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AGU100 ADVANCING EARTH AND SPACE SCIENCE

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

B. Jason West[1,*], Weiqing Han[2], Lei Zhang[3], and Yuanlong Li[4]

Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder, CO; 1: b.jason.west@colorado.edu, 2: weiqing.han@colorado.edu (PI), 3: lei.zhang-4@colorado.edu, 4: yuanlong.li@colorado.edu

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Key Points

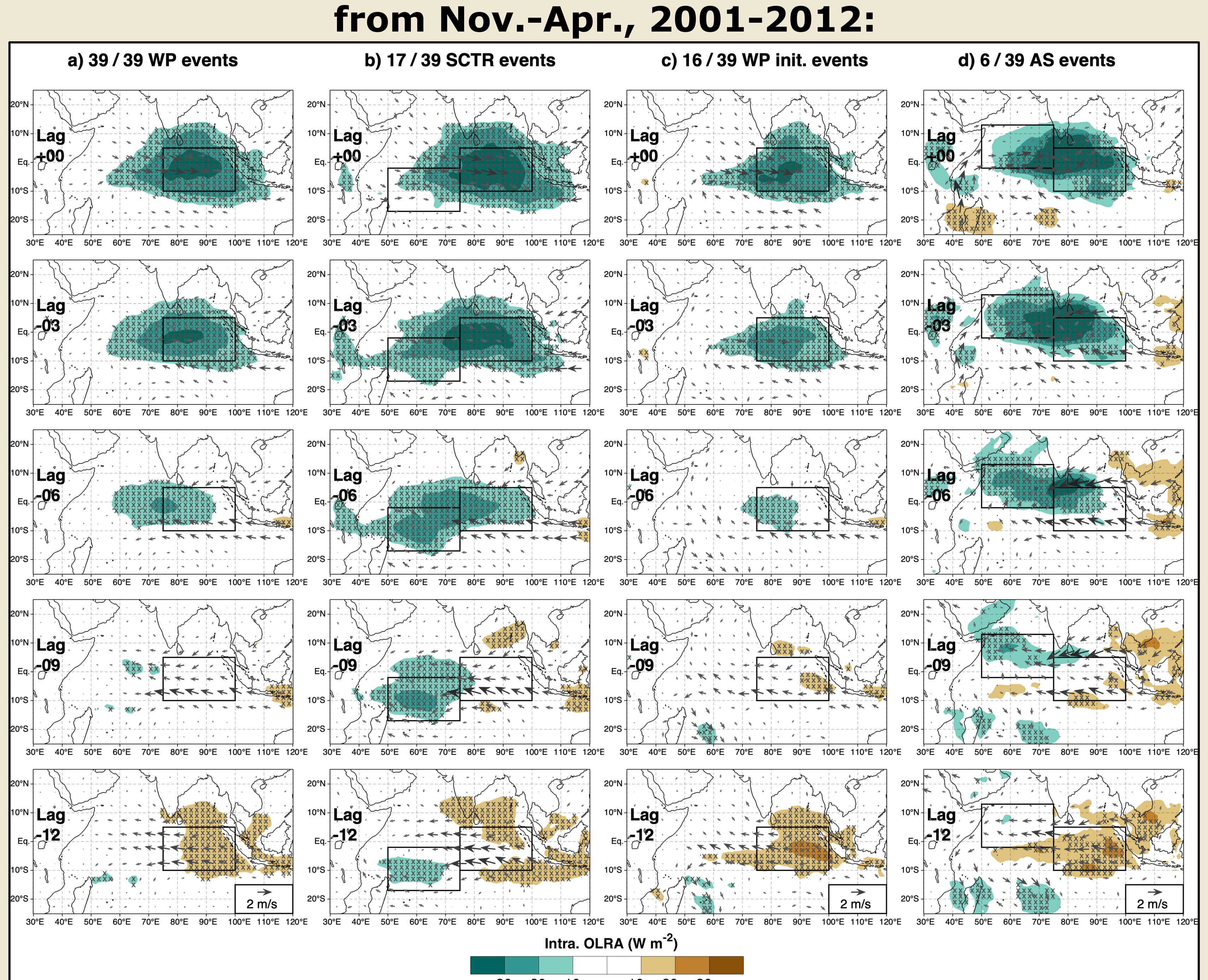
- Most (71%) of global-scale Indian Ocean MJO events from 2001-2012 initiated in the Seychelles-Chagos Thermocline Ridge (SCTR).
- Oceanic processes contributed about 30% of large-scale pre-convection sea surface temperature anomalies (SSTAs) in 4/17 of the Thermocline Ridge ISO events.
- Two of the oceanic process influenced events were primary MJO events and were associated with oceanic equatorial Rossby waves.

Background

The motivation for this project is to determine the role of oceanic processes (e.g., entrainment, upwelling, and advection) on +SSTAs prior to the initiation of the boreal winter MJO and other ISOs, which strongly impact weather and climate in the tropics and extratropics. To do this, we examined 39 ISO events that passed through the Indian Ocean Warm Pool (WP) during the Nov.—Apr. season from 2001—2012.

We separated the 39 WP events based on their initiation location, then examined intraseasonally filtered **satellite and in situ observations and reanalyses** and a set of **HYCOM OGCM experiments** to quantify to what degree pre-convection SSTAs were affected by: **wind stress** (**oceanic processes**), **radiative heat flux**, and **turbulent heat flux** (based on the setup of Li et al., 2014). Improving our understanding of how oceanic processes affect +SSTAs prior to the MJO initiation will inform how these processes are represented in weather and climate models, leading to improved predictability of the MJO.

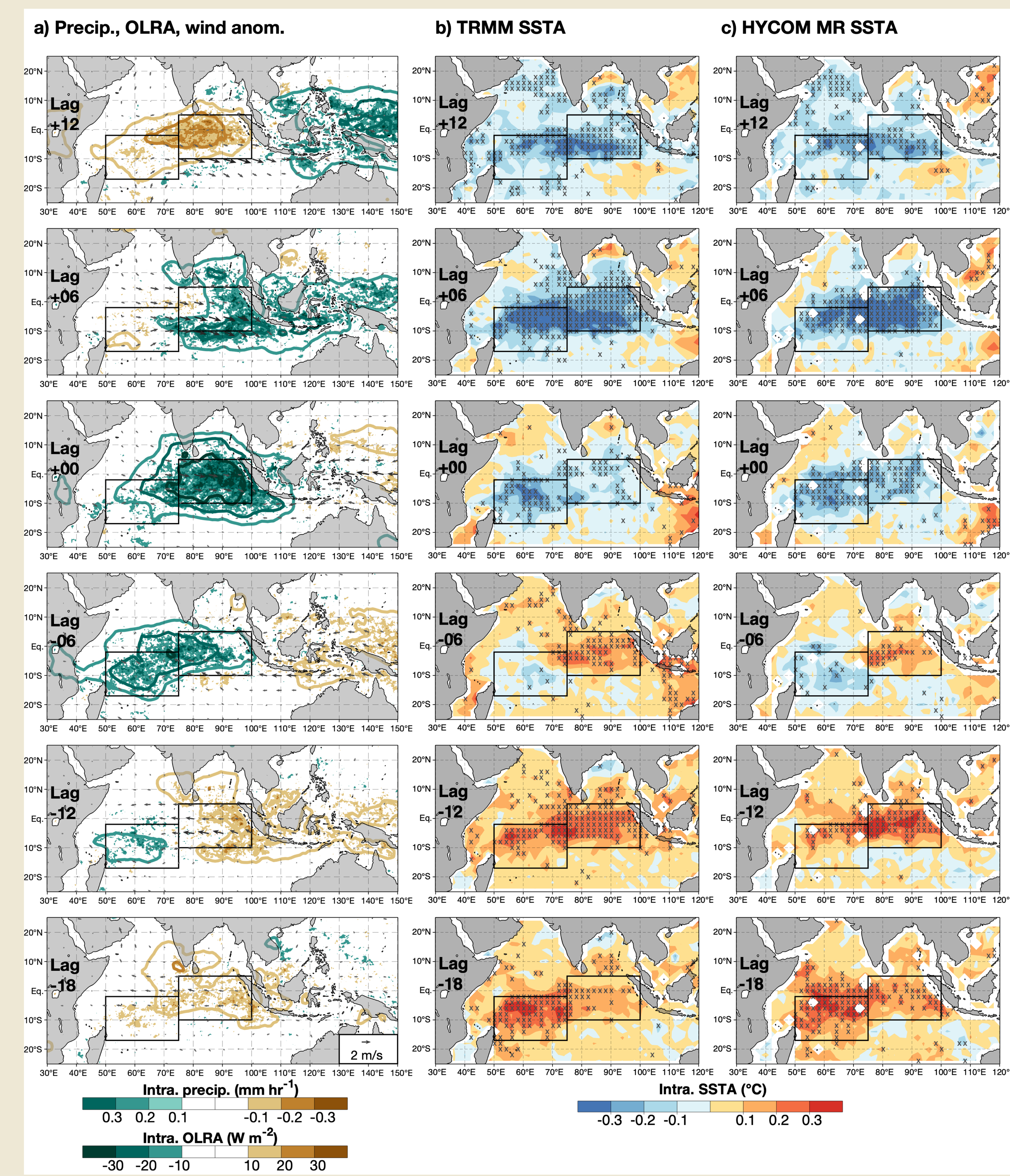
39 ISO events that initiated in the Seychelles-Chagos Thermocline Ridge (SCTR), Warm Pool (WP), and Arabian Sea (AS) from Nov.-Apr., 2001-2012:



71% of SCTR ISOs were global-scale MJOs. 24% of WP ISOs were global-scale MJOs. 17% of AS ISOs were global-scale MJOs.

Based on the OMI and RMM indices, as well as criteria described in Kiladis et al. (2014).

Composite of 17/39 WP ISO events that initiated in the SCTR



a) Observed NOAA OLRA, TRMM precip., and CCMP wind: The 17 TR events showed clear initiation (-OLRA) in the TR region, followed by eastward propagation to the Maritime Continent.

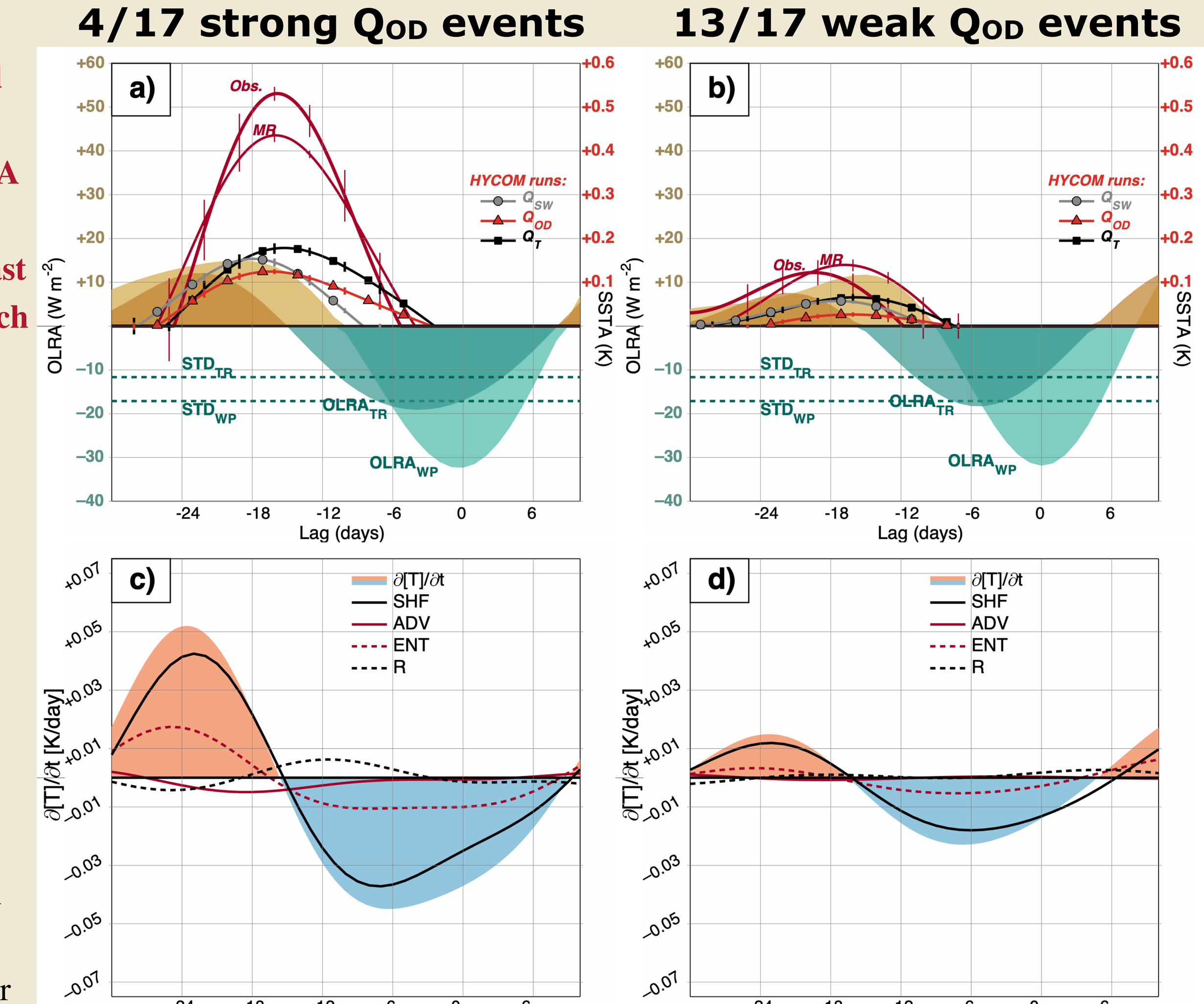
b) Observed TRMM SSTA: Mean SSTAs in the TR exceeded +0.4K, which is well above the required SSTA to support convection at high mean SSTs.

c) Modeled HYCOM Main Run SSTA: The HYCOM MR results matched TRMM observations quite closely, giving us confidence in the fitness of HYCOM to represent the ocean influence on winter ISOs.

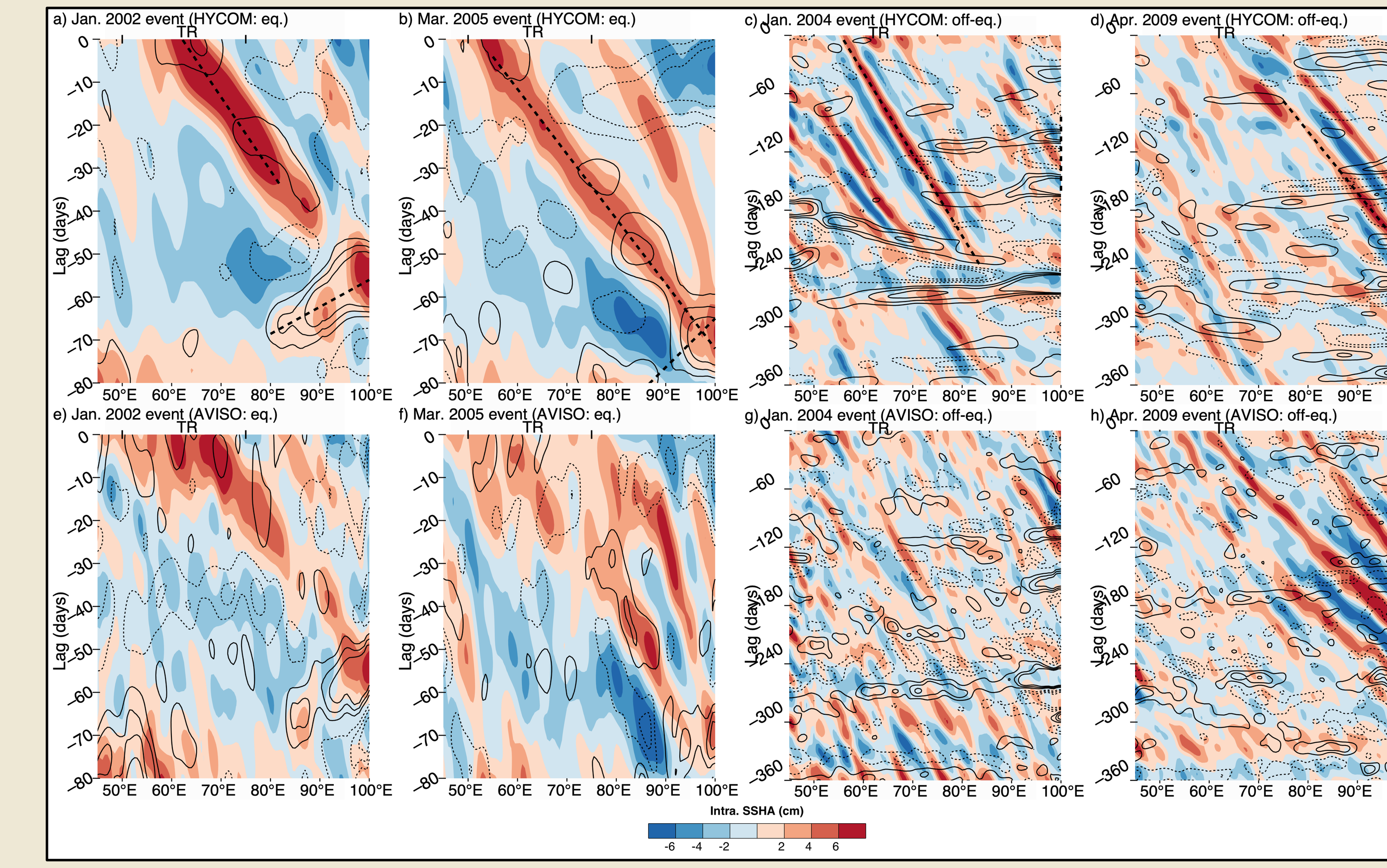
Composite time series for:

4/17 strong Q_{OD} events — 13/17 weak Q_{OD} events

- **Ocean dynamical processes accounted for ~30% of the total SSTA for the strong Q_{OD} composite (>+1 std. dev. of SSTA in the wind-stress-isolated HYCOM experiment) in contrast to the remaining 13 events, which had small Q_{OD} influence.**
- Based on an off-line mixed layer heat budget, the combined entrainment/upwelling effect was the dominant oceanic warming process for the strong events.
- This is in contrast to our results from boreal summer, where advection dominated over entrainment.
- Given that the entrainment and upwelling variations in the SCTR are often associated with oceanic Rossby waves, we next looked for evidence of them in SSHA data.

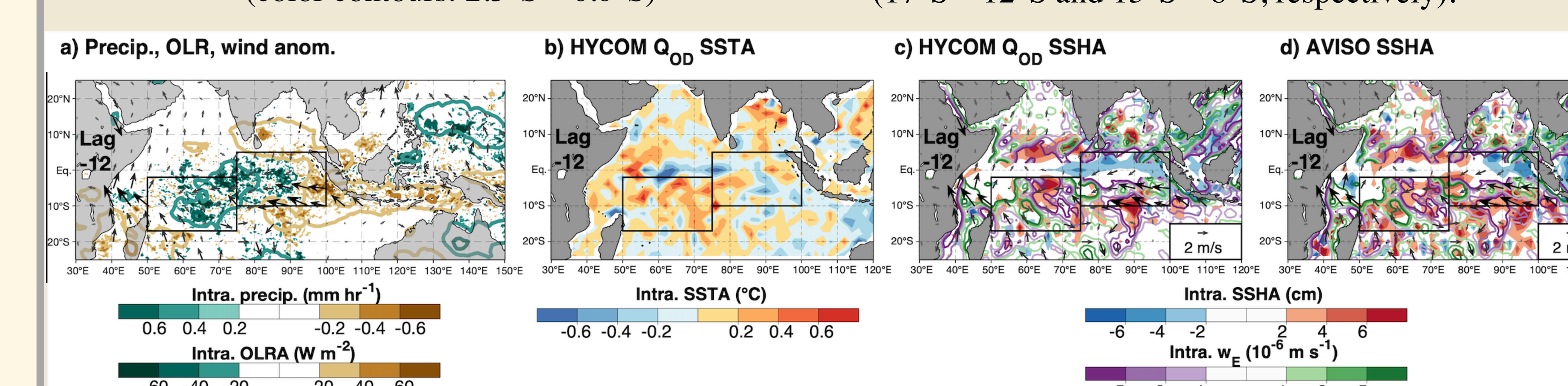


4/17 strong Q_{OD} SCTR events preceded by oceanic Rossby waves passing through the SCTR



Two events (both primary MJOs) were associated with equatorial Rossby waves. (color contours: 2.5°S—6.0°S)

The other two events (successive MJOs) were associated with off-equatorial Rossby waves, still within the SCTR (17°S—12°S and 13°S—8°S, respectively).



The Jan. 2002 event (shown above) and Mar. 2005 event (not shown) were associated with both the remote Rossby wave downwelling effect, as well as locally-forced negative Ekman pumping (panels c,d above).

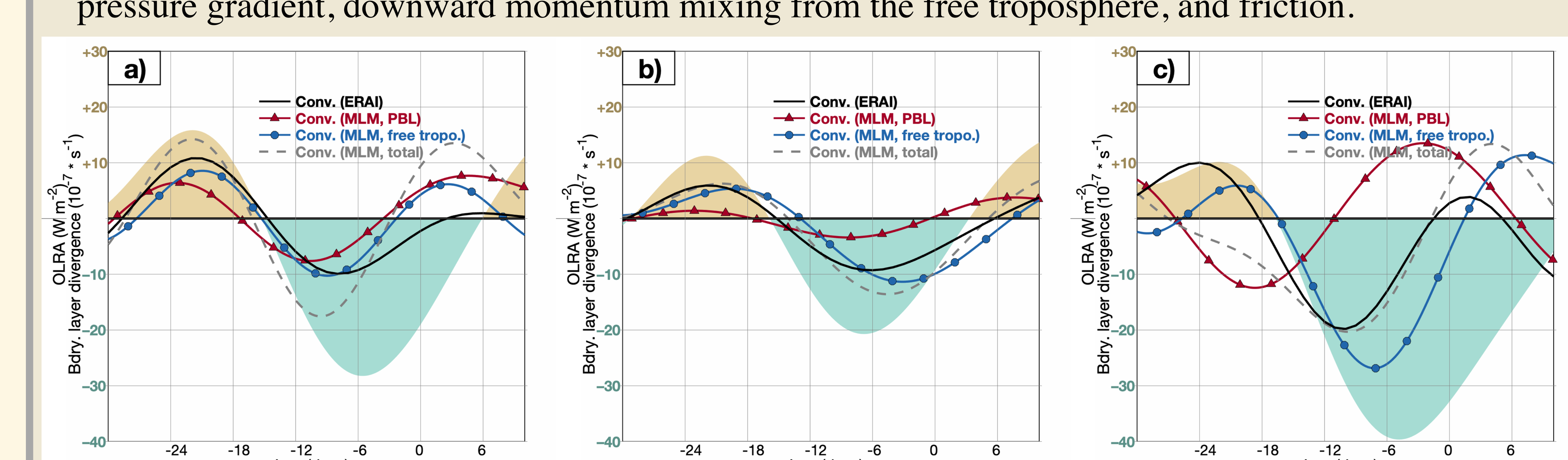
Feedback from the ocean to the atmosphere

$$U = \frac{U_T\epsilon_i\epsilon_e + V_T f\epsilon_e - \rho_0^{-1}(f\partial P_s/\partial y + \epsilon_i \partial P_s/\partial x)}{\epsilon_i^2 + f^2},\quad V = \frac{V_T\epsilon_i\epsilon_e - U_T f\epsilon_e + \rho_0^{-1}(f\partial P_s/\partial x - \epsilon_i \partial P_s/\partial y)}{\epsilon_i^2 + f^2} \qquad (2)$$

$$P_s = P_i + \Delta P_{BL} \quad \text{and} \qquad (3)$$

$$P_i = 850\,\text{hPa} + \rho_{850}(\Phi_{850} - \overline{\Phi}_{850}). \qquad (4)$$

We used the atmospheric Mixed Layer Model (MLM) of Back and Bretherton (2009a), based on Stevens et al. (2002)., which is based on a momentum balance in the mixed layer between Coriolis, pressure gradient, downward momentum mixing from the free troposphere, and friction.



The PBL component contributed >40% of the total convergence for the strong Q_{OD} events (a), but only ~20% for the weak Q_{OD} events (b). For the Jan. 2002 case study, the model performed particularly well and the **PBL component peaked 9 days prior to the total convergence, supporting the hypothesis that the ocean may act as a trigger for the initiation of some MJO events.**