Observing System Simulation Experiments to Evaluate the Potential Impact of Proposed Observing Systems on Hurricane Prediction:

R. Atlas, T. Vukicevic, L.Bucci, B. Annane, A. Aksoy,

NOAA Atlantic Oceanographic and Meteorological Laboratory

S. Majumdar, D. Nolan, B. McNoldy

University of Miami/RSMAS

In collaboration with: JCSDA, NESDIS CIMSS, NASA and SWA,

OBSERVING SYSTEM SIMULATION EXPERIMENTS

Objectives for Hurricanes:

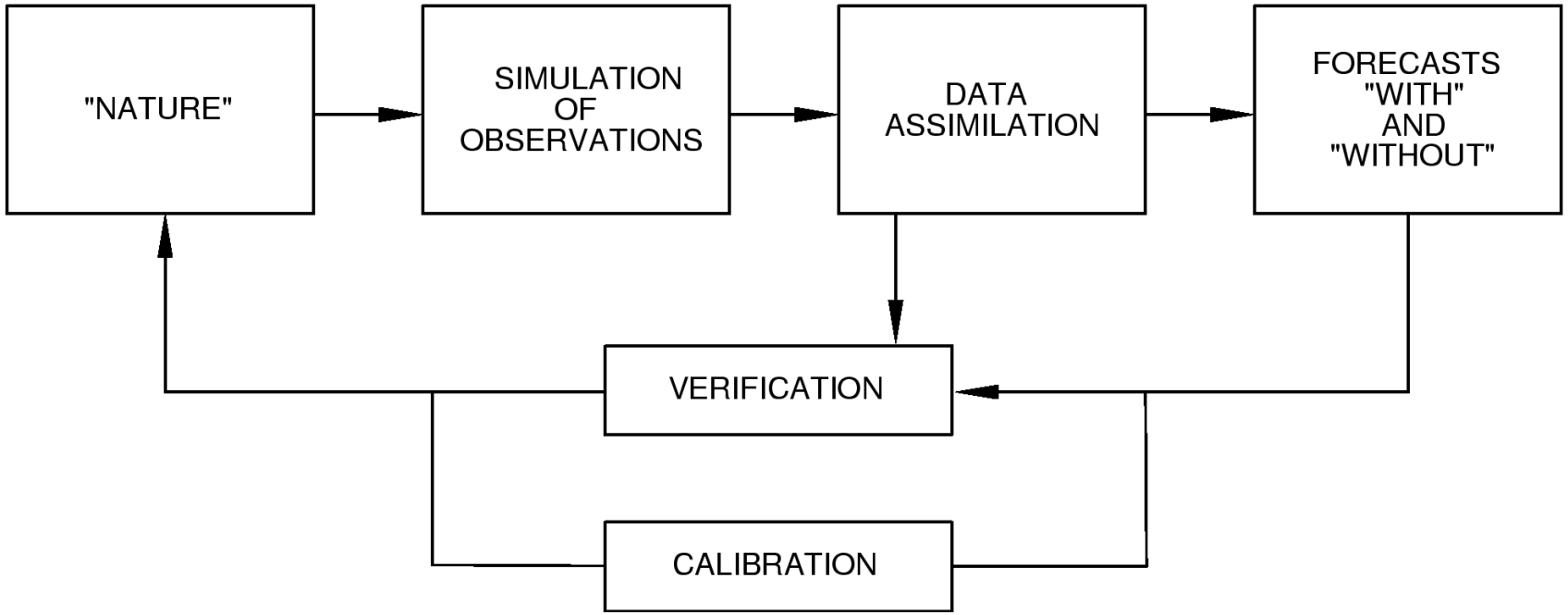
1. Evaluate the potential impact of new (proposed) observing systems on hurricane track and intensity predictions.

2. Evaluate tradeoffs in the design and configuration of proposed observing systems (e.g. coverage, resolution, accuracy and data redundancy).

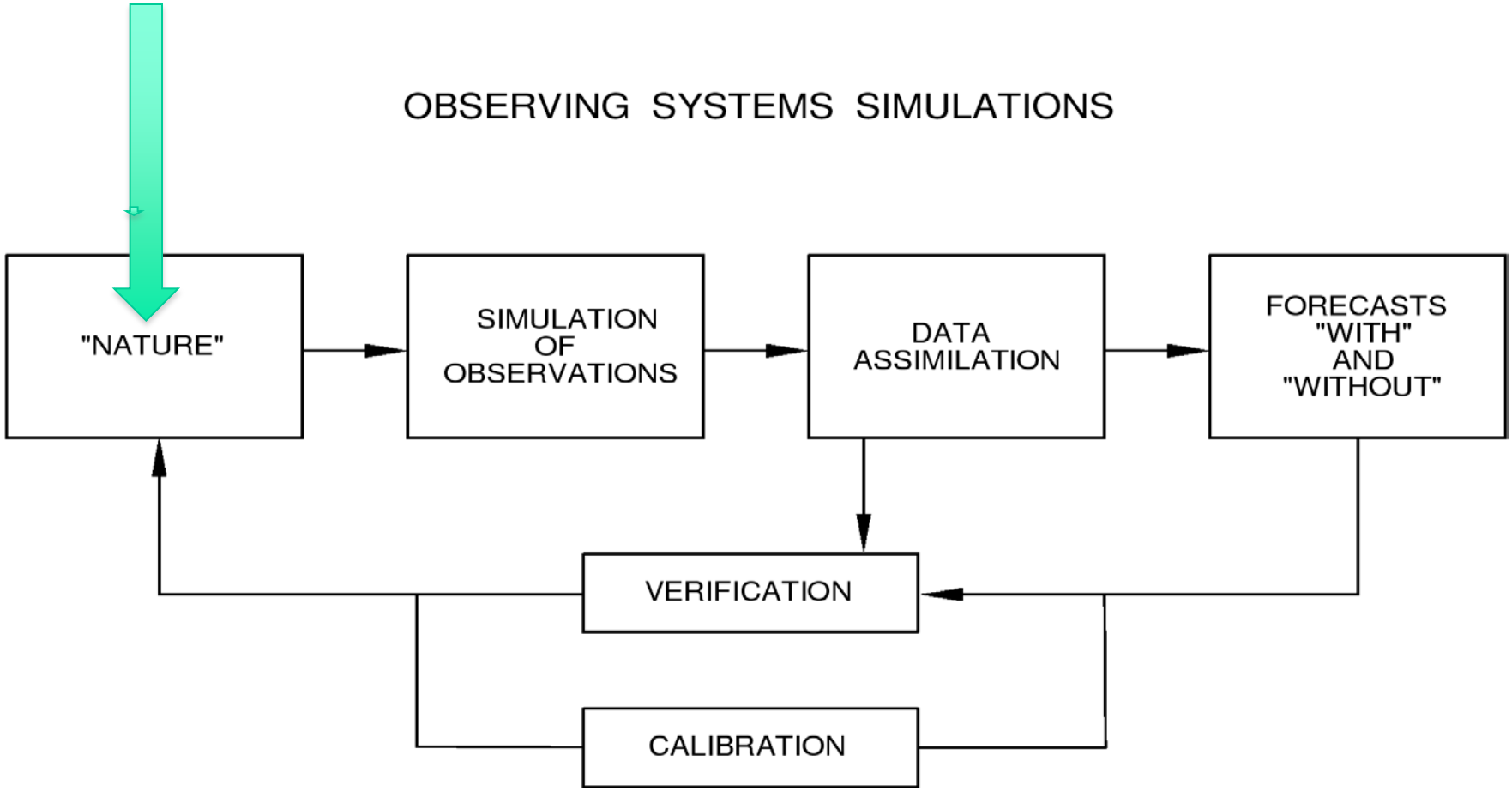
3. Optimize sampling strategies for current and future airborne and space-based observing systems.

4. Evaluate and improve data assimilation and vortex initialization methodology for hurricane prediction.

OBSERVING SYSTEMS SIMULATIONS



“Regional Nature Run”



Earlier OSSEs for Hurricanes

1. Global OSSEs Using 3&1/2 month fvGCM Nature run at .5 deg resolution
   - aimed at evaluating the potential impact of Doppler Lidar winds on hurricane track prediction

2. Global Quick OSSE using .25 deg fvGCM 5-day forecast as Nature
   - aimed at evaluating impact of wind profile observations on the forecast track for an Ivan like hurricane and in testing hypotheses relating to hurricane track forecasting

3. Regional Quick OSSE using mm5 nature run
   - aimed at evaluating the potential impact of HIRAD on hurricane surface wind analyses

4. Regional Quick OSSEs using WRF ARW 3-5 day forecasts as nature runs
   -aimed at evaluating potential value of AIRS, Doppler Wind Lidar or other data for hurricane intensity forecasting.

Current and planned OSSEs for hurricanes

- To determine potential impact of UAS and to optimize sampling strategies for both UAS and hurricane reconnaissance aircraft.
- To evaluate advanced hyperspectral sounders in both geostationary and polar orbit
- To evaluate microwave sounders in geostationary orbit
- To evaluate alternative wind lidar technologies
- To evaluate constellations of GNSS satellites (eg. COSMIC, CYGNSS)

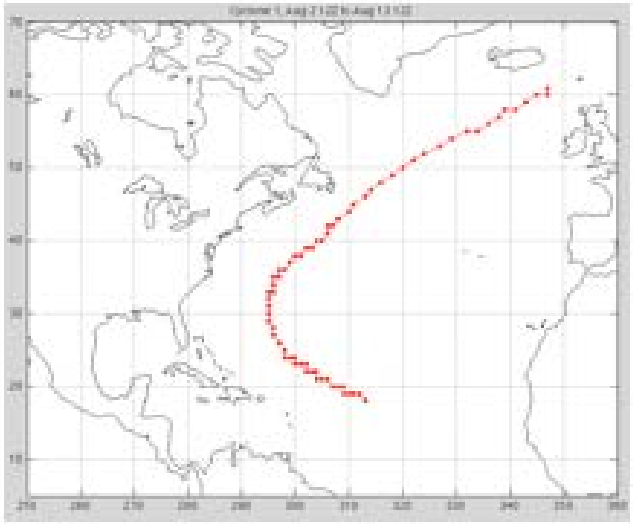
AOML's REGIONAL TC OSSE/OSE SYSTEM

Nature run: WRF ARW embedded within ECMWF T511 Global nature run

- **Numerical Assimilation and Forecast Model:**
  - NOAA's Hurricane Weather Research and Forecasting (HWRF) Model
    - Operational TC forecast model
    - WRF-NMM dynamical core with storm-following grid nesting
- **Options for data assimilation:**
  - 3DVAR with NOAA Gridpoint Statistical Interpolation (GSI)
    - Assimilation of conventional and satellite observations
    - Satellite radiances are used only in cloud-clear conditions
    - Grid-point-based static background errors
  - Hybrid 3DVAR with NOAA's GSI-Hybrid data assimilation system
    - Same capability for observations as GSI
    - Applies weighting between ensemble-based and static background errors
    - Ensemble perturbations updated by an EnKF
  - Ensemble Kalman Filter with NOAA/AOML/HRD Hurricane Ensemble Data Assimilation System (HEDAS)
    - EnKF
    - Developed in AOML as a research tool to study assimilation of TC airborne observations
  - H*Wind

ECMWF Nature run hurricanes

(a)



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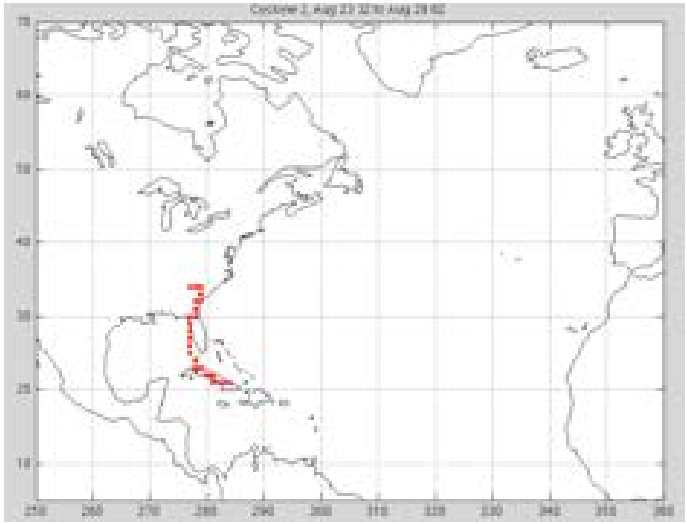

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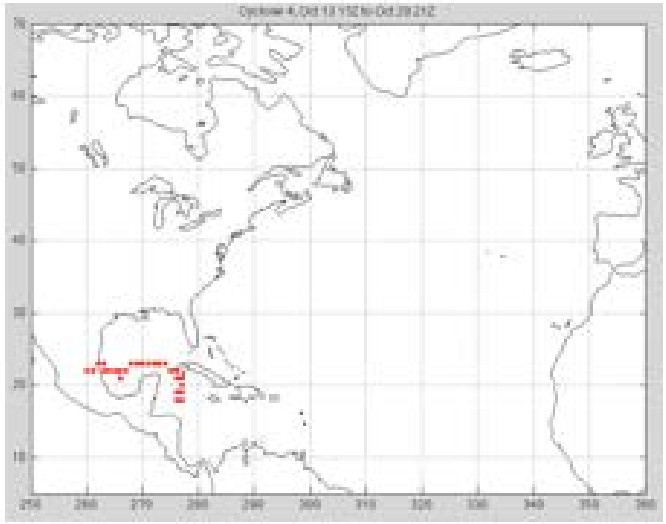
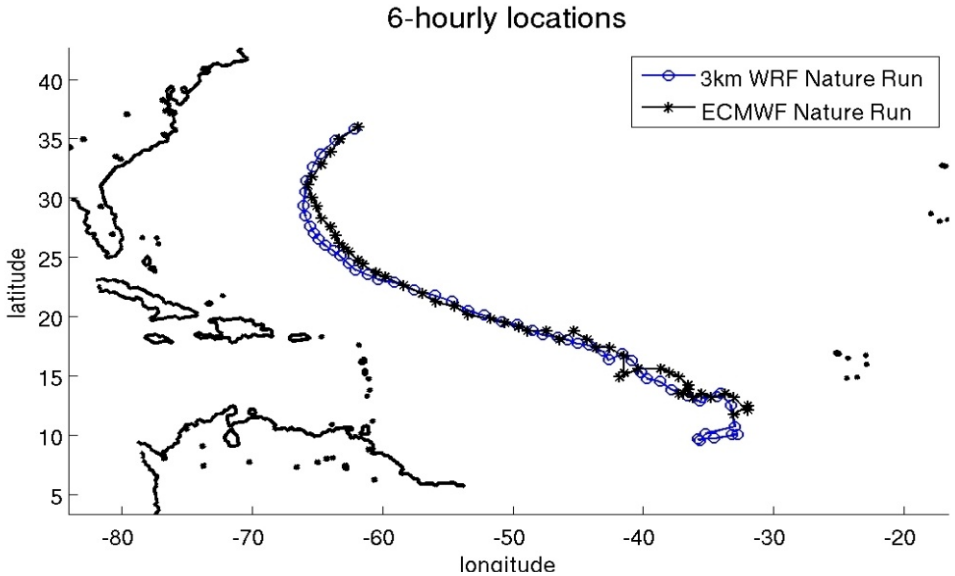
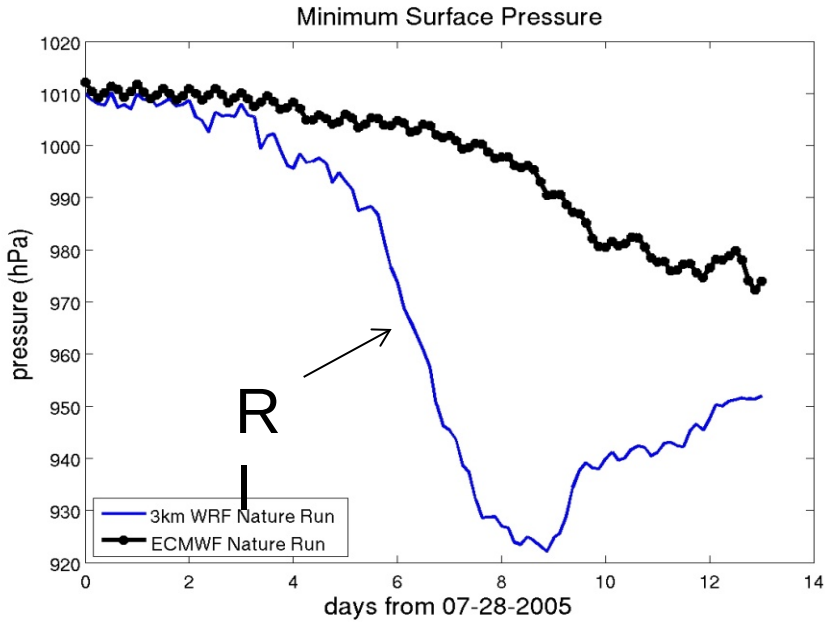


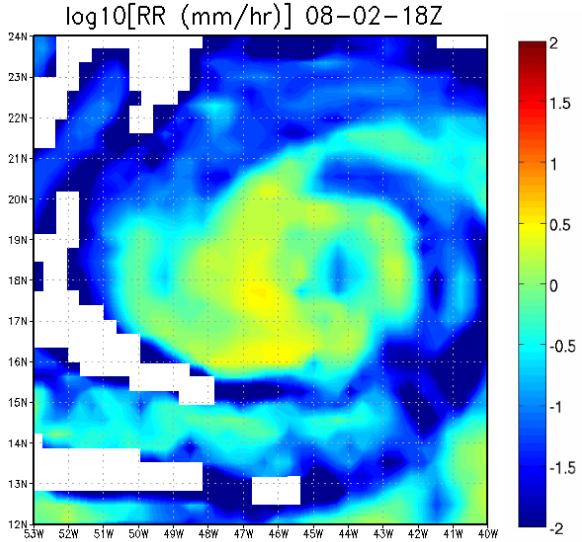
High Resolution Hurricane Nature Run: WRF Simulation Embedded Inside the ECMWF Nature Run

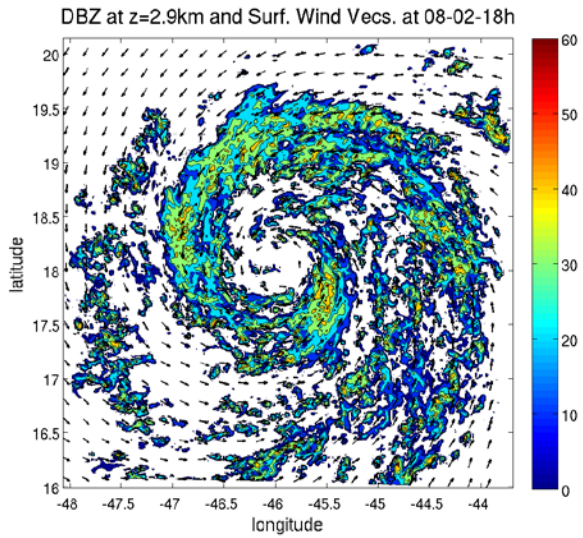
60 levels; 1km resolution; double-moment microphysics; advanced radiation schemes.





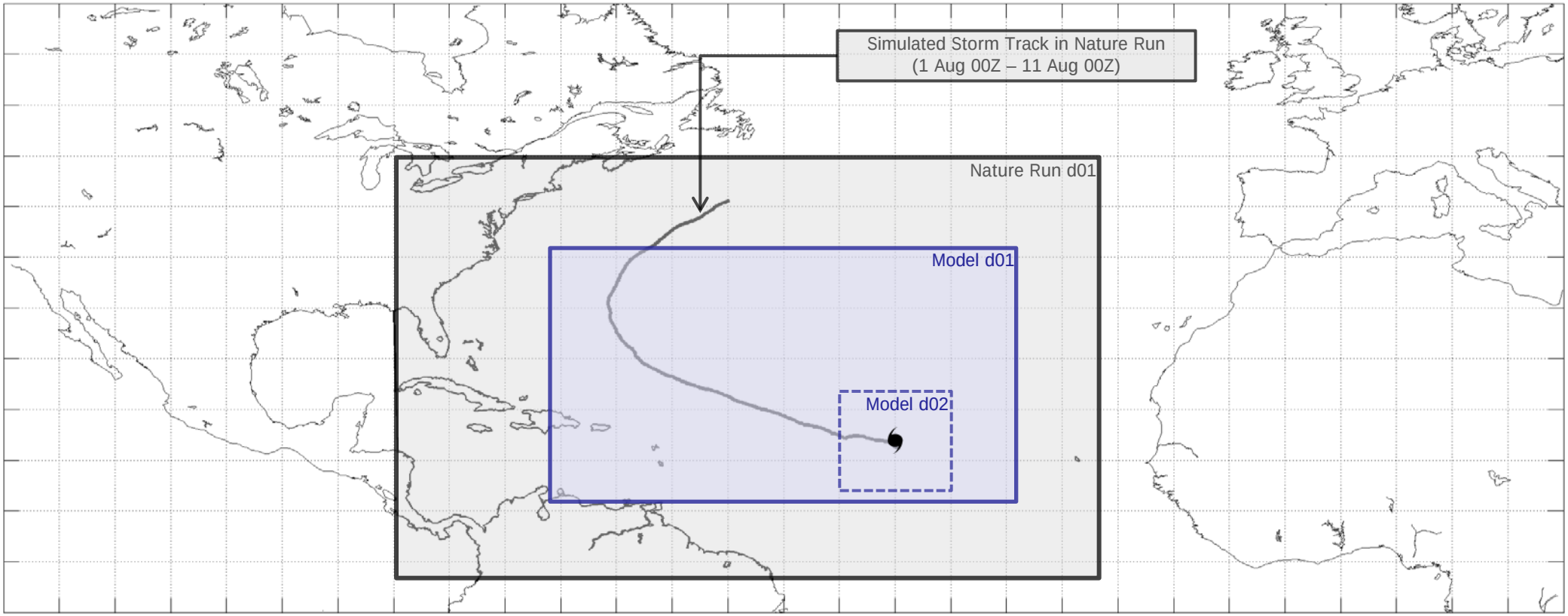
ECMWF T511 Nature Run





1 km WRF-ARW Nature Run

MODEL DOMAIN CONFIGURATION



- **Outer domain (d01):**
- Analysis domain
- Fits within the Nature Run outer domain & tries to capture most of storm life cycle
- 9 km horizontal grid spacing (708x412 grid points)
- 61 vertical levels
- **Inner domain (d02):**
- Only active during forecasts
- Storm-following moving nest
- 3 km horizontal grid spacing (352x340 grid points, ~10° x10°)
- 61 vertical levels

Description of Global OSSE to evaluate alternative lidar technologies

NATURE RUN:

ECMWF T511 Nature run for the period from May 10 2005 to May 31, 2006.

GLOBAL DATA ASSIMILATION SYSTEM USED:

NCEP GFS at T382 resolution

PERIOD OF ASSIMILATION: July 28 – August 24, 2005

DATA ASSIMILATION EXPERIMENTS:

CTRL (All standard conventional and space-based data)

OAWL (CTRL+OAWL lidar wind data)

WISSCRCOH (Conventional Data +WISCRCOH coherent lidar wind data)

FORECAST EXPERIMENTS: Twenty 7-day forecasts generated from each

Description of Regional OSSE

NATURE RUN:

WRF ARW embedded within the ECMWF T511 Global Nature run for the period from July 28 to August 10, 2005.

REGIONAL DATA ASSIMILATION SYSTEM USED:

Current operational version of HWRF with GSI

PERIOD OF ASSIMILATION: August 4, 00-18Z, 2005

DATA ASSIMILATION EXPERIMENTS:

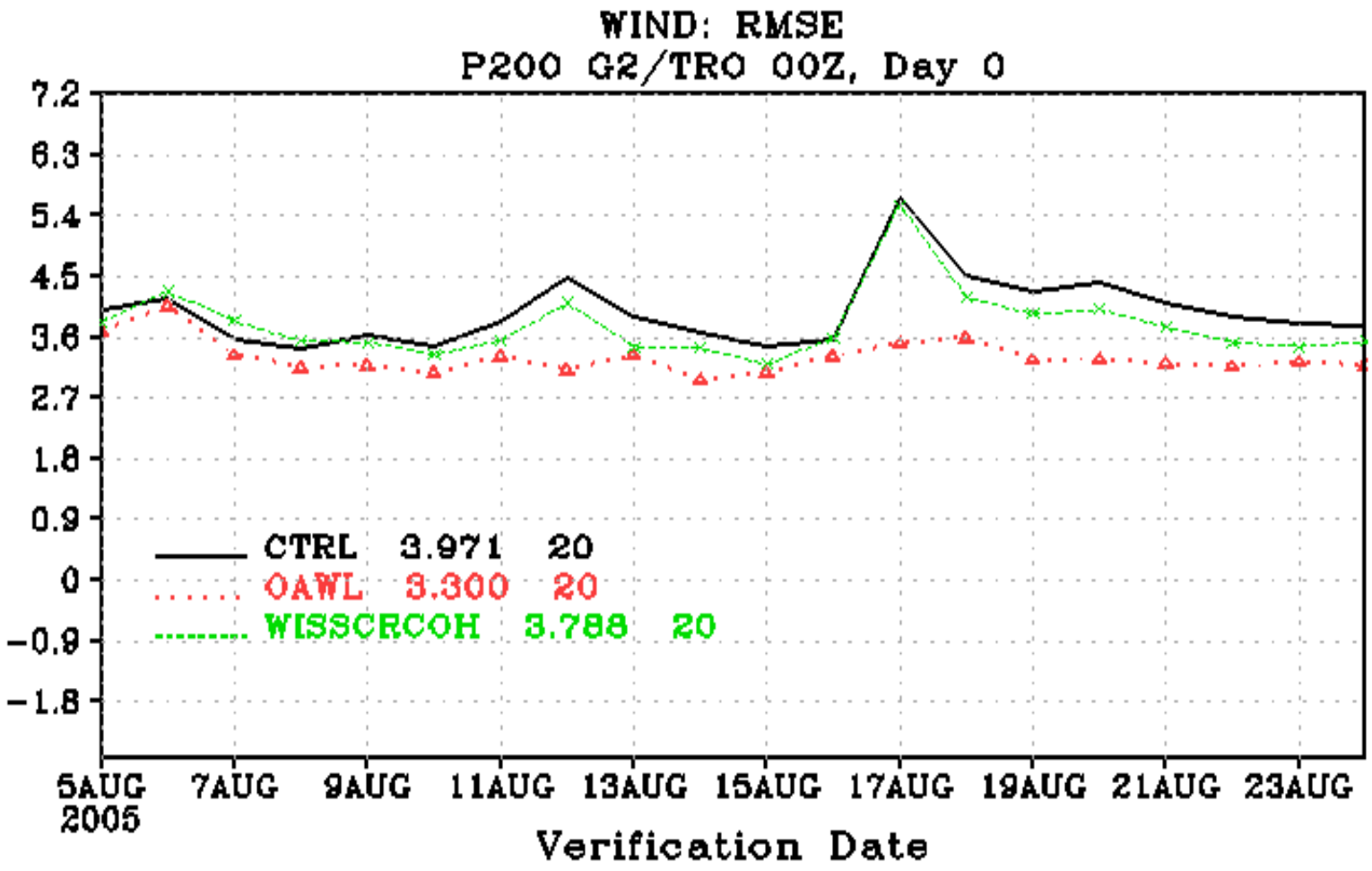
CTRL (All standard conventional and space-based data)

OAWL (CTRL+OAWL lidar wind data)

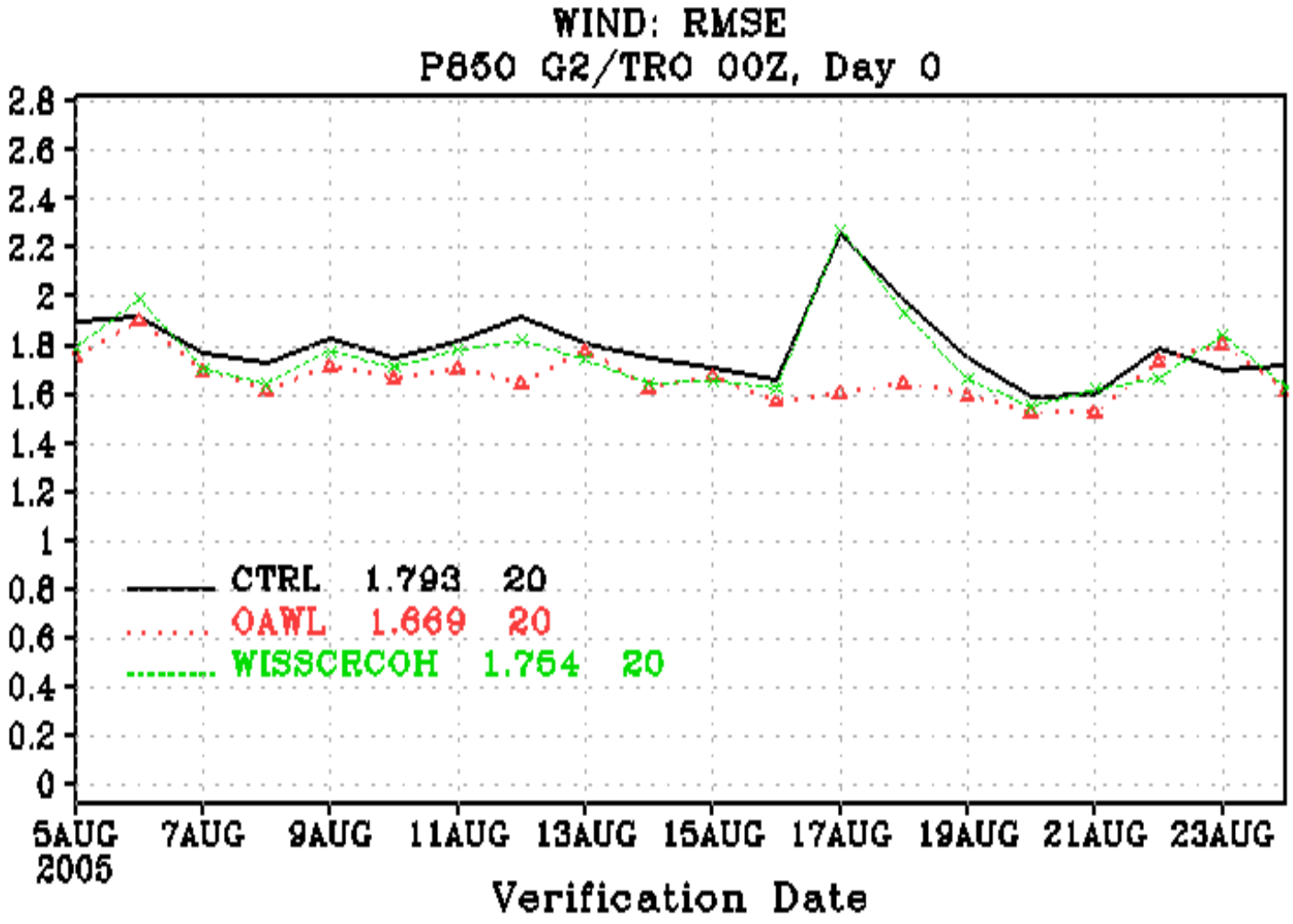
WISSCR (Conventional Data +WISCRCOH coherent lidar wind data)

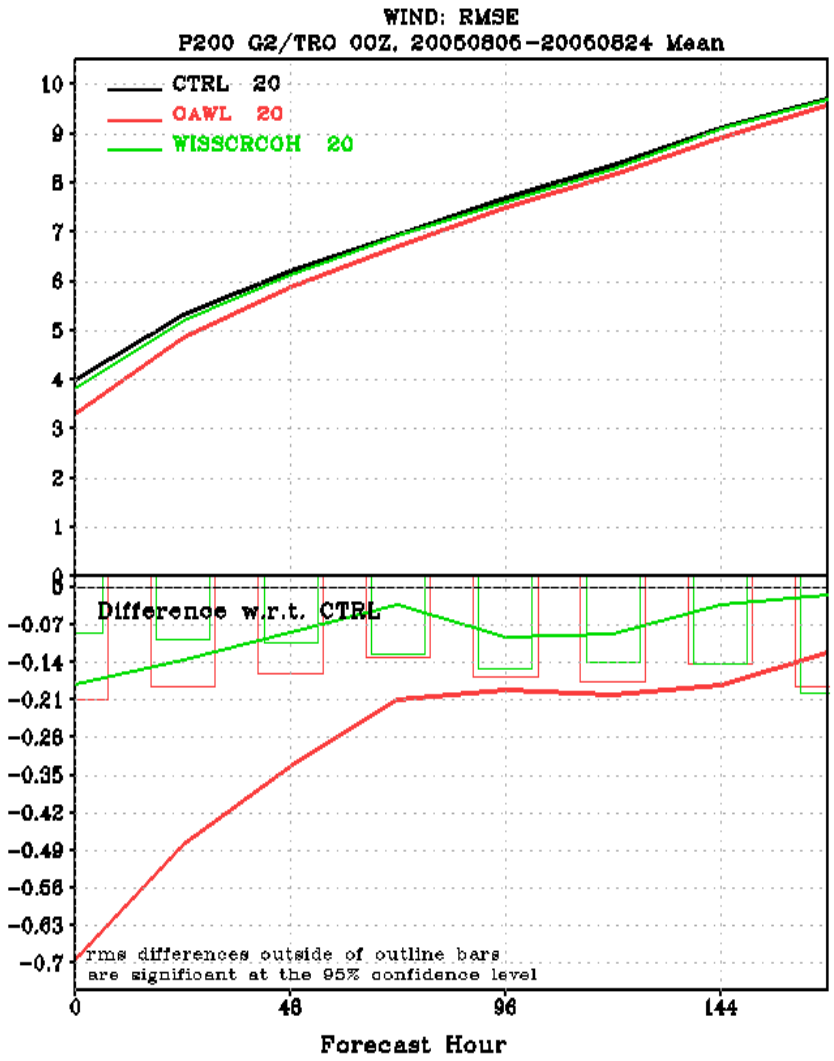
FORECAST EXPERIMENTS: Three up to 5-day forecasts generated from each

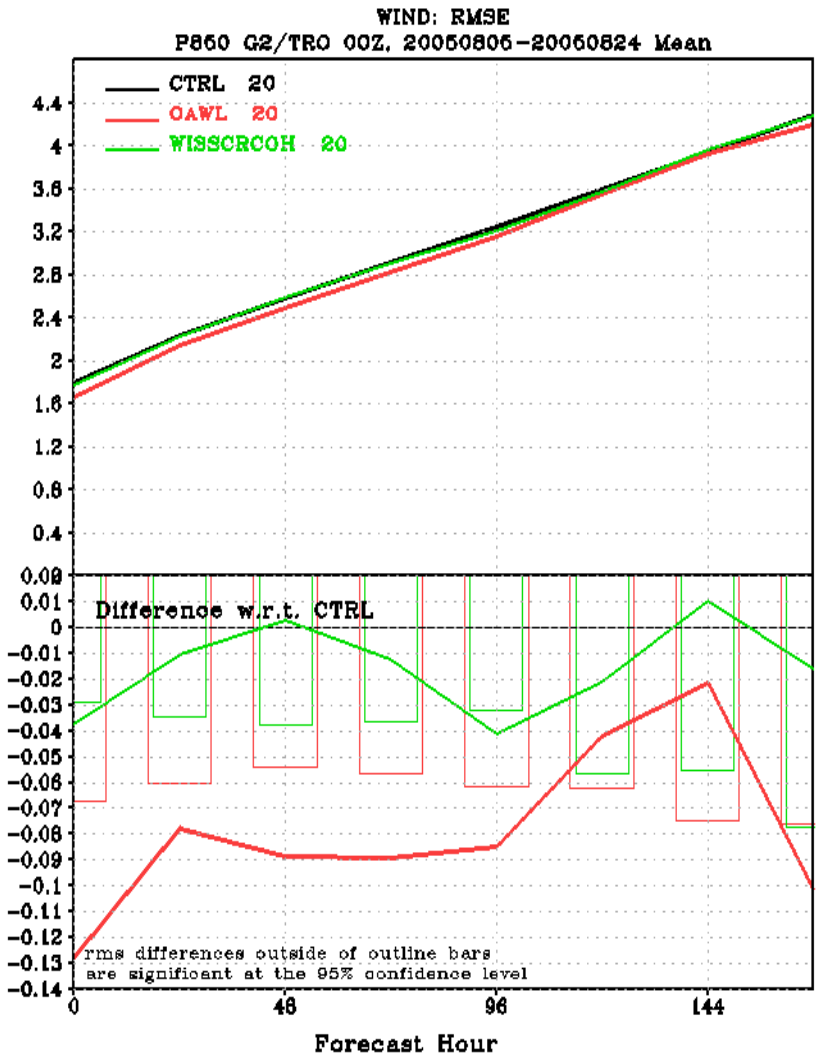
200 mb wind analysis accuracy



850 mb wind analysis accuracy

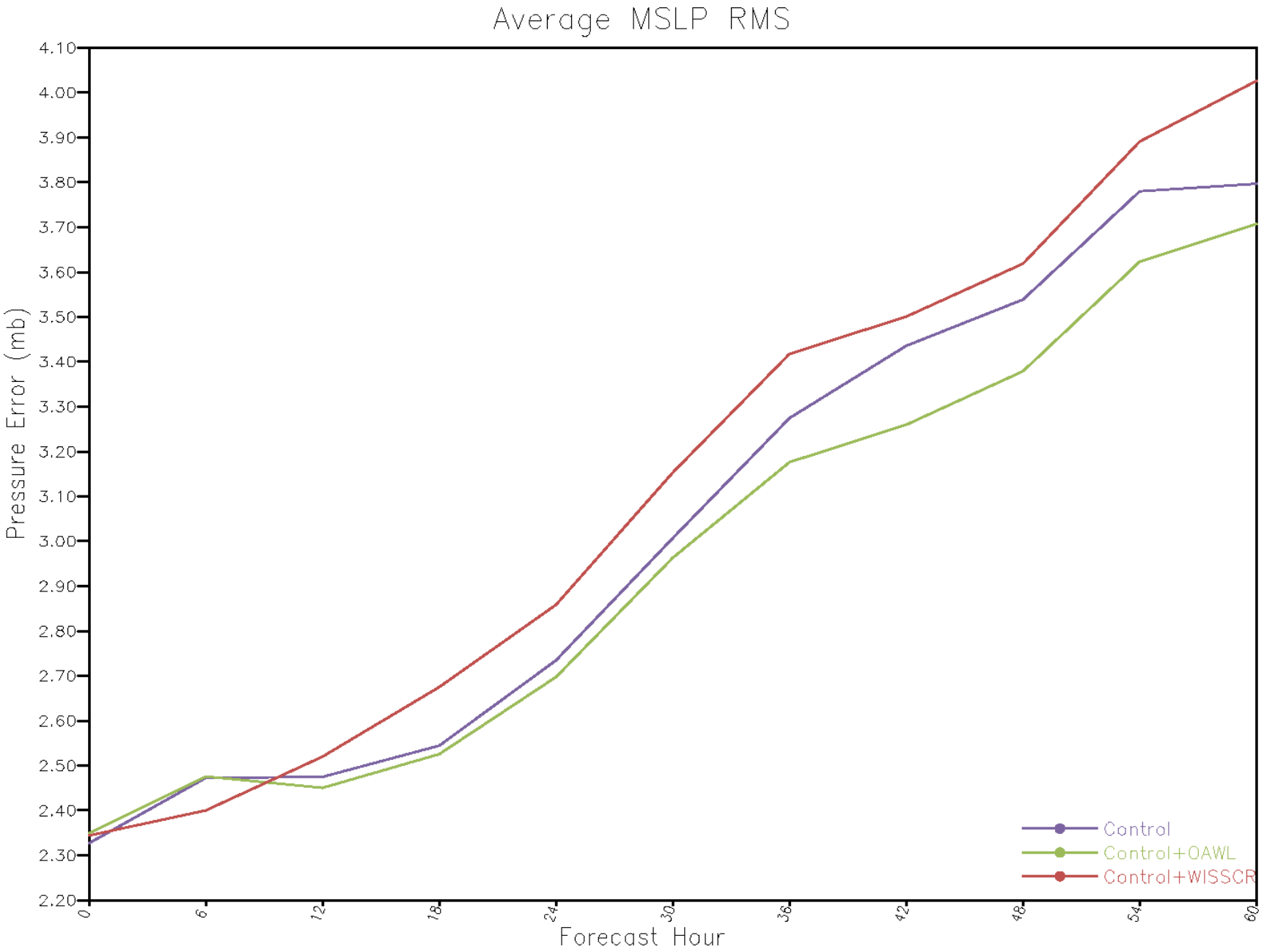


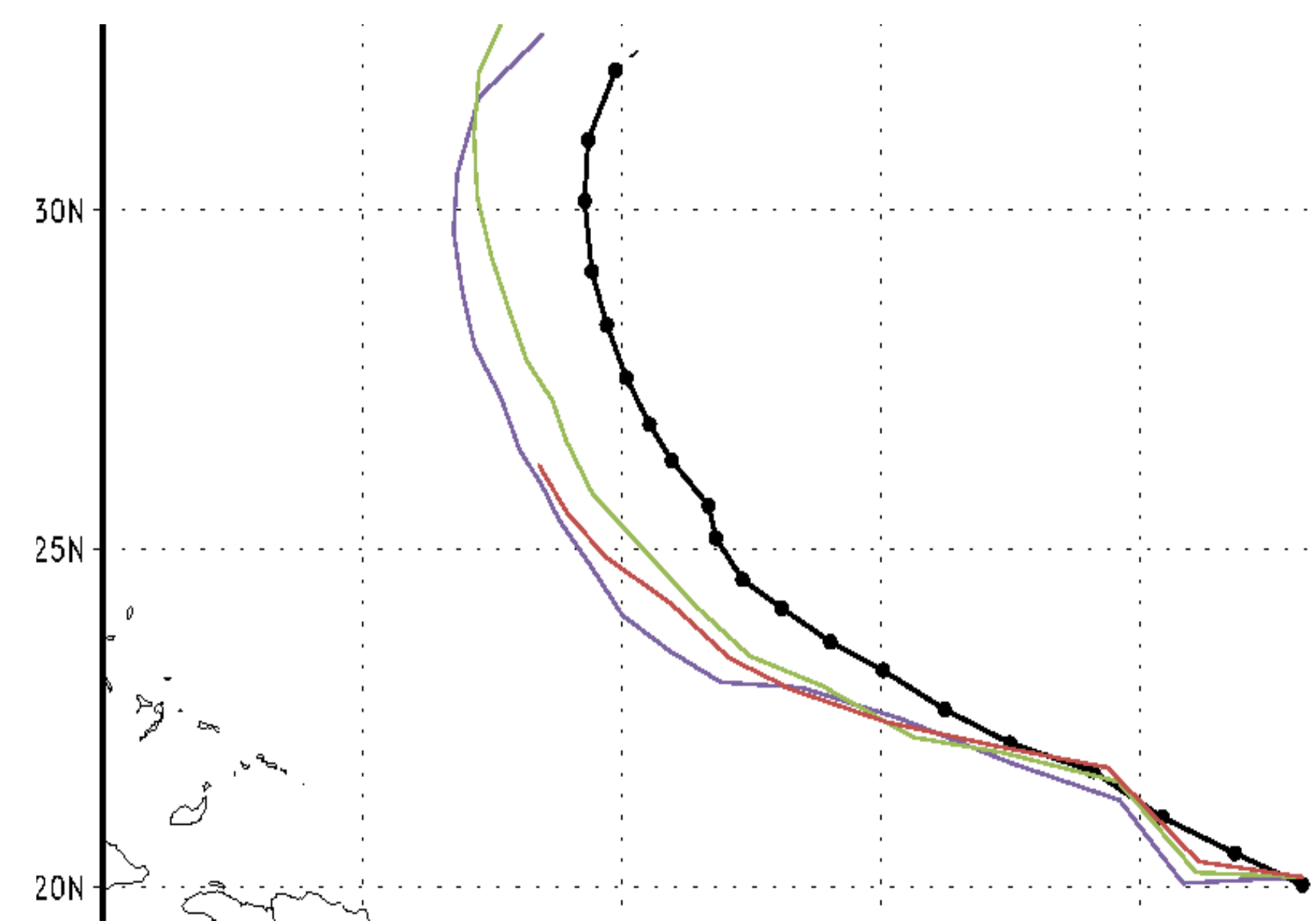




Impact on 200 mb (left) and 850mb (right) wind forecasts

Average sea level pressure errors over HWRF forecast domain





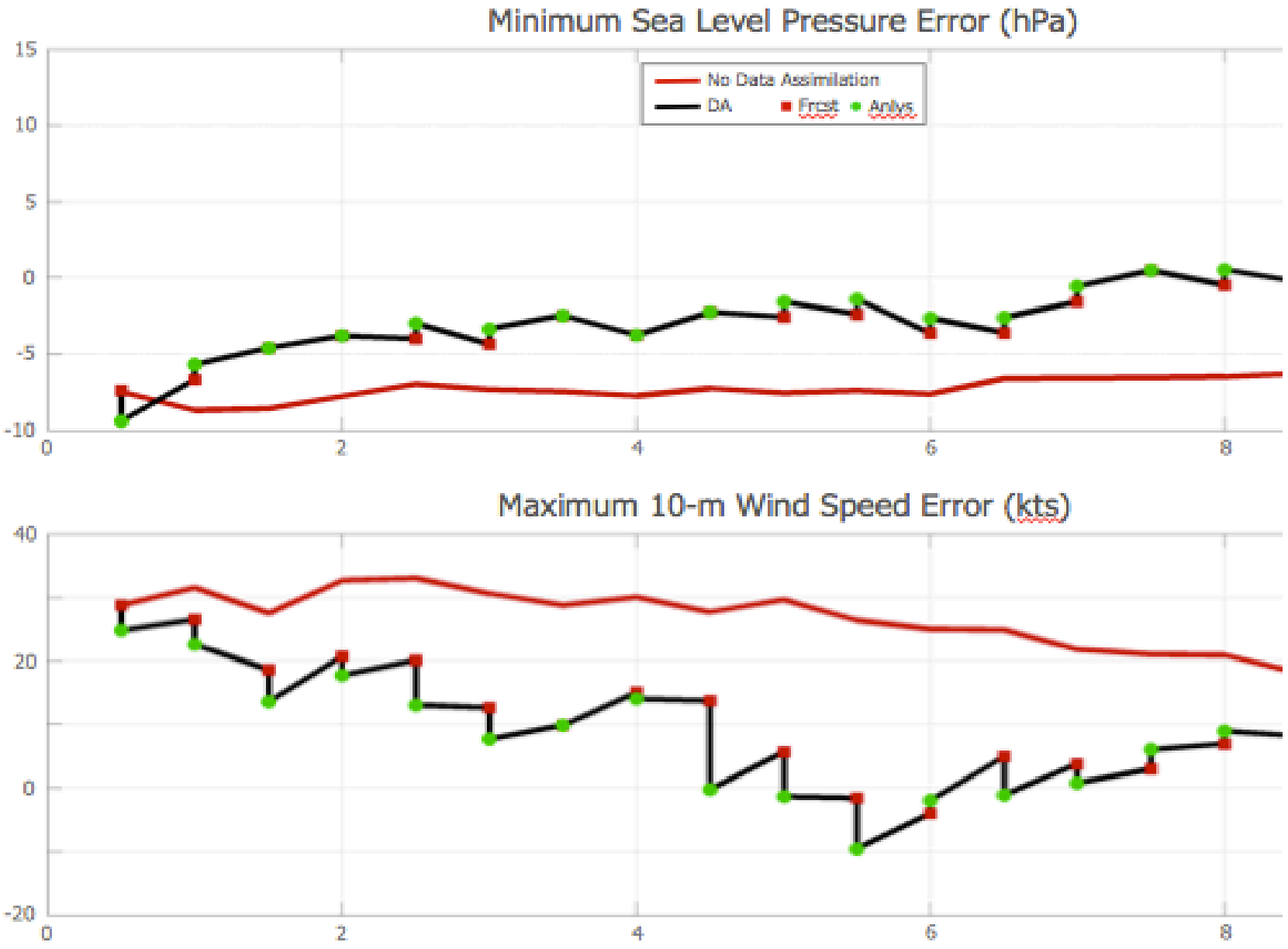
Track forecasts from August 4 06Z for Nature (black), Control (purple), Control+WISSCR_COH (red) and Control+OAWL (green).

EXPERIMENTS WITH SIMULATED GEOSTORM DATA

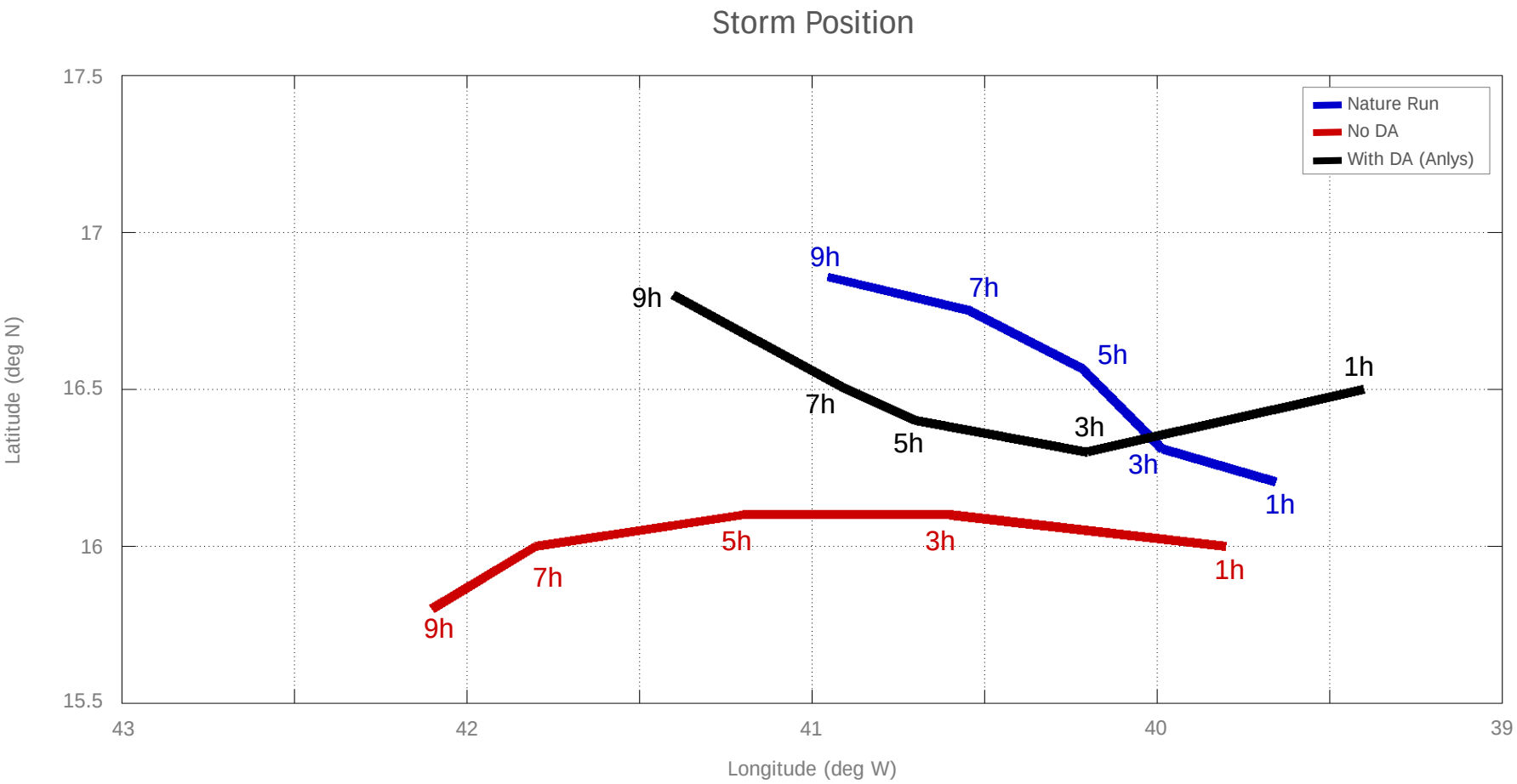
- Current limitations:
  - Data only available for d04 (inner-most domain) of the Nature Run: Limits effectiveness of DA because current setup of DA assimilates data in the outer domain
  - Only assimilating T and Q data because of unresolved issues with the rain rate
  - Preliminary results with limited number of cycles due to restricted computational resources: Runs were carried out on NOAA HFIP computers, but due to increasing restrictions because of the ongoing hurricane season, runs will be (at least temporarily) transferred to University of Miami computers

- What has been done?
  - GSI (3DVAR) Configuration, 2 runs:
    - No data assimilation run
    - Data assimilation experiment for 12 hours (24 30-min cycles) – only assimilated T
  - HEDAS (EnKF) Configuration, 2 runs:
    - No data assimilation run
    - Data assimilation experiment for 3 hours (3 1-h cycles) – assimilated T and Q
  - Ongoing GFS-Hybrid Global CTRL experiment:
    - Will enable runs in the GSI-Hybrid Configuration
    - Expected to improve ensemble covariances for the HEDAS Configuration

PRELIMINARY RESULTS WITH GSI



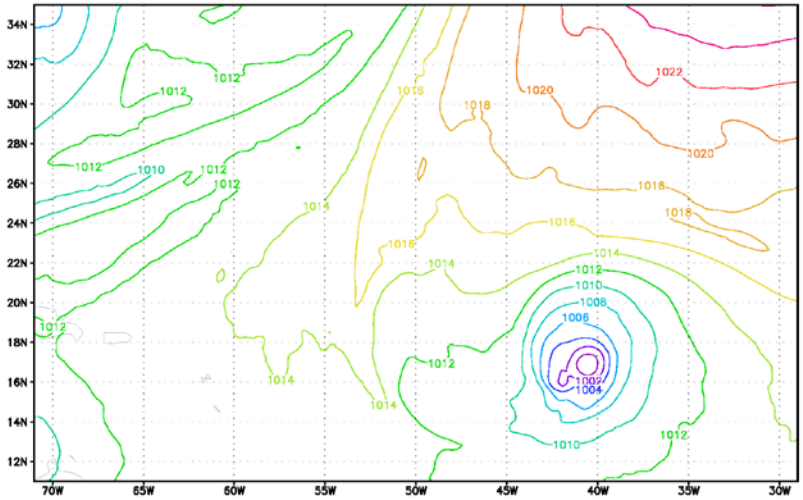
PRELIMINARY RESULTS WITH GSI



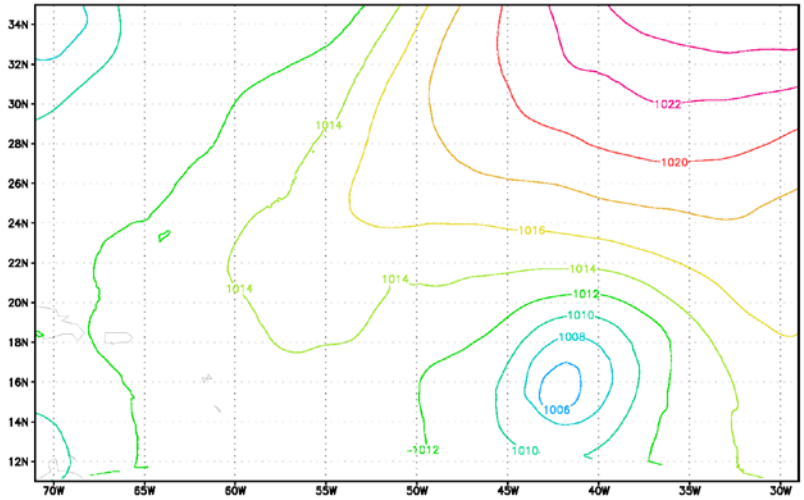
COMPARISON OF ANALYSES

Mean Sea Level Pressure (hPa) – Experiment Hour: 8

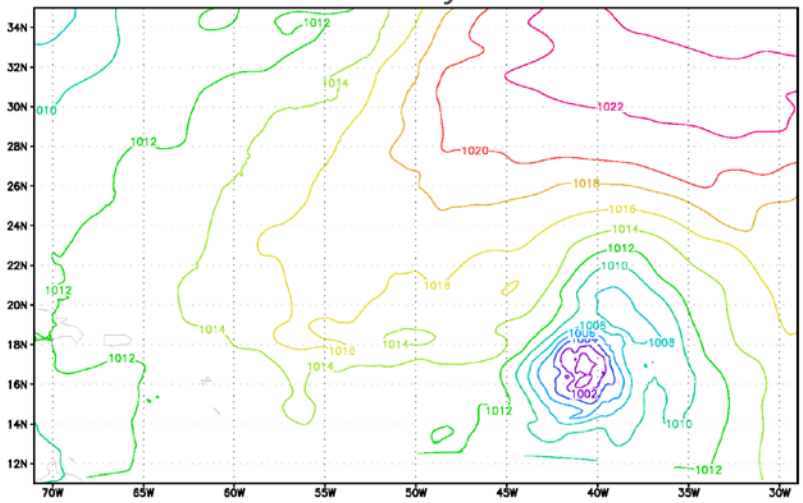
Nature Run



No Data Assimilation



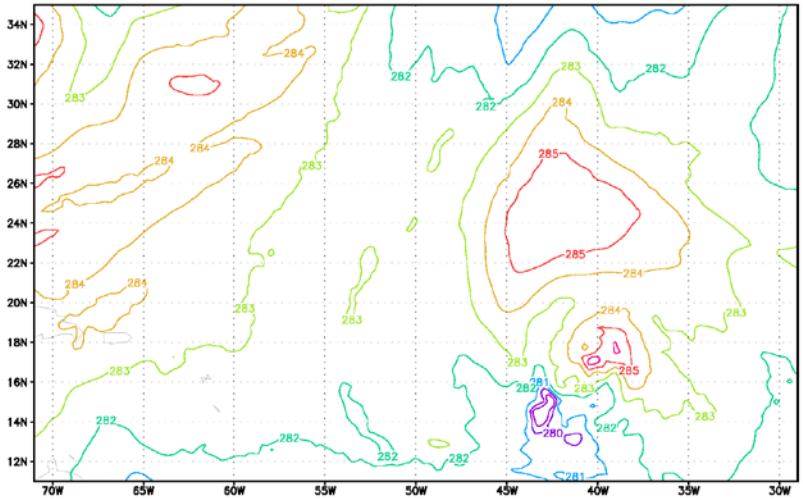
GSI Analysis



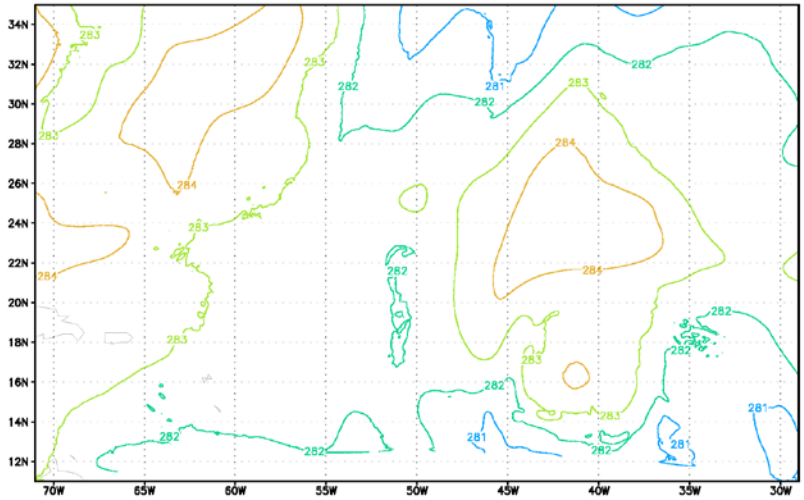
COMPARISON OF ANALYSES

700-hPa Temperature (K) – Experiment Hour: 8

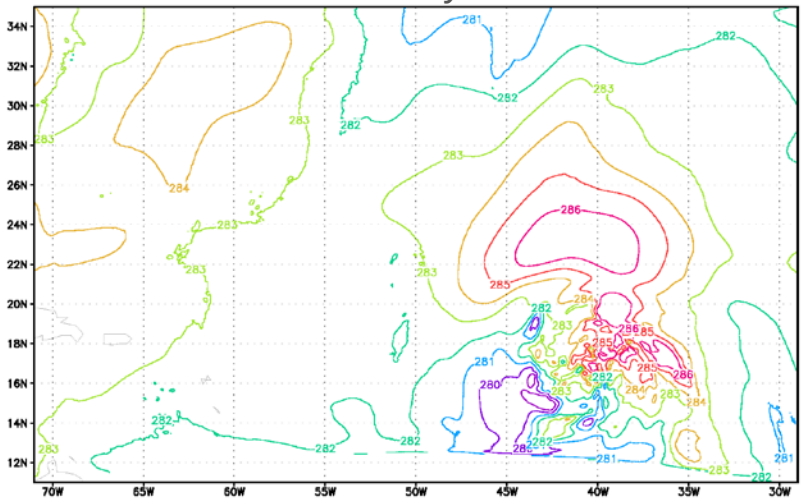
Nature Run



No Data Assimilation

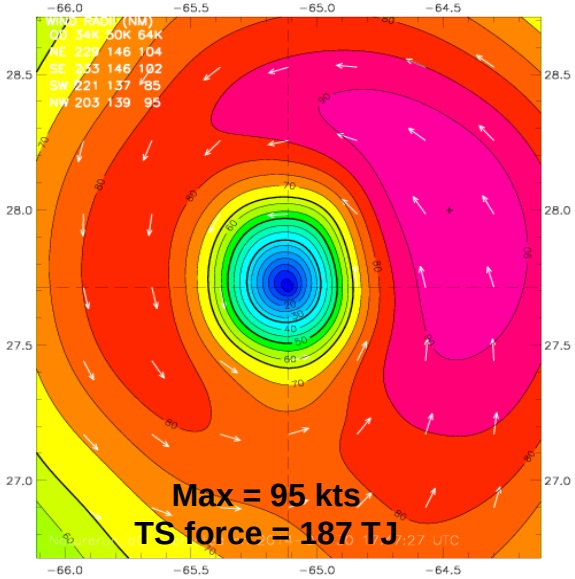


GSI Analysis

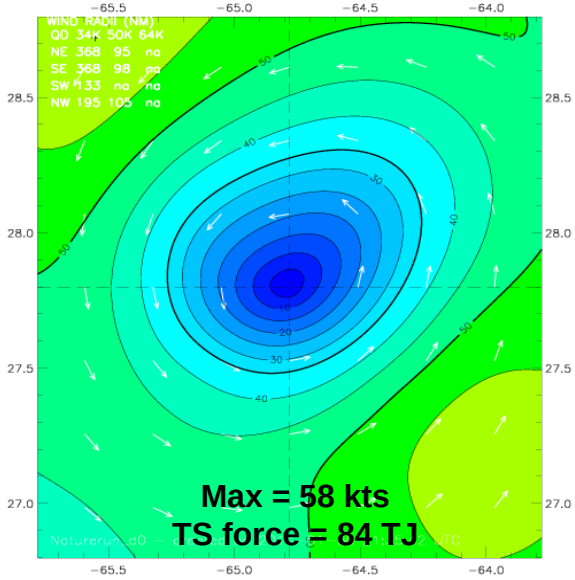


Impact of CYGNSS data on H*WIND Analyses on

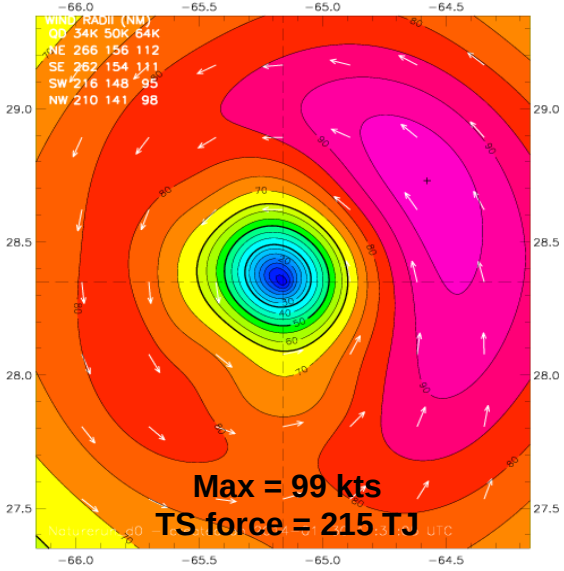
a. H*WIND Perfect analysis from 9km Nature

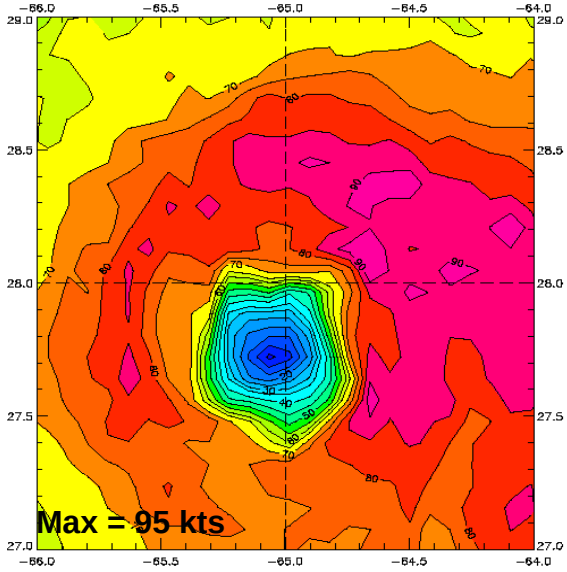


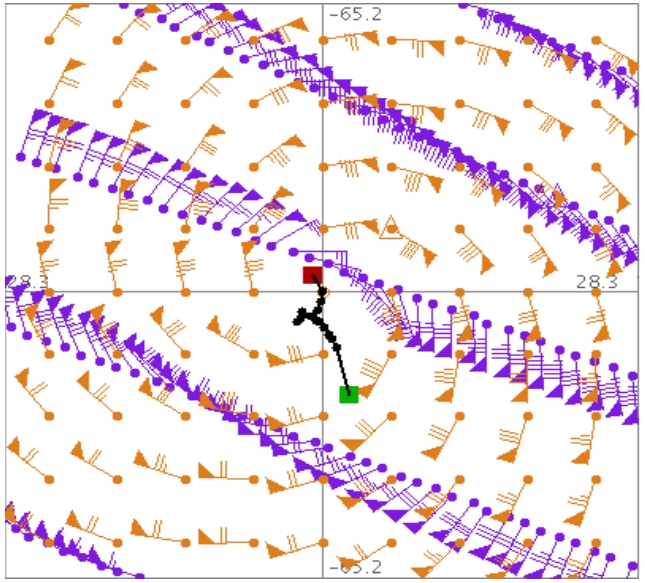
b. H*WIND Control analysis with



c. H*WIND with perfect CYGNSS data







Aug 08, 2005 @ 00Z

Summary

- Global OSSEs to date have shown significant potential for wind profile observations to improve hurricane track forecasting.

- At least for the near future, limited area models will be required to address hurricane intensity prediction. These mesoscale OSSEs are still in their infancy, but are progressing fast.

- Experiments are currently being conducted to evaluate UAS, hyperspectral IR and microwave sounders, CYGNSS, GNSS RO and alternative technologies for doppler wind lidar.