Impact of Simulated CYGNSS Ocean SurfaceWinds on Tropical Cyclone Analyses and Forecasts in a Regional OSSE Framework

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OBSERVING SYSTEM SIMULATION EXPERIMENTS

Objectives for Hurricanes:

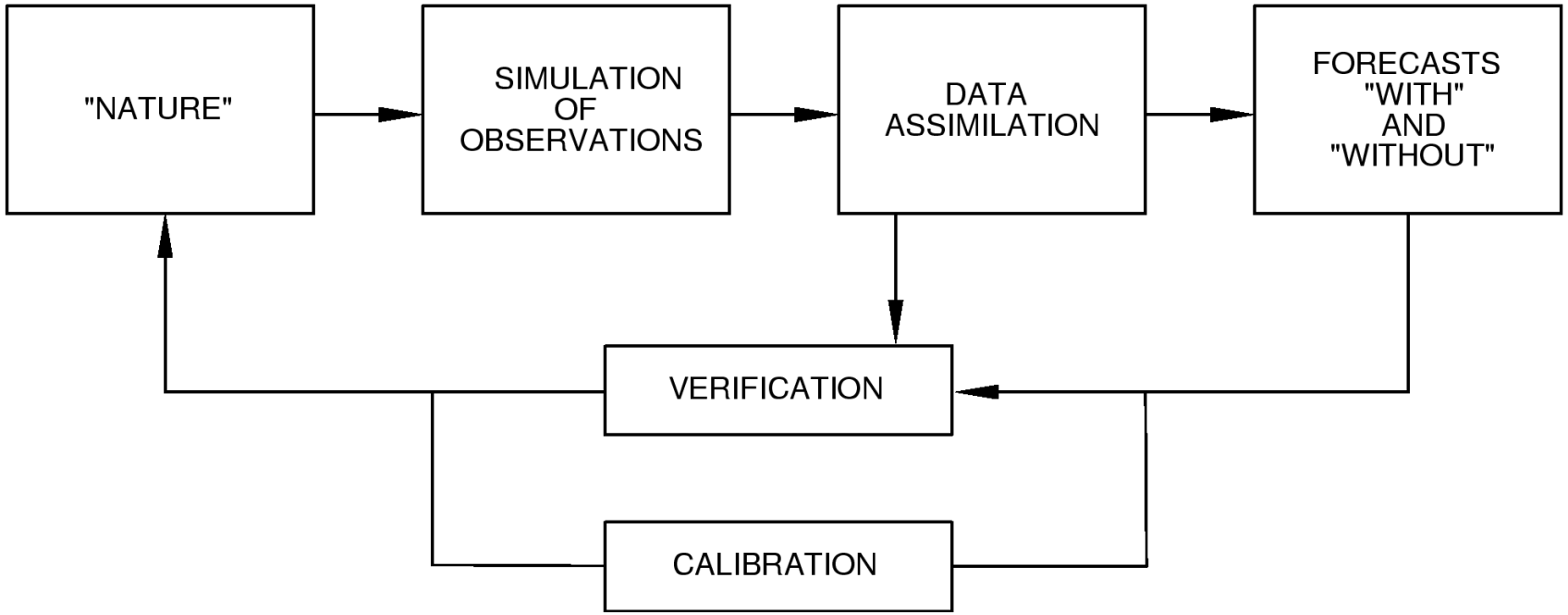
1. Evaluate the potential impact of new (proposed) observing systems on hurricane track and intensity predictions.

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

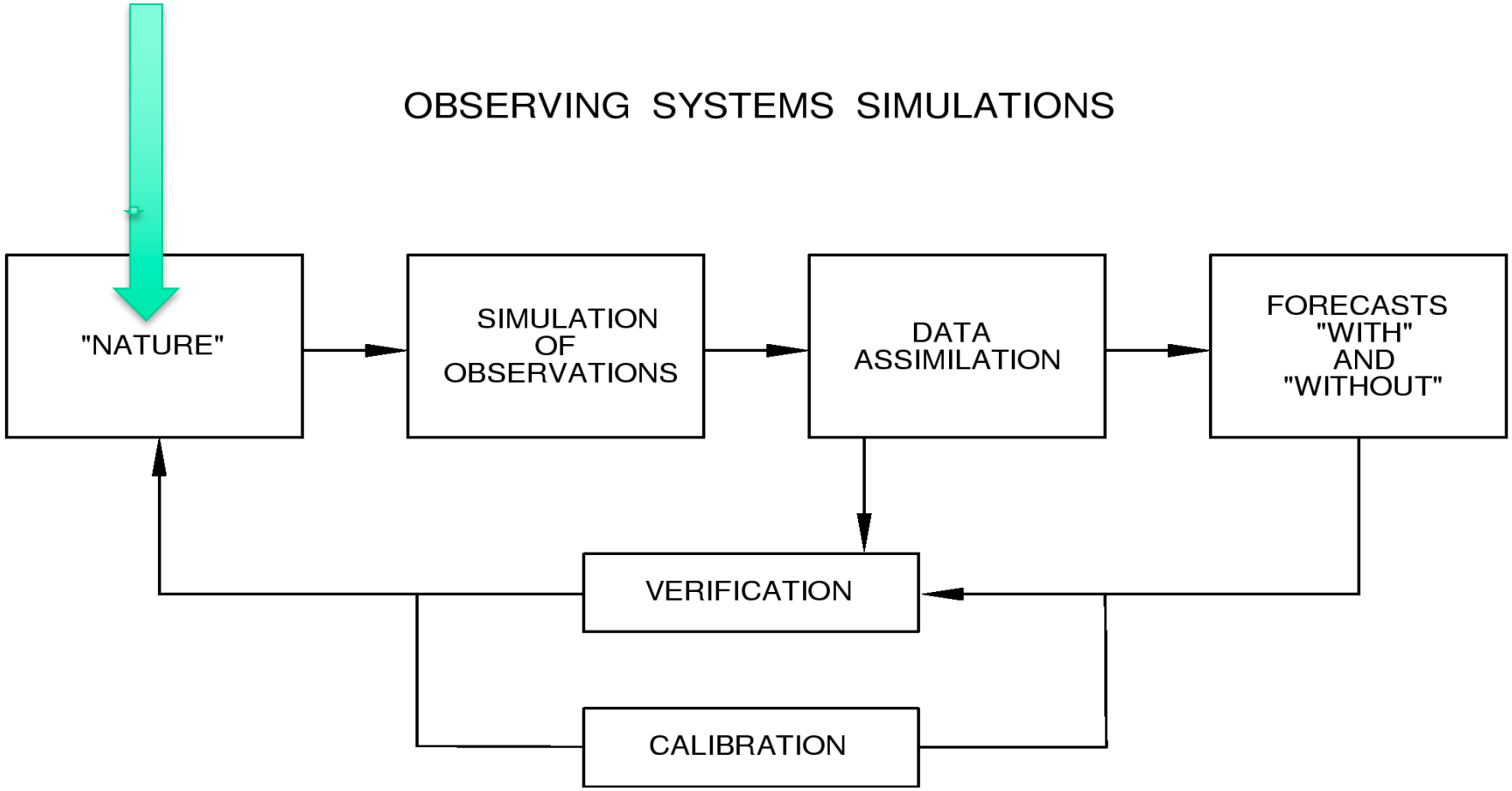
3. Optimize sampling strategies for current and future airborne and space-based observing systems.

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

OBSERVING SYSTEMS SIMULATIONS



“Regional Nature Run”



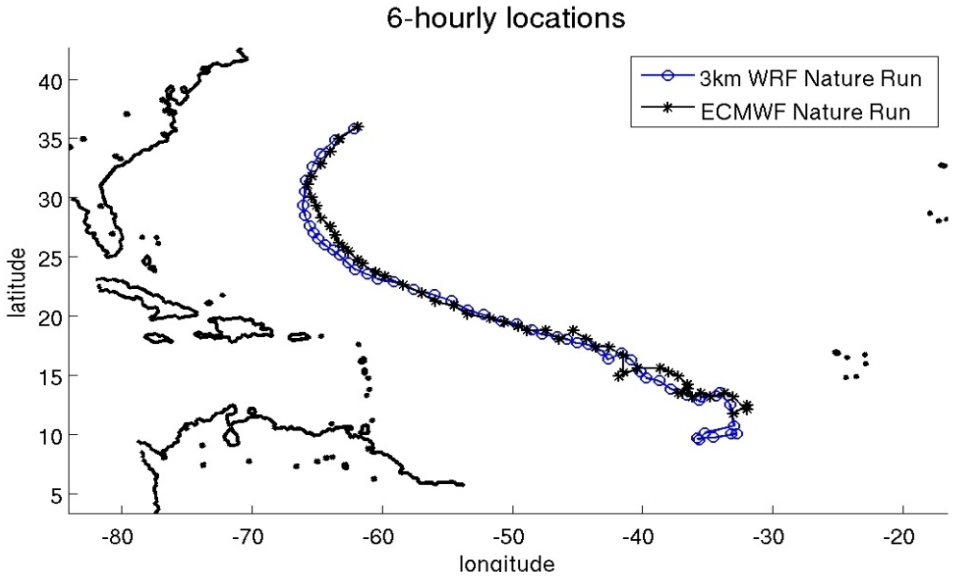
AOML's REGIONAL TC OSSE/OSE SYSTEM

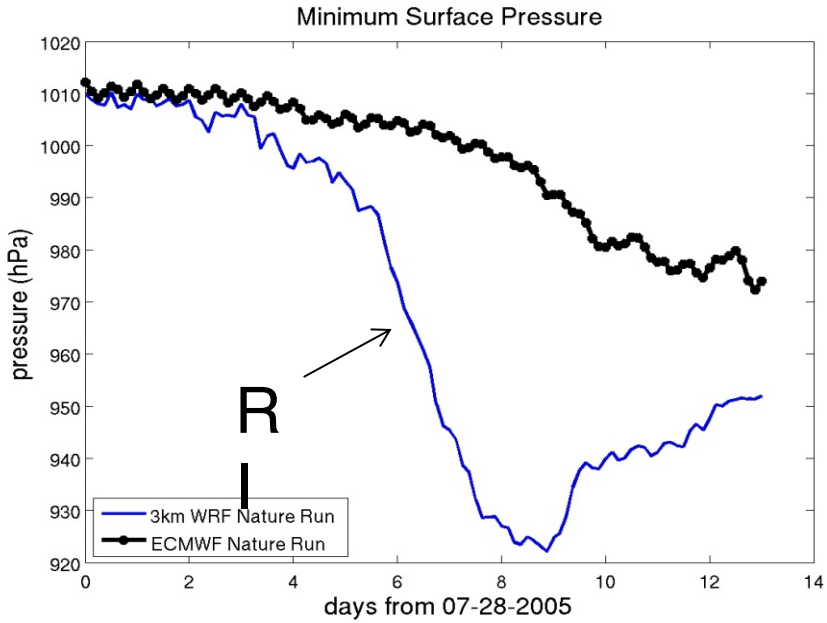
Nature runs: WRF ARW embedded within ECMWF T511 Global nature run and Basin scale version of HWRF embedded within G5NR

- **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
  - 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
  - NOAA's Operational 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
  - HWIND

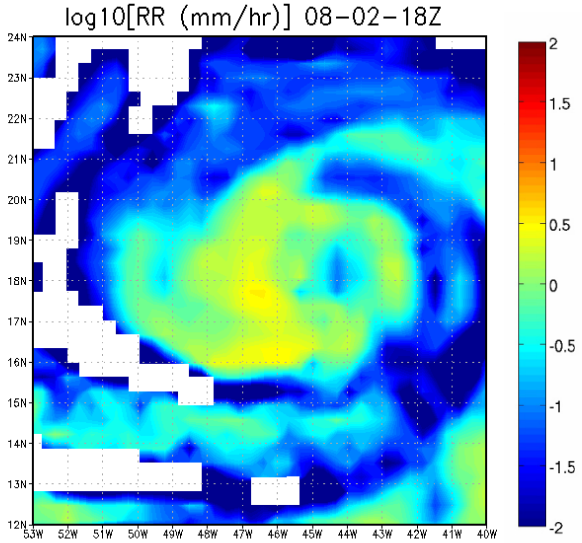
High Resolution Hurricane Nature Run: WRF Simulation Embedded Inside the ECMWF Nature Run

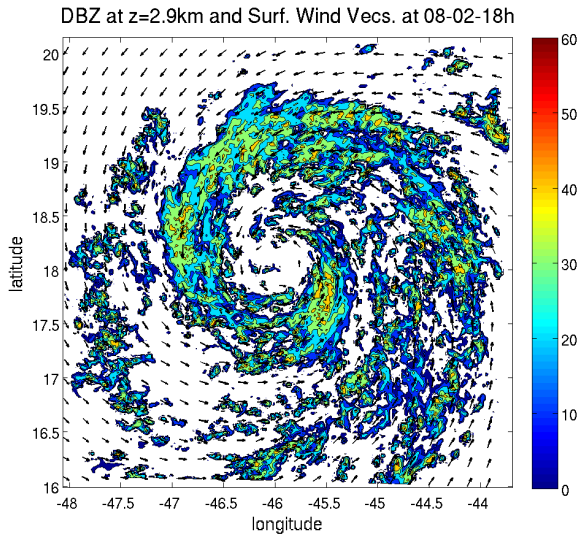
60 levels; 1km resolution; double-moment microphysics; advanced radiation schemes.





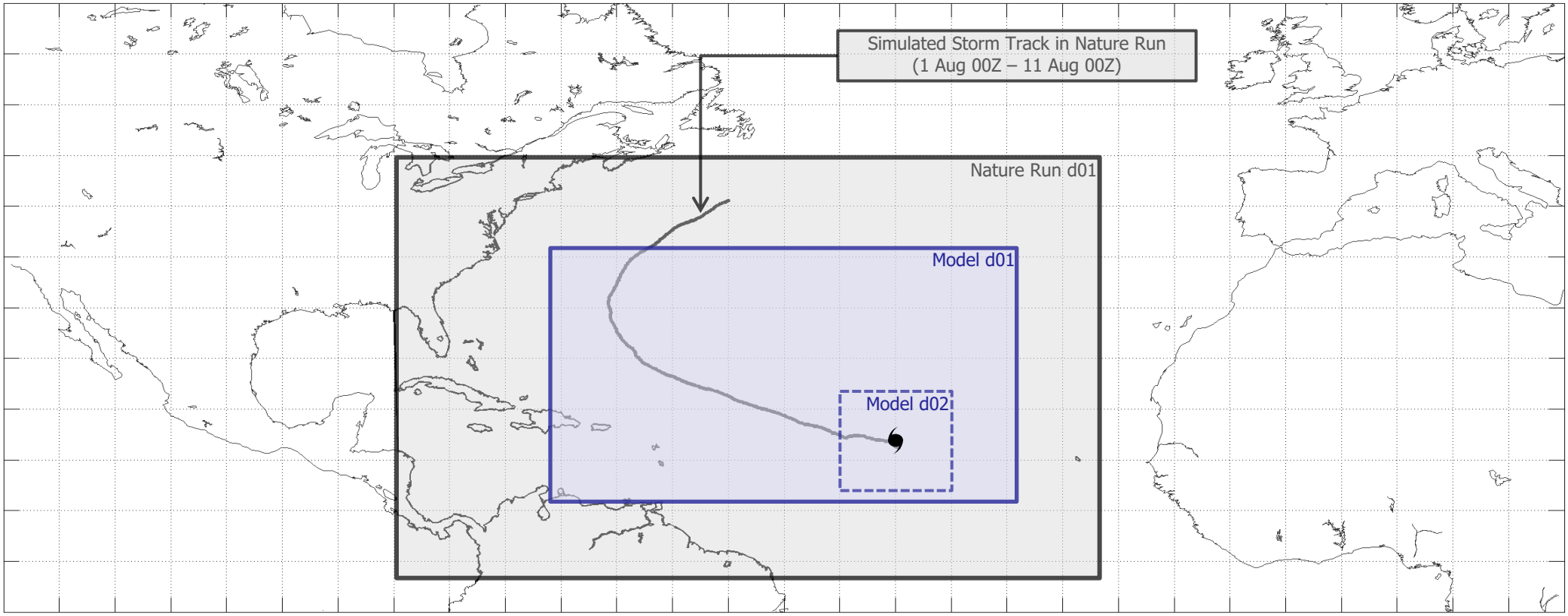
ECMWF T511 Nature Run





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

CYGNSS OSSEs using HWRF

Experiments:

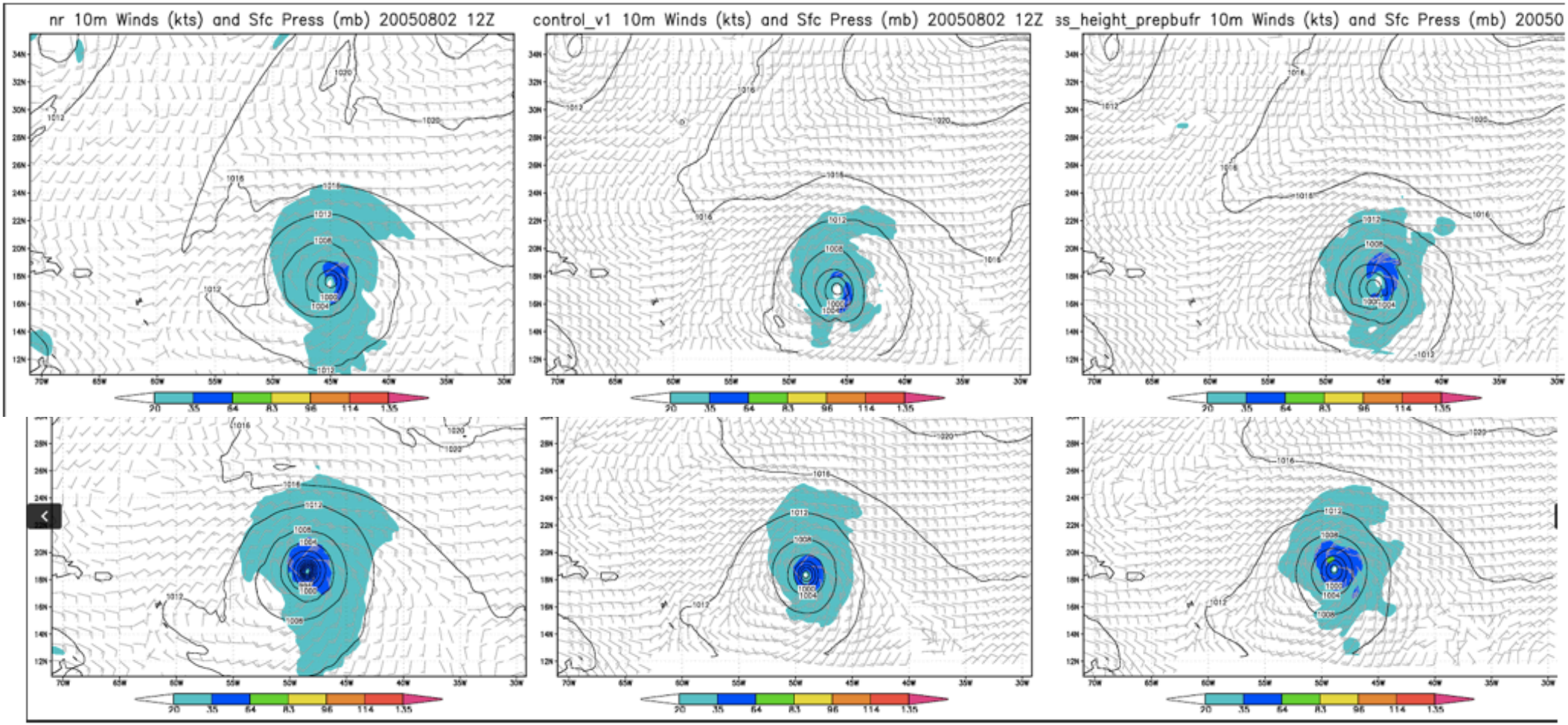
1. Control (C) includes all data except CYGNSS
2. C + Perfect CYGNSS Wind Speeds
3. C + Perfect CYGNSS Wind Vectors
4. C + Realistic CYGNSS Wind speeds
5. C + VAM CYGNSS Wind Vectors

6. Trade Studies CYGNSS Science Team
7. C + CYGNSS with Wind lidar and GOES R
8. Ocean OSSEs forced with and without CYGNSS

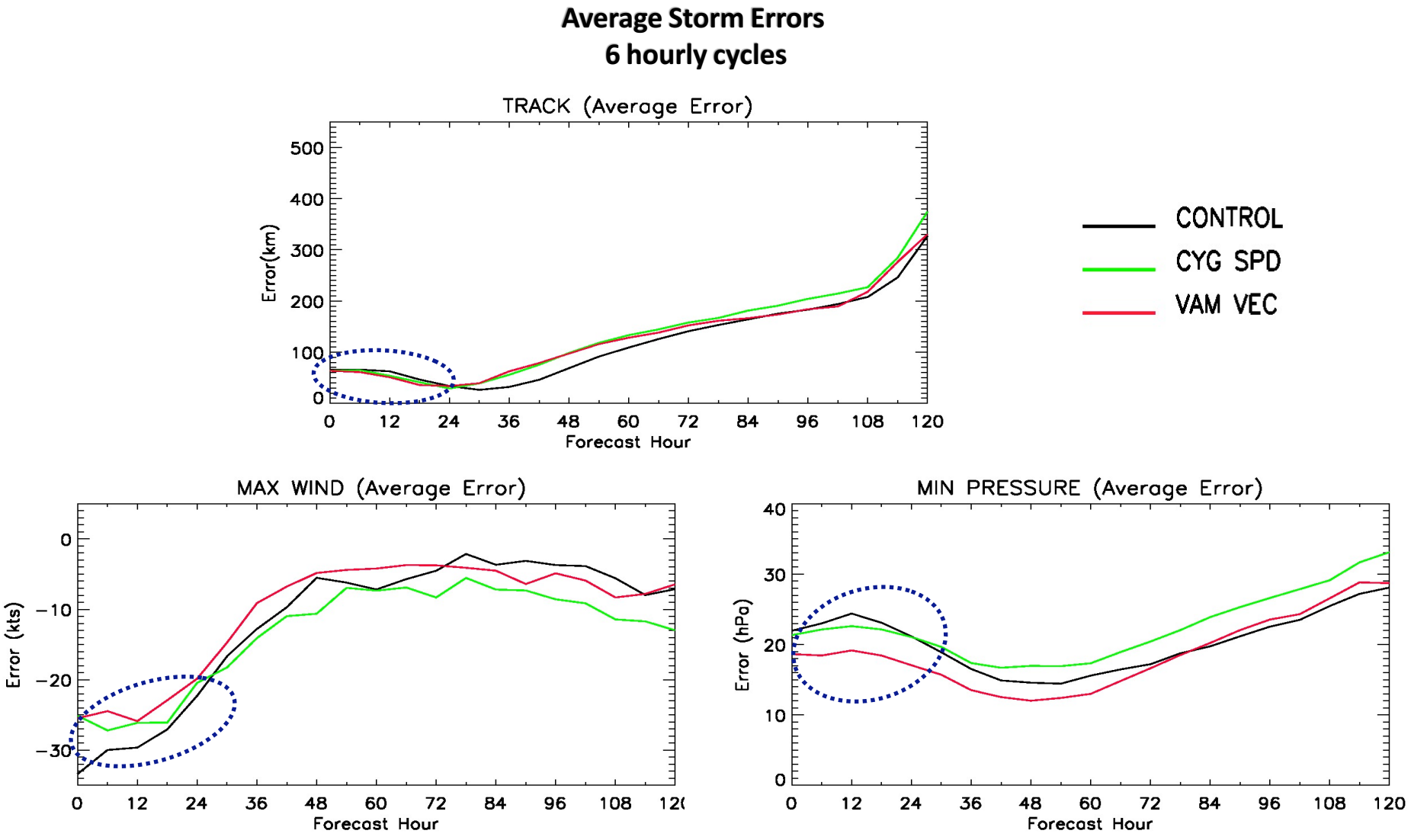
(Experiments 4 and 5 evaluated with 6, 3 and 1 hour updating)

Impact of CYGNSS on Analyses

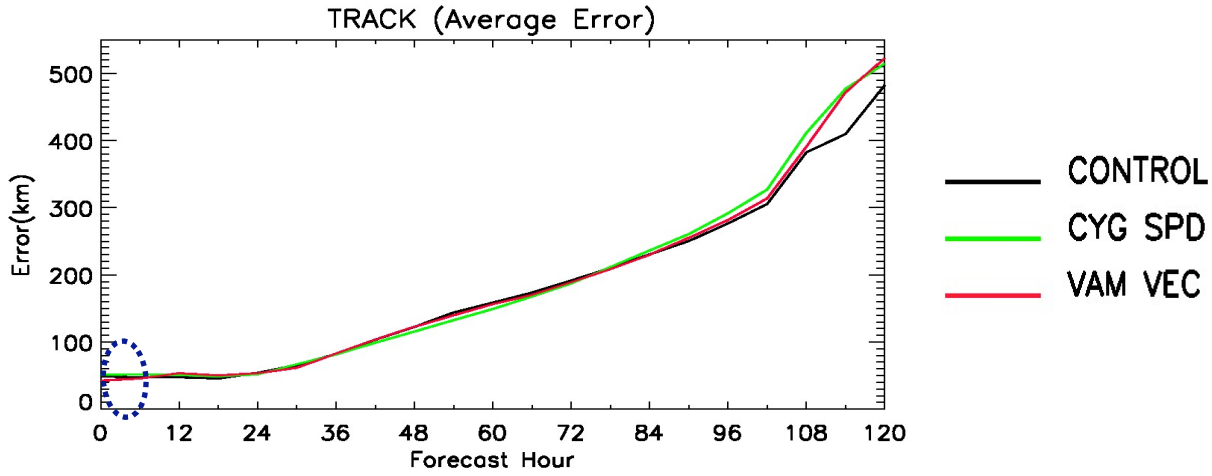
Nature Run | Control | Control+ CYGNSS

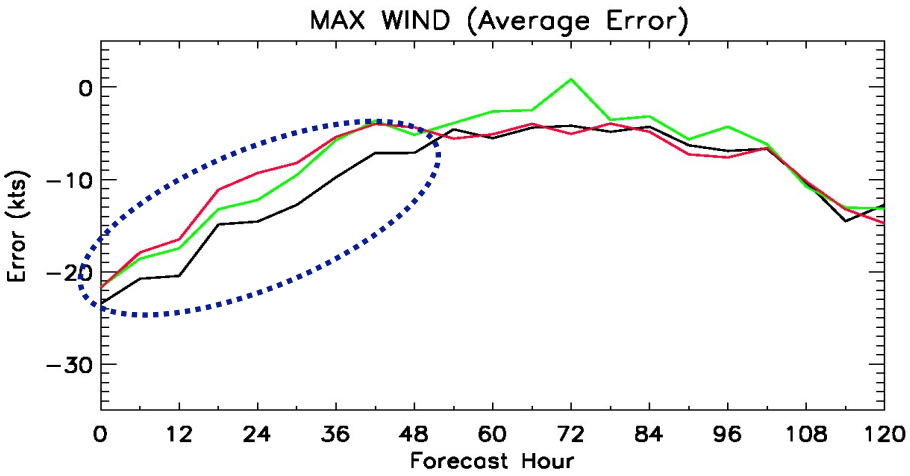


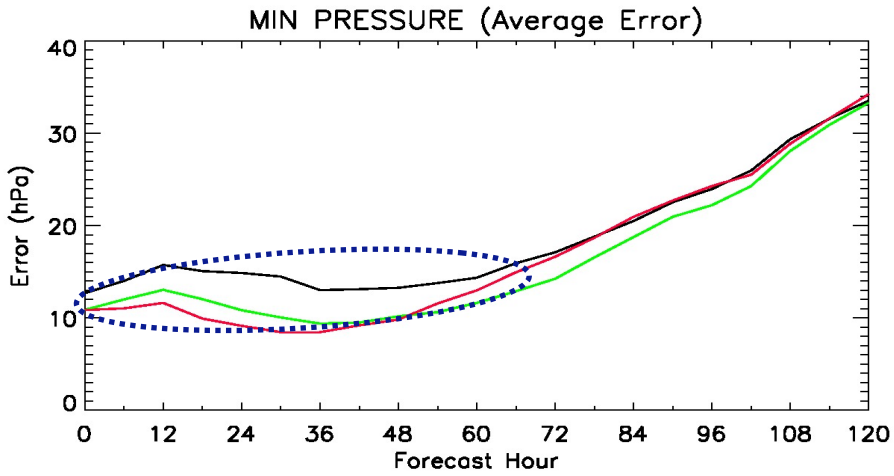
Impact on HWRF Forecasts



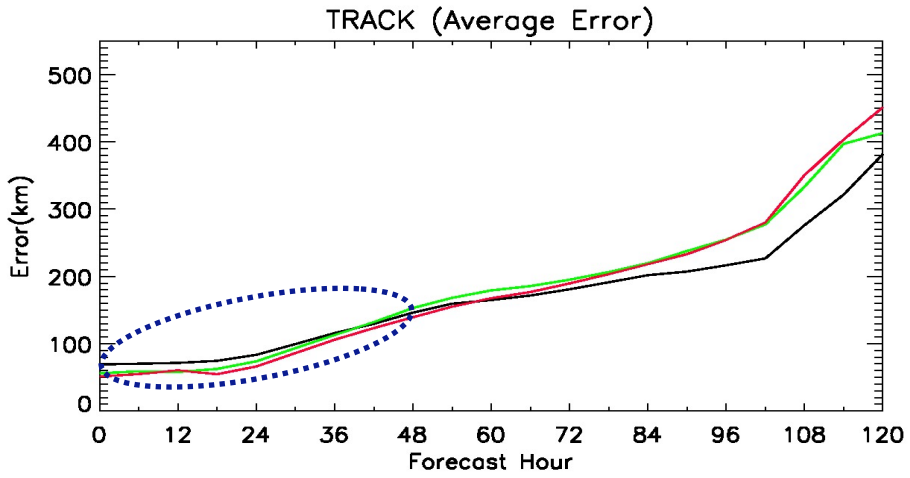
Average Storm Errors
3 hourly cycles



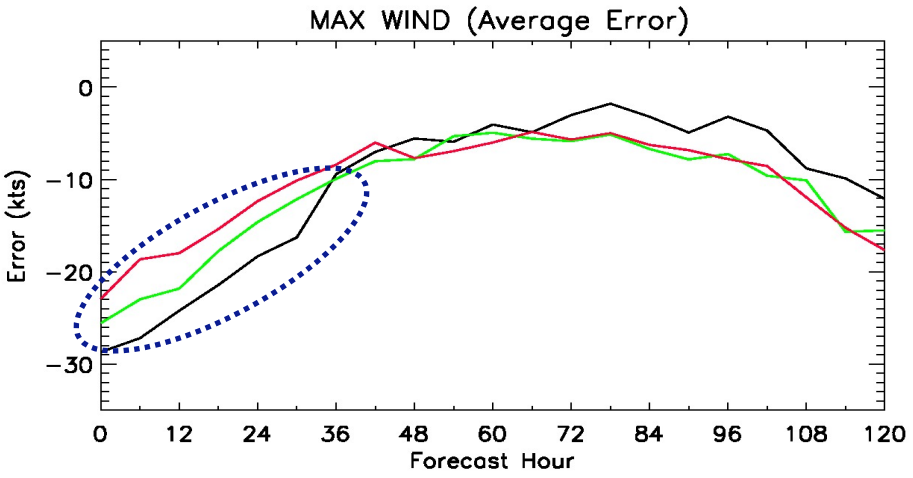


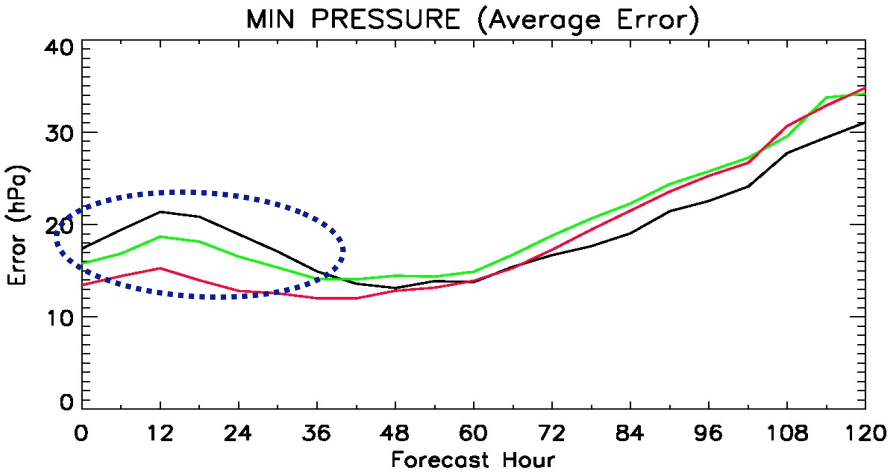


Average Storm Errors
hourly cycles

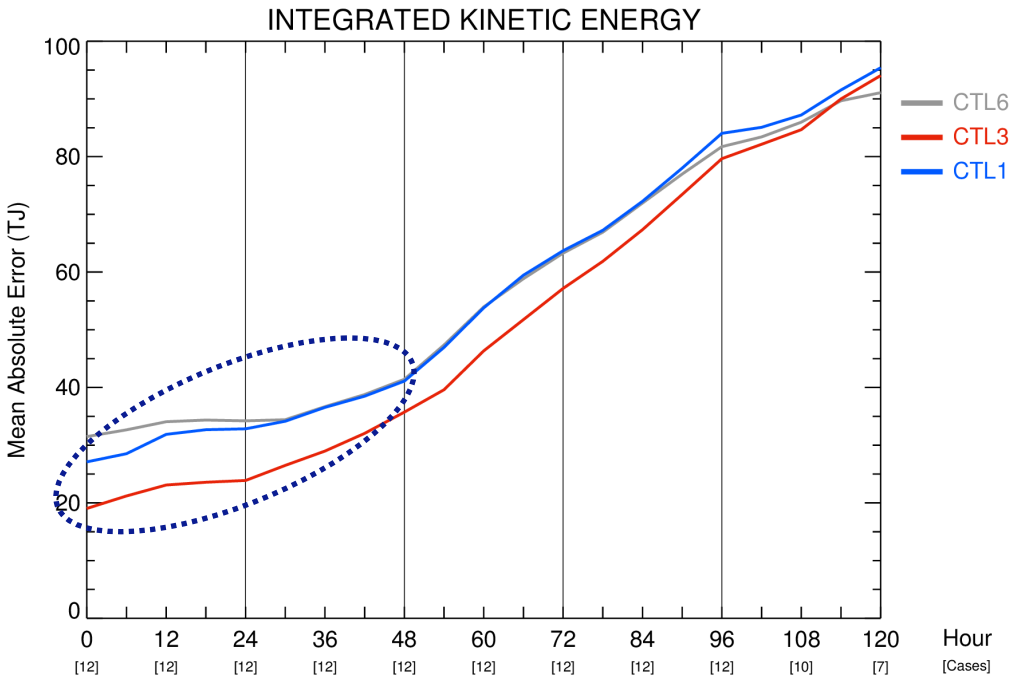


CONTROL
CYG SPD
VAM VEC

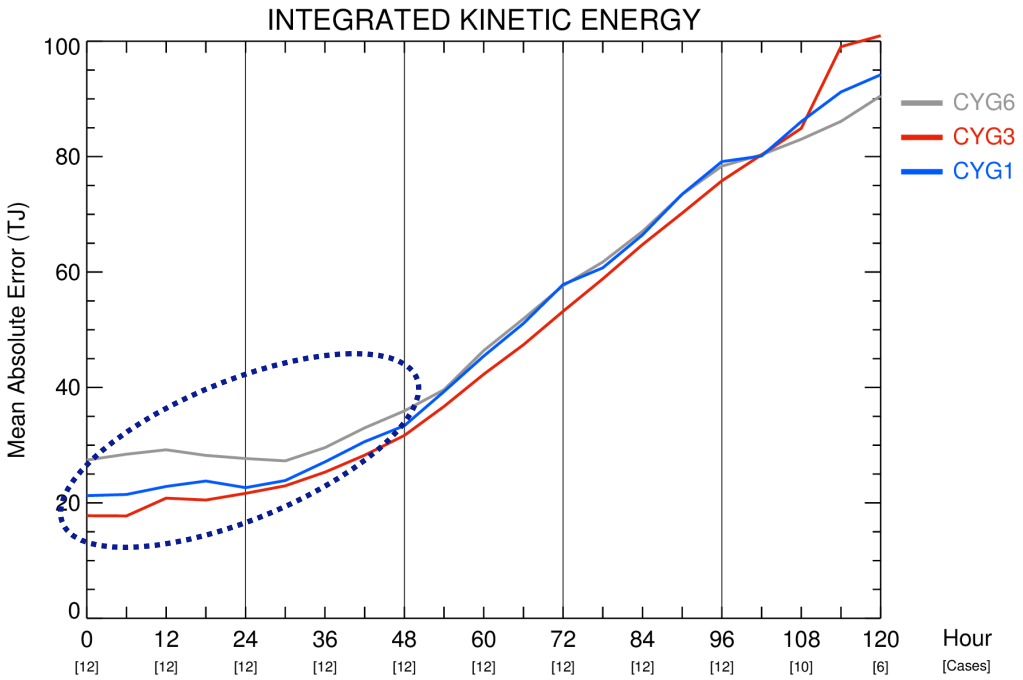




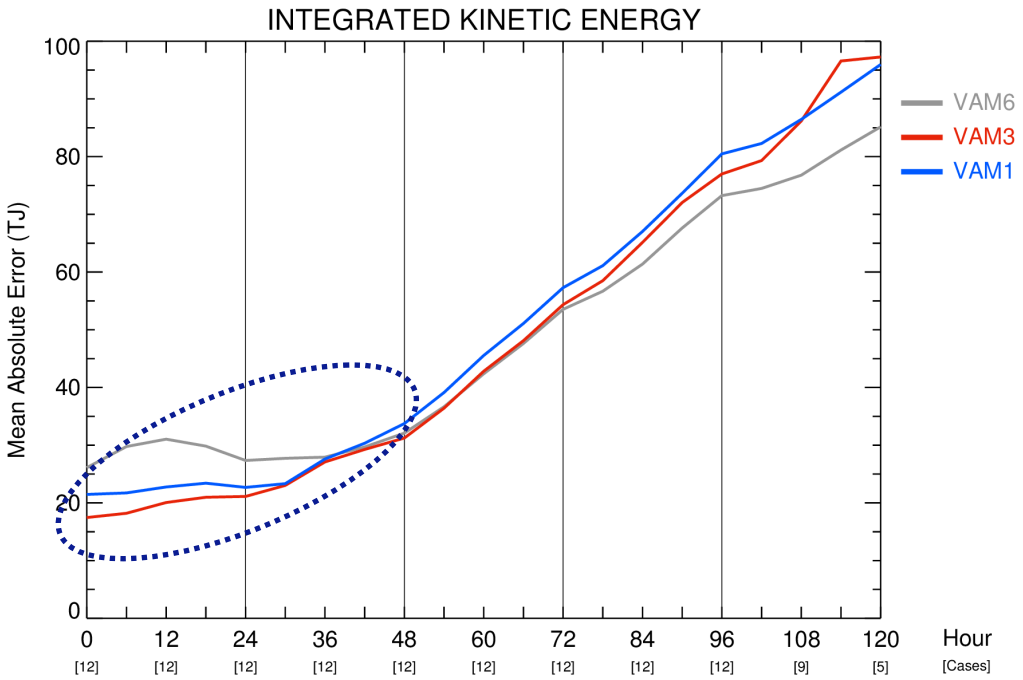
Integrated Kinetic Energy
Control
Different cycling frequencies plotted together



Integrated Kinetic Energy
Control+CYGNSS
Different cycling frequencies plotted together



Integrated Kinetic Energy
Control+VAM
Different cycling frequencies plotted together



Summary

1. CYGNSS data has potential to improve surface wind analyses and short range forecasts using HWRF.

2. The amount of impact depends upon CYGNSS data coverage, cycling frequency, preprocessing, and whether or not reconnaissance aircraft data are present.

3. We are preparing to evaluate the impact of real CYGNSS data using NOAA's operational hurricane forecast system this coming hurricane season.