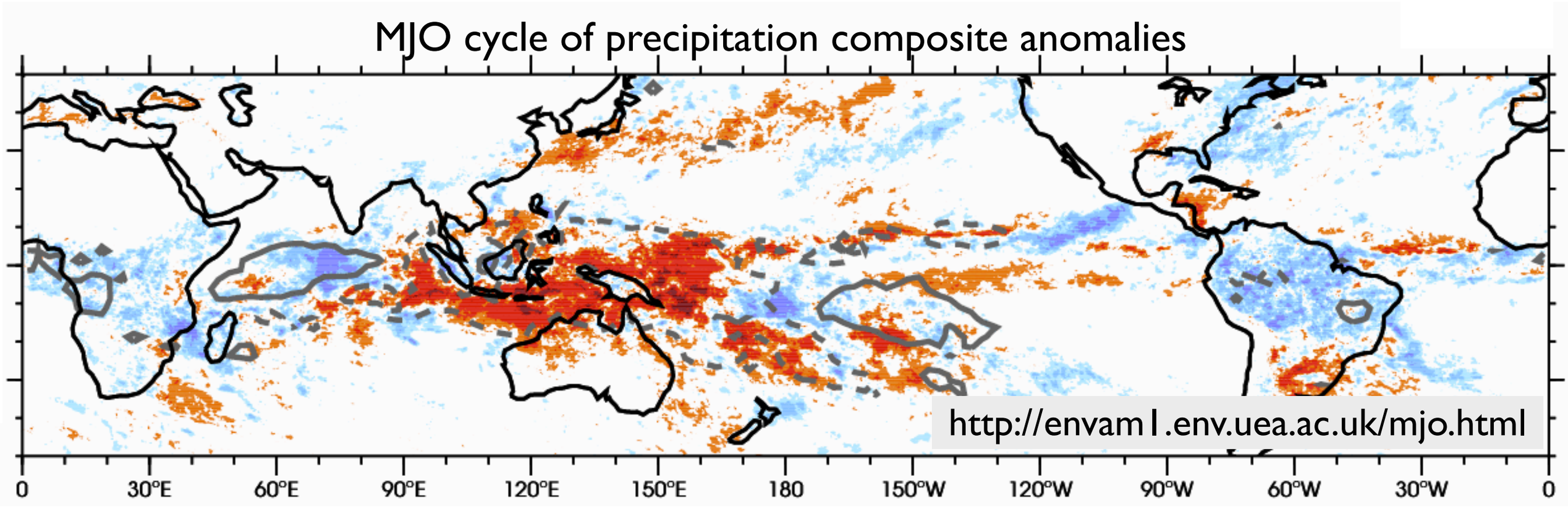
Coupled impacts of the diurnal cycle of sea surface temperature on the Madden-Julian Oscillation



- Planetary-scale, eastward propagating, equatorially-trapped, baroclinic oscillations
- 30-90 day variability & 10-30 day predictability time-scale.
- Global importance in weather and climate
- A coupled ocean-atmosphere process

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Oceanographic Institution

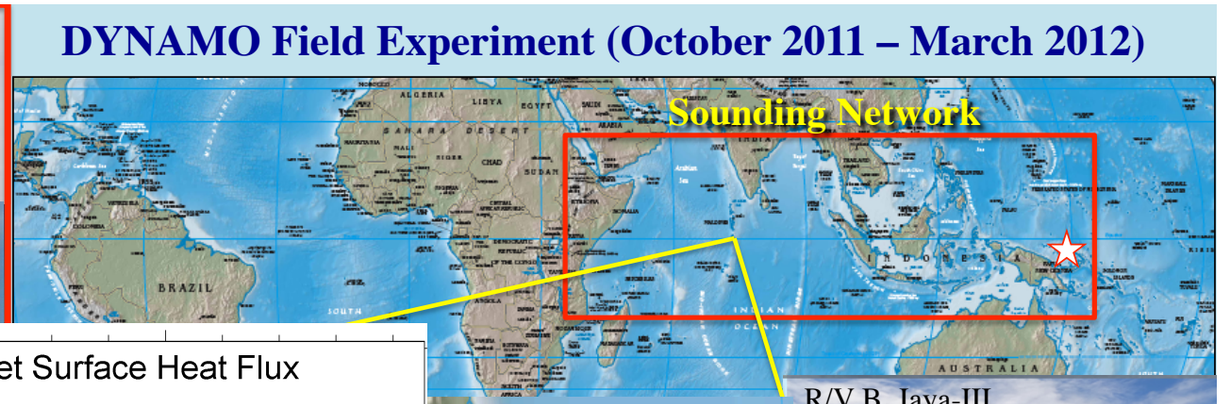
한국 해양학회
진해, 2014년 11월 7일

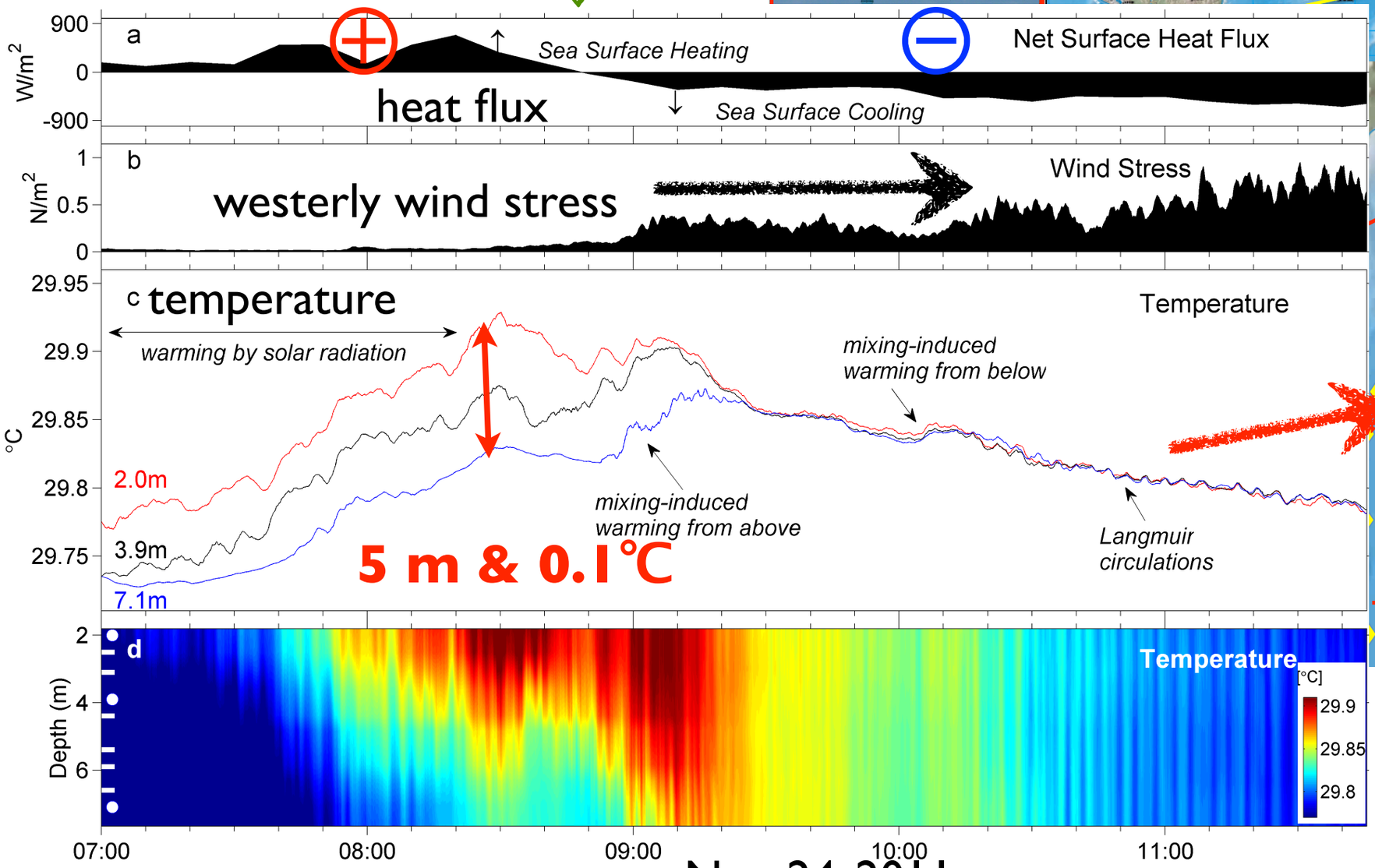
DYNAMO experiment (Dynamics of MJO):

initiation of MJO convection ↔ upper-ocean variability and air-sea flux

convection initiation

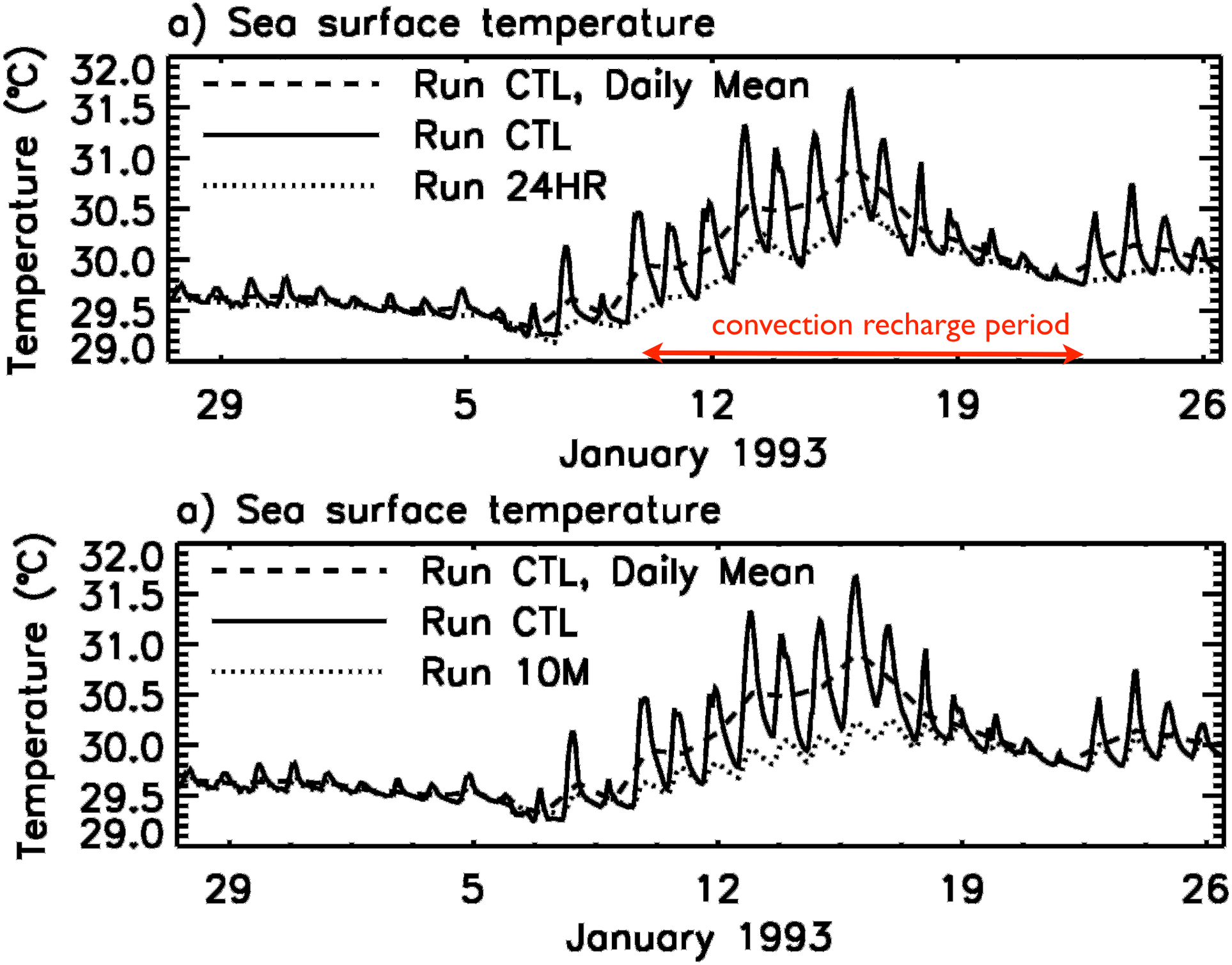
Moum et al. 2014





Chidong Zhang

Frequency of forcing & Vertical Resolution
1-D KPP modeling study (Bernie et al. 2005)

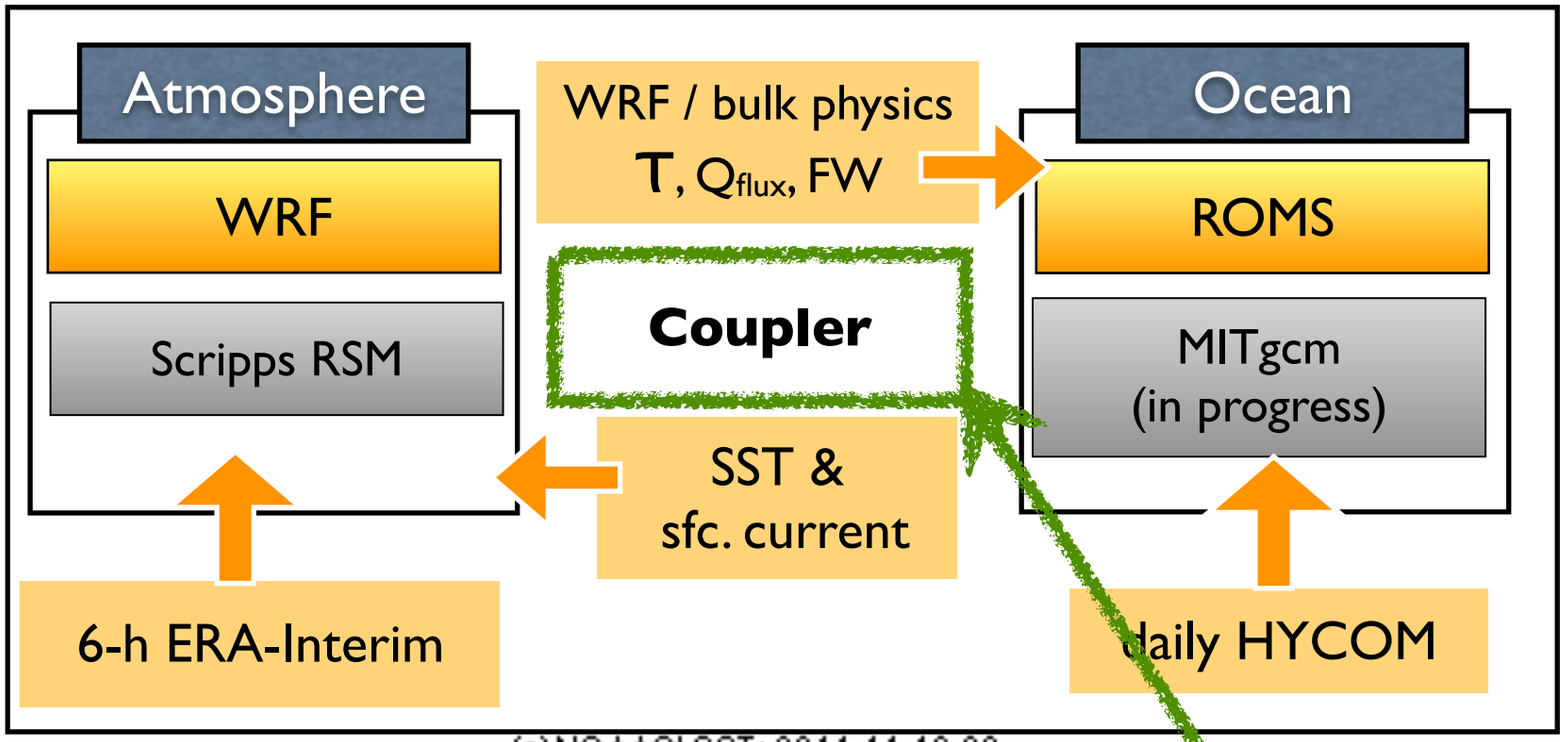


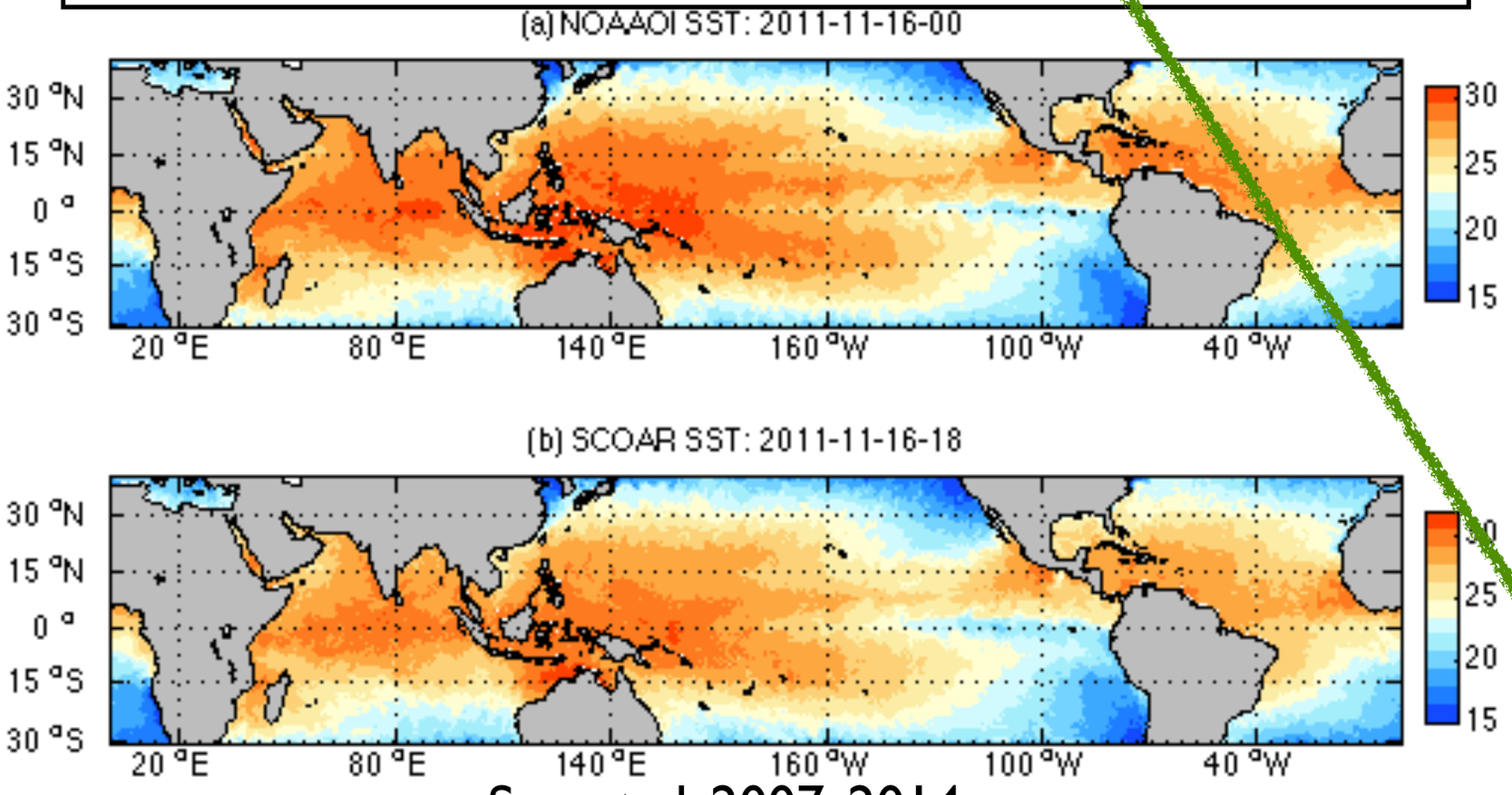
Forcing frequency
3h vs 24h

Vertical resolution:
1m vs 10m

Modeling of diurnal cycle of SST and the MJO

Scripps Coupled Ocean-Atmosphere Regional (SCOAR) model

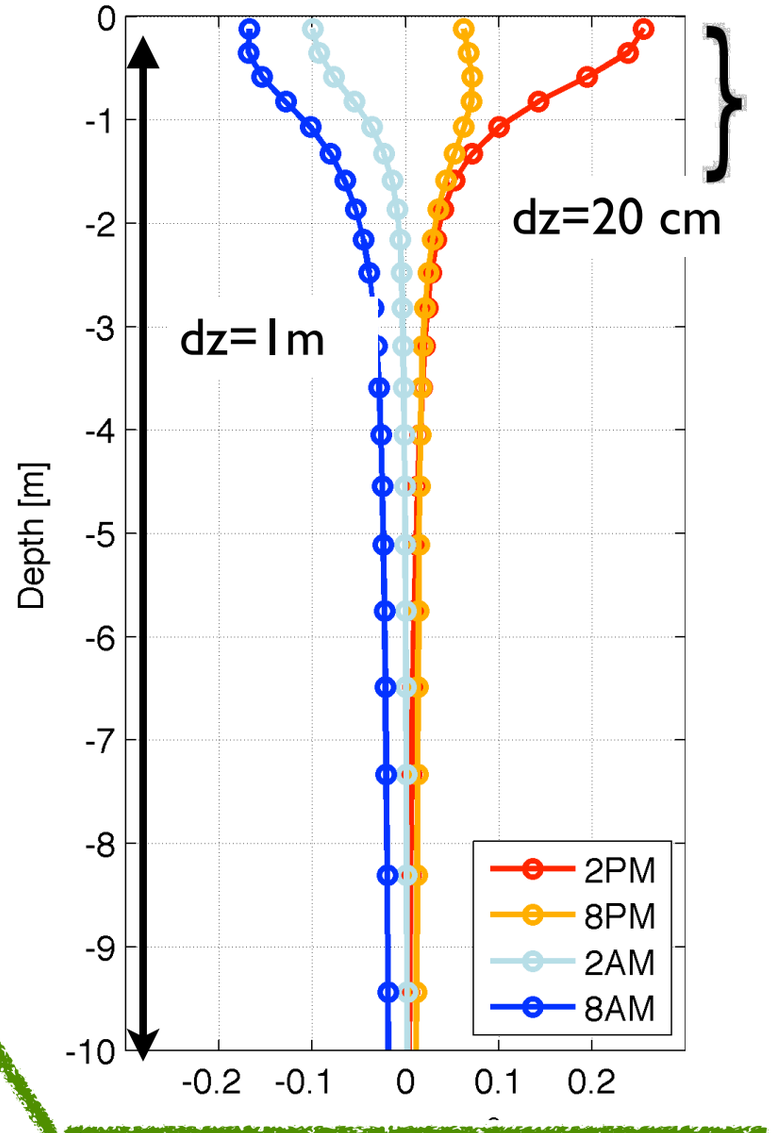




Seo et al. 2007; 2014

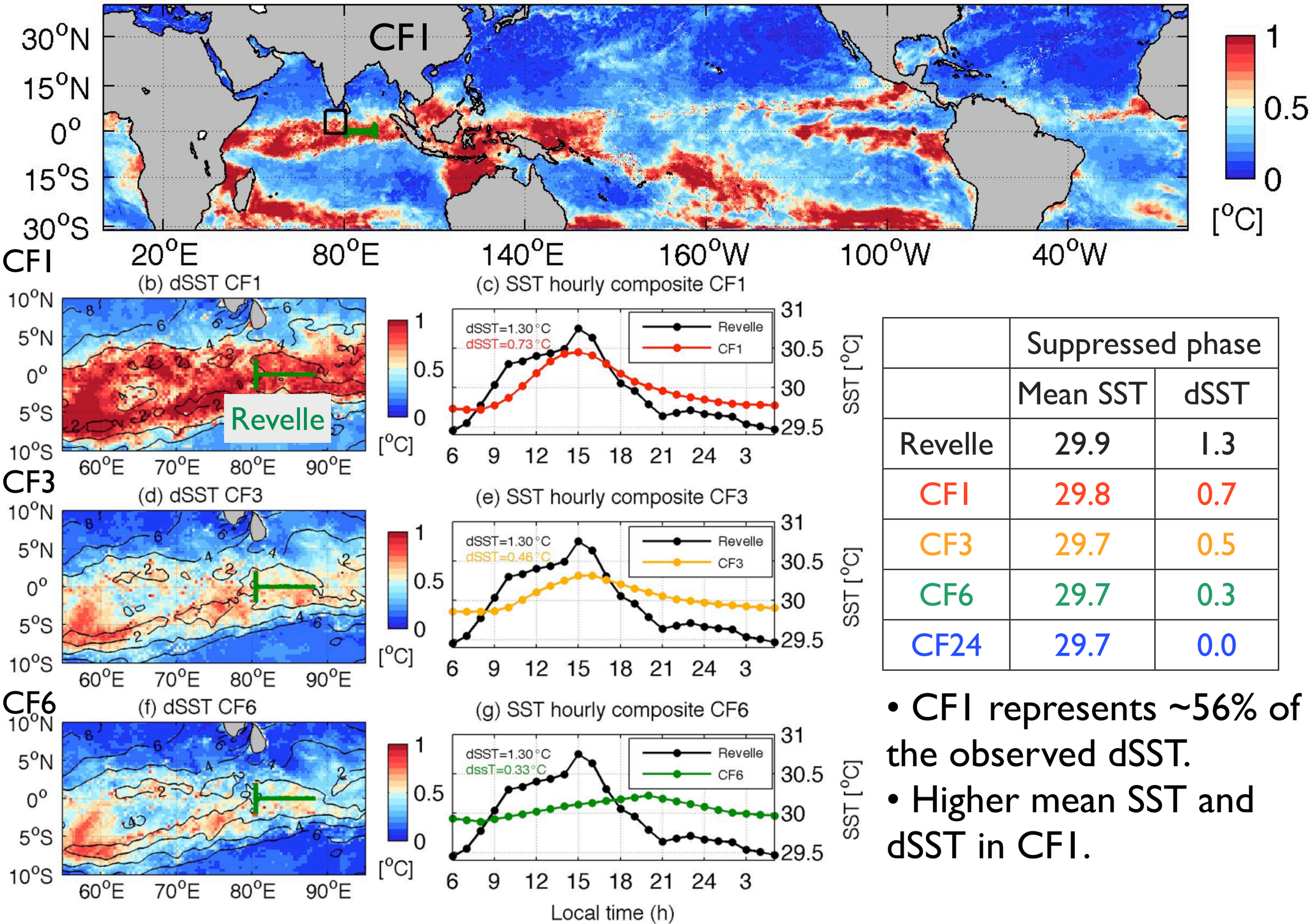
40km matching resolution in a tropical channel configuration

High vertical resolution



Coupling frequency
CF1, CF3, CF6, CF24

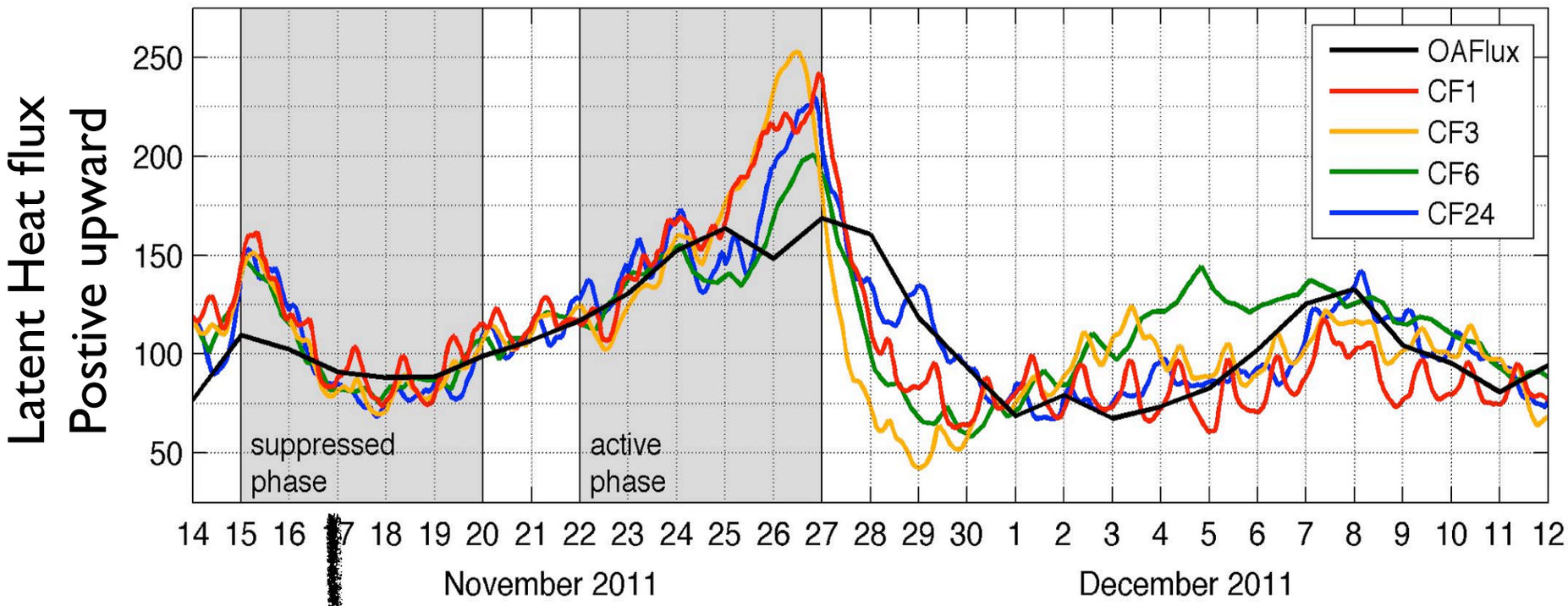
Diurnal SST amplitude prior to the deep convection



	Suppressed phase	
	Mean SST	dSST
Revelle	29.9	1.3
CF1	29.8	0.7
CF3	29.7	0.5
CF6	29.7	0.3
CF24	29.7	0.0

- CF1 represents ~56% of the observed dSST.
- Higher mean SST and dSST in CF1.

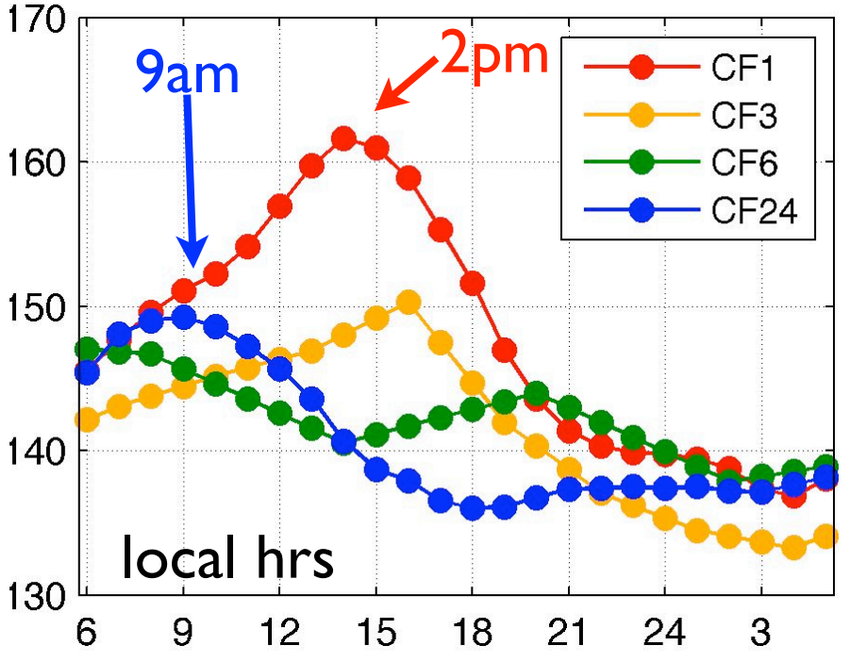
Diurnal SST and stronger moistening of the atmosphere



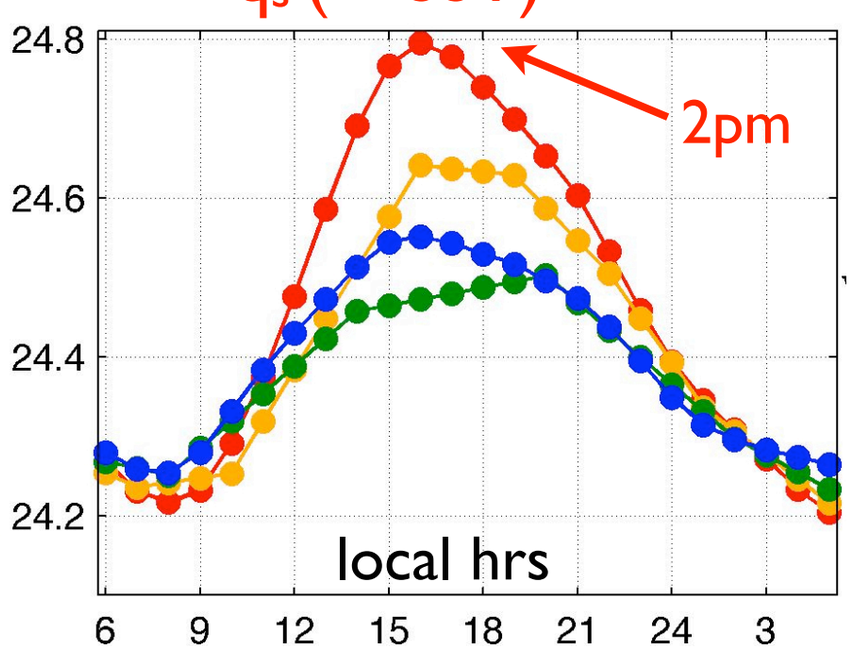
	Mean LH	dLH
OAFlux	96	N/A
CF1	104	30.2
CF3	99	24.6
CF6	98	21.1
CF24	97	30.2

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

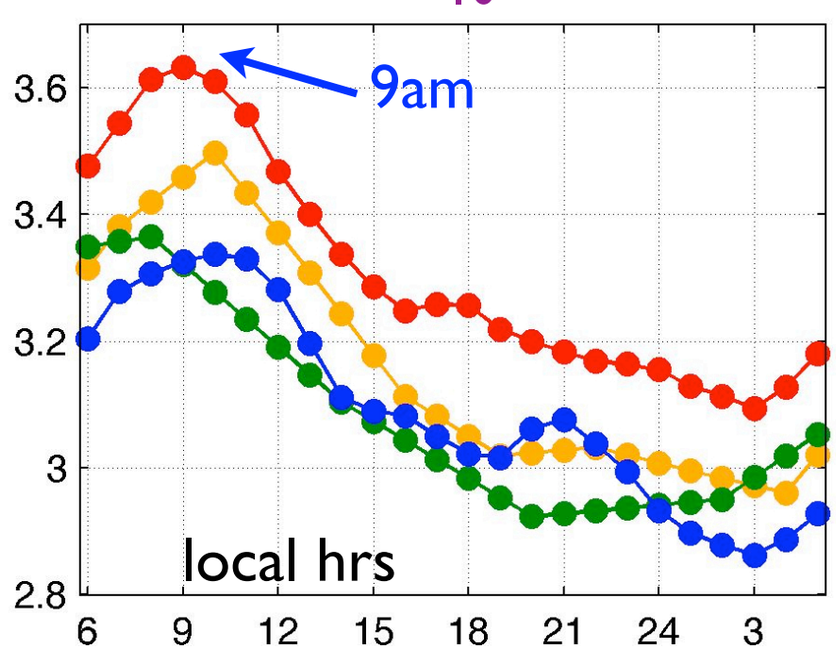
LH



q_s (←SST)

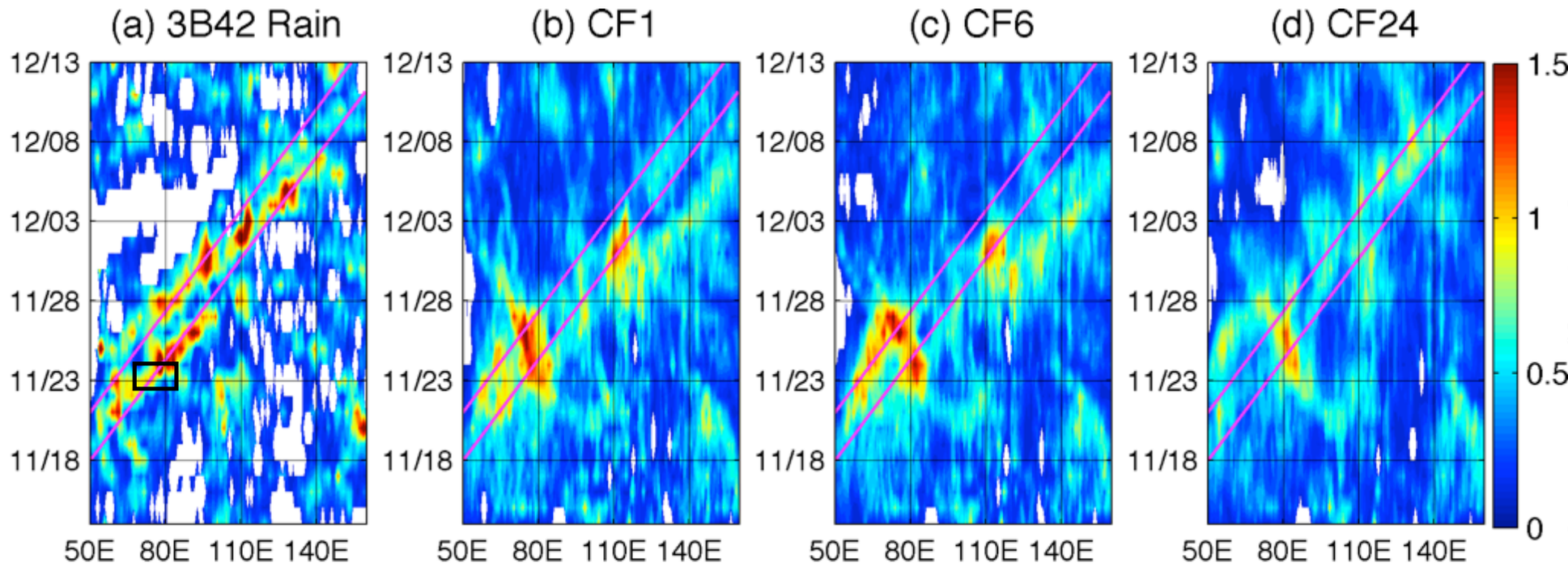


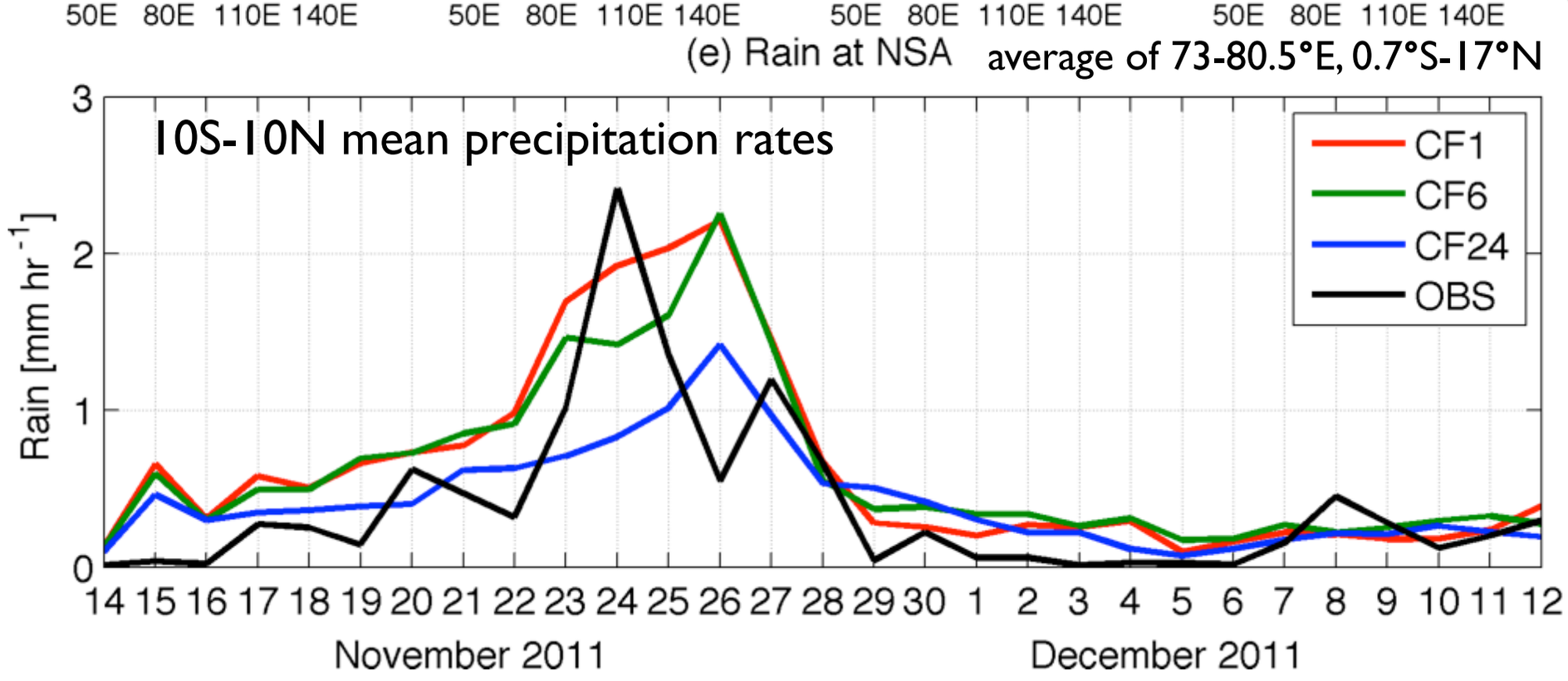
W_{10}



q_s (SST) plays a leading role in maximizing the moistening effect of the troposphere on a diurnal basis.

Precipitation intensity proportional to pre-convection diurnal SST





- MJO2 rainfall event on Nov. 24 with the eastward propagation at 5 ms^{-1}.
- Models: qualitatively consistent intraseasonal evolution of rainfall.
- Higher rainfall with higher dSST.

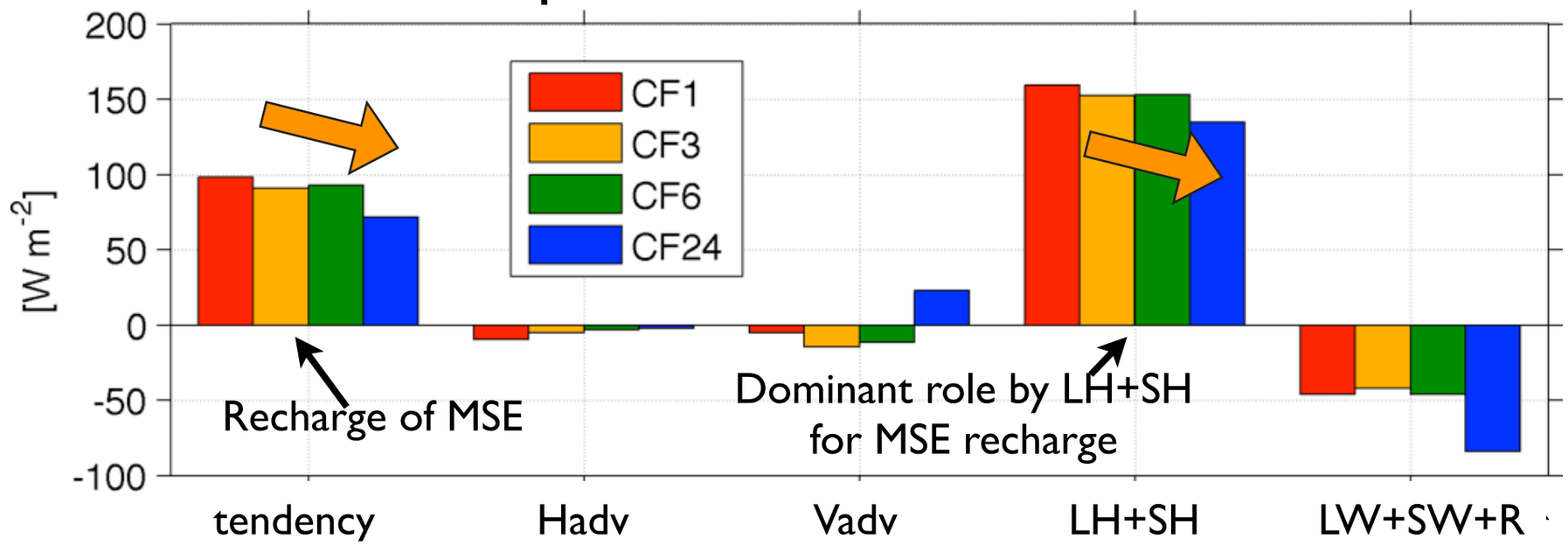
Column-integrated moist static energy (MSE) budget

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

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

Maloney 2009

prior to the convection



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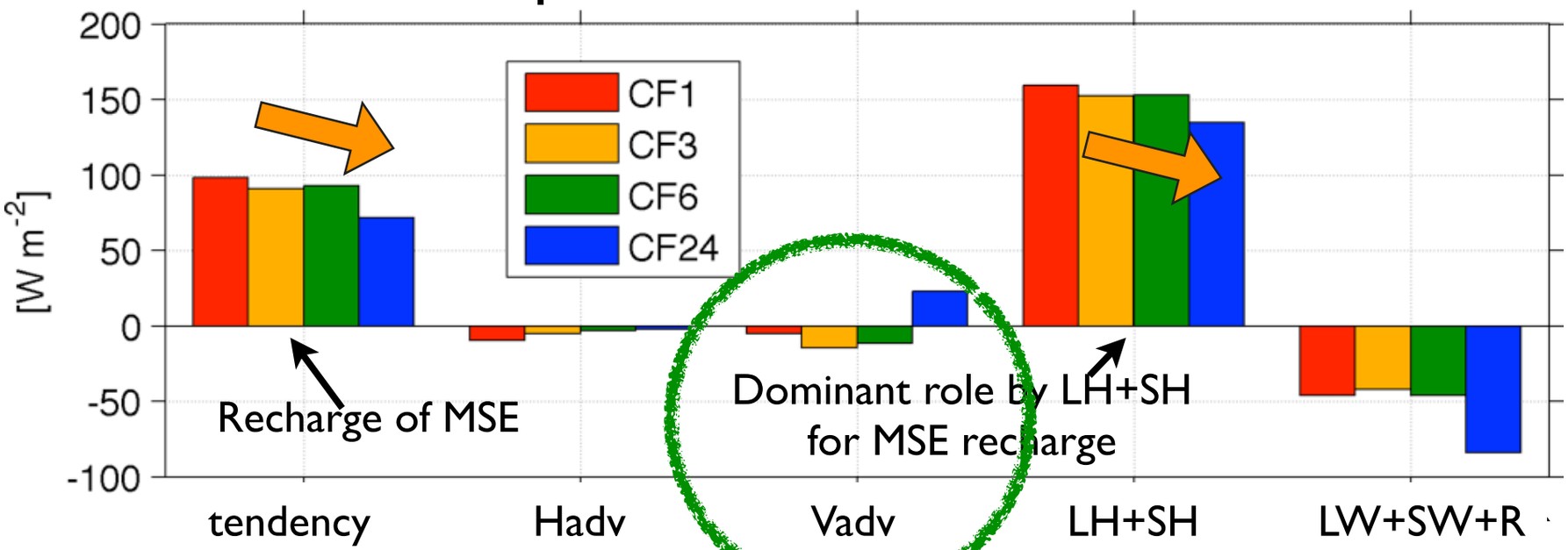
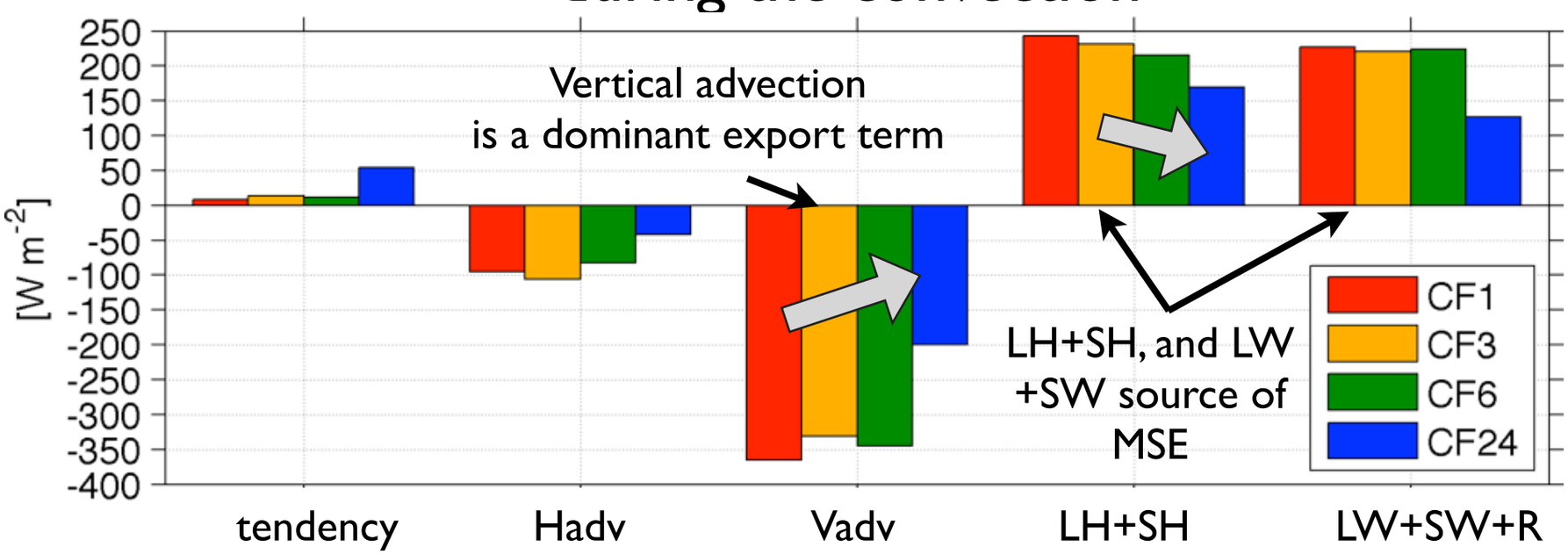


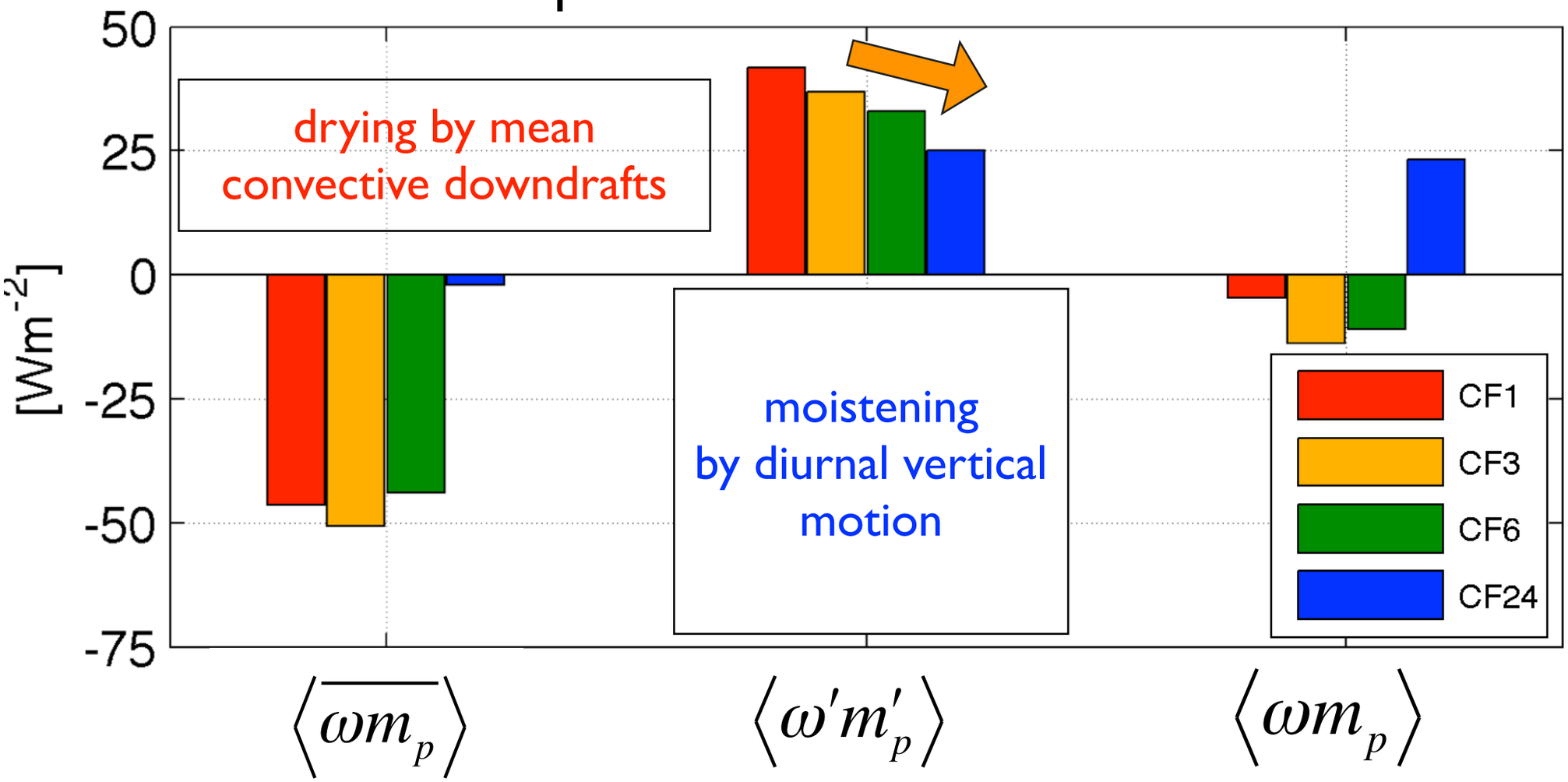
during the convection



Diurnal moistening of the lower troposphere

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

prior to the convection



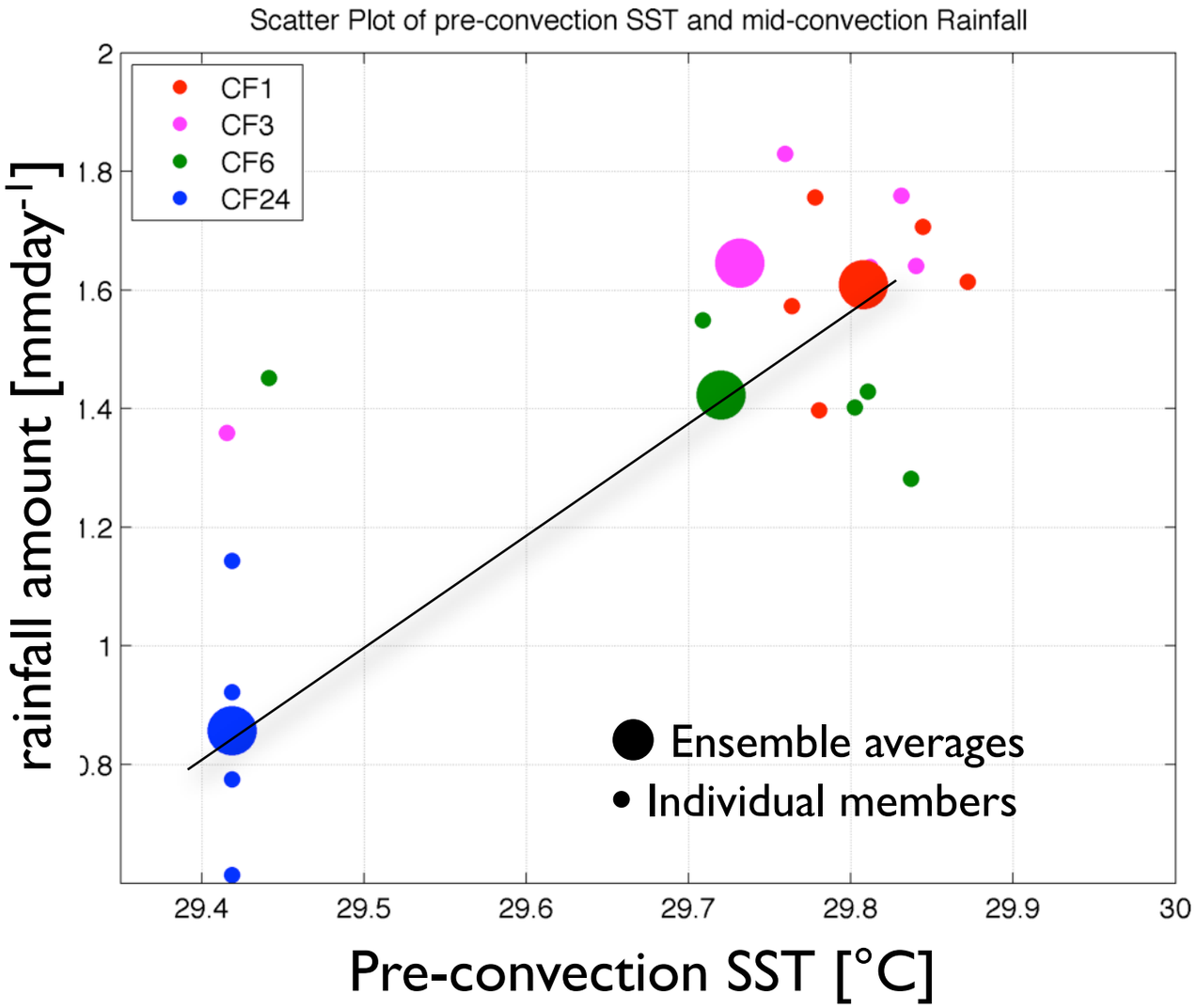
- The daily mean advection dries the air column (~ by mean convective downdrafts?)
- Not related to pre-convection dSST

- Diurnal moistening is a source of MSE and proportional to pre-convection dSST

Summary

1. SCOAR regional coupled modeling for the MJO and diurnal cycle of SST
   - Tropical channel, high vertical resolution, coupling, shallow/deep convection
2. Diurnal SST variability prior to the deep convection
   - raises time-mean SST and LH: via diurnal rectified effect
   - enhances diurnal moistening: via coincident diurnal peaks of LH & SST
3. Precipitation amount scales quasi-linearly with pre-convection diurnal SST

- LH feedback over higher SST instrumental in stronger convection intensity (Arnold et al. 2013).
- An improved representation of diurnally evolving SST is a potential source of MJO predictability.



감사합니다

Seo, Subramanian, Miller and Cavanaugh, 2014: Coupled impacts of the diurnal cycle of sea surface temperature on the Madden-Julian Oscillation. J. Climate