1. Introduction

One of the most distinctive signals of the Madden-Julian Oscillation (MJO) is the upscale development and organization of convection in the Indian Ocean. Dynamics of the MJO (DYNAMO) campaign occurred in late 2011 – early 2012 to investigate this genesis stage. One of the best non-satellite wind datasets ever obtained over the ocean.

The Cyclone Global Navigation Satellite System (CYGNSS) mission can exploit this dataset to better understand the performance of the satellite constellation in regions of deep convection, in particular for characterizing the MJO.

Three Scientific Objectives

1. Produce a high-resolution surface wind dataset for multiple MJO onsets using WRF-assimilated winds and other data from DYNAMO.
2. Use the DYNAMO datasets, along with available scatterometer observations, to study the causes and impacts of wind variability at spatial and temporal scales finer than those planned to be provided by CYGNSS, and the implications of these processes for CYGNSS observations.
3. Using a simulated CYGNSS dataset for the MJO, perform observing system simulation experiments to determine the benefits of CYGNSS for improving scientific understanding and forecasting of the MJO, particularly its genesis over the Indian Ocean.

2. WRF Model Simulations

WRF Model Simulation and Assimilation of DYNAMO Data

- Advanced Research WRF v3.5.1
- A: 3-km resolution DYNAMO domain
- B: 1-km high-resolution smaller domain
- 40 sigma levels (more levels in lower troposphere)
- Separate runs for domains A and B
- Mesoscale features for MJO events

WRF model domain setup

WRF 3DVAR

Solve for Cost Function:

\[ J = \frac{1}{2} (x - x_c)^T B (x - x_c) + \frac{1}{2} (H x - T)^T R (H x - T) \]

Background Error Matrix: NMC Method

Assimilation Plan:
- Cycled assimilation of available soundings, dropsondes, surface, buoy, radar, lidar, scatterometer data into both domains using WRF 3DVAR
- Progress:
  - Conducting WRF runs for B matrix generation
  - Processing the observational data and prepare for assimilation

WRF Simulation on 3-km grid (2011-11-24)

Focusing on roughly last two weeks of each DYNAMO month:
1. November 2011
2. October 2011
3. December 2011

Will produce high-res wind maps for each of these periods, at least 3 km resolution, 0.5-1 h time steps

Use these maps to study wind variability at time and spatial scales smaller than CYGNSS can provide

3. DYNAMO Datasets for Assimilation

DYNAMO Radars
- NASA TOGA (Revelle)
- Mirai C-band
- SMART-R (Gan)
- NCAR S-PolKa (Gan)

Assimilate radial velocity into WRF, will also test reflectivity
Most QC done, working with CSU and Texas A&M to de-alias the TOGA and SMART-R velocities, and also fix some azimuthal errors with TOGA

ASCAT
- 11/24/11 0338 UTC
- 11/19/11 1802 UTC

Scatterometer Vector Winds during DYNAMO
Assimilate when available, but also produce test dataset without these inputs but with rest of DYNAMO observations

Other DYNAMO datasets
- Radiosondes
- Dropsondes (P-3)
- Surface/buoy/ship-based meteorological observations

Straightforward assimilation process for WRF 3DVAR

4. Next Steps

De-alias SMART-R/TOGA velocities and correct occasional TOGA azimuthal errors, Prep other DYNAMO data for assimilation

Update WRF 3DVAR framework as needed to handle DYNAMO dataset, Test various assimilation schemes, determine which will be most useful, and execute

NOAA to begin HRDL/scatterometer comparison

Long-term goal:
- Observing System Simulation Experiments (OSSEs) to discover how best to assimilate CYGNSS data into a limited-domain forecast model

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Contact Info: Timothy Lang, NASA MSFC (2P11), huntsville, AL 35812, (256) 981-7861, timothy.lang@nasa.gov

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- Our goal is to produce the best possible surface wind dataset for the core DYNAMO region, during MJO onset periods in late 2011
- These wind maps will be ingested into the CYGNSS observational operator to produce simulated CYGNSS observations for DYNAMO
- This will provide an excellent core dataset for understanding how CYGNSS can improve our understanding of convective inflow/outflow structures, wind/precipitation feedbacks, and the initiation and development of the MJO