UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

Evaluation of the Impact of Synthetic CYGNSS Wind Speed Data on Tropical Cyclone Structure Analyses and Forecasts in a Regional OSSE

S. J. Majumdar[1], B. D. McNoldy[1], B. Annane[2], S. M. Leidner[3], R. Atlas[4] & R. N. Hoffman[2]
1. University of Miami / RSMAS, 2. University of Miami / CIMAS and NOAA/AOML
3. Atmospheric and Environmental Research (AER) Inc., 4. NOAA/AOML
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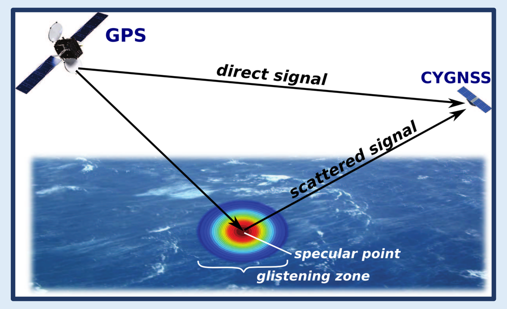
1. CYclone Global Navigation Satellite System (CYGNSS)

Constellation of 8 micro-satellites. Launched 15 December 2016.

- Capable of retrieving a large range of surface wind speed data in all precipitating conditions, with frequent revisit times.

- Receives GPS L-band signals at 19-cm wavelength
- Low-Earth orbit: 35S-35N
- Spatial resolution: 25 km
- Wind speed dynamic range: 0-70 m/s
- Median / mean revisit time: 2.8 h / 7.2 h



Reference: Ruf, C. et al., 2016: New Ocean Winds Satellite Mission to Probe Hurricanes and Tropical Convection, *Bull. Amer. Meteor. Soc.*, **97**, 385-395.

This study: Assess potential impact of assimilating CYGNSS data prior to launch, using Observing System Simulation Experiments (OSSEs)

2. Purposes of OSSEs

Observational network design

Assess impact of assimilating data from future platforms
- Future satellites or other platforms not yet built
- Different orbital configurations
- Design and configuration trade-offs of a given platform
- "Optimal mix" of different instruments
- Identify state variables, accuracy, and spatial/temporal/spectral density and resolution of data needed to significantly impact NWP

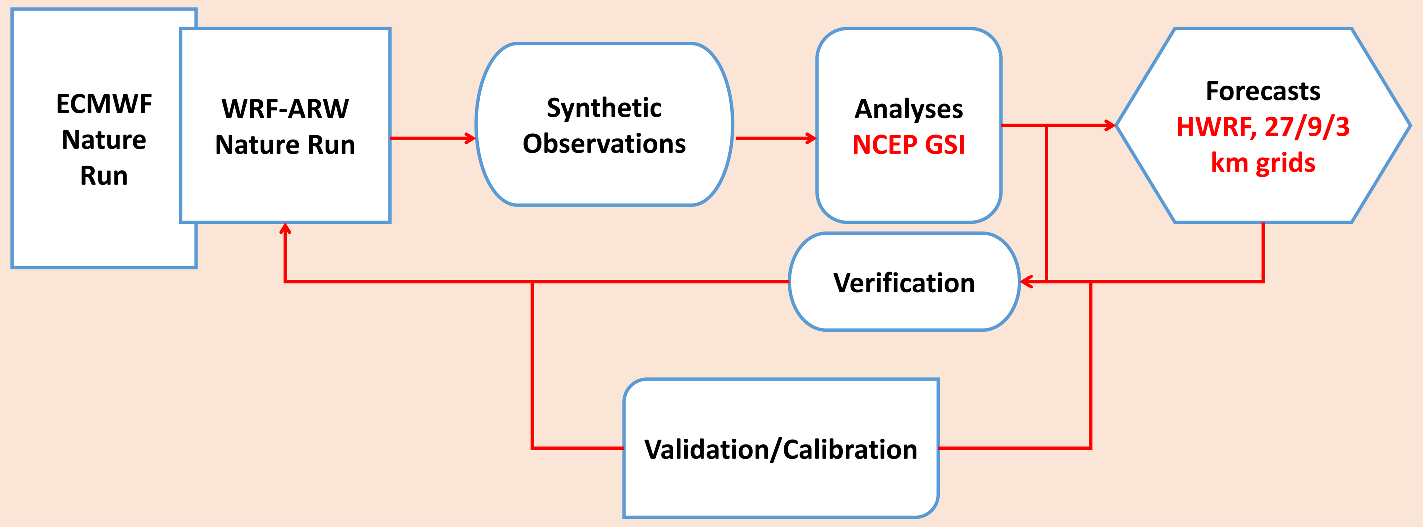
Assess impact of assimilating data from existing platforms
- Selective thinning and targeting of satellite radiances
- Aircraft flight tracks
- Optimal mix of existing observations

Reference: Hoffman, R. N., and R. Atlas, 2016: Future Observing System Simulation Experiments, *Bull. Amer. Meteor. Soc.*, **97**, 1601-1616.

Other Applications of OSSEs

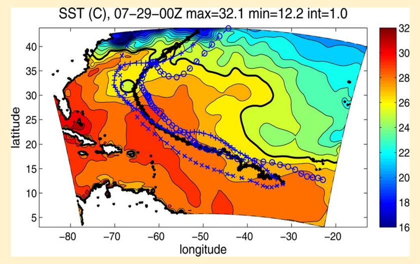
- **Developing and testing new data assimilation schemes**
- **Predictability and sensitivity studies in a controlled environment**
- **Extensions: Oceans; Chemistry; Coupled Systems**

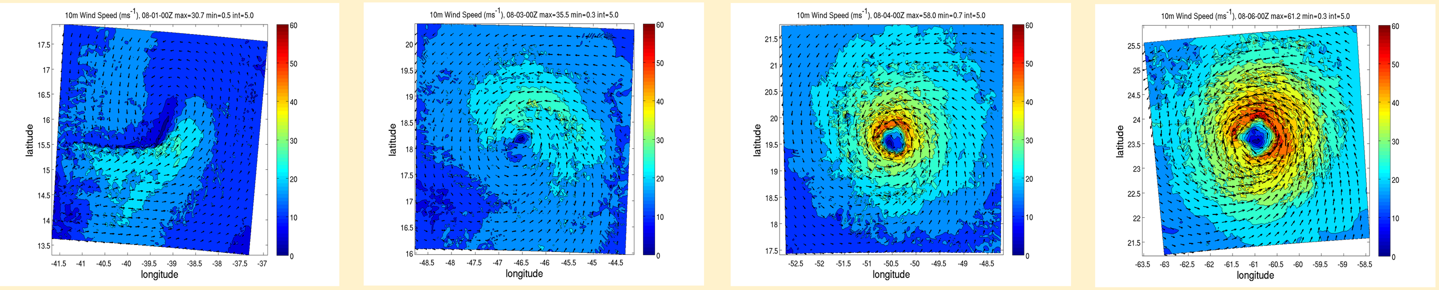
3. OSSE Framework for Tropical Cyclones



4. Hurricane Nature Run

13-day WRF-ARW simulation, 27/9/3/1 km grids.
Fields stored every 6 min.
"Perfect" observations directly extract data from Nature Run at observation locations.
"Realistic" observations use observation simulator to sample observations and prescribe errors.



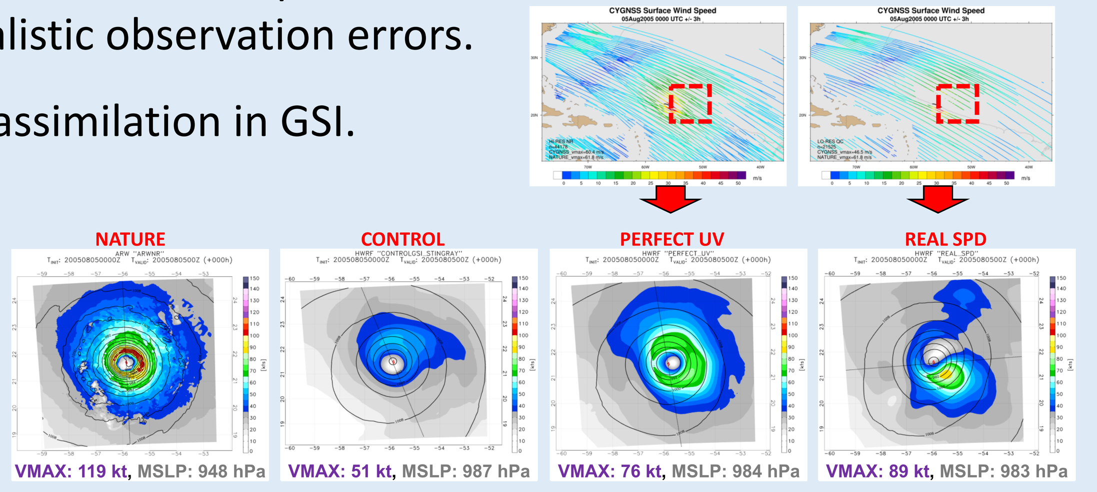


Reference: Nolan, D. S., R. Atlas, K. T. Bhatia, and L. R. Bucci, 2013: Development and validation of a hurricane nature run using the joint OSSE nature run and the WRF model, *J. Adv. Model. Earth Syst.*, **5**, 382–405.

5. Impact on HWRF Analyses

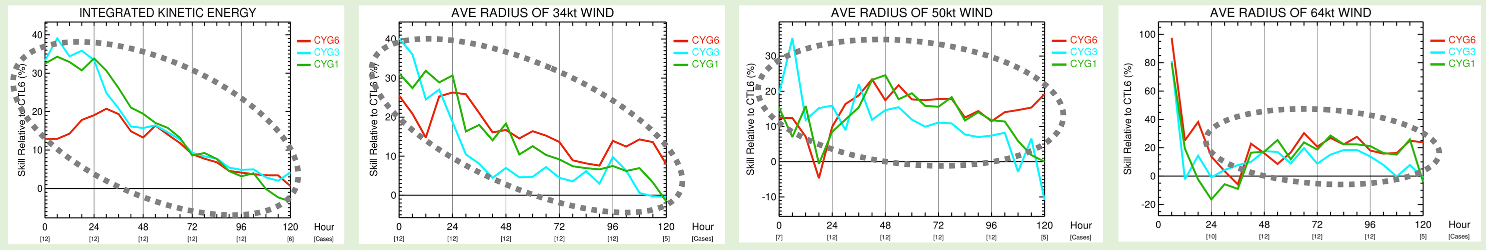
CONTROL = Conventional satellite / surface / soundings, no CYGNSS.
PERFECT UV = CONTROL + wind components directly from Nature at CYGNSS locations, no observation errors.
REAL SPD = CONTROL + wind speed from CYGNSS with realistic observation errors.

6-hourly cycled assimilation in GSI.



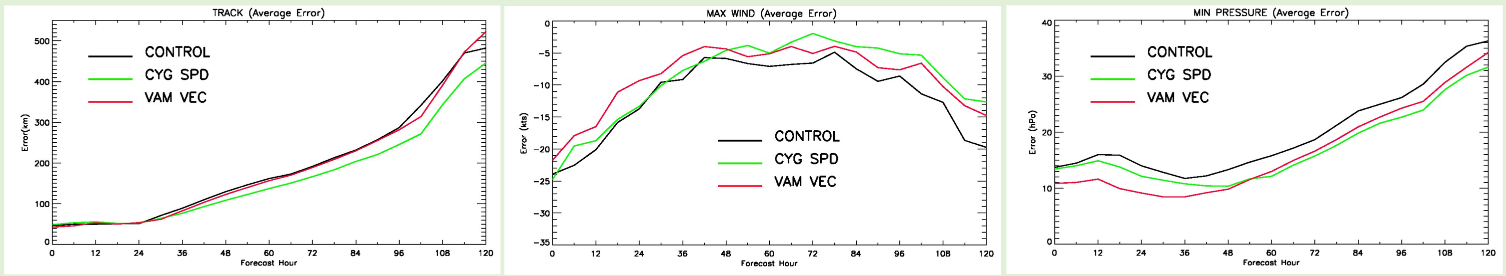
6. Impact on HWRF Forecasts

HWRF forecasts of Integrated Kinetic Energy (IKE) and critical radii are generally improved with realistic CYGNSS wind speed data at assimilation frequencies of 1 h, 3 h and 6 h.



Reference: McNoldy, B. D., B. A. Annane, S. J. Majumdar, J. Delgado, L. R. Bucci and R. Atlas, 2017: Impact of assimilating CYGNSS data on tropical cyclone analyses and forecasts in a regional OSSE framework, *Marine Tech. Soc. J.*, **51**, 7-15.

Introduction of the 2-d Variational Analysis Method (VAM) to assign directional information to CYGNSS improves the forecasts further.



7. Summary

- Assimilation of CYGNSS data with GSI almost always improves track and intensity analyses and short-range forecasts
- CYGNSS data have greatest impact on **storm structure metrics** such as critical wind radii and IKE
- Adding **directional information** to the CYGNSS wind improves hurricane analyses in GSI
- DA **cycling frequency** affects quality of analyses
- GSI analyses are limited: very sensitive to the exact location of the observational data. Symmetry and coverage affect the result
- Higher-resolution and/or noisier data degrade analyses when compared to lower-resolution and/or smoother data
- Note: results are for a limited sample

8. Current and Future Work

- Retrospective HWRF analyses and forecasts with the addition of actual CYGNSS data for selected tropical cyclones in 2017

- Synergistic utilization of future space-borne observations, including CYGNSS, Doppler Wind Lidar and Atmospheric Motion Vectors

- New gridded ocean surface wind vector analysis products using CYGNSS throughout the tropics, created using the VAM. Background fields: NCEP GFS; NASA MERRA-2; NASA CCMP.

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