Diagnostics of the MJO and upper ocean variability in a regional coupled model

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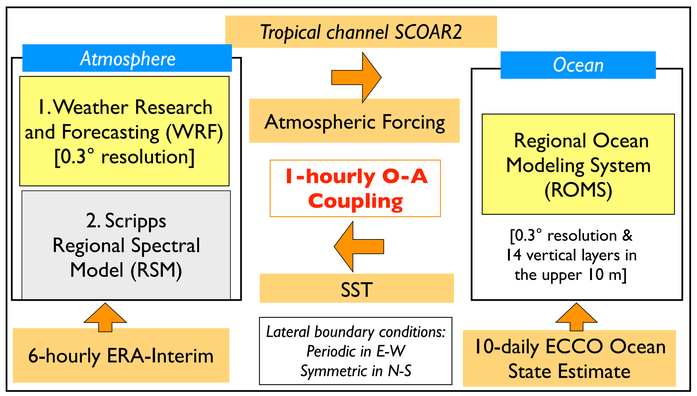
Summary

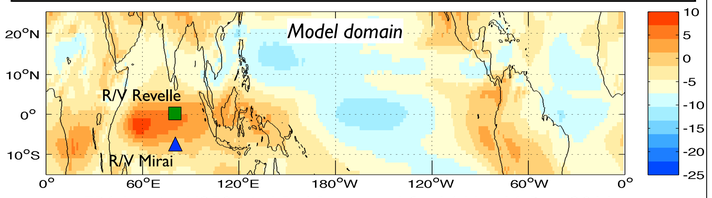
The primary goal of this study is to develop a regionally coupled ocean-atmosphere (O-A) modeling system for the improved representation of coupled boundary layer process associated with MJOs.

The Scripps Coupled Ocean-Atmosphere Regional Model Version 2 (SCOAR2) has been configured in a tropical channel mode at the identical 0.3° horizontal resolutions in the ocean and atmospheric models with the high vertical resolution in the upper ocean (e.g., <1 meter resolution in the upper 10 meters).

Using SCOAR2, this study demonstrates that
- the multi-year SCOAR2 simulation reveals reasonably realistic eastward propagating MJO signals,
- the interactive SST produces stronger intraseasonal variability compared to the fixed SSTs,
- the initial condition of the regional coupled model is relatively more important for MJO prediction than lateral boundary conditions,
- there exists a strong diurnal warm layer at Revelle and Mirai sites prior to onset of MJO2 during DYNAMO,
- the MJO rainfall events produce thin layers of low-salinity water (1psu lower than the ambient), which are confined to top several meters and last for 1-2 days. These freshwater puddles seem to affect the stratification and shear-driven mixing.

Regional coupled model: SCOAR2





ERA-Interim U850 wind [m/s] averaged for 14 Nov-16 Dec, 2011

Experiments

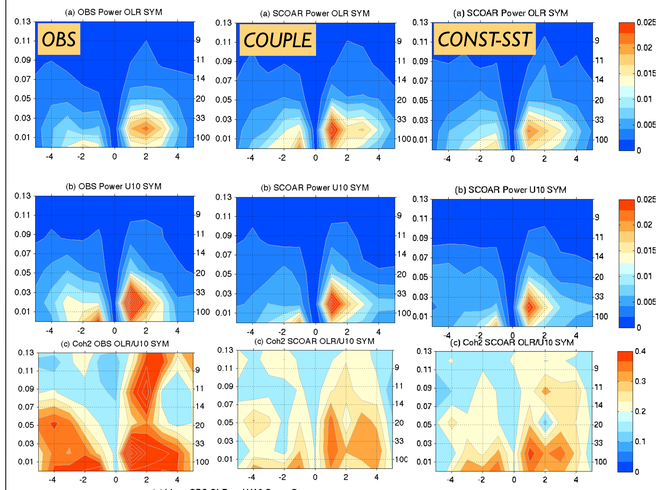
I. 5-year SCOAR simulations with and without air-sea coupling

	Couple vs uncouple	Period: 5 winters
COUPLE	Full WRF-ROMS coupling	Oct-Mar 2005-2010
CONST-SST	WRF forced with time-mean SST from COUPLE	Oct-Mar 2005-2010

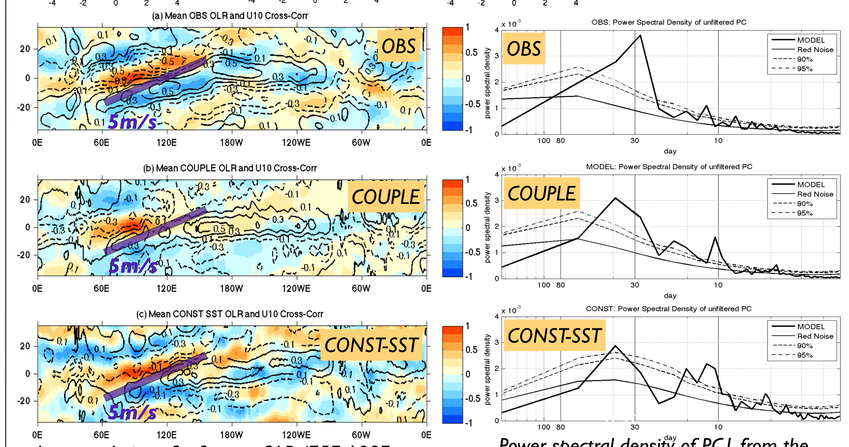
II. Predictability experiments for the 2nd MJO event during DYNAMO

	Frequency of initialization	Period: 33 days
fcst48	33-day successive 48 hr coupled run with daily initialization at 00UTC	14 Nov-16 Dec, 2011
fcst120	33-day successive 120 hr coupled run with daily initialization at 00UTC	14 Nov-16 Dec, 2011
cont	33-day continuous run with a single initialization at 00UTC14NOV, 2011	14 Nov-16 Dec, 2011

I. Diagnostics of MJOs in the multi-year simulations



(Left) October-March (2005-2009) averaged wavenumber-frequency spectral density of the symmetric component (2.5-10°N) of (a) NOAA OLR (W^2/m^4) and (b) NCEP U10 (m^2/s^2), and (c) coherence squared between OLR and U10. (Middle) The same but from COUPLE and (right) from CONST-SST.

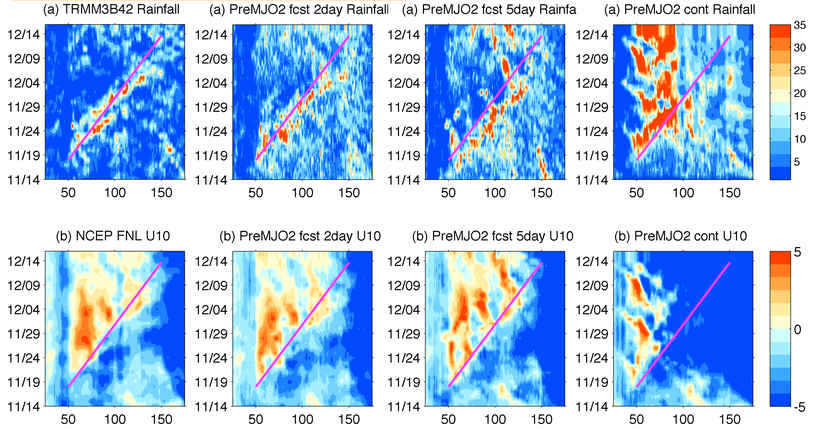


Lag correlation of reference OLR (75E-100E, 10S-10N) with rainfall (color) and OLR (contours), based on the 5-winter averages in (a) OBS, (b) COUPLE and (c) CONST-SST.

Power spectral density of PC1 from the (a) OBS, (b) COUPLE and (c) CONST-SST projected onto the respective unfiltered daily data.

We found a significant power in MJO OLR and zonal winds for both *COUPLE* and *CONST-SST*, but with a slight enhancement in *COUPLE*. Cross-correlation between zonal winds and OLR reveals an eastward propagation at roughly 5 m/s, indicating a convective coupling in the MJO. Sensitivity tests suggest that a relatively more realistic intraseasonal variability is obtained in the current configuration of SCOAR2 with the *use of the modified Zhang-McFarlane atmospheric convection scheme* including momentum transport and dilute plume approximation. Other convection schemes we tested produced eastward propagating convective signals with too short period (~15 days).

II. Predictability of MJO2 in SCOAR2



Hovmoeller diagrams of (top) rainfall (mm/day) and (bottom) U850 during the 14 Nov-15 Dec period, from left to right. OBS, fcst48, fcst120, and cont. Purple lines denote the 5m/s phase speed initiated from the rainfall event on 19 Nov.

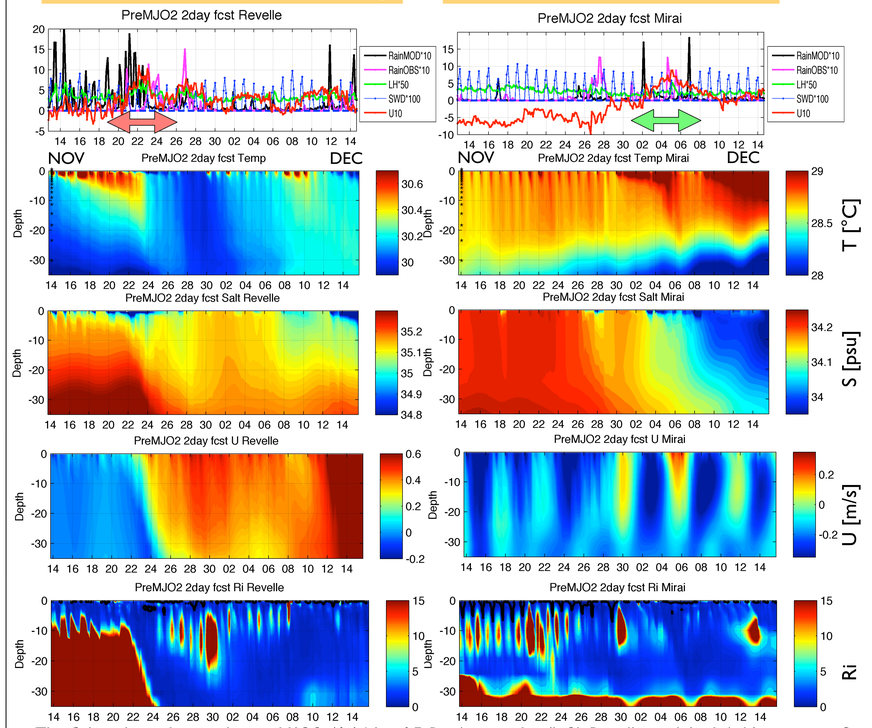
In terms of timing of convection, *fcst48* produces the most realistic evolution of rainfall associated with MJO2 during DYNAMO, indicating the relative importance of initial condition for the skill in MJO forecast than the lateral boundary condition in SCOAR2. *fast120* produces an incorrect (earlier) rainfall peak, while *cont* contains large mean bias.

▸ We will examine the upper ocean response during MJO2 in *fcst48*. in more detail.

III. Upper ocean diurnal variability in SCOAR2 during the MJO2 event: fcst48

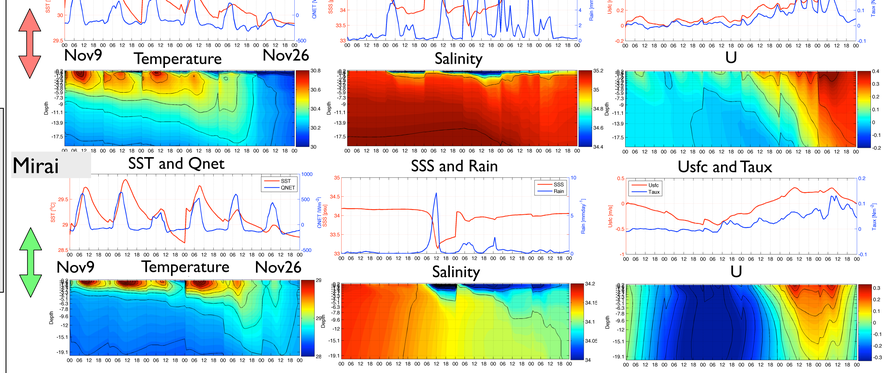
SCOAR2 at the Revelle site: 80E EQ

SCOAR2 at the Mirai site: 80E 8S



The 3-hourly evolution, during MJO2 (14 Nov-15 Dec) near the (left) Revelle and (right) Mirai sites, of the atmospheric (rainfall, LH, SW flux and U10), and the upper 35-meter oceanic (T, S, U, Ri) fields.

1-hourly evolution during 19-26 Nov near (top) Revelle and (bottom) Mirai sites



Near the Revelle site, the easterly wind, weaker evaporation and higher shortwave flux prior to onset of the 2nd MJO are favorable for the formation of warm ocean surface layer (0-20 m). Diurnal warm layers develop, with the thickness of O(1-5m). Diurnal variability in salinity is noticeable, but more striking is the occurrence of thin freshwater lenses with the thickness up to 5-10 m during the rainfall events. These freshwater puddles are short lived, lasting only 1-2 days, yet seem to strongly reduce the shear-driven mixing. During and after the convection, the diurnal warm layer is eroded by westerly wind. The Wyrtki jet is accelerated in response to westerly wind, reducing Ri below 0.25. Freshwater puddles episodically occur after MJO2. While salinity is reduced during the rainfall events, high salinity is maintained in the upper ocean due to eastward current advecting high salinity water from the west.

Near the Mirai site, the diurnal warm layer is much deeper, reaching >20 m during the easterly wind. Freshwater puddles are also produced during the rainfall events, lasting a day or two, confined to the surface layer. High upper ocean (~5m) temperature precedes the rainfall events, which is then accompanied with the dramatic reduction in salinity. Zonal currents show oscillatory behaviors with a period of 6-7 days, which increase the velocity shear. Overall the raining periods correspond to the reduced shear-driven mixing due to enhanced stratification by surface warming and freshwater puddles.

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