

Impact of Ocean Initial Conditions on Operational Hurricane Forecasting

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Issues Investigated

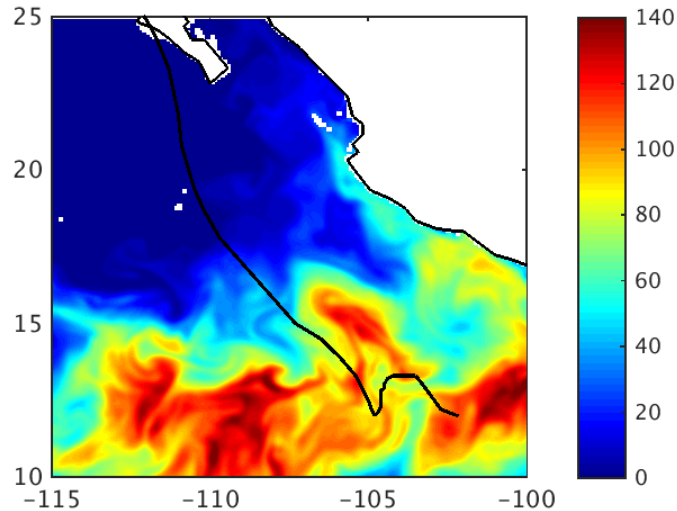
- Inaccurate ocean model initialization in coupled TC prediction models can produce inaccurate coupled intensity forecasts
- Interannual differences in upper-ocean conditions produce large differences in predicted intensity (cannot initialize from climatology)
- Assimilation of ocean observations substantially reduces initialization errors and corrects for interannual differences in upper-ocean conditions
- Three storms analyzed to illustrate these points:
 - Blanca (2015, EPAC)
 - Edouard (2014, NATL)
 - Gonzalo (2014, NATL)

Blanca Experiments

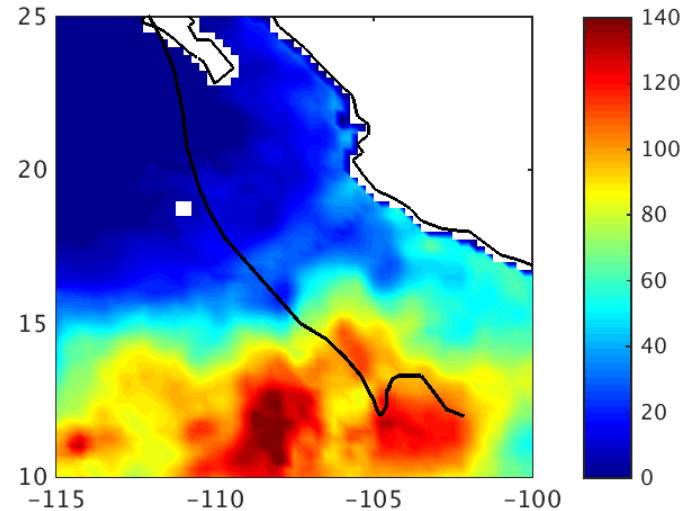
- **HCTL** – Operational POM-HWRF
 - Initialization procedure
 - Starts with ocean climatology
 - Requires spinup procedure to provide balanced ocean fields, assimilate SST, and spin up the ocean cold wake
 - No assimilation of subsurface ocean data in the EPAC
- **HY5Y** – Experimental HyCOM-HWRF
 - Initialization provided by a realistic data-assimilative ocean analysis product (RTOFS) which provides balanced initial ocean fields.
- **SPORTS Analysis** - Systematically merged Pacific Ocean Regional Temperature and Salinity Product (McCaskill *et al.*, JAOT, 2015) using daily altimetry/SST measurements that is used for evaluation.

Blanca Initial OHC

HY5Y (RTOFS)



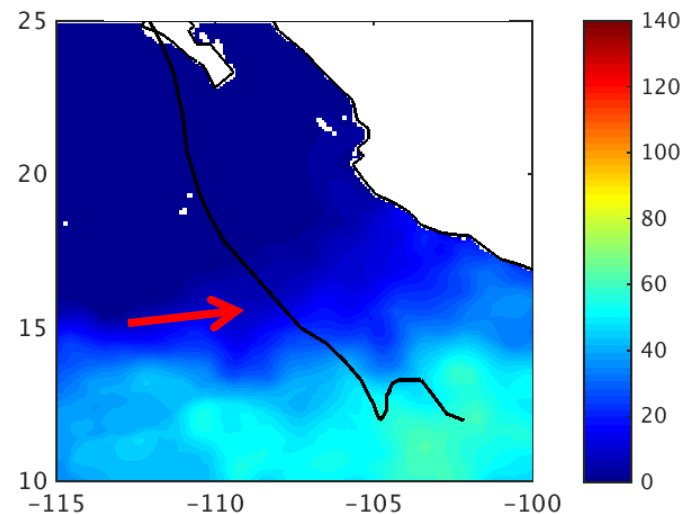
Sports Analysis



OHC in warm pool for HY5Y is similar to the SPORTS analysis.

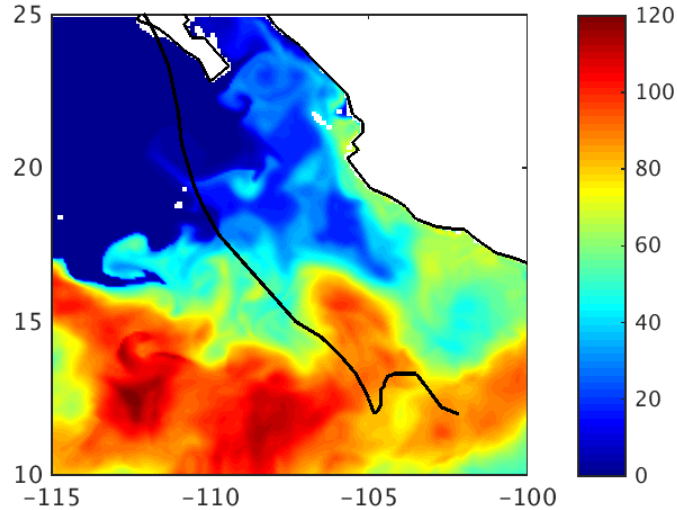
OHC in warm pool for HCTL is too small

HCTL

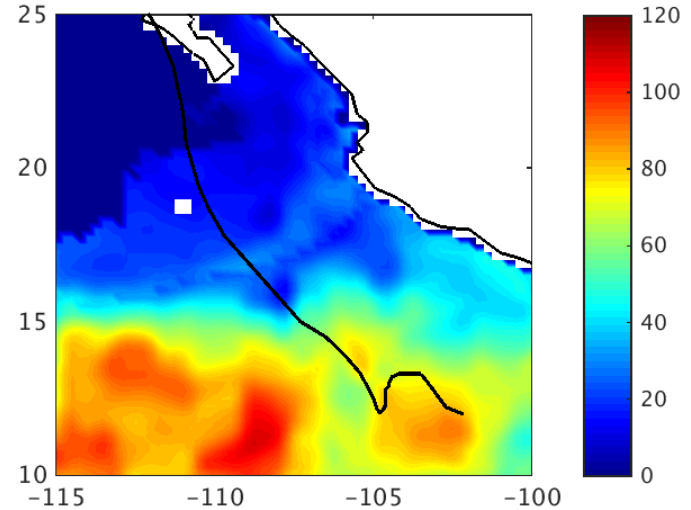


Blanca Initial H_{26}

HY5Y (RTOFS)



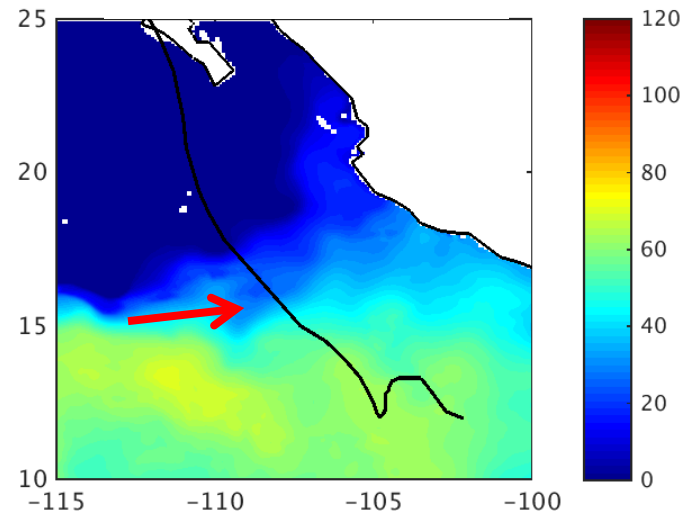
Sports Analysis



H_{26} in warm pool for HY5Y is similar to the SPORTS analysis.

H_{26} in warm pool for HCTL is too small

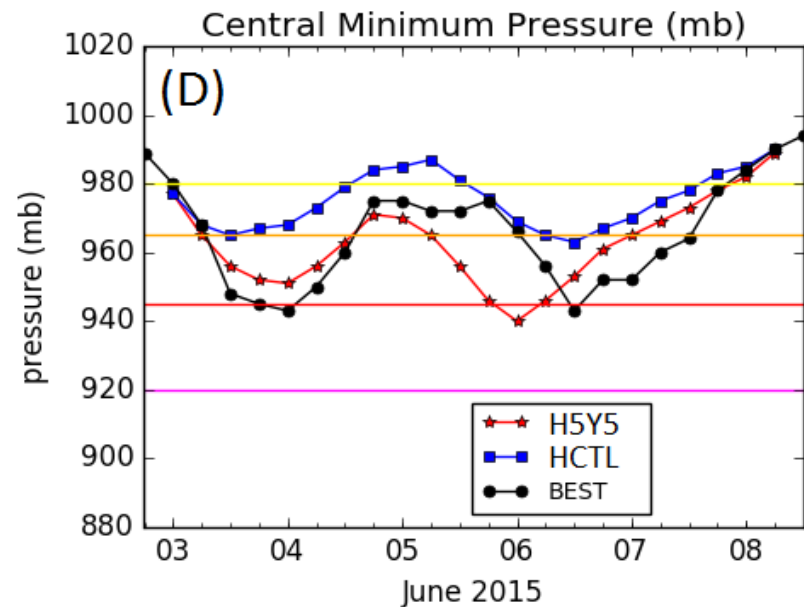
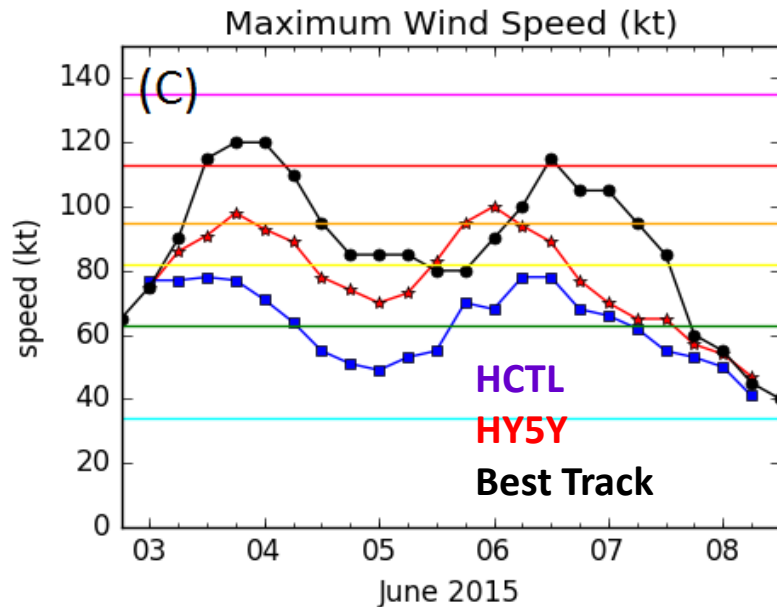
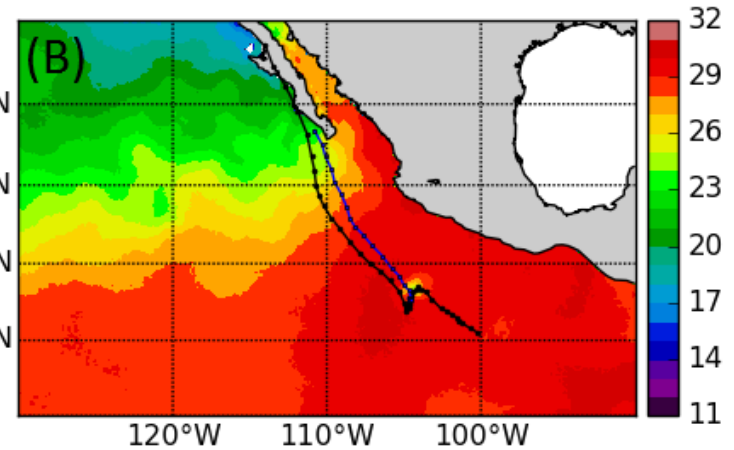
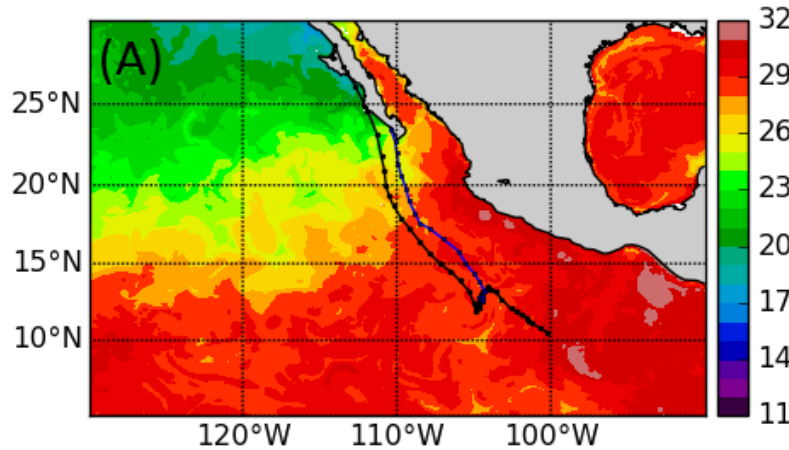
HCTL



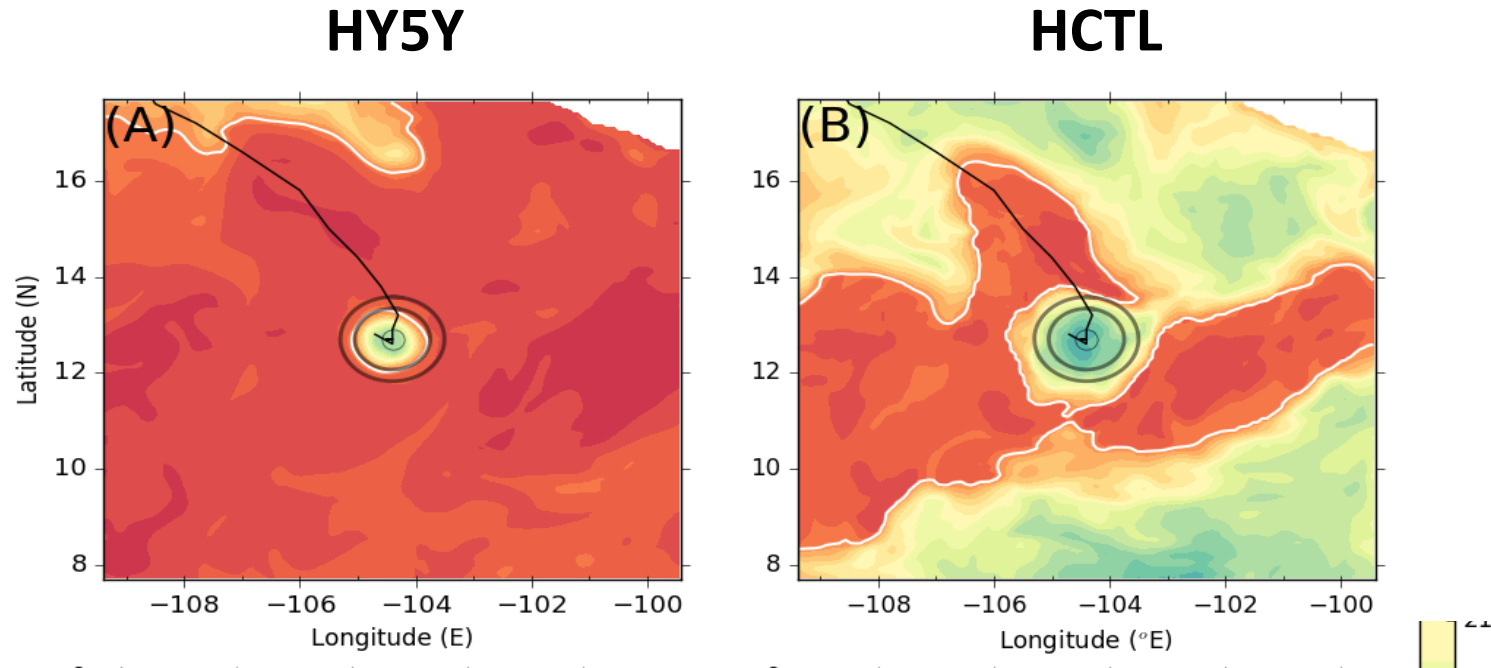
Blanca Initial SST and Forecast Intensity

HY5Y SST

HCTL SST



SST Maps During Forecast



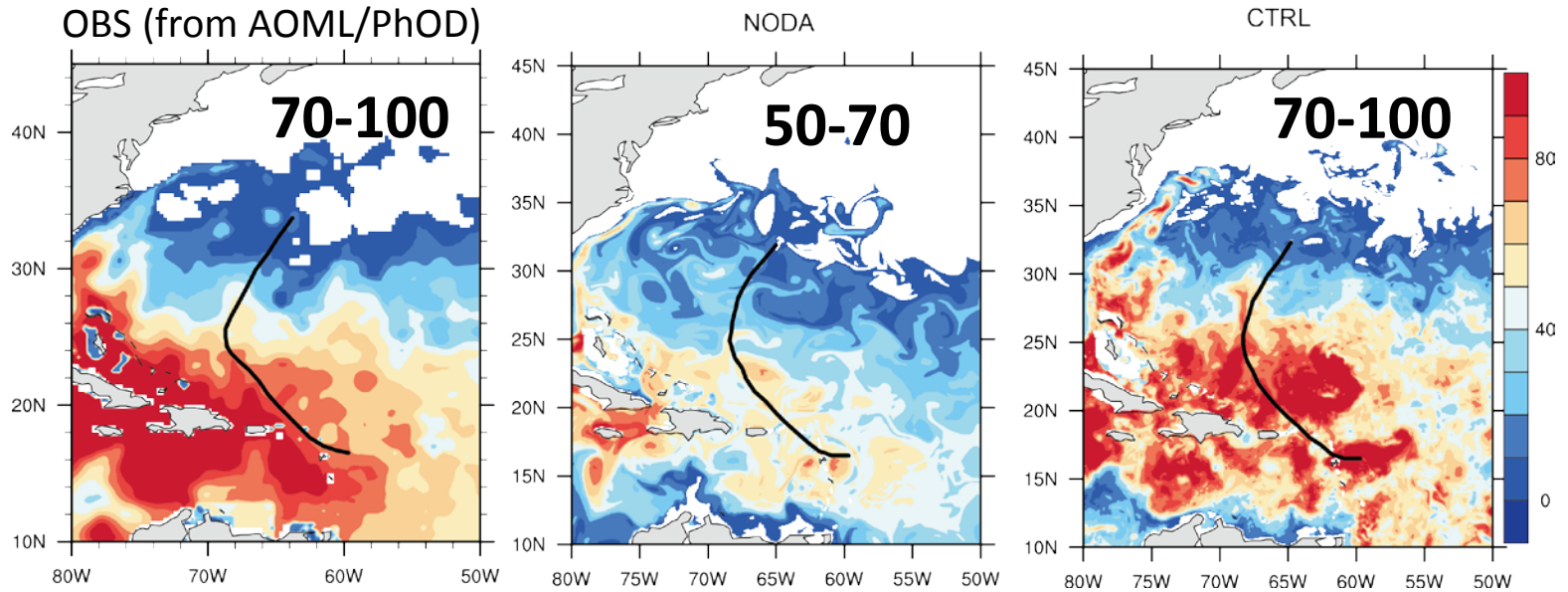
- HCTL produces greater SST cooling over larger area in the region where Blanca nearly stalled. Large impact on intensity.
- The anomalously thick surface warm layer during El Niño conditions was correctly reproduced in the HY5Y initialization.
- It is not adequate to correct SST and mixed layer temperature alone. The thickness of the upper warm layer must be accurate (subsurface ocean obs.)
- The impact of using two different ocean models is secondary (not shown)

Gonzalo Experiments

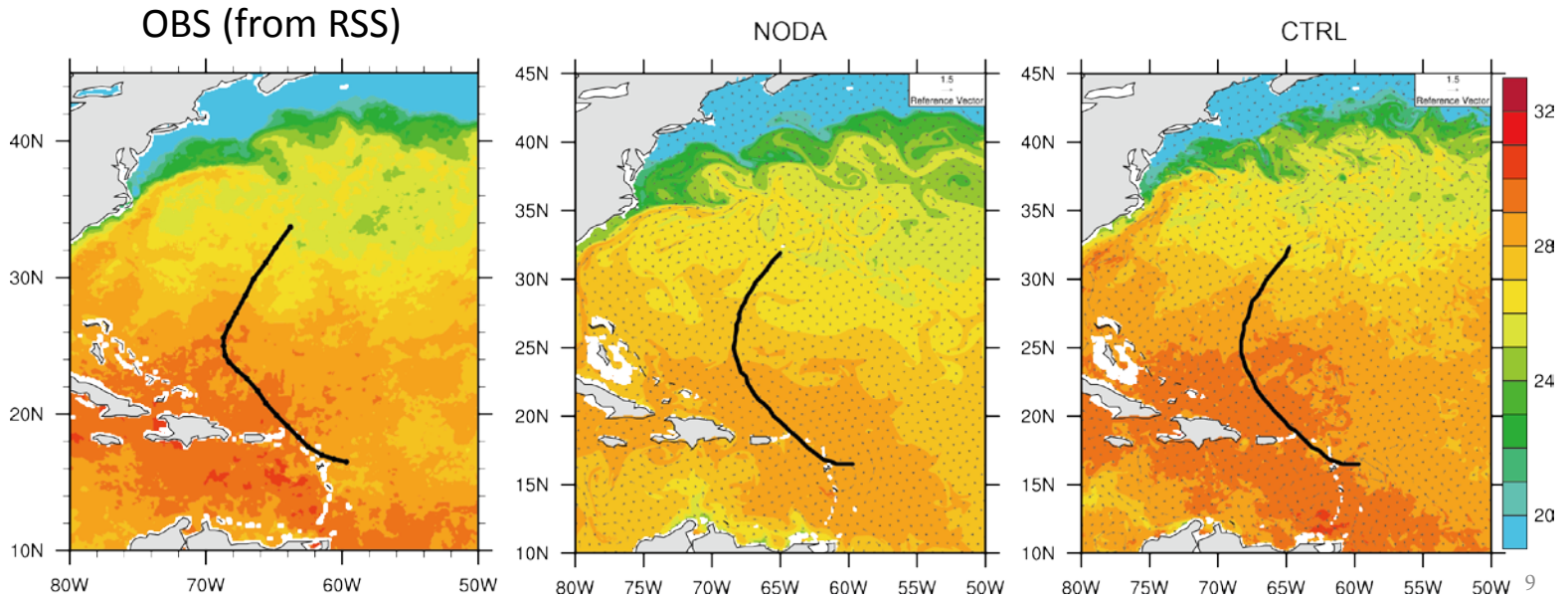
- Evaluate the impact of assimilating the existing operational ocean observing system on coupled model intensity forecasts for Hurricane Gonzalo (2014)
- Two experiments:
 - **CTRL** – Control experiment that assimilates all observations
 - **NODA** – Experiment that denies all observations
- Ocean analyses from these two experiments are used to initialize the HYCOM-HWRF regional coupled TC prediction system to performs the forecasts

Hurricane Gonzalo Initial Fields

OHC



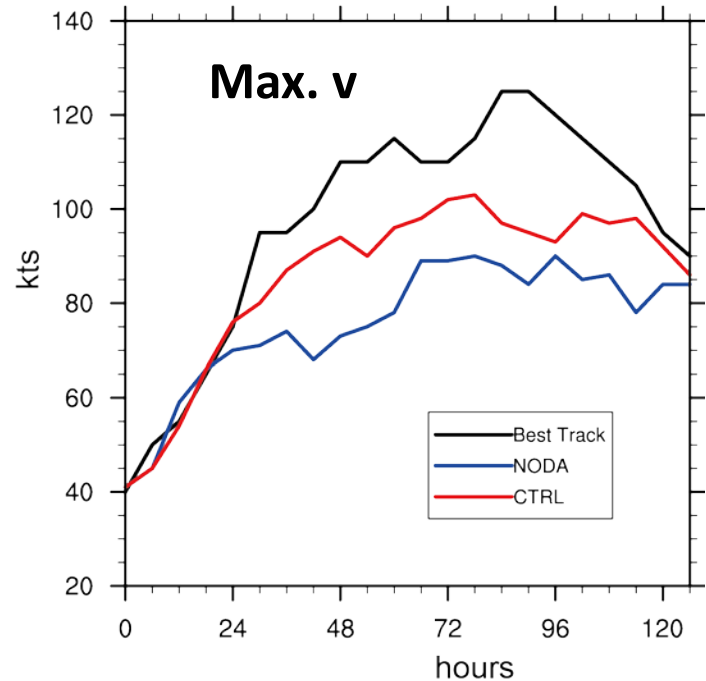
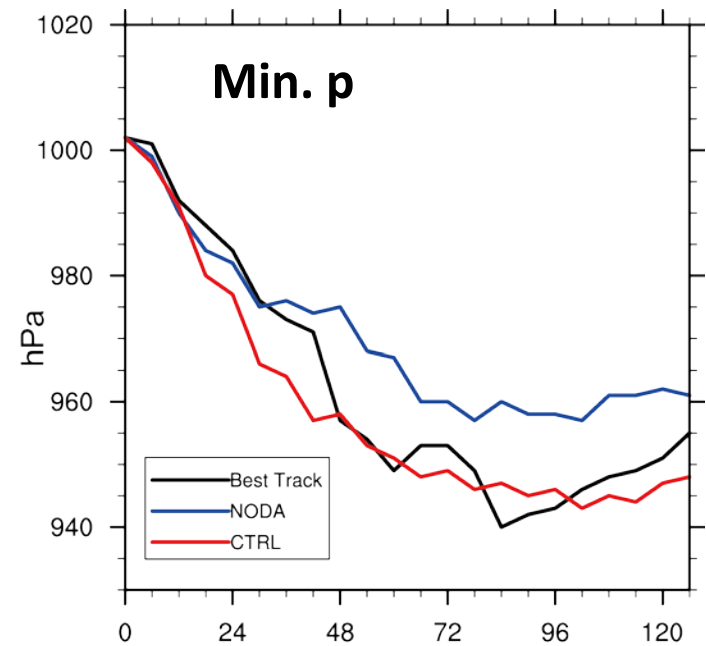
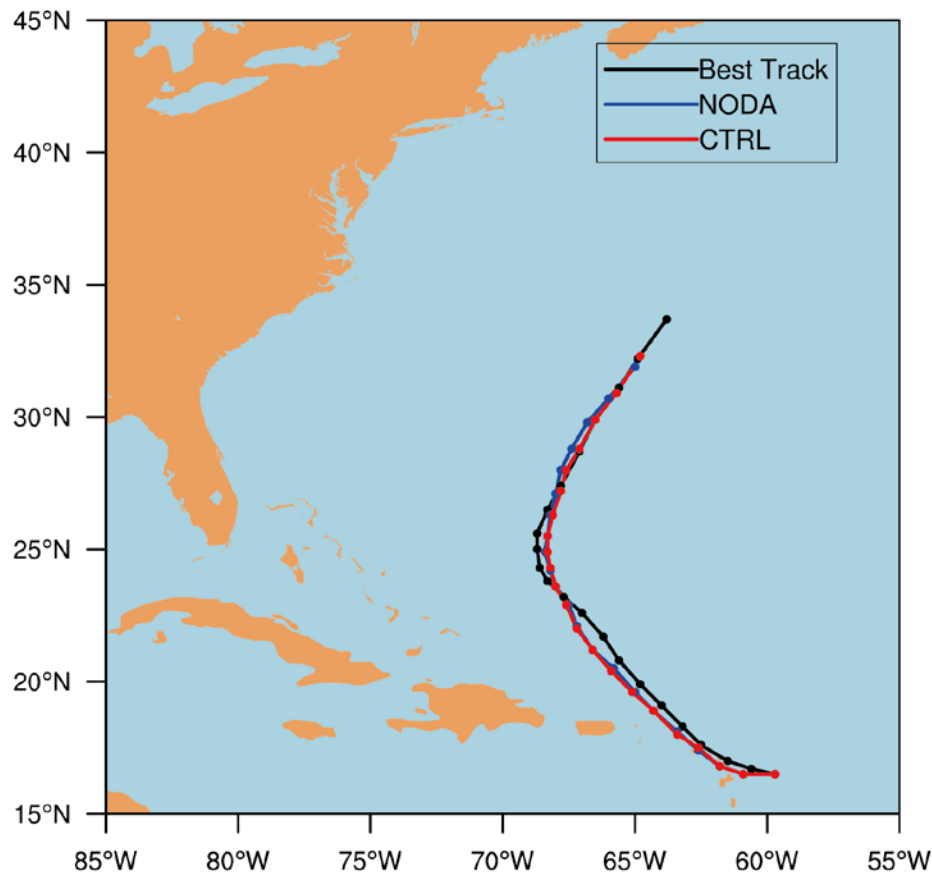
SST



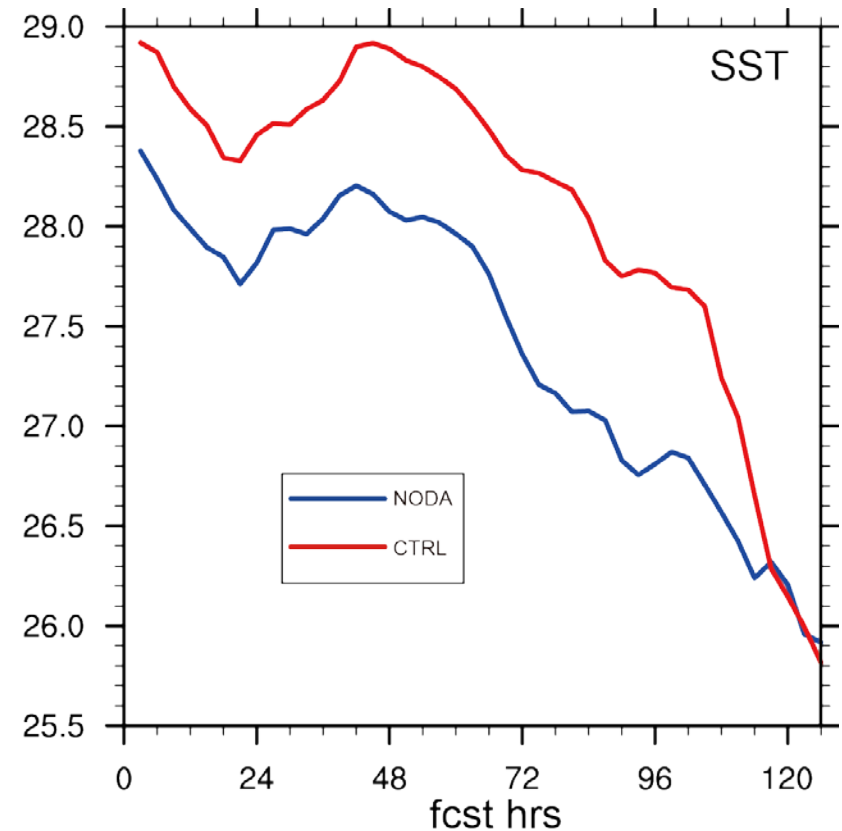
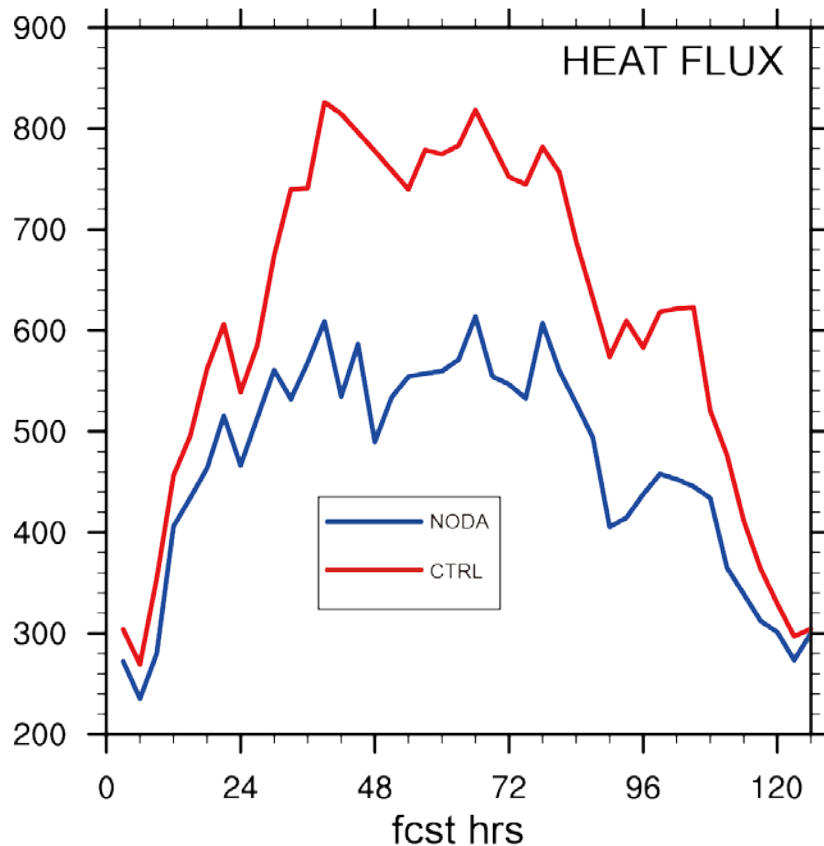
Hurricane Gonzalo Forecasts Compared to Best Track

Assimilation of operational ocean observing systems improves intensity forecast

2014 Gonzalo



Hurricane Gonzalo Enthalpy Flux and SST during Forecasts



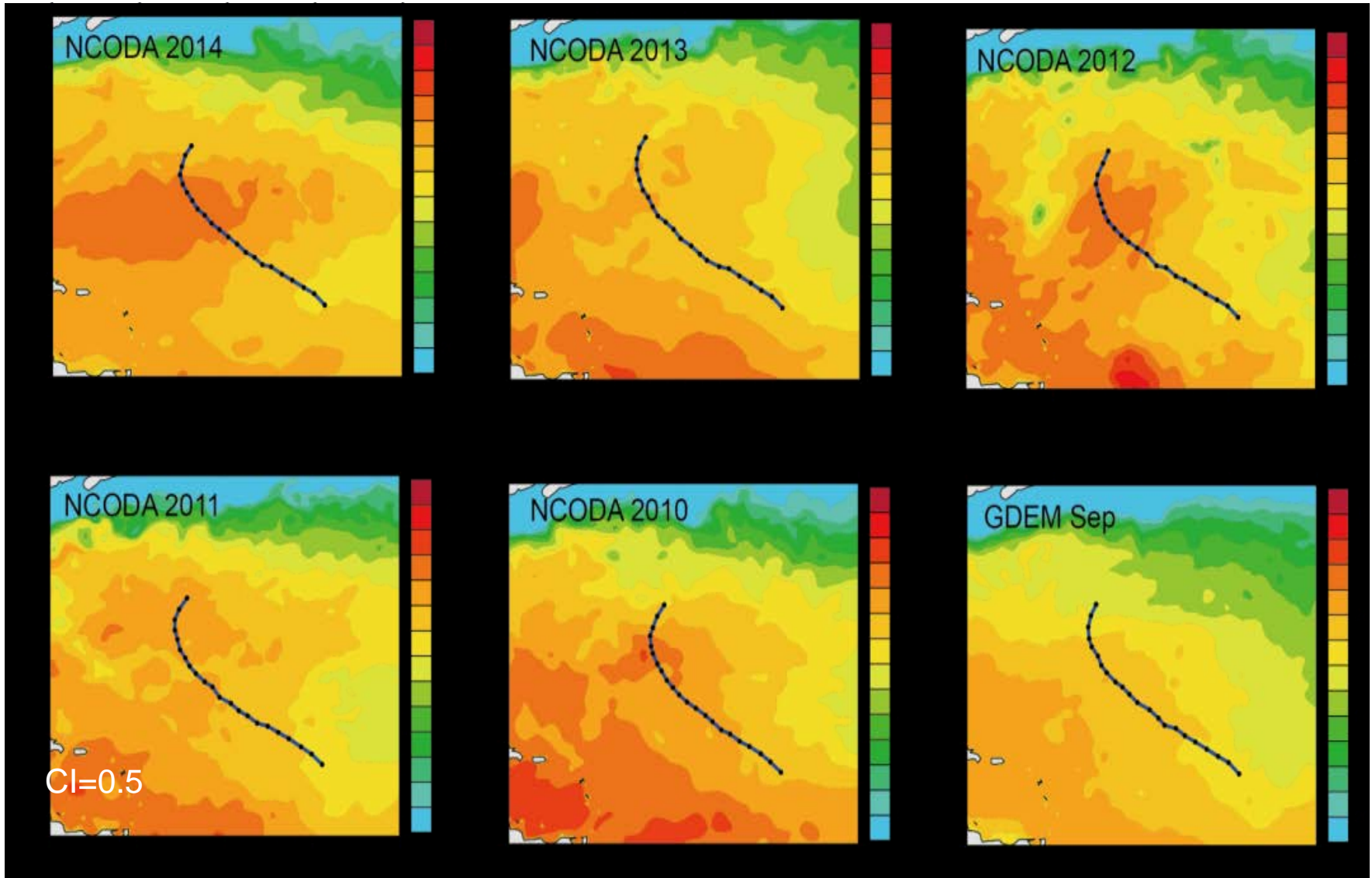
Assimilation of operational ocean observing systems substantially improves the intensity forecast for Hurricane Gonzalo.

Without assimilation, the upper-ocean heat content was close to climatology (too cold).

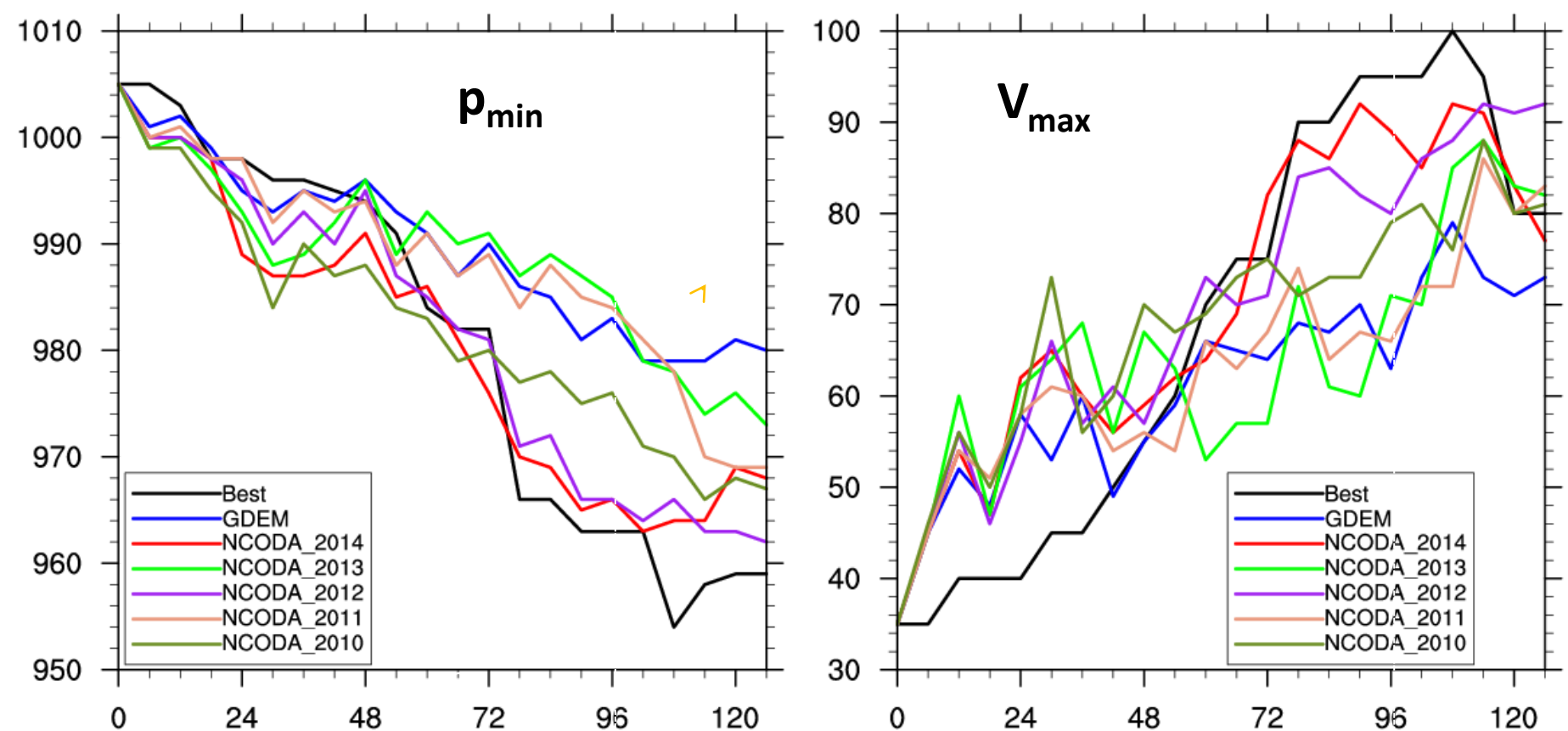
Edouard Experiments – Interannual Ocean Variability

- To illustrate the impact of interannual ocean variability, realistic ocean initial fields from a data-assimilative ocean analysis (Navy global HYCOM NCODA analysis) from five different years (2010-2014) are used to initialize the ocean model in HYCOM-HWRF.
- Six experiments:
 - NCODA2010
 - NCODA2011
 - NCODA2012
 - NCODA2013
 - NCODA2014
 - GDEM (ocean climatology)

Edouard Initial SST Fields



Edouard Experiment Intensity Forecasts



Year-to-year differences in the upper-ocean have a large influence on predicted intensity

Initialization from climatology is not adequate.

Assimilation of ocean observations is critically important.

Ongoing Work

- Perform ocean Observing System Experiments (OSE) and Observing System Simulation Experiments (OSSE) to evaluate and improve ocean observing strategies to reduce errors in initial ocean fields.
- A particular focus is to evaluate the impact of pre-storm ocean surveys for reducing ocean model initialization errors and potentially improving intensity forecasts.
 - Work to date demonstrates that airborne surveys substantially reduce ocean model initialization errors beyond the reduction achieved by assimilating existing ocean observing systems.
 - The next step is to demonstrate the impact on intensity prediction using coupled prediction systems.

Conclusions

- Error reduction in initial ocean fields is important for reducing errors in TC intensity prediction for the storms included in this analysis.
- Assimilation of high-quality ocean observations is necessary to reduce errors and bias in initial ocean fields.
- Research to evaluate and improve pre-storm ocean measurement strategies has the potential to improve intensity prediction.