Improving the Simulation of Intraseasonal Variability in GFDL AM3

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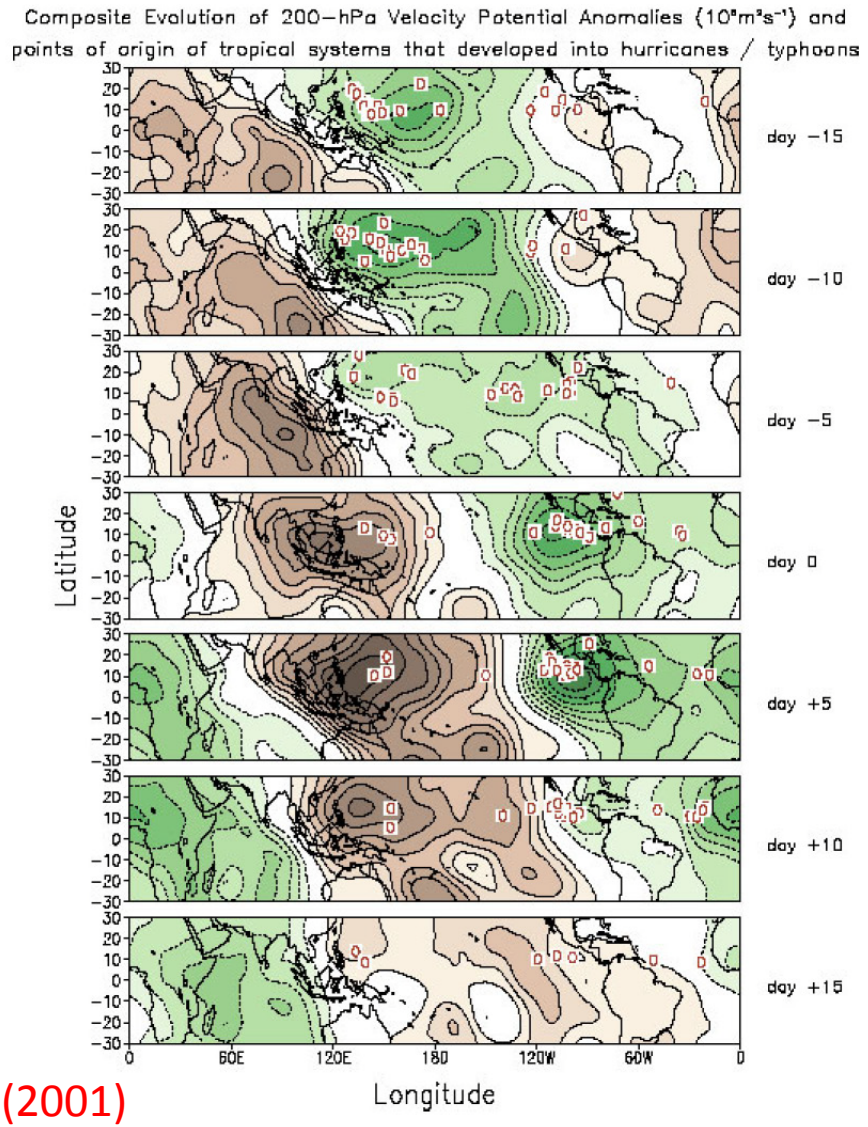
The Madden-Julian Oscillation

- Eastward-propagating phenomenon “initiated” in the Indian Ocean that repeats every 30-60 days.
- Affects precipitation, global winds, and many other fields.
- Modulates hurricanes, West Coast flooding, monsoons.



Higgins and Shi (2001)

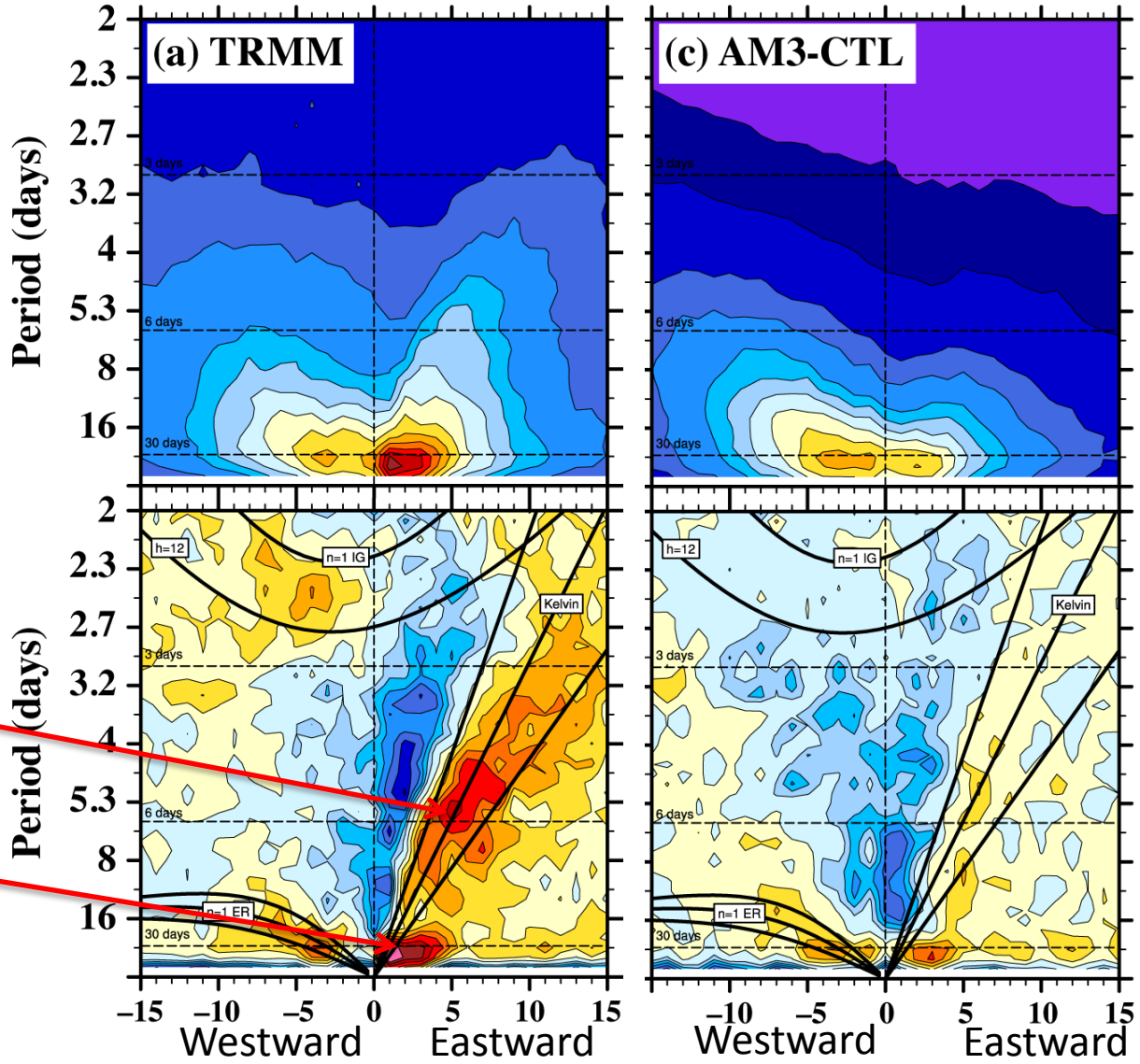
The Madden-Julian Oscillation in Climate Models

- Many climate and forecasting models produce too weak a Madden-Julian oscillation (MJO)
- This limits their ability to simulate aspects of tropical climate such as the modulation of tropical cyclone activity by the MJO, and possibly ENSO characteristics
- The GFDL Atmosphere Model 3 (AM3) is no exception
- Problems in simulating the MJO often attributed to deficiencies in how the model treats deep convection (e.g. interactions between convection and environmental moisture).

Standard AM3 Produces Poor MJO and Convectively Coupled Kelvin Waves

Based on space-time precipitation spectra of Wheeler and Kiladis (1999)

Also noted by Donner et al. (2011)



Kelvin waves

MJO

AM3 Convection Modifications

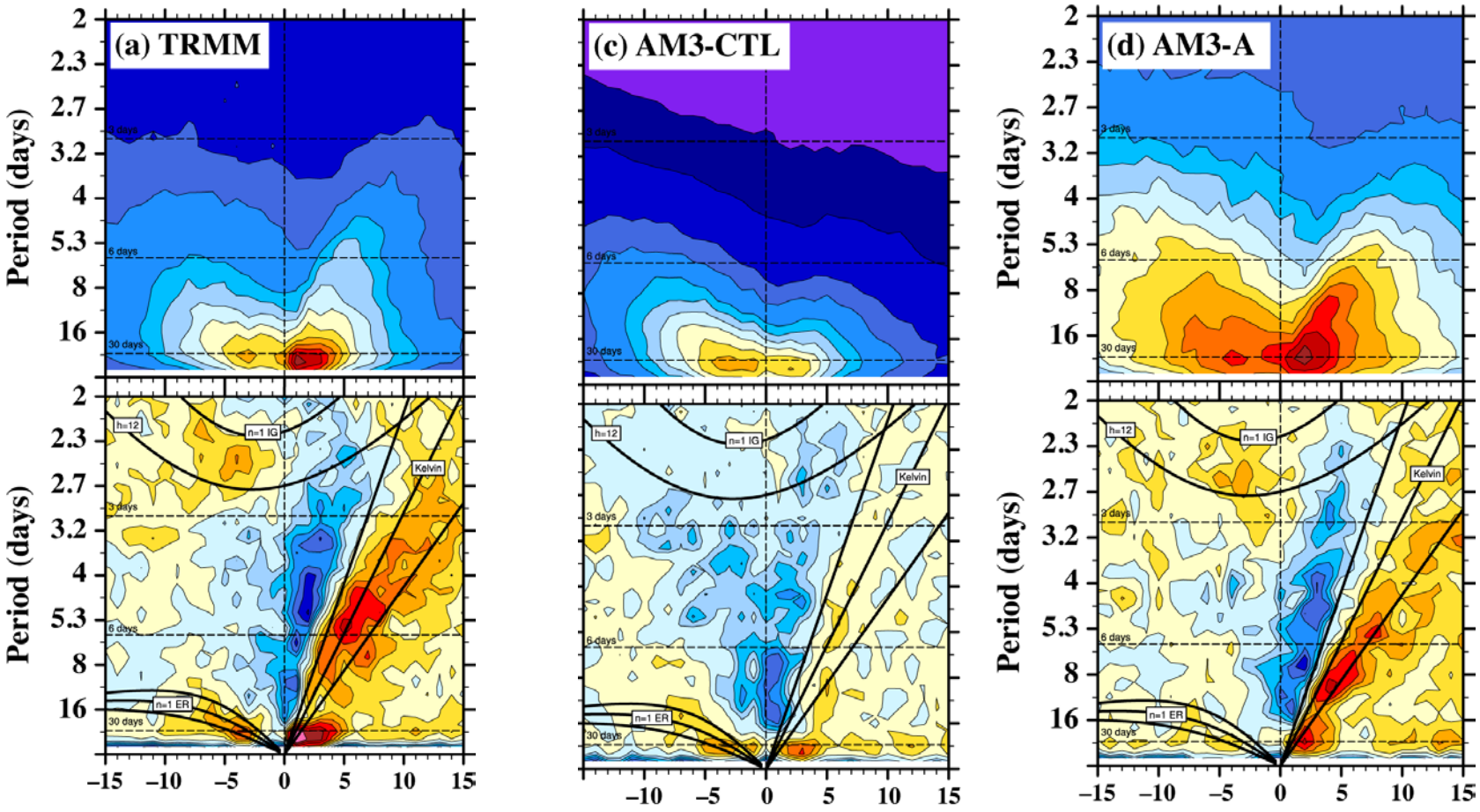
- We made a series of modifications to the Donner convection scheme that make it harder for deep convection to fire
  - CAPE closure changed (to Zhang 2002)
  - Low-level vertical velocity trigger implemented
  - Interaction with environmental moisture increased
    - Increased evaporation into environment and into downdrafts
    - Convective instability determined using dilution by entrainment
- Our modifications to the AM3 convection scheme extend those documented in Donner et al (2011).

AM3 Modifications Improve Intraseasonal Variability

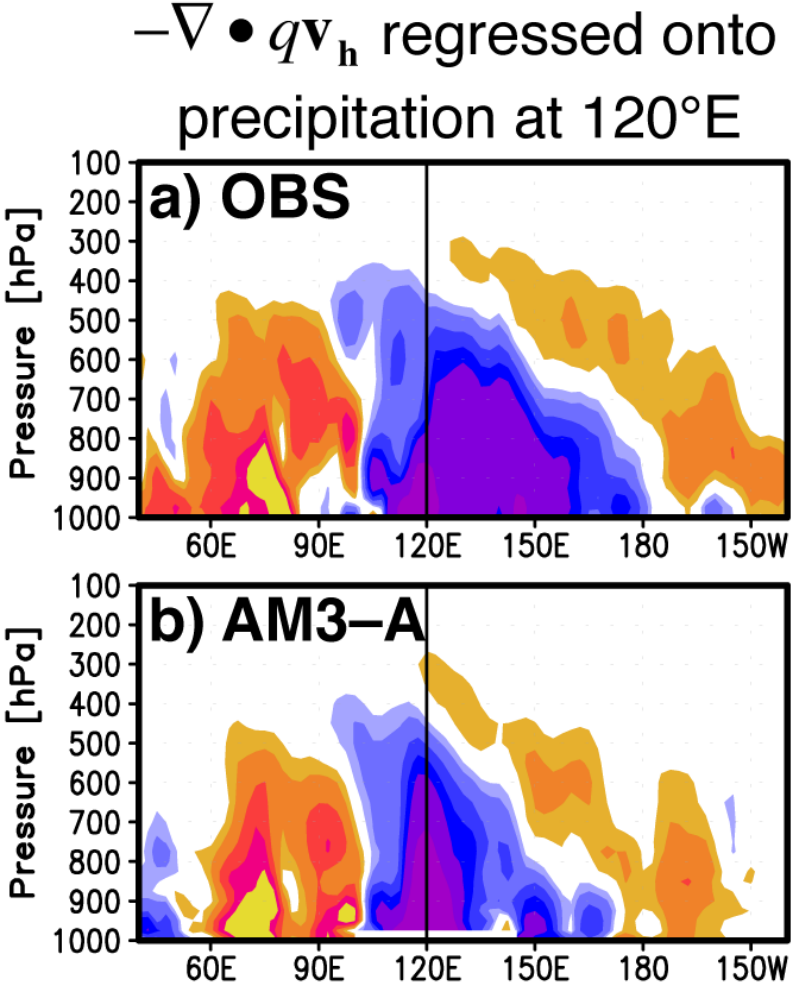
Observations

Control

Modified



Aspects of Vertical MJO Structure in Modified AM3 Look Realistic



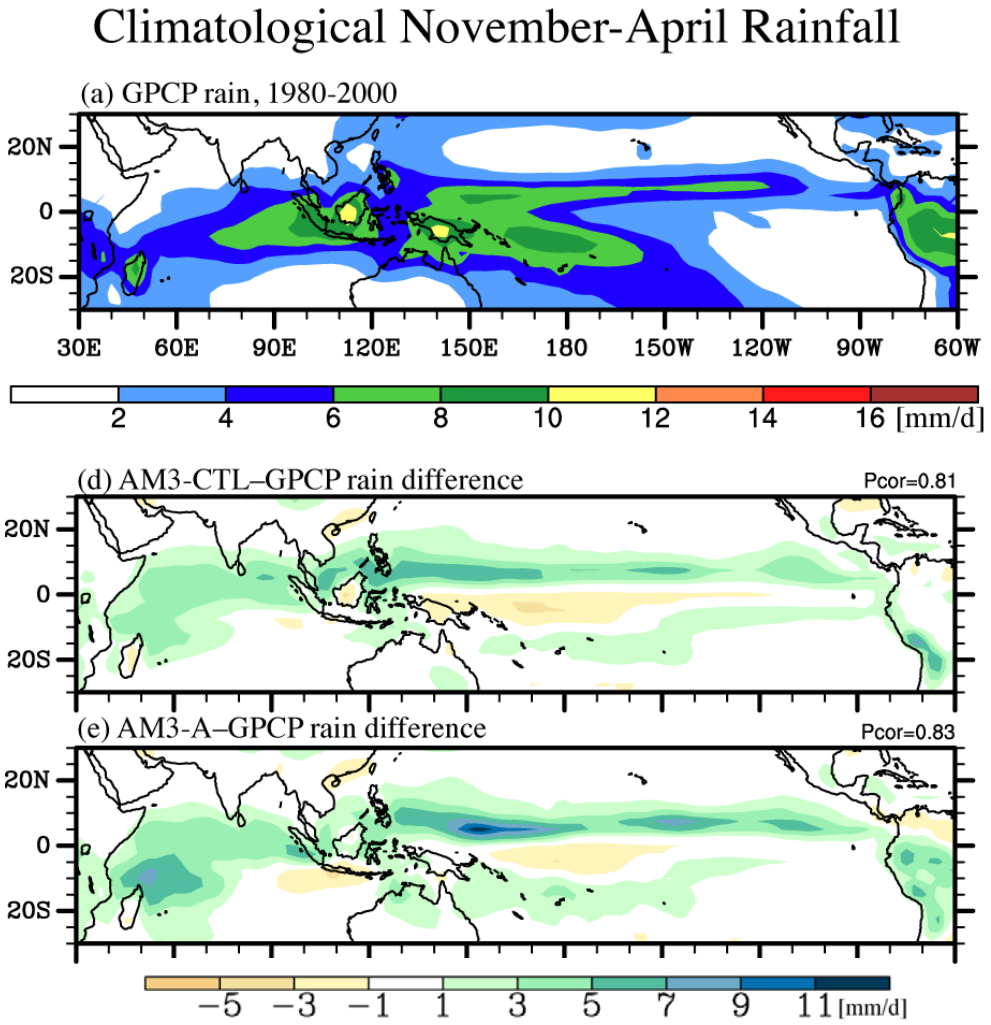
Moisture, clouds, and other quantities build upward in time (east to west in this equatorial snapshot) in the modified versions of AM3 like in observations.

We see this in DYNAMO observations as well.

Mean State Biases Do Not Look That Different, But Possibly Slightly Worsened With Convective Modifications

Control

Modified

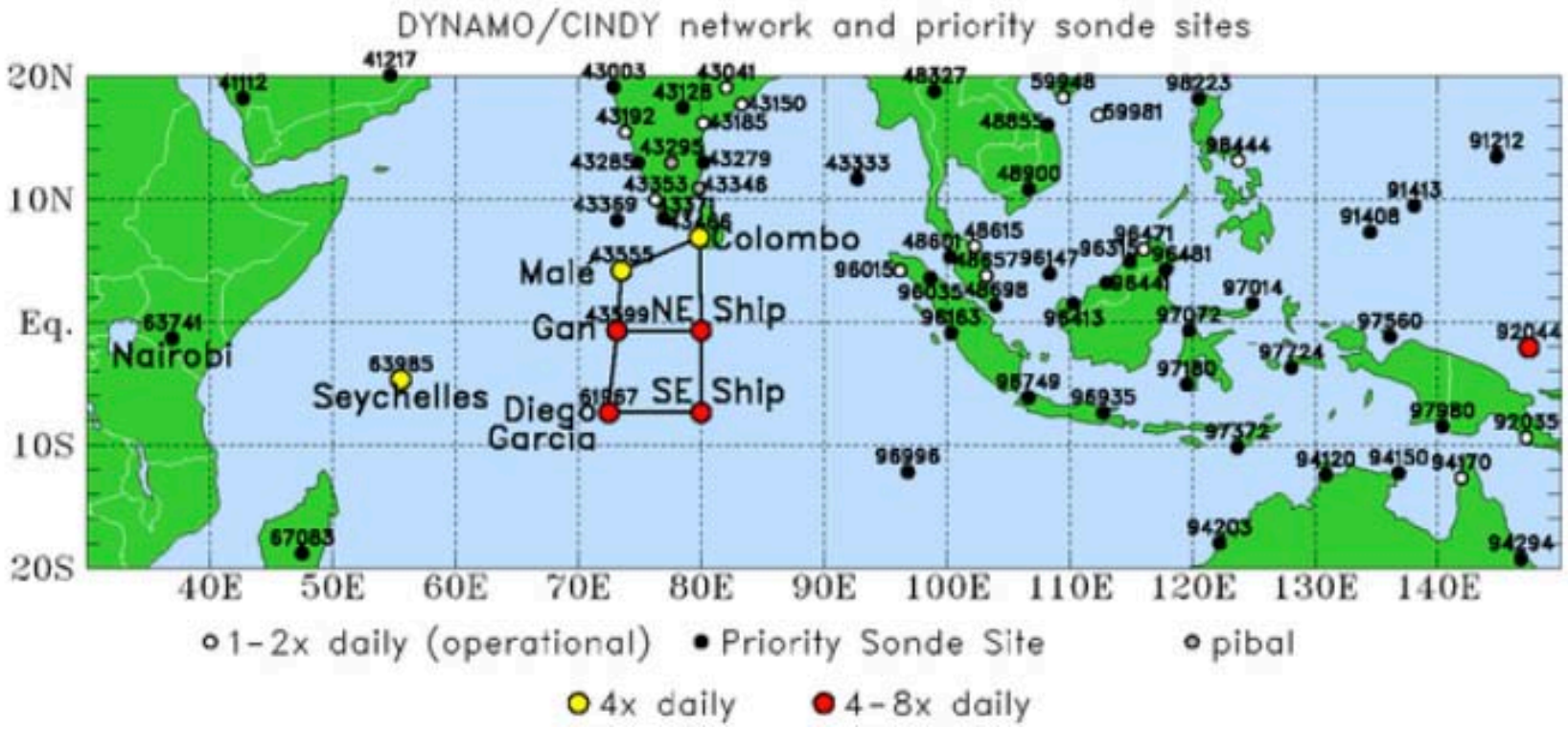


Conclusions of Part 1

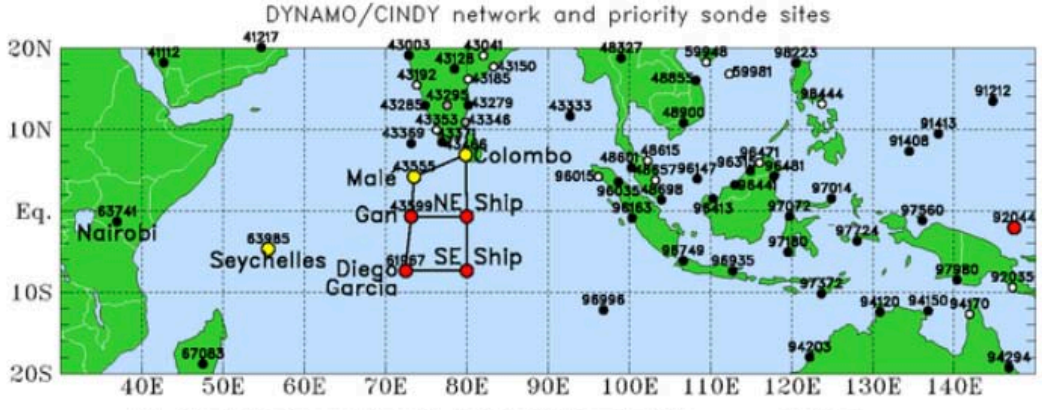
- The standard GFDL AM3 produces a very weak MJO and convectively coupled Kelvin waves.
- Modifications to the convection closure, triggering conditions, and interactions with environmental moisture improve the simulation of intraseasonal variability
- The mean state shows slight degradation with convective modifications

DYNAMO – a brief introduction and update

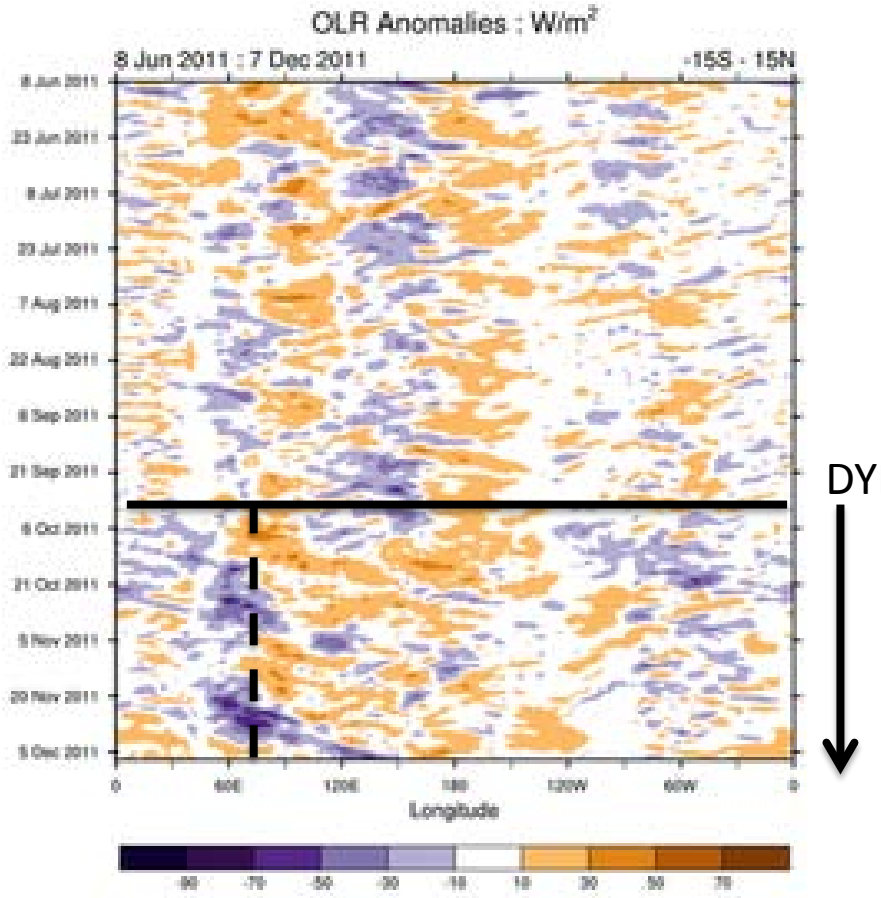
"The overarching goal of DYNAMO is to expedite our understanding of processes key to MJO initiation over the Indian Ocean and efforts to improve simulation and prediction of the MJO." (from the NSF SPO)



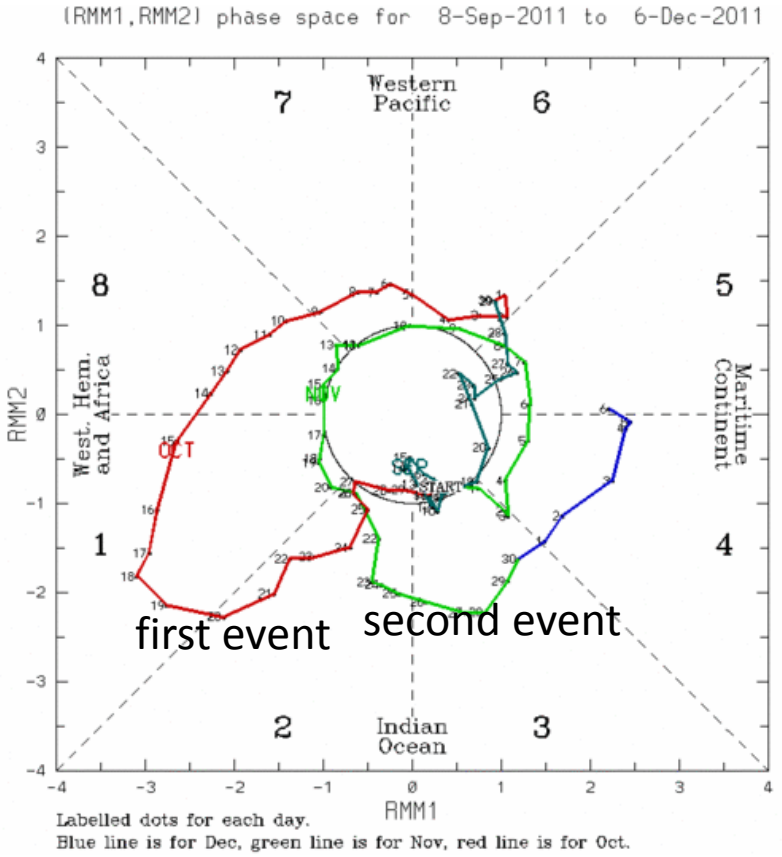
- Multiple nations (Japan, US, France, India…) & federal agencies (NOAA, NSF, DOE, ONR)
- Field observations October 2011-March 2012
- Different platforms in field different times, but most intensive phase Oct – mid-Dec
- Sounding array; Multiple radars; Ships (US Revelle, Japanese Mirai) with oceanography, fluxes, etc.; Aircraft (NOAA P3, French Falcon); DOE AMF2 packages on Gan & Manus



Nature has cooperated as perfectly as we could have hoped!
Two MJO events, 30 days apart, last weeks of Oct. & Nov.

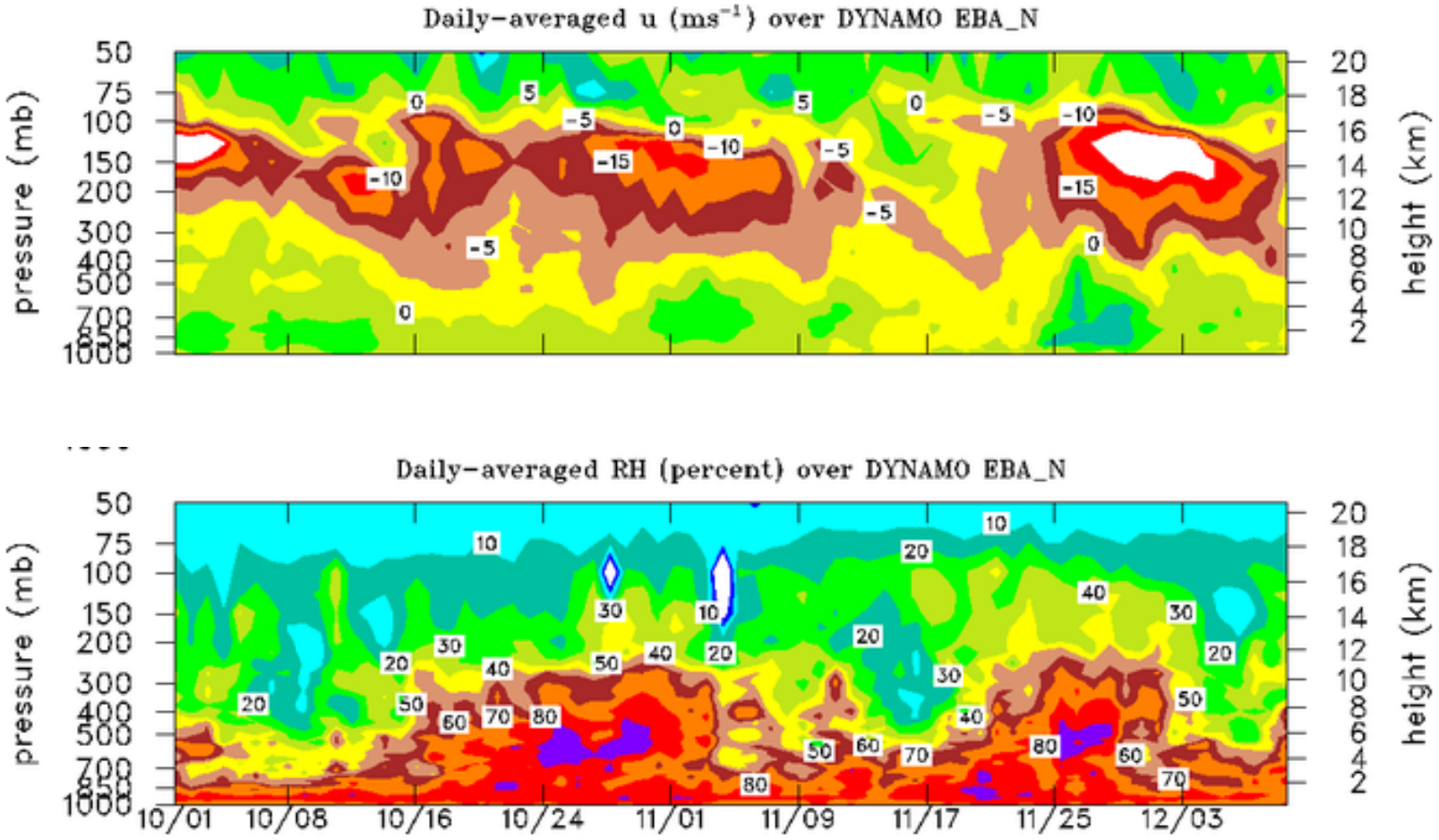


DYNAMO



http://www.bom.gov.au/climate/mjo/

Time-height sections of zonal wind and relative humidity from northern sounding array (R. Johnson, P. Ciesielski et al.)



If you want to know more…

- Field catalog, catalog1.eol.ucar.edu/dynamo includes lots and lots of data, PI reports, discussion forums…
- We have a blog, maddenjulianconversation.blogspot.com