

Supporting the Research to Operation Transition in Hurricane Prediction: The DTC

Bill Kuo¹, Ligia Bernardet¹, Shaowu Bao¹,
and Naomi Surgi^{1,2}

¹The Developmental Testbed Center

²National Centers for Environment Prediction



NOAA Hurricane Forecast improvement Project (HFIP) Goals:

- Reduce average track error by 50% for Days 1 through 5.
- Reduce average intensity error by 50% for Days 1 through 5.
- Increase the probability of detection (POD) for rapid intensity change to 90% at Day 1 decreasing linearly to 60% at Day 5.
- Decrease the false alarm ratio (FAR) for rapid intensity change to 10% for Day 1 increasing linearly to 30% at Day 5.
- Extend the lead time for hurricane forecasts out to Day 7.

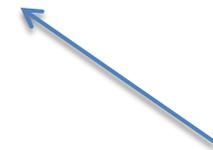
How are we going to do that?

Ingredients for Improvement

- Research and development
 - Model improvement:
 - Physical parameterizations, ocean and wave coupling, resolution, vortex initialization, ... etc
 - Observations:
 - New and innovative observations for the storm and its environment
 - Data assimilation and model initialization:
 - Optimal use of available in-situ and remote sensing observations
 - Ensemble:
 - Probabilistic forecast, data assimilation (EnKF), multiple-model ensemble
- Hurricane forecast improvements rely on EMC and NHC
- Mechanism to transition R&D to operations



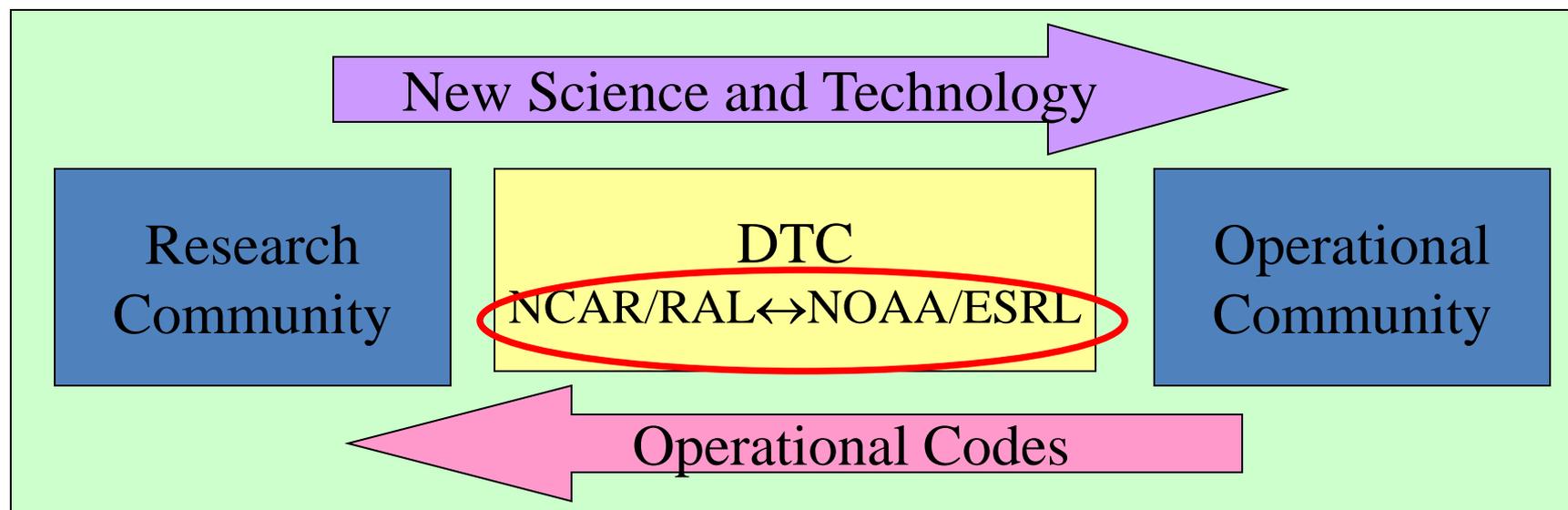
DTC



Fundamental Purpose of DTC

To serve as a bridge between research and operations to facilitate the activities of both halves of the NWP Community

- **Research:** functionally equivalent operational environment to test and evaluate new NWP methods over extended retrospective periods
- **Operational:** benefits from DTC & E of strengths and weaknesses of new NWP advances prior to consideration for operational implementation



DTC Goals on Hurricanes

Current focus : HWRF

- Facilitate transfer of research to operations by creating a framework for NCEP and the research community to collaborate
- Support the community in using HWRF (the current NCEP operational hurricane model)
- Develop and maintain a hurricane testing and evaluation infrastructure at DTC
- Perform HWRF tests to assure integrity of code and evaluate new developments for potential operational implementation

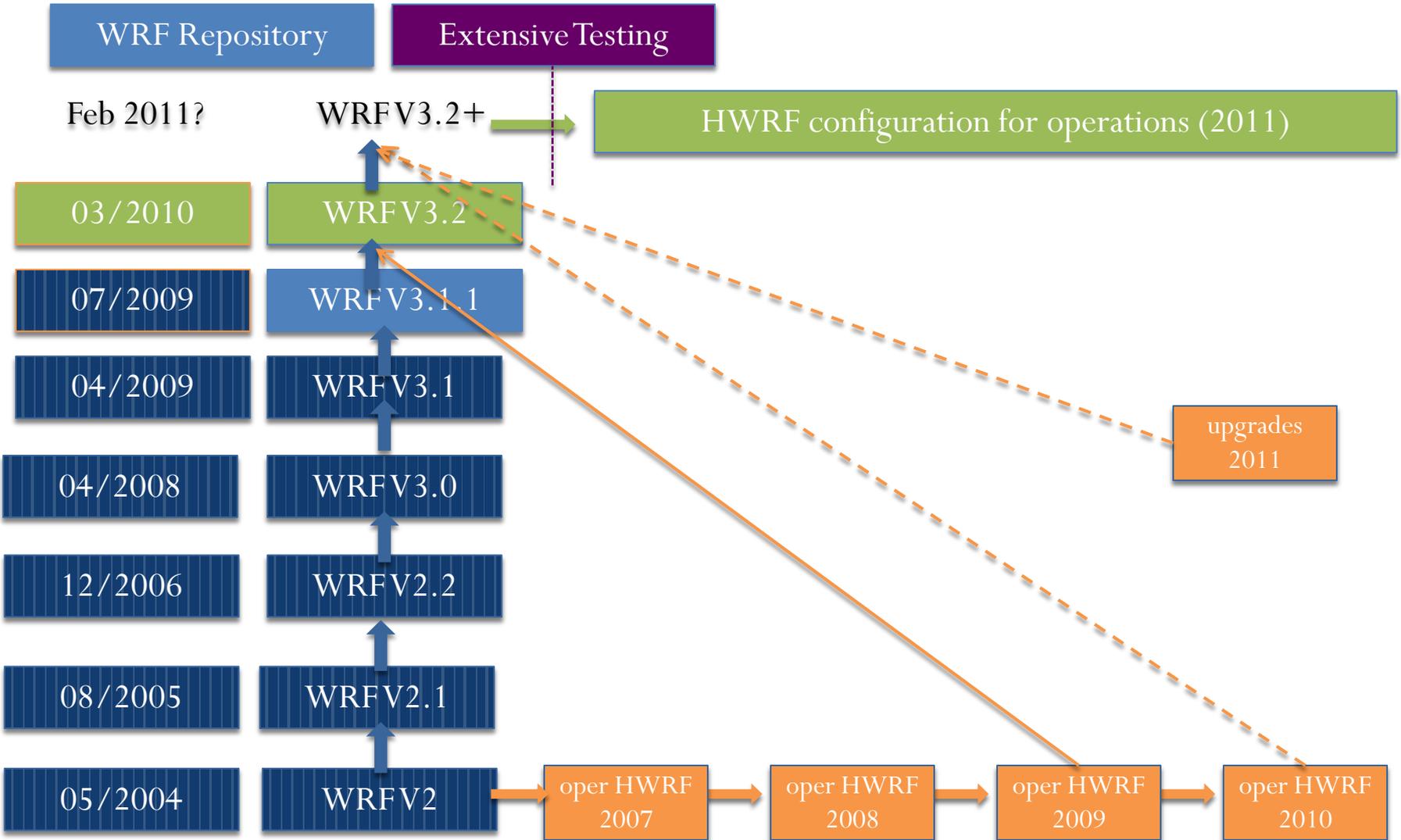
HWRF Code Management Agreement

Established between DTC and EMC in 2009

- Goal: NCEP and community use same code base for atmospheric component of WRF
- Accomplished: DTC and EMC worked together to port HWRF features to WRF repository in 2009
- Upcoming: Additional features (e.g., 2010 upgrades) will be ported and tested leading to the use of community HWRF code for operation at NCEP

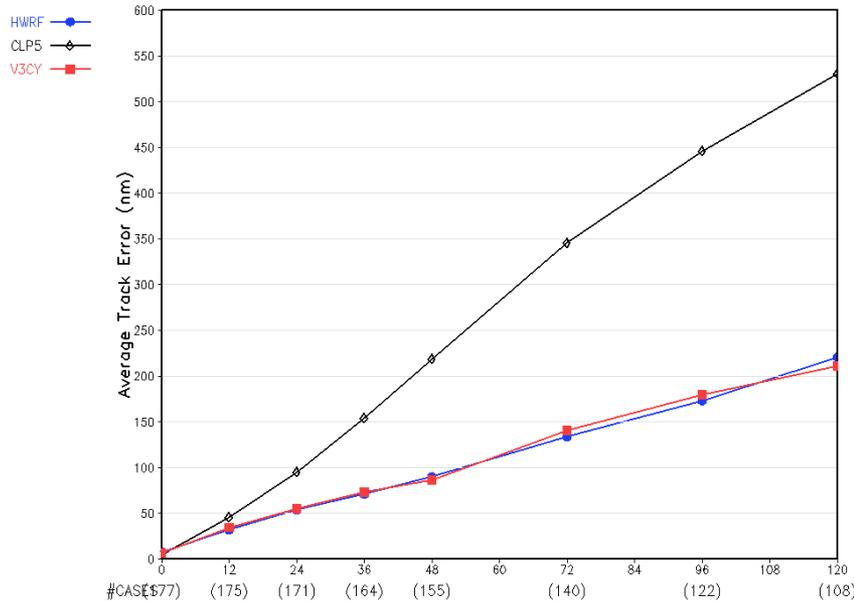
HWRF code management:

a new mechanism to facilitate collaboration between research and operations



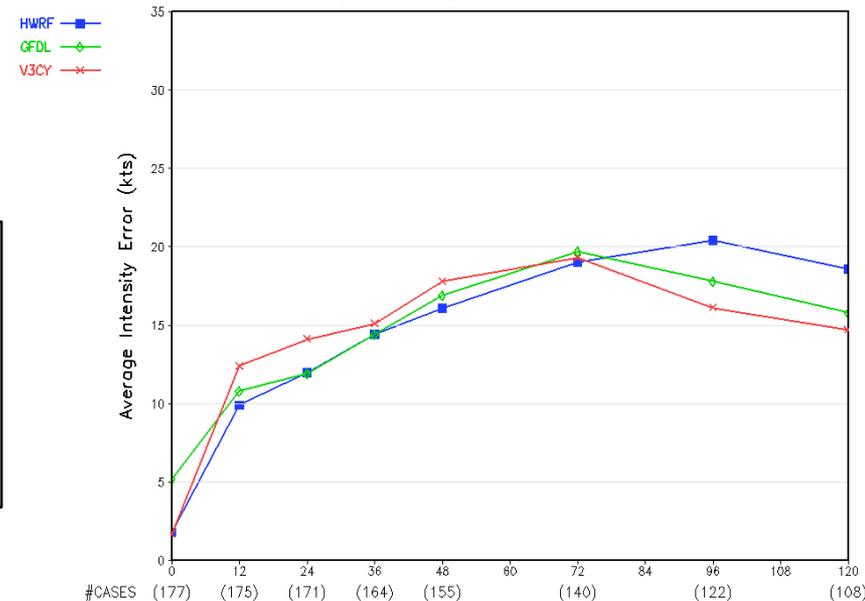
Testing results: 177 cases in 2008

HWRP: 2008 PROD; V3CY: HWRP V3; GFDL: 2008 PROD
Track Error Comparison, ATLANTIC HURRICANES, 2008



- V2 and V3 have “similar” track forecast
- Remaining differences between V2 and V3 intensity

HWRP: 2008 PROD; V3CY: HWRP V3; GFDL: 2008 PROD
Intensity Error Comparison, 2008 Atlantic Hurricanes



HWRP is a forecast from the operational model

V3CY is a forecast using the community WRF model code, after HWRP capabilities were added

Hurricane Research and Development

- Model development is not the primary responsibility of the DTC.
- DTC's primary role is to facilitate R2O and O2R in hurricane prediction, through collaboration with NCEP/EMC, NHC, ESRL, AOML, GFDL, NCAR, NRL and universities.
- DTC supports R2O function for HFIP.

DTC's contribution:
T&E

DTC Testing & Evaluation:

- Purposes
 - Asses integrity of repository code as it evolves
 - Assist NCEP with pre-implementation testing
 - Evaluate skill of new developments funded by HFIP
- Protocol
 - Code to be tested must be in community repository
 - Preferably test official release code

Hurricane Testing & Evaluation at DTC

- Testing environment functionally equivalent to NCEP's
- Currently using HFIP Linux Cluster njet
- Automation based on NOAA Workflow Manager: modularity and ease of use for DTC and other groups
- End-to-end coupled HWRF runs with cycling data assimilation
- National Hurricane Center forecast verification system
- Additional verification metrics developed at DTC / HFIP

Community Participation

- To get new developments tested for HWRF
 - Use code from official releases
 - Work with DTC to port your development into community repository

Community Support of HWRF

- In March 2010, DTC will start supporting WRF to the community in collaboration with DTC partners:
 - WRF V3.2 release (March 2010) will have HWRF features (MMM)
 - Princeton Ocean Model (URI)
 - Vortex Initialization (EMC)
 - Coupler (URI/EMC)
 - Vortex Tracker (GFDL)
- February 2010 Tutorial
- Documentation, website, helpdesk, code management

Future Work and Challenges

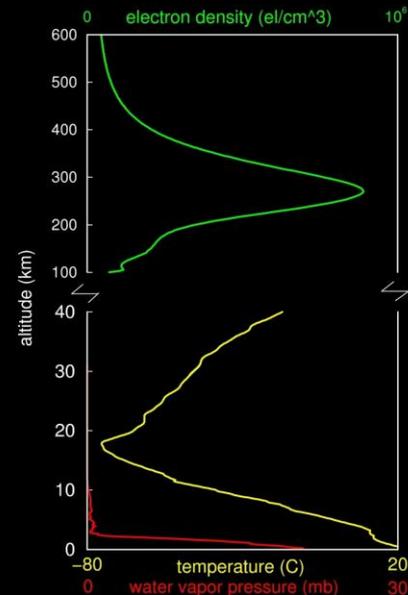
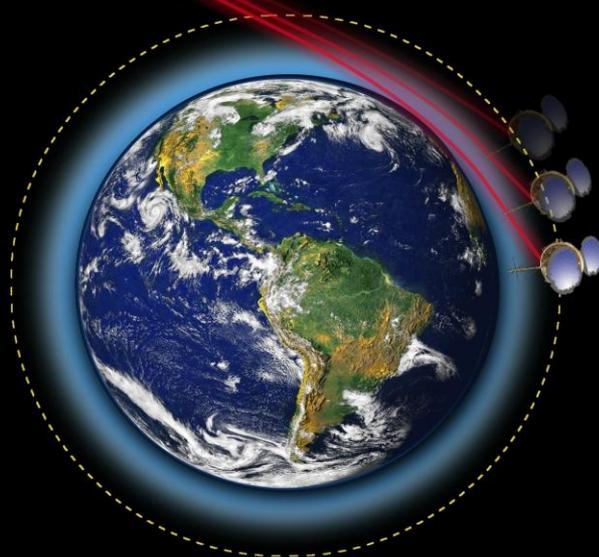
- Work with EMC to implement community HWRF (from the general WRF repository) for NCEP operation in 2011
- Establish functionally equivalent pre-implementation testing environment (parallel to EMC) for HWRF at DTC
- Work with HFIP to evaluate promising new development (from Stream 1) for possible operational implementation at NCEP
- Develop procedures to incorporate advances made by ARW and COAMPS in hurricane prediction into WRF repository and to evaluate them for possible operational implementation

Outlook

- DTC is a conduit for research to operation transition
- DTC should evaluate the most promising hurricane prediction systems, or components, for possible operational implementation.
- HWRF is the current focus, as it is the current NCEP operational system.
- In the longer-term future, DTC should work with EMC to evaluate other promising hurricane prediction systems, including:
 - Ensemble prediction
 - EnKF data assimilation
 - Global models for hurricane prediction



GPS



*Presentation of first
results from
COSMIC/
FORMOSAT-3
Published in
Bulletin of American
Meteorological
Society,
March 2008*

Anthes et al.

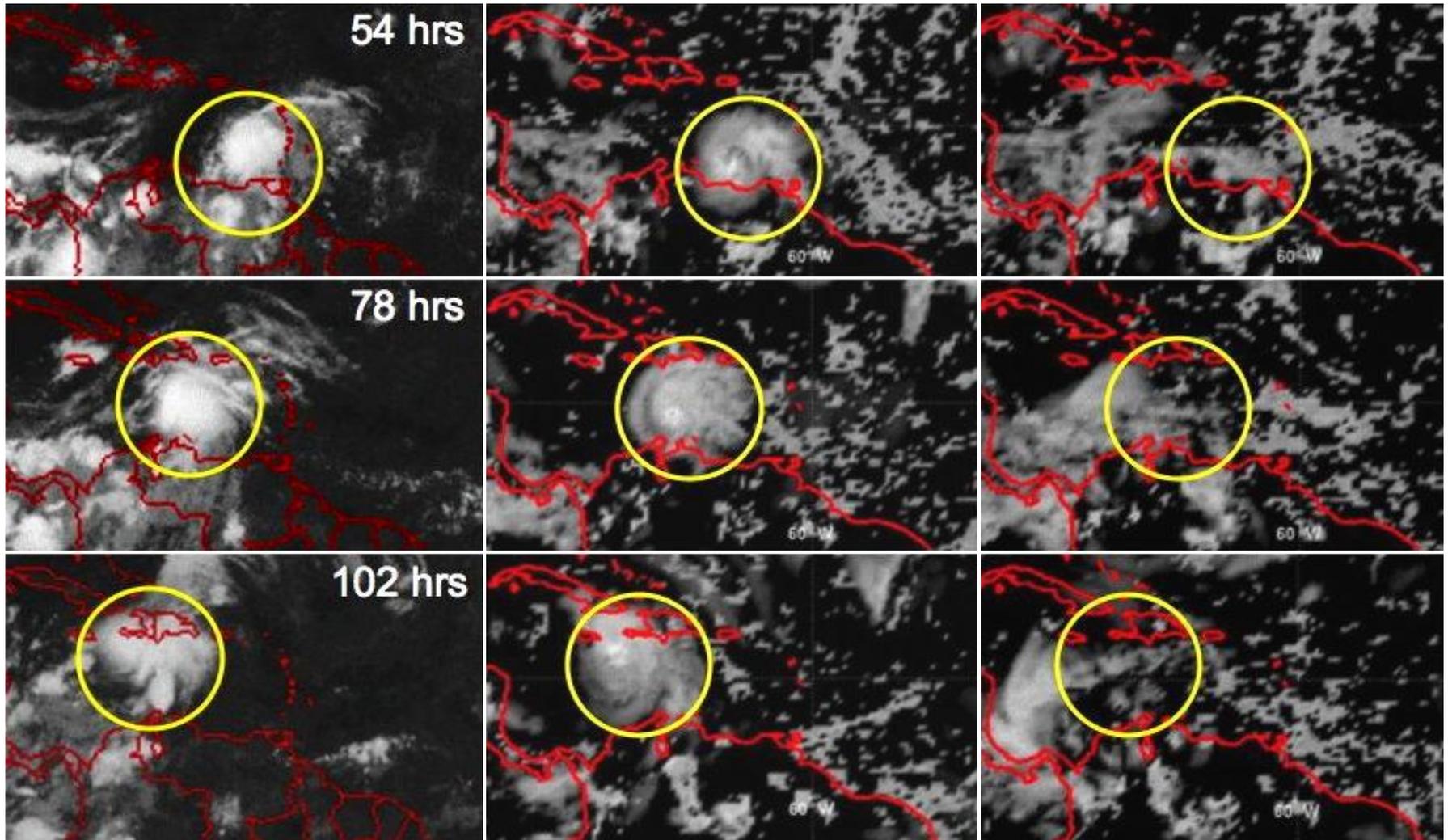
**COSMIC / FORMOSAT - 3
Profiling the Atmosphere by
Radio Occultation**

Four-Day Ernesto (2006) Forecasts

The Actual Storm

Forecast with GPS

Forecast without GPS

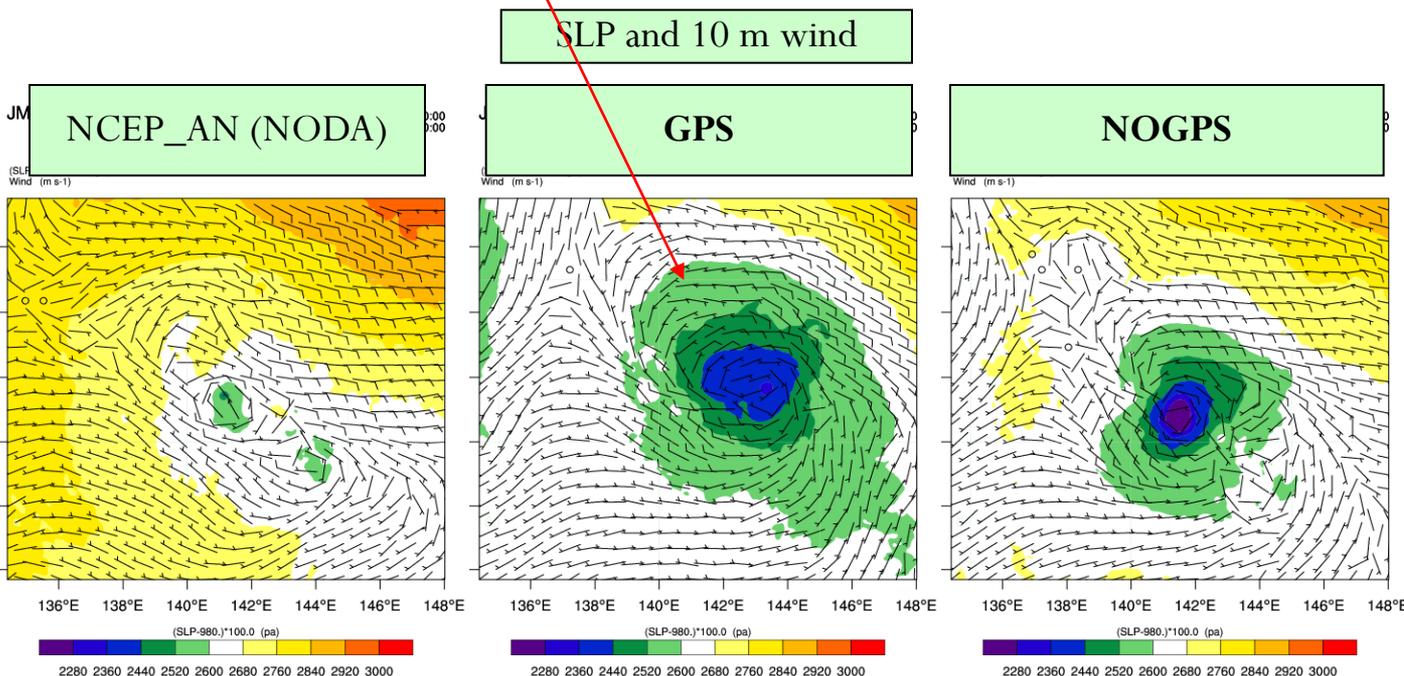
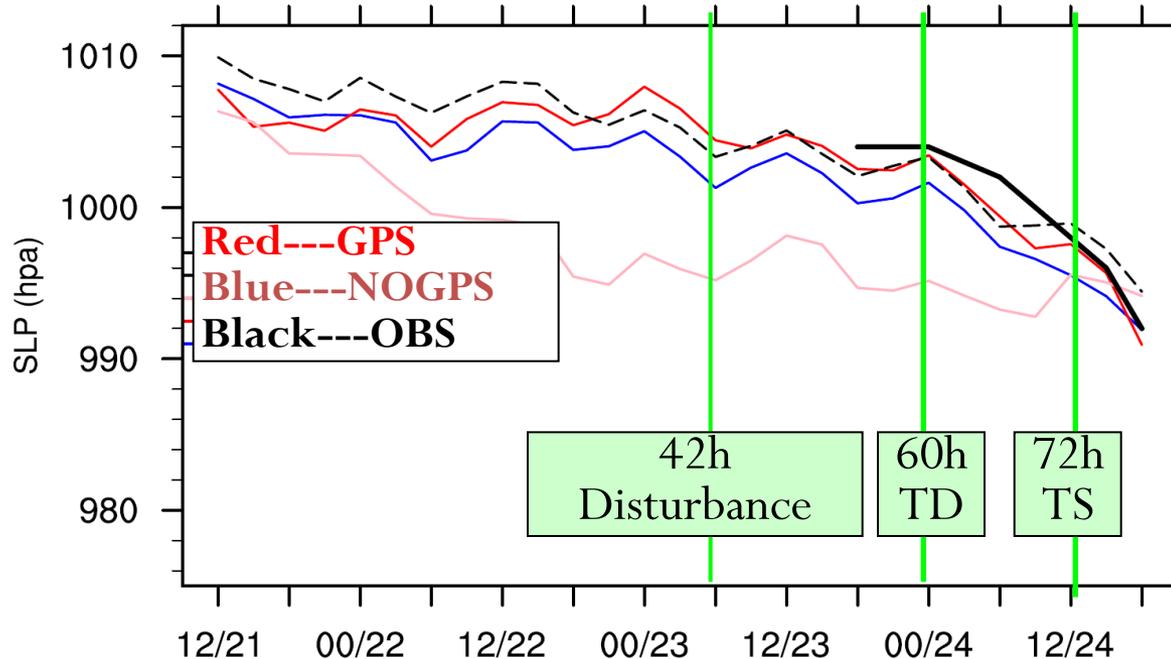


42 h forecast

GPS RO improves the disturbance prediction:

- with larger scale
- with more robust low level circulation
- Better moisture distribution
- with better precipitation

JANGMI TCG INTENSITY ENSEMBLE FORECAST FROM 2008092112 DART ANALYSIS
 DART ANALYSIS STARTED FROM 2008091900, WITH/WITHOUT GPS RO

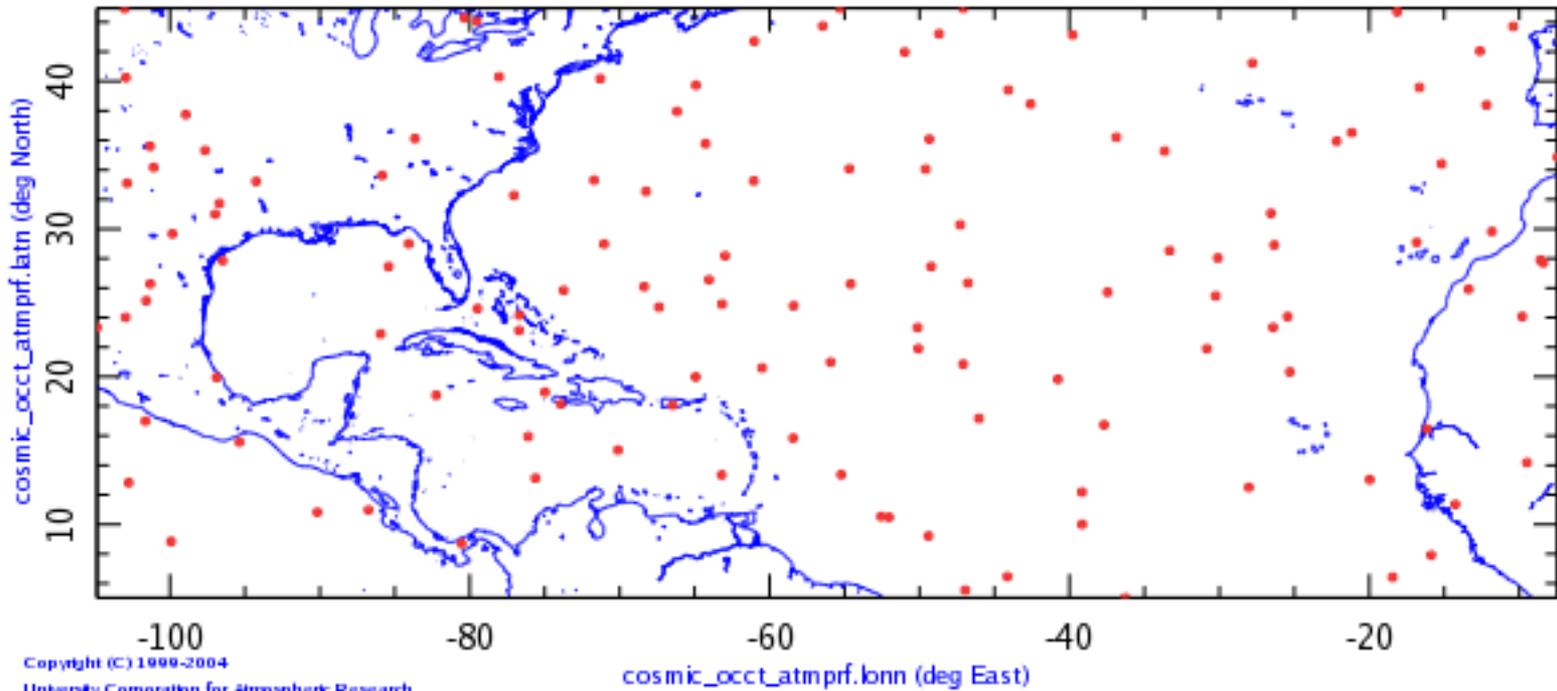


GPS RO also gives the best TD and TS intensity prediction.

From X. Fang (2010)

Actual COSMIC soundings in a day

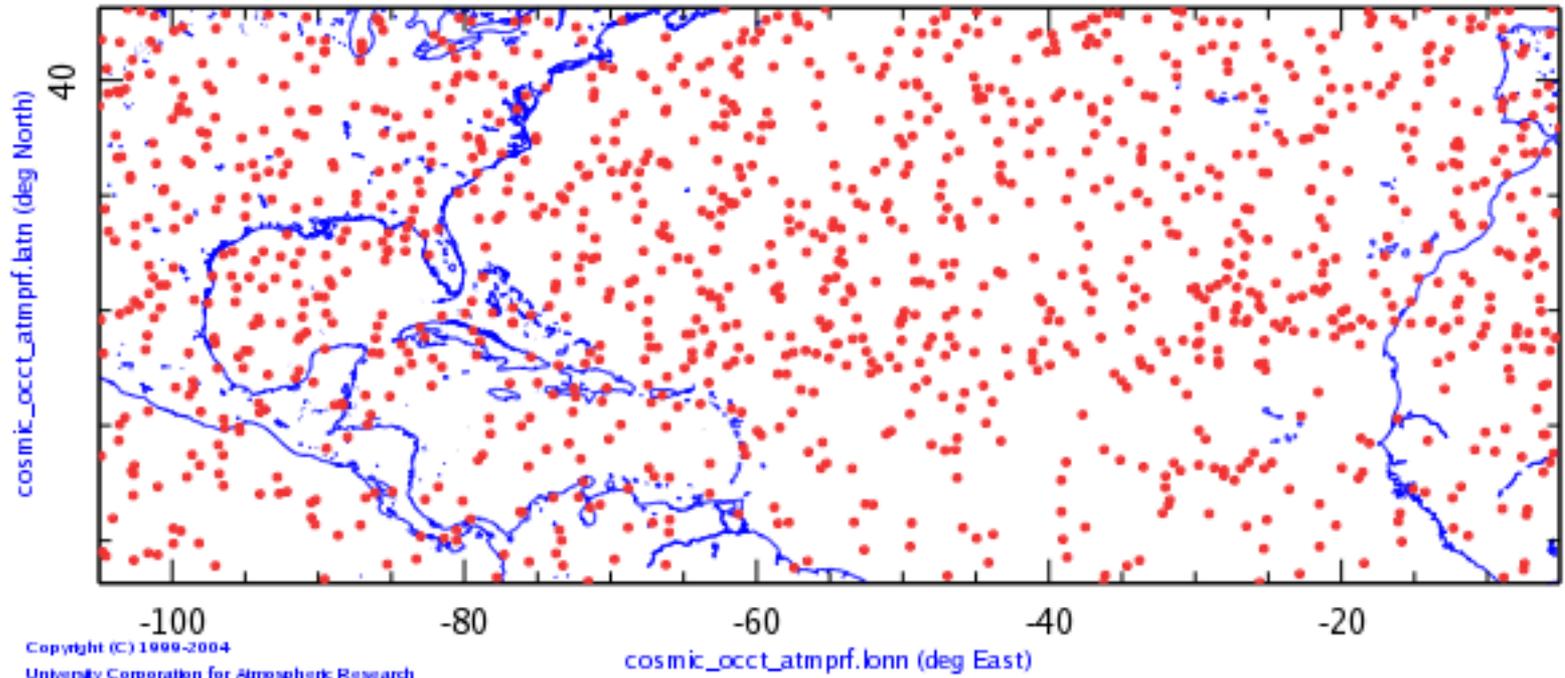
129 Matches



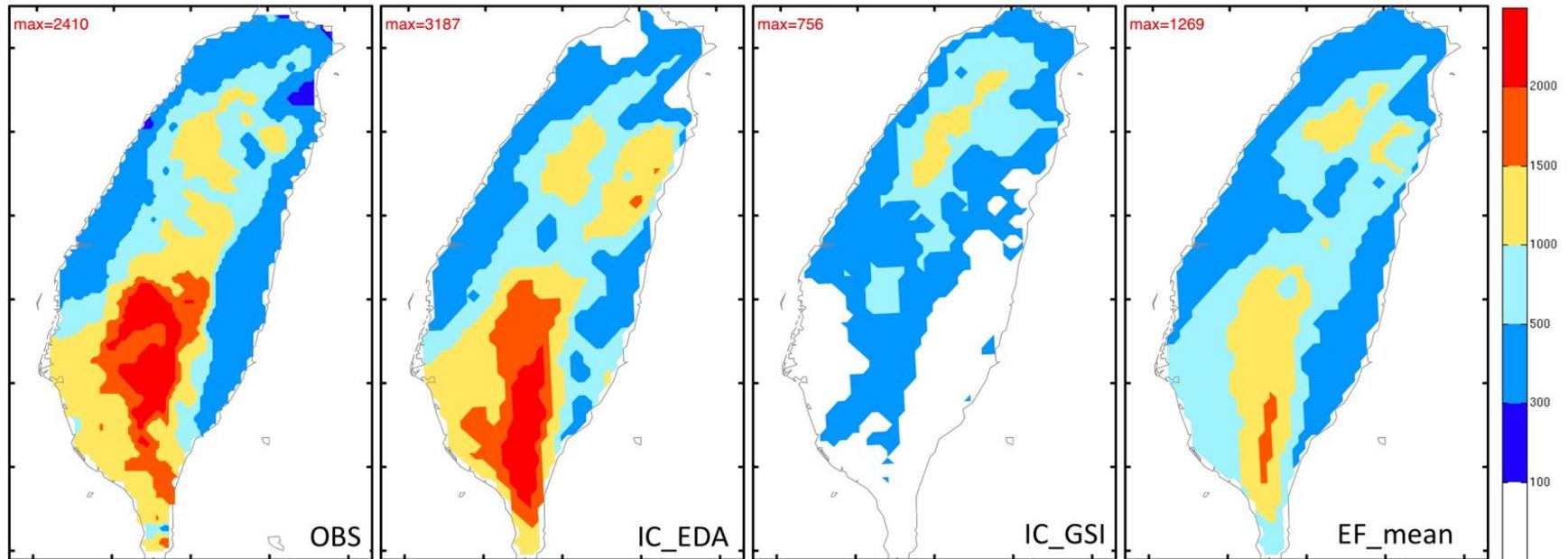
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Actual COSMIC soundings in a week

1176 Matches



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3-day accumulated rainfall from observation (OBS), a deterministic WRF forecast based on a NCEP GFS-based EnKF analysis (IC_EDA), WRF forecast based on NCEP GSI analysis, and WRF 60 member ensemble mean forecast (EF_mean).

WRF is run at 4-km horizontal resolution.

GPS RO data are assimilated for all studies.

The forecast started at 0000 UTC 5 August 2009, almost three days in advance of landfall of Typhoon Morakot (at 1800 UTC 7 August 2009).

Rain Probability Forecast (August 7-8 00Z)

Probability forecast (% , >500mm, Aug 7-8 00Z), CTL Probability forecast (% , >500mm, Aug 7-8 00Z), GPS

