# Studying Tropical Cyclone Intensity Changes with Numerical Simulations and Data Assimilation During Tropical Cyclone Intensity (TCI) Experiment

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# Objectives

- Understanding the role of upper level atmospheric processes on tropical cyclone formation and rapid intensification with observations during ONR TCS-08, TCI-14, and TCI-15
- Investigating the influence of data assimilation on numerical simulation and prediction of TC formation and intensity changes with high-resolution mesoscale models
- Evaluating the performance of NAVGEM model for TC track and intensity forecasting

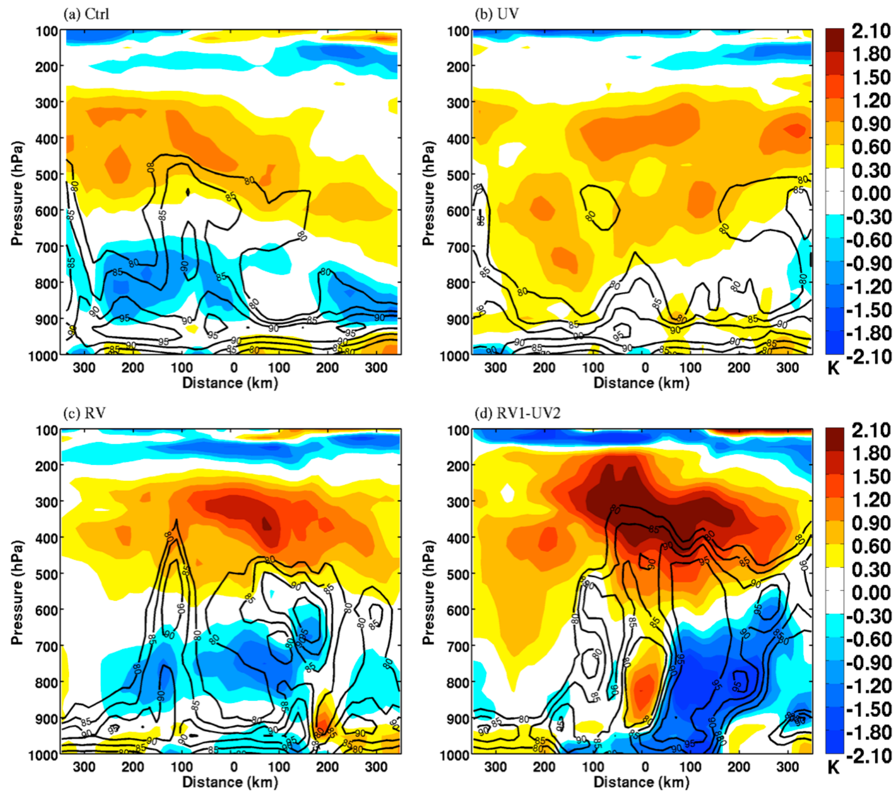
This presentation highlights some of our recent activities

# Studying the formation of Typhoon Nuri (2008)

- Upper level warming

➢ Assimilation of airborne Doppler radar and satellite (e.g., AIRS temperature and moisture profiles) data enhances the representation of TC structure and environmental conditions , especially the upper-level atmospheric conditions in the numerical simulations of Typhoon Nuri, resulting in significant understanding of the role of upper-level warming in TC rapid intensification.

Enhanced upper level warming with airborne radar data assimilation



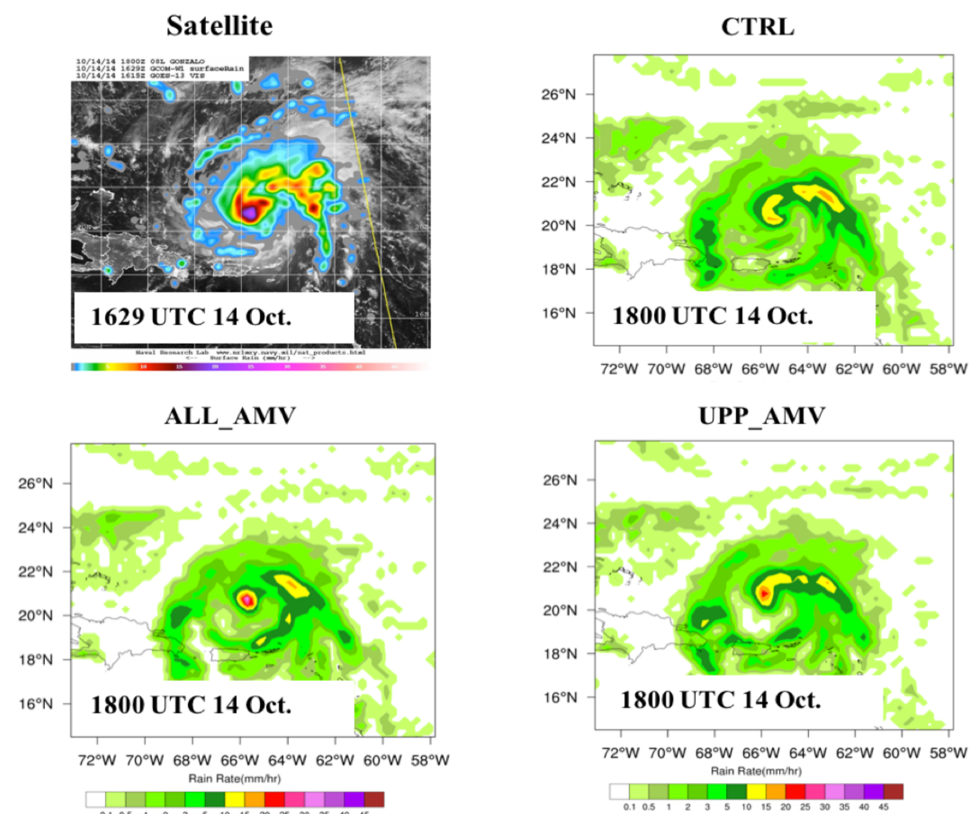

E-W cross section of the temperature anomaly (shaded) and the relative humidity (black contours) through the Nuri's center 1800 UTC 16 Aug 2008

Li and Pu 2014; Li et al. 2014; Pu 2015

# Assimilation of TCI-14 data

Significant Impact of AMVs on prediction of Hurricane Gonzalo

- Assimilating HS3 dropsondes, HIRAD, enhanced atmospheric motion vectors (AMVs), obtained during TCI-14 into HWRF model
- Hurricanes Edouard and Gonzalo (2014)
- In general, data assimilation experiments show that these observations during TCI have positive or neutral impacts on numerical simulations of hurricanes




Hourly precipitation

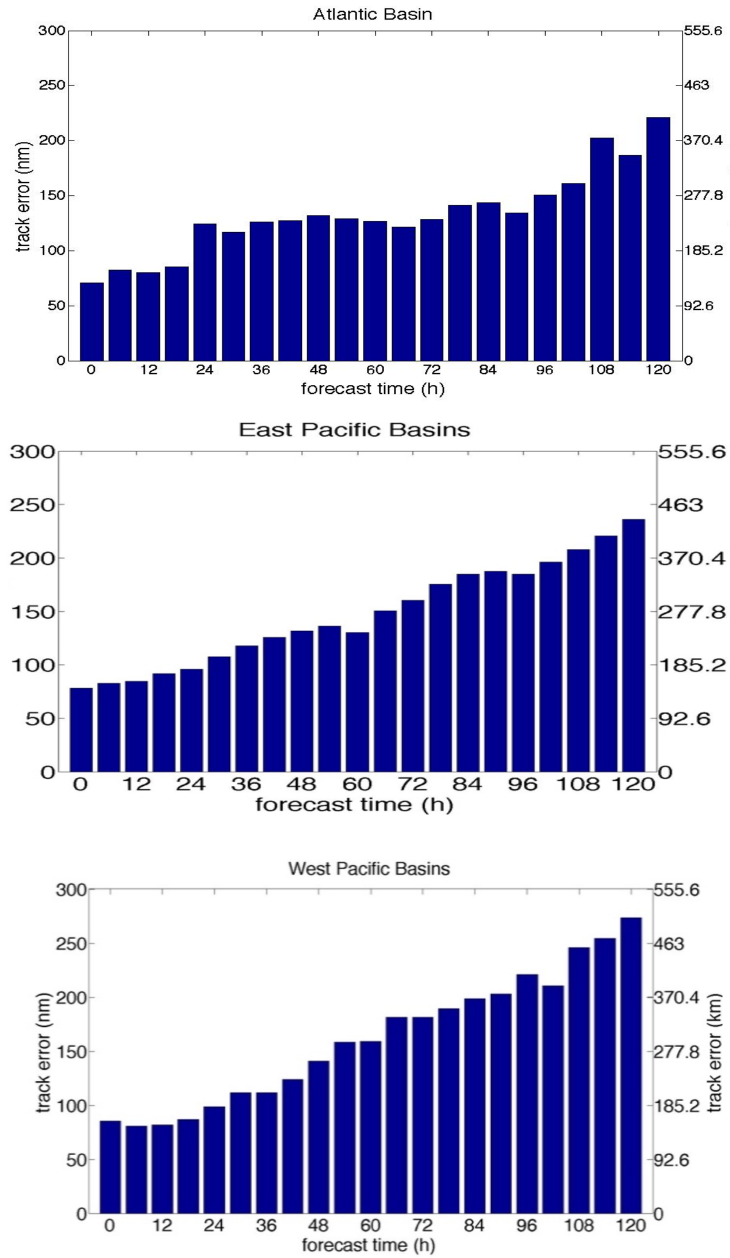
Zhang et al. (2016)

# Evaluating NAVGEM TC forecasting

- The statistical evaluation is performed from 1 June to 30 November 2014.
- The averaged track errors of NAVGEM range from 100 km at day 1 to 460 km at day 5
- The NAVGEM model has good skill in forecasting intensity trends, although the predicted intensifications lag the observed intensifications in many cases.

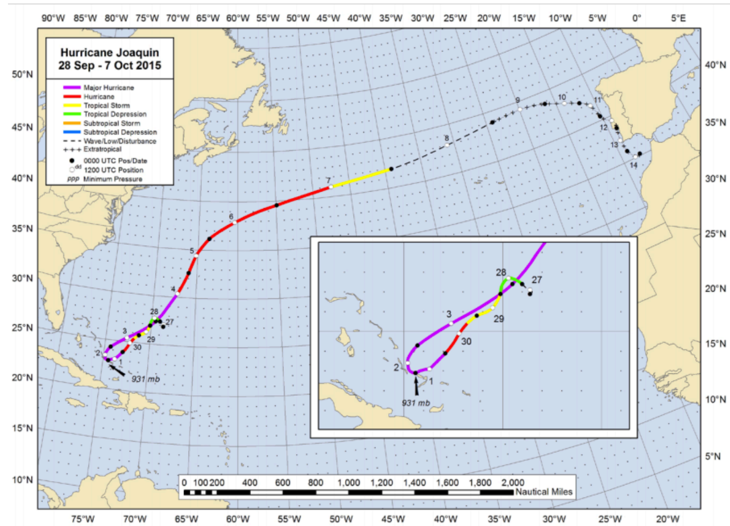
Yu, M.S. Thesis (2016)

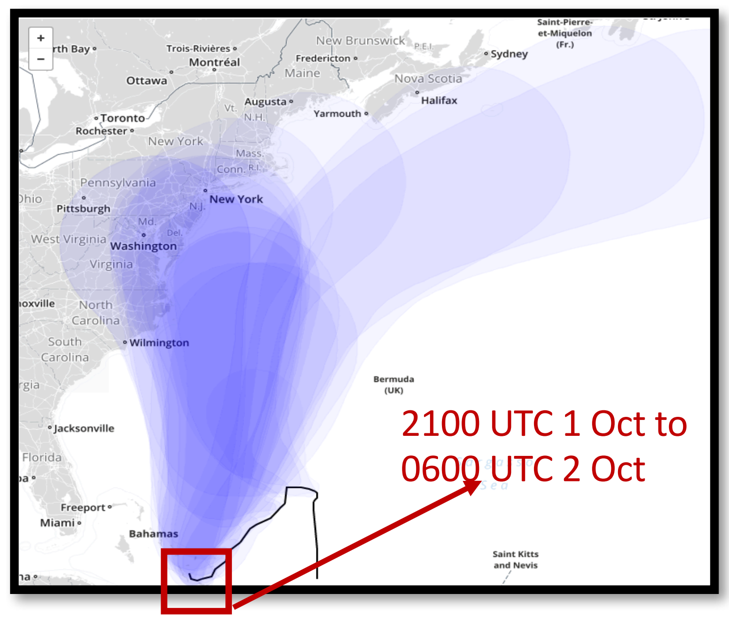
Averaged track errors in mature stage (MSW > 34 kt.)



# Hurricane Joaquin (2015)
# Numerical simulations and data assimilation studies

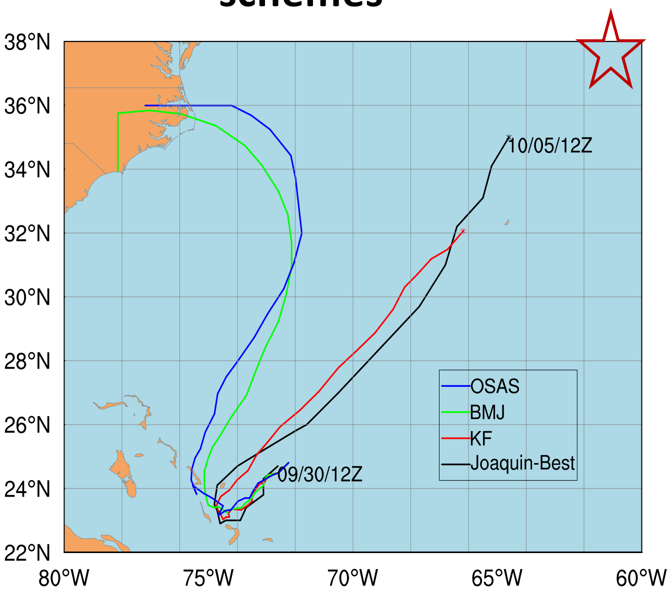
- Track forecast challenges
- Hairpin clockwise recurve
- Comprehensive observations during TCI-15. Specifically, WB-57 HDSS dropsoneds; Enhanced AMVs, etc.



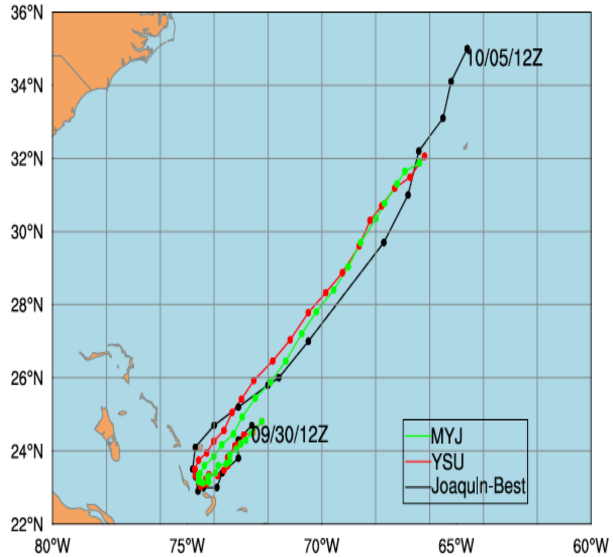



# Sensitivity of WRF numerical simulations of Hurricane Joaquin to physical parameterizations

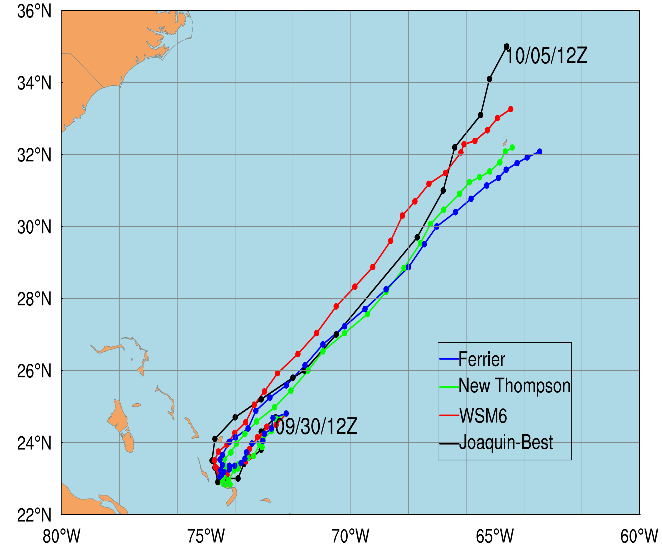
**Cumulus schemes**




**Boundary layer schemes**

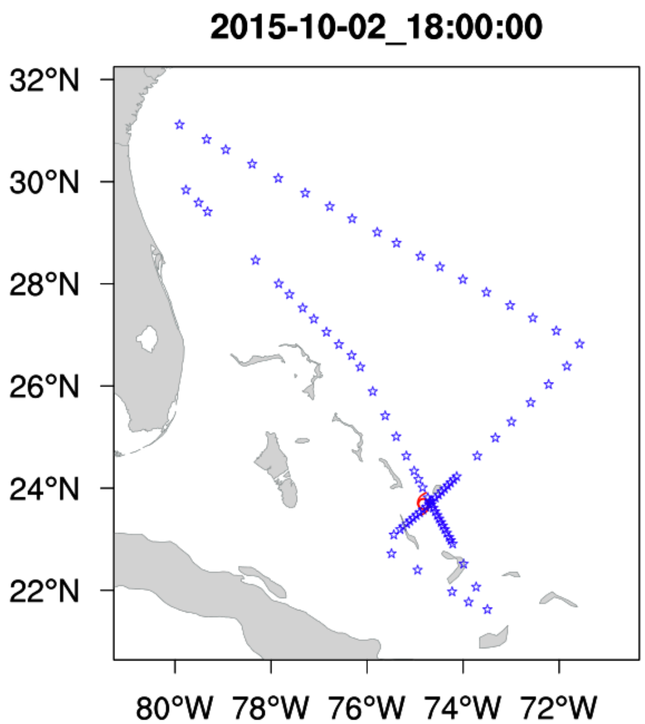



**Microphysics schemes**

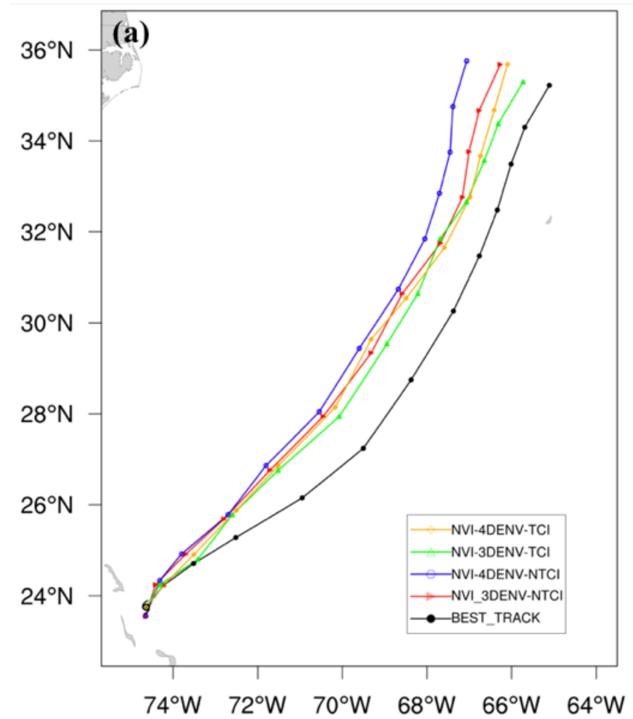


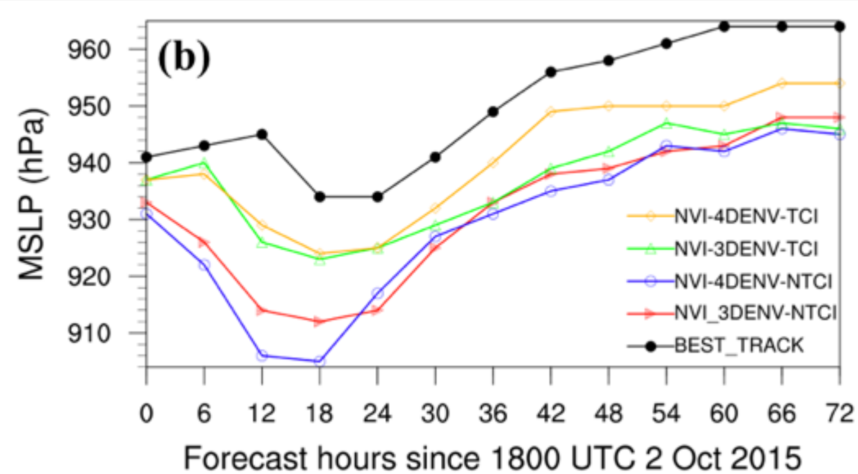
# Impact of assimilating WB-57 HDSS dropsonde data on HWRF prediction of Hurricane Joaquin

GSI-based 4DEnVar versus 3DEnVar




Distributions of WB-57 HDSS dropsondes



## Concluding remarks

- TCI field program provides many useful observations to study TC genesis and rapid intensification with data assimilation and numerical simulations

## On-going work

- Integrating the current efforts in high-resolution numerical simulations and data assimilation for process studies to understand the controlling factors (e.g., outflow) for TC intensity changes.