Impact of CYGNSS Data Assimilation on Tropical Cyclone Forecasts in August 2017









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Research goals

1. Conduct preliminary attempt to assimilate CYGNSS data in global data assimilation and forecasting system

2. Assess the output of a month-long Observing System Experiment

- Assimilation statistics
- Impact on tropical cyclone track and maximum wind speed forecasts

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Why use CYGNSS to observe tropical cyclones?

<u>Cy</u>clone <u>G</u>lobal <u>N</u>avigation <u>Satellite</u> <u>System</u>

- Derives surface wind speed over oceans using reflected GPS signals signal penetrates clouds and precipitation
- Offers access to poorly observed near-TC environment



Hurricane Michael – Mexico Beach, FL Courtesy: NY Times



Hurricane Harvey – Port Arthur, TX Courtesy: US Air National Guard

CYGNSS Impact Experiment

- Month-long global experiment 1-31 August 2017
 - 1-14 August spin-up; 15-31 August for impact study
 - week-long forecast at 00Z during impact study
 - Analysis cycling 4x per day
- GDAS/GFS experimental system (version FY17q3)
 - Global Data Assimilation System (T254)
 - Hybrid 4DEnVar Gridpoint Statistical Interpolation (GSI) 6 hr assimilation window
 - Global Forecast System (T670)
- Two tests: CTL and CYG
- Best track databases: HURDAT-2 (Atl/E. Pac.) and JTWC (W. Pac.)
- 9 tropical cyclones (Gert, Harvey, Irma, Kenneth, Lidia, Banyan, Hato, Pakhar, Sanyu)
 - 38 TC forecast initializations

How to prepare CYGNSS data for assimilation?

Data Thinning

- A LOT of CYGNSS data in close proximity and want to avoid overfitting to one observation type, thus data thinning
- Ideal to thin through GSI, but initial test acted unexpectedly
- Preprocess the data: 100km specular point thinning

GSI Data Type Processing

- No data processing subroutine specifically for CYGNSS
- Use subroutine for a type of ship wind speed data assimilated at 20-m (type 283 "spd")

Observation Errors

• CYGNSS gross error parameters modelled after those of ASCAT (allows o-b of 7-10 m s⁻¹)

Young Seas Limited Fetch near TC Fully Developed Seas away from TC



r= larger of 111km or 3x radius of maximum surface wind

 FDS inside radius and YSLF outside radius "turned off" through qc mark = 10



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CYGNSS Assimilation Statistics

CYGNSS Assimilation Statistics



- CYGNSS observations 6K
 10K per cycle
- Rejection rate below 2% for all cycles

- Bias greatly reduced during assim
- Perhaps too much overfitting?

 RMS reduced from 1.8-2.0 m s⁻¹ to 1.2-1.5m s⁻¹ during assim

CYGNSS Impact on Tropical Cyclone Forecasts

Global
Harvey

Global Impacts on Tropical Cyclones (15-31 August 2017)





- Minimal impact on averaged wind speed errors at all lead times (+/- 1 kt)
- Small improvements at 48-72 hr, only significant at 66 hr (NOTE: 29 forecasts)
- Small degradations otherwise, only significant at 30 hr (NOTE: 35 forecasts)

Global Impacts on Tropical Cyclones (15-31 August 2017)



- Minimal impact on averaged track errors first 108 hr
- Improved track errors after 108 hr
- Significant improvement only at 168 hr (NOTE: only 8 forecasts)



- Minimal impact on averaged wind speed errors at all lead times (+/- 1 kt)
- Small improvements at 48-72 hr, only significant at 66 hr (NOTE: 29 forecasts)
- Small degradations otherwise, only significant at 30 hr (NOTE: 35 forecasts)

Hurricane Harvey (track & duration)



Hurricane Harvey (track & wind errors)



Hurricane Harvey Track Maps



<u>24 AUG</u>

- CYG forecast on 24 AUG slightly closer to Best Tracks on approach to SE Texas
- Both show stall and loop in track

<u>25 AUG</u>

- Both forecasts much better approaching coastline
- Both loop to the southwest
- Major improvement in CYG track after storm reemerges into Gulf of Mexico

25 August 2017 00z



Hurricane Harvey Forecasts



Hurricane Harvey Forecasts



Conclusions and Next Steps

- Successful month-long experiment assimilating CYGNSS data into global modeling system
 - Rejection rate low (<2% for all cycles)
 - Bias (O-A) reduces to very small number at analysis
- Overall globally-averaged impact on TCs neutral
- Hurricane Harvey track notably improved, intensity neutral impact

Next Steps

- Need new subroutine to handle CYGNSS data in GSI (assimilating at 20-m not ideal)
- User-provided error parameters may need updating

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Thank You!

Questions?

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