Global Ocean Monitoring: Recent Evolution, Current Status, and Predictions

Prepared by

Climate Prediction Center, NCEP/NOAA

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http://www.cpc.ncep.noaa.gov/products/GODAS/

This project to deliver real-time ocean monitoring products is implemented by CPC in cooperation with NOAA's Ocean Observing and Monitoring Division (OOMD)

Outline

- Overview

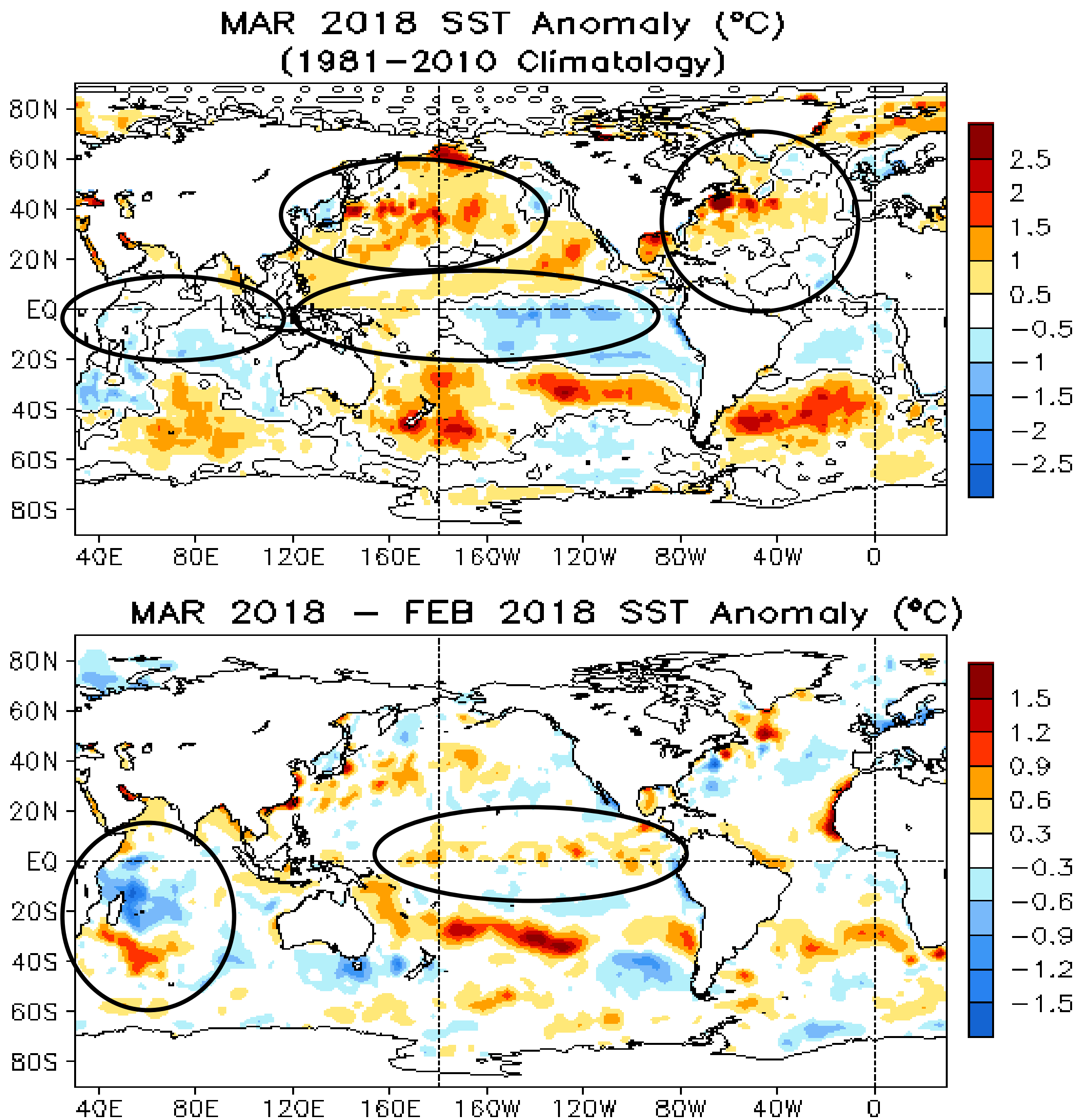
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
  - Global SST Predictions
  - Review of 2017/18 La Nina Predictions

Overview

- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 8 Mar 2018 indicated "*A transition from La Niña to ENSO-neutral is most likely (~55% chance) during the March-May season, with neutral conditions likely to continue into the second half of the year.*"**
  - **Negative SSTAs weakened in the east-central equatorial Pacific with NINO3.4=-0.73ºC in Mar 2018.**
  - **Positive subsurface ocean temperature anomalies presented in the western and central equatorial Pacific and propagated eastward in Mar 2018.**
  - **Positive SST anomalies presented in the N. Pacific with PDOI=-0.2 in Mar 2018.**
- **Indian Ocean**
  - **SSTs were near average in the tropics in Mar 2018.**
- **Atlantic Ocean**
  - **NAO switched to negative phase with NAOI=-1.4 in Mar 2018, and SSTAs were a tripole/horseshoe pattern with large positive anomalies in the middle latitudes of N. Atlantic.**

<u>Global Oceans</u>

Global SST Anomaly (^{0}C) and Anomaly Tendency

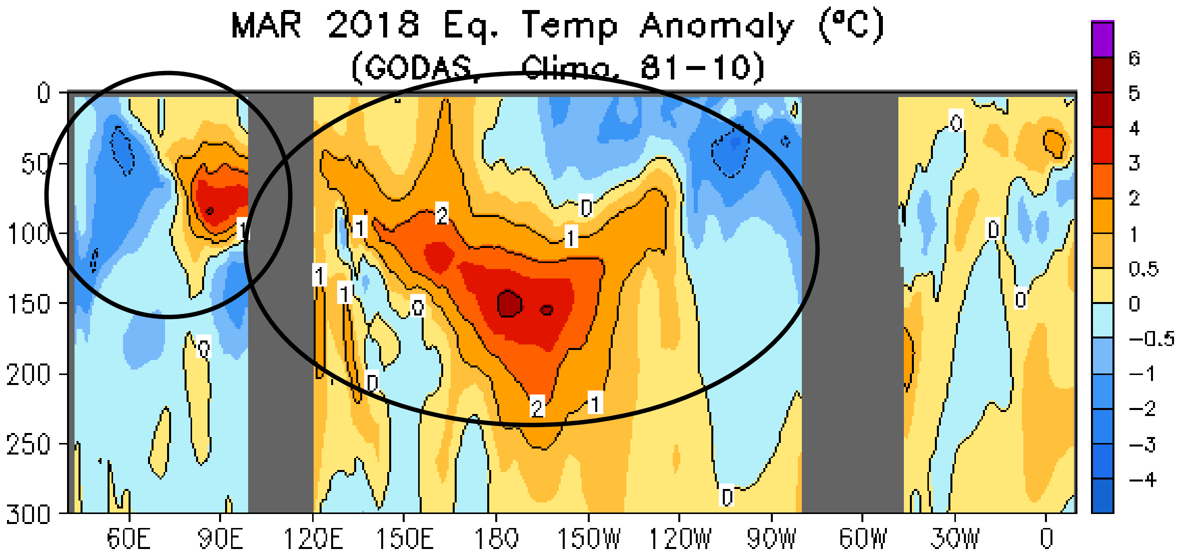


- SSTAs were positive in the western and negative in the eastern tropical Pacific, consisting with La Nina condition.
- Positive SSTAs were in the North Pacific.
- Horseshoe/tripole-like SSTA pattern presented in the North Atlantic.
- In Indian Ocean, SSTAs were near average in the tropics.

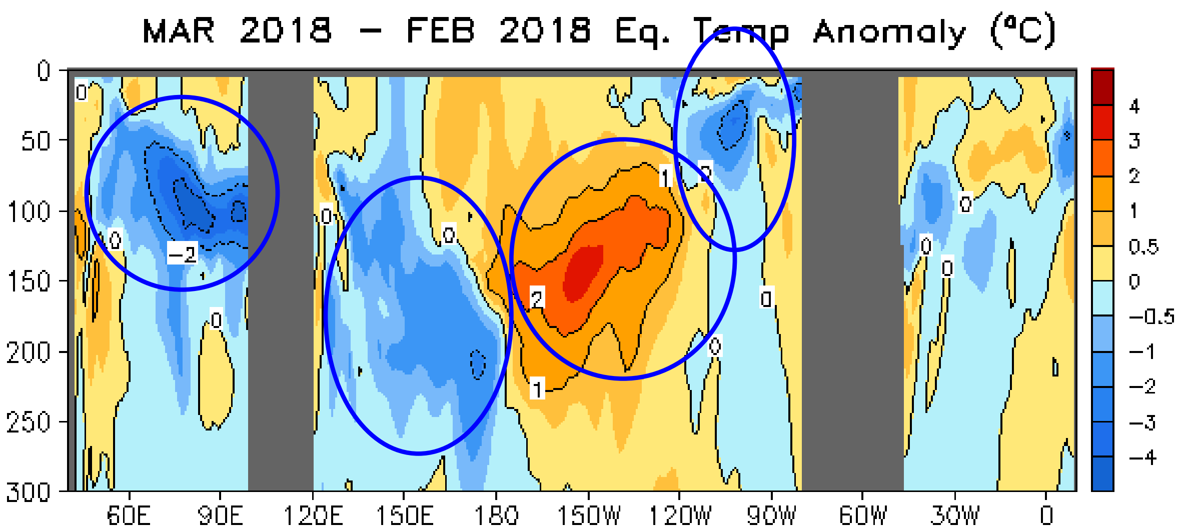
- Positive (negative) SSTA tendencies were observed in the central and eastern tropical North (South) Pacific.
- Bot positive and negative SSTA tendencies were seen in the SW Indian Ocean.

Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2^{O}S-2^{O}N



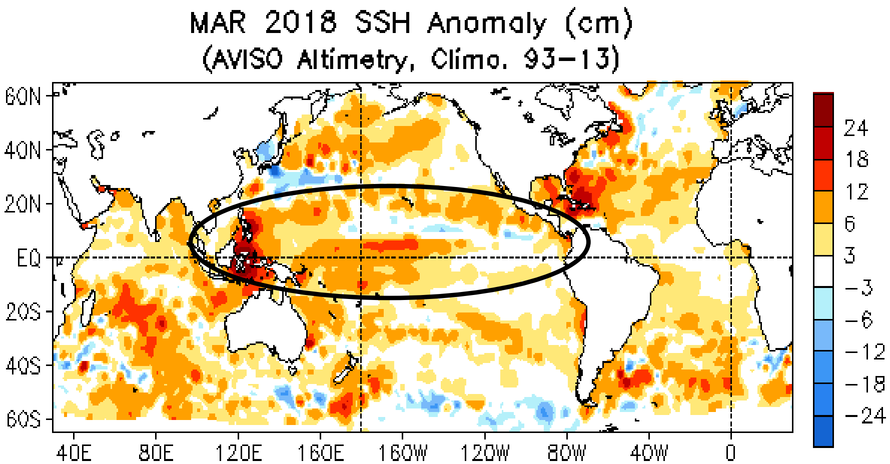
- Positive (negative) ocean temperature anomalies presented along the thermocline in the western-central (eastern) Pacific.
- Positive (negative) ocean temperature anomalies were in the eastern (western) Indian Ocean.

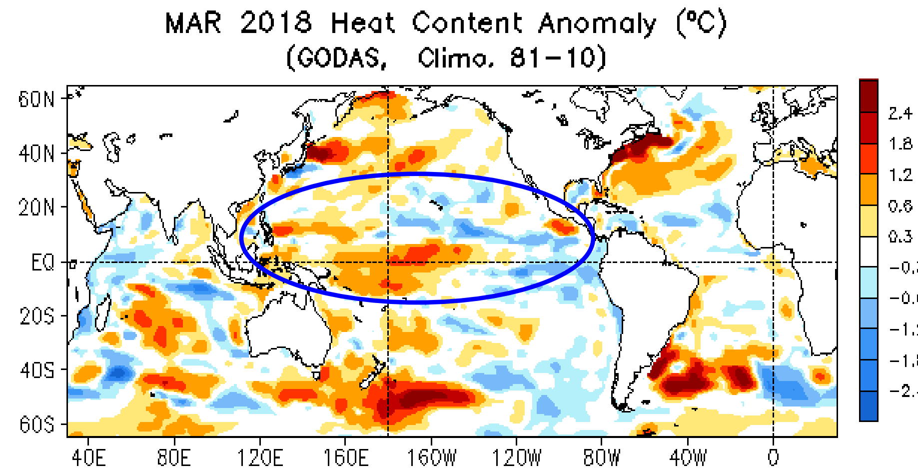


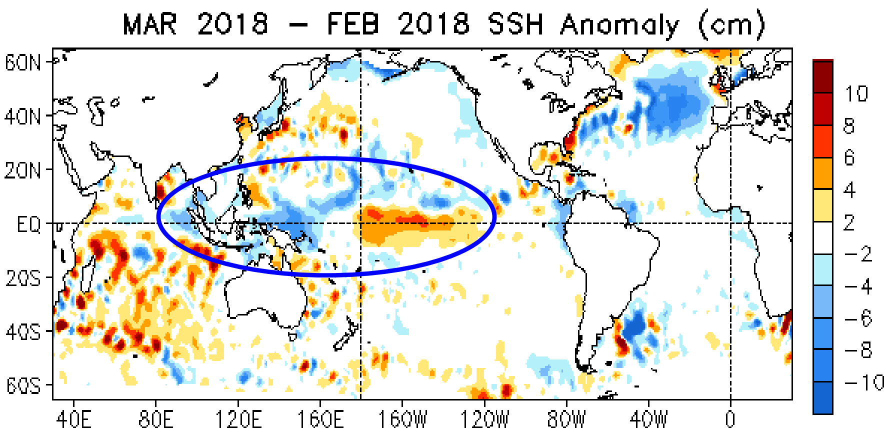
- It was a tripole tendency pattern in the Pacific: negative in the west and east, and positive in the central.
- Negative tendencies presented along the thermocline in Indian Ocean.

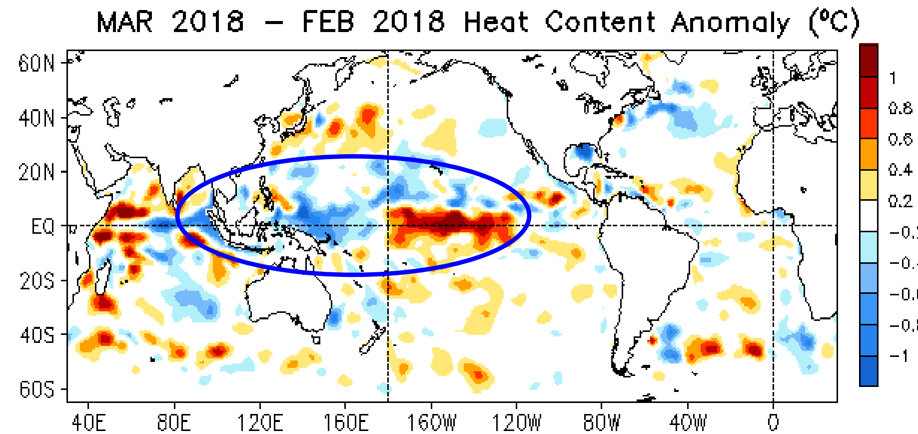
Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency







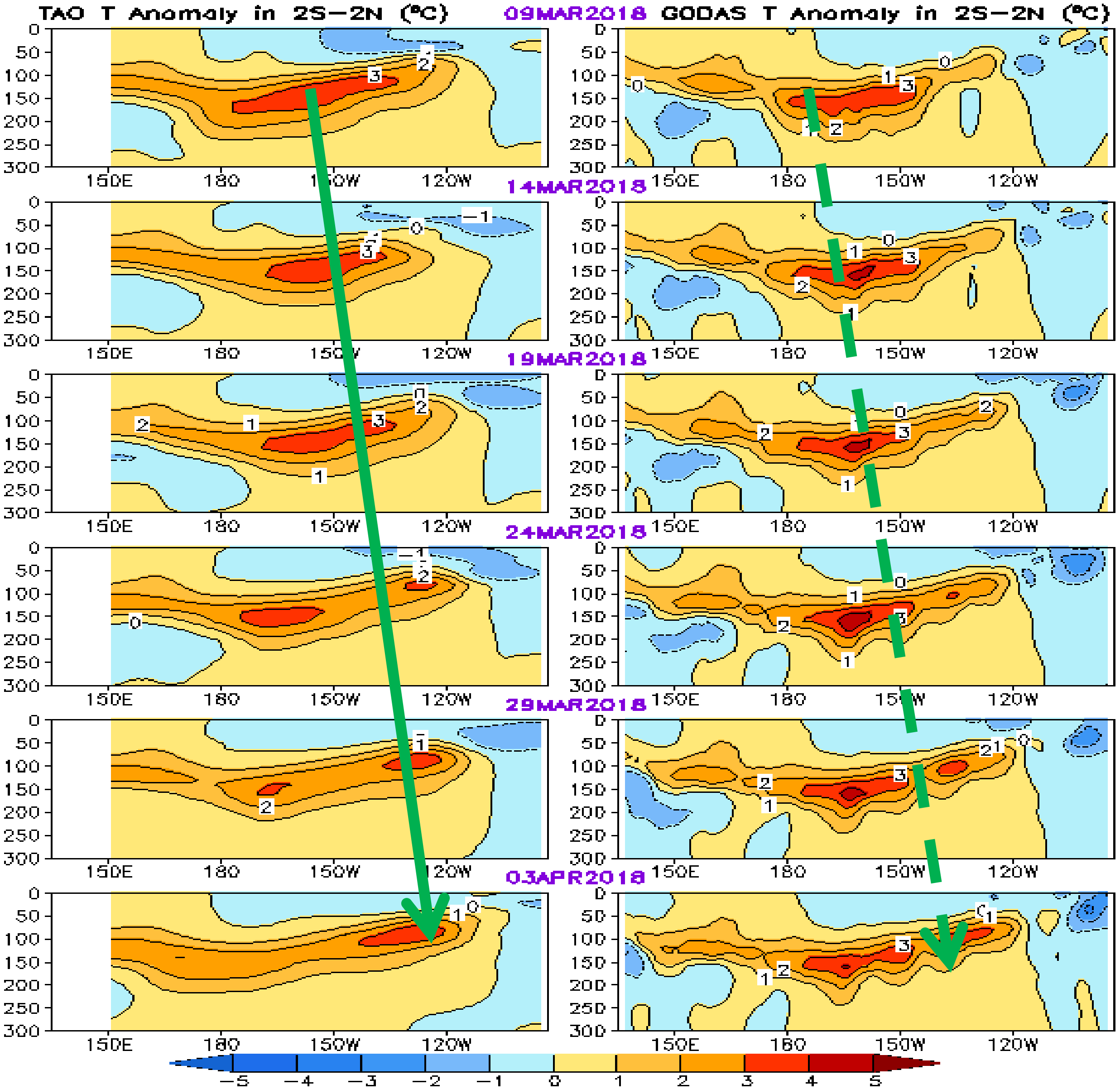


- **The SSHA pattern was overall consistent with HC300A pattern, but there were many detailed differences between HC300A and SSHA.**
- **Both SSHA and HC300A in the tropical Pacific were consisted with the cold phase of ENSO.**
- **The negative and positive tendencies of SSHA and HC300A in the tropical Pacific are associated with Kelvin wave activity.**

Tropical Pacific Ocean and ENSO Conditions

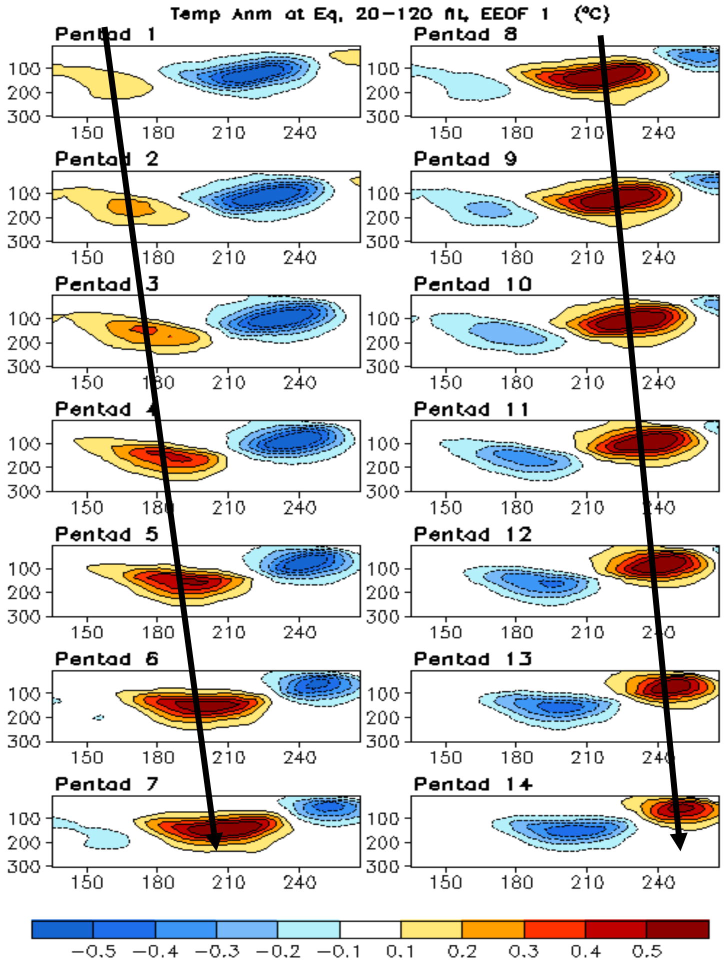
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

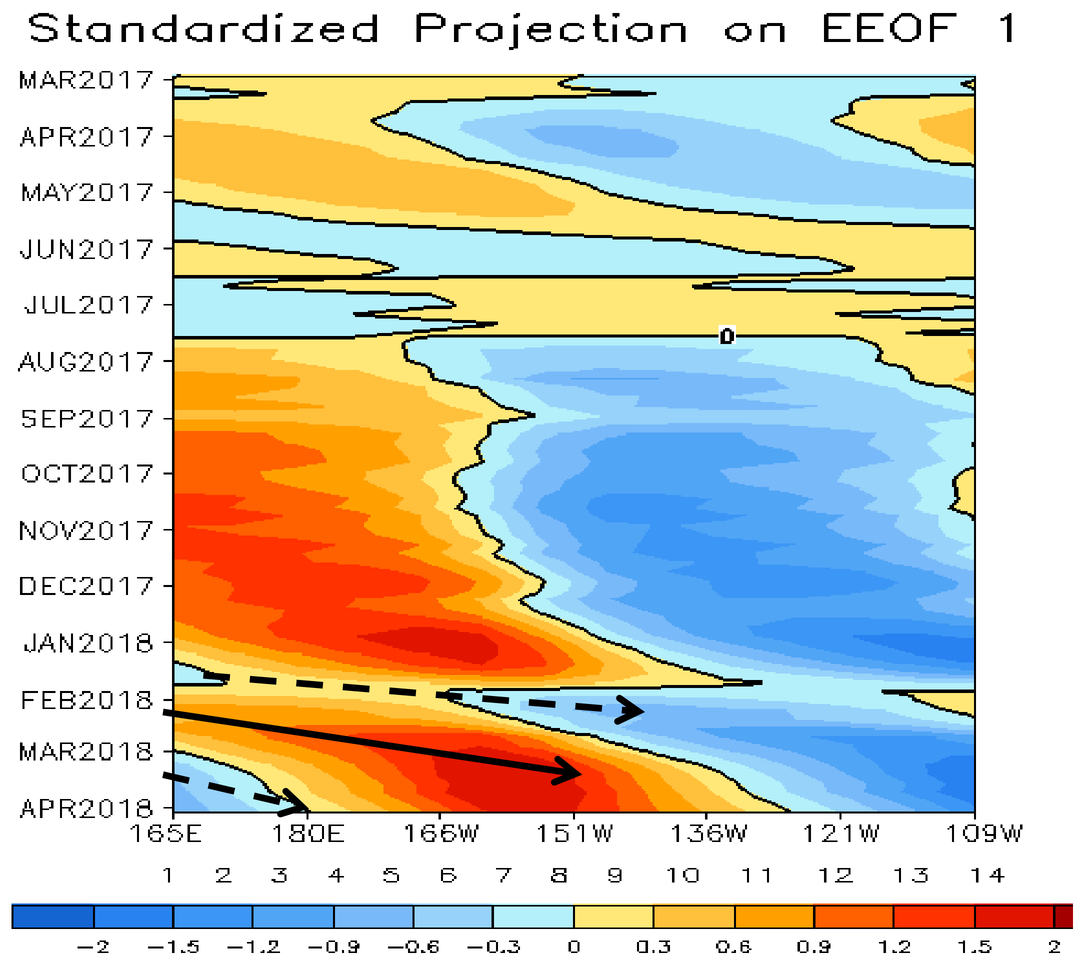
TAO GODAS



- **Positive ocean temperature anomalies in the western and central Pacific Ocean propagated eastward during last month and reached far-eastern Pacific, associated with eastward propagation of downwelling Kelvin wave.**
- **Both the anomalous amplitude and propagation speed are comparable between TAO and GODAS.**

Oceanic Kelvin Wave (OKW) Index



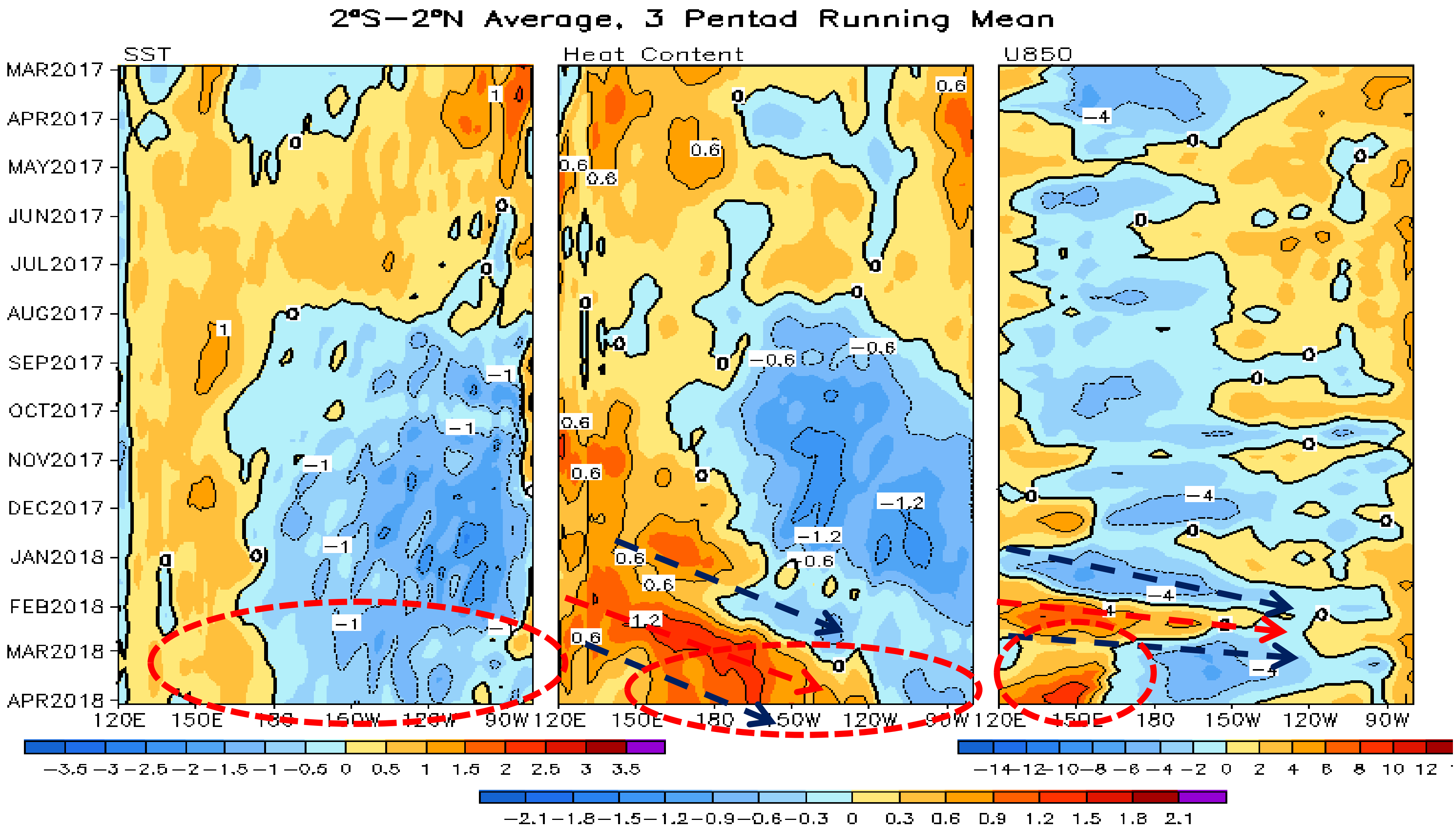


- **A downwelling Kelvin wave presented from Dec 2017- Mar 2018, and an upwelling Kelvin wave from mid Jan 2018 to present.**

- **Since early Mar 2018, another downwelling Kelvin wave has led to positive subsurface anomalies in the central Pacific.**

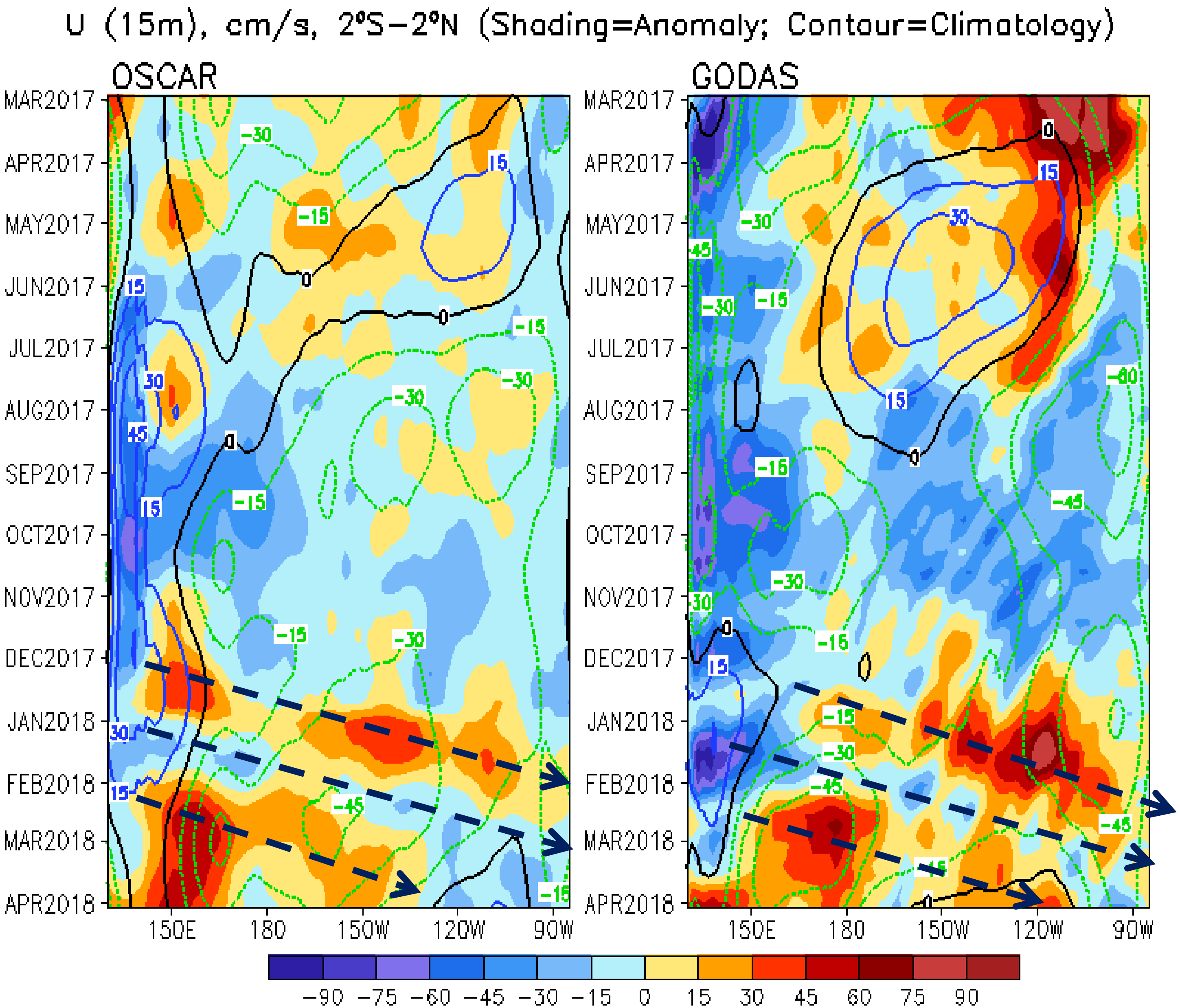
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

Equatorial Pacific SST (°C), HC300 (°C), u850 (m/s) Anomalies



- **Negative SSTA in the far-eastern Pacific weakened in last month.**
- **Positive HC300A in the western and central Pacific propagated eastward in Mar 2018, and low-level westerly wind bursts were observed in late Jan and Mar. 2018, consisting with Kelvin wave activity.**

Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Anomalous eastward currents were seen in Feb-Mar 2018 in OSCAR and GODAS. That was favorable for a weakening tendency of La Nina.

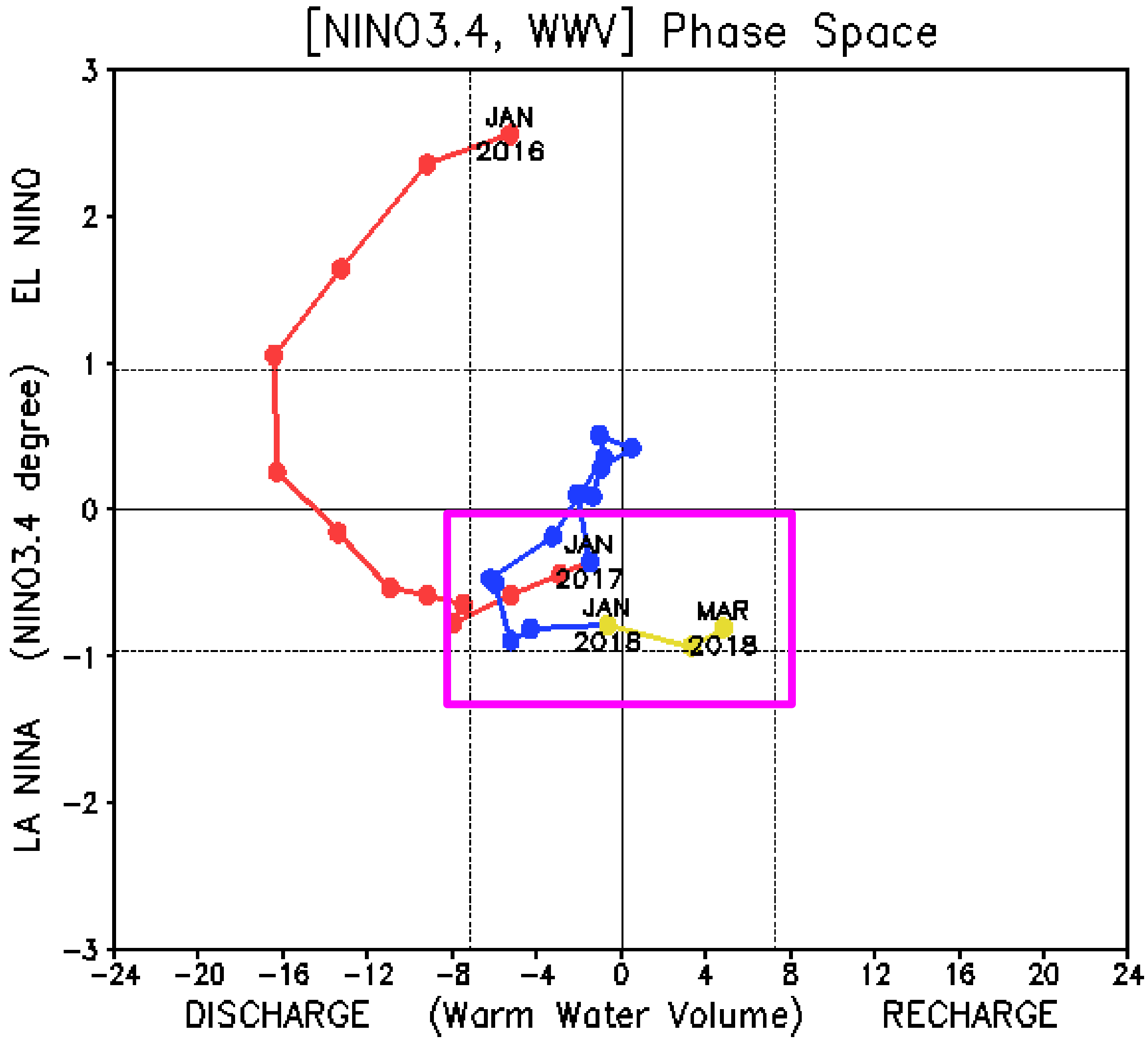
- The anomalous currents showed some differences between OSCAR and GODAS.

Warm Water Volume (WWV) and NINO3.4 Anomalies

- WWV is defined as average of depth of 20°C in [120°E-80°W, 5°S-5°N]. Statistically, peak correlation of Nino3 with WWV occurs at 7 month lag (Meinen and McPhaden, 2000).

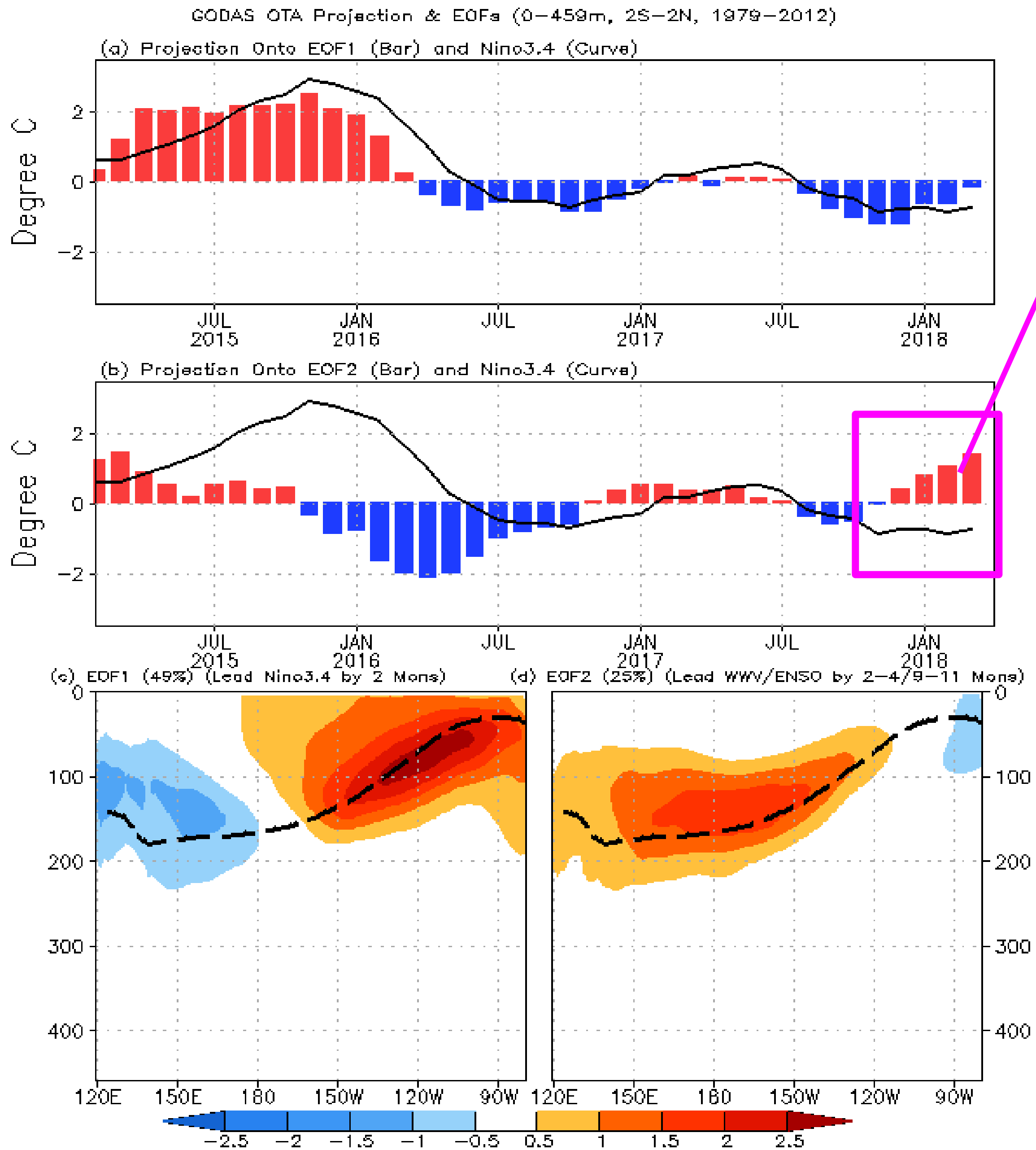
- Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).

- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



- **Equatorial Warm Water Volume (WWV) indicated recharging in Feb-Mar 2018.**

Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



Equatorial subsurface ocean temperature monitoring: ENSO was in recharge phase since Dec 2017.

Projection of OTA onto EOF1 and EOF2 (2S-2N, 0-459m, 1979-2010)

EOF1: Tilt mode (ENSO peak phase);

EOF2: WWV mode, Recharge/discharge oscillation (ENSO transition phase).

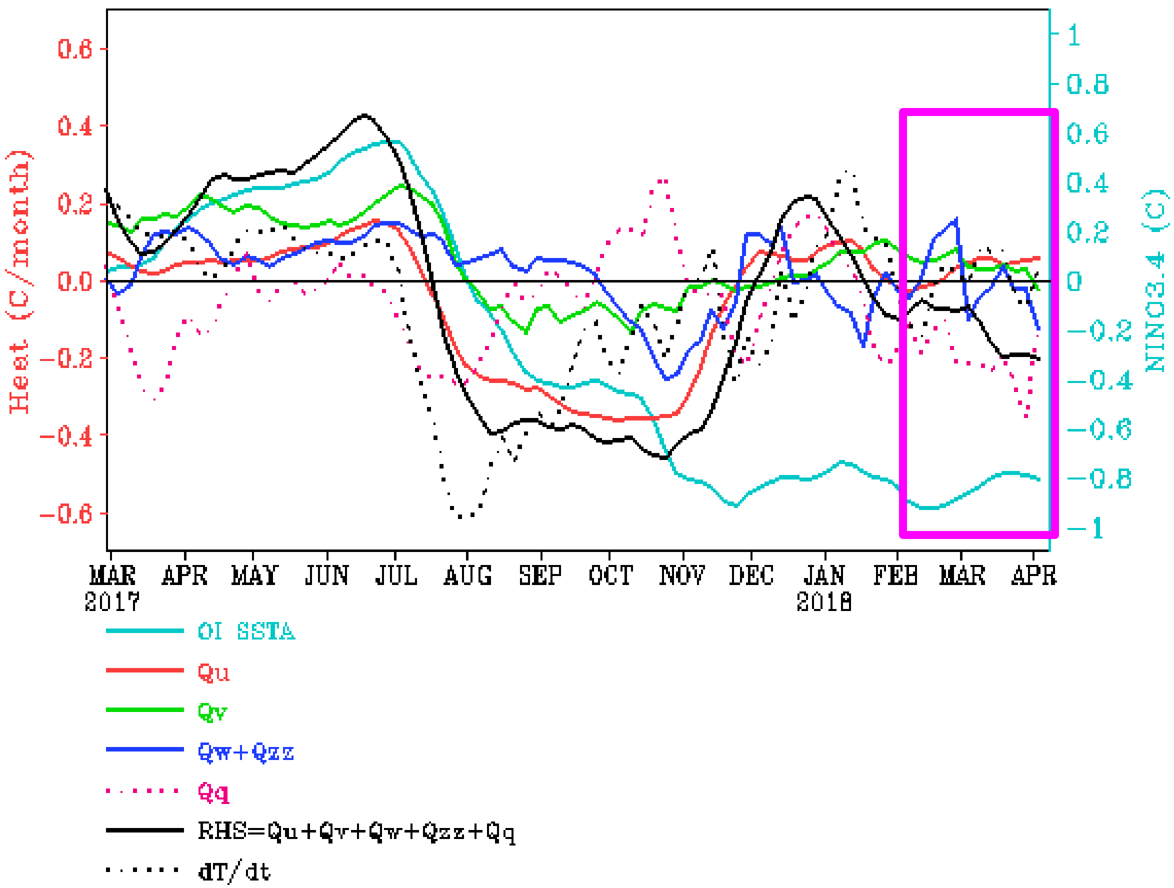
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

For details, see:

Kumar A, Z-Z Hu (2014) Interannual and interdecadal variability of ocean temperature along the equatorial Pacific in conjunction with ENSO. Clim. Dyn., 42 (5-6)**, 1243-1258.** *DOI: 10.1007/s00382-013-1721-0*.

NINO3.4 Heat Budget



- Observed SSTA tendency (dT/dt) in Nino3.4 region (dotted black line) was small, but total heat budget (RHS; solid black line) was negative.

- Dynamical terms (Qu, Qv, Qw+Qzz) were small and heat-flux terms (Qq) were negative in last month.

Huang, B., Y. Xue, X. Zhang, A. Kumar, and M. J. McPhaden, 2010 : The NCEP GODAS ocean analysis of the tropical Pacific mixed layer heat budget on seasonal to interannual time scales, J. Climate., 23, 4901-4925.

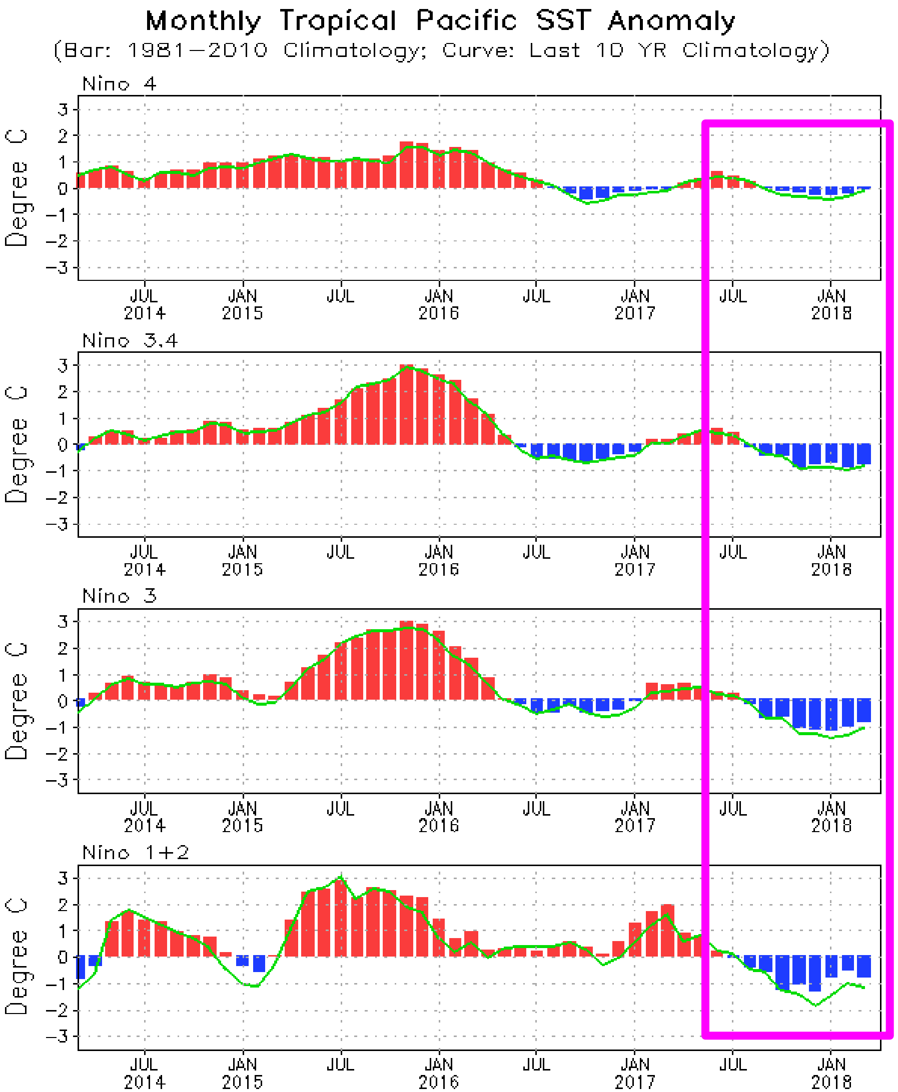
Qu: Zonal advection; Qv: Meridional advection;

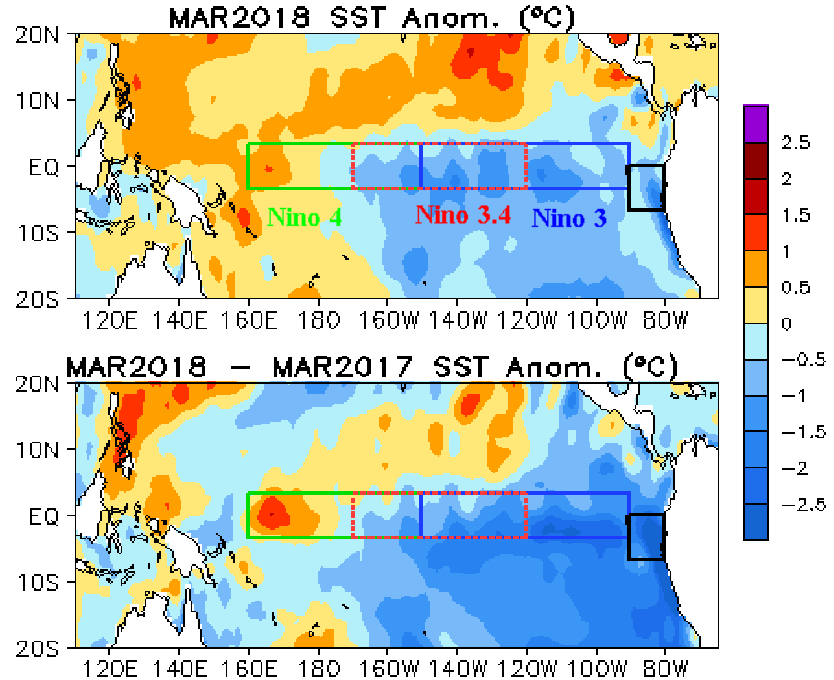
Qw: Vertical entrainment; Qzz: Vertical diffusion

Qq: (Qnet - Qpen + Qcorr)/ρcph; Qnet = SW + LW + LH +SH;

Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

Evolution of Pacific NINO SST Indices



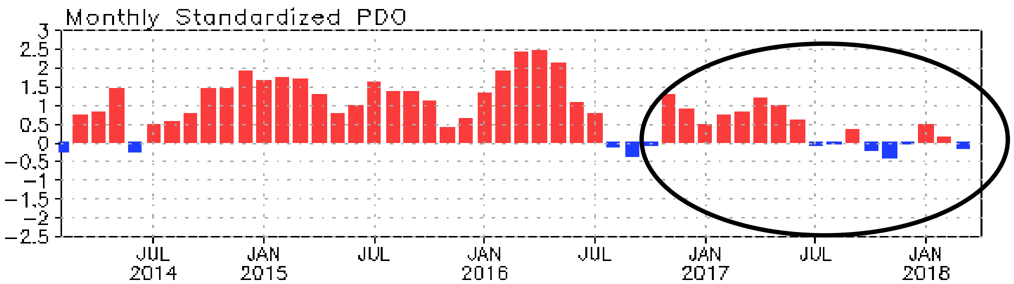


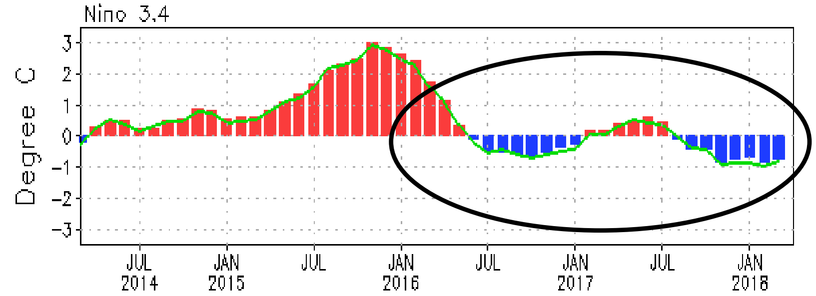
- **All Nino indices were negative in Mar 2018.**
- **Nino3.4 = -0.73C in Mar 2018.**
- **Compared with last Mar, the central and eastern equatorial and southern Pacific was cooler in Mar 2018.**
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v5.**

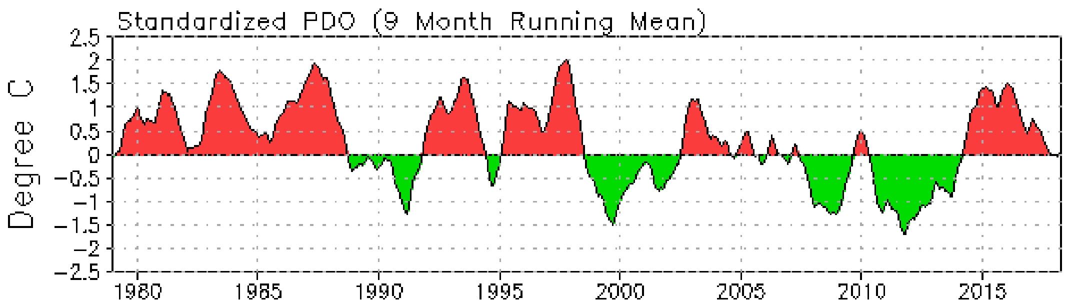
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

North Pacific & Arctic Oceans

PDO index

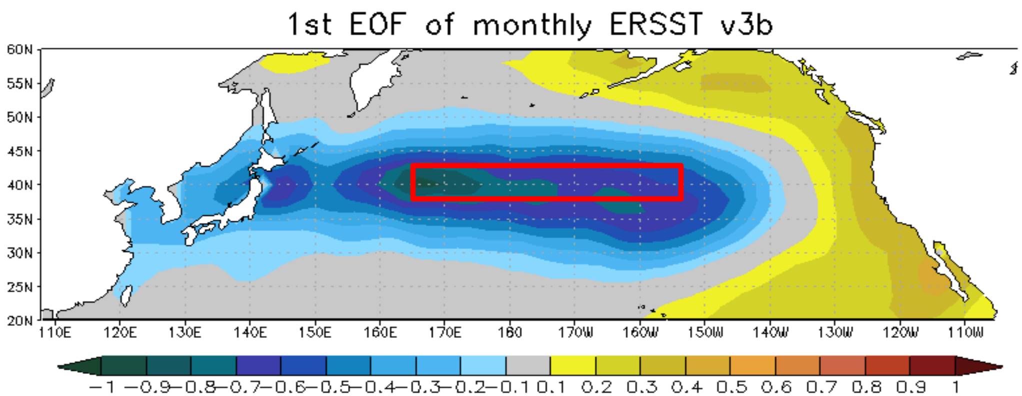






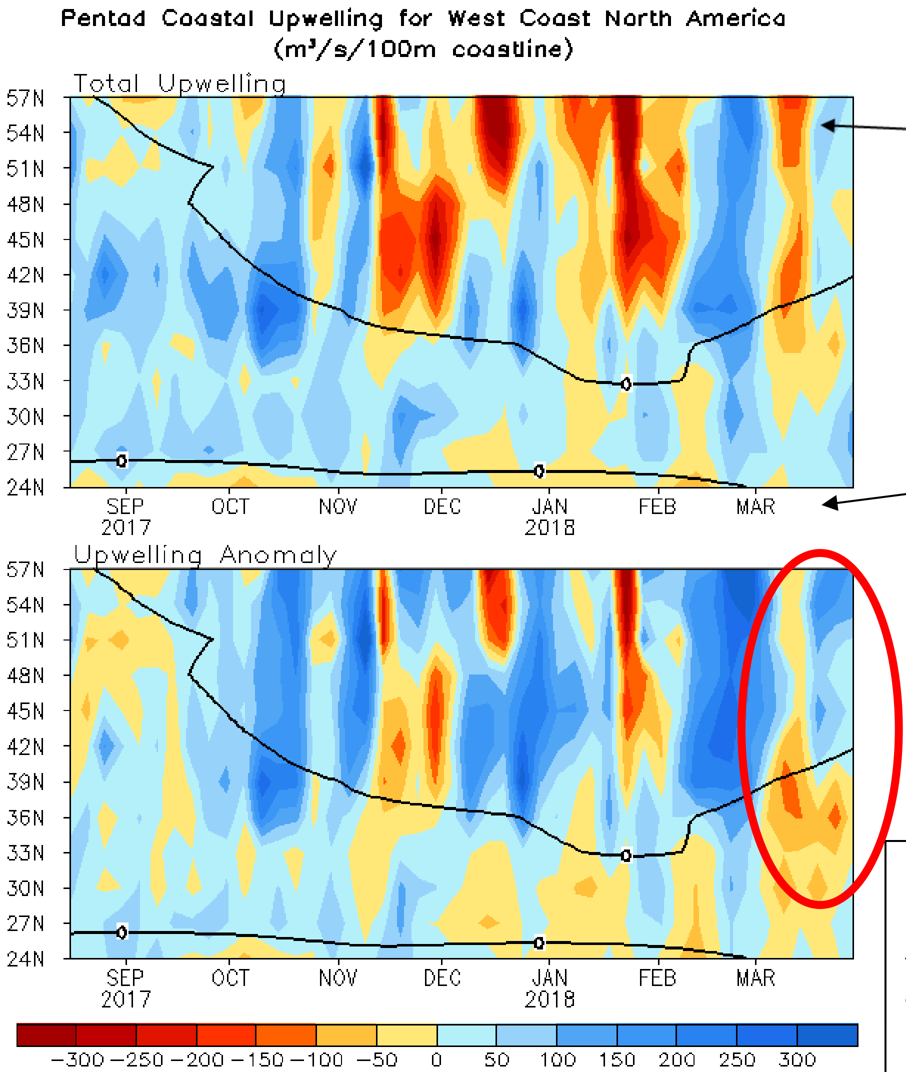
- **The positive SSTAs presented with PDO index =-0.2 in Mar 2018.**

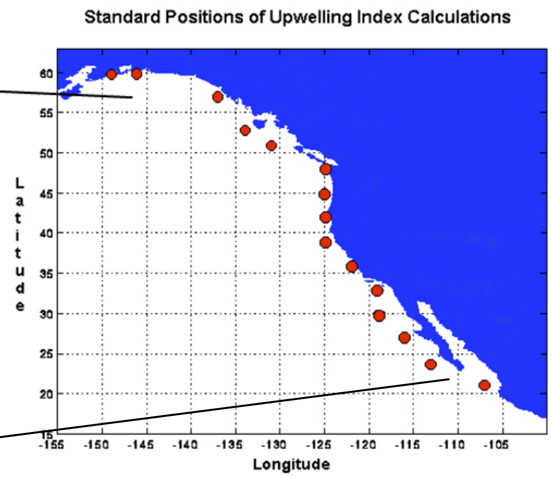
- **Statistically, ENSO leads PDO by 3-4 months, may through atmospheric bridge.**



- **Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.**
- **The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.**

North America Western Coastal Upwelling





- Recently, there were anomalous upwelling (downwelling) in the high (middle) latitudes in Mar 2018.

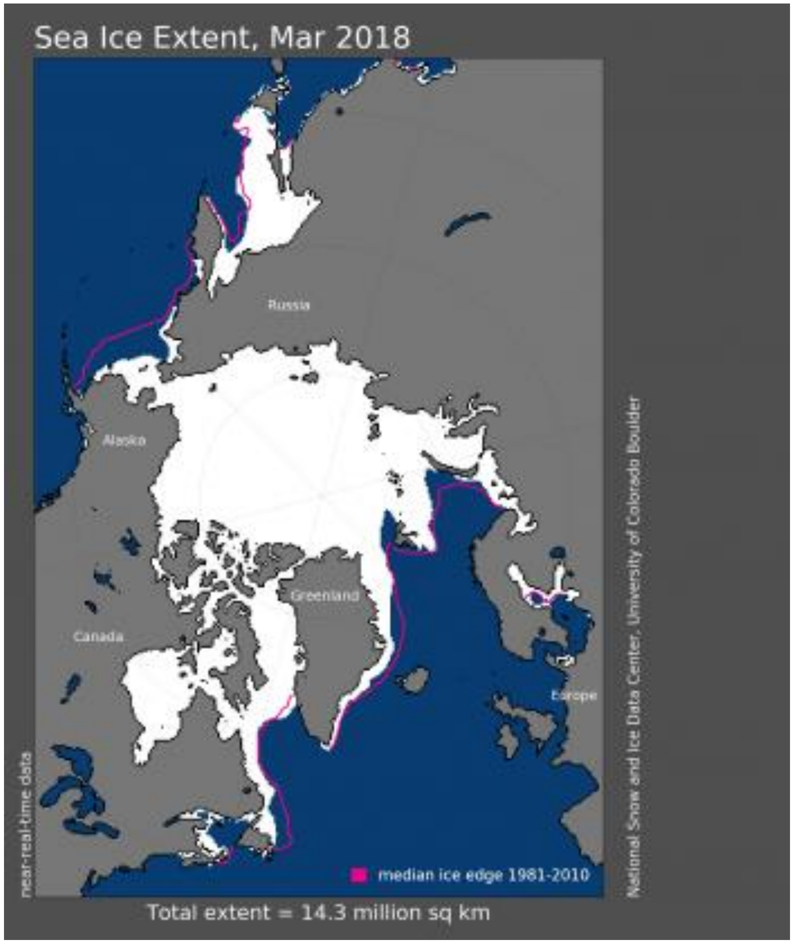
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point ($m^3/s/100m$ coastline). Anomalies are departures from the 1981-2010 base period pentad means.

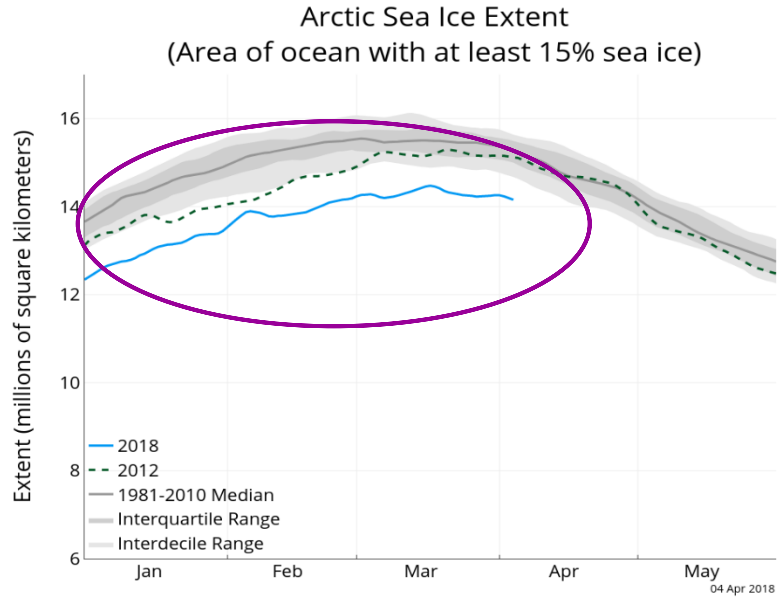
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

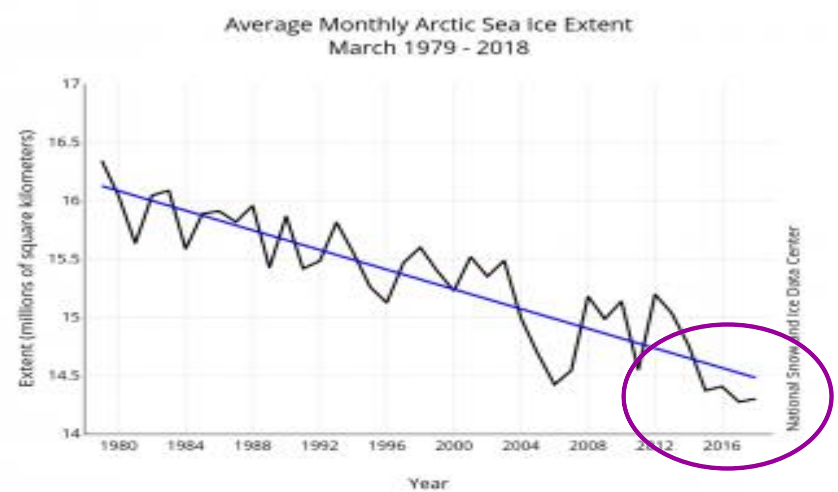
Arctic Sea Ice

National Snow and Ice Data Center

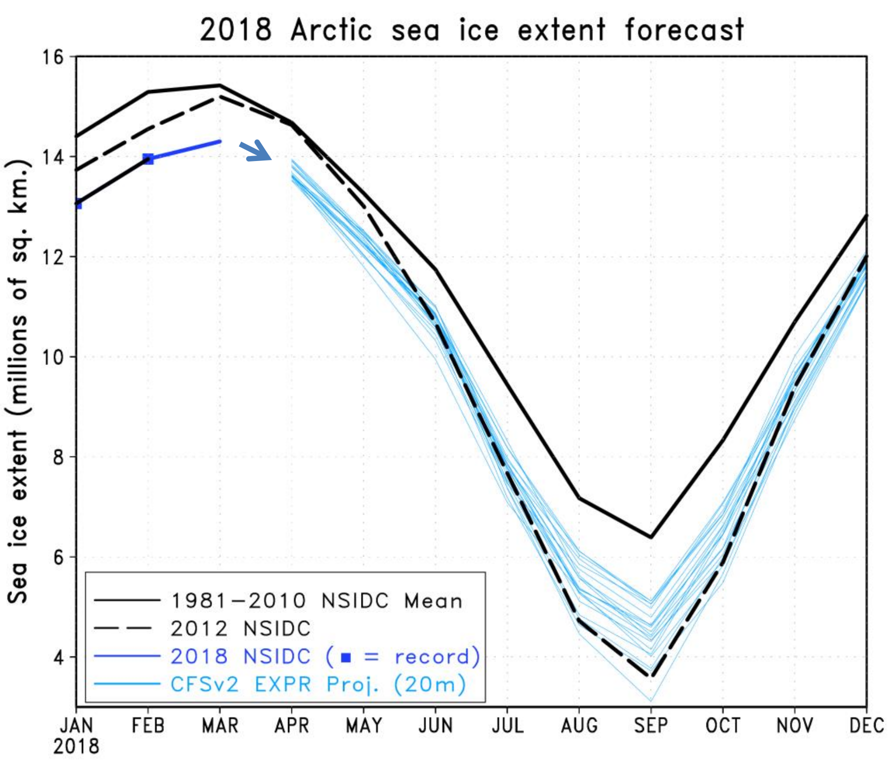
http://nsidc.org/arcticseaicenews/index.html

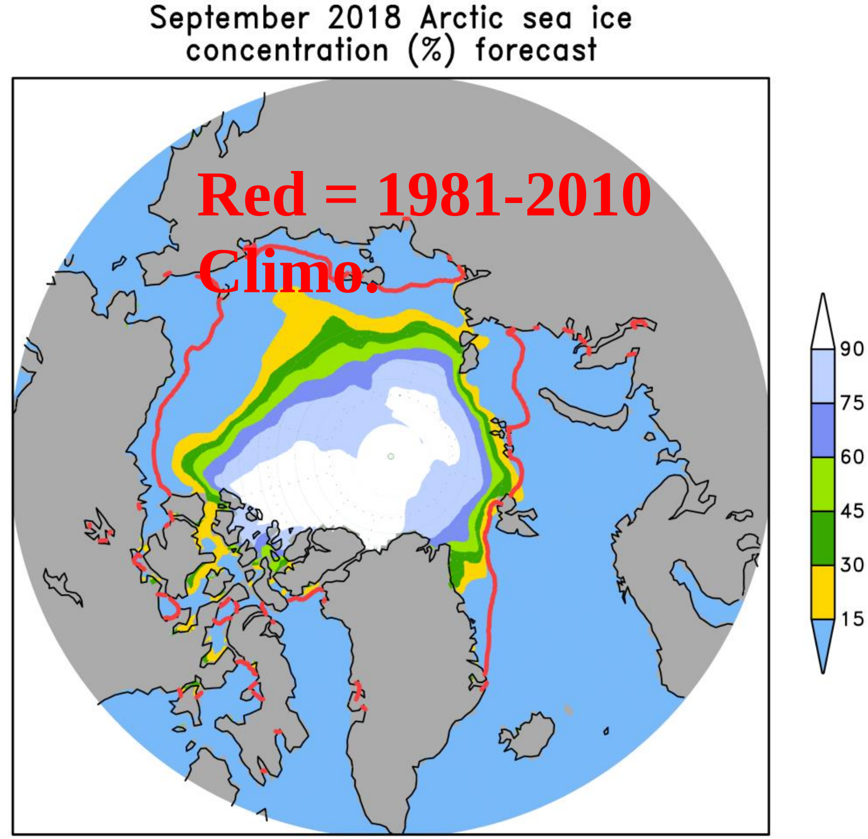


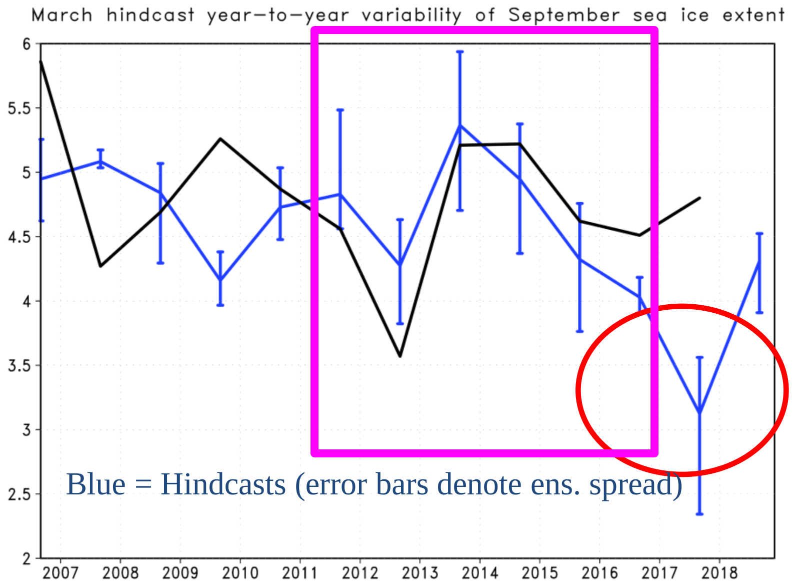




- **The 2018 winter sea ice maximum has passed, and the melt season has begun.**
- **Arctic sea ice extent for March 2018 is the 2nd lowest in the 1979 to 2018 satellite record, after the record low in 2017.**
- **The most notable aspect of the 2017 to 2018 winter ice extent was the persistently low ice extent in the Bering Sea.**







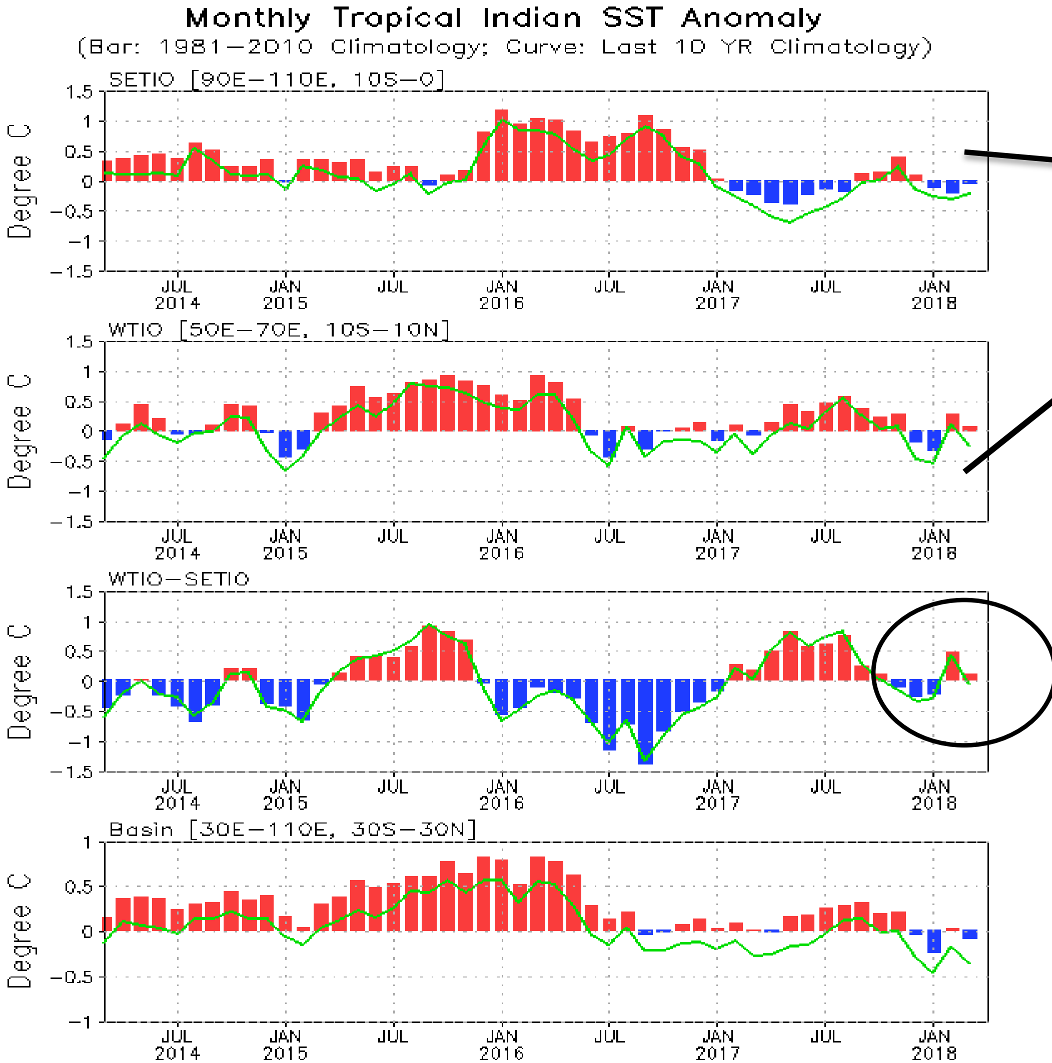
- 20-member ensemble experimental CFSv2 Arctic sea ice forecast was initialized Mar 21-25, 2018 using ICs from the CPC Sea ice Initialization System (CSIS).

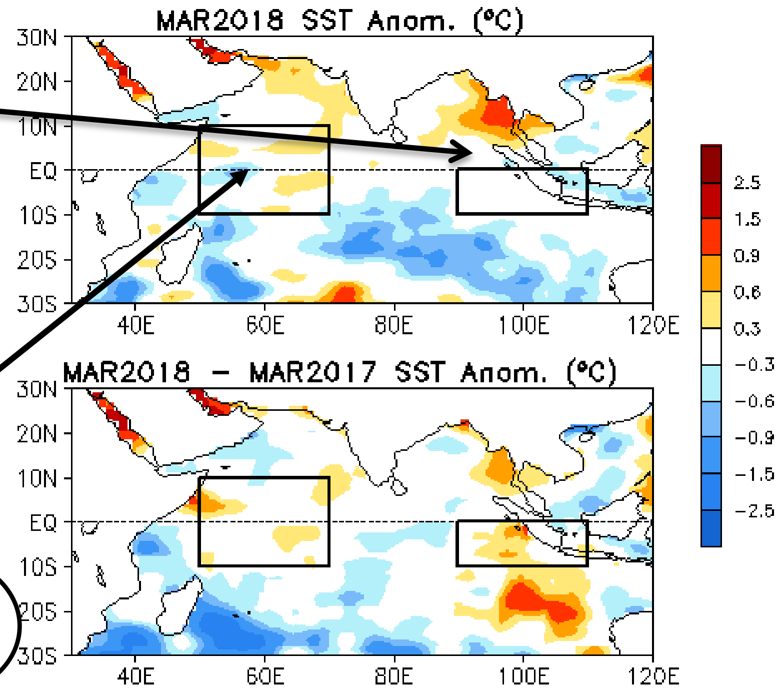
- The projected Sep Arctic sea ice extent based on this forecast is 4.44 +/- 0.51 * 10^6 km^2 (Large variability expected at long lead time).

- The 5-ensemble member historical simulations, which are used to remove biases from the forecast, show fairly good representation of year to year variability of predicted Sep sea ice extent between 2011-2016, but a very low predictive skill for 2017 (sea ice thickness was at a record low in Mar 2017). The 2018 prediction is increased relative to last year and is similar to 2015-2016.

Indian Ocean

Evolution of Indian Ocean SST Indices

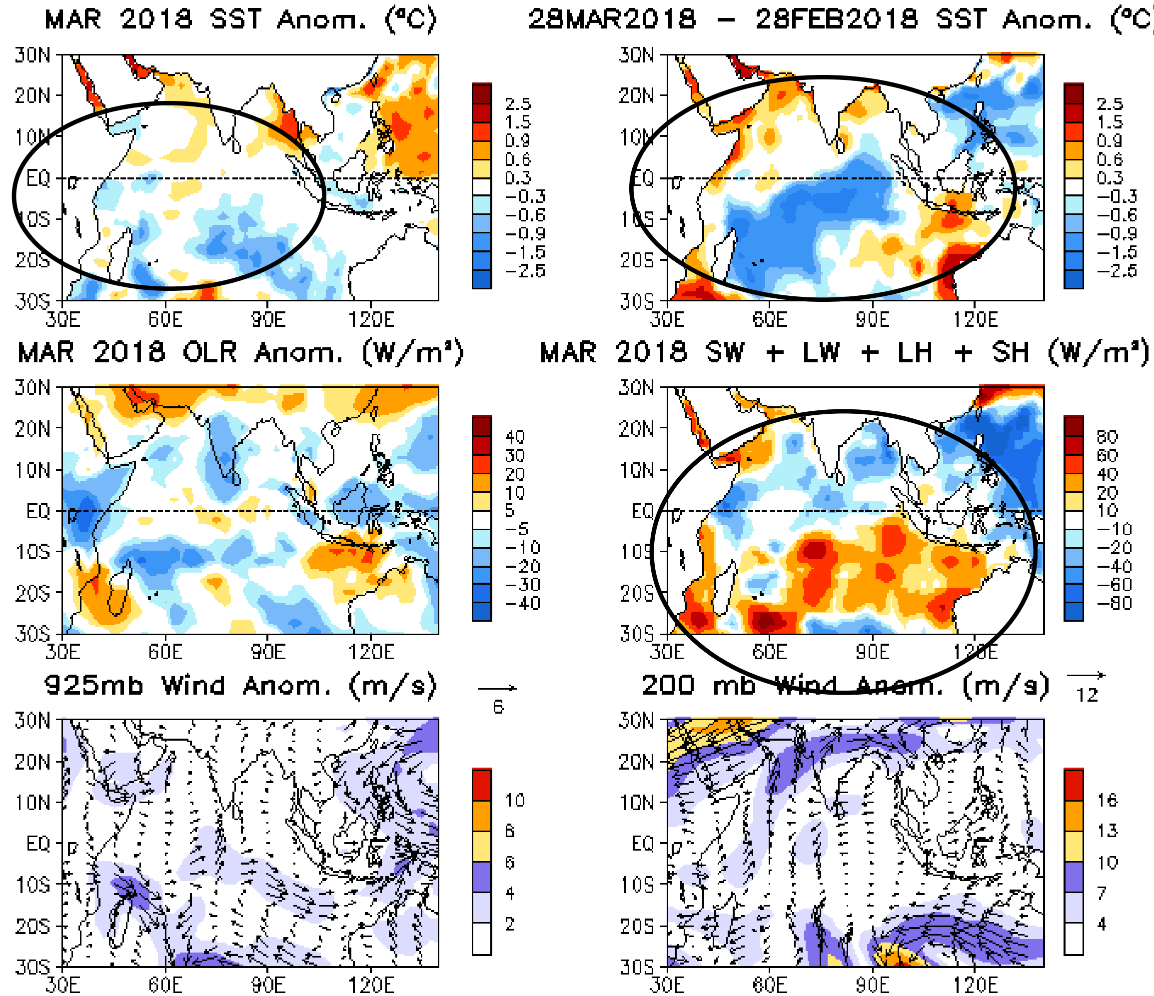




- Overall, tropical SSTAs were small.

Fig. I1a. Indian Ocean Dipole region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the SETIO [90°E-110°E, 10°S-0] and WTIO [50°E-70°E, 10°S-10°N] regions, and Dipole Mode Index, defined as differences between WTIO and SETIO. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Tropical Indian: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Wind Anom.

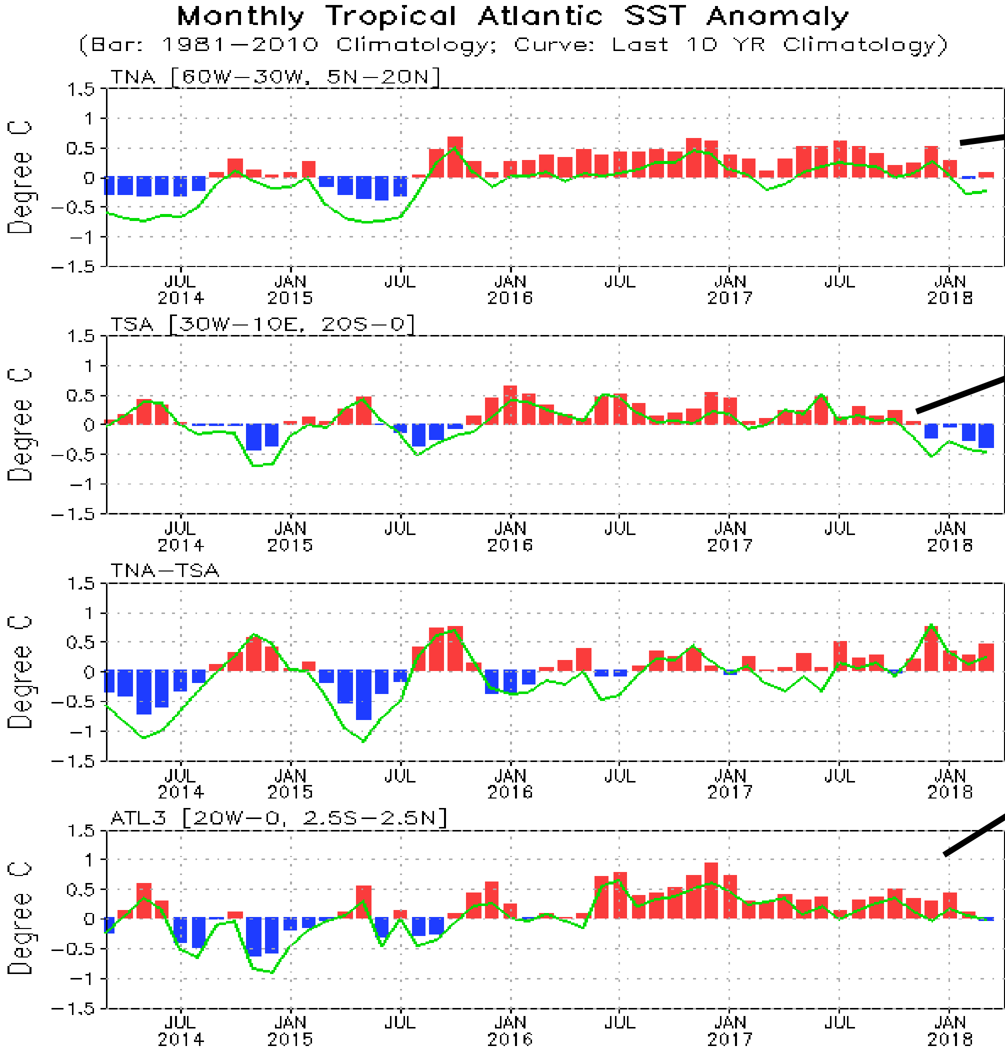


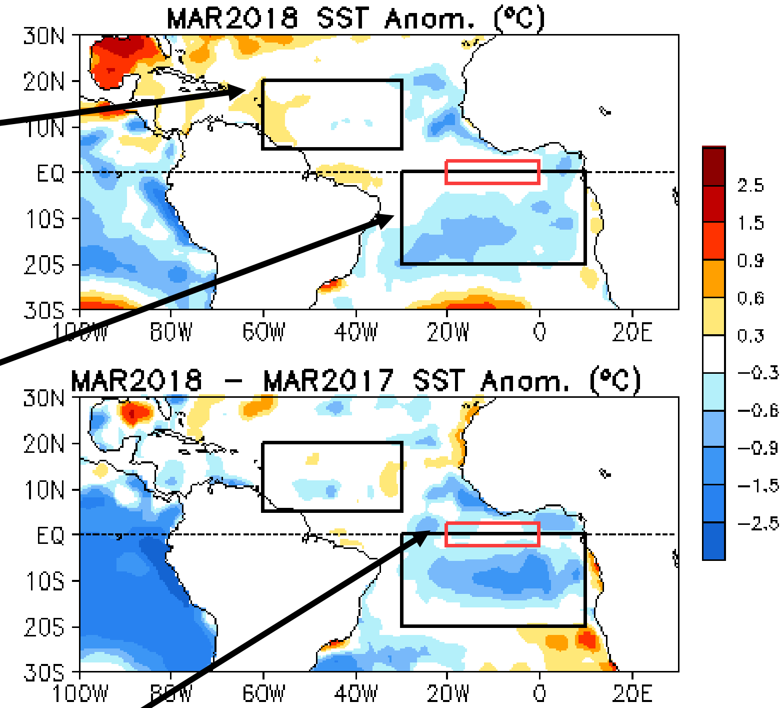
- Overall SSTAs ↘ were small in the tropics.
- SSTA tendency was partially determined by heat flux.

Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Tropical and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

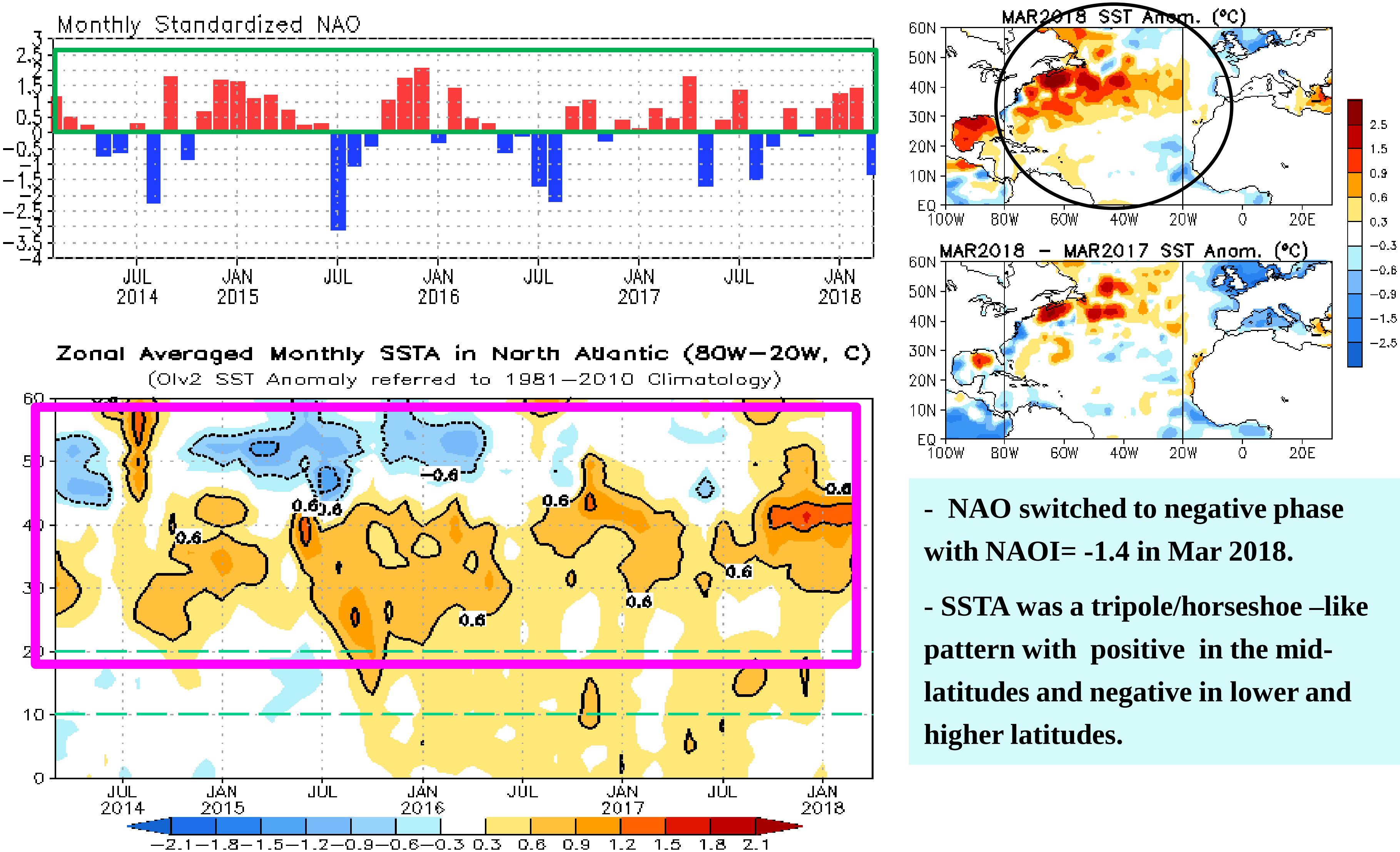




- **SSTAs were small in the equatorial and North Atlantic and negative in the South Atlantic in Mar 2018.**

Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

NAO and SST Anomaly in North Atlantic



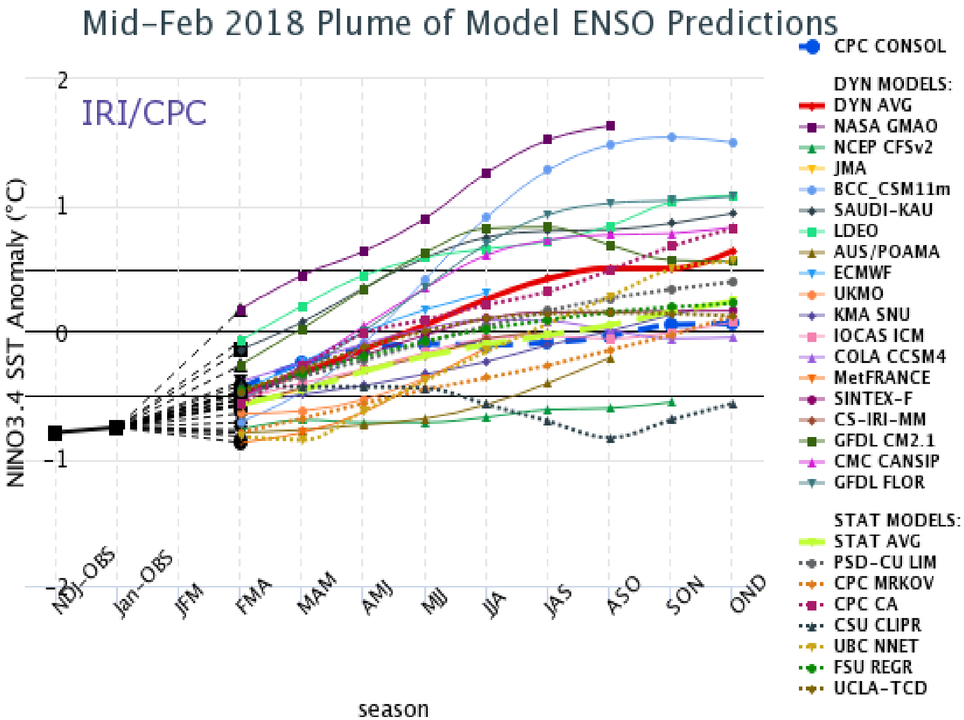
- NAO switched to negative phase with NAOI= -1.4 in Mar 2018.

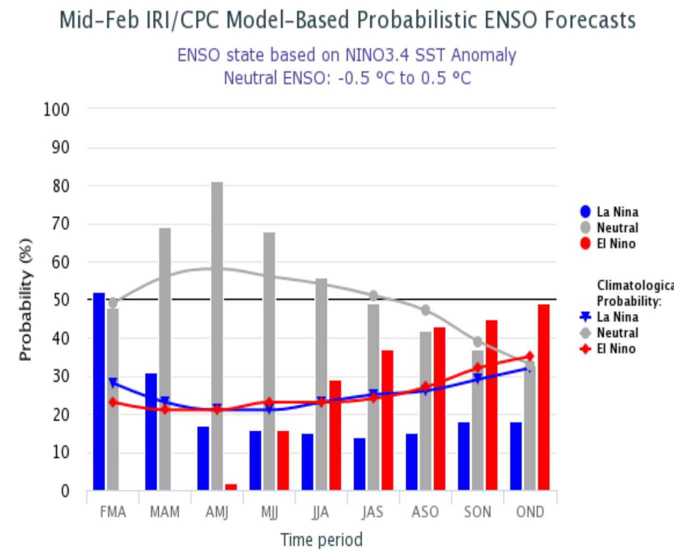
- SSTA was a tripole/horseshoe –like pattern with positive in the mid-latitudes and negative in lower and higher latitudes.

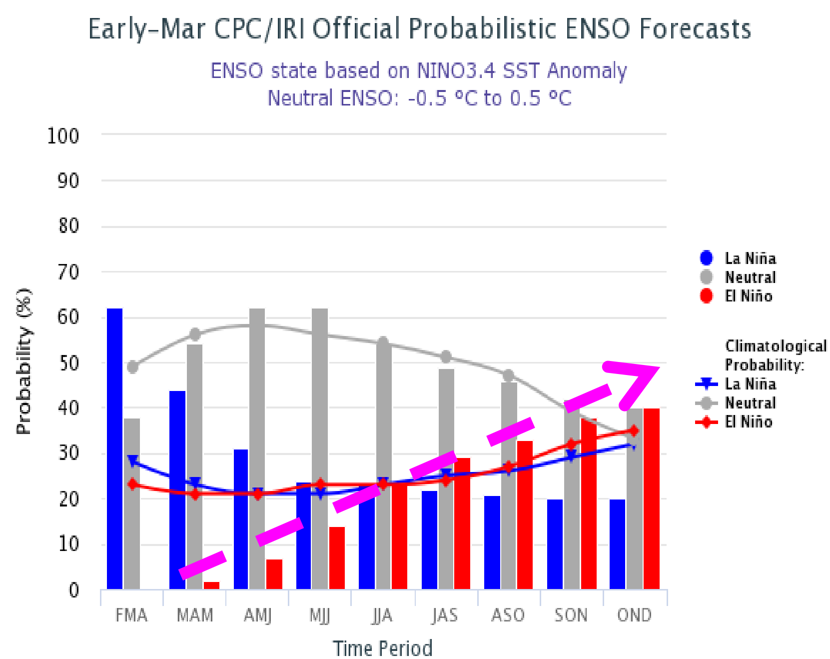
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum

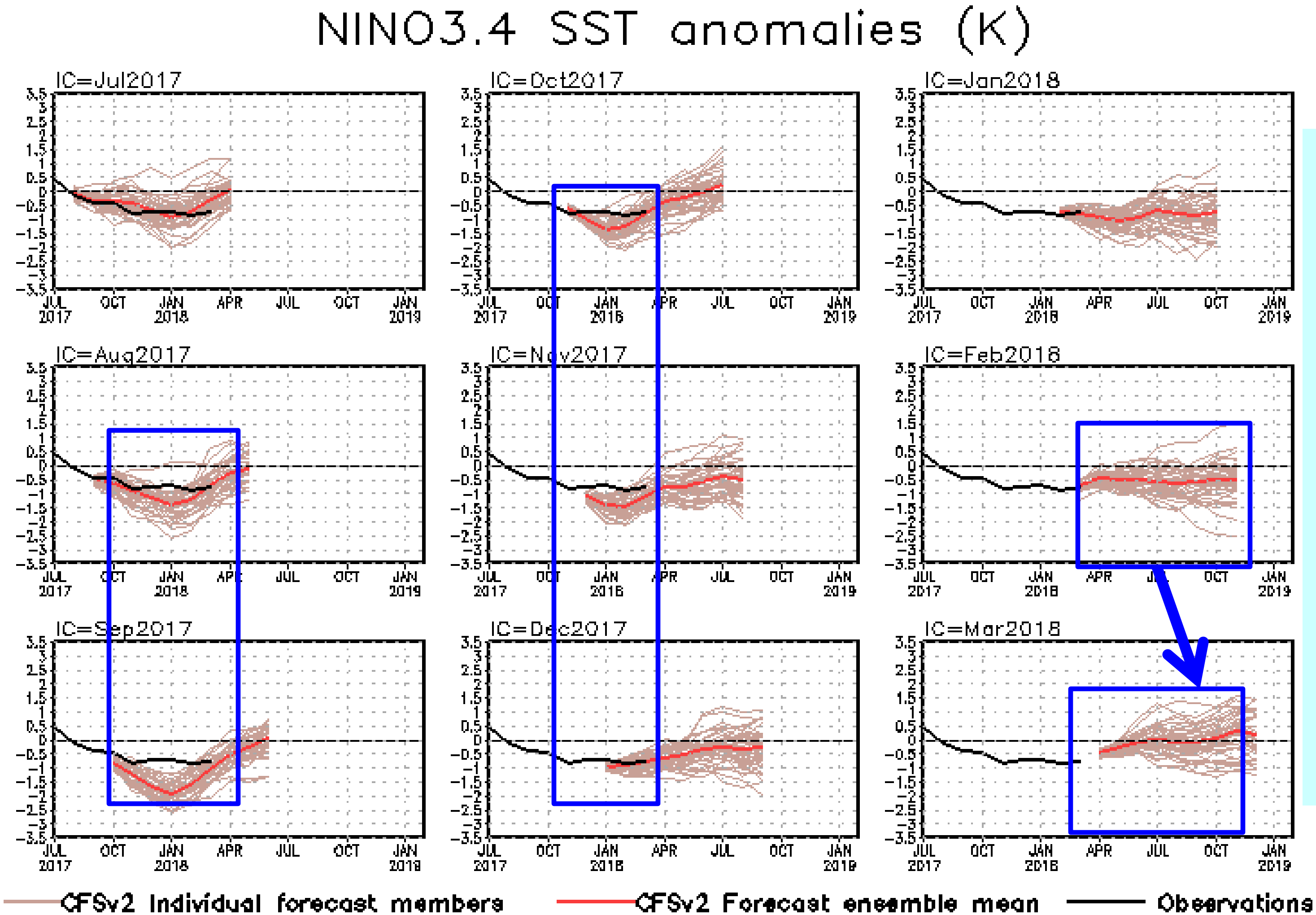






- **Majority of models predict ENSO-neutral in 2018 with a warming tendency.**
- **NOAA "ENSO Diagnostic Discussion" on 08 Mar 2018 suggested that *"A transition from La Niña to ENSO-neutral is most likely (~55% chance) during the March-May season, with neutral conditions likely to continue into the second half of the year."***

CFS Niño3.4 SST Predictions from Different Initial Months

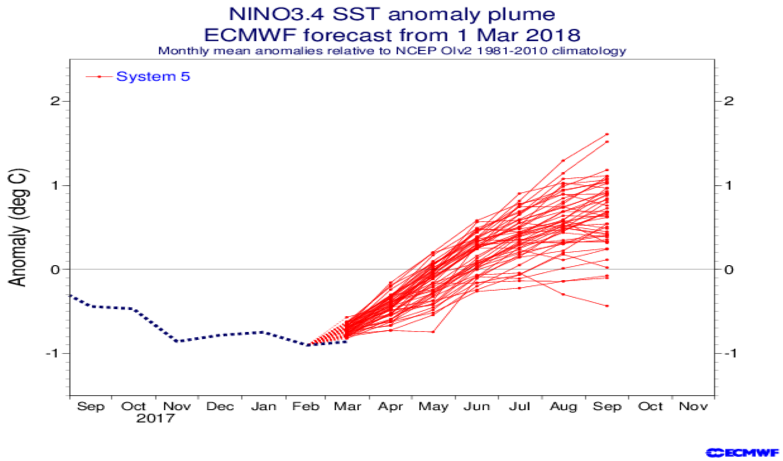


- Latest CFSv2 forecasts call for a ENSO-neutral during summer-autumn 2018.
- CFSv2 predictions had cold biases with ICs in Aug-Nov 2017.

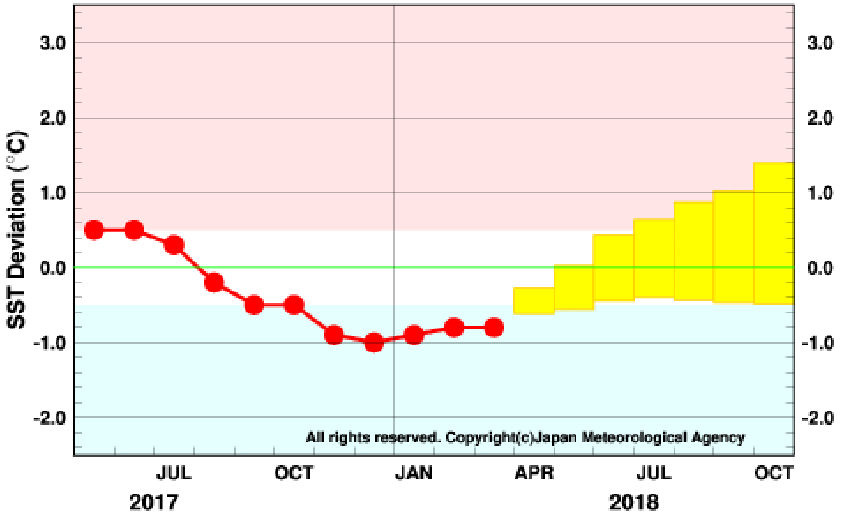
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

Individual Model Forecasts: neutral or El Nino

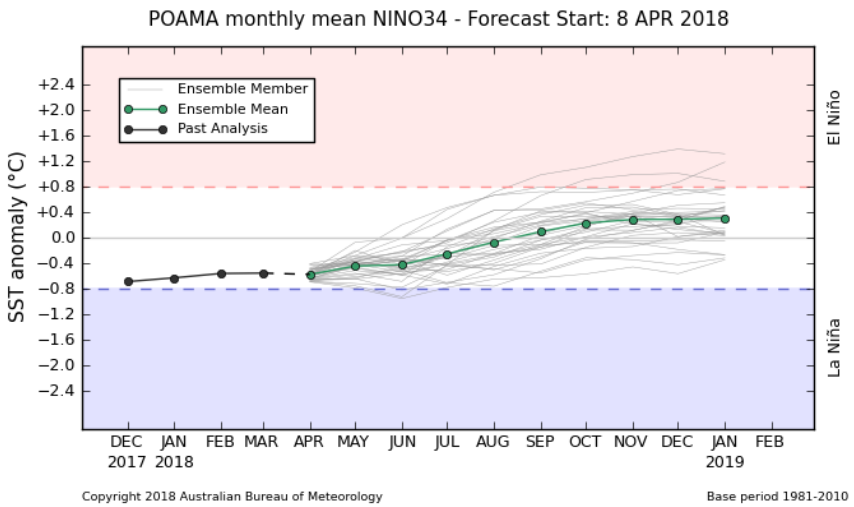
EC: Nino3.4, IC=01Mar 2018



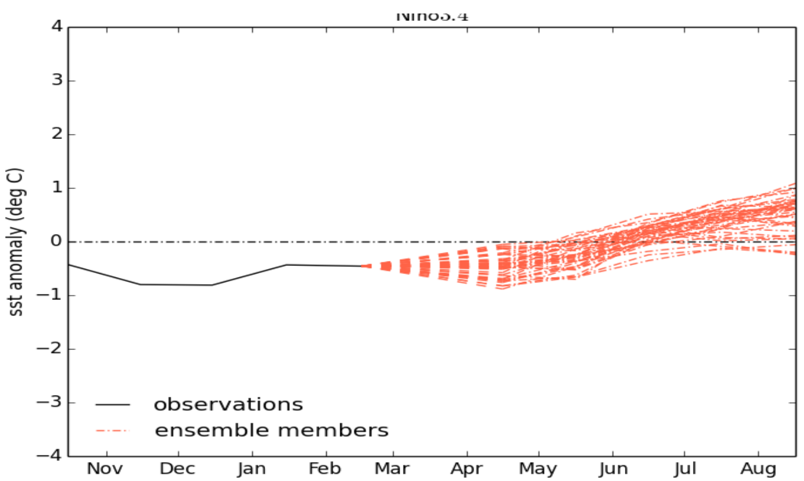
JMA: Nino3, IC/updated = 10 Apr 2018

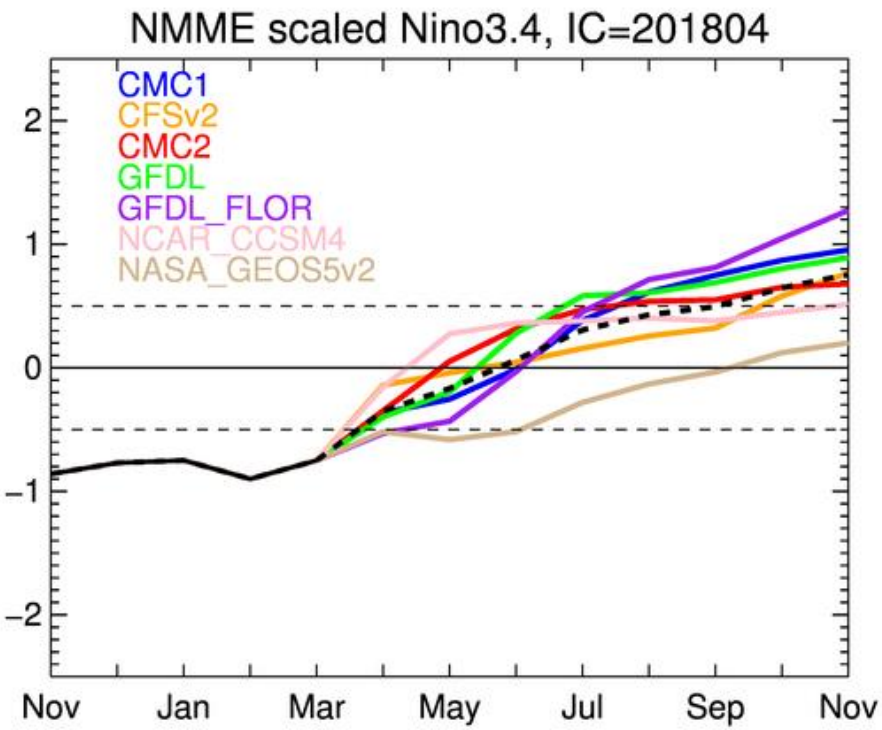


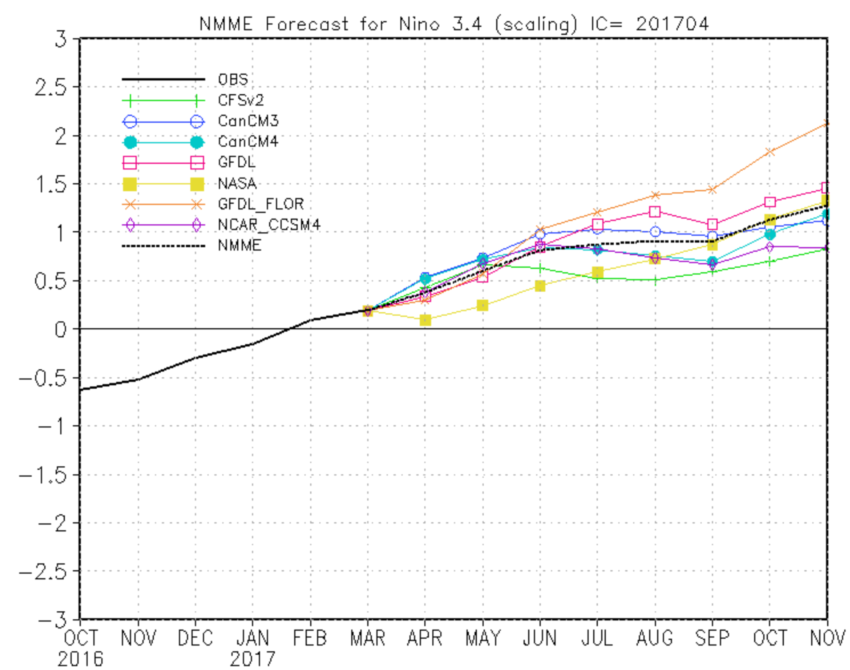
Australia: Nino3.4, IC=8 Apr 2018

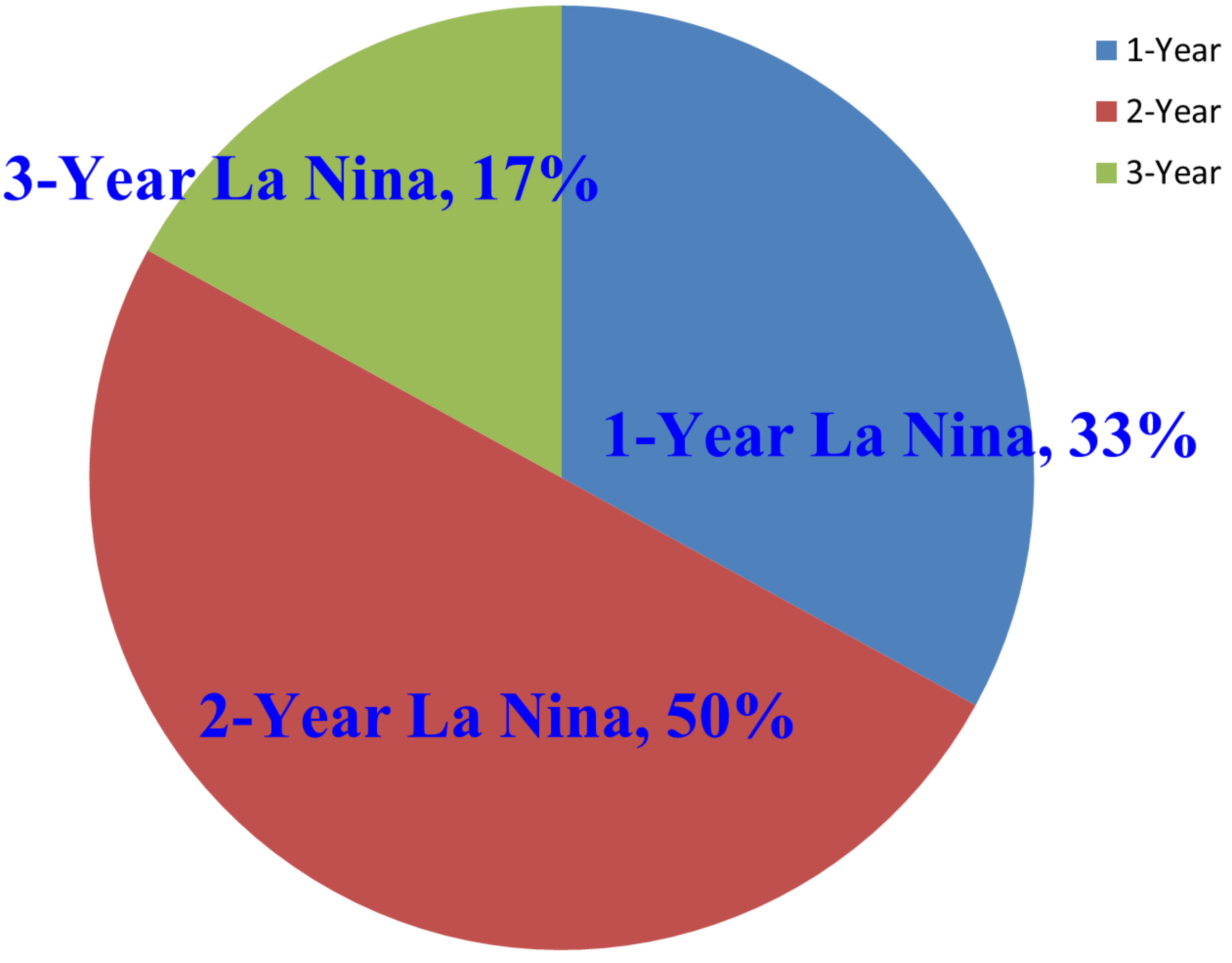


UKMO: Nino3.4, IC=Mar 2018




NMME scaled Nino3.4, IC=201804
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
2
1
0
−1
−2
Nov
Jan
Mar
May
Jul
Sep
Nov


NMME Forecast for Nino 3.4 (scaling) IC= 201704
OBS
CFSv2
CanCM3
CanCM4
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
OCT 2016
NOV
DEC
JAN 2017
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV

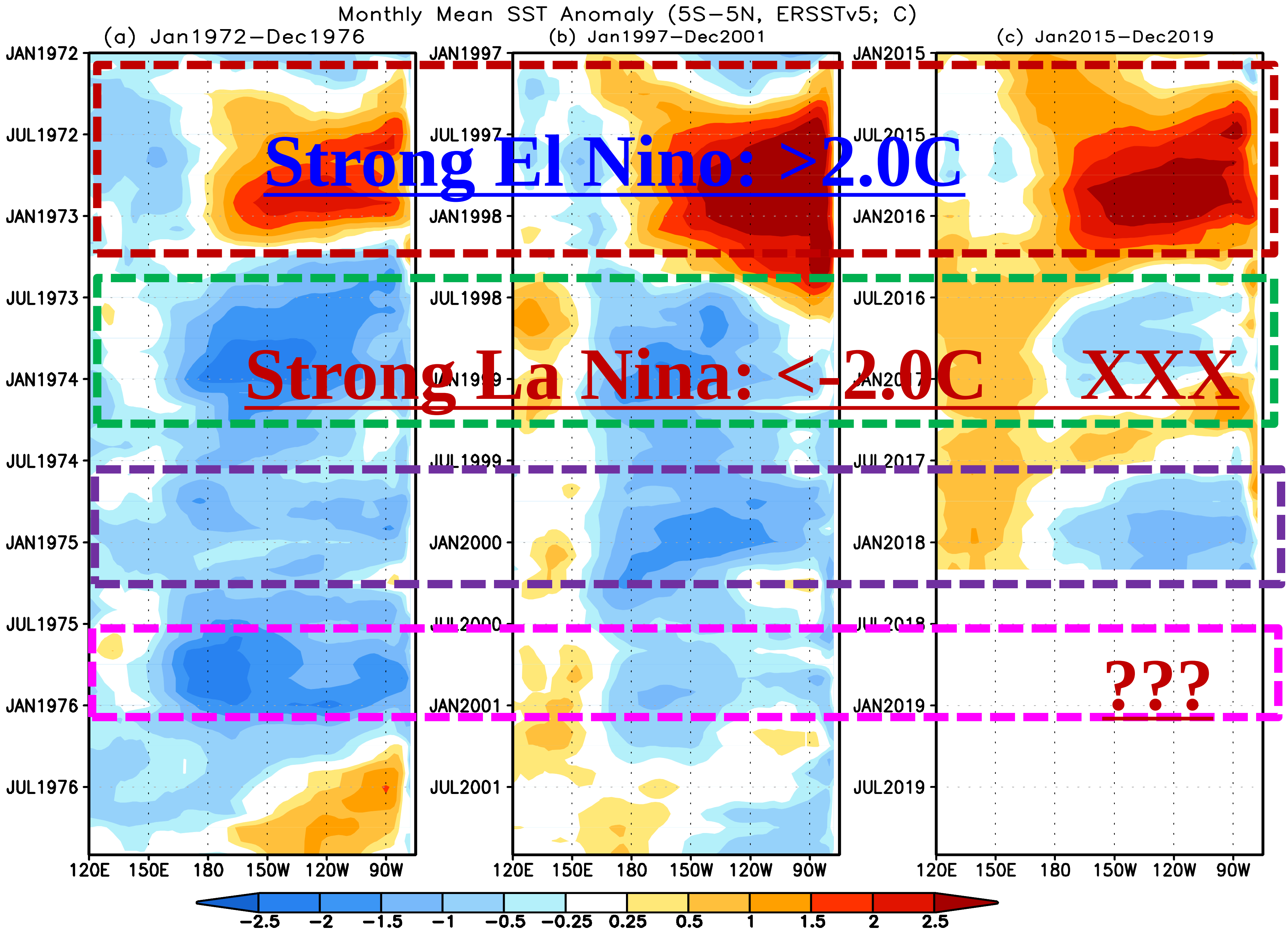

1-Year
2-Year
3-Year
3-Year La Nina, 17%
1-Year La Nina, 33%
2-Year La Nina, 50%

According to ENSO definition of CPC/NCEP/NOAA

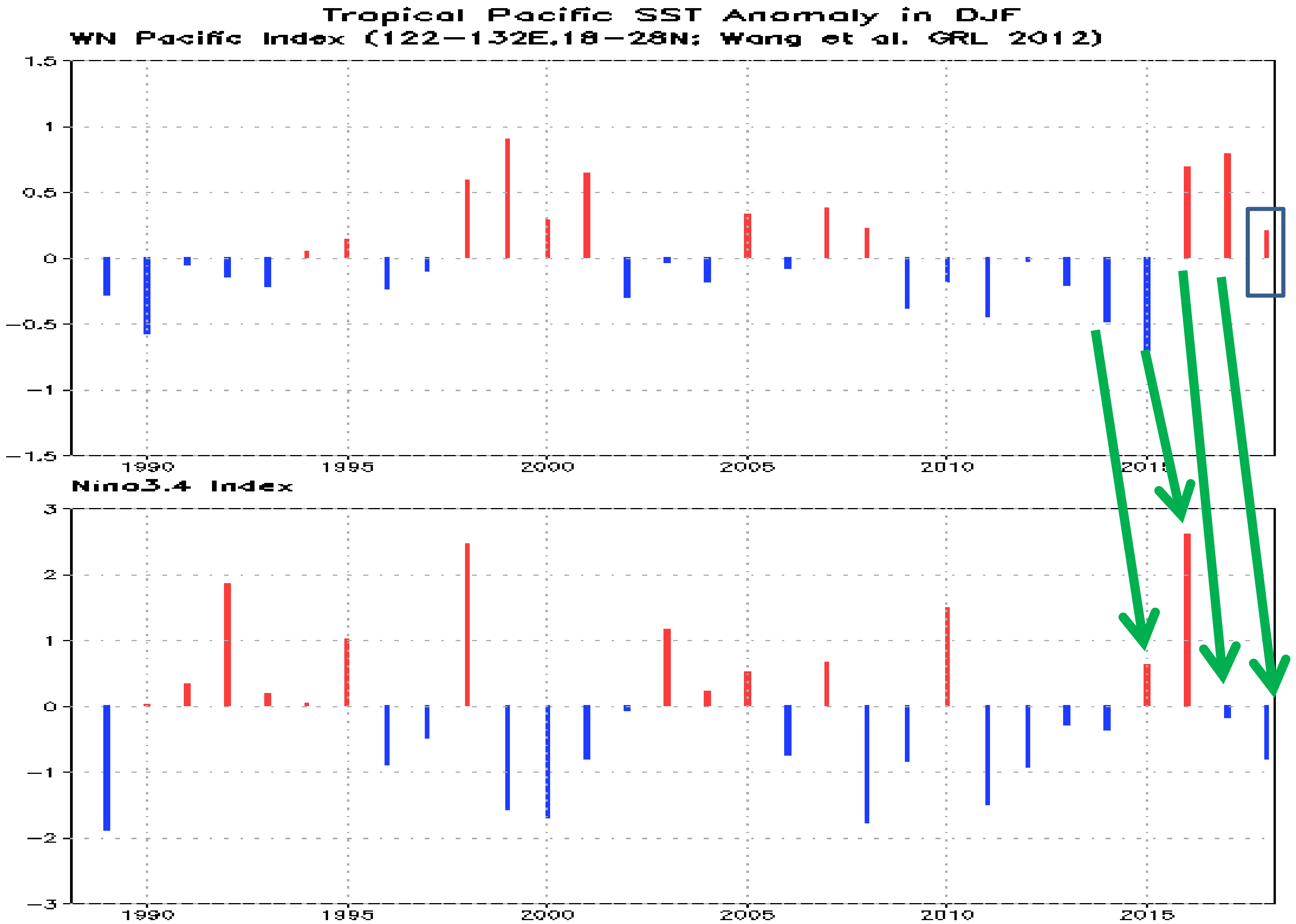
(http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php)

Since 1951, there are total 12 La Niñas

1. 2 three-year Niñas (17%): 1973/76, 1998/2001
2. 6 two-year La Niñas (50%): 1954/56; 1970/72; 1983/85; 2007/09; 2010/12; *2016/18?*
3. 4 one-year La Niñas (33%): 1964/65; 1988/89; 1995/96; 2005/06



Monthly Mean SST Anomaly (5S–5N, ERSSTv5; C)
(a) Jan1972–Dec1976
(b) Jan1997–Dec2001
(c) Jan2015–Dec2019
JAN1972
JUL1972
JAN1973
JUL1973
JAN1974
JUL1974
JAN1975
JUL1975
JAN1976
JUL1976
JAN1997
JUL1997
JAN1998
JUL1998
JUL1999
JAN2000
JUL2000
JAN2001
JUL2001
JAN2015
JUL2015
JAN2016
JUL2016
JUL2017
JAN2018
JUL2018
JAN2019
JUL2019
120E 150E 180 150W 120W 90W
Strong El Nino: >2.0C
Strong La Nina: <-2.0C XXX
???
–2.5 –2 –1.5 –1 –0.5 –0.25 0.25 0.5 1 1.5 2 2.5



Wang, S.-Y., M. L'Heureux, and H.-H. Chia, 2012: ENSO prediction one year in advance using western North Pacific sea surface temperatures. Geophys. Res. Lett., 39, L05702.

Review of 2017/18 La Nina Predictions

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by

CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society

14 September 2017

ENSO Alert System Status: La Niña Watch

<u>Synopsis:</u> **There is an increasing chance (~55-60%) of La Niña during the Northern Hemisphere fall and winter 2017-18.**

Over the last month, equatorial sea surface temperatures (SSTs) were near-to-below average across the central and eastern Pacific Ocean (Fig. 1). ENSO-neutral conditions were apparent in the weekly fluctuation of Niño-3.4 SST index values between -0.1°C and -0.6°C (Fig. 2). While temperature anomalies were variable at the surface, they became increasingly negative in the sub-surface ocean (Fig. 3), due to the shoaling of the thermocline across the east-central and eastern Pacific (Fig. 4). Though remaining mostly north of the equator, convection was suppressed over the western and central Pacific Ocean and slightly enhanced near Indonesia (Fig. 5). The low-level trade winds were stronger than average over a small region of the far western tropical Pacific Ocean, and upper-level winds were anomalously easterly over a small area of the east-central Pacific. Overall, the ocean and atmosphere system remains consistent with ENSO-neutral.

A majority of the models contained in the IRI/CPC suite of Niño-3.4 predict ENSO-neutral through the Northern Hemisphere 2017-18 winter (Fig. 6). However, the most recent predictions from the NCEP Climate Forecast System (CFSv2) and the North American Multi-Model Ensemble (NMME) favor the formation of La Niña as soon as the Northern Hemisphere fall 2017 (Fig. 7). Forecasters favor these predictions in part because of the recent cooling of surface and sub-surface temperature anomalies, and also because of the higher degree of forecast skill at this time of year. In summary, there is an increasing chance (~55-60%) of La Niña during the Northern Hemisphere fall and winter 2017-18 (click CPC/IRI consensus forecast for the chance of each outcome for each 3-month period).

This discussion is a consolidated effort of the National Oceanic and Atmospheric Administration (NOAA), NOAA's National Weather Service, and their funded institutions. Oceanic and atmospheric conditions are updated weekly on the Climate Prediction Center web site (El Niño/La Niña Current Conditions and Expert Discussions). Forecasts are also updated monthly in the Forecast Forum of CPC's Climate Diagnostics Bulletin. Additional perspectives and analysis are also available in an ENSO blog. The next ENSO Diagnostics Discussion is scheduled for 12 October 2017. To receive an e-mail notification when the monthly ENSO Diagnostic Discussions are released, please send an e-mail message to: ncep.list.enso-update@noaa.gov.

Climate Prediction Center
National Centers for Environmental Prediction
NOAA/National Weather Service
College Park, MD 20740

NOAA/NCEP/CPC issued La Niña Watch on 14 September 2017

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by

CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society
9 November 2017

ENSO Alert System Status: La Niña Advisory

Synopsis: La Niña conditions are predicted to continue (~65-75% chance) at least through the Northern Hemisphere winter 2017-18.

During October, weak La Niña conditions emerged as reflected by below-average sea surface temperatures (SSTs) across most of the central and eastern equatorial Pacific Ocean (Fig. 1). The weekly Niño indices were variable during the month, with values near -0.5° C during the past week in the Niño-3.4 and Niño-3 regions (Fig. 2). Sub-surface temperatures remained below average during October (Fig. 3), reflecting the anomalously shallow depth of the thermocline across the central and eastern Pacific (Fig. 4). Also, convection was suppressed near the International Date Line and slightly enhanced over parts of the Maritime Continent and the Philippines (Fig. 5). Over the equatorial Pacific Ocean, low-level trade winds were mainly near average, but the upper-level winds were strongly anomalously westerly and the Southern Oscillation Index was positive. Overall, the ocean and atmosphere system reflects the onset of La Niña conditions.

For the remainder of the Northern Hemisphere fall and winter 2017-18, a weak La Niña is favored in the model averages of the IRI/CPC plume (Fig. 6) and also in the North American Multi-Model Ensemble (NMME) (Fig. 7). The consensus of forecasters is for the event to continue through approximately February-April 2018. In summary, La Niña conditions are predicted to continue (~65-75% chance) at least through the Northern Hemisphere winter (click CPC/IRI consensus forecast for the chance of each outcome for each 3-month period).

La Niña is likely to affect temperature and precipitation across the United States during the upcoming months (the 3-month seasonal temperature and precipitation outlooks will be updated on Thursday November 16th). The outlooks generally favor above-average temperatures and below-median precipitation across the southern tier of the United States, and below-average temperatures and above-median precipitation across the northern tier of the United States.

This discussion is a consolidated effort of the National Oceanic and Atmospheric Administration (NOAA), NOAA's National Weather Service, and their funded institutions. Oceanic and atmospheric conditions are updated weekly on the Climate Prediction Center web site (El Niño/La Niña Current Conditions and Expert Discussions). Forecasts are also updated monthly in the Forecast Forum of CPC's Climate Diagnostics Bulletin. Additional perspectives and analysis are also available in an ENSO blog. The next ENSO Diagnostics Discussion is scheduled for 14 December 2017. To receive an e-mail notification when the monthly ENSO Diagnostic Discussions are released, please send an e-mail message to: ncep.list.enso-update@noaa.gov.

Climate Prediction Center
National Centers for Environmental Prediction
NOAA/National Weather Service
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NOAA/NCEP/CPC issued La Niña Watch on 14 September 2017

NOAA/NCEP/CPC issued La Niña Advisory on 9 November 2017

NOAA/NCEP/CPC issued La Niña Watch on 14 September 2017

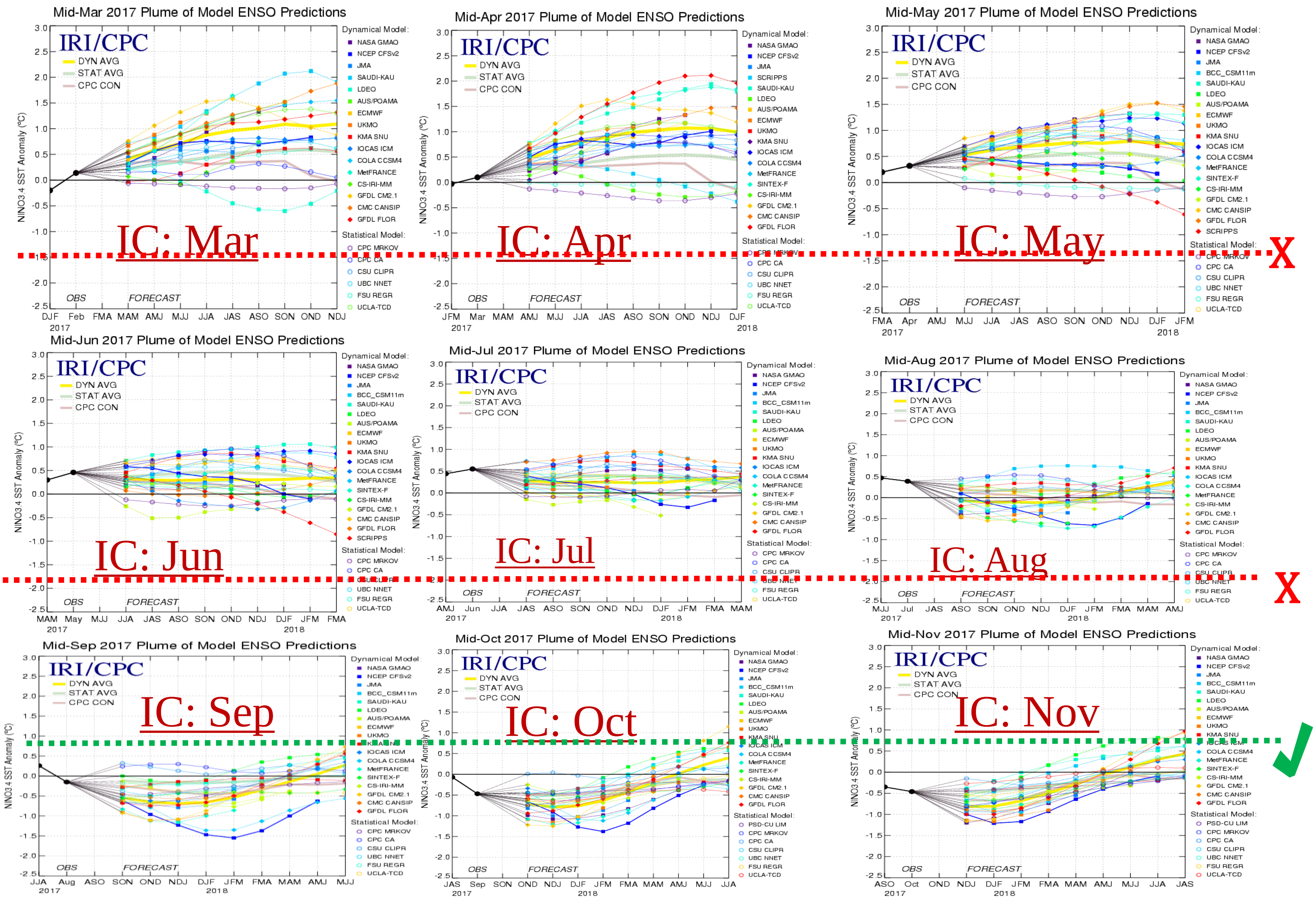
NOAA/NCEP/CPC issued La Niña Advisory on 9 November 2017

Season (Nino3.4)	SON17	OND17	NDJ17/18	DJF17/18	JFM18	
ERSSTv5	**-0.7**	**-0.9**	**-1.0**	**-0.9**	**-0.8**	✓
OIv2	**-0.6**	**-0.7**	**-0.8**	**-0.8**	**-0.8**	✓

A threshold of +/- 0.5°C for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v5 SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W)] is met for a minimum of 5 consecutive over-lapping seasons, based on centered 30-year base periods updated every 5 years.

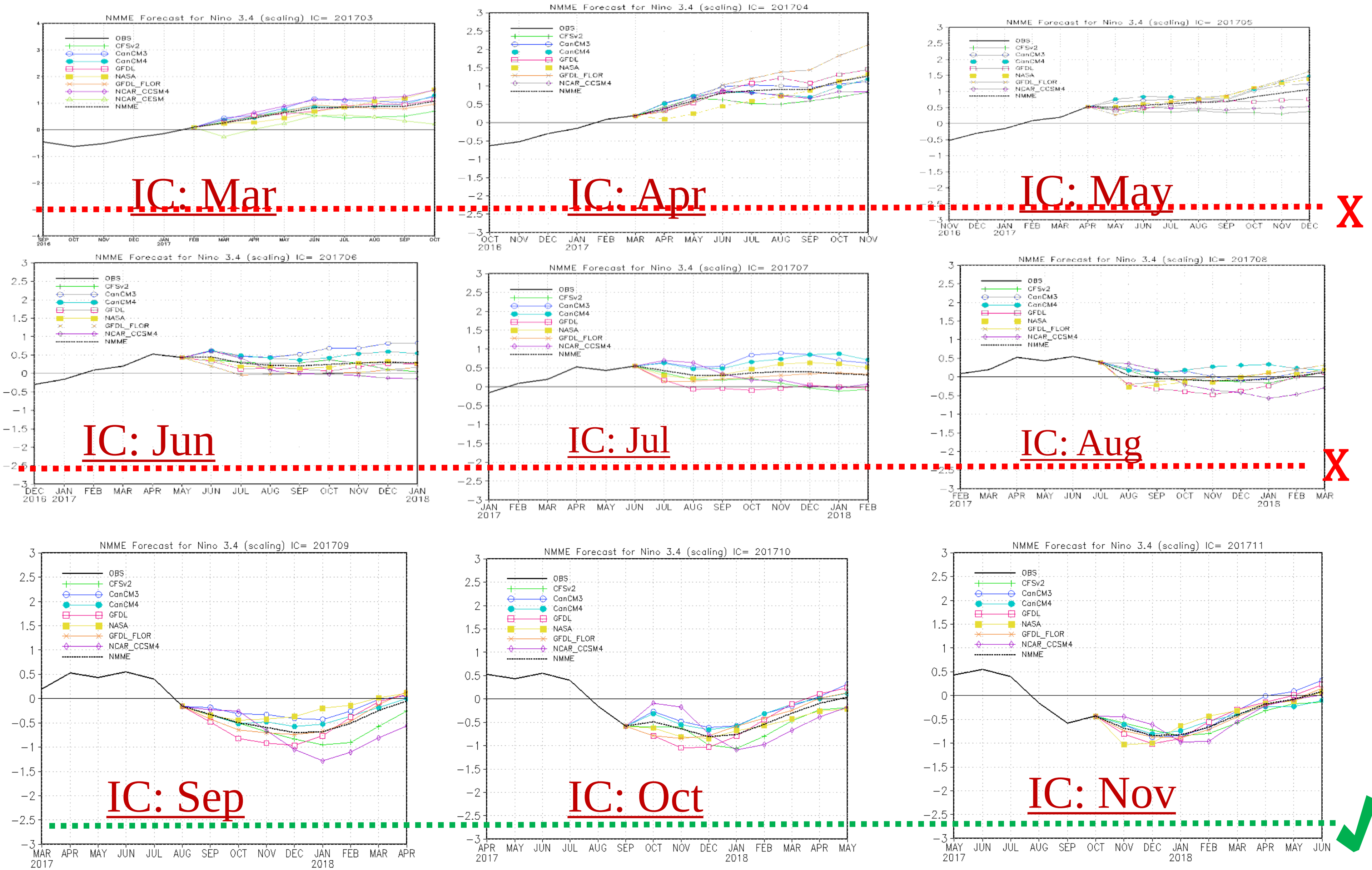
Large Uncertainty: IRI/CPC ENSO Plume with ICs in Mar-Nov 2017

(https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table)



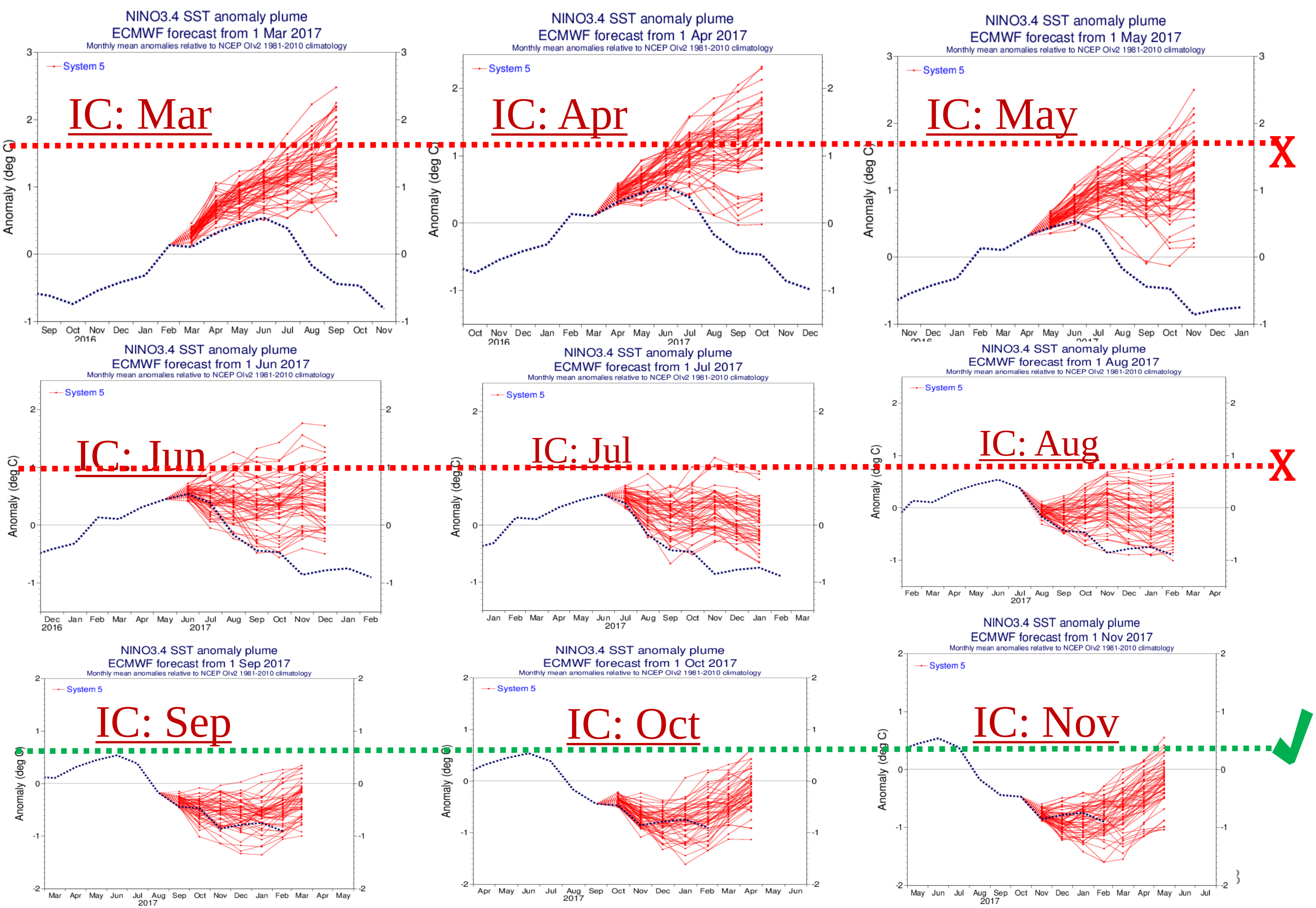
Large Uncertainty: 7 NMME Models with ICs in Mar-Nov 2017

(http://www.cpc.ncep.noaa.gov/products/NMME/)



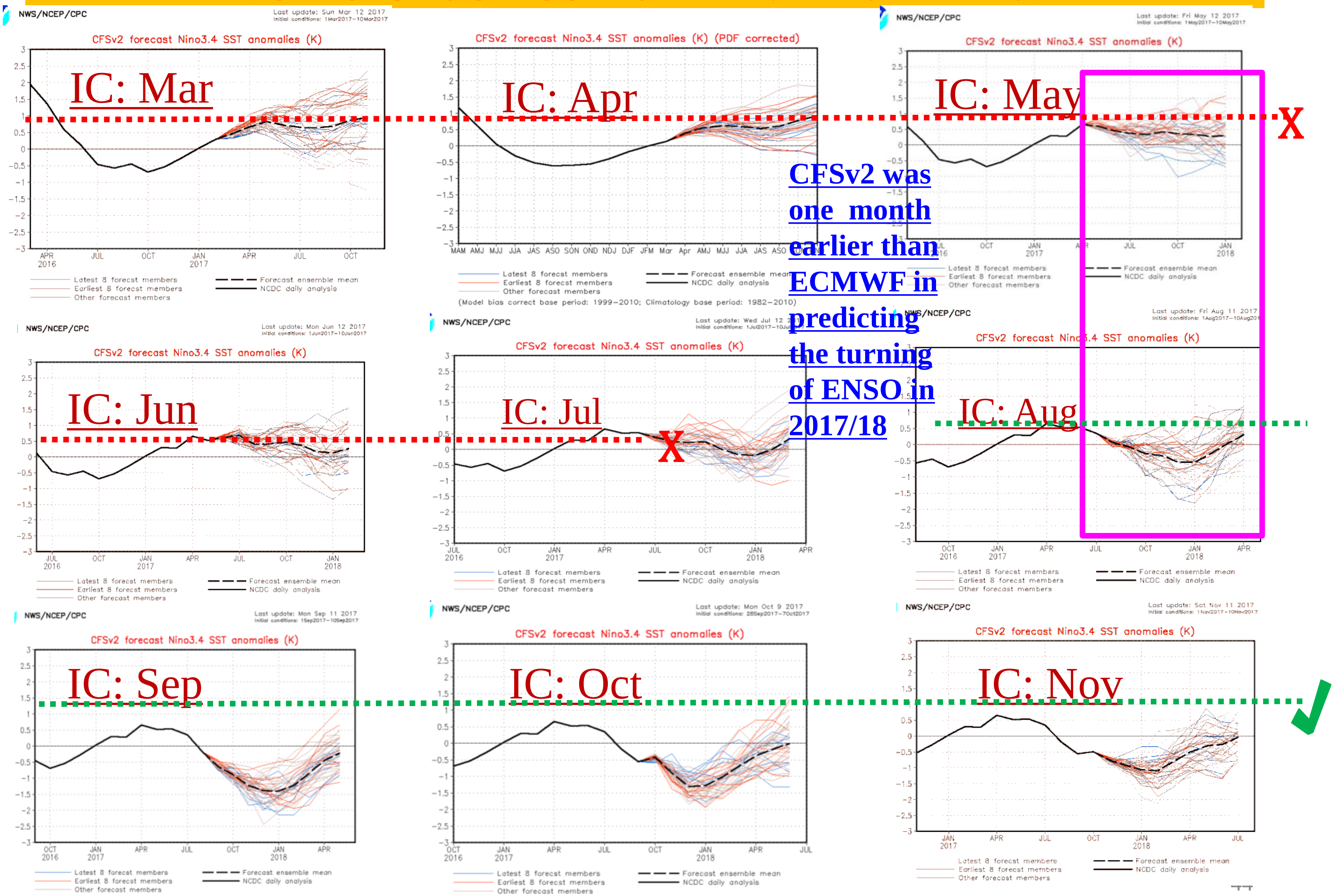
ECMWF Model with ICs in Mar-Nov 2017

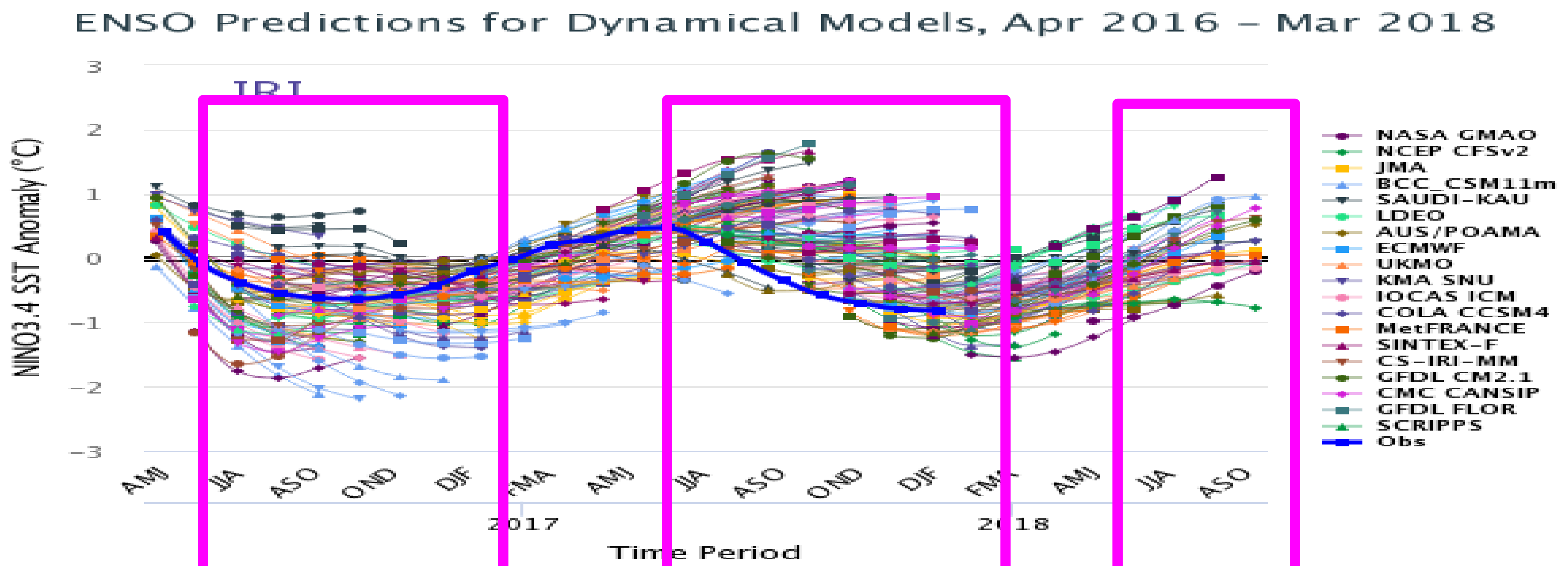
(https://www.ecmwf.int/en/forecasts/charts/catalogue/seasonal_system5_public_nino_plumes?facets=undefined&time=2017110100,0,2017110100&nino_area=NINO3-4)

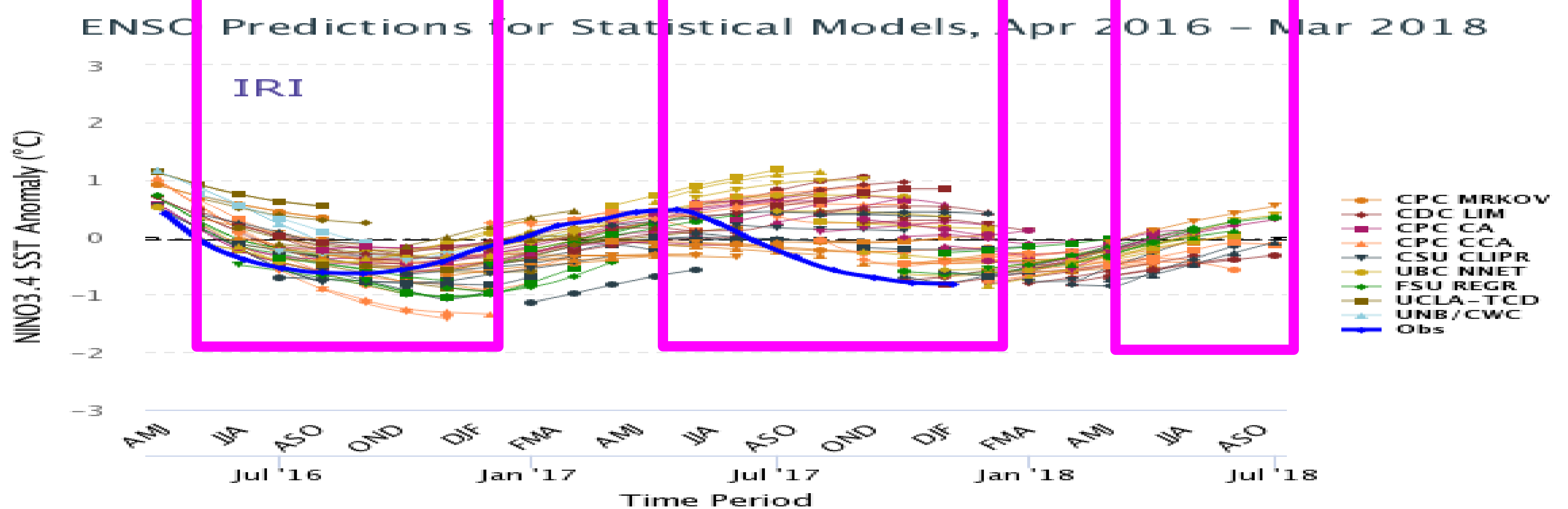


NOAA/NCEP CFSV2 Model with ICs in Mar-Nov 2017

(http://www.cpc.ncep.noaa.gov/products/people/wwang/cfsv2_fcst_history/201711/imagesInd3/nino34Mon.gif)







https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table

Markov Model Niño3.4 Predictions from Different Initial Months

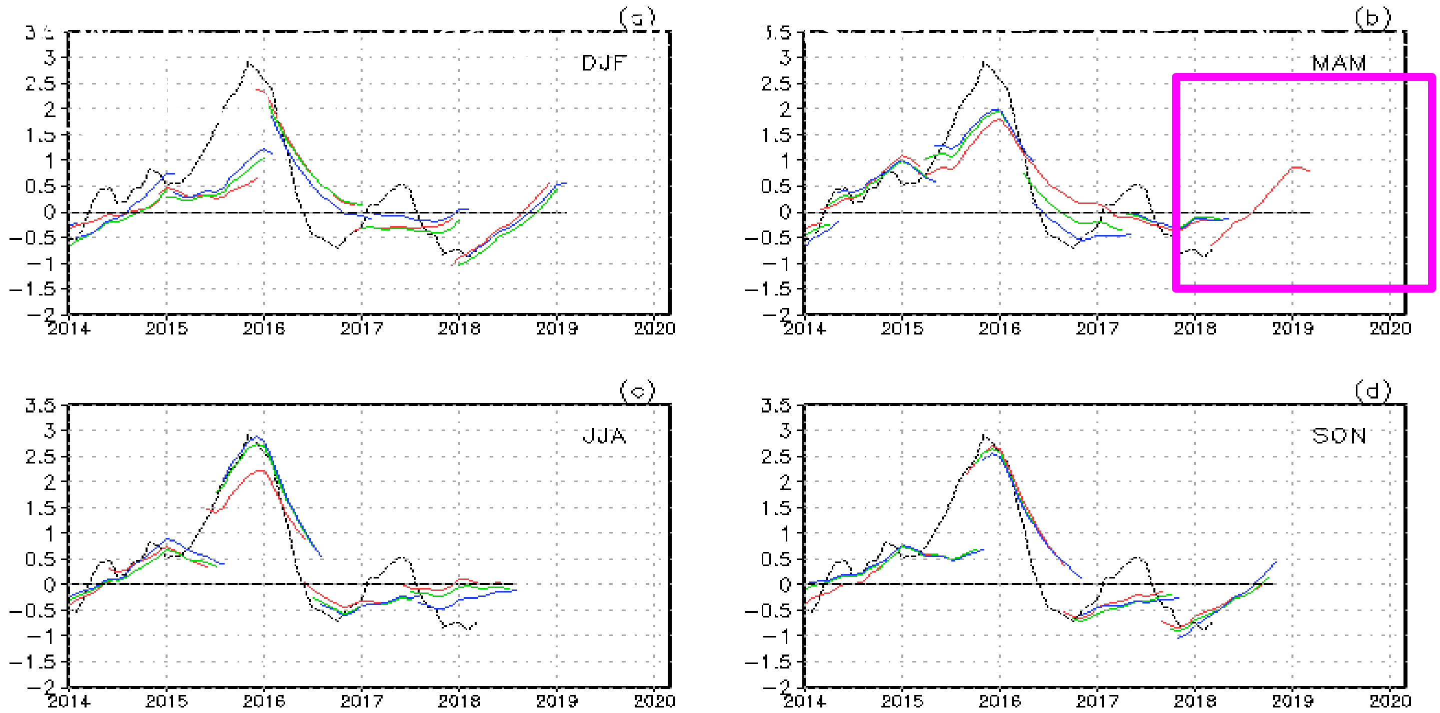
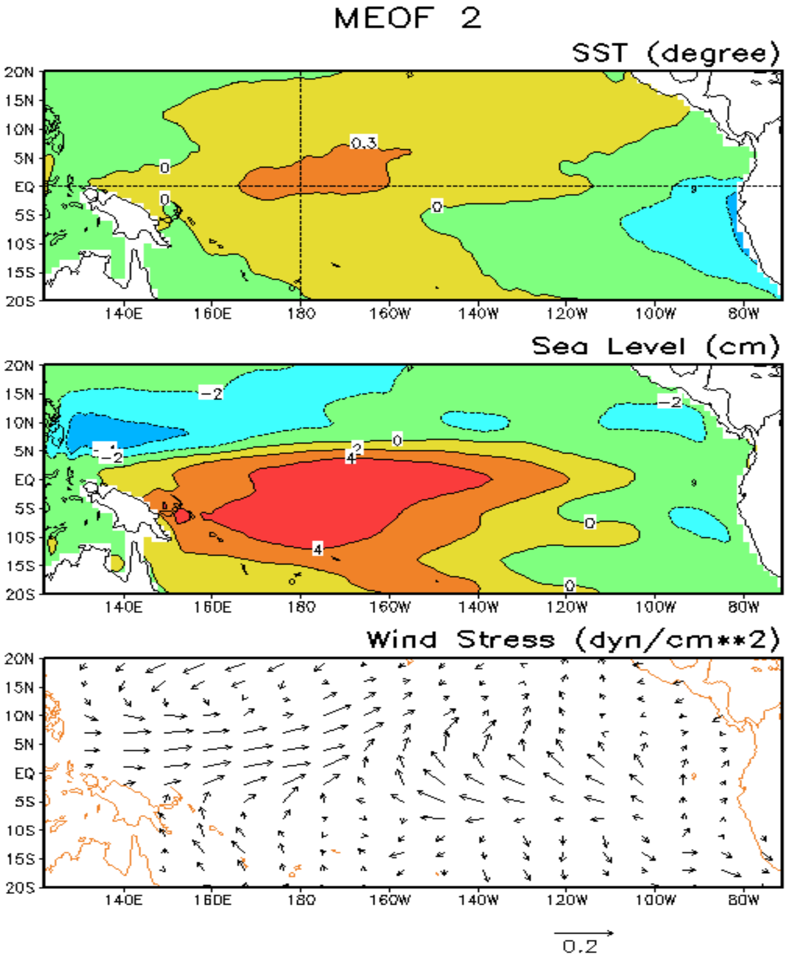
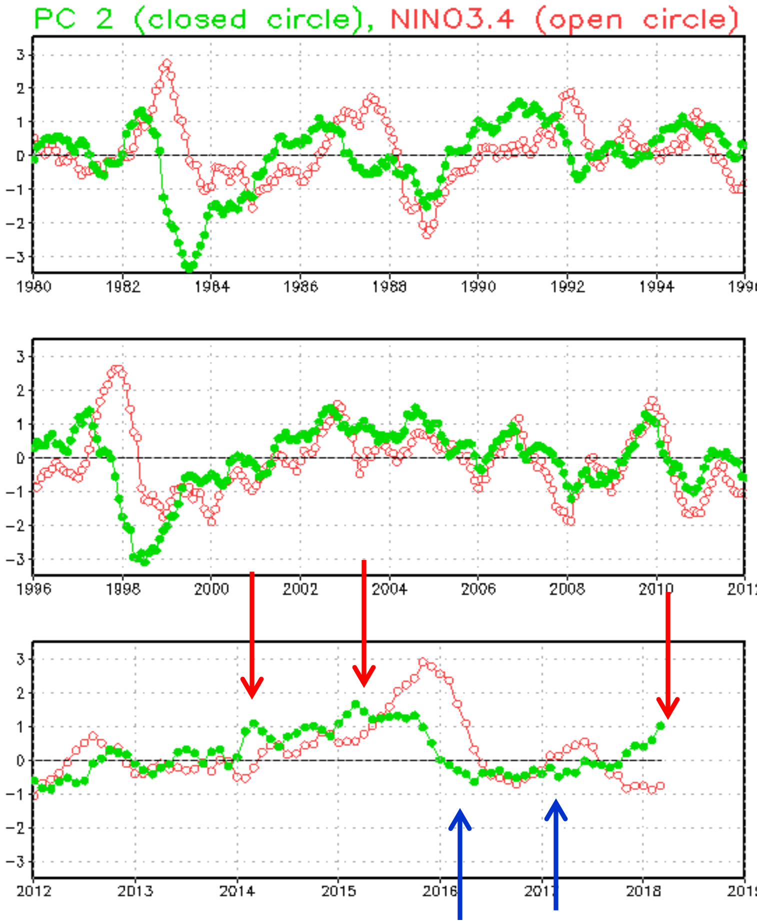


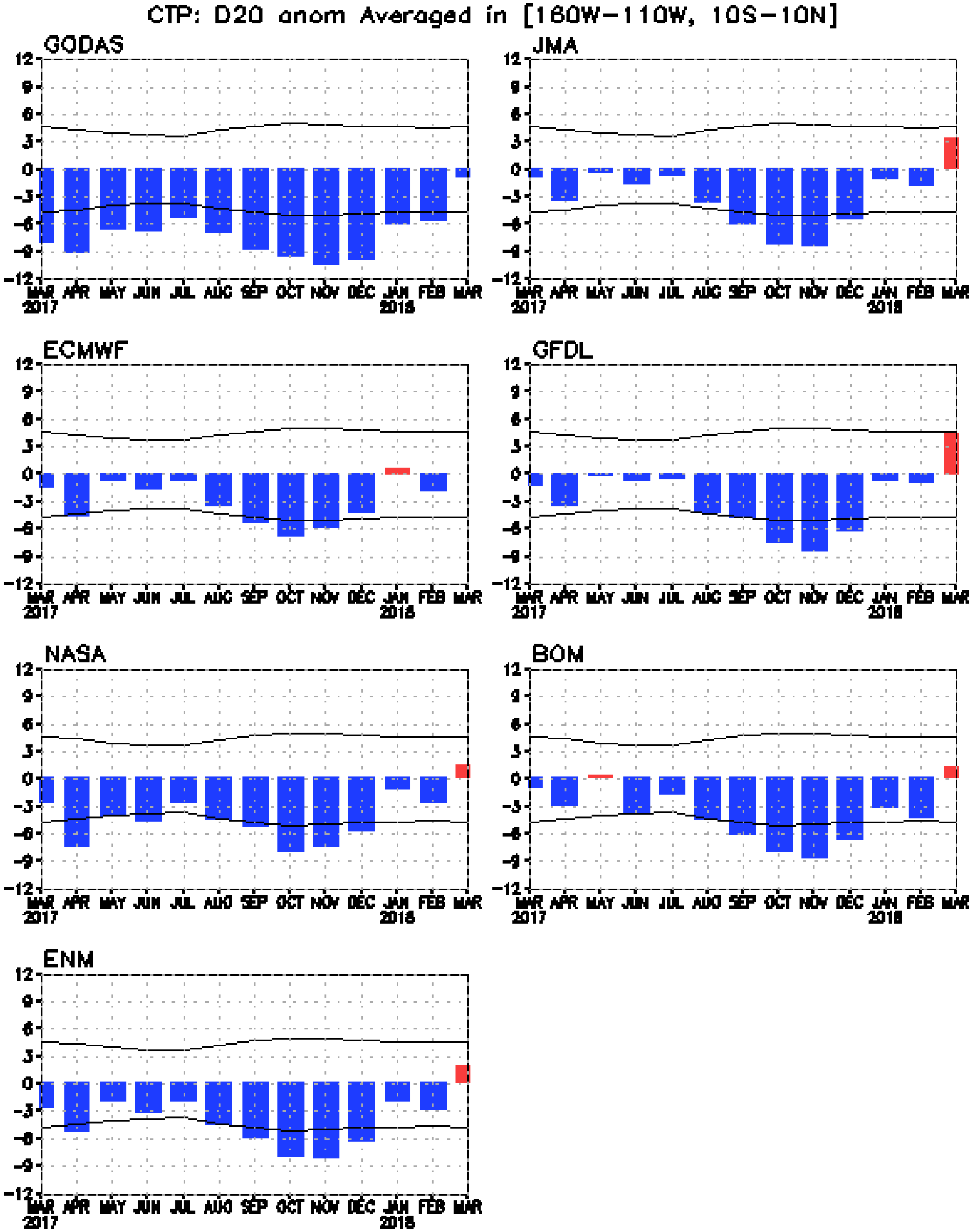
Fig. 4. Time evolution of NINO3.4 forecasts up to 12 lead months by the Markov model initiated monthly up to March 2018 . Shown in each panel are the forecasts grouped by three consecutive starting months: (a) is for December, January and February, (b) is for March, April and May, (c) is for June, July and August and (d) is for September, October and November. The observed NINO3.4 SST anomalies are shown in the heavy-dashed lines.

- **It forecast the 2015/16 El Nino starting from Feb 2015 I.C.**
- **It forecast the 2016/17 La Nina starting from May 2016 I.C.**
- **It forecast the 2017/18 La Nina starting from Aug 2017 I.C.**
- **It forecast potential 2018/19 El Nino starting from Mar 2018 I.C.**

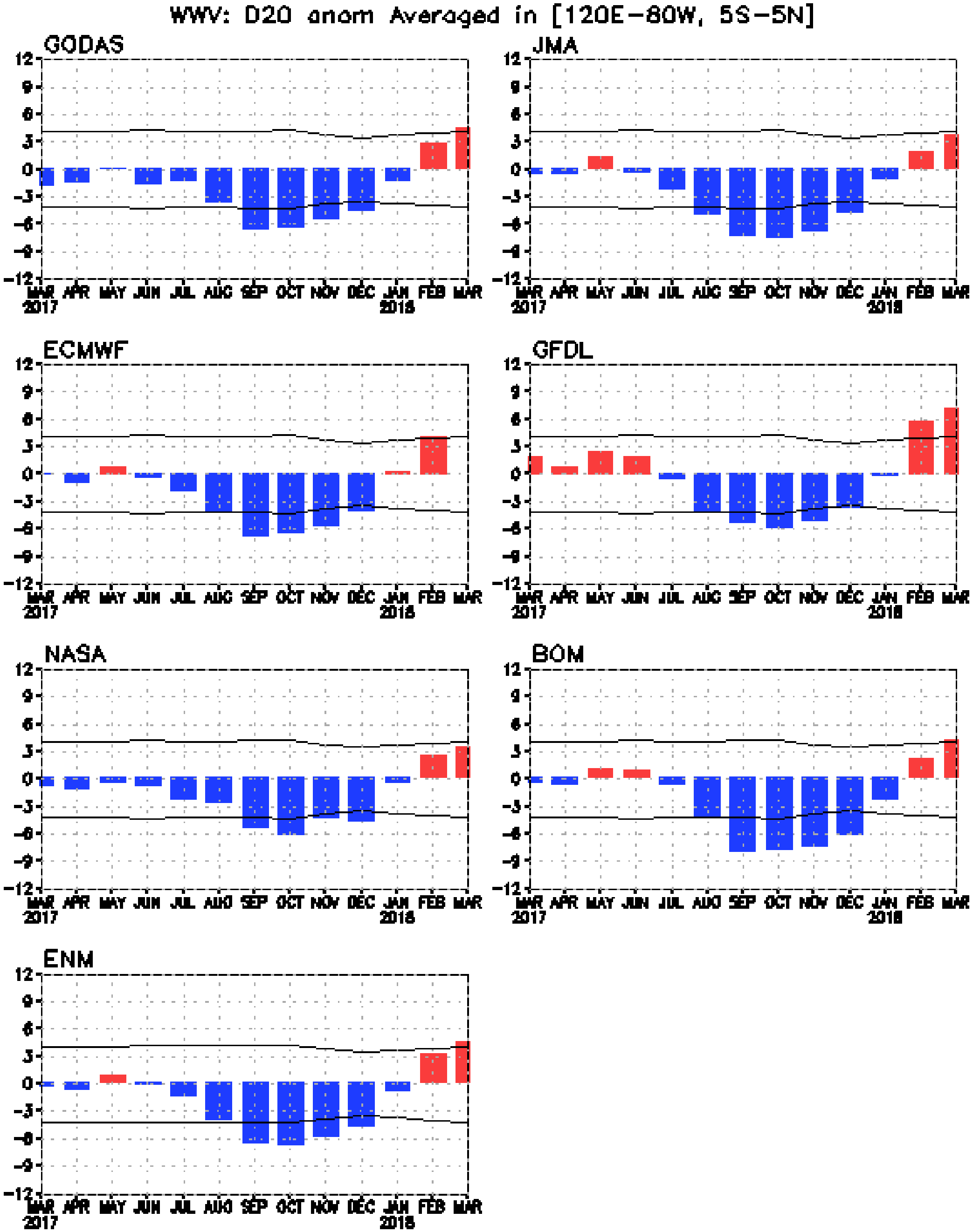




- The current conditions projected moderately onto the second MEOF ENSO precursor, which is similar to that in Mar 2014 and slightly lower than that in Mar 2015. So there is an increased chance for El Nino.
- On comparison, the projection was negative in Mar 2016 and Mar 2017, favoring La Nina conditions.



- CTP indices from all six ocean reanalysis were all negative during spring/summer 2017.
- ENM CTP successfully predicted the 2017/18 La Nina as early as Apr 2017. GODAS predicted the 2017/18 cold event with 1-yr lead.
- CTP indices IC on Mar 2018 from all the ocean reanalysis prefer ENSO-neutral condition in the coming northern hemispheric winter.
- Prediction skill of positive CTP IC on March is relative low in term of 50% hit rate,55% false alarm and 65% percent correct rate.

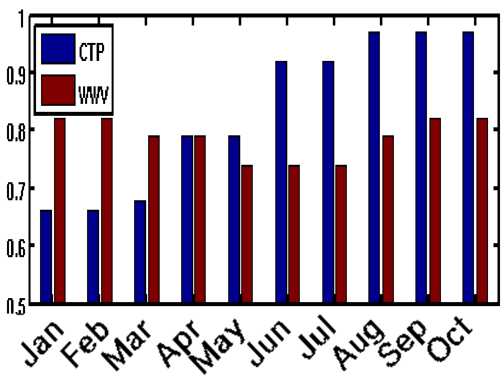


- ENM WWV predicted the 2017/18 La Nina since Sep 2017. WWV from JMA,GFDL and BOM predicted the La Nina event with one month earlier.
- ENM WWV IC on Mar 2018 prefer El Nino condition in the coming northern hemispheric winter.
- Prediction skill of positive CTP IC on March is low in term of 45% hit rate,65% false alarm and 60% percent correct rate.

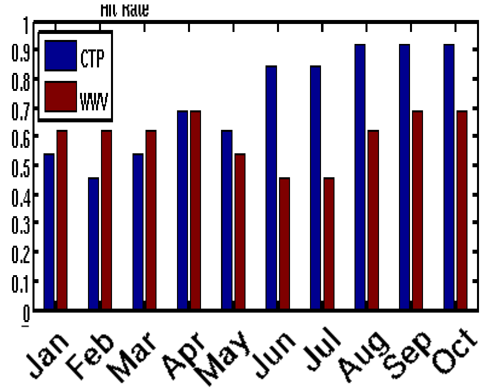
2x2 contingency table for La Nina case

NINO34 Target season: DJF

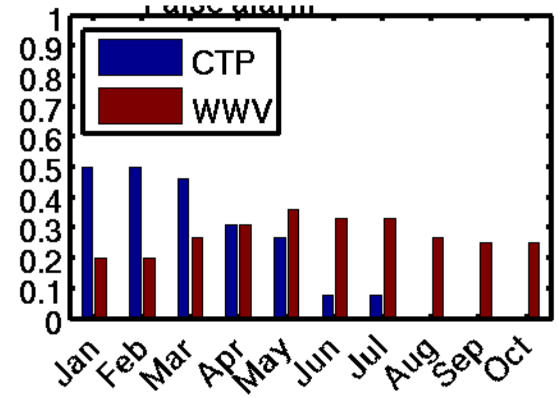
Percent correct



Hit Rate



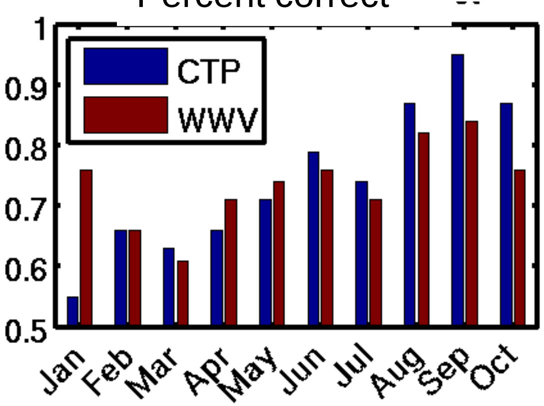
False Alarm



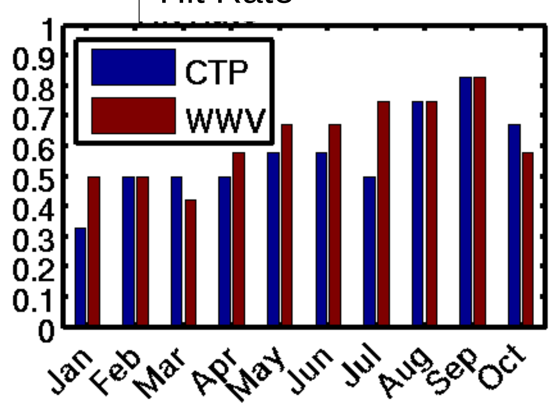
2x2 contingency table for El Nina case

NINO34 Target season: DJF

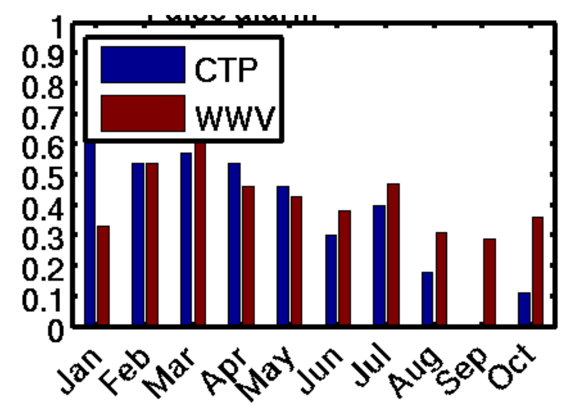
Percent correct



Hit Rate



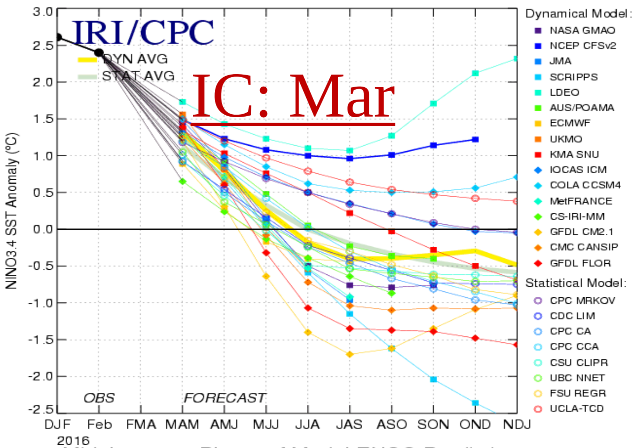
False Alarm



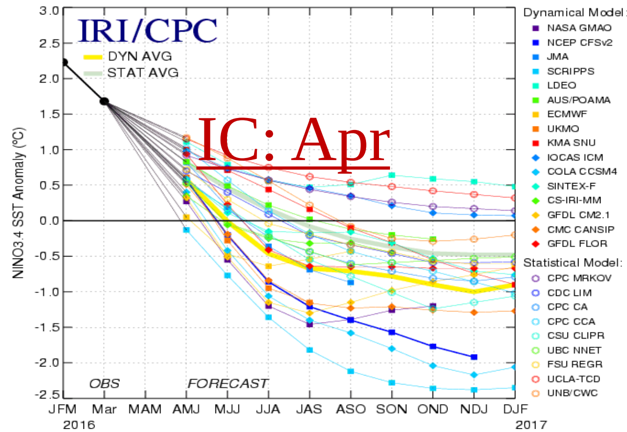
Large Uncertainty: IRI/CPC ENSO Plume with ICs in Mar-Nov 2016

(https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table)

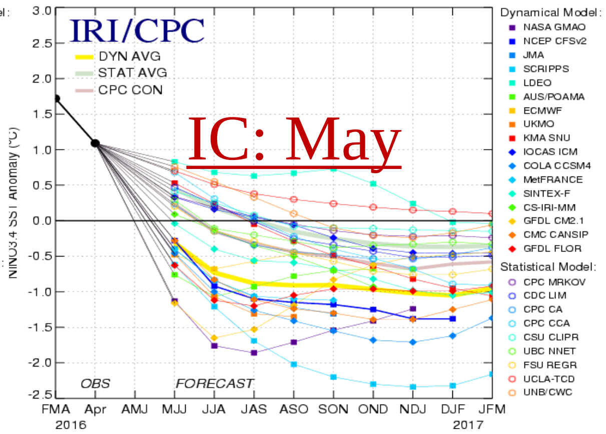
Mid-Mar 2016 Plume of Model ENSO Predictions



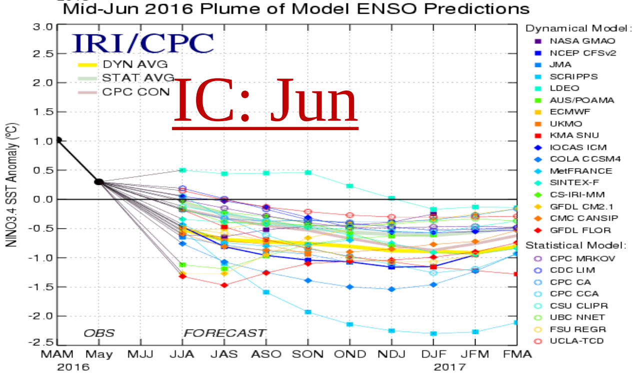
Mid-Apr 2016 Plume of Model ENSO Predictions



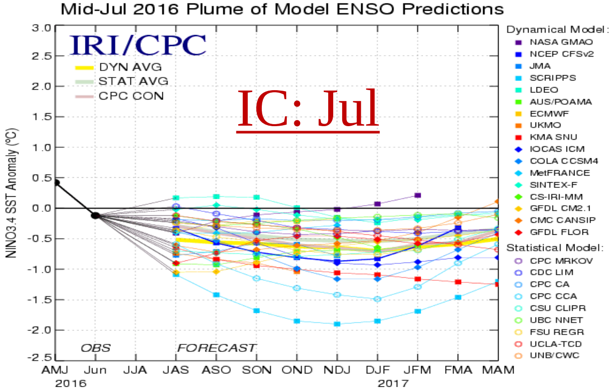
Mid-May 2016 Plume of Model ENSO Predictions



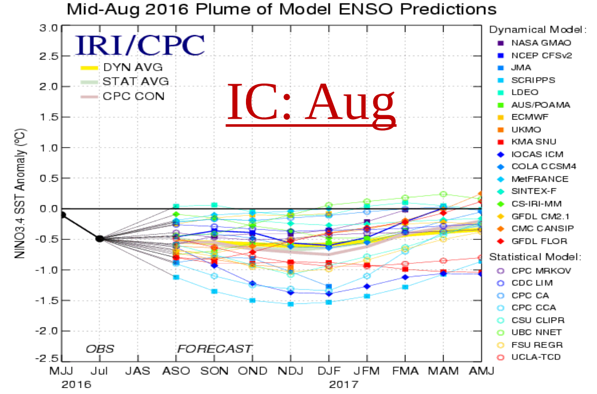
Mid-Jun 2016 Plume of Model ENSO Predictions



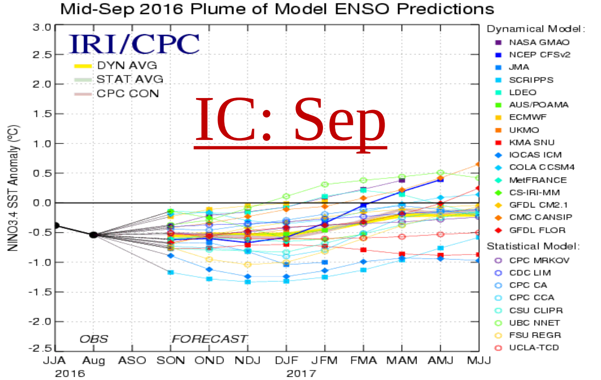
Mid-Jul 2016 Plume of Model ENSO Predictions



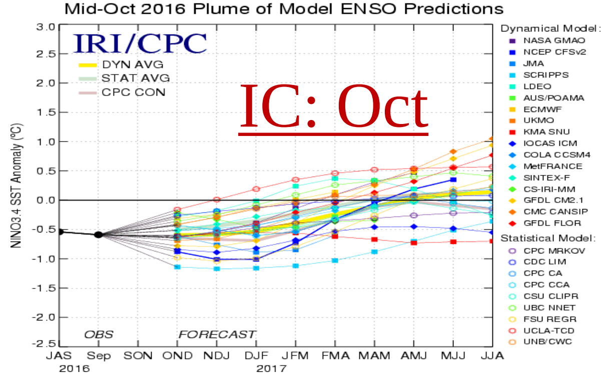
Mid-Aug 2016 Plume of Model ENSO Predictions



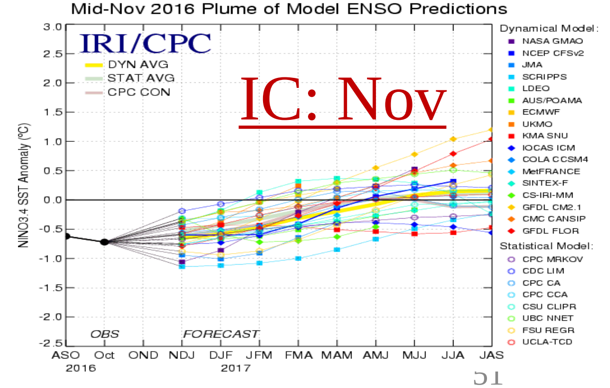
Mid-Sep 2016 Plume of Model ENSO Predictions

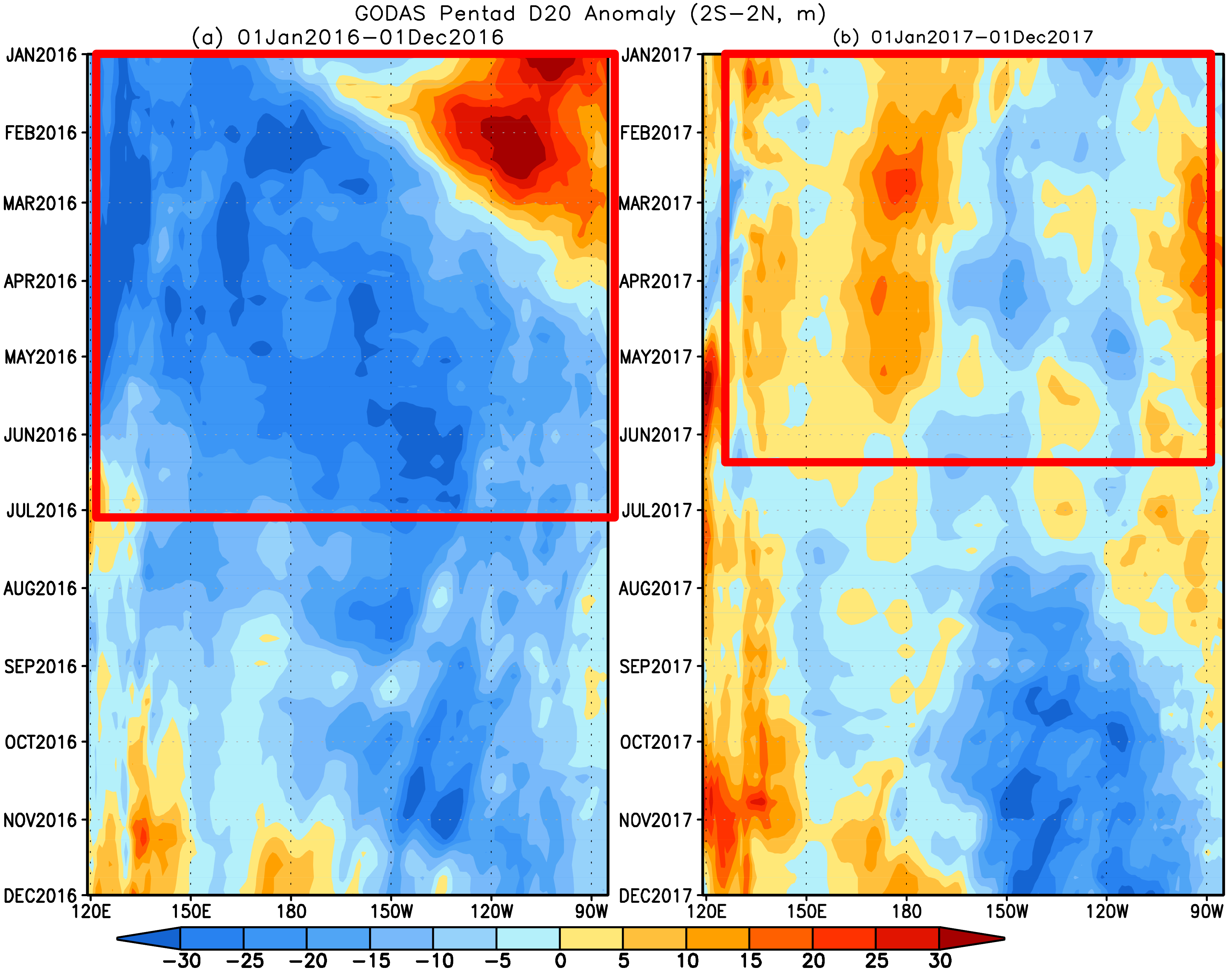


Mid-Oct 2016 Plume of Model ENSO Predictions

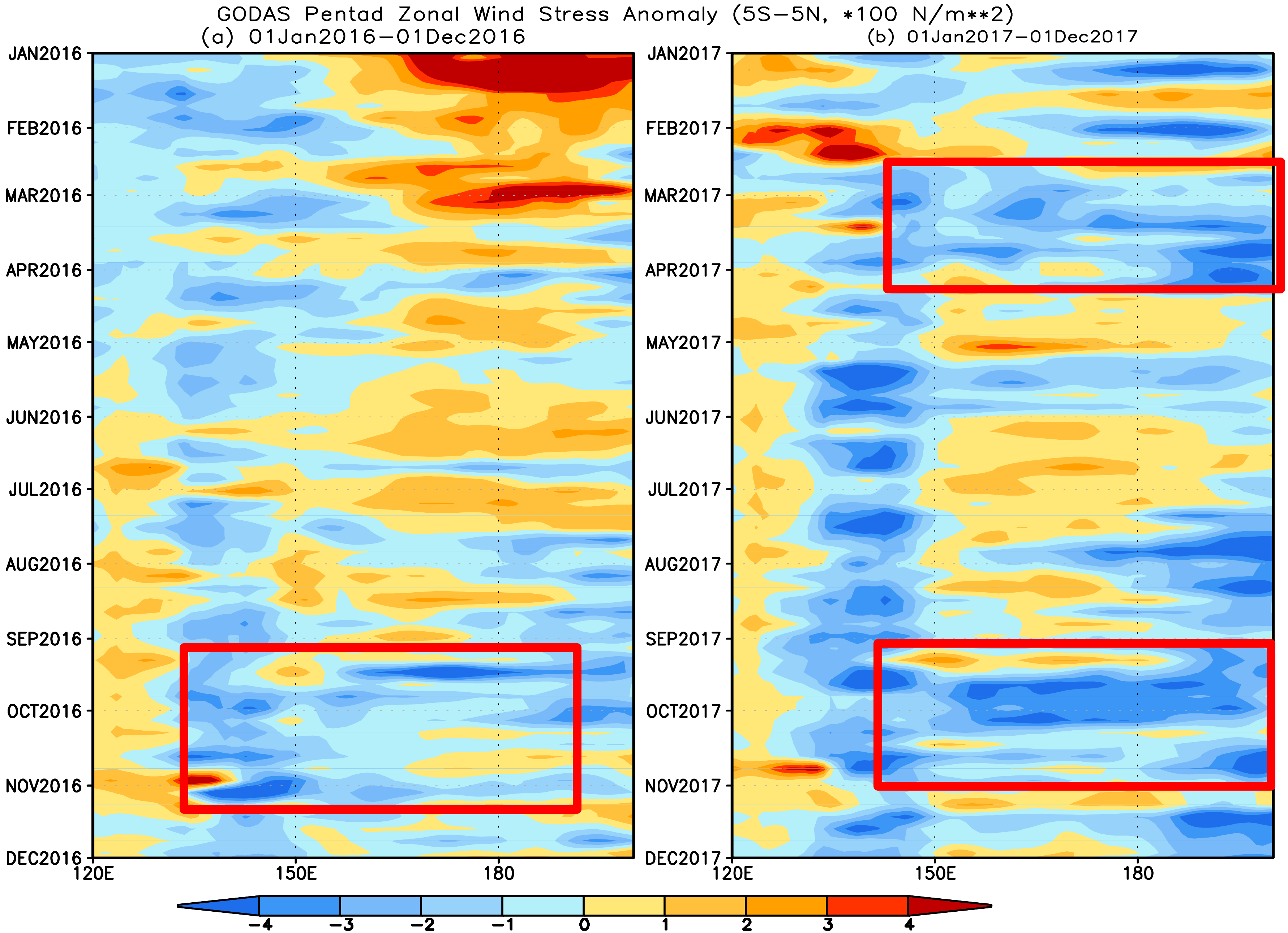


Mid-Nov 2016 Plume of Model ENSO Predictions





GODAS Pentad D20 Anomaly (2S–2N, m)
(a) 01Jan2016–01Dec2016
(b) 01Jan2017–01Dec2017
JAN2016
FEB2016
MAR2016
APR2016
MAY2016
JUN2016
JUL2016
AUG2016
SEP2016
OCT2016
NOV2016
DEC2016
JAN2017
FEB2017
MAR2017
APR2017
MAY2017
JUN2017
JUL2017
AUG2017
SEP2017
OCT2017
NOV2017
DEC2017
120E
150E
180
150W
120W
90W
−30 −25 −20 −15 −10 −5 0 5 10 15 20 25 30



GODAS Pentad Zonal Wind Stress Anomaly (5S-5N, *100 N/m**2)
(a) 01Jan2016-01Dec2016
(b) 01Jan2017-01Dec2017
JAN2016
FEB2016
MAR2016
APR2016
MAY2016
JUN2016
JUL2016
AUG2016
SEP2016
OCT2016
NOV2016
DEC2016
JAN2017
FEB2017
MAR2017
APR2017
MAY2017
JUN2017
JUL2017
AUG2017
SEP2017
OCT2017
NOV2017
DEC2017
120E
150E
180
−4 −3 −2 −1 0 1 2 3 4

Large uncertainty in analyzed SST affects the classification of ENSO in 2016/17 (Huang et al.: 2016)

ERSSTv5=La Nina

OIv2: Neutral

Season (Nino3.4)	JJA16	JAS16	ASO16	SON17	OND16	NDJ16/17	DJF16/17
ERSSTv5 Nino3.4	**-0.3**	**-0.6**	**-0.7**	**-0.7**	**-0.7**	**-0.6**	**-0.3**
OIv2	**-0.4**	**-0.5**	**-0.6**	**-0.6**	**-0.6**	**-0.4**	**-0.2**

✓

X

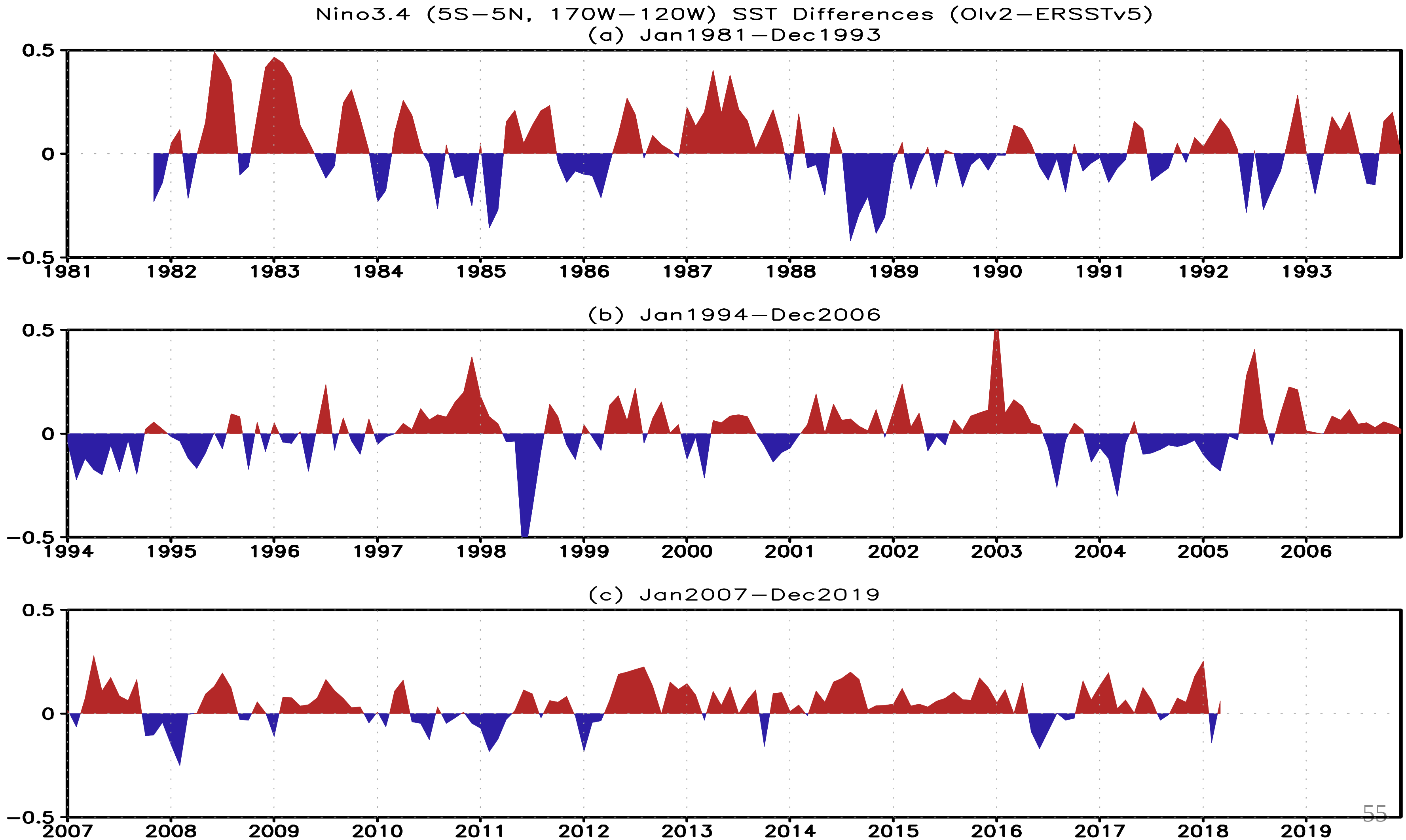
A threshold of +/- 0.5°C for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v5 SST anomalies in the Niño 3.4 region (5°N-5°S, 120°-170°W)] is met for a minimum of 5 consecutive over-lapping seasons, based on centered 30-year base periods updated every 5 years.

Huang, B., M. L'Heureux, Z.-Z. Hu, and H.-M. Zhang, 2016: Ranking the strongest ENSOs while incorporating SST uncertainty. *Geophys. Res. Lett.*, **43 (17),** 9165-9172. DOI: 10.1002/2016GL070888.

(a) OIv2-ERSSTv5 Nino3.4: >0.5C, <-0.5C;

(b) OIv2 is NOT always better than ERSSTv5 on ENSO time scales.

(Huang, B., M. L'Heureux, J. Lawrimore, C. Liu, H.-M. Zhang, V. Banzon, Z.-Z. Hu, and A. Kumar, 2013: Why did large differences arise in the sea surface temperature datasets across the tropical Pacific during 2012? J. Atmos. Ocean. Tech., 30 (12), 2944-2953. DOI: 10.1175/JTECH-D-13-00034.1)



Acknowledgements

- Drs. Caihong Wen, Yan Xue, and Arun Kumar: reviewed PPT, and provide insight and constructive suggestions and comments

- Drs. Li Ren and Pingping Xie: Provided SSS slides

- Dr. Emily Becker: timely provided NMME plot

- Ms. Michelle L'Heureux: reviewed the 2017/18 La Nina prediction slides

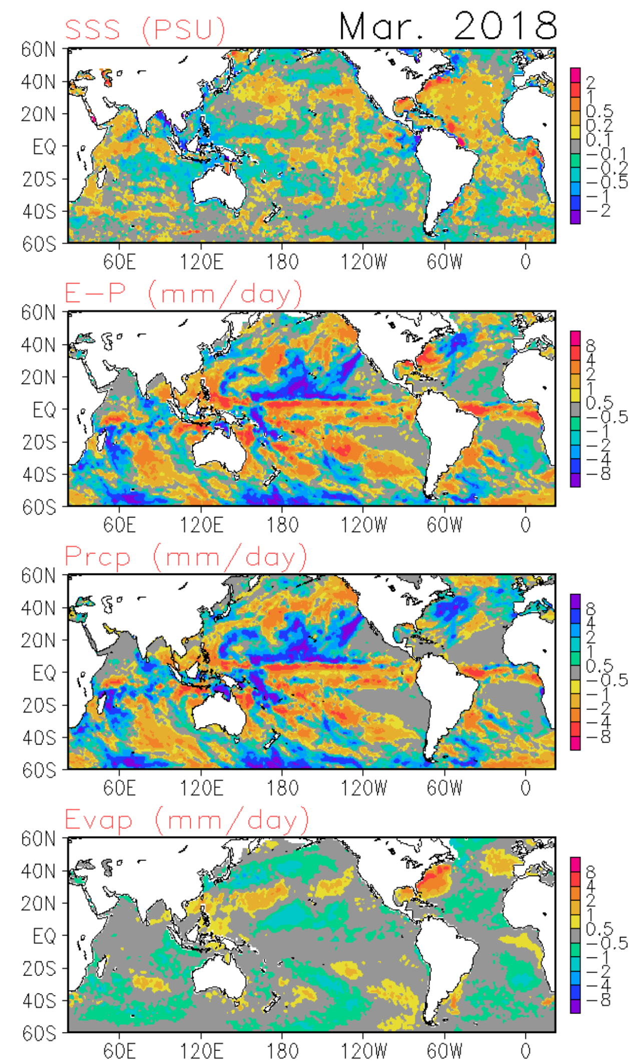
- Drs. Thomas Collow and Wanqiu Wang: Provided sea ice slides

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for March 2018

- **New Update: The input satellite sea surface salinity of SMAP from NSAS/JPL was changed from Version 3.0 to Version 4.0 in January 2018.**
- The negative SSS signal continued in the Indonesia equatorial Pacific. However, the precipitation was generally reduced in this area. The negative SSS in the west basin of South Pacific subtropics is co-incident with increased precipitation. In the Indian Ocean, a large scale of negative SSS signal appear between 0° and 20°S. In the Bay of Bengal, the SSS significantly decreased, especially in the north and east basin. The positive SSS in the sea of Okhotsk became weaker with no significant precipitation change. In the Atlantic Ocean, the positive SSS shows in most of the tropical and subtropical regions.



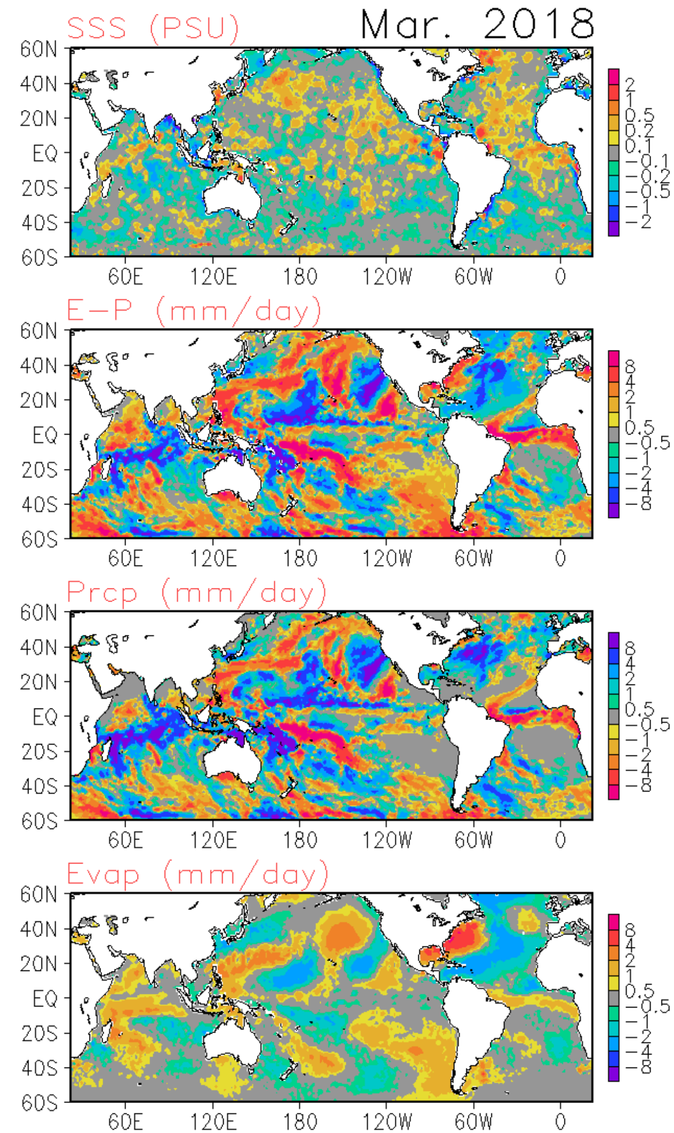
- **Data used**

SSS : Blended Analysis of Surface Salinity (BASS) V0.Z
(a CPC-NESDIS/NODC-NESDIS/STAR joint effort)
(Xie et al. 2014)
ftp.cpc.ncep.noaa.gov/precip/BASS
Precipitation: CMORPH adjusted satellite precipitation estimates
Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for March 2018

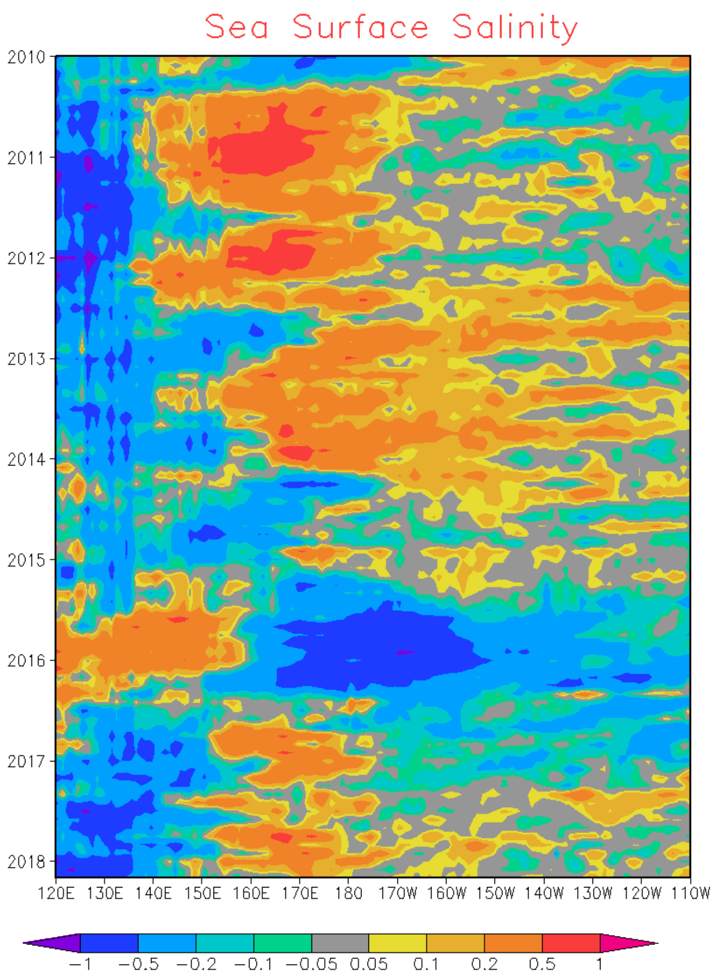
Compared with last month, the SSS in the Bay of Bengal significantly decreased possibly due to ocean advection/entrainment. The SSS in the Indian Ocean between 0° and 20°S decreased with increased precipitation. In the west basin of the South Pacific subtropics, the SSS decreased with the precipitation increasing in this area. A large scale of SSS increased in the tropics of Atlantic ocean with no significant changes in the freshwater input.



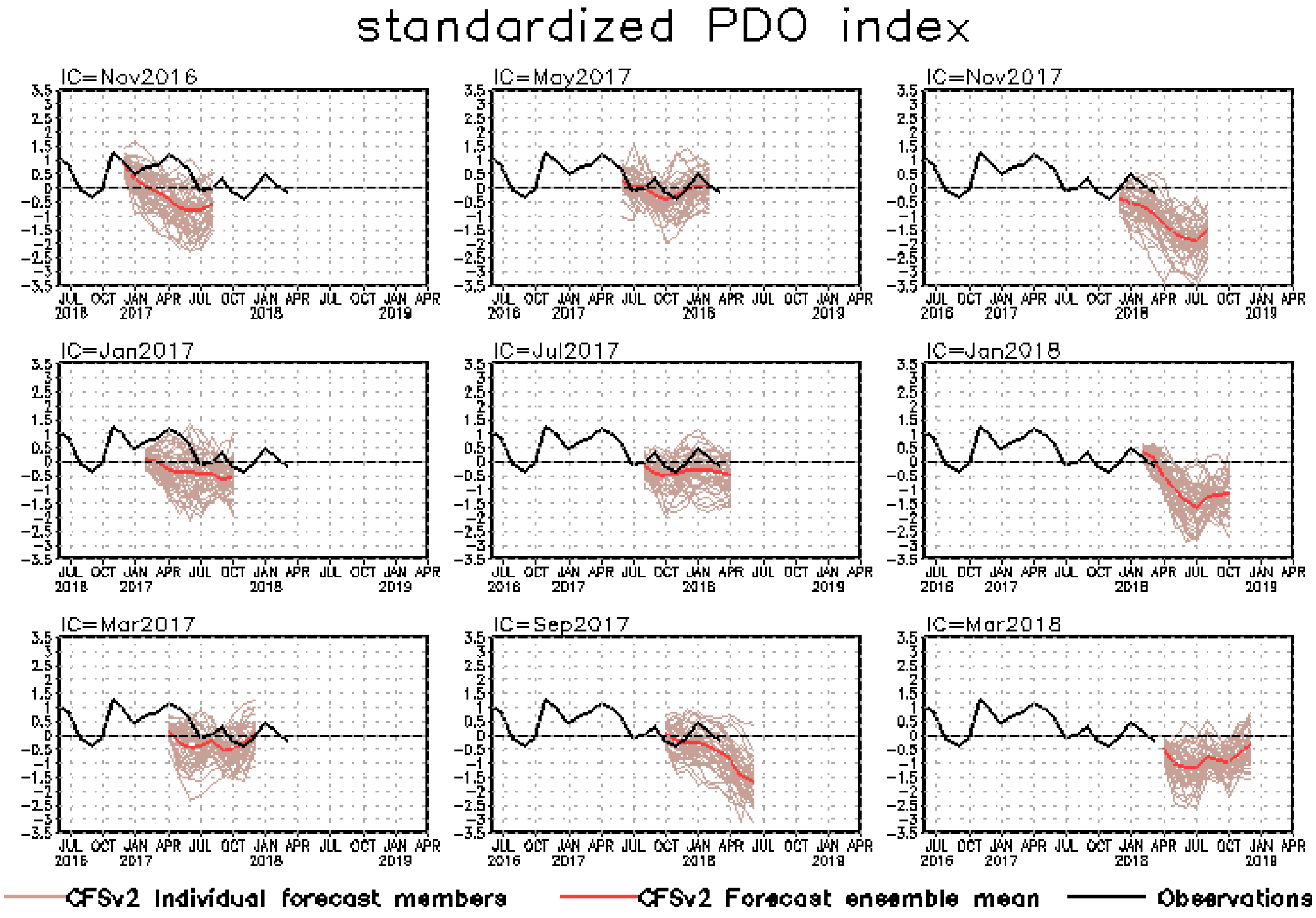
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

NOTE: Since June 2015, the BASS SSS is from in situ, SMOS and SMAP; before June 2015,The BASS SSS is from in situ, SMOS and Aquarius.

- Hovemoller diagram for equatorial SSS anomaly **(5˚S-5˚N);**
- In the equatorial Pacific Ocean, from 120°E to 150°E, the negative SSS signal continues in this month. The positive SSS anomaly signal in the central equatorial Pacific Ocean continues from 150°E to 150°W. The SSS generally stays at its natural condition west of 150°W.



CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



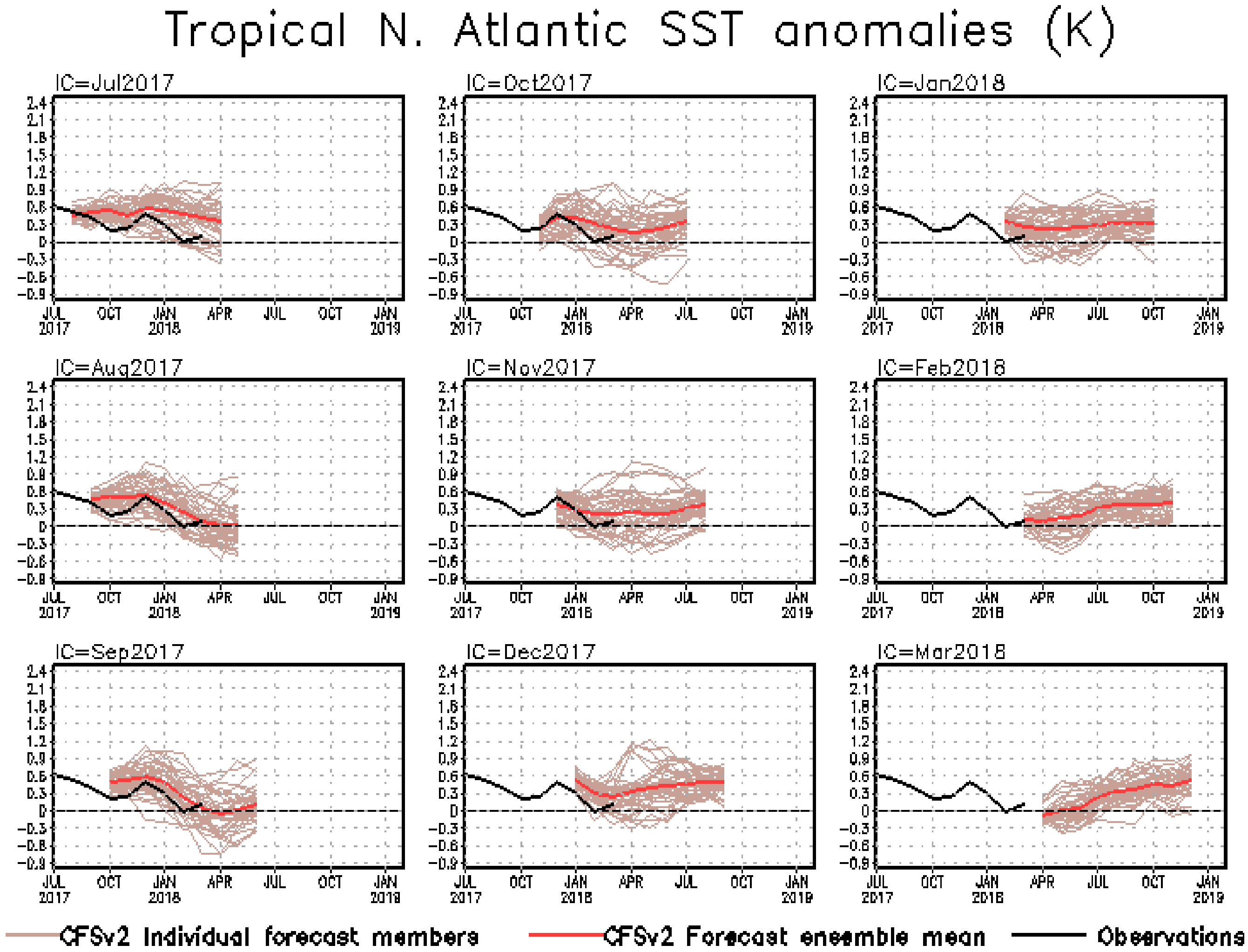
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

- CFSv2 predicts a negative phase of PDO in 2018.

Fig. M4. CFS Pacific Decadal Oscillation (PDO) index predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months

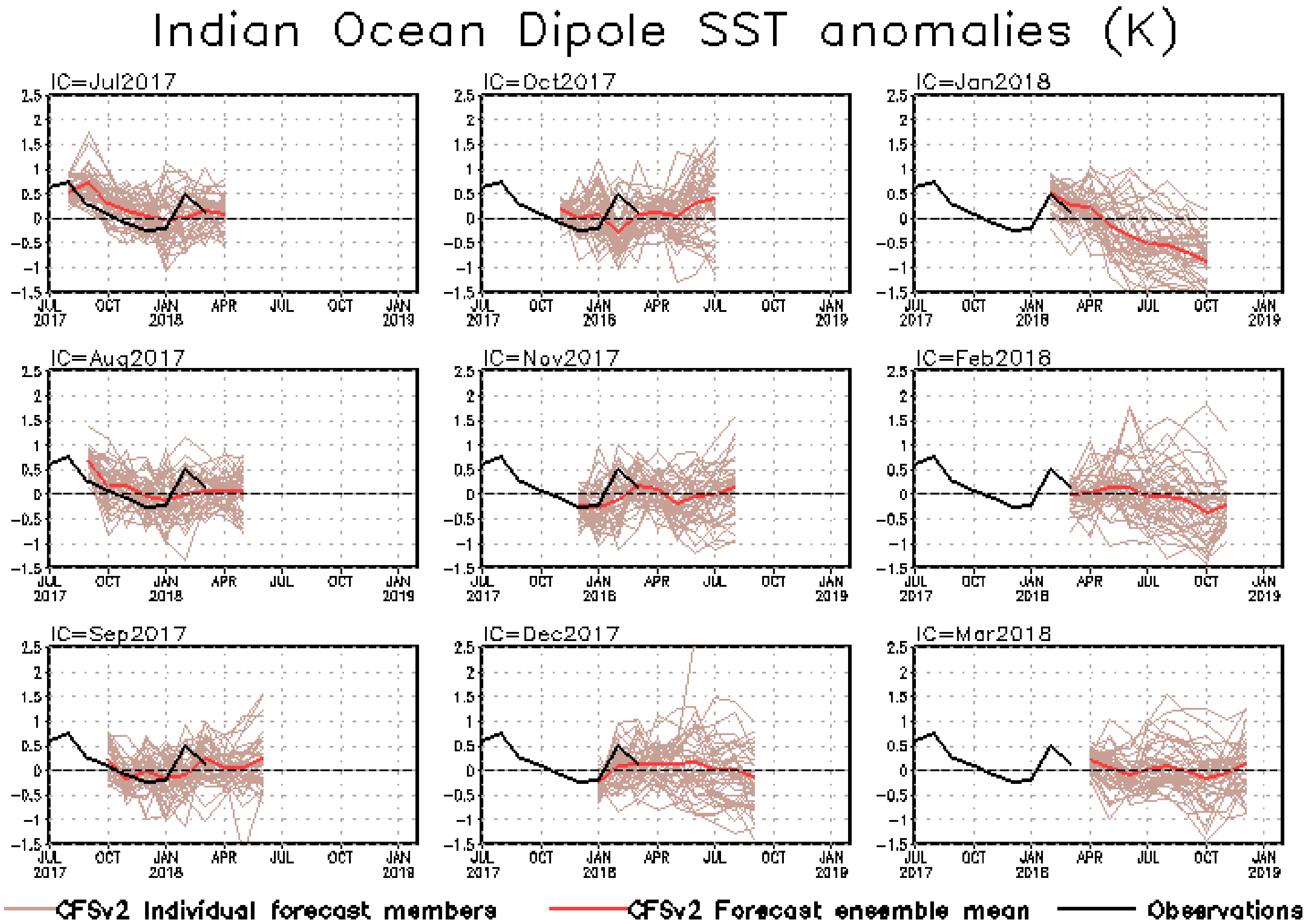


TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].

- Latest CFSv2 predictions call above normal SSTA in tropical N. Atlantic in summer-autumn 2018.

Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with respect to the 1981-2010 base period means.

NCEP CFS DMI SST Predictions from Different Initial Months



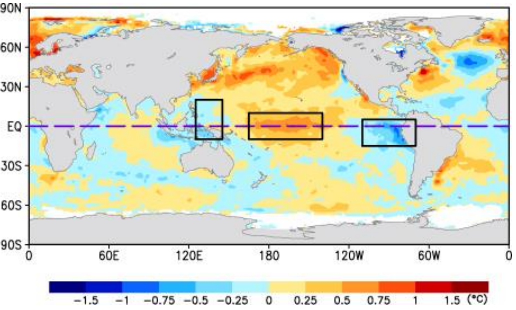
DMI = WTIO- SETIO

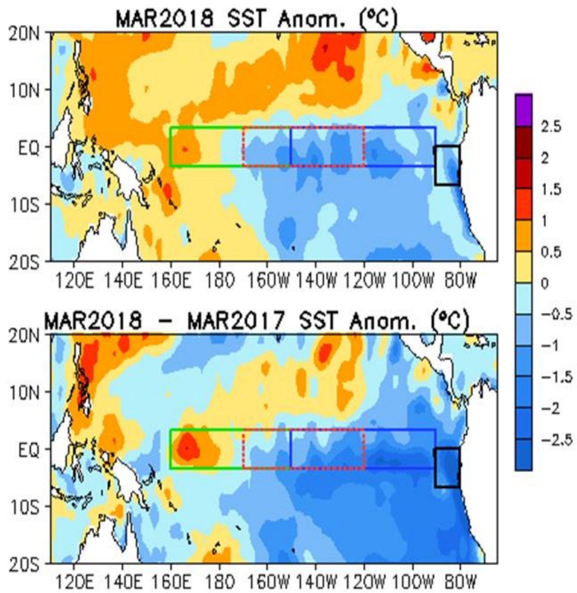
SETIO = SST anomaly in [90°E-110°E, 10°S-0]

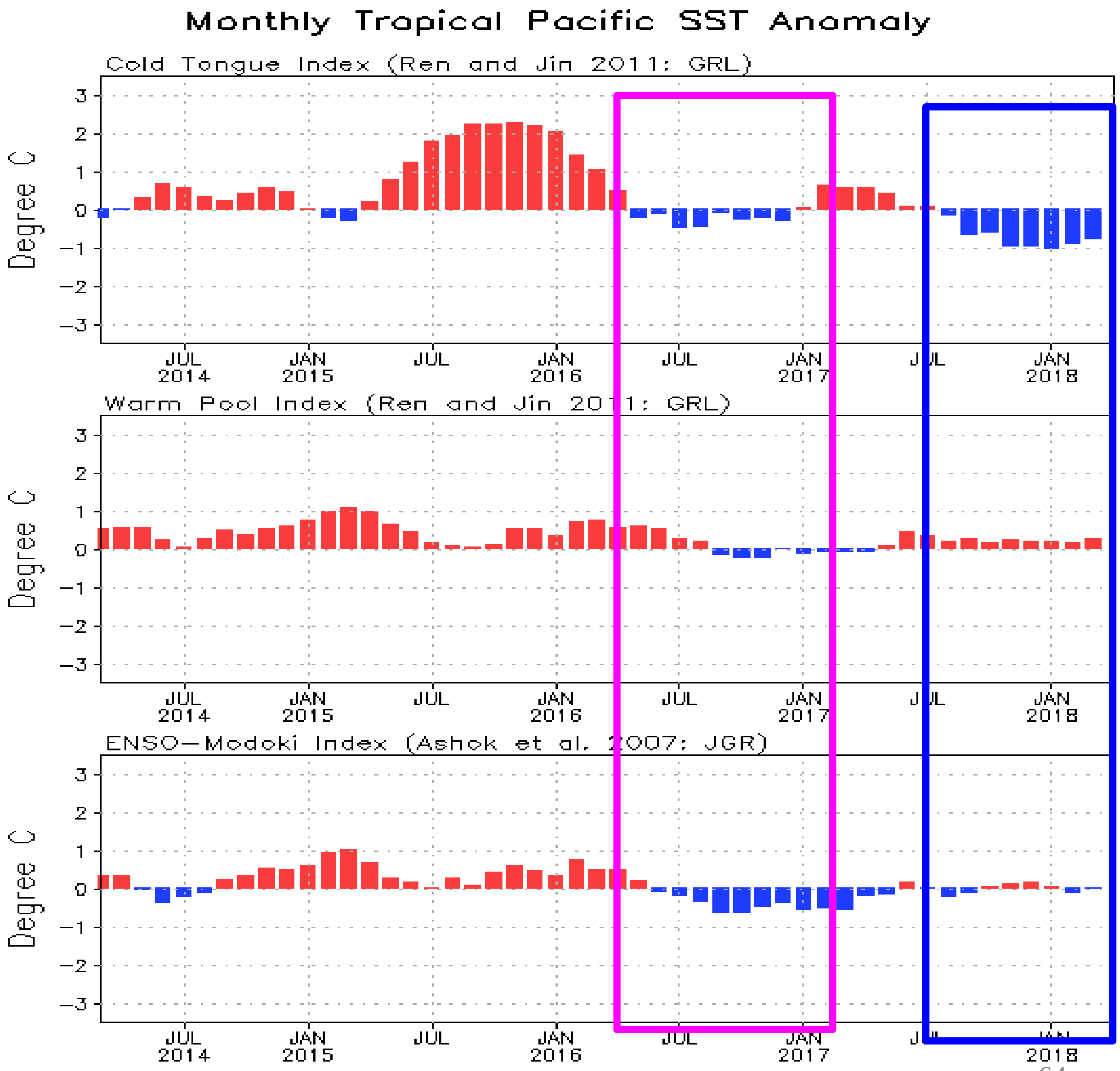
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1981-2010 base period means.

SSTA projections were larger in the cold tongue in 2017/18 La Nina than in 2016/17 La Nina







Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds

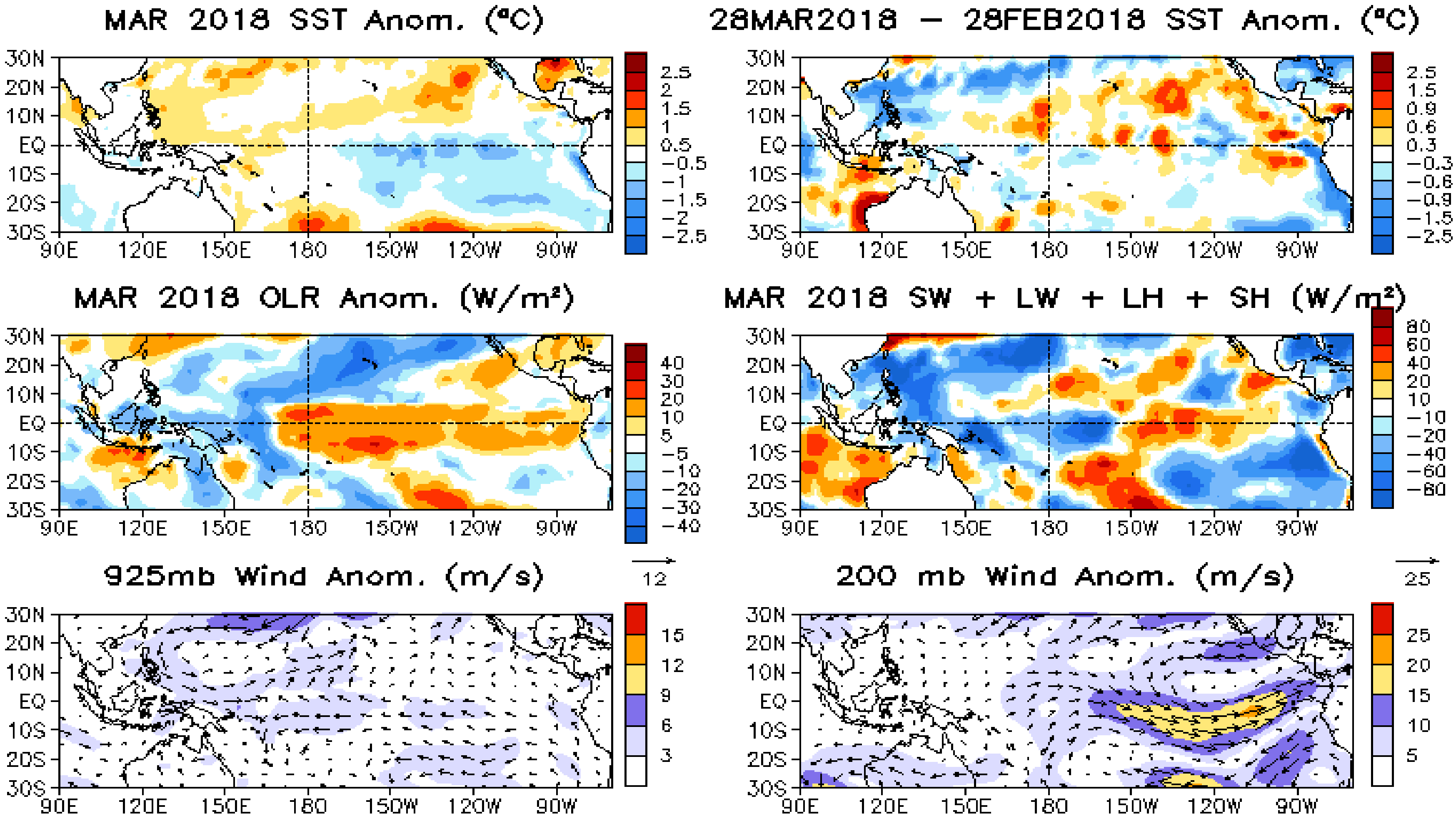


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (bottom-left), 200-mb wind anomaly vector and its amplitude (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, winds and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

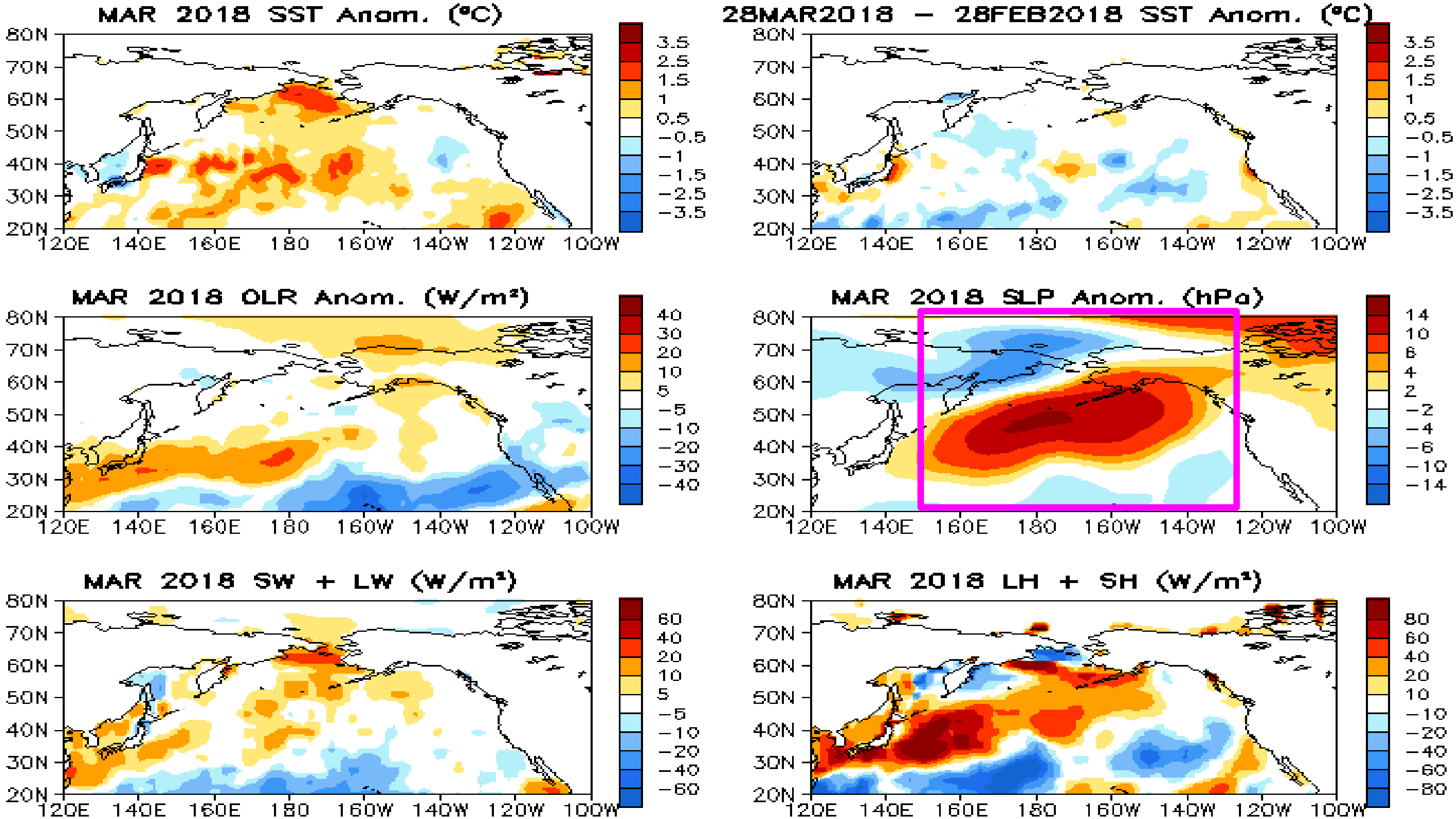
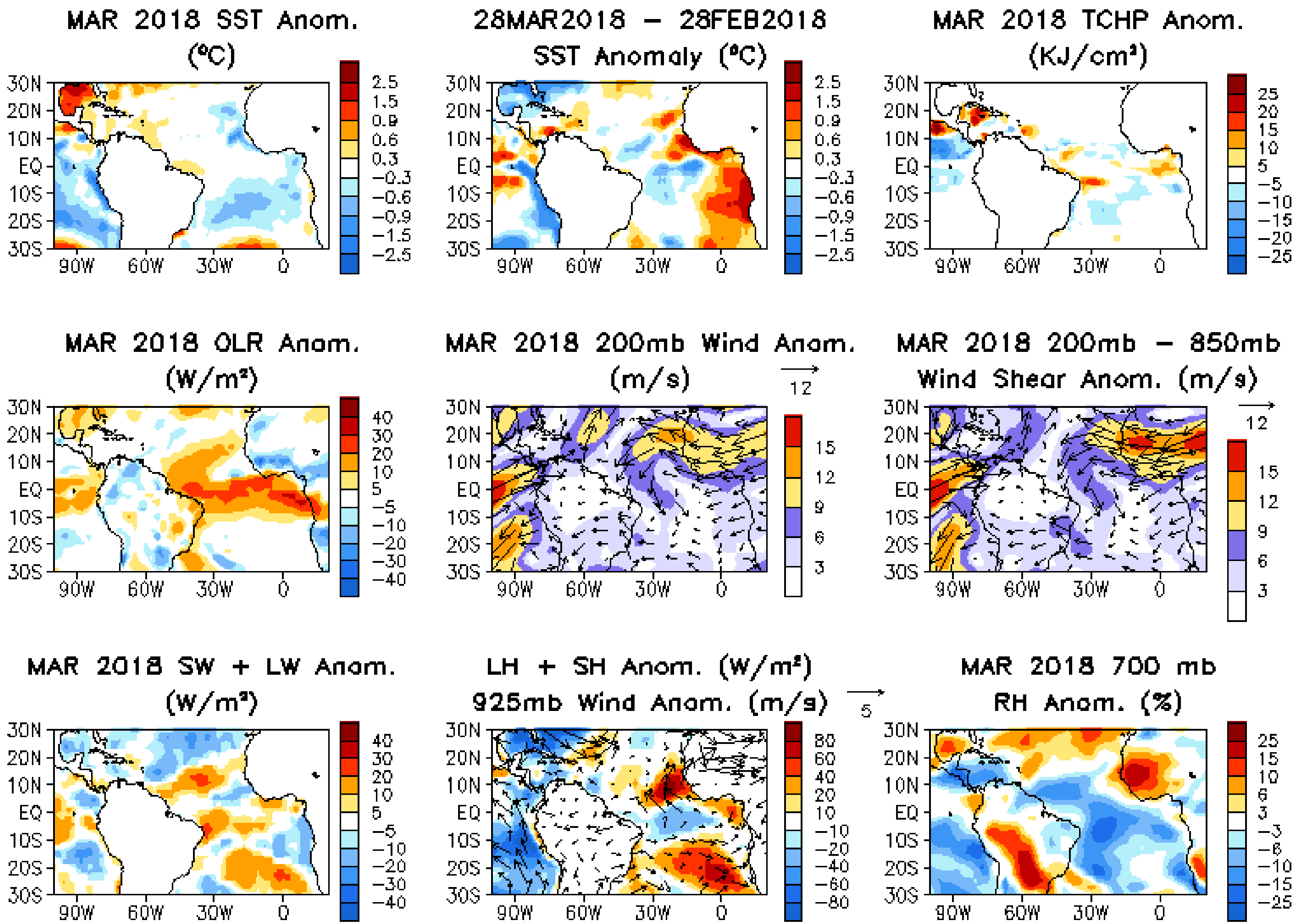


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.

Tropical Atlantic:



North Atlantic: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

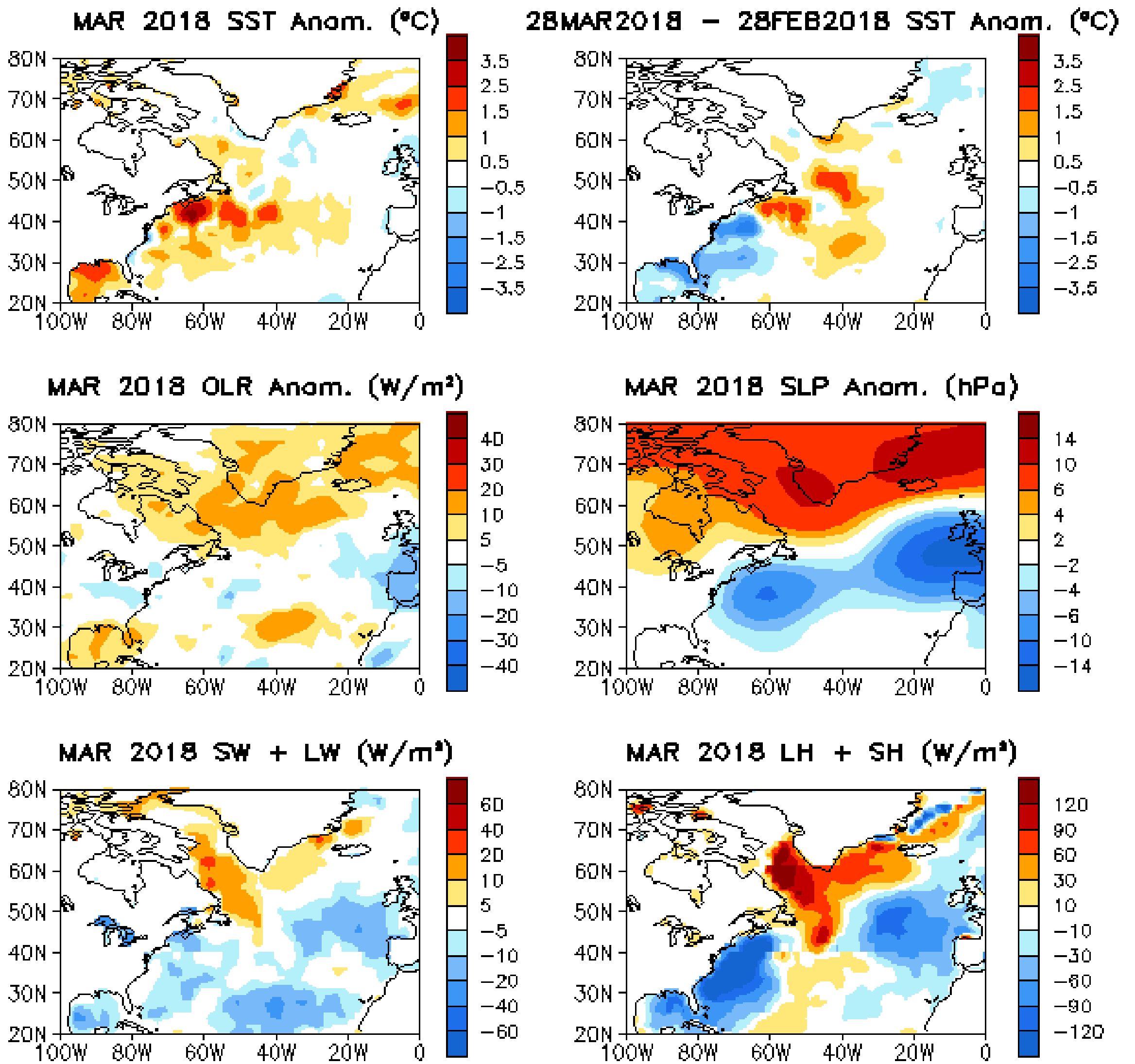


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible heat flux anomalies (bottom-right). SST are derived from the NCEP OI SST analysis, OLR from the NOAA 18 AVHRR IR window channel measurements by NESDIS, sea surface pressure and surface radiation and heat fluxes from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period means.