Finding maximum predictable patterns in a S2S model over summer East Asia

By

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- **Using APT finding maximum predictable patterns**
  - **Region of interest**
  - **Forecast time of interest**

- **Exploring four S2S models: *CNRM, ECMF, CFSv2, JMA***

- ***Reforecasts* (hindcasts) up to *45 days***

	ECMWF	JMA	CNRM	CFSv2
Ensemble members	**10**	**10**	**9**	**3**
Ocean coupling	√	**X**	√	√

(Vitar et al 2017) BAMS)

APT (1)
Average Predictability Time

- Standard measure of predictability

$$P(\tau) = \frac{\sigma_\infty^2 - \sigma_\tau^2}{\sigma_\infty^2}$$

- σ_∞^2 *climatological variance;*
  ensemble spread of long-term mean
- σ_τ^2 *ensemble forecast spread at lead time τ*

$P(\tau)$ varies from nearly ***1*** to ***0*** as τ increases and $\sigma_\tau^2 = \sigma_\infty^2$

- *When the forecast spread equals the climatological spread*
- In other words, *a forecast is no better than a random guess from the climatologies*.

(Jia et al 2015 Jclim; Delsole & Tippett 2009 JAS)

APT (2)
Average Predictability Time

- Define APT
  - ✓ **Characteristic timescale of a (climate) system**
    - *When a system has strong damping, it has shorter memory and hence less predictable*
  - ✓ **Independent of forecast lead times**
    - *average/integrate over all lead times*
  - ✓ **Consistent with the common e-folding (half life) timescale**
    - *multiply by 2*

$$\mathrm{APT} =: 2\sum_{\tau=1}^{\infty}\frac{\sigma_{\infty}^{2}-\sigma_{\tau}^{2}}{\sigma_{\infty}^{2}}$$

(Jia et al 2011 Jclim; Delsole & Tippett 2009 JAS)

Maximize APT (3)
Eigenvalue Problem

- Maximizing APT
  - A system described by linear stochastic dynamics

$$\frac{dW^{obs}}{dt} = \mathbf{A}W^{obs} + \mathbf{F}\xi$$

W : state vector
A : dynamics matrix
F : forcing matrix
ξ : white noise

  - Lower and upper bounds for predictability of such a system
  - Maximizing APT leads to a generalized eigenvalue problem ;

$$\sigma_\tau^2 = \boldsymbol{q}^T \Sigma_\tau \boldsymbol{q}; \quad \sigma_\infty^2 = \boldsymbol{q}^T \Sigma_\infty \boldsymbol{q}$$

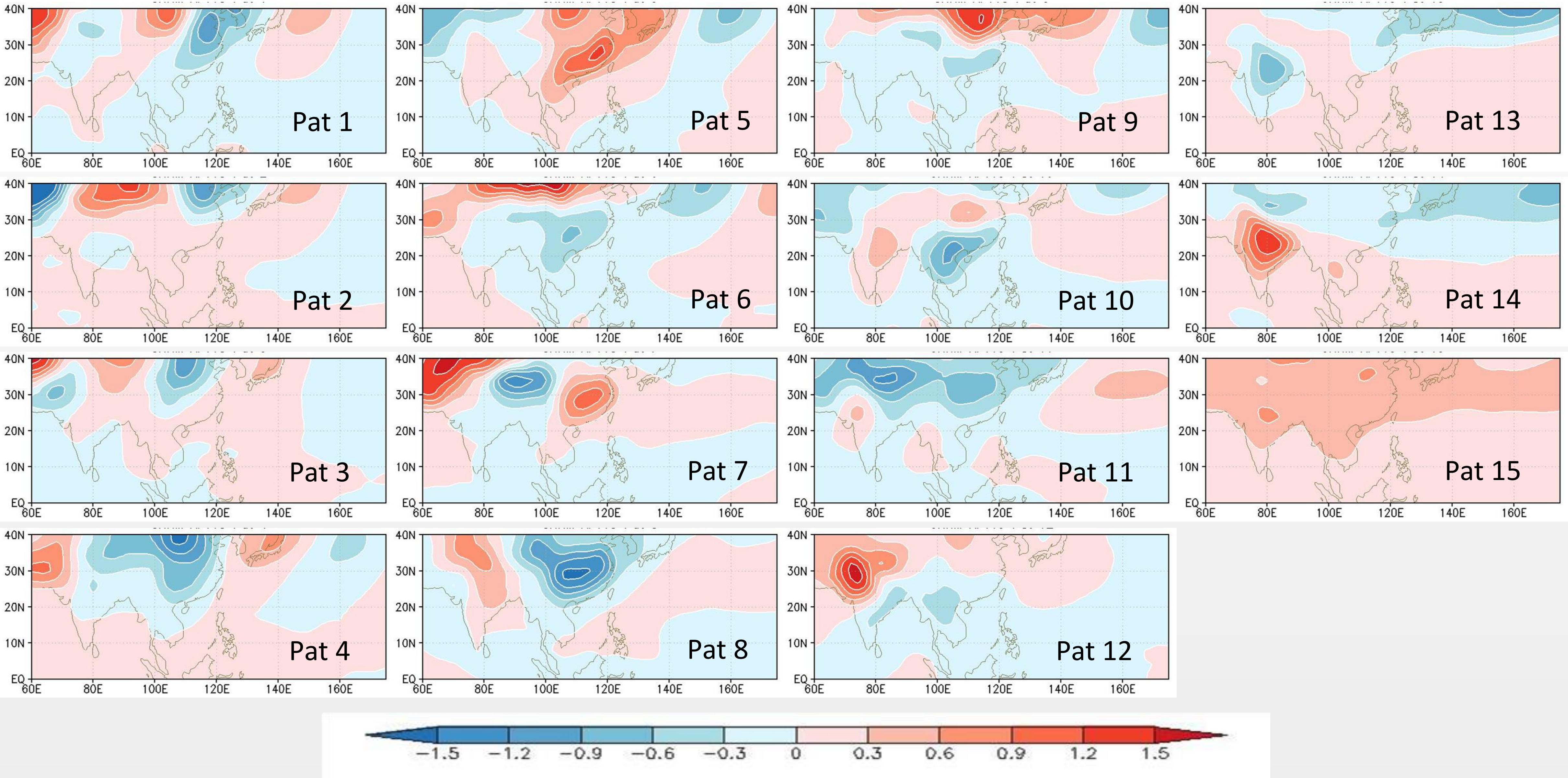
q : projection vector such that $\mathbf{q}^T\mathbf{W}$ maximizes APT

Eigen modes = *Most predictable modes/patterns*

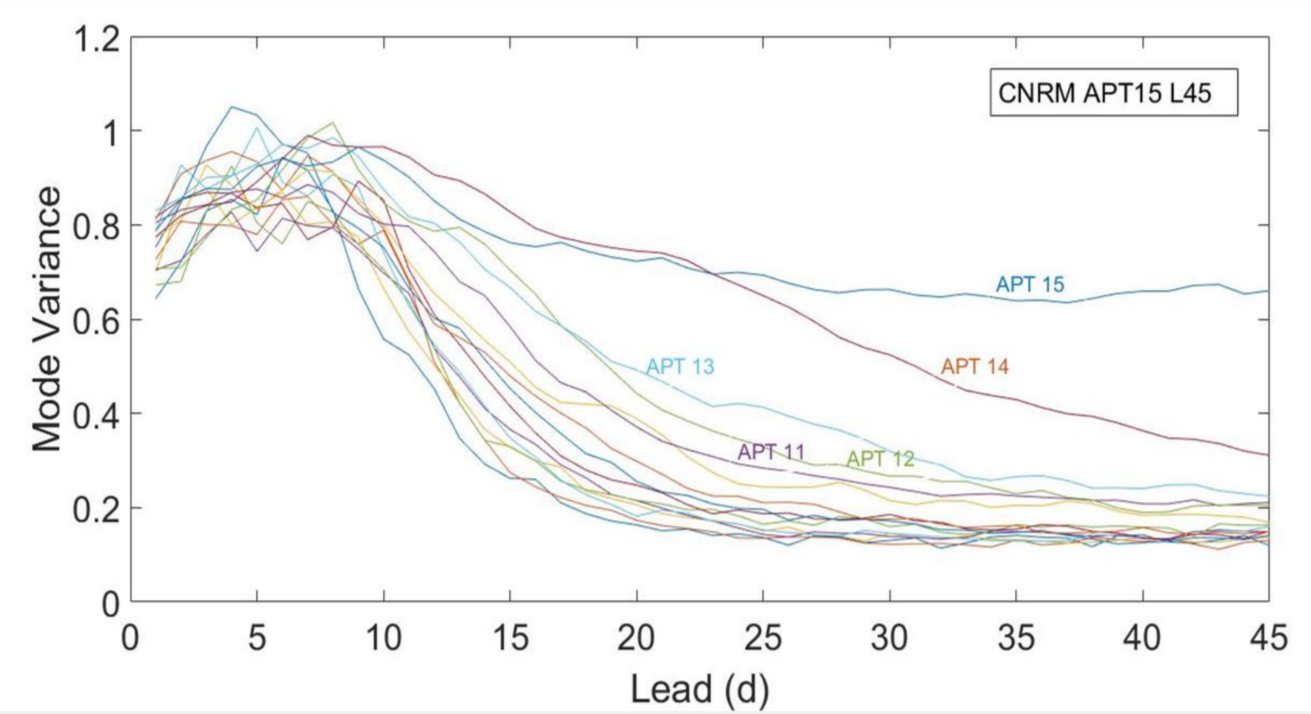
$$2\sum_{\tau=1}^{\infty}(\Sigma_\infty - \Sigma_\tau)\boldsymbol{q} = ?\,\Sigma_\infty \boldsymbol{q}$$

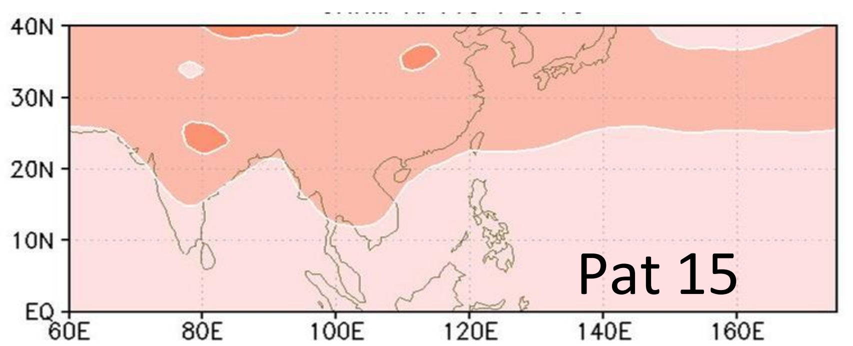
(Tippett & Chang 2003 Tellus; Jia et al 2011 Jclim)

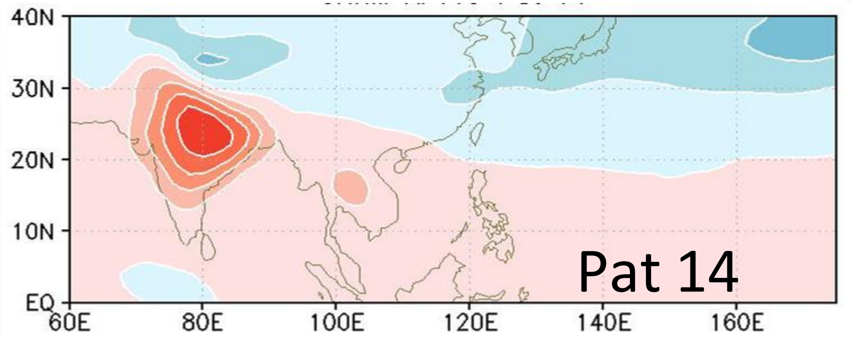
Maximum Predictable Modes Indo Pacific T2m
May-Oct ***S2S CNRM***

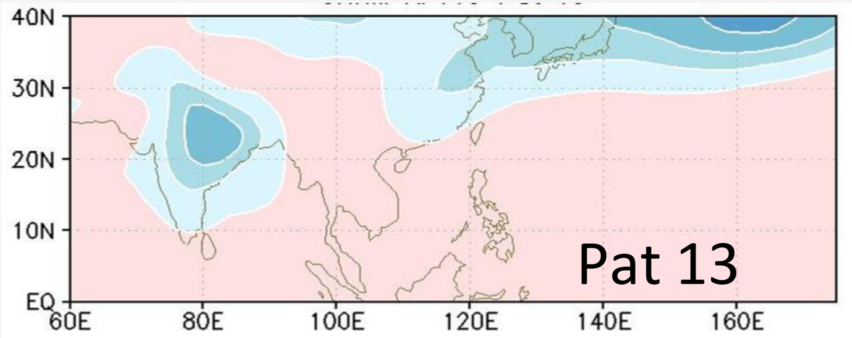


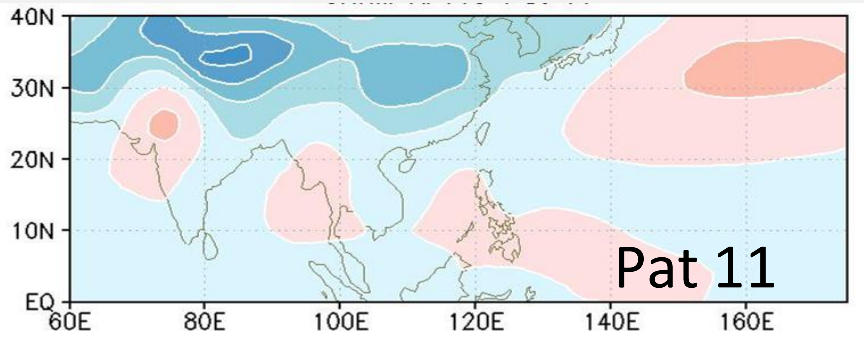
Persistent Signals
APT15 Lead = 45 ***S2S CNRM***

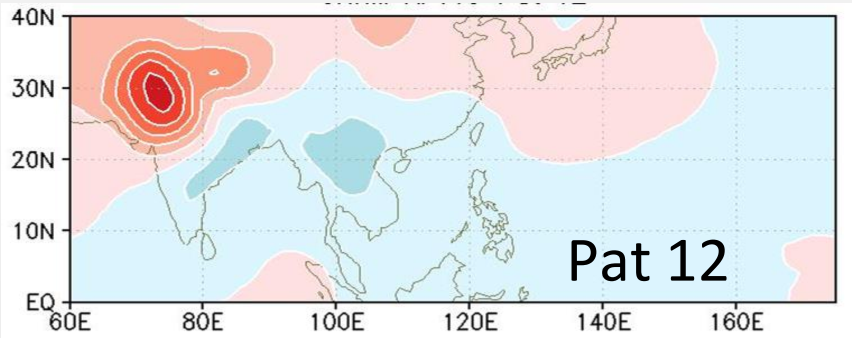




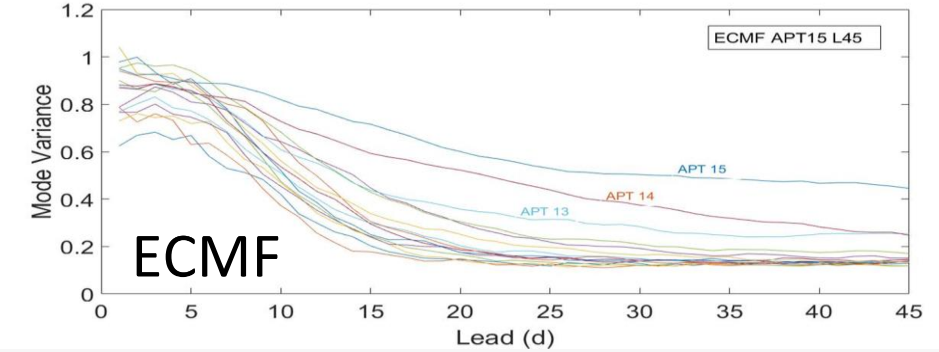


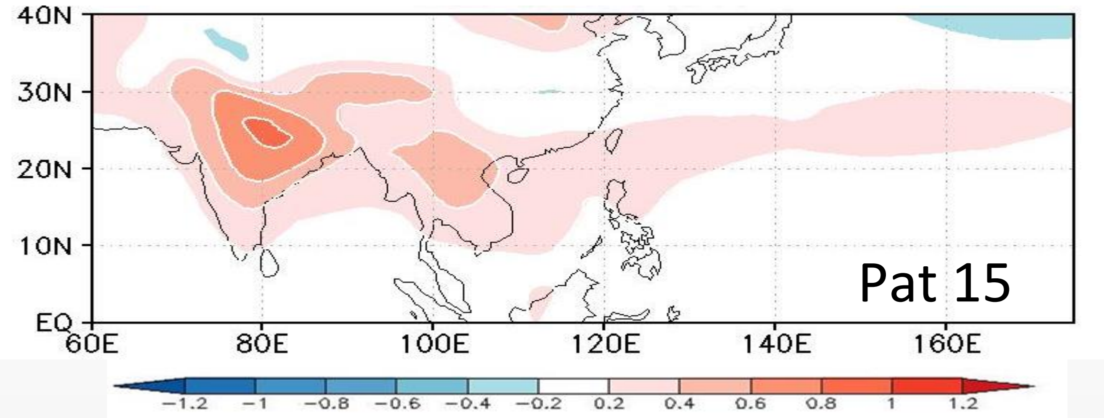


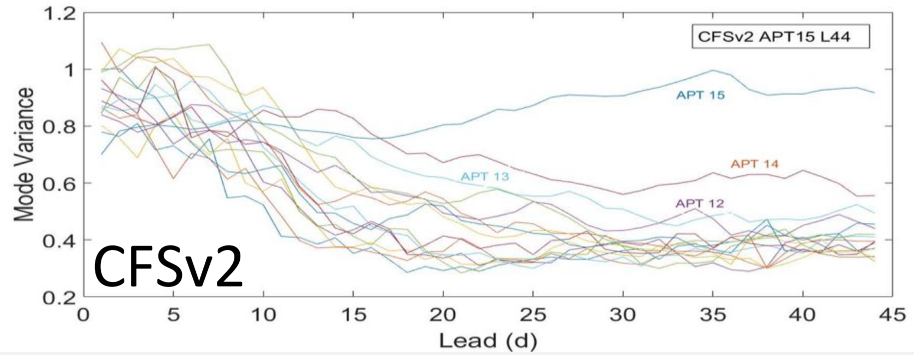


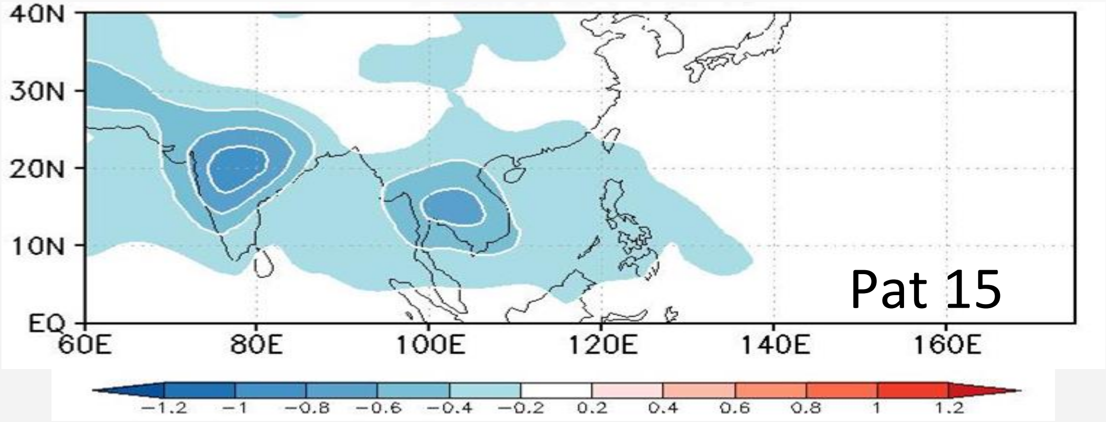


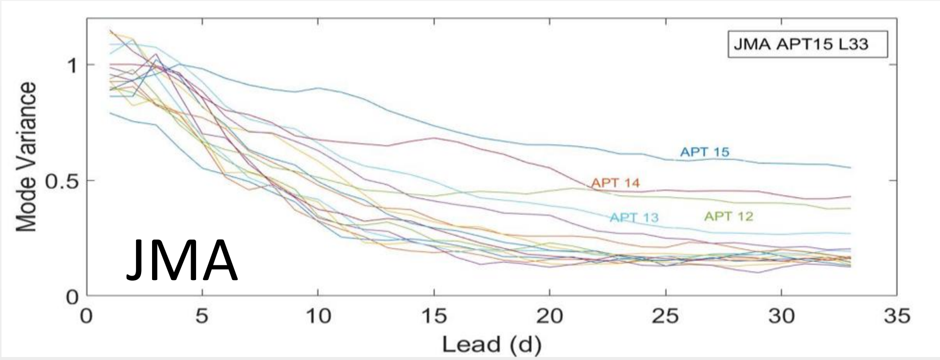
Persistent Signals *APT15*

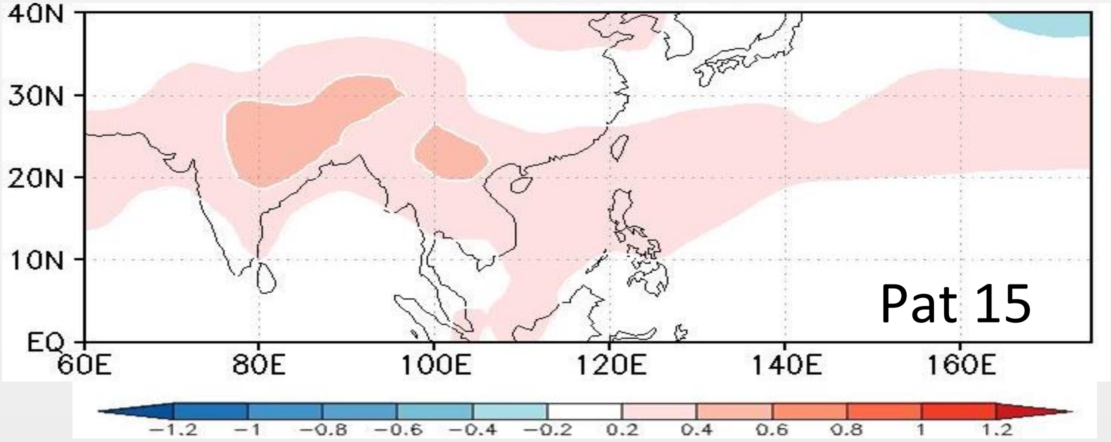




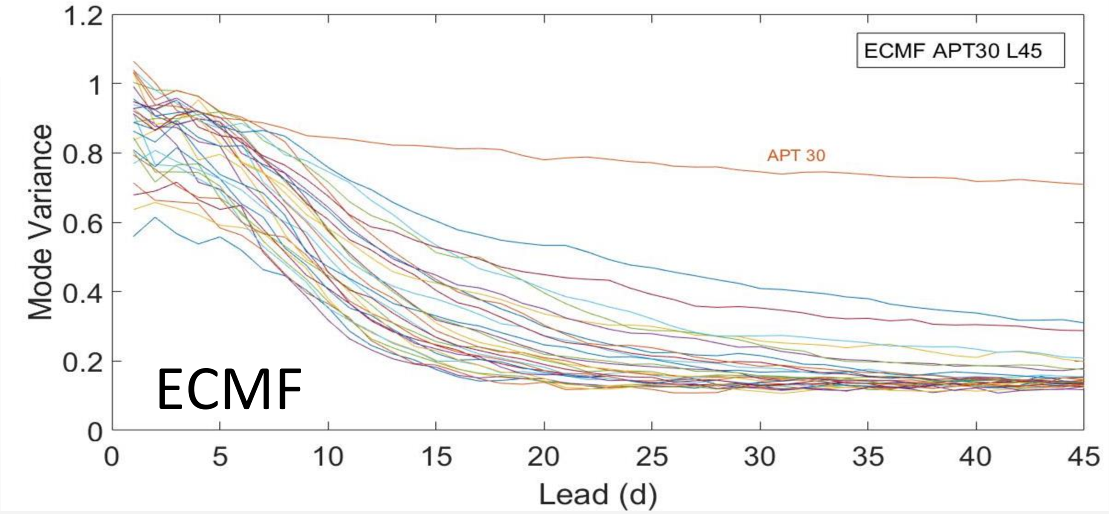


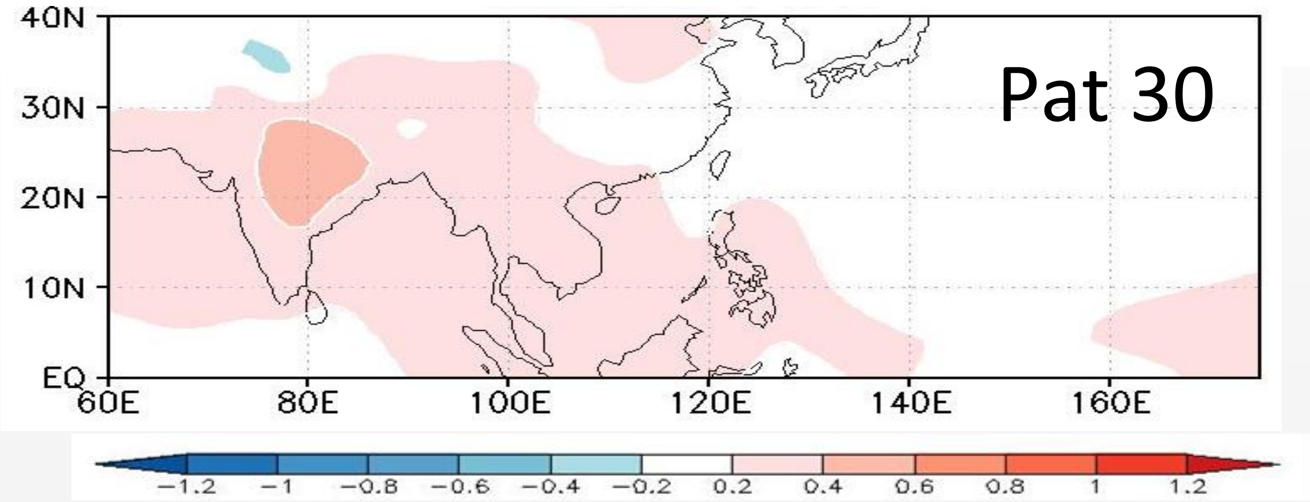


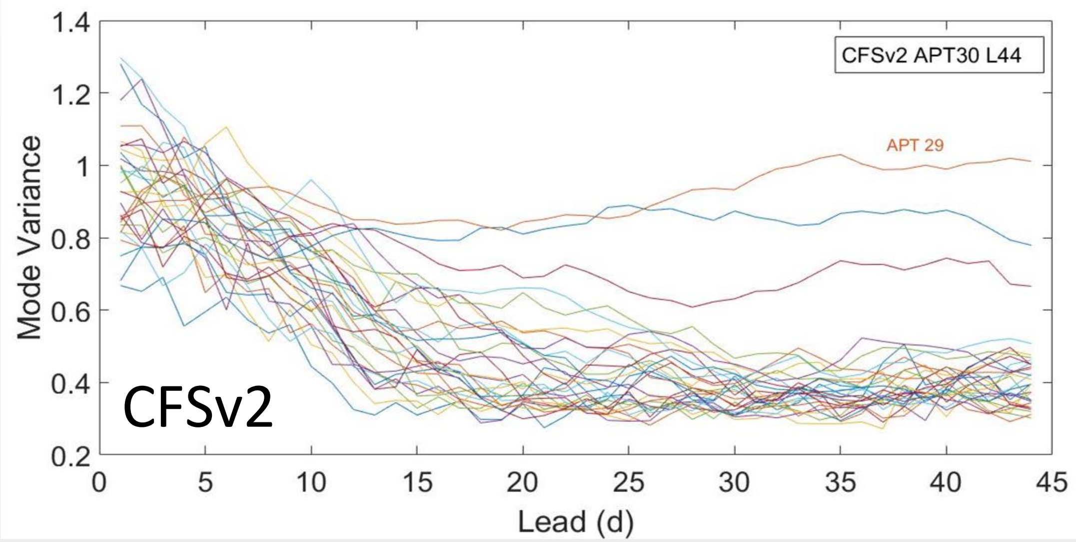


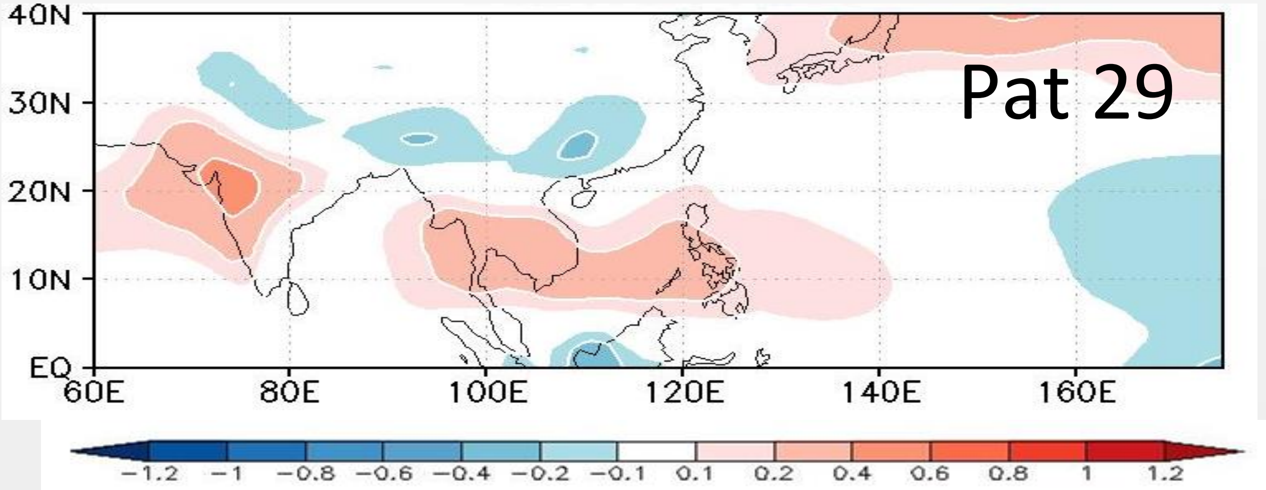


Persistent Signals ***APT30***









Reconstruction of Subseasonal Index

Tw-Ph SST Index