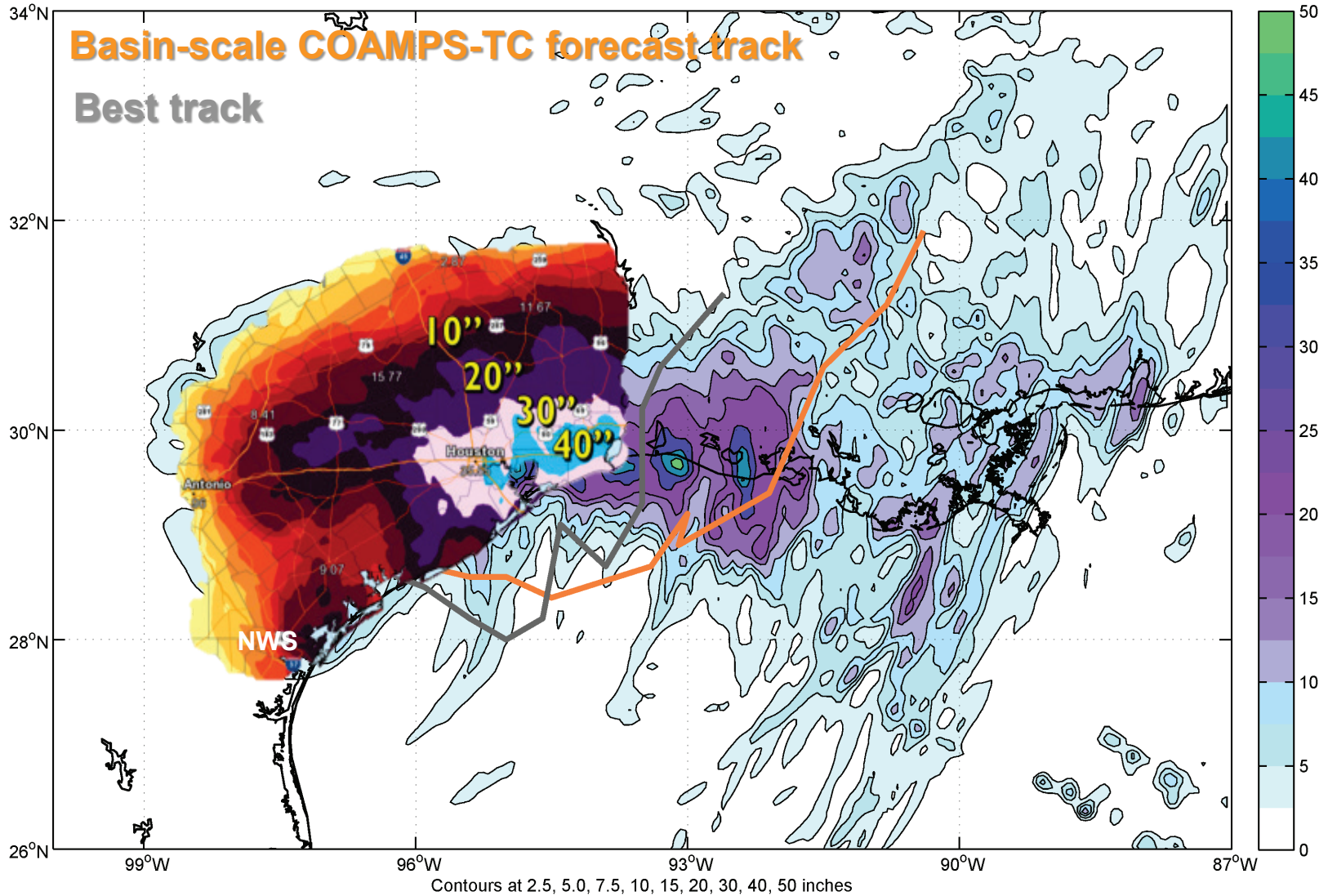


- Conventional (triple nested) COAMPS-TC application on left (45-15-5km)
- 5 km basin-scale high-resolution grid (right); entire mesh convective permitting
- Capable of predicting genesis of disturbances that do not exist at initial time
- More expensive (but parallelizes well), step towards hi-res global forecasts



# Basin-Scale COAMPS-TC

Harvey (09L) 2016082606 initial time: Precipitation forecast challenge



Basin-scale COAMPS-TC track takes Harvey offshore, closer to best track than CTCX. Axis of heaviest precipitation is near the coast instead of inland

## Summary and Future Plans

### ➤ **COAMPS-TC Much Improved for Track & Intensity in 2015-17:**

- Improved intensity error (higher resolution; ocean coupling; new  $C_D$  param, vortex init)
- Improved track errors (new initialization; new physics)
- Multi-model high-res. ensemble (NOAA/Navy) and air-ocean coupling promising
- Challenges: i) Prediction of RI; ii) TC physics (PBL, microphysics); iii) inner core DA

### ➤ **COAMPS-TC 2017/18:**

- Deterministic: 4 km resolution & various upgrades; CTCX run worldwide (may be ops)
- Ensemble: 4 km resolution, 11 members, initial & boundary condition perturbations CTCX over W. Atlantic, E. Pacific, W. Pacific

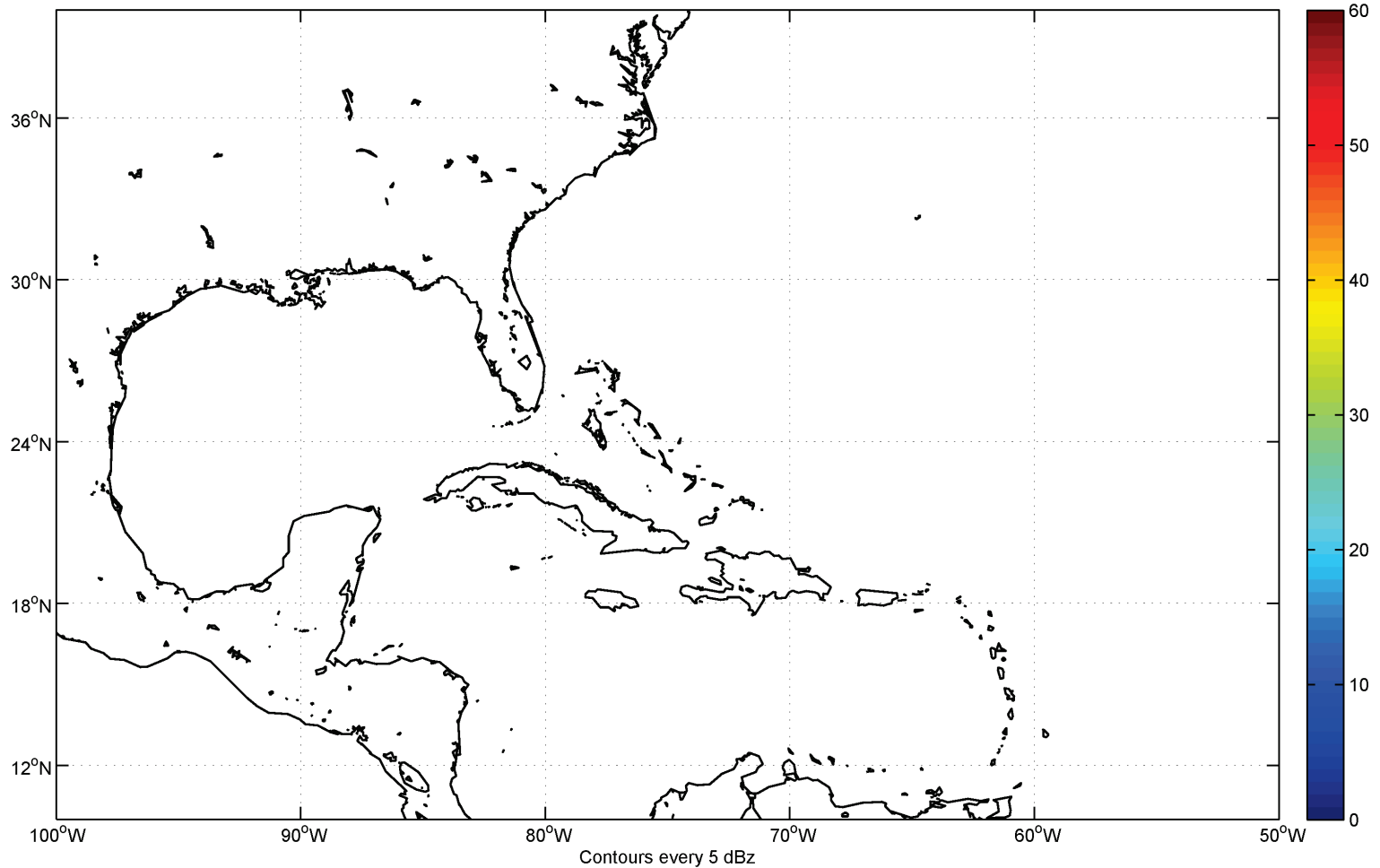
### ➤ **COAMPS-TC Priorities (2018-20):**

- |             |  |
|-------------|--|
| TC physics: | Improved PBL (testing), cloud microphysics (testing Thompson)<br>New shallow CU (planned 2018), New cumulus (planned 2018) |
| Analysis:   | 4D-Var (testing in 2018), emphasis on satellite DA   |
| Ensemble:   | 11 members (ops in 2018); stochastic physics (testing)   |
| Coupling:   | Ocean, waves (2019), coupled DA  |
| Resolution: | 4 km (2017), 2 km (2020), 4 km basin scale (2022+)   |

Utilize field observations: ONR TCI, NASA HS3, SHOUT

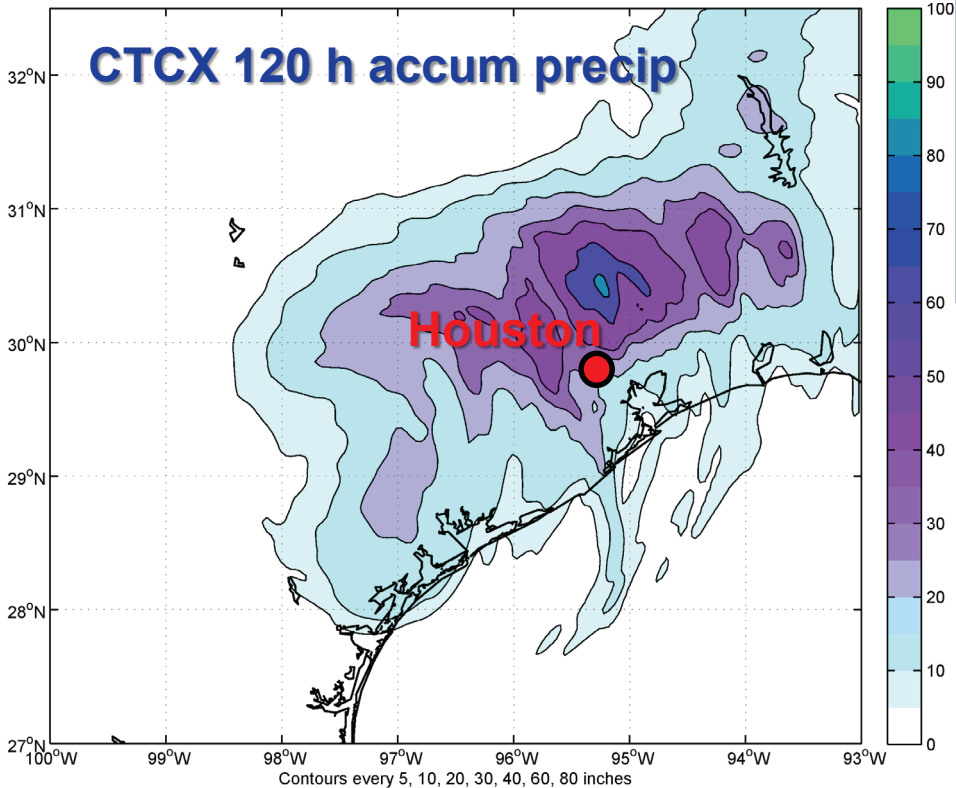
Basin-scale COAMPS-TC example: 2017090600 initial time (Irma/Jose/Katia)

*Western Atlantic inset radar reflectivity forecast loop*



# Nested COAMPS-TC

Harvey (09L) 2016082606 initial time: Precipitation forecast challenge



- Weak steering flow challenged models in predicting post-landfall track of Harvey
- For this initial time CTCX correctly indicated eastward motion, but tracked TC too far north

Axis of heaviest precipitation too far inland in CTCX forecast, due to track error

