Coupled impacts of the diurnal cycle of sea surface temperature on the Madden-Julian Oscillation

— Diurnal SST and MJO convection

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Dynamics of MJO (DYNAMO)

Initiation/Intensity of MJO convection ↔ Upper-ocean variability and air-sea flux

Chidong Zhang

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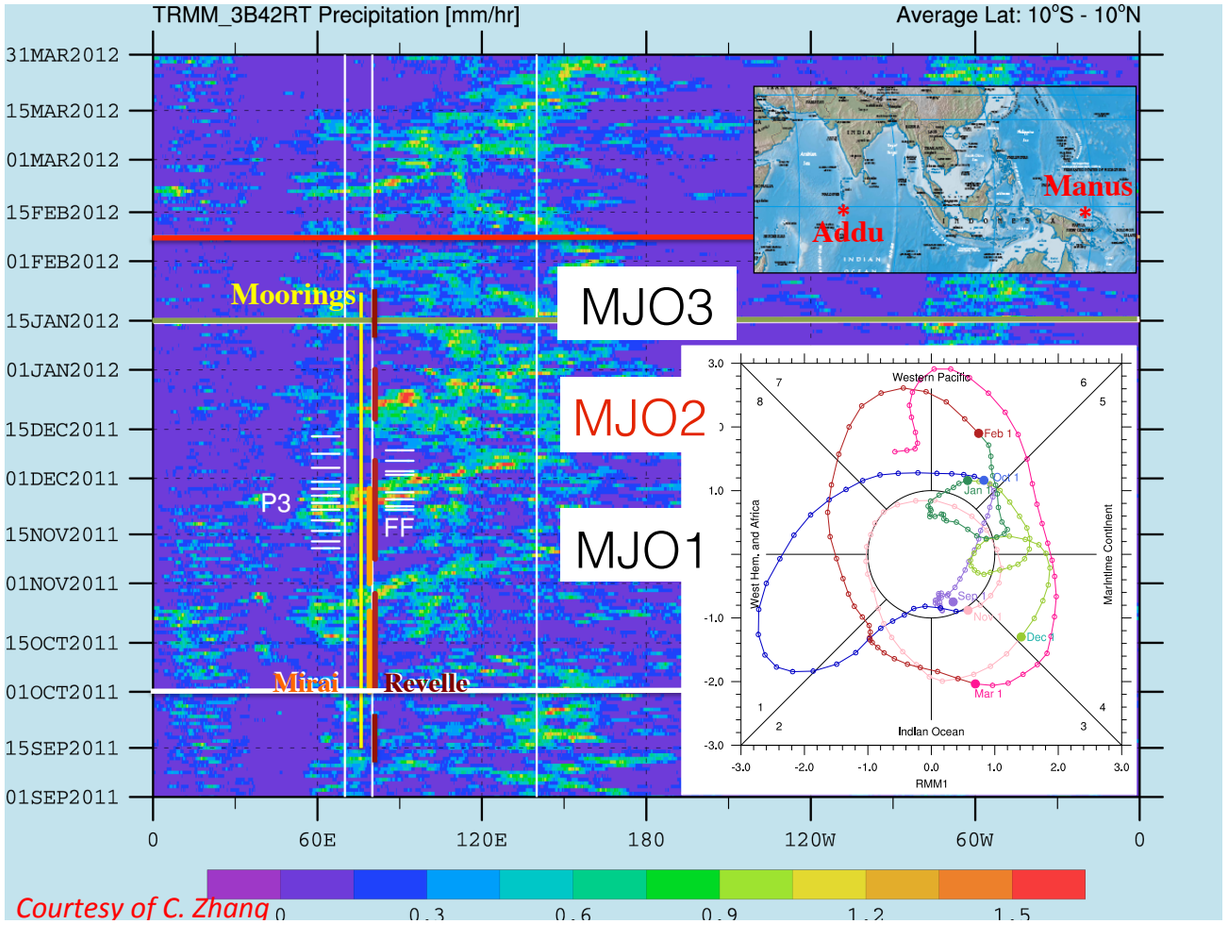

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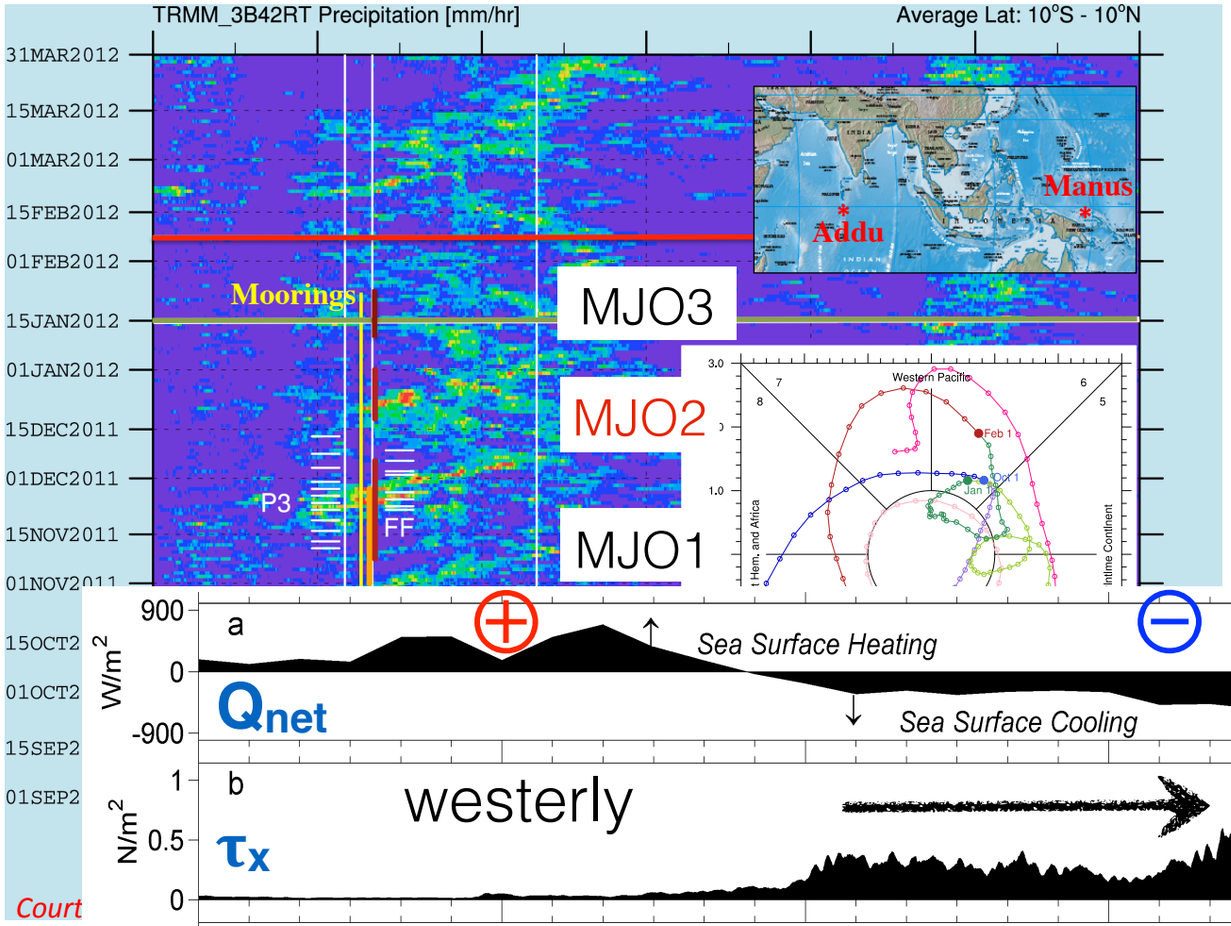
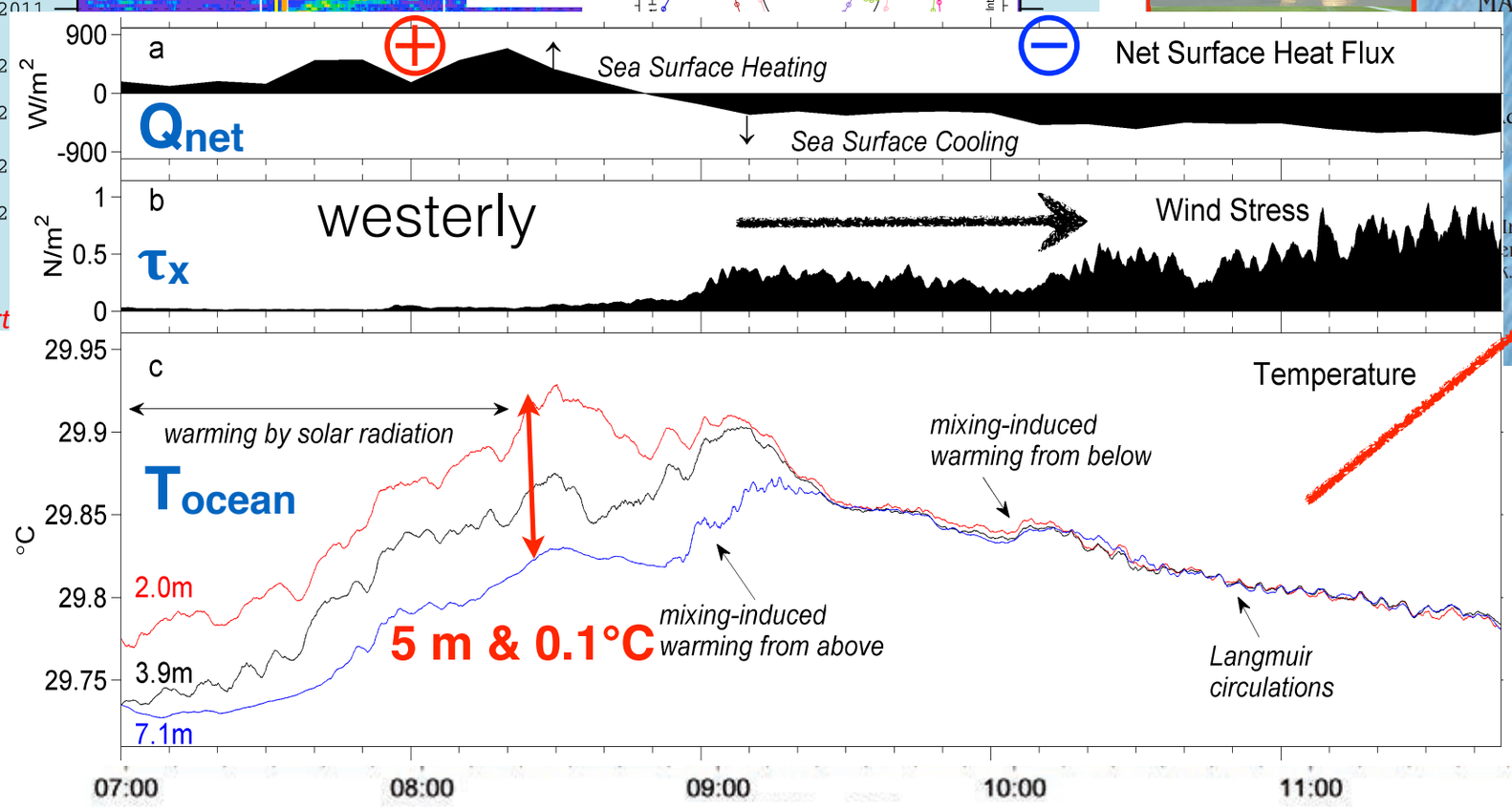
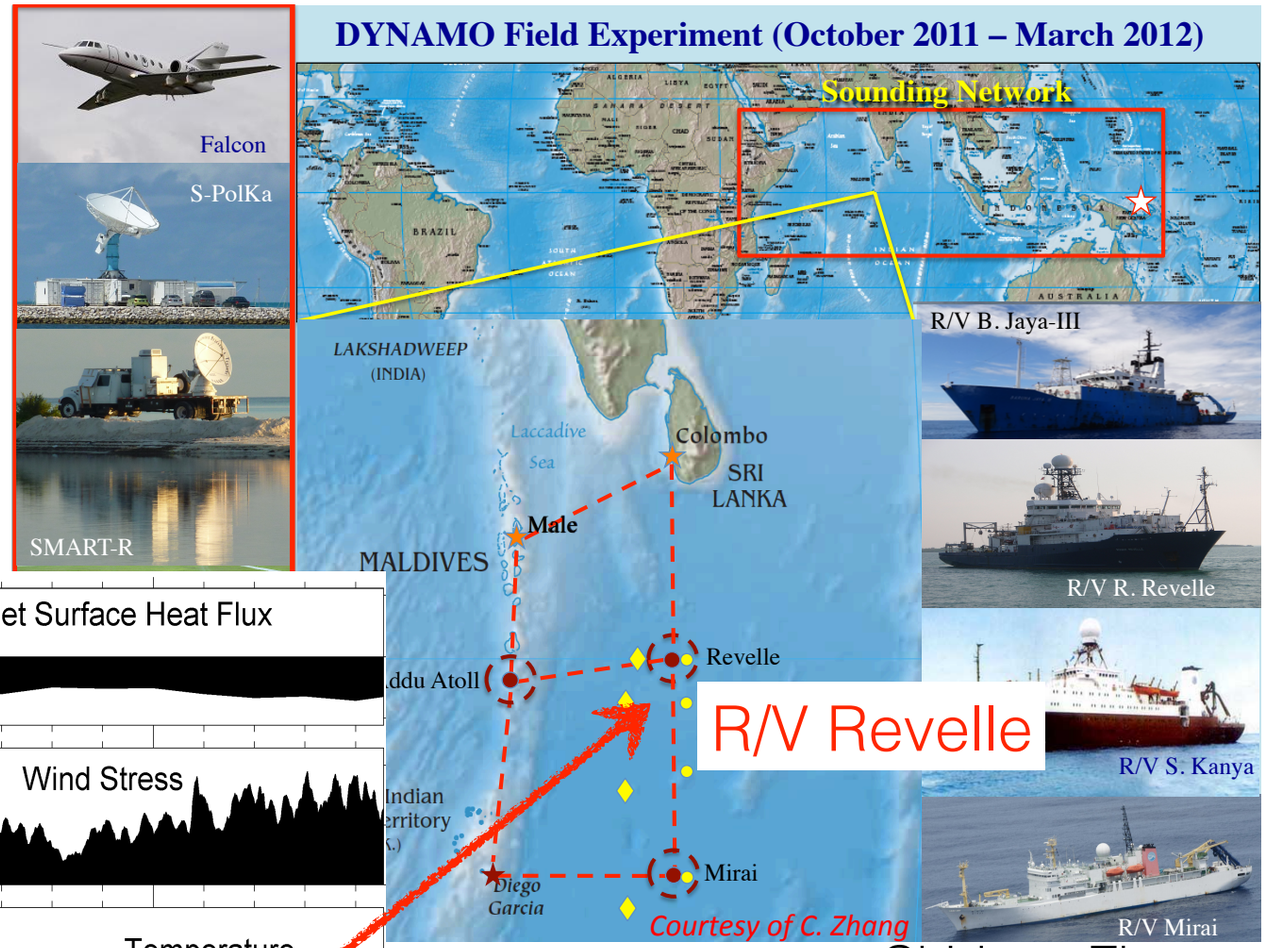
Initiation/Intensity of MJO convection ↔ Upper-ocean variability and air-sea flux





Nov. 24, 2011

Moum et al. 2014



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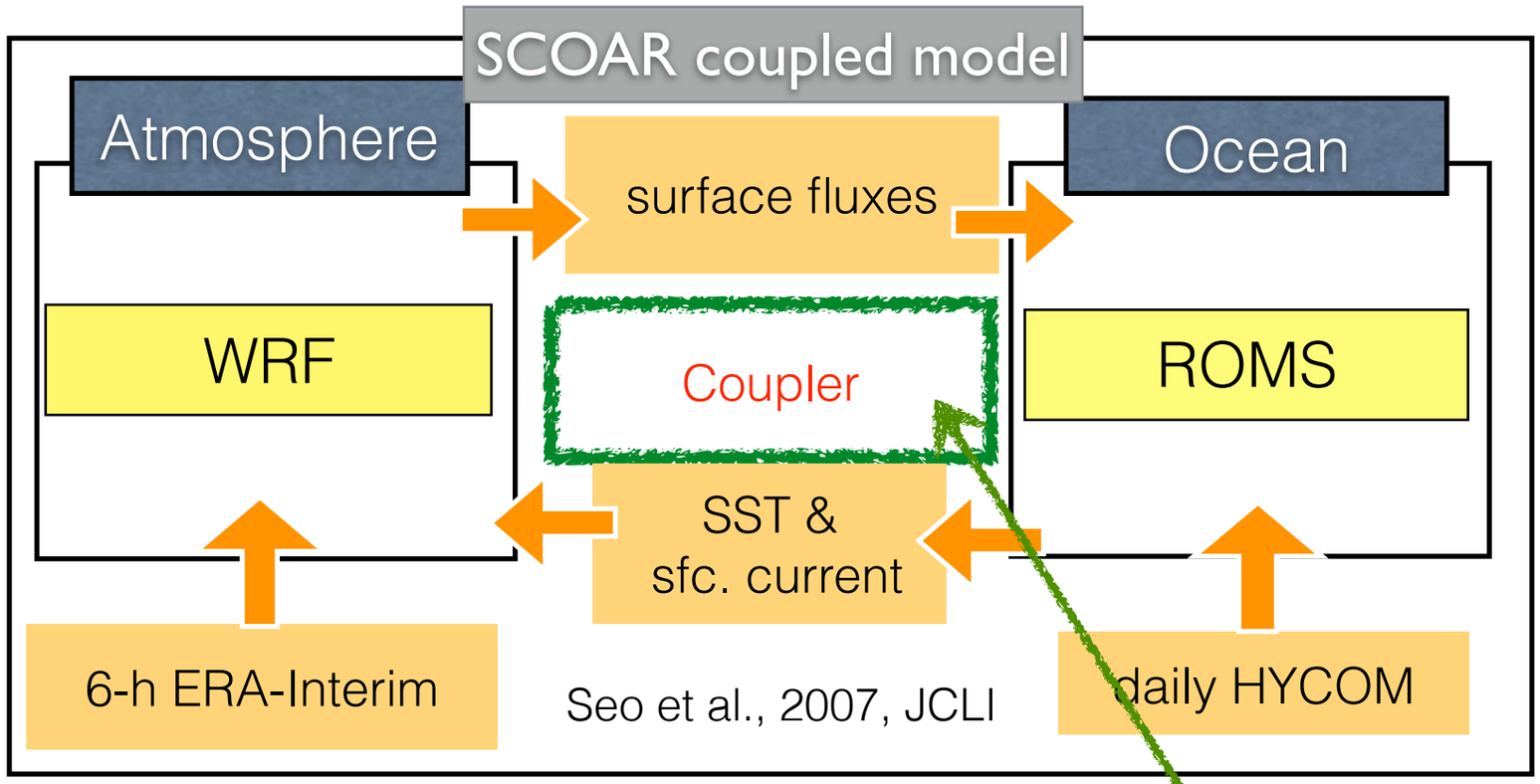
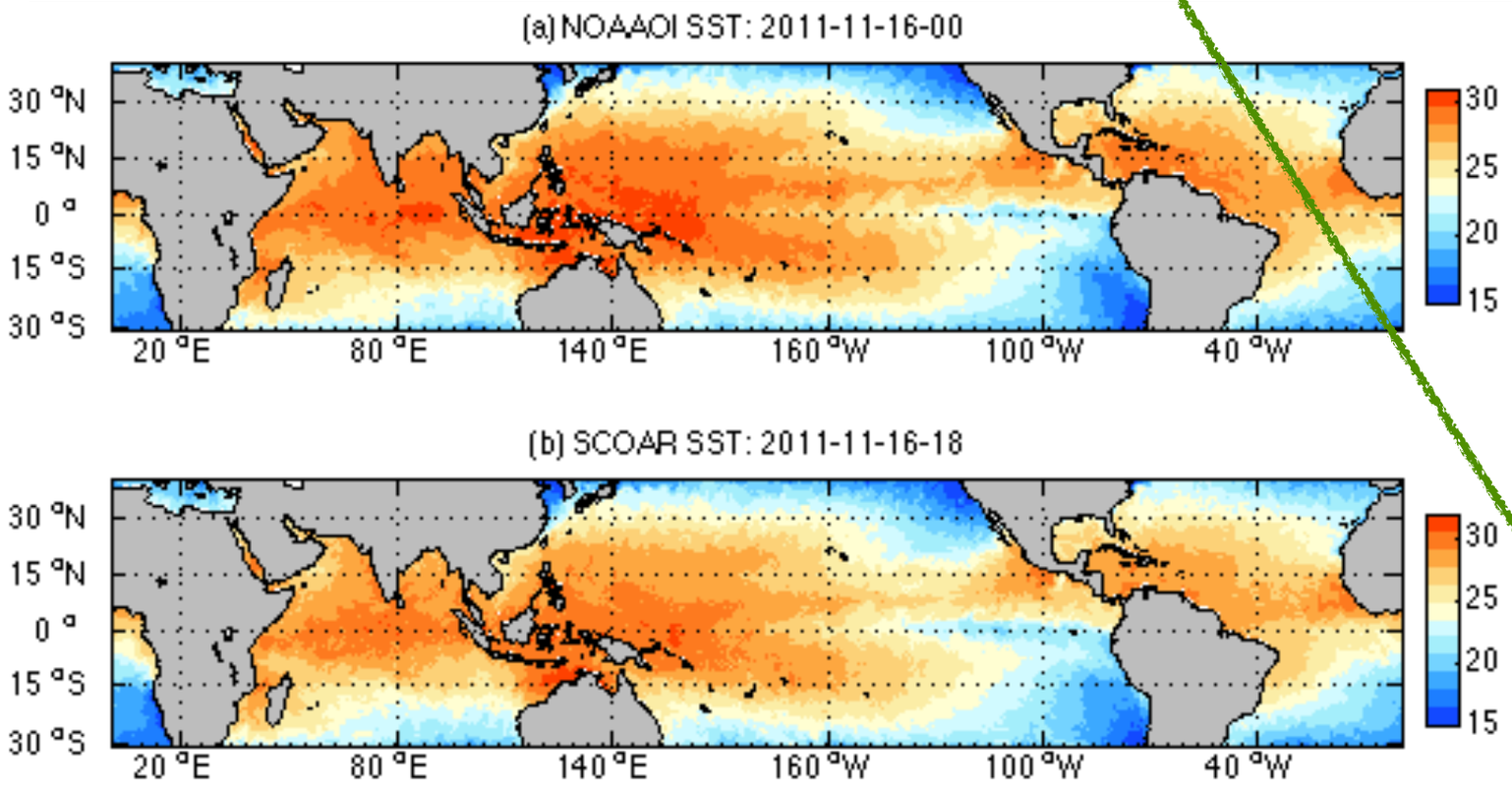
- Diurnal warm layer thickness of ~1 to 5 m
- >0.1°C temperature difference across the diurnal warm layer

What is the effect of SST diurnal cycle on MJO?

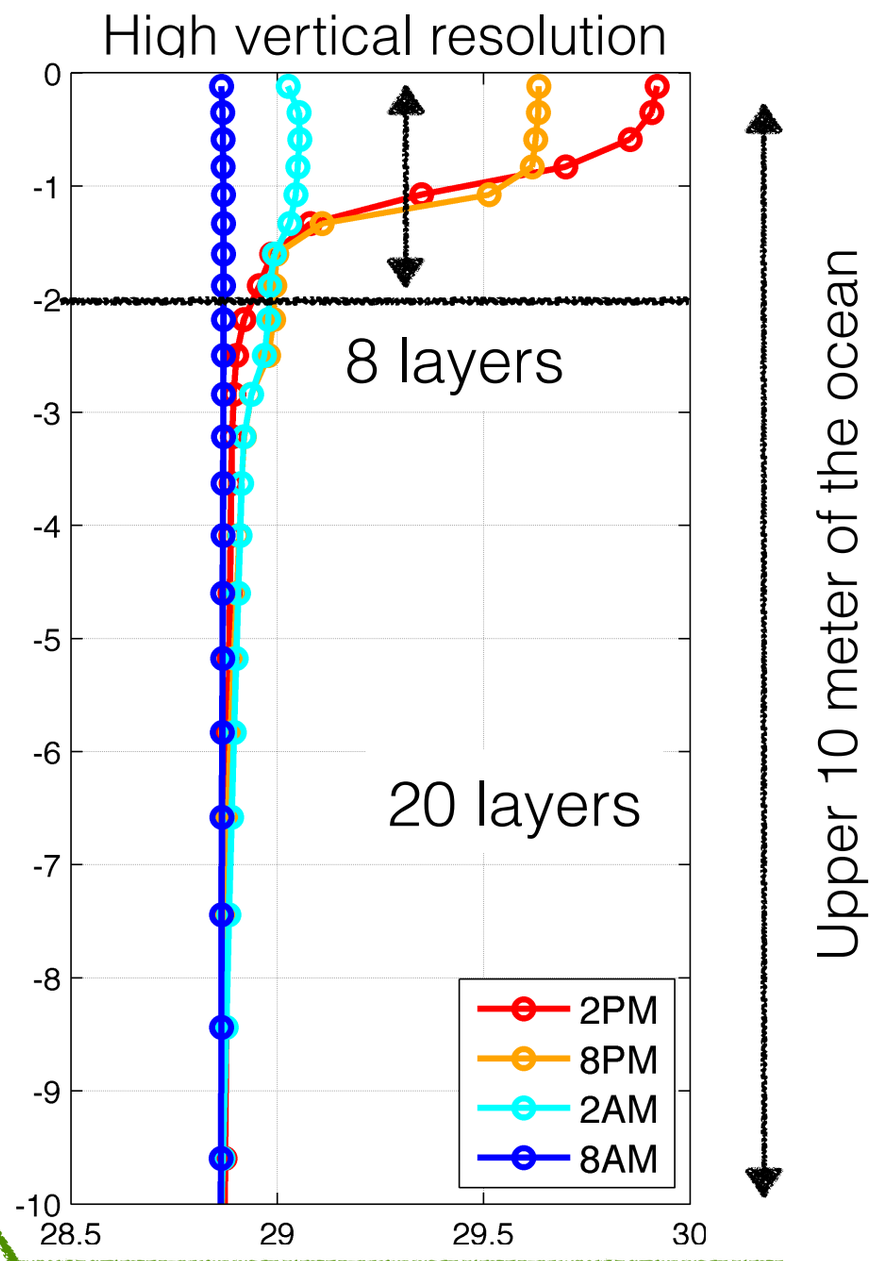
Numerical model experiments: forcing frequency & vertical resolution (e.g. Bernie et al. 2005)





Seo et al. 2014 JCLI

40km resolution tropical channel regional coupled model



Coupling frequency
CF1, CF3, CF6, CF24

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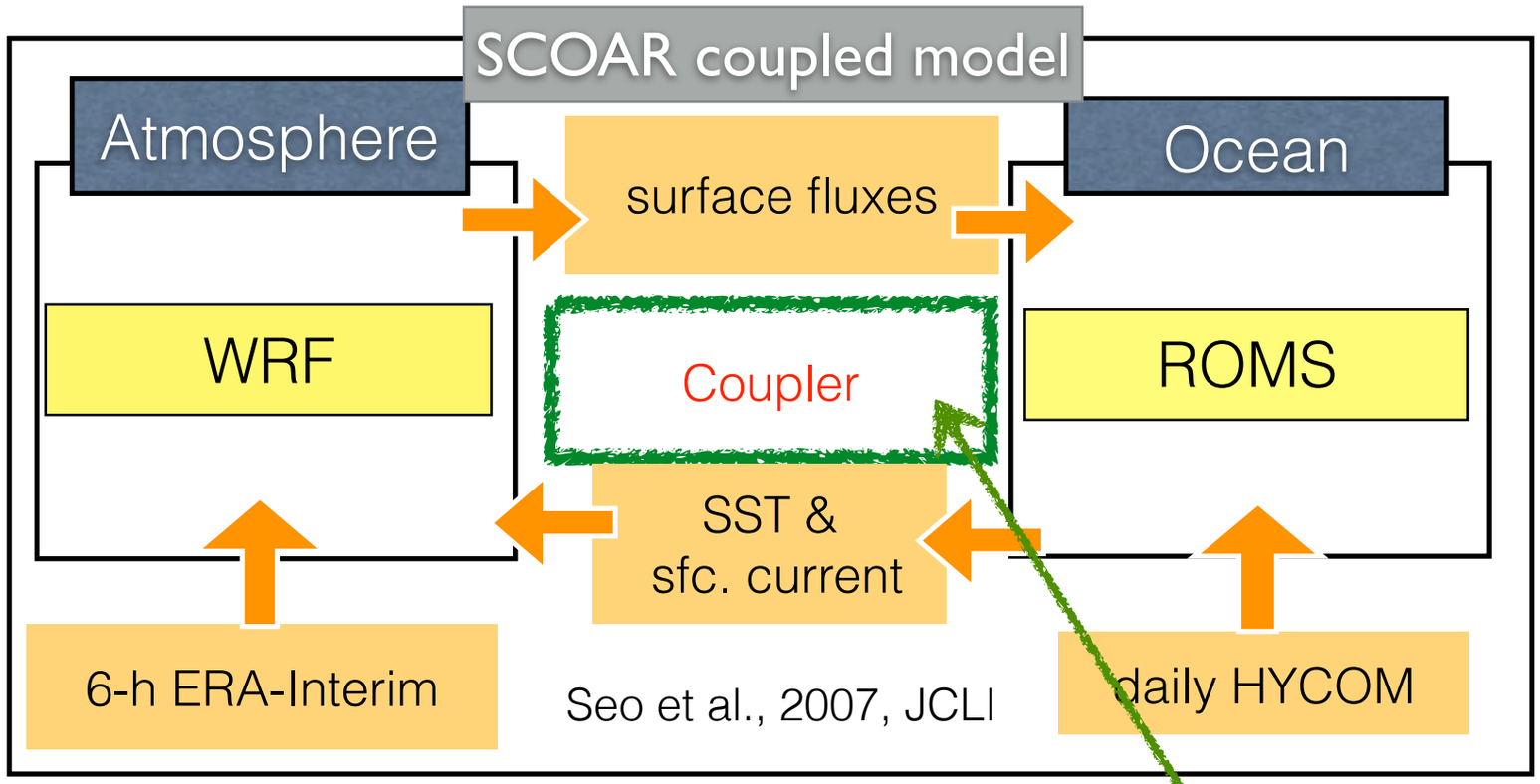

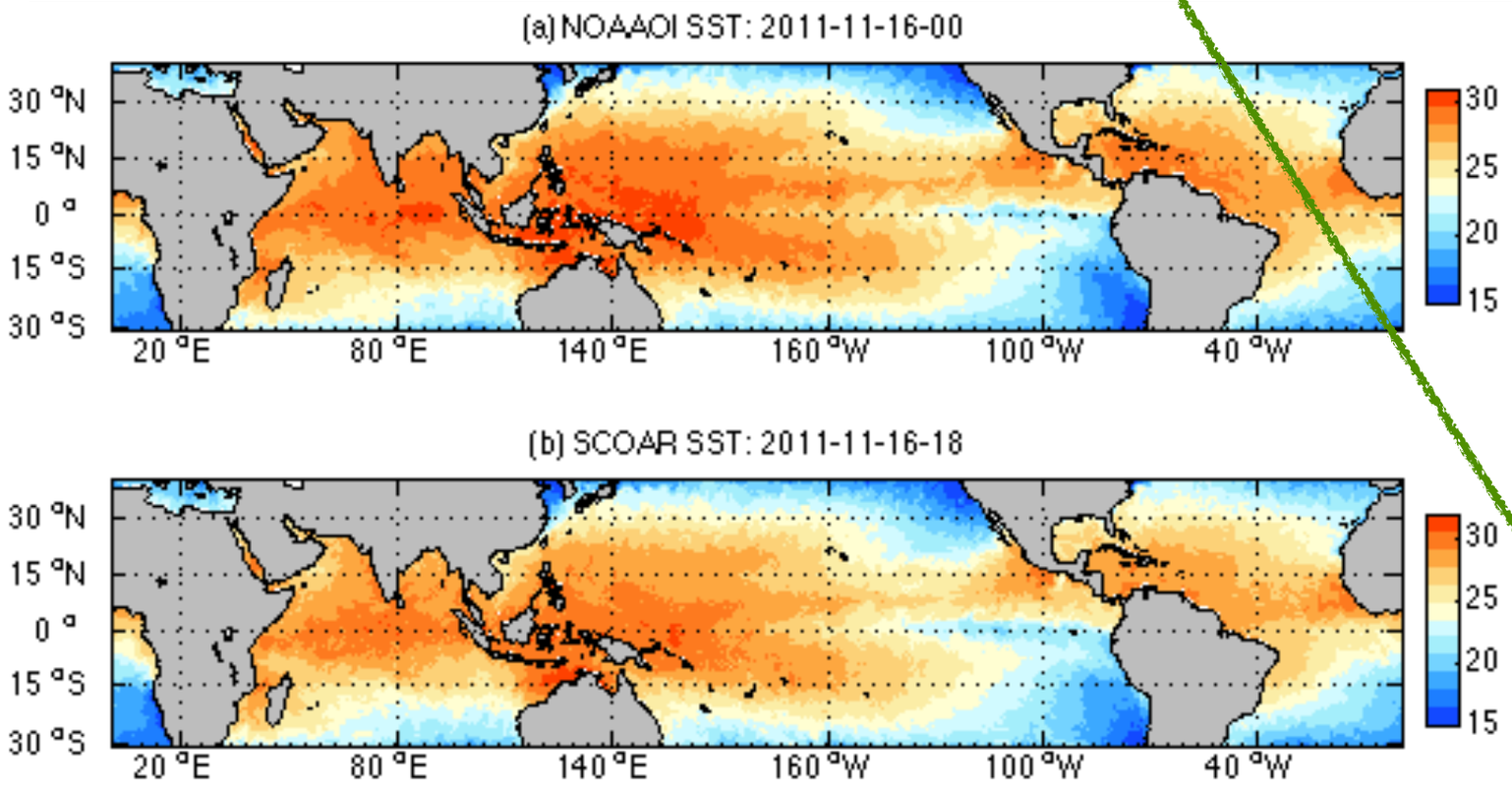

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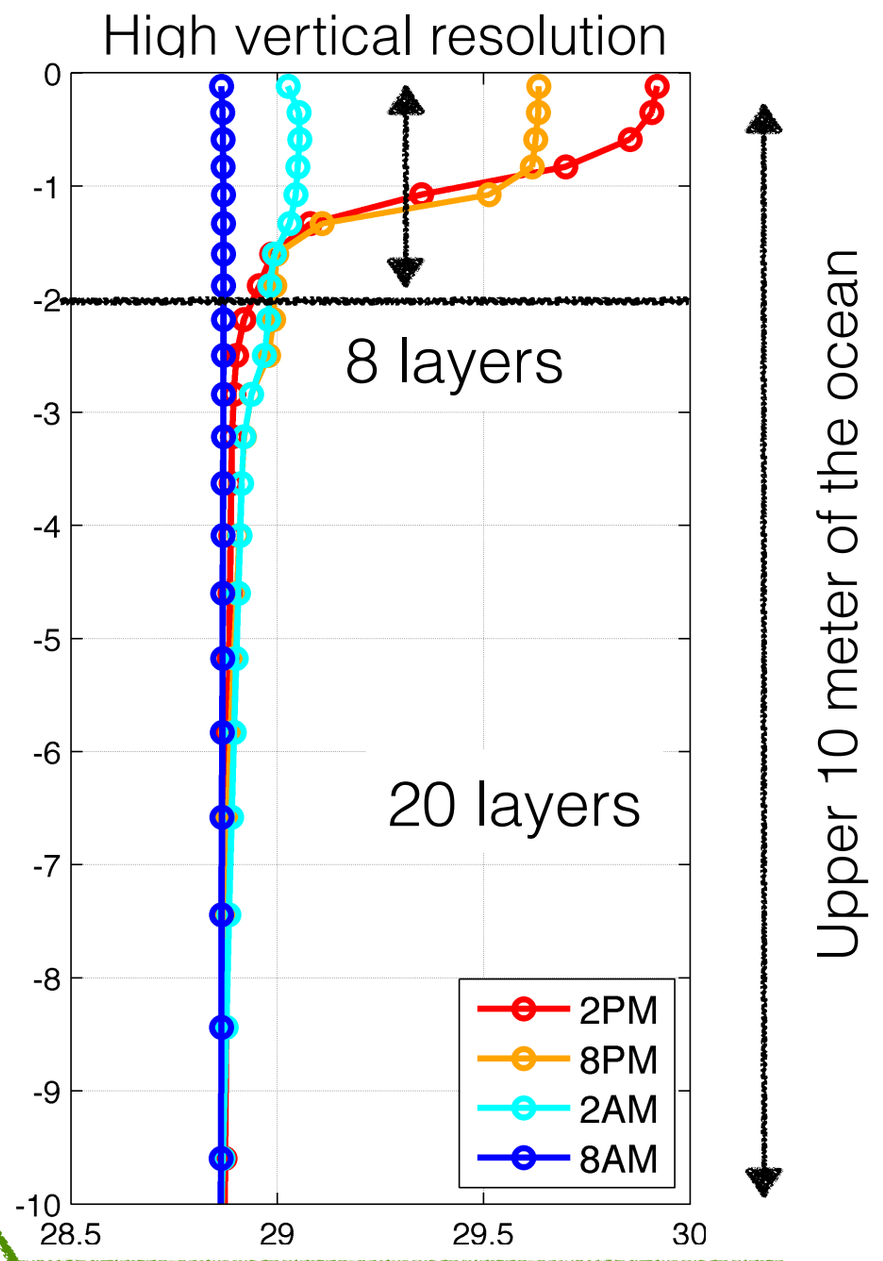

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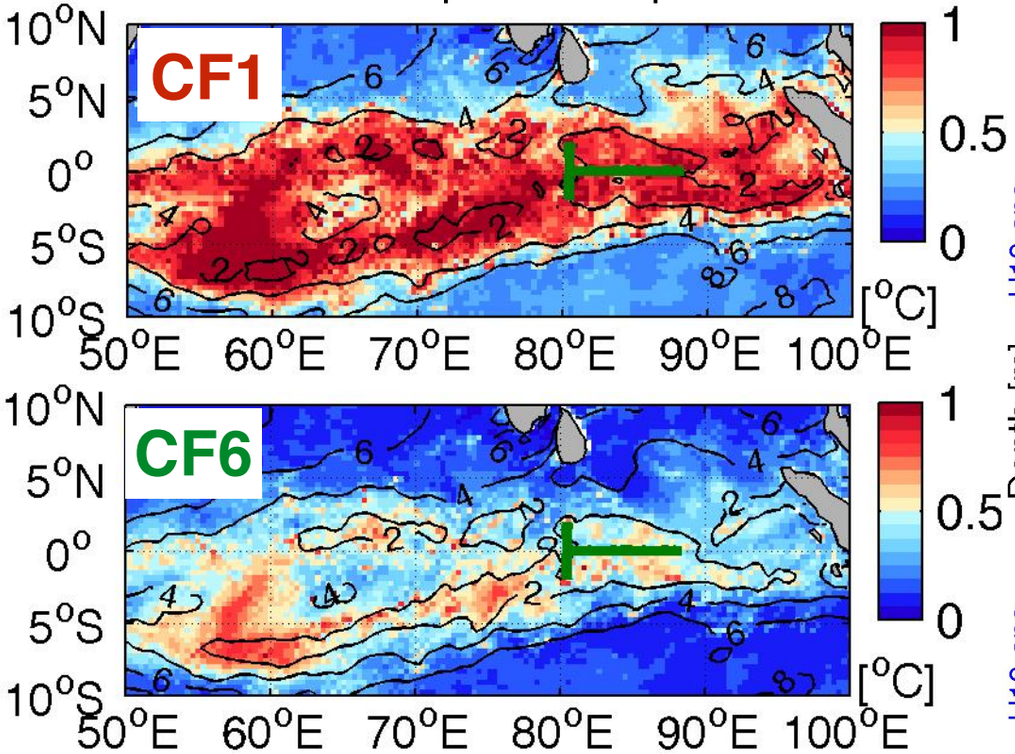
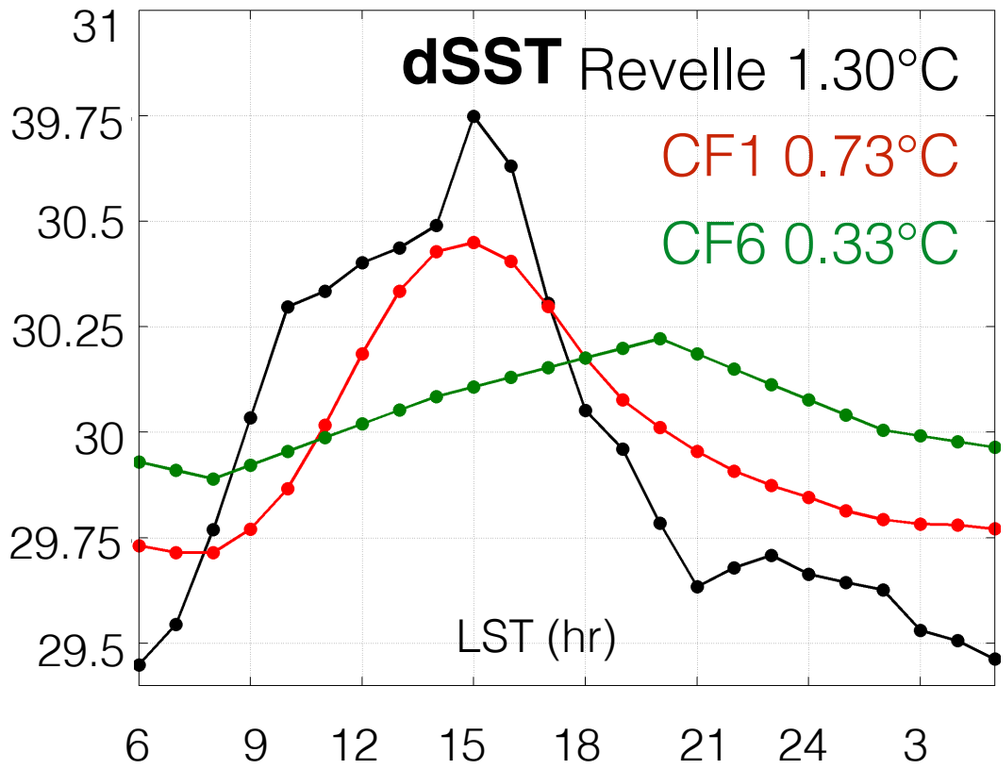
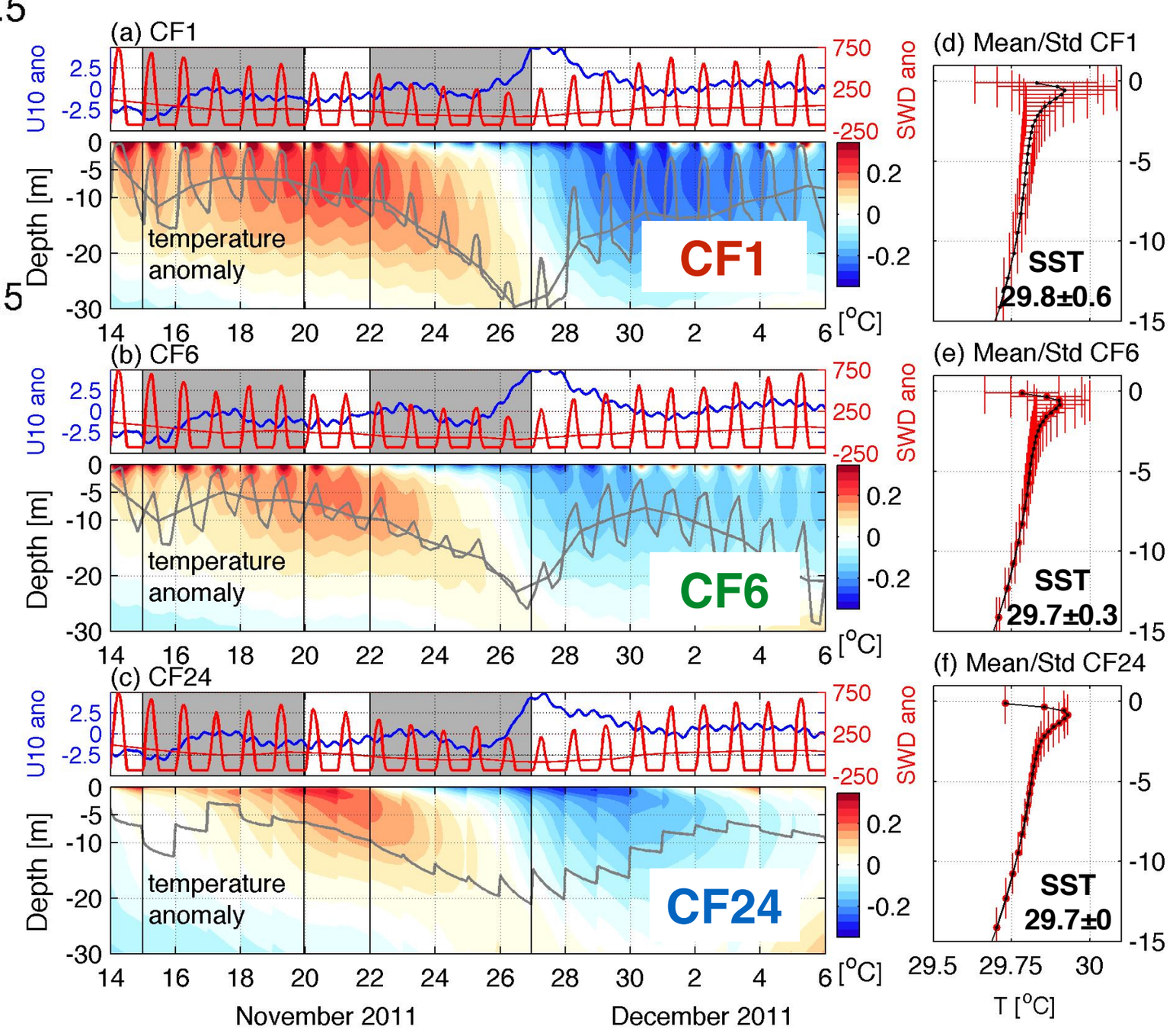
Diurnal SST raises the *time-mean SST* prior to the deep convection

diurnal SST amplitude prior to MJO2



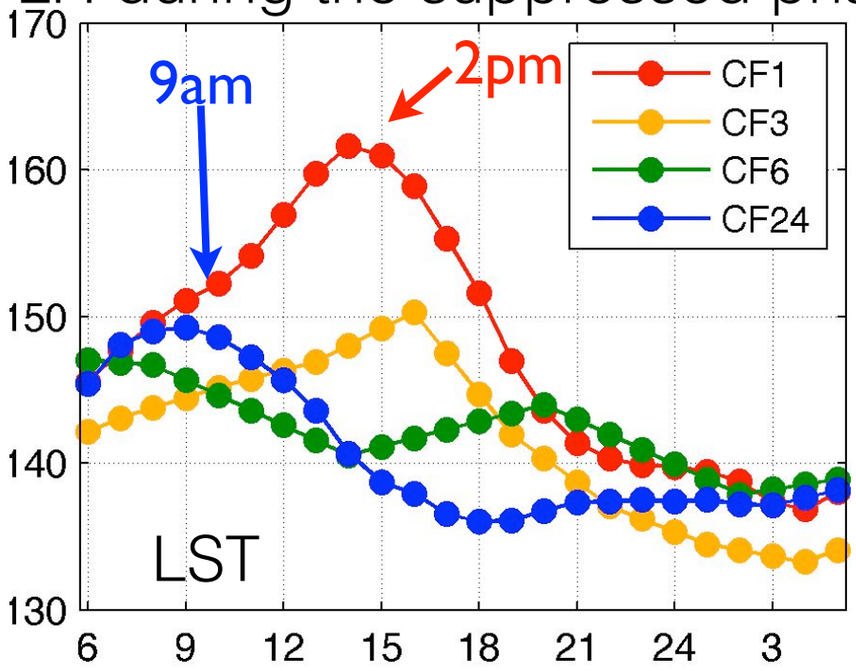


Upper ocean temperature evolution



Diurnal SST strengthens the *diurnal moistening* of the atmosphere

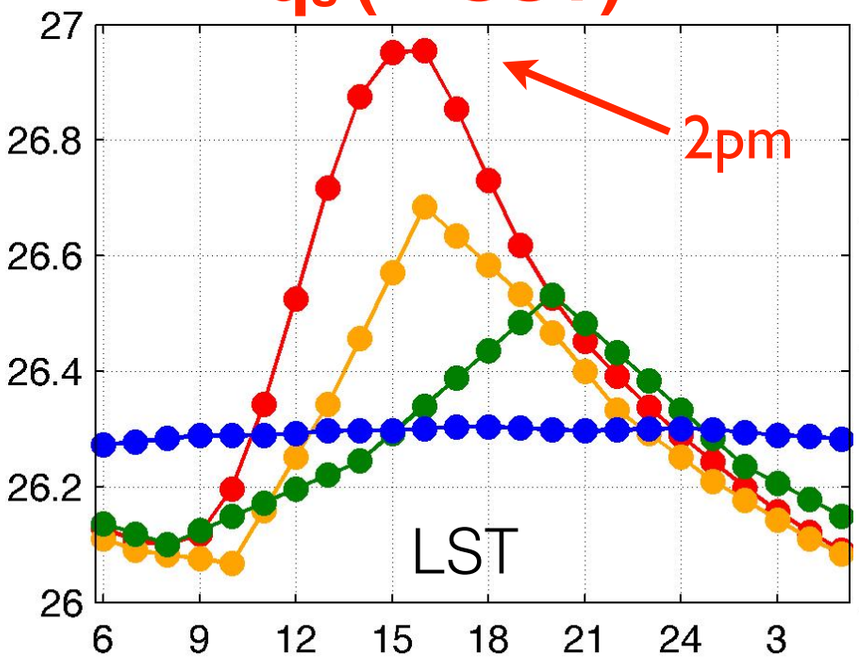
LH during the suppressed phase



	Mean LH	dLH
CF1	104	30.2
CF3	99	24.6
CF6	98	21.1
CF24	97	30.2

$LH=\rho L C_H(q_s-q_a)W_{10}$

q_s (←SST)



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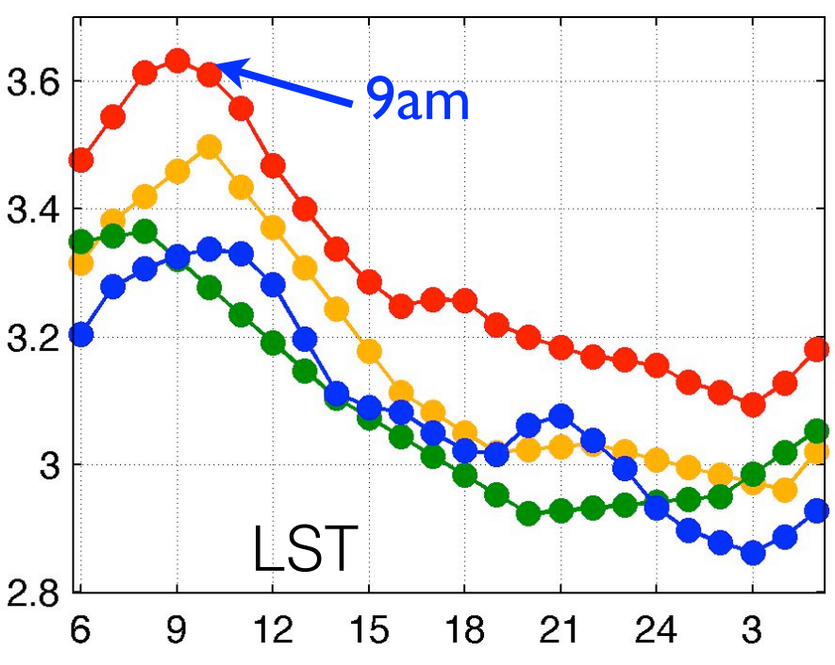
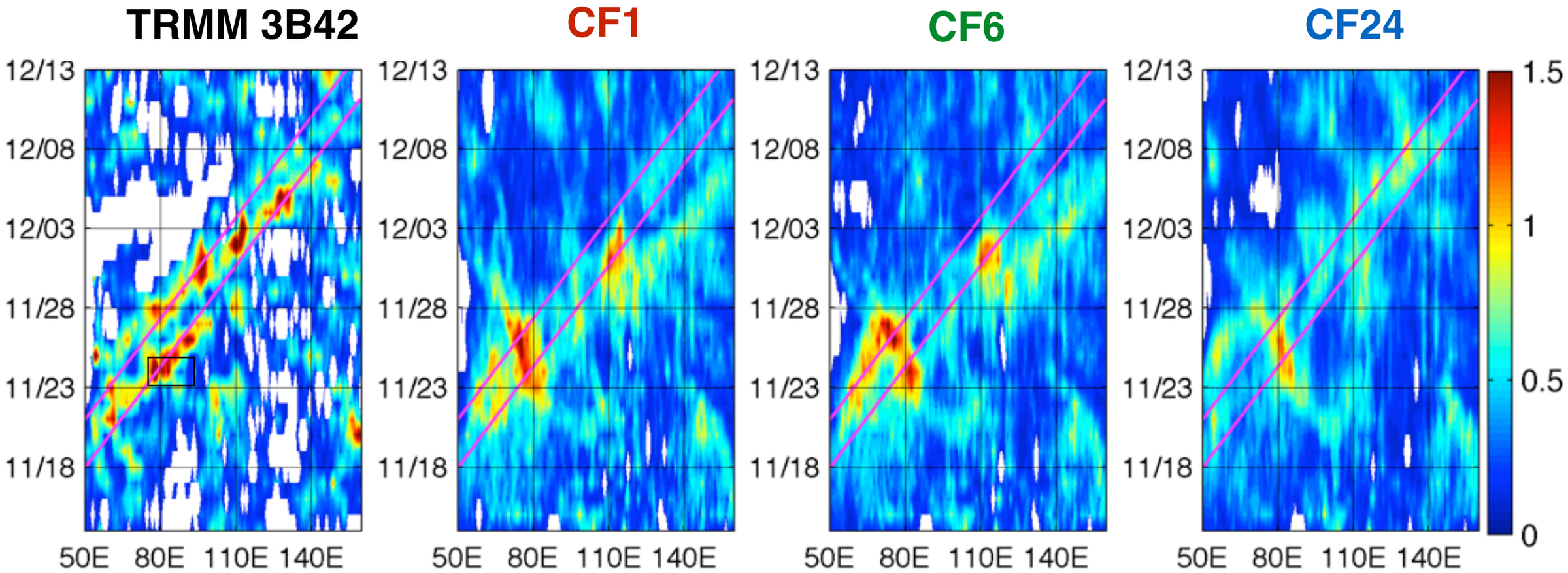


Diurnal q_s plays a leading role in maximizing the moistening the troposphere

Impact on MJO rainfall:

Rainfall intensity proportional to pre-convection diurnal SST



- MJO 2 on Nov. 24 with the eastward propagation ~5 ms^{-1}.
- Models: qualitatively consistent intraseasonal evolution of rainfall
  - Higher mean rainfall amount with stronger dSST.

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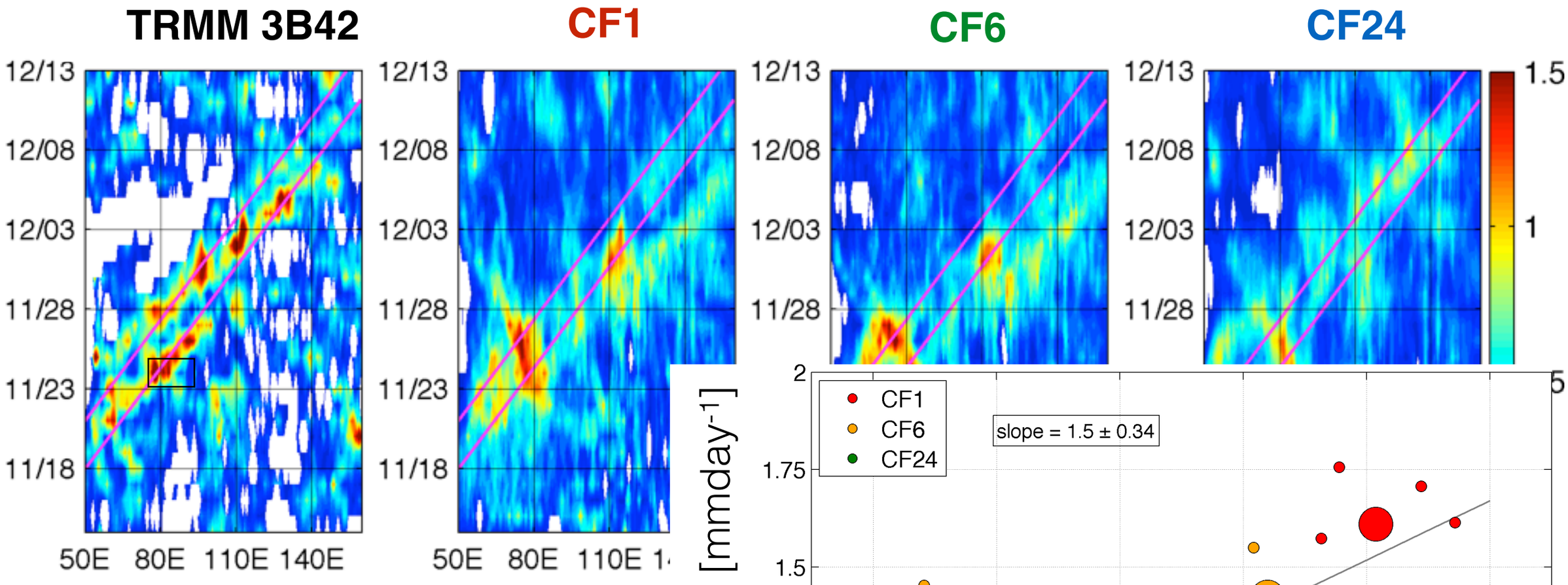

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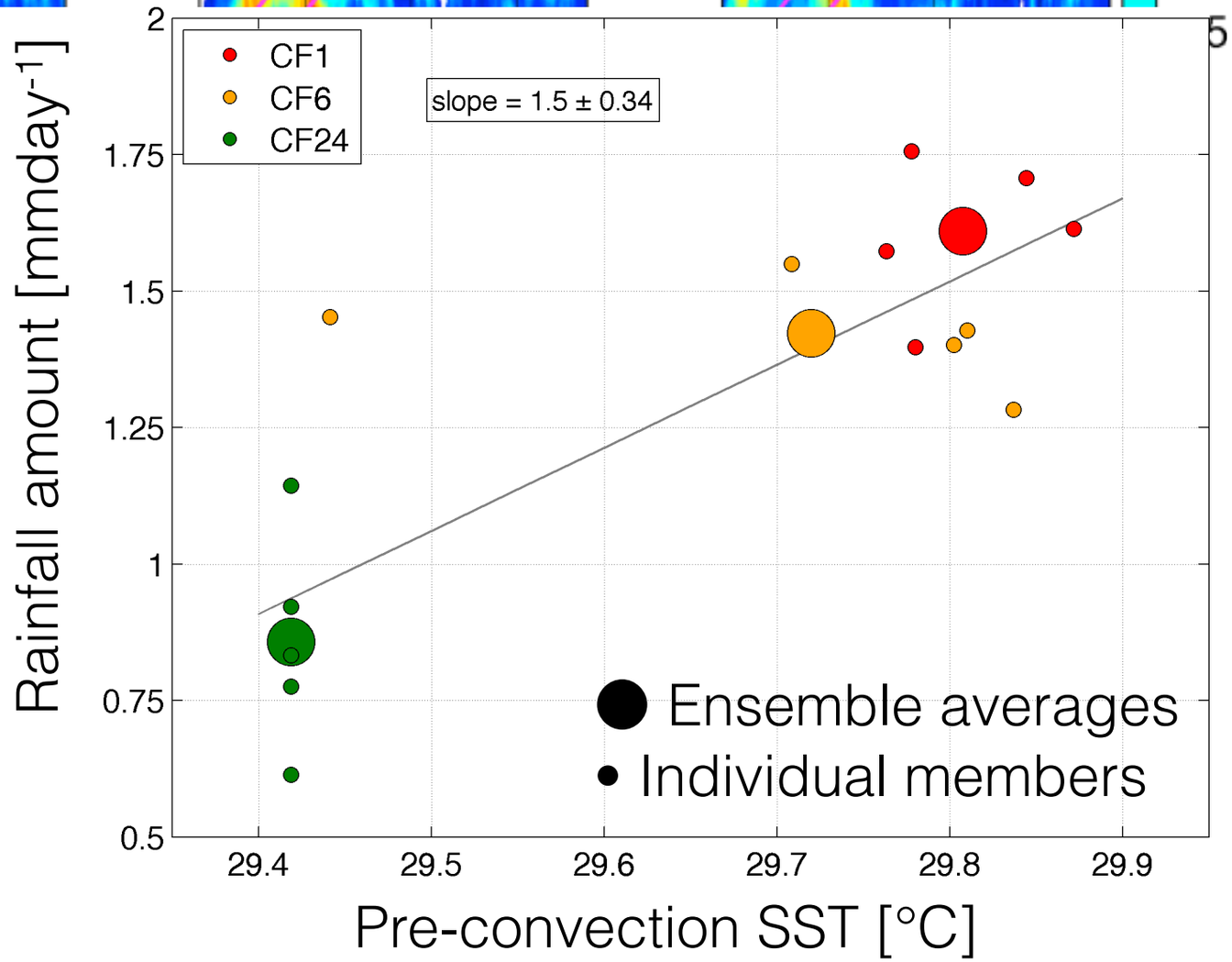


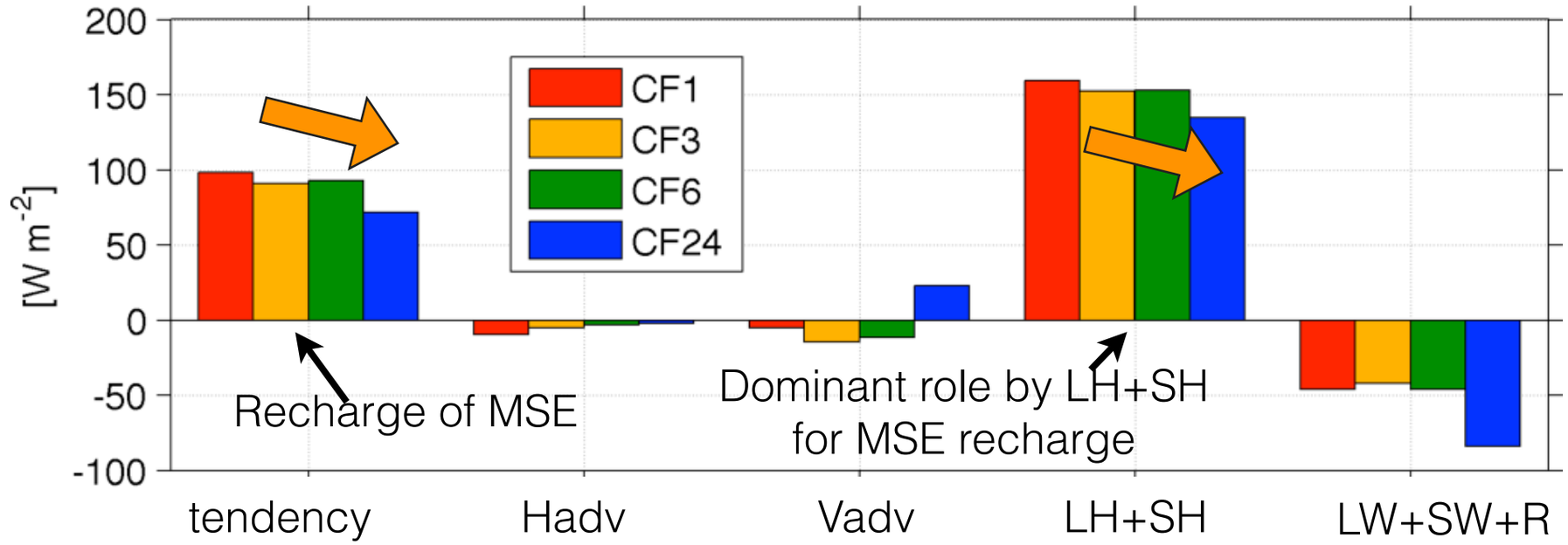
Column-integrated moist static energy (MSE) budget

$$\underbrace{\langle m_t \rangle}_{\text{tendency}} = \underbrace{-\langle v_h \cdot \nabla m \rangle}_{\text{Hadv}} \underbrace{-\langle \omega m_p \rangle}_{\text{Vadv}} \underbrace{+(LH + SH)}_{\text{LH+SH}} \underbrace{+\langle LW + SW \rangle}_{\text{LW+SW}}$$

$$m = c_p T + gz + Lq$$

Maloney 2009

prior to the convection



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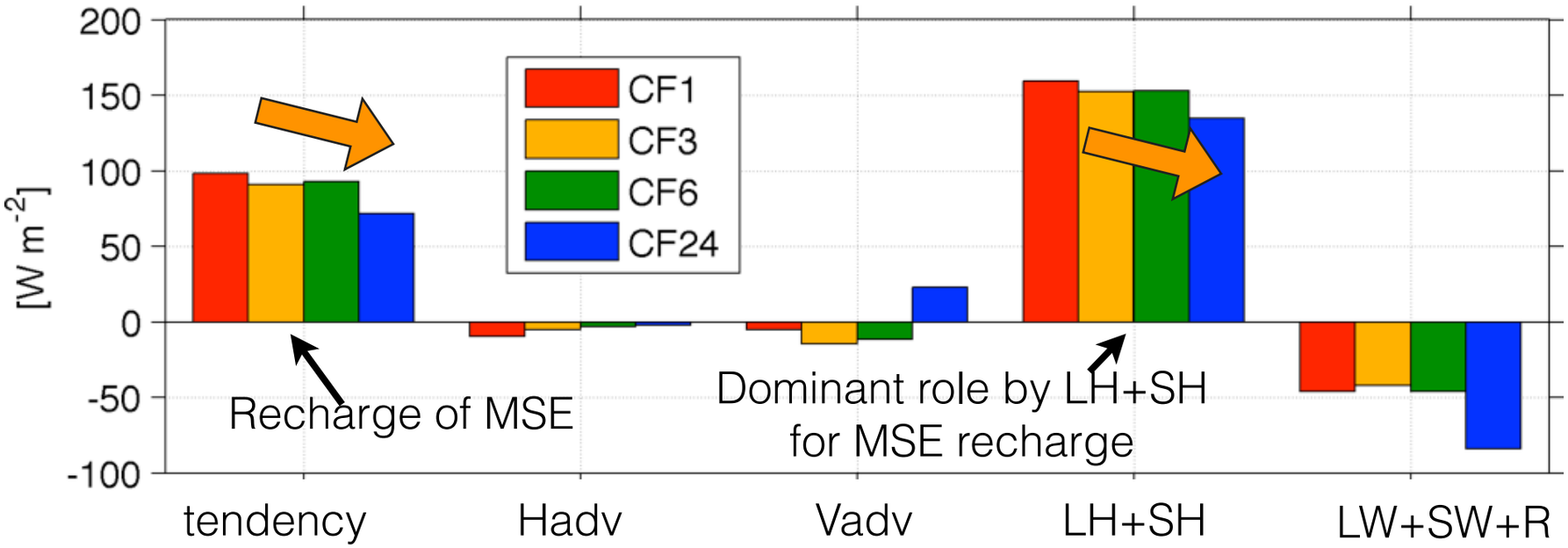
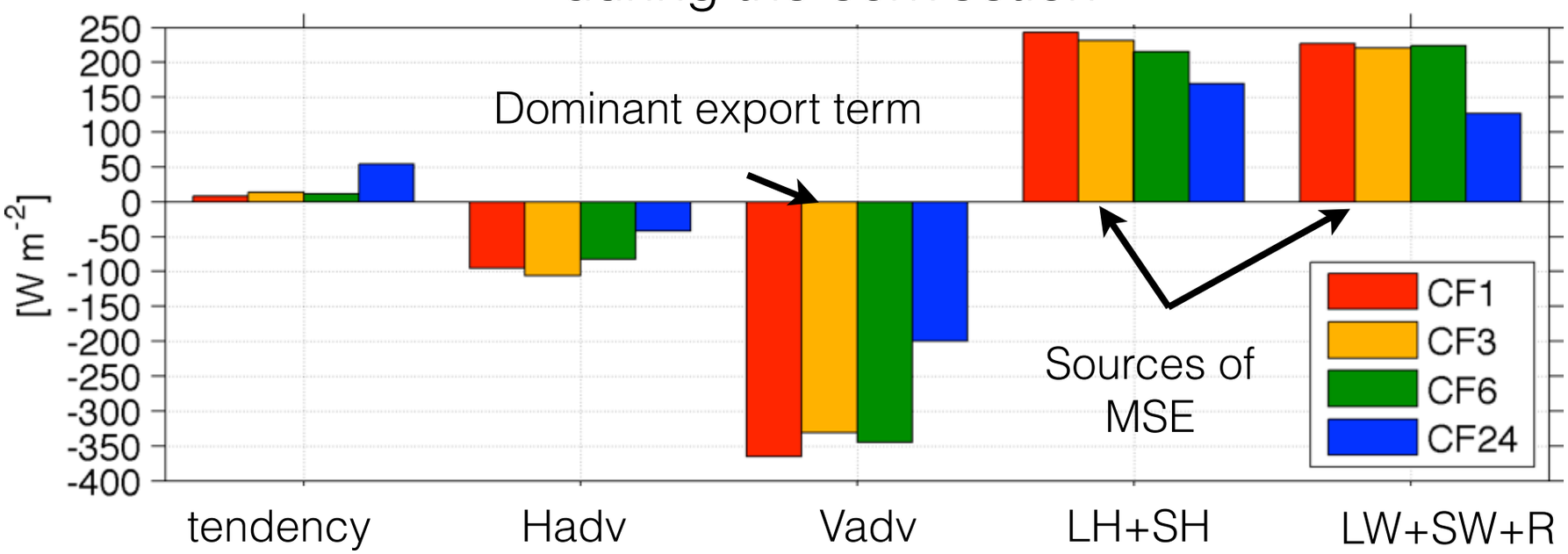


during the convection



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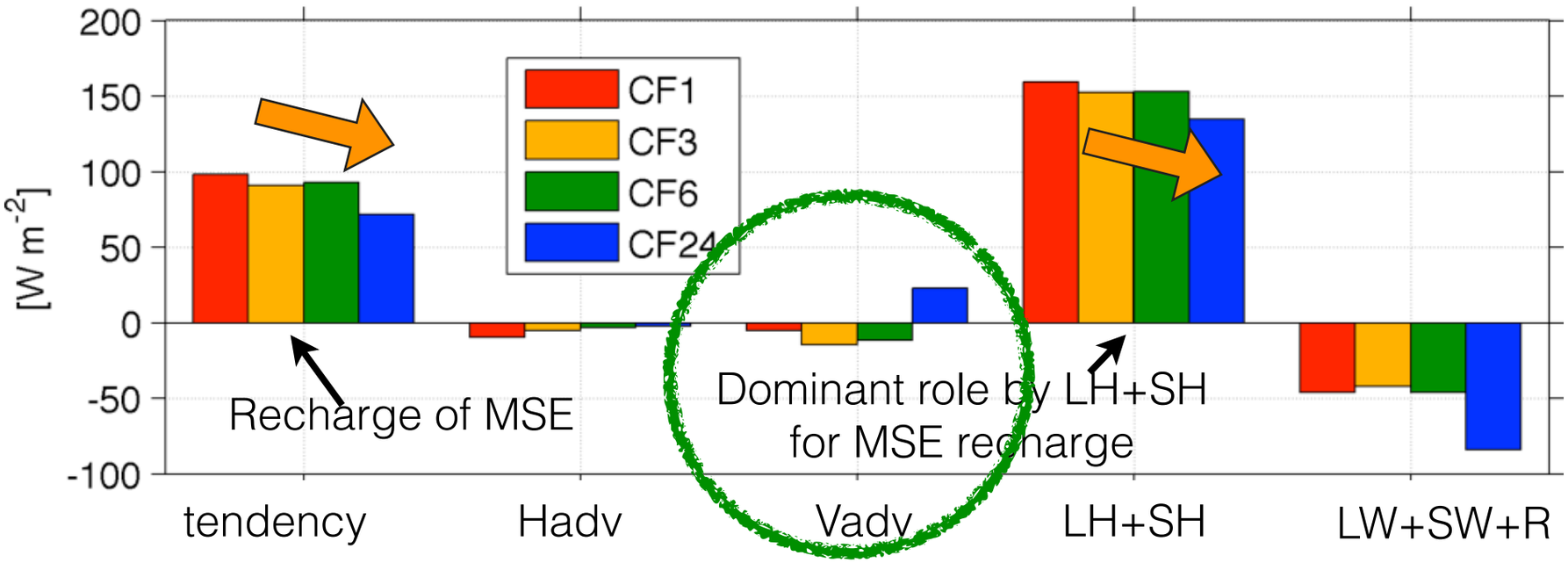

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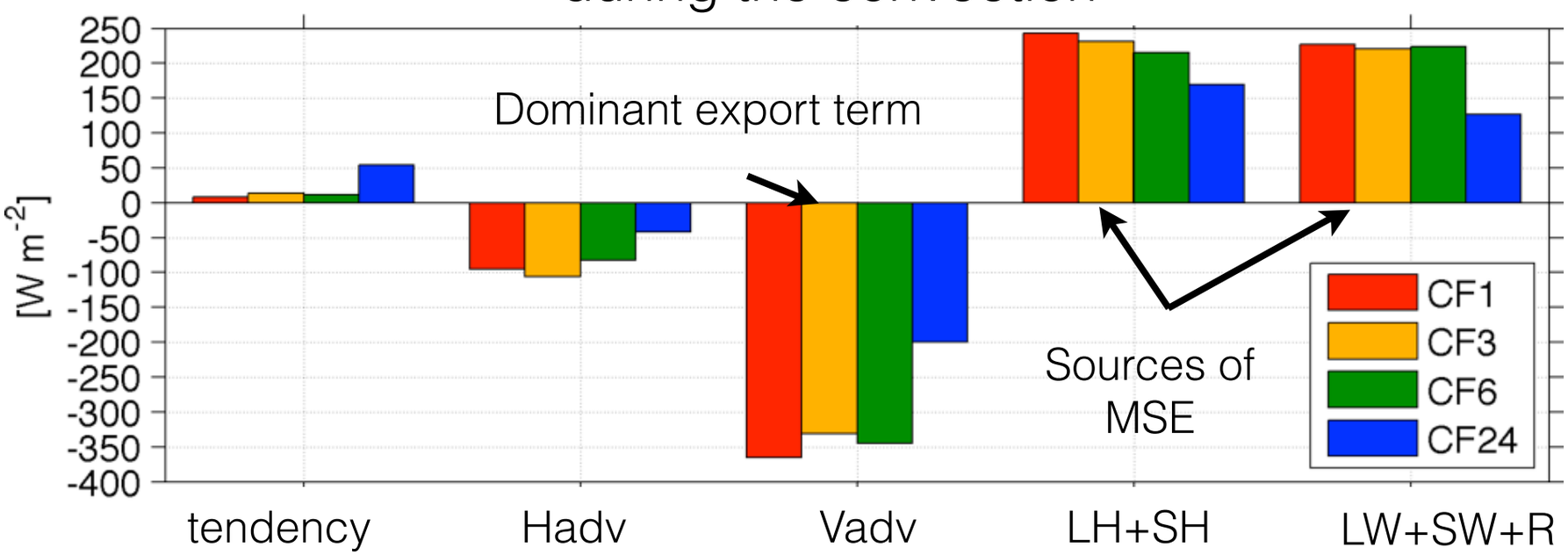
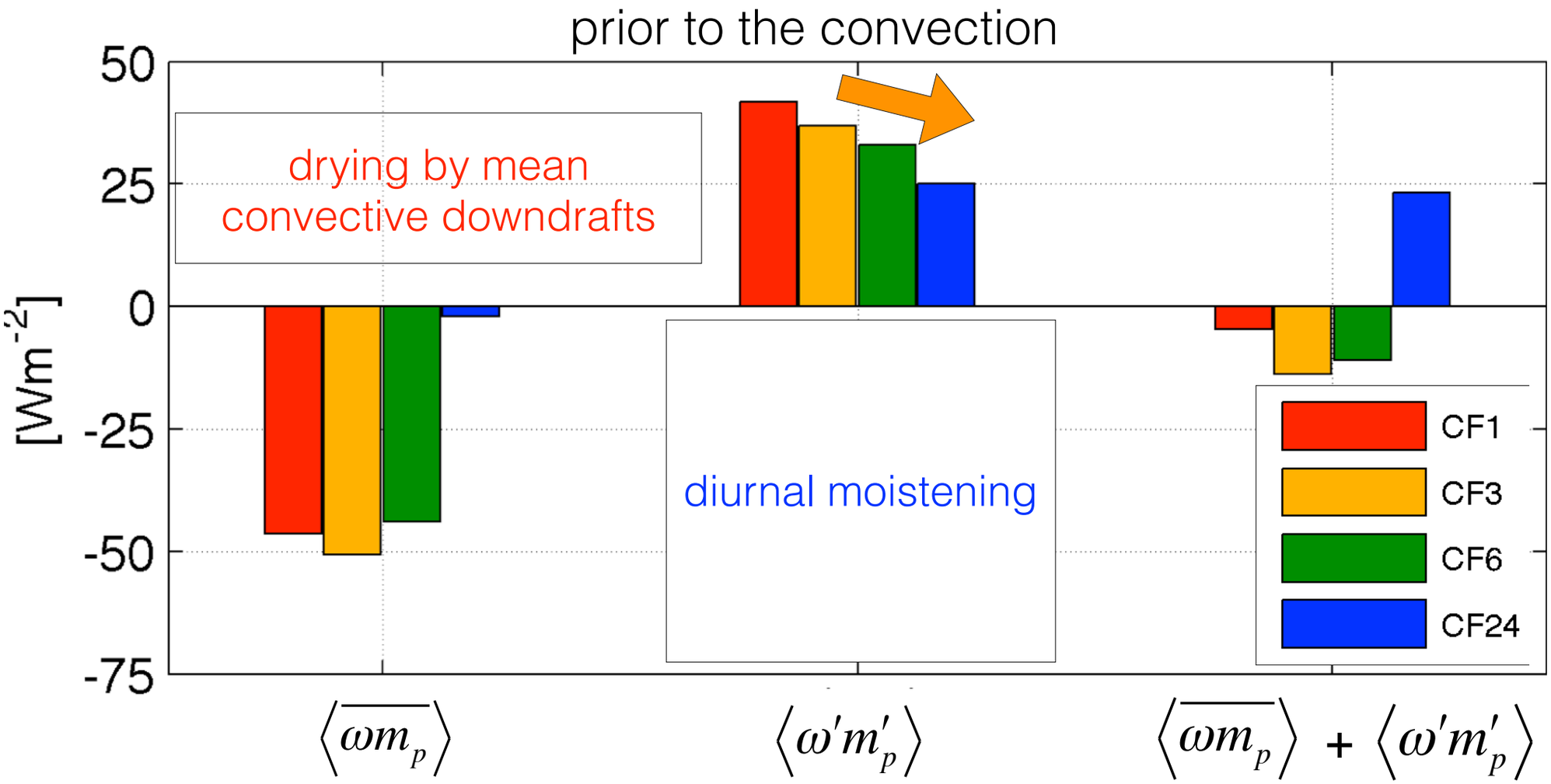


Diurnal moistening of the lower troposphere

$$\left\langle \omega m_p \right\rangle = \left\langle \overline{\omega m_p} \right\rangle + \left\langle \overline{\omega' m'_p} \right\rangle$$



- The daily mean advection dries the air column; not related to dSST
- Diurnal moistening is a source of MSE; proportional to dSST

Summary and discussion

1. SCOAR regional coupled modeling for the MJO and diurnal SST
   - Tropical channel, high vertical resolution, air-sea coupling
2. Diurnal SST variability prior to the deep convection
   - raises time-mean SST (and LH): via diurnal rectified effect
   - enhances diurnal moistening: via coincident peaks of LH & SST
3. Precipitation amount scales quasi-linearly with pre-convection diurnal SST amplitude
4. An improved representation of diurnal SST as a potential source of MJO predictability.

Thanks!

hseo@whoi.edu

Seo et al. 2014, Coupled impacts of the diurnal cycle of sea surface temperature on the Madden-Julian Oscillation. J. Climate