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Analysis and Assimilation of CYGNSS Wind Data for Improved Tropical Convection Forecasts

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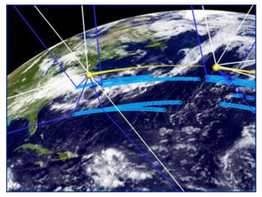
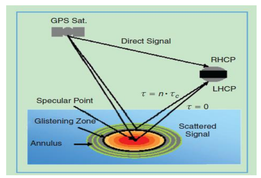
1. Introduction





CYGNSS: The Cyclone Global Navigation Satellite System mission, launched in December 2016

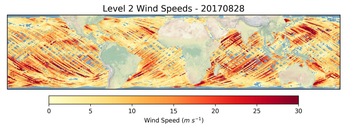
Instruments: 8 micro-satellite observatories receive both direct and reflected signals from GPS satellites

Observation: Retrieved ocean surface wind with rapid revisit times in regions of deep convection, in particular TCs and MJO events.

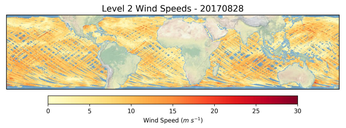
2. CYGNSS V2 beta data

CYGNSS V1 L2 winds featured significant errors due to a variety of reasons. CYGNSS V2 beta data (covering most of August and September 2017) has been made available recently. The dataset includes two different GMFs, one suitable for high winds (**LF**) and one suitable for all other situations (**FD**). V2 beta winds show drastic improvement over V1, with RMSE close to the expected 2 m/s.

Version 1

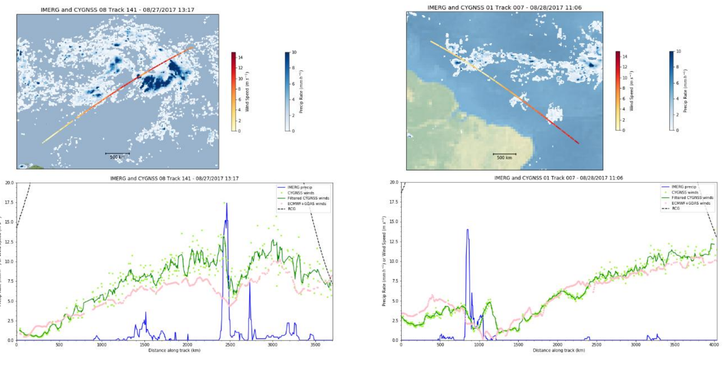


Version 2 beta FD



Track-based analysis with IMERG

When combined with precipitation data along the track, as well as simple filtering of the oversampled CYGNSS data, gust fronts and other surface features near precipitation systems are readily apparent.



CYGNSS vs. ECMWF+GDAS

8/26/17-8/30/17	RMSE (m s^{-1})	Bias (m s^{-1})
FD_{rain}	2.7	+0.0
FD_{norain}	2.0	-0.1
LF_{rain}	3.6	+0.7
LF_{norain}	2.8	+0.3

Since CYGNSS is mostly transparent to precipitation, we hypothesize that sharper gradients and increased offsets between CYGNSS V2 beta winds and ECMWF+GDAS winds in precipitation could be due to model-unresolved cold pools, gust fronts, and/or altered sea states associated with the convection.

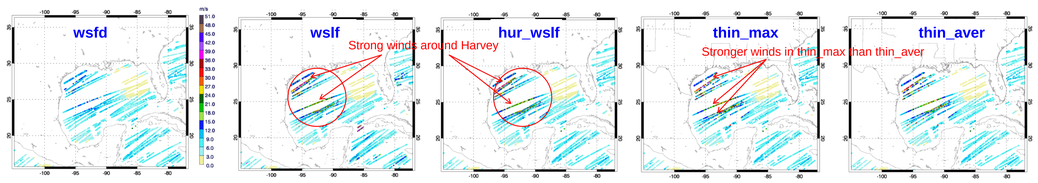
3. Model configuration and data assimilation

- WRF ARW v3.8 and hybrid Ensemble 3D-Var DA system
- 9-km resolution, 06 UTC 24 August – 00 UTC 01 September 2017
- Observation: CYGNSS v2 beta Level 2 wind speed data with errors set as 2 m/s for windspeed < 20 m/s and 10% for windspeed > 20 m/s.
- DA: To assimilate the most available wind around Hurricane Harvey area. Cycles at 06 & 12 UTC 08/25, 12 UTC 08/27, 06 & 12 UTC 08/28, 06 & 12 UTC 08/29, 06 & 12 UTC 08/30, 06 & 12 UTC 08/31.

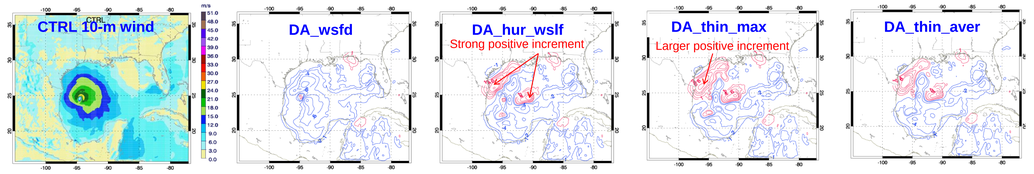
Experiments	Data Assimilation
CTRL	No
DA_wsfd	CYGNSS FD wind speed
DA_hur_wslf	LF wind around Hurricane Harvey plus FD wind anywhere else
DA_thin_aver	Thinned hur_wslf by taking average of all data within the model grid
DA_thin_max	Thinned hur_wslf by using the maximum of all data within the model grid

4. Result

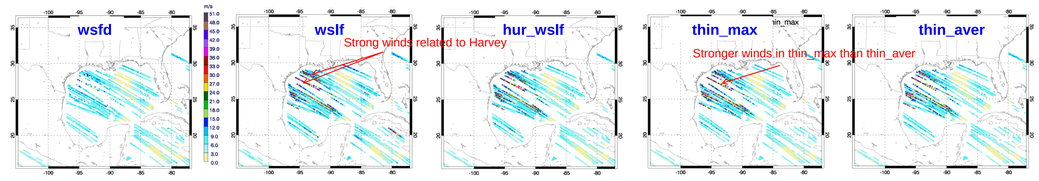
CYGNSS V2 beta L2 wind speed at 04 – 08 UTC 2017-08-25



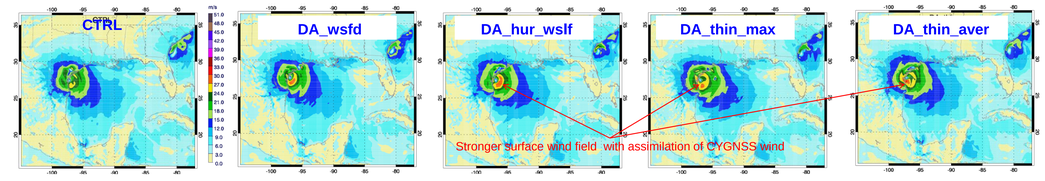
Data assimilation 10-m wind increment from 1st DA cycle at 06 UTC 2017-08-25



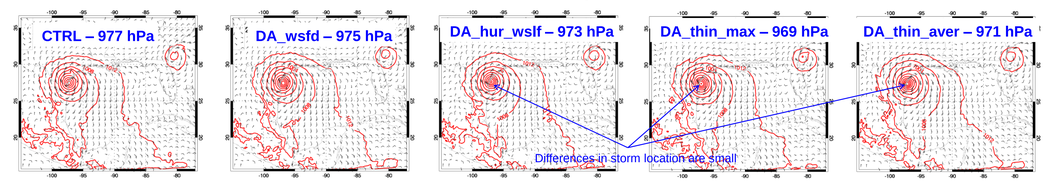
CYGNSS V2 beta L2 wind speed at 10 – 14 UTC 2017-08-27



10-m wind from different experiments after the 3rd DA cycle at 12 UTC 2017-08-27

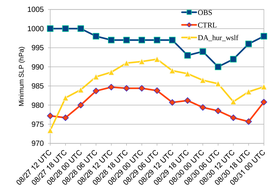


SLP and 10-m wind vector from different experiments at 12 UTC 2017-08-27

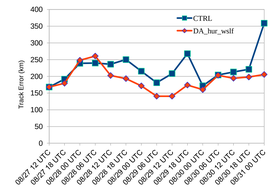


Impact of CYGNSS data assimilation on Intensity and track forecast

Intensity MSLP



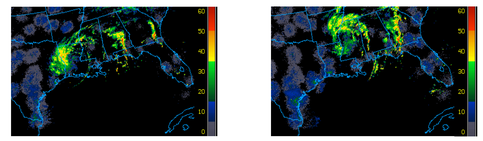
Track Error



Impact of CYGNSS data assimilation on precipitation forecast

00 UTC 2017-08-31 **18 UTC 2017-08-31**

NEXRAD reflectivity



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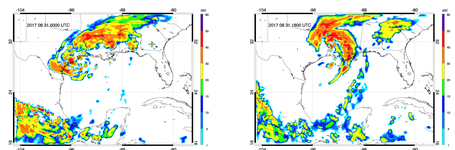
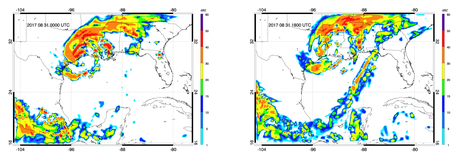


DA_hur_wslf



Threat Scores (threshold = 2 mm/hr) against IMERG rain rate

Time	CTRL	DA_hur_wslf
00 UTC 8/31/2018	0.16	0.18
06 UTC 8/31/2018	0.10	0.11
12 UTC 8/31/2018	0.10	0.12
18 UTC 8/31/2018	0.12	0.18

5. Discussion and Further Works

- It seems promising to improve the forecast of Hurricane Harvey with assimilation of CYGNSS V2 beta L2 wind speed.
- Different thinning procedure produce moderate impact on data assimilation effect.
- A better CYGNSS data coverage (both temporal and spatial) is needed to further improve forecast. Assimilation of combined datasets, such as IMERG rain, other scatterometer wind, conventional data might be important for further forecast improvement.

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