Dynamical Filtering of Tropical Variability

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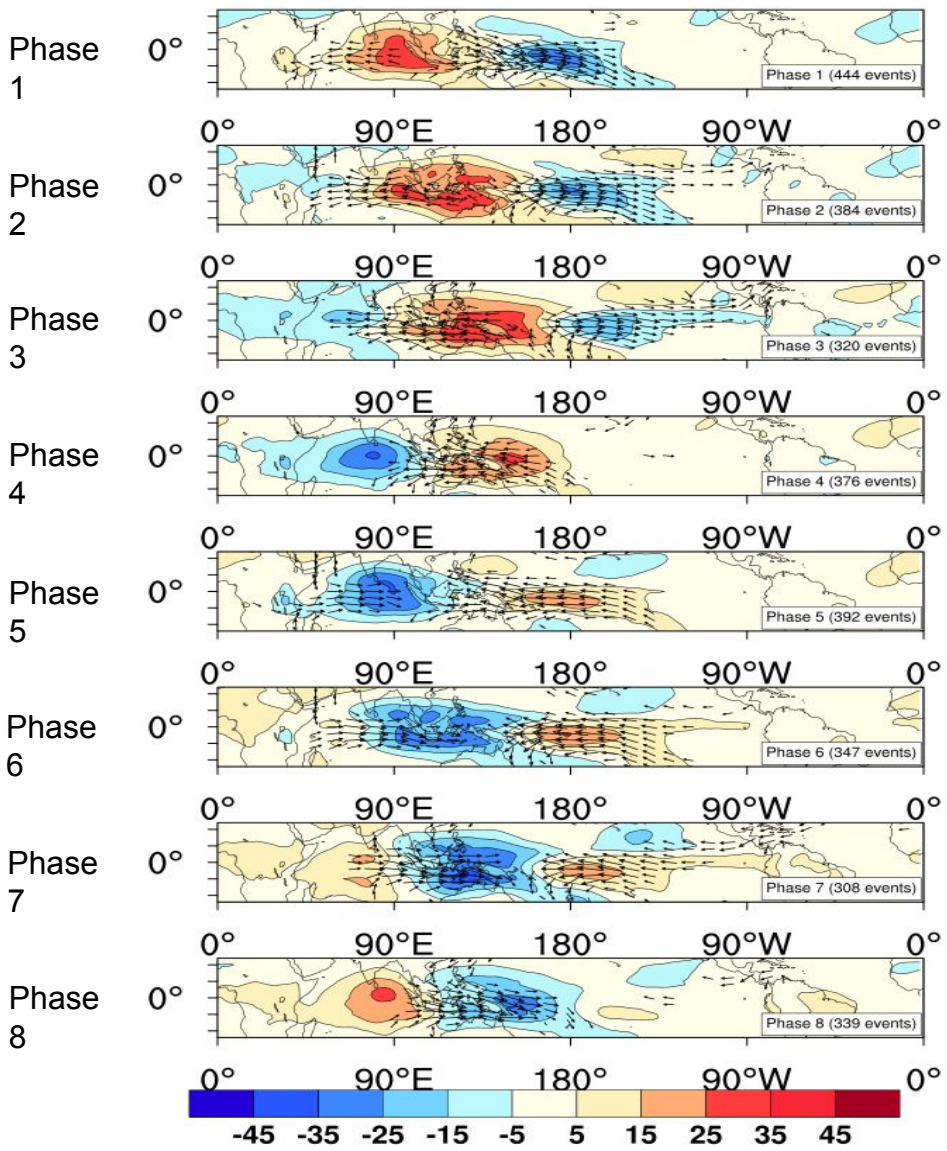
Background

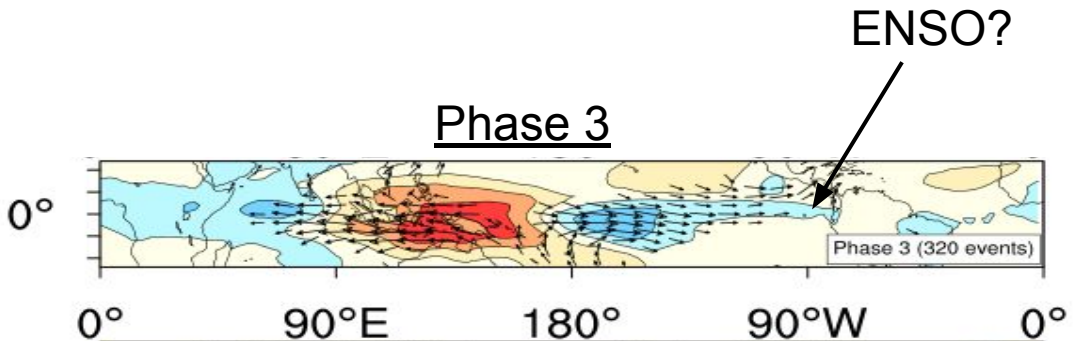
- Forecast models' tropical biases, notably for the MJO and ENSO, impact forecasts of US climate on sub-seasonal timescales
- We aim to run nudging experiments targeted on the impact of UFS errors in MJO/ENSO variability upon downstream teleconnections
- First step: Design a "dynamical filter" to cleanly separate the MJO and ENSO from other forms of tropical variability

RMM Composites

ERA-5 1979-2021



Phase 3



Linear Inverse Model (LIM)

$$\frac{d\vec{x}}{dt} = L\vec{x} + \vec{\xi}$$

Linear operator

State vector

Stochastic forcing

$$L = \tau_0^{-1} \ln[\langle \vec{x}(t+\tau_0)\vec{x}(t)^T \rangle (\langle \vec{x}(t)\vec{x}(t)^T \rangle)^{-1}]$$

τ_0: time lag
$\langle * \rangle$: expectation operator
ln: matrix natural logarithm

LIM Construction

LIM trained on 5-day lag covariances of 5-day running mean anomalies of winter (Nov 1st – May 1st, 1979-2021) ERA5 data on a 2-degree grid

Variables

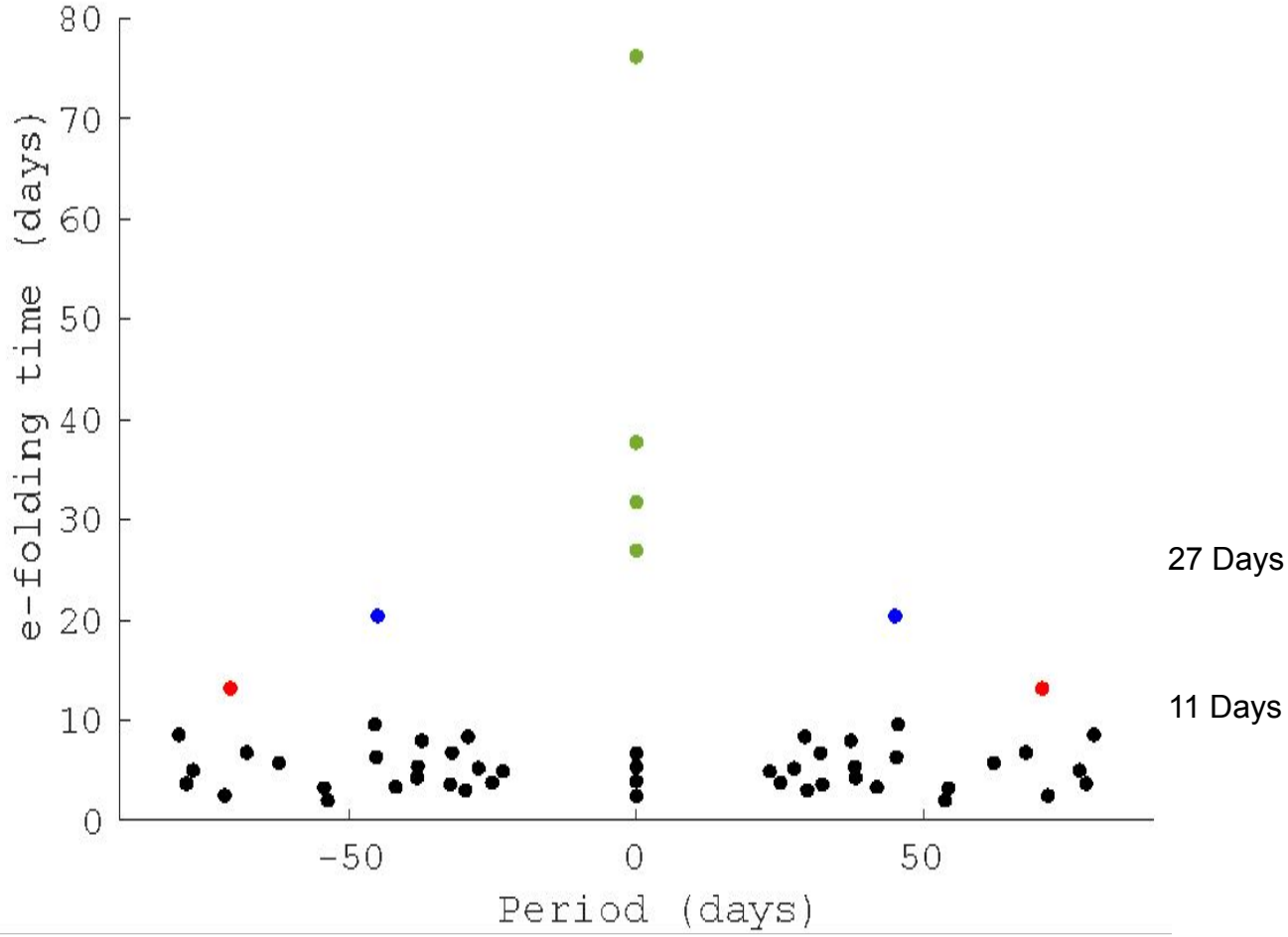
- 200-hPa and 850-hPa zonal and meridional winds, SST, and OLR ($24^{\circ}S$-$24^{\circ}N$)

- Anomalies are projected onto leading EOFs (82 in total):

    1. Combined wind ($u_{200}, v_{200}, u_{850}, v_{850}$) (28 EOFs, 48% of total variance)
    2. SST (14 EOFs, 66% of total variance)
    3. OLR (40 EOFs 62% of total variance)

LIM Eigenvalues

Subset of LIM Eigenvalues

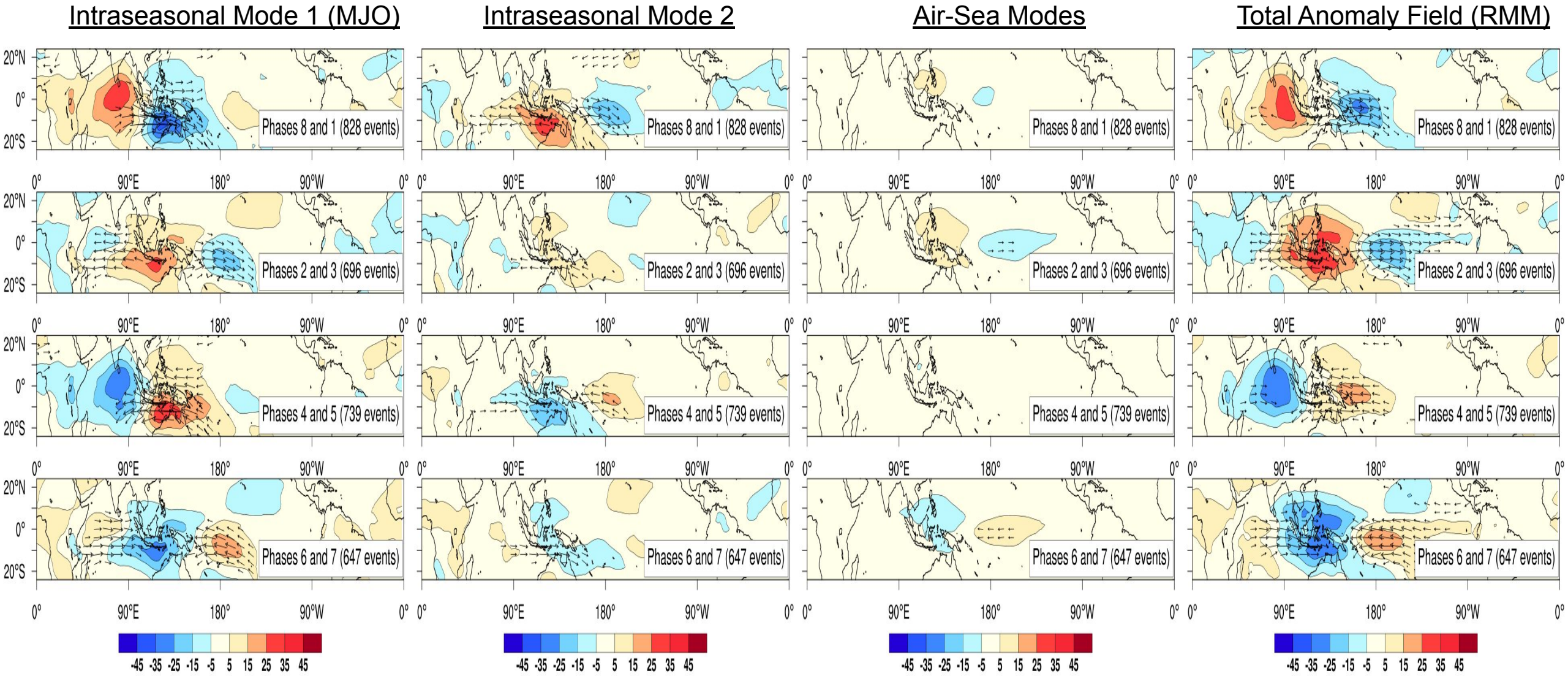


4 groups/subspace of modes

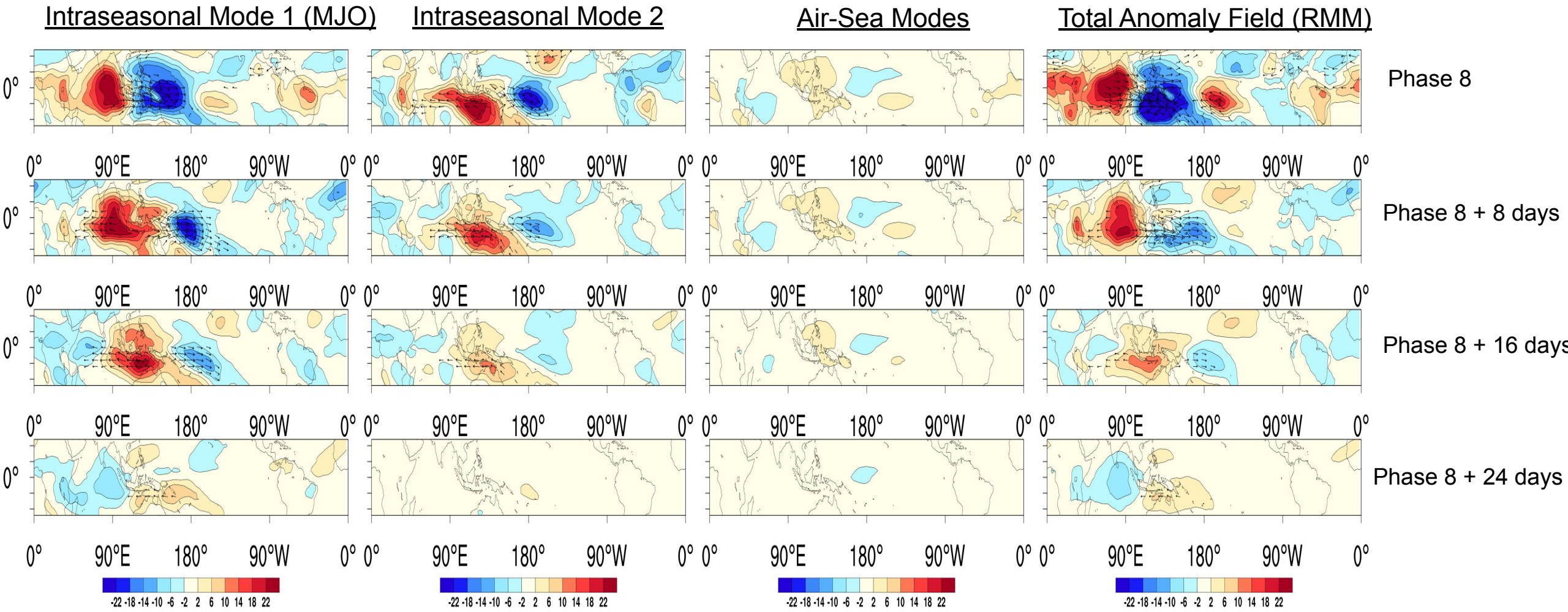
Intra-seasonal variability

- Air-Sea modes (modes 69-82), e-fold time > 27 days
- Intraseasonal Mode 1 (modes 67/68), e-fold time = 20 days
- Intraseasonal Mode 2 (modes 65/66), e-fold time = 13.1 days
- Fast decaying processes (modes 1-64), e-fold time <=12 days

LIM-Filtered RMM Composites



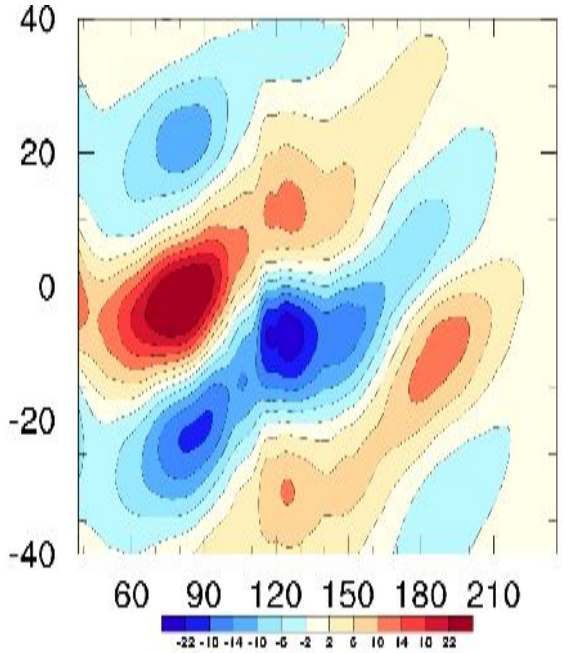
LIM-Filtered Lagged Composites



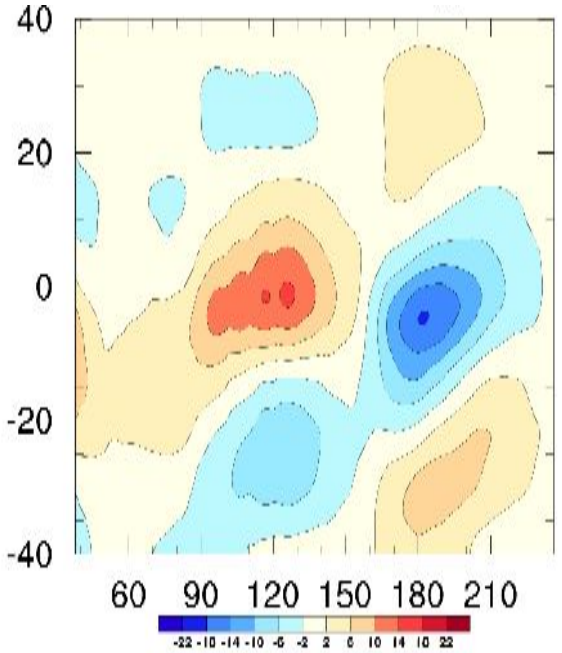
LIM-Filtered Lagged Hovmoellers

Phase 1 Lagged Hovmoellers (OLR)

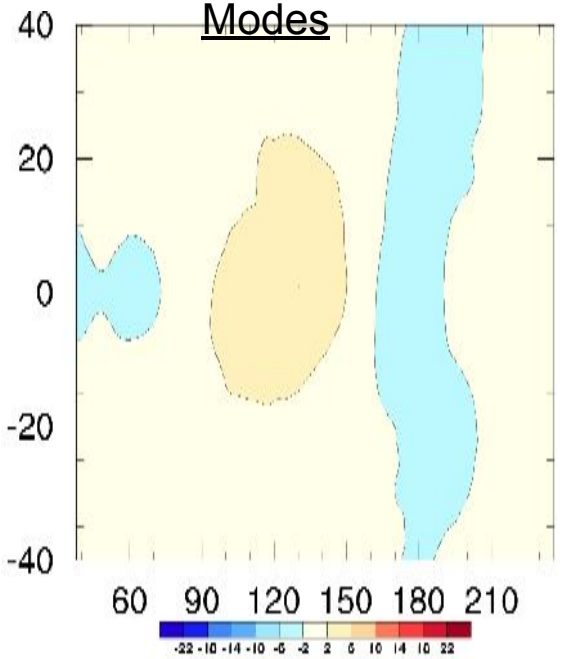
Intraseasonal Mode 1 (MJO)



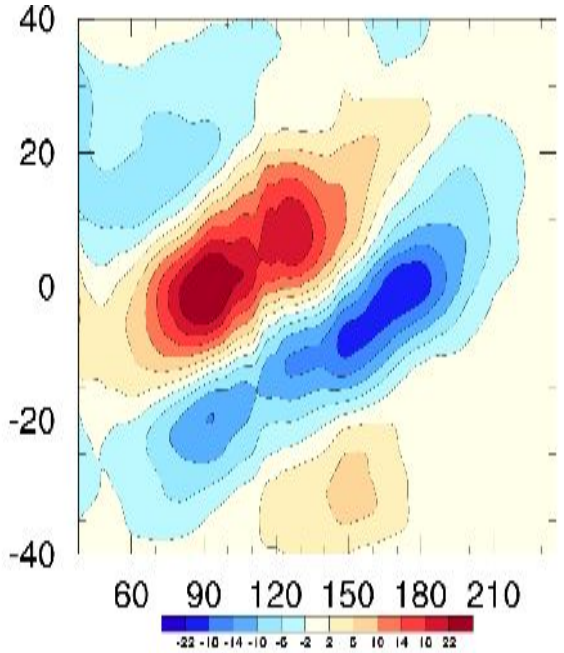
Intraseasonal Mode 2



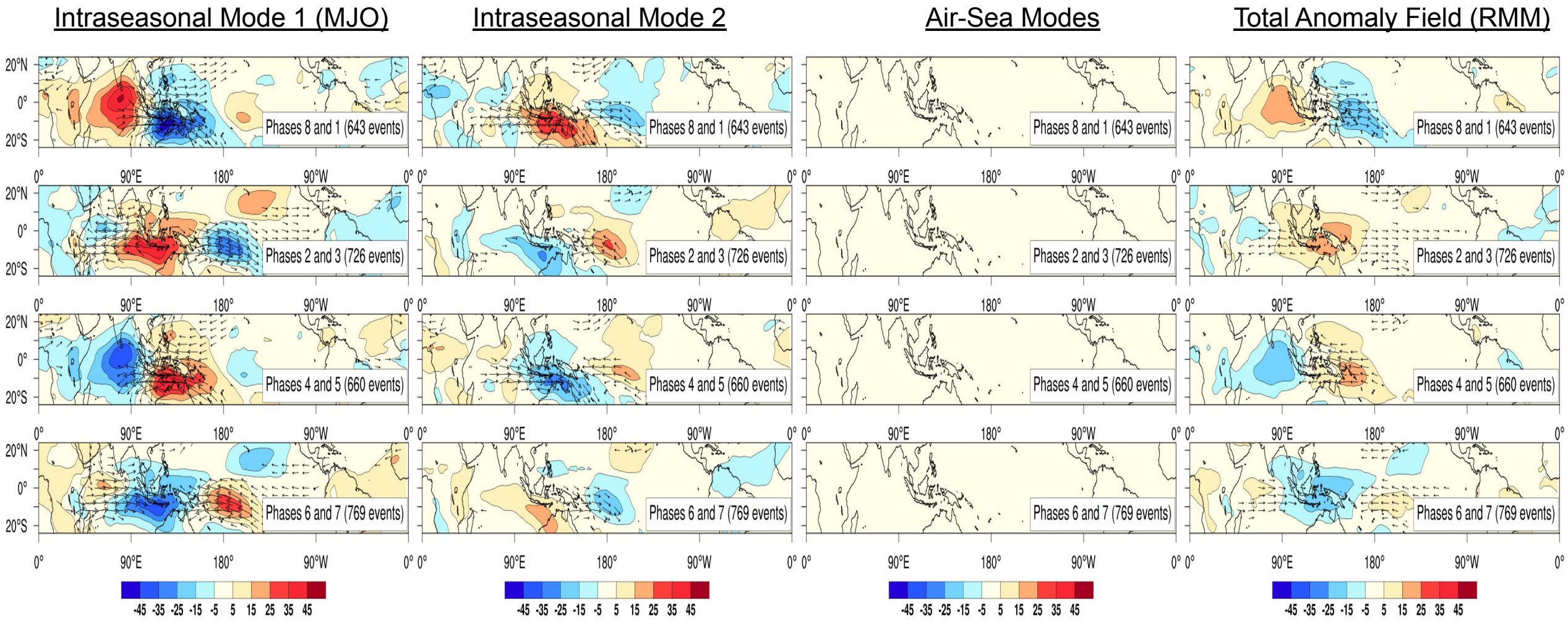
Air-Sea Modes



Total Anomaly (RMM)



LIM MJO Index Composites



Key Takeaways

- A linear inverse model is used to construct a filter of tropical variability
- This filter effectively separates MJO and ENSO from other forms of tropical variability
- The LIM defines a new MJO index