The Role of Oceanic Processes in the Initiation of Northern Winter Intraseasonal Oscillations over the Indian Ocean

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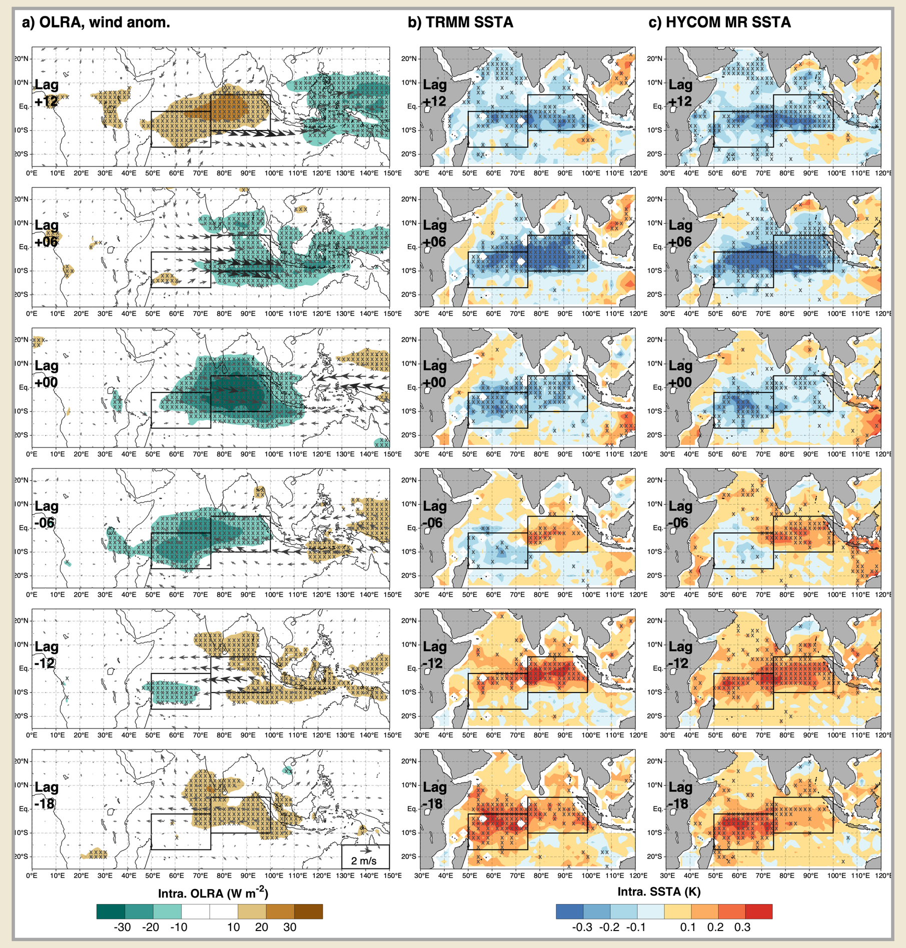
Seychelles-Chagos Thermocline Ridge (SCTR) events (n=17/39)

Column 1: observed OLRA and wind:
the 17 TR events showed clear initiation (-OLRA) in the SCTR region, followed by eastward propagation to the Maritime Continent.

Column 2: observed SSTA:
mean TRMM SSTAs in the TR exceeded +0.3K in some areas, which is well above the required SSTA to support convection at high mean SSTs.

Column 3: modeled SSTA:
the HYCOM Main Run matched TRMM observations quite closely, giving us confidence in the fitness of HYCOM to represent intraseasonal SSTAs.



MJO event status:
'P' = primary
'S' = successive
bold = passed strict criteria
red = strongly influenced by oceanic processes

y	m	d	OMI	RMM
2001	11	17	P	-
2002	1	22	**(P)**	**S**
2002	11	13	**P**	**S**
2004	1	27	**S**	**S**
2004	4	30	**(P)**	**S**
2005	3	28	**P**	**S**
2006	4	24	P	-
2006	12	25	**P**	**S**
2007	12	13	**S**	-
2008	4	18	-	-
2009	4	10	**S**	**S**
2009	11	10	**(P)**	**(P)**
2009	12	30	**P**	-
2010	11	25	P	-
2011	11	27	S	**S**
2012	1	27	**S**	**P**
2012	3	9	**S**	**S**

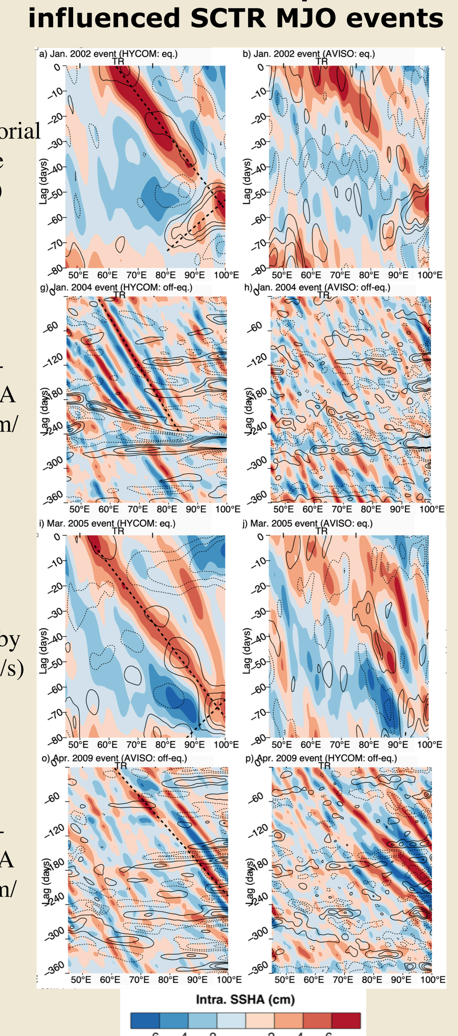
SSHA time-longitude plots for the 4 oceanic process-influenced SCTR MJO events

Jan. 2002: equatorial Rossby wave (c=0.85 m/s)

Jan. 2004: off-equatorial SSHA signal (c=0.15 m/s)

Mar. 2005: equatorial Rossby wave (c=0.85 m/s)

Apr. 2009: off-equatorial SSHA signal (c=0.22 m/s)

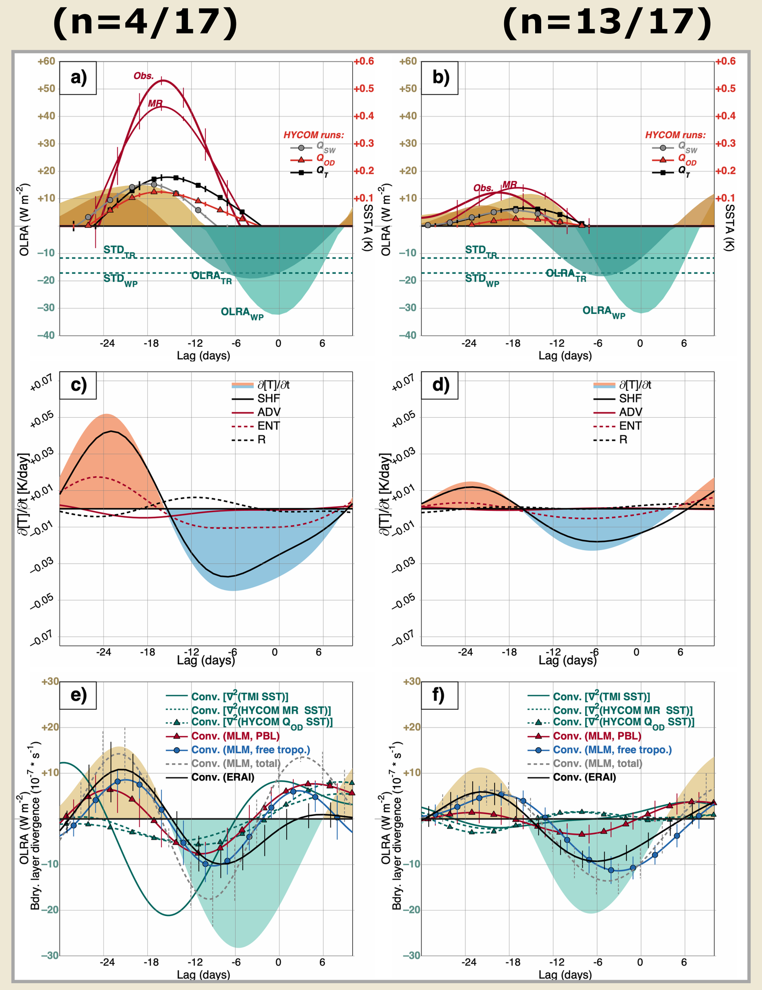


Strongly influenced by oceanic processes (n=4/17) | **Weakly influenced by oceanic processes (n=13/17)**

OLRA (Obs.) and SSTA (Obs. & HYCOM experiments):
Ocean dynamical processes accounted for ~28% of the total SSTA, in contrast to the remaining 13 events, which had small OD influence.

Off-line mixed layer heat budget (HYCOM Main Run):
Entrainment/upwelling accounted for ~20% of the warming tendency for the strong events.

Boundary layer convergence (Laplacian(SST) and Mixed Layer Model (MLM)) results:
Atmospheric convergence associated with SSTs peaked 5-10 days prior to the convection peak. (this corroborates evidence that the SSTs caused convection to initiate)



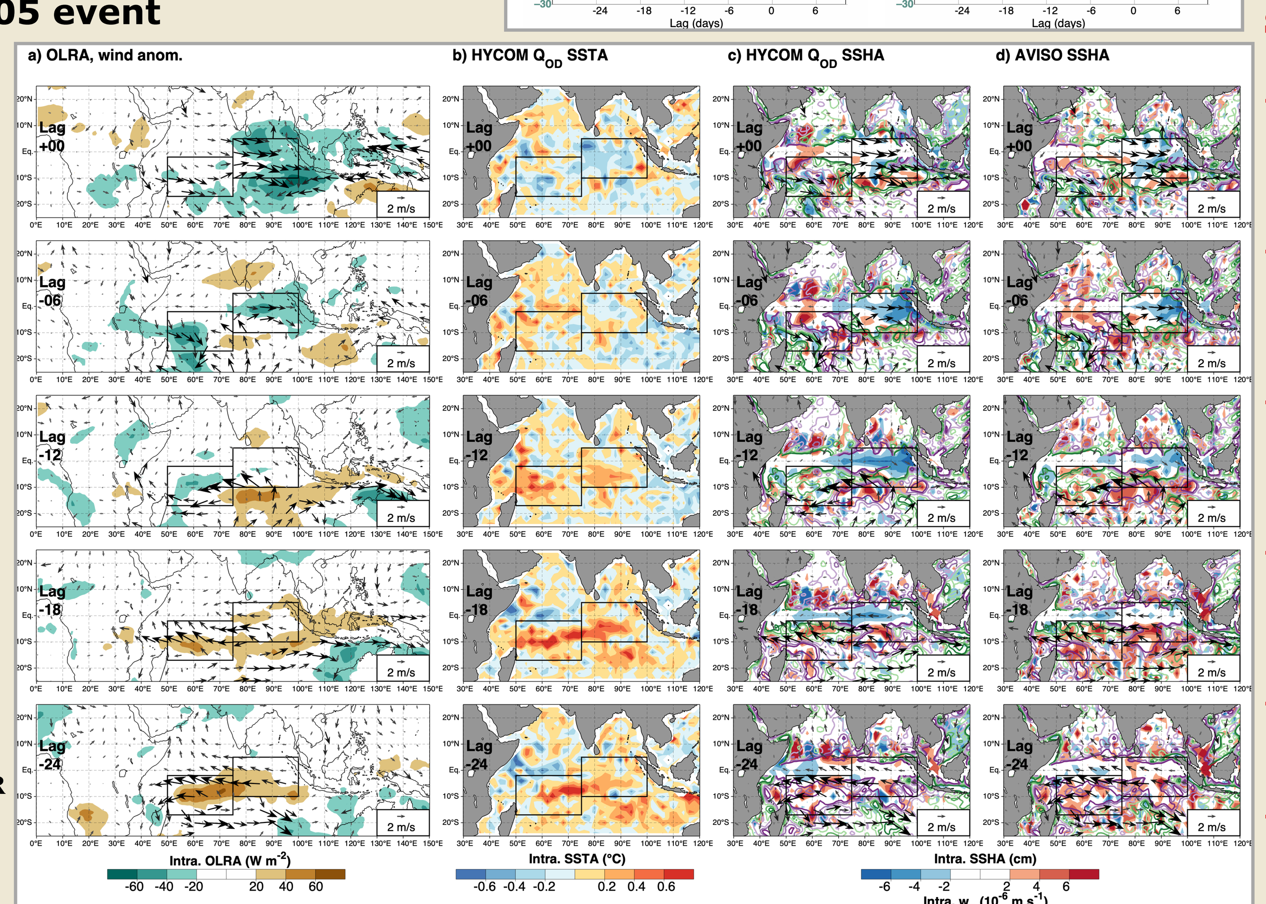
Case study: Mar. 2005 event

OLRA peak over the WP

OLRA initiation over the TR

OD SSTA peak over the TR

(4th column): ERW passage & $-w_E$ in the TR



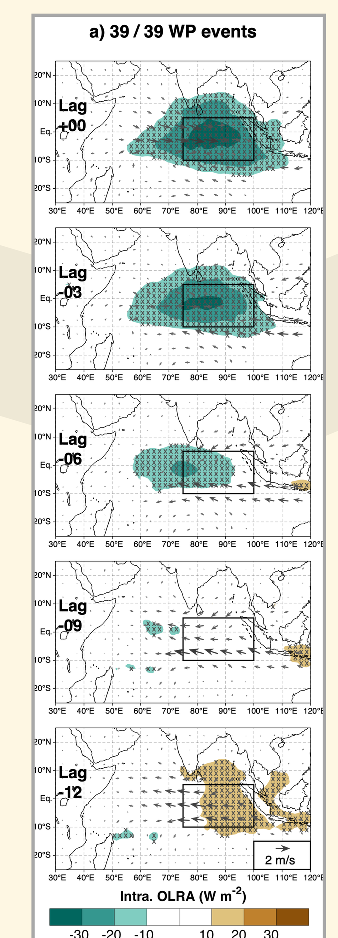
SCTR conclusions:

- 76% of SCTR ISO events from 2001-2012 were global-scale MJOs, based on the OMI and strict criteria from Kiladis et al. (2014).
- 4/17 SCTR ISO events were preceded by oceanic process-induced warming that accounted for ~28% of the total warming.
- The warming was induced by entrainment and upwelling reduction, which makes sense given the shallow climatological thermocline.
- 2/4 of those events were associated with oceanic equatorial Rossby waves passing through the SCTR.
- The other 2/4 were associated with off-equatorial westward-propagating SSHA signals.
- The upwelling/entrainment reduction resulted from both local Ekman pumping and the remote influence of the downwelling Rossby waves.

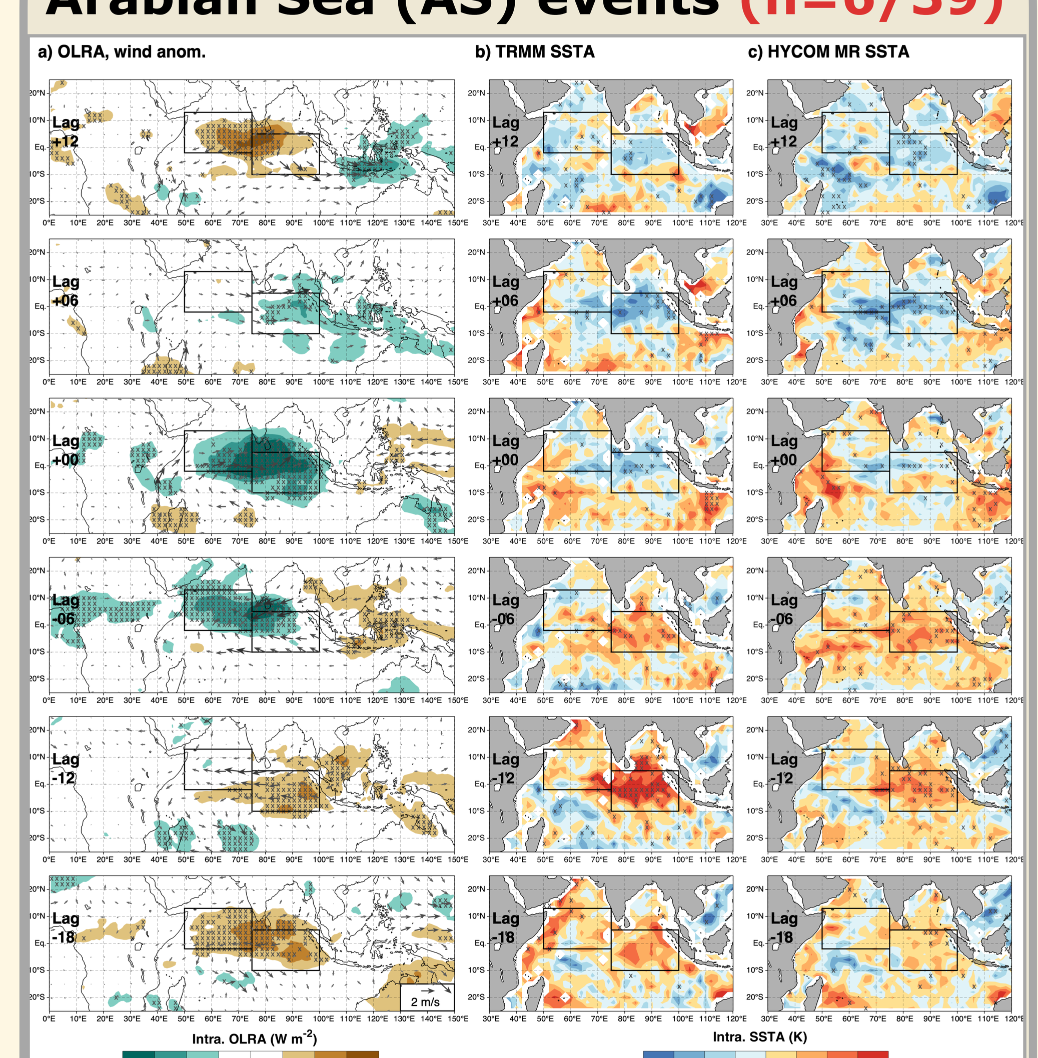
Background

The motivation for this project is to determine the role of oceanic processes (e.g., entrainment, upwelling, and advection) on the initiation of the northern winter MJO and related ISOs. To do this, we examined 39 ISO events that passed through the I.O. Warm Pool (WP) during the Nov.—Apr. season from 2001—2012 (see composite directly below).

We separated the 39 WP events based on their initiation location (see 3 boxes to the left, right, and below), then examined **satellite and in situ observations and reanalyses** and a set of **HYCOM OGCM experiments** to quantify how much pre-convection SSTAs were affected by:
wind stress (**oceanic processes**),
radiative heat flux, and
turbulent heat flux.



Arabian Sea (AS) events (n=6/39)

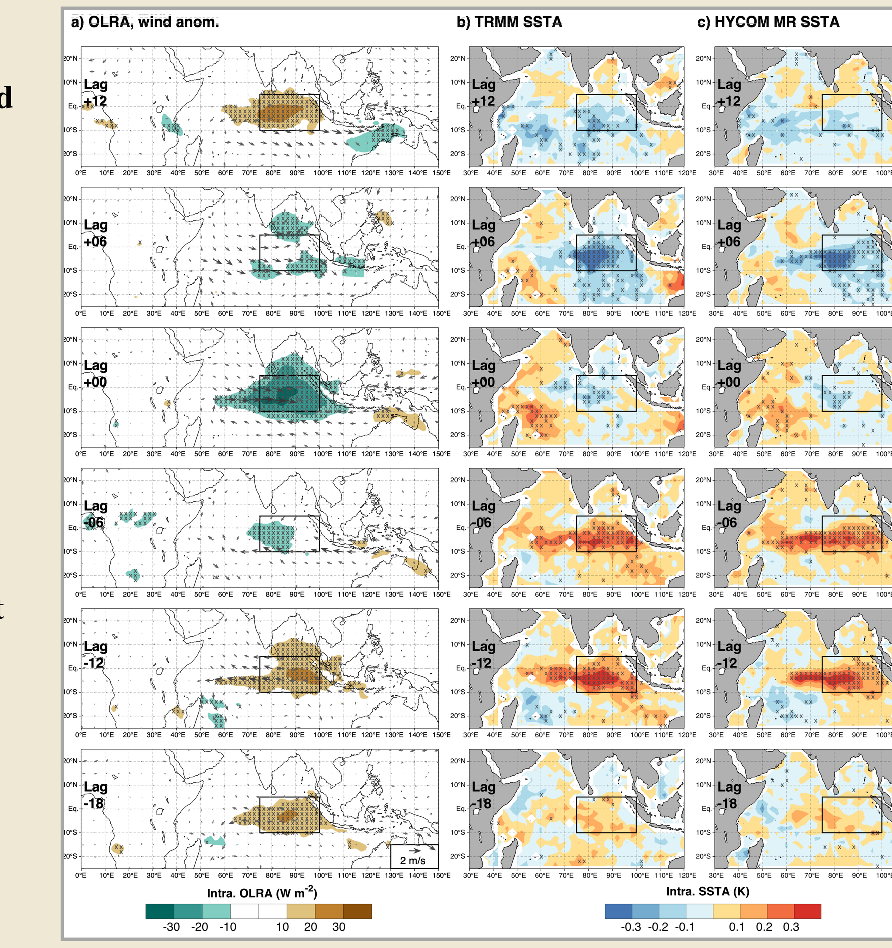


Arabian Sea conclusions: there were no statistically significant +SSTAs associated with these ISO events.

Indian Ocean Warm Pool (WP) events (n=16/39)

Column 1: observed OLRA and wind:
the 16 WP events showed clear initiation (-OLRA) in the WP region, followed by eastward propagation to the Maritime Continent.

Columns 2 & 3: observed and modeled SSTA:
there is a large region of statistically significant +SSTA prior to convection in the WP. Next, we will examine the subset of WP events that were strongly influenced by oceanic processes.



MJO event status:
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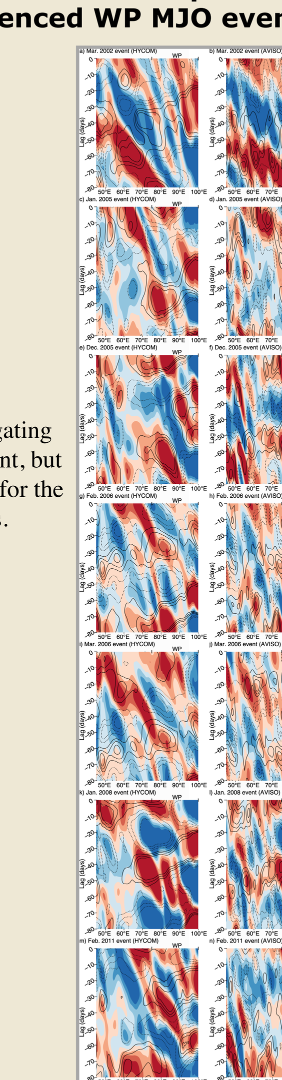
y	m	d	OMI	RMM
2002	3	21	-	**P**
2003	1	30	-	-
2003	2	27	**P**	P
2003	12	8	**P**	**P**
2005	1	3	-	**(P)**
2005	2	19	P	-
2005	12	12	P	-
2006	2	21	**S**	**S**
2006	3	20	P	-
2008	1	29	**S**	S
2008	11	16	S	-
2008	12	10	-	-
2010	2	13	S	-
2010	3	27	P	S
2011	2	3	-	-
2011	4	30	-	**P**

SSHA time-longitude plots for the 7 oceanic process-influenced WP MJO events

Westward-propagating signals were present, but not as coherent as for the SCTR events.



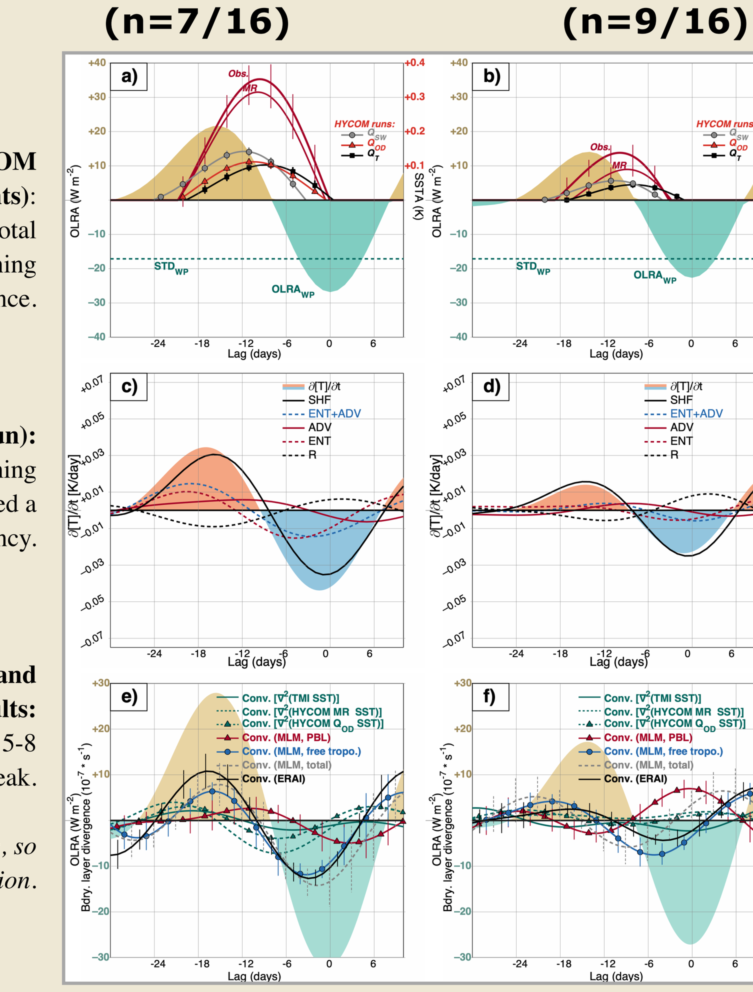
Strongly influenced by oceanic processes (n=7/16) | **Weakly influenced by oceanic processes (n=9/16)**

OLRA (Obs.) and SSTA (Obs. & HYCOM experiments):
Ocean dynamical processes accounted for ~1/3 of the total SSTA in the strong composite, in contrast to the remaining 9 events, which had small OD influence.

Off-line mixed layer heat budget (HYCOM Main Run):
Entrainment/upwelling accounted for ~20% of the warming tendency for the strong events. Advection also played a small role in the warming tendency.

Boundary layer convergence (Laplacian(SST) and Mixed Layer Model (MLM)) results:
Atmospheric convergence associated with SSTs peaked 5-8 days prior (Laplacian(SST)) to the OLRA peak.

Error bars were large for the MLM composite here, so these results should be interpreted with caution.



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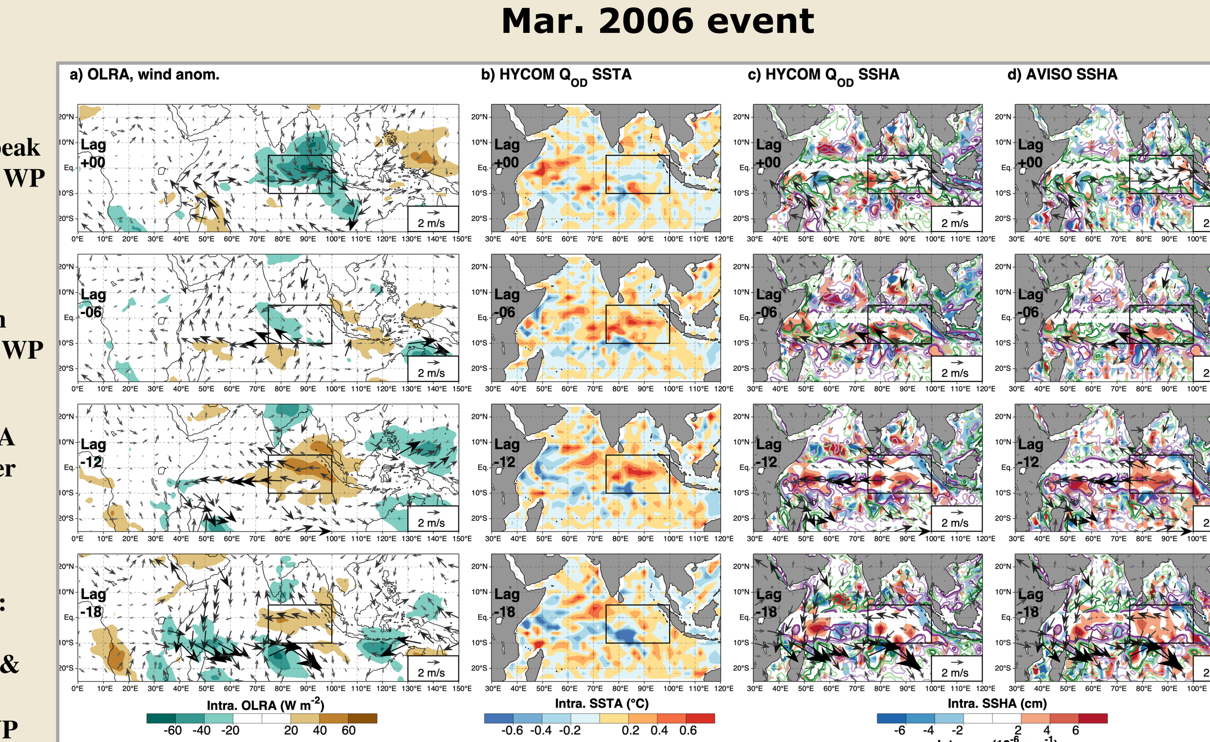
(4th column): ERW passage & $-w_E$ in the WP



WP conclusions:

- 44% of WP ISO events from 2001-2012 were global-scale MJOs, based on the OMI and strict criteria from Kiladis et al. (2014).
- 7/16 WP ISO events were preceded by oceanic process-induced warming that accounted for ~33% of the total warming.
- The warming was induced by entrainment and upwelling reduction, as with the SCTR events, but here, advection also played a minor role.
- Rossby wave signals were present, but less coherent than for the SCTR events.