P1001

Assimilation of CYGNSS Ocean Surface Winds in HWRF

Preparing for post-launch assessment of impact on hurricane analysis and forecasts

UNIVERSITY OF MIAMI ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

aer Atmospheric and Environmental Research

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CYGNSS: new eyes on the Tropical Oceans

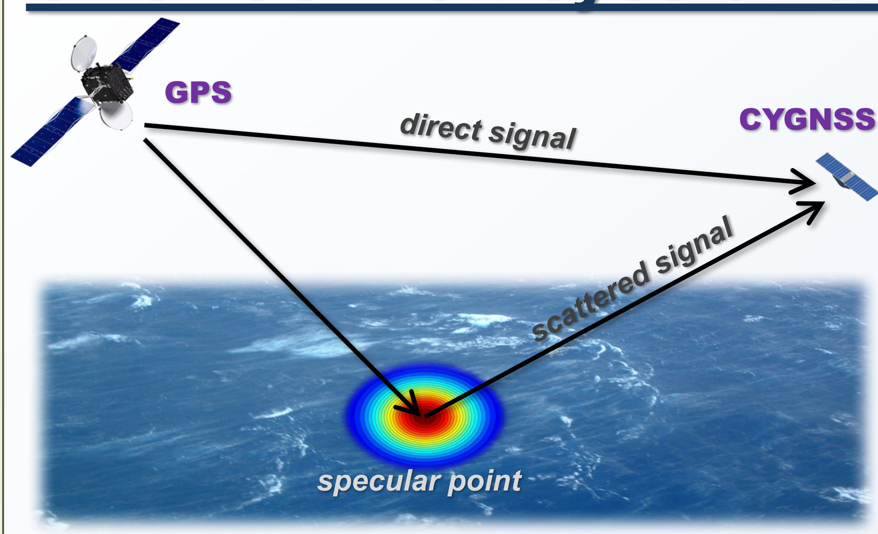


Fig 1. Geometry of GPS-based quasi-specular surface scattering. The GPS direct signal provides location, timing, and frequency references, while the forward scattered signal contains ocean surface information.

The NASA Cyclone Global Navigation Satellite System (CYGNSS) launched Dec 15, 2016, consists of a constellation of 8 micro-satellites.

These swan-sized satellites will receive signals reflected by the ocean from existing GPS satellites.

Scattered signals contain information on ocean surface roughness, from which a wind speed can be retrieved under precipitating conditions and with sensitivity up to at least 70 m/s.

Spatial and temporal coverage provided by CYGNSS will be complementary to ASCAT and OSCAT combined in the tropics.

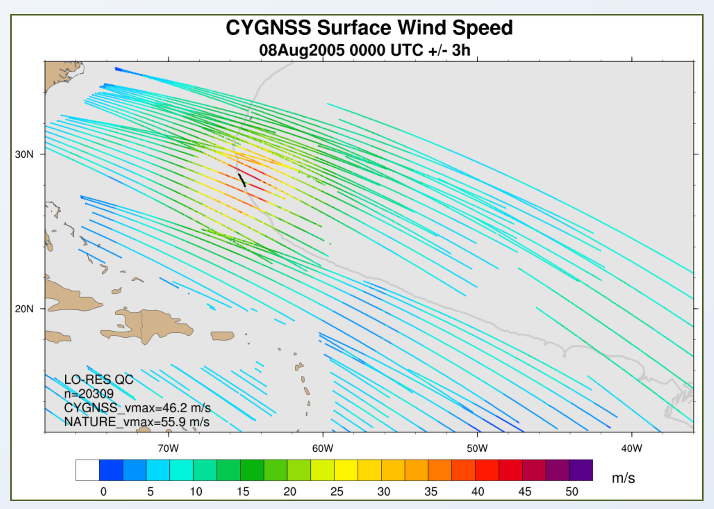


Fig 2. Example of synthetic CYGNSS data coverage over a 6-hour window. Colors correspond to retrieved wind speed.

Creation of VAM-CYGNSS wind vectors

- CYGNSS will observe ocean surface wind speed
- Wind vectors are more valuable to 3D data assimilation

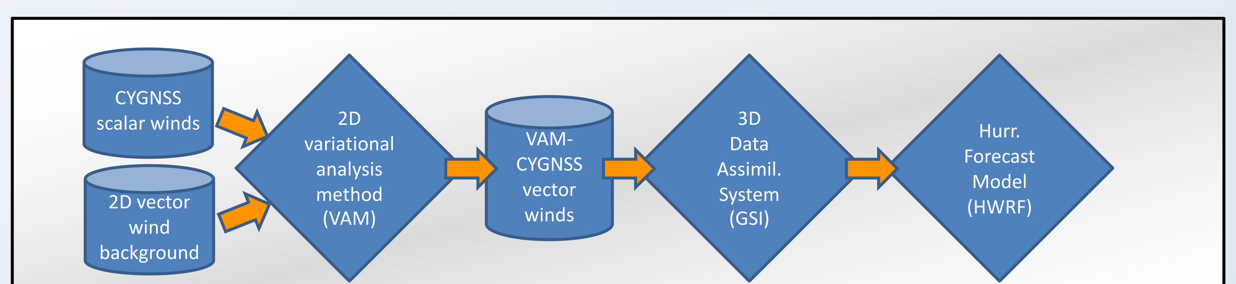


Fig 3. Flow chart to generate VAM-CYGNSS wind vectors.

- **Level 2 CYGNSS retrieved winds**
  - Produced by the CYGNSS Science Team
  - Nominally 25 km resolution
- **Choice of Background Vector Winds**
  - We have tested low- and high-resolution backgrounds "off-line"
  - Higher resolution backgrounds perform better
  - For 2017 hurricane season, we will use HWRF forecasts
- **2D Variational Assimilation Method (VAM)**

VAM finds an optimal fit to wind observations, given a 1st guess wind vector field

$$J(x) = J_b(x) + J_o(x) + J_c(x)$$

The VAM creates gridded 2D surface wind vector analysis by minimizing an objective function, J, which measures the misfit of the analysis to the background (J_b), the observations (J_o), and a priori constraints (J_c). The analyzed dynamical balance must be close to that of the background.

Integration of VAM analysis in HWRF

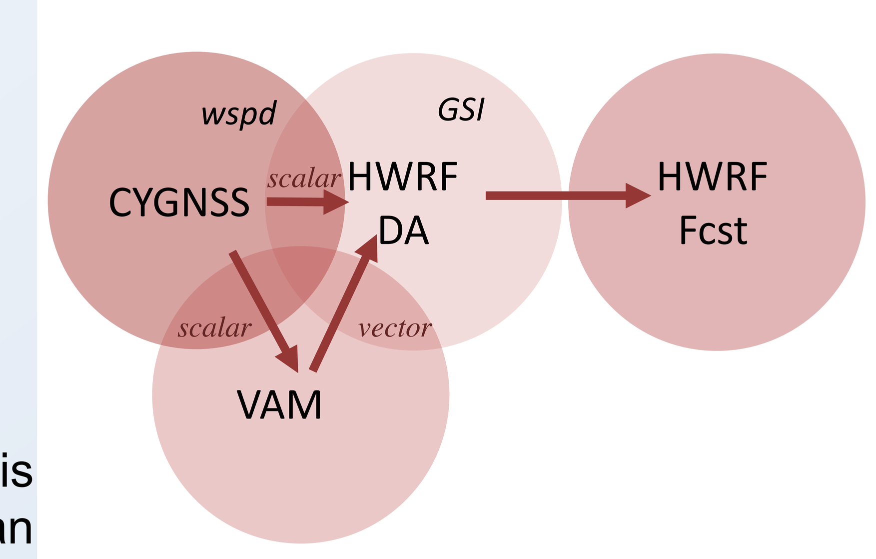
Three technology areas intersect to allow for integration of the VAM:

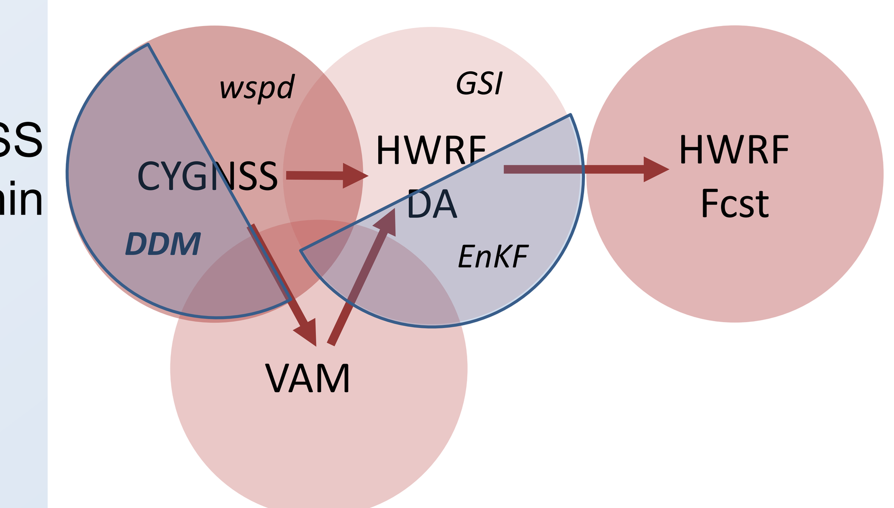
1. CYGNSS data (L1 or L2)
2. HWRF DA
3. 2D variational analysis (VAM)

Integration of the VAM analysis "in-line" within HWRF 2016 is an on-going task.

Other pathways for CYGNSS data are being developed within this integrated framework.

- Use of Level 1 Delay-Doppler Maps (DDM) in the VAM
- More advanced HWRF DA schemes





Impact Assessment: 2017 hurricane season

Assess the impact of CYGNSS data on hurricane analysis and forecasts
Assessment with a near-operational assimilation and forecast framework
Variations of assimilation strategies:

- assimilate on HWRF domain 2 (6 km) only
- assimilate on HWRF domain 3 (2 km) only
- assimilate on HWRF domains 2 & 3

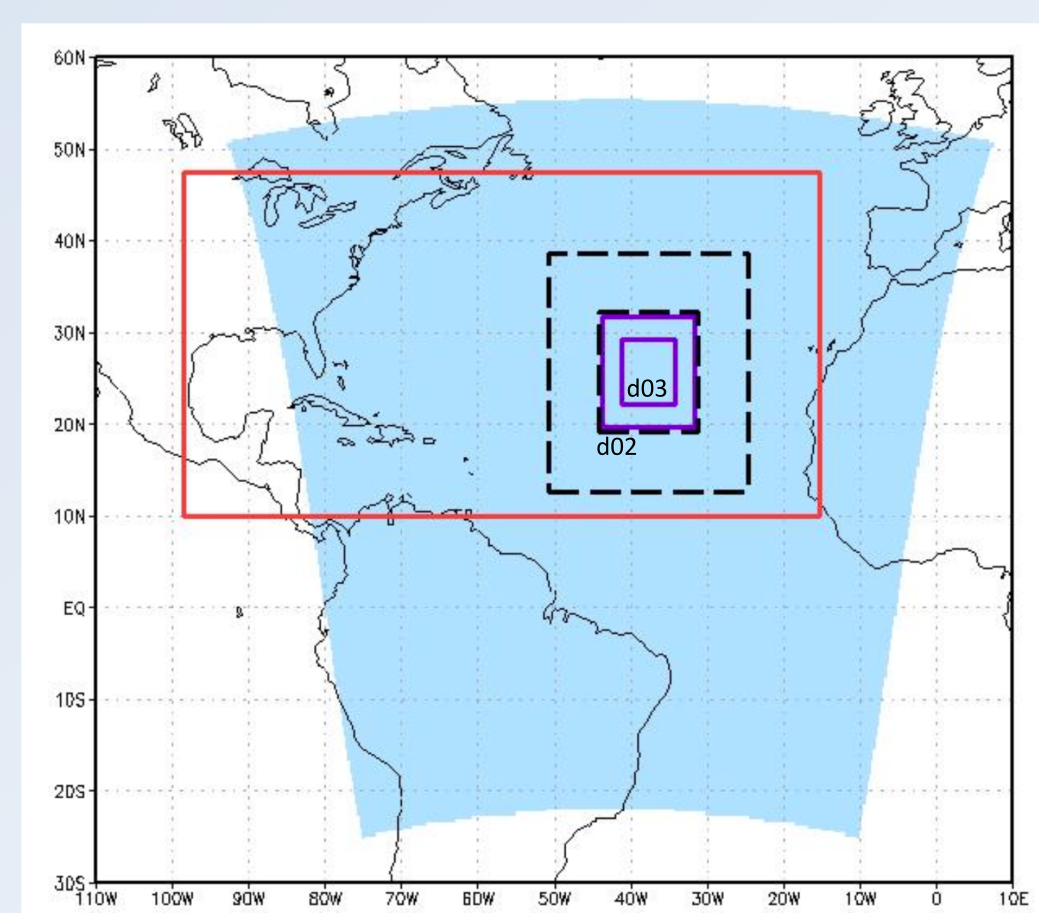


Fig 4. Grid nesting of the HWRF 2016 used in operations. The blue region is the outer18-km domain. The purple solid boxes show the sizes of the vortex-following 6-km and 2-km domains, while the black dashed lines are the ghost domains for d02 and d03. The red box is the unified Atlantic MPIPOM-TC domain. (Figure courtesy DTC.)

Assessment with and without vortex relocation
Assessment using CYGNSS scalar winds / VAM-CYGNSS vector winds
Evaluation by comparison with NCEP operational HWRF forecasts

Example Effects on Storm Structure (OSSE)

- Addition of CYGNSS surface wind information generally improves hurricane analyses and forecasts, bringing the analyzed TC closer to NATURE in terms of symmetry, peak intensity, central pressure, and wind radii.

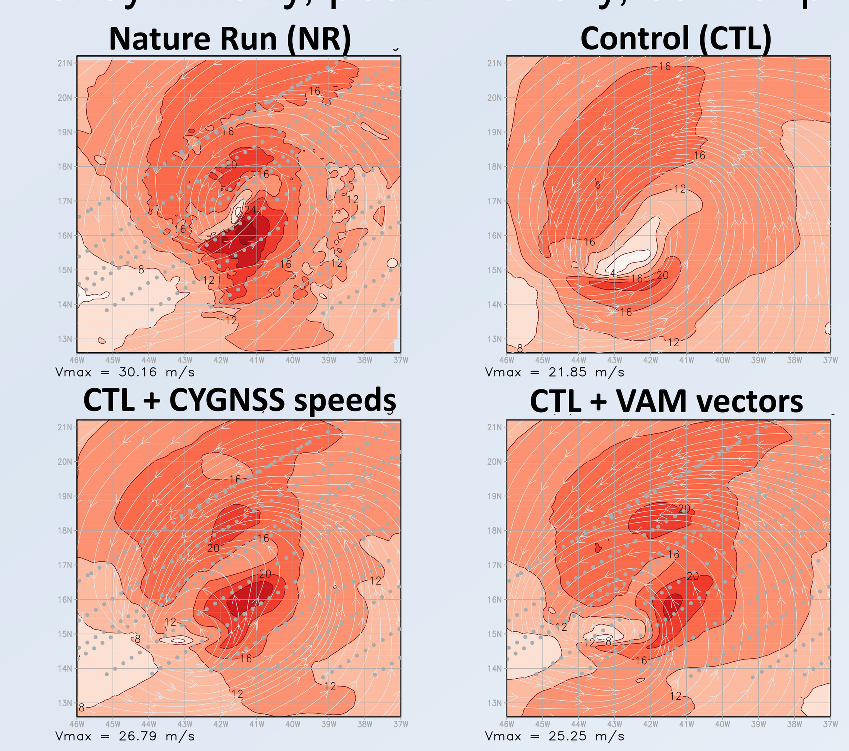


Fig 5. Layer-average, near-surface wind speed and streamlines [lowest 30 mb] from the Nature Run (NR) and from the analysis of three OSSEs, valid at 1200 UT August 1. The storm is just forming in all DA treatments, as in the NR, but with a significant southwest displacement compared to the NR. Wind speed is shaded according to the color scale in Fig. 6.

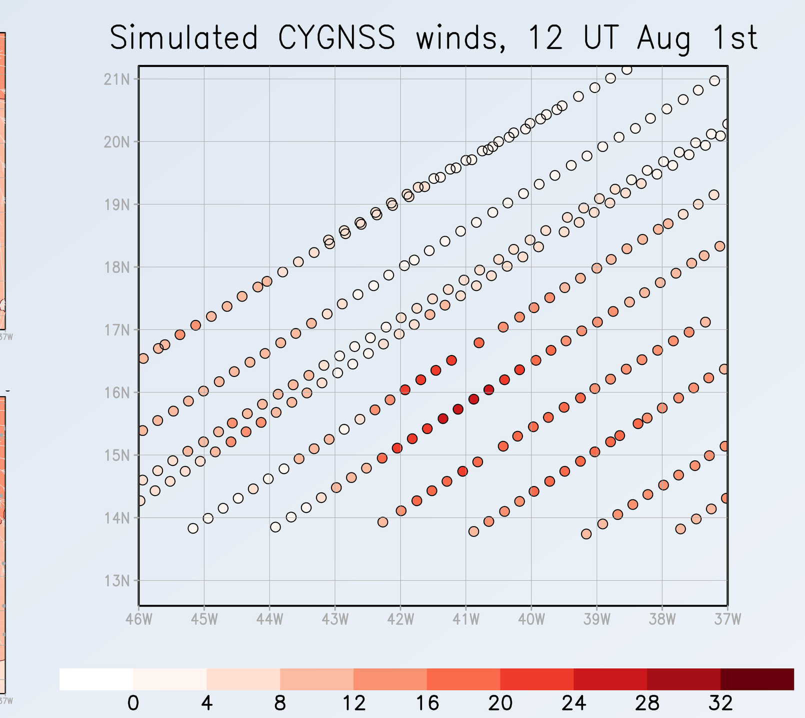


Fig 6. Simulated CYGNSS wind speed data in the domain of Fig.5 and +/- 1.5 hours around 1200 UT August 1. For clarity, every 5th CYGNSS retrieved wind speed location is plotted. For reference, CYGNSS locations are plotted as solid gray circles in Figs. 5, 7 and 8.

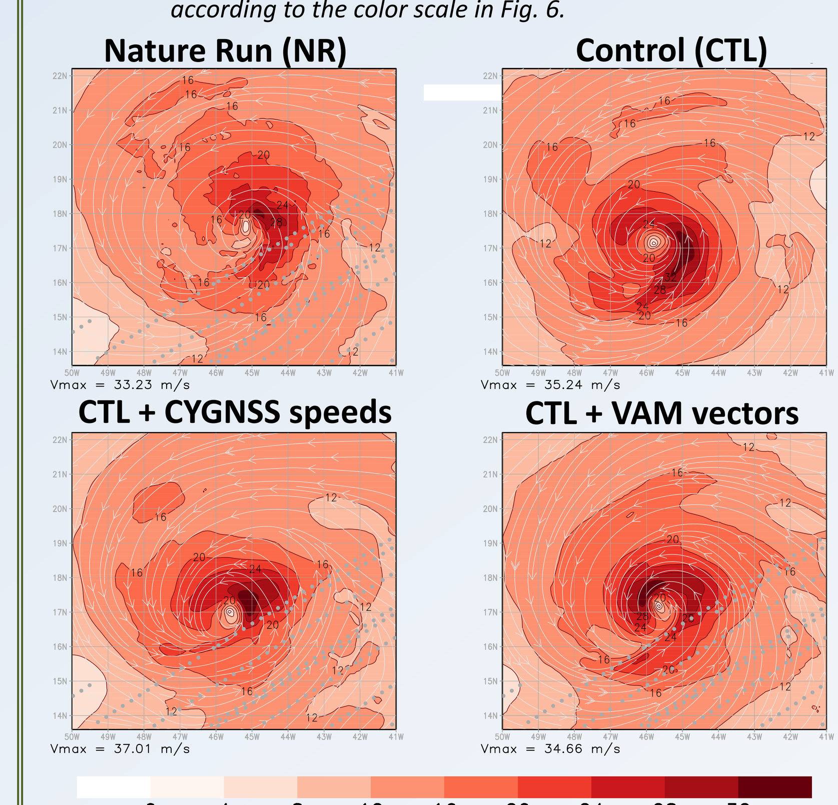


Fig 7. As in Fig. 5, but 24 hours later. The storm has strengthened in all treatments, but CYGNSS data have slowed the westward movement and brought the storm further north, in better agreement with the NR.

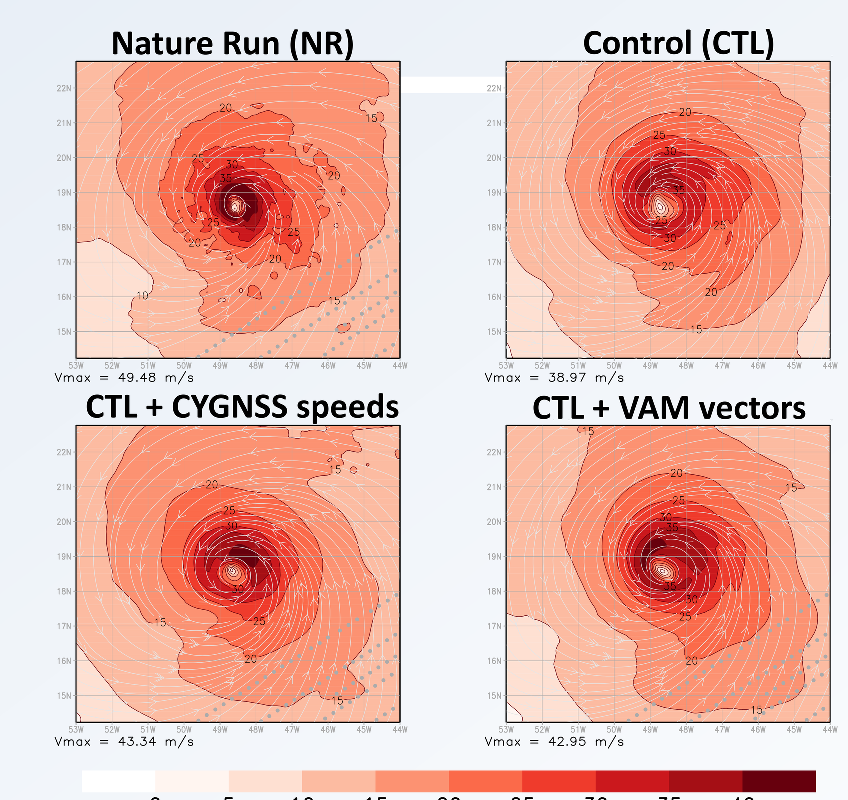


Fig 8. As in Fig. 5, but 48 hours later. The storm has strengthened further. CYGNSS treatments are in better agreement with the NR in terms of intensity and overall wind field structure.

Summary

- Preparations are underway for impact assessment of CYGNSS during the 2017 hurricane season.
- OSSE results suggest that CYGNSS observations can improve the depiction of hurricane intensity and wind field structure
- Two oral presentations earlier in this conference detail the methods and results of the pre-launch CYGNSS OSSEs:
  1. 21st I IOAS-AOLS, Paper 5.1 Leidner *et al.*
  2. 21st IOAS-AOLS, Paper 5.2 Annane *et al.*

Acknowledgements

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