Tropical ocean surface energy balance variability: linking weather to climate scales

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Outline

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- Approach
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  - Compositing Methodology
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  - Changes associated with Madden-Julian Oscillation
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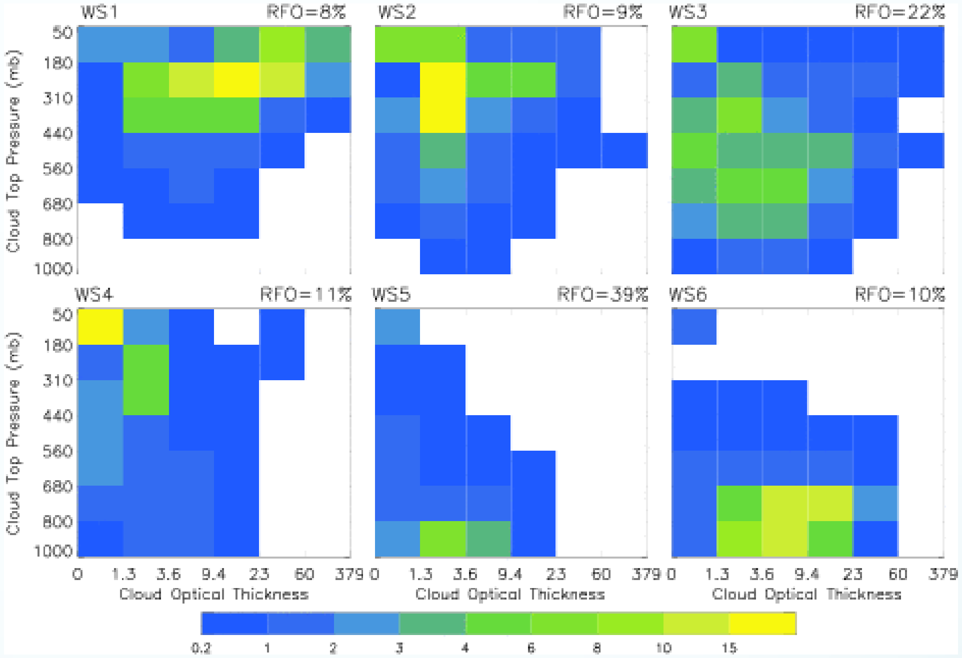
Motivation and background

- Clustering techniques have recently been applied to ISCCP cloud-top temperature, optical thickness diagrams resulting in a set of robustly-defined cloud regimes (Jakob and Tselioudis 2003)
- Further studies have shown these regimes to be characterized by coherent variations in both cloud-radiative and atmospheric characteristics (e.g. water vapor, temperature) leading to the terminology of “weather states” for these regimes (Jakob et al. 2005; Oreopoulos & Rossow, 2011)
- Conditional sampling of geophysical parameters using weather-regimes provides a useful way to examine variability and intercompare observations and models
  - Used to examine tropical convection and large-scale circulation interactions associated with MJO (Tromeur and Rossow, 2010)
  - Has recently been used for cloud radiative fluxes and feedbacks in climate models (Williams et al. 2008)



Example: Cloud Top Pressure – Cloud Optical Thickness histogram centroids for for 6 cloud regimes

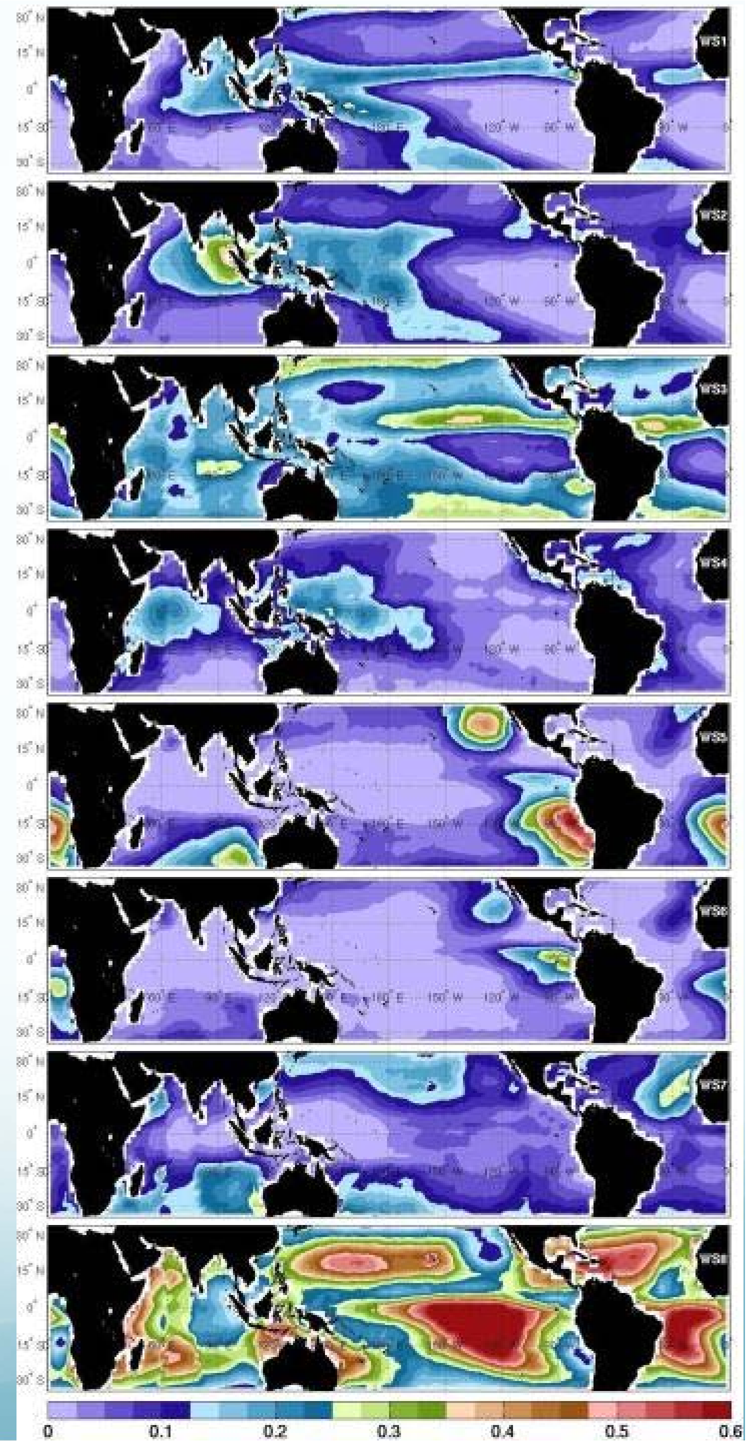
Taken from http://isscp.giss.nasa.gov

Datasets and Clustering

- Datasets:
  - ISCCP Extratropical Cloud Clusters (35N/S, 2.5°x2.5° 1985-2007, 3-hr)
  - OAFLUX (1985-2007, 1°x°1,daily), LHF/SHF/Surface Variables
  - SEAFLUX (1998-2007,0.25°x0.25° 3-hr), LHF/SHF/Surface Variables
- Product Homogenization:
  - Fluxes regridded and resampled to ISCCP 2.5x2.5
  - Fluxes and variables averaged to daily resolution
  - ISCCP 3-hr used to assign a daily class based on the most frequent cluster

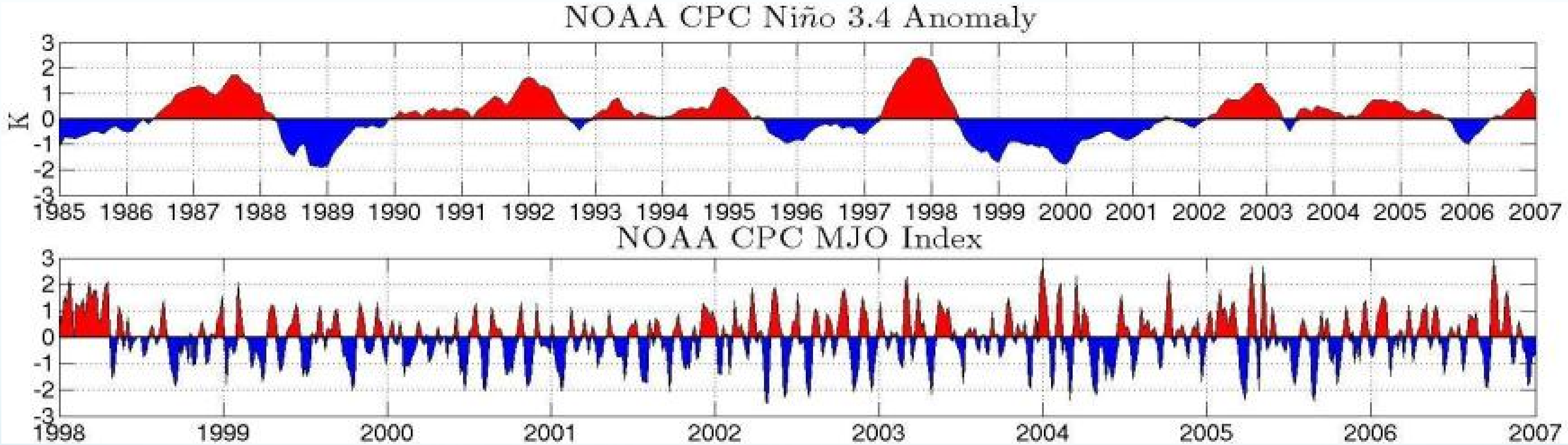
More convection

Less convection



Compositing methodology

- Conditionally sample a set of data using weather state classification (WS1-WS8; most convective to least convective)
- The set can be further sampled based on use of a compositing index to identify changes associated with low-frequency coupled variability
- Use NOAA Climate Prediction Center (CPC) indices for MJO and ENSO



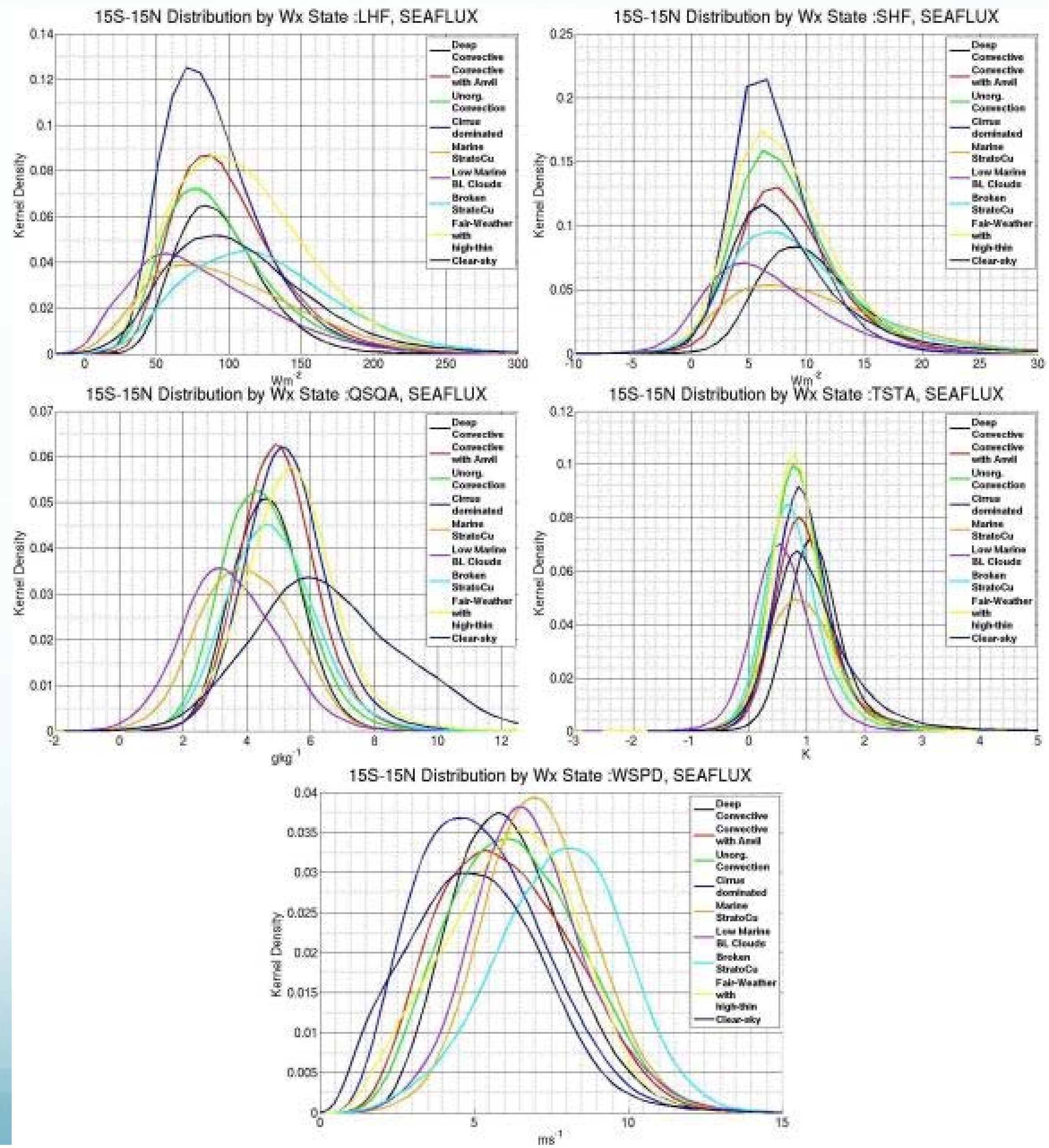
- Examining differences in means can be decomposed as changes in class mean (A), changes in RFO (B), and covariant changes (C)

$$\Delta\bar{X}_{(2-1)} = \sum_{i=1}^{K} RFO_i^1 \delta\bar{x}_i + \bar{x}_i^1 \delta RFO_i + \delta\bar{x}_i \delta RFO_i$$

A B C

Decomposition of fluxes by weather state

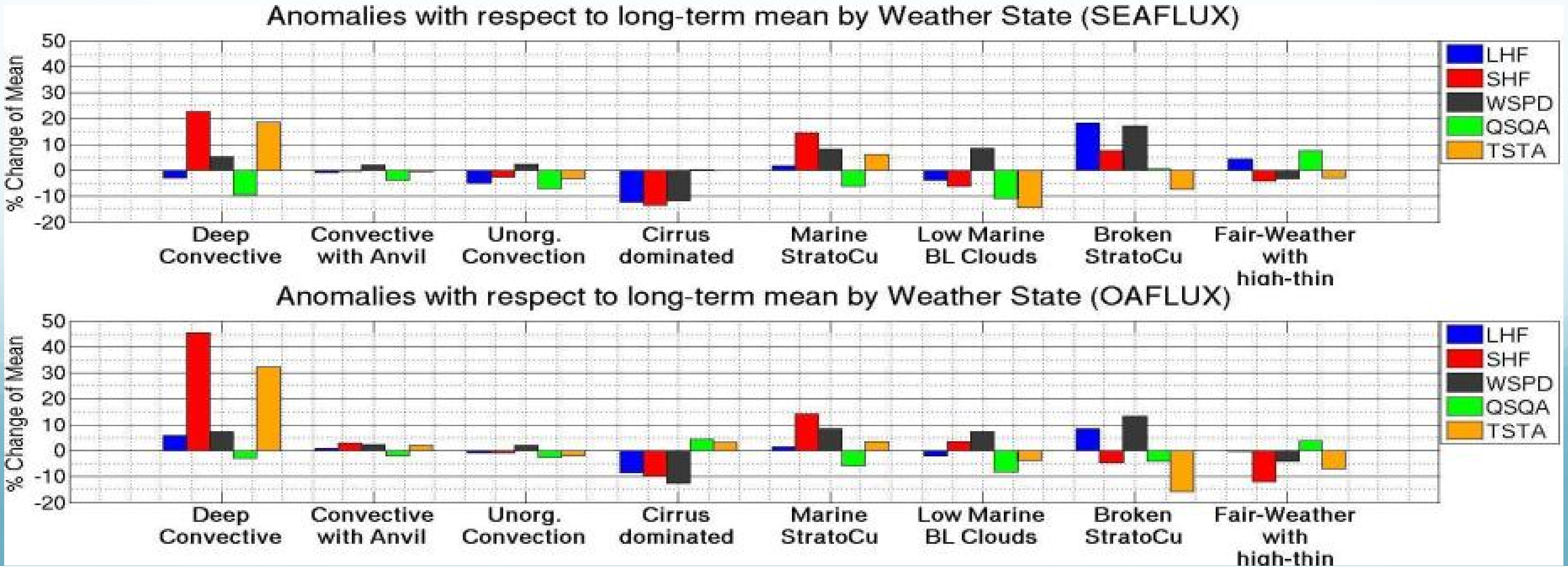
- The conditionally sampled weather regimes result in distributions of fluxes with different mean and extreme characteristics
- These are associated with changes in the bulk variables, as should be expected
- Both wind speed and near-surface humidity gradients are particularly well stratified, though the latent heat flux means are less so
  - Indicates potential compensations



Intercomparing products by weather state

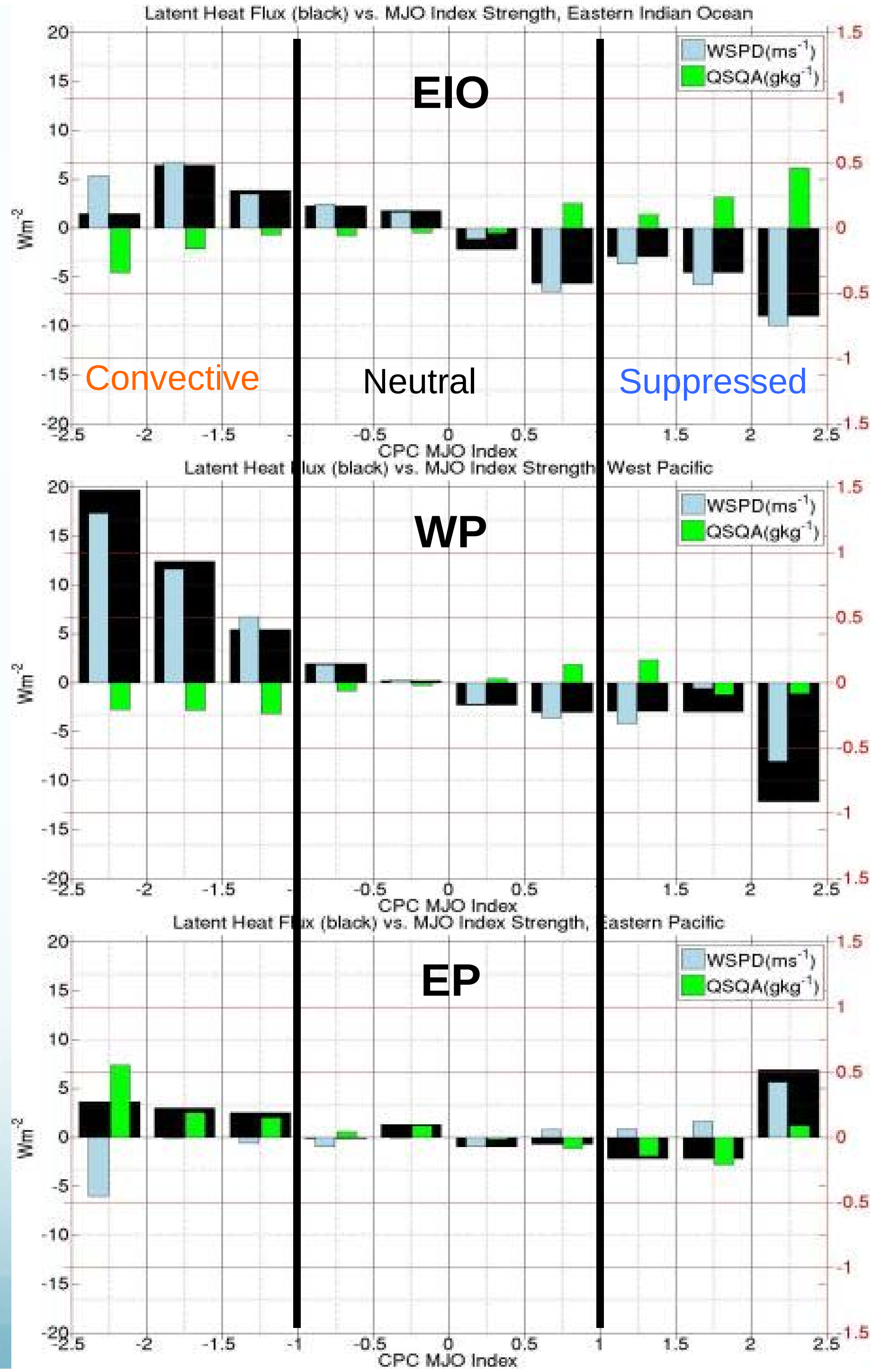
- While there are systematic mean differences in products, the anomalous changes between products (here, SeaFlux & OAFlux) are more closely aligned.

- The differences here can be related to specific types of weather regimes
  - OAFlux shows a slight increase in the latent heat flux associated with deep convective conditions while SeaFlux shows a slight decrease.
  - In broken stratocumulus conditions, SeaFlux indicates about a 20% change, nearly 2x that of OAFlux, again primarily from differences in near-surface moisture gradients



MJO Composites by strength

- Composite MJO based on index strength rather than just time-lagged around events
- All three regions typically show increased evaporation during convective phase and decreased evaporation during suppressed phase
- The Indo-Pacific region changes are primarily wind-driven while the Eastern pacific changes are more inline with near-surface moisture gradient changes

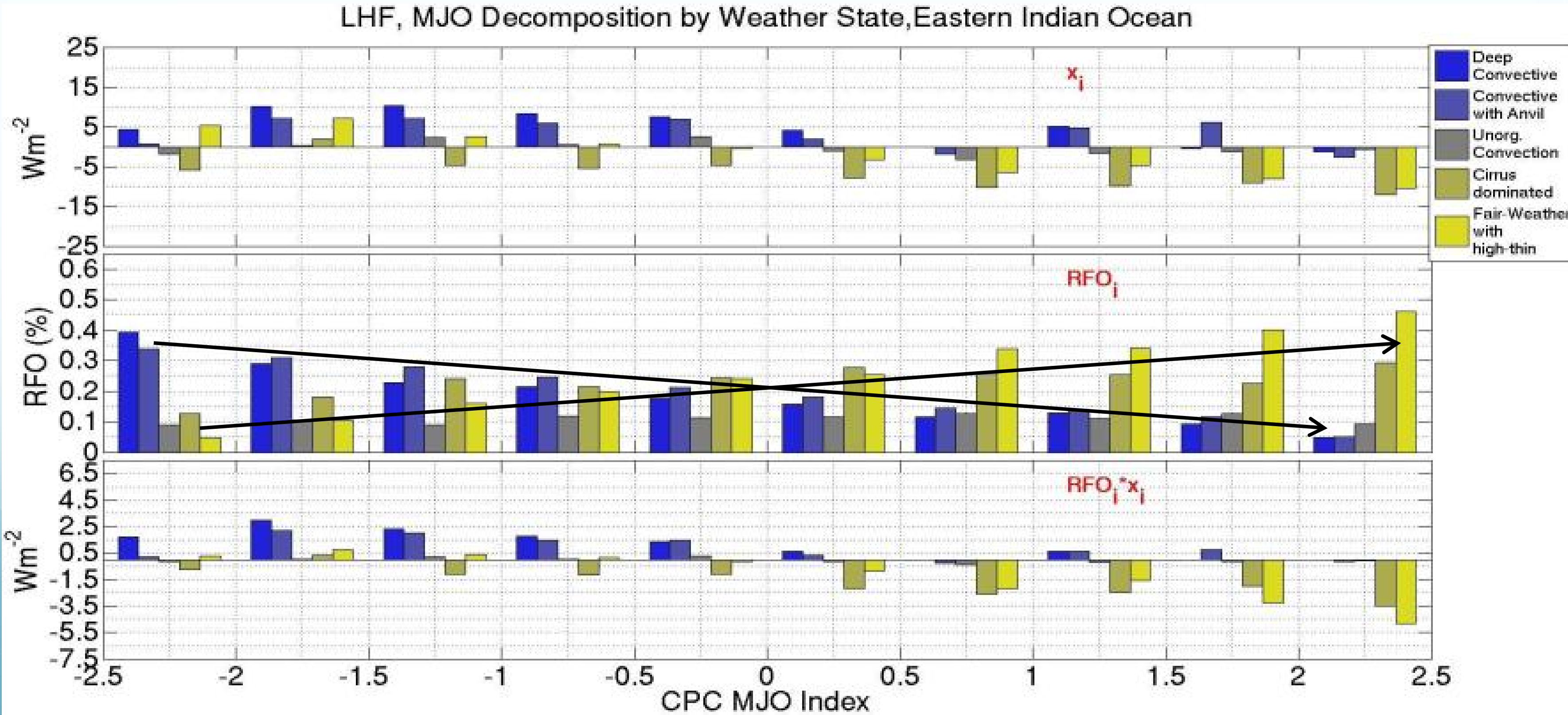


MJO Composites – Decomposition into Weather states

- Decompose the mean heat flux (LHF, here) into weather state means and relative frequency of occurrence (RFO)

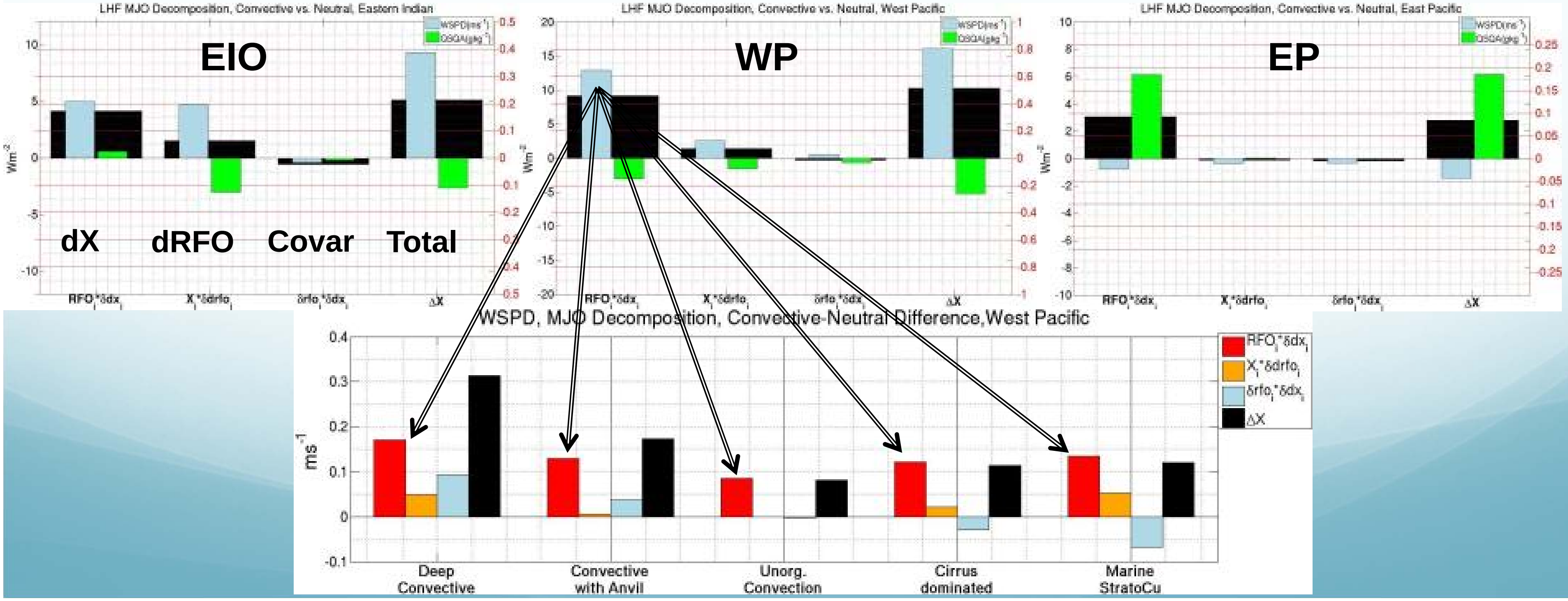
- Systematic variations of both weather state means and RFO with MJO index

- Both variations contribute to the total impact of a given weather state on the mean energy exchange associated with MJO evolution



MJO Composites – Decomposition of changes

- The difference between convective, neutral, and suppressed conditions can be quantitatively decomposed into Mean-,RFO-, and covariant- driven change
- Convective vs. Neutral changes are primarily set by the systematic variation of class properties rather than RFO changes
- Changes in Indo-Pacific are primarily wind-speed driven while East Pacific are driven by near-surface specific humidity



Summary and Future Work

- Cloud-based weather states can be used to provide improved understanding of surface energy flux variability
- MJO variability is particularly well decomposed using ISCCP weather regimes from convective to neutral and suppressed states
- Different regions in the tropics show MJO variability driven by different processes
- Expand these analyses to investigate extratropical climate variability