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

Prepared by

Climate Prediction Center, NCEP/NOAA

June 8, 2018

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**

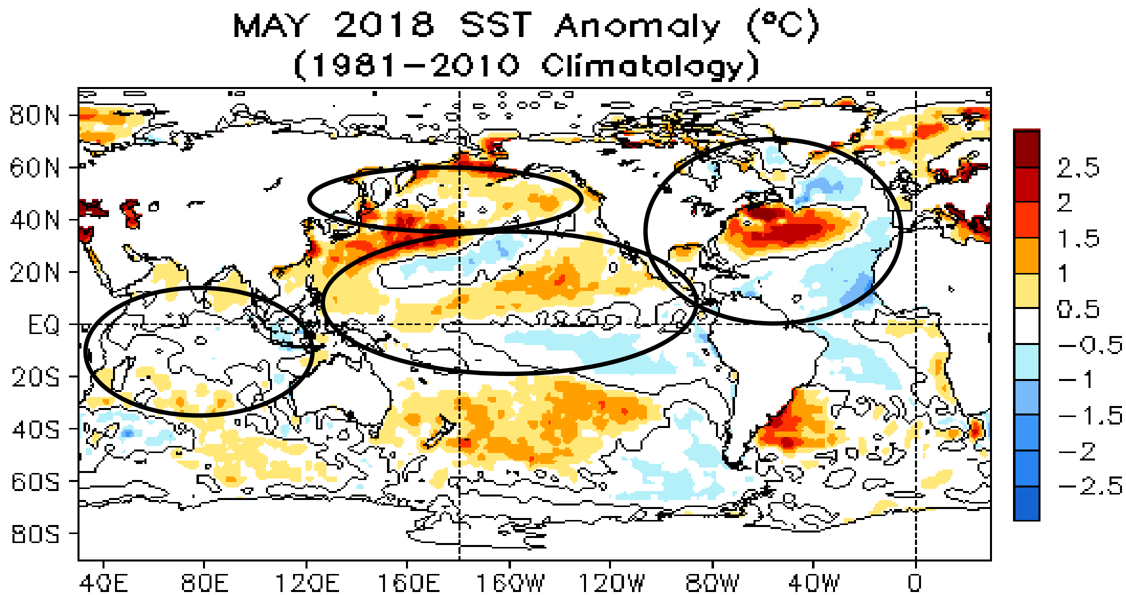
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Global SST Predictions**
    - ***ENSO Status and Forecast***
    - ***Biases in CFSR and Possible Impact on CFSv2 Forecast***
    - ***NOAA Atlantic and East Pacific Hurricane Outlooks***

Overview

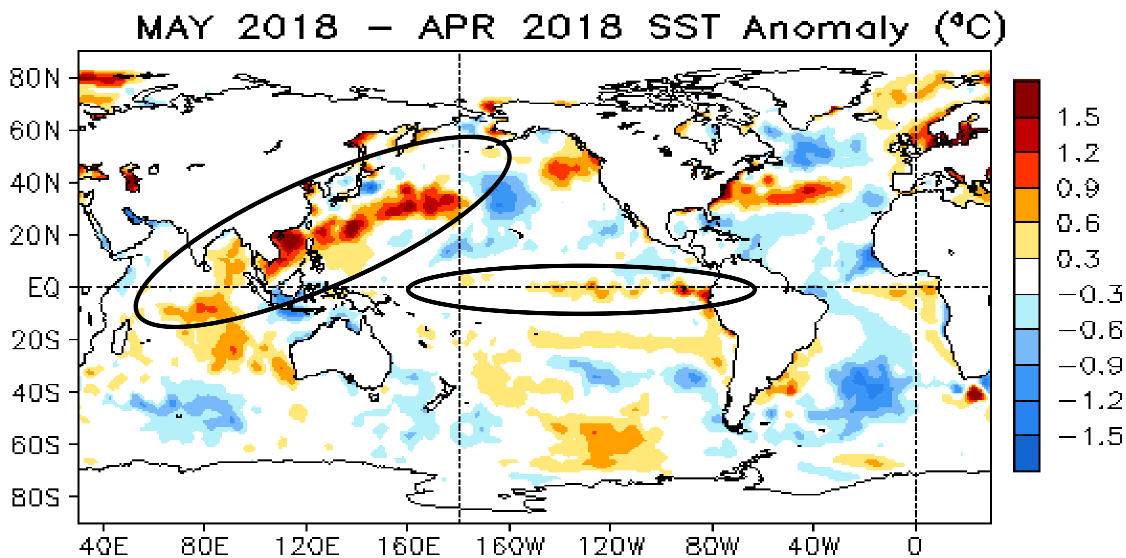
- **Pacific Ocean**
  - **<u>NOAA "ENSO Diagnostic Discussion" on 10 May 2018 issued "Final La Niña Advisory" and indicated *"ENSO-neutral is favored through September-November 2018, with the possibility of El Niño nearing 50% by Northern Hemisphere winter 2018-19.*</u>"**
  - **SSTAs were small in the central and eastern tropical Pacific with NINO3.4=-0.13^{o}C in May 2018.**
  - **Positive subsurface ocean temperature anomalies were present in the equatorial Pacific in May 2018.**
  - **SSTAs were mainly positive in the N. Pacific with PDOI=0.0 in May 2018.**
- **Indian Ocean**
  - **SSTAs were small along the equator and dipole index was positive in May 2018.**
- **Atlantic Ocean**
  - **NAO was in positive phase with NAOI=2.0 in May 2018, and SSTAs were a tripole/horseshoe pattern with large positive anomalies in the middle latitudes of N. Atlantic.**

Global Oceans

Global SST Anomaly (^0C) and Anomaly Tendency



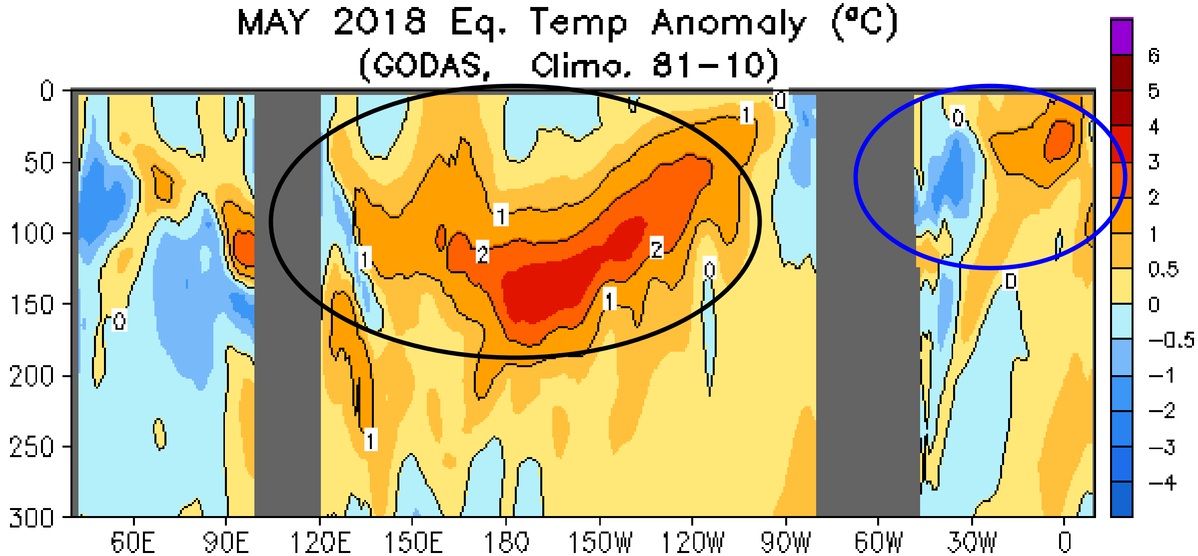
- SSTAs were positive (negative) in the NE (SE) tropical Pacific, showing a large meridional gradient in the E. Pacific.
- SSTAs were mainly positive in the N. Pacific.
- Horseshoe/tripole-like SSTA pattern presented in the N. Atlantic.
- SSTAs were small in the tropical Indian Ocean.



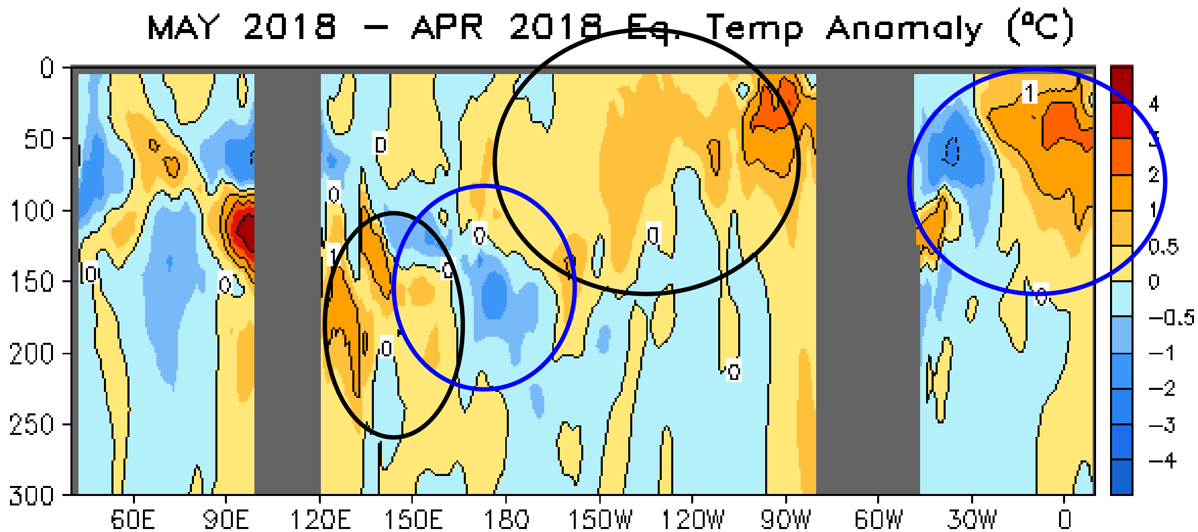
- Positive SSTA tendencies were observed in the central and eastern equatorial Pacific.
- Strong positive SSTA tendencies were seen in the NW Pacific.

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 ocean temperature anomalies were present along the thermocline in the equatorial Pacific.**
- **Positive (negative) anomalies were observed along the thermocline in the eastern (western) Atlantic Ocean.**



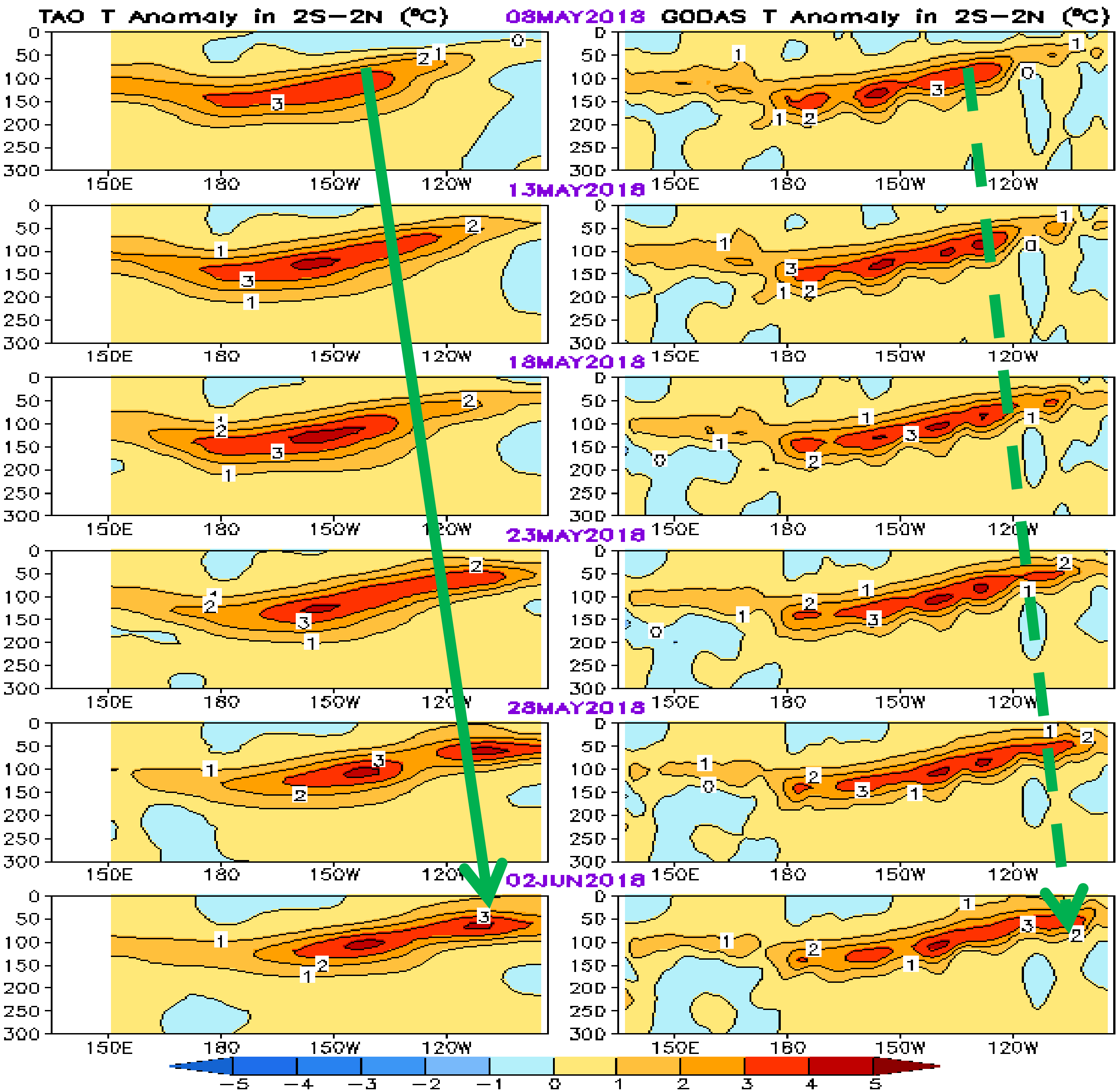
- **There was a tripole tendency pattern in the Pacific: positive in the west and east, and negative in the central.**
- **Positive (negative) tendencies were seen along the thermocline in the eastern (western) Atlantic Ocean.**

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.

Tropical Pacific Ocean and ENSO Conditions

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

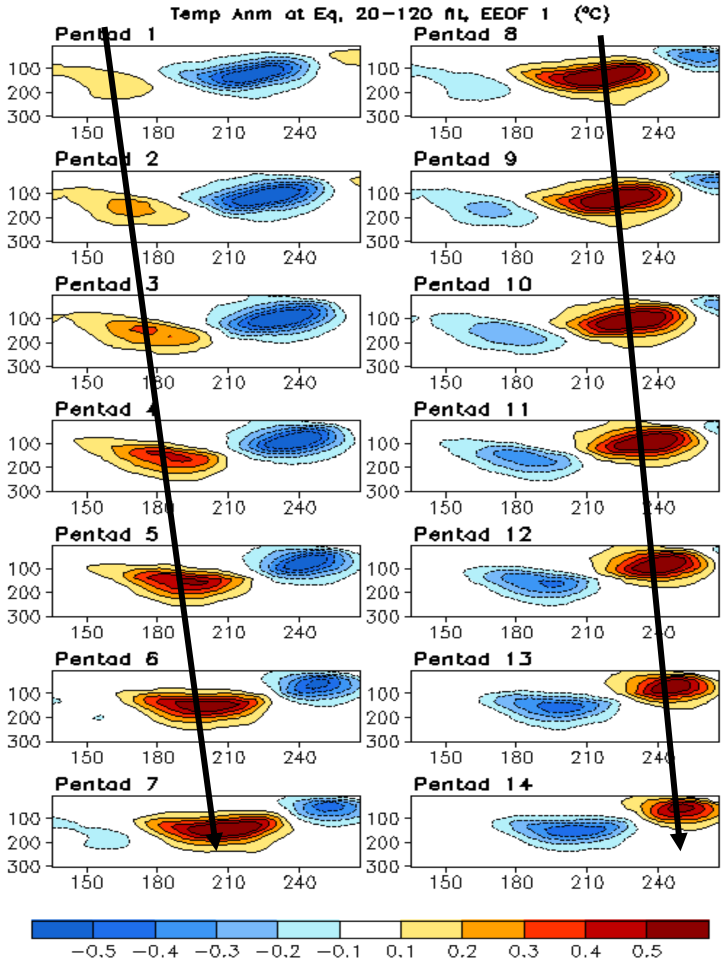
TAO GODAS

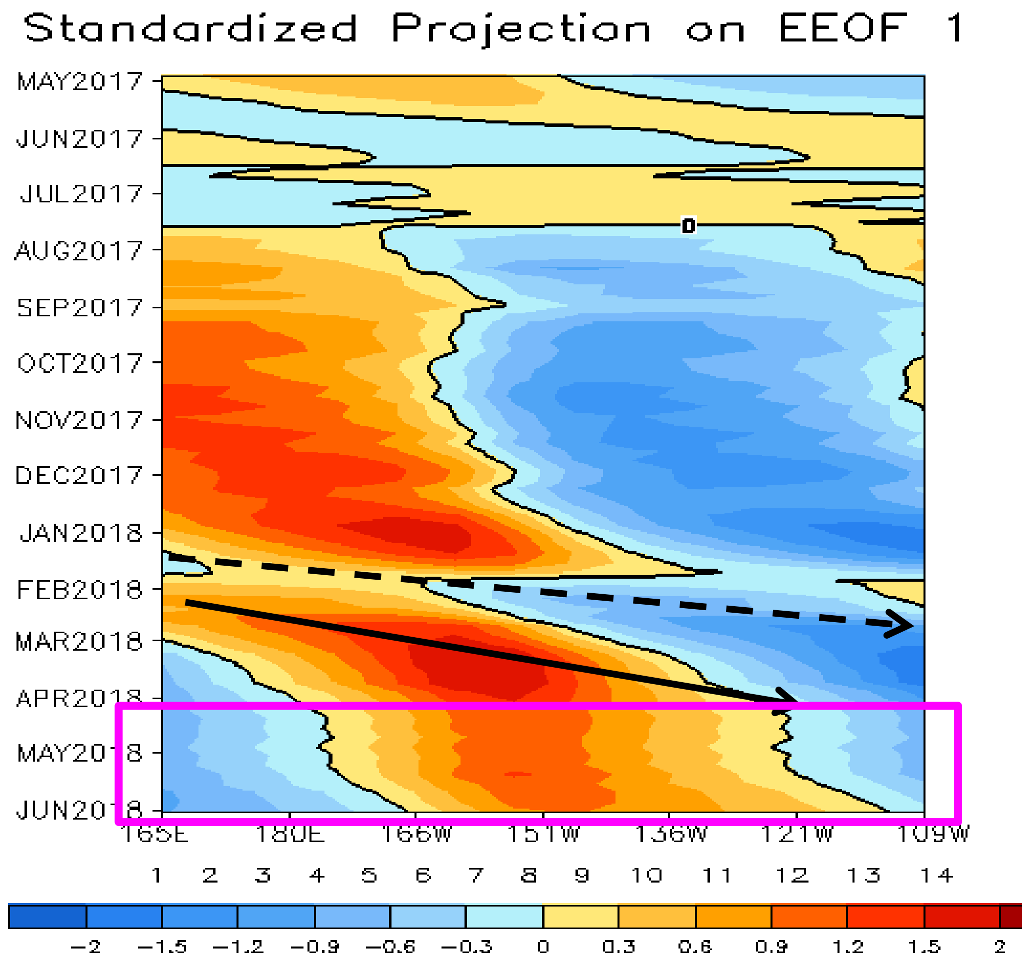


- Positive ocean temperature anomalies in the Pacific Ocean propagated eastward during last month and reached far-eastern Pacific, associated with eastward propagation of downwelling Kelvin wave.

- Both the anomalous amplitude and propagation speed are comparable between TAO and GODAS.

Oceanic Kelvin Wave (OKW) Index

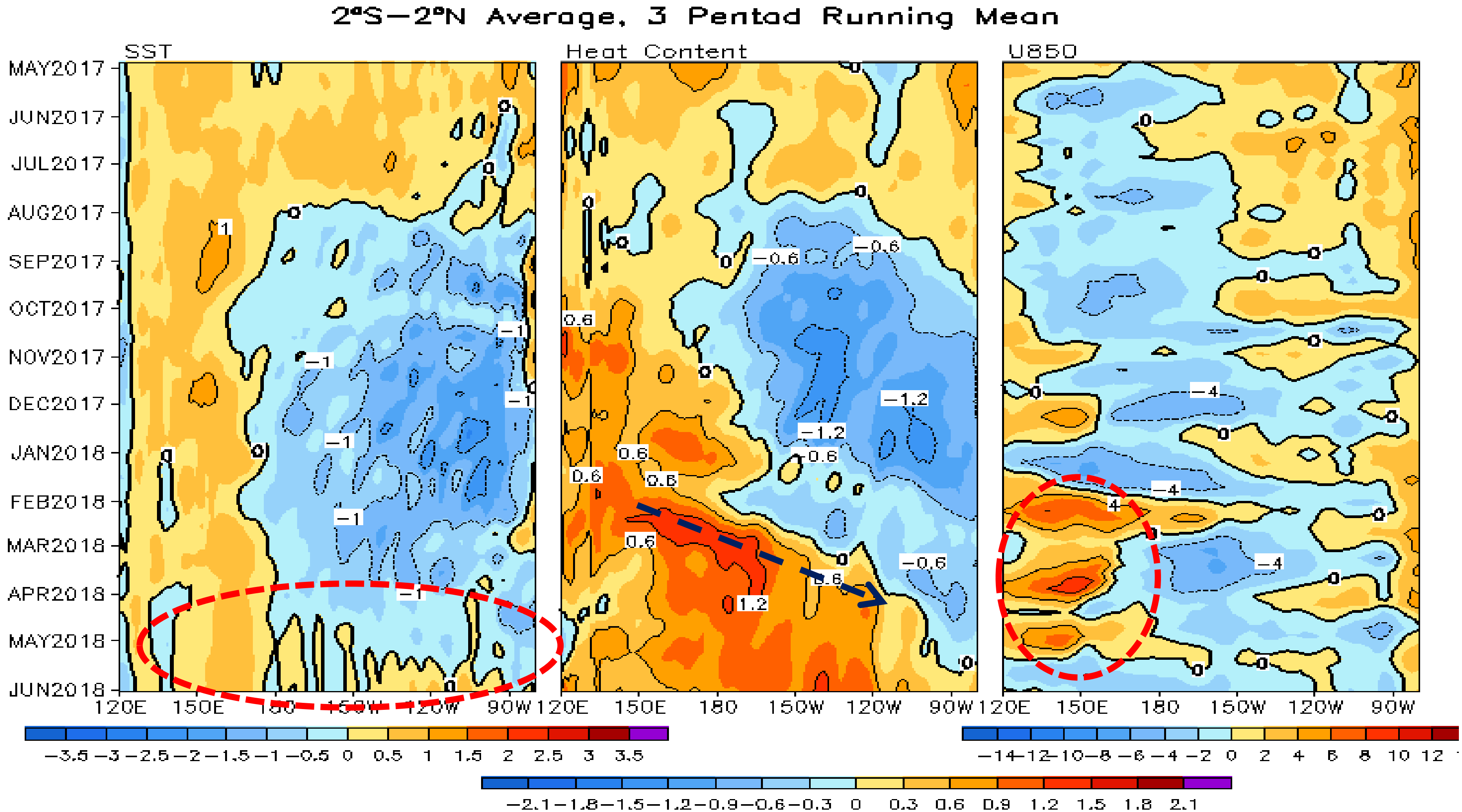




- A downwelling Kelvin wave propagated eastward from Feb - Mar 2018, and a stationary variation was observed since May 2018.

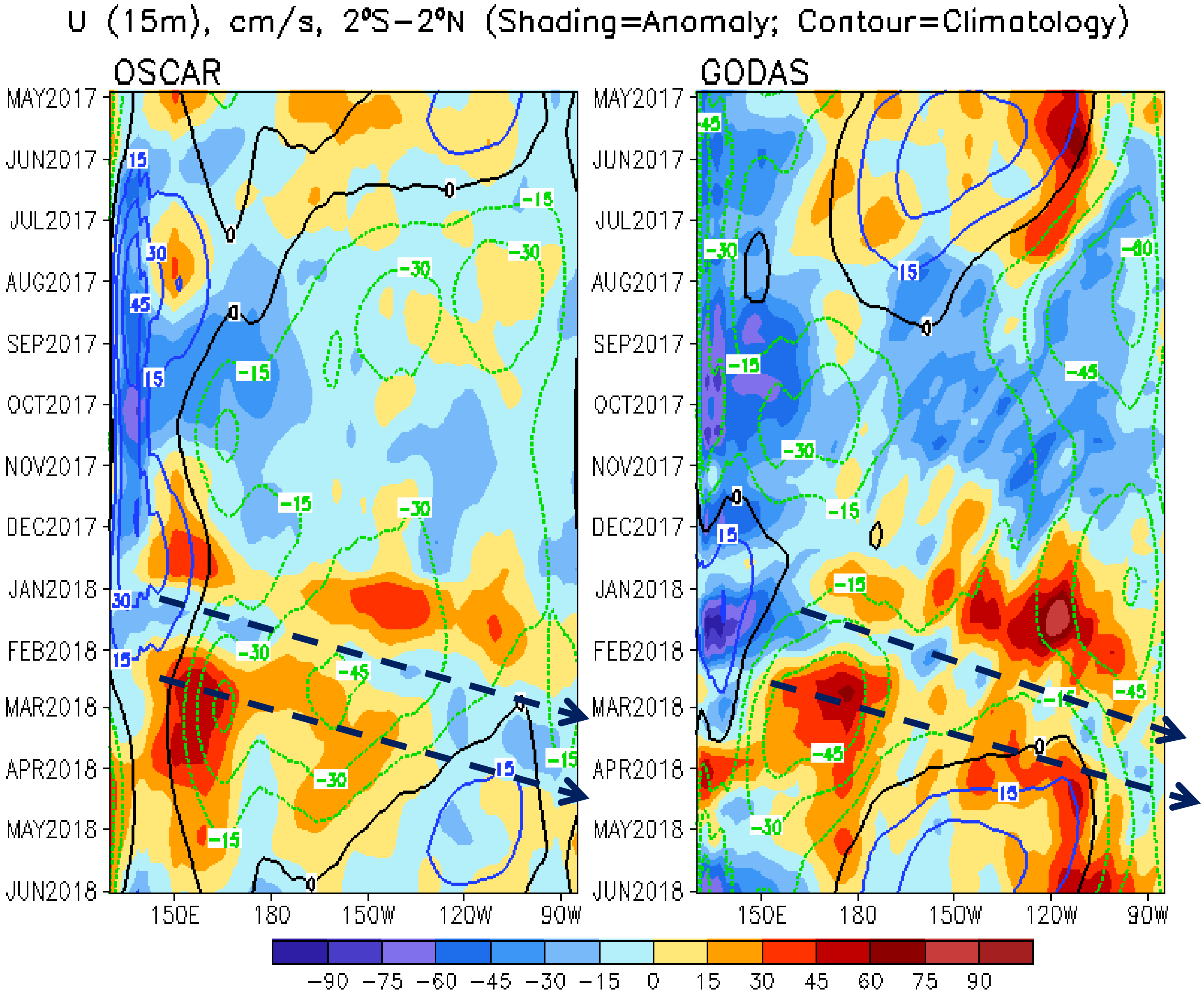
(OKW index is defined as standardized projections of total anomalies onto the 14 patterns of Extended EOF1 of equatorial temperature anomalies (Seo and Xue , GRL, 2005).)

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



- **Small positive SSTA presented in the eastern Pacific since late May 2018.**
- **Positive HC300A in the western and central Pacific propagated eastward in Feb-Mar 2018.**
- **Three low-level westerly wind burst events were observed during Jan-May 2018.**

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



- Anomalous eastward currents weakened in May 2018 in OSCAR and GODAS.

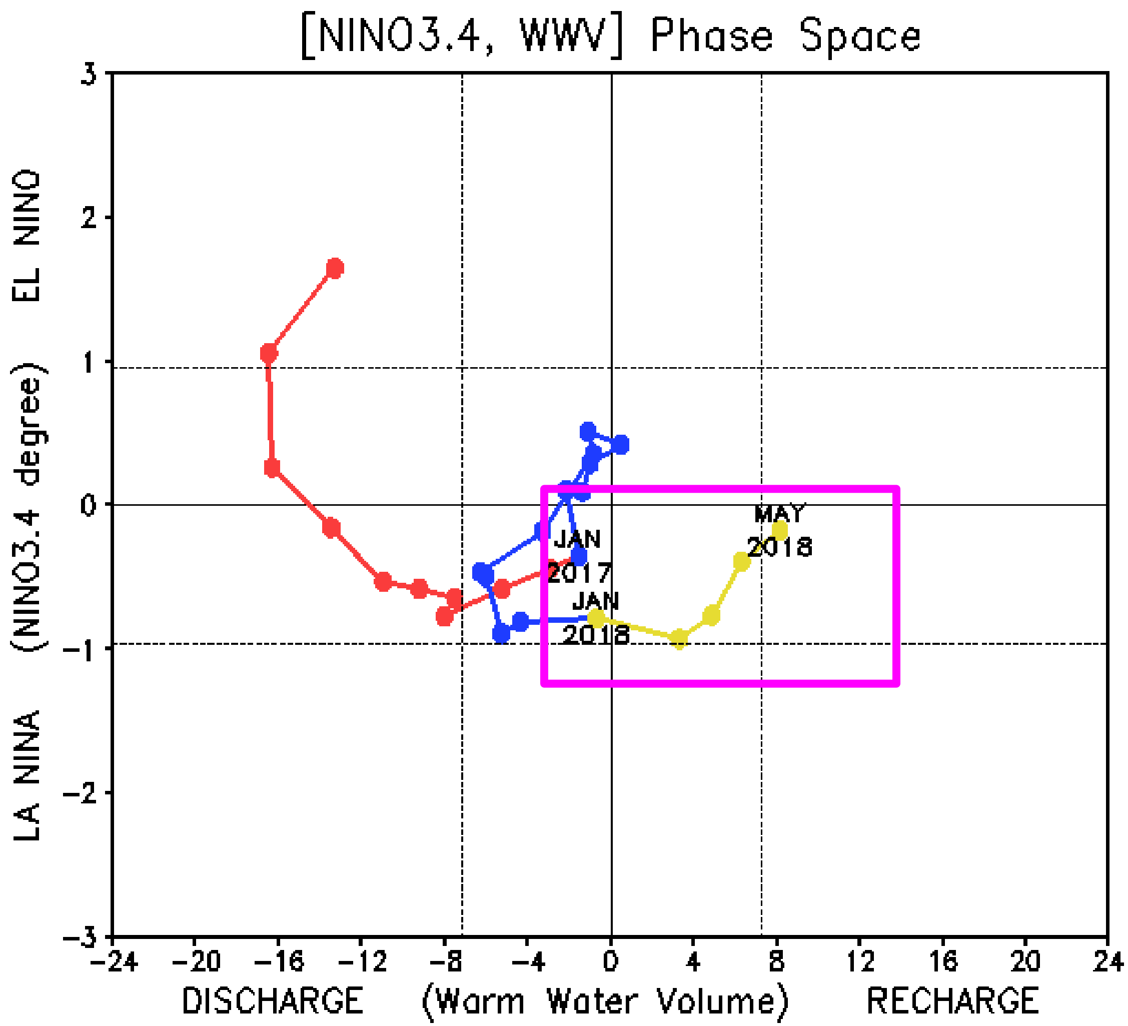
- The anomalous currents showed some differences between OSCAR and GODAS.

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).

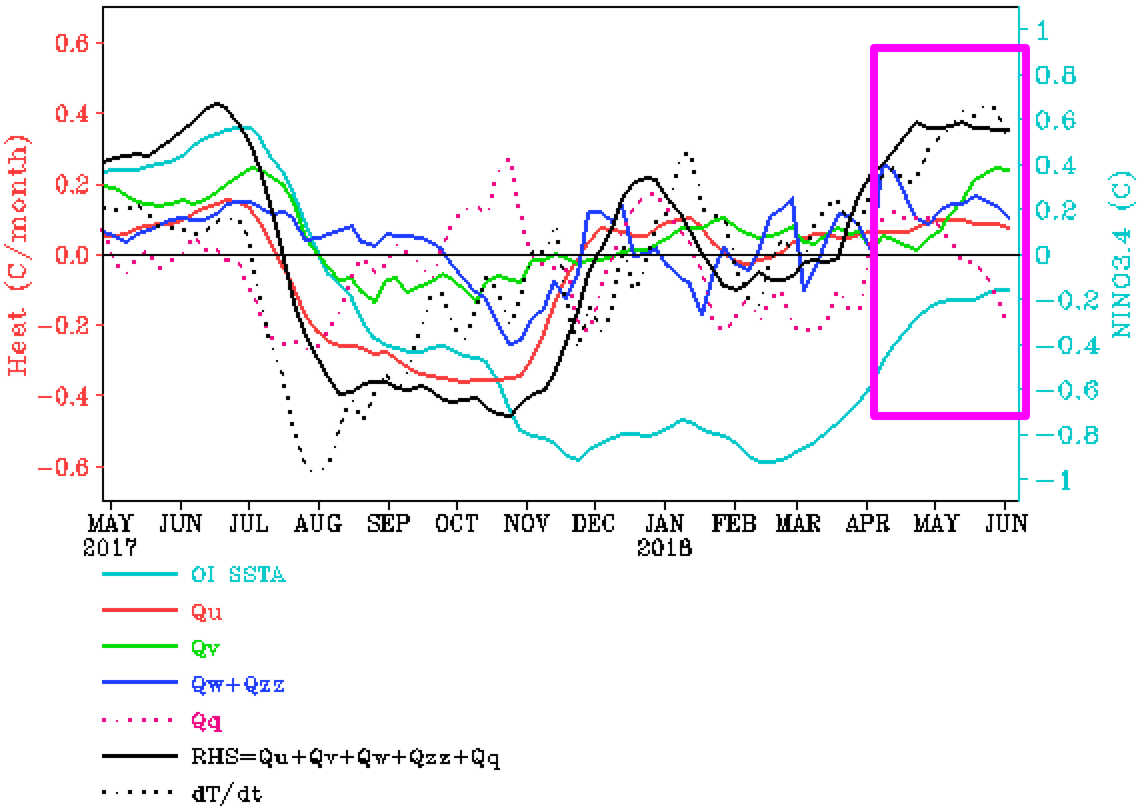
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



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

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

NINO3.4 Heat Budget



- **Both observed SSTA tendencies (dT/dt; dotted black line) and total heat budget (RHS; solid black line) in the Nino3.4 region were positive since later Mar 2018.**

- **All dynamical terms (Qu, Qv, Qw+Qzz) were positive, and total heat-flux (Qq) was 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.

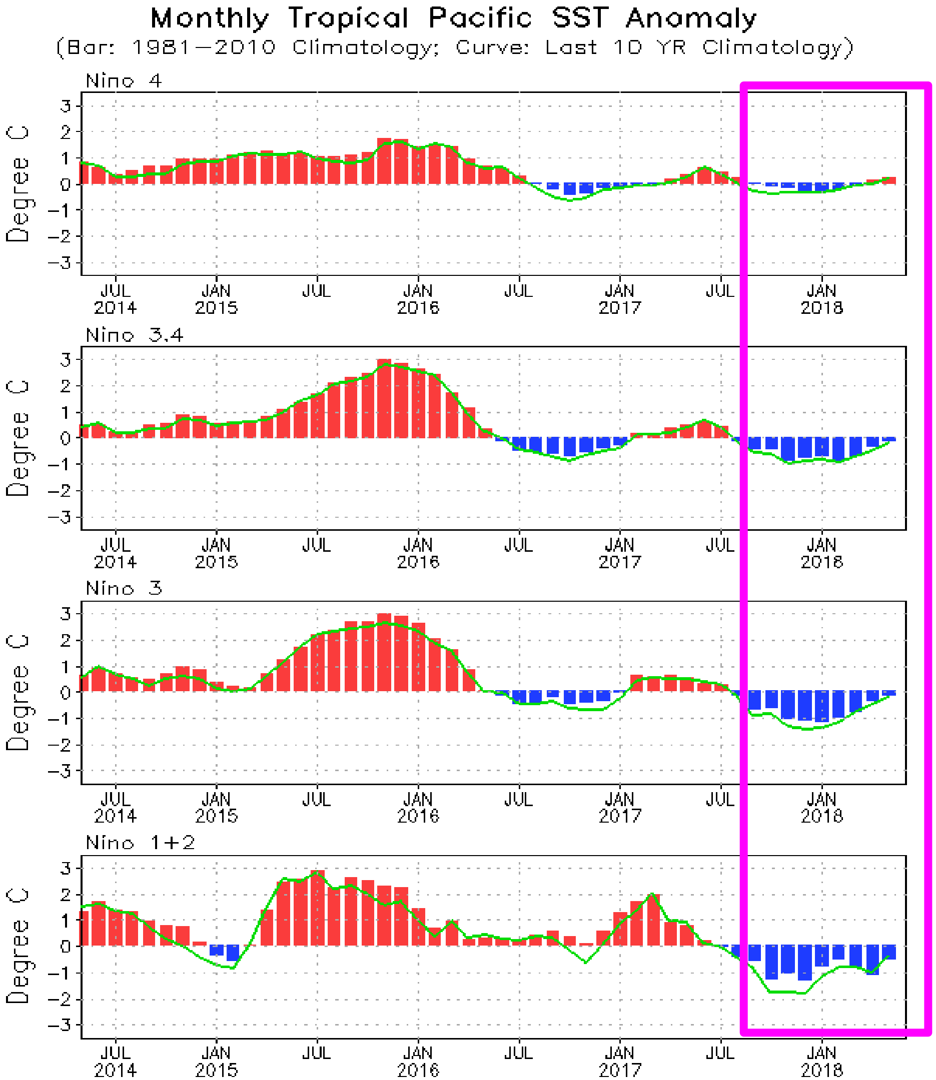
Qu: Zonal advection; Qv: Meridional advection;

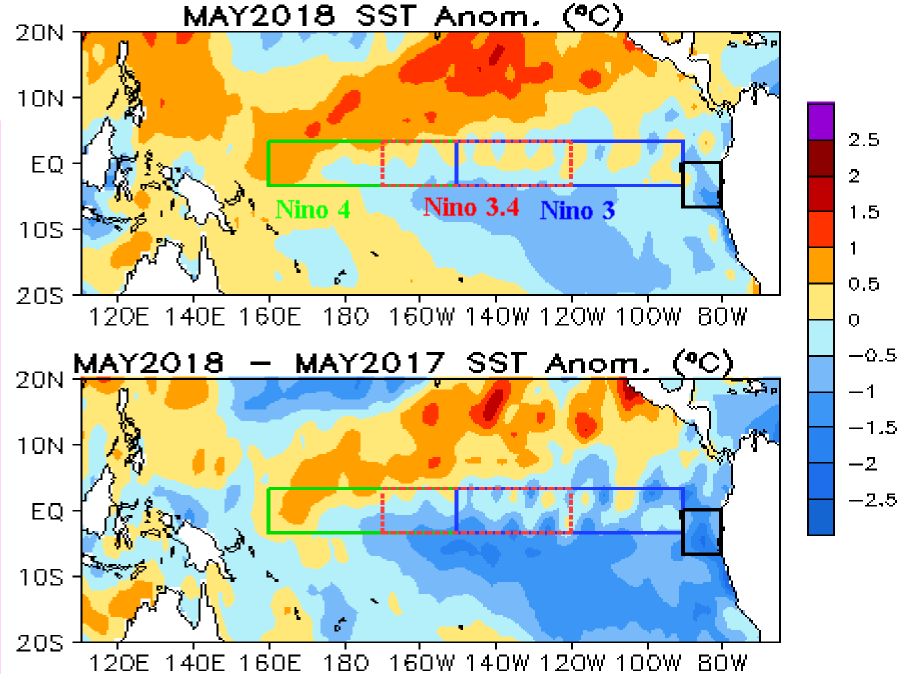
Qw: Vertical entrainment; Qzz: Vertical diffusion

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





- Nino4 became positive since Apr 2018, and Nino3 & Nino3.4 & Nino1+2 were negative and weakened in May 2018.

- Nino3.4 = -0.13 C in May 2018.

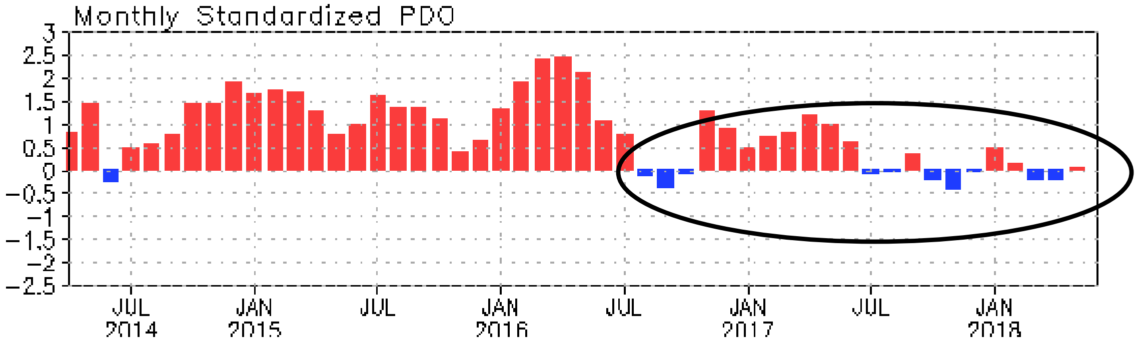
- Compared with last May, the central and eastern equatorial and southern Pacific were cooler in May 2018.

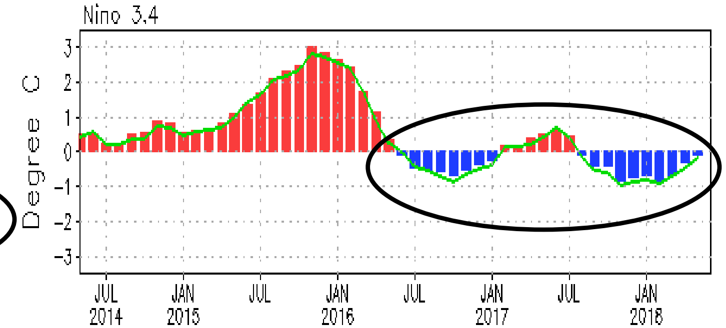
- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v5.

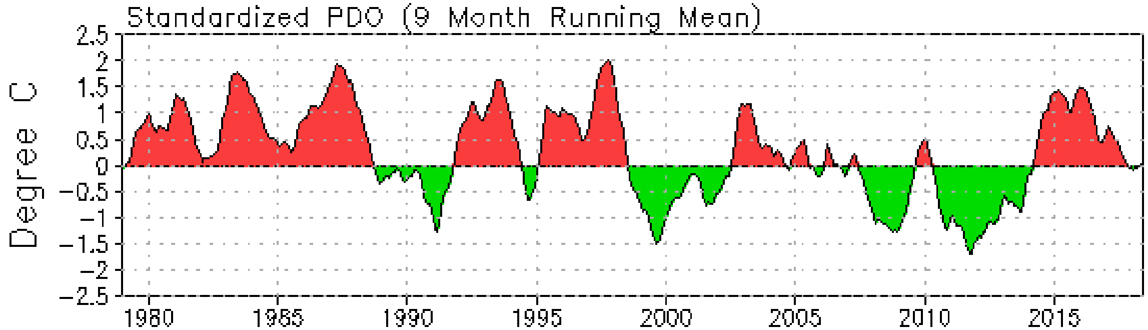
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

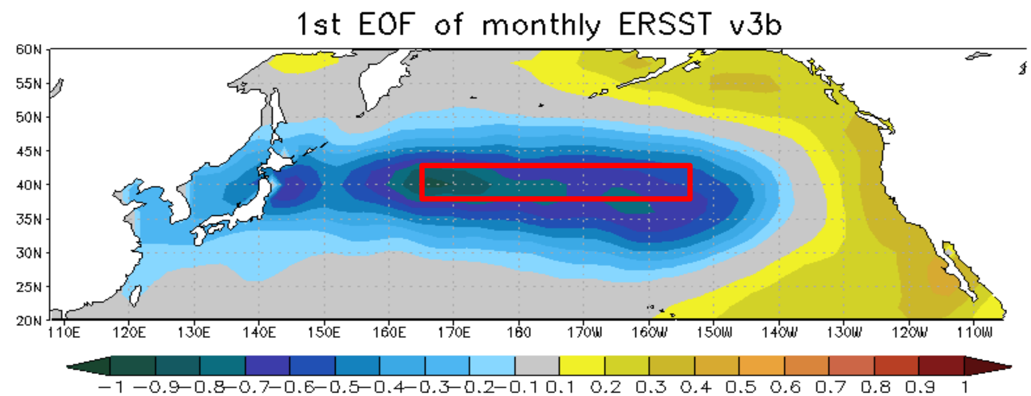
North Pacific & Arctic Oceans

PDO index









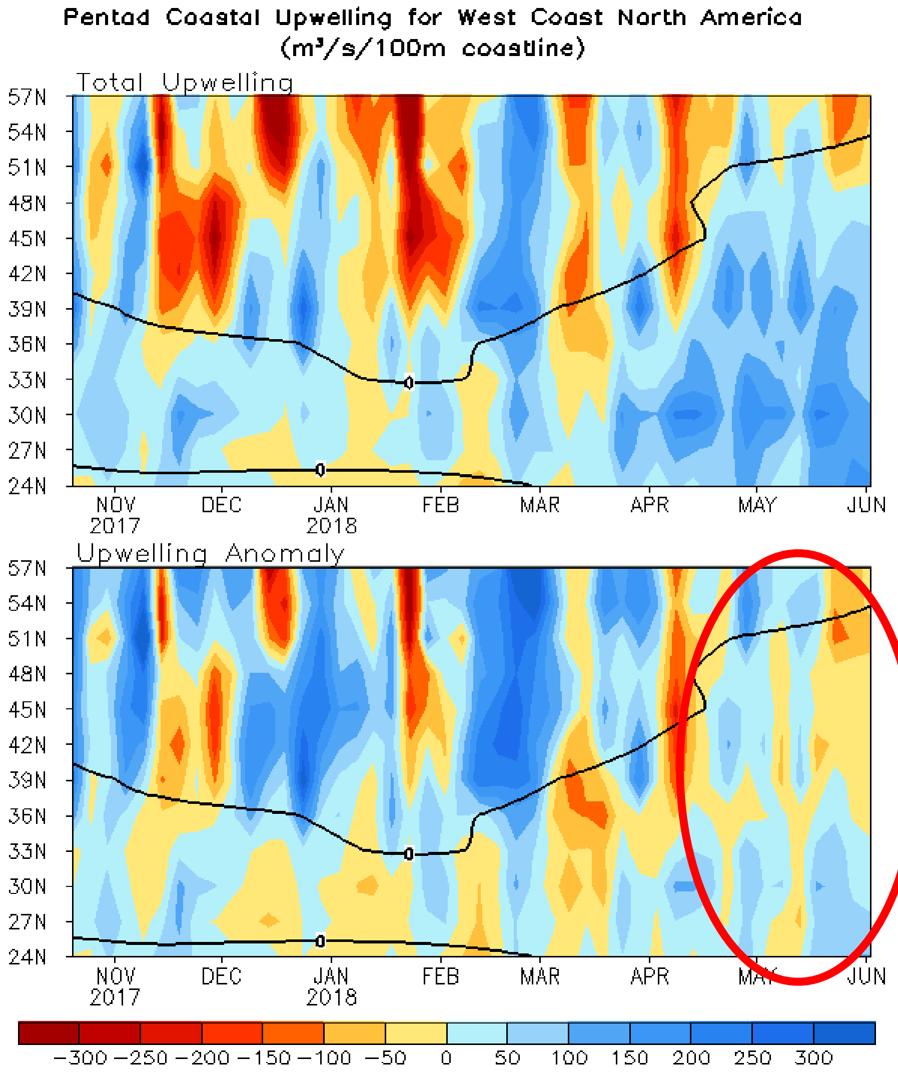
- The positive SSTAs presented with PDO index =0.0 in May 2018.

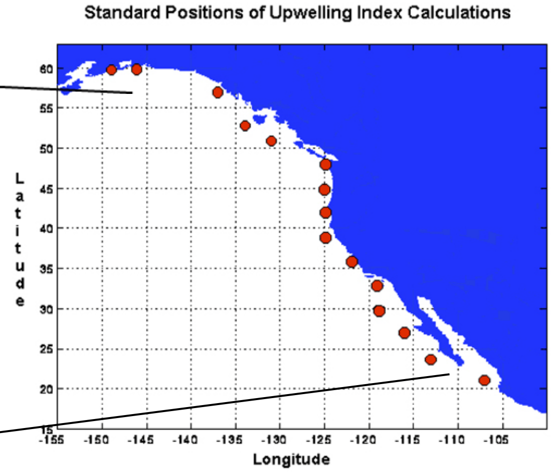
- Statistically, ENSO leads PDO by 3-4 months, may through atmospheric bridge.

- 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





- Both anomalous upwelling and downwelling were small since mid-Apr 2018.

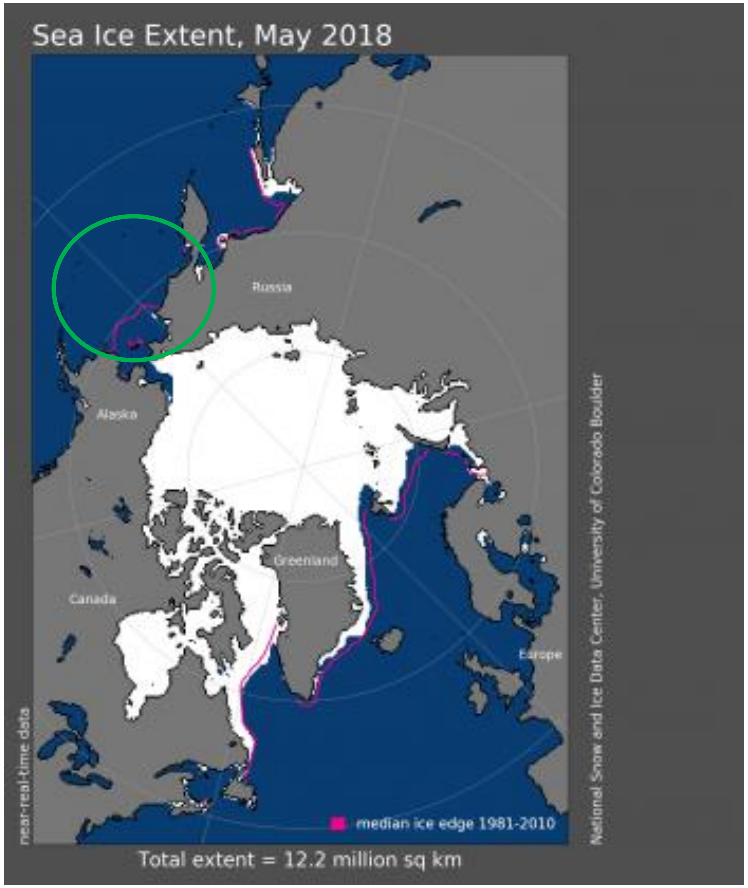
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport at 50 meter depth from each location to its nearest coast point (m³/s/100m coastline). Anomalies are departures from the 1981-2010 base period pentad means.

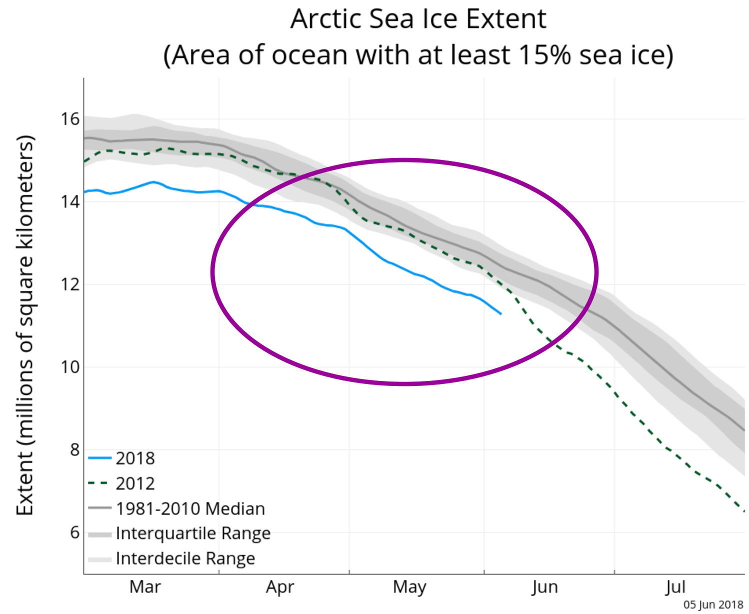
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from Mayil to July along the west coast of North America from 36ºN to 57ºN.**

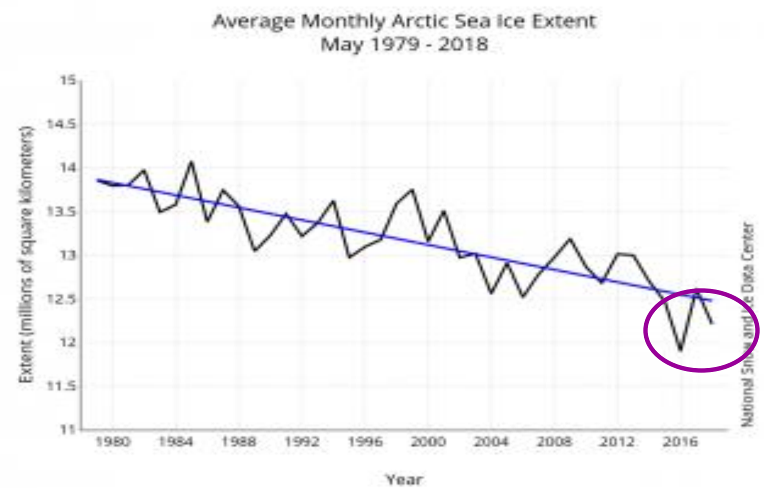
Arctic Sea Ice

National Snow and Ice Data Center

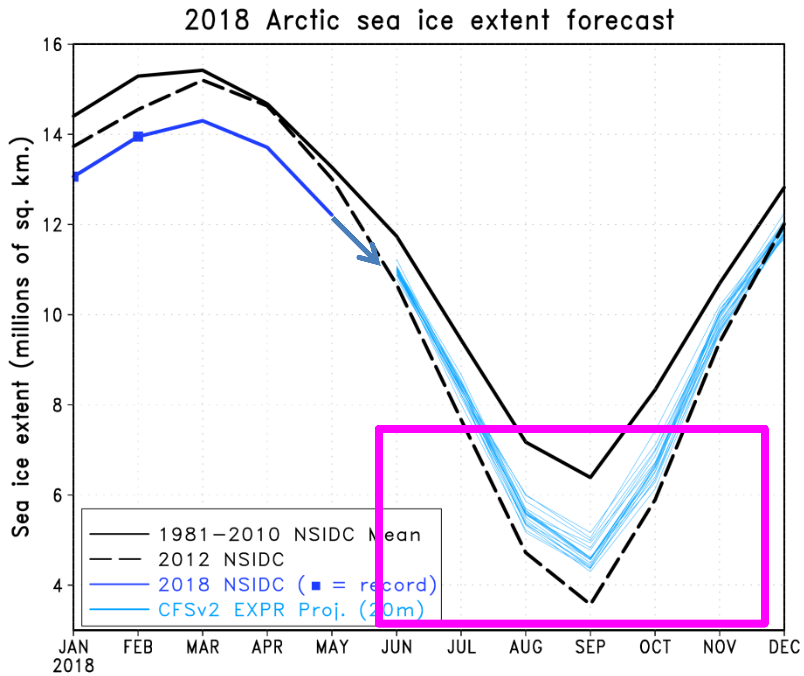
http://nsidc.org/arcticseaicenews/index.html



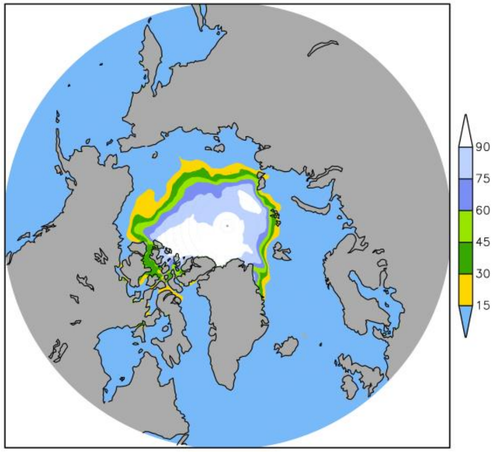




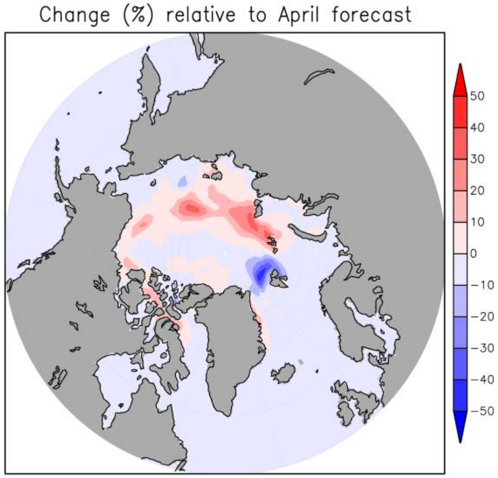
- **Arctic sea ice extent for May 2018 was the second lowest in the satellite record after May 2016, the record low for the month.**
- **Above average temperatures and high sea level pressure prevailed over most of the Arctic Ocean, while some surrounding continental regions were colder than usual.**

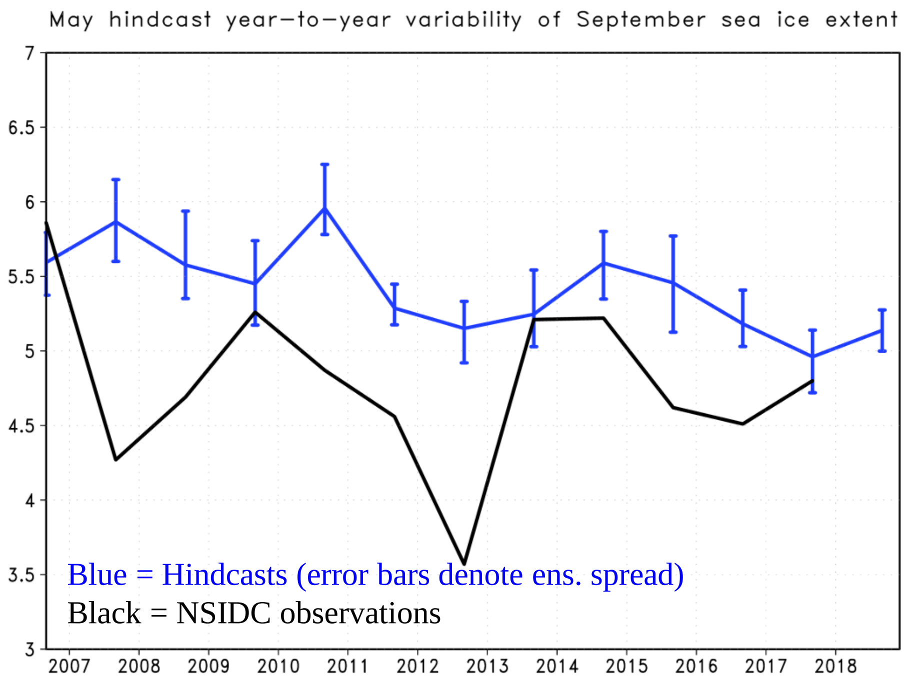


Sept 2018 SIC forecast



Red = 1981-2010 Climo.





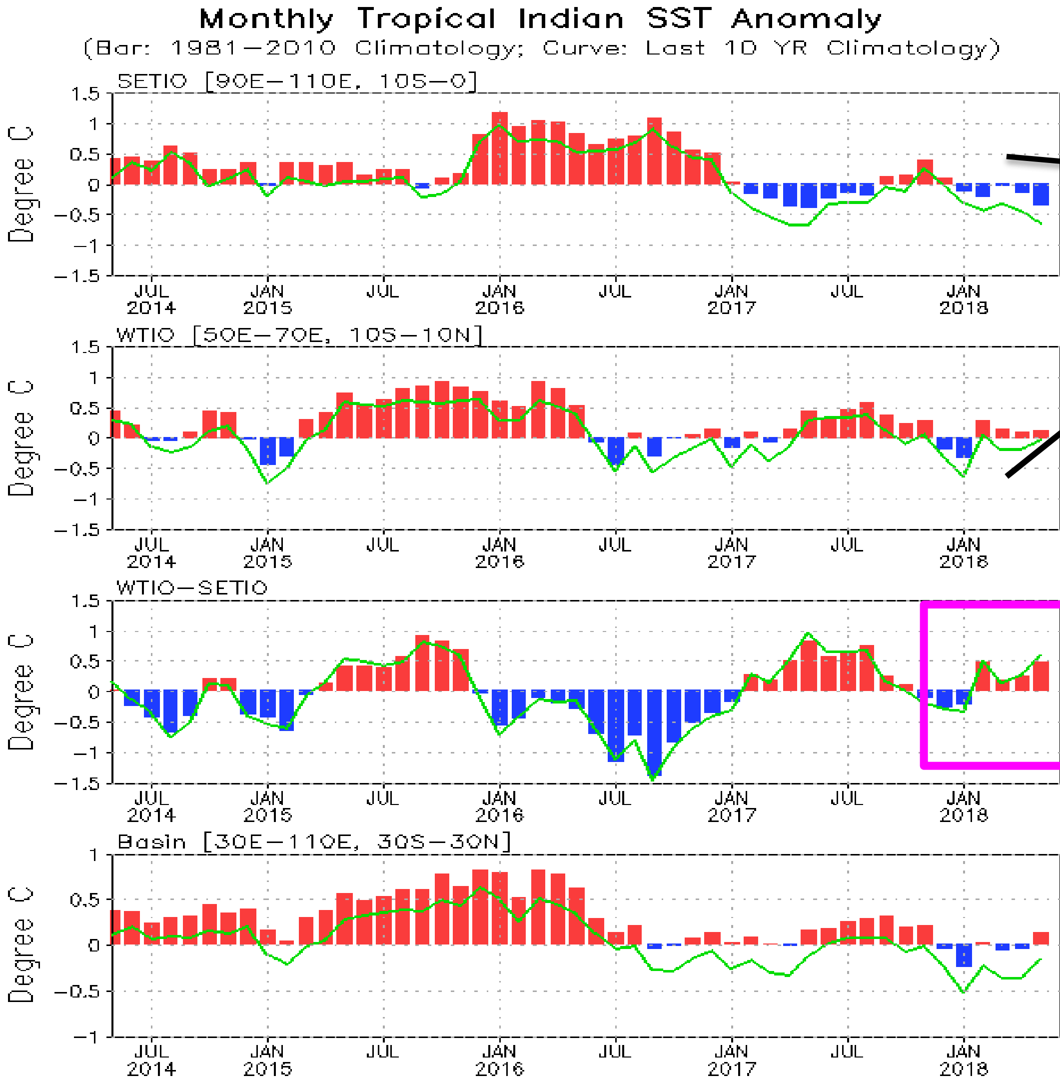
- **20-member ensemble experimental CFS Arctic sea ice forecast was initialized May 21-25, 2018 using ICs from the CPC Sea ice Initialization System (CSIS).**

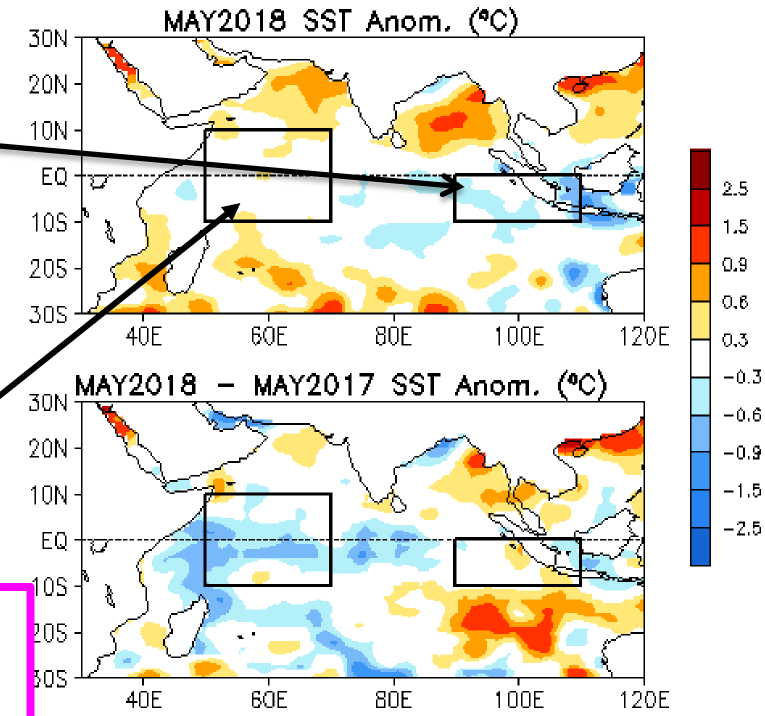
- **The projected September Arctic sea ice extent based on this forecast is 4.63 +/- 0.24 * 10^6 km^2 (April forecast was 4.50 +/- 0.29 * 10^6 km^2)**

- **There is an increase in the mean and a decrease in the ensemble variability compared to last month.**

Indian Ocean

Evolution of Indian Ocean SST Indices





- Dipole index was positive since Feb 2018.

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.

- SSTAs were small in the tropics.
- SSTA tendency was mainly determined by heat flux.

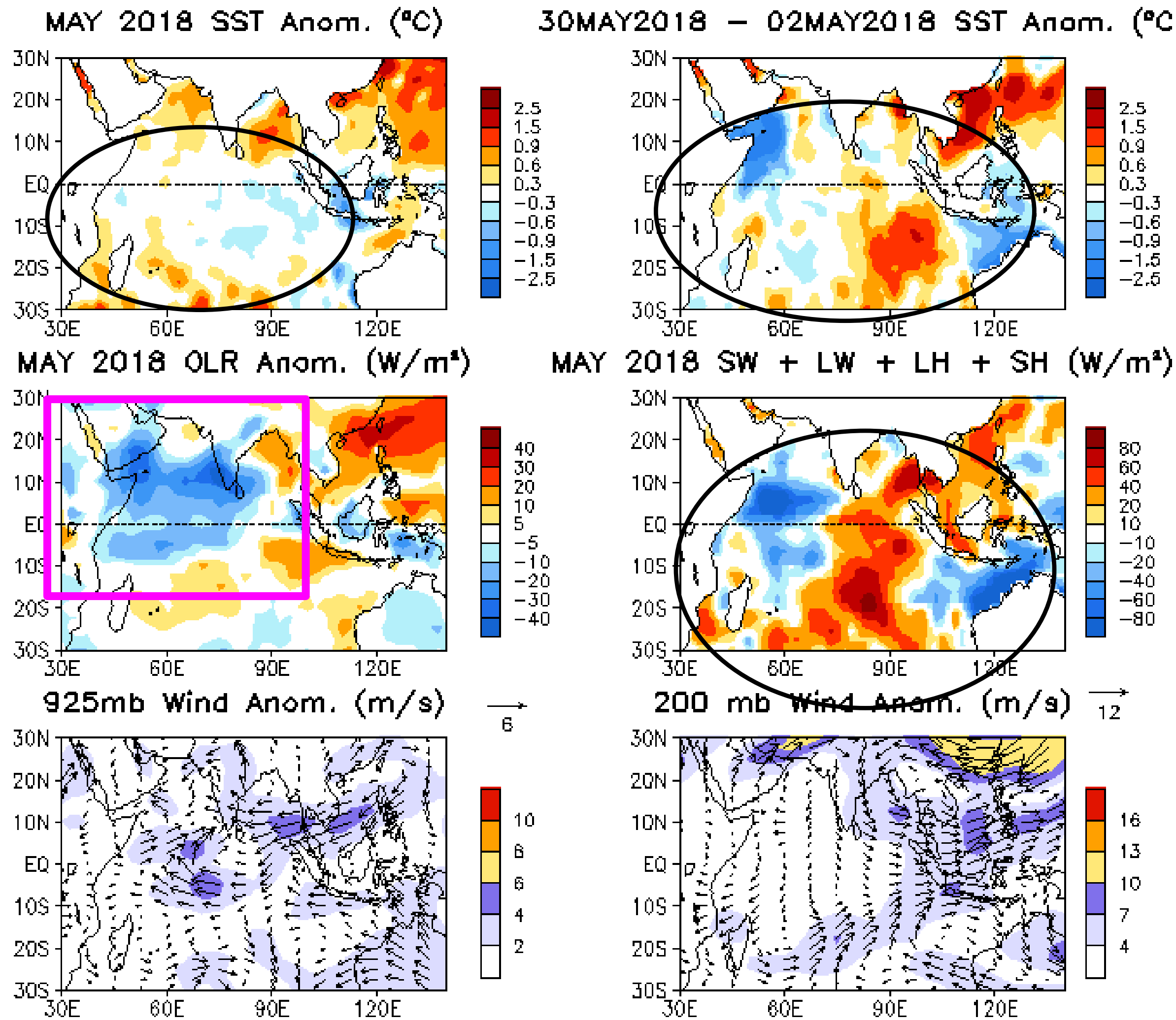
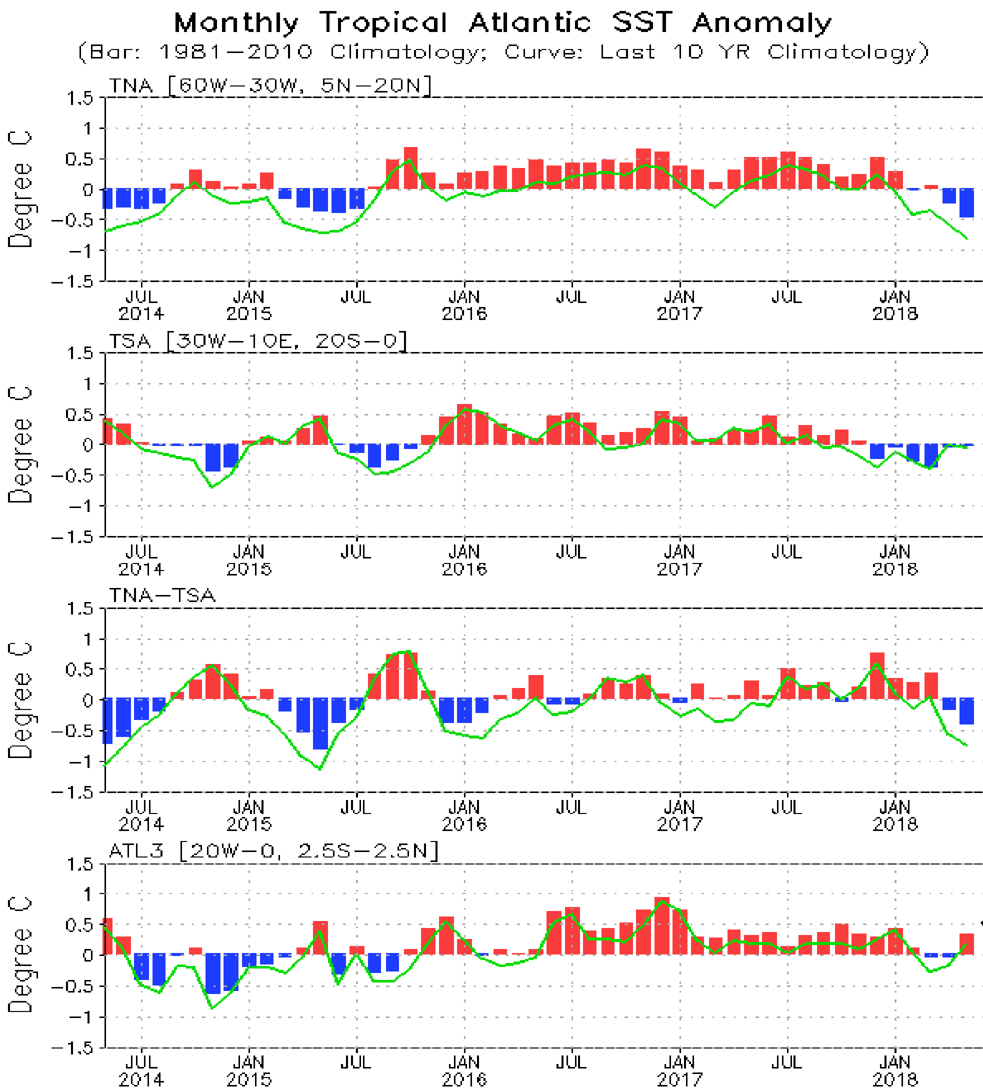
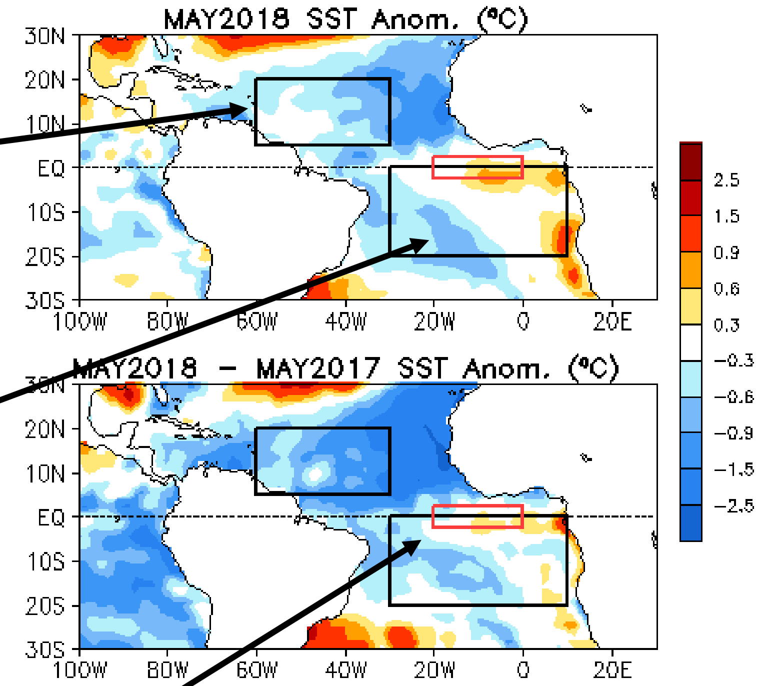


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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



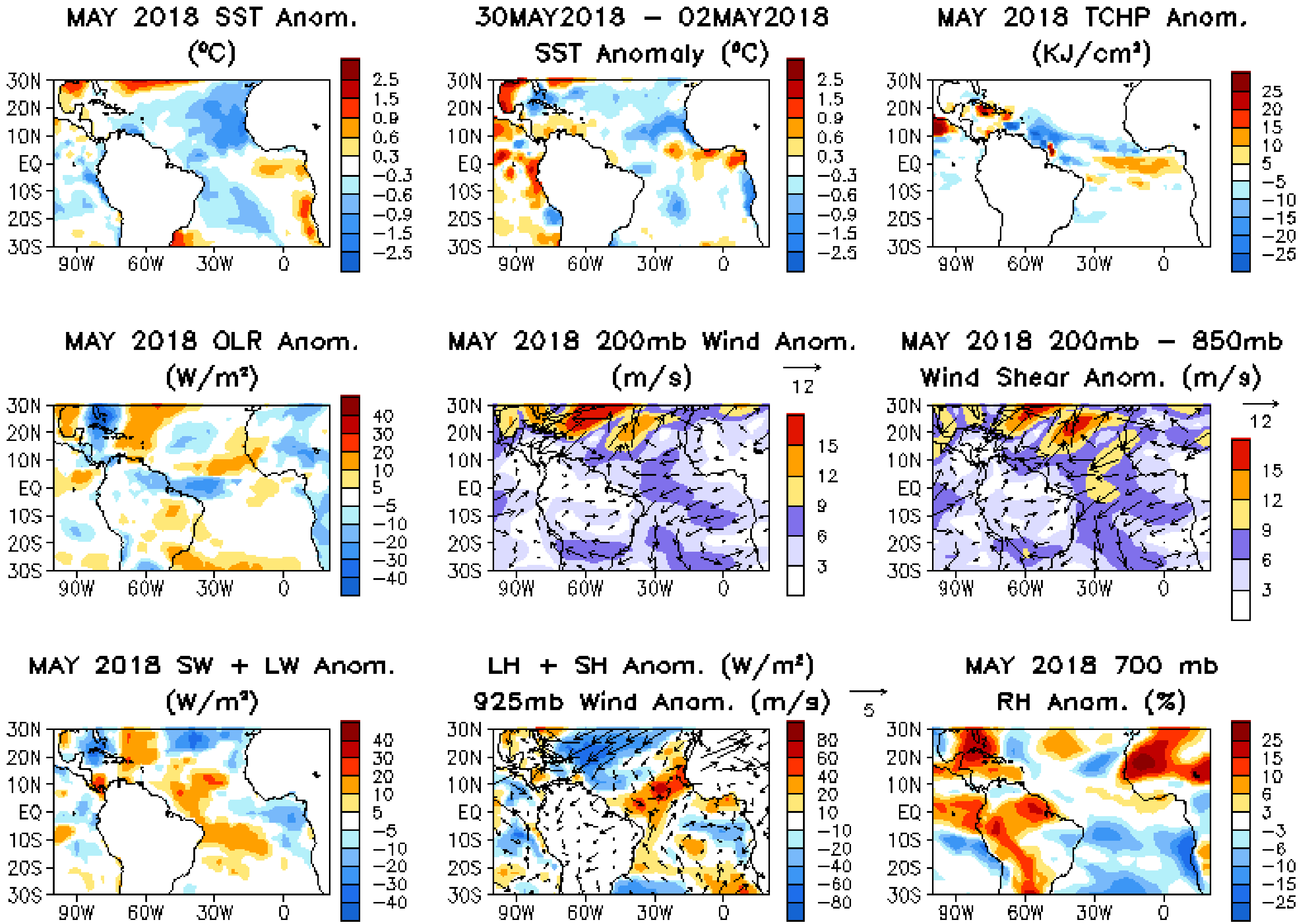


- **SSTAs were small on the equator and negative in the N Atlantic in May 2018.**

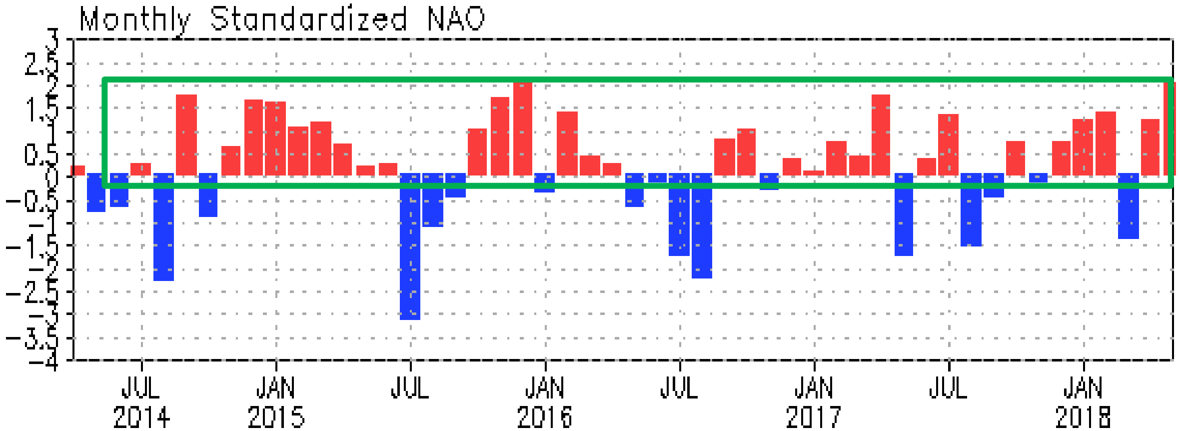
- **The SST in the tropical N Atlantic was much cooler than last May.**

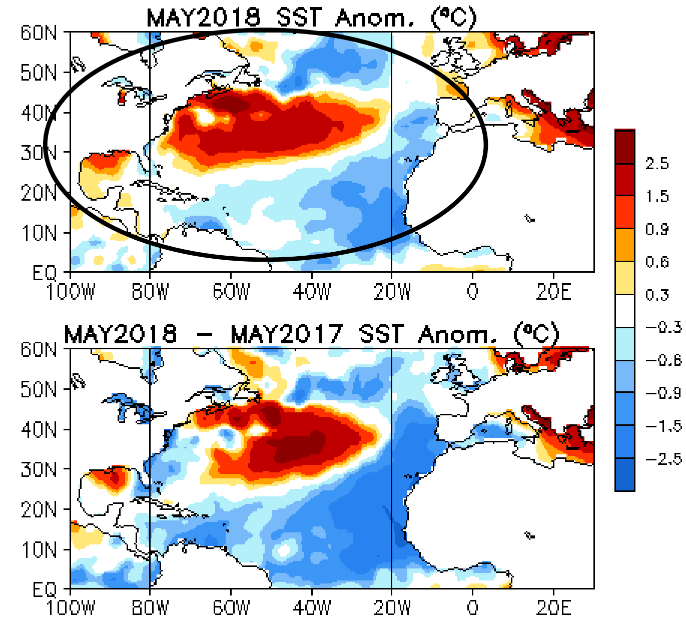
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between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

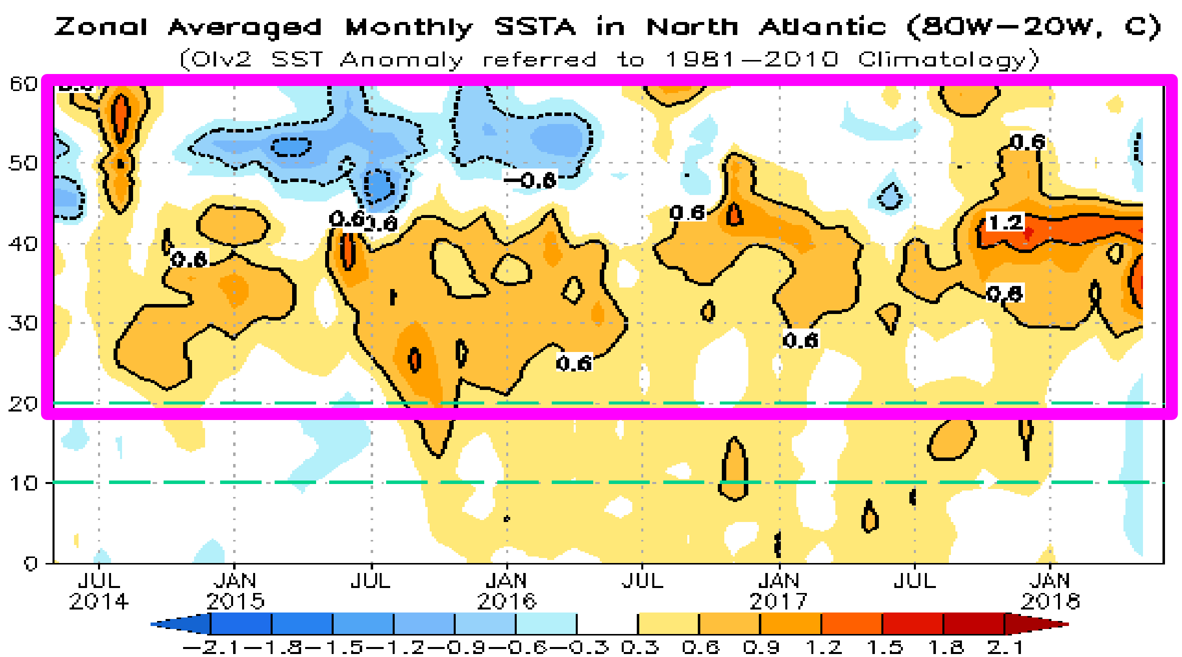
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic







- NAO was in positive phase with NAOI= 2.0 in May 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.

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

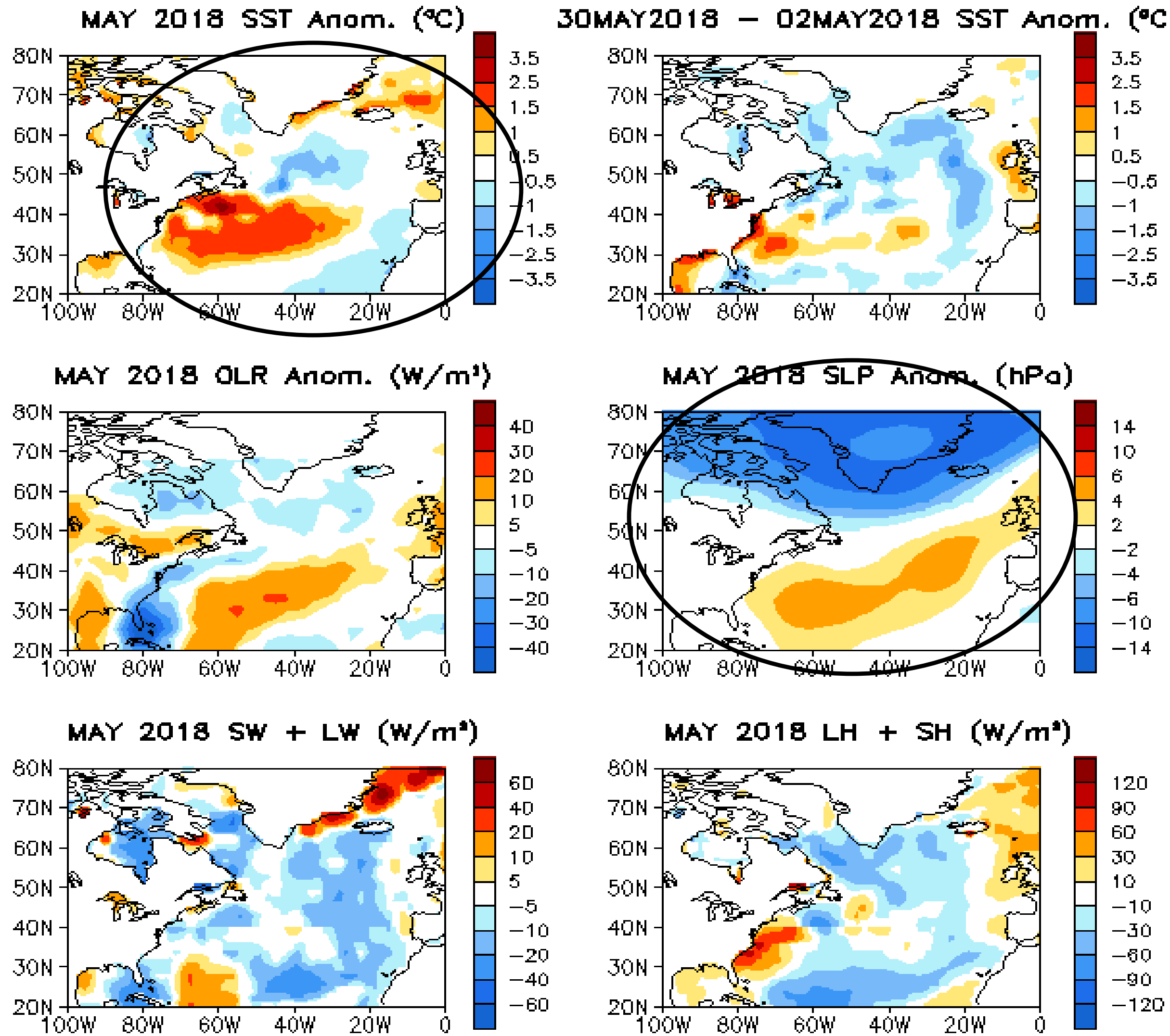


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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.

ENSO and Global SST Predictions

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 last La Niña Advisory on 10 May 2018

Season (Nino3.4)	**SON17**	**OND17**	**NDJ17/18**	**DJF17/18**	**JFM18**	**FMA18**	**MAM18**	
ERSSTv5	**-0.7**	**-0.9**	**-1.0**	**-0.9**	**-0.8**	**-0.6**	**-0.4**	✓
OIv2	**-0.6**	**-0.7**	**-0.8**	**-0.8**	**-0.8**	**-0.6**	**-0.4**	✓

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.

EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by

CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society
10 May 2018

ENSO Alert System Status: Final La Niña Advisory

Synopsis: ENSO-neutral is favored through September-November 2018, with the possibility of El Niño nearing 50% by Northern Hemisphere winter 2018-19.

During April 2018, the tropical Pacific returned to ENSO-neutral, as indicated by mostly near-to- below average sea surface temperatures (SSTs) along the equator (Fig. 1). The latest weekly Niño indices were near zero in all regions (between +0.2°C and -0.3°C), except for Niño-1+2, which remained negative (-0.6°C; Fig. 2). Subsurface temperature anomalies (averaged across 180°-100°W) remained positive (Fig. 3), due to the continued influence of a downwelling oceanic Kelvin wave (Fig. 4). Atmospheric indictors related to La Niña also continued to fade. While convection remained suppressed near and east of the Date Line, rainfall near Indonesia was also below average during the month (Fig. 5). Low-level winds were near average over most of the tropical Pacific Ocean, and upper-level winds were anomalous westerly over the eastern Pacific. Overall, the ocean and atmosphere system reflected a return to ENSO-neutral.

The majority of models in the IRI/CPC plume predict ENSO-neutral to continue at least through the Northern Hemisphere summer 2018 (Fig. 6). As the fall and winter approaches, many models indicate an increasing chance for El Niño. Therefore, the forecaster consensus hedges in the direction of El Niño as the winter approaches, but given the considerable uncertainty in ENSO forecasts made at this time of year, the probabilities for El Niño are below 50%. In summary, ENSO-neutral is favored through September-November 2018, with the possibility of El Niño nearing 50% by Northern Hemisphere winter 2018-19 (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 14 June 2018. 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.

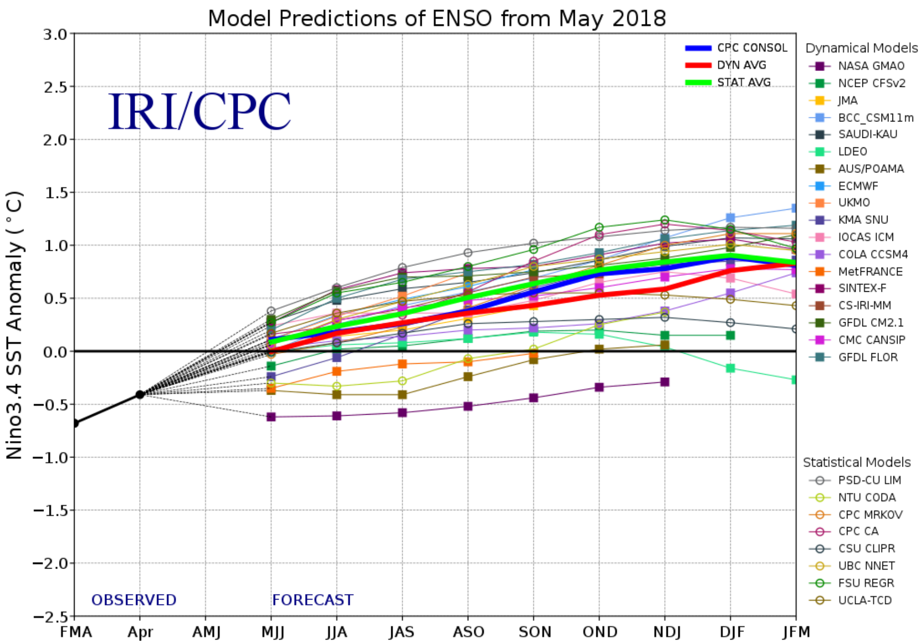
Climate Prediction Center
National Centers for Environmental Prediction
NOAA/National Weather Service
College Park, MD 20740

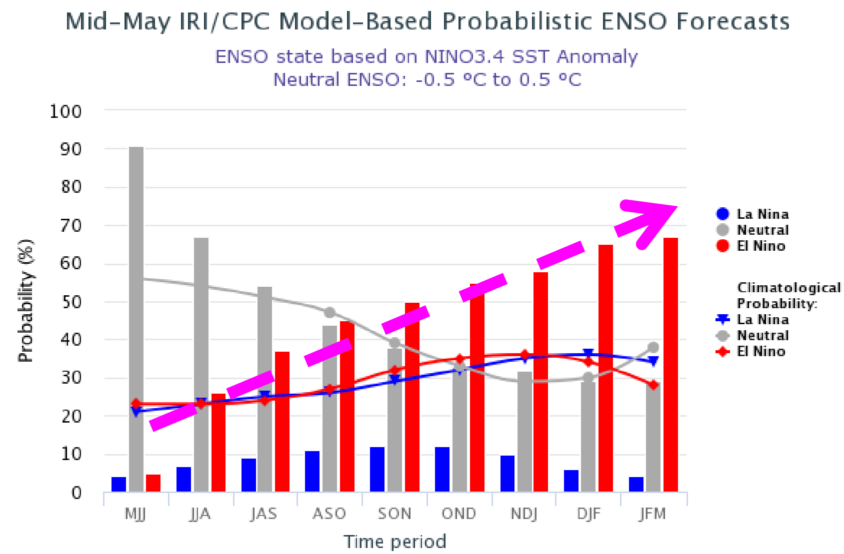
NOAA/NCEP/CPC issued La Niña Watch on 14 September 2017

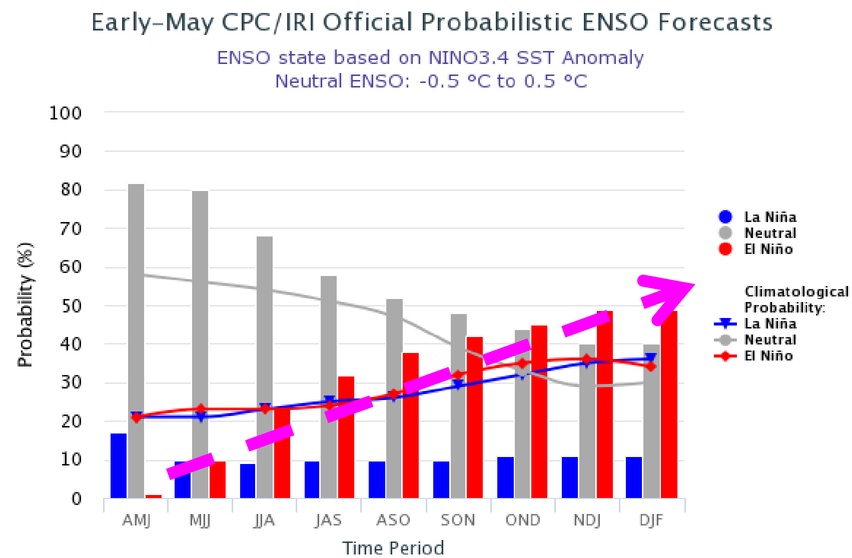
NOAA/NCEP/CPC issued La Niña Advisory on 9 November 2017

On 10 May 2018, NOAA/NCEP/CPC issued Final La Niña Advisory. **"ENSO-neutral is favored through September-November 2018, with the possibility of El Niño nearing 50% by Northern Hemisphere winter 2018-19."**

IRI NINO3.4 Forecast Plum



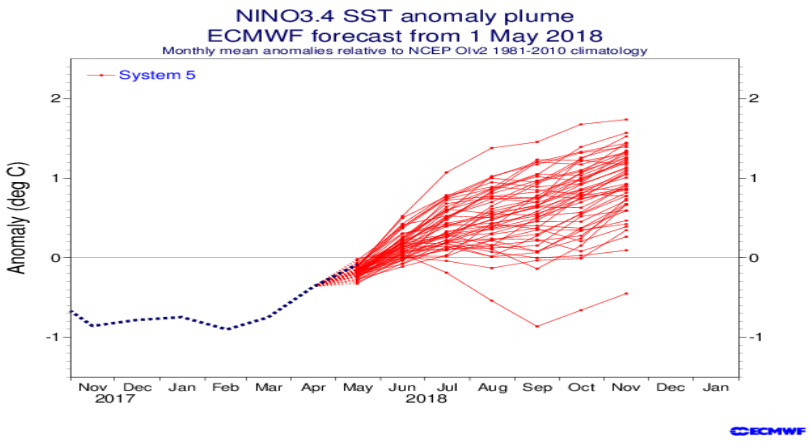




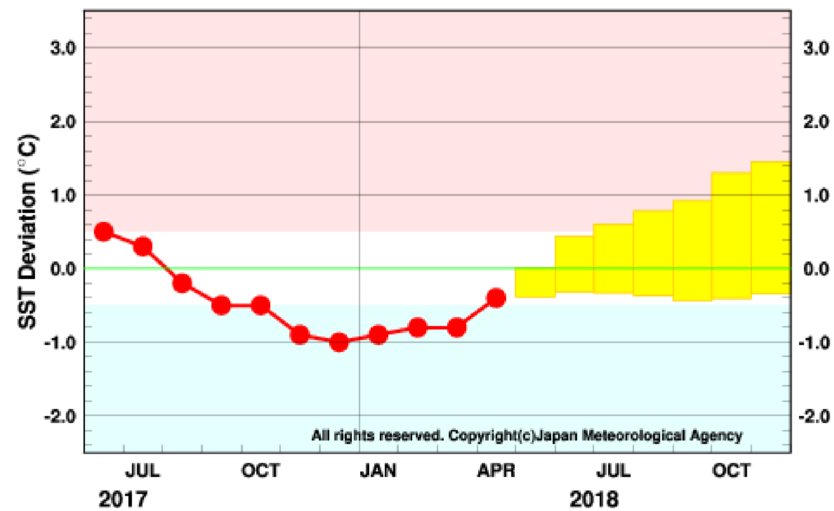
- **Majority of models predict El Nino in 2018.**
- **The consensus of model forecasts is more confident on El Nino (65% chance in DJF) than the consensus of forecasters (50% chance in DJF).**
- **On average, the statistical models are more bullish than the dynamical models on the development of El Nino, which is uncommon.**

Individual Model Forecasts: neutral or El Nino

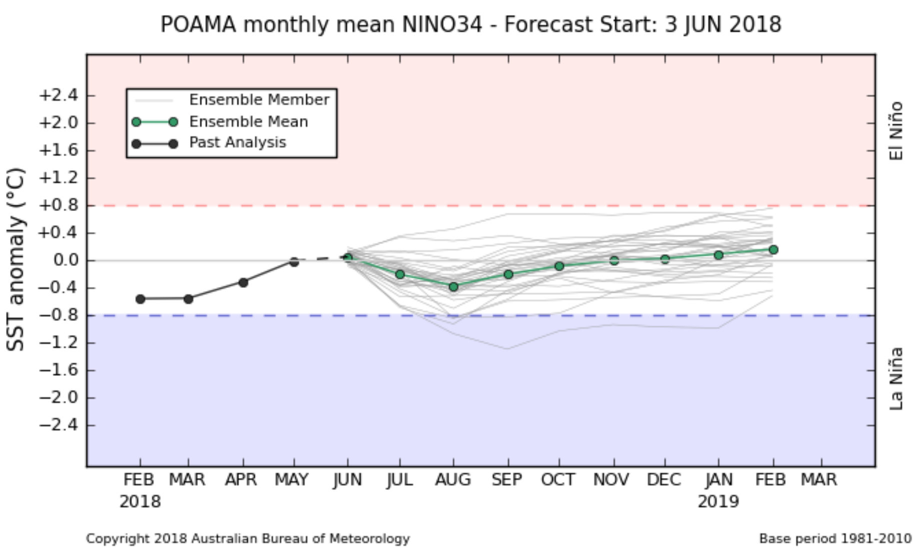
EC: Nino3.4, IC=01May2018



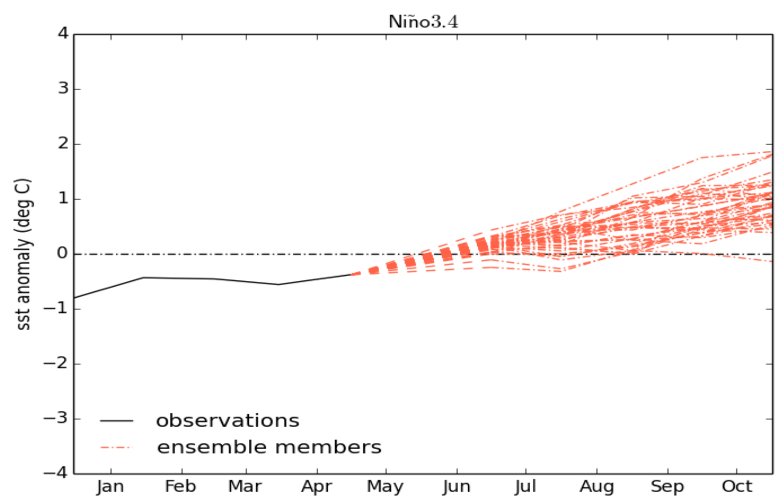
JMA: Nino3, IC/updated = 11 May 2018



Australia: Nino3.4, IC=3 Jun 2018



UKMO: Nino3.4, IC=May 2018



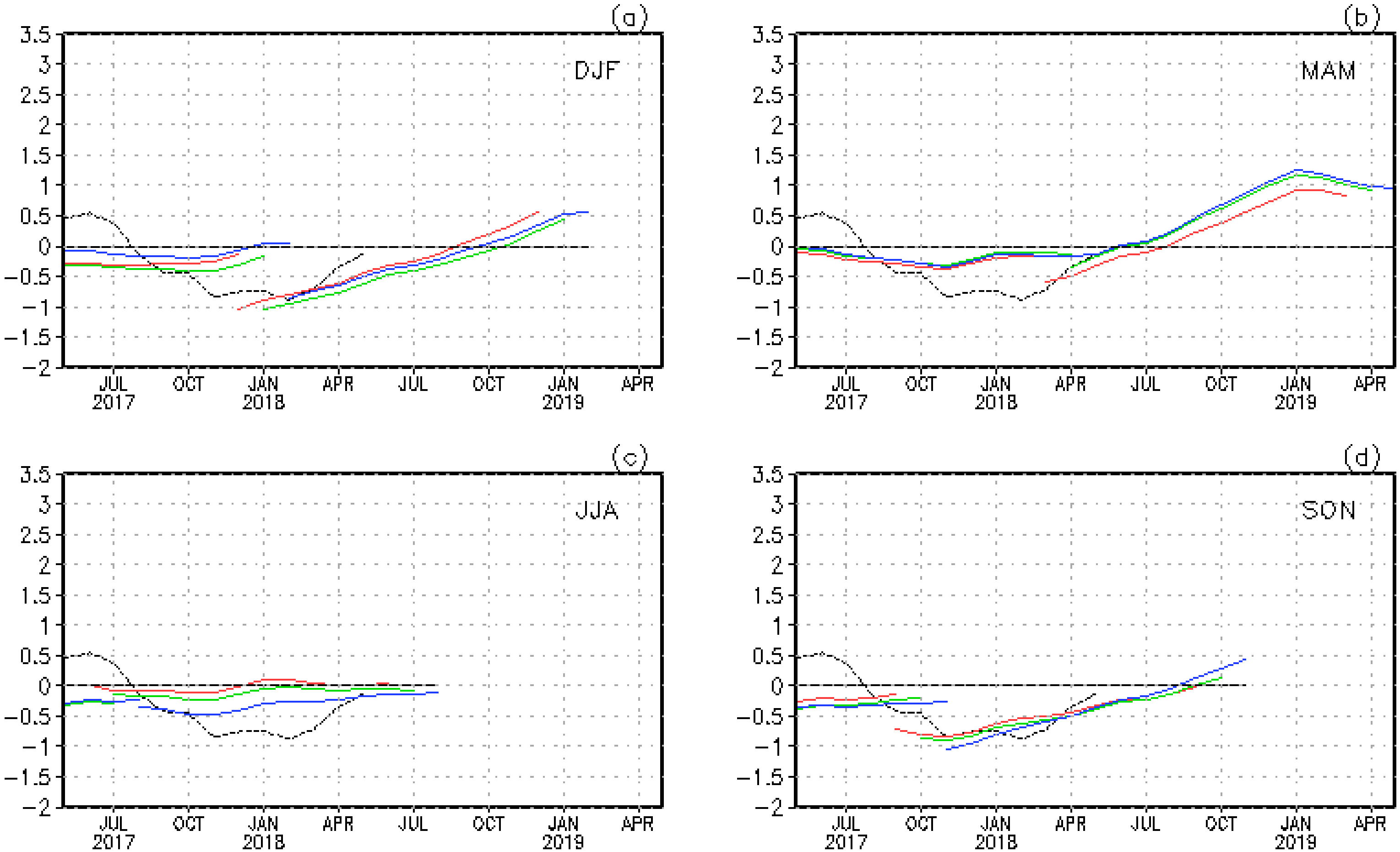
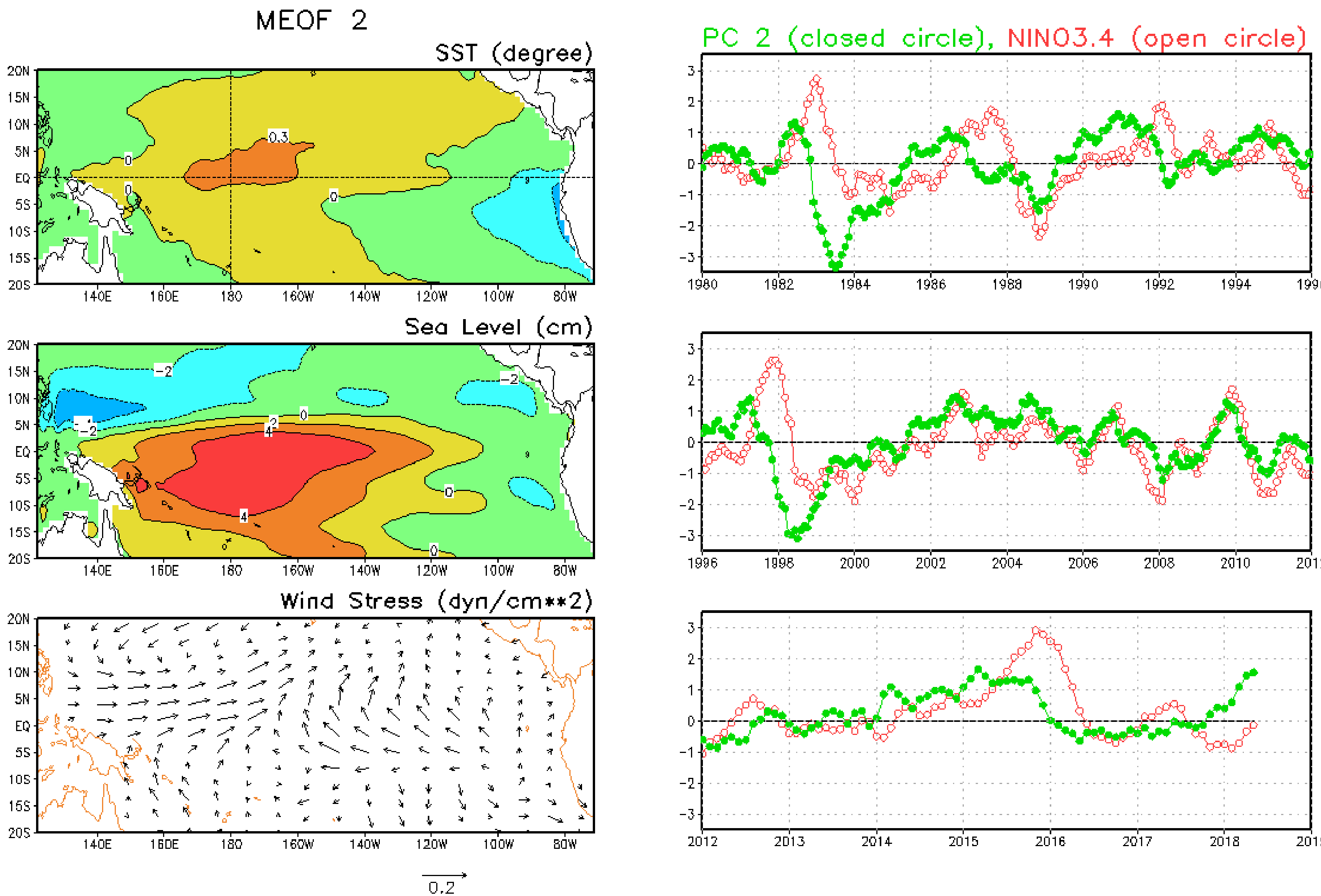
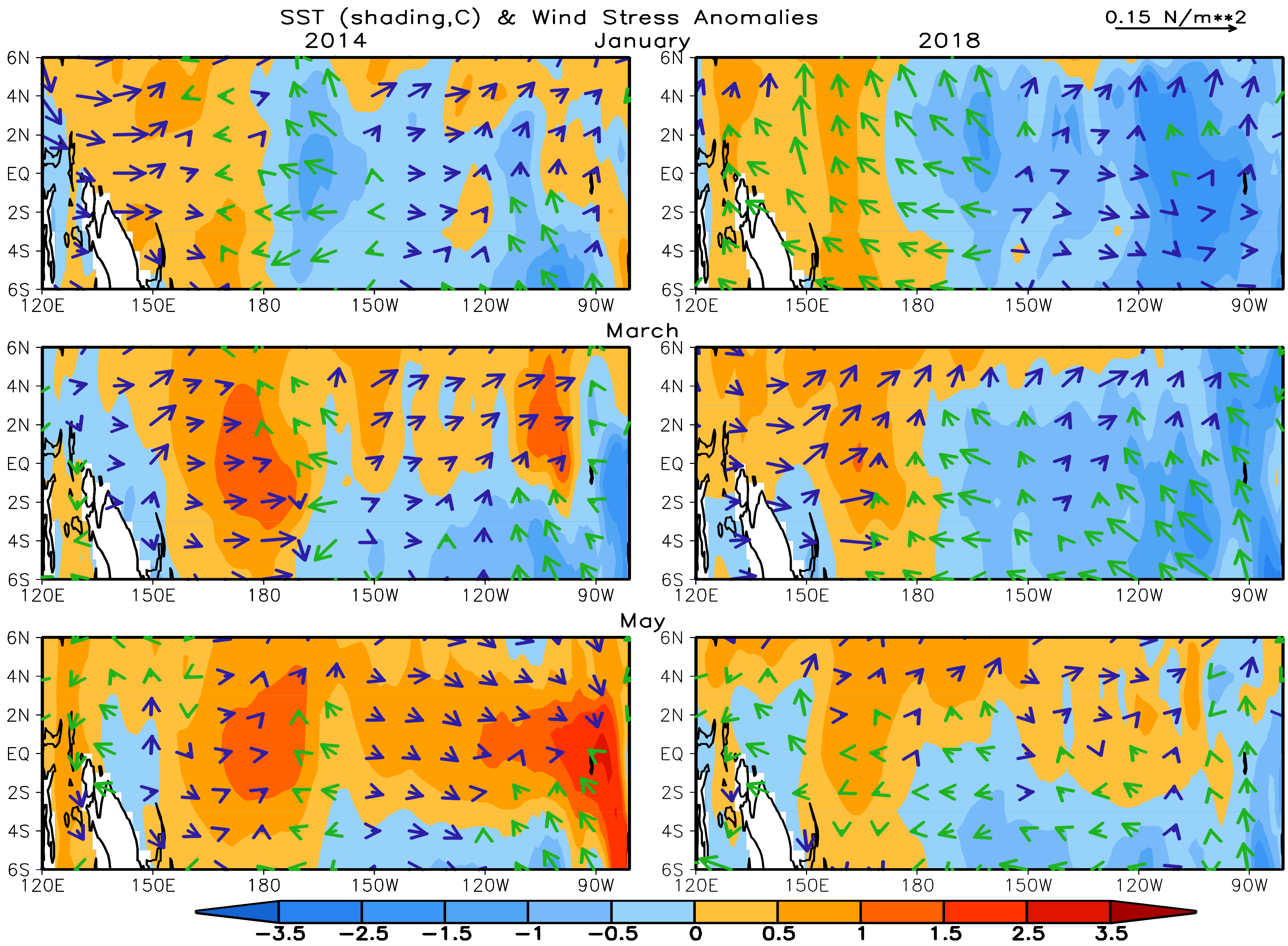


Fig. 4. Time evolution of NINO3.4 forecasts up to 12 lead months by the Markov model initiated monthly up to May 2018 . Shown in each panel are the forecasts grouped by three consecutive starting months: (a) is for December, January and February, (b) is for March, April and May, (c) is for June, July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

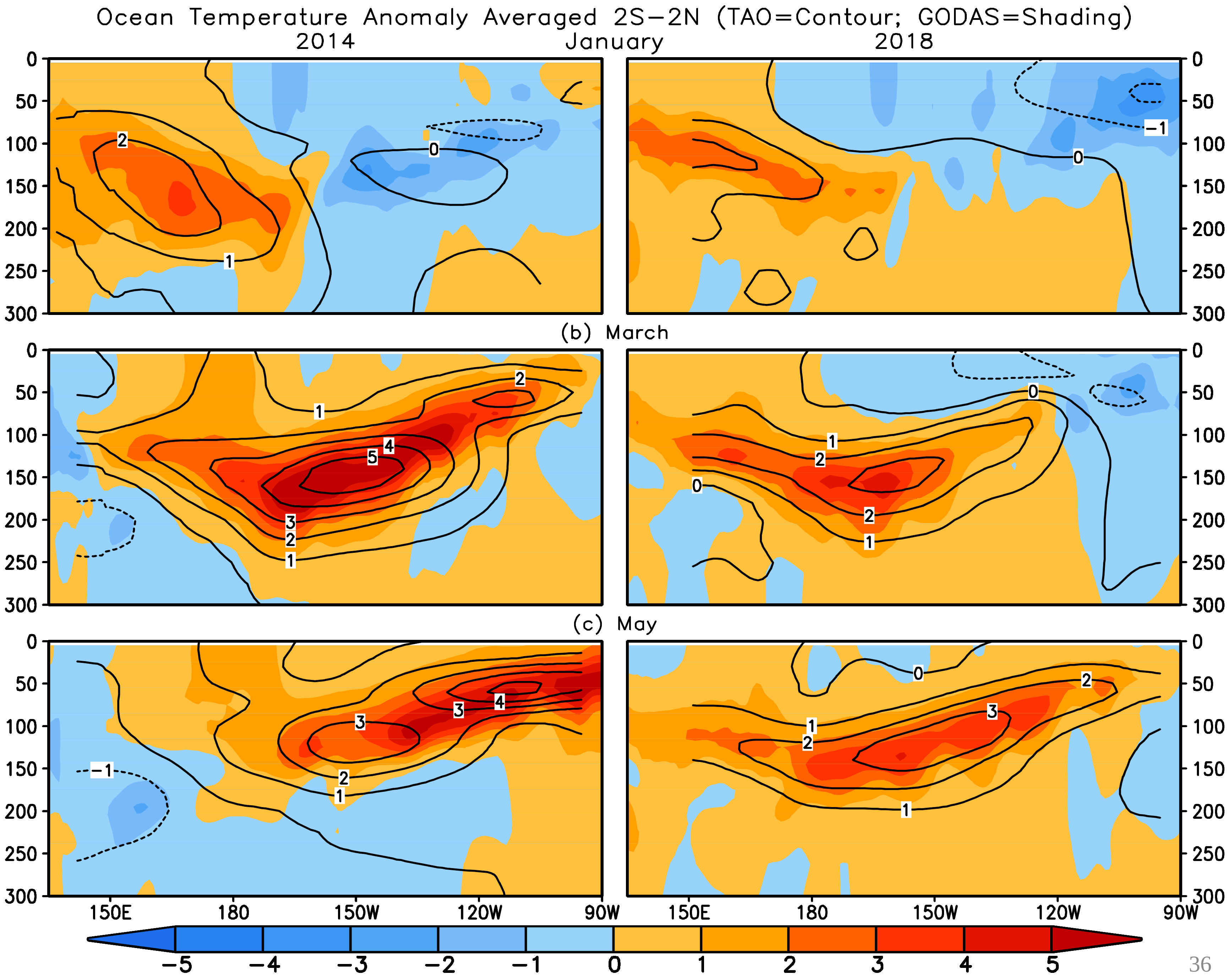


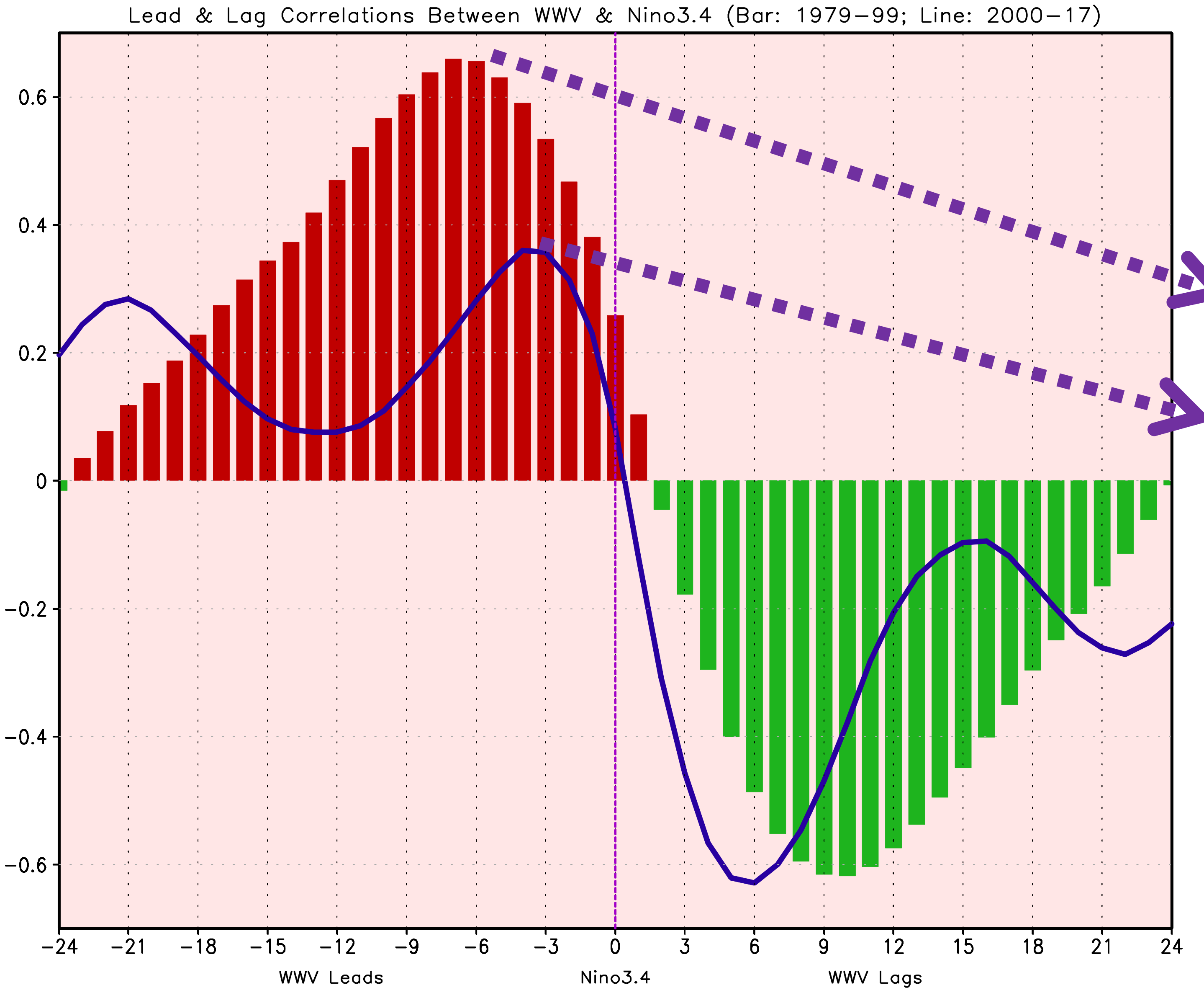
- The current conditions projected strongly onto the second MEOF ENSO precursor, which is precursor for El Nino.

April	82	86	91	94	97	02	04	06	09	14	15	18
PC2	1.0	0.8	1.5	0.8	1.4	0.8	0.6	0.1	-0.1	0.9	1.5	1.4

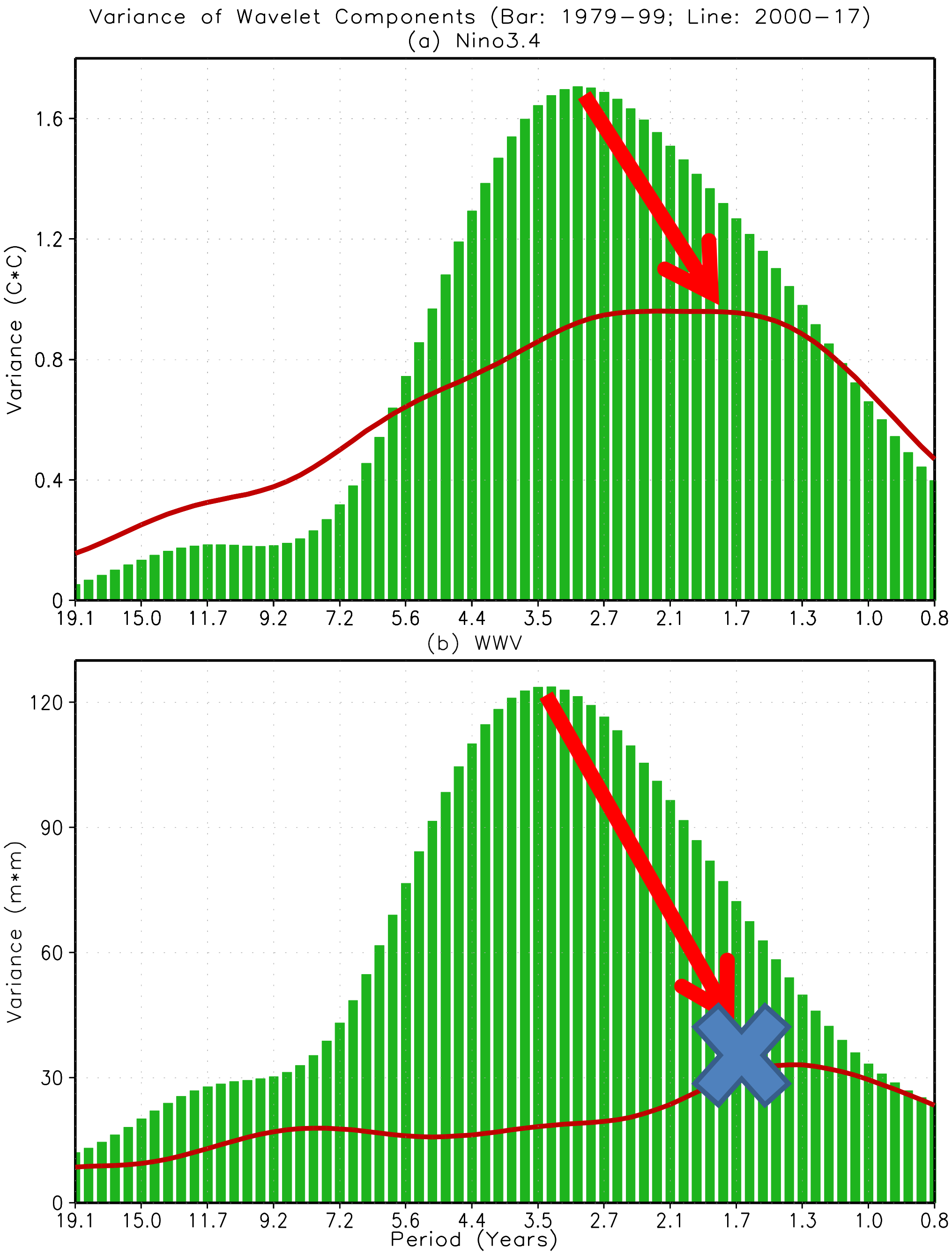


SST (shading,C) & Wind Stress Anomalies
0.15 N/m**2
2014
January
2018
March
May
6N
4N
2N
EQ
2S
4S
6S
120E
150E
180
150W
120W
90W
−3.5
−2.5
−1.5
−1
−0.5
0
0.5
1
1.5
2.5
3.5


Ocean Temperature Anomaly Averaged 2S–2N (TAO=Contour; GODAS=Shading)
2014
January
2018
(b) March
(c) May
0
50
100
150
200
250
300
150E
180
150W
120W
90W
−5
−4
−3
−2
−1
0
1
2
3
4
5



The leading time of WWV to Nino3.4 decreased from 6-8 months during 1979-99 (bar) to 3-4 months since 2000 (line) (McPhaden, GRL 2012; Kumar and Hu, CD 2014).

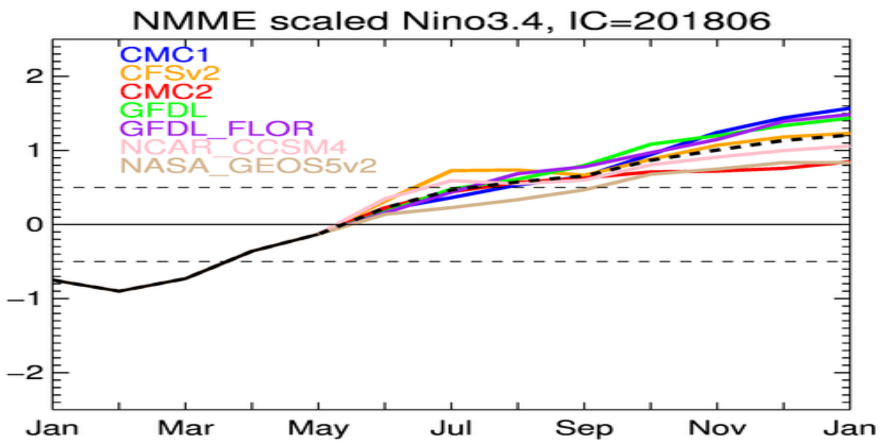


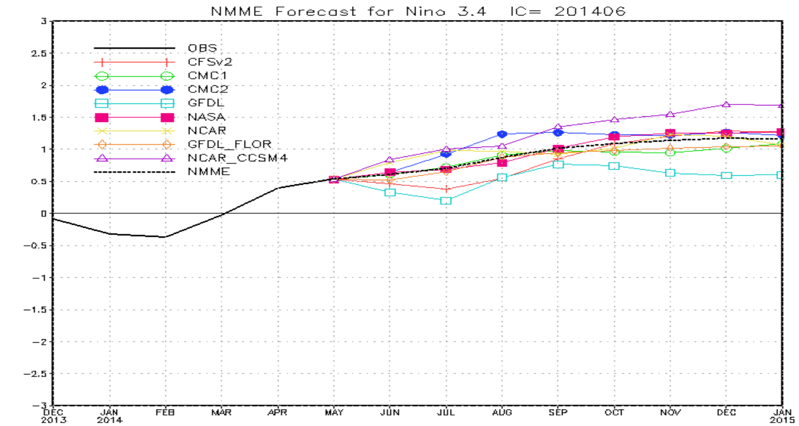
ENSO shifted to higher frequency since 2000:

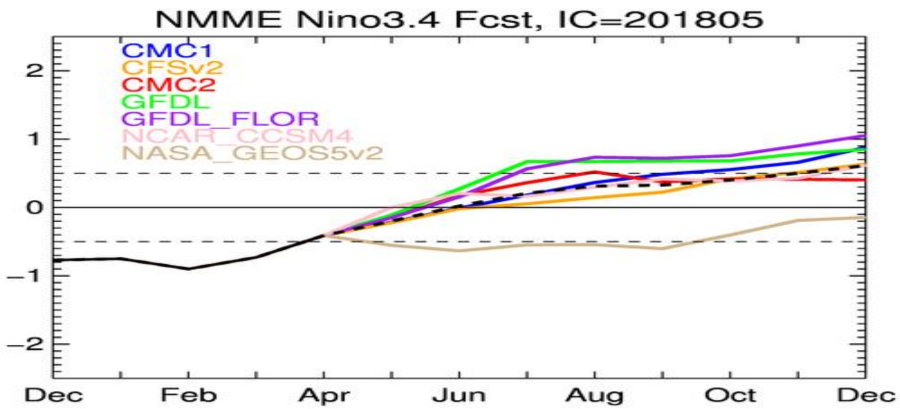
Specifically, the maximum variability of the Niño3.4 index was confined in the period band of 1.5-5 years in 1979-99, while the variance distribution was flatter with a much smaller peak around 1.5-3.5 years in 2000-17.

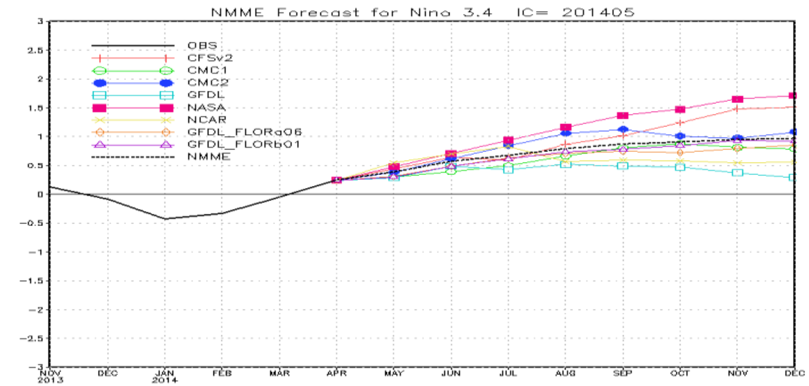
The WWV index was totally no peak in 2000-17, implying closer to a white noise process in 2000-17.

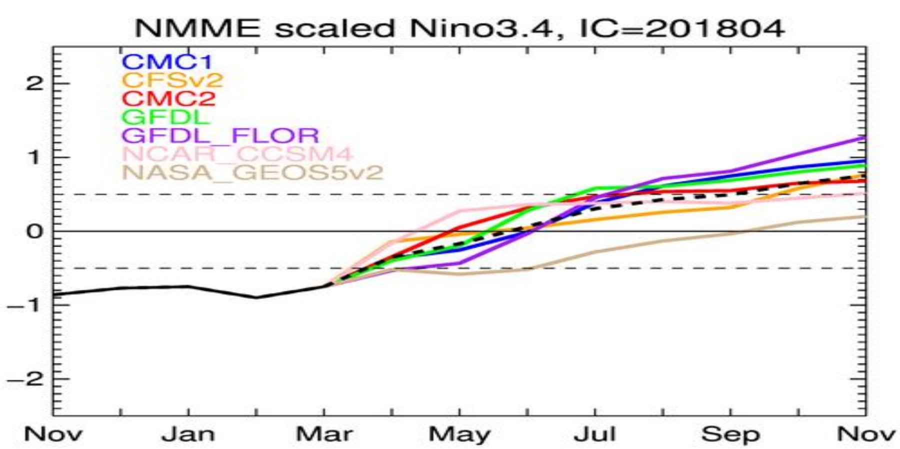
Hu, Z.-Z., A. Kumar, J. Zhu, B. Huang, Y.-h. Tseng, and X. Wang, 2017: On the shortening of the lead time of ocean warm water volume to ENSO SST since 2000. Sci. Rep., 7, 4294. DOI: 10.1038/s41598-017-04566-z.

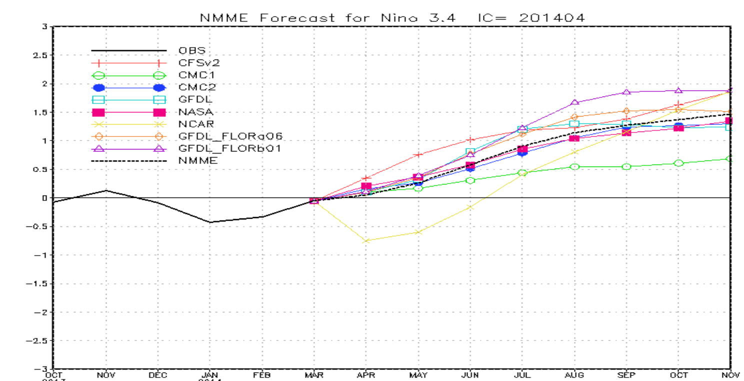

NMME scaled Nino3.4, IC=201806
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Jan
Mar
May
Jul
Sep
Nov
Jan

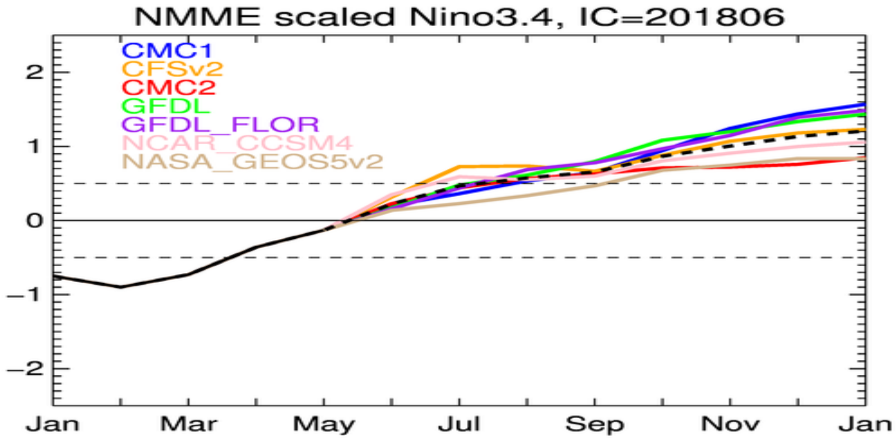

NMME Forecast for Nino 3.4 IC= 201406
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
NCAR
GFDL_FLOR
NCAR_CCSM4
NMME

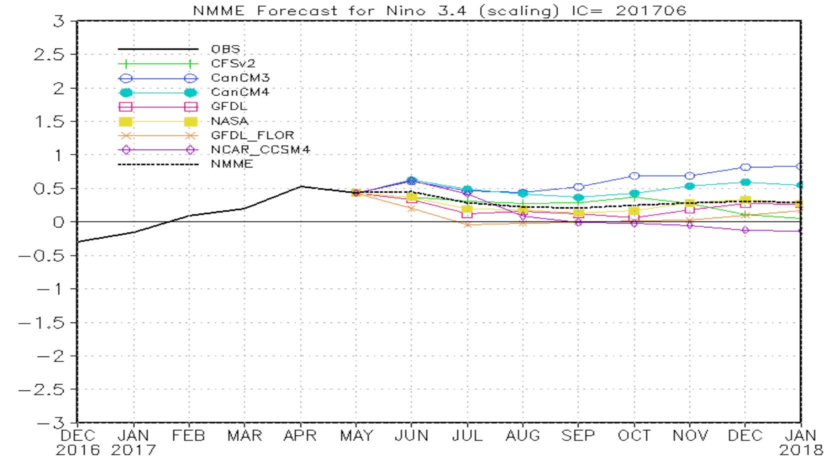

NMME Nino3.4 Fcst, IC=201805
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Dec
Feb
Apr
Jun
Aug
Oct
Dec

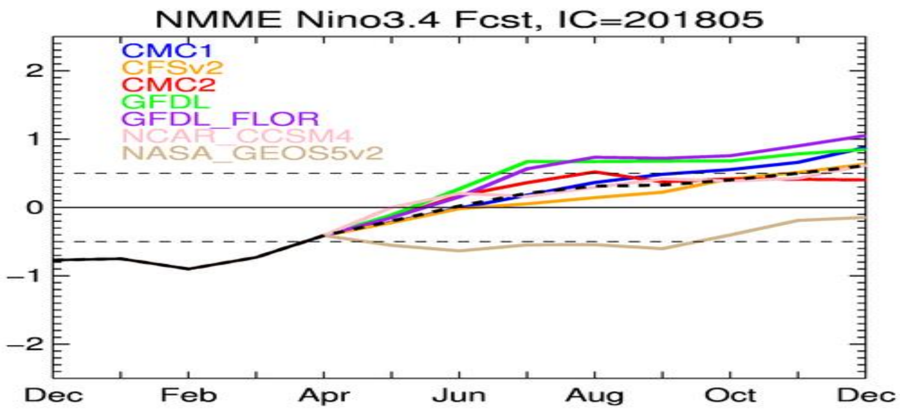

NMME Forecast for Nino 3.4 IC= 201405
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
NCAR
GFDL_FLORa06
GFDL_FLORb01
NMME

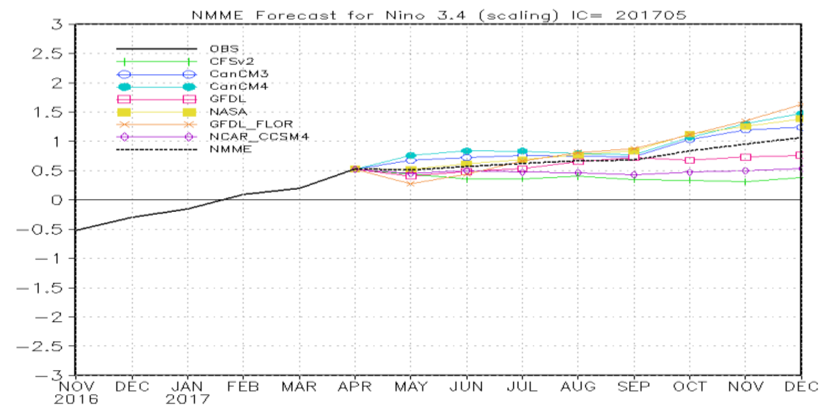

NMME scaled Nino3.4, IC=201804
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Nov
Jan
Mar
May
Jul
Sep
Nov

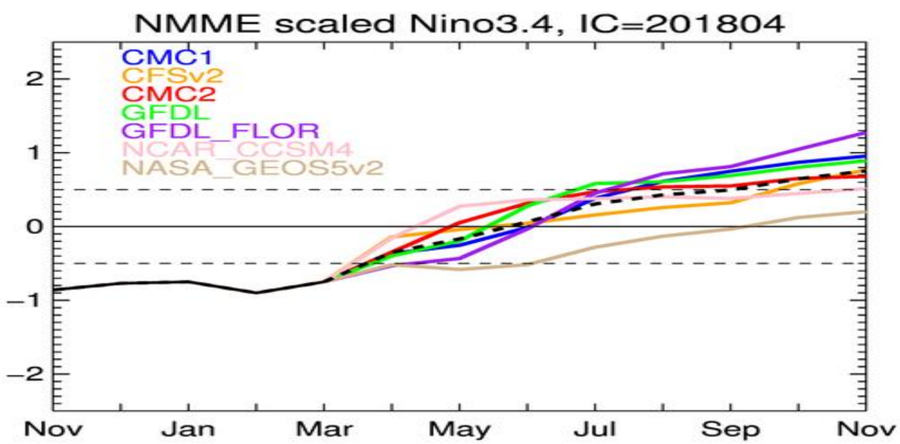

NMME Forecast for Nino 3.4 IC= 201404
OBS
CFSv2
CMC1
CMC2
GFDL
NASA
NCAR
GFDL_FLORa06
GFDL_FLORb01
NMME

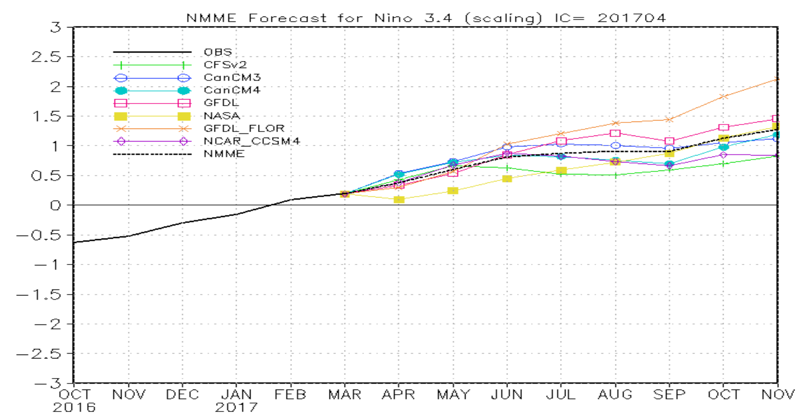

NMME scaled Nino3.4, IC=201806
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Jan Mar May Jul Sep Nov Jan

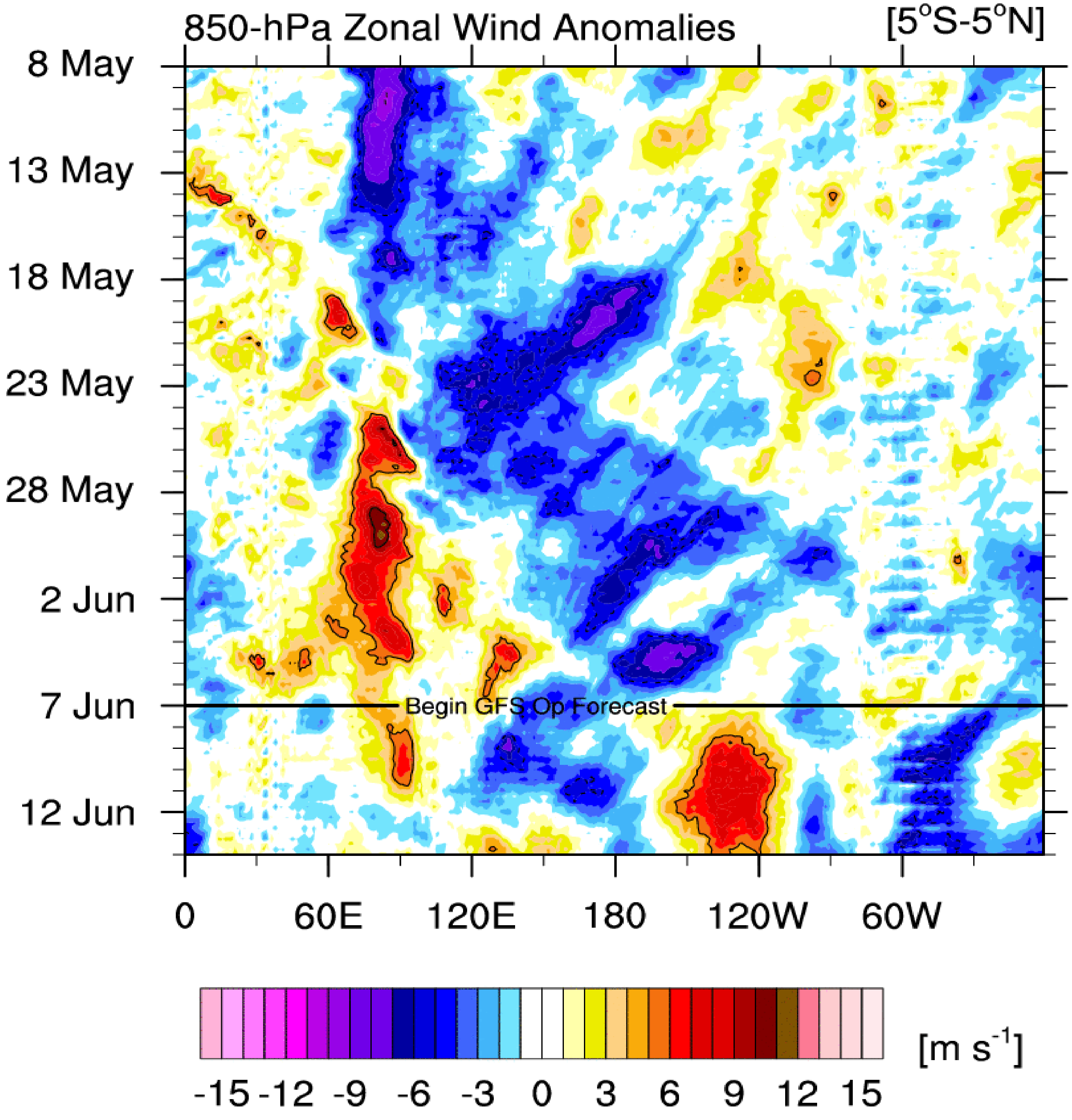

NMME Forecast for Nino 3.4 (scaling) IC= 201706
OBS
CFSv2
CanCM3
CanCM4
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
DEC 2016 JAN 2017 FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN 2018


NMME Nino3.4 Fcst, IC=201805
CMC1
CFSv2
CMC2
GFDL
GFDL_FLOR
NCAR_CCSM4
NASA_GEOS5v2
Dec Feb Apr Jun Aug Oct Dec


NMME Forecast for Nino 3.4 (scaling) IC= 201705
OBS
CFSv2
CanCM3
CanCM4
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
NOV 2016 DEC JAN 2017 FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC


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

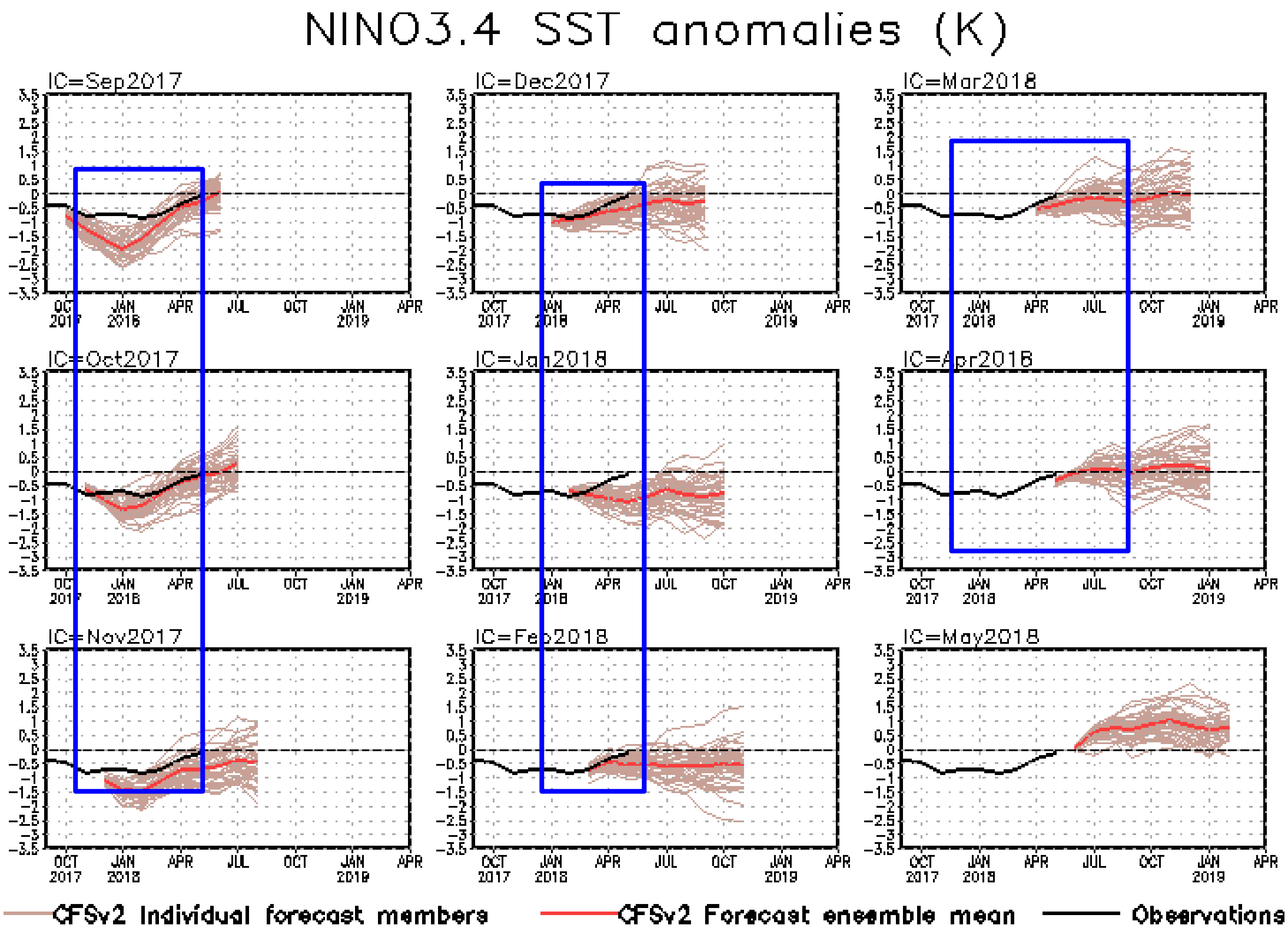

NMME Forecast for Nino 3.4 (scaling) IC= 201704
OBS
CFSv2
CanCM3
CanCM4
GFDL
NASA
GFDL_FLOR
NCAR_CCSM4
NMME
OCT 2016 NOV DEC JAN 2017 FEB MAR APR MAY JUN JUL AUG SEP OCT NOV



Both easterly and westerly wind anomalies were predicted in the following week by GFS.

From: http://mikeventrice.weebly.com/hovmollers.html

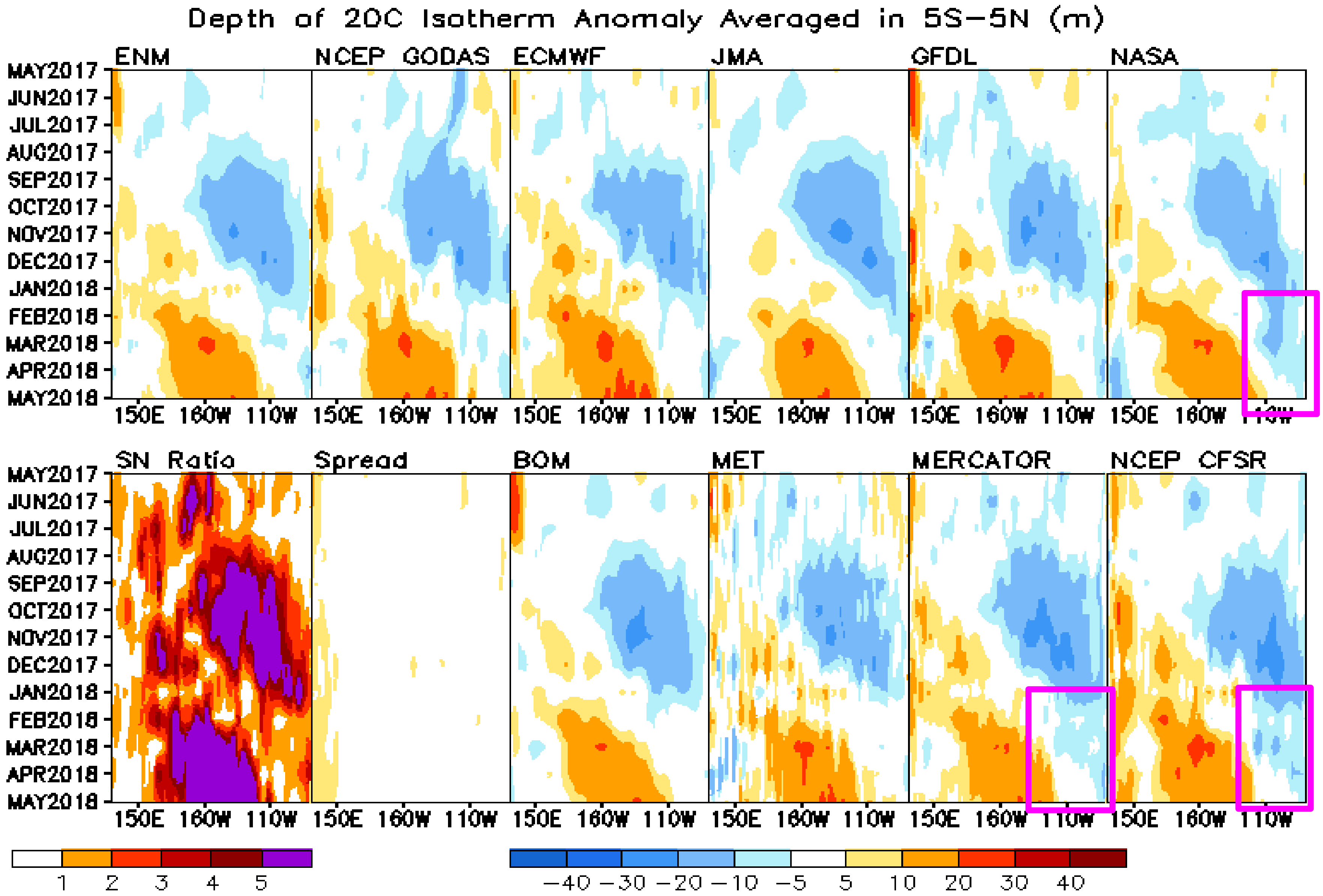
CFS Niño3.4 SST Predictions from Different Initial Months



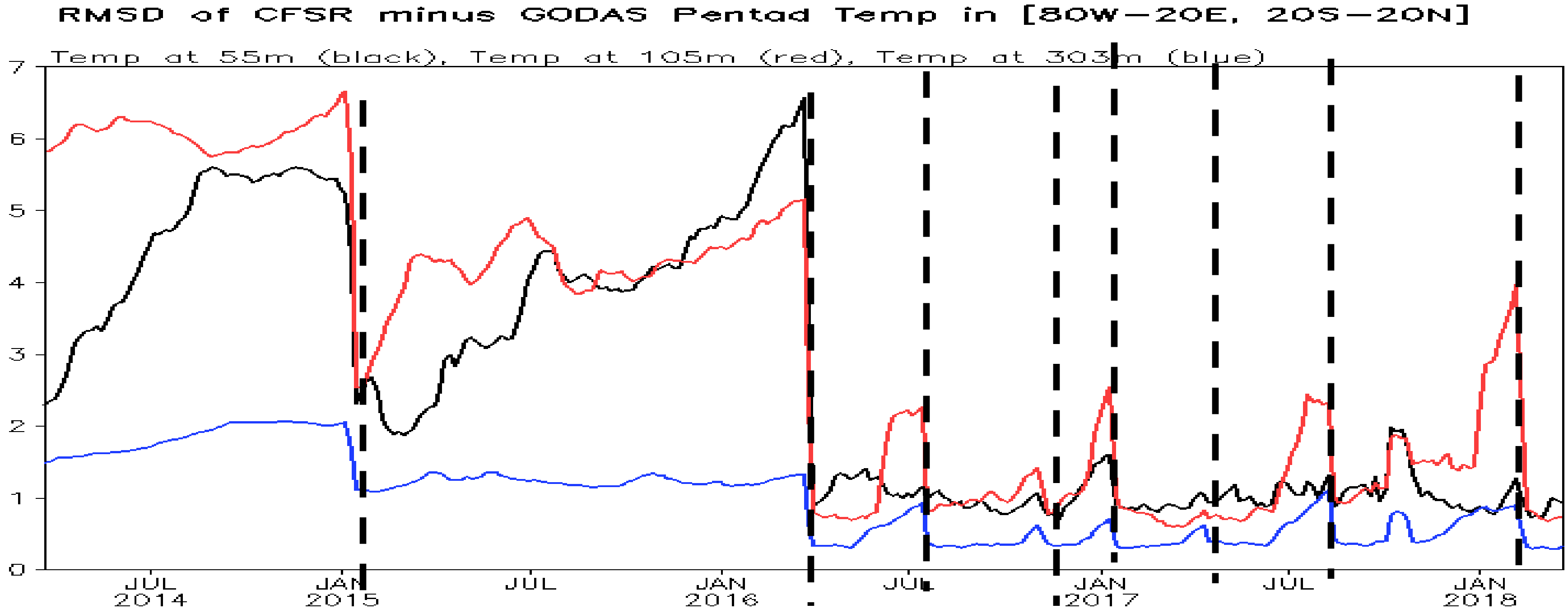
Latest CFSv2 forecasts call for a weak El Nino during summer-winter 2018.

CFSv2 predictions had cold biases with ICs in Aug-Dec 2017 and Jan-Apr 2018.

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.



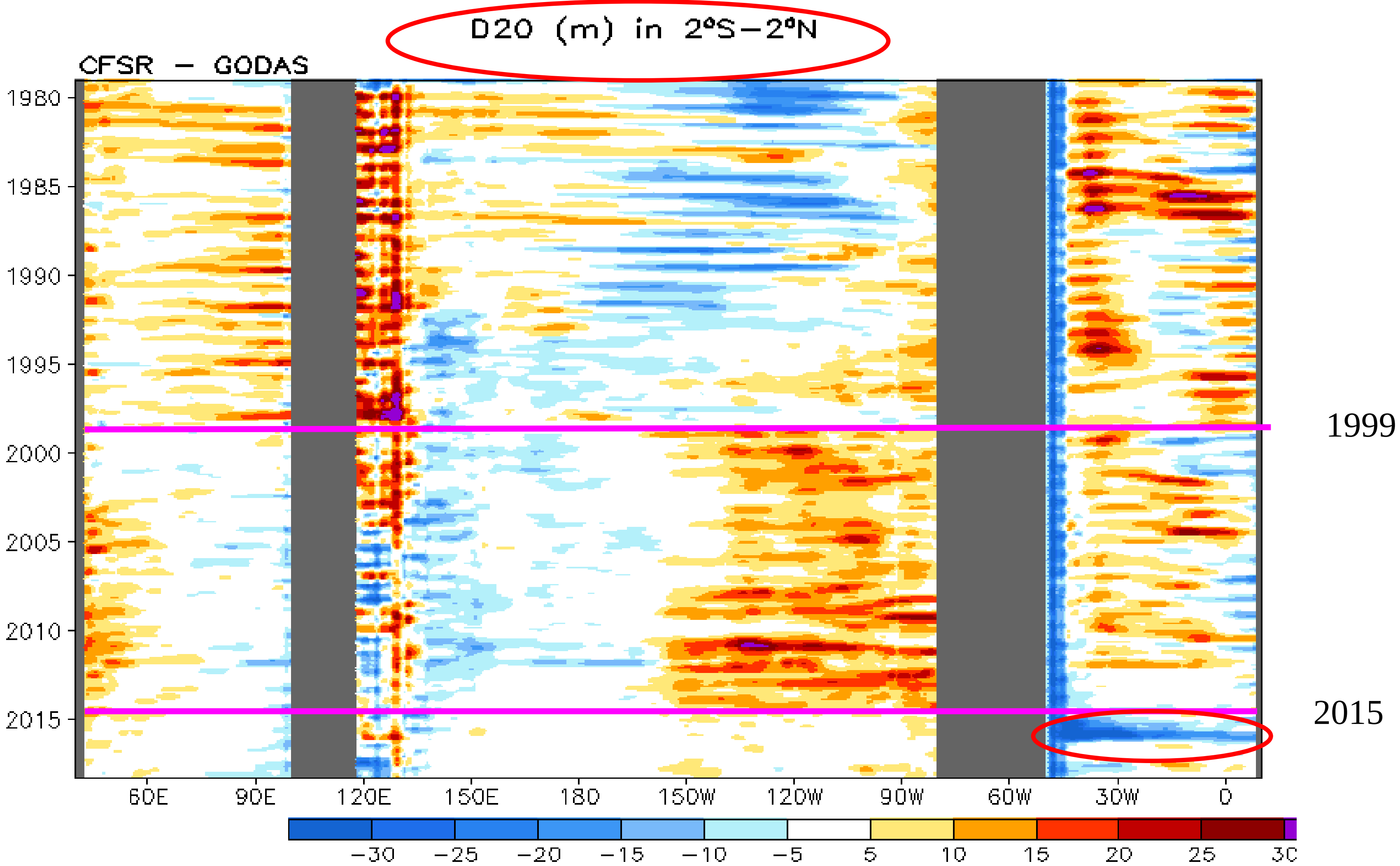
- The evolution of positive D20 anomaly was consistent among the multiple ocean reanalyses, but negative D20 anomaly was only observed in NASA, CFSR and MERCATOR in the far-eastern eq. Pacific (east of 120W) in Feb-Apr 2018, which could damp the El Nino forecast in their coupled models.



- A periodic reset of the CFSR ocean initial conditions with a parallel GODAS run is used to remove the cold bias in the tropical Atlantic, which is indicated as a fast growth of RMSD between CFSR and GODAS in the region.

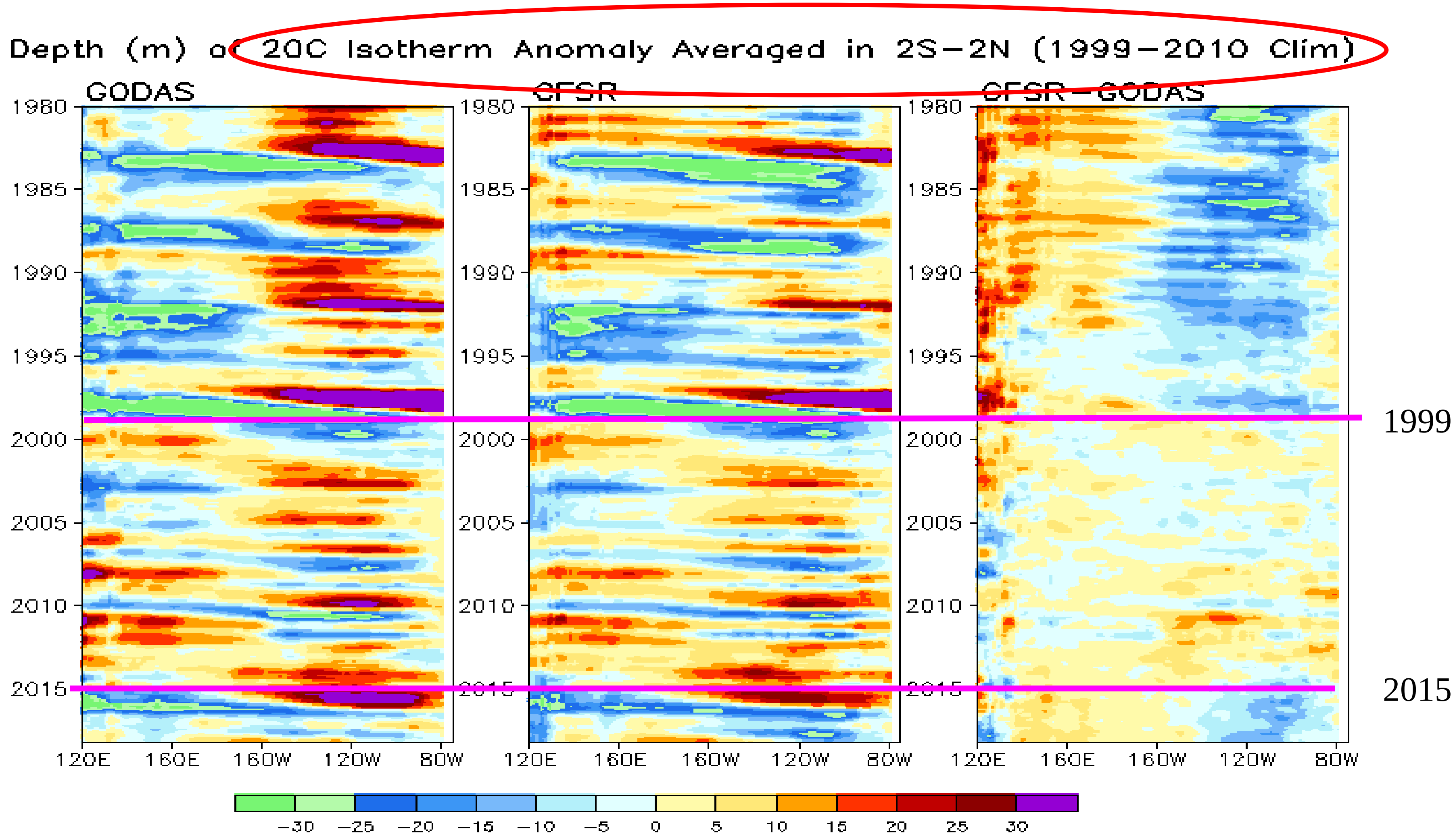
- The dates of the resets can be identified as the time when the RMSD rapidly decreased (2015: Jan) (2016: Mar, Jul, Nov) (2017: Jan, 18Apr, Aug, Oct) (2018: Feb)

- There were cold biases in D20 anomaly in the Atlantic Hurricane MDR in Mar-Apr 2015, 2016, 2017, which have contributed to the cold biases in the summer MDR SST forecast.



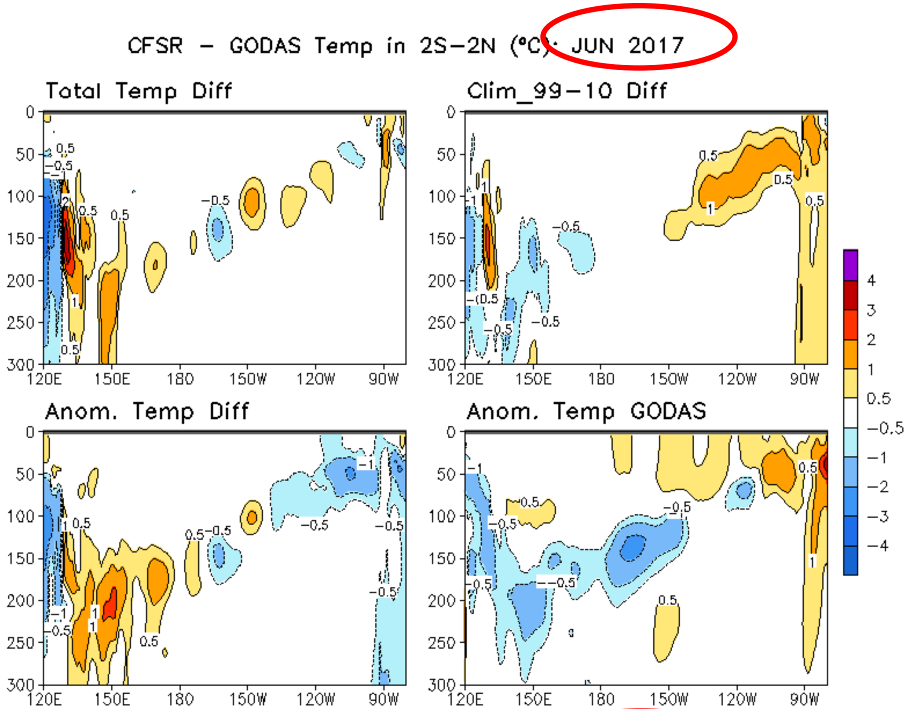
- **There was a shift in D20 difference between CFSR and GODAS around 1999, which was related to the shift of trade wind bias resulted from assimilation of the Advanced TIROS Operational Vertical Sounder (ATOVS) satellite observations (Xue et al. 2011; Zhang et al. 2012).**

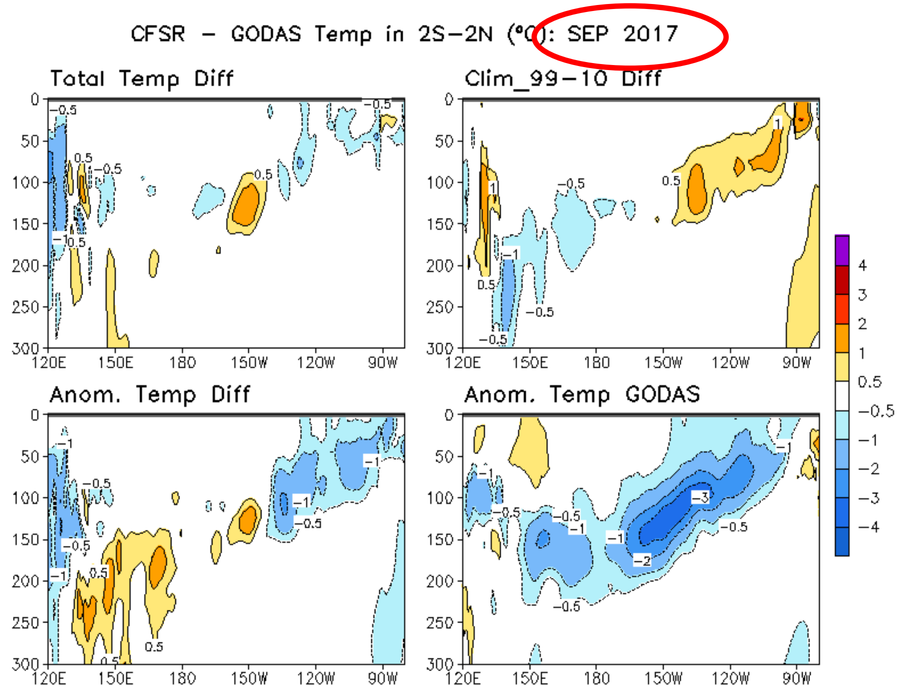
- **There was another shift around 2015, which was related to the reset of CFSR ocean ICs with a parallel GODAS run to control a cold bias growth in the tropical Atlantic in CFSR.**

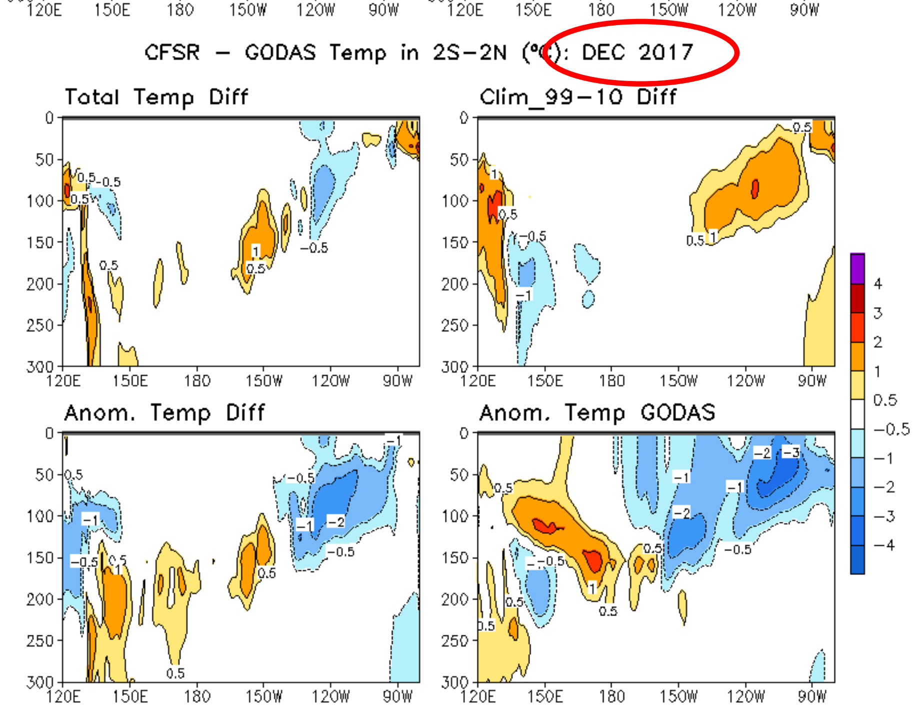


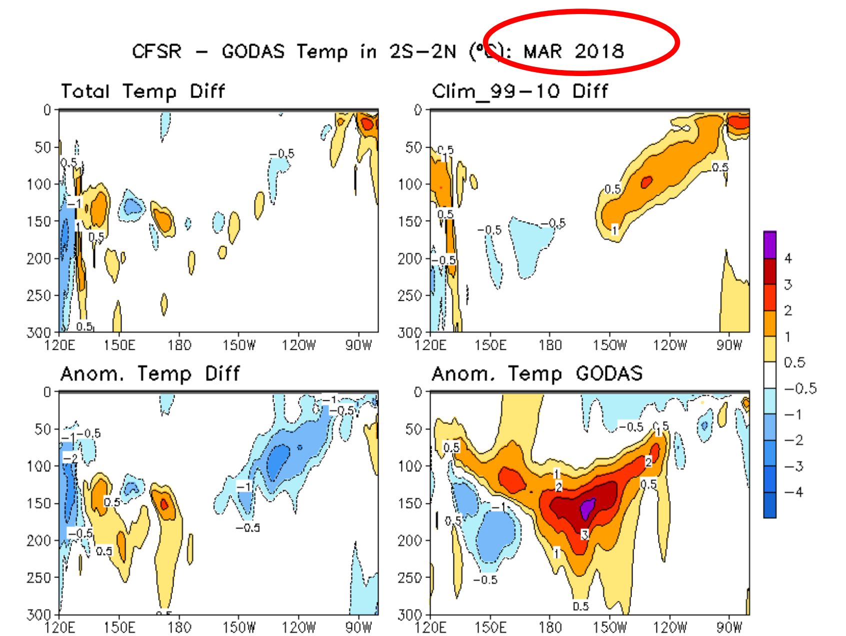
- **Anomalies have been calculated based on the 1999-2010 base period. Therefore, D20 anomaly differences between CFSR and GODAS were small in 1999-2010 as expected, but they reached -10 m before 1999 and after 2015.**

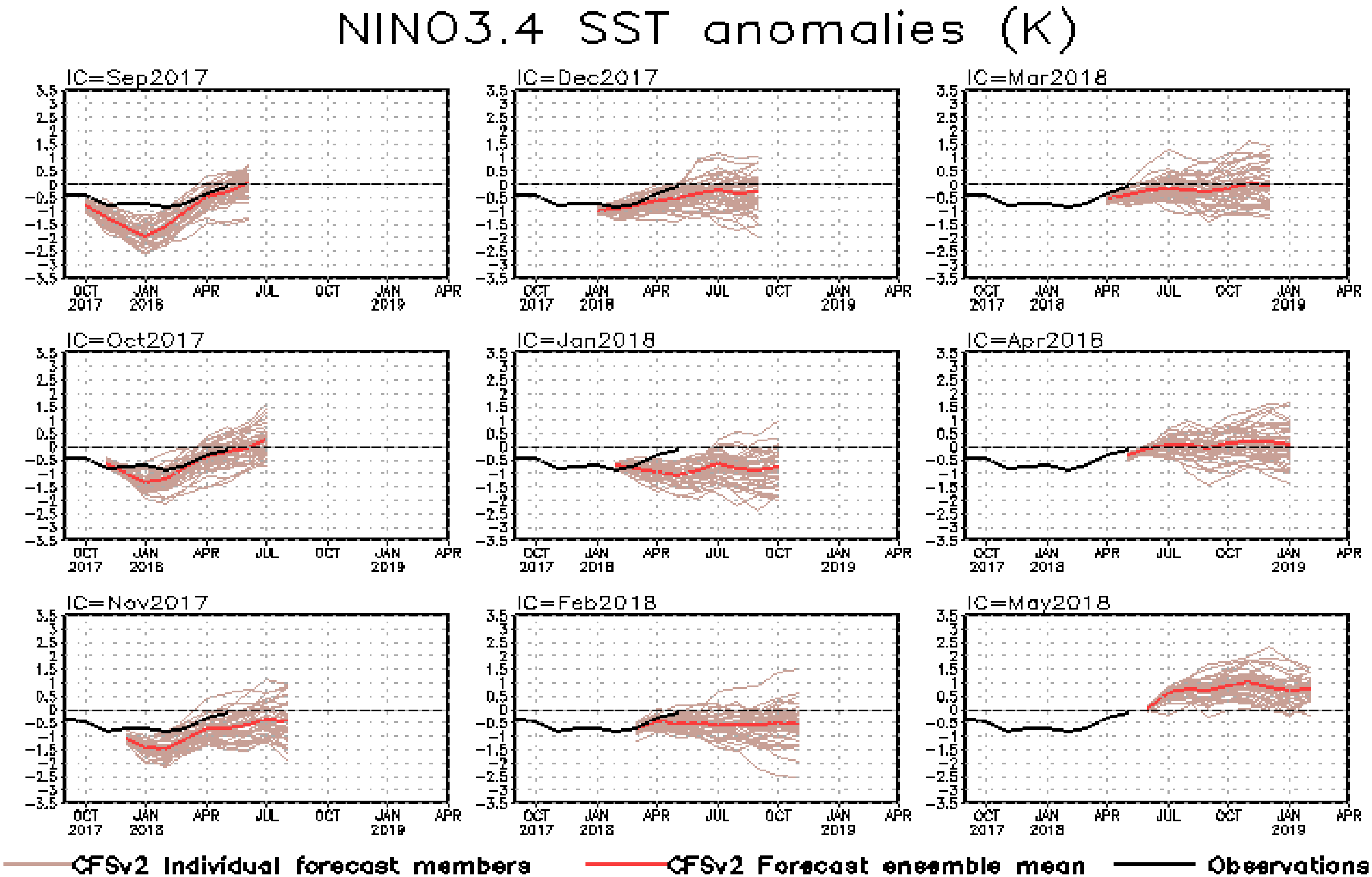
- **We will show next that the differences in anomalies were largely due to the differences in the climatology in the 1999-2010 base period.**


CFSR – GODAS Temp in 2S–2N (°C): JUN 2017
Total Temp Diff
Clim_99–10 Diff
Anom. Temp Diff
Anom. Temp GODAS


CFSR – GODAS Temp in 2S–2N (°C): SEP 2017
Total Temp Diff
Clim_99–10 Diff
Anom. Temp Diff
Anom. Temp GODAS


CFSR – GODAS Temp in 2S–2N (°C): DEC 2017
Total Temp Diff
Clim_99–10 Diff
Anom. Temp Diff
Anom. Temp GODAS

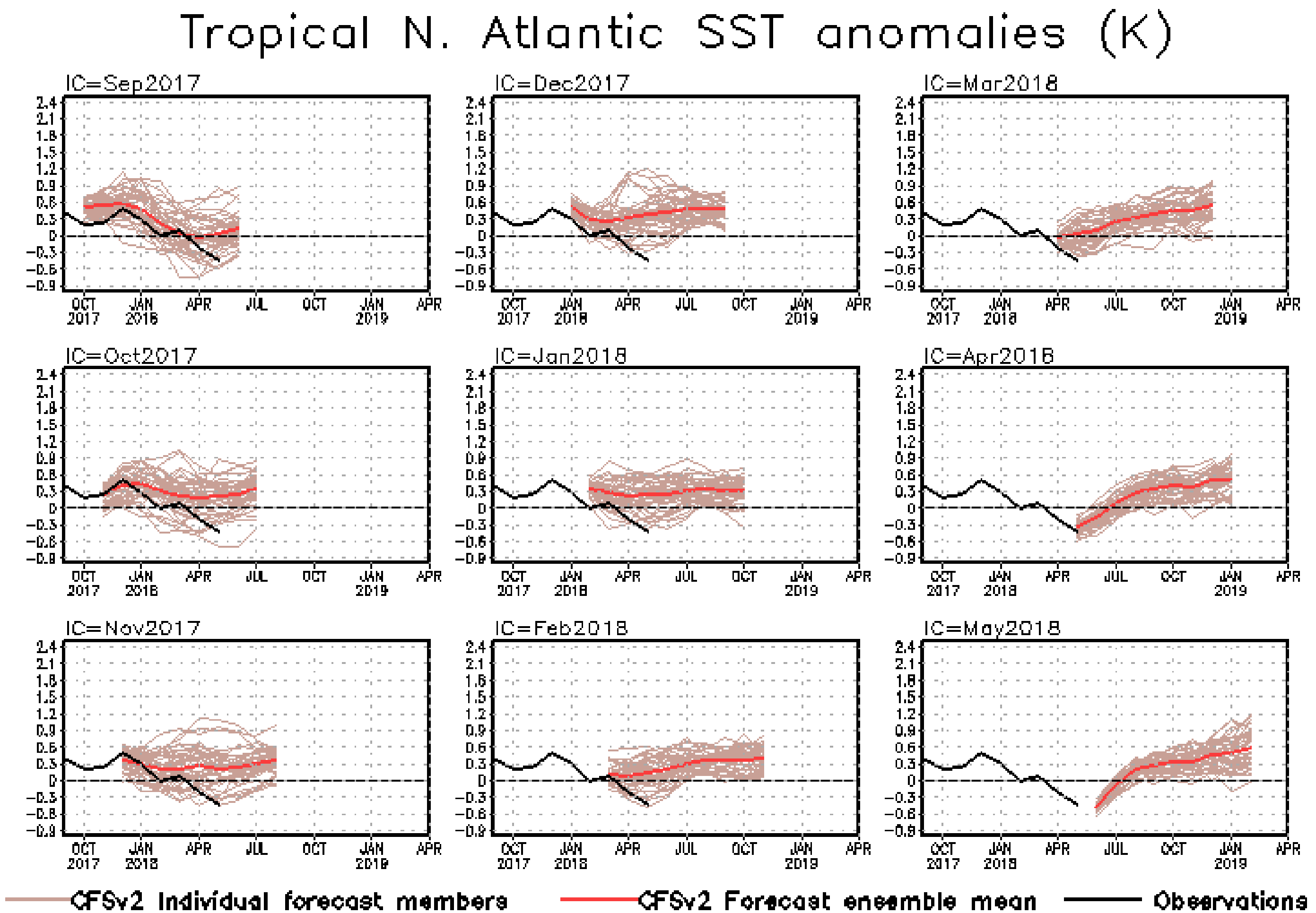

CFSR – GODAS Temp in 2S–2N (°C): MAR 2018
Total Temp Diff
Clim_99–10 Diff
Anom. Temp Diff
Anom. Temp GODAS



- **The CFSv2 SST hindcast has been calibrated based on the 1999-2010 base period as well** **http://www.cpc.ncep.noaa.gov/products/people/wwang/cfsv2fcst/CFSv2SST8210.html**
- **The shift around 2015 effectively injected "negative temperature bias in the eq. eastern Pacific" in CFSR ICs that contributed to a cold NINO3.4 forecast bias.**
- **The amplitude of the cold NINO3.4 forecast bias is likely the largest for forecasts starting from early spring when the signal in ICs is small and the error growth rate is the largest → delaying the onset of El Nino**

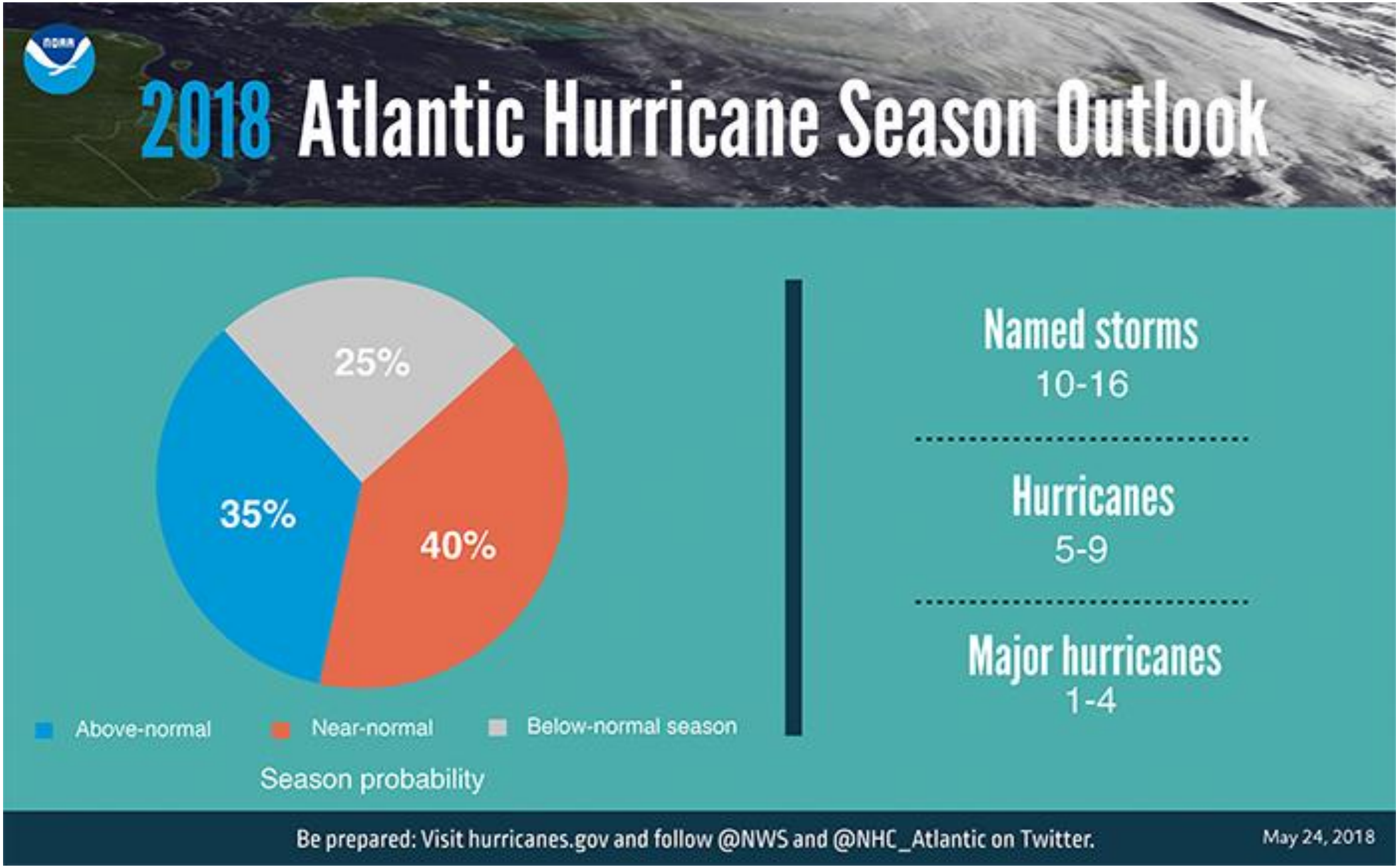
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months

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



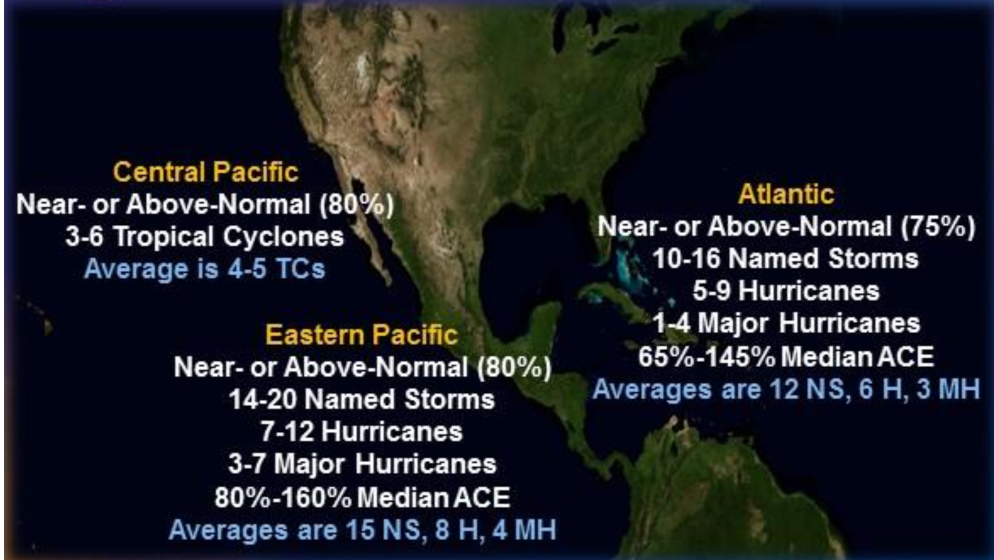
- Latest CFSv2 predictions call above normal SSTA in the tropical N. Atlantic in autumn-winter 2018.

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.



http://www.noaa.gov/media-release/forecasters-predict-near-or-above-normal-2018-atlantic-hurricane-season

NOAA's 2018 Hurricane Season Outlooks



For 2018 the probabilities of each season type are:

	Atlantic	Eastern Pacific	Central Pacific
Above Normal	35%	45%	40%
Near Normal	40%	35%	40%
Below Normal	25%	20%	20%

- Accumulated Cyclone Energy (ACE) measures the overall strength of the hurricane season.
- Tropical Cyclones include tropical depressions, tropical storms and hurricanes.

For the Atlantic hurricane season, climate signals and model forecasts indicate an 75% chance of a near-normal or above-normal season, with a near-normal season being most likely (40% chance) followed by an above-normal season (35% chance).

For the eastern and central Pacific hurricane regions, the outlooks also indicate an 80% chance of a near-normal or above-normal season. The eastern Pacific has the highest likelihood of an above-normal season (45% chance)

http://www.cpc.ncep.noaa.gov/products/outlooks/archives/hurricane2018/May/Slide1.JPG

Reasoning behind the outlook

Currently, we have ENSO-neutral (no El Niño or La Niña) conditions in the Pacific Ocean, along with anomalously cool sea-surface temperatures (SSTs) in the Atlantic hurricane Main Development Region (MDR).

Looking forward, there is considerable uncertainty in the predictions for both El Niño and Atlantic SSTs during the August-October period. This outlook reflects our expectation of ENSO-neutral conditions or a weak El Niño, along with a return to near-average SSTs in the MDR as the summer progresses.

These conditions are set upon a backdrop of the ongoing high-activity era for Atlantic hurricanes that began in 1995. This increased activity has been associated with the warm phase of the Atlantic Multi-Decadal Oscillation (AMO), which produces a set of atmospheric and oceanic conditions that are conducive to stronger hurricane seasons.

The combination of ENSO-neutral conditions and a warmer MDR could favor hurricane activity near the upper ends of the predicted ranges, while the combination of El Niño and a cooler MDR could favor activity near the lower ends of the predicted ranges.

http://www.cpc.ncep.noaa.gov/products/outlooks/archives/hurricane2018/May/Slide1.JPG

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

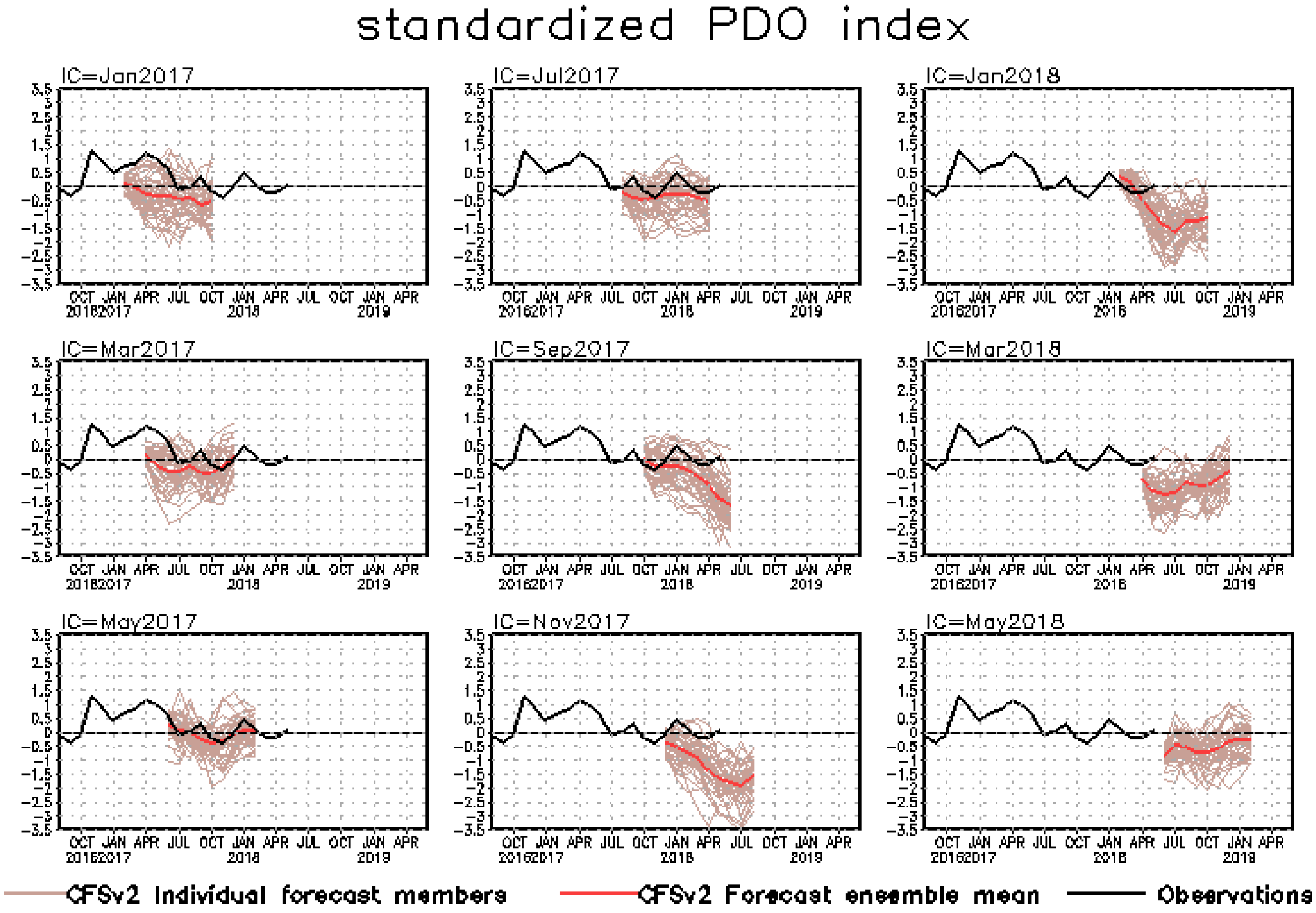
- Dr. Emily Becker: timely provided NMME plot

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

- Dr. Hui Wang: Review the hurricane forecast slides

Backup Slides

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



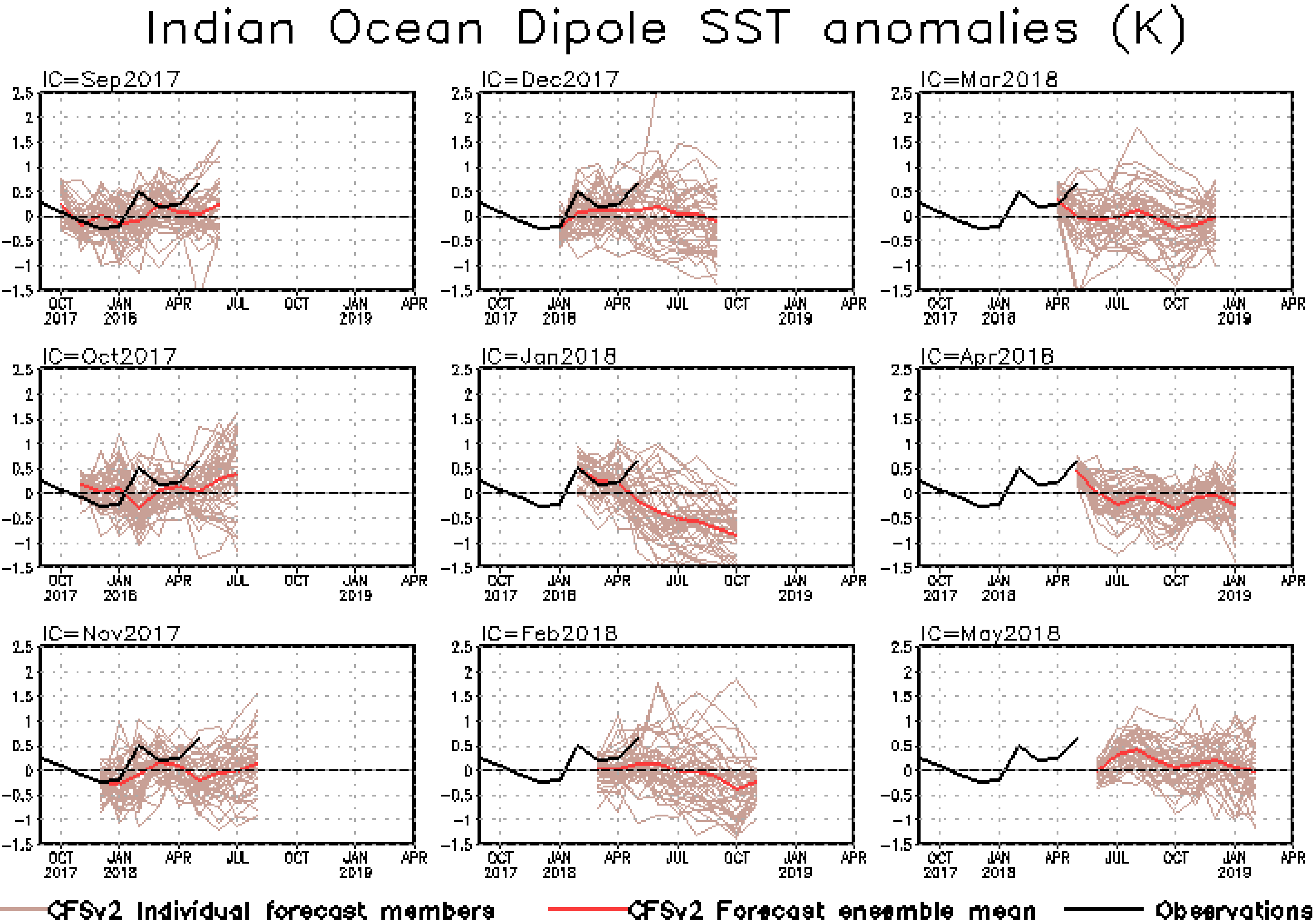
PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

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.

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

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

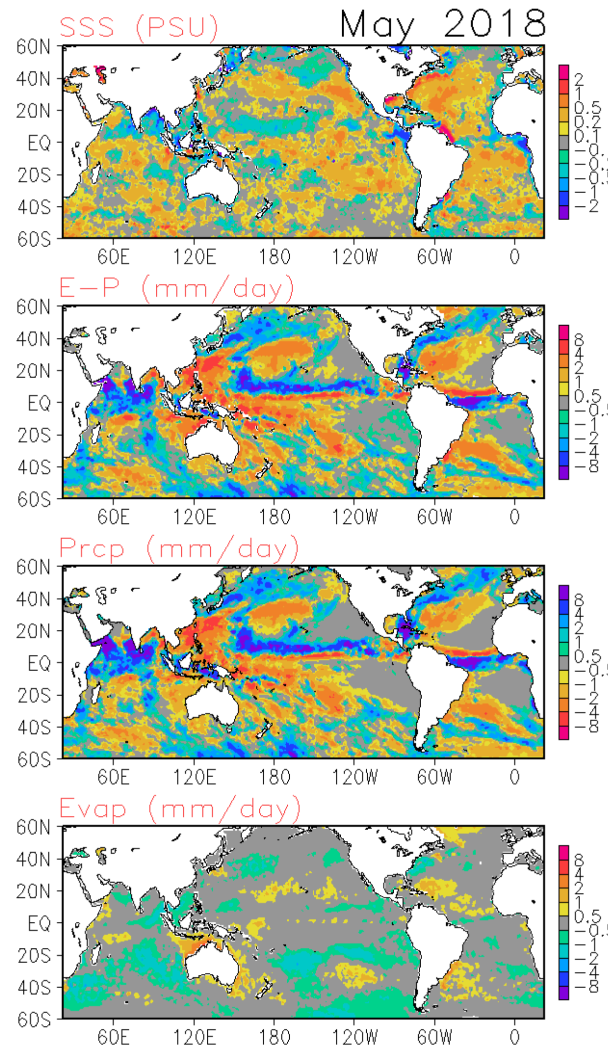
WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

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.

Global Sea Surface Salinity (SSS)

Anomaly for May 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 became weaker in the Indonesia equatorial Pacific with the precipitation being reduced in this area. The heavier precipitation in the north of equator between 5°N and 15°N is accompanied with the negative SSS signals in this region, particularly in the west basin. In the Bay of Bengal, the negative SSS signal continued with the precipitation being increased in the southern basin and decreased in the northern basin. In the Atlantic Ocean, the negative SSS in the equatorial region is likely caused by the increased precipitation.



- **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

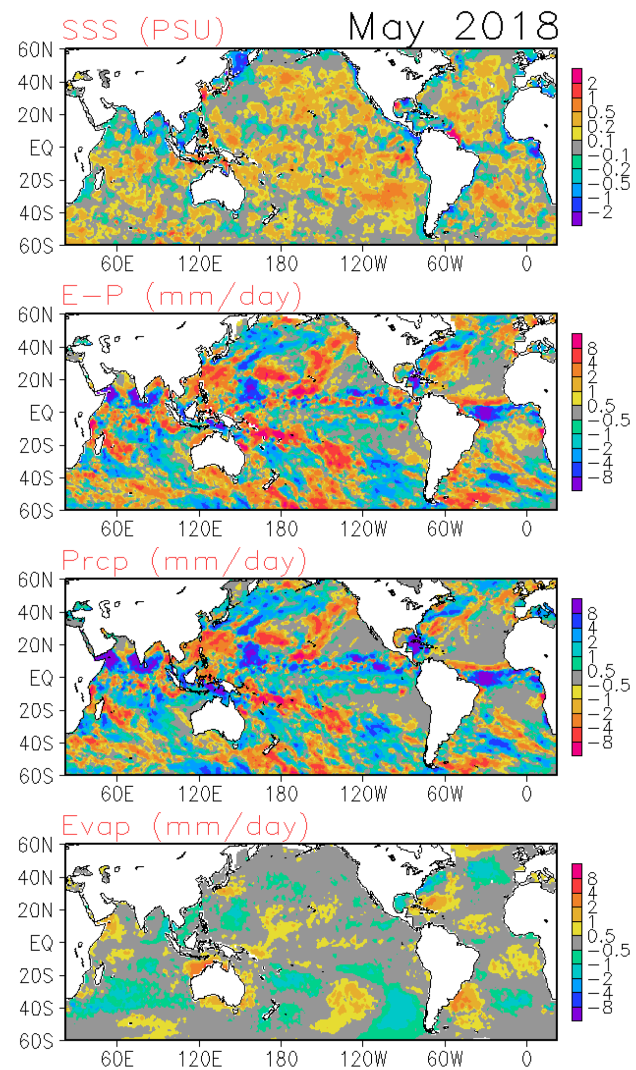
  Precipitation: CMORPH adjusted satellite precipitation estimates

  Evaporation: Adjusted CFS Reanalysis

Global Sea Surface Salinity (SSS)

Tendency for May 2018

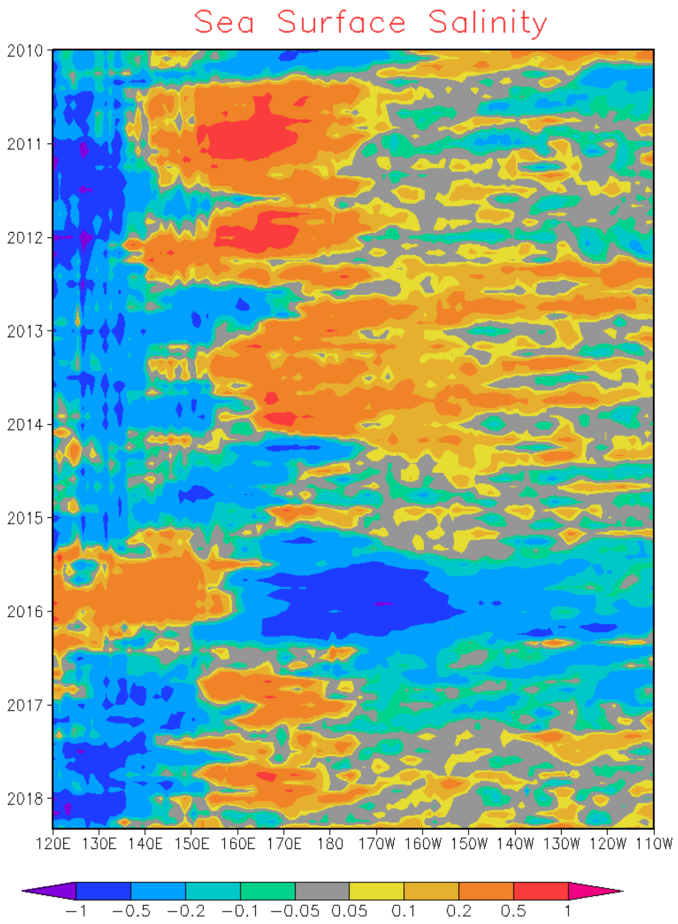
Compared with last month, the SSS in the Bay of Bengal decreased. In the northern basin, such change is possibly due to ocean advection/entrainment; while in the southern basin, such change is likely caused by the increased precipitation. The SSS in the Equatorial Atlantic Ocean is decreased, meanwhile the precipitation is increased in this region. The SSS in the Sea of Okhostk is significantly decreased.



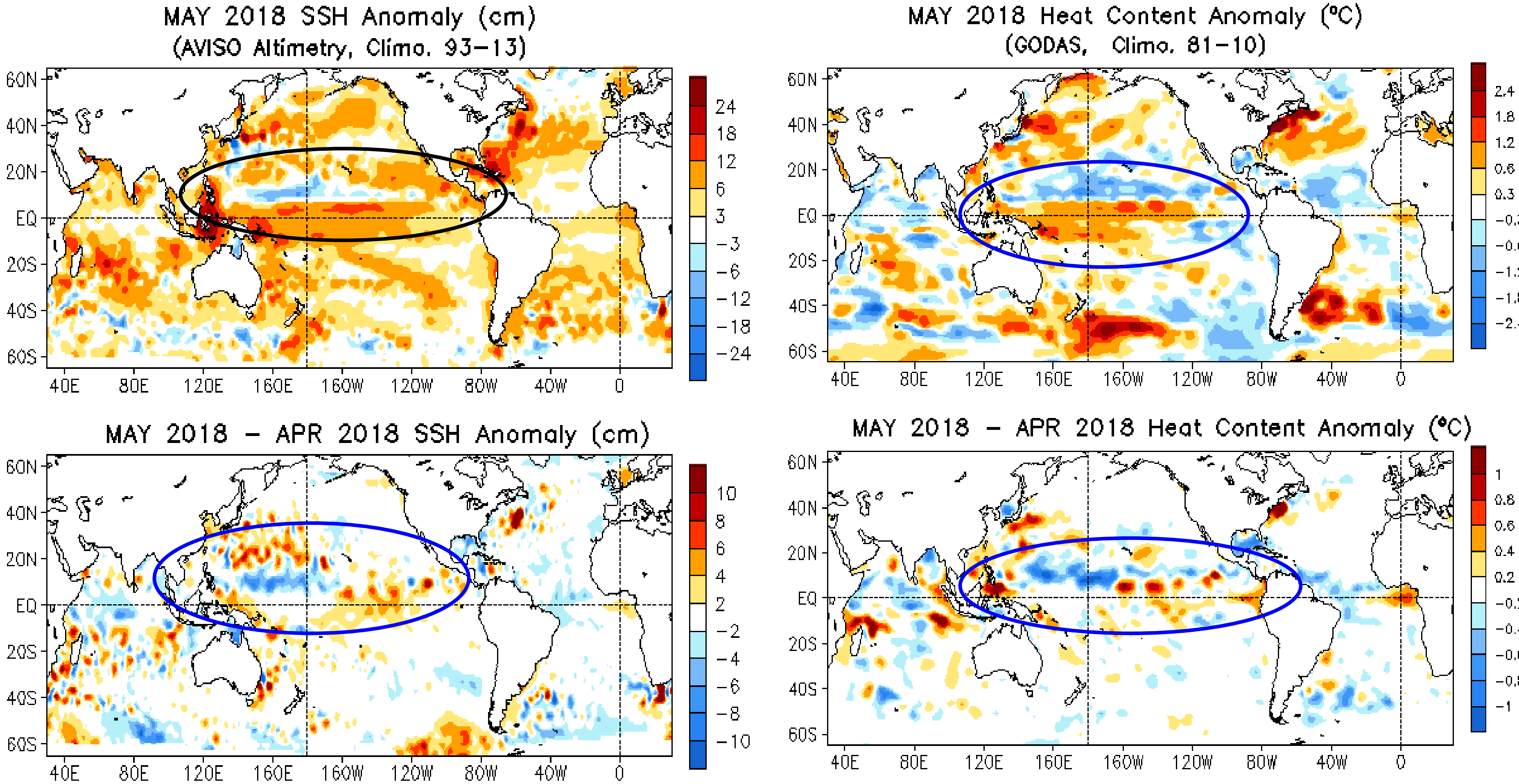
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

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.

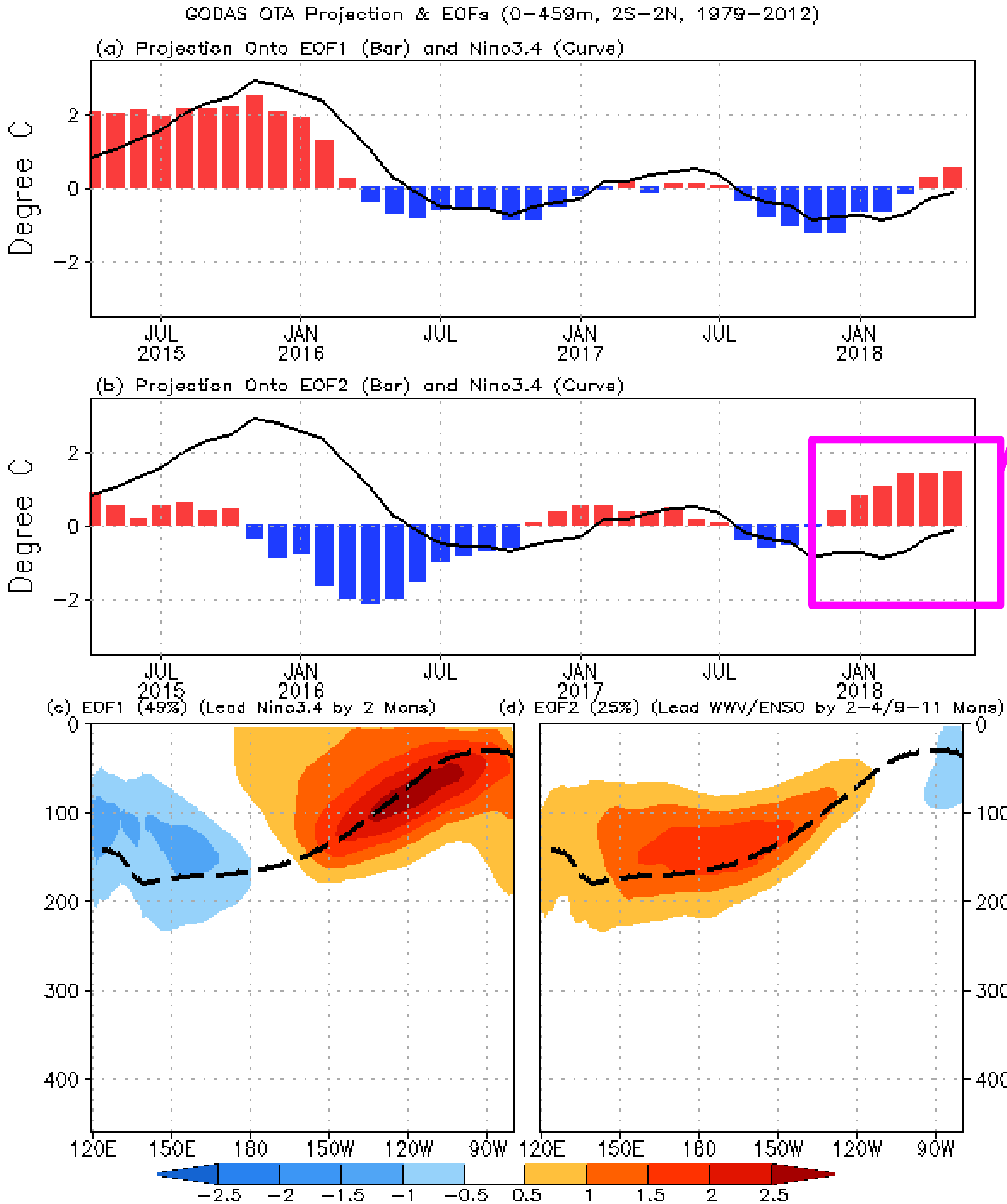
- Hovemoller diagram for equatorial SSS anomaly **(5˚S-5˚N);**
- In the equatorial Pacific Ocean, from 120°E to 150°E, the negative SSS signal continues in this month. The SSS anomalies generally show positive signs east of 150°E, although the signal is relatively weak.



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 neutral phase of ENSO.**



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).

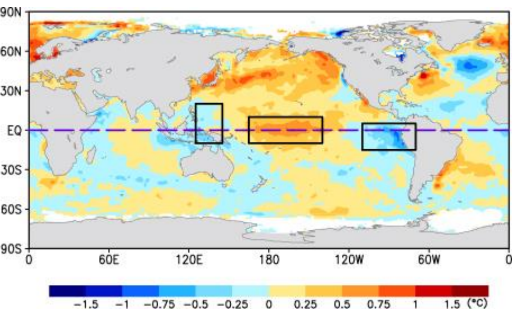
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

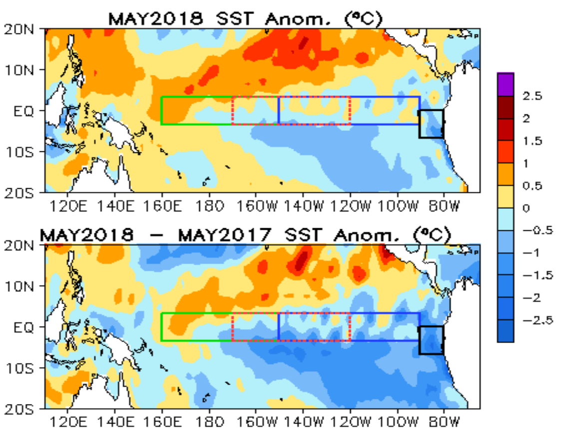
Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

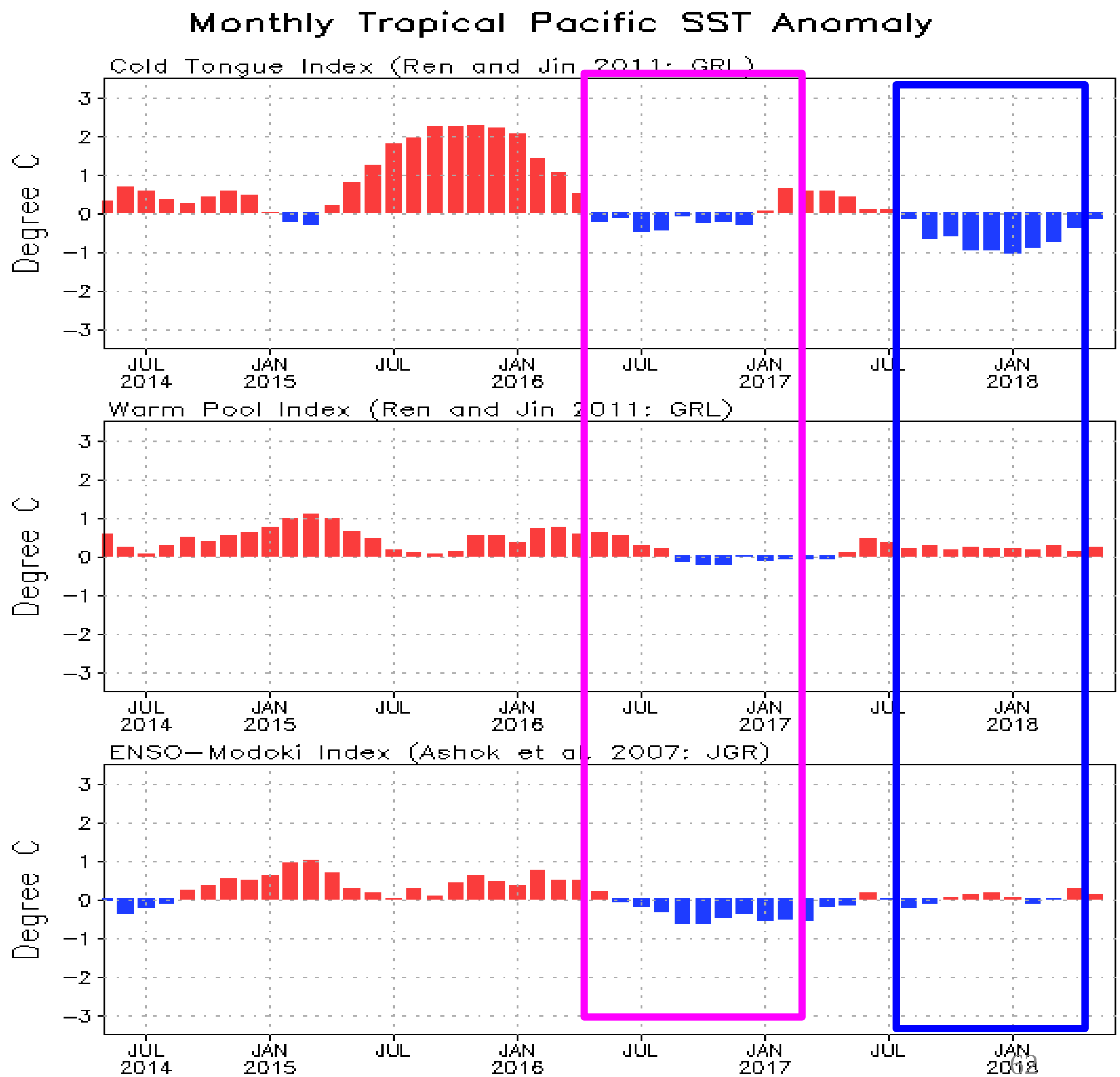
For details, see:

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*.

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

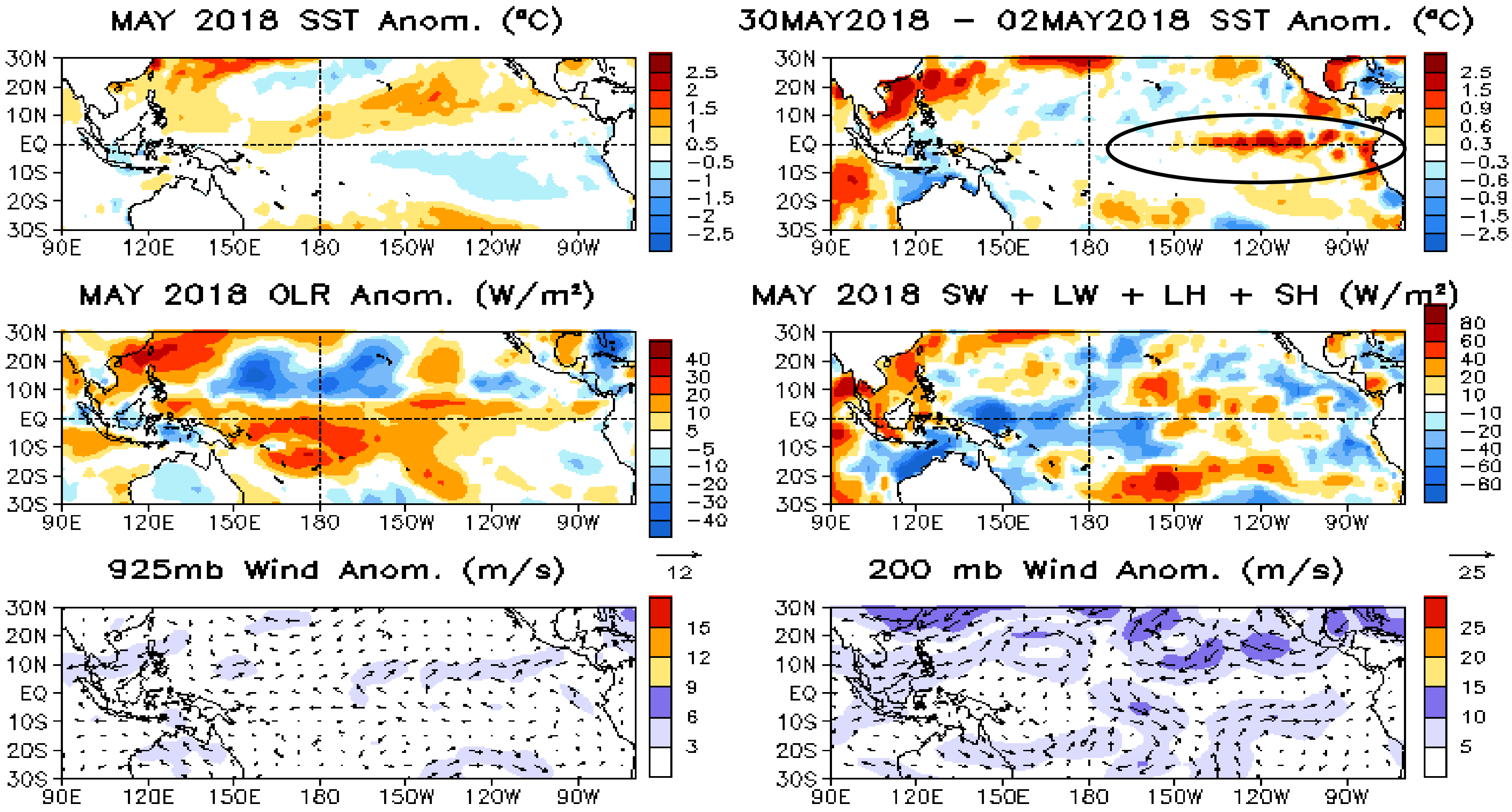


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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

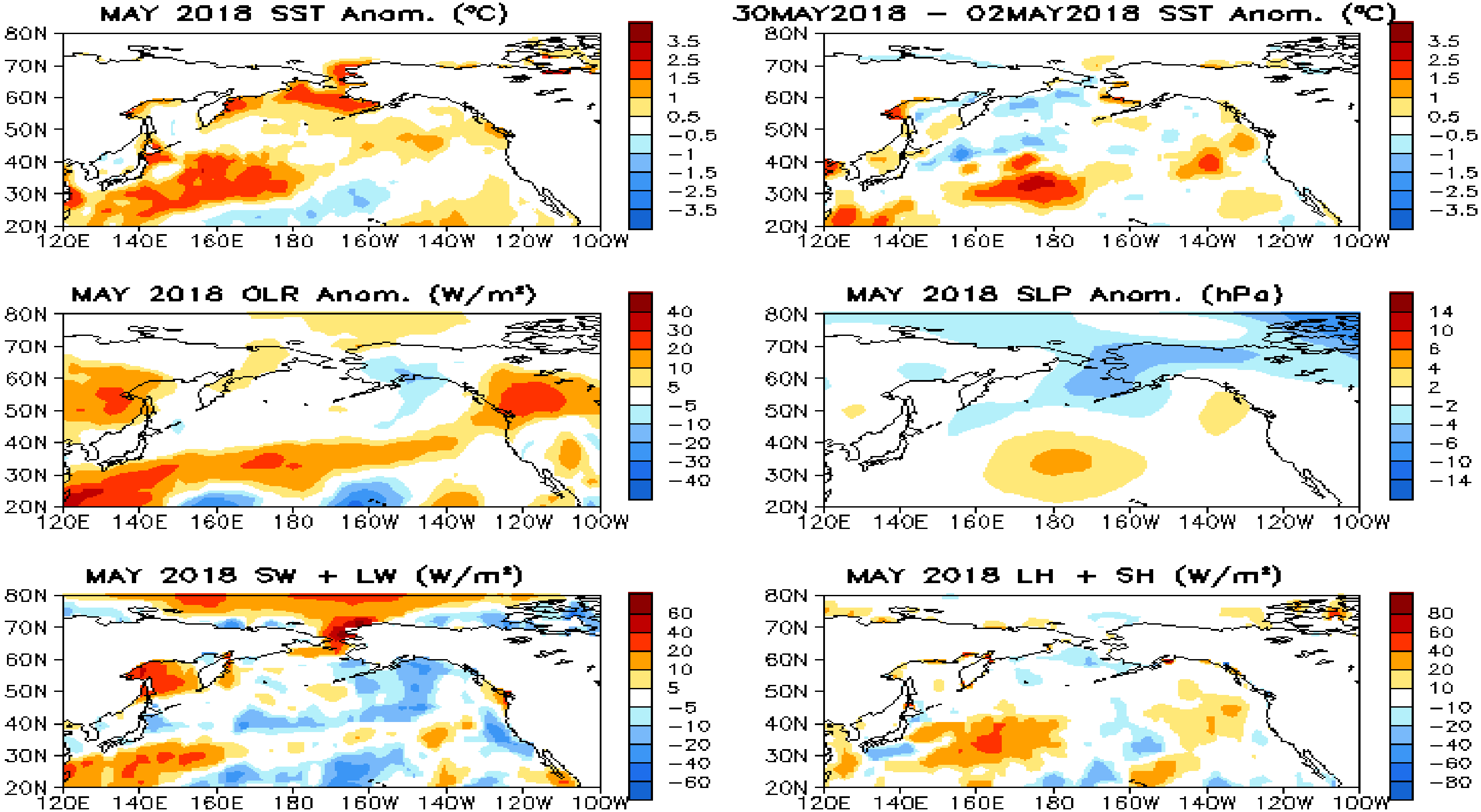


Fig. NP1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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.