Tropical Pacific SST in CFSv2: Prediction Skill and Predictability

Yan Xue, Mingyue Chen, Arun Kumar, Zeng-Zhen Hu, Wanqiu Wang

Climate Prediction Center
NCEP/NOAA, Maryland, U.S.A.

CFSv2 Evaluation Workshop, April 30 – May 1, 2012
Cold bias dominated before 1999, is largest during summer/fall

- Cold bias dominated before 1999, is largest during summer/fall
Outline

• Model Data
  – 9-month hindcasts, every 5th day and 4 times per day over 1982-2010
  – Lagged ensemble with 20 members
  – 3-month-running mean SST

• Validation Data
  – OIv2 SST
  – R2 wind stress
  – EN3 heat content

• Forecast Biases
  – Forecast biases for each initial month and lead month
  – Ocean I.C. biases
Outline

• **Interannual variability**
  – Standard deviation ratio

• **Prediction skill and predictability**
  – Anomaly correlation, RMSE, Amplitude ratio
  – NINO3, NINO4, NINO3.4
  – Perfect-model skill
  – Ensemble spread

• **El Nino composites**
  – NINO3, NINO4, NINO3.4
- Cold bias near the equator, subtropical N. Pacific
- Warm bias in S.E. and N.E. Pacific.
Cold bias near the equator reduced significantly
Warm bias in S.E. and N.E. Pacific enhanced

Yan Xue  
Climate Prediction Center
Why does SST Bias Differ in 1982-1998 and 1999-2010?

- There is a sudden increase in subsurface temperature in E. Pacific around 1998/1999 in CFSR, related to a sudden reduction of easterly wind biases (Xue et al. 2011)

- The sudden shift around 1998/1999 is evident in many atmospheric fields (Wang et al. 2011; Chelliah et al. 2011; Ebisuzaki et al. 2011)

- The shift is related to assimilation of ATOV satellite observations (Zhang et al. 2012)

- The shift in subsurface temperature in E. Pacific attributes to a shift in SST forecast bias around 1998/99 (Kumar et al. 2012)
**Forecast Bias Diff. is Linked to I.C. Bias Diff.**

I.C. bias + model error = forecast bias

I.C. bias diff (82-98 minus 99-10) + model error diff (82-98 minus 99-10) = forecast bias diff (82-98 minus 99-10)

---

Yan Xue  Climate Prediction Center
I.C. Bias in 2S-2N

1982-1998

1999-2010


SST Bias

CFSR Bias in [2S-2N]
CFSv2 is as skillful as CFSv1 if systematic biases in 1982-1998 and 1999-2010 are removed separately.

CFSv2 is inferior to CFSv1 if systematic biases in 1982-2010 is removed.

So we will analyze the skill in 1982-1998 and 1999-2010 separately in the following.
SST Standard Deviation Ratio in 2S-2N

1982-1998
- STD is 20% too strong in E. Pac
- STD is 40% too weak in W. Pac

1999-2010
- STD is 100% too strong in E. Pac
- STD in 99-10 is 40% of that in 82-98
3-Month-Lead Anomaly Correlation in 1982-1998

Jul-Aug-Sep

CFSv2

Perfect-model

CFSv2 minus Perfect-model

Dec-Jan-Feb

Yan Xue
Climate Prediction Center

12
3-Month-Lead Anomaly Correlation in 1999-2010

Jul-Aug-Sep

Dec-Jan-Feb

CFSv2

Perfect-model

CFSv2 minus Perfect-model

Yan Xue  Climate Prediction Center
Anomaly Correlation for CFSv2 SST

NINO3

(a) NINO3, 82–98

(b) NINO3, 99–10

Target Season

Lead Month

1982-1998

NINO4

(a) NINO4, 82–98

(b) NINO4, 99–10

Target Season

Lead Month

1999-2010

NINO3.4

(a) NINO3.4, 82–98

(b) NINO3.4, 99–10

Target Season

Lead Month

Legend:

0.9

0.85

0.8

0.75

0.7

0.65

0.6

0.5

0.4
NINO3 and NINO4 in 82-98
NINO3 and NINO4 in 99-10
El Nino Composite

(Black=OBS, Red=0-mon-L, Blue=3-mon-L, Blue=6-mon-L)
Summary

• CFSv2 has a systematic cold bias near the Eq. that is largest (- 2.5°C) during summer/fall before 1999

• The equatorial cold bias weakened by more than 1°C from 1982-1998 to 1999-2010, related to a sudden increase in subsurface temperature in E. Pacific in CFSR when ATOVS satellite observations were assimilated in late 1998

• STD of SST is simulated well in 1982-1998, but is overestimated (underestimated) in E. Pacific (W. Pacific) in 1999-2010

• Deterministic skill suggests that CFSv2 has a higher skill in 1982-1998 than in 1999-2010, probably related to weakened variability in the later period and model’s failure in capturing the changes in variability.

• CFSv2 has a weak “spring predictability barrier” in 1982-1998, but a strong “spring predictability barrier” in 1999-2010, related to changes in variability in the two periods

• RMSE in NINO3.4 generally agrees with model’s ensemble spread, indicating that the model has a realistic ENSO instability mechanism
Anomaly Correlation of Persistence SST

1982-1998

1999-2010

Yan Xue
Climate Prediction Center
SST Forecast Bias in 2S-2N

1982-1998

1999-2010


Yan Xue Climate Prediction Center
Persistence RMSE

82-98

99-10

STD of Obs

CFSv2 RMSE (solid)
CFSv2 spread (dash)
NINO3.4 at 3-mon-L

RMSE

ACC

Target Season

Target Season

Yan Xue    Climate Prediction Center
Anomaly Correlation – SST
CFSv1 Ocean I.C. ➔ CFSv2 Ocean I.C.

Ocean-alone

Global Ocean Data Assimilation System (GODAS, implemented in 2003)

Partially Coupled System

Climate Forecast System Reanalysis (CFSR, implemented in 2011)

Atmosphere Data Assimilation System (T382L64 GSI)

Ocean Data Assimilation System (MOM4 Ocean Model and 3D VAR)

Yan Xue Climate Prediction Center
Fig. 5 (Yan)
Fig. 4 (Yan)

CFSv2 SST: 99–10 minus 82–98

(a) Jan–Feb–Mar
(b) Apr–May–Jun
(c) Jul–Aug–Sep
(d) Apr–May–Jun
(e) Jul–Aug–Sep
(f) Oct–Nov–Dec
(g) Jul–Aug–Sep
(h) Oct–Nov–Dec
(i) Jan–Feb–Mar
(j) Oct–Nov–Dec
(k) Jan–Feb–Mar
(l) Apr–May–Jun

OI SST

Yan Xue
Climate Prediction Center
Fig. 8 (Yan)

Temperature in 1S–1N Anomaly Correlation Skill

- (a) Jan–Feb–Mar
- (b) Apr–May–Jun
- (c) Jul–Aug–Sep
- (d) Apr–May–Jun
- (e) Jul–Aug–Sep
- (f) Oct–Nov–Dec
- (g) Jul–Aug–Sep
- (h) Oct–Nov–Dec
- (i) Jan–Feb–Mar
- (j) Oct–Nov–Dec
- (k) Jan–Feb–Mar
- (l) Apr–May–Jun

Yan Xue  Climate Prediction Center

37