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

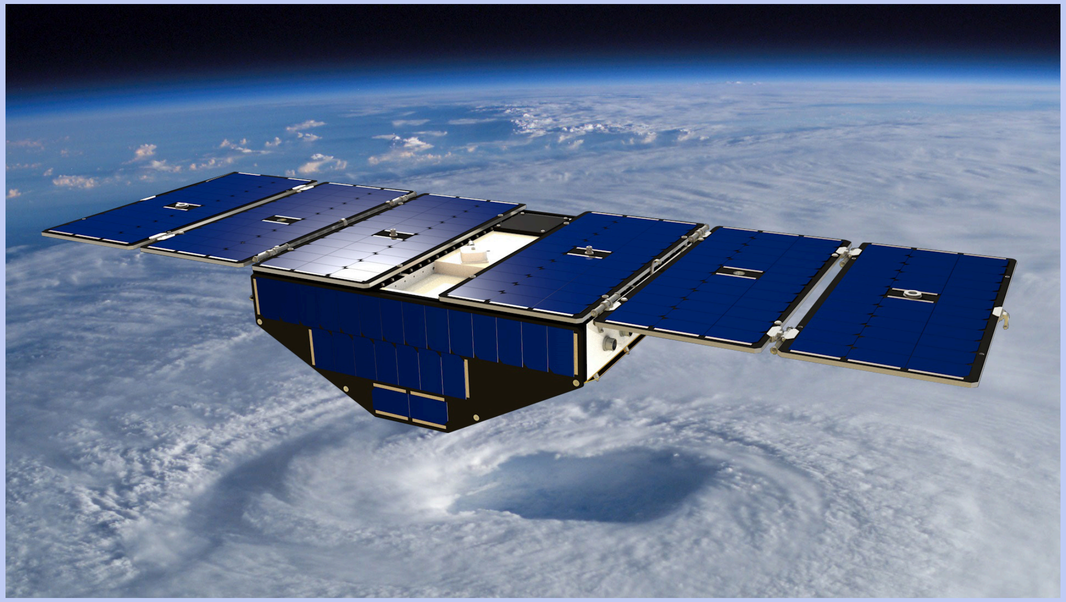
Bachir Annane[1], Brian McNoldy[2], Mark Leidner[4],
Robert Atlas[3] , Ross Hoffman[1],Sharanya Majumdar[2]

[1] Univ. of Miami/CIMAS and NOAA/AOML/HRD, Miami, FL
[2] Univ. of Miami/RSMAS, Miami, FL
[3] NOAA/AOML, Miami, FL
[4] AER, Lexington, MA

What is CYGNSS?

The Cyclone Global Navigation Satellite System (CYGNSS) is a NASA mission that consists of a constellation of 8 micro-satellites.

- **The body of each satellite measures roughly 51x64x28 centimeters, slightly larger than a standard carry-on suitcase.**
- **When fully assembled, the satellites will each weigh about 29 kilograms.**
- **With its solar panels deployed, each microsatellite will have a wingspan of 1.67 meters.**

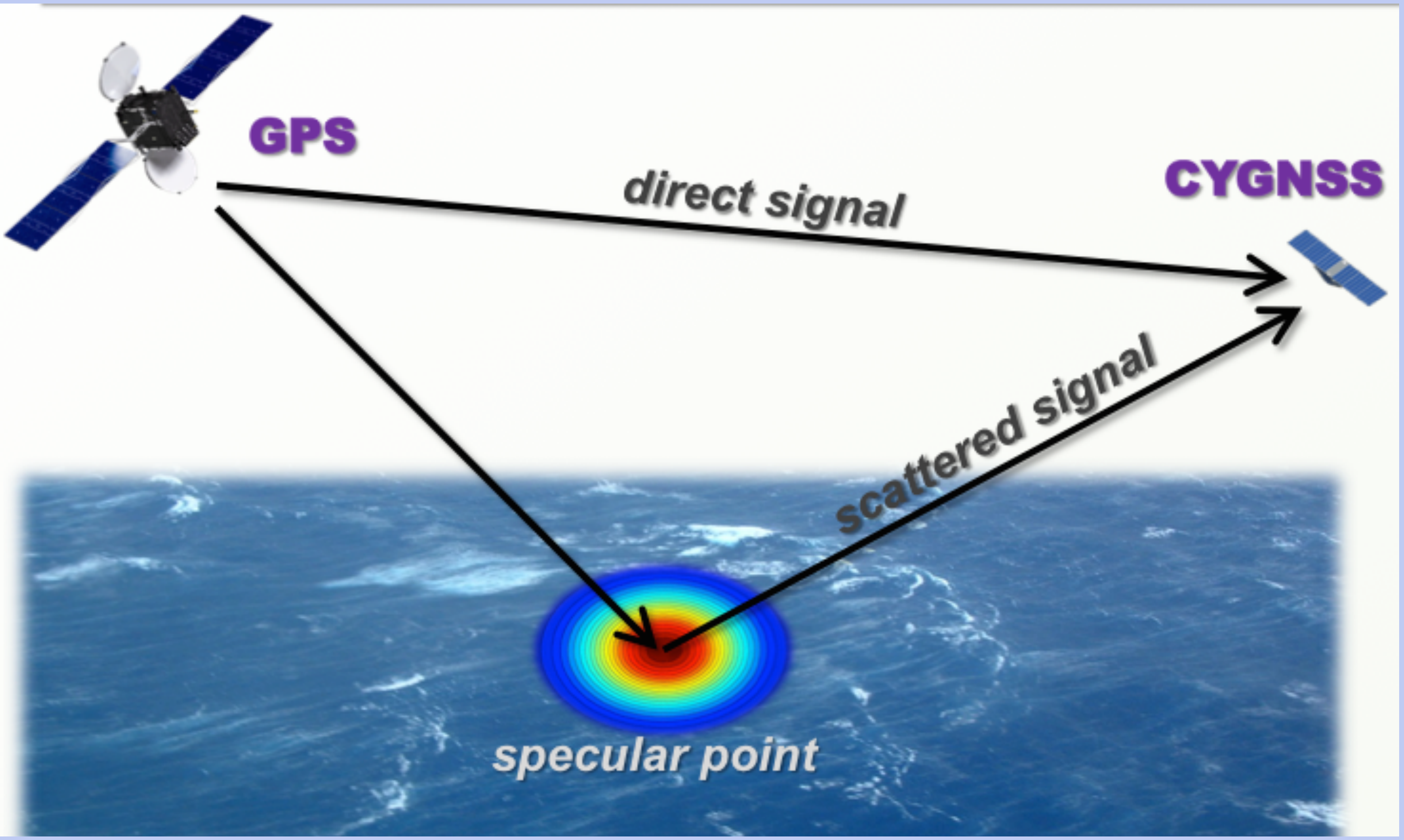


Rendition of a single CYGNSS observatory in orbit over a hurricane. (NASA)

Mission Updates:

- **CYGNSS successfully launched on December 15, 2016 and the eight observatories are all on orbit**
- **Successfully measured out first ocean DDMs on January 4, 2017, just east of Brazil.**

What is CYGNSS?



Basic geometry of bi-static quasi-specular scatterometry

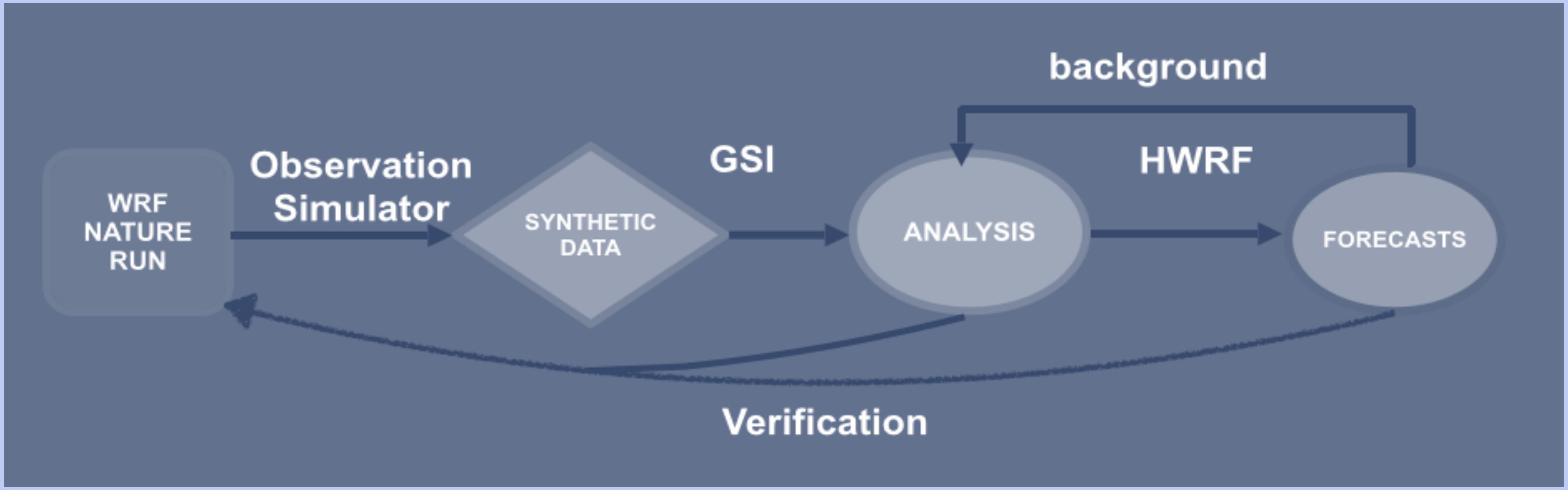
Utilize signals from existing GPS satellites to measure surface wind speeds (surface roughness affects forward-scattered signal) along the satellite ground tracks.

Capable of retrieving usable data over a large range of wind speeds (0-70 m/s) in all precipitating conditions throughout the tropics and subtropics with a frequent revisit times.

OSSE Framework

The regional OSSE (Observing System Simulation Experiment) framework was developed at NOAA/AOML and UM/RSMAS and features a high-resolution regional nature run embedded within a lower-resolution global nature run.

Simulated observations are generated and provided to a data assimilation scheme which provides analyses for a high-resolution regional forecast model.

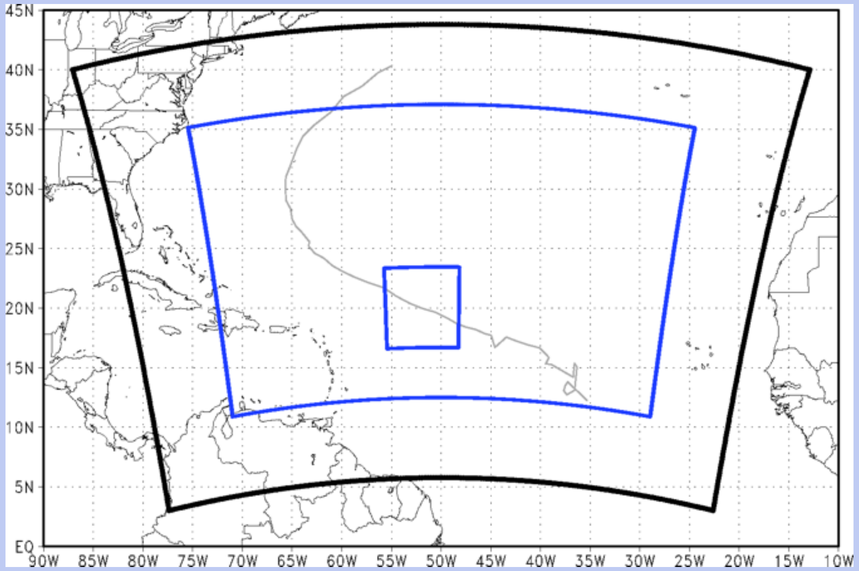


OSSE Framework Details

•Nature Runs
- *ECMWF*: low-resolution T511 (~40km) "Joint OSSE Nature Run"
- *WRF-ARW*: high-resolution 27km regional domain with 9/3/1 km storm-following nests (v3.2.1)

• Data Assimilation Scheme
- *GSI*: Gridpoint Statistical Interpolation. a standard 3D variational assimilation scheme (v3.3).
Analyses performed at 9km resolution.

•Forecast Model
- *HWRF*: the 2014 operational Hurricane-WRF model (v3.5).
Parent domain has ~9km resolution, single storm-following nest has ~3km resolution.



•*DA and model cycling performed every 6, 3, 1 hours, each run producing a 5-day forecasts every 6 hours.*

CYGNSS data

One synthetic CYGNSS datasets generated to span the WRF nature run.

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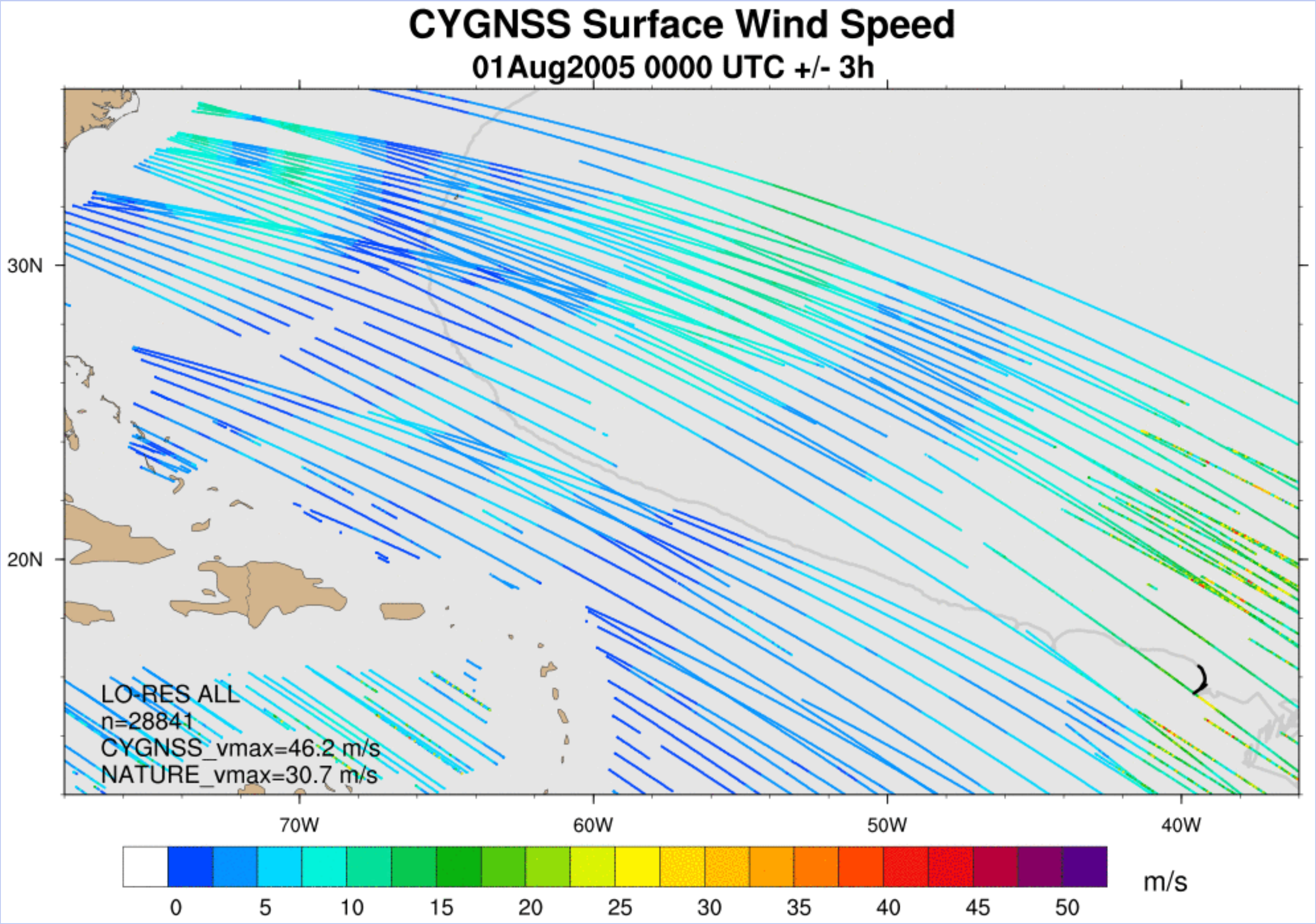
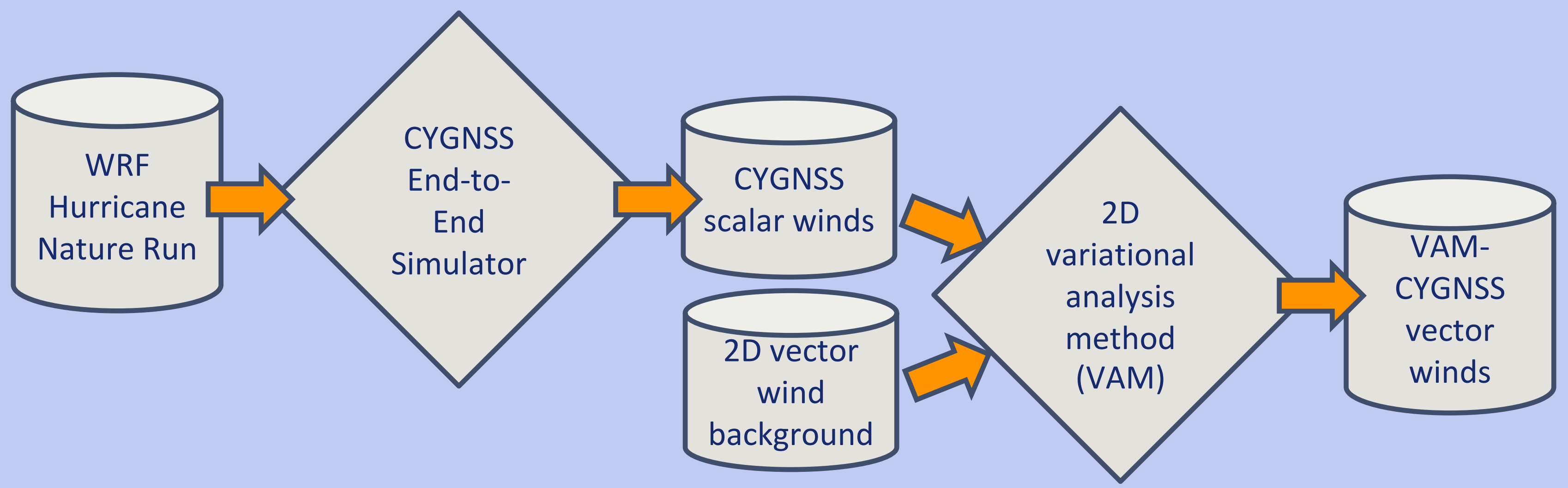


Synthetic data generated

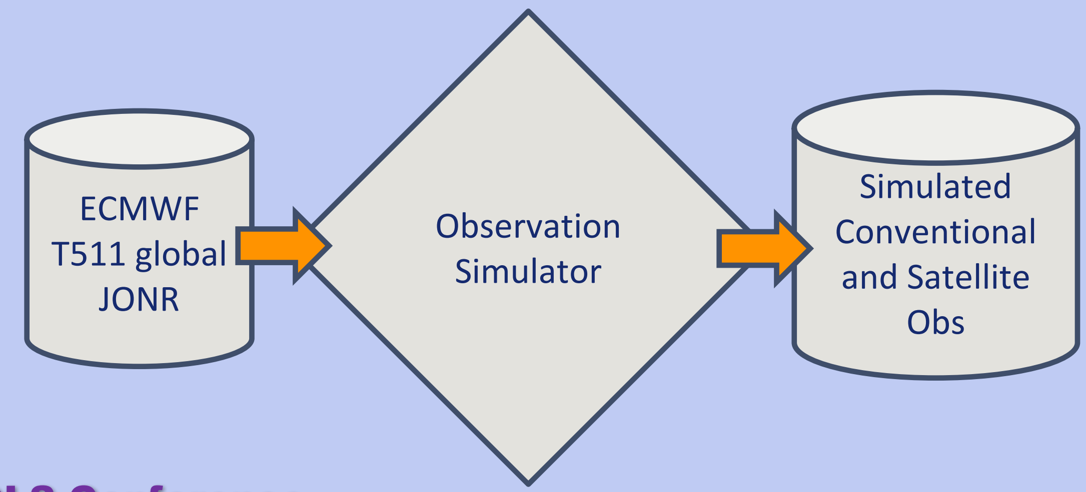
Direction information added to CYGNSS wind speeds using 2D Variational Analysis Method (VAM)



CONTROL :

Conventional Satellite/ Surface /sounding data, no CYGNSS

Taken from T511 “Joint OSSE Nature Run”



Experiments

All experiments listed use identical configurations of GSI for data assimilation and HWRF for forecasts.

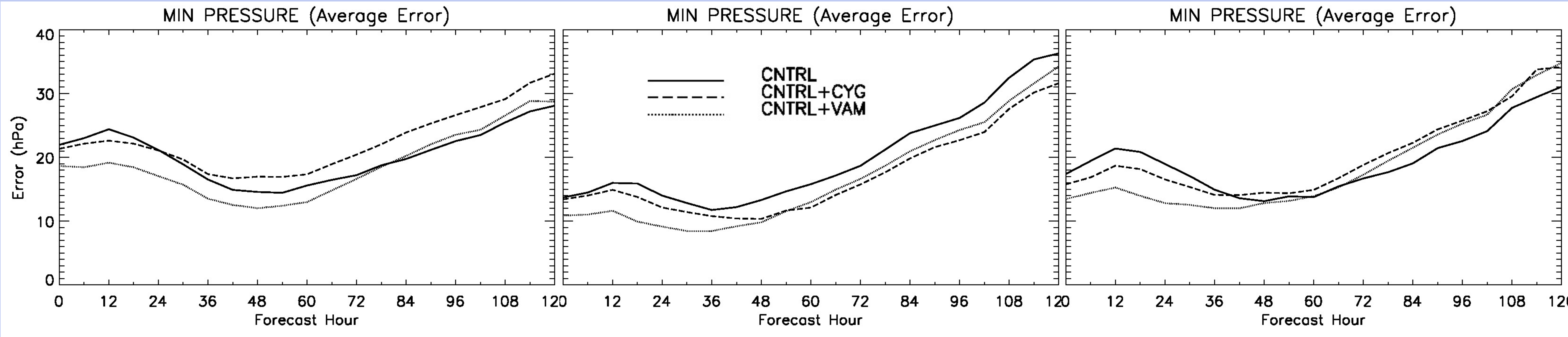
1) CONTROL: Conventional Satellite/ Surface /sounding data, no CYGNSS
2) CONTROL+CYG: CONTROL plus all available CYGNSS wind speed
3) CONTROL+VAM: CONTROL plus VAM wind vectors at CYGNSS retrieval coordinates. (VAM analyses use 9-km HWRF background; 6-hr forecasts)

There are a total of 16, 5-day forecasts, but first 4 forecasts runs omitted from verification to allow for model spin-up (12 cases)

- Vary data assimilation cycling frequency
  - 6 hourly cycling: 16
  - 3 hourly cycling: 32
  - 1 hourly cycling: 96

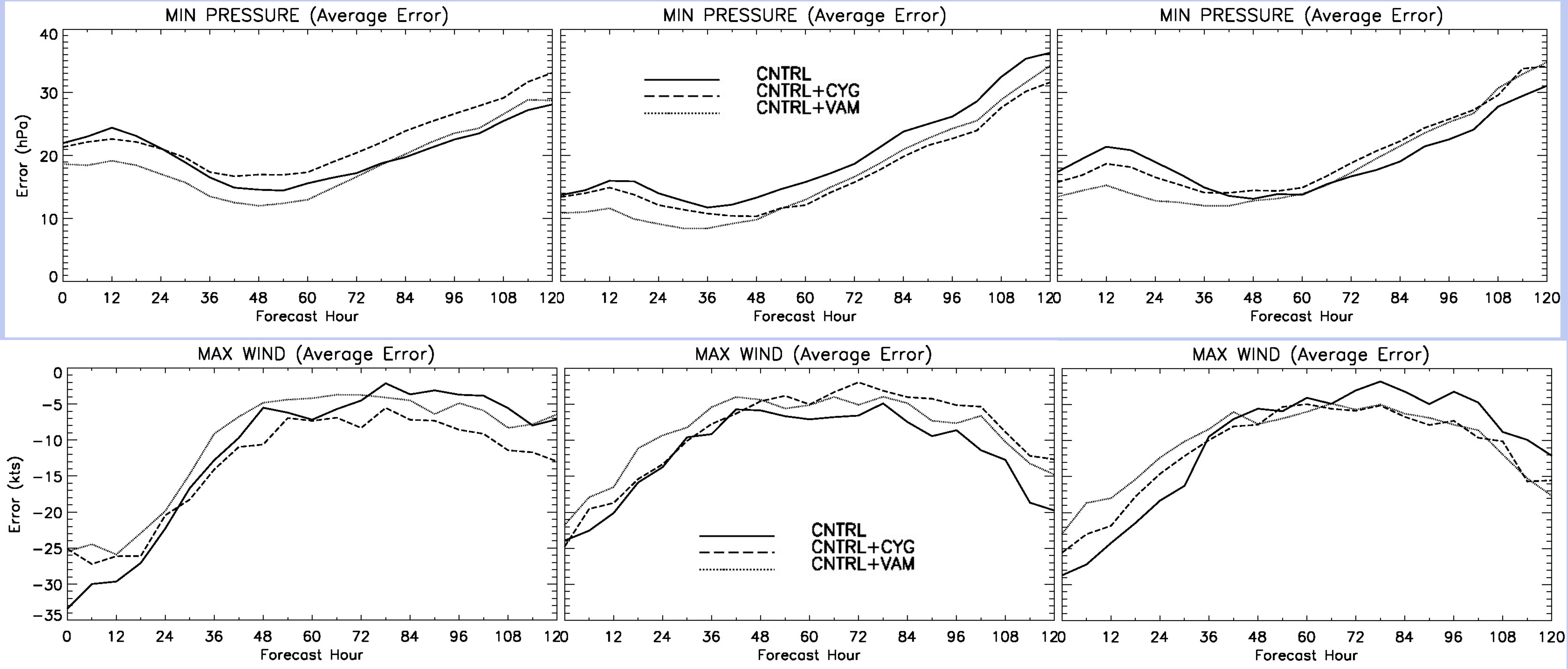
Average Forecast Errors N = 12 five-day forecasts

6-hourly DA cycling | 3-hourly DA cycling | Hourly DA cycling



Average Forecast Errors N = 12 five-day forecasts

6-hourly DA cycling 3-hourly DA cycling Hourly DA cycling



Average Forecast Errors

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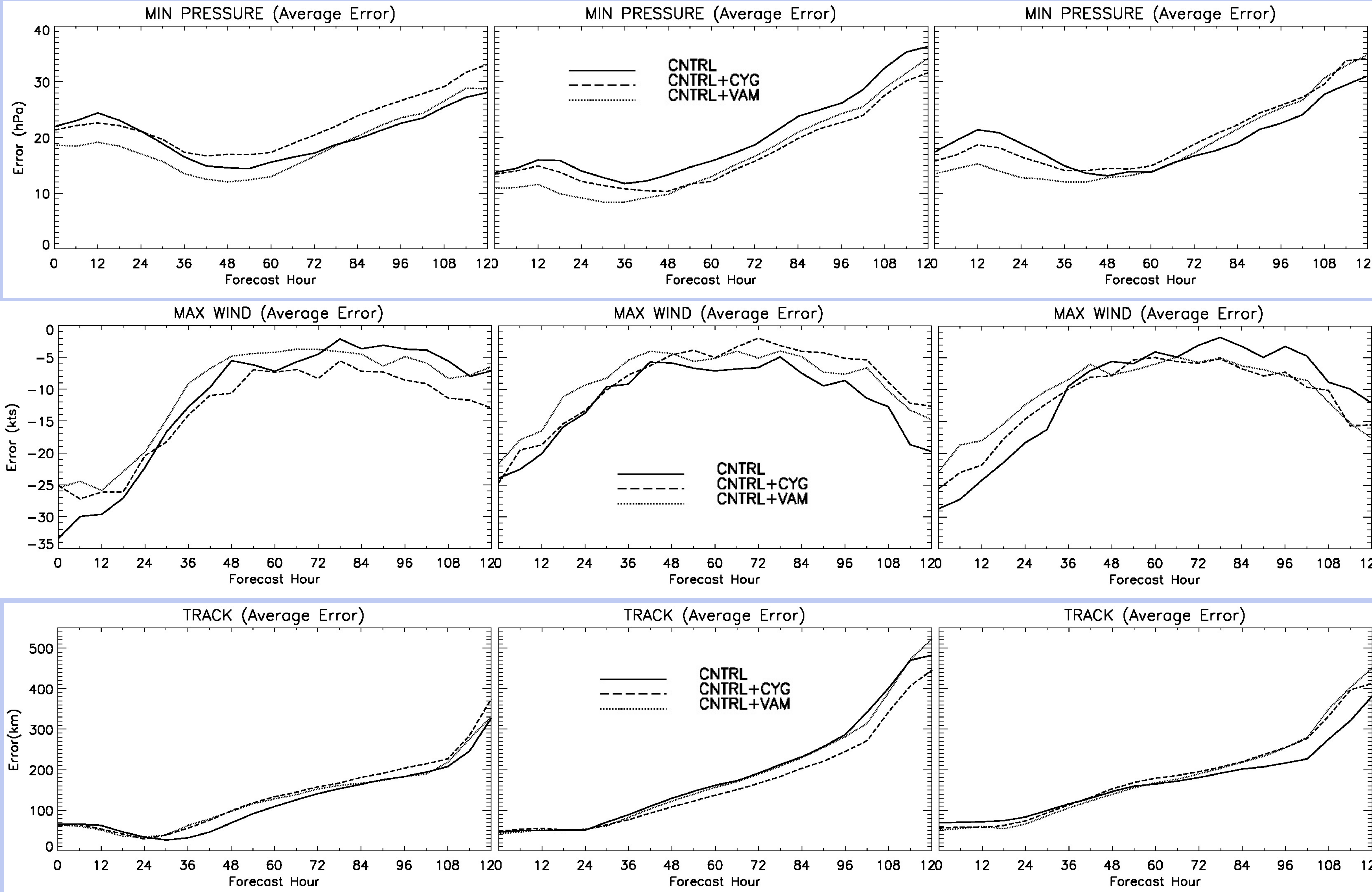


Statistical Significance

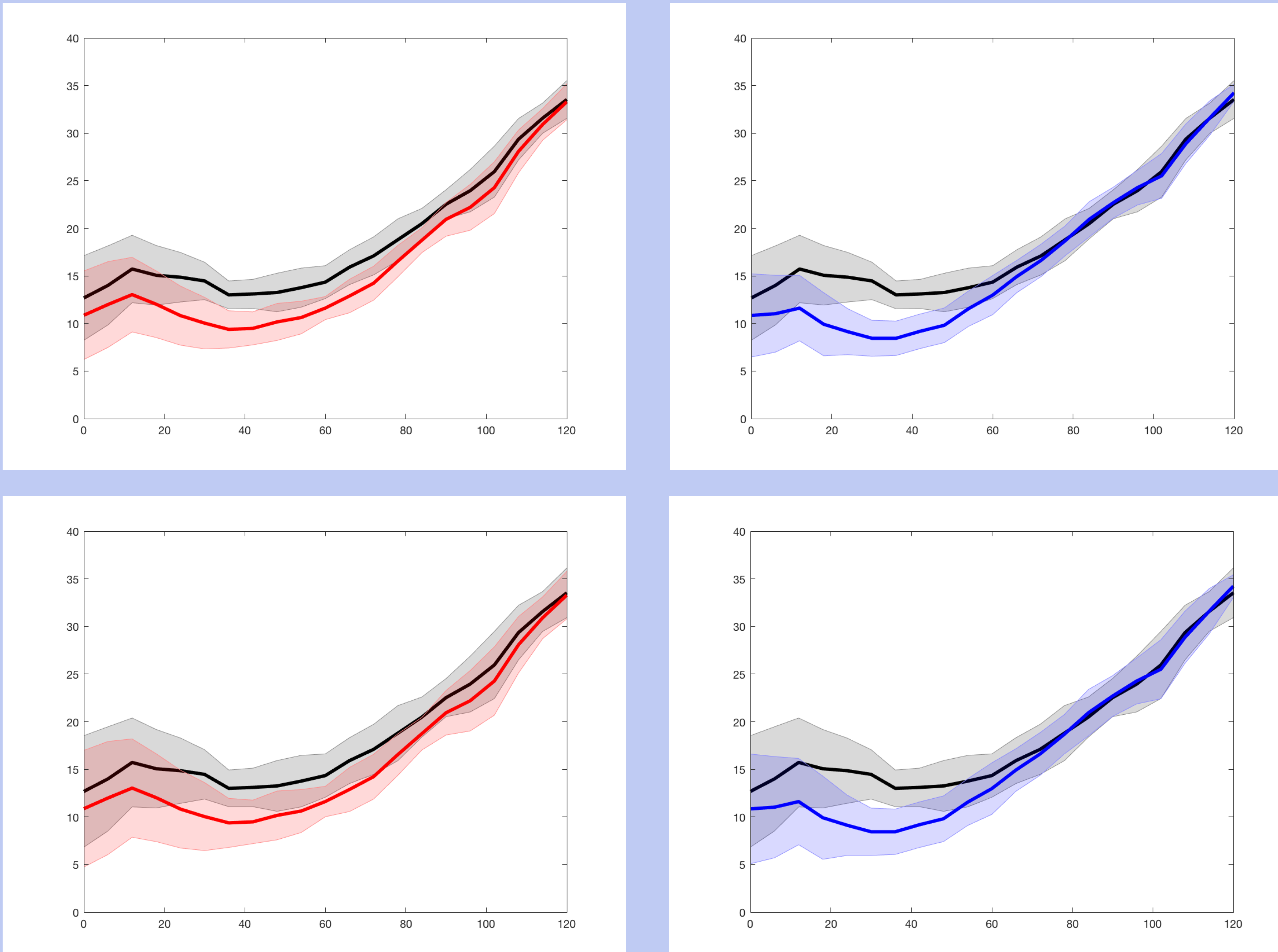
N = 12 five-day forecasts 3-hourly DA cycling

Min. central pressure error [hPa]

Control+CYG   Control+VAM

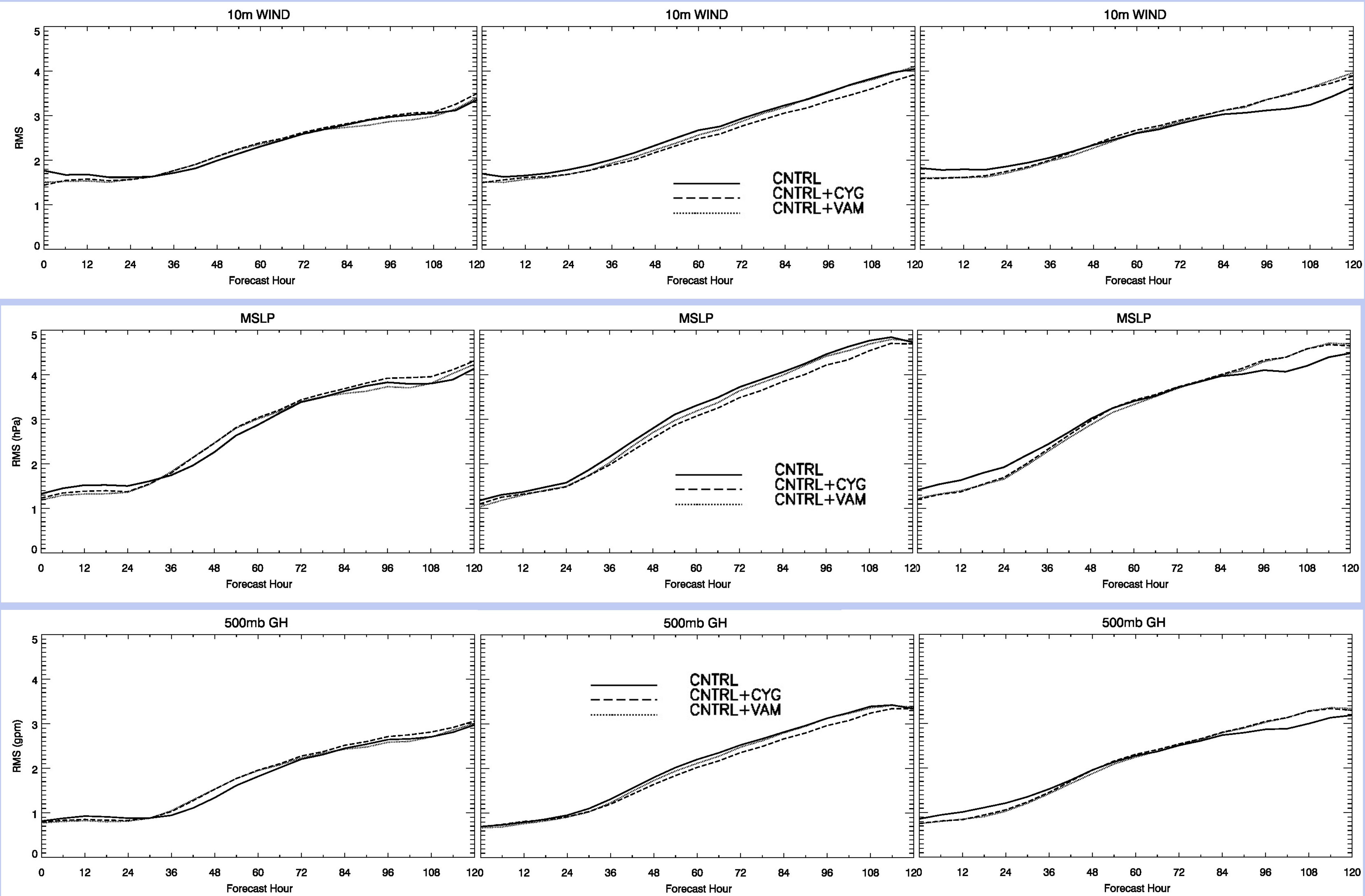
80% Confidence Interval

90% Confidence Interval



Domain Average statistics

6-hourly DA cycling | 3-hourly DA cycling | Hourly DA cycling



SUMMARY

1- Analysis of TC intensity (pressure, wind) improved with addition of CYGNSS data at all DA cycling frequencies

2- DA cycling frequencies affects analyses and forecasts

3- 3-hourly cycling produces the smallest errors for this sample

4- RMS track error at 0-24 hr very slightly improved with addition of CYGNSS data

5- CYGNSS data improves the representation of the surface wind speed structure (intensity and asymmetry)

6- We have relatively a few samples from one storm, so error statistics are not robust but provide guidance.

Future work

- **Preparations are underway for impact assessment of CYGNSS during the 2017 hurricane season**

- **Assessment with a near-operational assimilation and forecast framework (HWRF)**

- **Variations of assimilation strategies: nests, scalar/vector**

- **Comparison with NCEP HWRF operational forecasts**

For more, see poster 1001 tomorrow, Observation Symposium, 2:30 pm:

“Assimilation of CYGNSS Ocean Surface Winds in HWRF”

QUESTIONS?

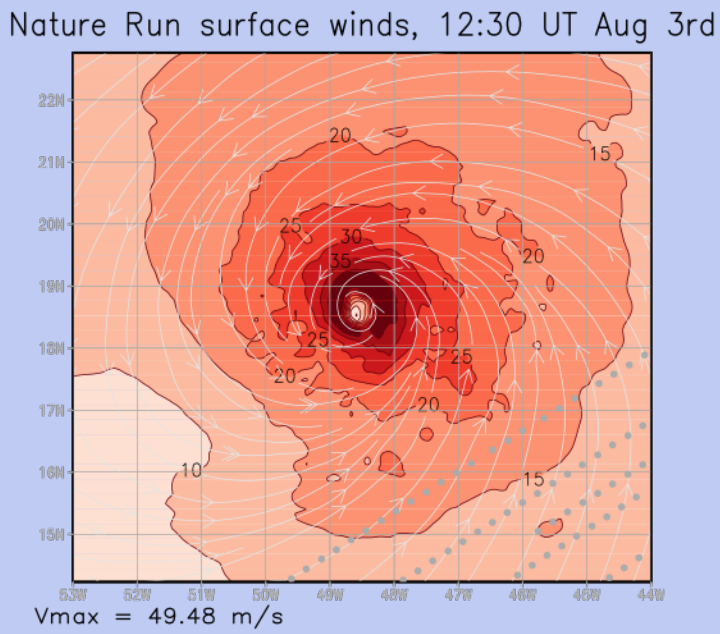
Backup Slides

Surface Layer Wind analysis 1200 UTC August 3, 2005

After 10 DA cycles (6 hourly); lowest 30 hPa

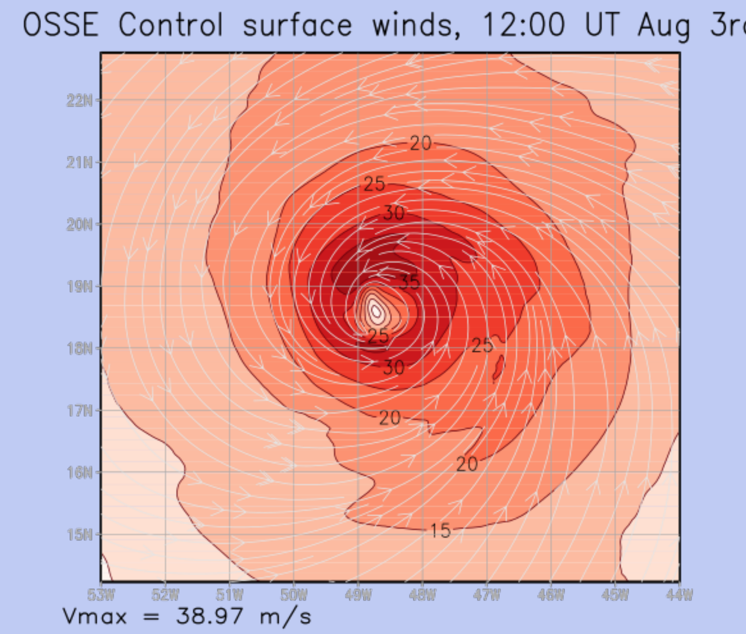
Nature

49.5 m/s



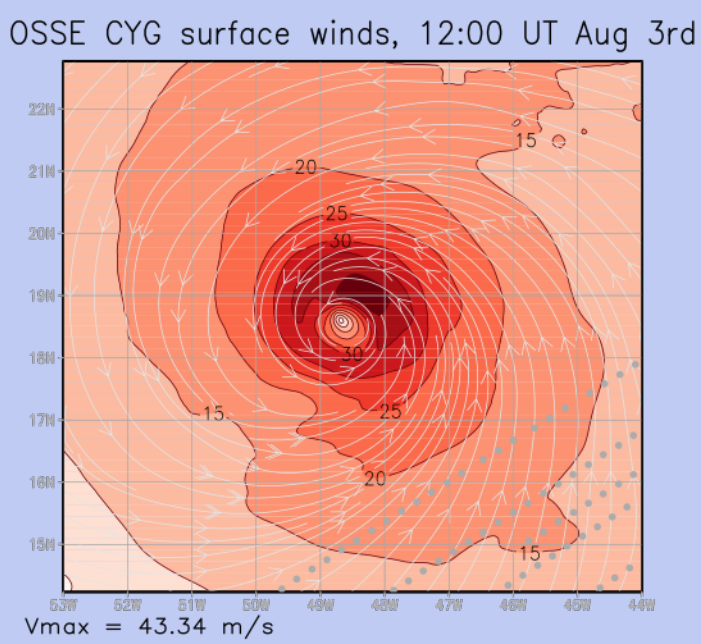
Control

39.0 m/s



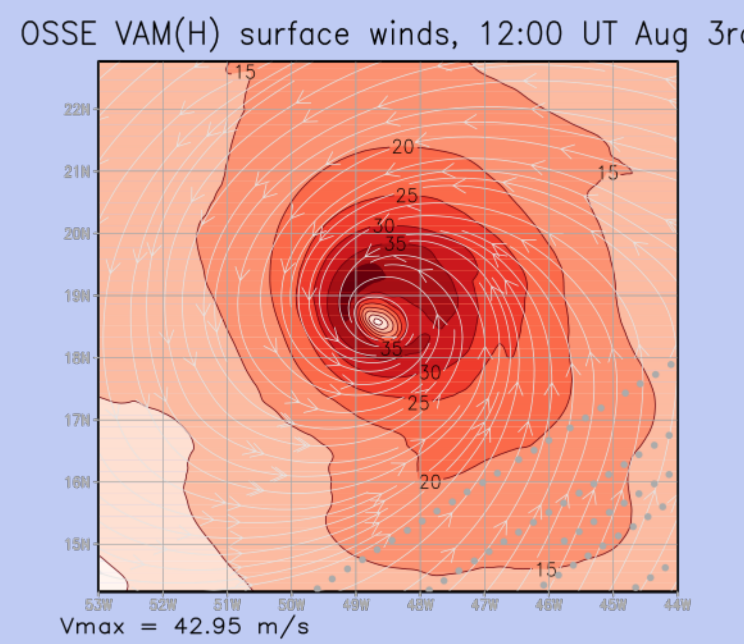
Control+CYG

43.3 m/s



Control+VAM

43.0 m/s



Hurricane Error Std. Deviation

3-hourly DA cycling N = 12 five-day forecasts

Control Control+CYG Control+VAM ALL