An assessment of the skill of GEOS-5 seasonal forecasts

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GMAO Seasonal Forecast Systems

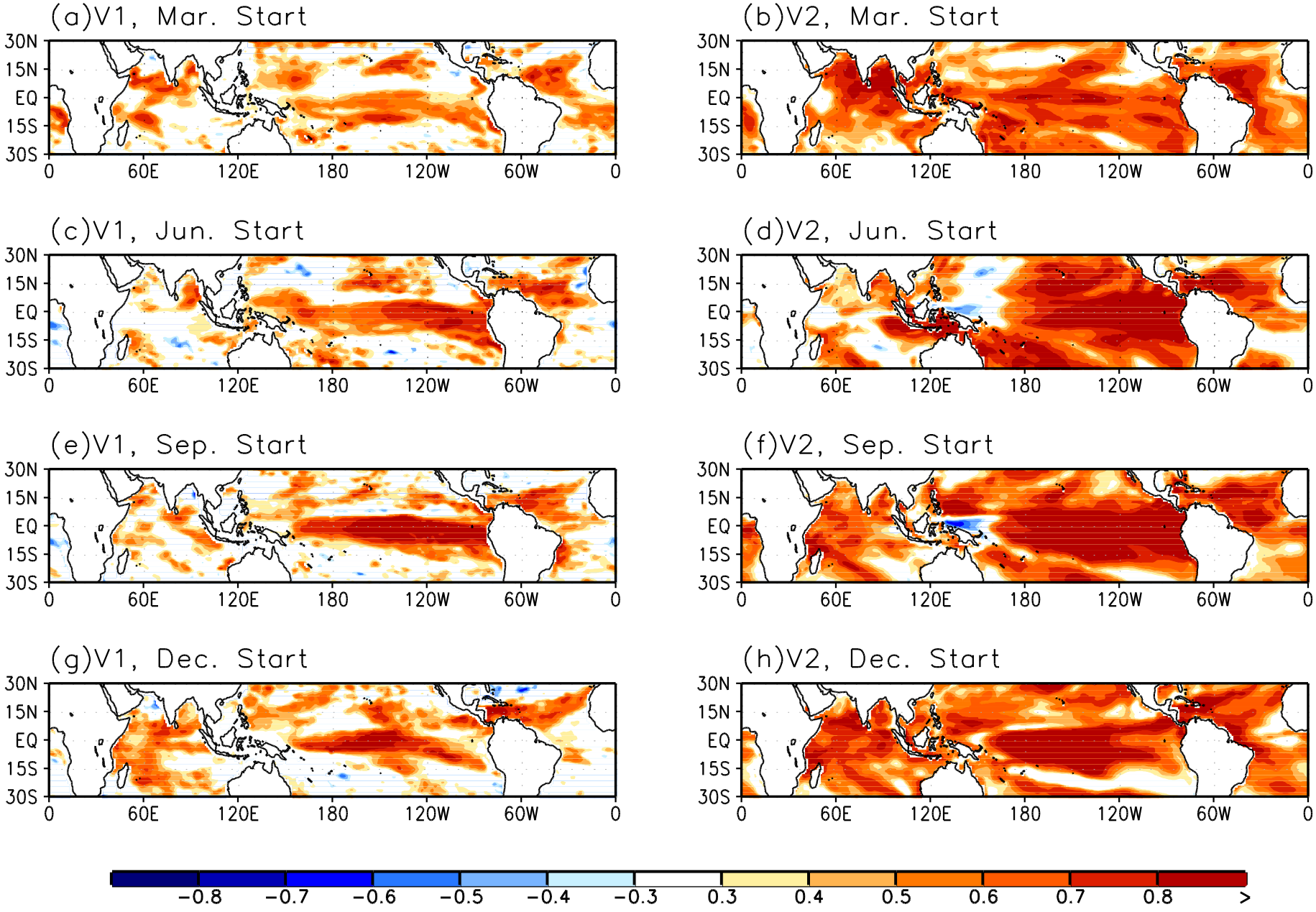
Old System (V1) **v.s** **New System (V2)**

NSIPP CGCM
(NSIPP1 AGCM + Poseidon)

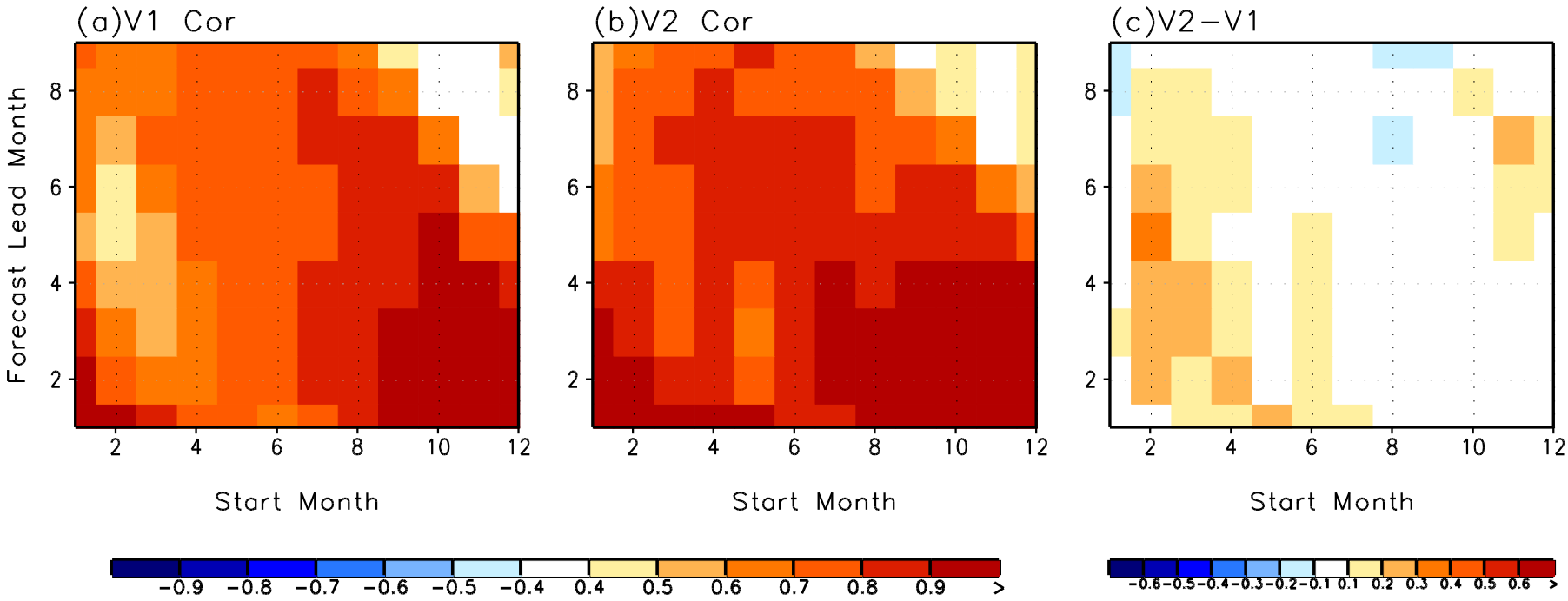
GEOS-5 AOGCM
(GEOS-5 AGCM + MOM4)

- Oceanic initialization scheme : **Optimal Interpolation**
- Hindcast period : **1993-2010**
- Forecast duration : **9 months**
- Number of ensemble member : **6**
- Validating reanalysis : ECMWF ORA S3

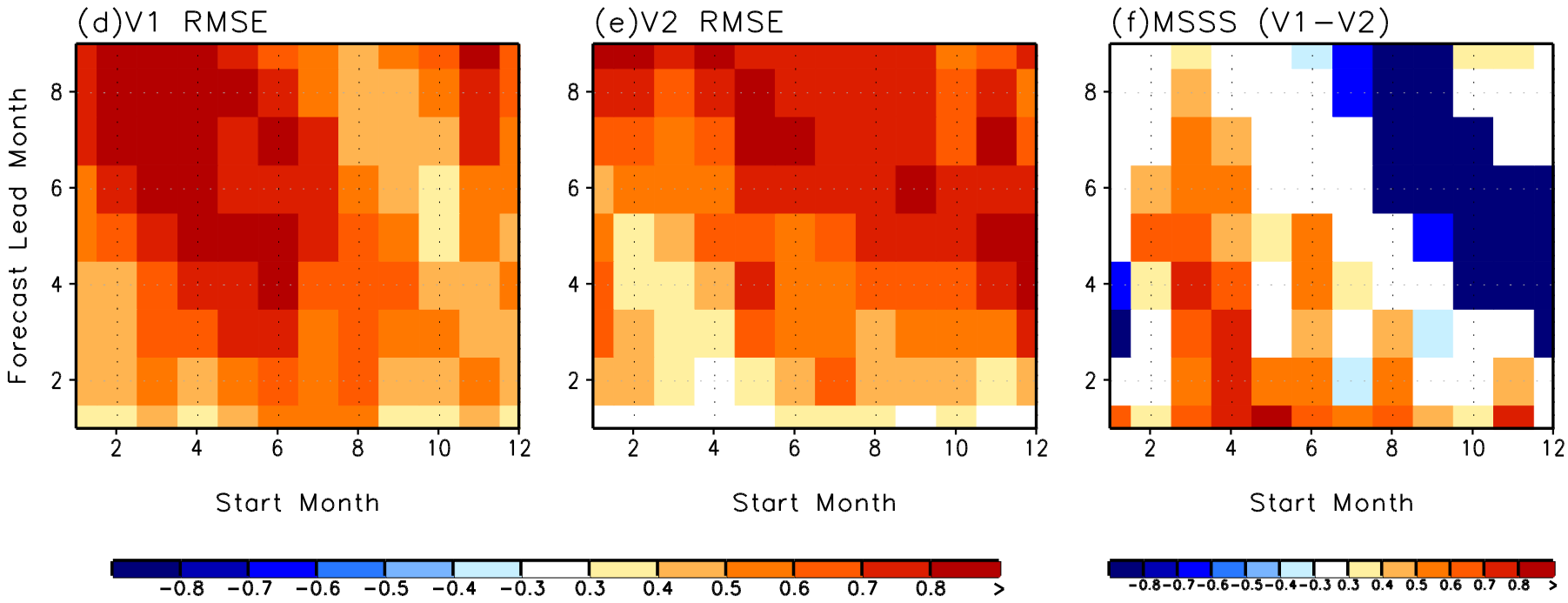
SST Correlation skill, 3-month avg., lead 2 to 4



Correlation skill of Nino3.4 index



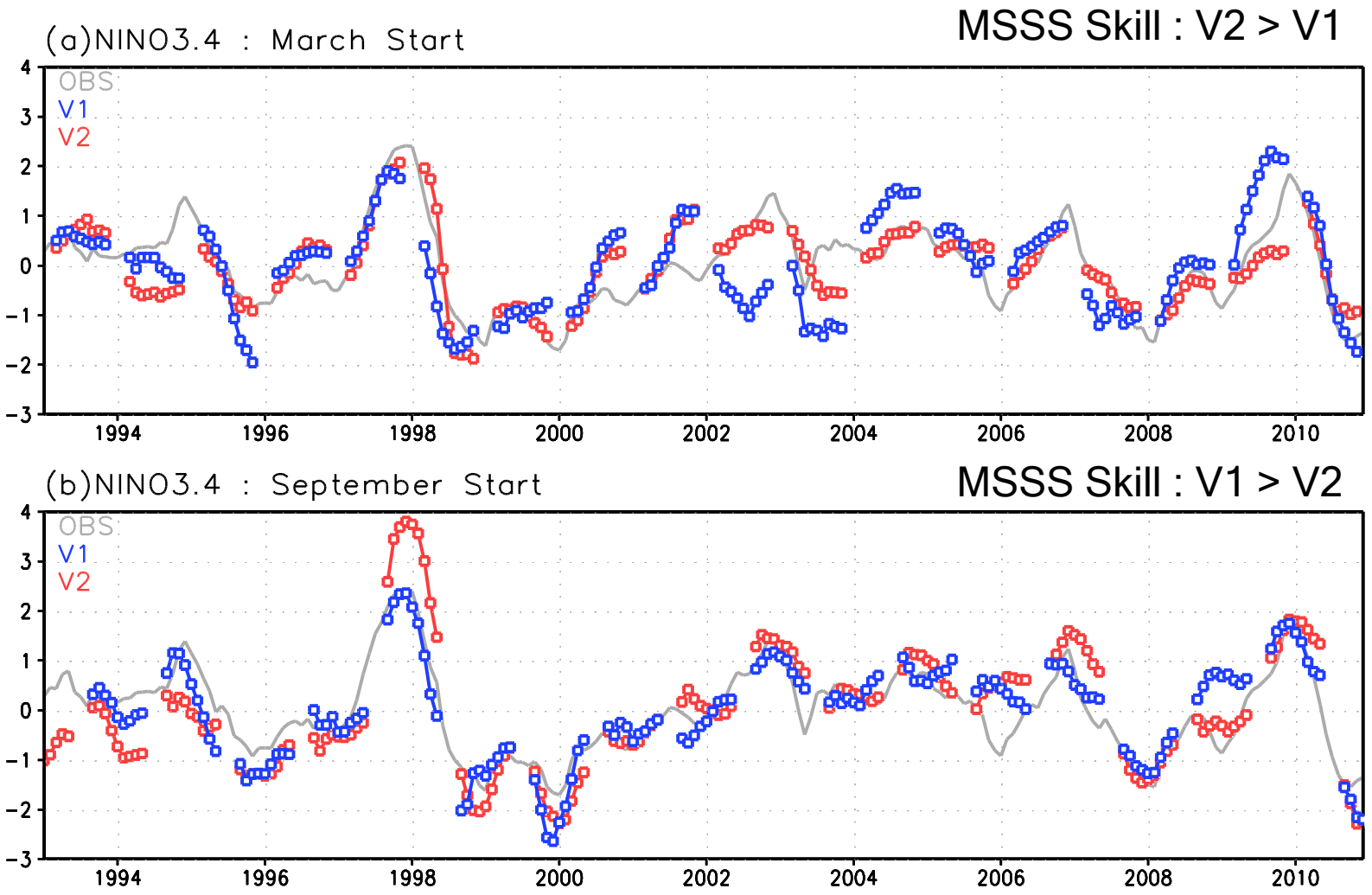
RMSE skill of Nino3.4 index



Which version exhibits better skill?

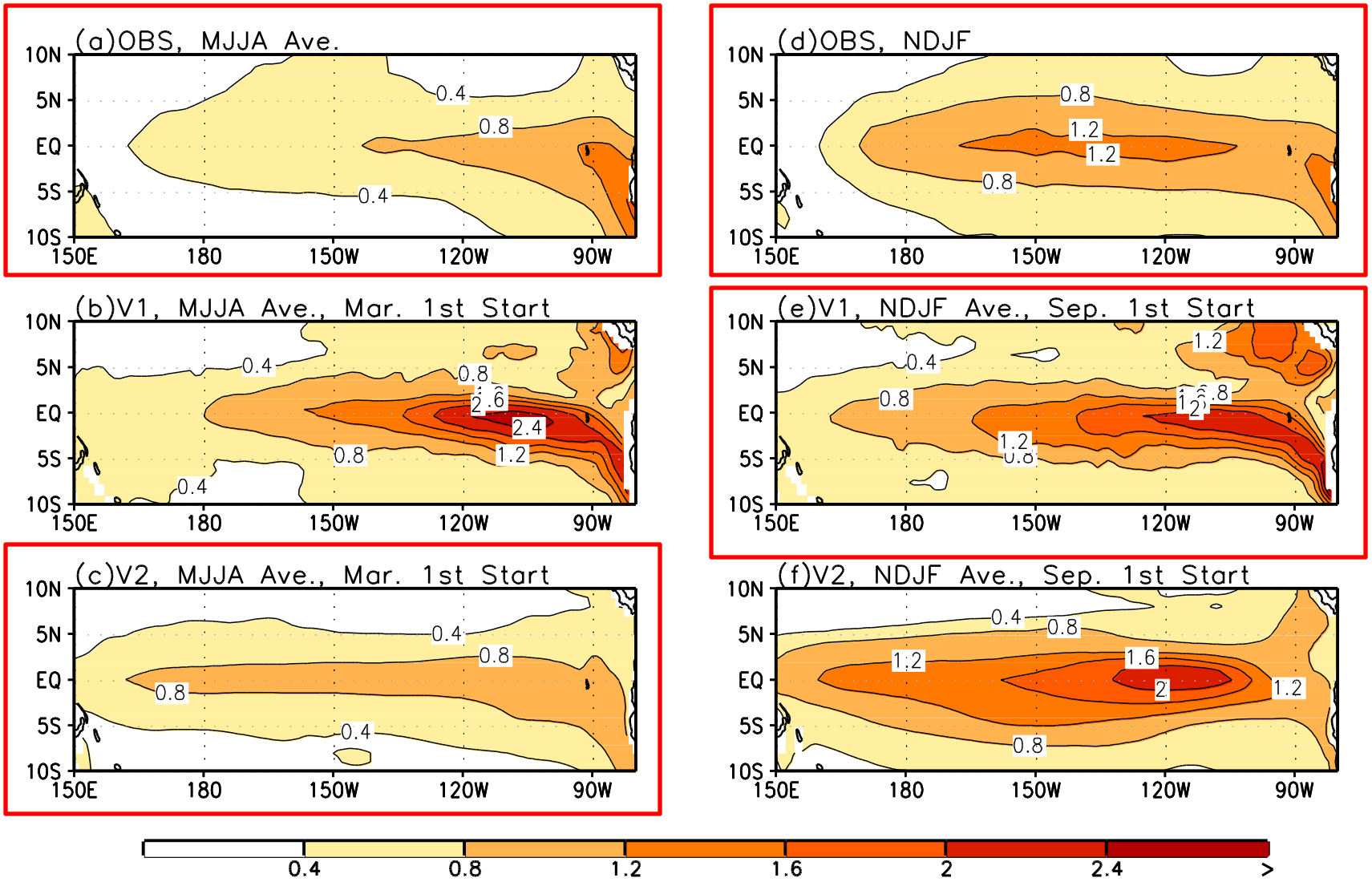
	Correlation Skill	RMSE Skill
Staring at Early calendar month	V2	V2
Starting at Late calendar month	V1~V2	V1

Time series of N34



Too strong ENSO in the forecasts ruins the forecast skill

Standard deviation of SST



Skill : V2 > V1

Skill : V1 > V2

SST equation

$$\frac{dT}{dt} = -\left(\frac{d(\bar{u}T)}{dx} + \frac{d(\bar{v}T)}{dy}\right) + Q - u\frac{d\bar{T}}{dx} - v\frac{d\bar{T}}{dy} - \frac{d(\bar{w}T)}{dz} - w\frac{d\bar{T}}{dz}$$

1. Mean Advection
2. Thermal damping
3. Zonal advective feedback
4. Thermocline feedback
5. Ekman feedback

BJ Index (Jin et al. 2006)

$$\frac{dT}{dt} = 2I_{BJ}T + F[h]$$

I_{BJ} : The growth rate of the oscillator

$$2I_{BJ} = -\left(a_1\frac{<\Delta u>_E}{L_x} + a_1\frac{<\Delta v>_E}{L_y}\right) - \alpha_s$$

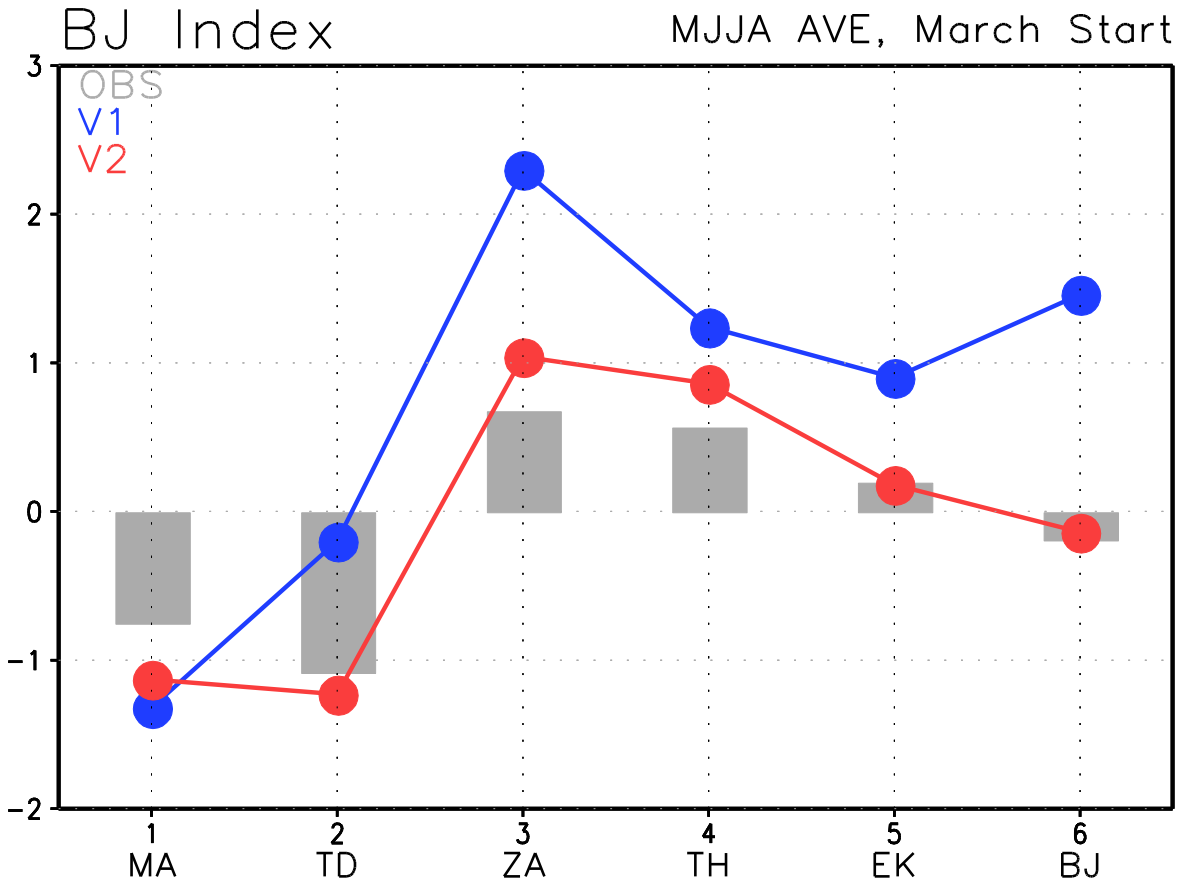
1. Mean Advection
2. Thermal damping

$$+\mu_a\beta_u<\frac{d\bar{T}}{dx}> + \mu_a\beta_h<\frac{\bar{w}}{H_1}>a_h + \mu_a\beta_w<\frac{d\bar{T}}{dz}>$$

3. Zonal advective feedback
4. Thermocline feedback
5. Ekman feedback

BJ index, March start

*ENSO amplitude : V1 >> V2 ~ OBS



1. MA : Mean Advection
2. TD : Thermal damping
3. ZA : Zonal Advective feedback
4. TH : Thermocline feedback
5. EK : Ekman feedback
6. BJ : BJ index (instability)

Zonal advective feedback, March Start

El Nino SST

Air-sea coupling strength

Westerly wind stress

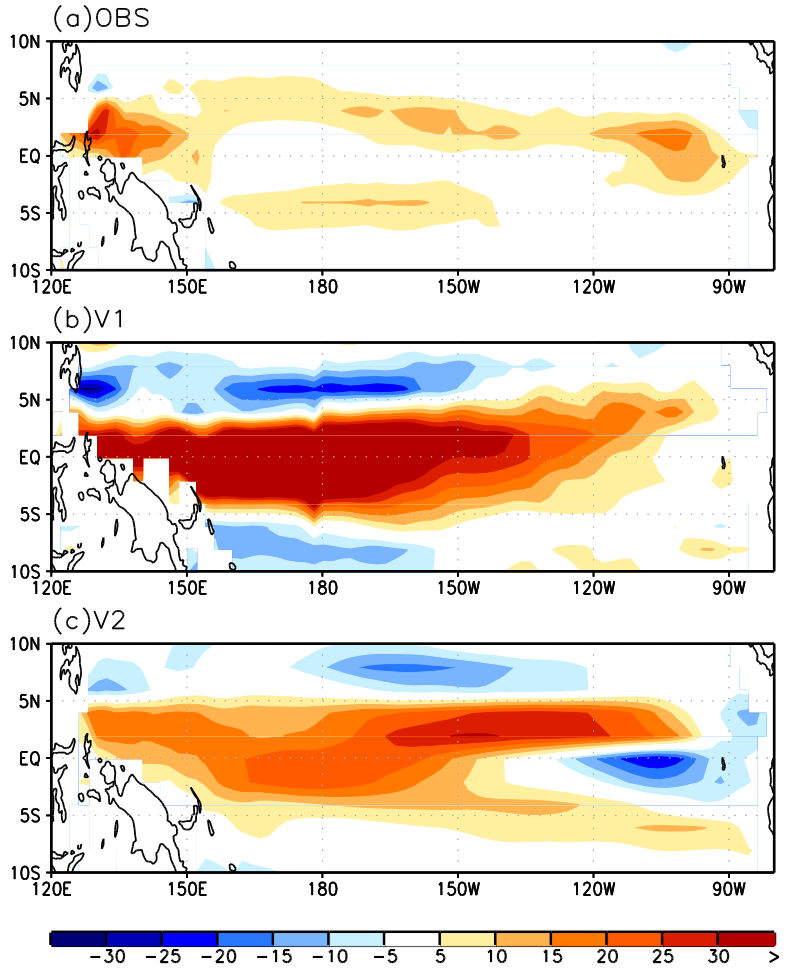
Sensitivity of Ocean current to wind forcing

:Quite Strong in Model

Westerly current

Mean zonal temperature gradient

A response of an ocean zonal current to a wind forcing (m/s/N/m^2), MJJA



Decomposition of zonal current

$U = U_s + U_m$

U_s

Wind driven current

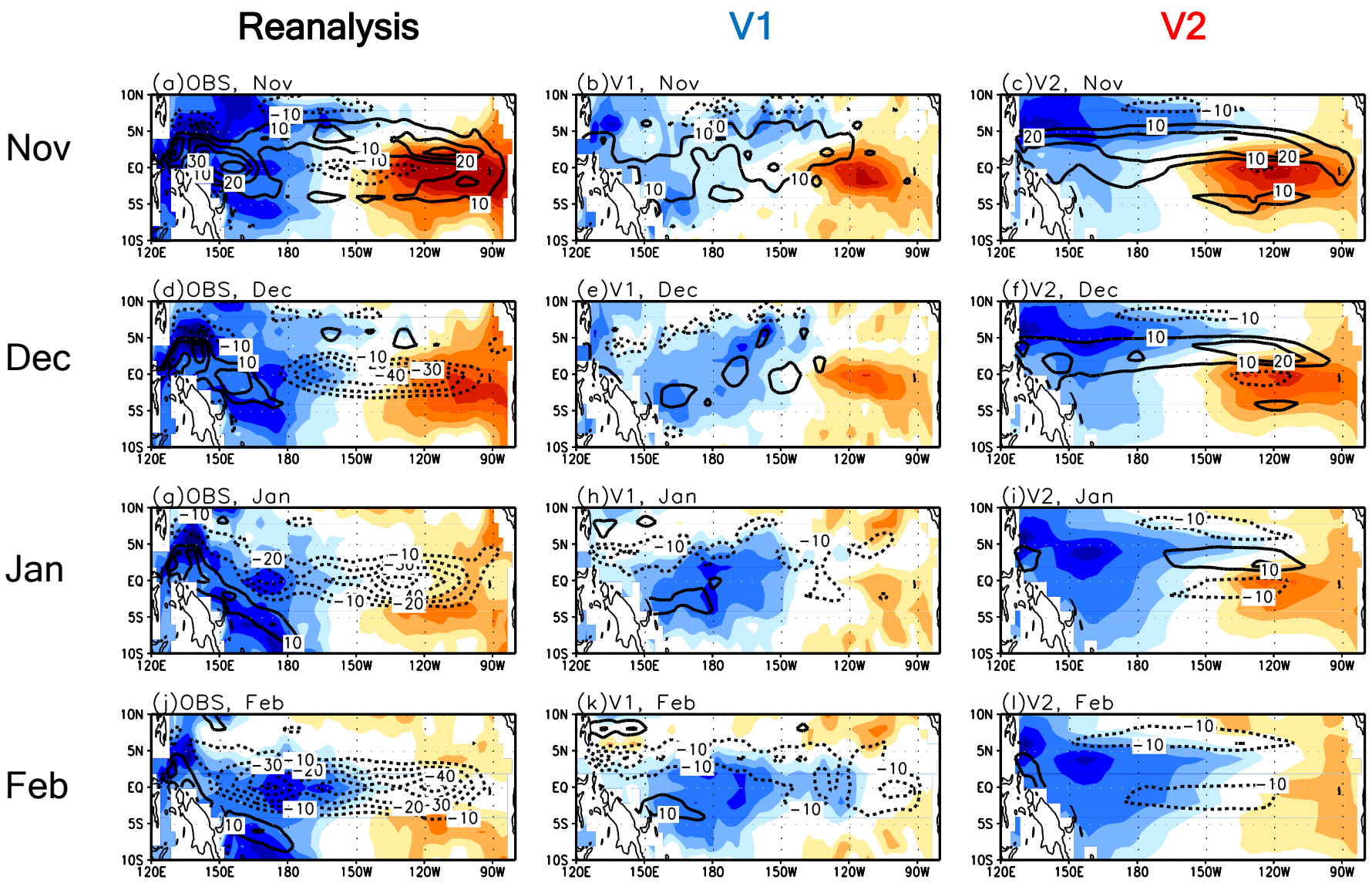
- Determined by surface wind
- Fast process
- Included in BJ index

U_m

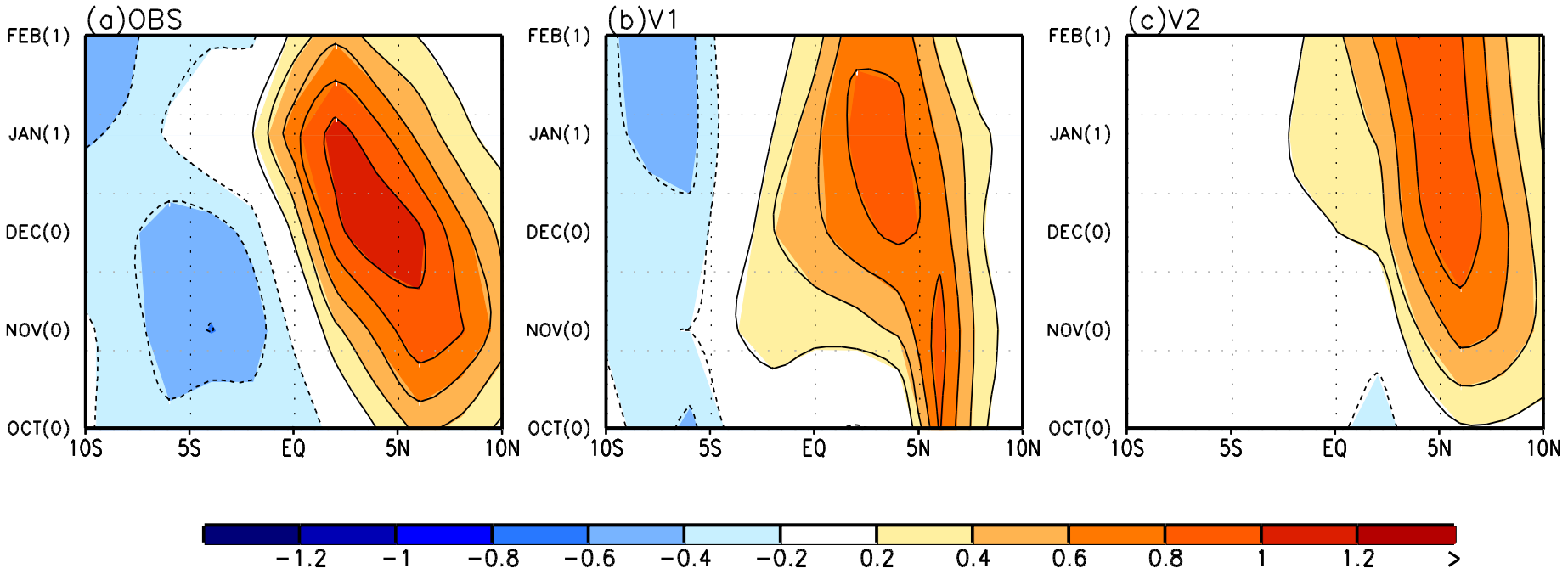
Geostrophic current

- Determined by zonal mean thermocline
- Slow process
- Excluded from BJ index

El Nino composite, Z20 & U50, Starting at September



El Nino composite, central Pacific V200, Starting at Sep. 1st



Weak divergent flow in V2
→ Lead slow discharge process
→ Slow phase transition in zonal current

*Central Pacific = 160E-100W

Summary and conclusion

- The recent GEOS-5 seasonal prediction results exhibit better forecast skill starting at early calendar month, similar or slightly worse skill starting at late calendar month.

- During the forecast starting at early (late) calendar month, the simulated ENSO in V1 (V2) is excessive, and it is responsible for the degradation of the forecast skill.

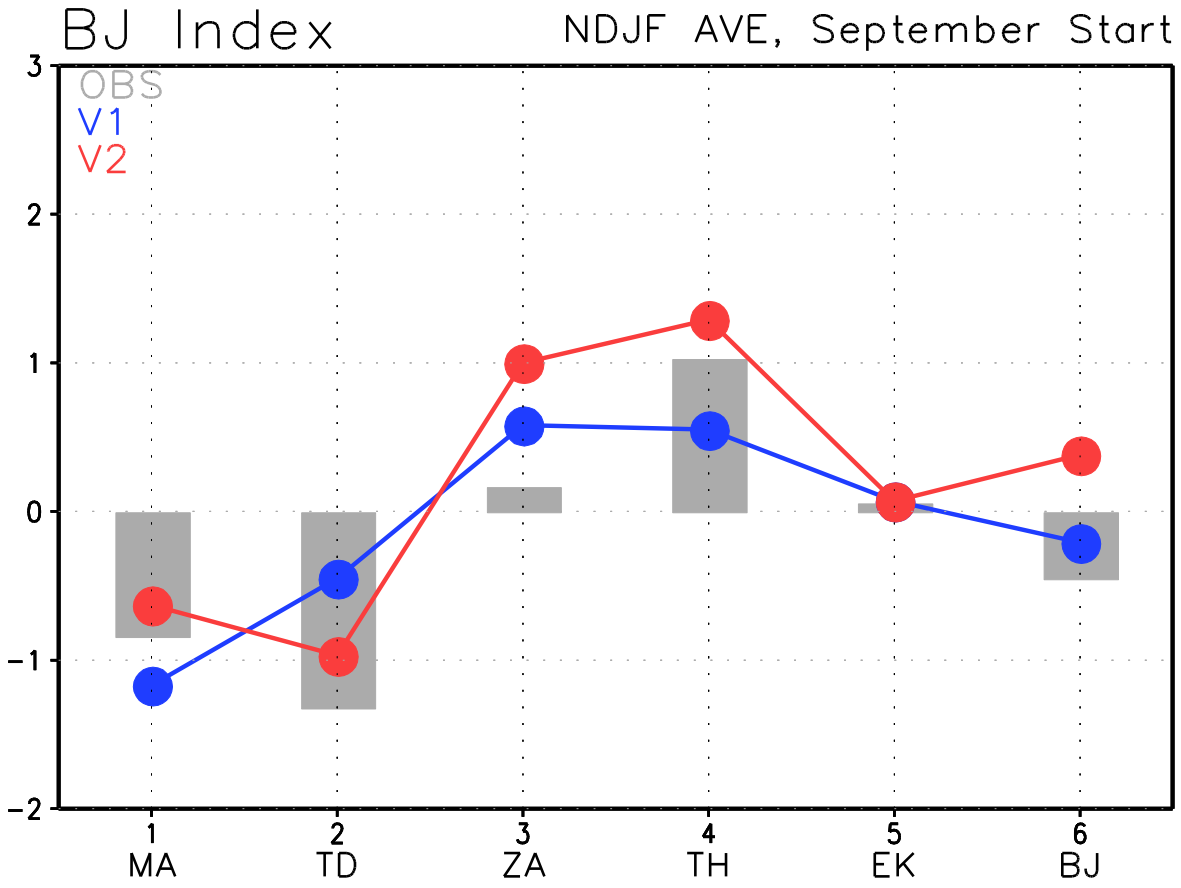
- The zonal advective feedback is responsible for the excessive ENSO magnitude in the forecasts. Especially, the sensitivity of zonal currents to the wind stress forcing is too strong in the forecasts.

- The weak discharge of the equatorial heat content in V2 delays the phase transition of ENSO.

Thank you!

BJ index, Sep. start

*ENSO amplitude : V2 > V1 > OBS



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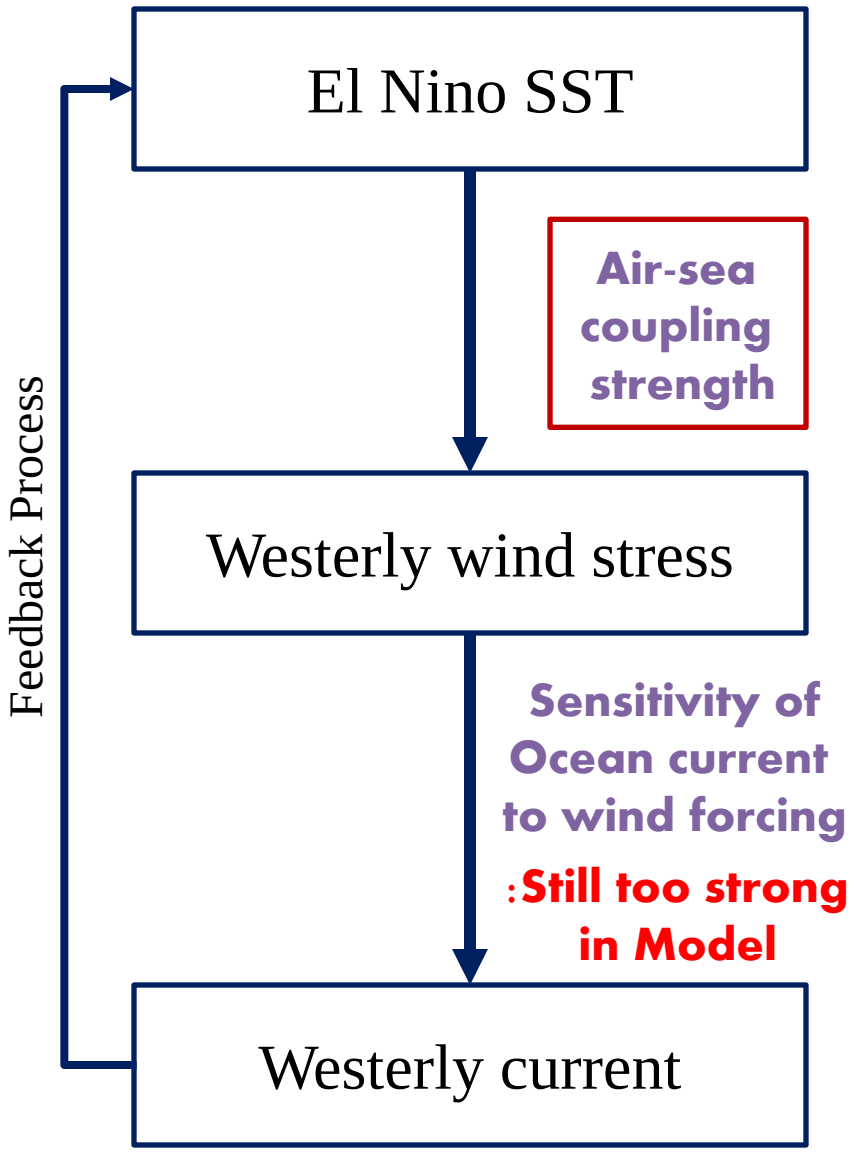
Zonal advective feedback, September Start

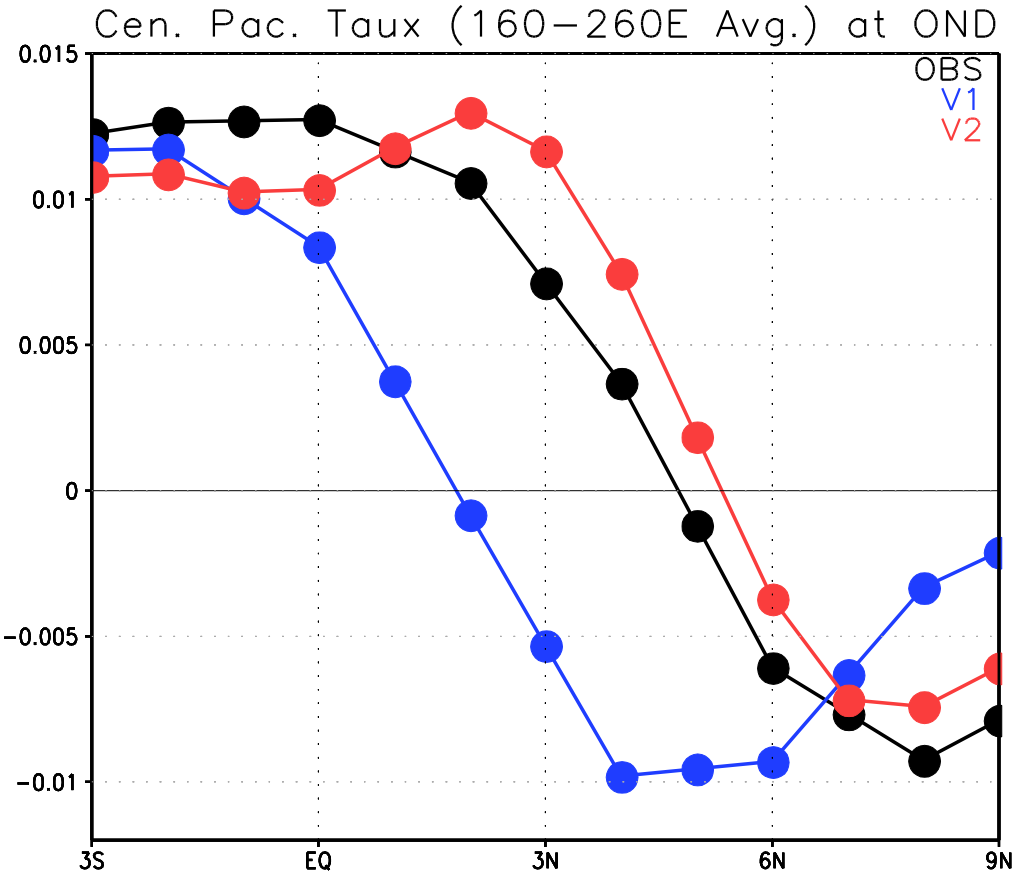


A response of an Zonal mean Taux to a SST forcing ($N/m^2/^oC$), NDJF

	Taux/N34 SST
Obs	0.0047
V1	0.0020
V2	0.0045

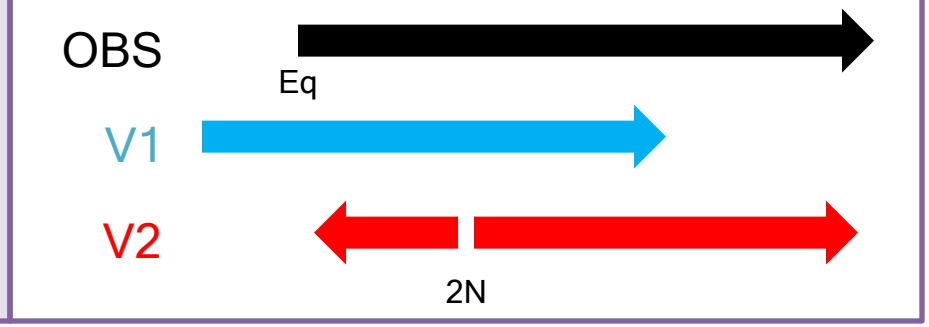
Weak air-sea coupling strength mitigates the strong zonal advective feedback in V1

El Nino composite, Taux, Starting at Sep. 1st

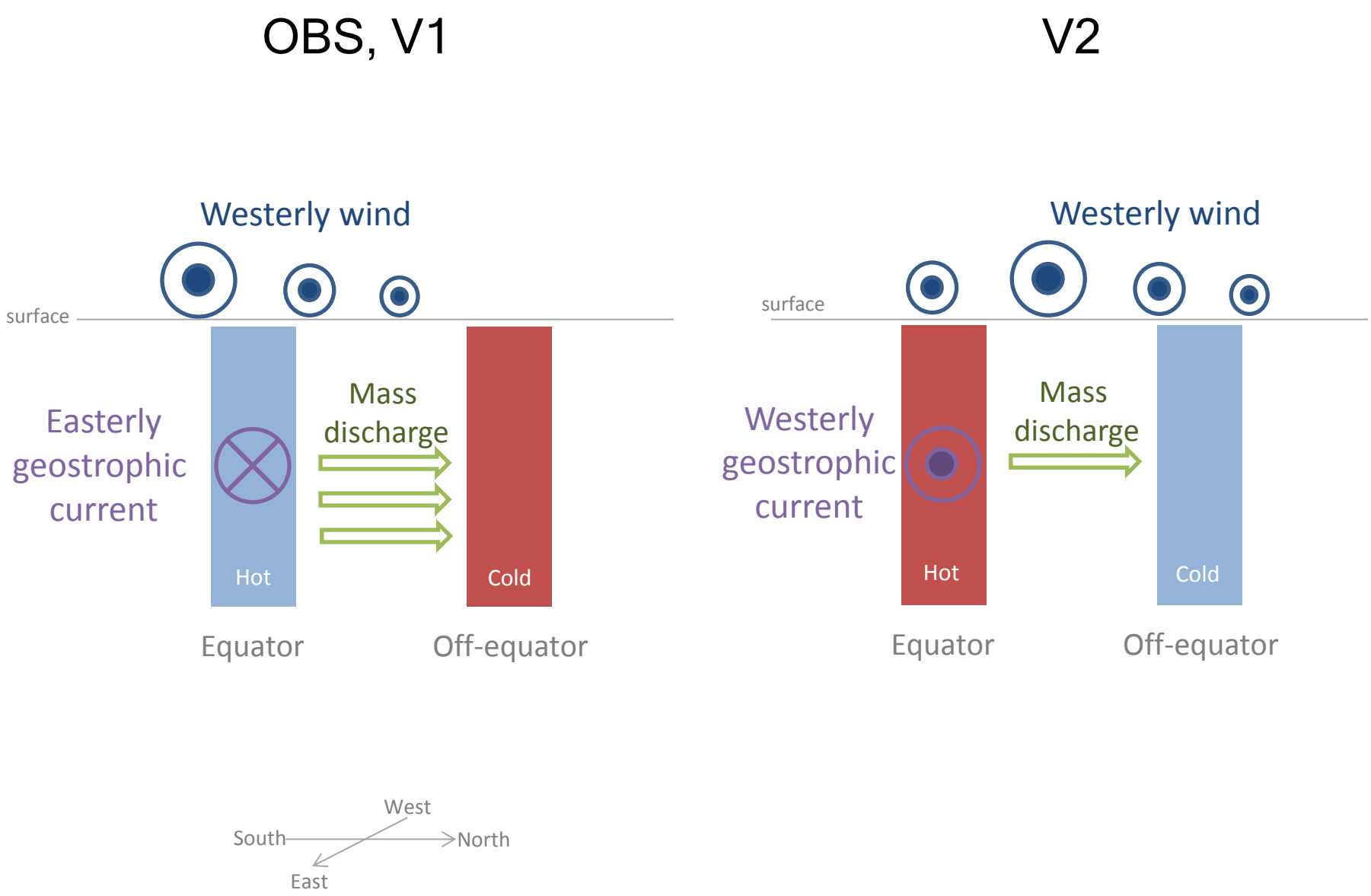


Schematic Geostrophic current

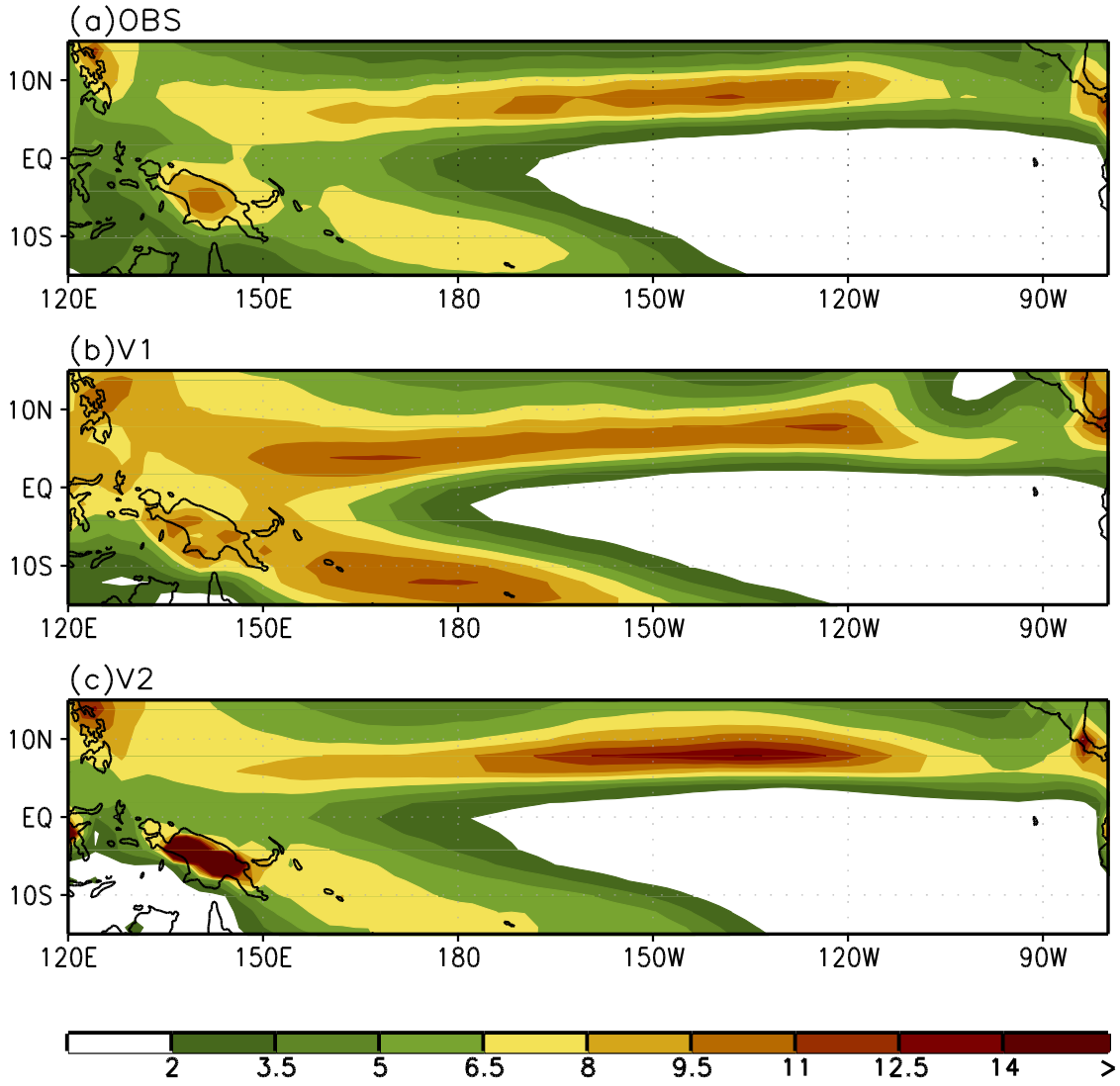
$$v_g \propto -\frac{d\tau_x}{dy}$$



Schematic Diagram of El Nino phase transition



Climatological OND PRCP, Starting at Sep. 1st



El Nino composite at OND, Taux & Prcp, Starting at Sep. 1st