Using CYGNSS to Observe Convectively Driven Near-Surface Winds in Tropical Precipitation Systems during Madden-Julian Oscillation Events

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1. Introduction

The Cyclone Global Navigation Satellite System (CYGNSS) is a multi-satellite constellation that launched 15 December 2016. The primary objective of CYGNSS is to use bistatic Global Positioning System (GPS) reflectometry to accurately measure near-surface wind speeds within the heavily raining inner core of tropical cyclones.

CYGNSS also features rapid revisit times over a given region in the tropics - ranging from several minutes to a few hours, depending on the constellation geometry at that time. Despite the focus on tropical cyclones, the ability of CYGNSS to provide rapid updates of winds, unbiased by the presence of precipitation, has many other potential applications related to general tropical convection.

2. Data and Methodology

WRF Simulations

MJO onset periods during October, November, December 2011

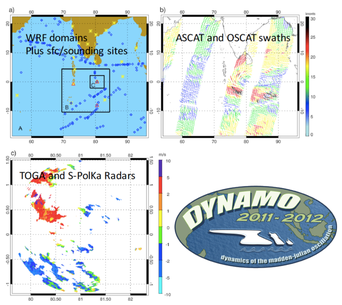
Triple-nested domain (9-3-1 km)

Assimilate DYNAMO observations
- Soundings and surface stations
- Scatterometer overpasses
- DYNAMO radars

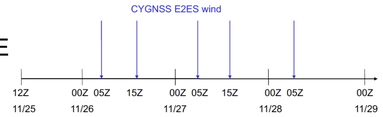
Mixture of experiments – including single outer domain, cycled assimilation, etc.

Apply CYGNSS E2ES to resulting fields

Explore how CYGNSS represents tropical convection during MJO



Cycled Data Assimilation
2011-11-25 – 2011-11-29



CYGNSS OSSE
- Single-nest
- MJO tropical storm

3 Experiments:
Nature run: WRF model simulation (9-km resolution) starts at 00 UTC 25 Nov 2011, initialized by ERA Interim analysis
CYGNSS E2ES wind: Generated from E2ES with WRF nature run files
CTRL: WRF model starts at 12 UTC 25 Nov 2011, initialized by GFS analysis
DA: Cycled assimilation of E2ES wind using CTRL as first guess

GEOS-5 Nature Run
- 7-km resolution, 30-minute updates
- Simulates tropical convection but not MJO
- Apply CYGNSS End-To-End Simulator (E2ES)

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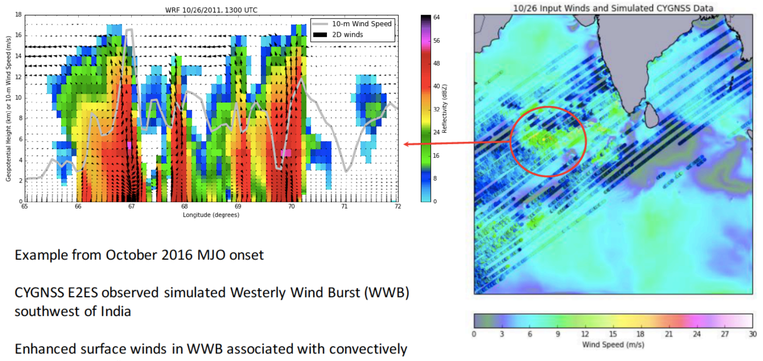
3. Simulated CYGNSS Views of Convection

October 2011

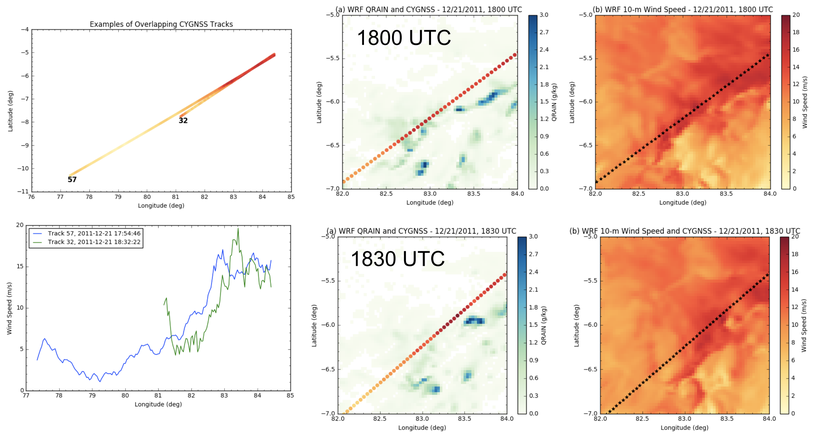


Example from October 2016 MJO onset

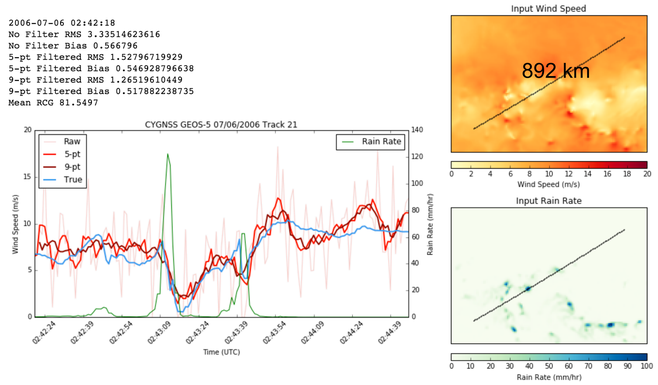
CYGNSS E2ES observed simulated Westerly Wind Burst (WWB) southwest of India

Enhanced surface winds in WWB associated with convectively driven downdrafts

December 2011



GEOS-5 Nature Run



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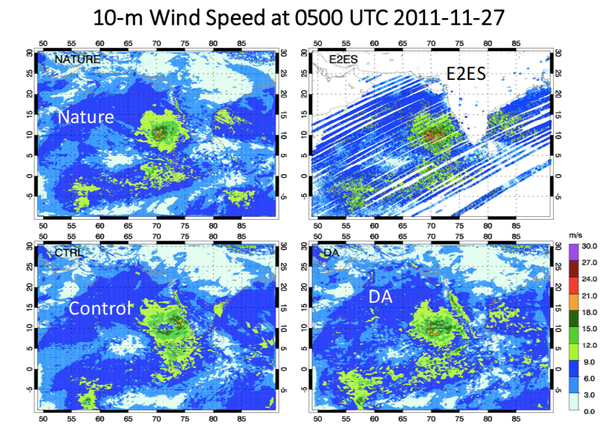
CYGNSS should detect mesoscale wind features such as Westerly Wind Bursts and gust fronts, even in the presence of heavy precipitation. CYGNSS likely will provide benefits to future tropical oceanic field campaigns that should be considered during their planning processes.

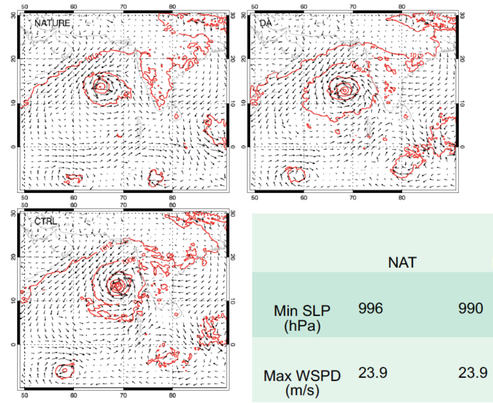
4. CYGNSS OSSE of MJO Convection

November 2011



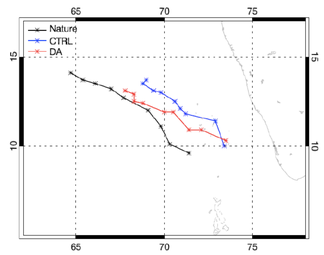
Variable and Forecast	CTRL-NAT RMSE	DA-NAT RMSE
10-m Wind Speed (m/s) @ 11/26, 05 UTC (0-h)	4.9	2.4
10-m Wind Speed (m/s) @ 11/28, 05 UTC (0-h)	4.6	2.0
10-m Wind Speed (m/s) @ 11/28, 15 UTC (10-h)	2.4	2.3
6-h Rainfall (mm) @ 11/28, 18 UTC (13-h)	10.8	9.5

Forecast: SLP and wind vector at 18 UTC 2011-11-28

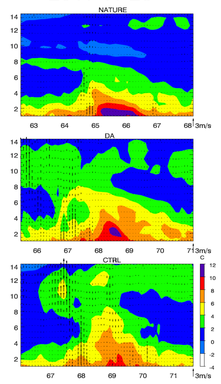


	NAT	DA	CTRL
Min SLP (hPa)	996	990	985
Max WSPD (m/s)	23.9	23.9	32.8

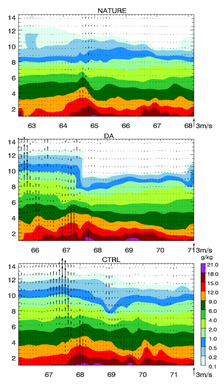
Storm Track
00 UTC 2011-11-27 to 00 UTC 2011-11-29



Forecast: Temperature Anomaly at 18 UTC 2011-11-28



Forecast: Water Vapor Mixing Ratio at 18 UTC 2011-11-28



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This was a tropical storm during an MJO onset that did not develop further. CYGNSS Data Assimilation helped the model to resist the tendency of the Control Run to further strengthen the storm. In addition, storm track position was significantly improved over the Control.