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Developmental Testbed Center (DTC) Activities in Support of Transition of Research to the Operational Hurricane WRF model

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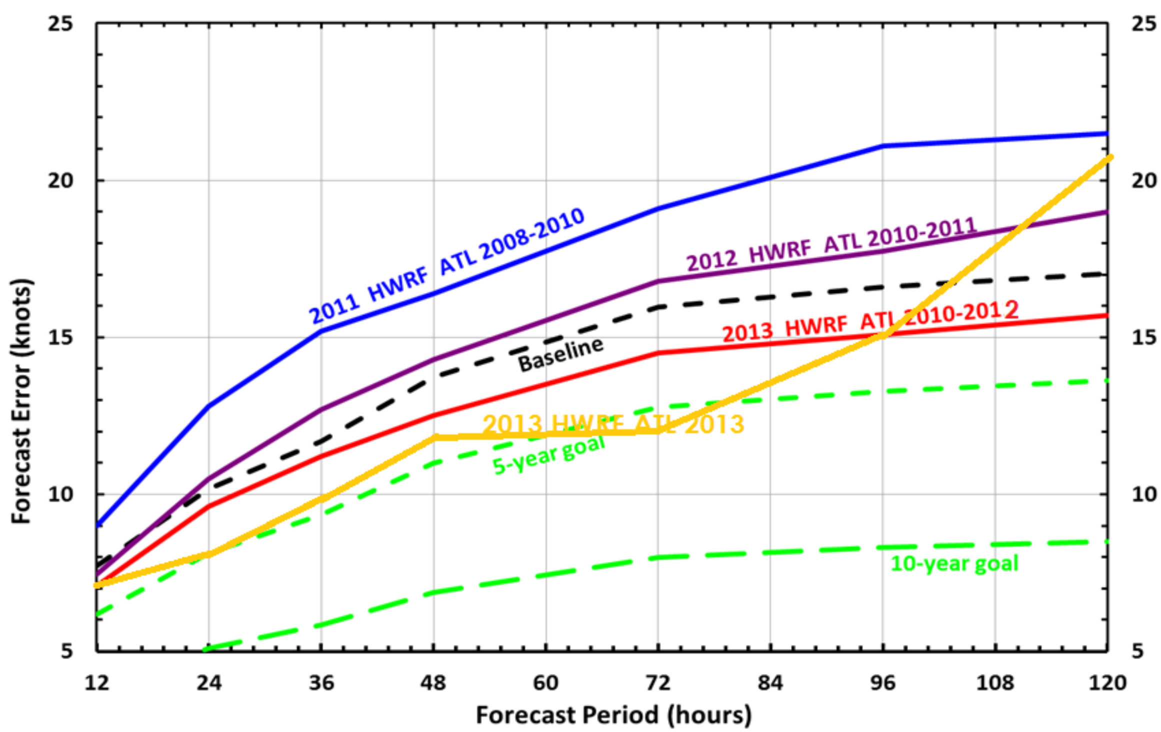
Developmental Testbed Center

Hurricane WRF history

Operational goal:
Provide tropical cyclone track and intensity guidance to the National Hurricane Center
2007: initial operational implementation
2007-2013: yearly upgrades



Intensity Errors (kt) in Atl
- Decrease yearly up to 96-h
- Approach 5-y goal of the Hurricane Forecast Improvement Project (HFIP)

How does improvement happen and what is the role of the <u>Developmental Testbed Center</u> in the process?

About HWRF: components

Atmospheric Pre-Processing
WPS and prep_hybrid

Data Assimilation
Gridpoint Stat Interp (GSI)

Vortex Improvement
HWRF Utilities

Atmospheric Model
WRF
↔
Coupler
NCEP
↔
Ocean
POM-TC

Postprocessing
UPP

Vortex Tracker
Geophys Fluid Dyn Laboratory

HWRF is a complex regional forecast system

- Eight software components + diagnostics/graphics/vx
- Running scripts
- Namelists
- Fixed files

Several HWRF components are used by wider community, in particular

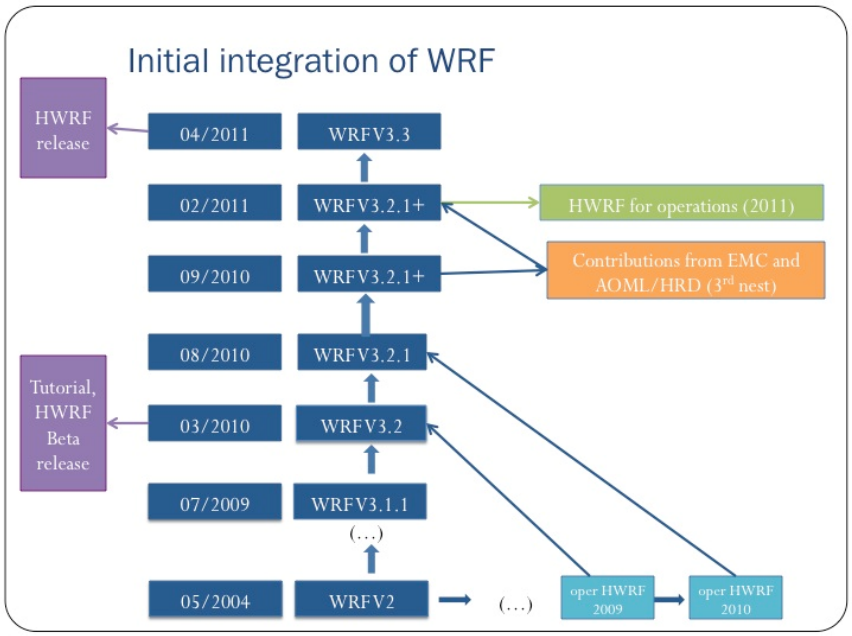
- WRF/WPS (AFWA, NCEP RAP, SREF etc., research)
- GSI data assimilation (GFS, NAM etc.)

Potentially makes developments available for HWRF

HWRF code: divergence and unification of atmospheric component (WRF)

- 2007: HWRF initial operation
  - 2004: WRF code was obtained from community
  - 2004-2009: HWRF at EMC evolved and diverged from community
  - Operational HWRF could not benefit from HRD's HWRFX or community

WRF component integration



2009-2010: DTC/EMC integrated codes. Operations and community now use same source

2011-2014: HWRF code management maintains codes integrated, making available 3-nest configuration, physics (cu, microphysics, PBLs, and LSMs) and multiple moving nests (*basinscale*) for potential operational implementation

DTC Strategies to promote HWRF R2O

Code Management

- Create a framework for NCEP and the research community to collaborate; maintain the code unified

DTC Visitor Program – some approved projects involving HWRF

- *Development of an HWRF diagnostics module to evaluate intensity and structure using synthetic flight paths through tropical cyclones* (J. Vigh - NCAR)
- *Diagnosing tropical cyclone motion forecast errors in HWRF* (T. Galarneau - NCAR)
- *Improving HWRF track and intensity forecasts via model physics evaluation and tuning* (R. Fovell - UCLA)

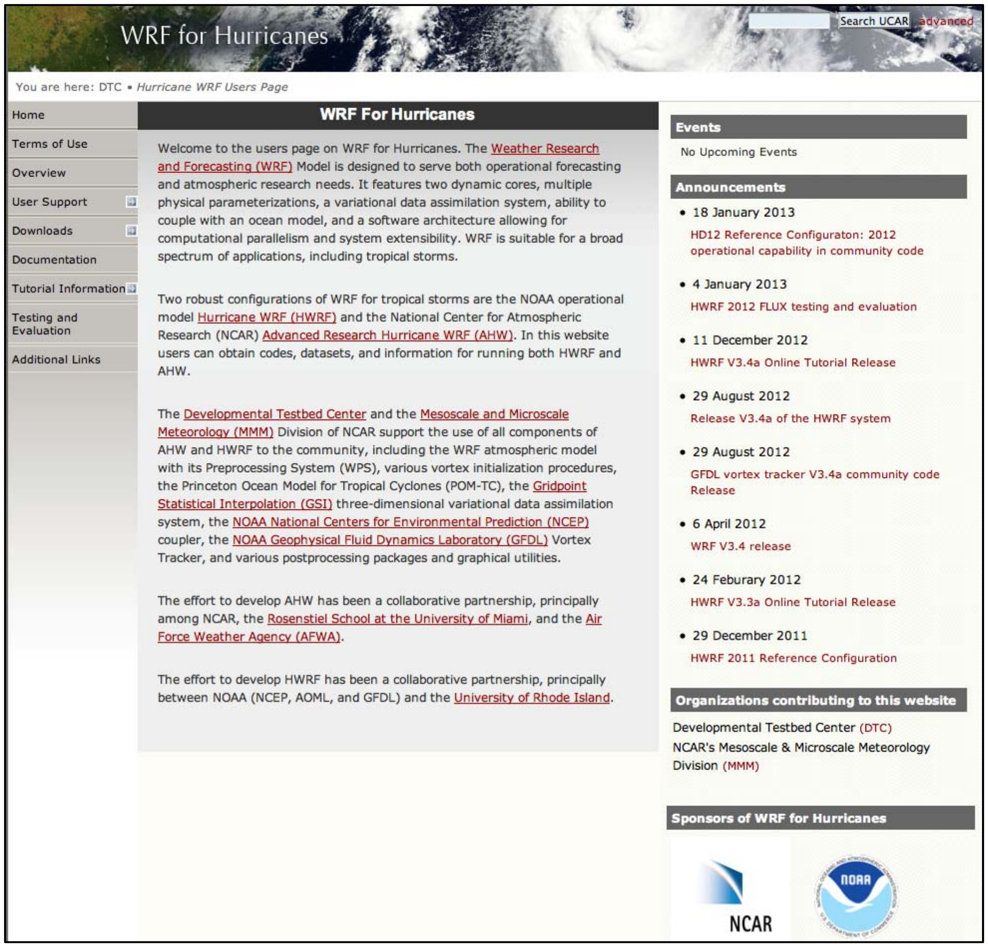
User and developer support

- Support the community in using an operational hurricane model

Testing and Evaluation

- Perform tests to assure integrity of community code and evaluate new developments for potential operational implementation www.dtcenter.org/HurrWRF/users

Support to users and developers



WRF for Hurricanes

Search UCAR advanced

You are here: DTC • Hurricane WRF Users Page

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WRF For Hurricanes

Welcome to the users page on WRF for Hurricanes. The Weather Research and Forecasting (WRF) Model is designed to serve both operational forecasting and atmospheric research needs. It features two dynamic cores, multiple physical parameterizations, a variational data assimilation system, ability to couple with an ocean model, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable for a broad spectrum of applications, including tropical storms.

Two robust configurations of WRF for tropical storms are the NOAA operational model Hurricane WRF (HWRF) and the National Center for Atmospheric Research (NCAR) Advanced Research Hurricane WRF (AHW). In this website users can obtain codes, datasets, and information for running both HWRF and AHW.

The Developmental Testbed Center and the Mesoscale and Microscale Meteorology (MMM) Division of NCAR support the use of all components of AHW and HWRF to the community, including the WRF atmospheric model with its Preprocessing System (WPS), various vortex initialization procedures, the Princeton Ocean Model for Tropical Cyclones (POM-TC), the Gridpoint Statistical Interpolation (GSI) three-dimensional variational data assimilation system, the NOAA National Centers for Environmental Prediction (NCEP) coupler, the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) Vortex Tracker, and various postprocessing packages and graphical utilities.

The effort to develop AHW has been a collaborative partnership, principally among NCAR, the Rosenstiel School at the University of Miami, and the Air Force Weather Agency (AFWA).

The effort to develop HWRF has been a collaborative partnership, principally between NOAA (NCEP, AOML, and GFDL) and the University of Rhode Island.

Events

No Upcoming Events

Announcements

- 18 January 2013
  HD12 Reference Configuraton: 2012 operational capability in community code
- 4 January 2013
  HWRF 2012 FLUX testing and evaluation
- 11 December 2012
  HWRF V3.4a Online Tutorial Release
- 29 August 2012
  Release V3.4a of the HWRF system
- 29 August 2012
  GFDL vortex tracker V3.4a community code Release
- 6 April 2012
  WRF V3.4 release
- 24 Feburary 2012
  HWRF V3.3a Online Tutorial Release
- 29 December 2011
  HWRF 2011 Reference Configuration

Organizations contributing to this website

Developmental Testbed Center (DTC)
NCAR's Mesoscale & Microscale Meteorology Division (MMM)

Sponsors of WRF for Hurricanes

NCAR
NOAA

700 registered users

Stable well-tested code downloads, documentation, helpdesk

Yearly releases: current HWRF v3.5a (2013 operational)

Tutorials in 2014
- College Park, MD (Jan)
- Taiwan (May)

Support to developers
- Direct access to code repository
- Use of experimental configurations
- Code integration to avoid divergence
- Inter-developer collaboration

HWRF testing and evaluation by DTC

- **Comprehensive T&E with DTC as a neutral evaluator**
  - **2011: Cumulus parameterization**
    - New SAS, Tiedtke, and Kain-Fritsh versus HWRF SAS
  - **2012: Atmosphere-ocean fluxes changes**
    - Operational implementation HWRF FY2013
  - **2013: Alternate physics suite**
    - Thompson microphysics and RRTMG radiation versus HWRF Ferrier microphysics and GFDL radiation

Test of HWRF with Thompson/RRTMG

	Control HC35	Experiment HDTR
Microphysics	Ferrier	**Thompson**
LW radiation	GFDL	**RRTMG**
SW radiation	GFDL	**RRTMG**
Cumulus	SAS	SAS
PBL	GFS	GFS
LSM	Slab	Slab
Dynamics (s)	45/15/5	45/15/5
Phys (s)	90/**90/30**	90/**60/20**
Radiation (min)	**60/60/60**	**15/15/15**

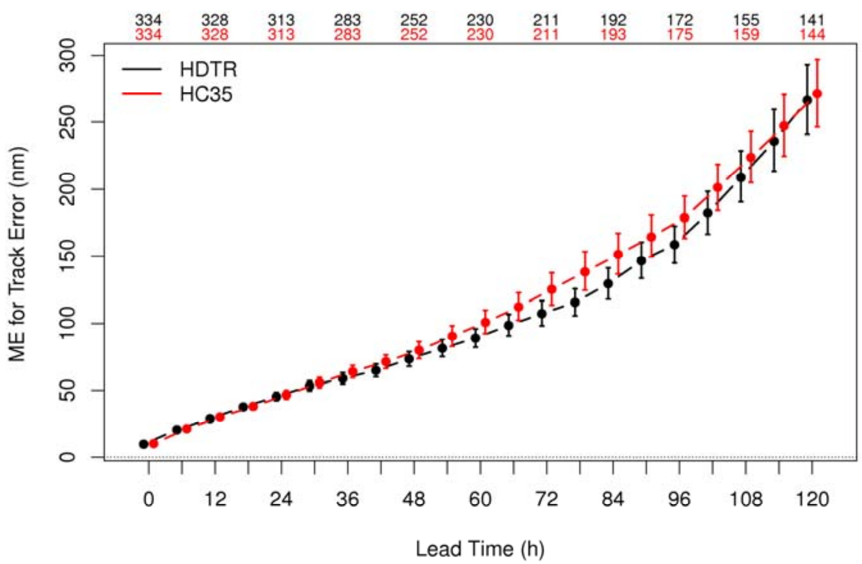
Domains, initialization, cycling etc. same as operational HWRF

Cases: 2012 season for AL and EP

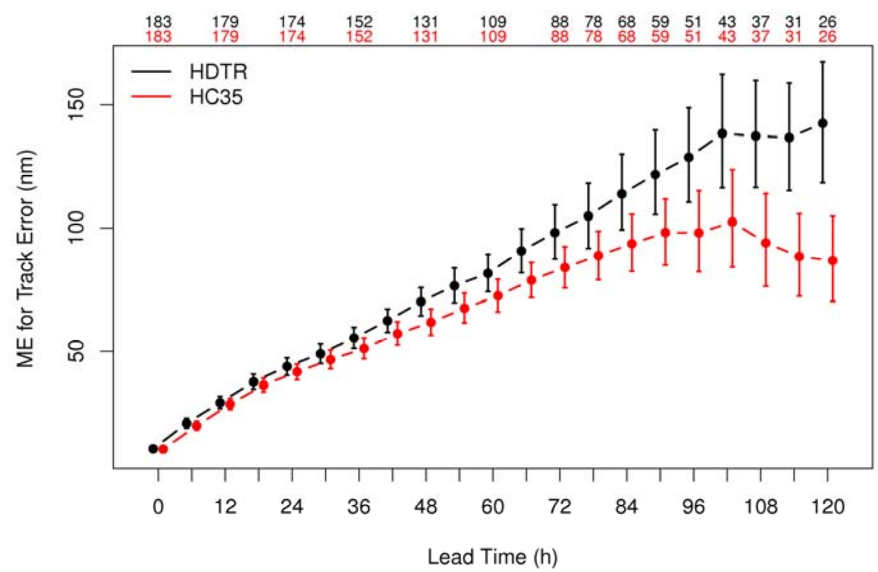
HDTR = Experiment
HC35 = Control

Track error

North Atlantic



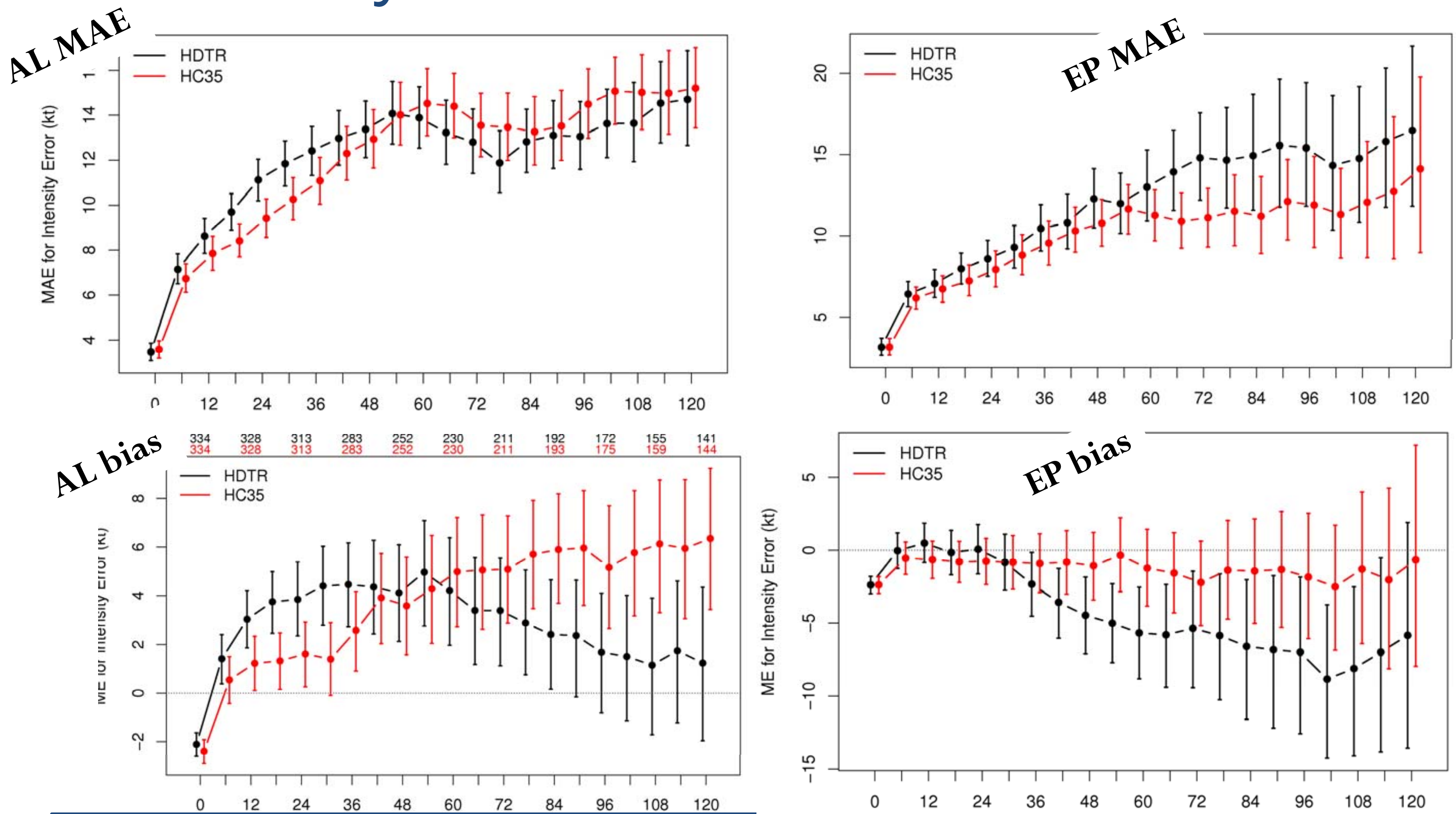
Eastern North Pacific



Experimental configuration improves track for AL but degrades for EP

HDTR = Experiment
HC35 = Control

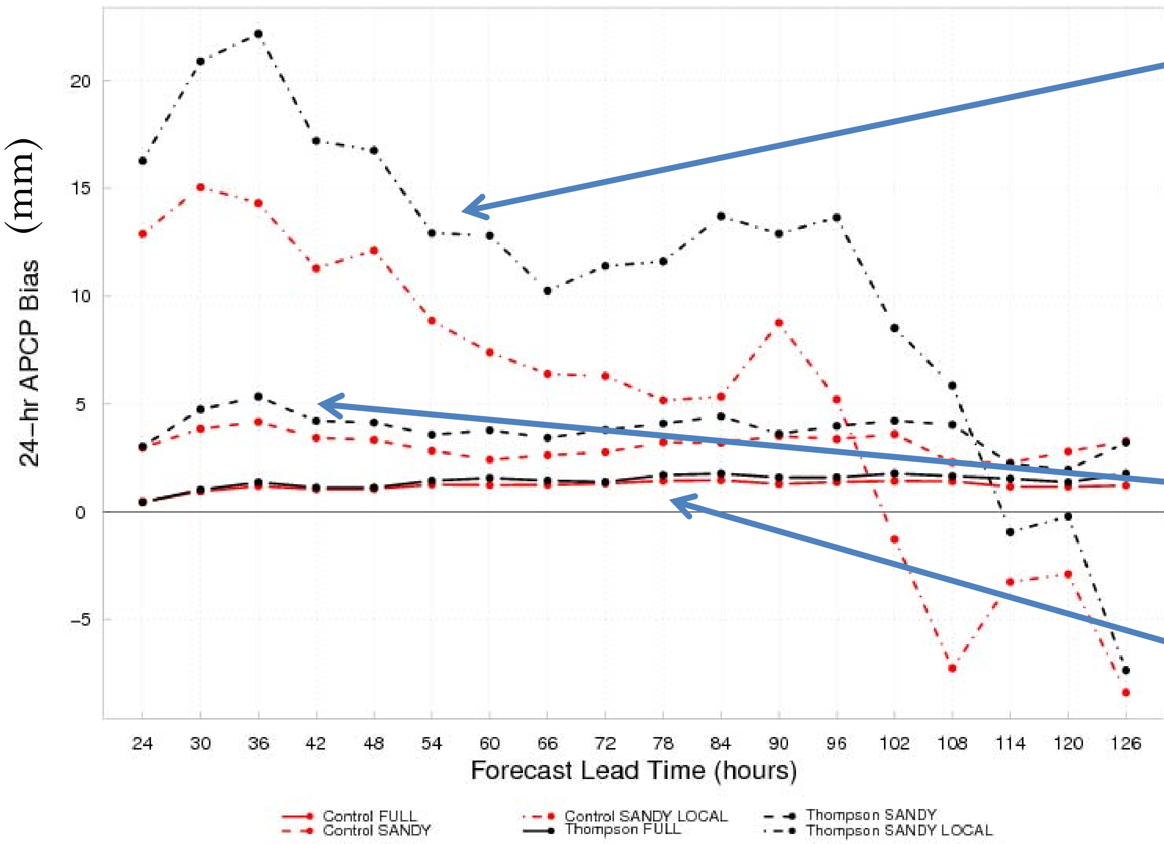
Intensity mean absolute-error and bias



Experiment: AL increased intensity for short lead times, decreased for longer lead times
EP decreased (degraded) intensity

HDTR = Experiment
HC35 = Control

Advanced diagnostics: precipitation bias



Subdomain (Under observed storm): High overprediction. Later in the forecast: models away from best track, therefore underprediction on this domain

Subdomain (10 deg centered on Sandy's entire track): both configurations overpredict

Entire domain: positive bias

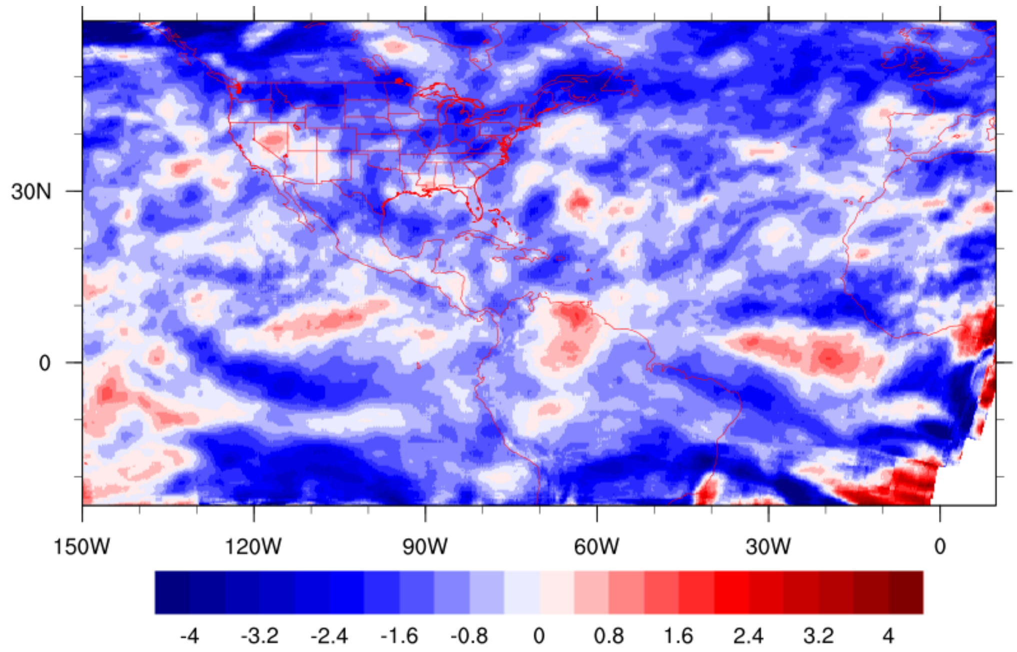
Higher bias in experiment

Dataset: TRMM 3B42 v7 (0.25°)
Accumulation: 24-h buckets
Cases: Hurricane Sandy

Advanced diagnostics: large-scale

HWRF forecasts vs GFS analyses

- T, geopotential height, RH, wind speed
- Various levels
- Bias and RMSE computed for 2012 season



Example: 48-h 250-hPa wind speed bias for control is mostly negative

Is this bias important to understand intensity forecast errors?

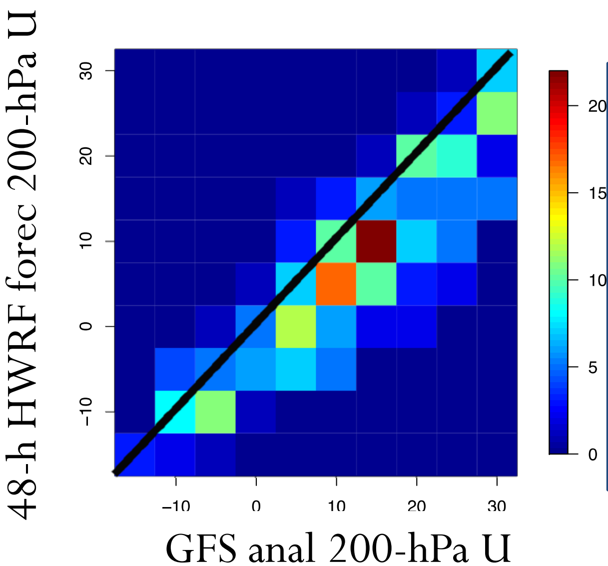
Advanced diagnostics: SHIPS predictors

Background

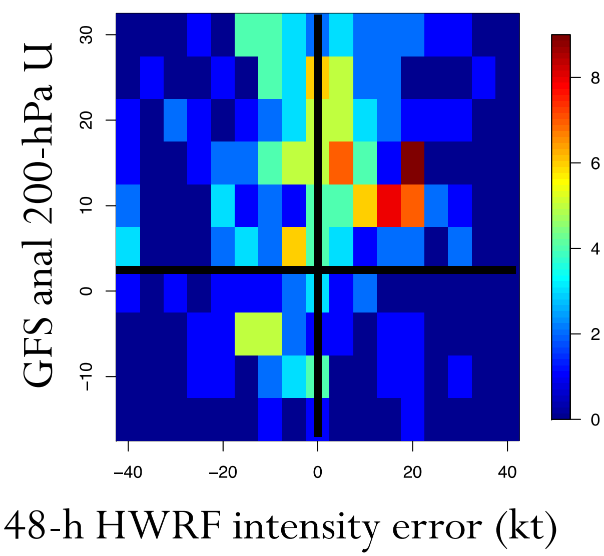
- De Maria and Kaplan (1999) showed that TC intensity can be explained by near-storm environmental factors: shear, moisture content, upper level winds etc (SHIPS predictors)
- Therefore, it is important to forecast the environment accurately

Comparison of near-storm environment in HWRF forecasts and GFS analyses

Comparison of near-storm environment errors against intensity errors



200-hPa forecast zonal wind averaged around storm has low bias



Largest positive intensity errors occur when winds 10-15 ms^{-1}, which are under forecast

Summary

- Code management and user support
  - Well established and successful
- Testing of innovations
  - Been successful with R2O transition for atmos-ocean fluxes
  - Produced negative (cumulus) or mixed (Thompson) results
  - Requires the use of innovative, advance diagnostic tools
  - Suggests that a closer partnership between DTC and developers is needed because innovations need to be tested-tuned-retested in HWRF context
- Going forward: DTC plans to partner with HFIP PIs to facilitate adding innovations and conducting testing