The Seasonal Footprinting Mechanism in CFSv2: Simulation and Impact on ENSO Prediction

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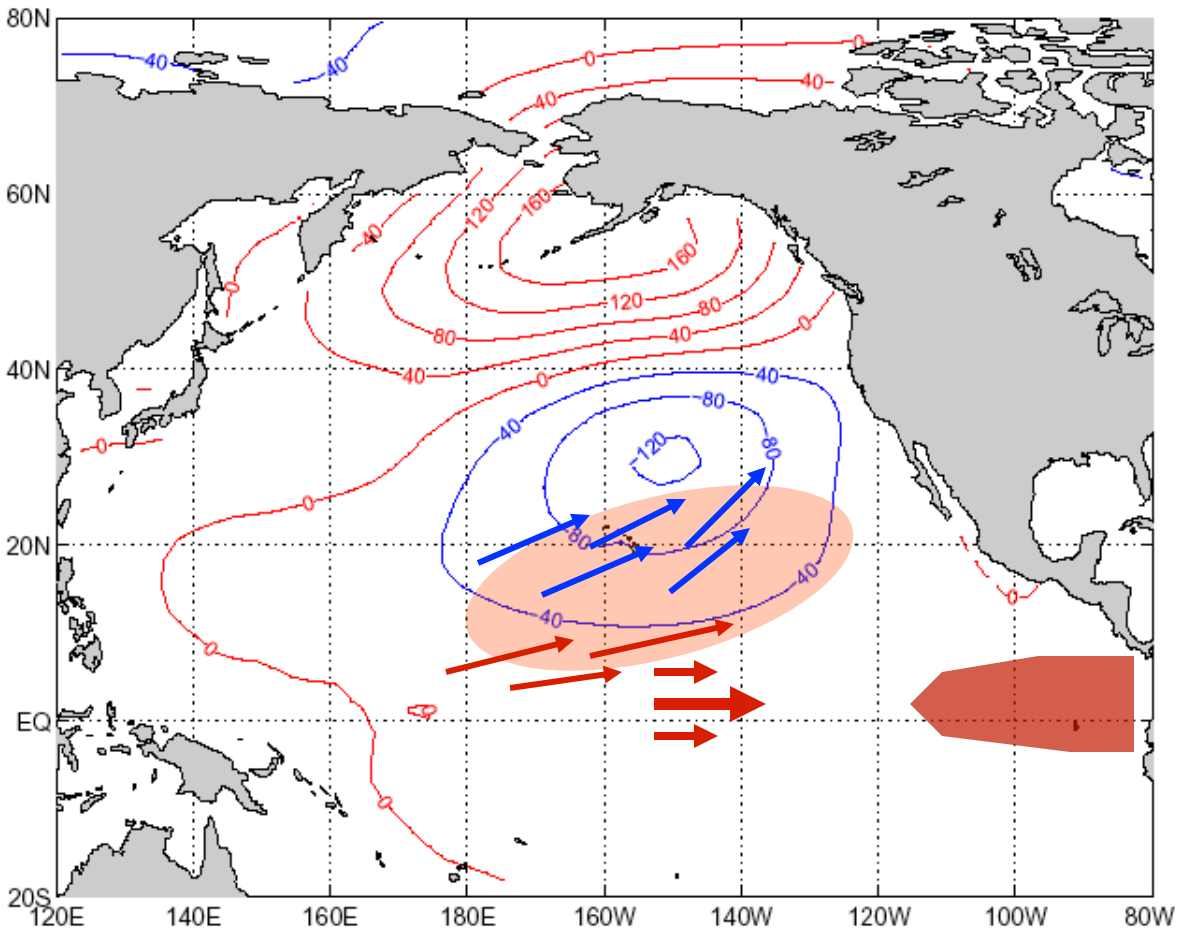
What is the Seasonal Foot Printing Mechanism (SFM)?



- NPO in NDJ (-1)
  ⇓
- Winds & Heat Flux
  ⇓
- SST in FMA (0)
  ⇓
- Tropical Winds
- Feedback (e.g. WES) JJAS(0)
  ⇓
- El Nino in NDJ(0)

Vimont et al. 2001, GRL; 2003a&b, J. Climate

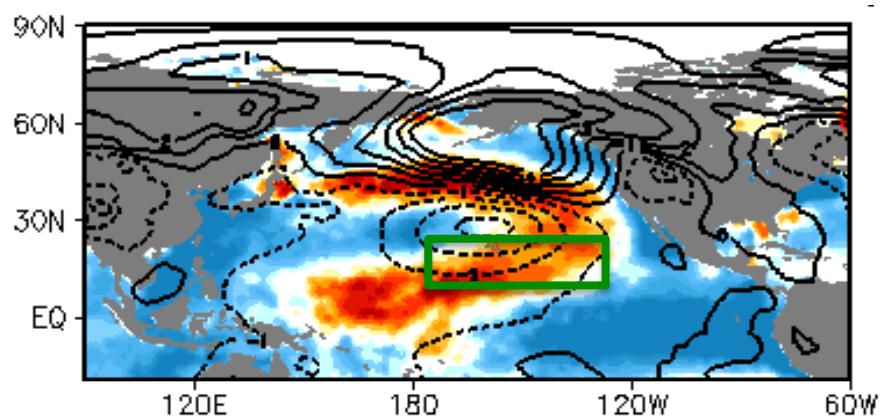
Extratropical Forcing of ENSO by the Seasonal Footprinting Mechanism

- Fluctuations in the north Pacific SLP anomalies in winter leave a SST footprint in the subtropics in spring and summer that impacts ENSO the following winter (Vimont et al. 2001, 2003a,b; Anderson 2003)

- The effectiveness of the SFM to force ENSO events depends on whether the Tropics are pre-conditioned (Vimont et al. 2003; Anderson 2007; Alexander 2010)

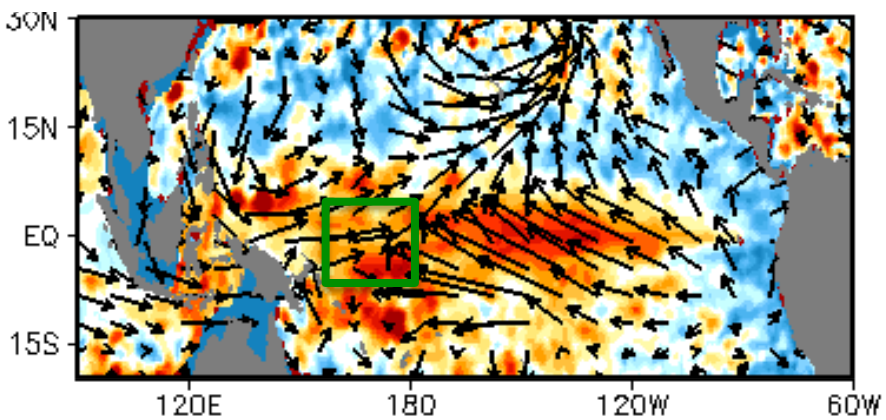
ENSO Pre-cursor Indices

1. Sea Level Pressure Index (SLPI)



- Identifies when the SFM is active
- Nov(-1)-Mar(0)
- [10°N-25°N;175°W-145°W]
- Anderson 2003, 2007

2. Depth of 15°C isotherm Index (Z15I)



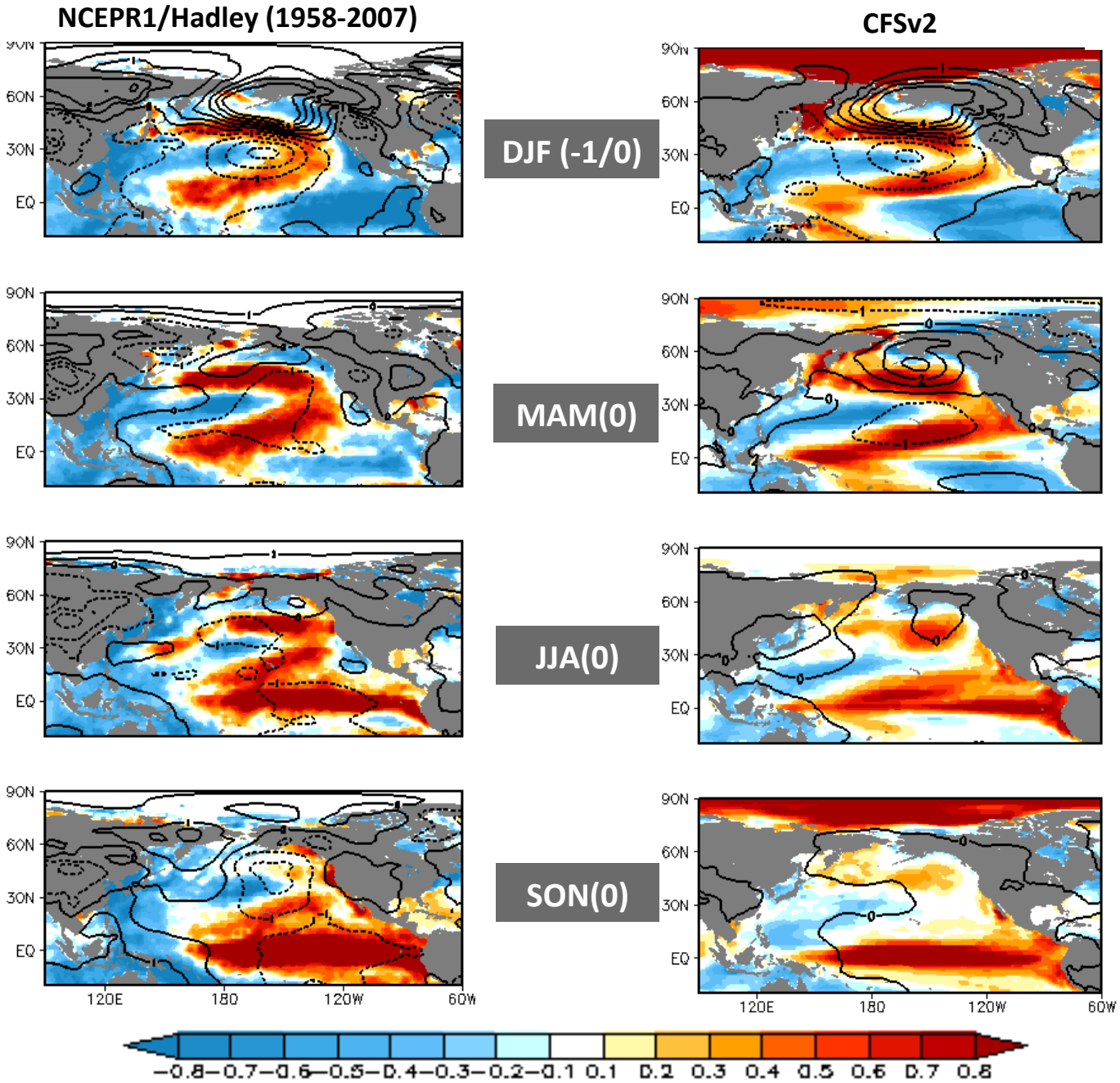
- Identifies whether the Tropics are pre-conditioned
- Dec(-1)-Feb(0)
- [5°S-5°N;160°E-180°]
- Anderson 2007, but for JJASO (12-18 months in advance of ENSO)

Does the NCEP/CFSv2 Simulate the SFM and its relationship with ENSO?

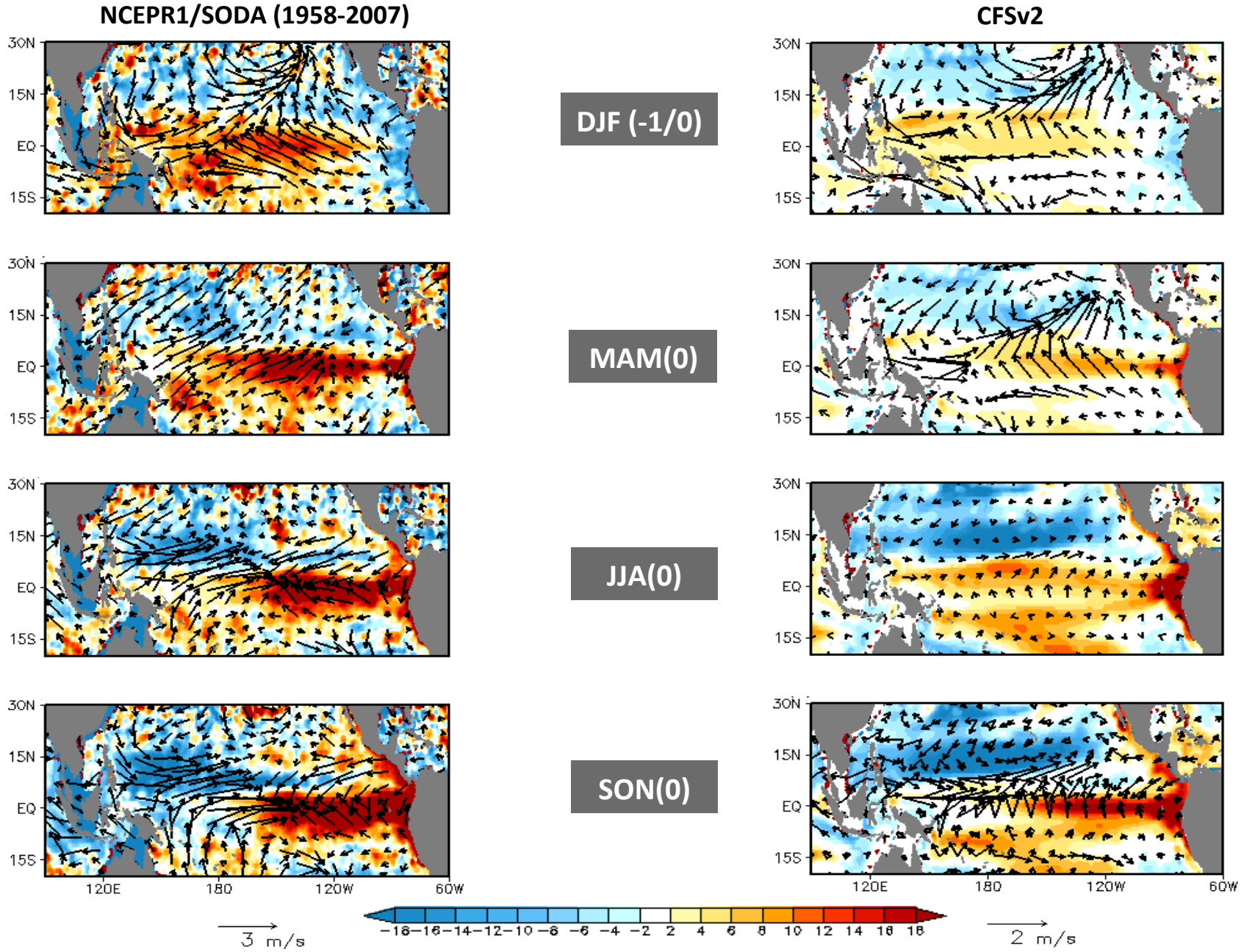
COLA/CFSv2 Decadal Experiments

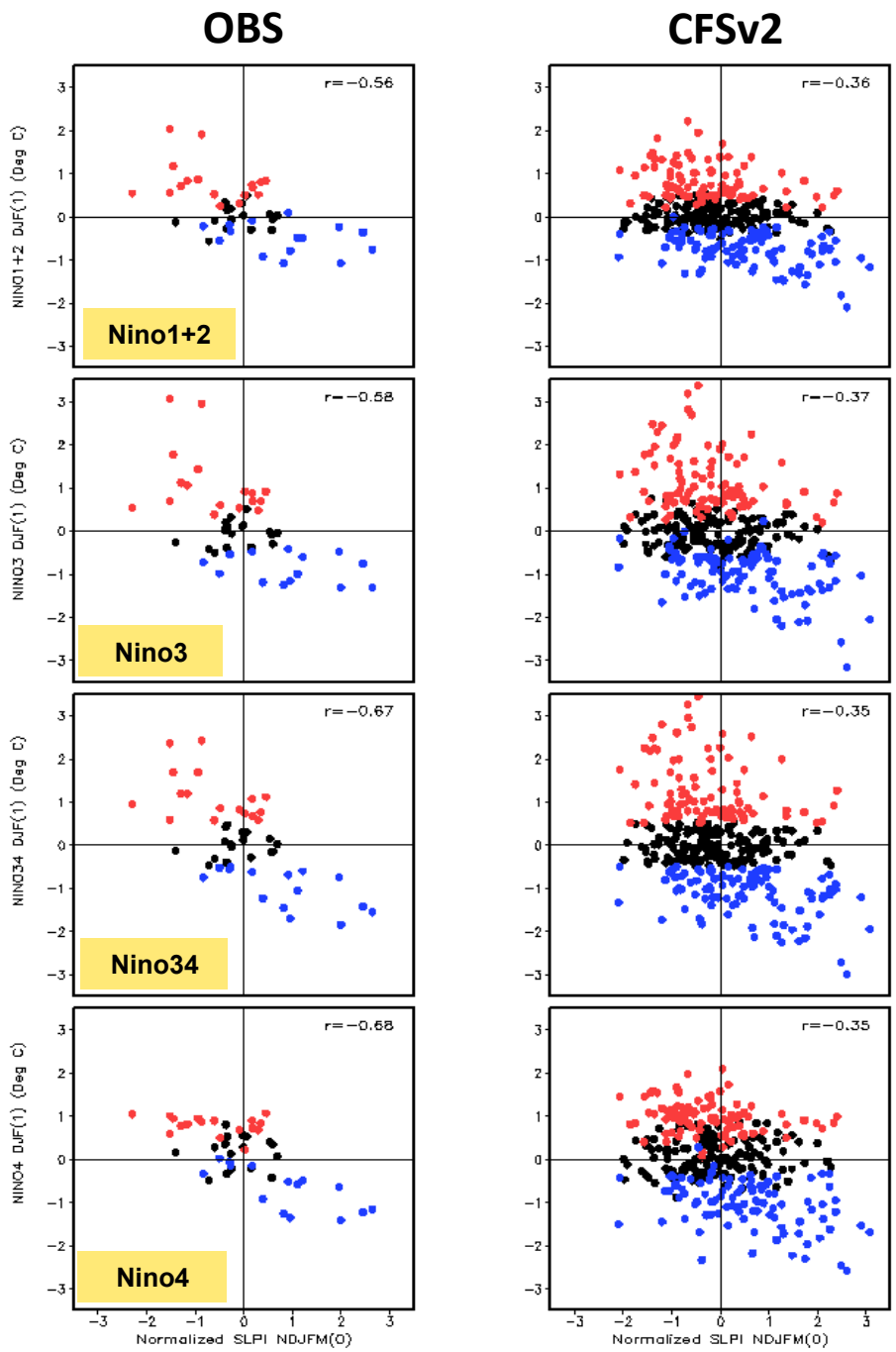
Model	Atm ICs	Ocn ICs	Land ICs	CO2	Duration	Initialization Dates
CFSv2	CFSR	ECMWF/NEMO-ODA	CFSR	Time-varying	30 years	1,2,3,4, Nov 1960,1980,2005

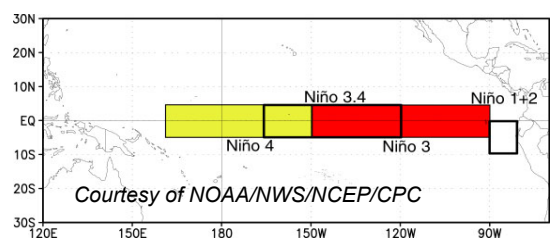
Composites of SLP (hPa) & SST (°C)
SLPI (<1σ) *minus* SLPI (>1σ)



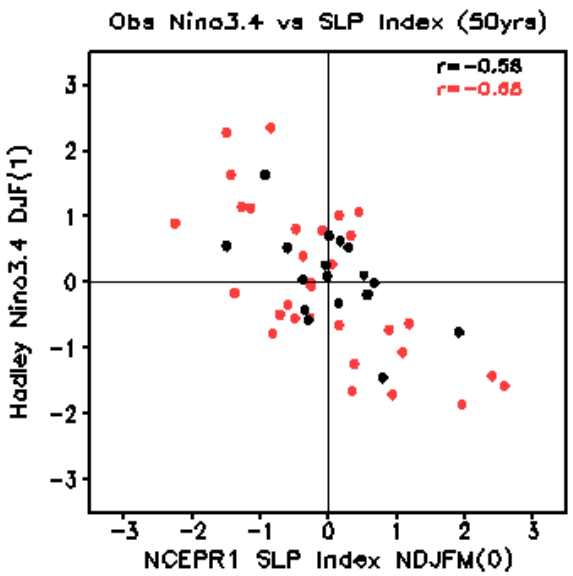
Composites of 10m Winds (m/s) & Z15 (m)
SLPI (<1σ) *minus* SLPI (>1σ)

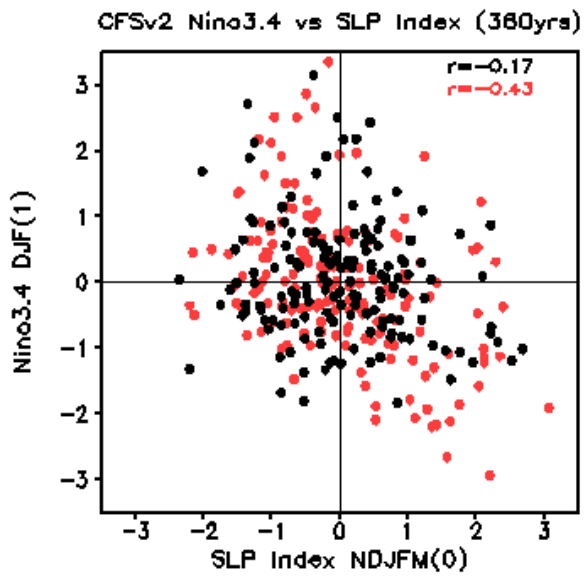



OBS
CFSv2
r=−0.56
r=−0.36
Nino1+2
r=−0.58
r=−0.37
Nino3
r=−0.67
r=−0.35
Nino34
r=−0.68
r=−0.35
Nino4
NINO1+2 DJF(1) (Deg C)
NINO3 DJF(1) (Deg C)
NINO34 DJF(1) (Deg C)
NINO4 DJF(1) (Deg C)
Normalized SLPI NDJFM(0)


Niño 3.4
Niño 1+2
Niño 4
Niño 3
Courtesy of NOAA/NWS/NCEP/CPC

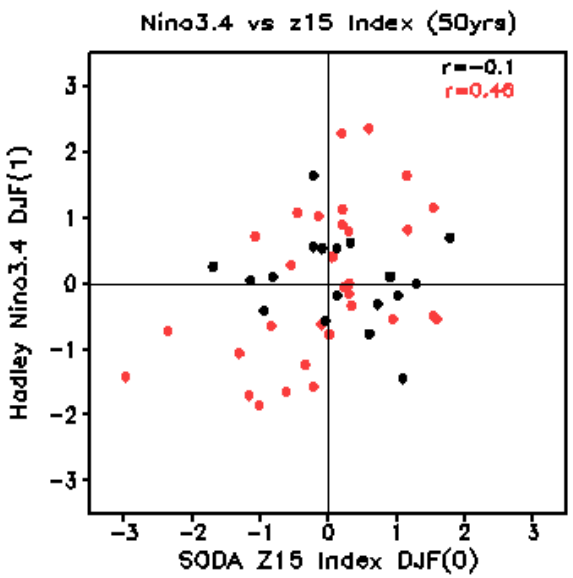
Anderson 2007
(JJASO)
OBS: -0.37/-0.72

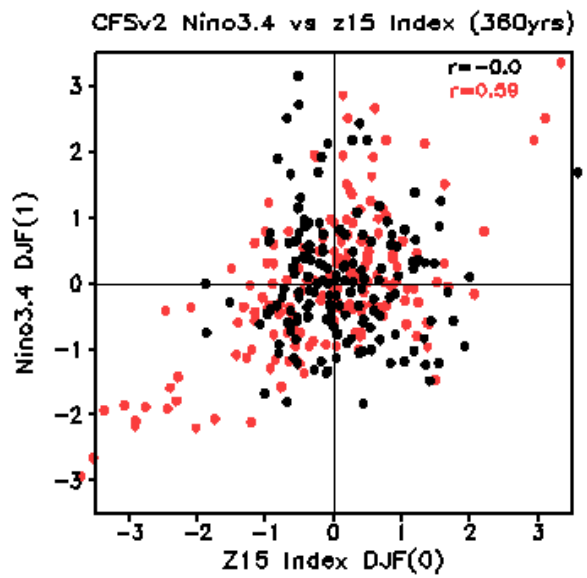




Deser et al. 2012
(JJASO)
CCSM4: -0.22/-0.69

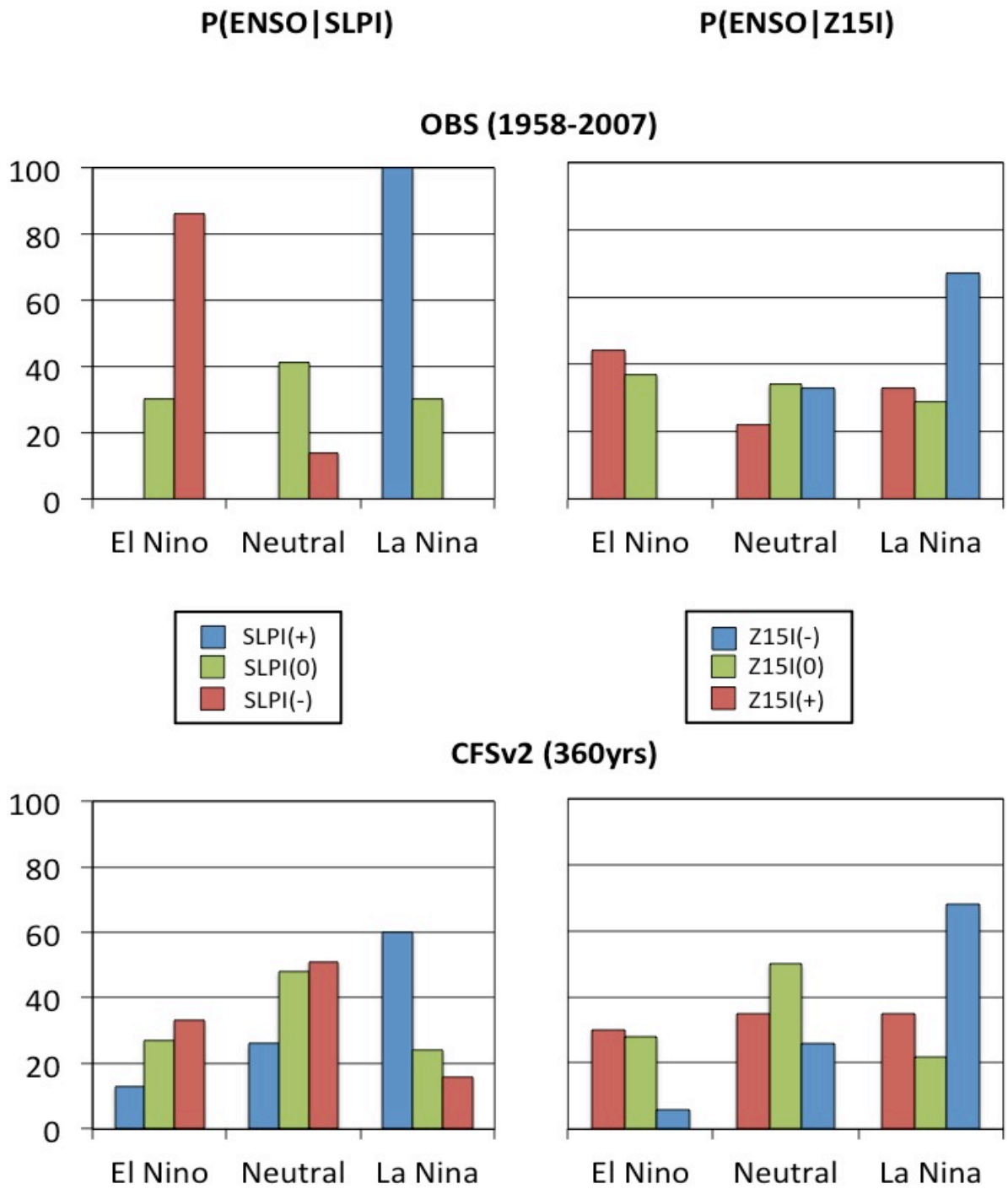
Anderson 2007
(JJASO)
OBS: -0.06/0.69





Deser et al. 2012
(JJASO)
CCSM4: 0.14/0.69

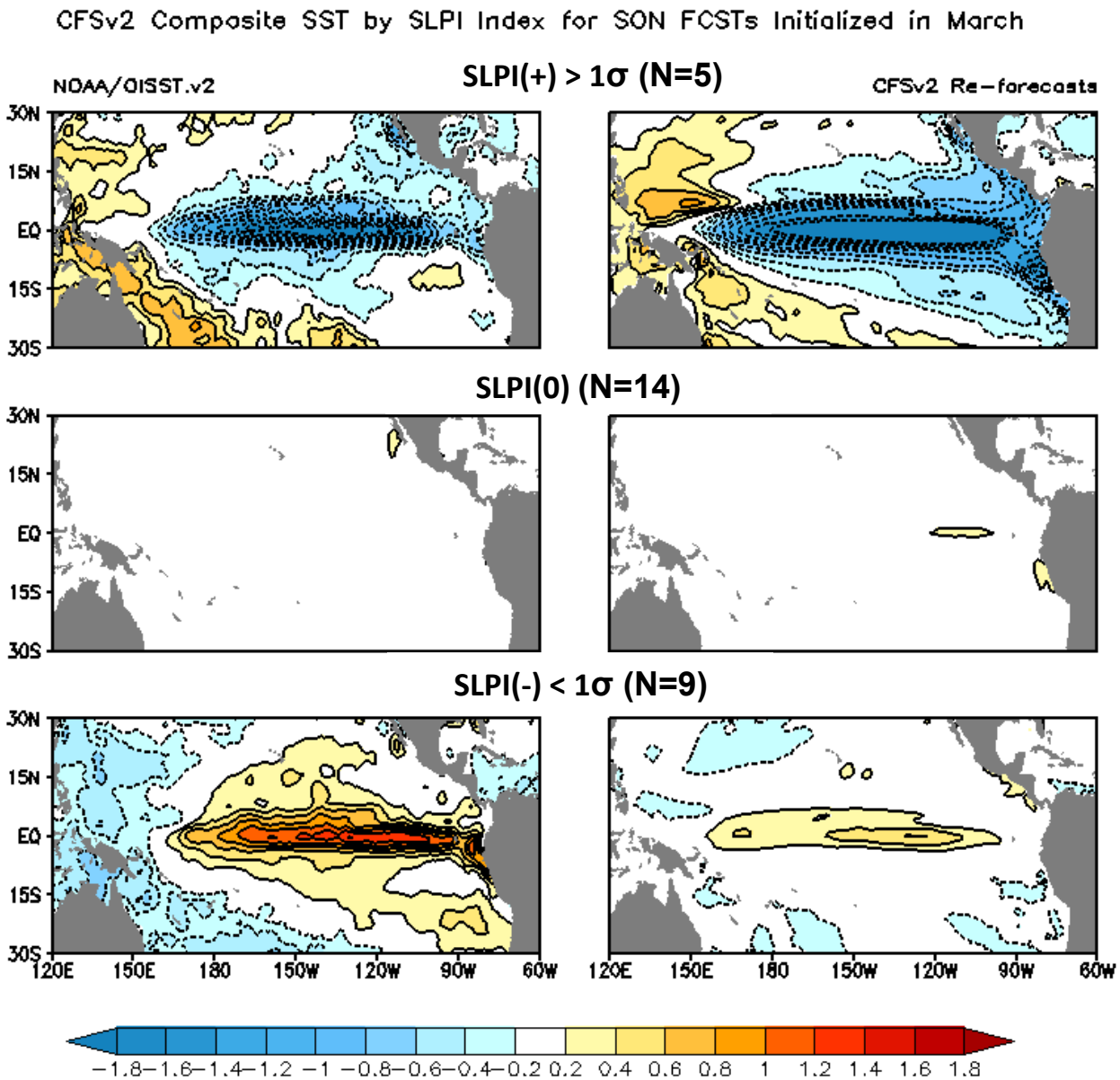
● SLPI & Z15I have same sign ● SLPI & Z15I have opposite sign


P(ENSO|SLPI)
P(ENSO|Z15I)
OBS (1958-2007)
100
80
60
40
20
0
El Nino
Neutral
La Nina
SLPI(+)
SLPI(0)
SLPI(-)
Z15I(-)
Z15I(0)
Z15I(+)
CFSv2 (360yrs)

Can the NCEP/CFSv2 predict ENSO based on SFM-related pre-cursors?

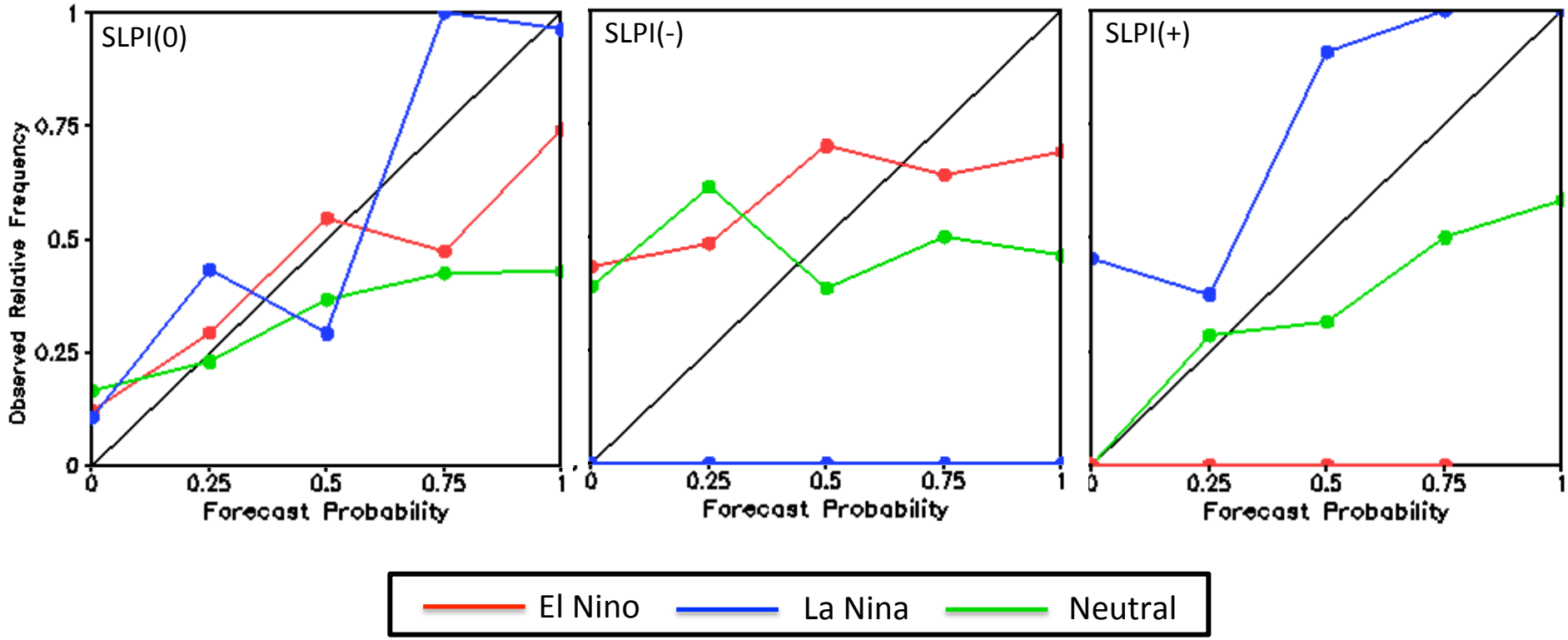
NCEP CFSv2 Retrospective Forecasts

Model	AGCM	OGCM	Duration	Years	Initialization
CFSv2	GFS T126 ICs: CFSR	MOM4 ICs: CFSR	0-9 months	1982-2009	Every 5th day @ 0,6,12,18z 24 ensemble members per month (except Nov = 28)


CFSv2 Composite SST by SLPI Index for SON FCSTs Initialized in March
NOAA/OISST.v2
SLPI(+) > 1σ (N=5)
CFSv2 Re-forecasts
SLPI(0) (N=14)
SLPI(-) < 1σ (N=9)
30N
15N
EQ
15S
30S
120E
150E
180
150W
120W
90W
60W
−1.8 −1.6 −1.4 −1.2 −1 −0.8 −0.6 −0.4 −0.2 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8

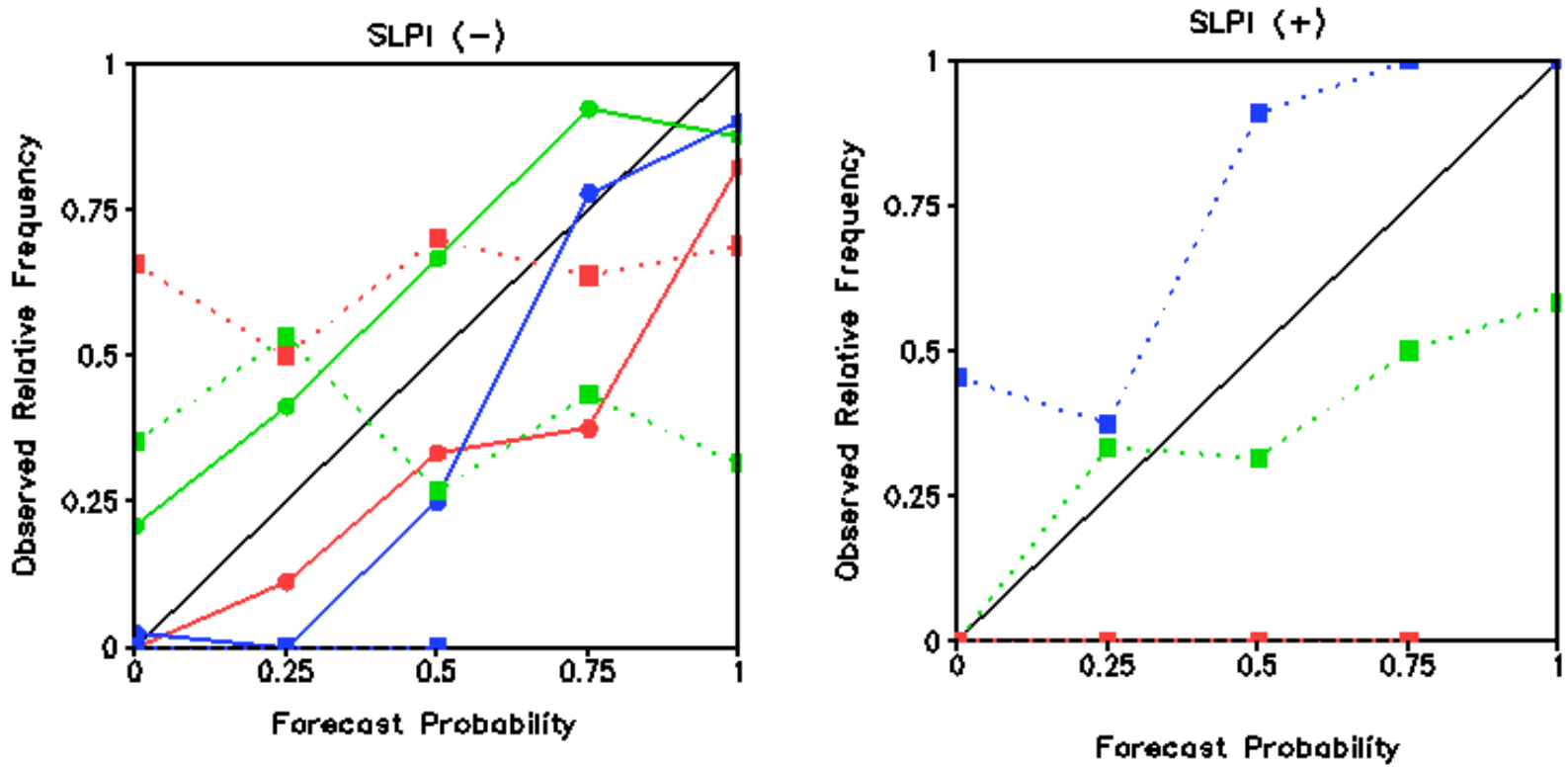
Forecast Reliability

Initialized: Feb, Mar, Apr 1982-2009 Valid: ASO, SON,OND
4-member Ensembles



Forecast Reliability

Initialized: Feb, Mar, Apr 1982-2009 Valid: ASO, SON,OND
4-member ensembles



El Nino | La Nina | Neutral | Opposite Sign | Same Sign

Conclusions

- There is no strong preference for ENSO “flavor” in the model or reanalysis based on the SFM-related pre-cursors.

- The correct sign of the response to the SFM-related forcing is simulated and predicted by CFSv2 in a composite sense. However, its predicted amplitude is weak for El Nino and strong for La Nina.

- The CFSv2 does not produce reliable forecasts of ENSO based on the SFM-related pre-cursors. *Is this because of small ensemble, model deficiency, or fundamental predictability?*