UNIVERSITY
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ATMOSPHERIC SCIENCE

Building the bridge between ENSO theories and operational predictions

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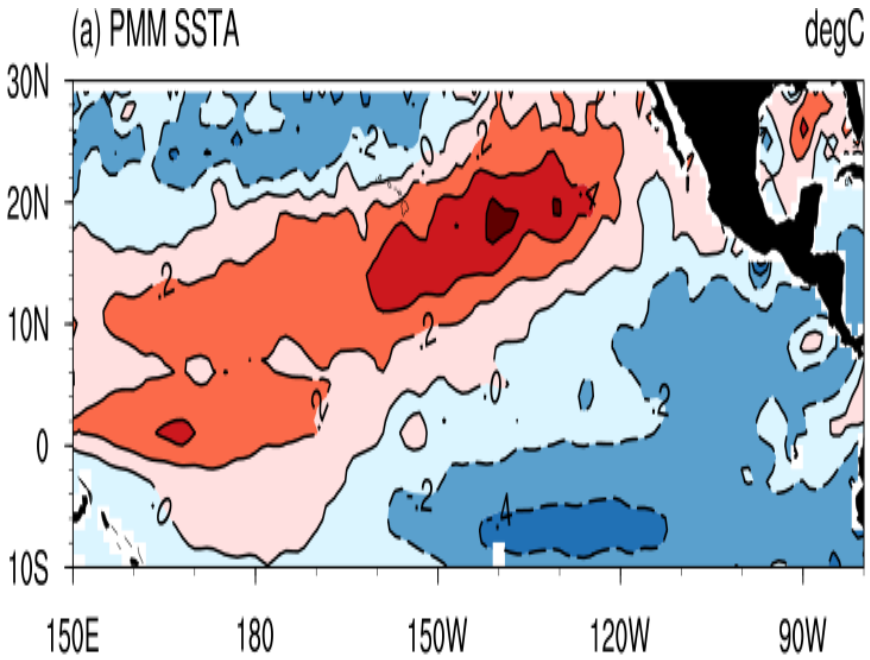
Motivation

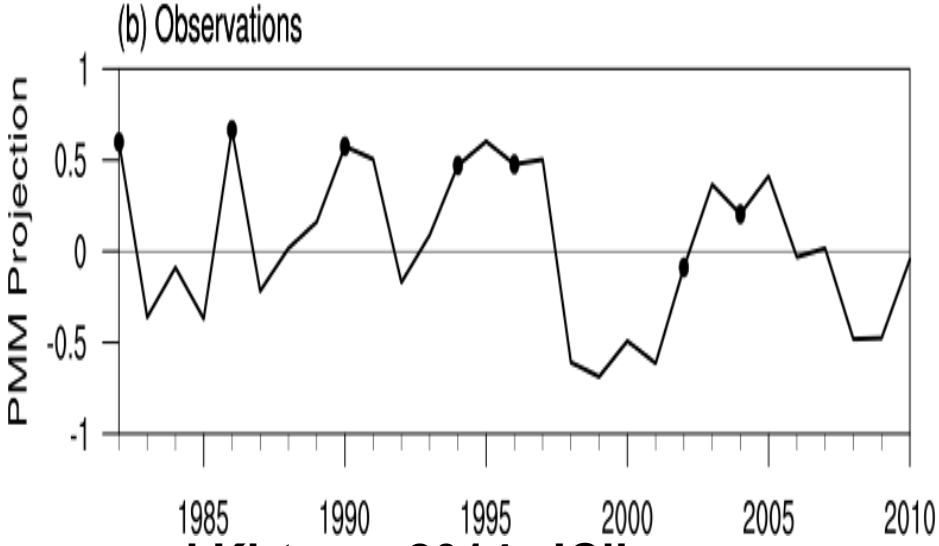
- **NRC Assessment of Intraseasonal to Interannual Climate Prediction and Predictability**
  - **"Predictability is used *qualitatively* … processes that improve Forecast quality"**
  - **Not possible to quantify the true limit of predictability for the climate system**
  - **Quantitative statements about the lower bound possible**
- **Approach in NRC Assessment is Understandable but Unsatisfying**
  - **Difficult to see how predictability research impacts operational forecasts**

Bridging Predictability to Prediction

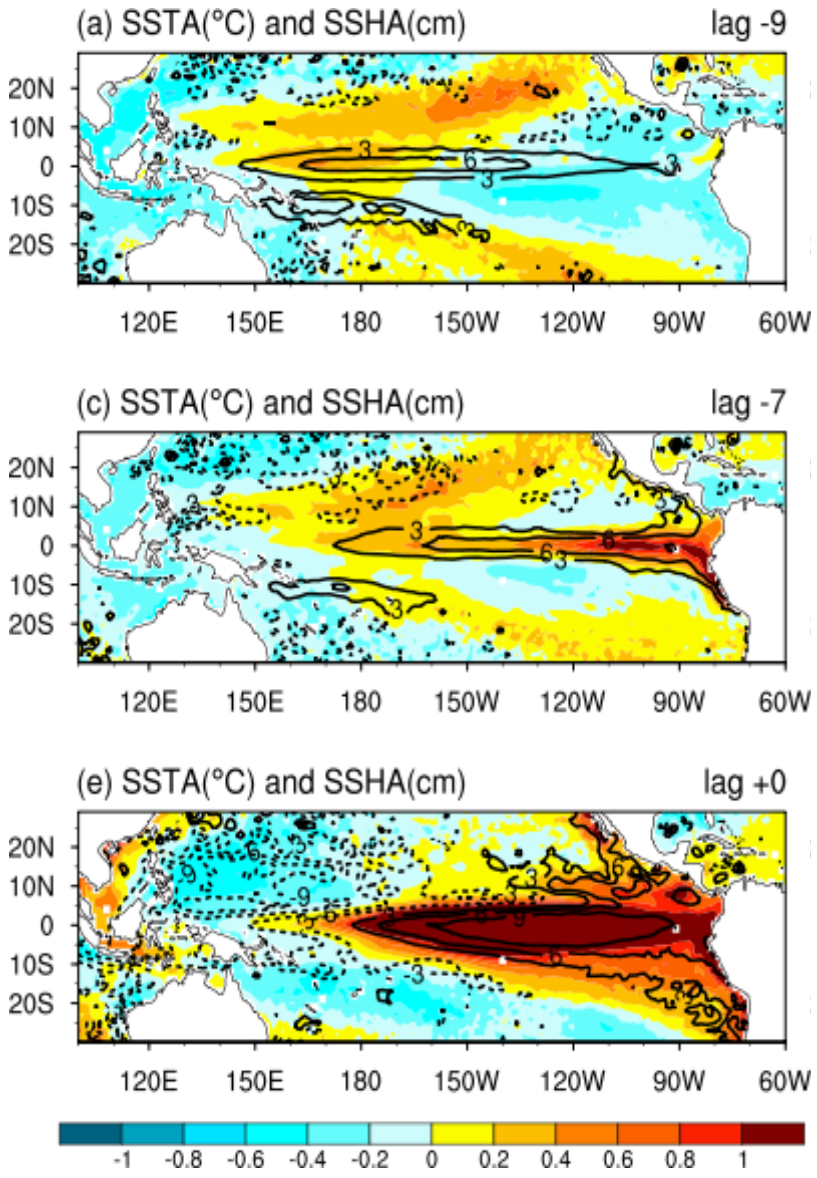
- **Mantra: Marry Predictability and Prediction**
- **Examples:**
  - **Pacific Meridional Mode as ENSO Trigger**
  - **Westerly Wind Bursts and Forecast Quality**
  - **ENSO Diversity**
  - **Coupled Instability and Forecast Spread**
- **Outstanding Problems**

PPM ENSO Trigger



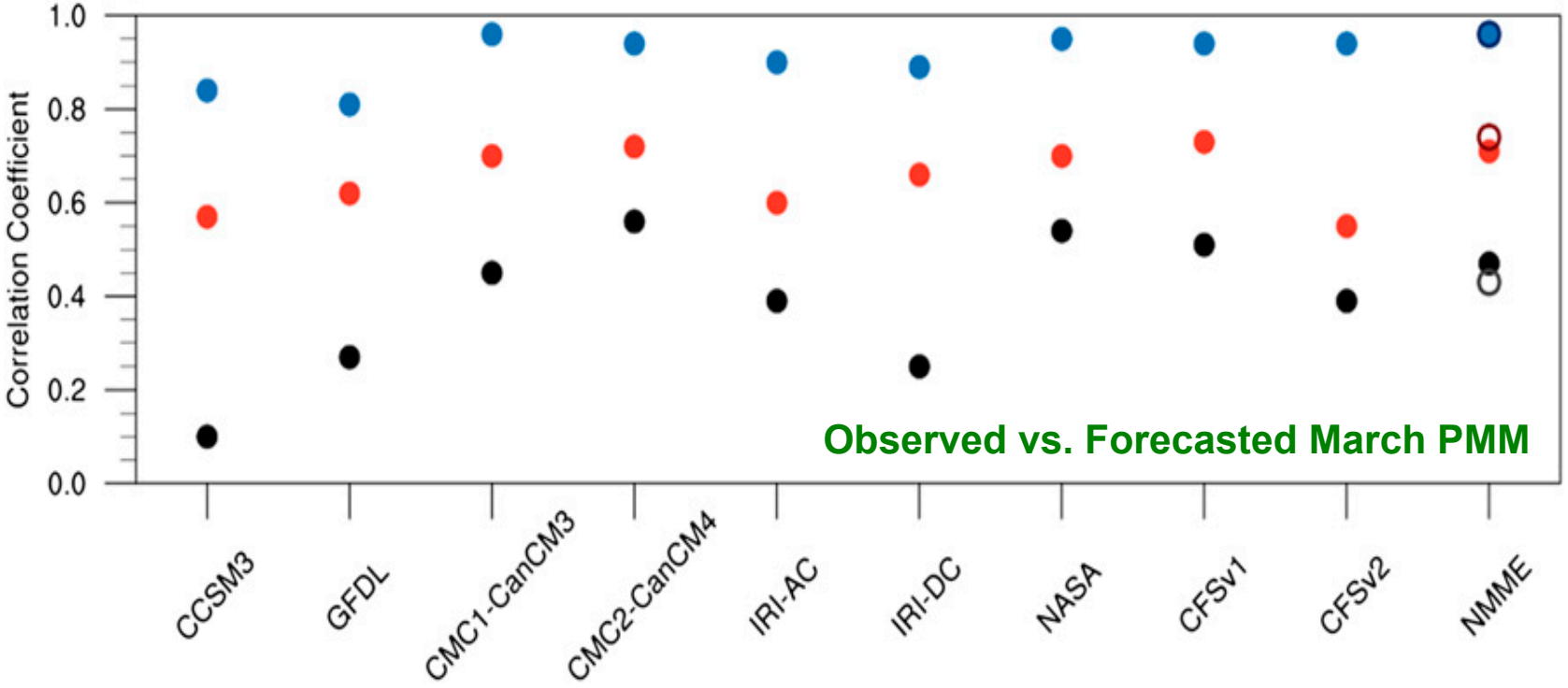


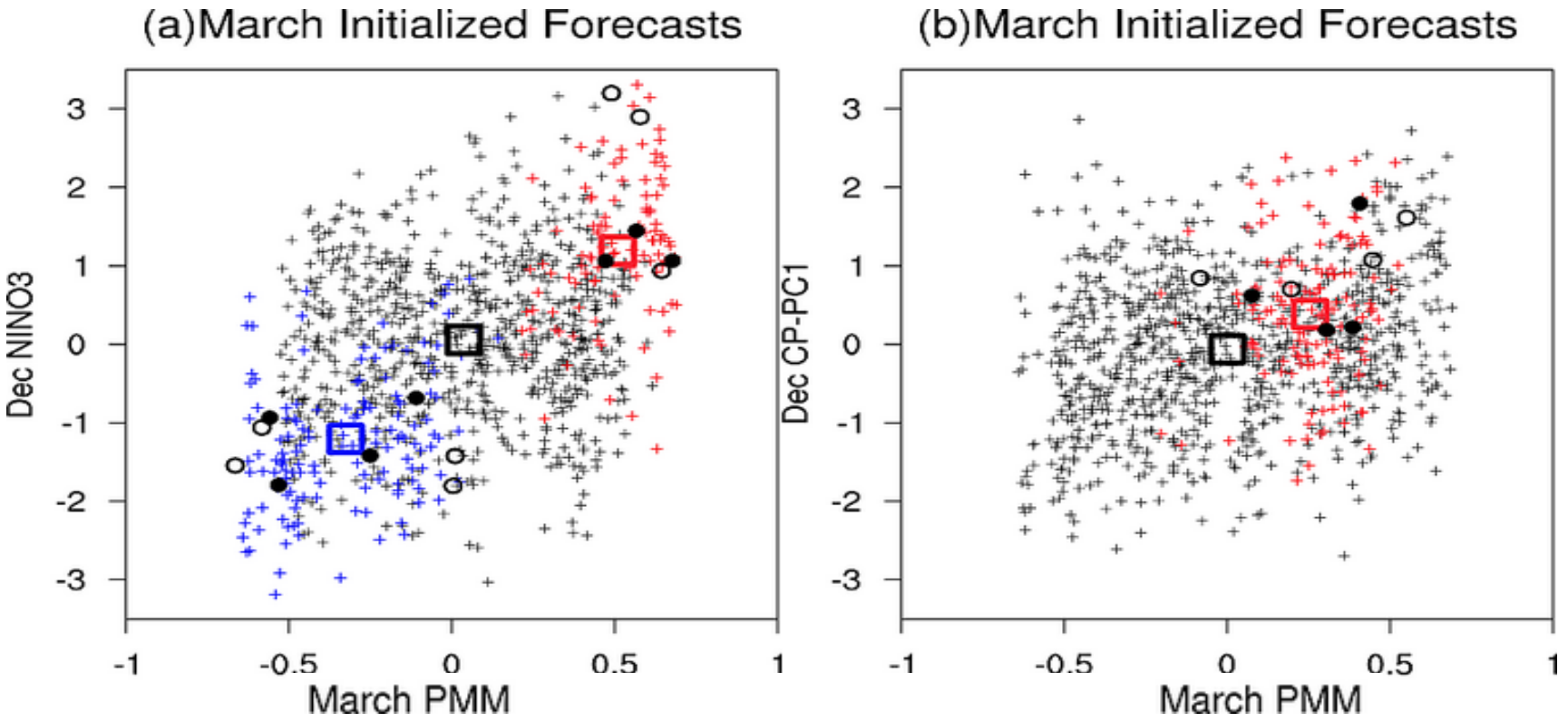
Larson and Kirtman 2014, JClim



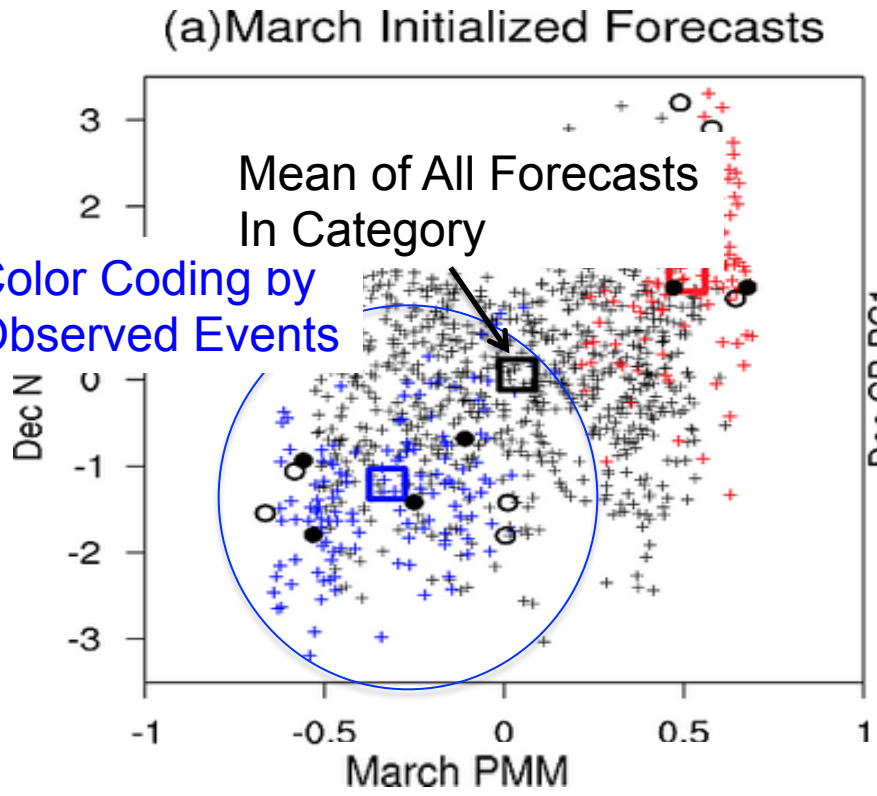
Larson and Kirtman 2013, GRL

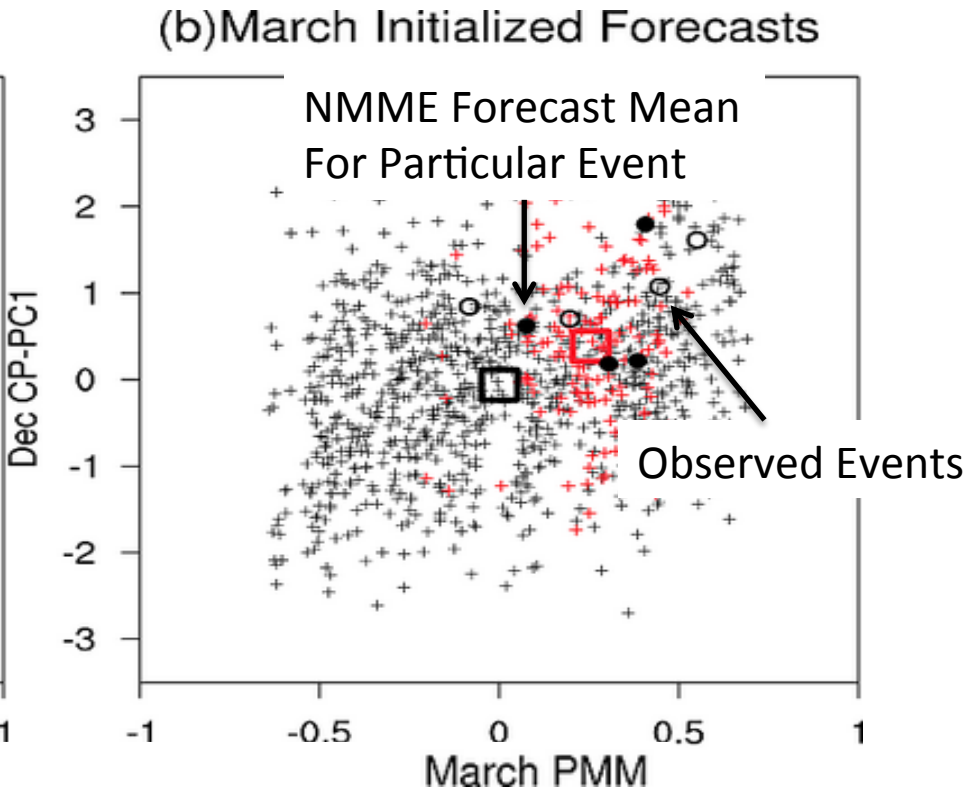
Can PMM be Predicted?





Model Initialization Month	PMM Phase	ENSO Index Threshold	% Correct *Observed ENSO*	% Correct *ENSO Forecast*
March	+ Forecast (Upper tercile forecast)	+ NINO-3 (Upper tercile NINO-3)	53% (56%)	63% (48%)
March	− Forecast (Lower tercile forecast)	− NINO-3 (Lower tercile NINO-3)	79% (34%)	61% (52%)
March	+ Forecast (Upper tercile forecast)	+ CP Index (Upper tercile CP index)	78% (44%)	57% (43%)
---	+ Observed (Upper tercile observed)	+ NINO-3 (Upper tercile NINO-3)	47% (60%)	---
---	− Observed (Lower tercile observed)	− NINO-3 (Lower tercile NINO-3)	71% (25%)	---
---	+ Observed (Upper tercile observed)	+ CP Index (Upper tercile CP index)	73% (40%)	---





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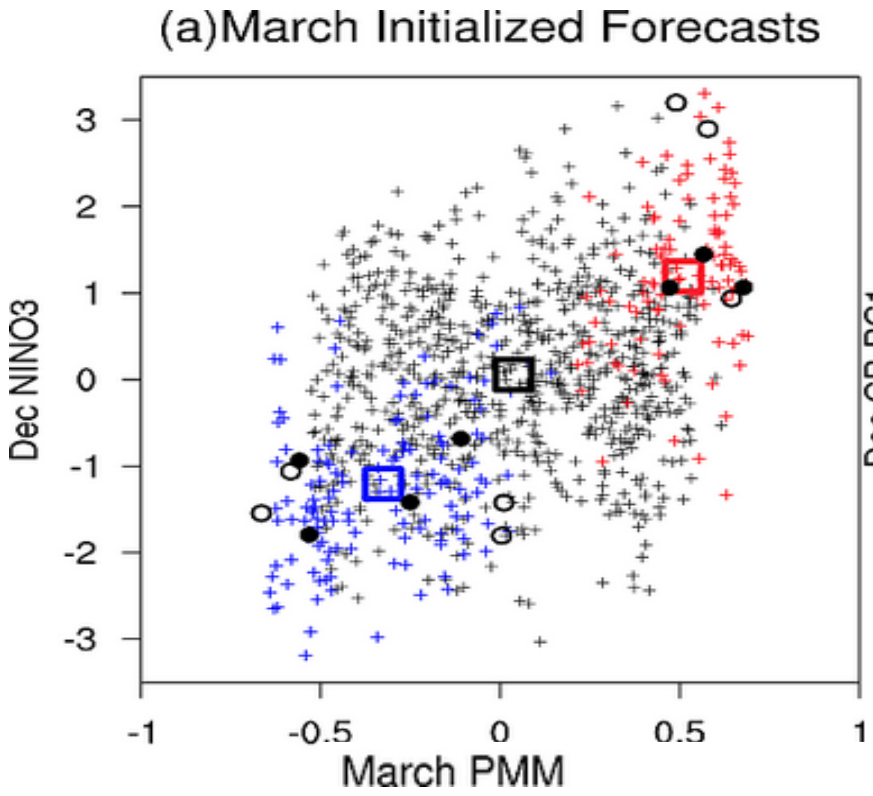

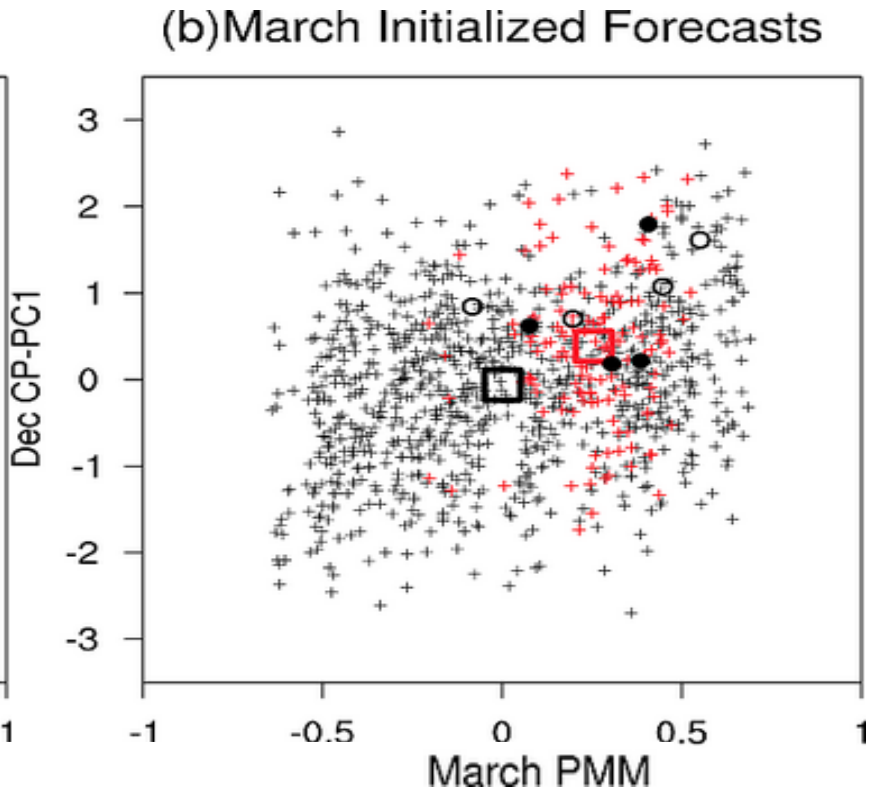

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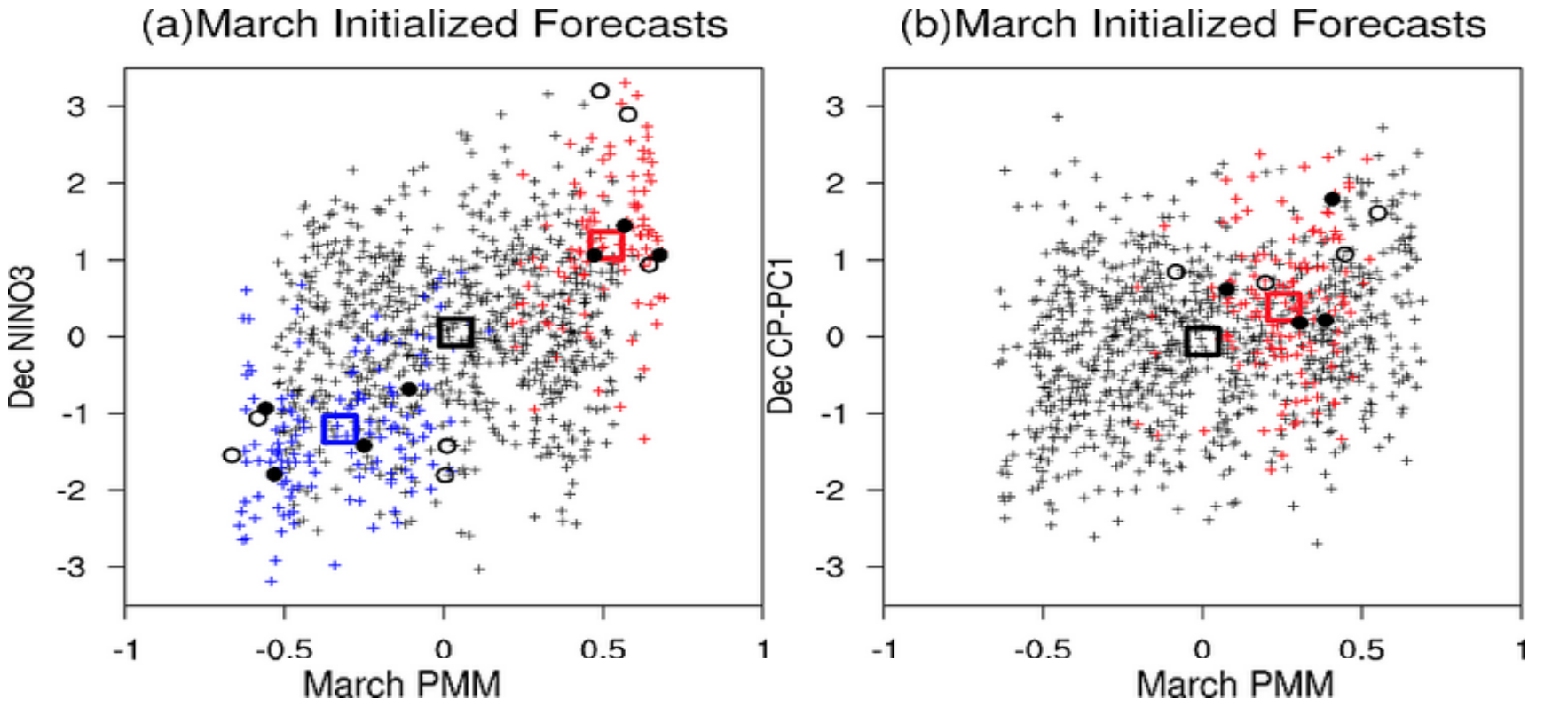

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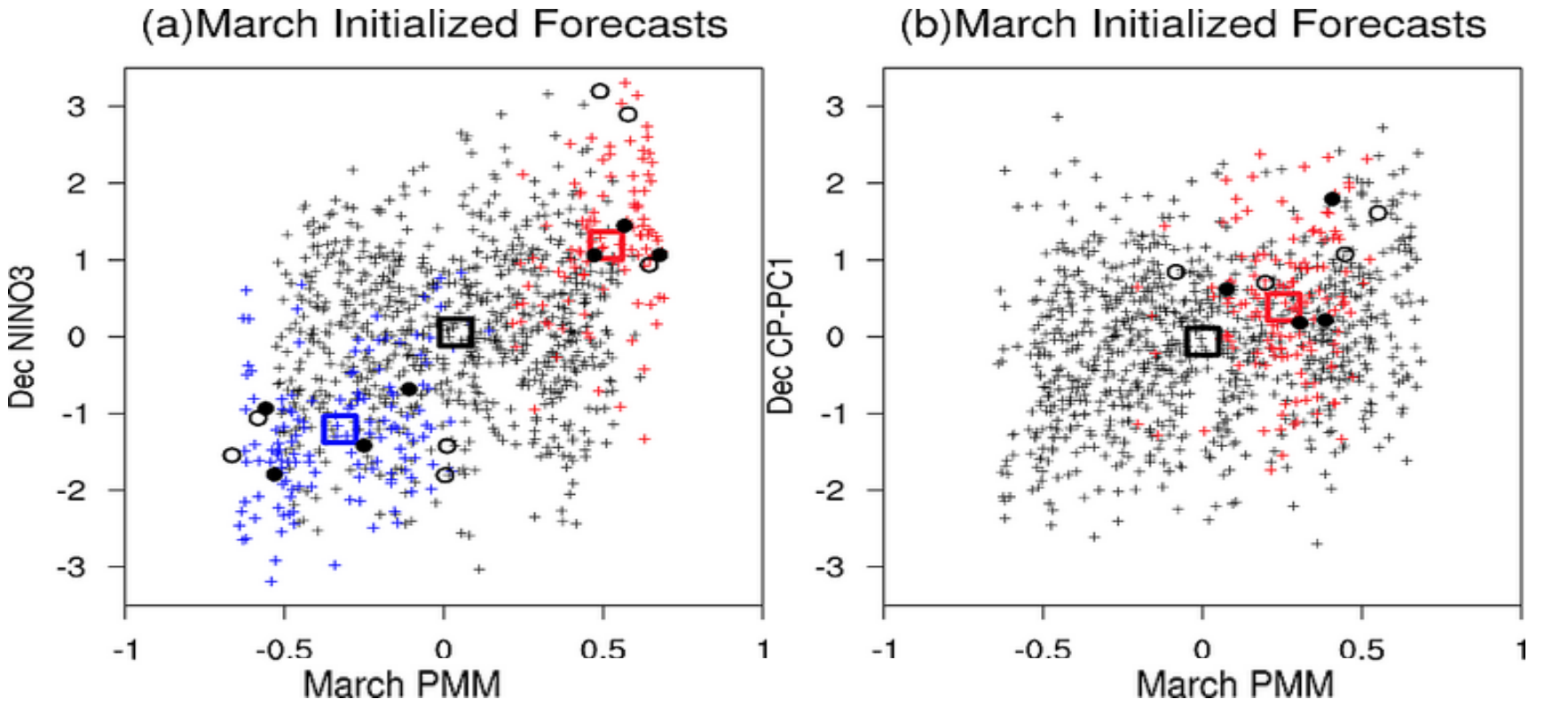

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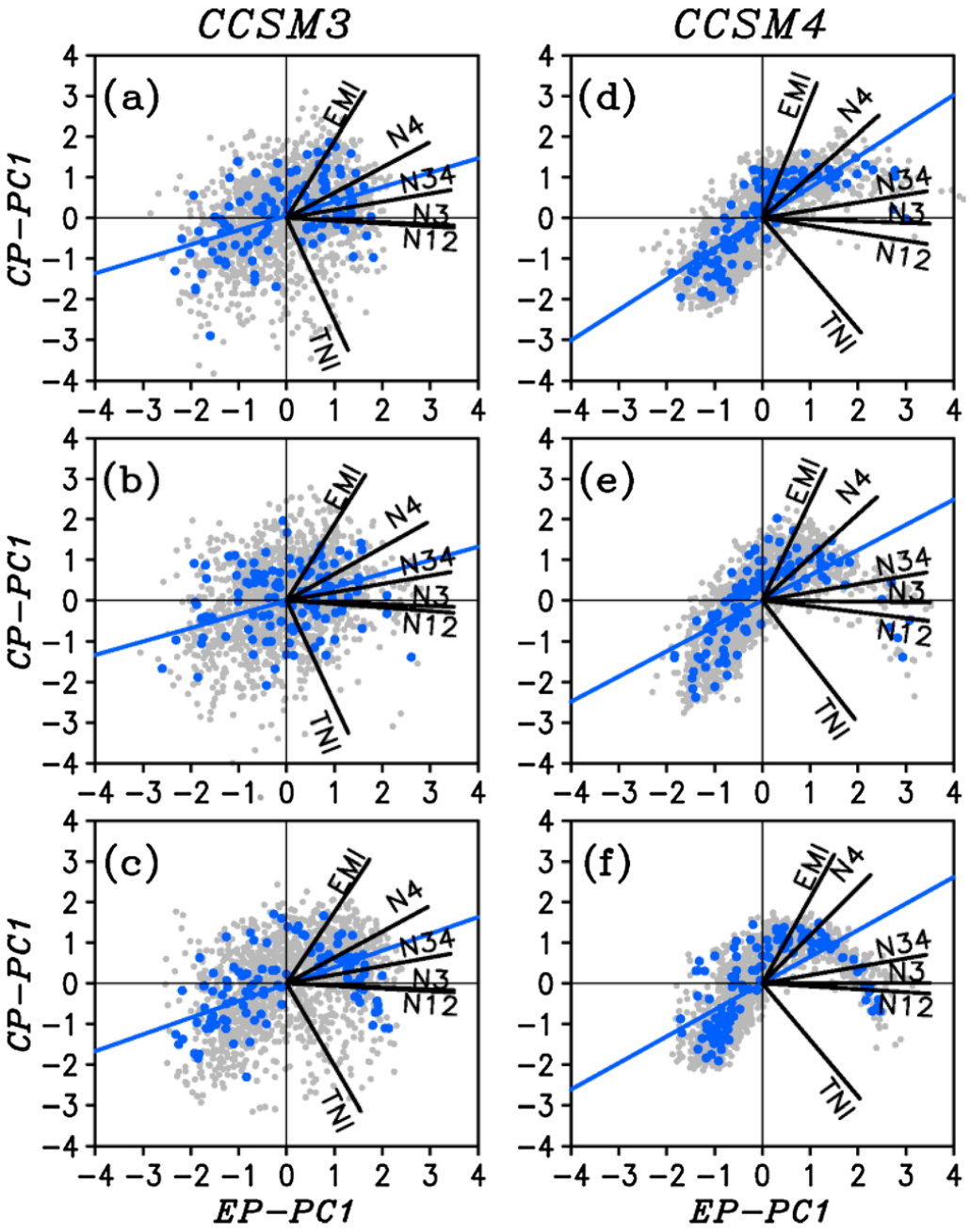
Westerly Wind Burst and ENSO

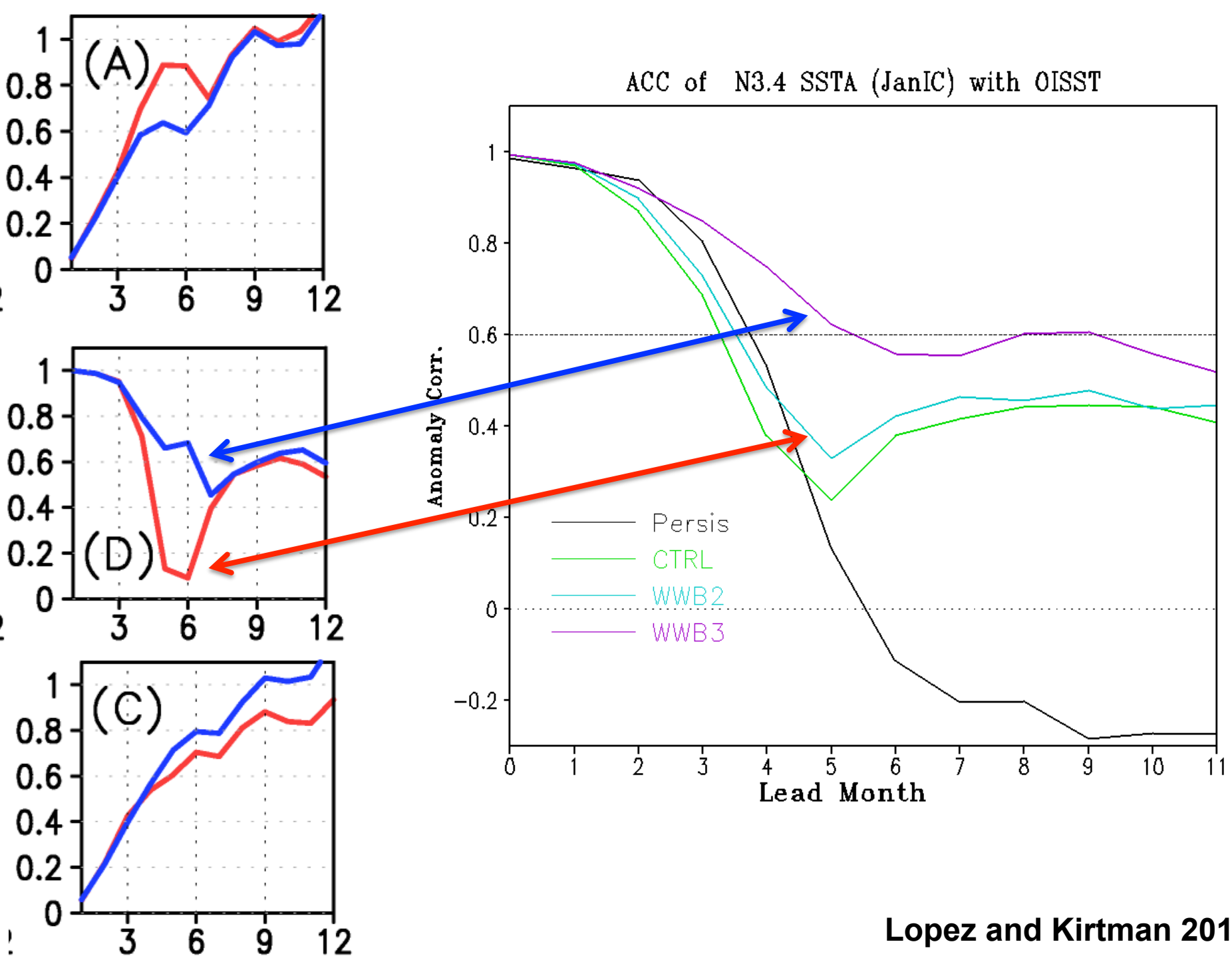
Control

State Independent

State Dependent

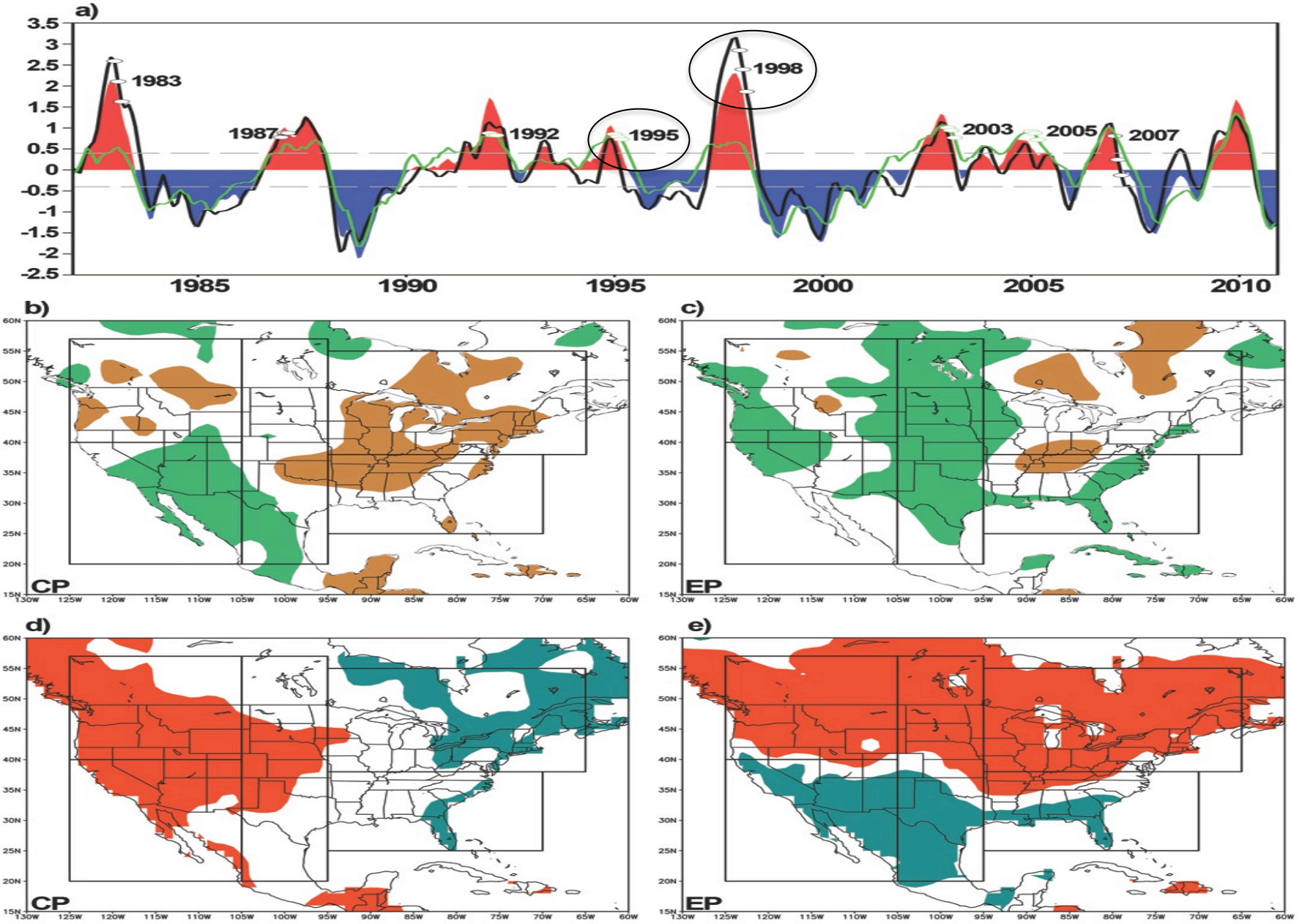


Lopez and Kirtman 2013

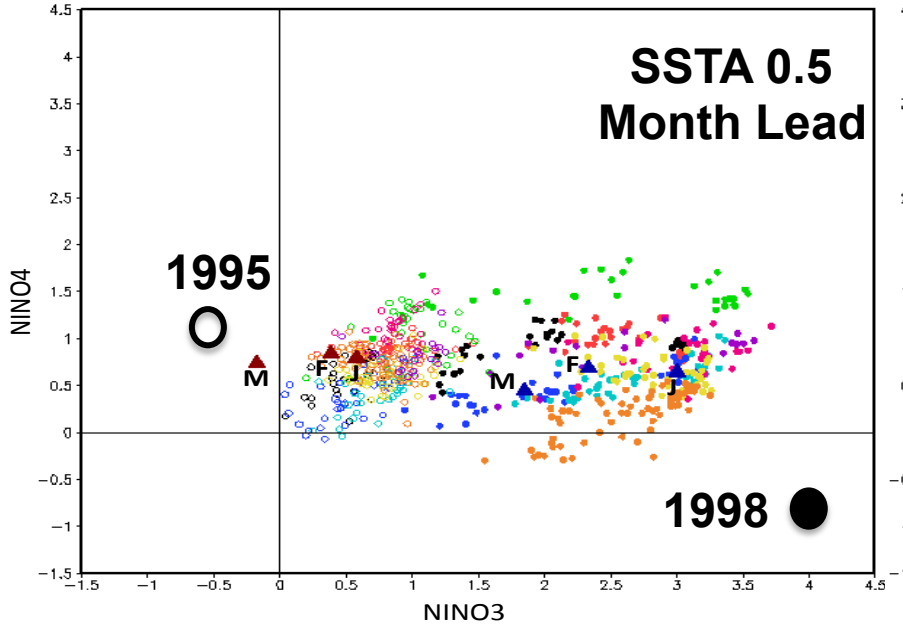


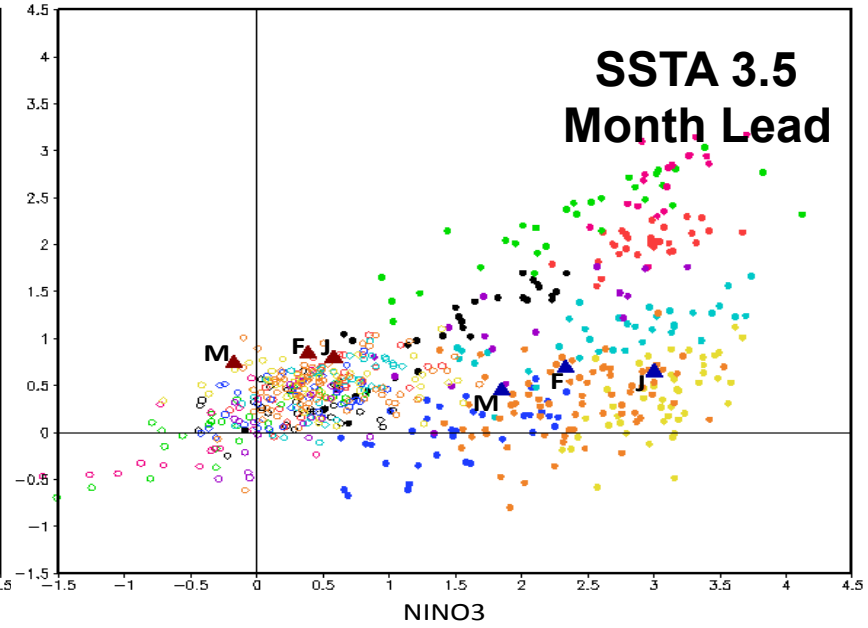
Lopez and Kirtman 2013

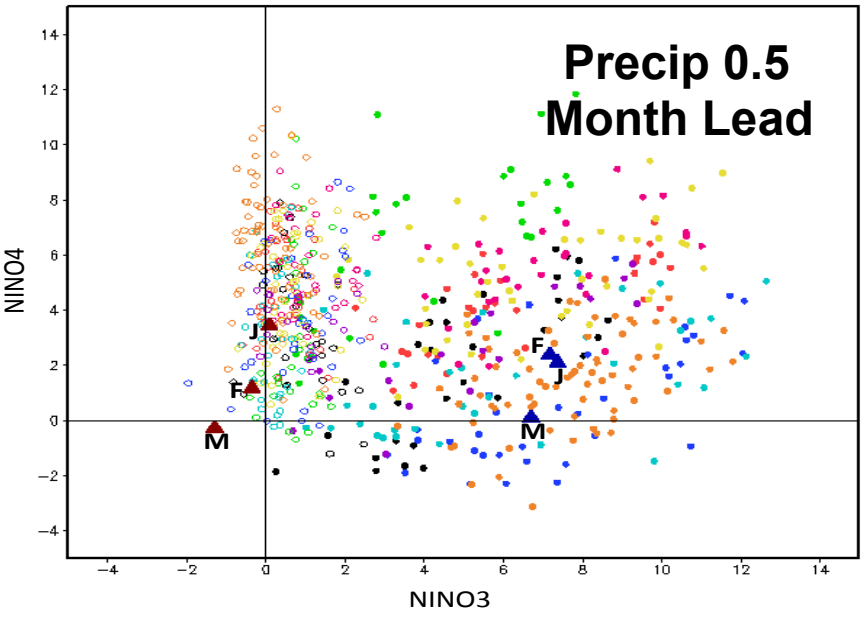
Central Pacific vs. East Pacific Warm Events

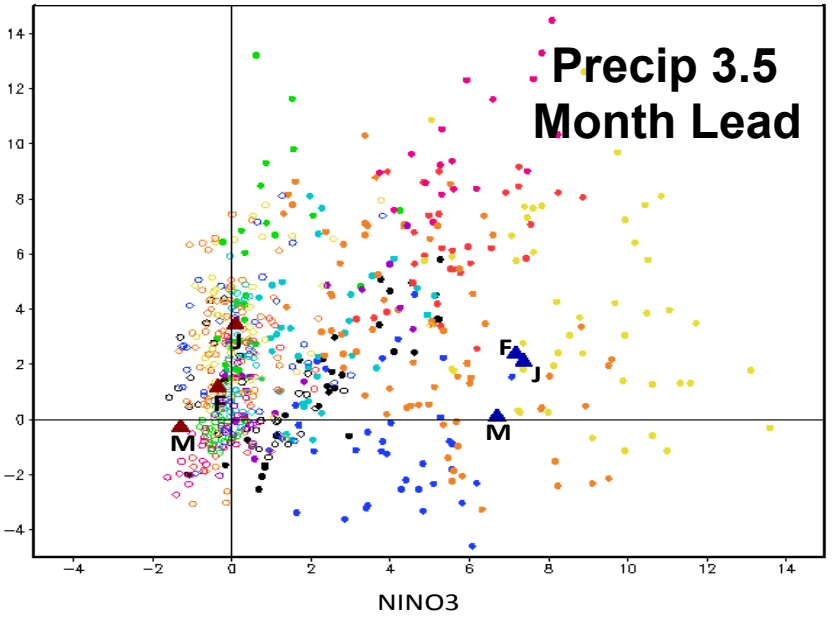


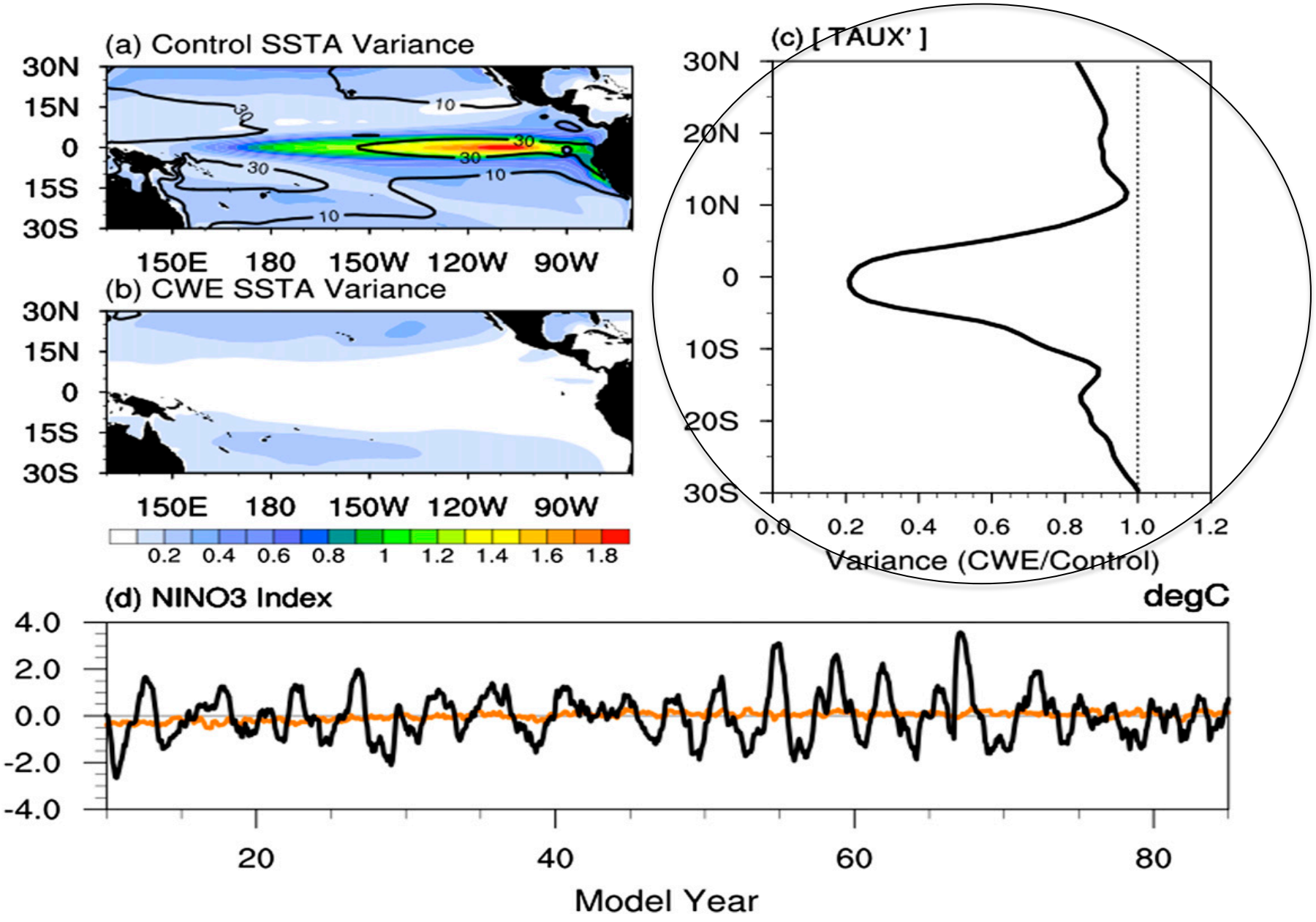
Infanti and Kirtman 2015


SSTA 0.5
Month Lead
1995
1998
M
F
J
M
F
J
NINO4
NINO3

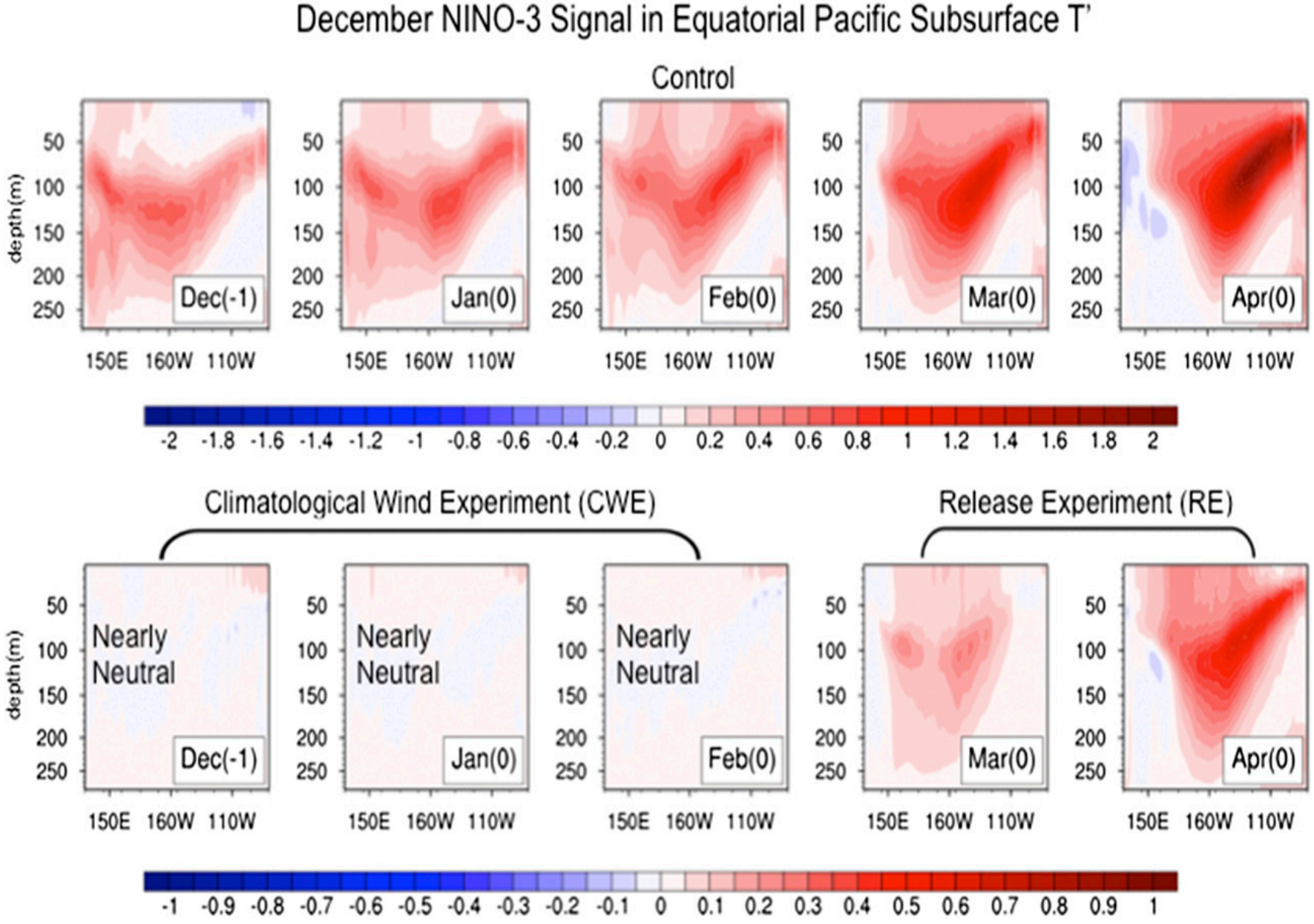

SSTA 3.5
Month Lead
M
F
J
M
F
J
NINO3

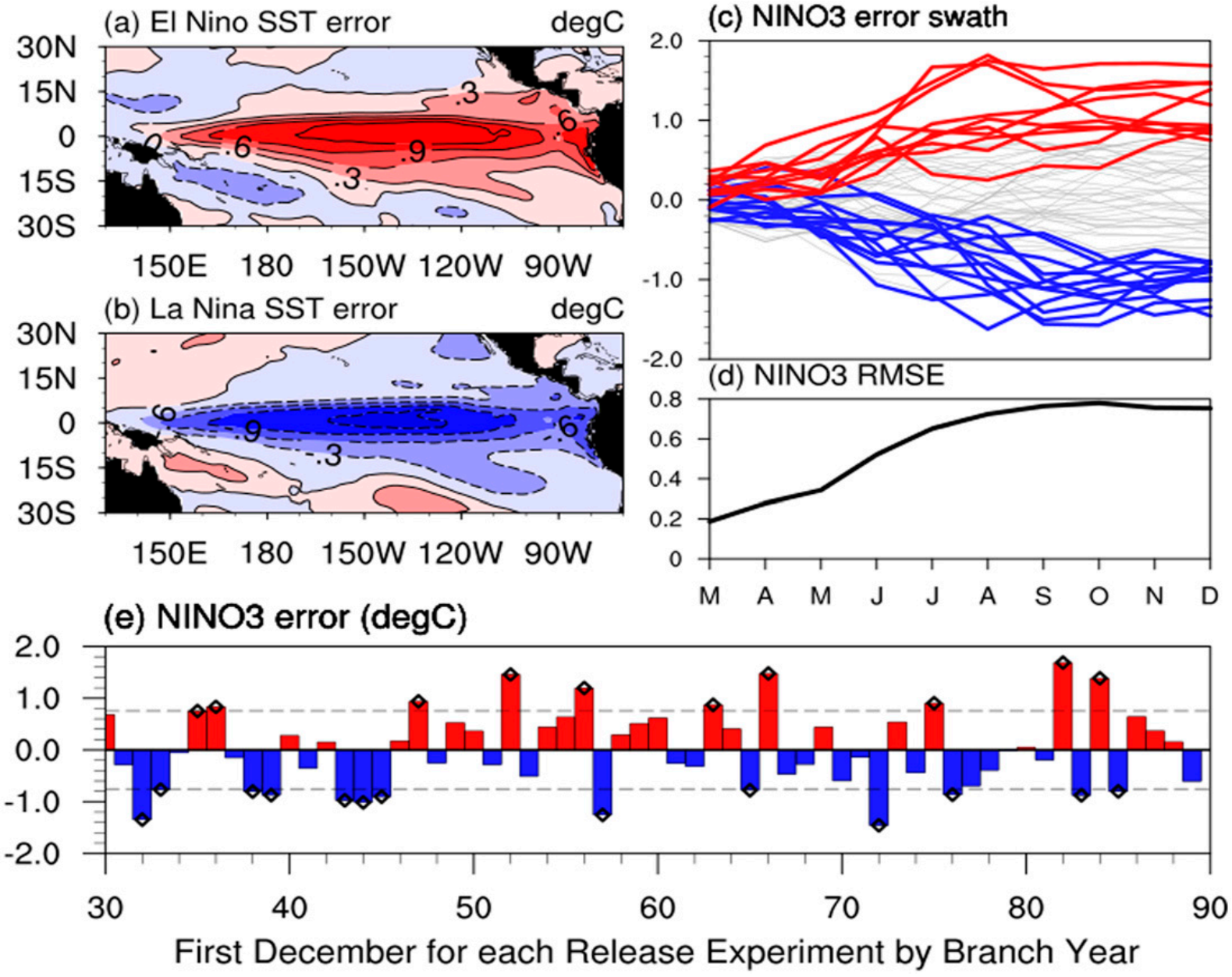

Precip 0.5
Month Lead
J
F
M
F
J
M
NINO4
NINO3


Precip 3.5
Month Lead
J
F
M
F
J
M
NINO3

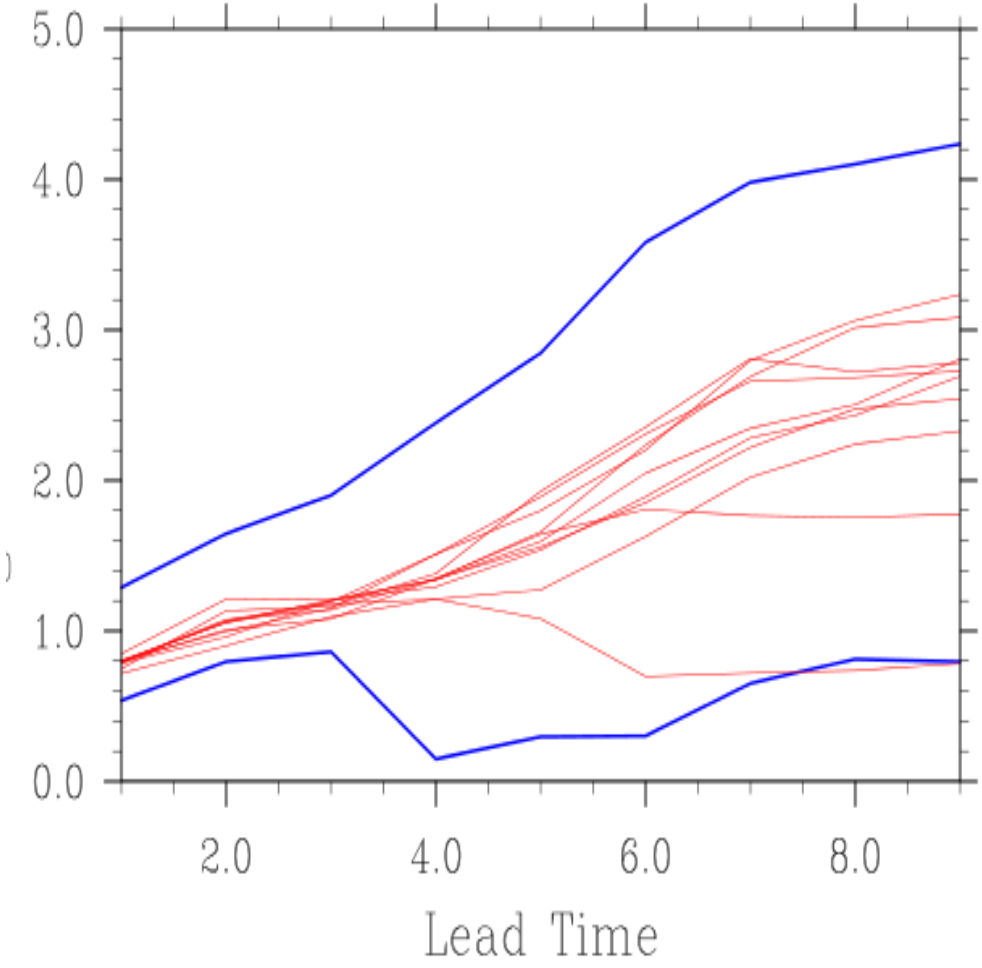


Larson and Kirtman 2015

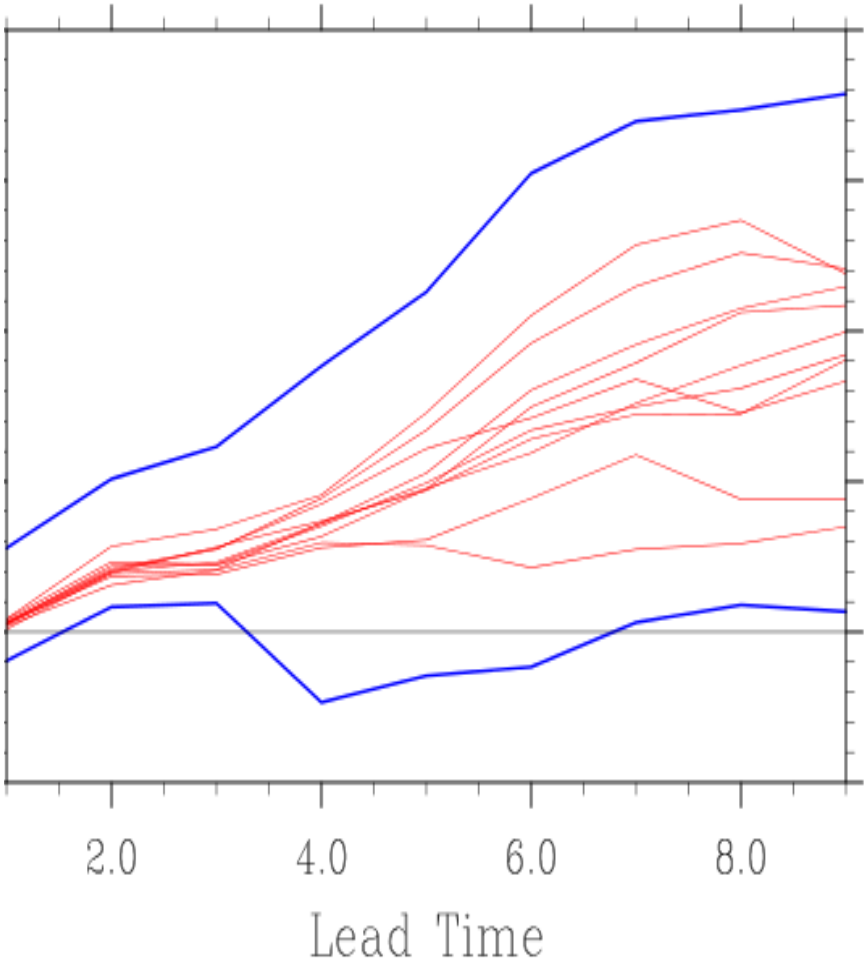

December NINO-3 Signal in Equatorial Pacific Subsurface T'
Control
depth(m)
50
100
150
200
250
150E 160W 110W
Dec(-1)
Jan(0)
Feb(0)
Mar(0)
Apr(0)
-2 -1.8 -1.6 -1.4 -1.2 -1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
Climatological Wind Experiment (CWE)
Release Experiment (RE)
Nearly Neutral
-1 -0.9 -0.8 -0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

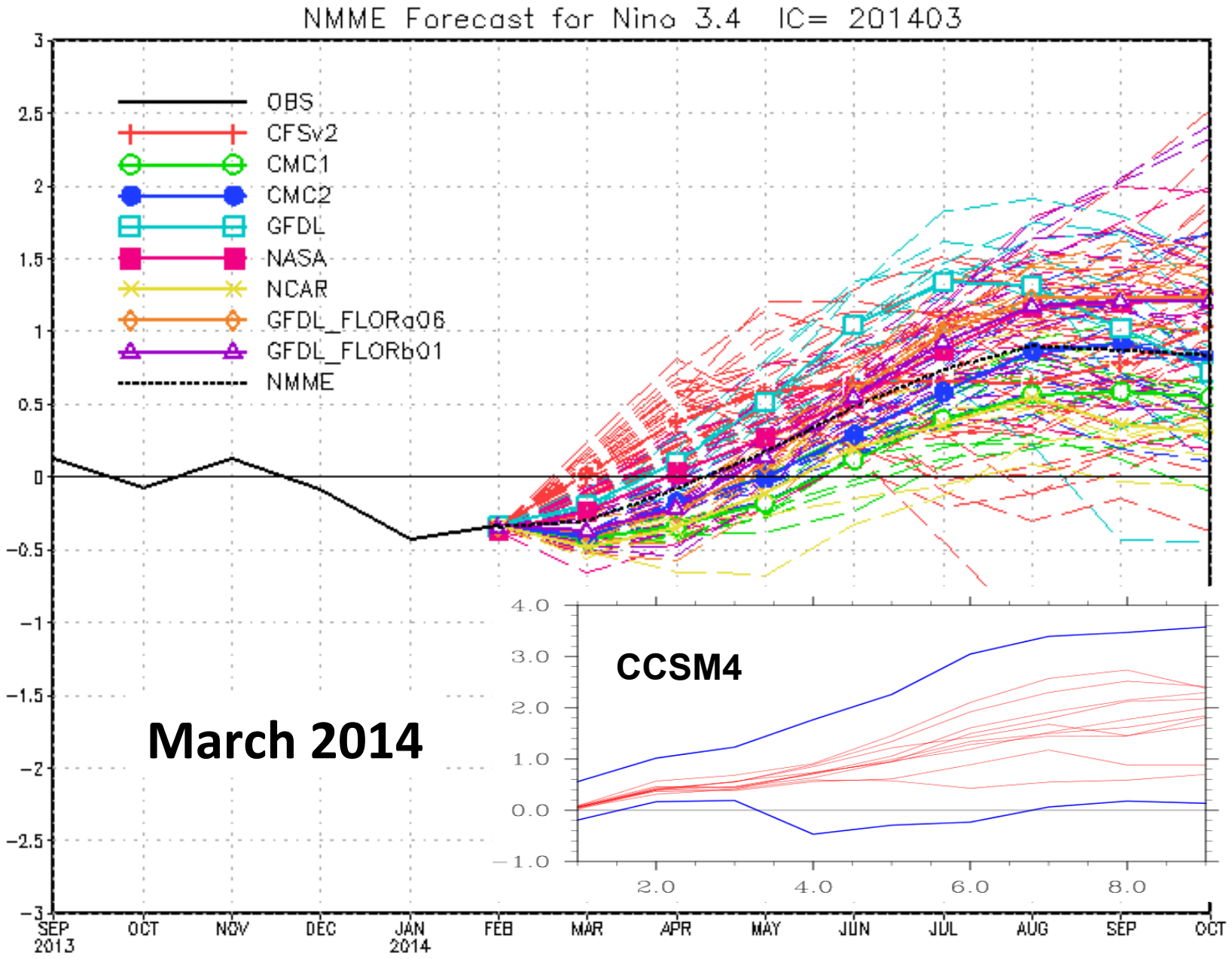

(a) El Nino SST error
degC
30N
15N
0
15S
30S
.3
.6
.9
.6
.3
150E 180 150W 120W 90W
(b) La Nina SST error
degC
30N
15N
0
15S
30S
.6
.9
.3
.6
150E 180 150W 120W 90W
(c) NINO3 error swath
2.0
1.0
0.0
-1.0
-2.0
(d) NINO3 RMSE
0.8
0.6
0.4
0.2
0
M A M J J A S O N D
(e) NINO3 error (degC)
2.0
1.0
0.0
-1.0
-2.0
30 40 50 60 70 80 90
First December for each Release Experiment by Branch Year

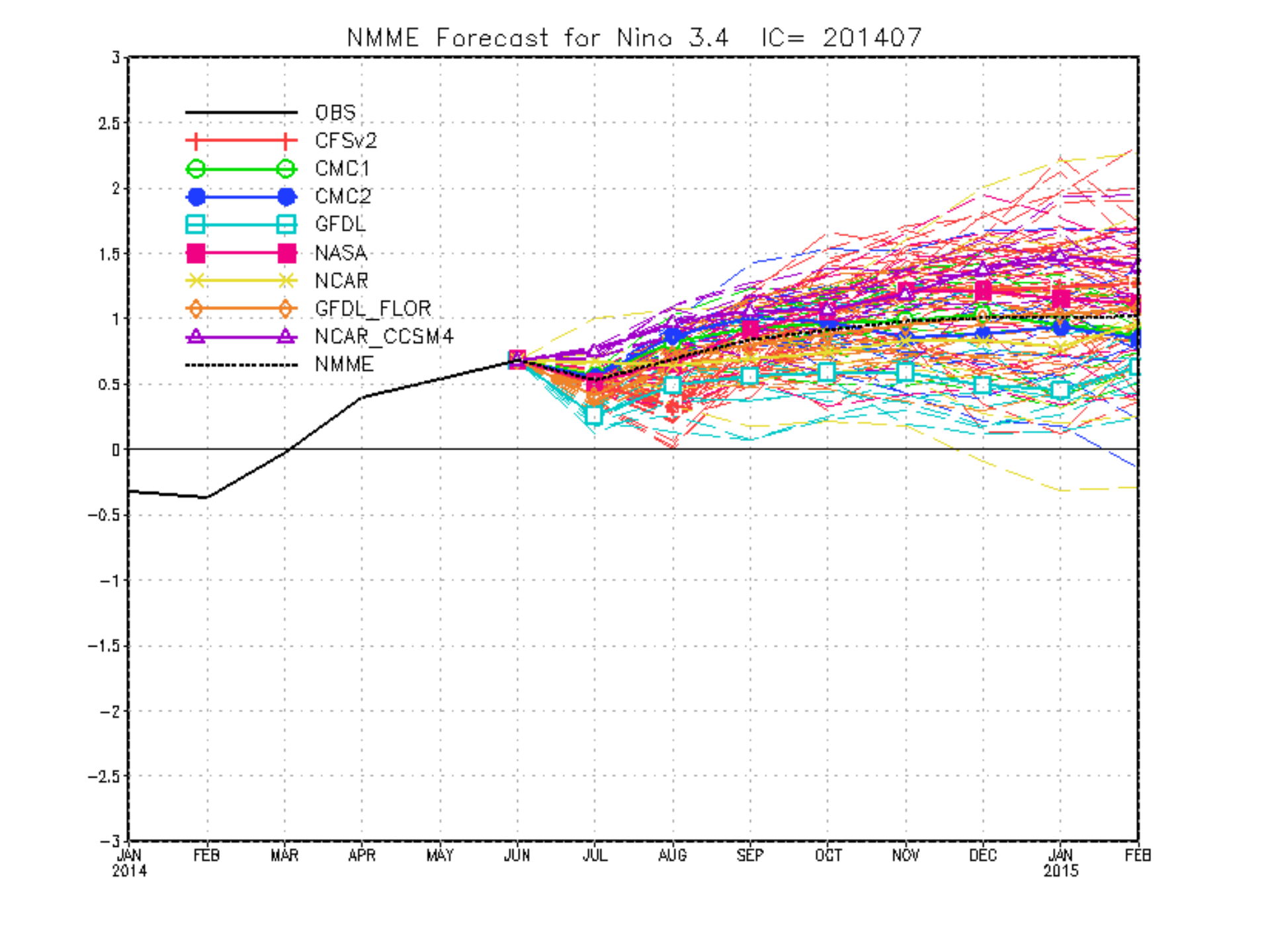
CCSM4 March 2015

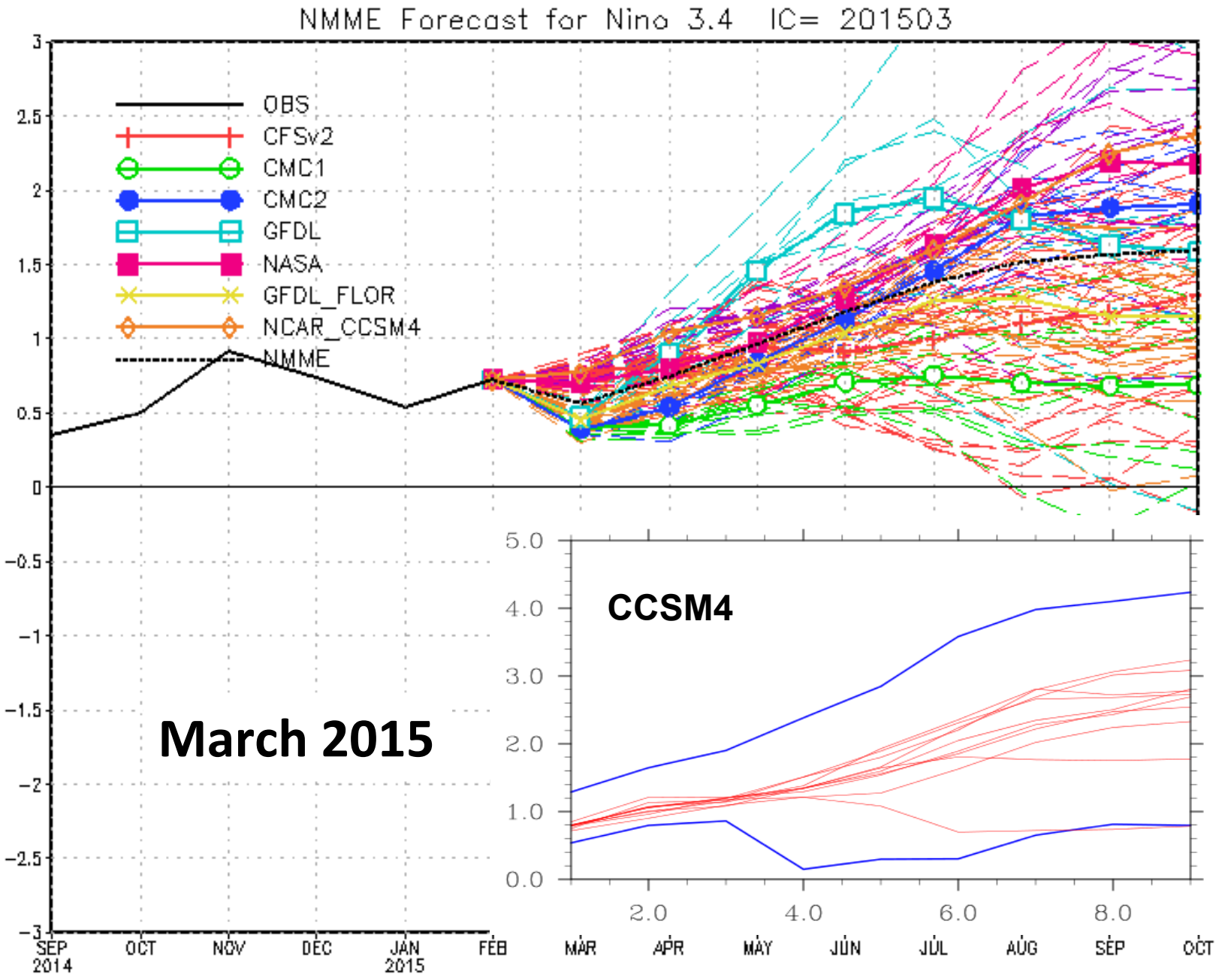


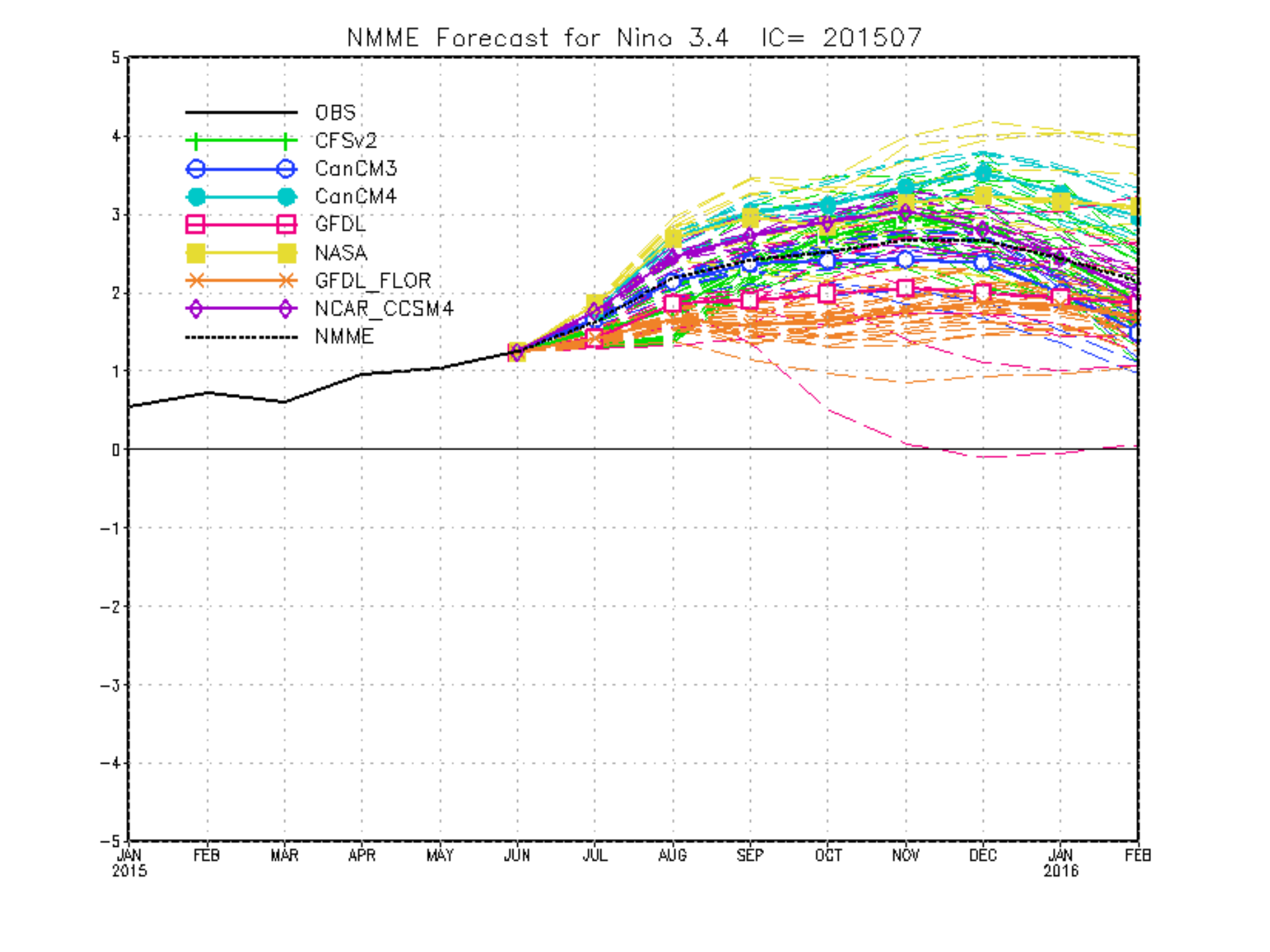
CCSM4 March 2014




NMME Forecast for Nino 3.4 IC= 201403
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
NCAR
GFDL_FLORa06
GFDL_FLORb01
NMME
CCSM4
March 2014
SEP 2013
OCT
NOV
DEC
JAN 2014
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT

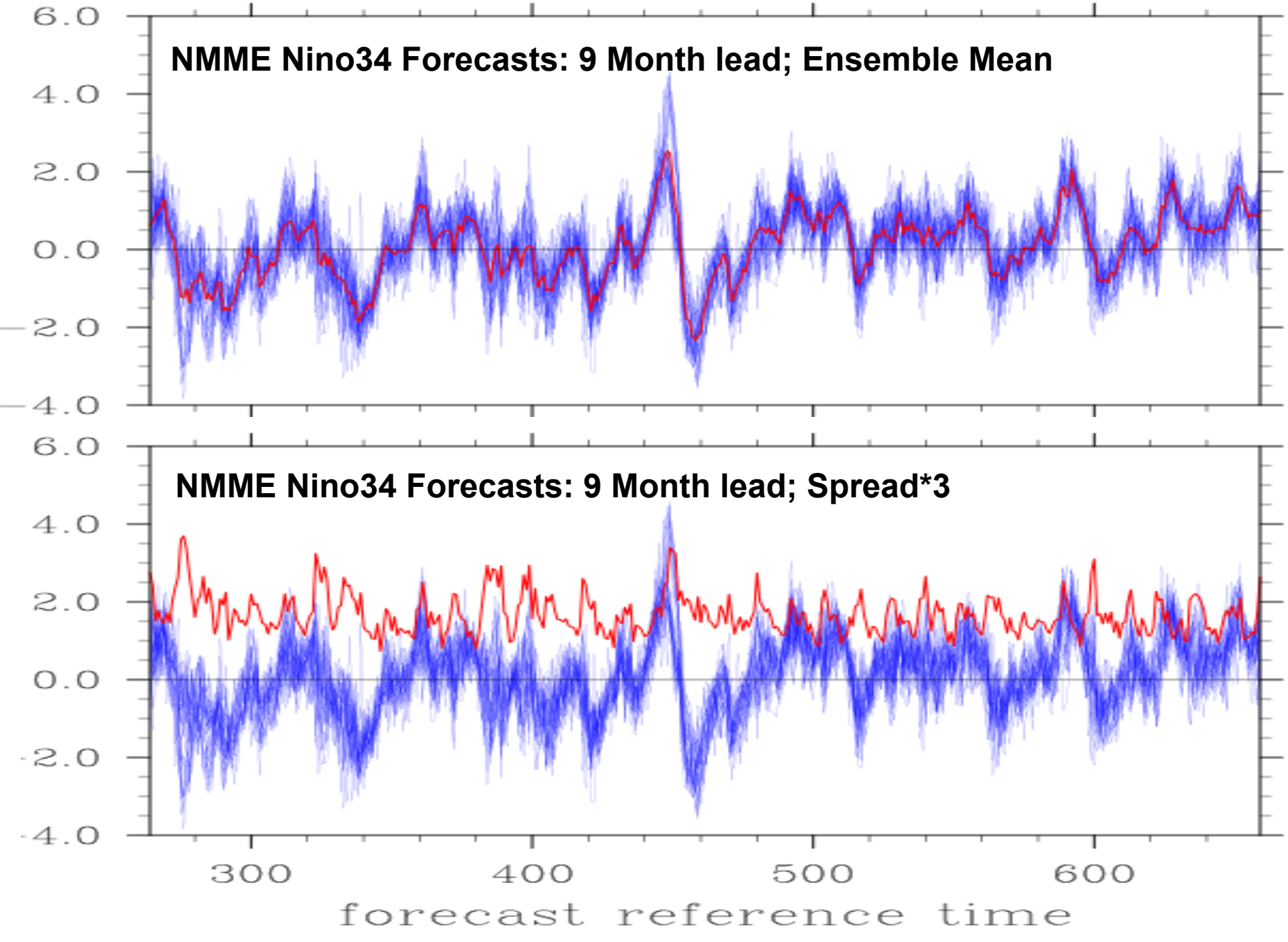

NMME Forecast for Nino 3.4 IC= 201407
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
NCAR
GFDL_FLOR
NCAR_CCSM4
NMME
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
JAN 2014
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN 2015
FEB


NMME Forecast for Nino 3.4 IC= 201503
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
March 2015
CCSM4
SEP 2014
OCT
NOV
DEC
JAN 2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT


NMME Forecast for Nino 3.4 IC= 201507
OBS
CFSv2
CanCM3
CanCM4
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
5
4
3
2
1
0
−1
−2
−3
−4
−5
JAN
2015
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
2016
FEB

Brier Skill Score for Nino3.4

	A/N/B	Lead 0	Lead 1	Lead 2	Lead 3	Lead 4	Lead 5
CFS (24 Members)	Above	0.54	0.45	0.39	0.33	0.28	0.25
	Normal	0.10	0.05	0.03	0.03	0.03	0.02
	Below	0.49	0.43	0.40	0.38	0.36	0.35
Mini-NMME (24 Members)	Above	0.68	0.60	0.55	0.48	0.42	0.37
	Normal	0.34	0.24	0.18	0.15	0.13	0.09
	Below	0.66	0.59	0.56	0.53	0.49	0.45
Full NMME	Above	0.68	0.61	0.55	0.49	0.43	0.38
	Normal	0.35	0.25	0.19	0.16	0.14	0.11
	Below	0.65	0.58	0.54	0.52	0.49	0.46


NMME Nino34 Forecasts: 9 Month lead; Ensemble Mean
NMME Nino34 Forecasts: 9 Month lead; Spread*3
6.0
4.0
2.0
0.0
-2.0
-4.0
300
400
500
600
forecast reference time

Outstanding Problems

- Able to Use Predictions to Inform Predictability, but the Reverse?
- How to Define a "Skillful" Probabilistic Forecast
  - Was the 2014 ENSO Forecast Anomalously Bad?
  - Tension between "Spread" and "Sharpness"
- Forecast of the Forecast Skill
  - State Dependent Skill Mask
  - Why are Dynamic Forecasts So Over-Confident
- Forecast Problem is about Getting the Details Right
  - Forecast Evolution
  - ENSO Diversity
- Weather within Climate
  - Sub-seasonal Statistics
  - Extremes
- Trends