Wintertime intraseasonal SST variability in the tropical South Indian Ocean and Role of Ocean Dynamics in the MJO Initiation

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1. Li Y., W. Han, and coauthors, 2014 (JPO)
2. West J., W. Han, and Y. Li, 2015, Work in progress

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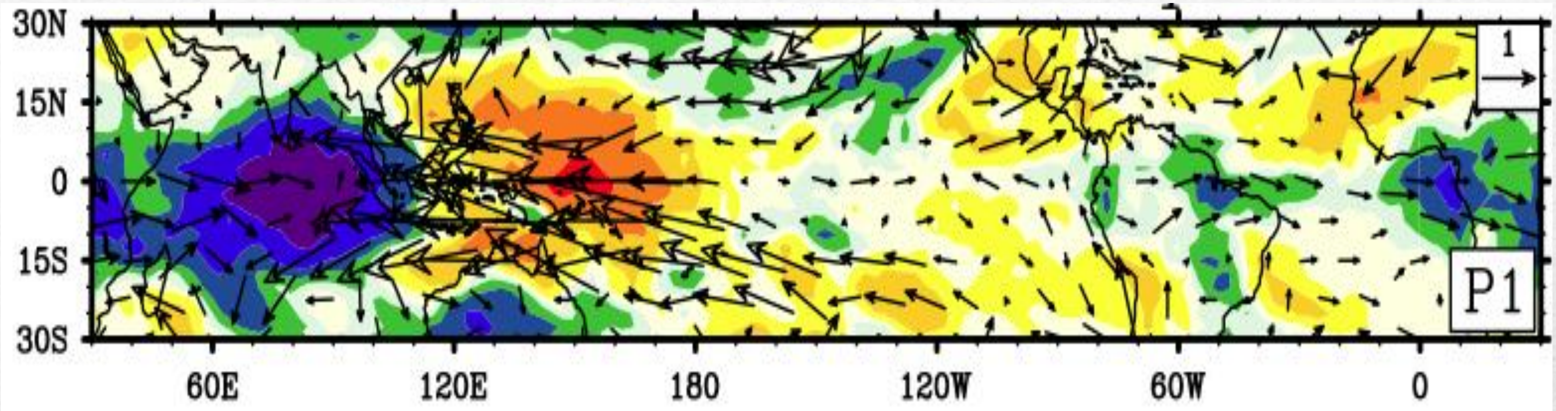
1. Background

***Madden-Julian Oscillations** (MJOs)*
Many of them initiate in the tropical Indian Ocean & propagate eastward , impact weather & climate around the globe

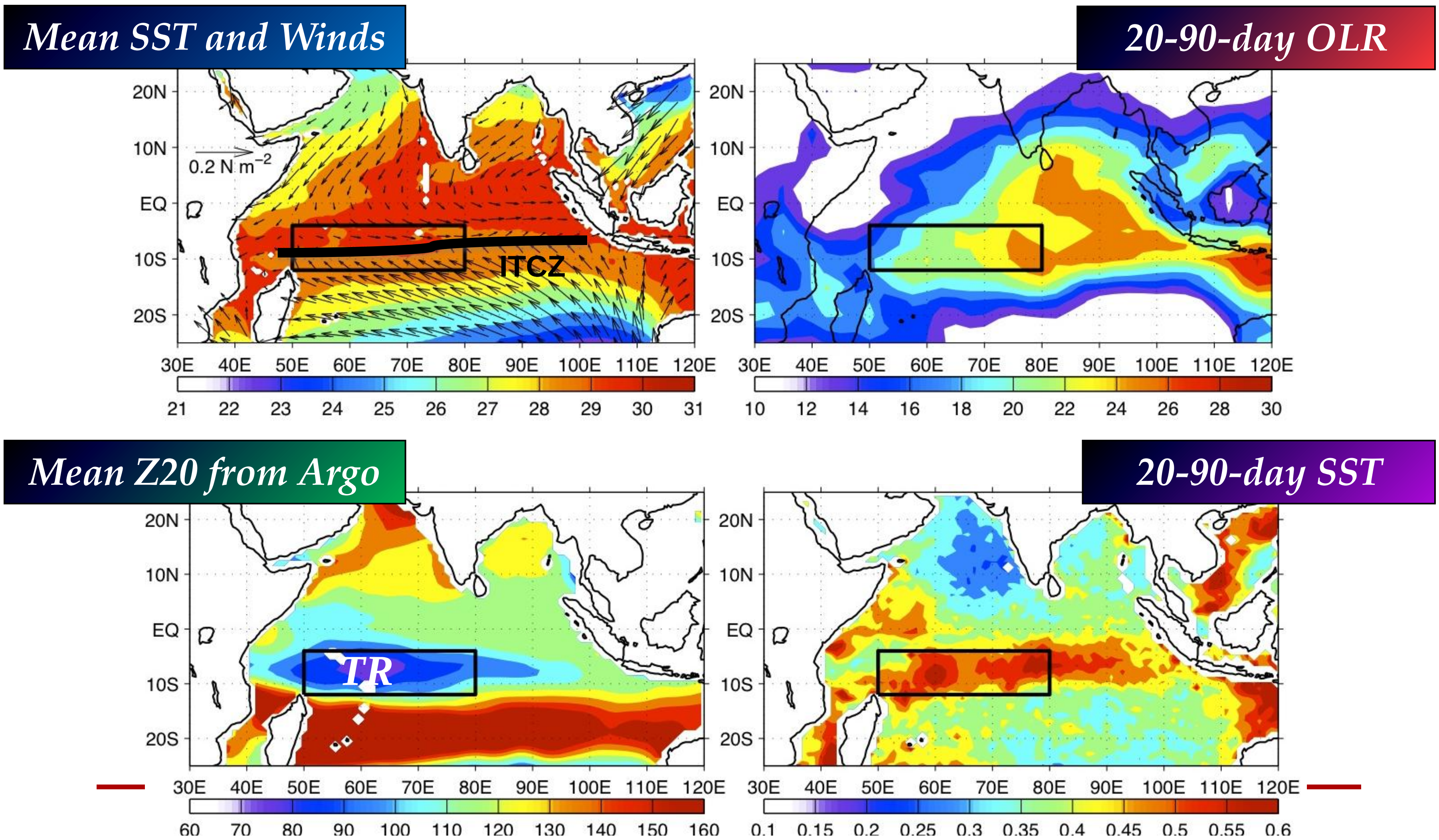


***Air-sea coupling processes** over Indian Ocean – influence MJO amplitude and propagation.*

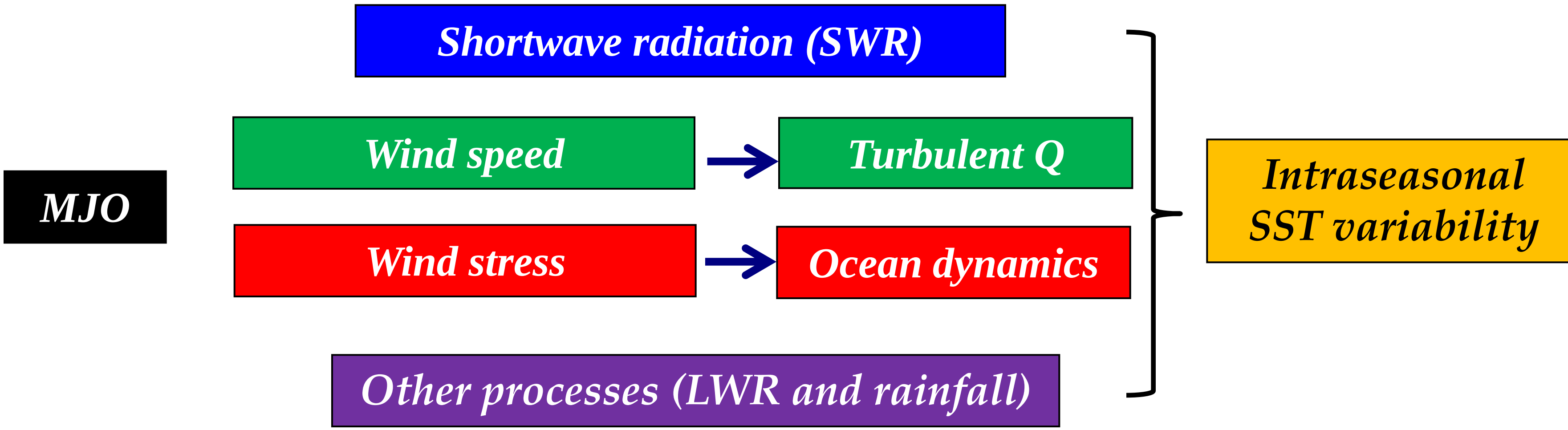
Issues: Air-sea coupling processes are not well understood.
Existing studies still have diverged views on mechanisms of intraseasonal SST variability; how the SSTA affects the wintertime (Nov-Apr) MJO initiation – remains largely unknown.

Seychelles-Chagos thermocline ridge (TR)

In boreal winter (November-April), many strong MJOs are initiated from here.



Processes controlling intraseasonal SST variability related with MJOs



Aim of the present research:

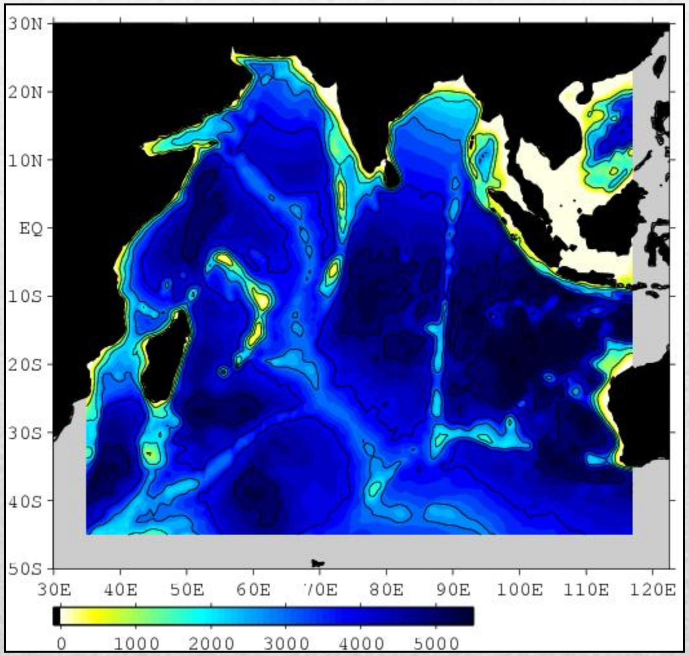
Analyze observational data and perform OGCM experiments to clarify the mechanisms of wintertime intraseasonal SST variability in the TR region and explore its possible relationship with MJO initiation.

2. Approach

Configure HYCOM 2.2.18 to the Indian Ocean between 50S-30N using best available forcing fields:

- *Wind forcing: daily satellite-derived CCMP surface wind vectors during 1989-2011.*
- *Radiation forcing: satellite-derived daily CERES shortwave/long-wave radiation during 2000-2011*
- *Precipitation forcing: daily TRMM satellite precipitation (1998-2011)*
- *2-m air temperature and humidity: daily ERA Interim reanalysis (1989-2011)*
- *River discharge in the Bay of Bengal: monthly Papa et al. (2011) river discharge for G-B river and Dai et al. (2011) fresh water flux for other rivers in the BOB*

- *Resolution: 1/4 x 1/4 degree horizontal resolution and 26 vertical layers.*



HYCOM experiments for 2000-2011

Experiments	Forcing	Description
MR	Daily forcing	Complete
NoMJO	105d Low-passed forcing	Remove MJO effects
NoSWR	105d low-passed SWR	Remove MJO SWR
NoWND	105d low-passed winds	Remove MJO total wind effect (wind stress + wind speed)
NoTAU	105d low-passed stress	Remove MJO wind stress-induced ocean dynamics
NoOIV	Monthly climatology + instraseasonal forcing	Remove Ocean Interannual Variation (OIV) in D20 and mixed layer thickness.

No MJO effect → NoMJO

No SWR effect → NoSWR

No wind effect (wind stress or speed) → NoWND

No wind stress → NoTAU

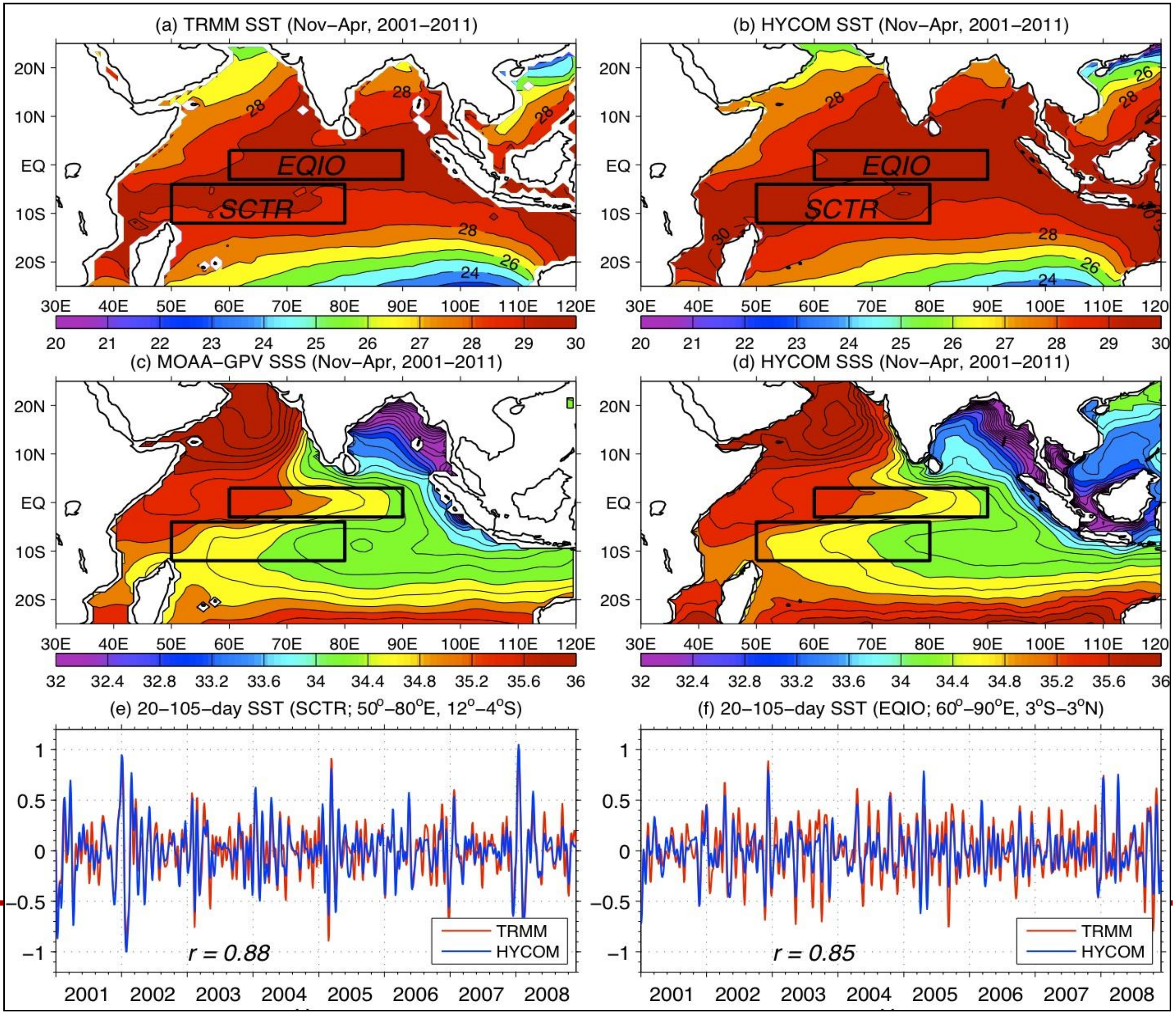
No Ocean Interannual Variation → NoOIV

3. Results

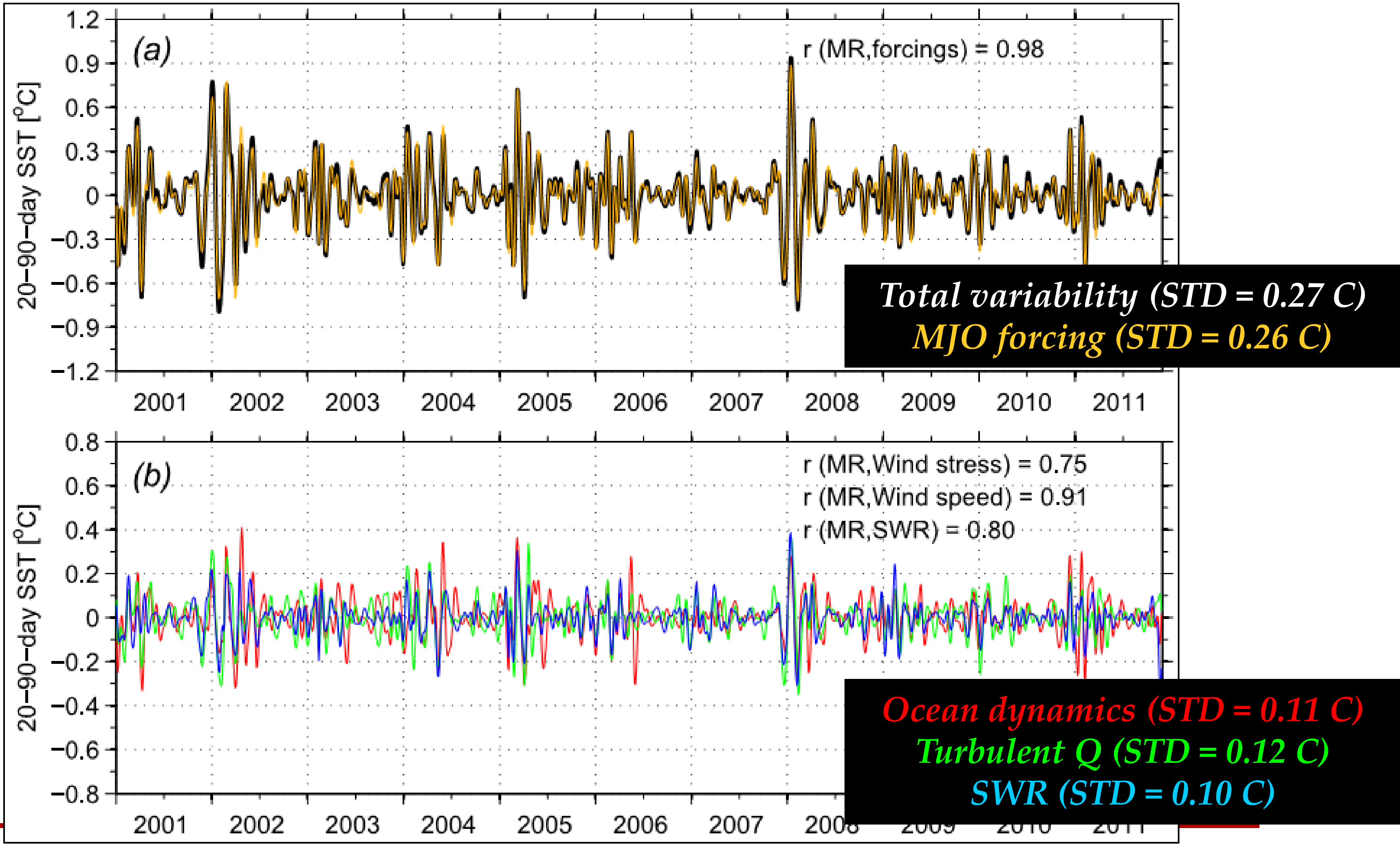
Mean SST

Mean SSS

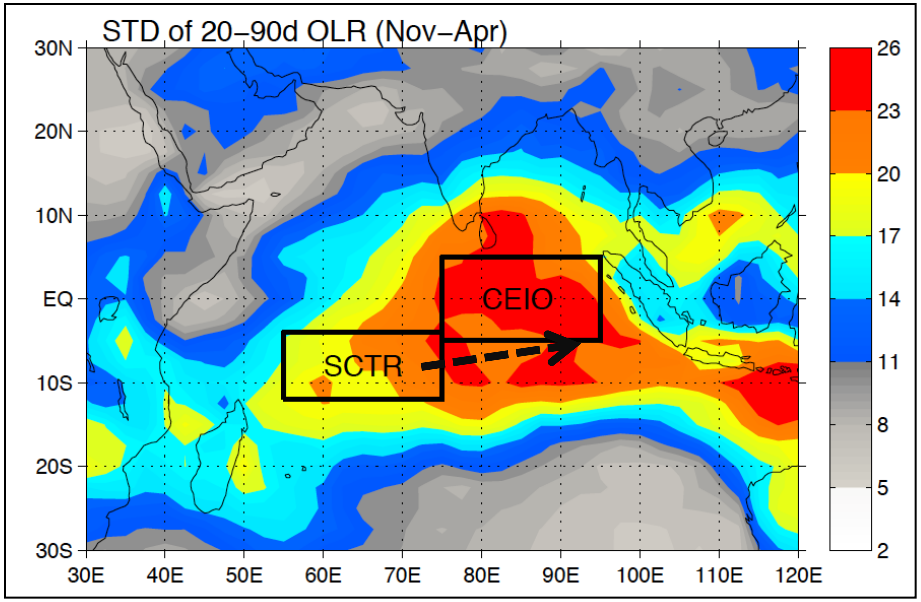
Intraseasonal SSTA



Effects of different processes on TR intraseasonal SST variability



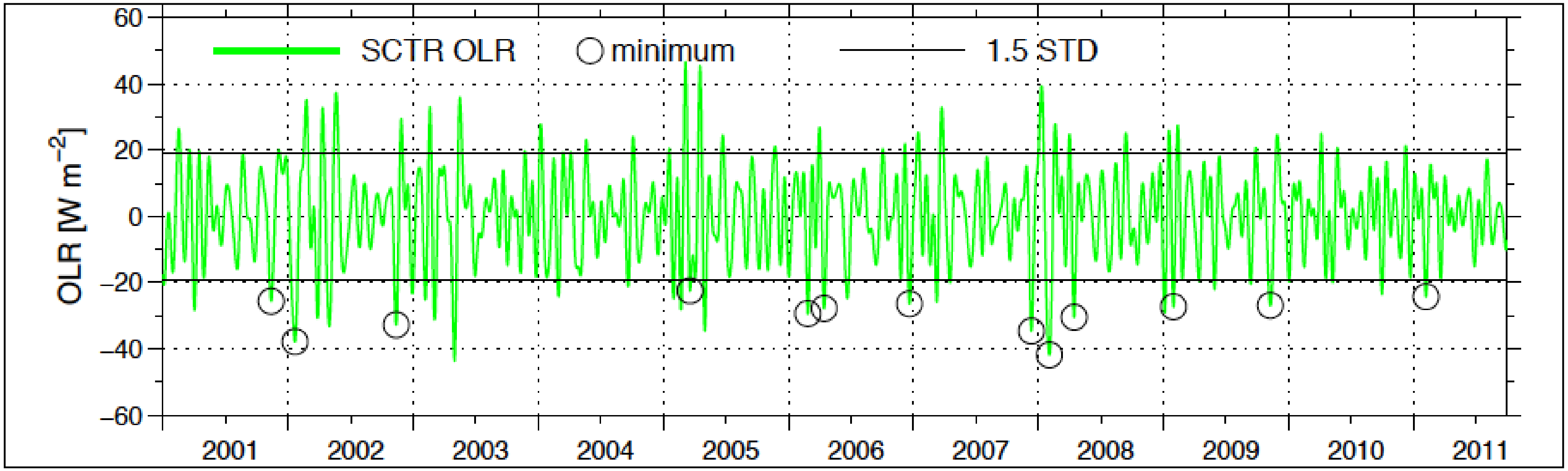
MJO composite



Year 2001-2011

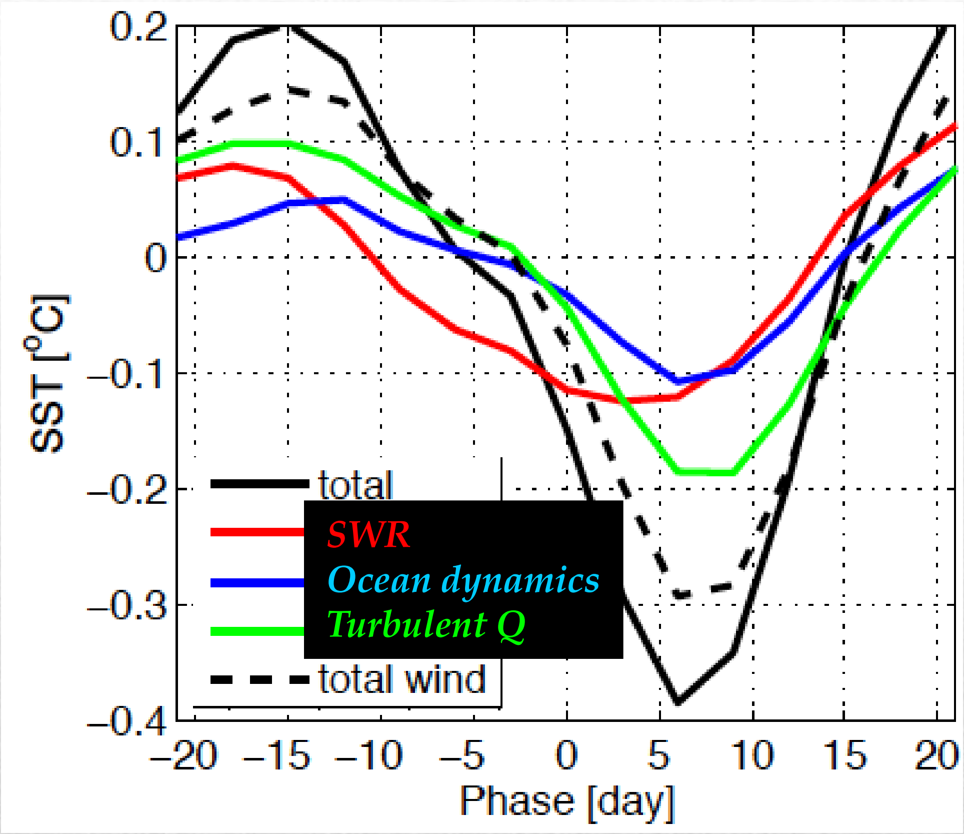
29 winter MJO events

13 of them begun in the TR and amplify in the CEIO (TR MJO)

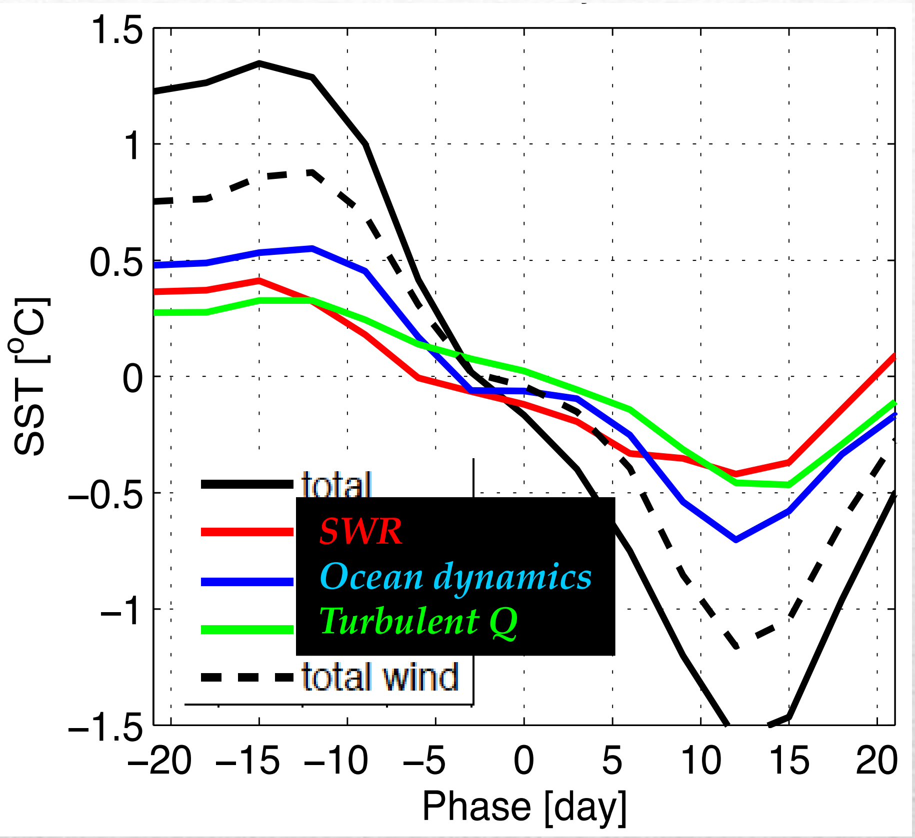


MJO composite

SSTA composite of the 13 *TR* MJO events



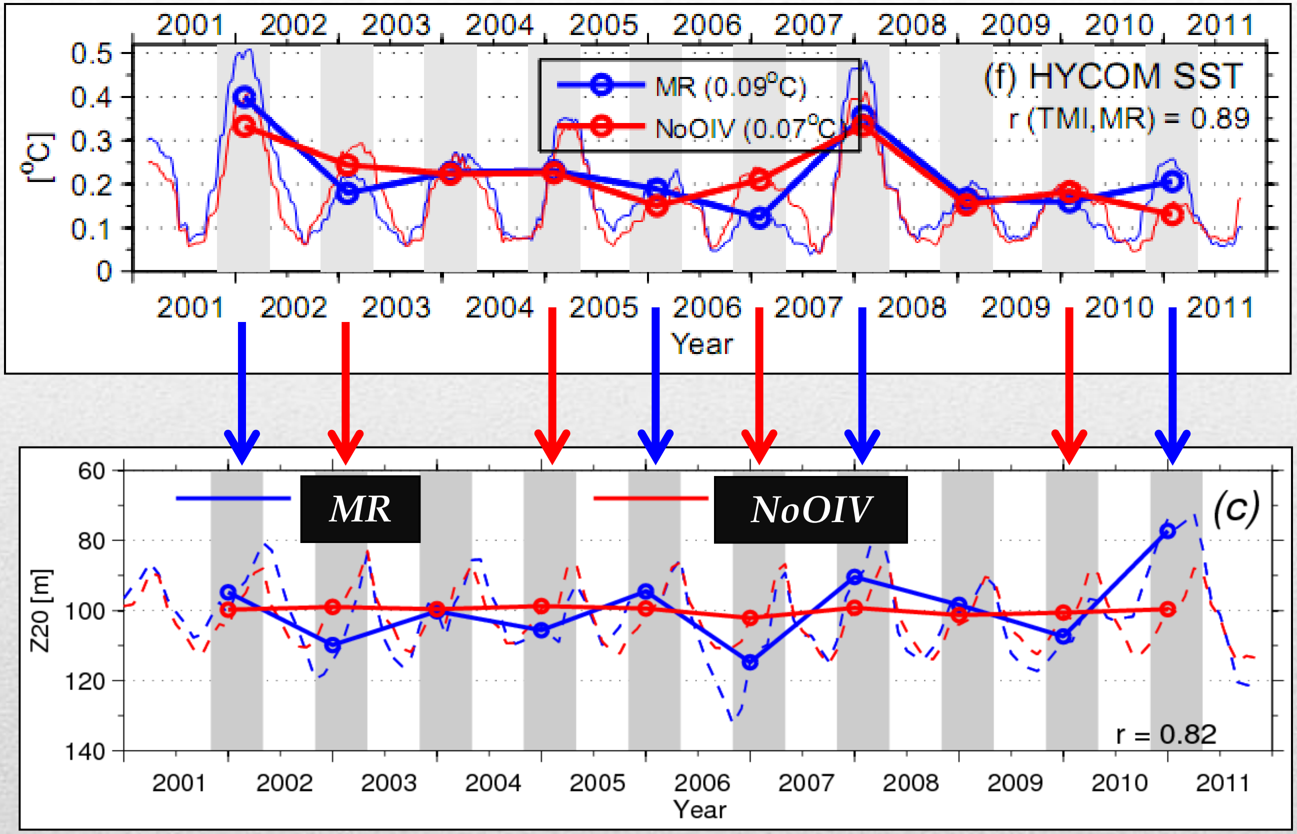
The *strongest* event in Feb 2008



Implies that Indian Ocean dynamics may play an active role in the initiation of the LARGE TR MJO events!

OIV affects the amplitude of intraseasonal SST variability

Yearly Amplitude of 20-90-day SST from MR and NoOIV



Yearly D20 from MR and NoOIV

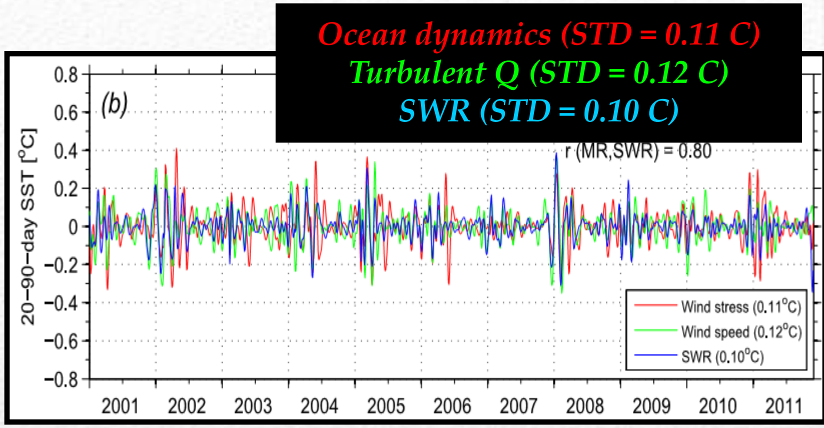
***A Strong TR** (shallow thermocline & MLD) **enhances** intraseasonal SSTA, while **a weak TR** (deep thermocline & MLD) **reduces** intraseasonal SSTA.*

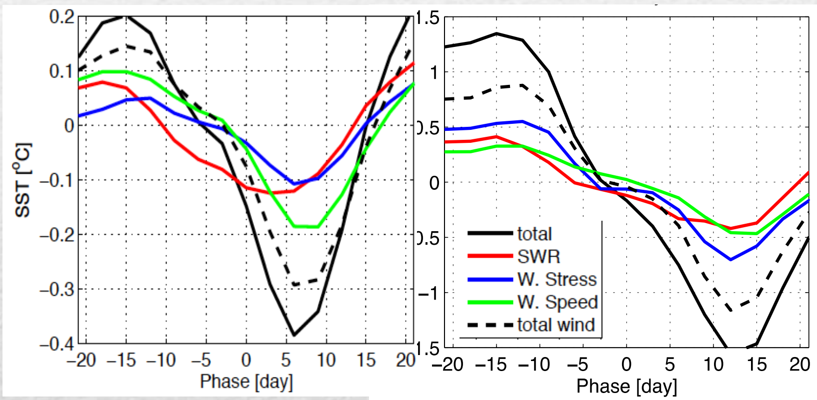
4. Conclusions

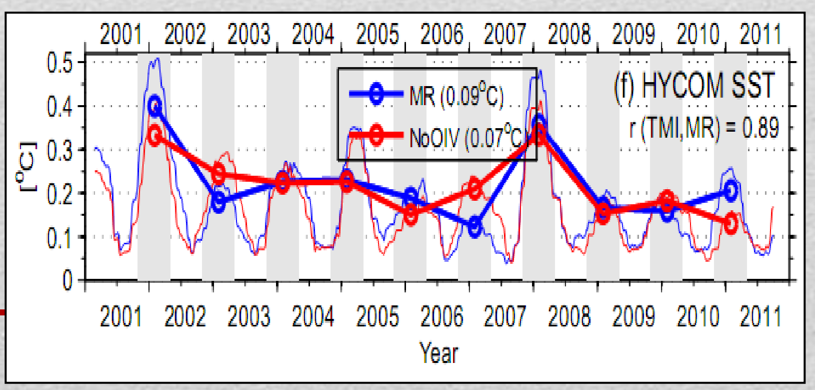
(i) MJOs induce large intraseasonal SSTA in the TR region through wind stress-driven oceanic dynamics, turbulent Q, and SWR – overall, 3 effects are comparable;

(ii) For strong TR MJO event, ocean dynamics can play the most important role - Implies possible importance of Indian Ocean in initiating LARGE MJO event;

(iii) Ocean interannual variation (in MLD and D20) acts to modulate the amplitude of intraseasonal SSTA.





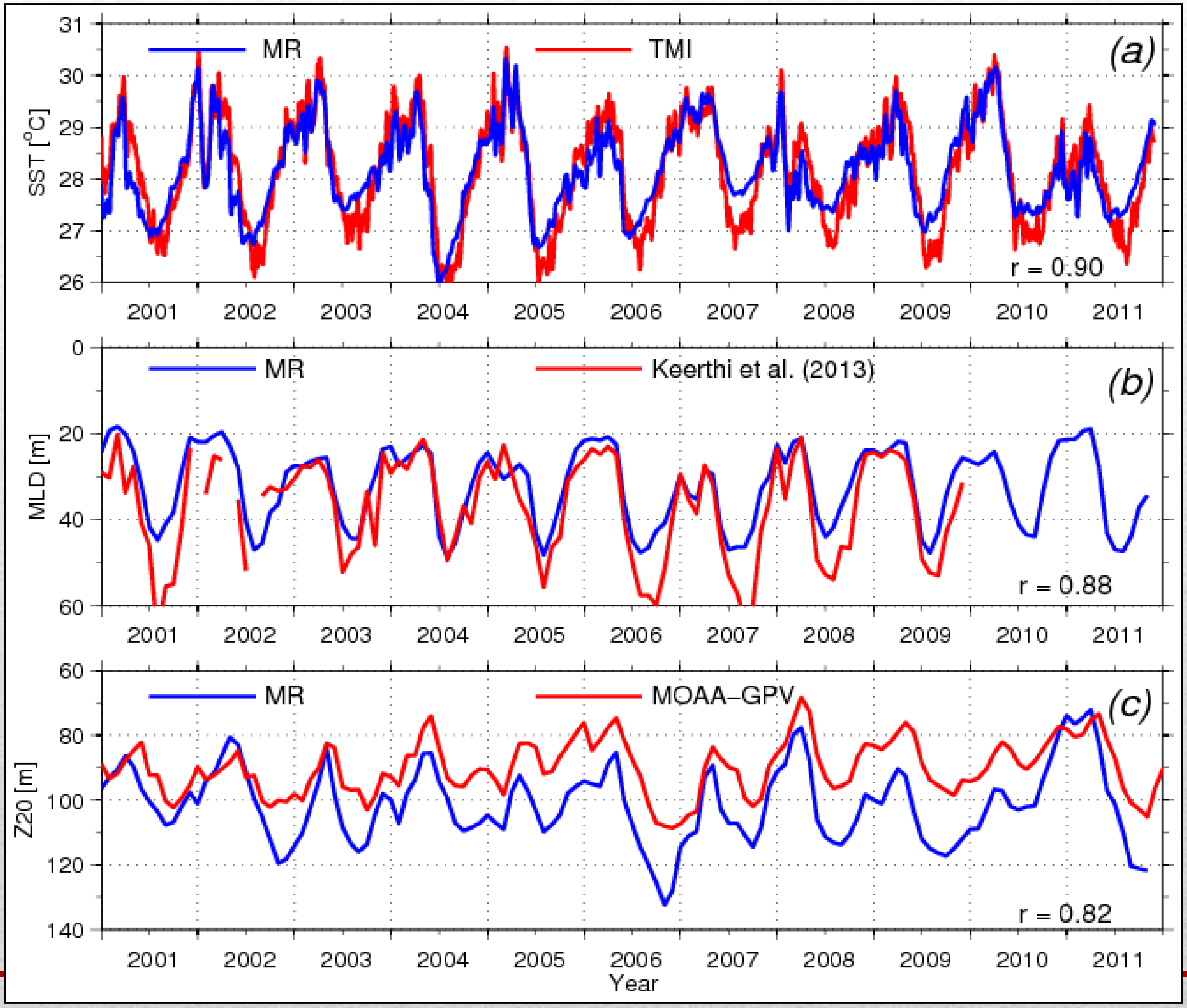


SST, MLD, & D20 time series in the TR

SST

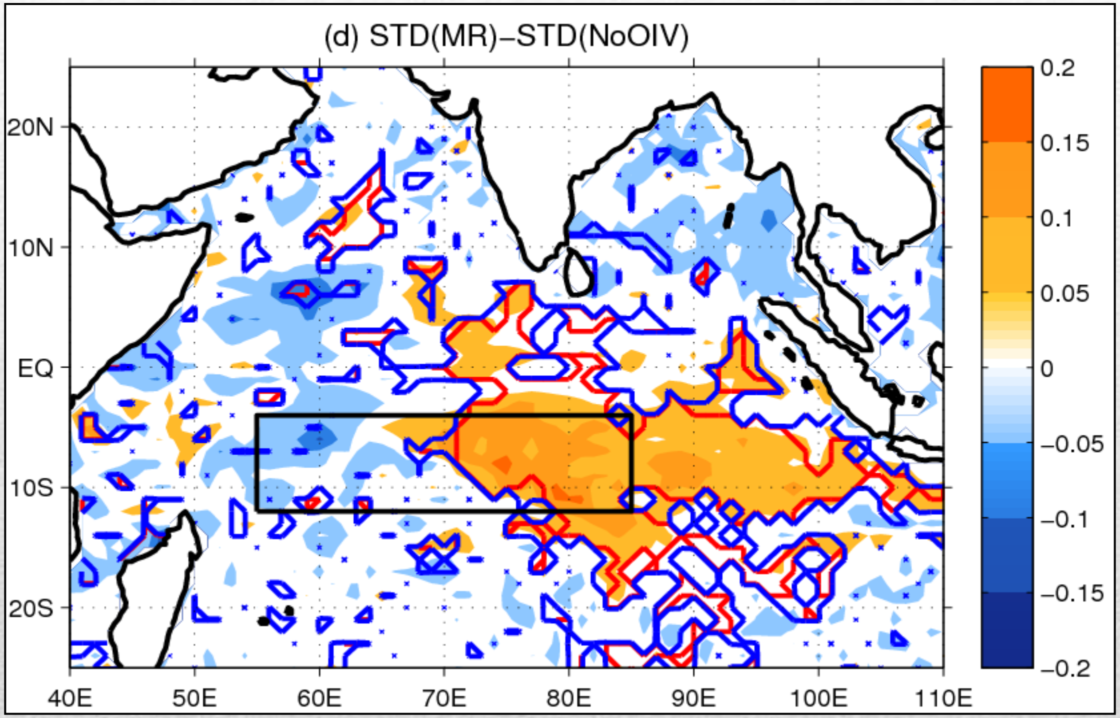
MLD

D20



The overall OIV effect: Enhancing !

Difference of STD of the wintertime 20-90-day SST between MR and NoOIV,
STD (MR) – STD (NoOIV)



---------- 95% significance ----------- 85% significance based on F-test

The OIV effect enhances the intraseasonal SSTs in the eastern TR region by about 0.1 C (20% of the total SST variability) (significant at 95% level) and slightly reduces them in the western TR (not significant).

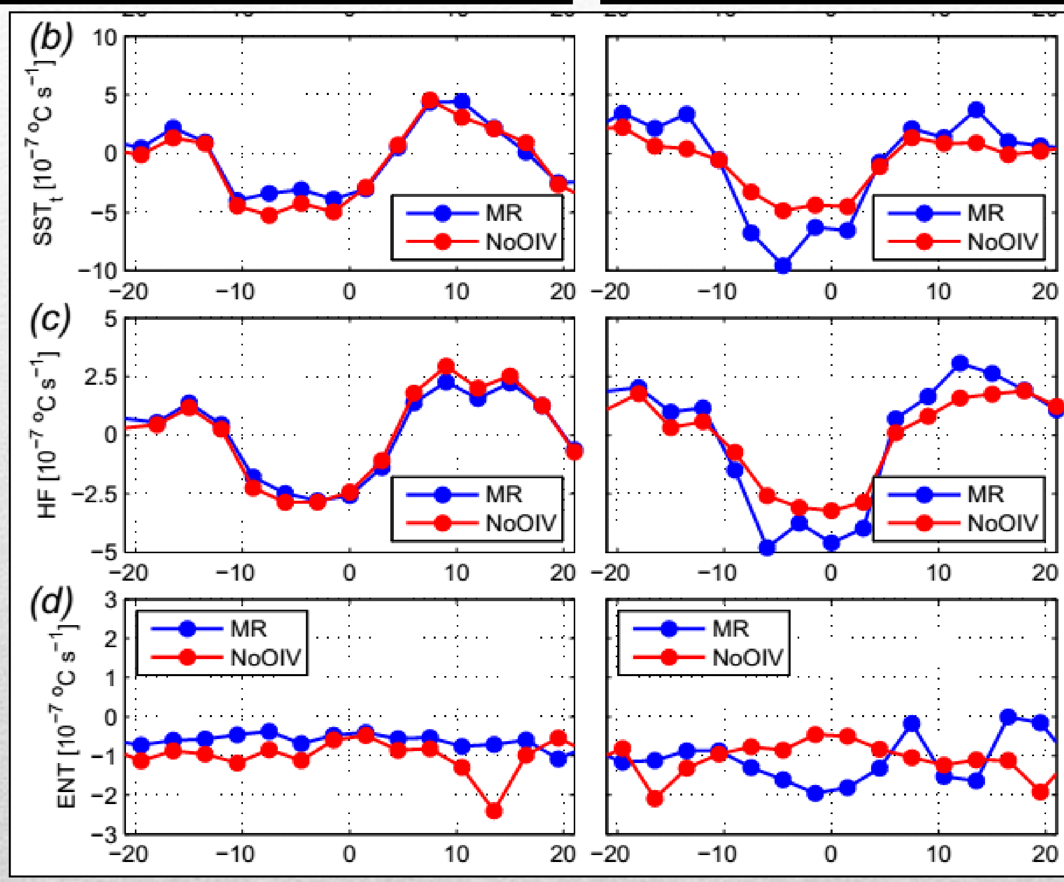
Composite analysis for strong and weak TR years

Weak-year composite | **Strong-year composite**

SST_t

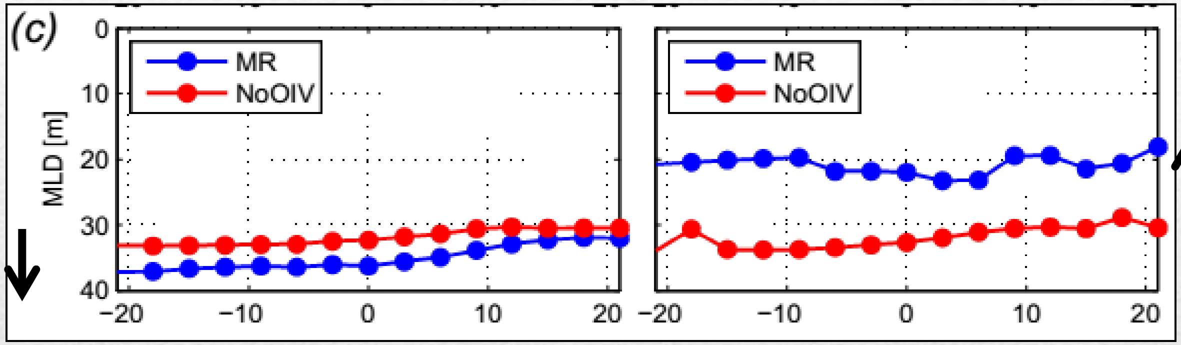
HF

ENT



SST variability, HF and ENT are greatly enlarged by a strong TR year, but only slightly reduced by a weak TR.

Weak-year composite *Strong-year composite*



< 5 m

> 10 m

$$HF = (\sigma c_p)^{-1} Q/H$$

$$ENT = -\frac{\partial H}{\partial t}\frac{\Delta T}{H}h^*,$$

***An important source of the asymmetry:** the **MLD changes**, which is shallower than normal by at least 10m in strong TR years, but is deeper than normal by only less than 5m in weak TR years. This difference leads to the strong/weak asymmetry of ENT and HF and thus the overall enhancing effect of the OIV.*

OIV affects the mechanisms of intraseasonal SST variability

Wind Stress

Wind Speed

SWR