Theoretical and Modeling Issues Related to ISO/MJO

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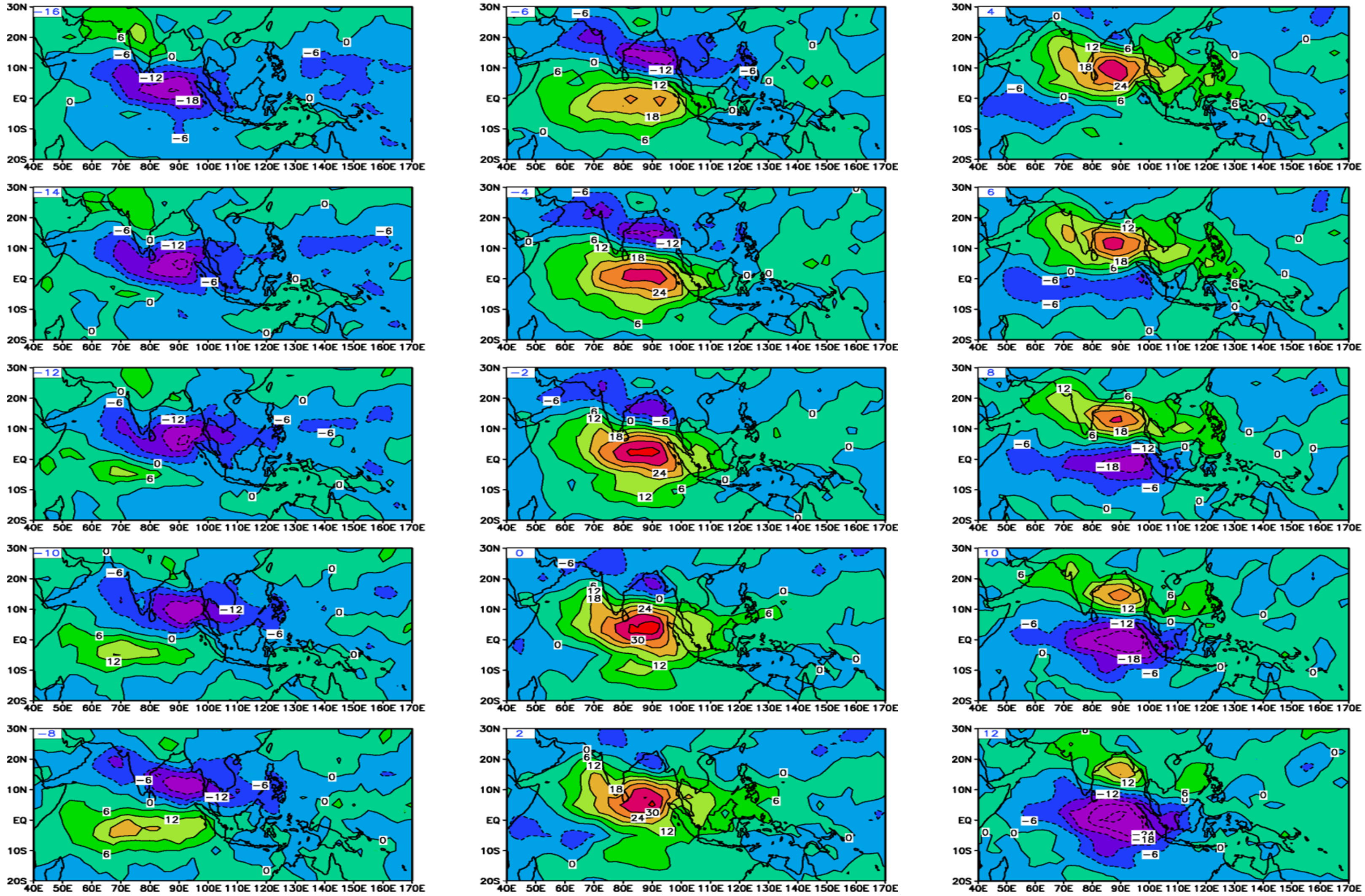
DYNAMO workshop, April 13-14, Boulder, Colorado

1. MJO Initiation issue: Role of air-sea interaction

Observed OLR Composite in northern summer (1980-2005)



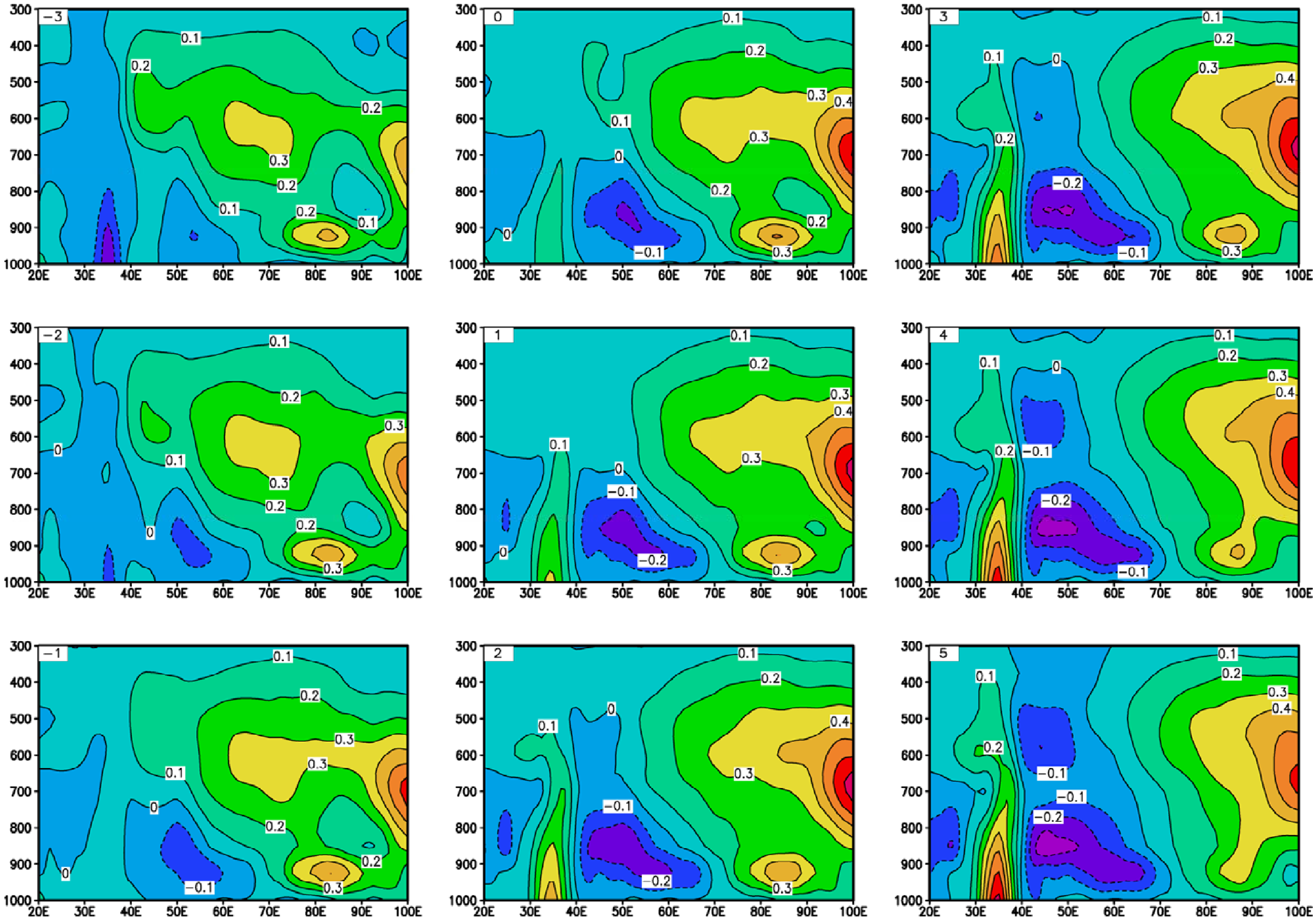
Seasonal difference in ISO propagation:

Winter: continuous eastward propagation across the maritime continent

Summer: northward bifurcation over the eastern IO/maritime continent

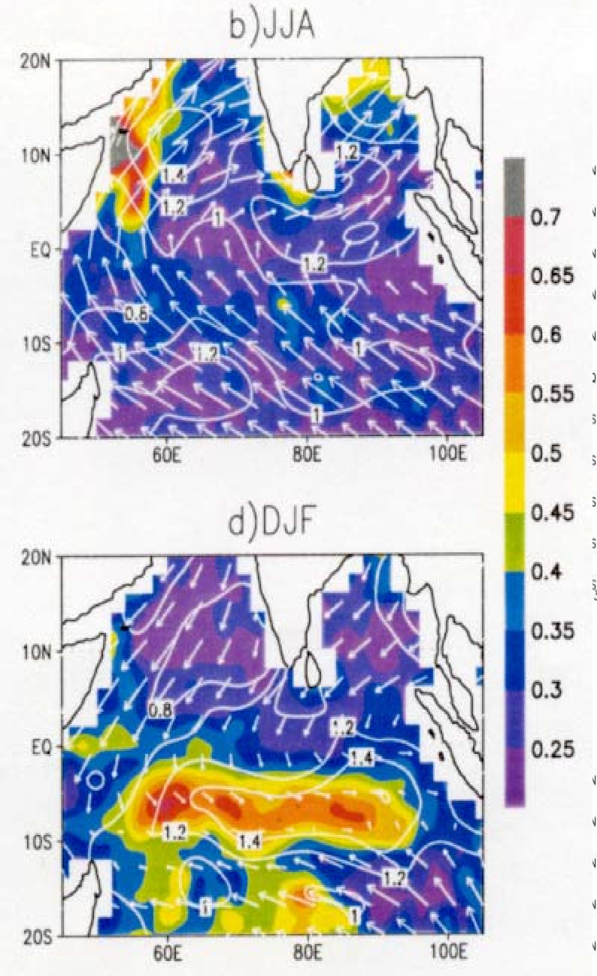
0 is initiation date

Evolution of specific humidity (-2.5ºS-2.5ºN)

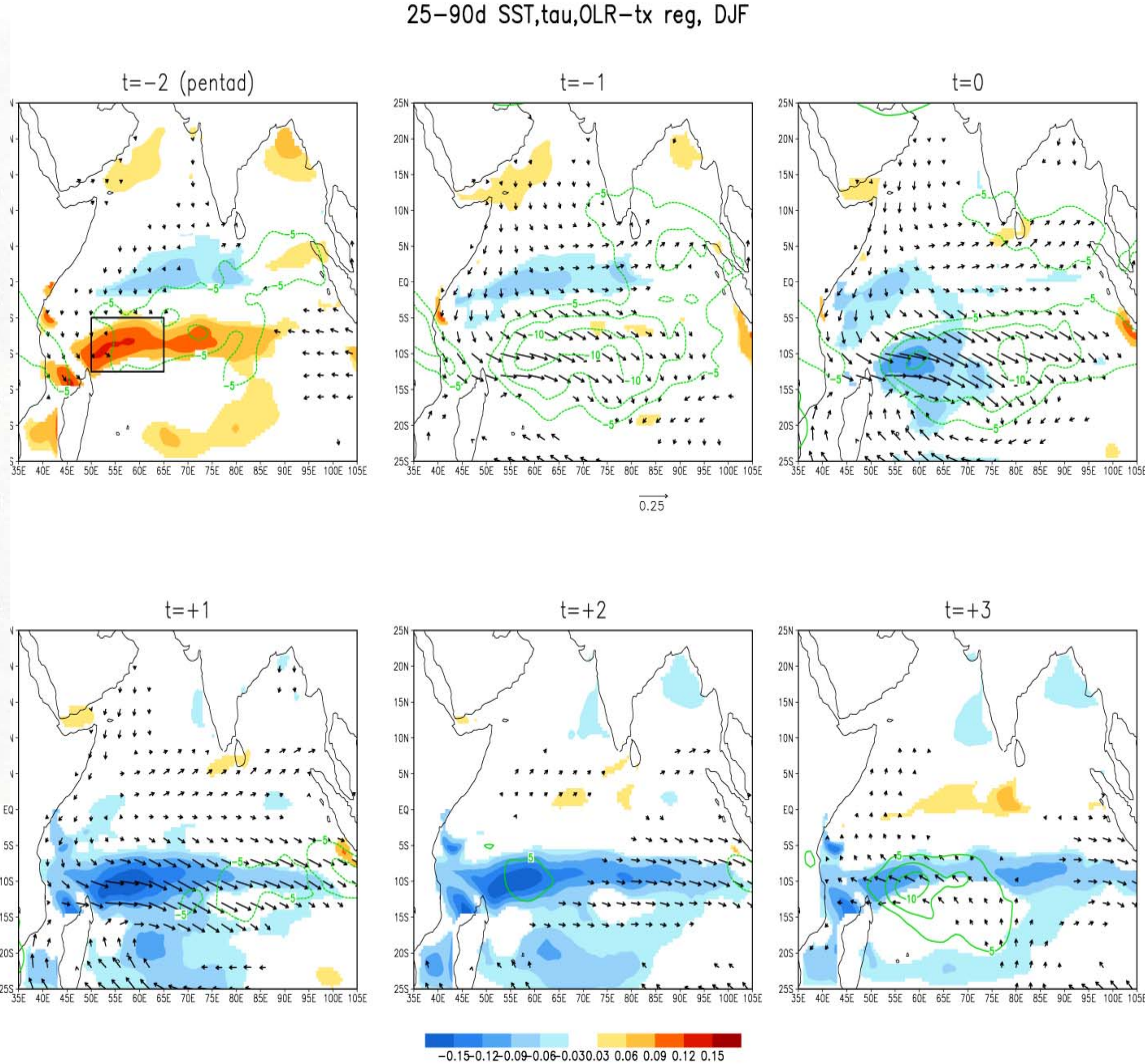


Precursor signals for initiation of an opposite phase of ISO in boreal summer occur in PBL moisture field. Jiang and Li 2005 J. Climate

Ocean model simulation with ERA40 daily forcing (Li et al. 2008)



TMI SST, Saji et al. 2006

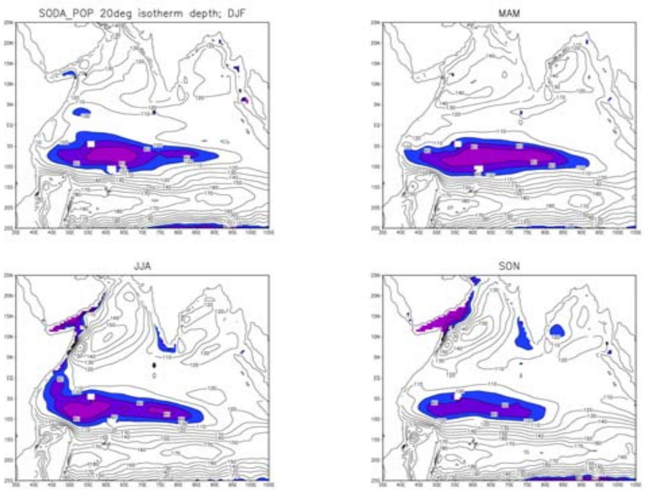


***OPEN ISSUE*: Is the effect of air-sea interaction on initiation season-dependent?**

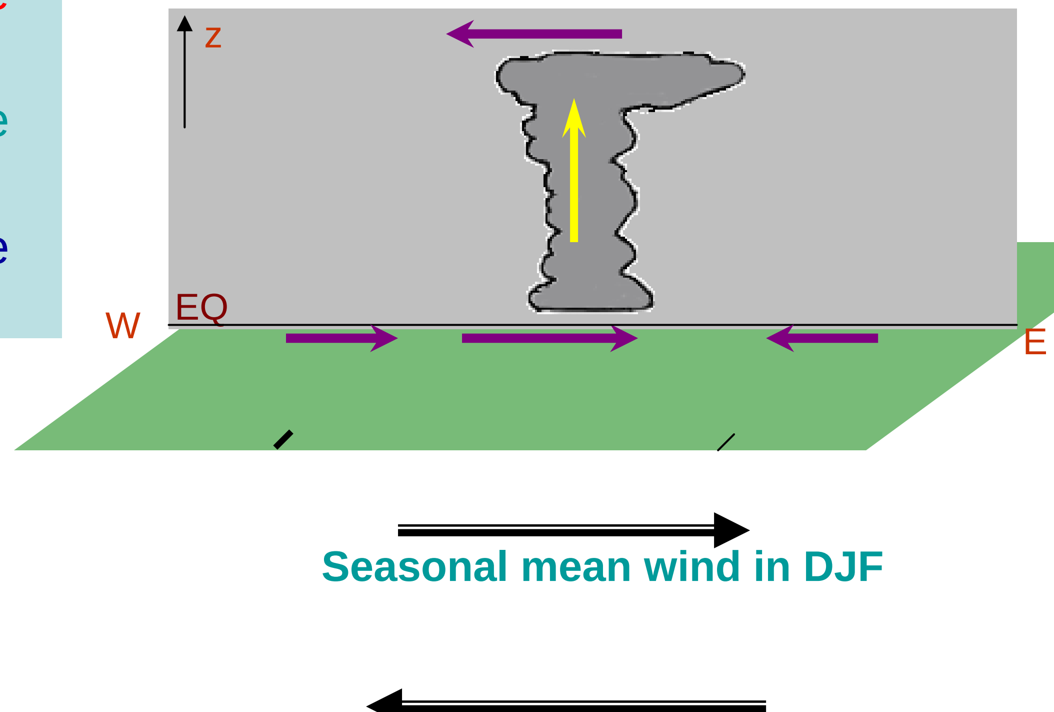
The response of SST to the previous convective phase of ISO may have a delayed impact on initiation of a subsequent opposite phase of ISO in western IO.

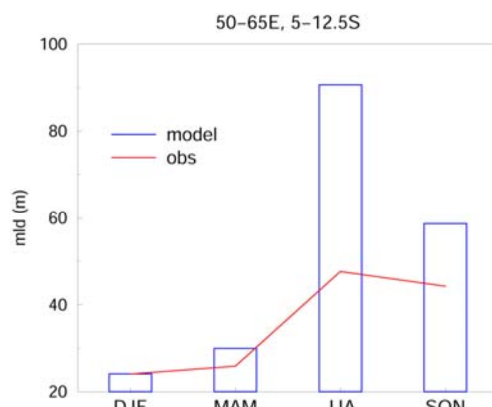
Seasonal dependence of intraseasonal SST variability is caused by

1. Summer-winter difference in the background zonal wind
2. Summer-winter difference in the ISO forcing
3. Summer-winter difference in the mixed layer depth



Atmospheric ISO convection





SST tendency is mainly affected by

- **Short wave cloud forcing**
- **Latent heat flux/ocean mixing**

Li et al. 2008

2. MJO prediction issue:

Does air-sea coupling extend the predictability?

UH Hybrid coupled GCM
(UH_HcGCM)

- **Atmospheric component:**

  ECHAM-4 AGCM

  (Roeckner et al. 1996)

- **Ocean component:**

  Wang-Li-Fu intermediate upper ocean model (0.5^ox0.5^o)

  (Wang, Li, Chang 1995; Fu and Wang 2001)

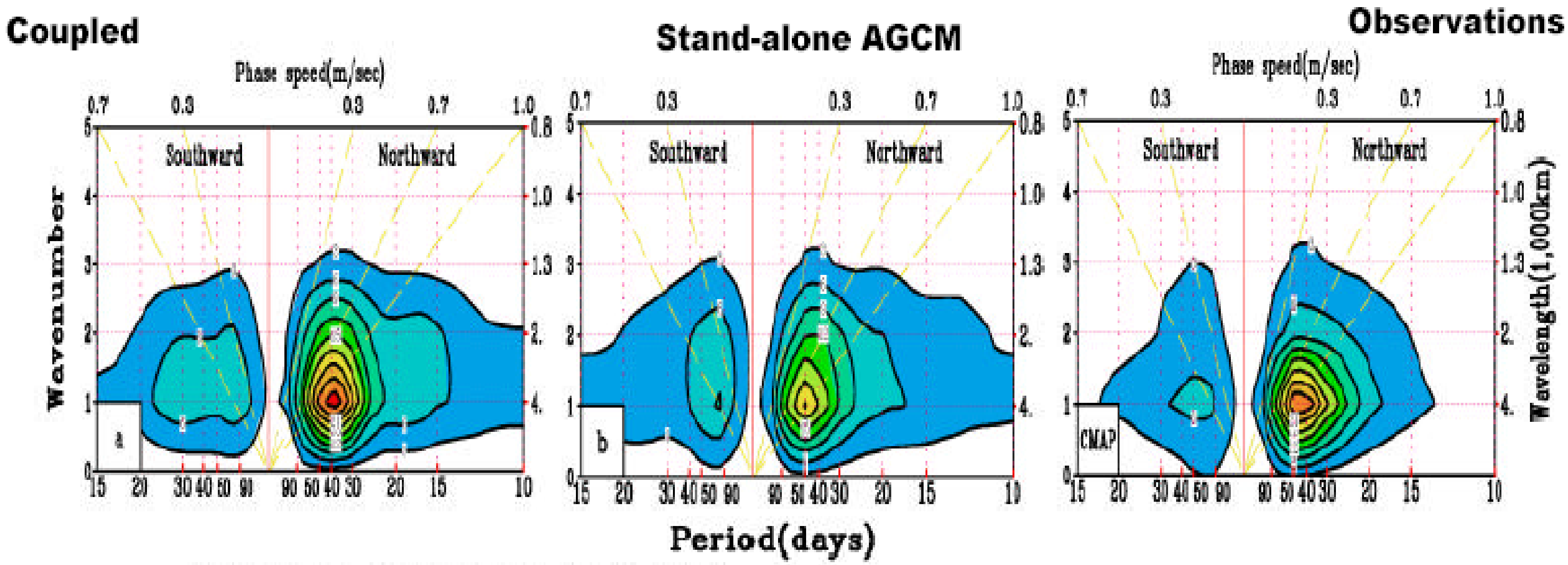
  - **Wang, Li, and Chang (1995): upper-ocean thermodynamics**
  - **McCreary and Yu (1992): upper-ocean dynamics**
  - **Jin (1997) : mean and ENSO (intermediate fully coupled model)**
  - **Zebiak and Cane (1987): ENSO (intermediate anomaly coupled model)**

- **Fully coupling without heat flux correction**
- **Coupling domain: Tropical Indian and Pacific Oceans**

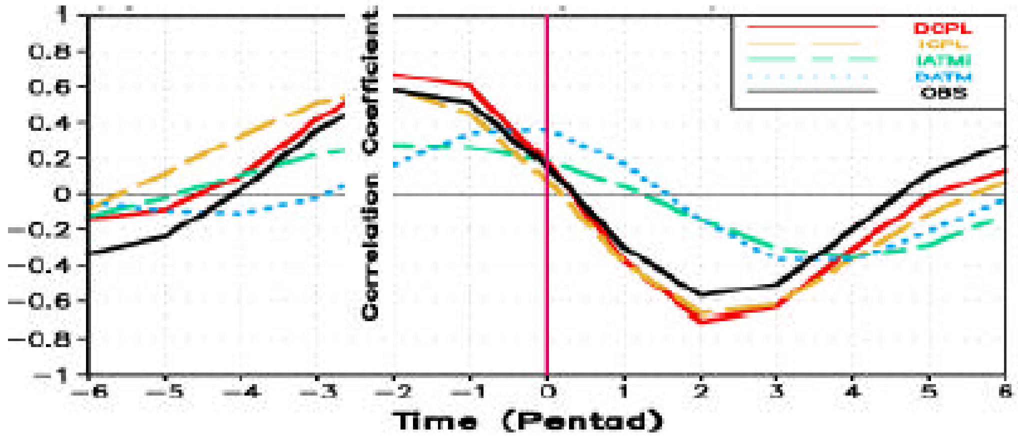
  (30^oS-30^oN)

- **Coupling interval: Once per day**

Air-sea coupling increases the intensity of ISO

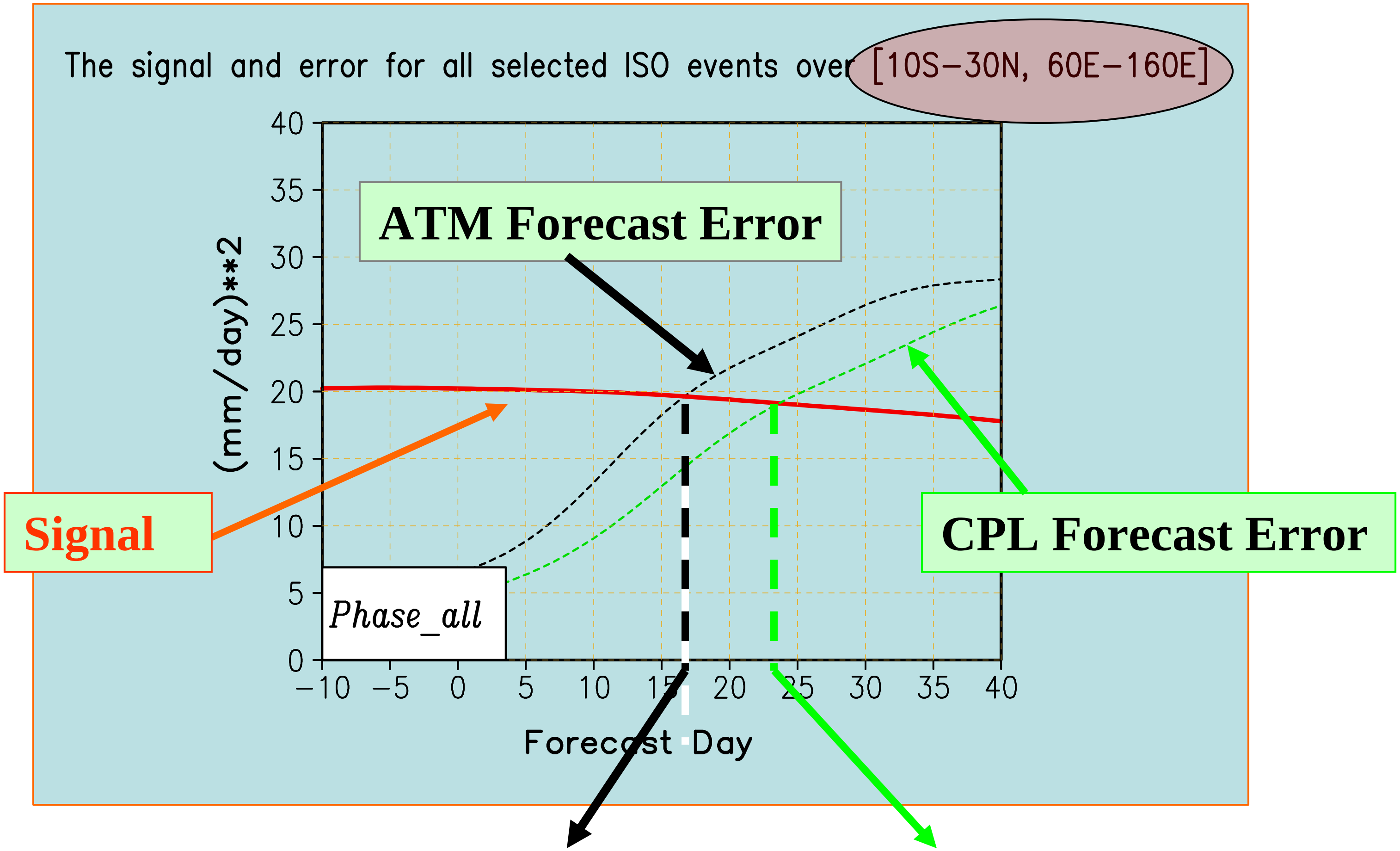


Air-sea coupling reproduces observed rainfall-SST relationship



Fu, Wang, Li, McCreary (2003)

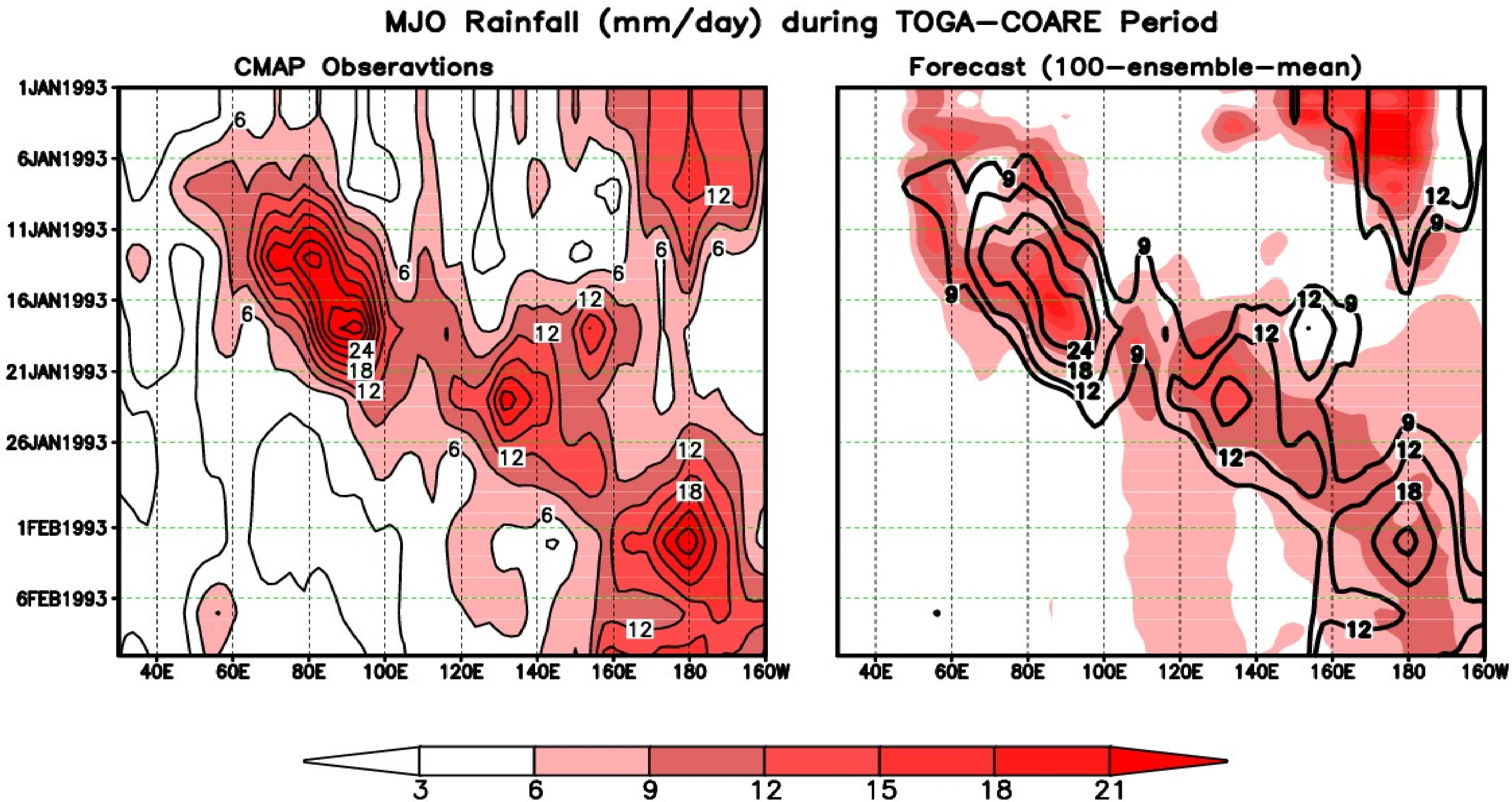
Air-Sea Coupling Extends the Predictability of Tropical Intraseasonal Variability



[ATM: 17 days; CPL: 24 days]

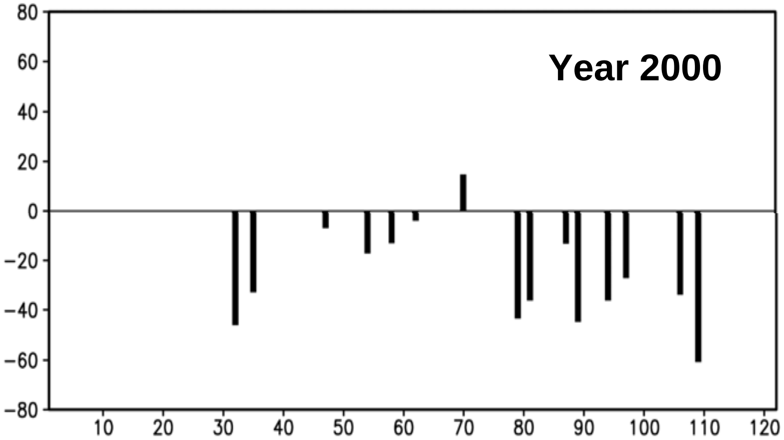
Fu et al. (2007)

A Real-Case MJO Forecast



Impact of ISO on Tropical Cyclones over western Pacific

TC Genesis



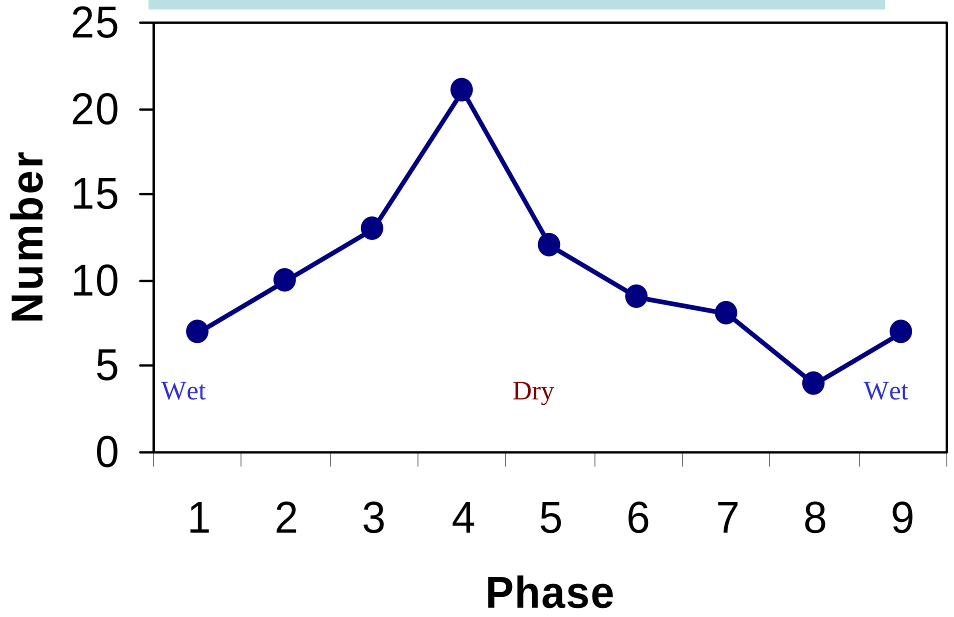
20-70-day filtered OLR at TC genesis location and time

Horizontal axis: time (day) from June 1 to September 30, 2000

Each bar represents one TC genesis case in WNP

Fu, Li, et al. 2007

TC Rapid Intensification (RI)



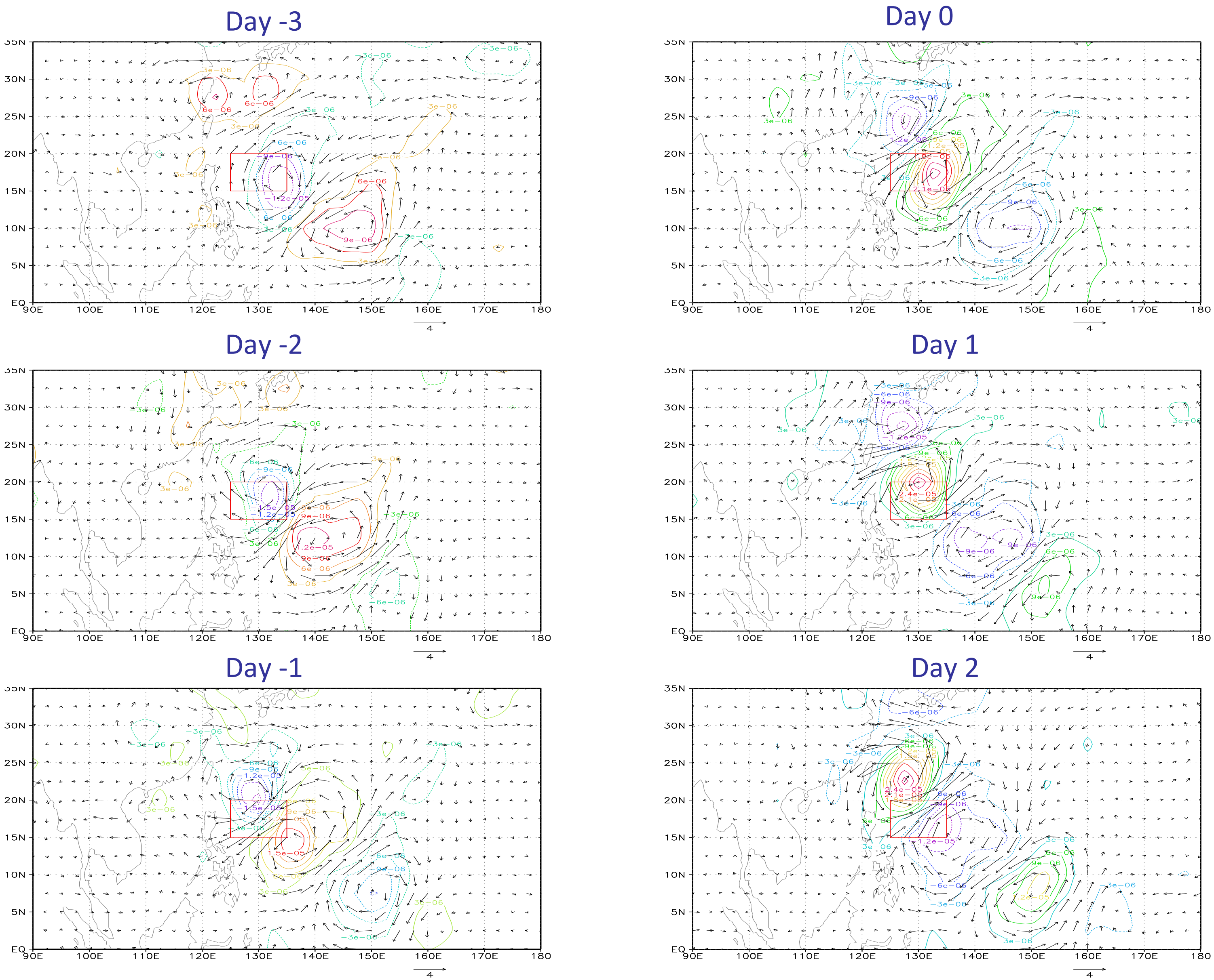
The maximum occurrence of RI over the WNP lags the peak wet phase of ISO in the equatorial western Pacific by three phases (about 12 days). (Wang and Zhou 2008).

Does a better ISO prediction improve short-range and extended-range typhoon forecast?

3. Scale interaction issue:

How does ISO impact synoptic-scale variability? How does synoptic-scale variability feed back to ISO?

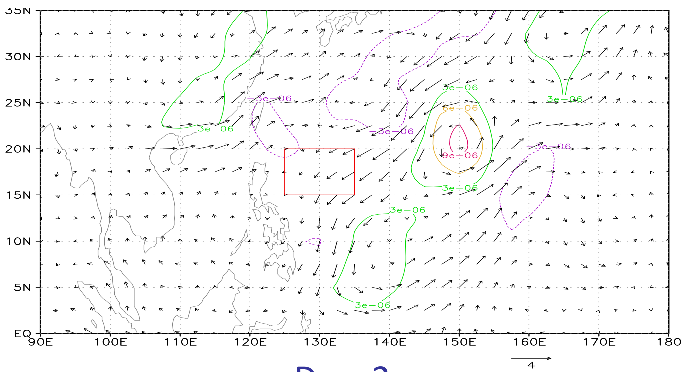
Evolution of synoptic disturbances during ISO wet phase



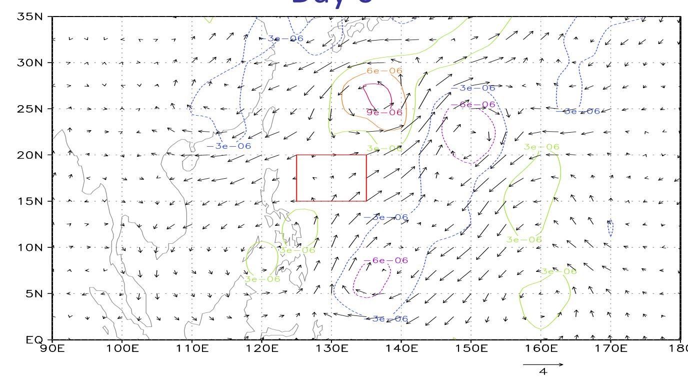
850hPa wind (vector) and vorticity (contour)

Evolution of synoptic disturbances during ISO dry phase

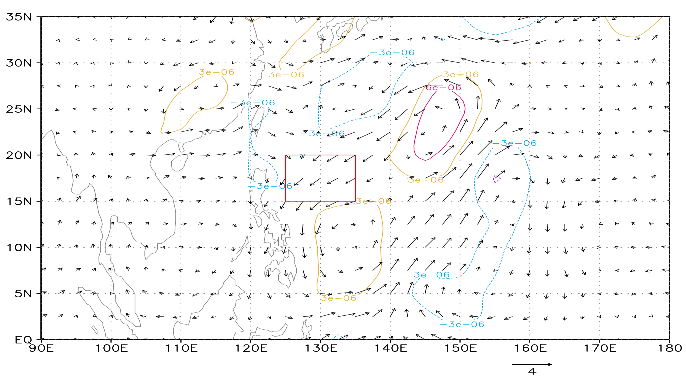
Day -3



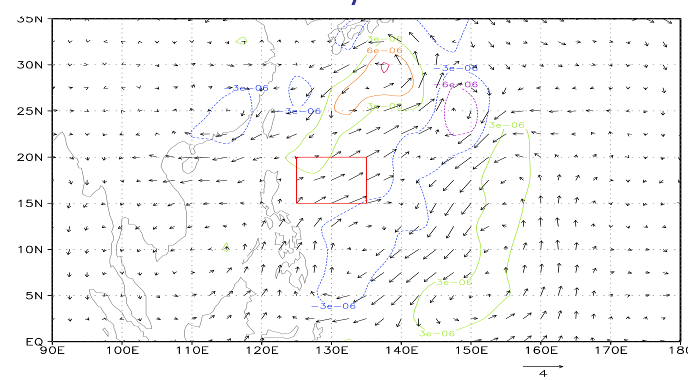
Day 0



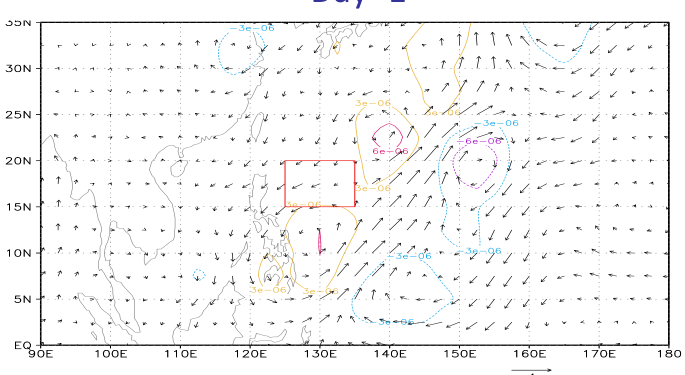
Day -2



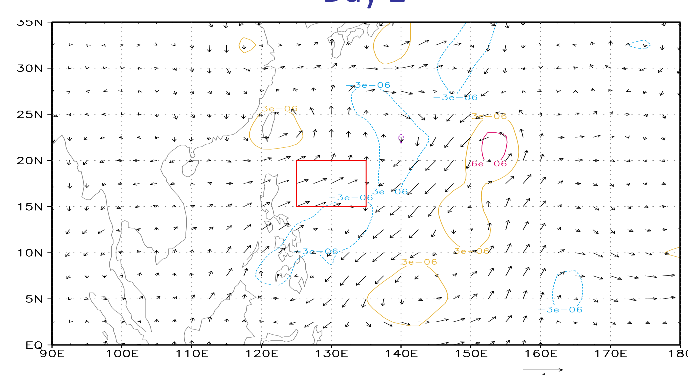
Day 1



Day -1



Day 2



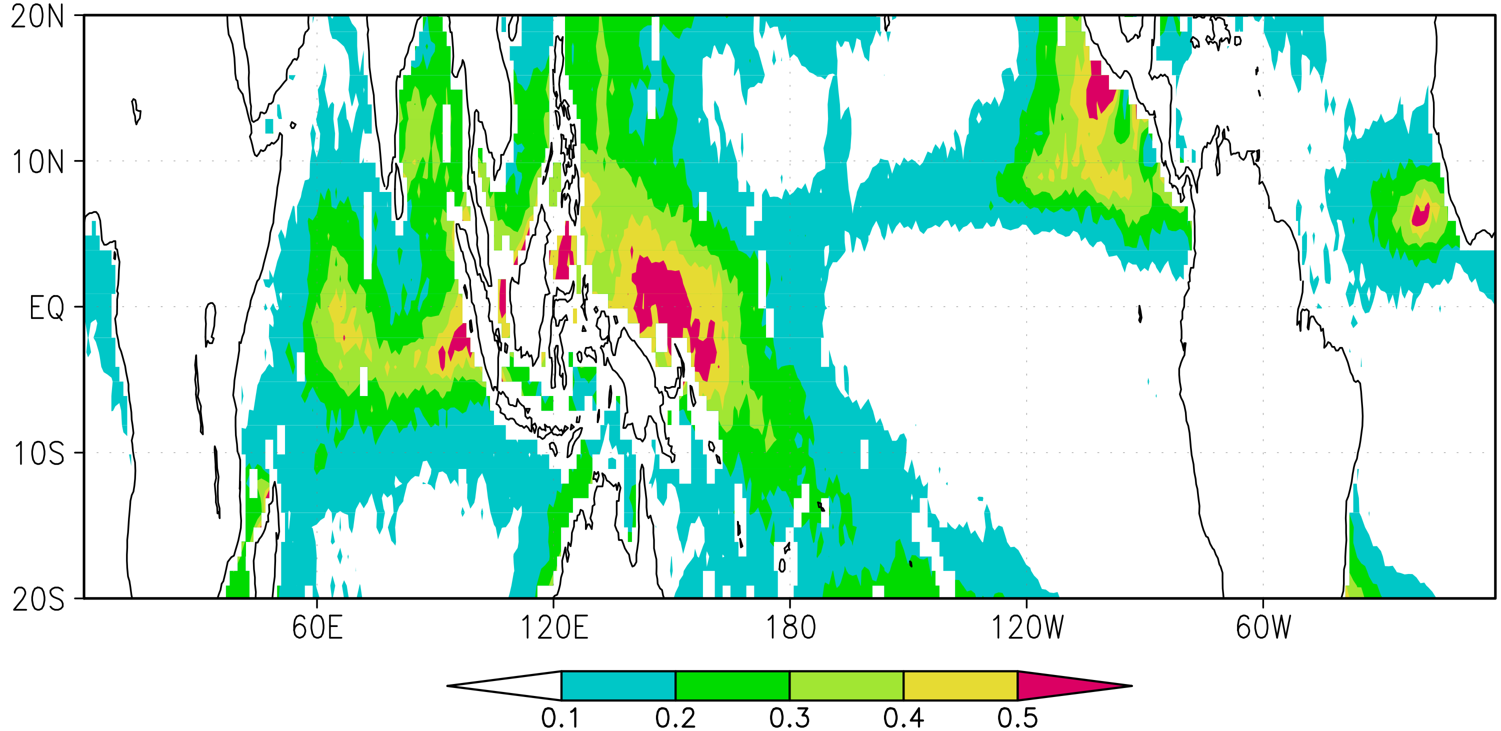
850hPa wind (vector) and vorticity (contour)

$$LH = \rho L_c C_E \sqrt{u^2 + v^2}(q_s - q_a)$$

$$u = \bar{u} + \tilde{u} + u'; \; v = \bar{v} + \tilde{v} + v'; q = \bar{q} + \tilde{q} + q'$$

(¯) : climatological mean annual cycle; ('): synoptic (3-8d);

(~) : intraseasonal (20-90d)

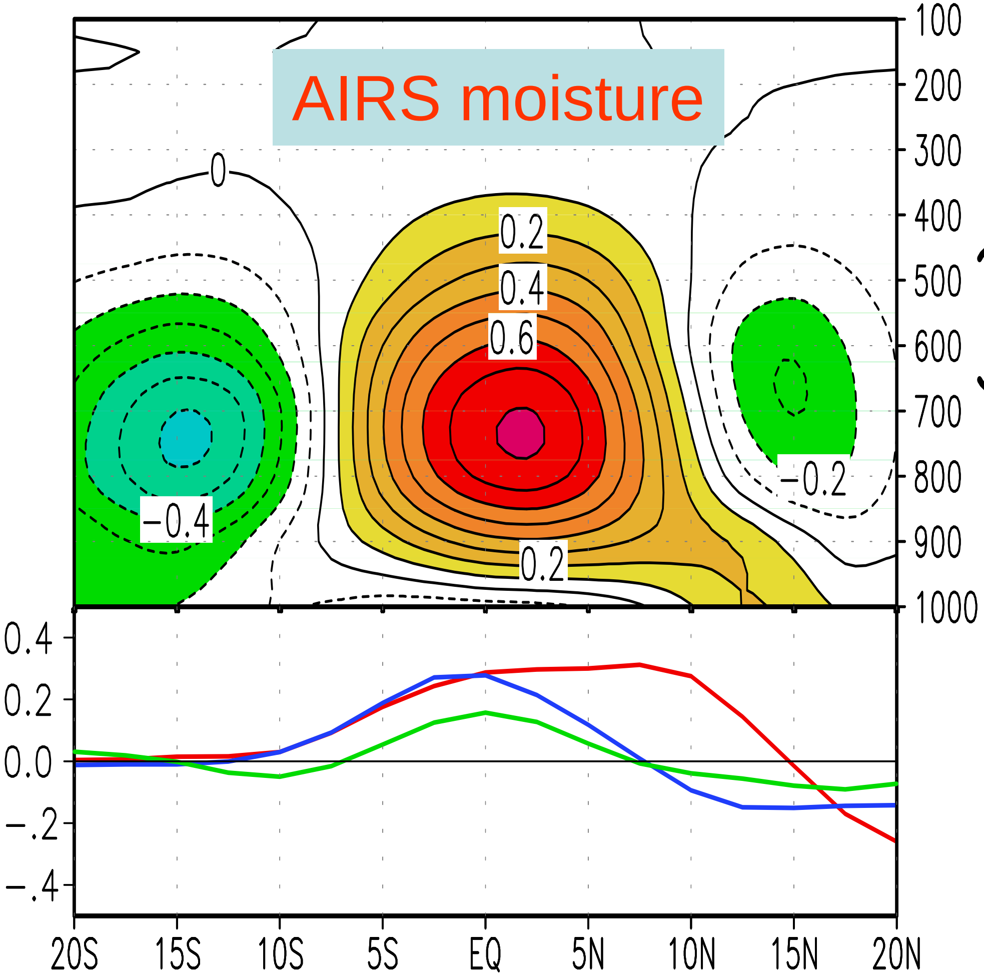


$$\frac{\text{STD (20-90d LH, based on 3-8d + mean u,v,dq)}}{\text{STD (20-90d LH, based on total u,v,dq)}}$$

4. MJO PBL structure issue

AIRS data reveal a new observational feature: boundary layer dryness under MJO convection

MJO Over eastern Indian Ocean

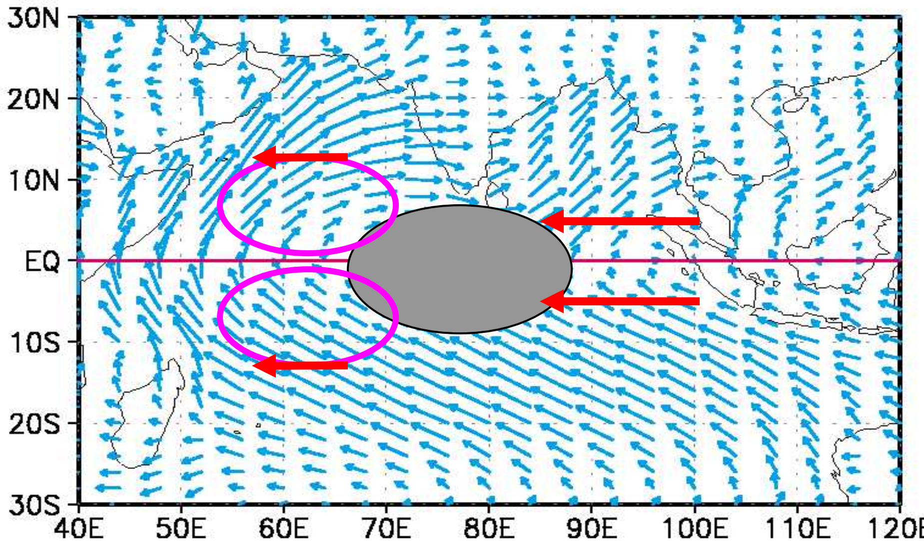


Red line: TMI SST
Green line: Surface Convergence (from QuikSCAT wind)
Blue line: TMI rainfall

SST-wind-LHF-q phase relation ?

Decrease in LHF → SST warming

Decrease in LHF → Decrease in air specific humidity



Summary of the issues:

- **PBL dryness**, what is corresponding dynamic /thermodynamic structure? what cause the dryness, and what is its impact? What leads to complex phase relationships among SST, wind, moisture, LHF and SWR associated with MJO at air-sea interface?
- **Effect of air-sea interaction in ISO initiation** – Is it season-dependent?
- **ISO prediction**: does a better ISO prediction help short-range and extended-range typhoon forecast?
- **Multi-scale interaction**: is the current model able to capture two-way interactions between ISO and synoptic-scale variability?