Mechanism and Predictability of South Pacific Dipole Mode in NCEP CFSv2

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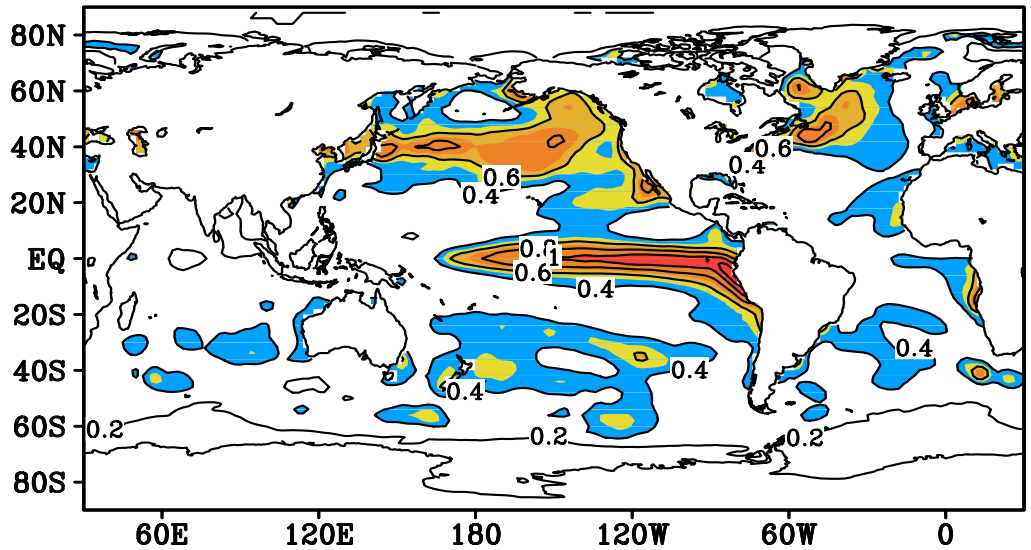
References

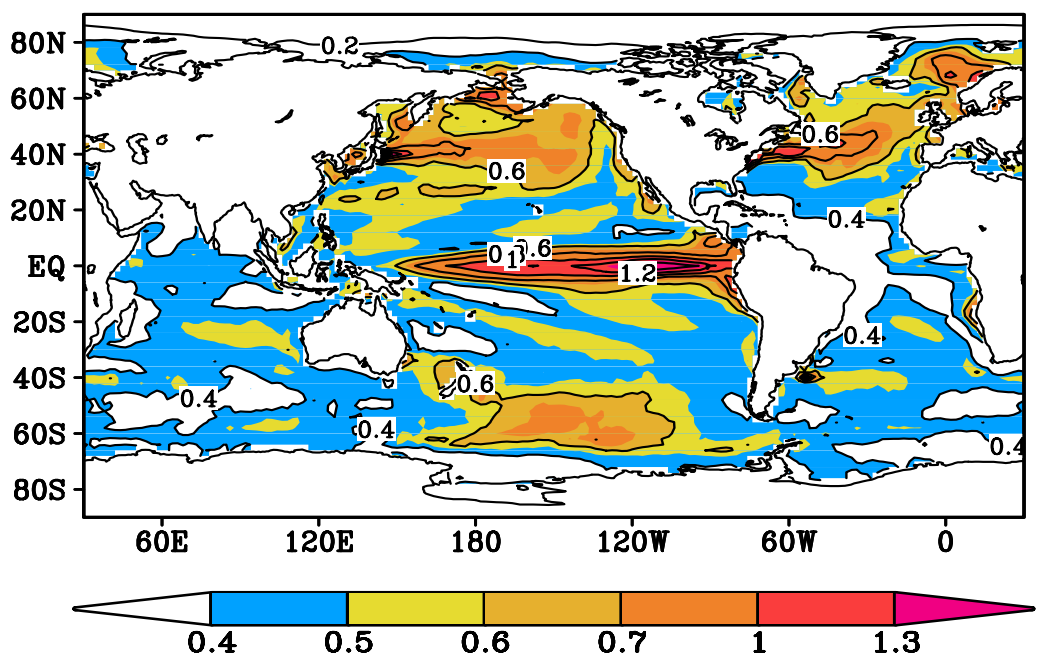
- Guan, Y., J. Zhu, B. Huang, Z.-Z. Hu and J. L. Kinter, 2013a: South Pacific Ocean Dipole: A predictable mode on multi-seasonal time scales. *J. Climate*, accepted.
- Guan, Y., B. Huang, J. Zhu, Z.-Z. Hu and J. L. Kinter, 2013b: Interannual variability of the South Pacific Ocean in observations and simulated by the NCEP Climate Forecast System, version 2. *Climate Dynamics*, submitted.

Standard Deviation of Seasonal Mean SSTA

(a) OBS (1961–2010)



(b) CFSv2 (50yr)



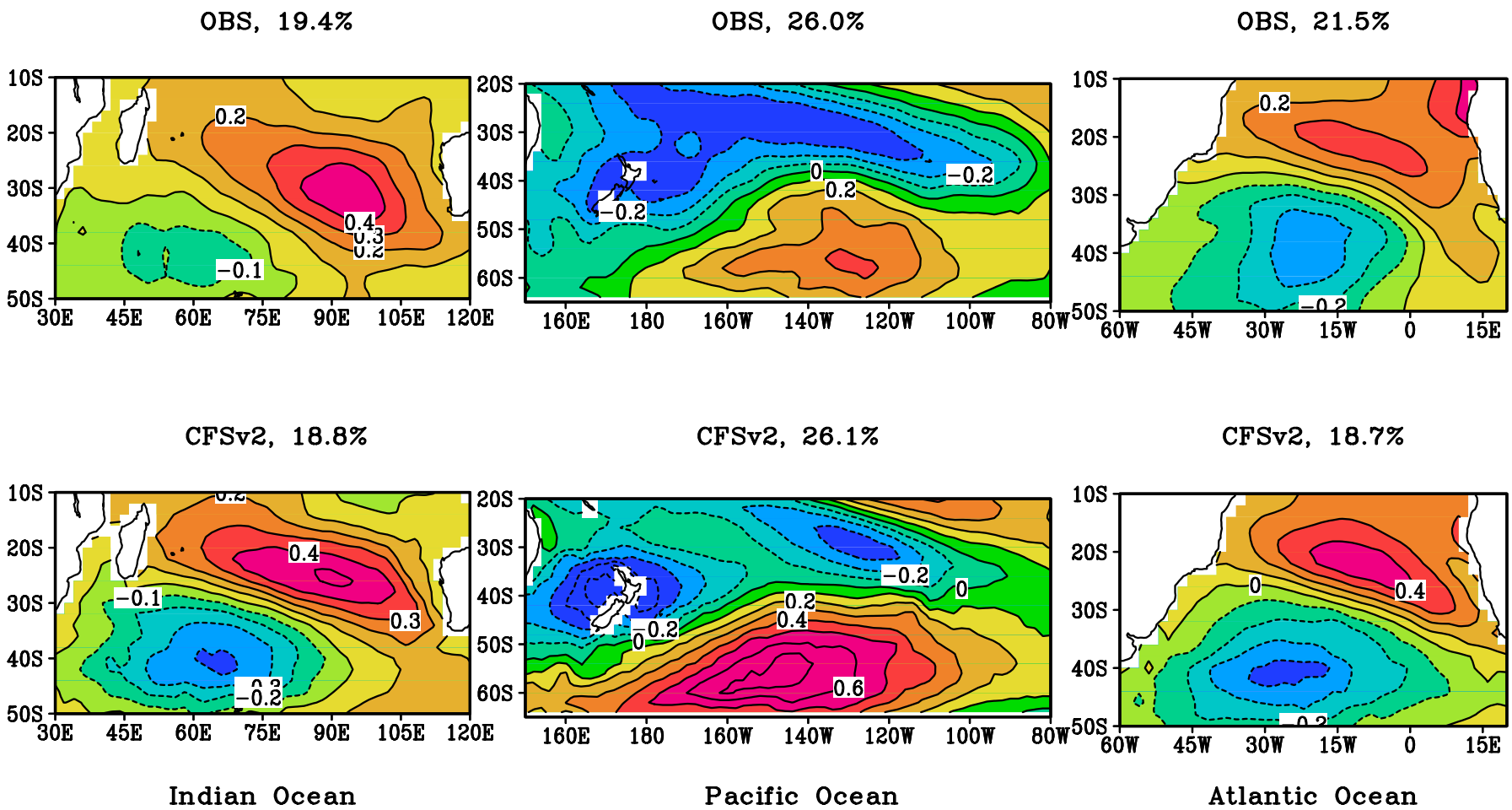
Unique Character of Southern Ocean SSTA

Open Ocean Formation

CFSv2 reproduces the STD distribution of the observed SSTA

Overestimate and shift in South Pacific

1st EOF Modes in Southern Basins

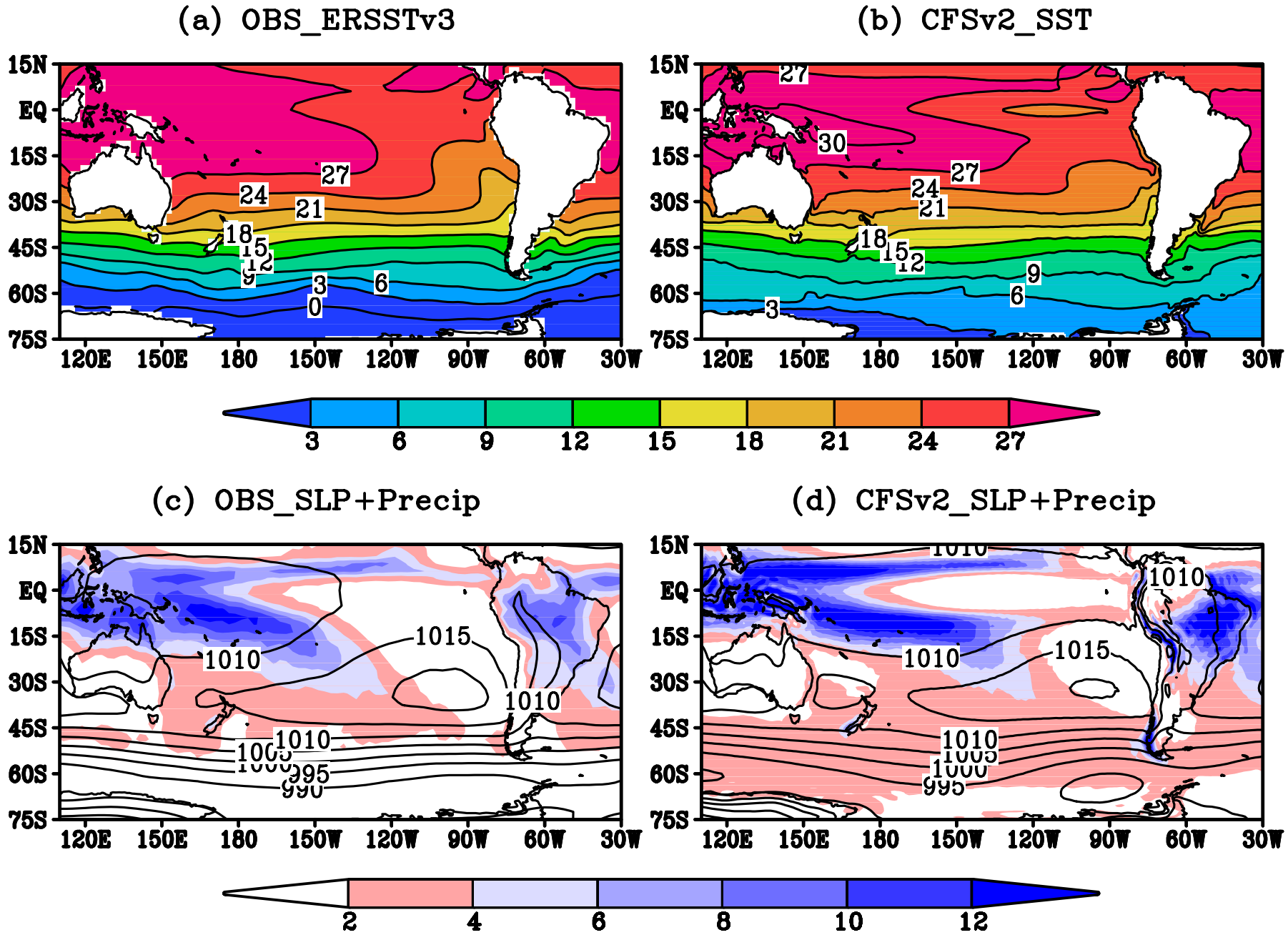


Southern Subtropical Indian Ocean Dipole (SSID)

South Pacific Dipole (SPD)

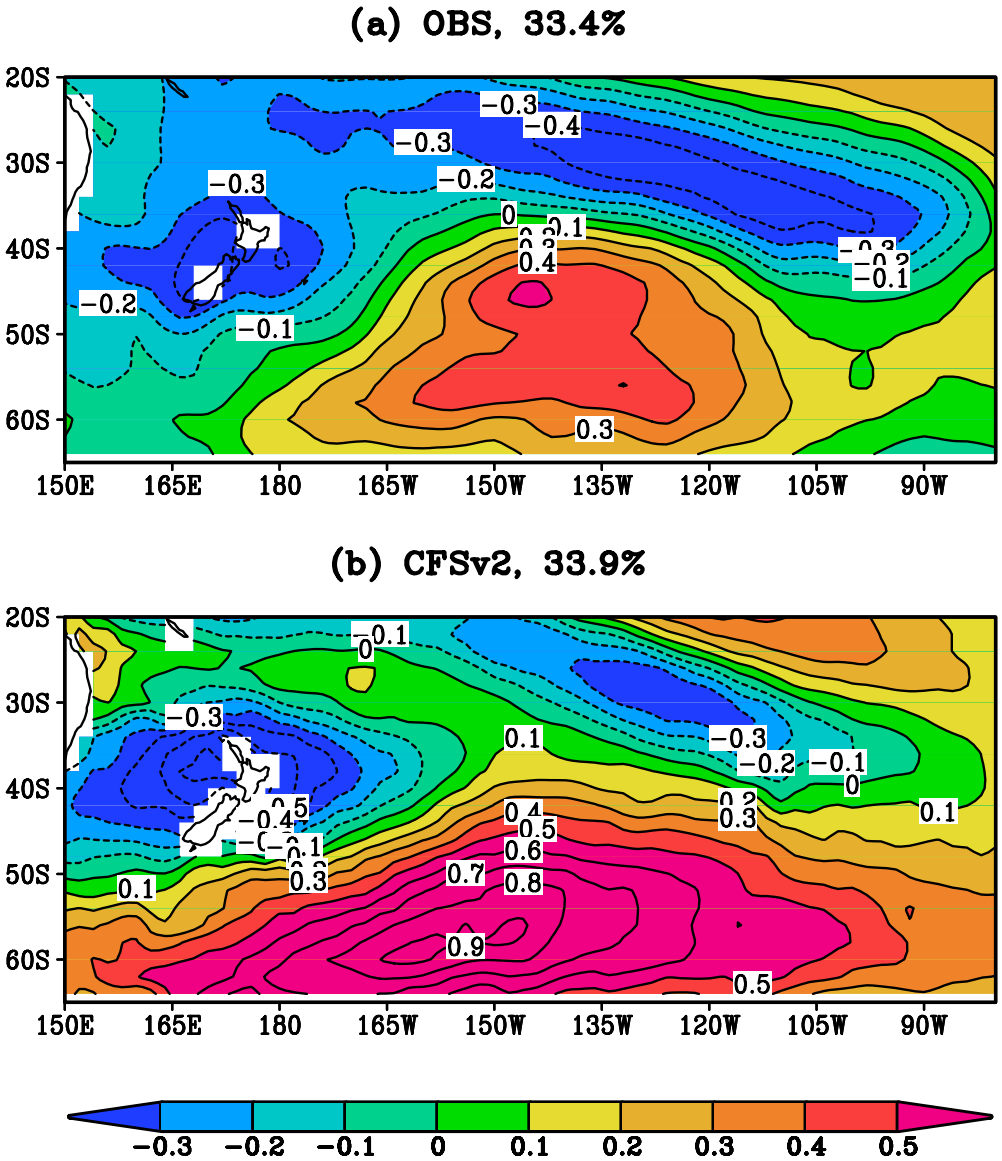
Southern Subtropical Atlantic Dipole (SSAD)

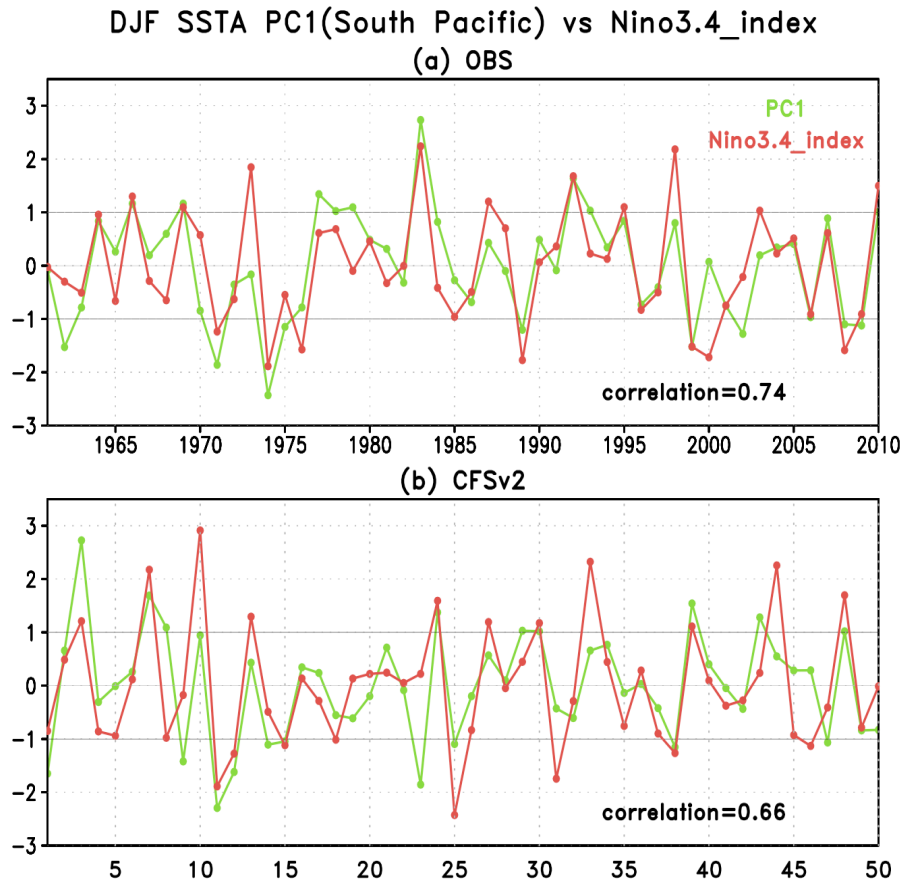
DJF Mean SST,SLP and Precipitation



DJF 1st SSTA EOF in South Pacific

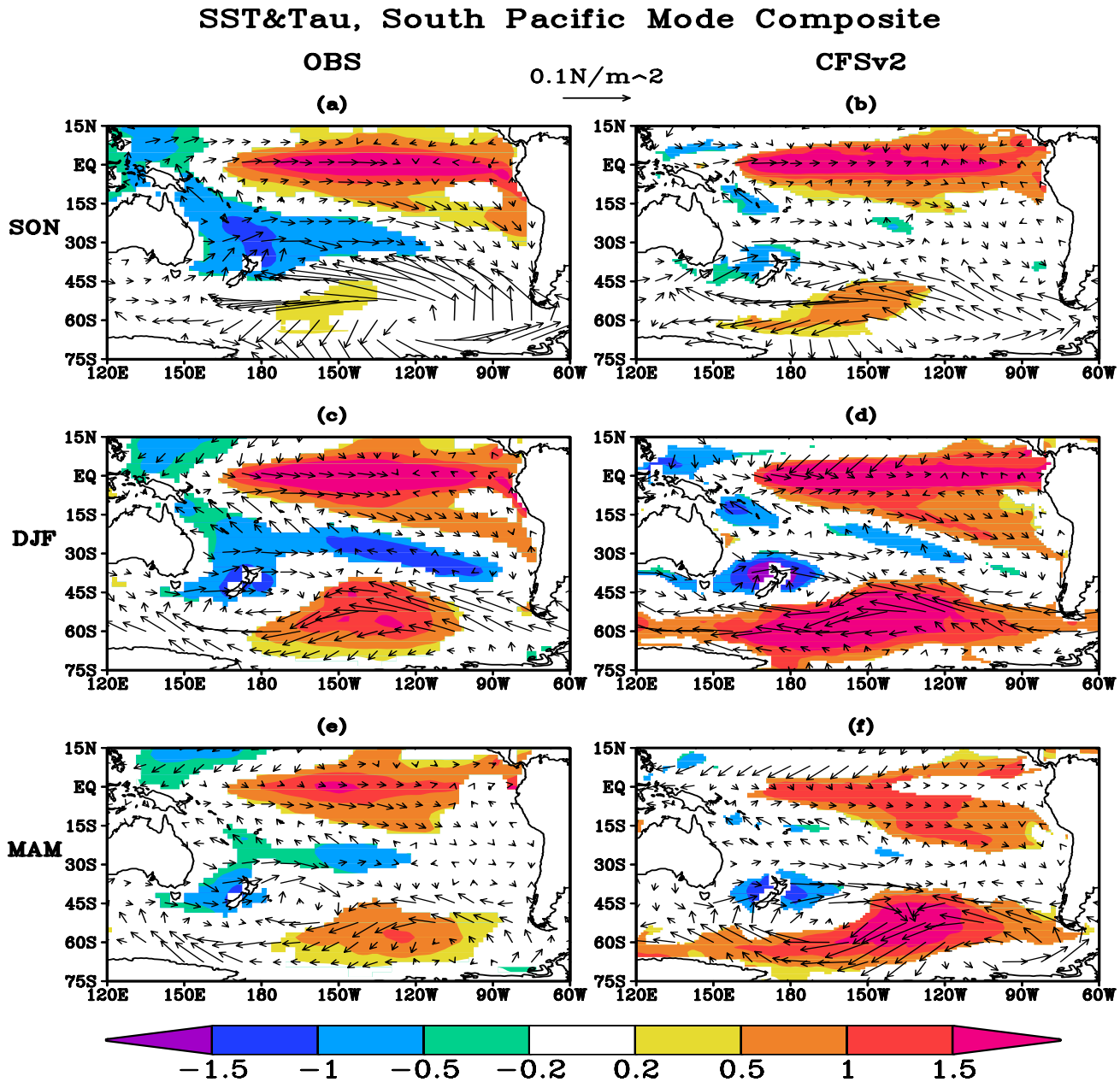
South Pacific Dipole (SPD) Mode





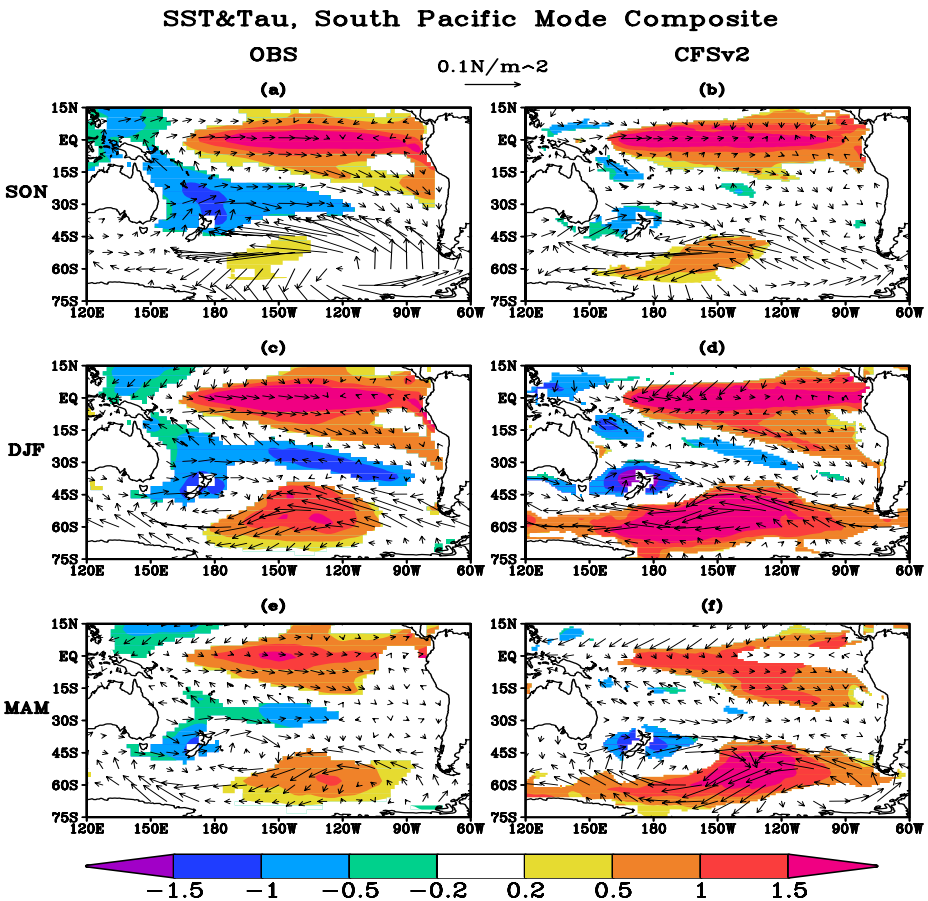
SPD is highly coherent with ENSO in both observations and CFSv2

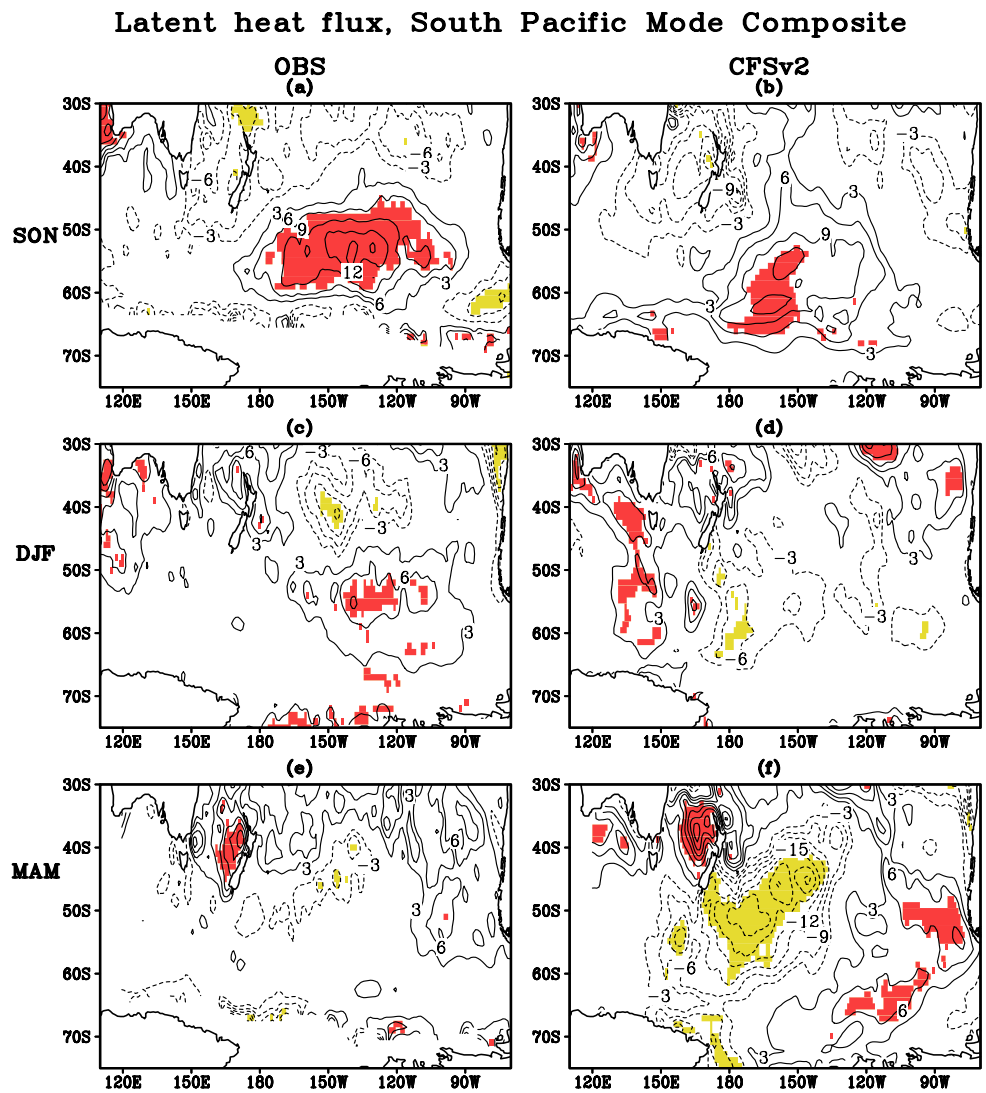
Lifecycle of Composite SPD Event



Regional Air-Sea Feedback

Surface Heat Flux, ΔQ



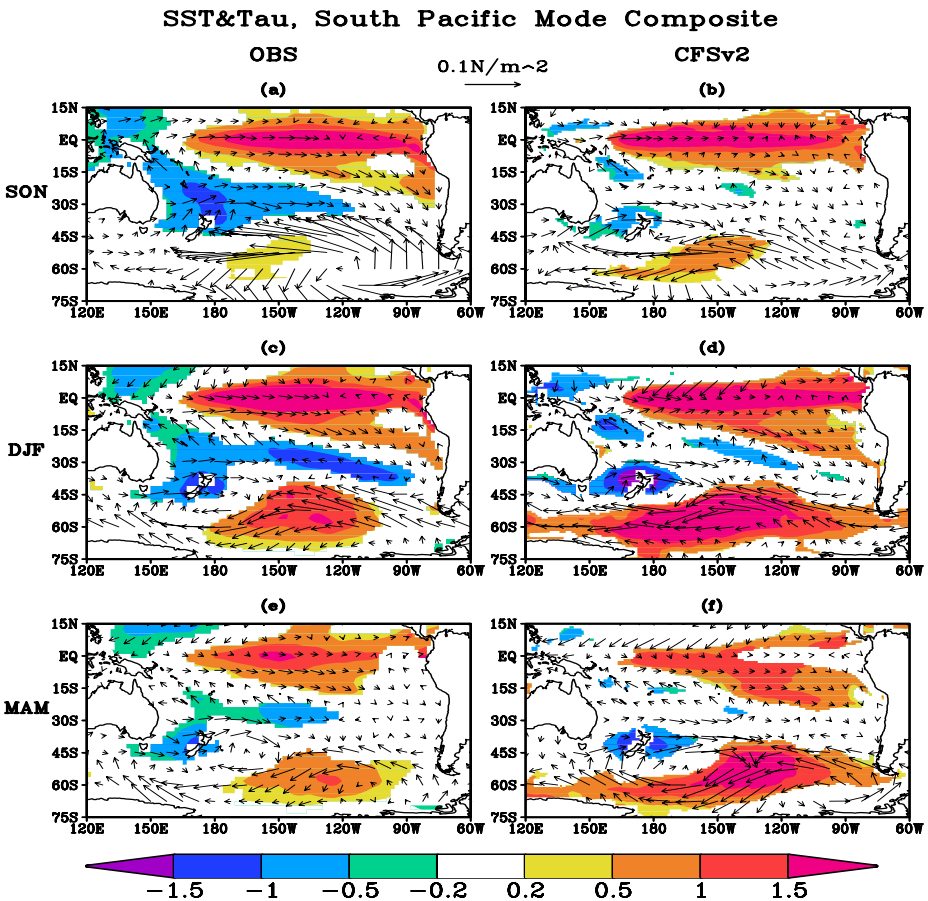


$$\frac{\partial\left(SST_a\right)}{\partial t} \approx \frac{\Delta Q}{c_p \rho \bar{H}}$$

$\bar{H}$ *Monthly climatological mixed layer depth. In developing phase,* $\Delta Q_L \sim c_{pa}\rho_a C_E V' \delta\bar{q}$

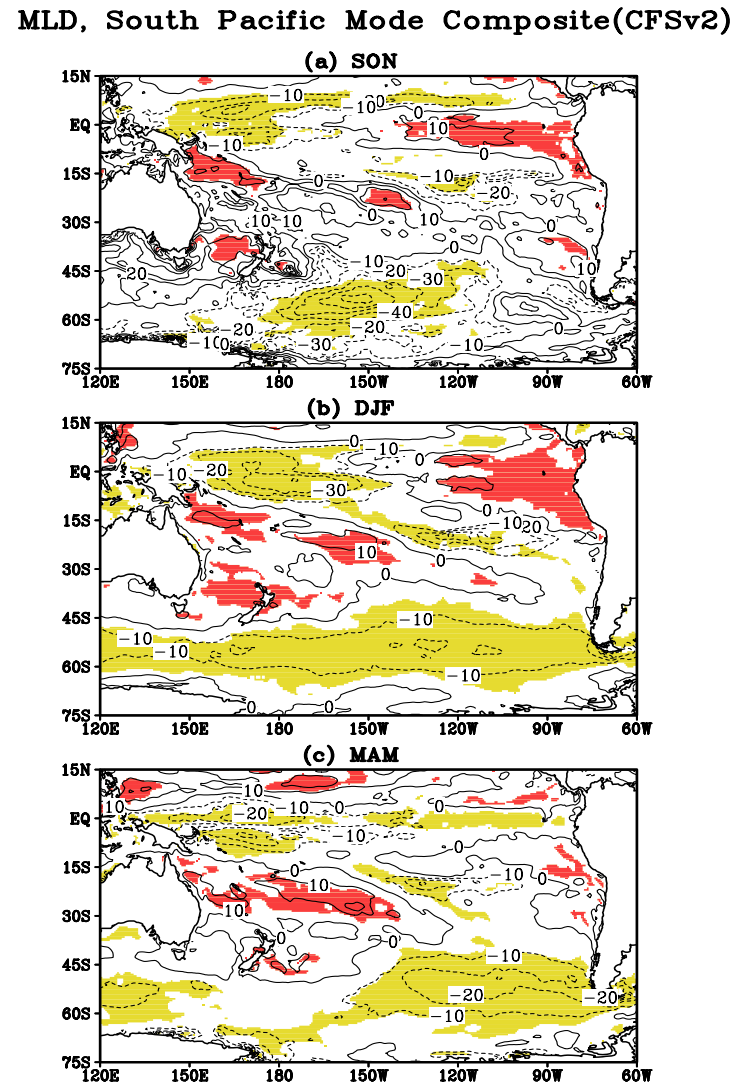
Regional Air-Sea Feedback

$$\Delta H \sim F(\Delta u_*^3, \Delta Q)$$



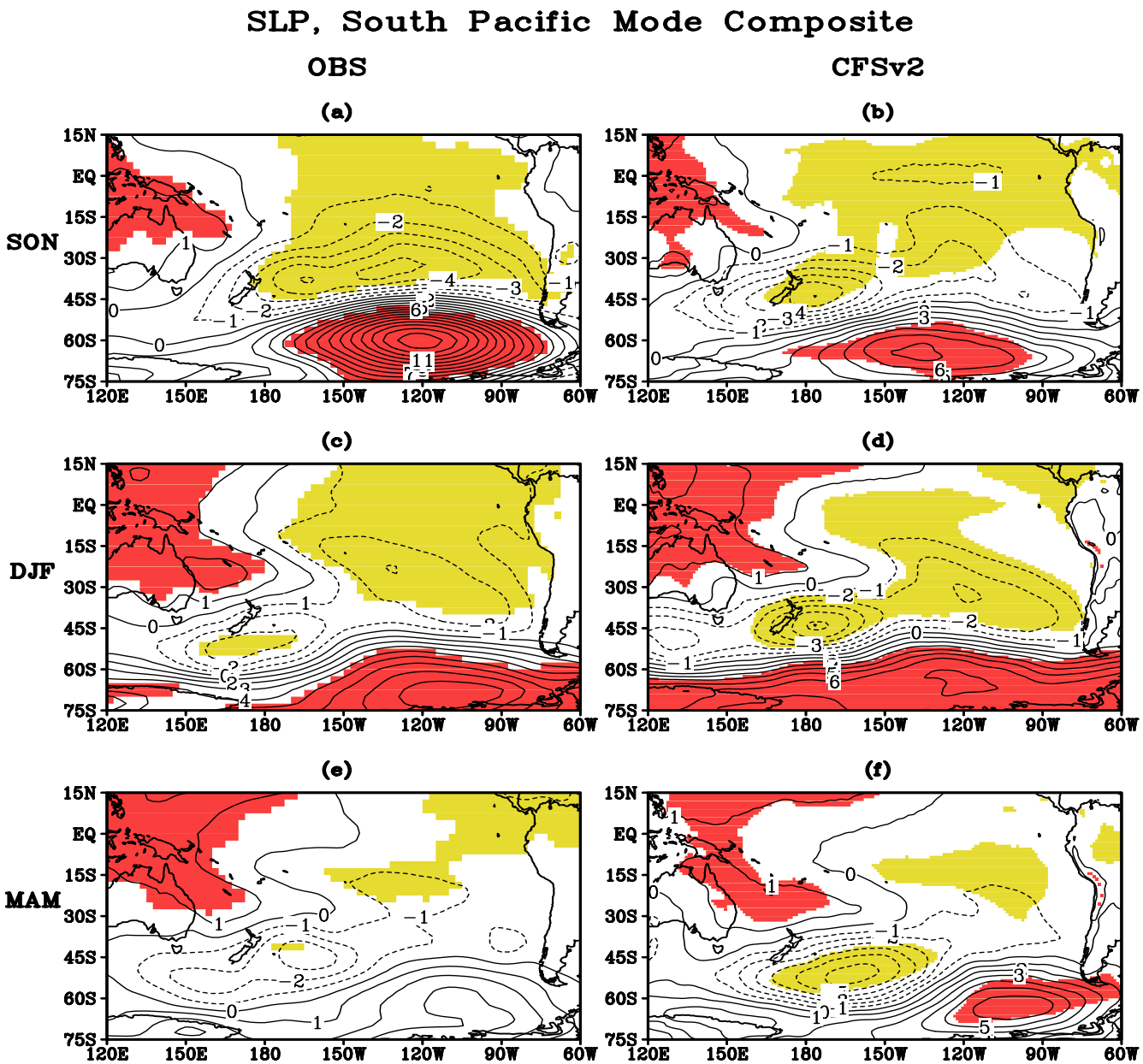
$$\frac{\partial(SST_a)}{\partial t} \approx \frac{\Delta Q}{c_p \rho \bar{H}} - \frac{\Delta H \bar{Q}}{c_p \rho \bar{H}^2}$$

Morioka et al. (2010, 2012)

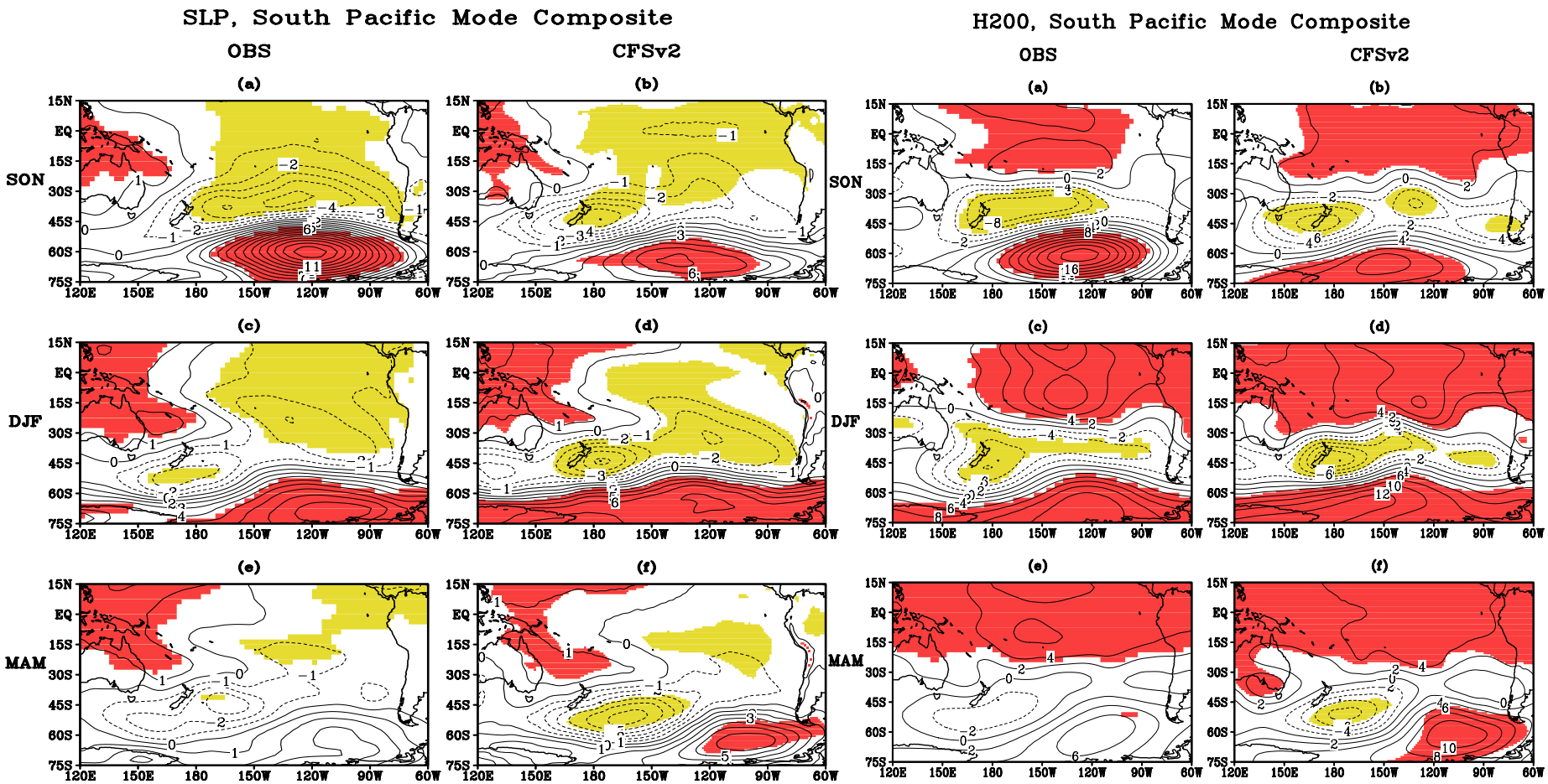


Influence of wind anomalies is significant

Where the wind anomalies come from?

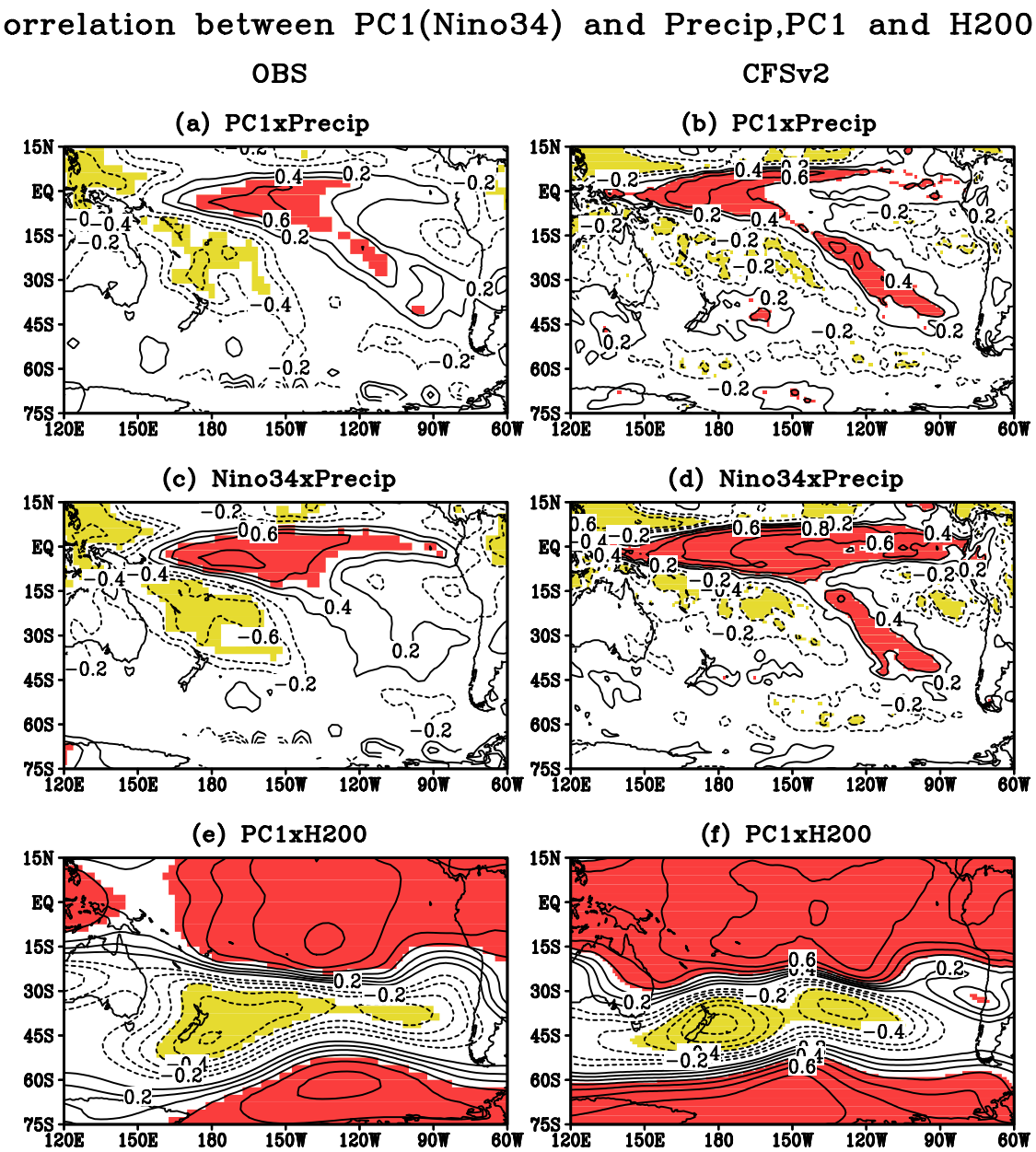


Atmospheric Tele-Connection

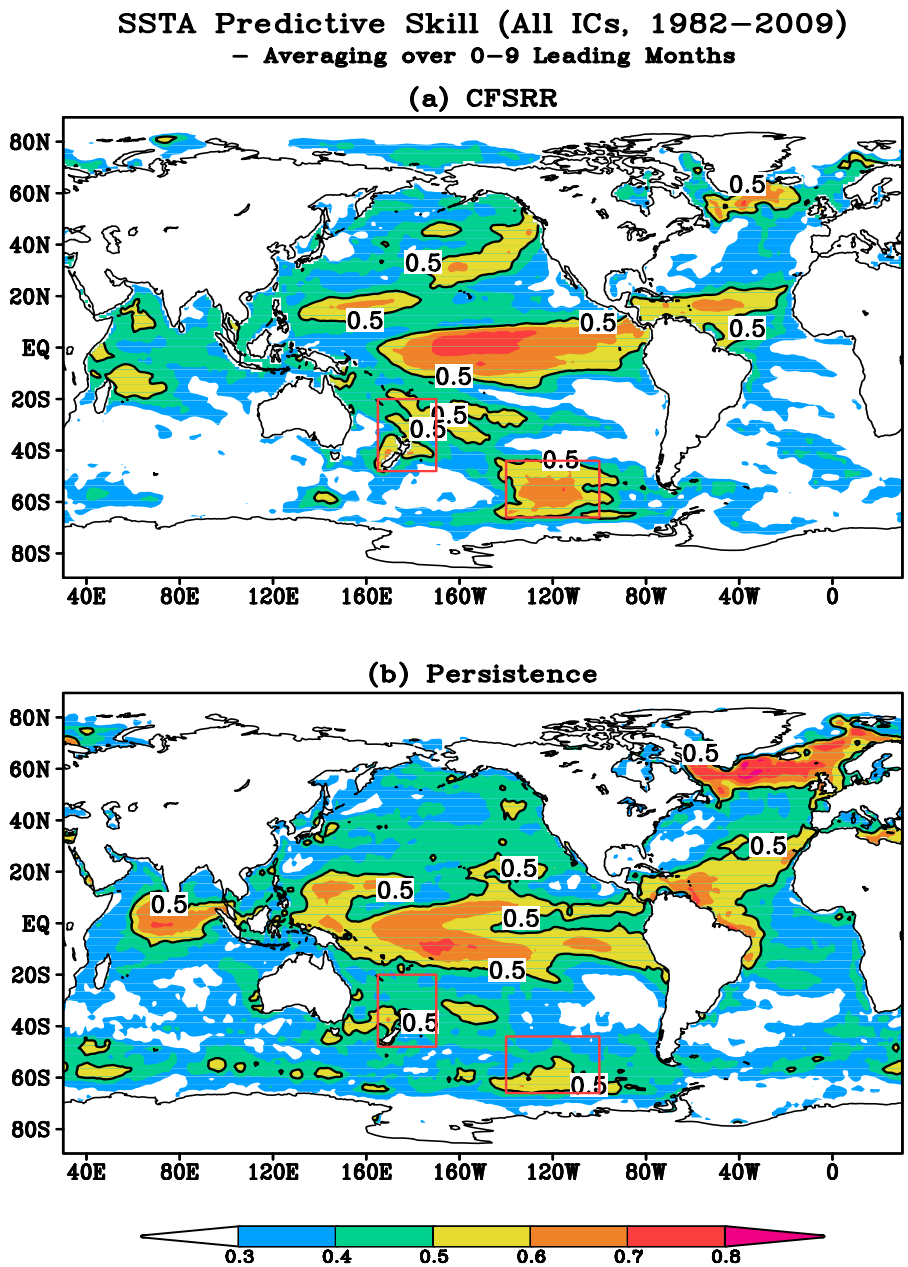


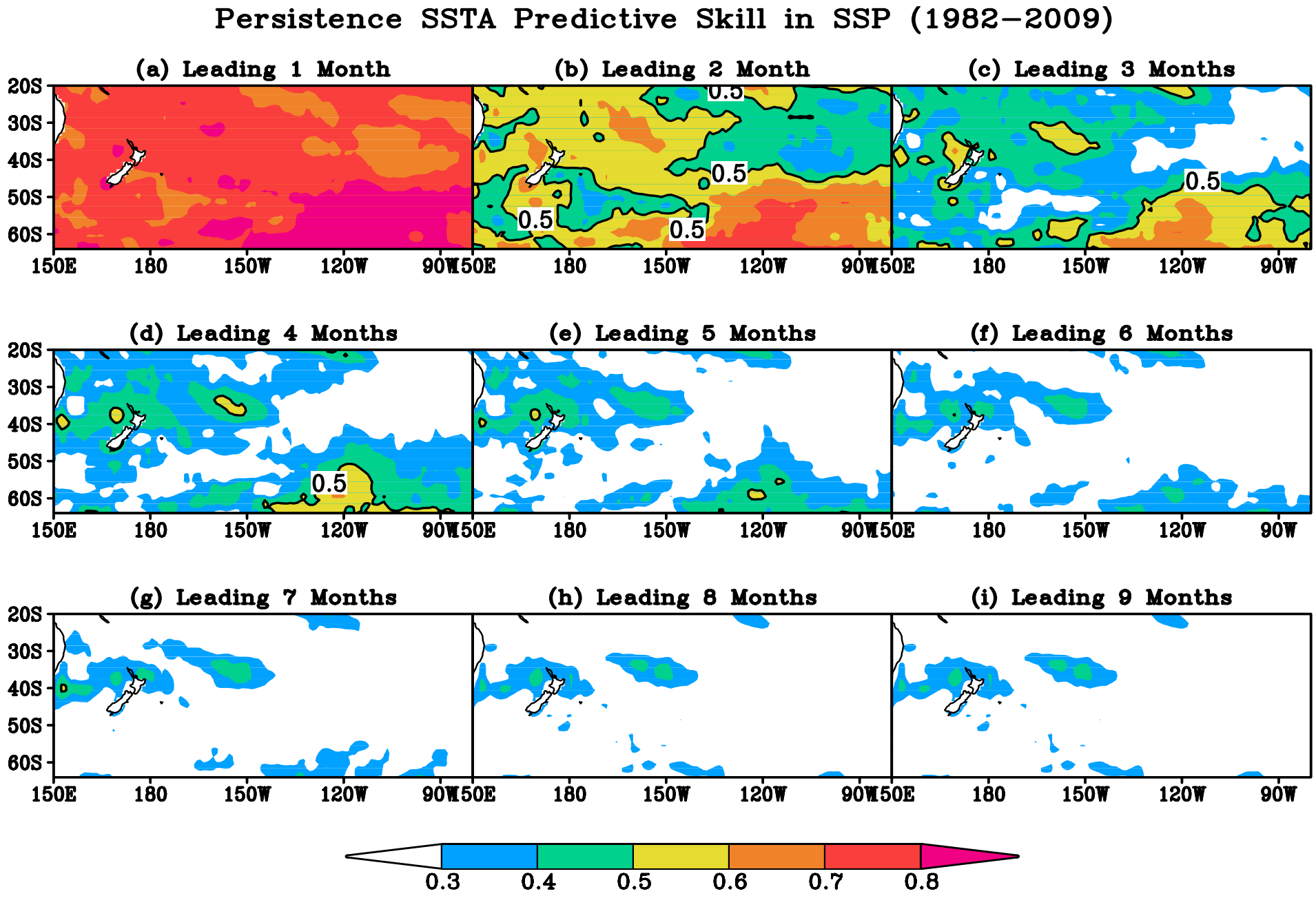
Atmospheric anomalies in South Pacific are characterized by Pacific-South American (PSA) Pattern (Mo and Higgins 1998)

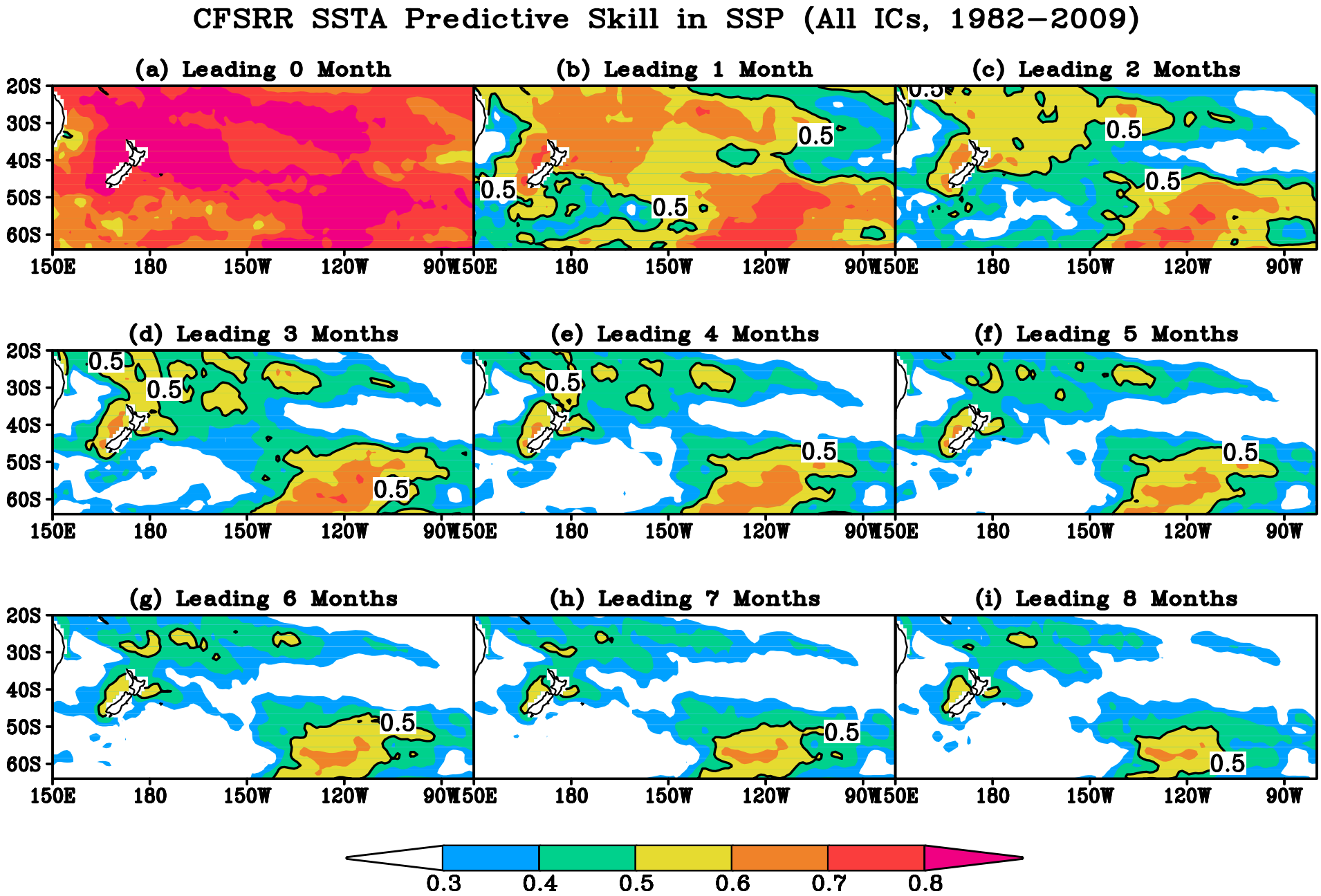
Connection to ENSO Heating Sources

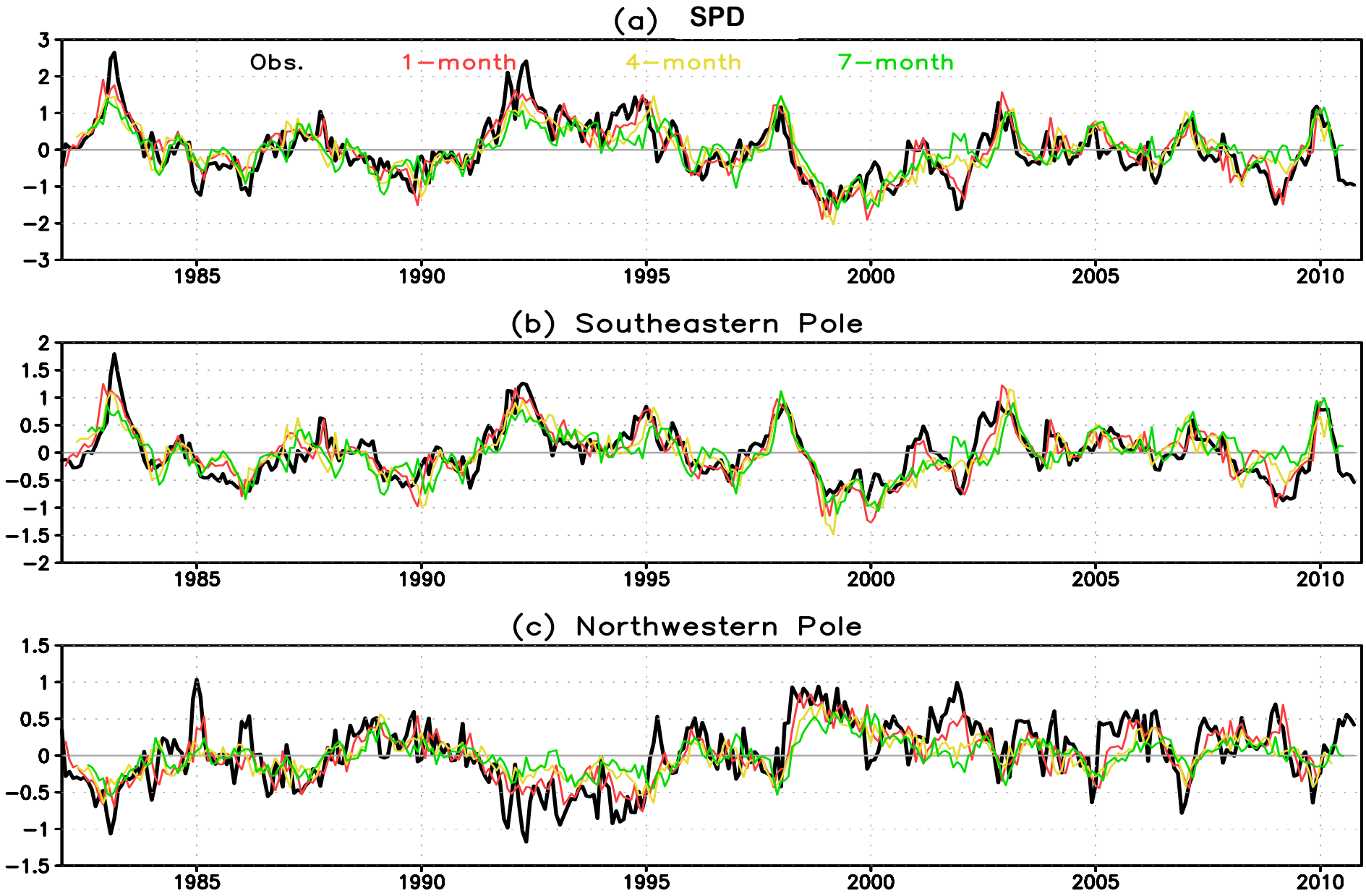


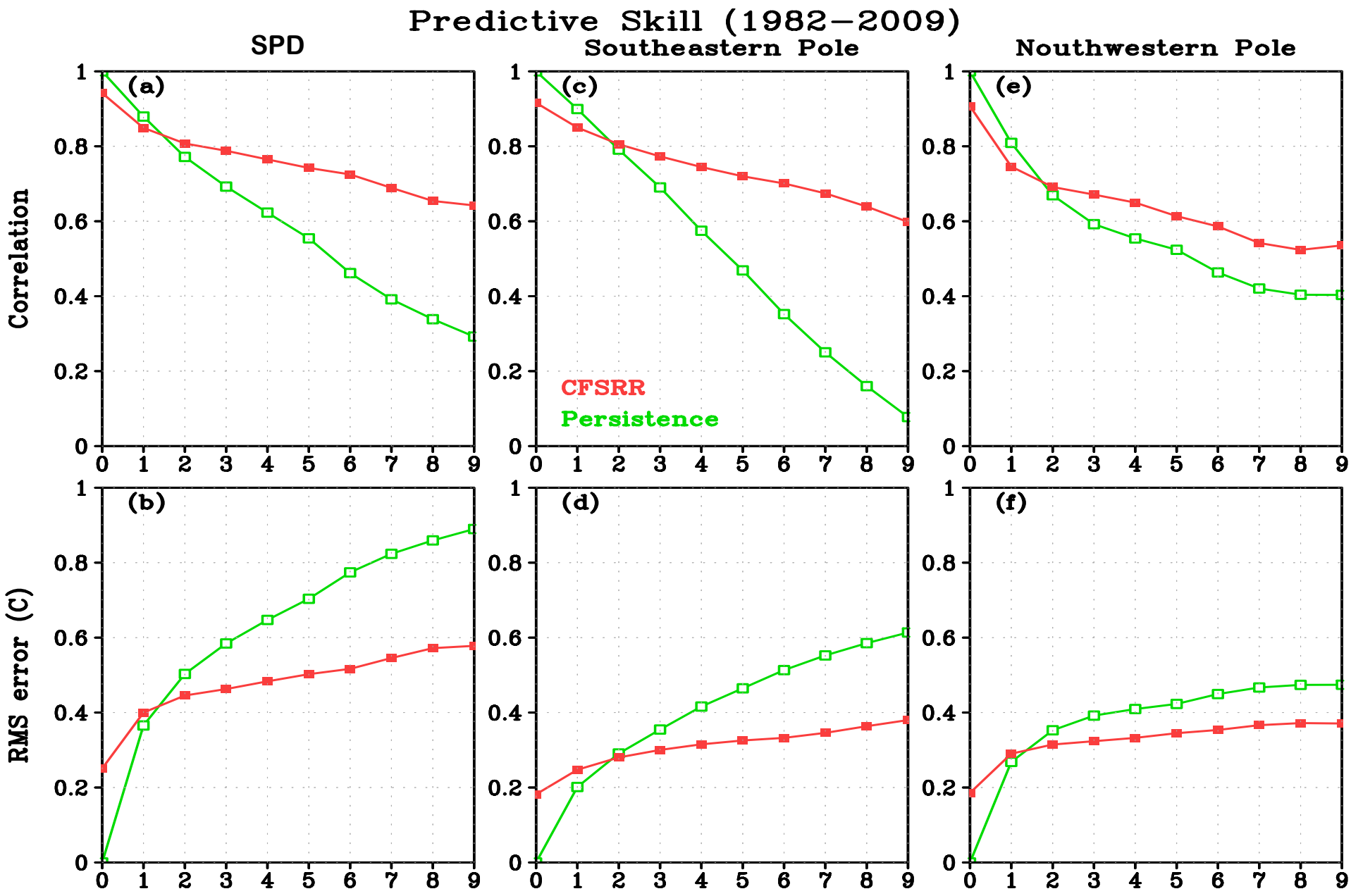
SPD Prediction Skill and Predictability

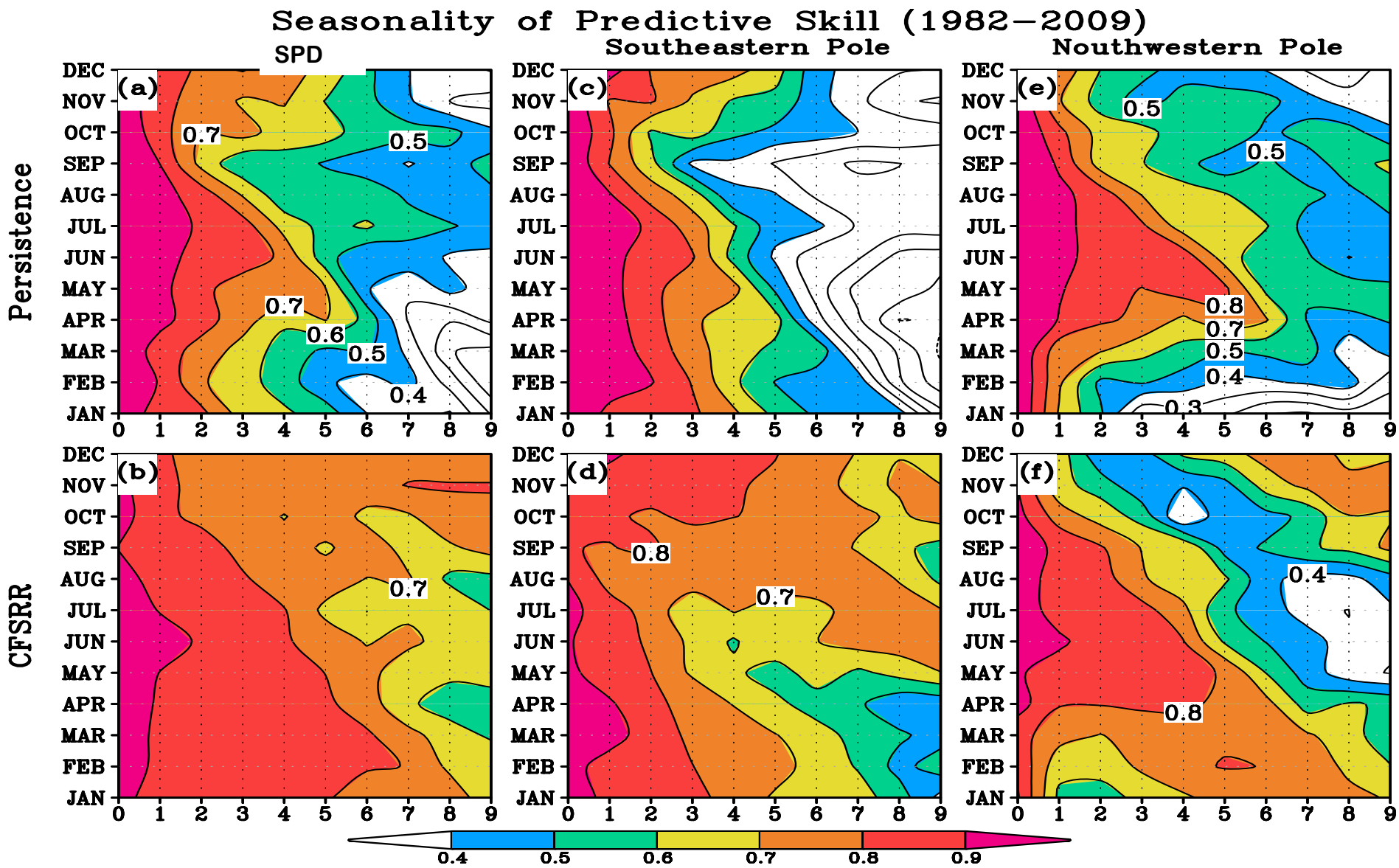



Persistence SSTA Predictive Skill in SSP (1982–2009)
(a) Leading 1 Month
(b) Leading 2 Month
(c) Leading 3 Months
(d) Leading 4 Months
(e) Leading 5 Months
(f) Leading 6 Months
(g) Leading 7 Months
(h) Leading 8 Months
(i) Leading 9 Months
20S
30S
40S
50S
60S
150E
180
150W
120W
90W
0.5
0.3
0.4
0.5
0.6
0.7
0.8


CFSRR SSTA Predictive Skill in SSP (All ICs, 1982–2009)
(a) Leading 0 Month
(b) Leading 1 Month
(c) Leading 2 Months
(d) Leading 3 Months
(e) Leading 4 Months
(f) Leading 5 Months
(g) Leading 6 Months
(h) Leading 7 Months
(i) Leading 8 Months
20S
30S
40S
50S
60S
150E
180
150W
120W
90W
0.5
0.3
0.4
0.5
0.6
0.7
0.8


(a) SPD
Obs.
1−month
4−month
7−month
3
2
1
0
−1
−2
−3
1985
1990
1995
2000
2005
2010
(b) Southeastern Pole
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
1985
1990
1995
2000
2005
2010
(c) Northwestern Pole
1.5
1
0.5
0
−0.5
−1
−1.5
1985
1990
1995
2000
2005
2010


Predictive Skill (1982–2009)
SPD
Southeastern Pole
Nouthwestern Pole
Correlation
RMS error (C)
(a)
(b)
(c)
(d)
(e)
(f)
CFSRR
Persistence
0
0.2
0.4
0.6
0.8
1
0 1 2 3 4 5 6 7 8 9


Seasonality of Predictive Skill (1982–2009)
SPD
Southeastern Pole
Nouthwestern Pole
Persistence
CFSRR
(a)
(b)
(c)
(d)
(e)
(f)
DEC
NOV
OCT
SEP
AUG
JUL
JUN
MAY
APR
MAR
FEB
JAN
0 1 2 3 4 5 6 7 8 9
0.7
0.5
0.7
0.6
0.5
0.4
0.5
0.5
0.8
0.7
0.5
0.4
0.3
0.7
0.8
0.7
0.4
0.8
0.4 0.5 0.6 0.7 0.8 0.9

Summary

- SPD is the leading SSTA pattern in South Pacific during summer.
- CFSv2 simulates SPD realistically, including its lifecycle, seasonality and ENSO connection.
- SPD events are initiated by wind-induced surface latent heat flux anomalies.
- Persistent mixed layer depth anomalies enhance SPD.
- ENSO-forced PSA wave train generates wind perturbations over South Pacific for SPD.
- CFSv2 shows high predictive skill of SPD mode, due to its good prediction of ENSO and its PSA tele-connection.
- Seasonal dependence: An austral “fall barrier” of prediction skill appears near New Zealand.
- Extratropical SPD sources need further investigation.