Tropical intraseasonal rainfall variability in the CFSR

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Motivations

- Accuracy of tropical rainfall in reanalyses is a good measure of the quality of dynamical fields
- Diagnostics of the relationships between rainfall and dynamical fields in reanalyses help understand the impacts of models physics

Objectives

- Assess rainfall ISV in CFSR. How does CFSR compare with the previous reanalyses and with other new reanalyses (R1, R2, MERRA, ERAI)?
- Analyze relationship between rainfall and large-scale fields. To what extent does the relationship between large-scale fields and rainfall differ among the reanalyses, and what is the relevance of the difference to the dynamics of the MJO?
- Diagnose diabatic heating related to rainfall ISV. How different is the heating directly generated in the reanalysis model from that re-derived based on large scale fields and what are the implications to the model physics?

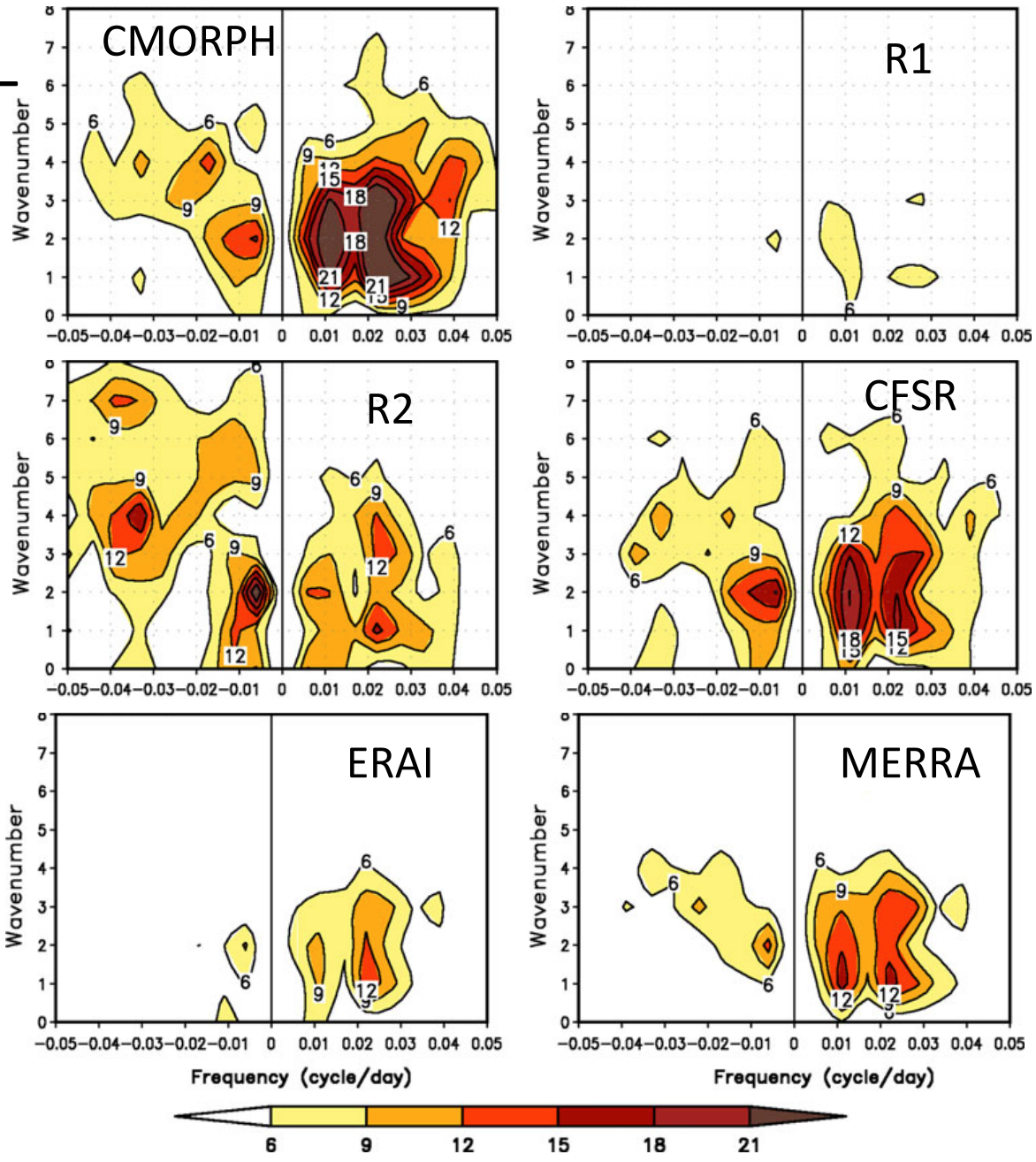
Data and methodology

- Observations
  - CMORPH rainfall (2000–2009)
  - NOAA AVHRR OLR (1979-2009)
- Reanalyses (1979-2009)
  - Rainfall from CFSR, R1, R2, MERRA, ERAI (2000-2009)
  - Winds, q, PWAT from CFSR, R1, R2
  - Diabatic heating from CFSR
- Daily mean anomalies
  - Raw anomalies: Departure from seasonal climatology
  - Intraseasonal anomalies: 20–100-day band-pass filtered
- Analysis (Nov-Apr)
  - Anomaly correlation, variance
  - Wavenumber-frequency spectra
  - Composites for MJO events selected based on observed OLR EOF1 and EOF2

Intraseasonal rainfall variability

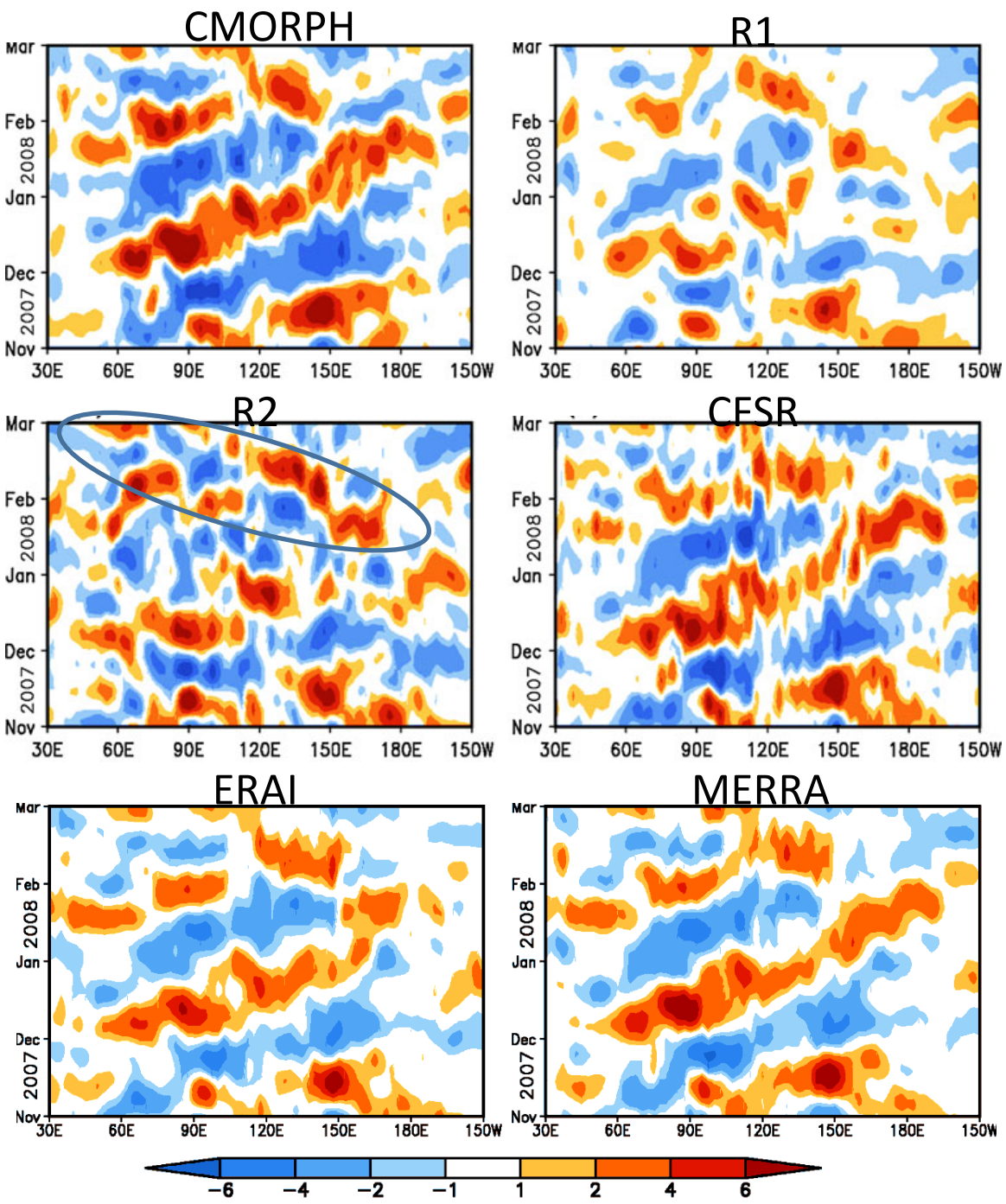
Rainfall wavenumber-frequency spectra (10S–10N average)

- Variability in R1 too weak
- Too much westward variance in R2
- All new reanalyses captured the observed eastward/westward contrast
- Amplitude in CFSR relatively better



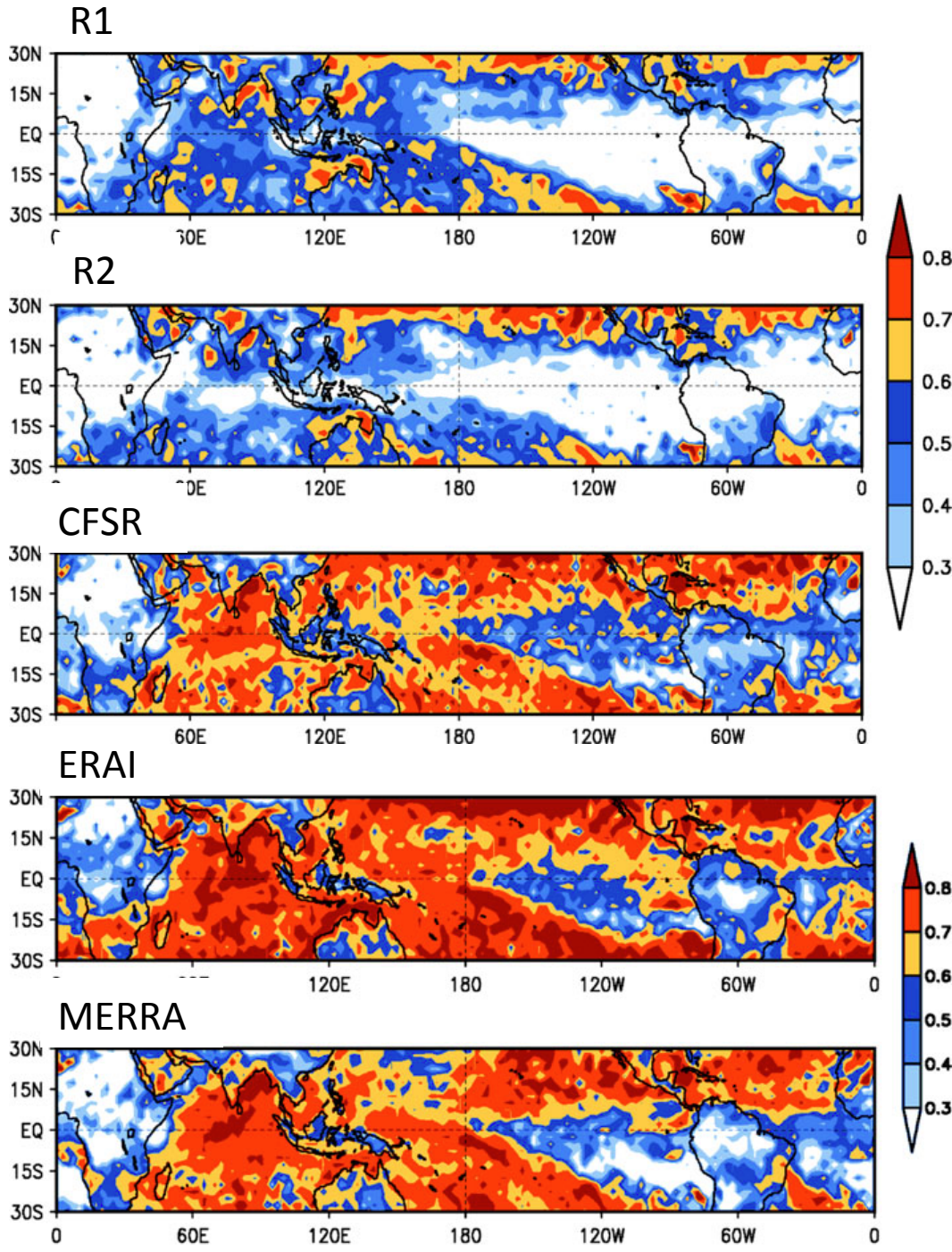
Evolution of 10S–10N average intraseasonal rainfall for Nov 2007 to Feb 2008

- Two full MJO cycles
- Weak anomalies in R1
- Propagation in R2 dis-organized with more westward propagation
- All three new reanalyses captured observed dominant eastward propagation
  (Anomalies in ERAI and MERRA seem to be smoother)



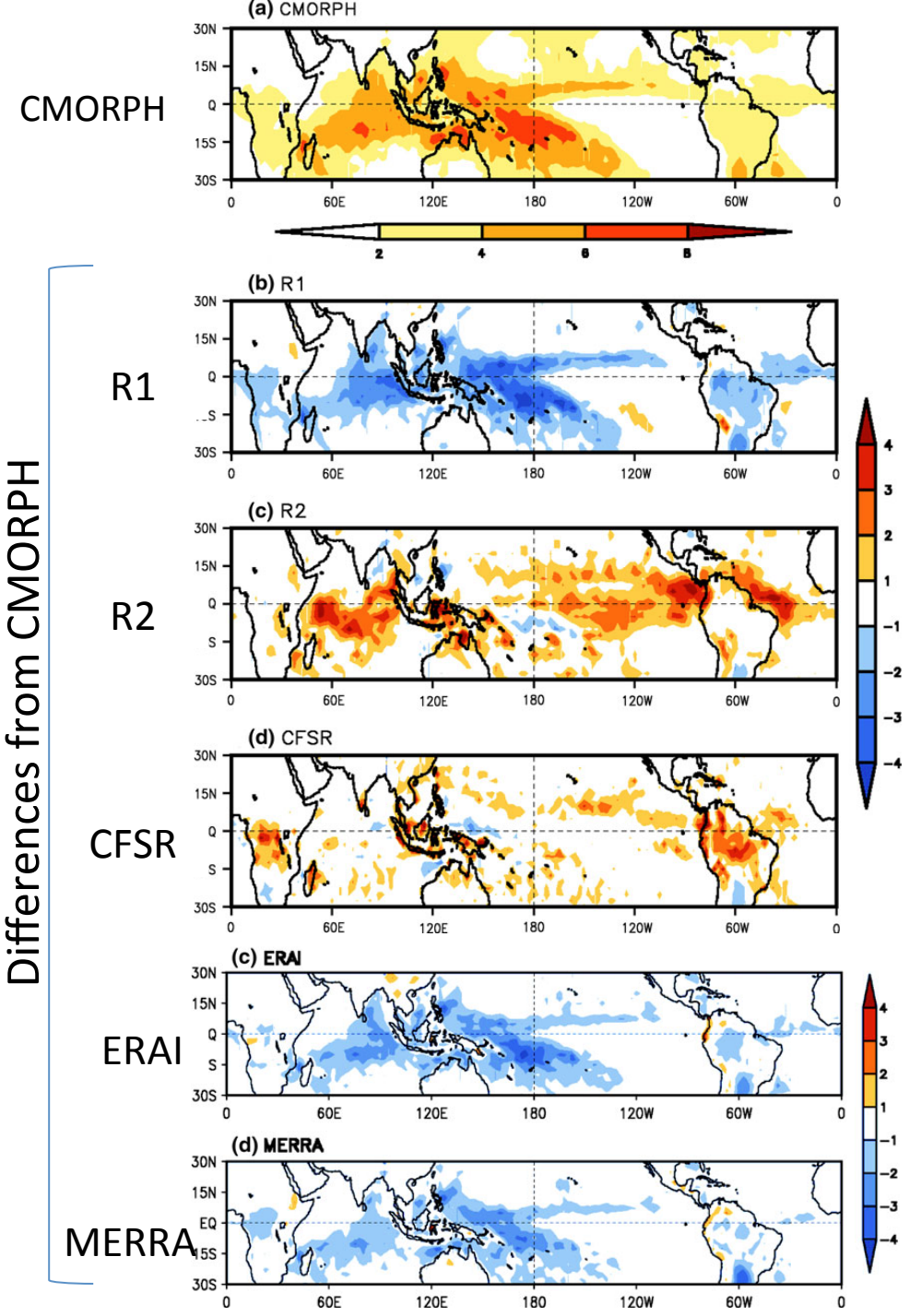
Anomaly correlation of intraseasonal rainfall

- Correlations relatively larger over Indian Ocean and western Pacific
- All three new reanalyses are much better than R1 and R2
- Overall, ERAI skill is the highest

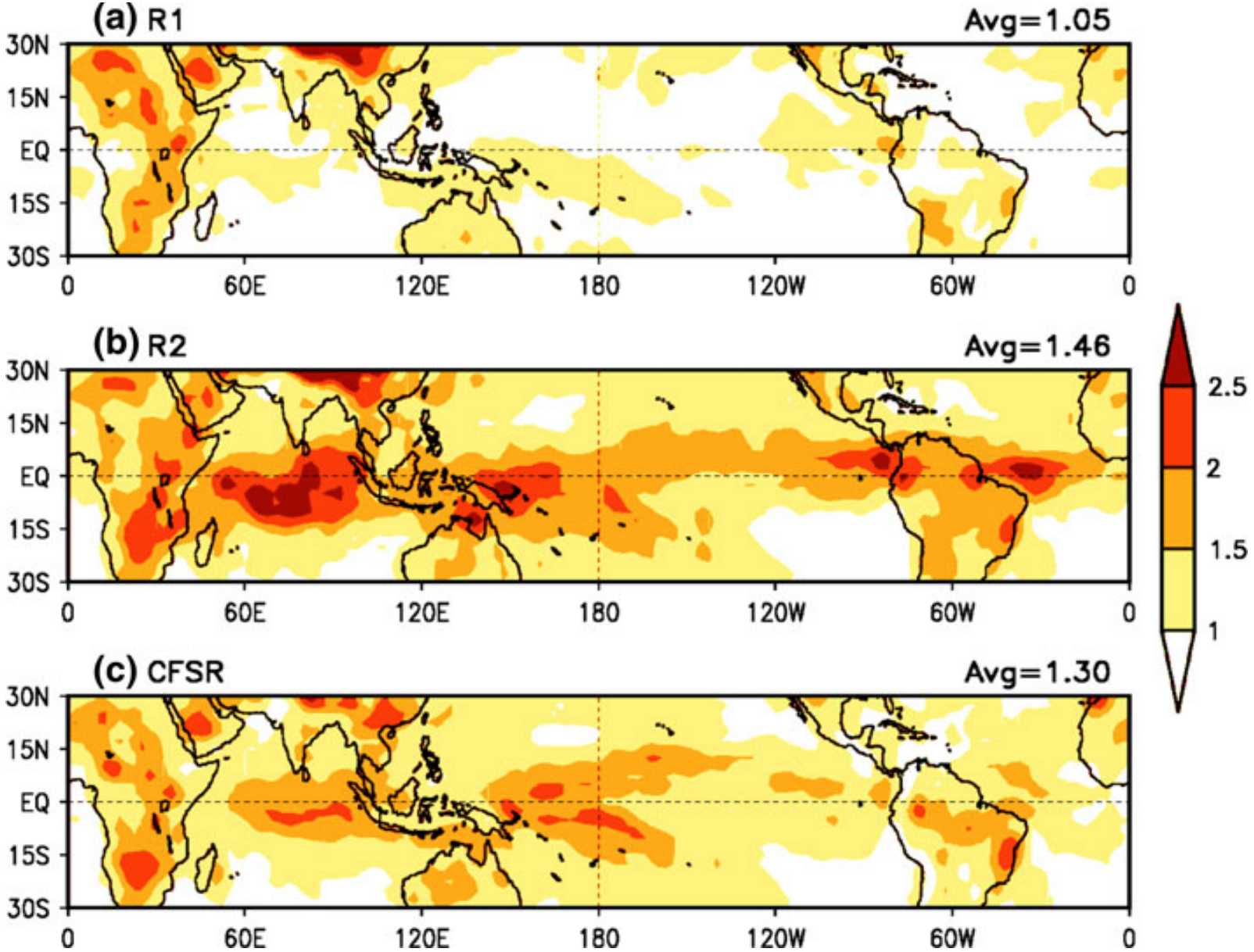


Standard deviation of intraseasonal rainfall anomalies

- Too weak ISV in R1
- Too strong ISV in R2
- More reasonable amplitude in CFSR
- Slightly too weak variability in ERAI and MERRA



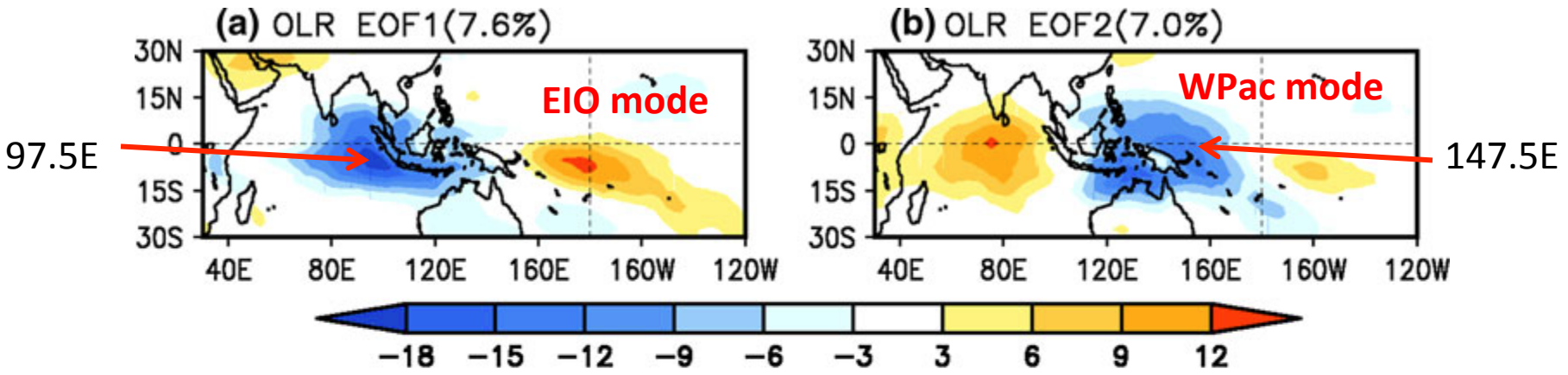
Standard deviation of intraseasonal $-\text{div}(v_{850})$ anomalies



MJO related variability

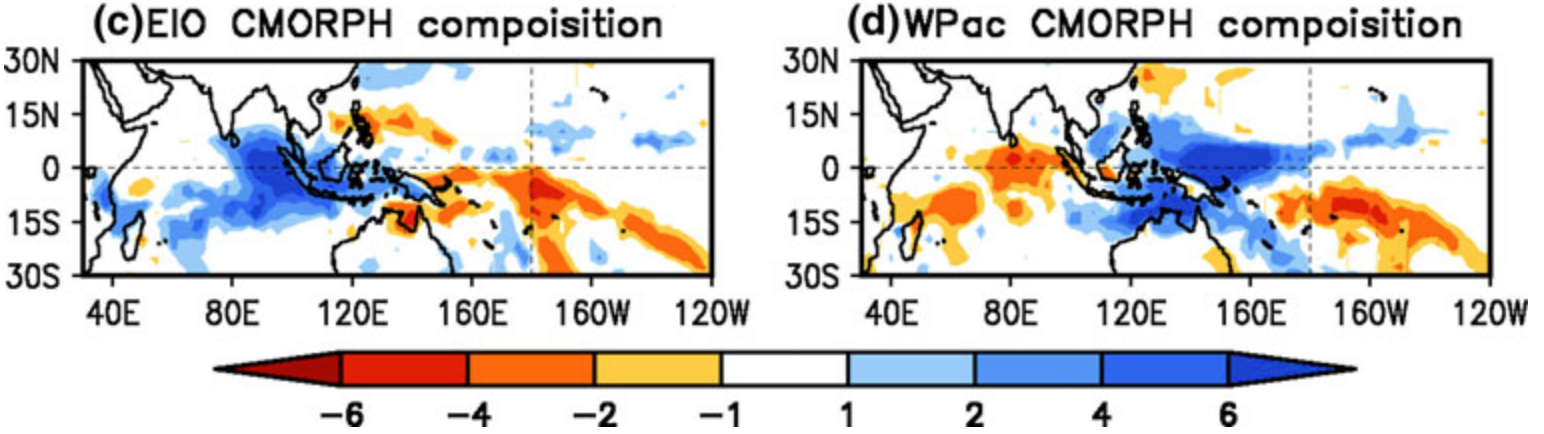
- Selection MJO events based on OLR EOF1 and EOF2
- Composites for MJO events

EOF1 and EOF2 of observed intraseasonal OLR anomalies



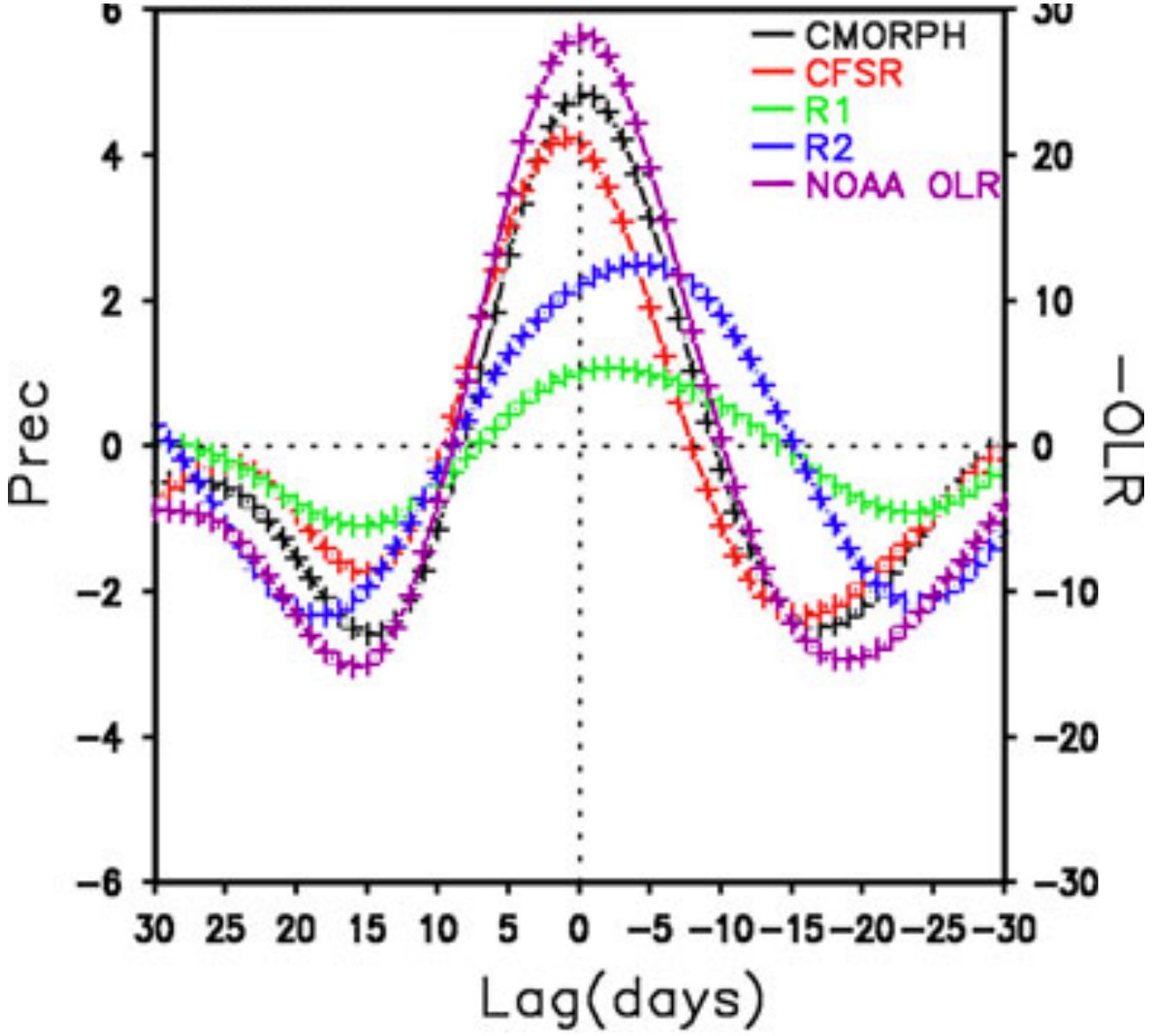
1979-2009: 44 events; 2000-2009: 13 events

CMORPH rainfall composites



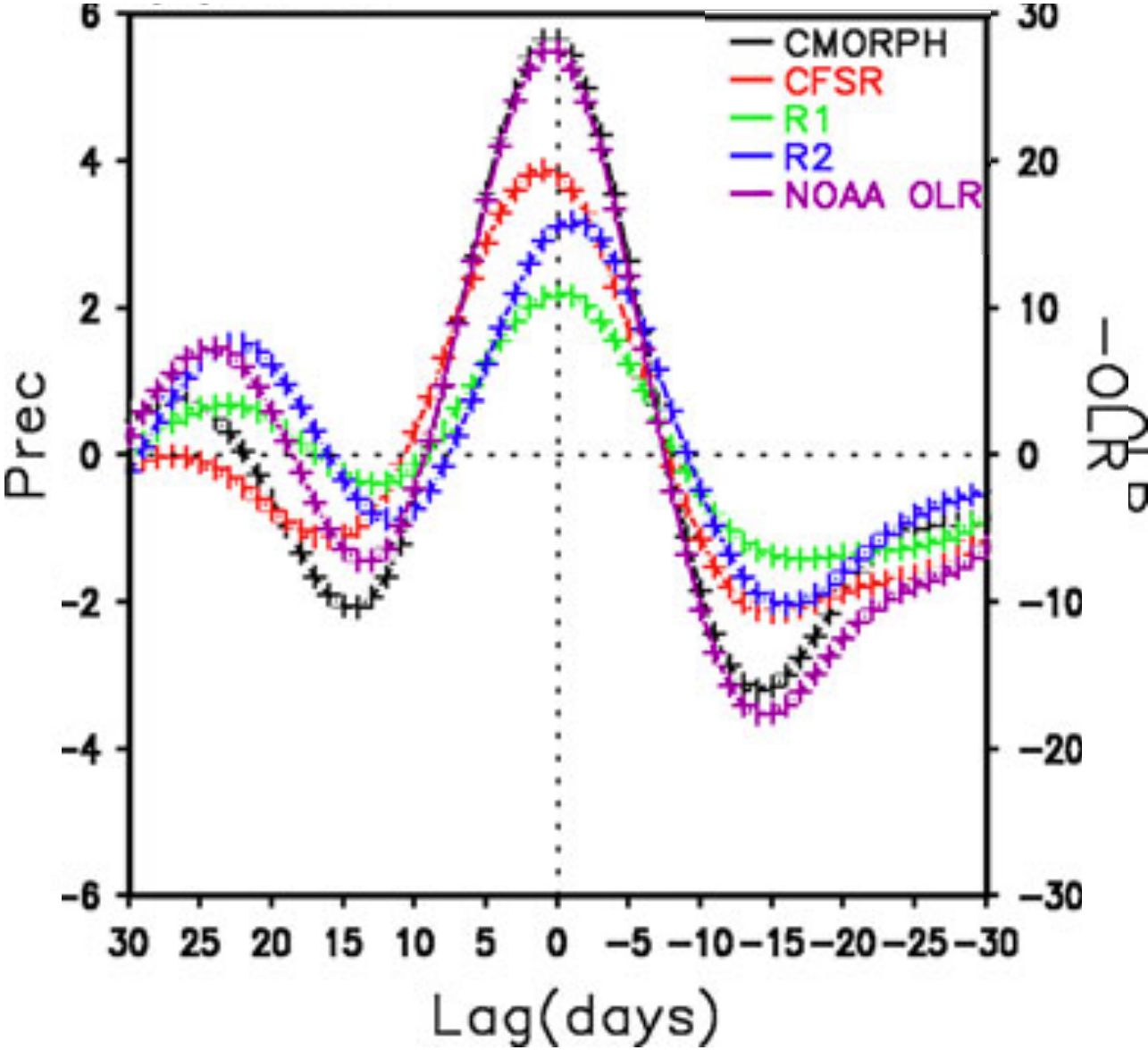
Lagged EIO rainfall composites at 97.5E

- Composites relative to PC1 peak values
- Consistent CMORPH and NOAA OLR
- Rainfall maximum in R1 and R2 occur 2-6 days too early
- CFSR rainfall peak is slightly too late



Lagged WPac composites at 147.5E

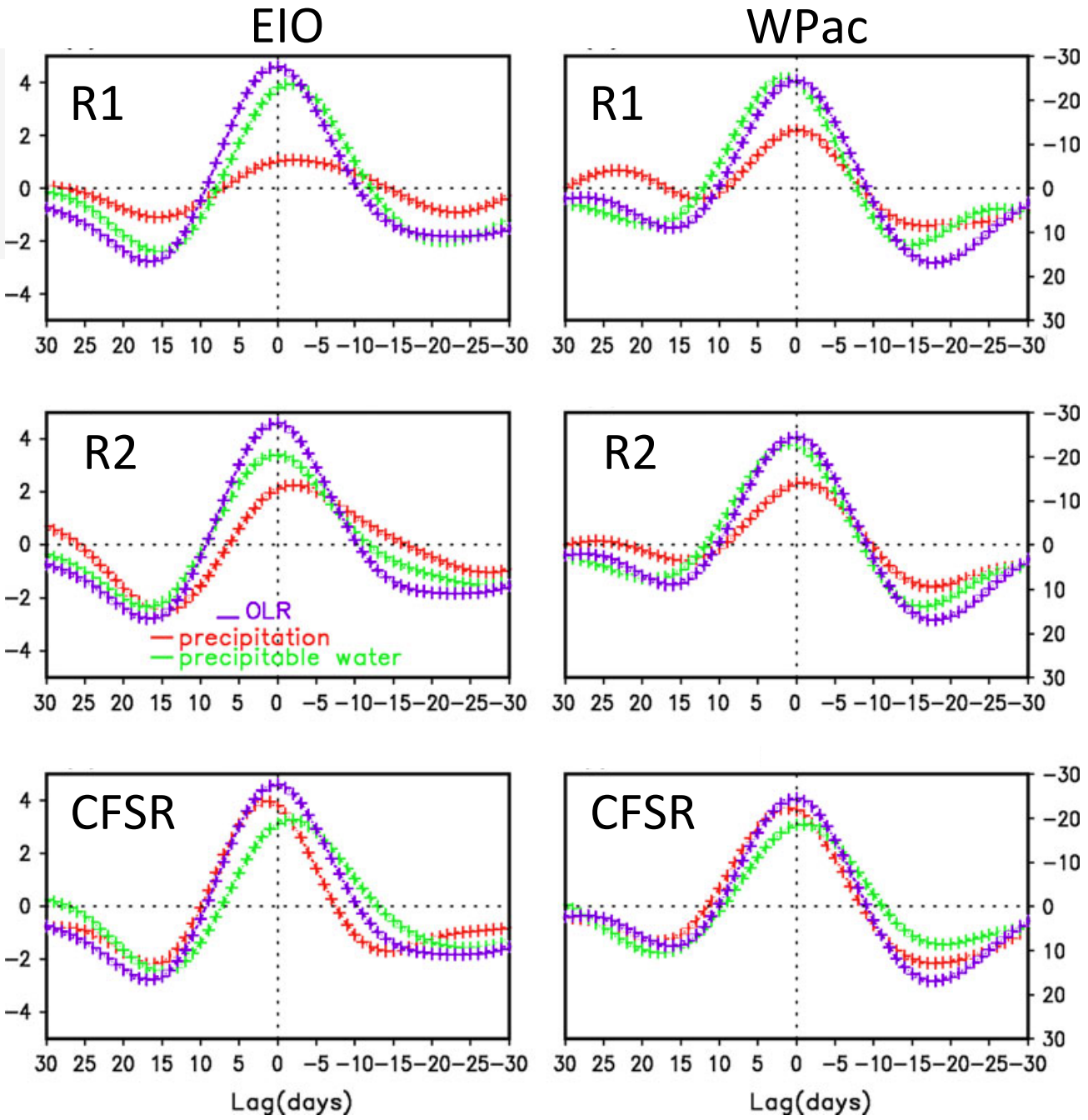
- Composites relative to PC2 peak values
- CMORPH and NOAA OLR consistent
- R1 has the right phasing but its amplitude is too weak.
- Rainfall maximum in R2 1-2 days too early.
- CFSR rainfall peak is slightly too late



Purple : Observed OLR
Red : Rainfall
Green : PWAT

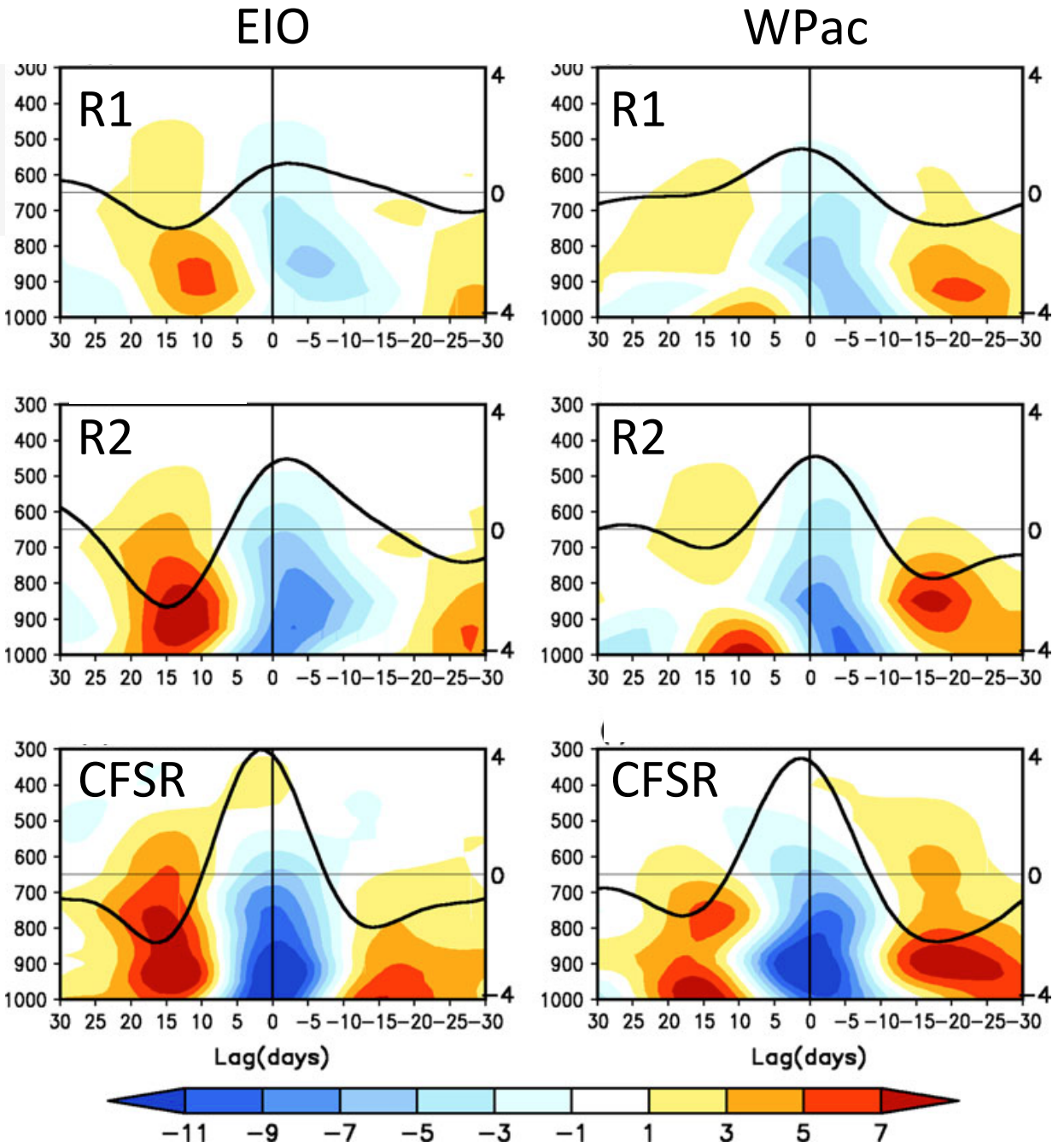
- PWAT lagging or in phase with rainfall in R1 and R2
- PWAT leading rainfall in CFSR

Rainfall occurs too early in R1 and R2 !



Black curves: Rainfall
Shadings : -div(vq)

- Similar structures among reanalyses but different in amplitude
- WPac: Leading convergence near surface in
- EIO: Leading convergence above surface



Diabatic heating

CFSR diabatic heating

- Convective heating dominates
- No clear transition from shallow to deep convection ahead of deep convection
- Stratiform heating tilts westward with height
- Larger amplitude of re-derived heating than model produced
- Relatively larger positive anomalies in lower troposphere before deep convection in derived heating than model produced

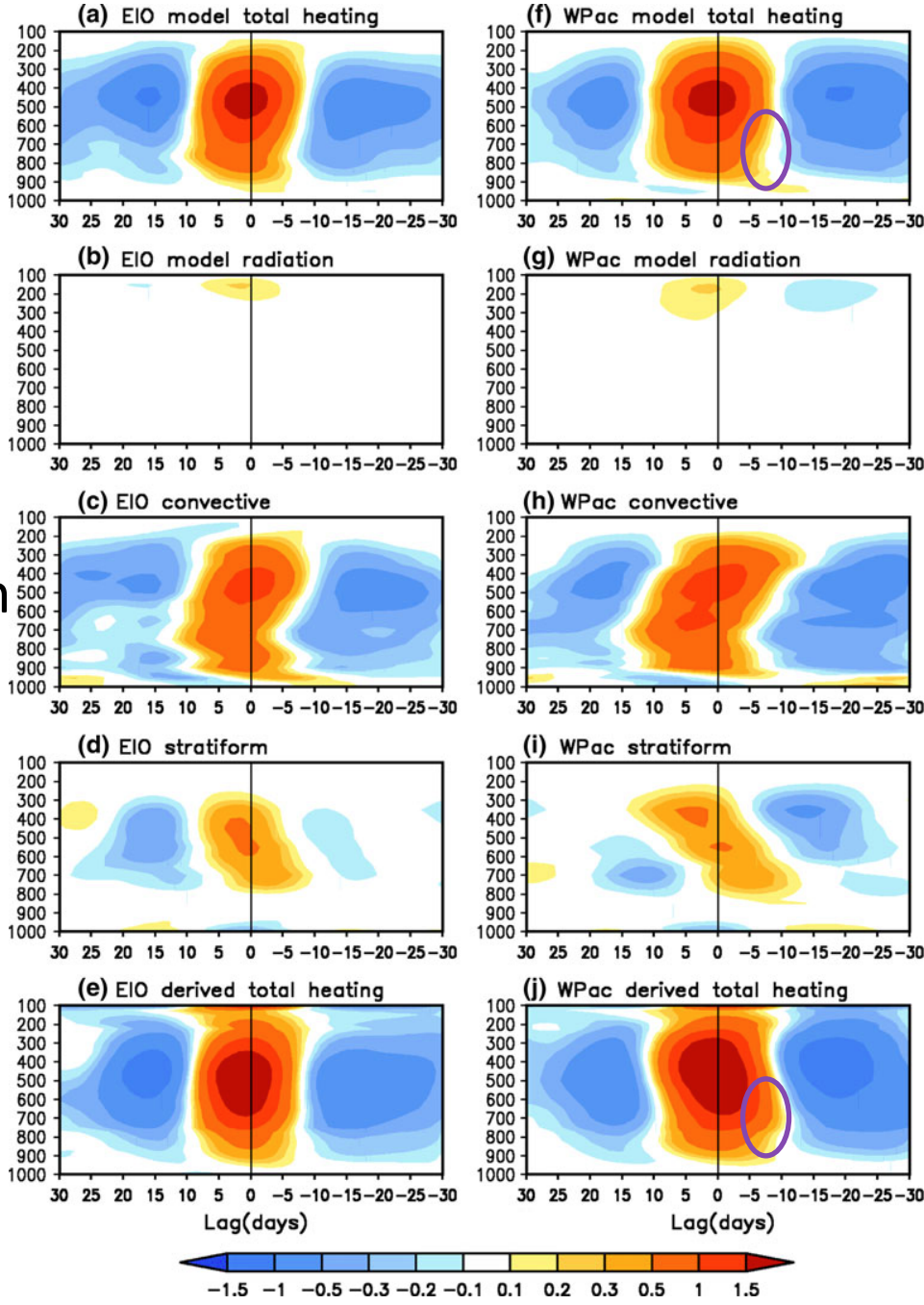
Total

Radiation

Convection

Large scale

Re-derived total



Summary

- Rainfall ISV variability in CFSR is much improved compared to earlier reanalyses, implying better large-scale fields.

- Relationship between rainfall and large-scale fields in CFSR also appears to be more reasonable, with rainfall lagging PWAT, compared to those in R1 and R2.

- Large-scale moisture convergence is maximized near the surface in WPac but at higher levels in EIO, suggesting the dominance of different dynamical processes.

- The too-weak stratiform heating and the too-weak low-level total heating suggest large uncertainties in physical parameterizations.

Reference:

Wang, J., W. Wang, X. Fu, and K.-H. Seo, 2011: Tropical intraseasonal rainfall variability in the CFSR. Clim Dyn (In press), DOI 10.1007/s00382-011-1087-0