

AIRS View of Monsoon Intraseasonal Waves

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Fu, X., B. Wang, and L. Tao (2006), *Geophys. Res. Lett.*, 33, L03705, doi:10.1029/2005GL025074

AIRS Science Team Meeting, March 7-9, 2006, Pasadena, CA

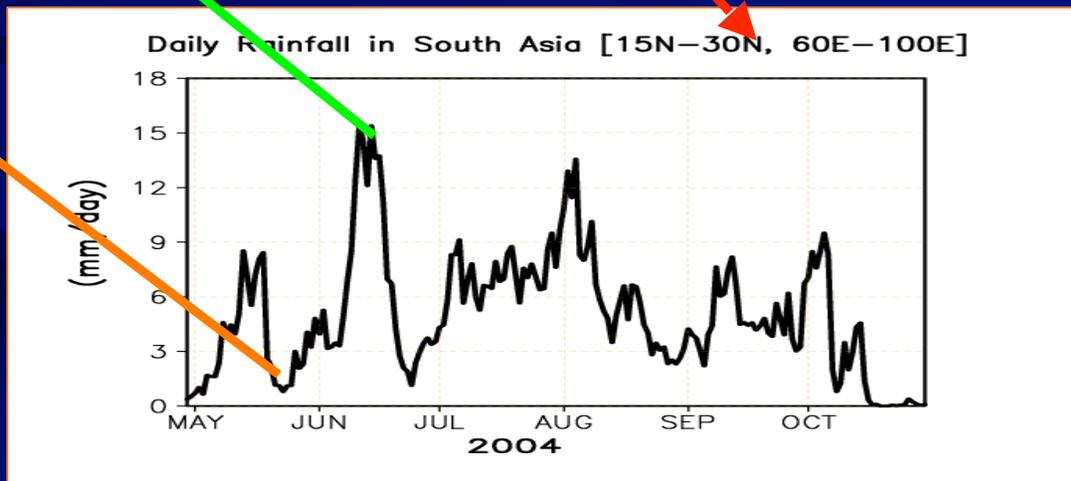
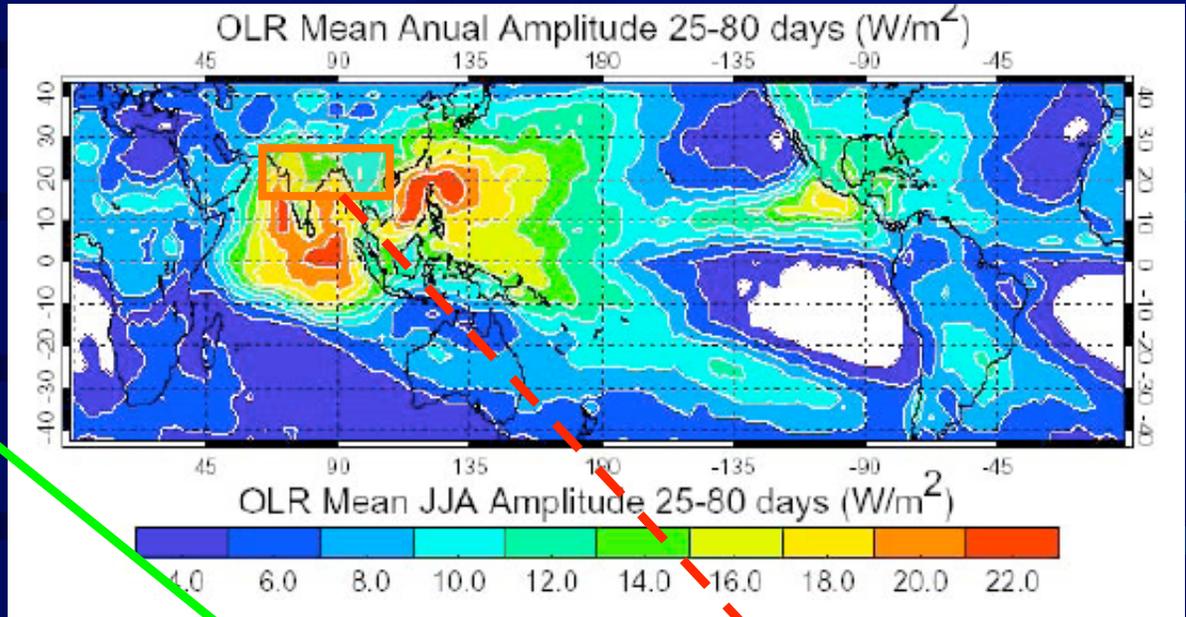
OUTLINE

- Introduction of Monsoon Intraseasonal Waves

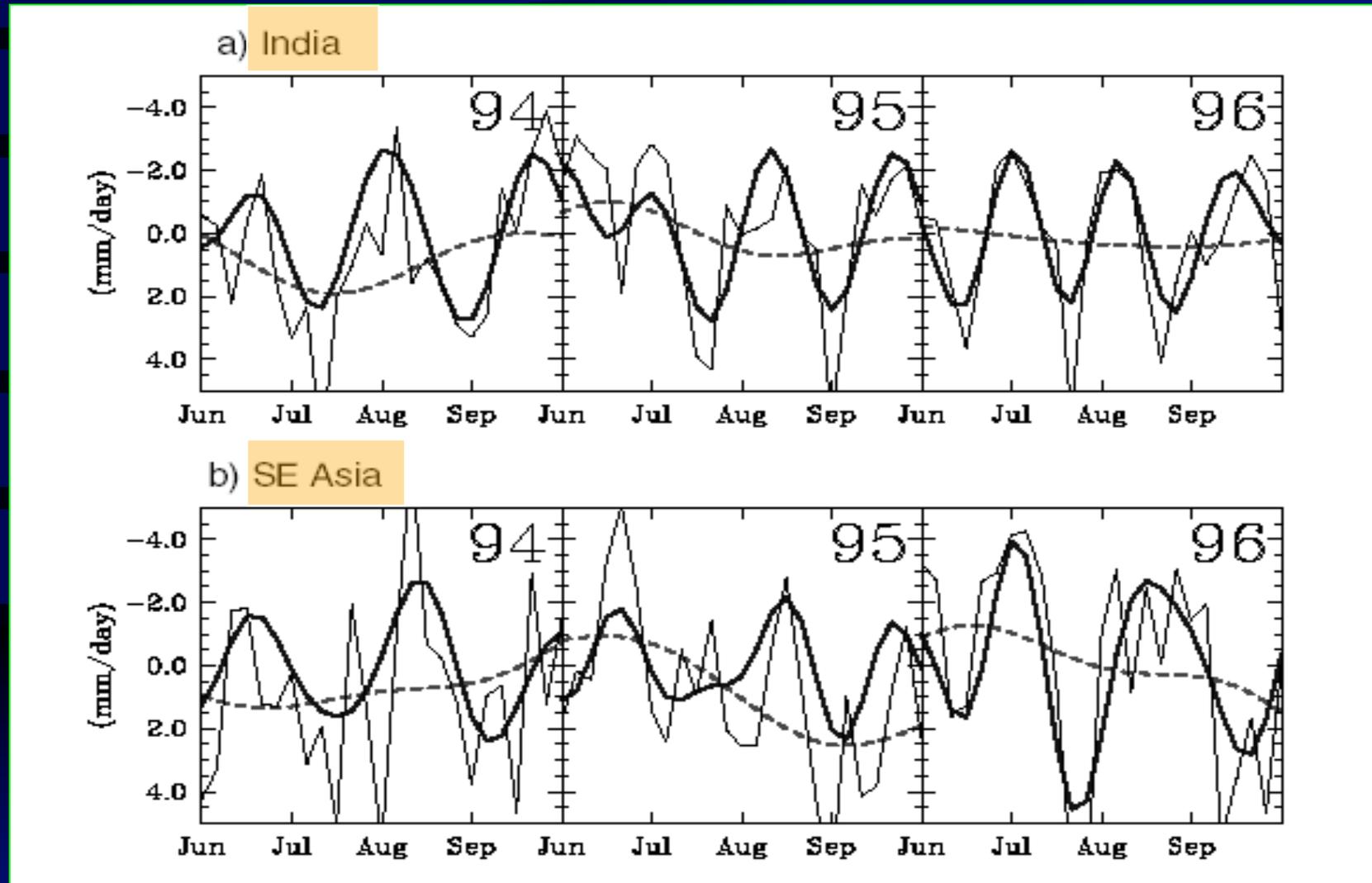
(Oscillations)

- Simulation of State-of-the-art Models
- Major Modeling Issues and Hypotheses
- Results from AIRS and Other Satellite Data
- A Brief Summary
- Future Research
- Tropical Cyclone Reanalysis Using AIRS Data

Monsoon Intraseasonal Waves In Boreal Summer

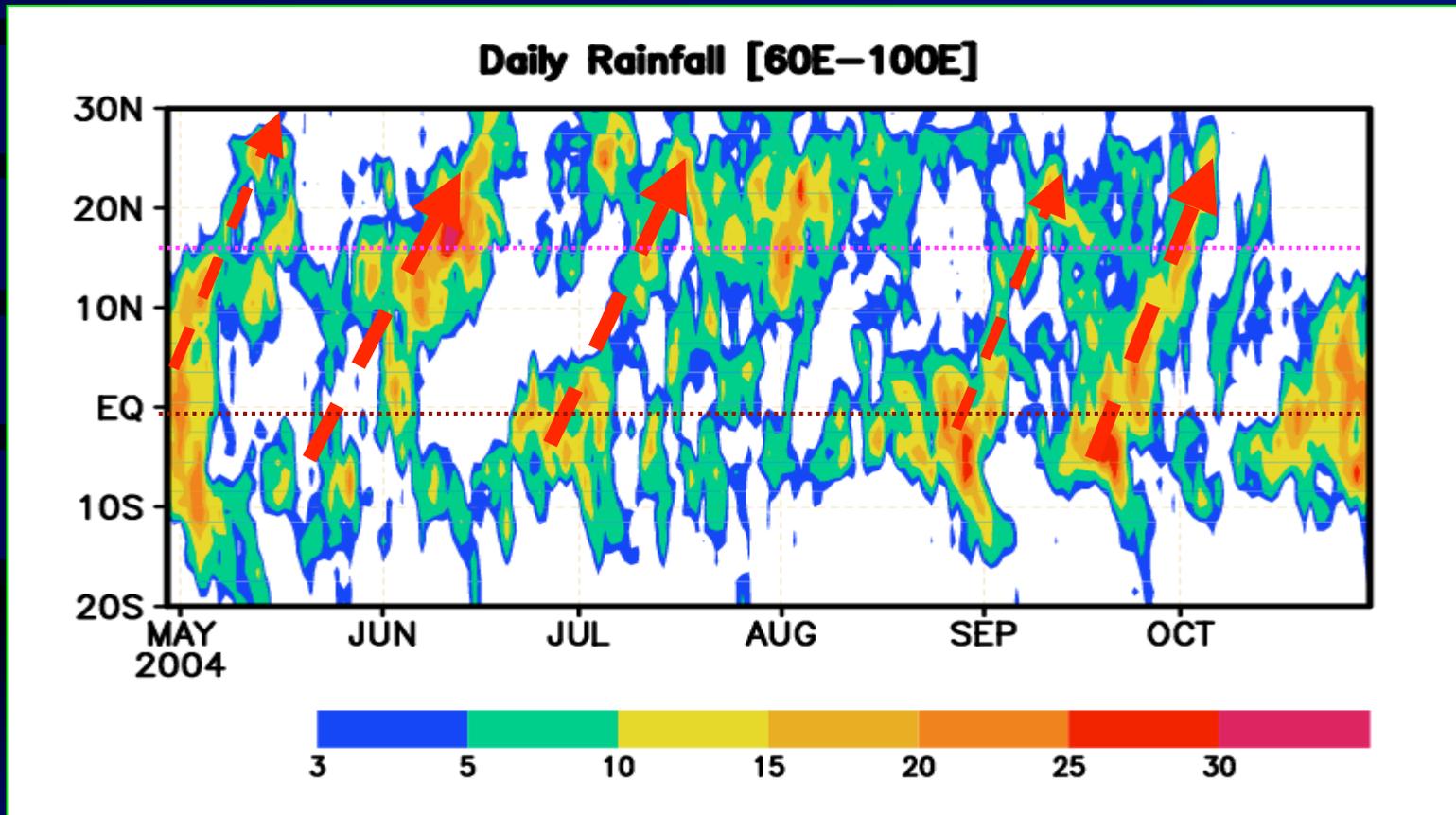


Monsoon Intraseasonal Waves



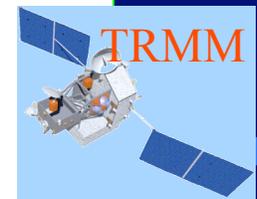
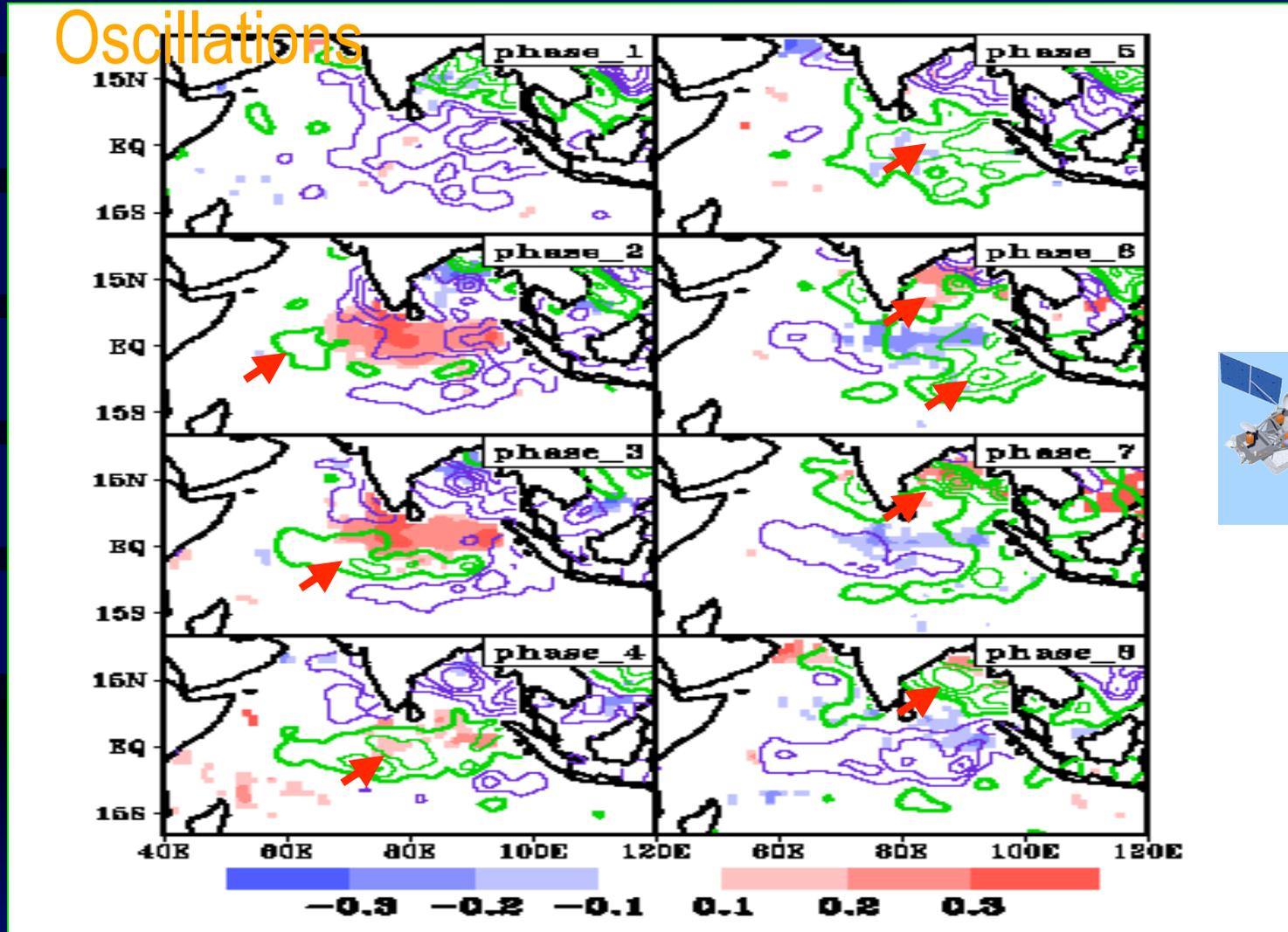
Waliser et al. (2003)

Northward-propagating Monsoon Intraseasonal Oscillations (MISO)



Life Cycle of Monsoon Intraseasonal Oscillations

Oscillations



SST: Shading; Rainfall: Contours

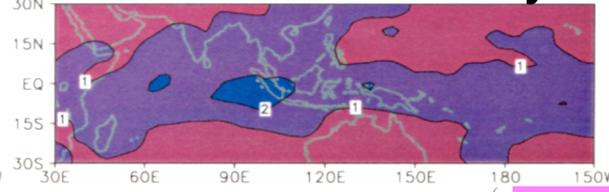
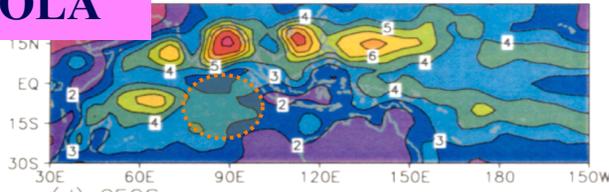
Wang et al. (2005)

AIRS Science Team Meeting, March 7-9, 2006, Pasadena, CA

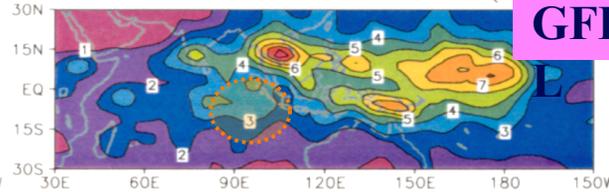
Observation

MISO
Rainfall
Variability

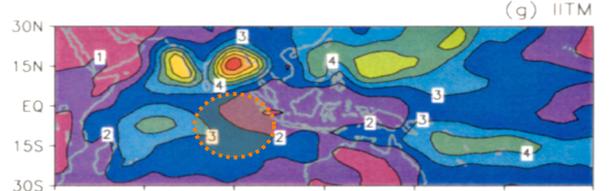
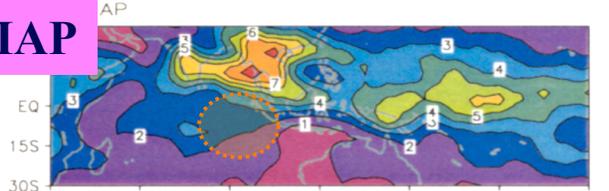
COLA



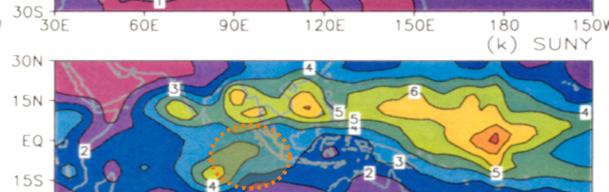
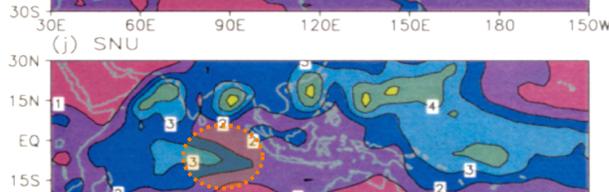
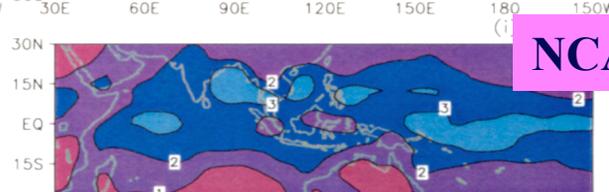
GFDL



IAP



NCAR



Simulation of
10 State-of-the-art
AGCMs

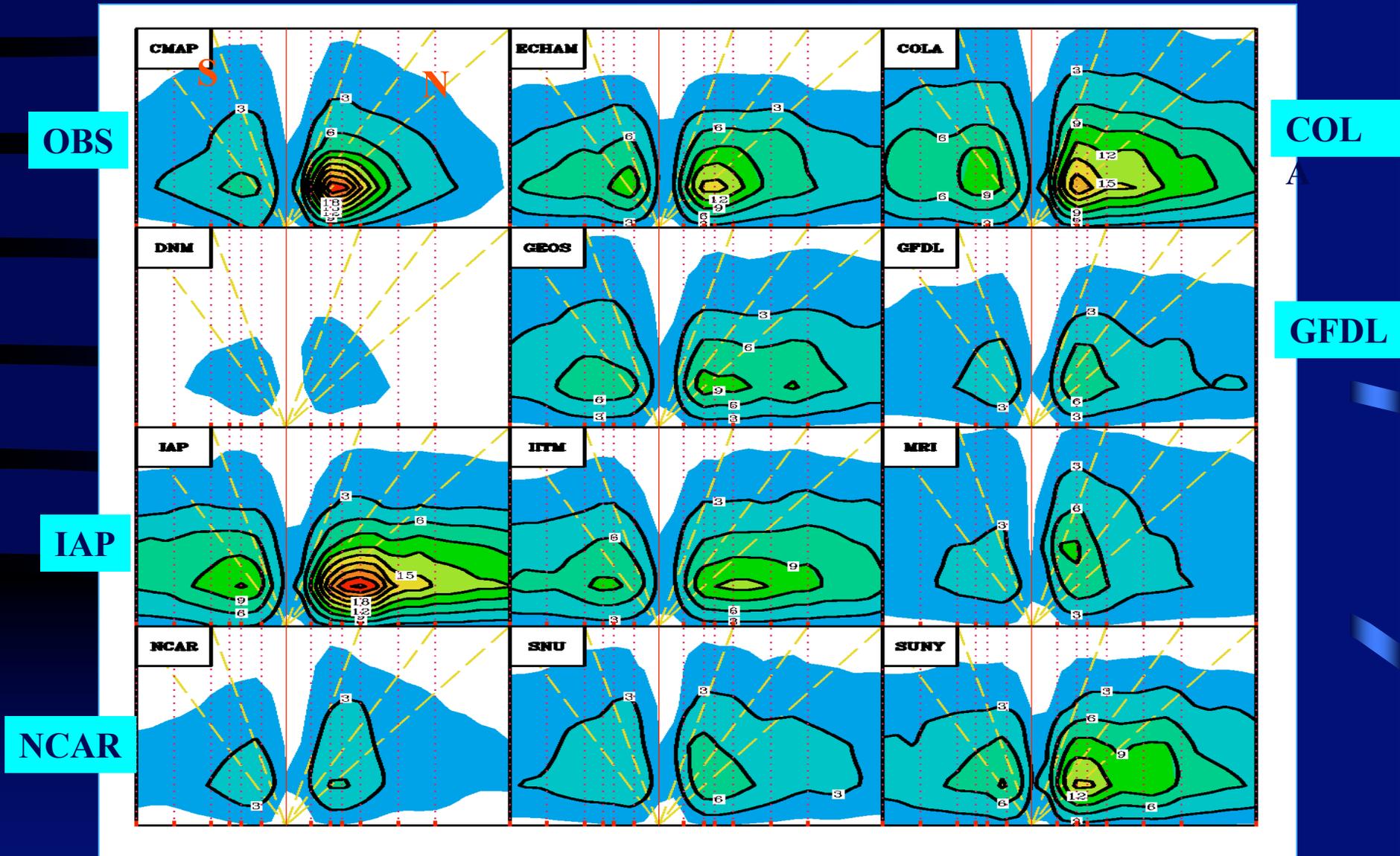
➤ Very strong/weak
MISO in some models

➤ Too weak MISO in
eastern equatorial
Indian Ocean



Weak Northward-
Propagating
Mode of MISO

Northward-propagating MISO (65°E-95°E)



Major Modeling Issues and Hypotheses

1. Active air-sea coupling

Krishnamurti et al. 1988, Flatau et al. 1997, Wang and Xie 1998, Waliser et al. 1999, Fu et al. 2003, Fu and Wang 2004, Zheng et al. 2004

2. Representation of moist convection

➤ triggering of convection

Tokioika et al. 1988, Wang and Schlesinger 1999

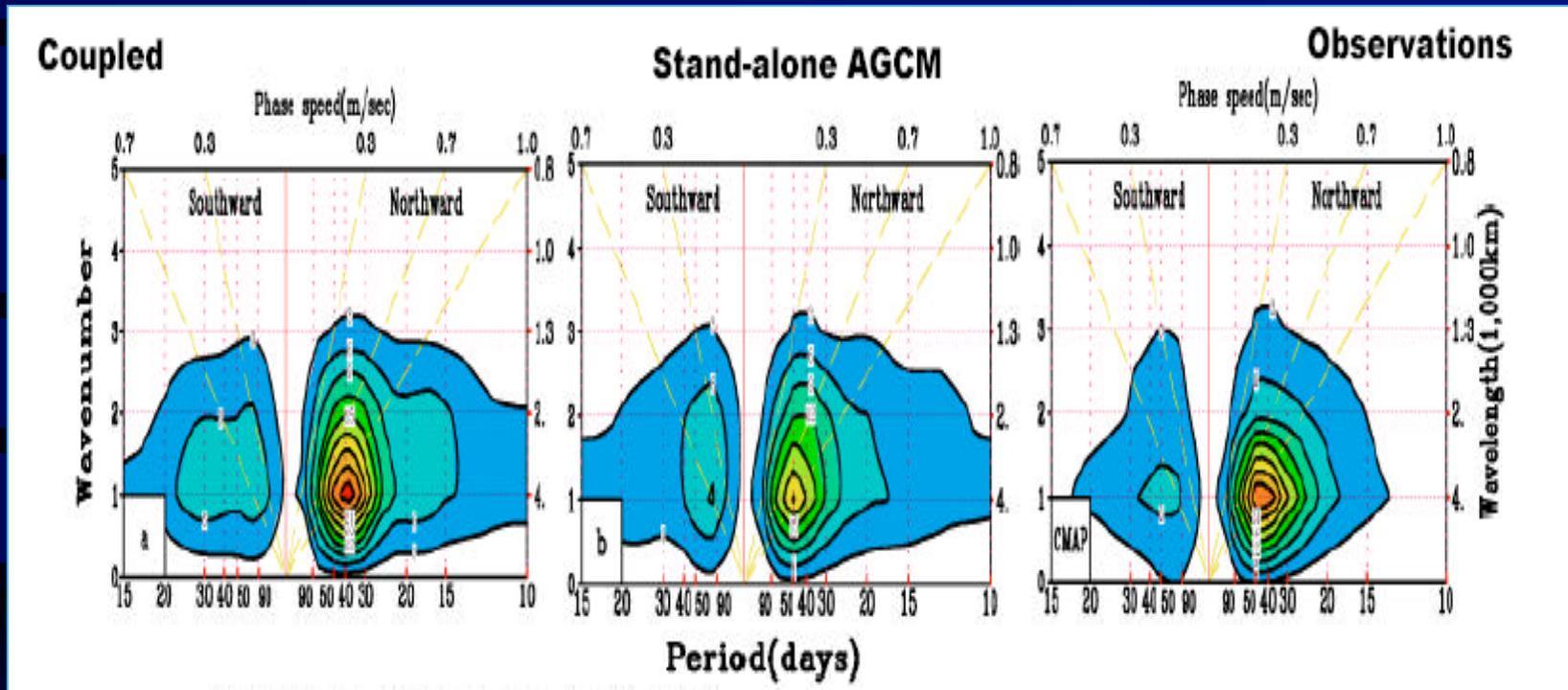
➤ Properly moistening of lower-troposphere

Inness et al. 2001, Tompkins 2001, Grabowski 2003

3. Cloud-radiation interaction

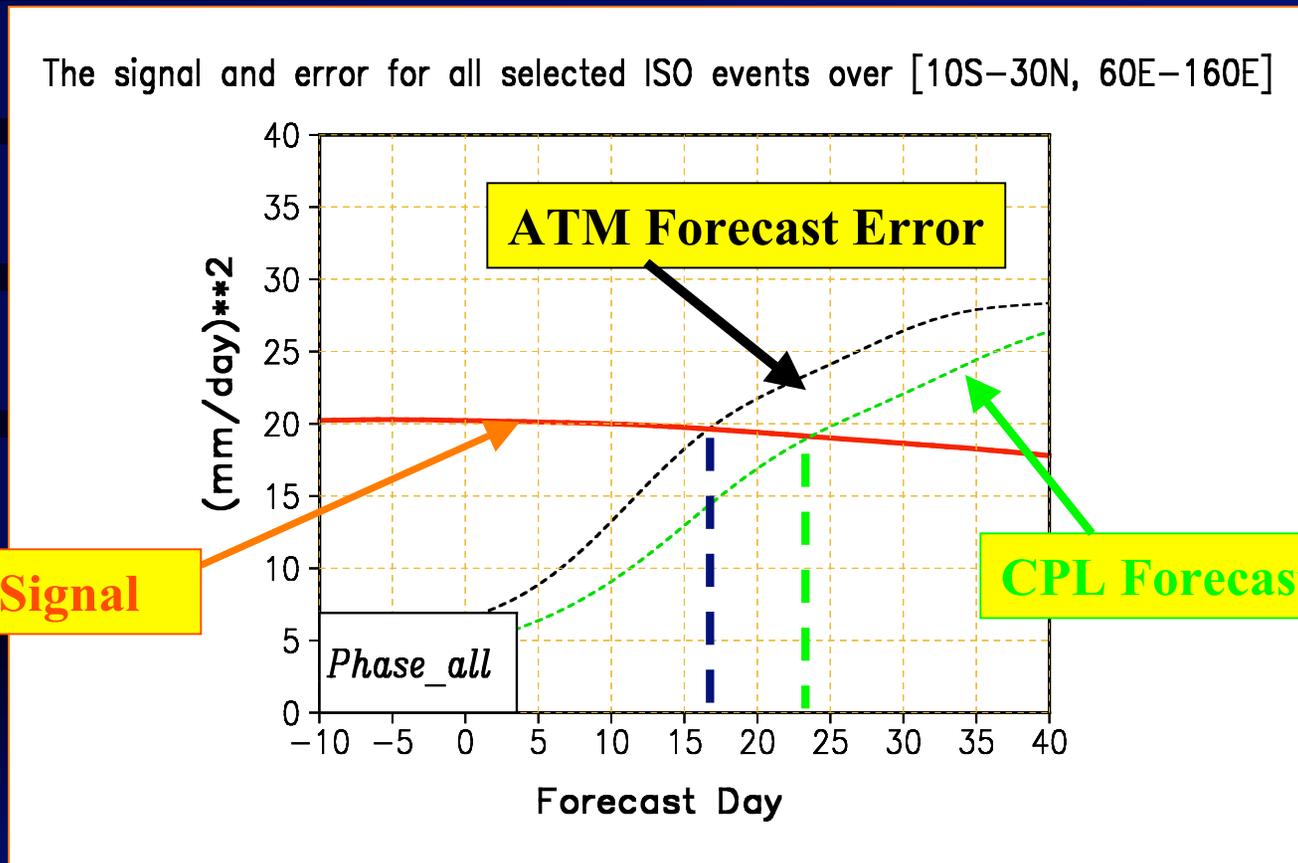
Hu and Randall 1994, Mehta and Smith 1997, Raymond 2001, Lee et al. 2001

Air-sea Coupling Enhances the Northward-propagating Monsoon ISO



Flatau et al.1997, Wang and Xie 1998,Waliser et al. 1999, Fu et al. 2003,
Fu and Wang 2004, Zheng et al. 2004

Air-Sea Coupling Extends the Predictability of Monsoon Intraseasonal Oscillations



[ATM: 17 days; CPL: 24 days]

□ Issues related to air-sea coupling

- Many modeling studies have shown that active air-sea coupling improves the simulations of ISO

Flatau et al. 1997, Wang and Xie 1998, Waliser et al. 1999, Fu et al. 2003, Fu and Wang 2004, Zheng et al. 2004

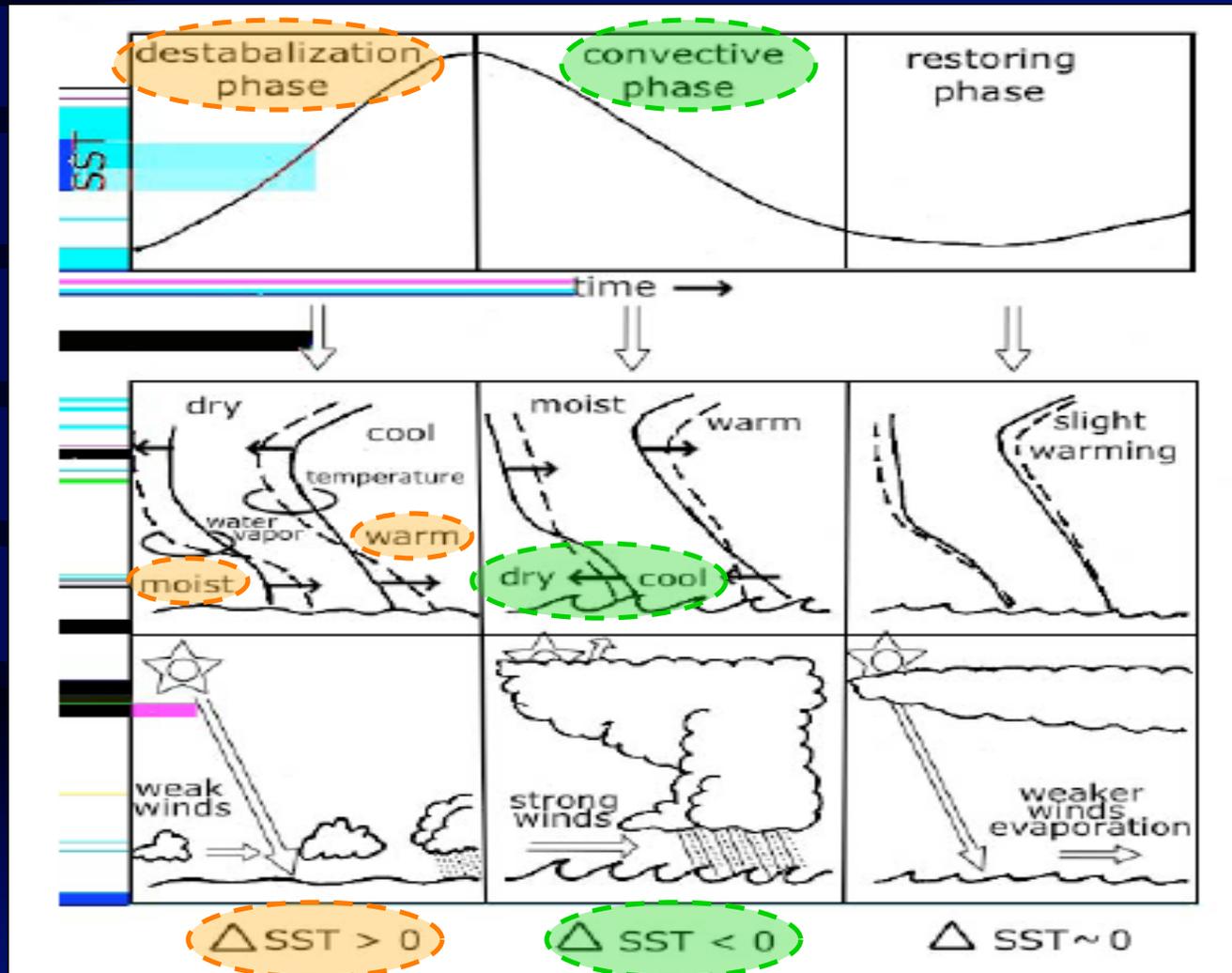
- ISO modifies underlying sea-surface temperature primarily through changing surface heat fluxes (✓)

Krishnamurti 1988, Waliser 1996, Lau and Sui 1997, Jones et al. 1998, Wang and Xie 1998, Shinoda et al. 1998, Sengupta and Ravichandran 2001, Waliser et al. 1999, Fu et al. 2003

- How do intraseasonal SST anomalies feed back to ISO (?)

Lau and Sui 1997, Stephens et al. 2004

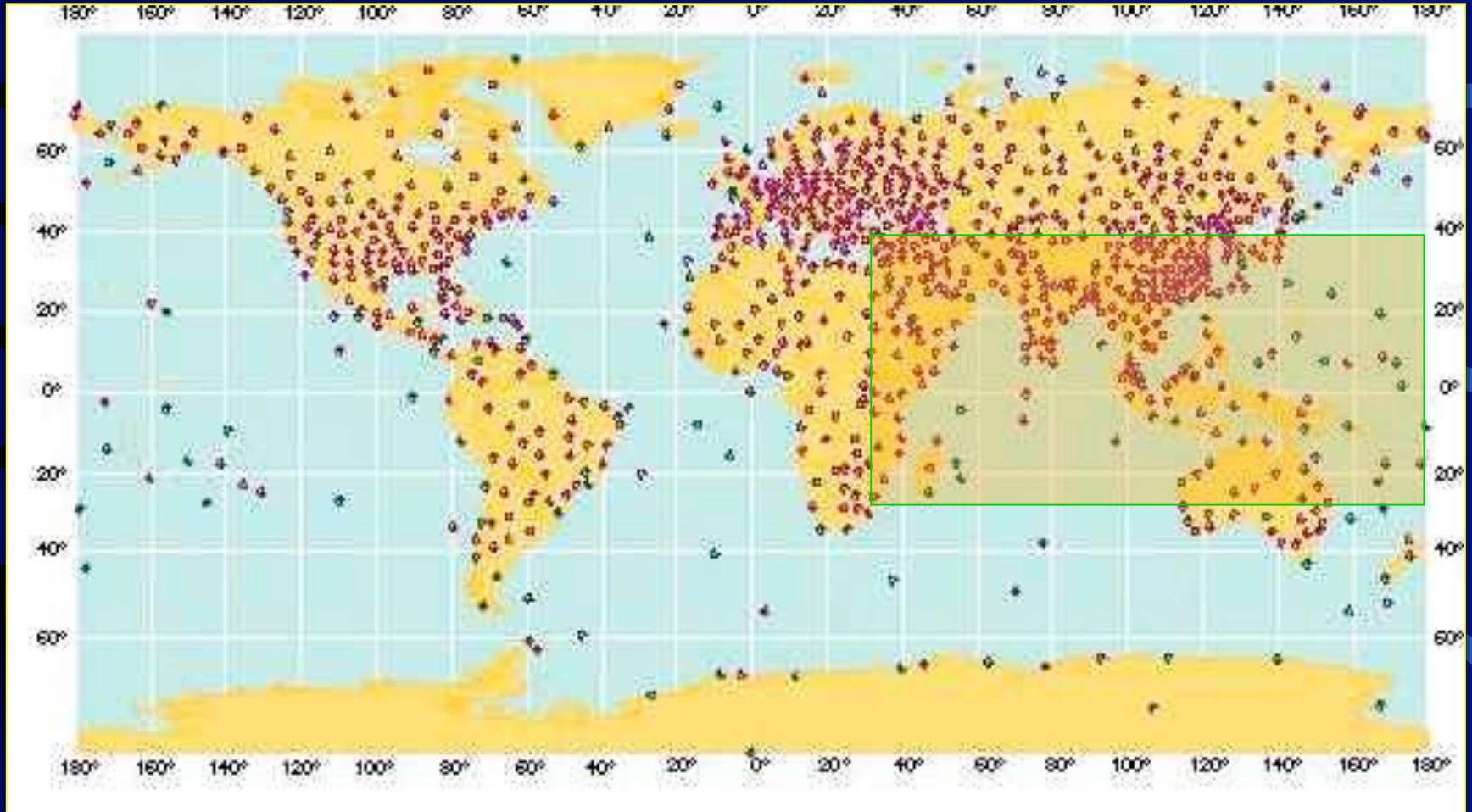
Proposed mechanism for SST-feedback-to-ISO



Lau and Sui 1997; Stephens et al. 2004

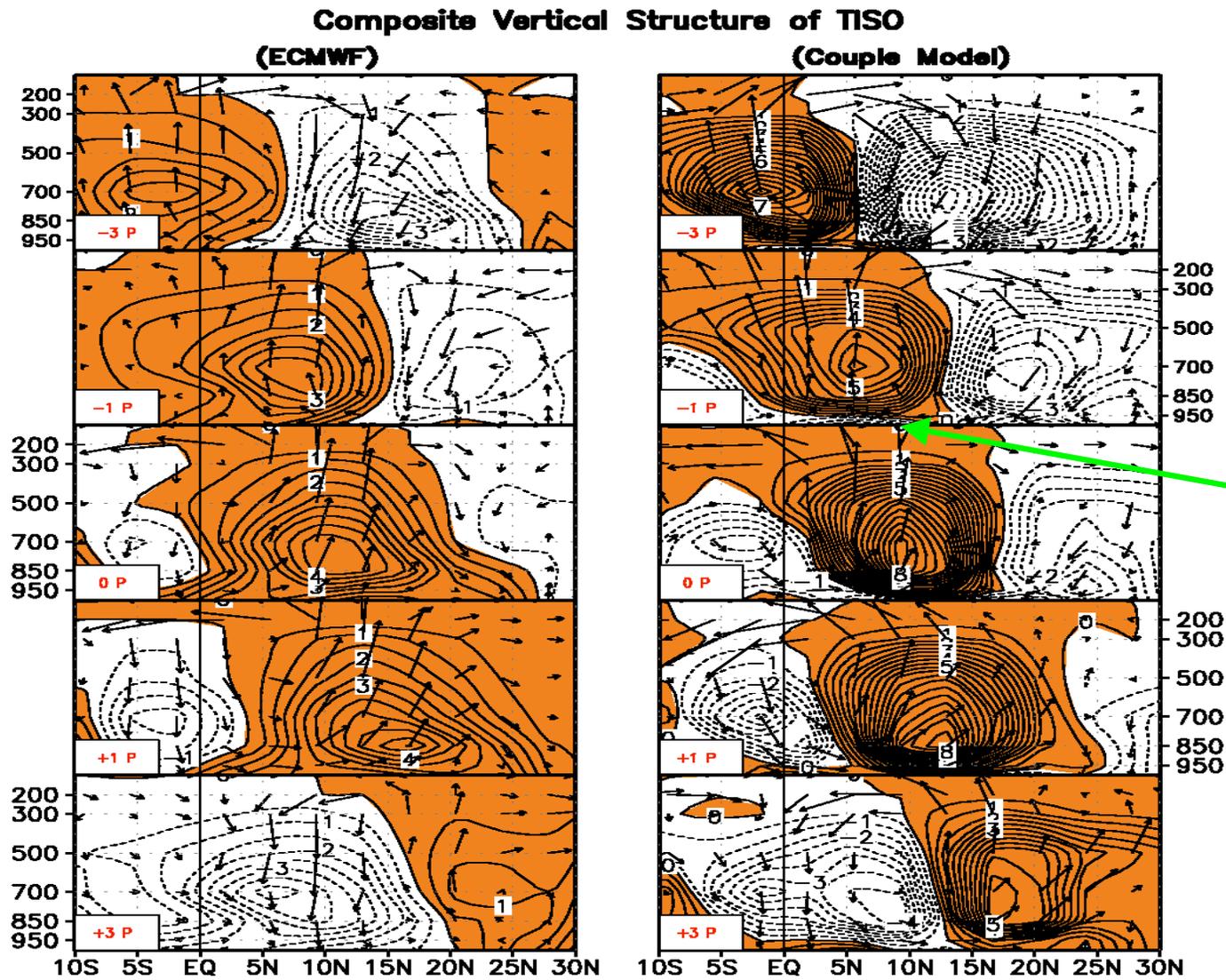
AIRS Science Team Meeting, March 7-9, 2006, Pasadena, CA

Upper-air Observations



<http://www.wmo.ch/>

Vertical moisture structure of ISO



Major Differences

➤ Intensity of Moisture Pert.

➤ Surface Dry Zone

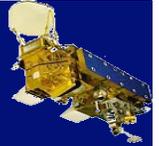
Averaged between 85°E-95°E

ECMWF Analysis

?

UH Coupled Model

Fu and Wang 2004



Objectives

- Document the 3-D water-vapor Structure of MISO
- Investigate the Interactions between MISO and underlying

ocean

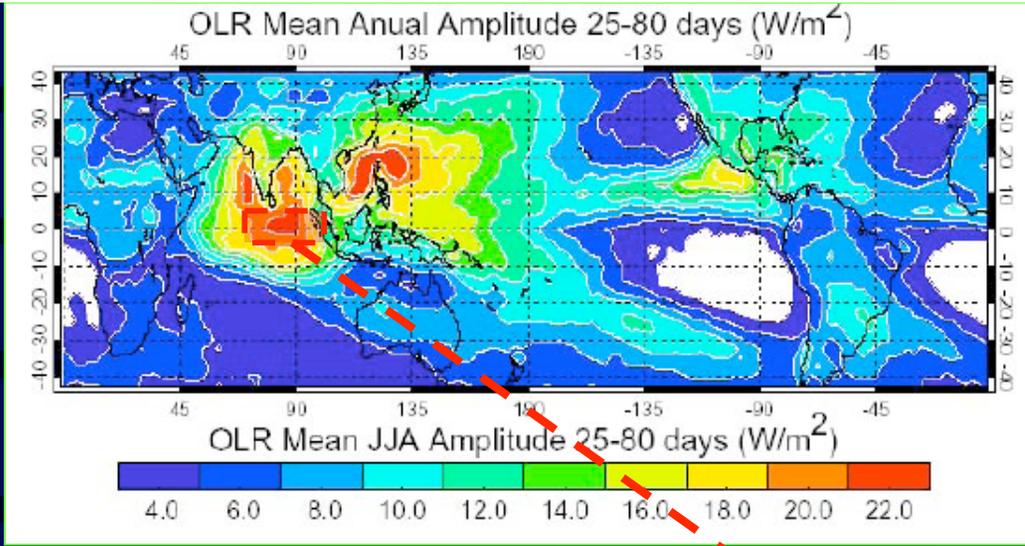
AIRS Level_3 Product V4.0.4.0

- 12 levels water vapor mass mixing ratio profile (specific humidity) from 1000 to 100mb
- Twice daily, 1°x1° grid, 2003-2004 (May-October)

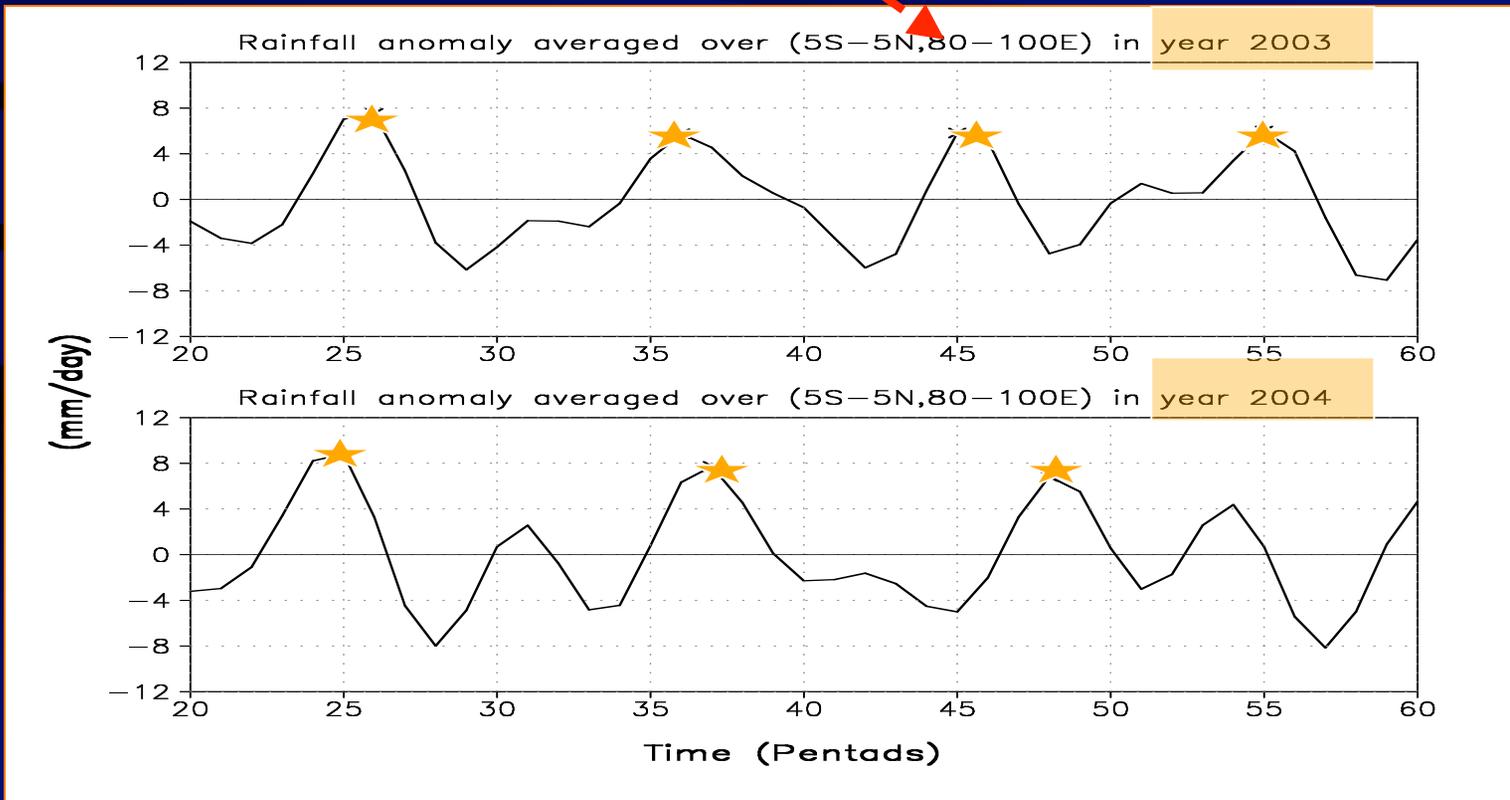
Other Satellite Data

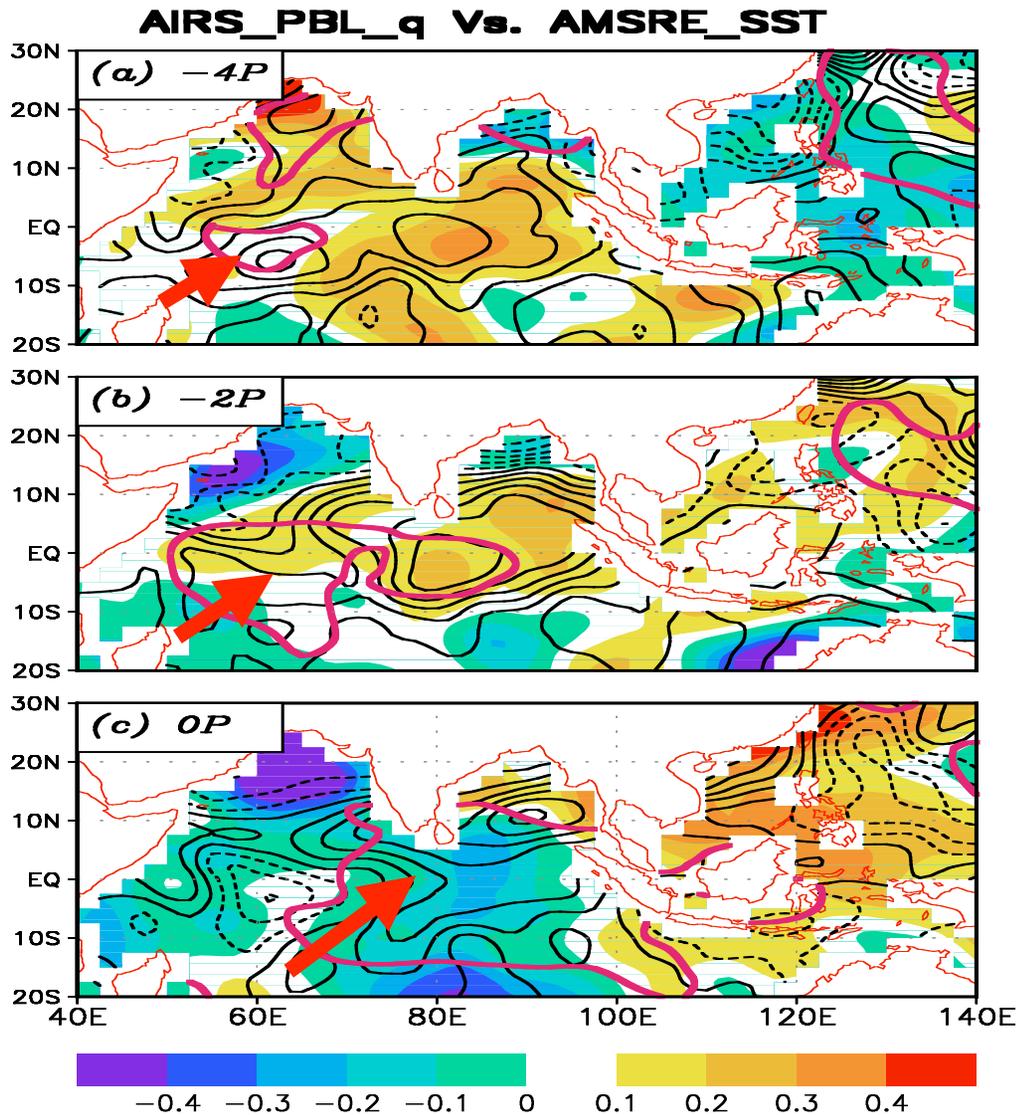
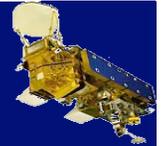
- Aqua AMSR_E SST (daily)
- GPCP rainfall (daily), QuikSCAT surface winds (daily)

All data have been averaged into 5-day mean (pentad), then 20-70-day anomalies are extracted.

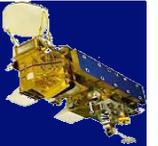


Seven MISO Events (2003-2004)

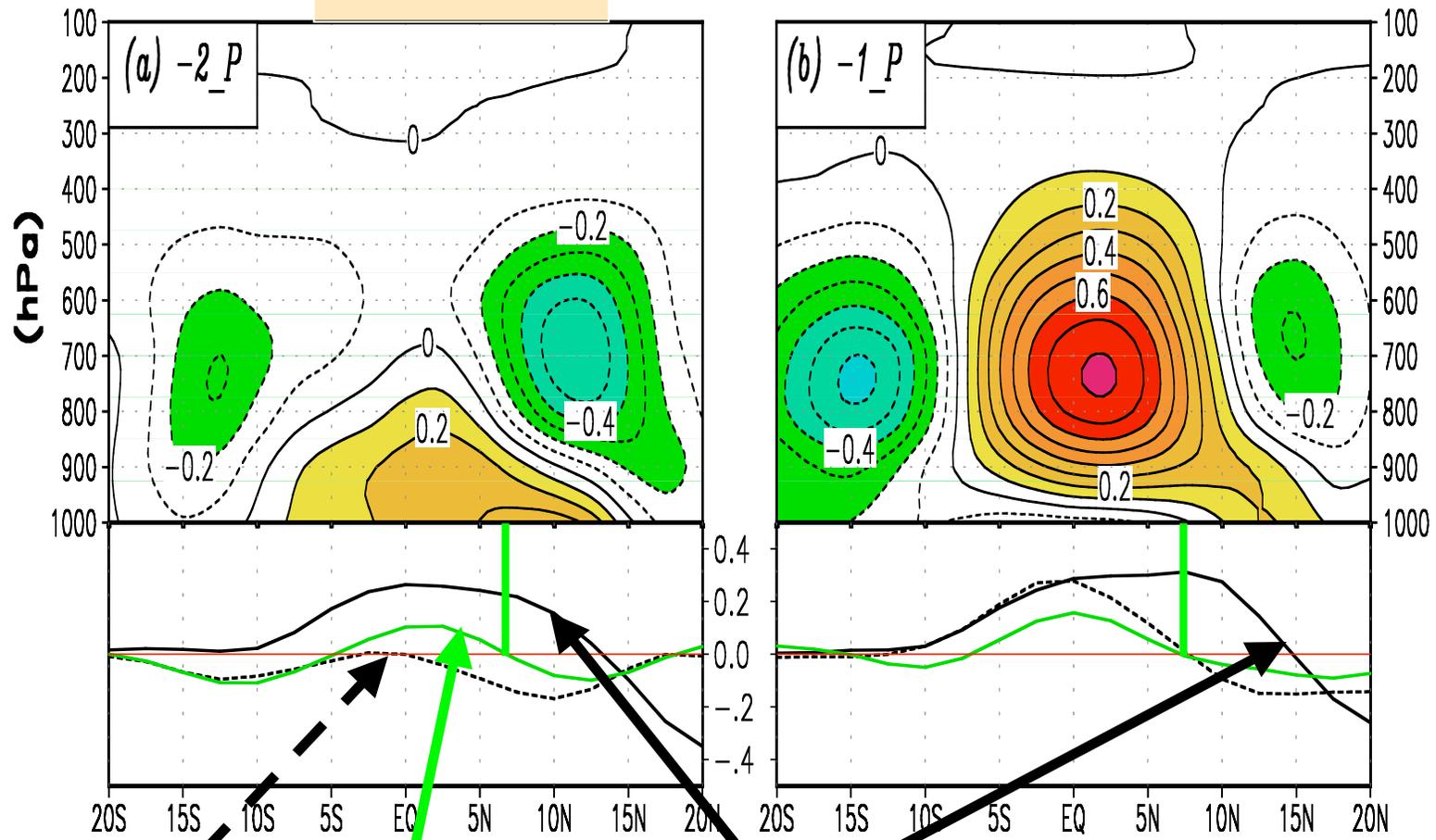




- Positive moisture/SST anomalies coexist in front of convection.
- Convection acts to reduce surface moisture through downdrafts (?).
- Cause of positive surface moisture anomaly:
 - ▶ Surface convergence?
Kemball-cook and Wang 2002
 - ▶ Evaporation (SST)?
Shinoda et al. 1998



Specific Humidity Vs. Rainfall/Convergence/SST

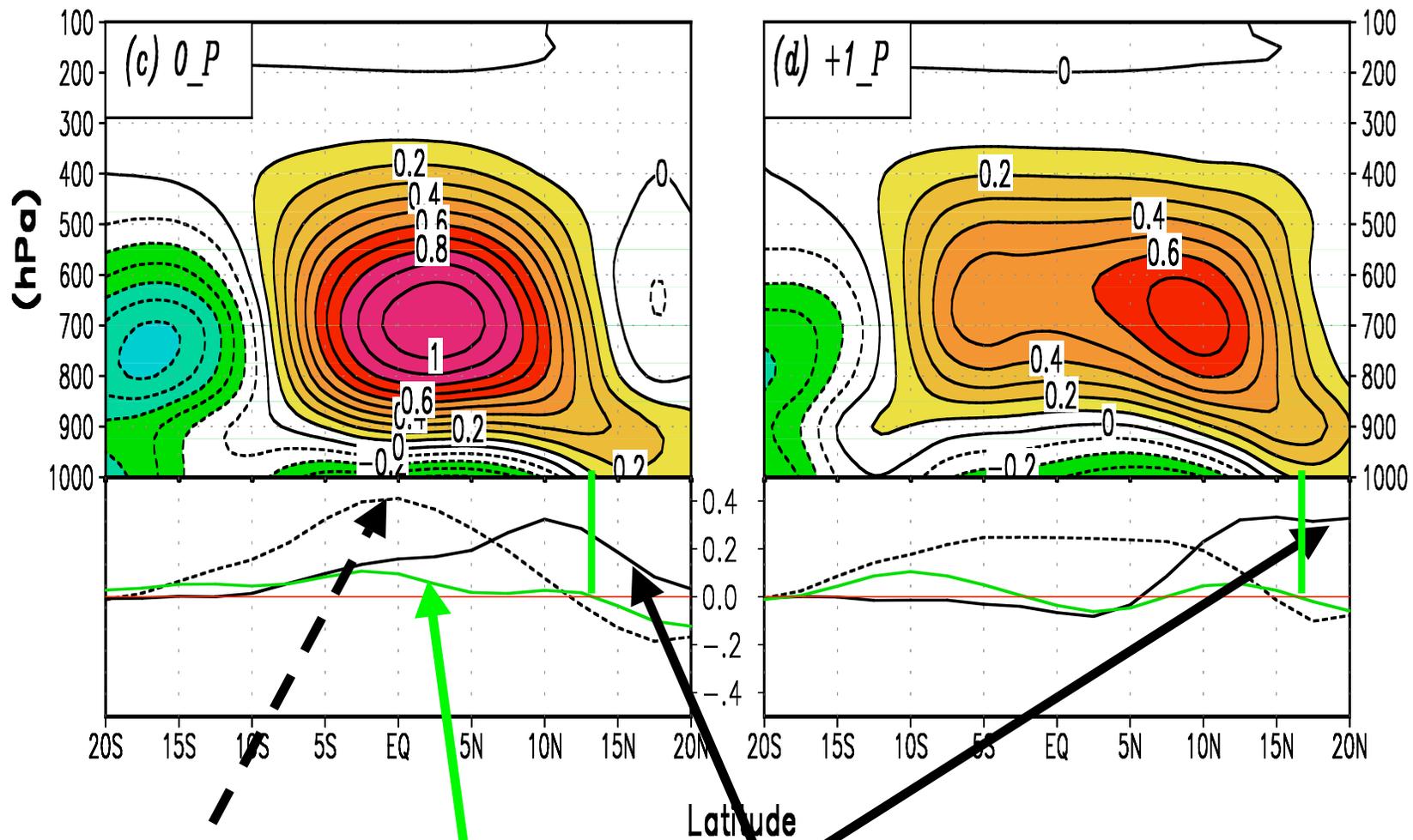
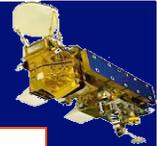


Rainfall

Convergence

SST

Averaged between
85°E-95°E



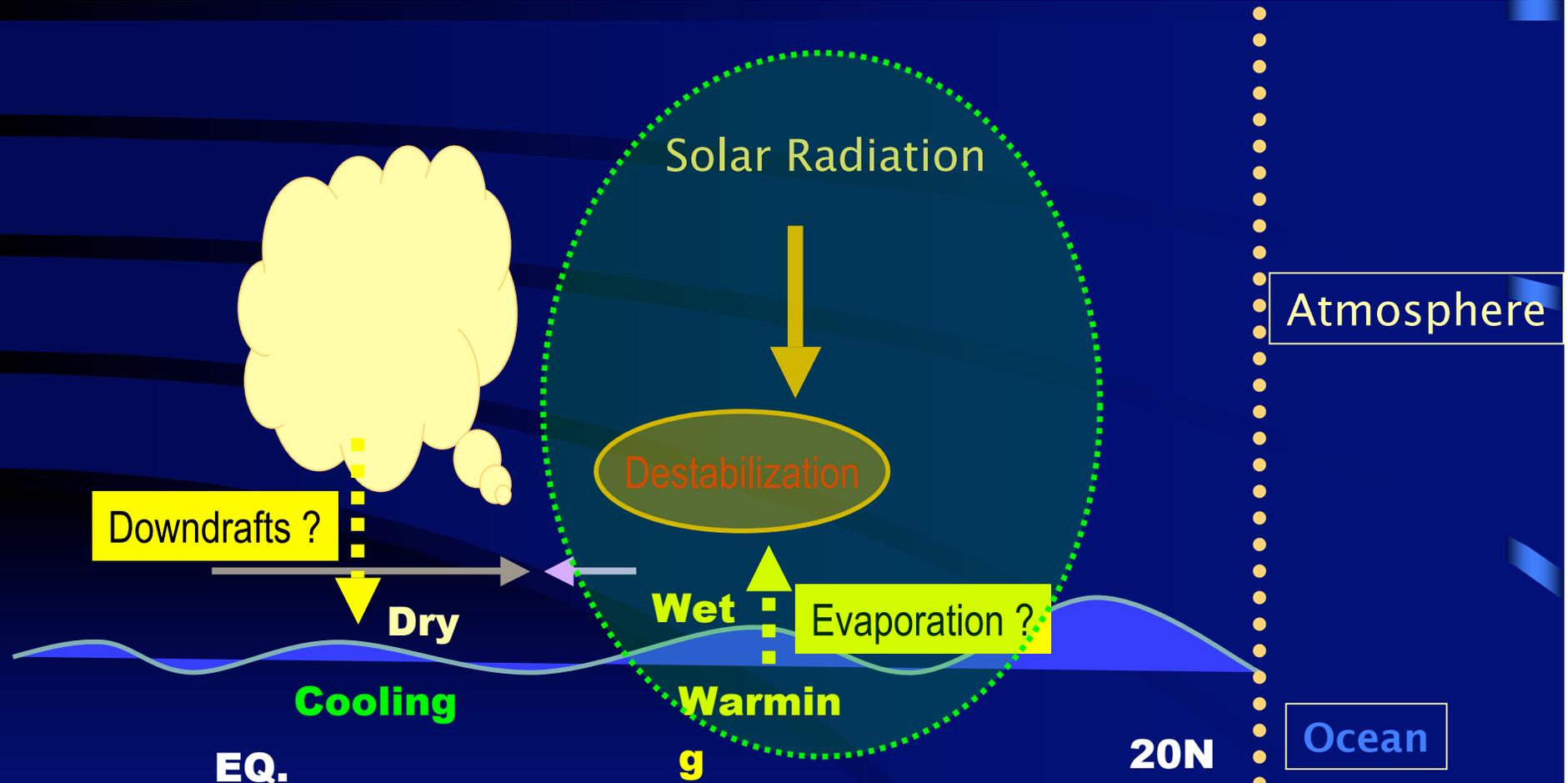
Rainfall

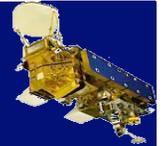
Convergence

SST

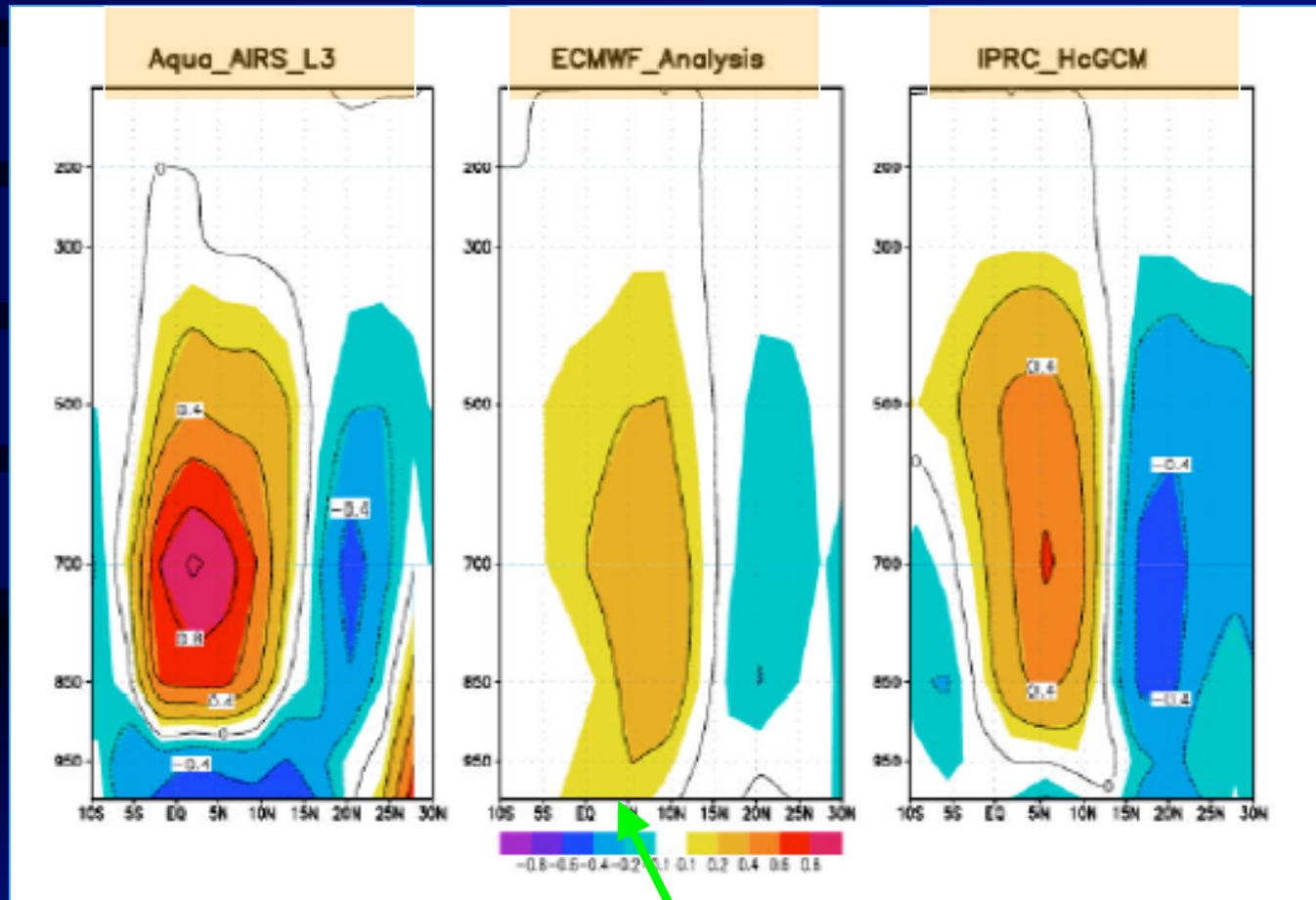
Averaged between
85°E-95°E

Atmosphere-Ocean Coupling Contributes to the Northward Propagation of the MISO



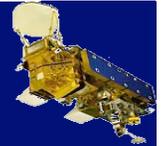


Composite Vertical Moisture Anomalies of MISO Using ECMWF Analysis and UH Coupled Model Output

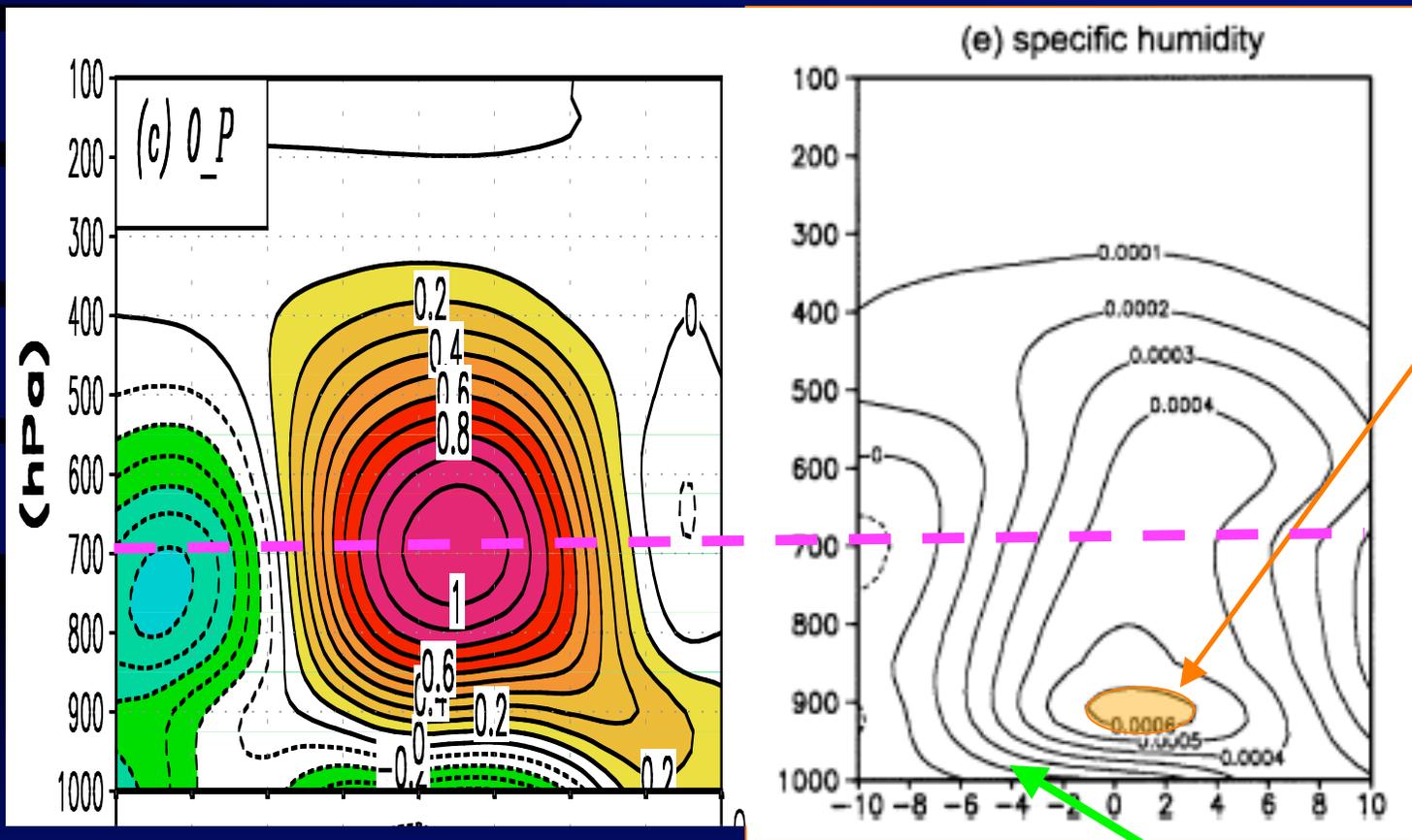


Fu and Wang 2004

No Surface Dry Zone



Composite Vertical Moisture Anomalies of MISO Using NCEP Reanalysis

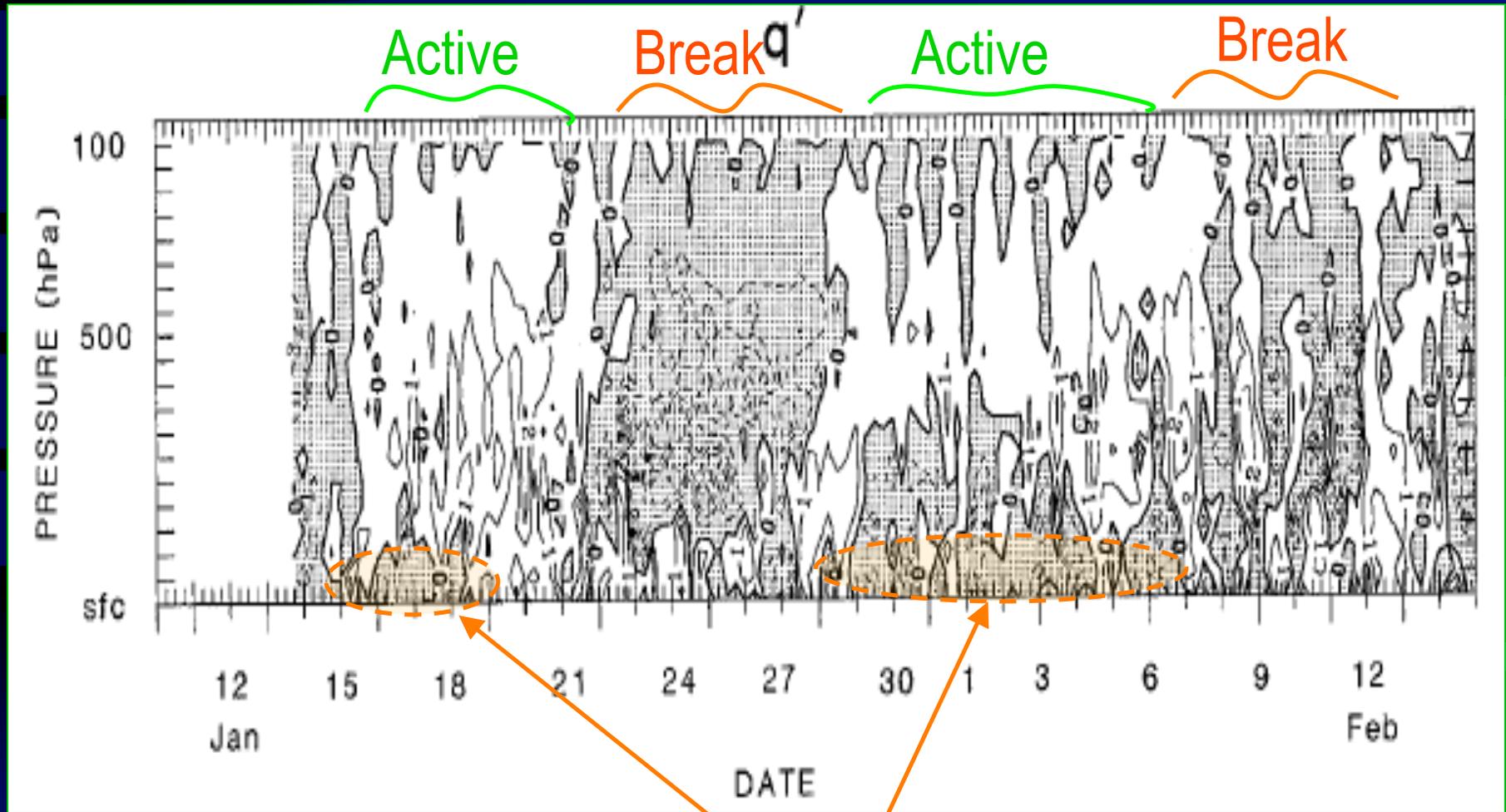


Maximum anomaly ~ 910 hPa

No Surface Dry Zone

Jiang et al 2004

In-Situ Sounding Observed Moisture Anomalies at (12°S, 140°E)



McBride and Frank (1999)

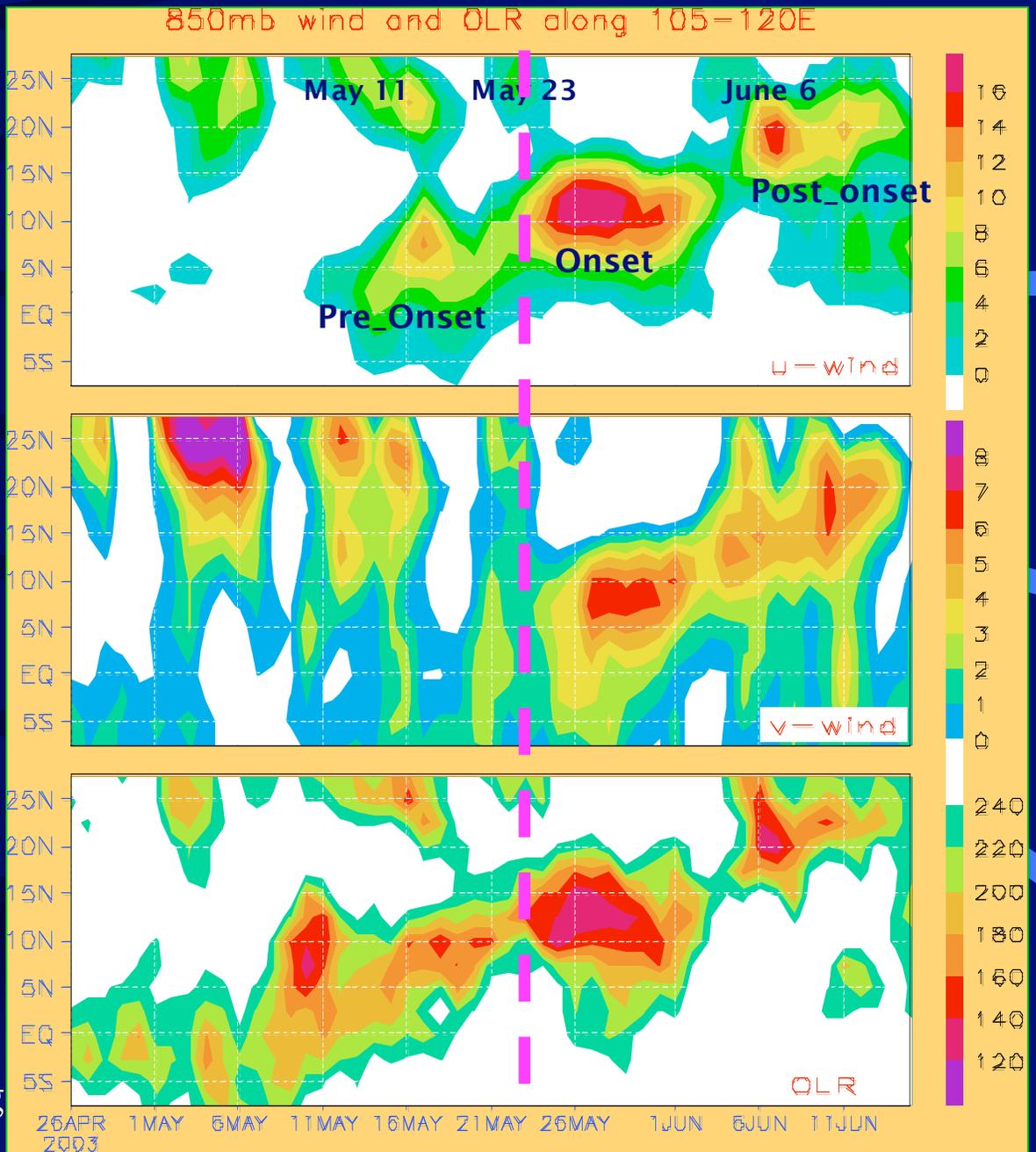
Surface Dry Zones

SCS summer monsoon onset in 2003:

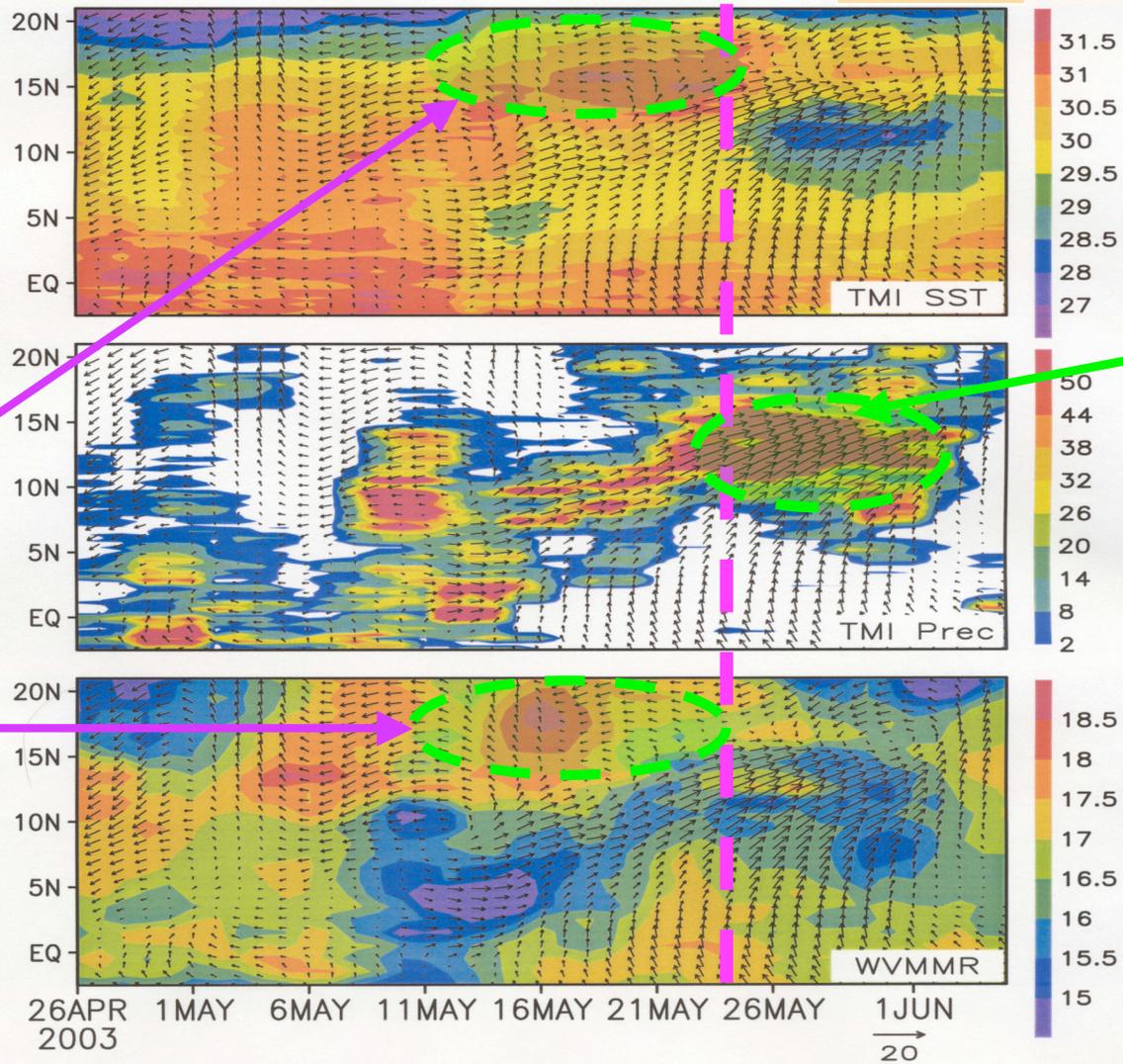
- Pre-onset, May 11
- Onset, May 23
- Post-onset, June 6

(Averaged between 105°E-120°E)

Courtesy Dr. Yongsheng Zhang
at University of Hawaii



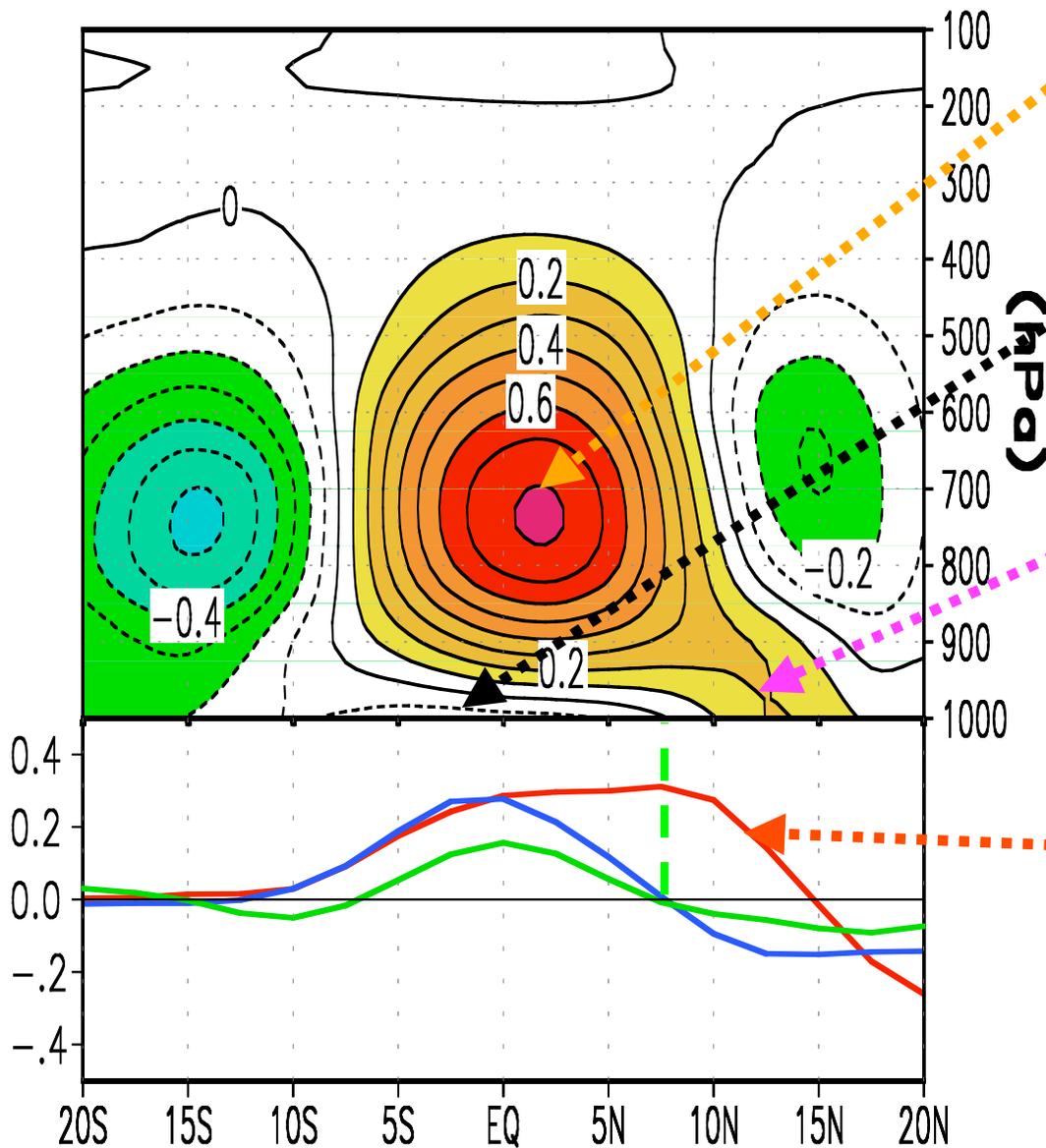
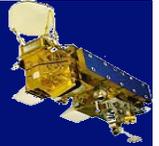
SST, Prec. 1000hPa WVMMR, and QSCAT wind, 105–120E



Preconditioning
:
High SST
Moist Boundary
Layer

SCS
Monsoon
Onset

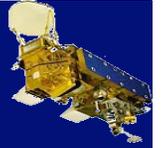




- Larger moisture perturbations compared to ECMWF & NCEP reanalysis.
- Surface dry layer below MISO convection probably induced by downdrafts.
- Boundary-layer moistening ahead of the convection preconditions the northward movement of MISO.
- Positive SST anomaly rather than surface convergence is the major factor for the BL moistening in this period.

□ Future Research

- Diagnose new analysis/reanalysis datasets (ECMWF/NCEP ?) that have used AIRS products in the data assimilation.
- Get more surface and sounding observations in the tropical Indian Ocean to further validate AIRS data. Particularly, to verify the drying surface layer associated with MISO convection.
- Understand why atmospheric general circulation models (AGCM) can't hold more moisture in the convective phase and why AGCM can't generate a drying surface layer under MISO convection.
- Conduct case study with original twice daily AIRS data to understand detail processes.

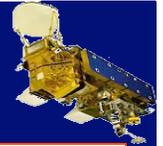


□ Tropical Cyclone Reanalysis Using AIRS Data

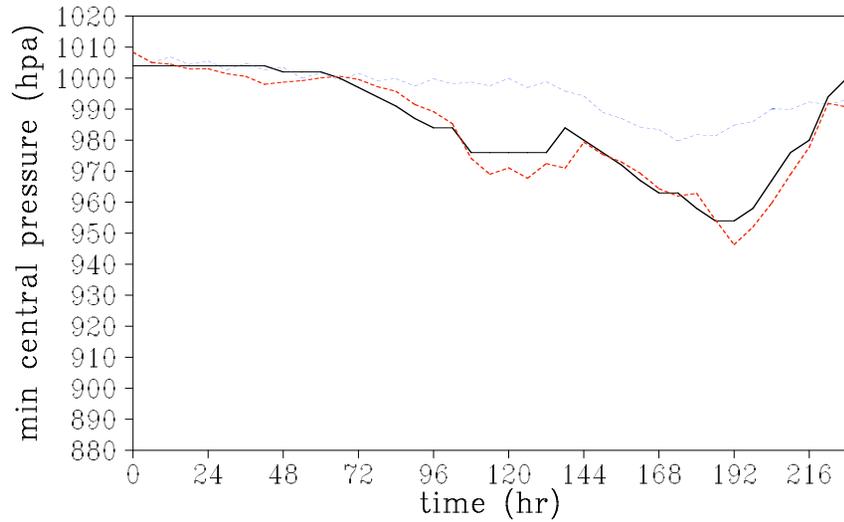
The latest satellite sensors such as Atmospheric Infrared Sounder (AIRS) on board of NASA (Aqua) can penetrate deep convective clouds and provide 3D temperature and moisture profiles (Level_2 data)

Courtesy Dr. Tim Li at University of Hawaii

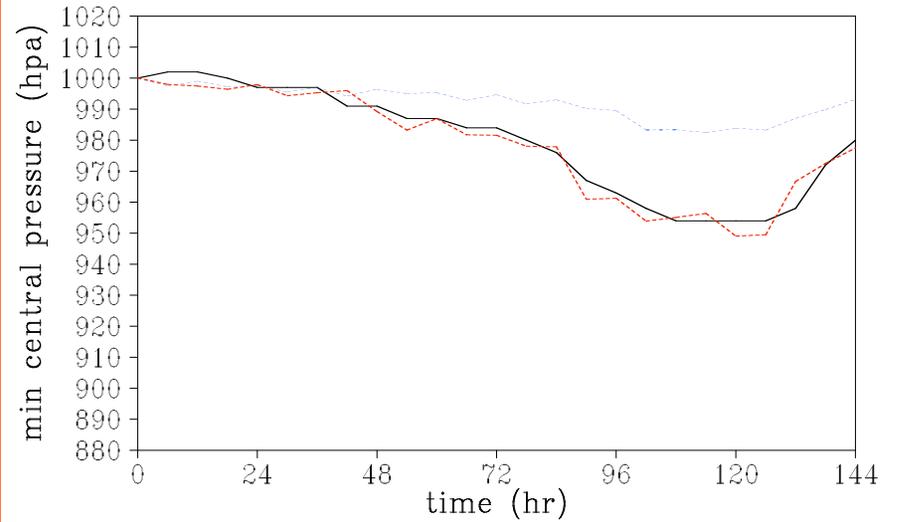
Observation vs. NCEP Analysis vs. TC Reanalysis



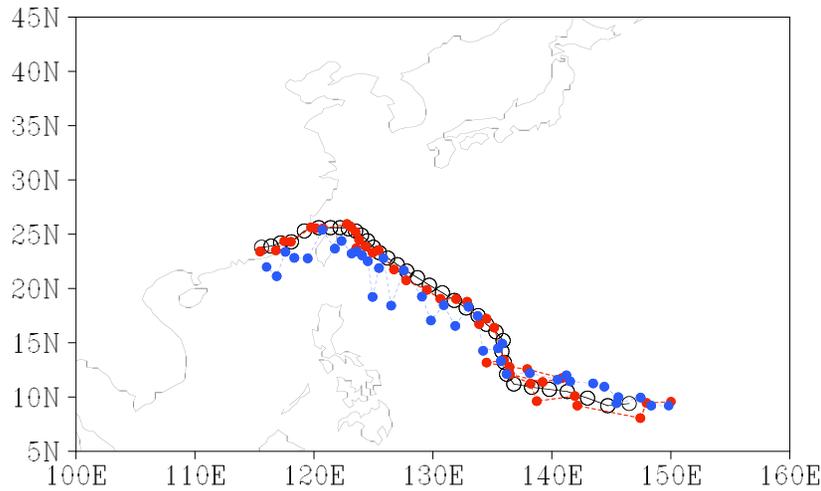
WP20 intensities



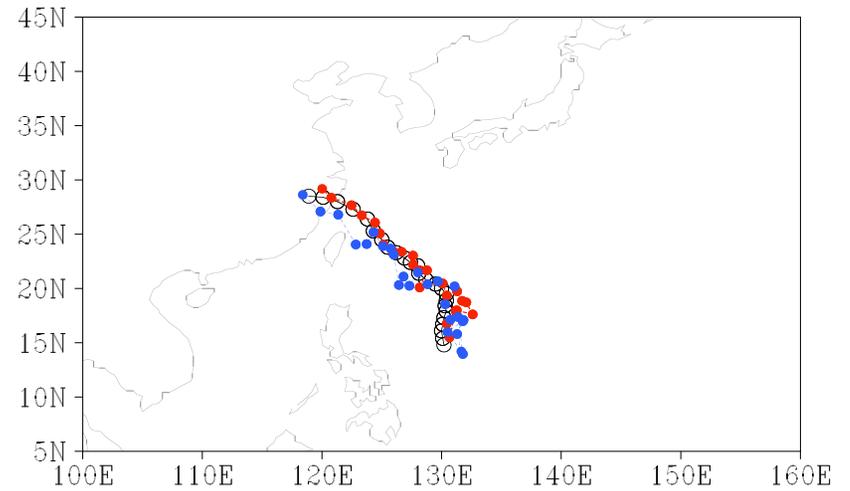
WP16 intensities



WP20 tracks



WP16 tracks



Thanks

Diamond Head



3B43 Seasonal Rainfall Climatology (JJA 1998 - 2003)

