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**

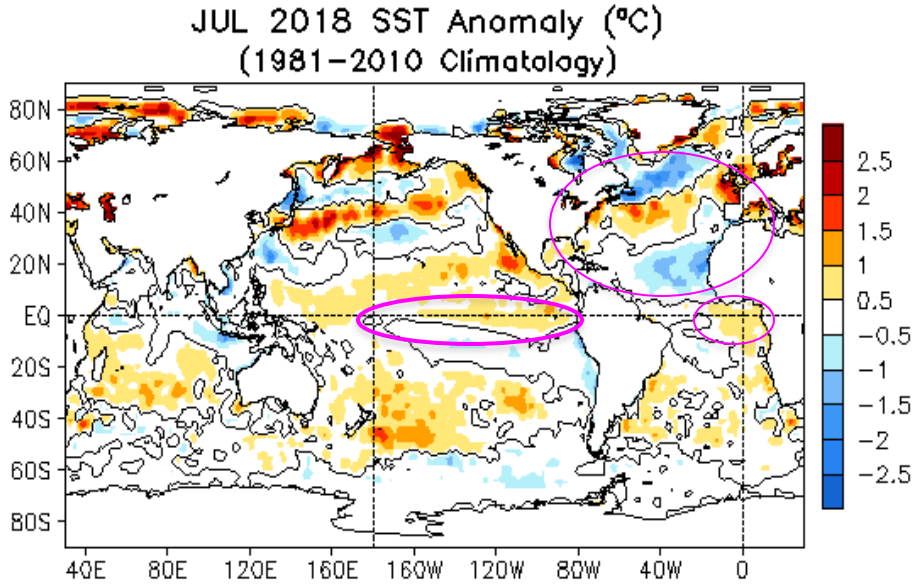
- **Recent highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
  - **Global SST Predictions**
    - ***TIW-related Sea Surface Salinity(SSS) signals observed from the new CPC pentad SSS product***
    - ***ENSO conditions compared with historical events and predictions***
    - ***AMO-related North Atlantic temperature and Ocean Heat Content***

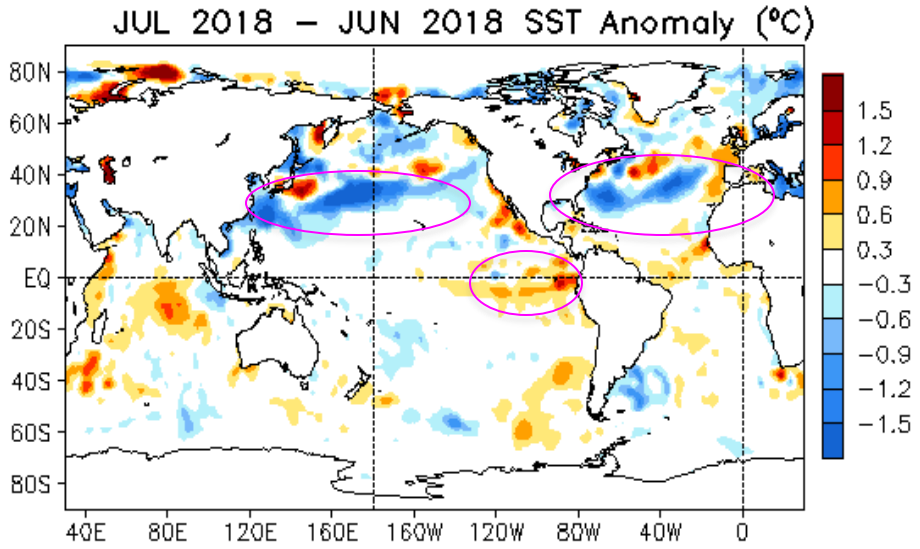
Overview

- **Pacific Ocean**
  - **ENSO-neutral conditions continued in Jul 2018.**
  - **Positive subsurface anomaly weakened along the thermocline in the equatorial central-eastern Pacific.**
  - **NOAA "ENSO Diagnostic Discussion" continuously issue El Nino watch on 9 Aug 2018.**
  - **SST-based PDO switched to a positive phase in July 2018, while heat content-based PDO continued in negative phase.**
- **Indian Ocean**
  - **Negative SSTAs dominated across the equatorial Indian Ocean.**
- **Atlantic Ocean**
  - **NOAA 2018 Atlantic Hurricane Season Outlook revision suggest the chance of below-normal Atlantic hurricane season is 60%.**
  - **Positive NAO has persisted since Apr 2018 with NAOI=+1.4 in July 2018.**
  - **The North Atlantic "cold blob" in 2014-16 was comparable to that before 1996, and its strength weakened substantially during 2017-18.**

Global Oceans

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



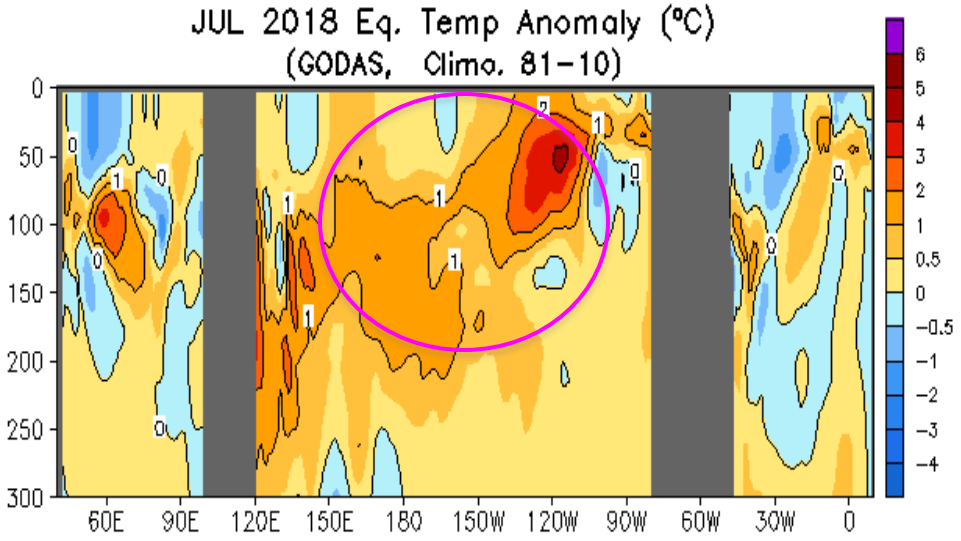


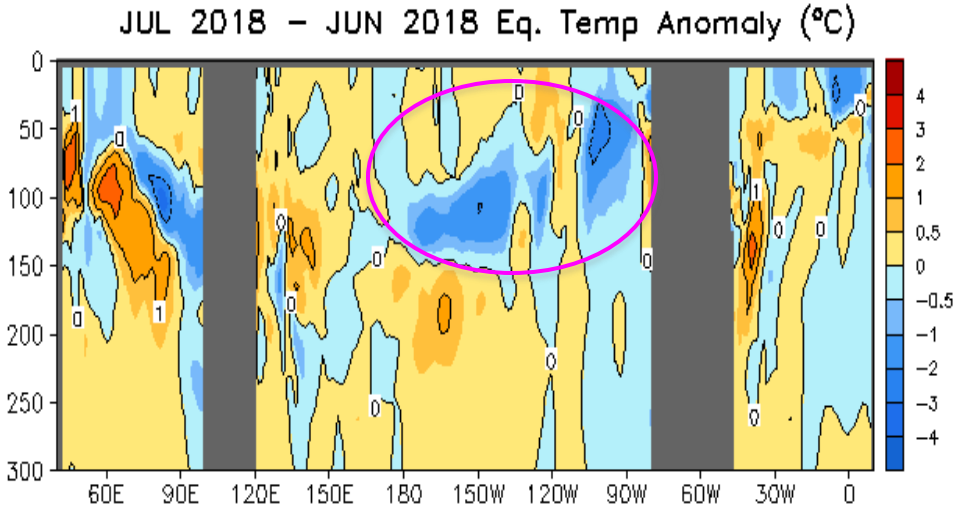
- **SST were slightly above average across most of the Eq. Pacific and eastern Eq. Atlantic oceans.**
- **Strong positive SSTAs persisted in the western N. Pacific.**
- **Horseshoe/tripole-like SSTA pattern continued in the N. Atlantic.**
- **SSTAs were small in the tropical Indian Ocean.**

- **Positive SSTA tendencies dominated near the central-eastern equatorial Pacific.**
- **Negative SSTA tendencies were seen in the NW Pacific and NW Atlantic.**

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°S-2°N





- Positive temperature anomalies presented along the thermocline in the equatorial Pacific.

- Negative temperature tendency presented along the thermocline in central-eastern Pacific 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.

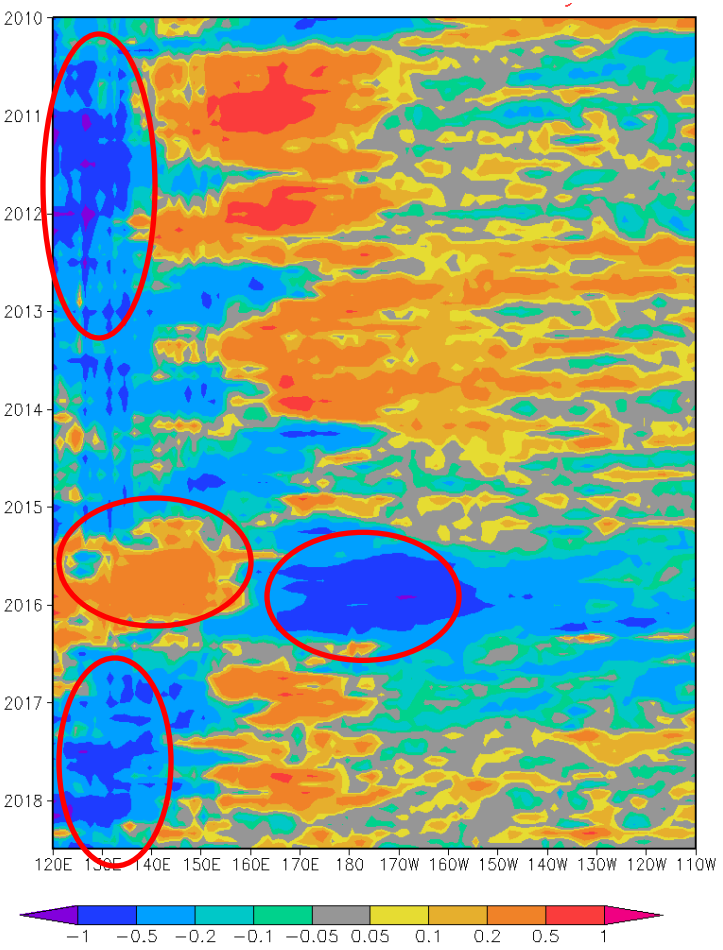
Tropical Pacific Ocean and ENSO Conditions

Monthly Sea Surface Salinity (SSS) Anomaly across Equatorial Pacific

NOTE: Since June 2015, the Blended Analysis of Surface Salinity (BASS) SSS is from in situ, SMOS and SMAP; before June 2015, BASS SSS is from in situ, SMOS and Aquarius.

- Negative (positive) SSS anomaly presented west (east)of 140E during 2010, 2011, 2016,2017 La Nina events.
- Strong positive (negative) SSS anomaly presented west (east) of 160E during 2015 El Nino events
- Negative SSS anomaly continued in the far western Pacific in Jul 2018.

SSS anomaly [5S-5N]



Pentad SSS, SST and precipitation anomalies across 2N-6N

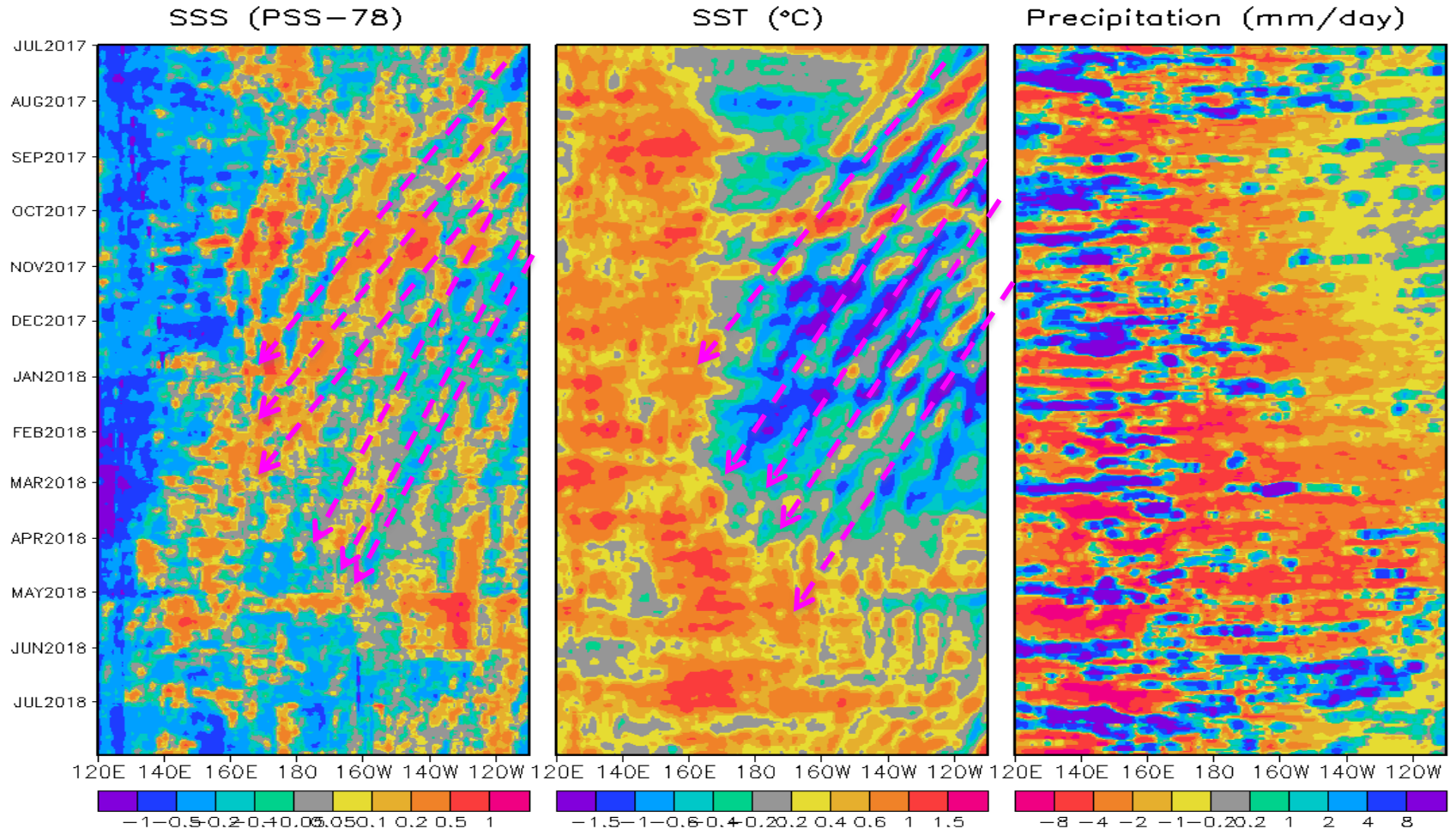
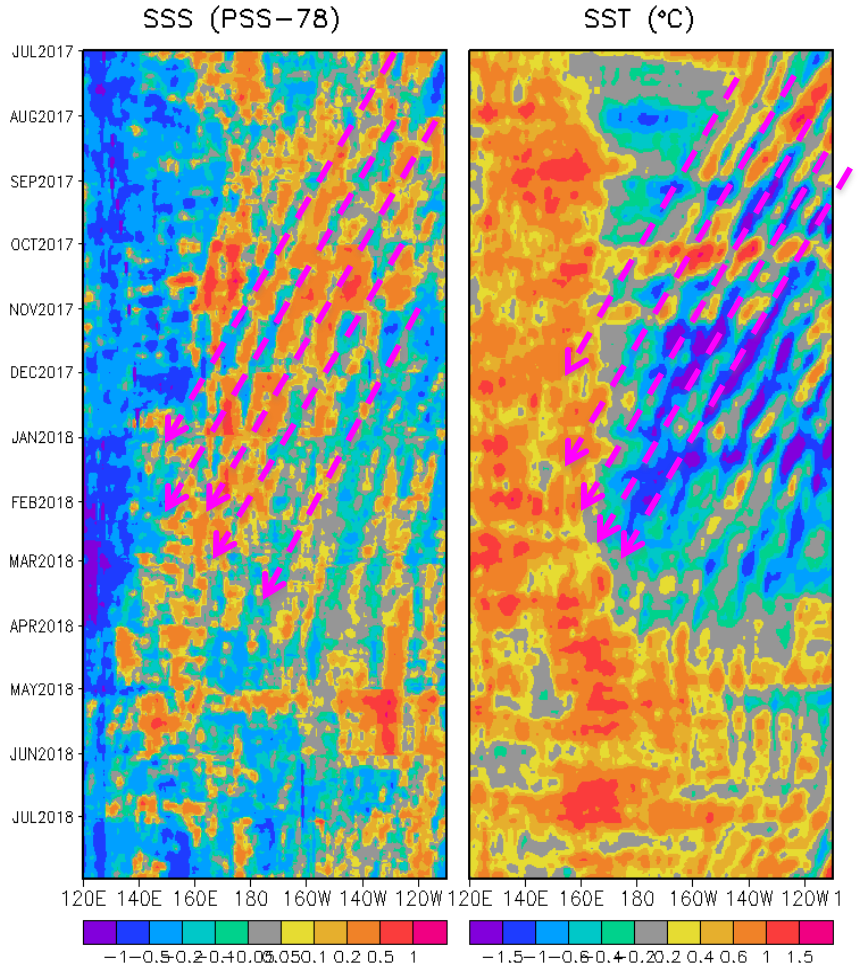
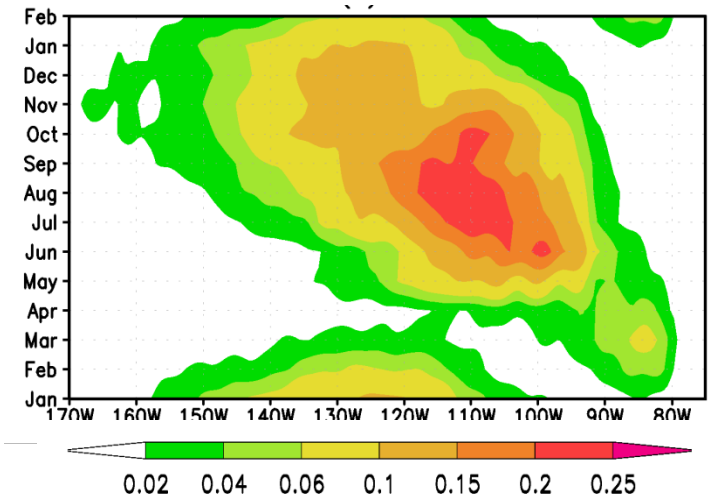


Figure caption: Hovemoller diagram for equatorial (2° N-6° N) SSS, SST and precipitation anomalies. The climatology for SSS is Levitus 1994 climatology. The SST data used here is the OISST V2 AVHRR only daily dataset with its climatology being calculated from 1985 to 2010. The precipitation data used here is the adjusted CMORPH dataset with its climatology being calculated from 1999 to 2013.

TIW-related SSS and SST anomalies



Seasonal TIW-related SST variance 0-4N

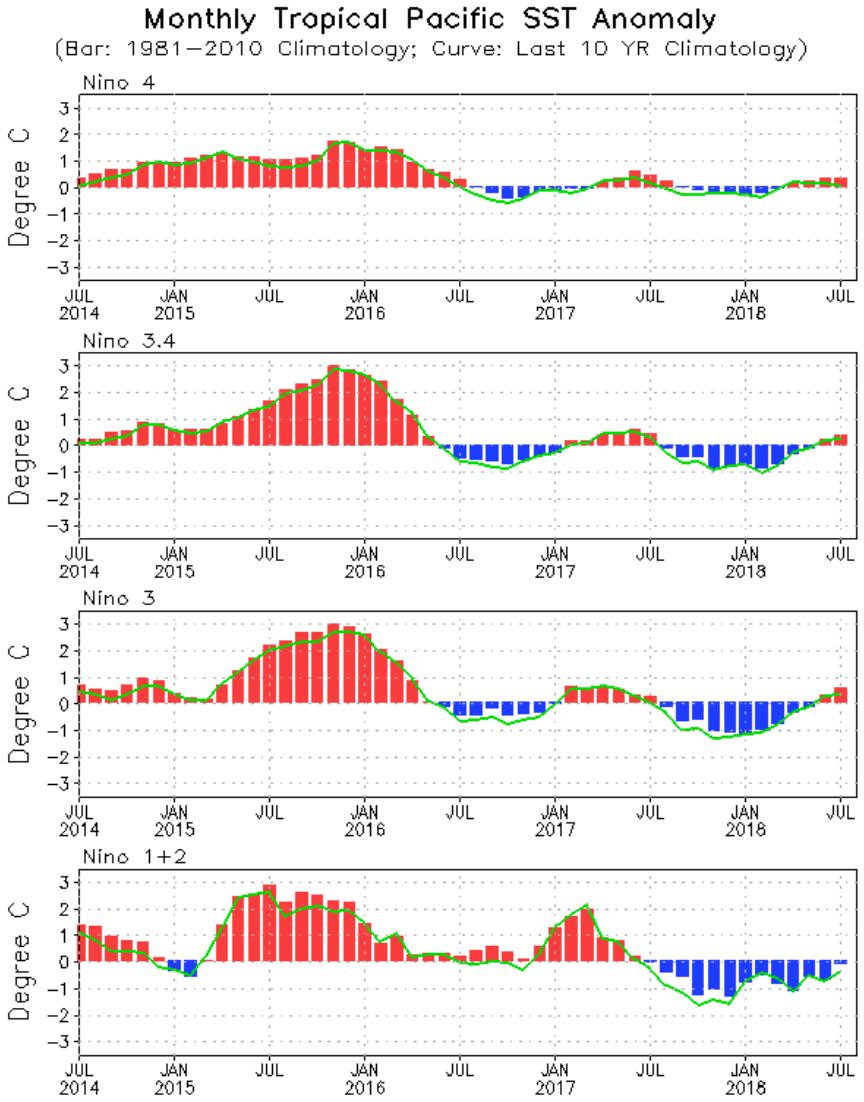


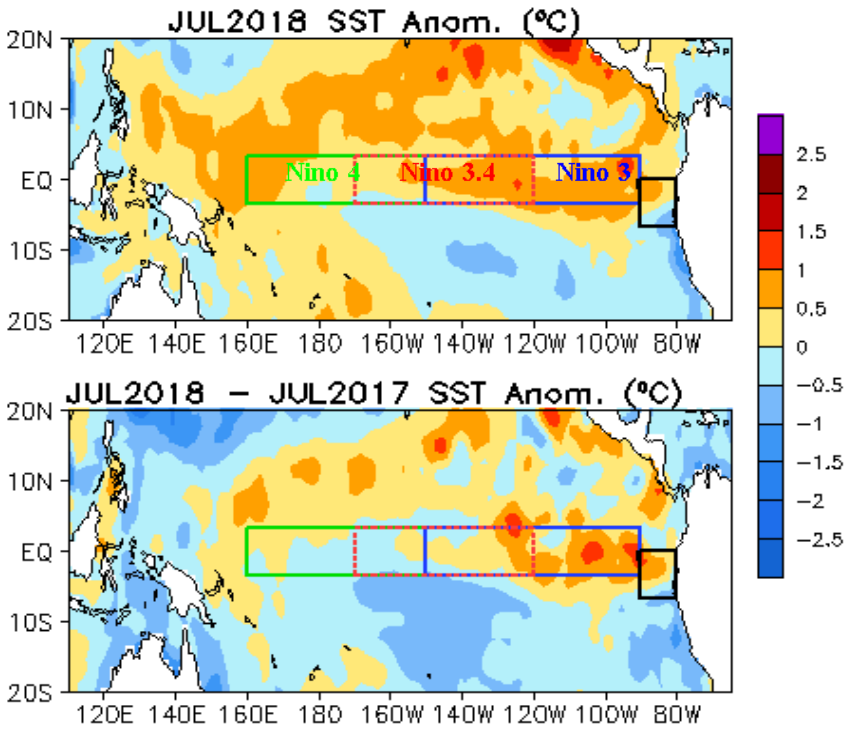
(Adapted from Wen et al. 2012)

- The new CPC pentad SSS product is able to capture meso-scale dynamical features on sub-monthly time scale.

Wen,C, Y.Xue, A.Kumar, 2012: Ocean–Atmosphere Characteristics of Tropical Instability Waves Simulated in the NCEP Climate Forecast System Reanalysis. *J. Climate*, 25, 6409–6425.

Evolution of Pacific NINO SST Indices





- **All Nino indices warmed up in Jul 2018**
- **Nino3.4 = +0.3 C in Jul 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.

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

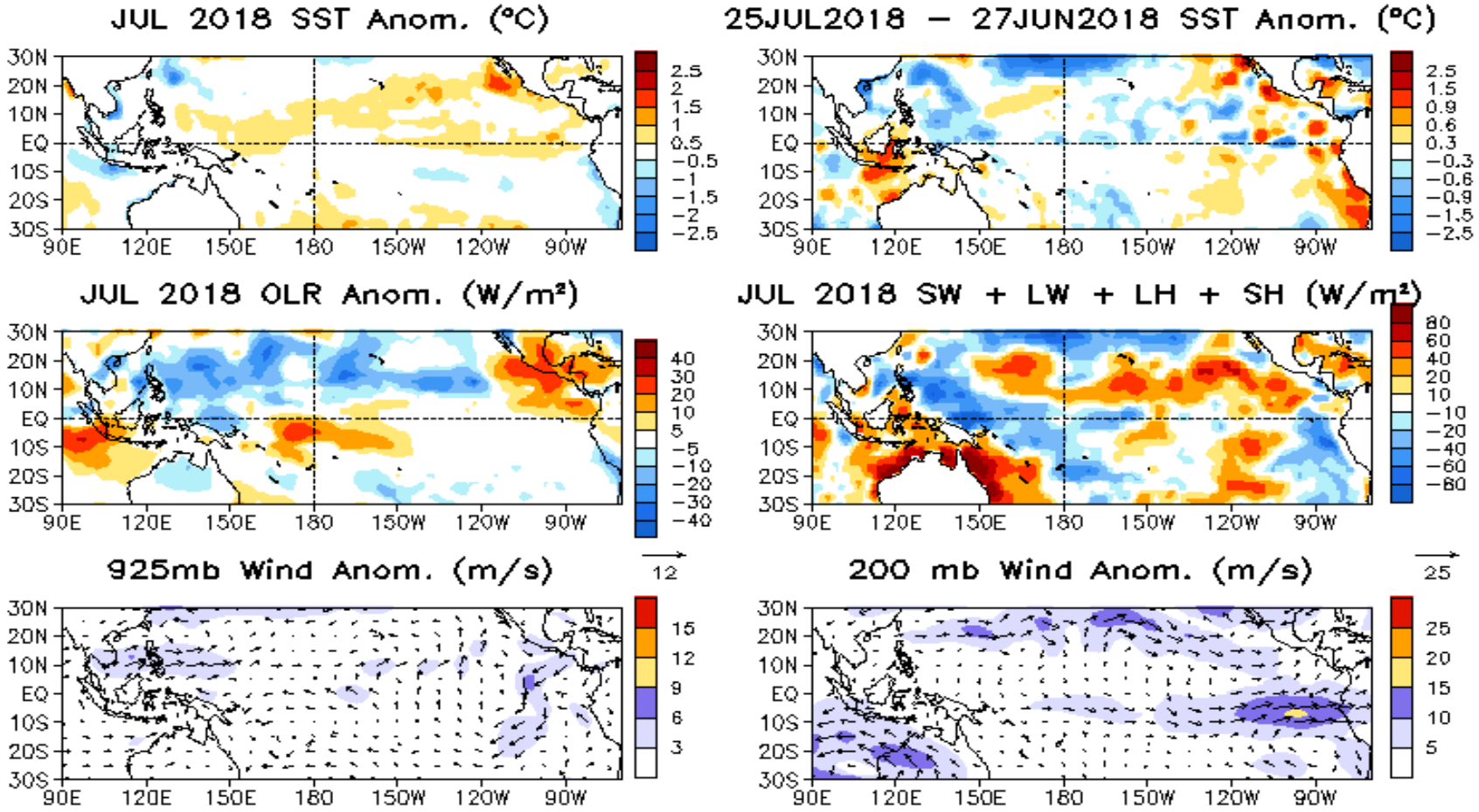
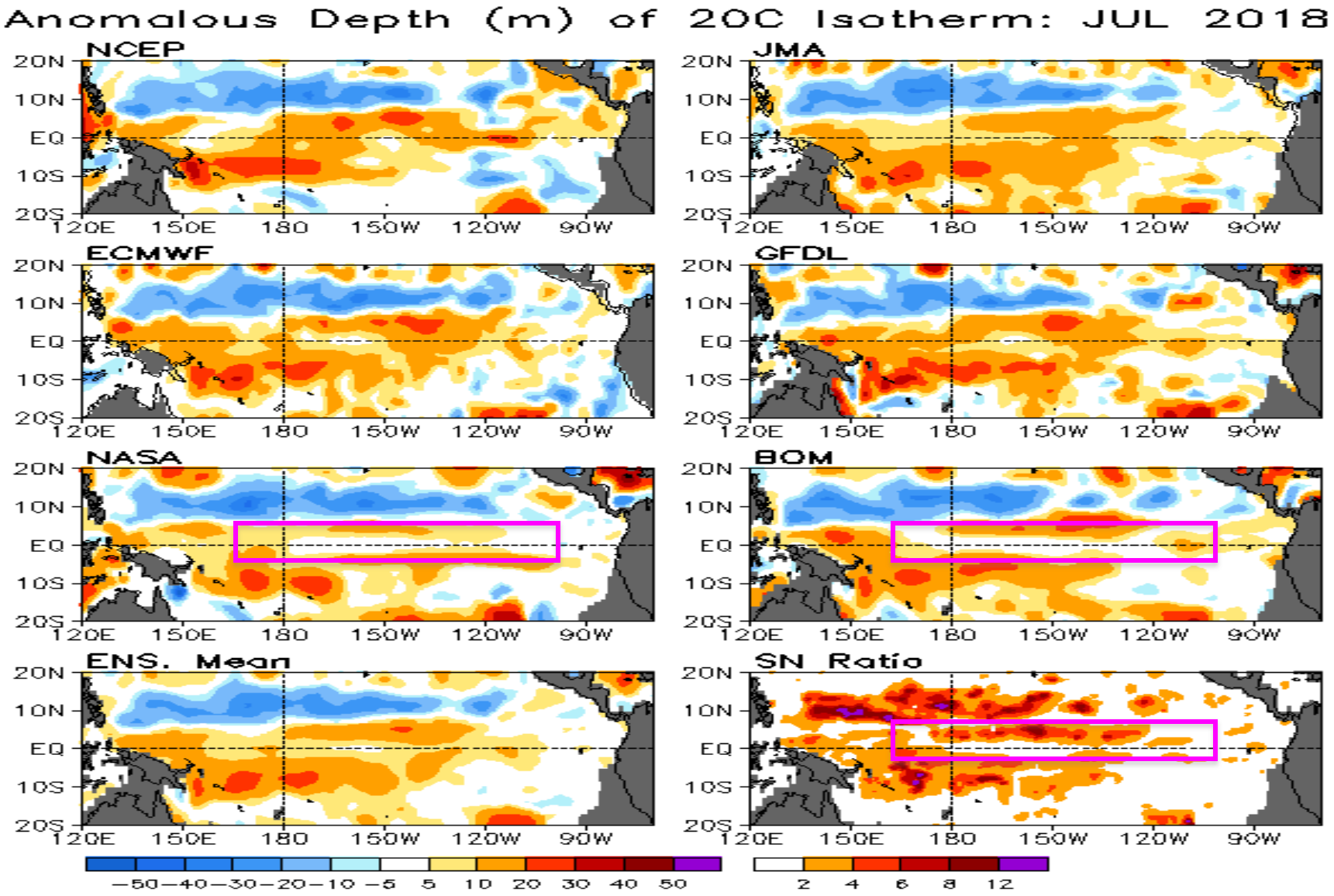


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

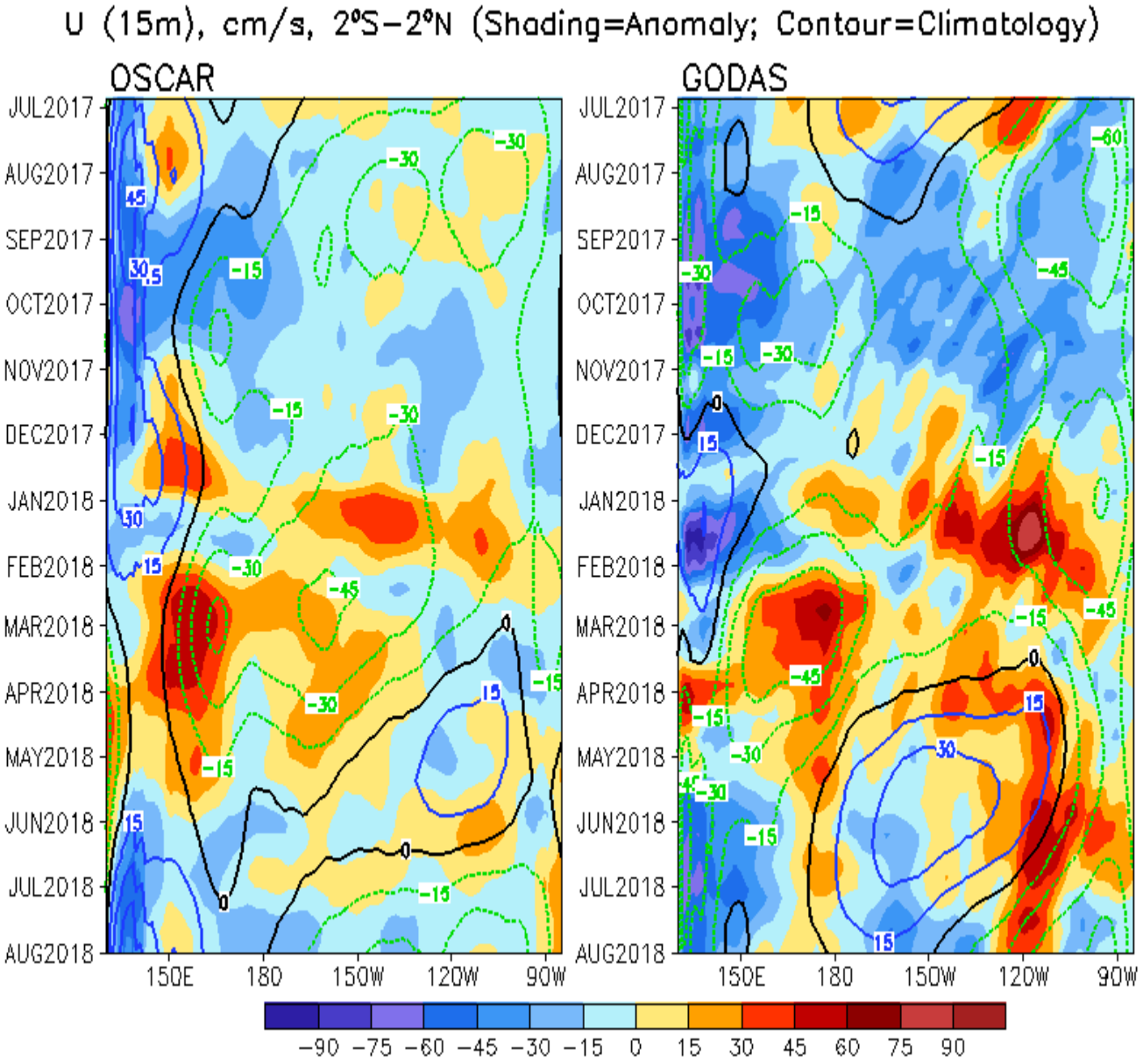
Real-Time Ocean Reanalysis Intercomparison: D20

Climatology : 1981-2010

(http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html)

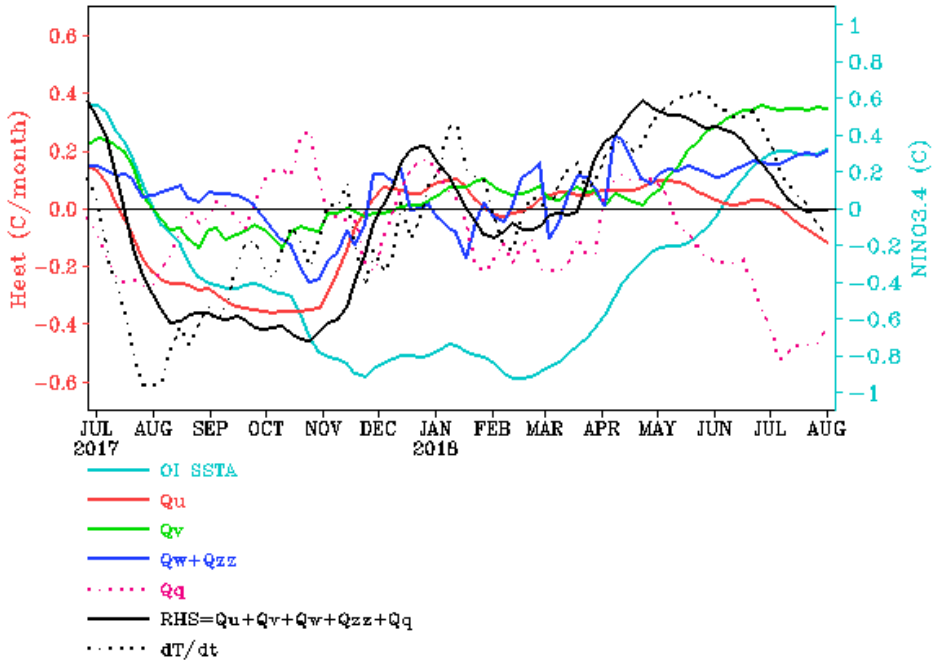


Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



-Westward anomalous currents dominated in the central-eastern Pacific in Jul 2018.

NINO3.4 Heat Budget



- Observed SSTA tendencies (dT/dt; dotted black line) switched to negative in the second half of Jul 2018.

- Zonal advection (Qu) was negative and the rest of dynamical terms (Qv, Qw+Qzz) remained positive.

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.

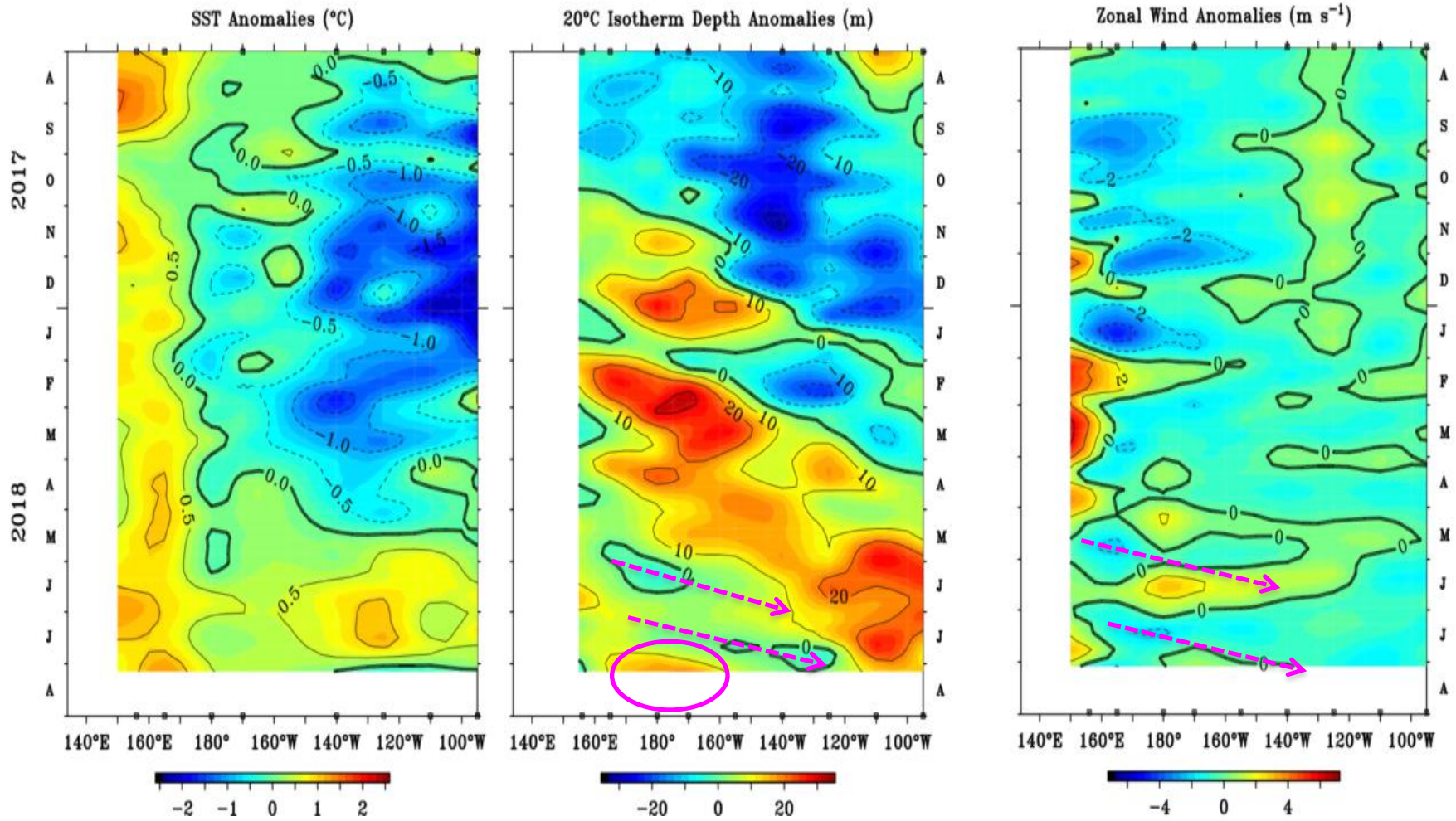
Qu: Zonal advection; Qv: Meridional advection;

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

TAO Equatorial (2S-2N) Pacific SST (°C), D20 (m) and Zonal wind(m/s) Anomalies



(https://www.pmel.noaa.gov/tao/drupal/disdel/)

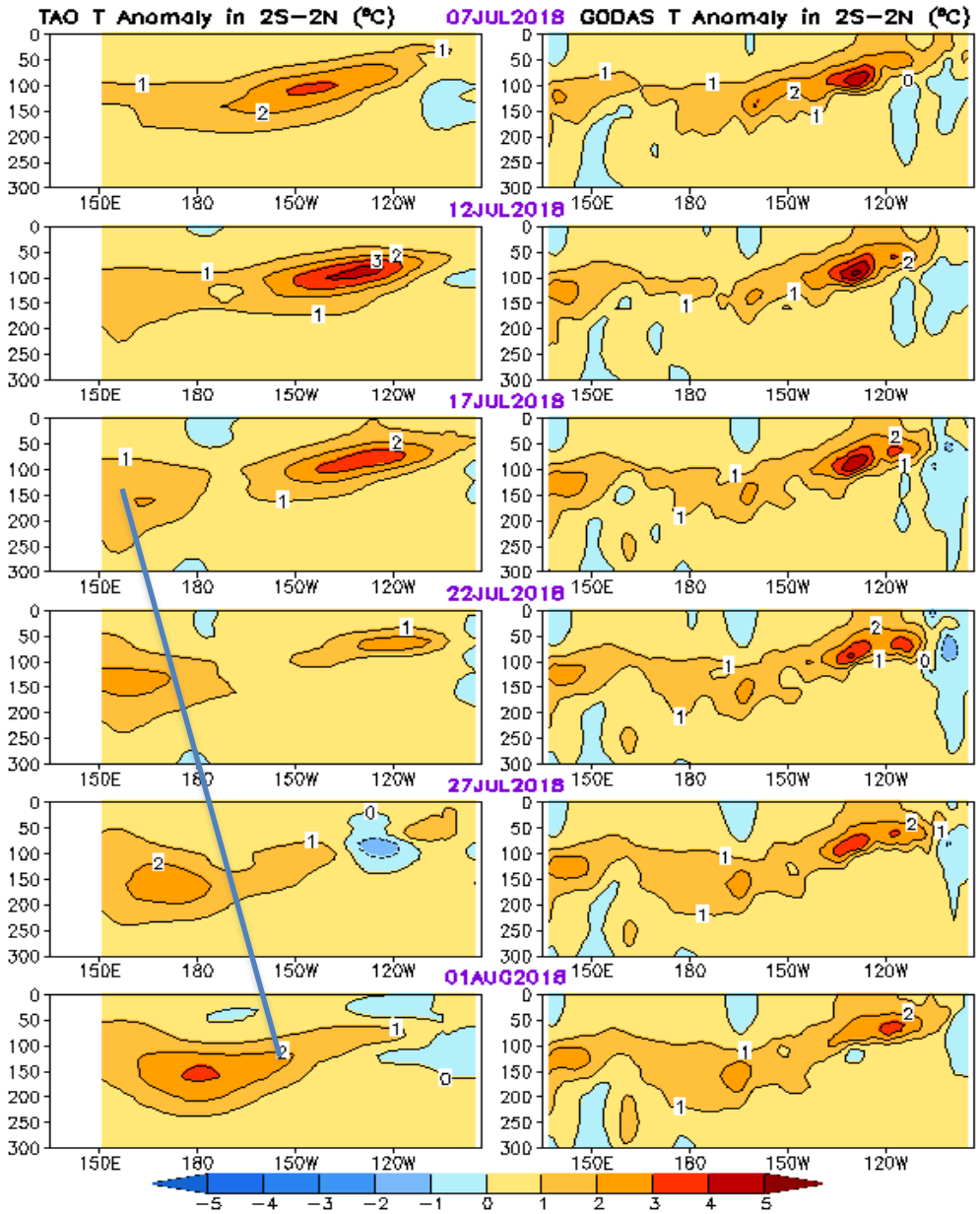
- **Positive SSTA weakened in the central-eastern Pacific since mid of Jul, 2018.**

- **Two upwelling oceanic Kelvin waves propagated eastward during May-June, giving rise to the weakening positive D20 anomaly in the central equatorial Pacific.**

- **Positive D20 anomaly emerged near the Date Line.**

Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

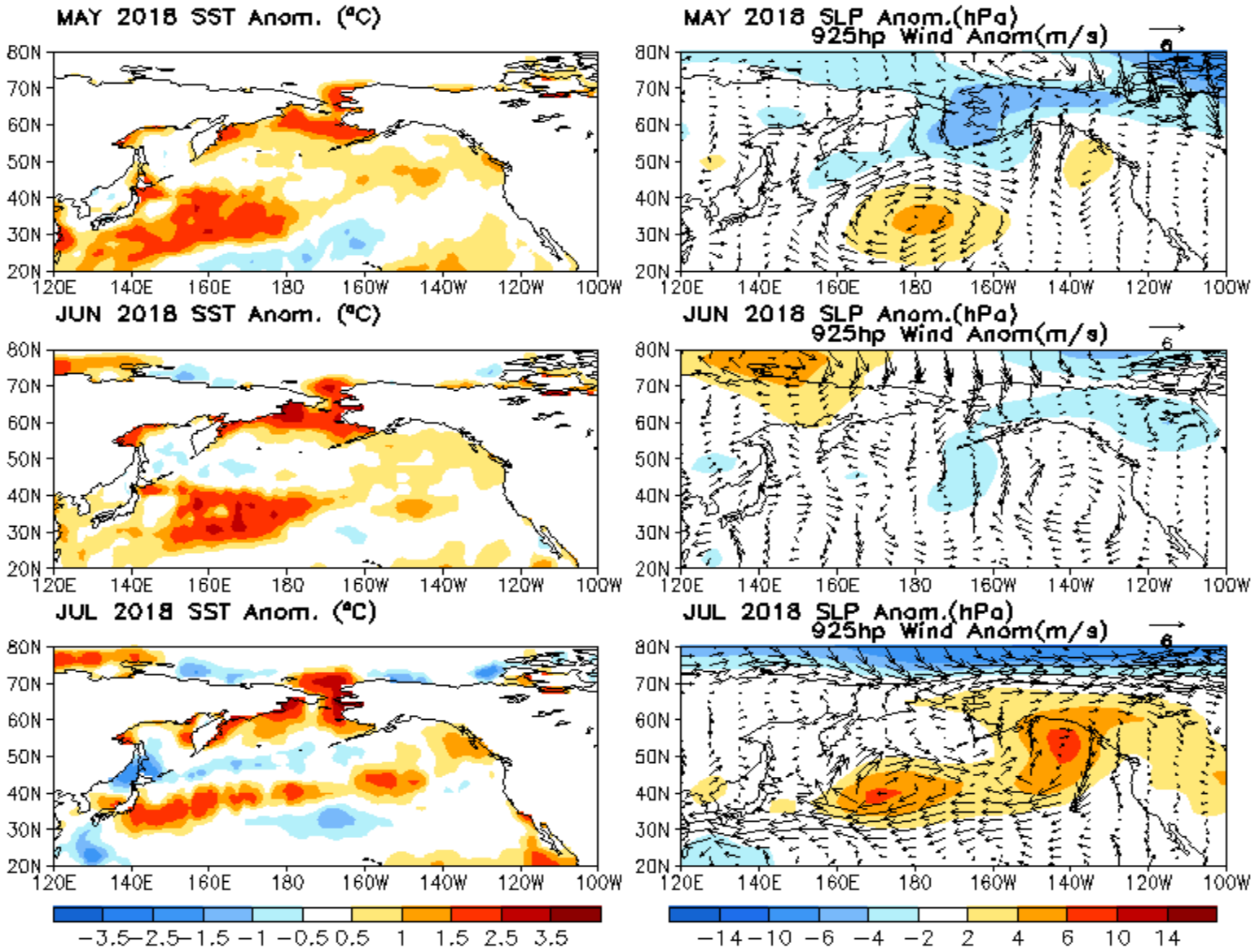
TAO GODAS



- **Positive subsurface temperature anomaly in the central Pacific strengthened during the last couple pentads.**

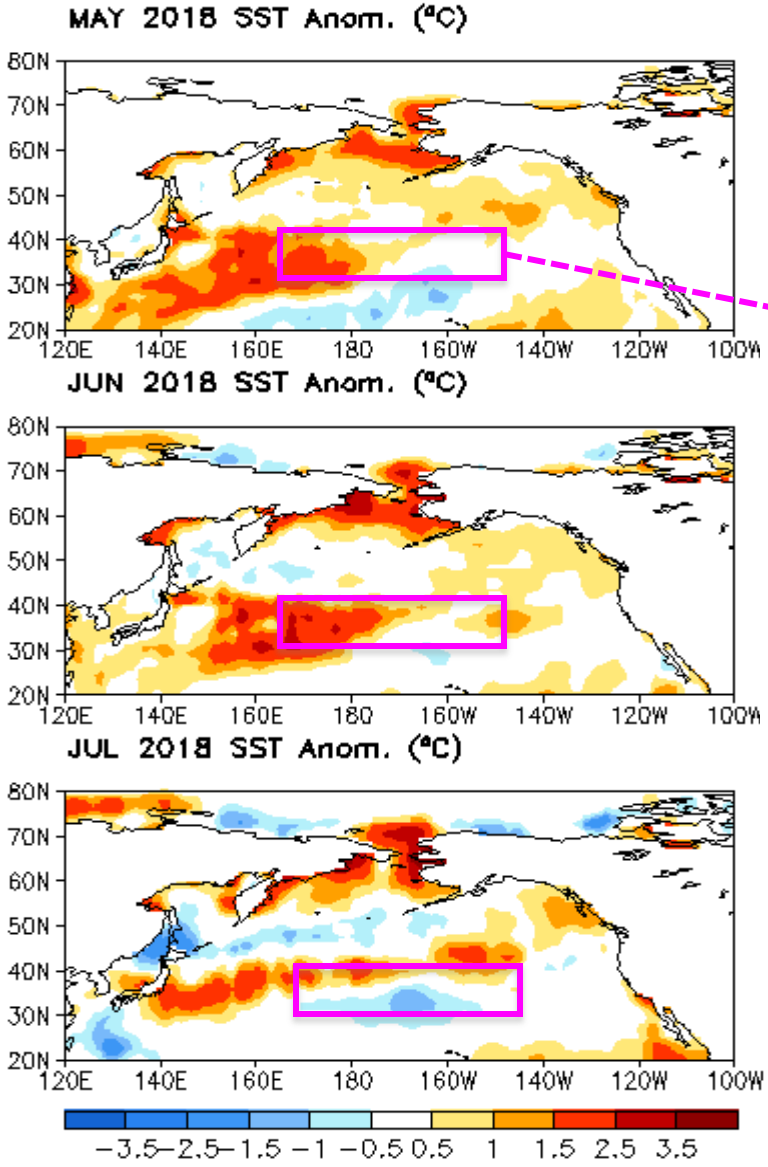
North Pacific & Arctic Oceans

Last Three Month SST, SLP and 925hp Wind Anomalies

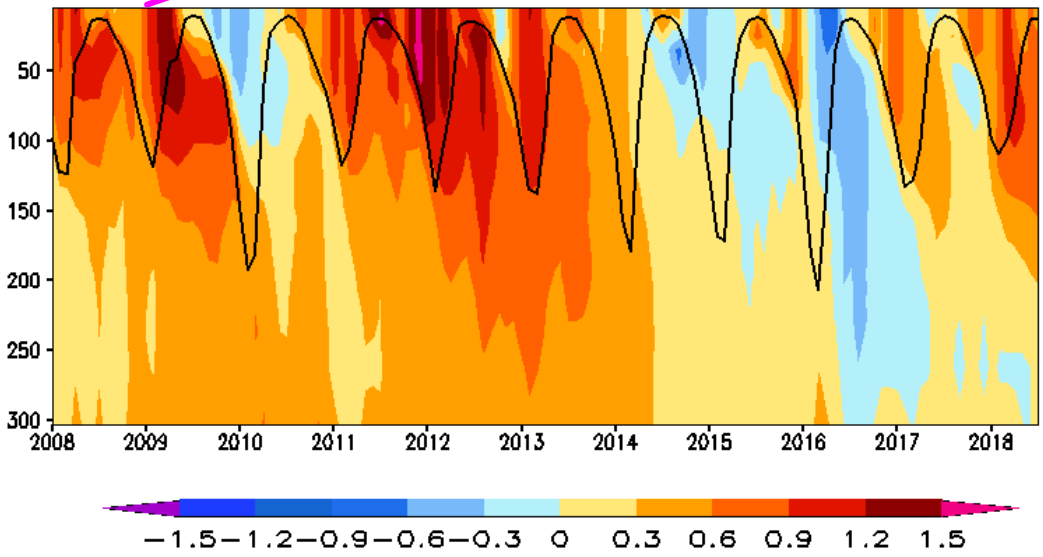


- **Distribution of SST anomalies between 20° -50° N varied month by month, owing to the high frequency changes in the atmospheric circulation.**

Last Three Month SST, SLP and 925hp Wind Anomalies



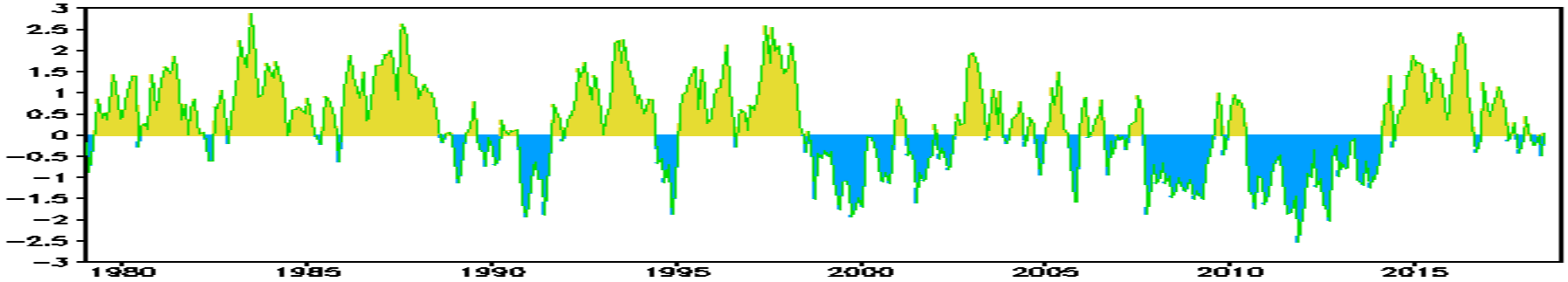
Temperature anomaly averaged in [170E-150W,30N-40N]



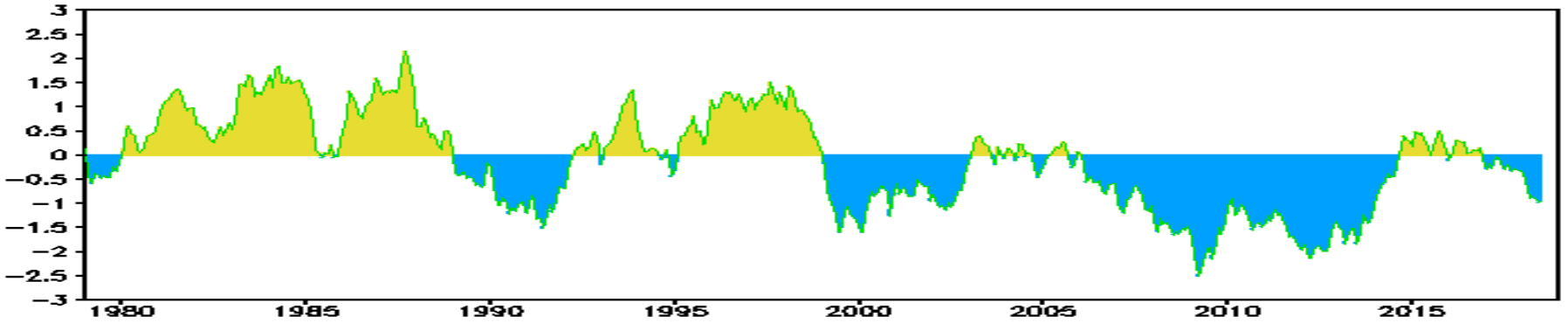
- **Positive subsurface temperature anomaly in the central North Pacific has persisted since 2016.**

Two Oceanic PDO indices

SST-based PDO



H300-based PDO



- **SST-based PDO index switched to positive phase in Jul 2018, with PDO index =0.1.**
- **Negative H300-based PDO index has persisted 10 months since Nov 2016, with HPDO = -1 in Jul 2018.**
- **SST-based PDO index has considerable variability both on seasonal and decadal time scales.**

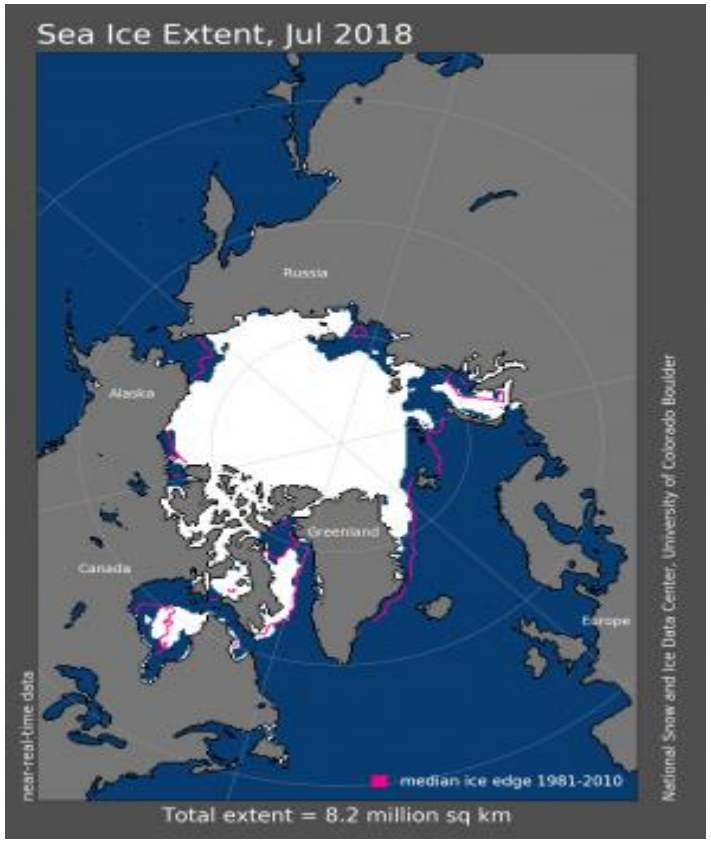
(H300-based PDO index is downloadable from http://www.cpc.ncep.noaa.gov/products/GODAS/PDO_body.html)

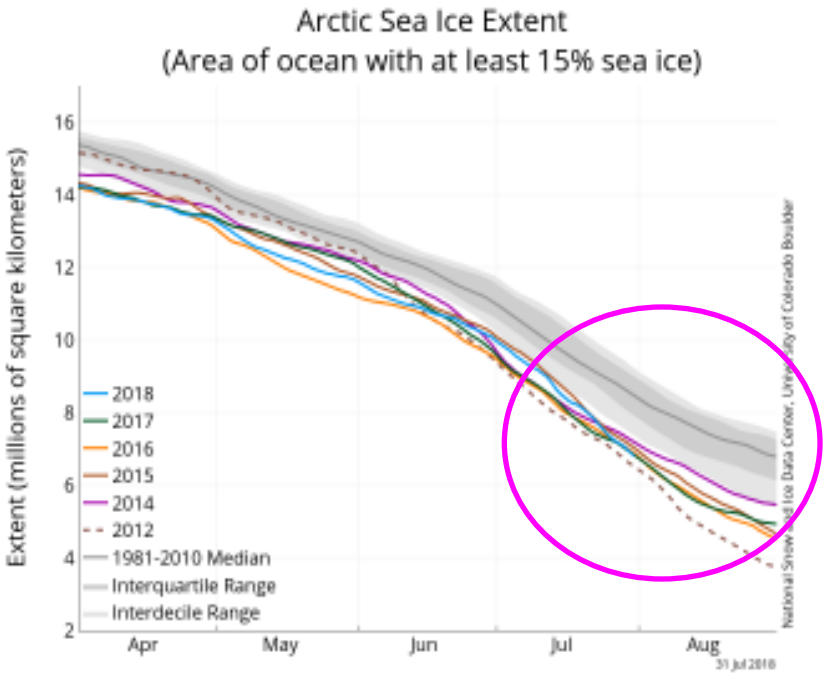
SST-based Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the ERSST v4 monthly SST anomalies onto the 1st EOF pattern. H300-based Pacific Decadal Oscillation is defined as the projection of monthly mean H300 anomalies from NCEP GODAS onto their first EOF vector in the North Pacific.

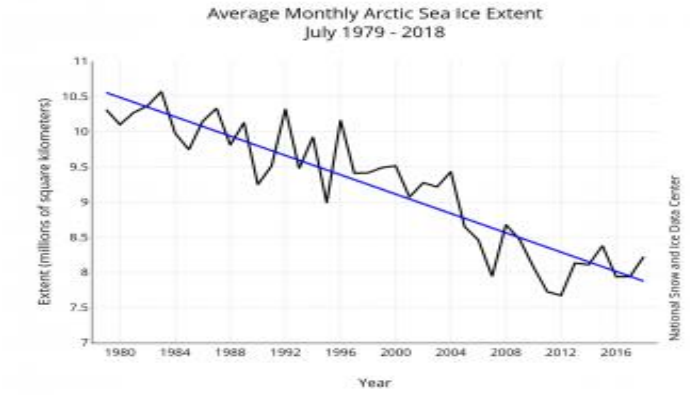
Arctic Sea Ice

National Snow and Ice Data Center

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



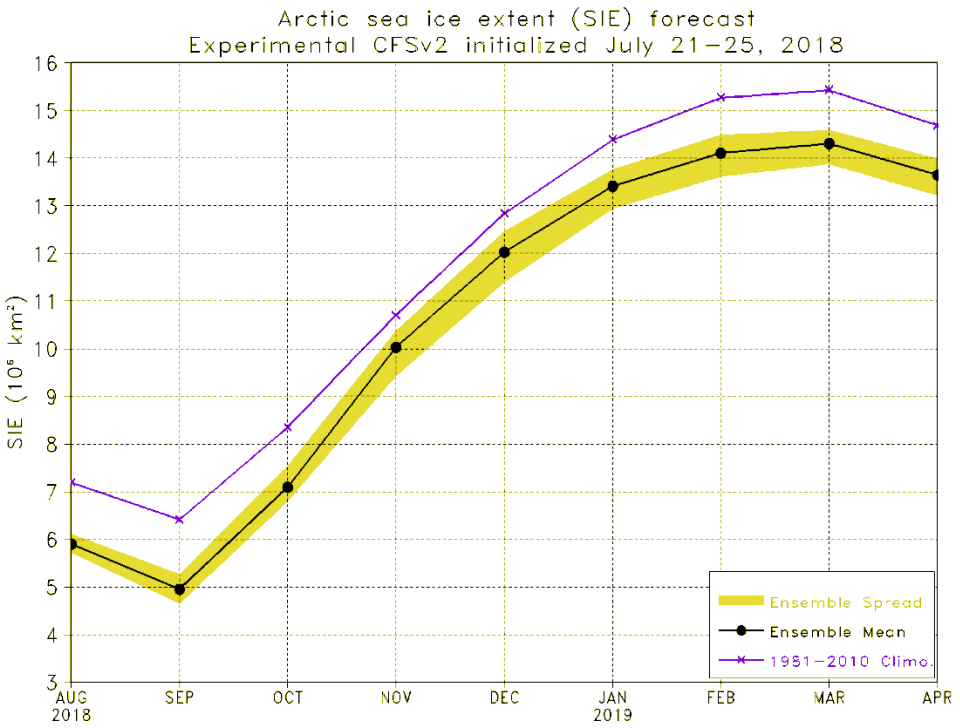




- **Arctic sea ice extent declined rapidly in the second half of Jul 2018.**

September 2018 SIE forecast

Source	SIE (10^6 km^2)
NSIDC 1981-2010 Climatology	6.41
NSIDC 2017	4.80
NSIDC 2012	3.57
CPC 2018 forecast	**4.93**



Month September Prediction for this year's forecasts

Month	March	April	May	June	July	August
Ens. Mean	4.44	4.50	4.63	4.77	4.93	
Std. Dev.	0.51	0.29	0.24	0.19	0.19d	

Indian Ocean

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

- **Negative SSTA presented across much of equatorial Indian Ocean.**

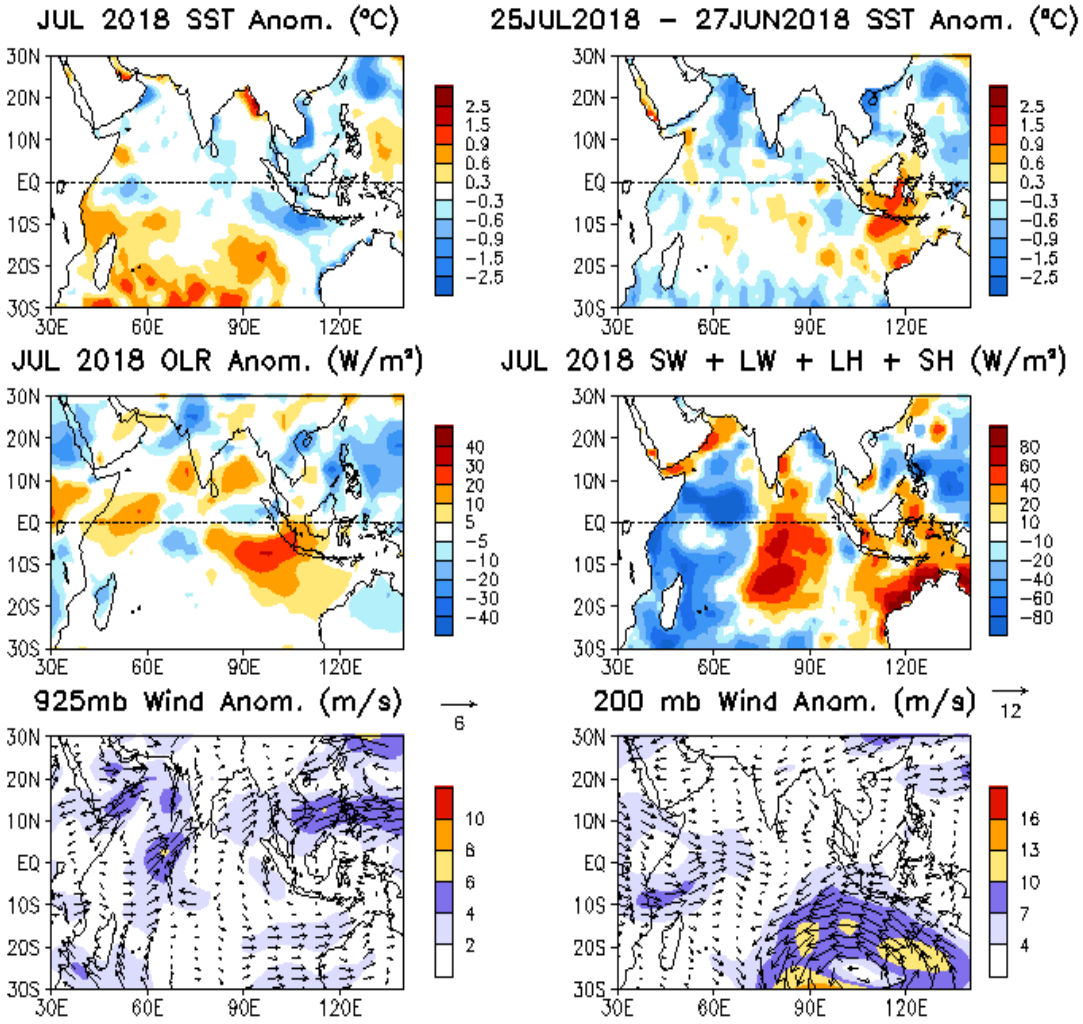
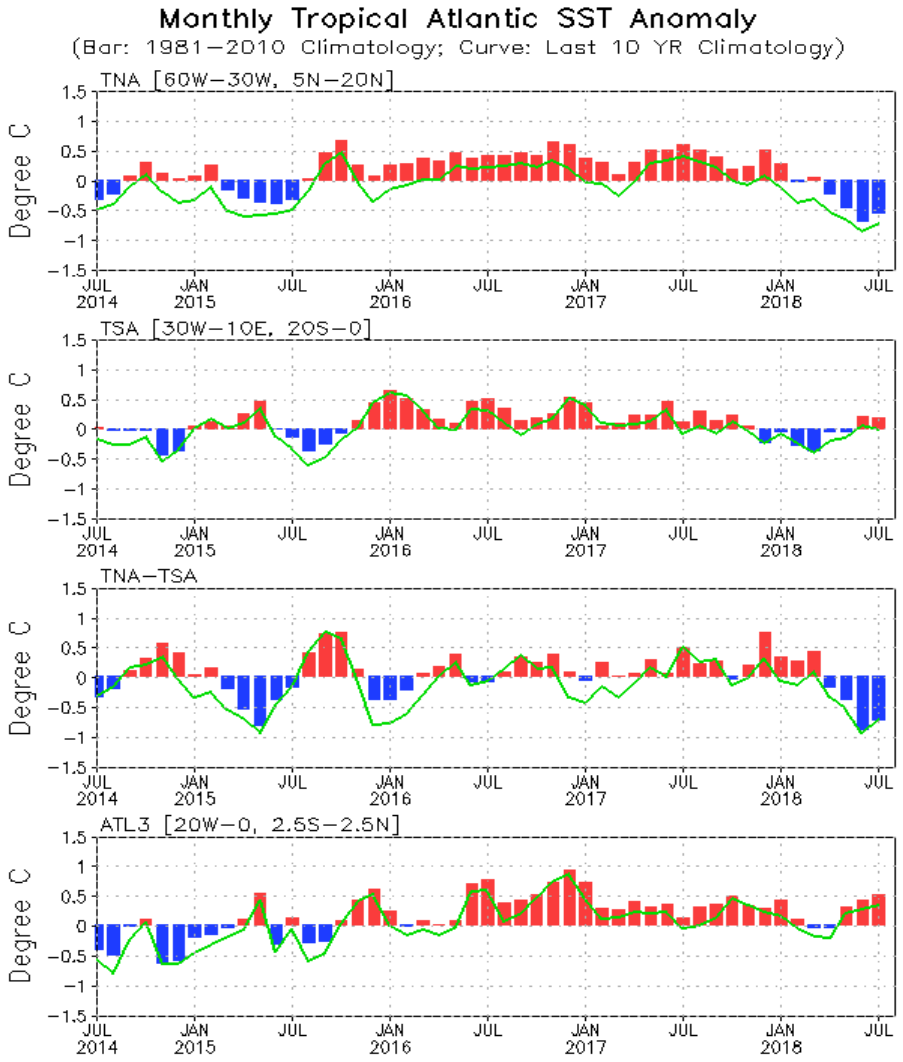
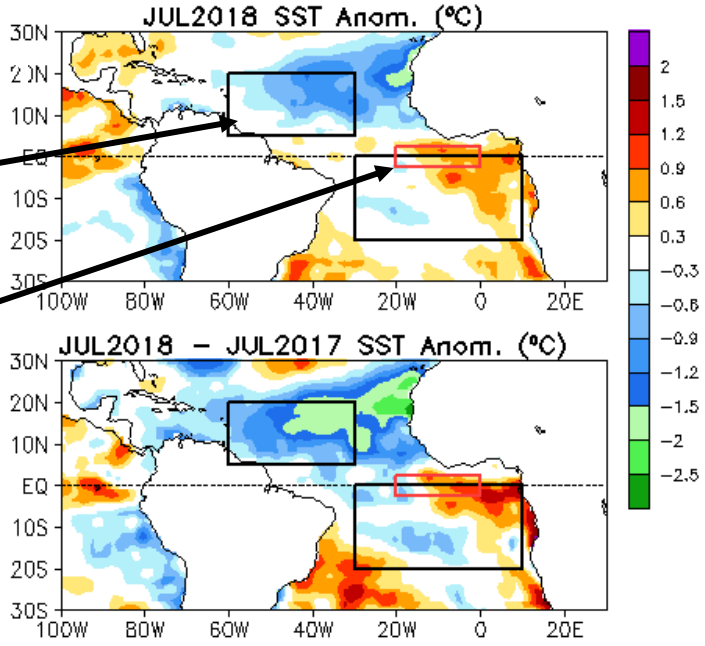


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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





- Both negative TNA and the gradient mode (TNA-TSA) weakened slightly in Jul 2018.

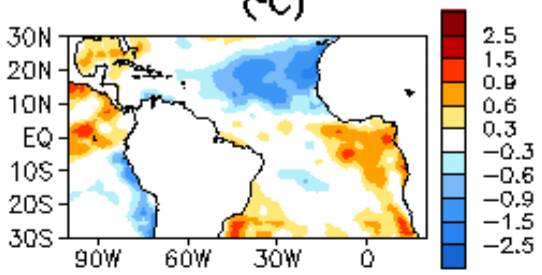
- The SST in the eastern tropical N Atlantic in Jul 2018 was about 2 degree colder than that in Jul 2017 .

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.

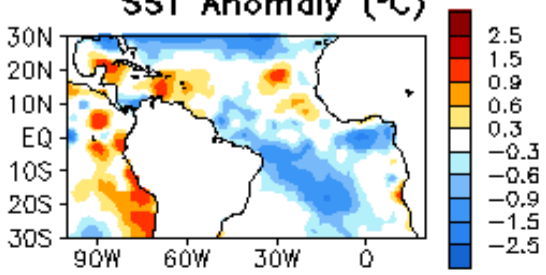
Tropical Atlantic:

SST, SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, TCHP, 925-mb/200-mb Winds anom.

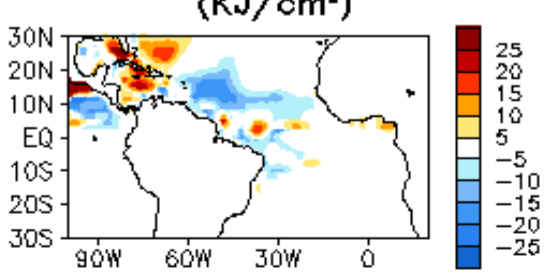
JUL 2018 SST Anom. (°C)



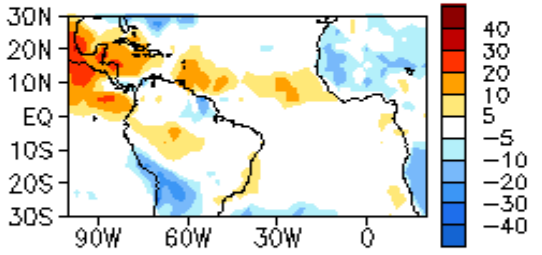
25JUL2018 – 27JUN2018 SST Anomaly (°C)



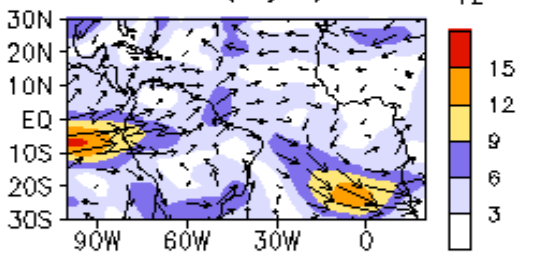
JUL 2018 TCHP Anom. (KJ/cm²)



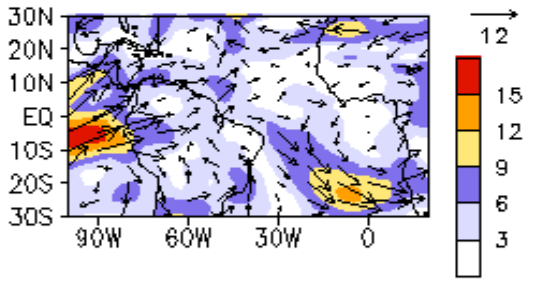
JUL 2018 OLR Anom. (W/m²)



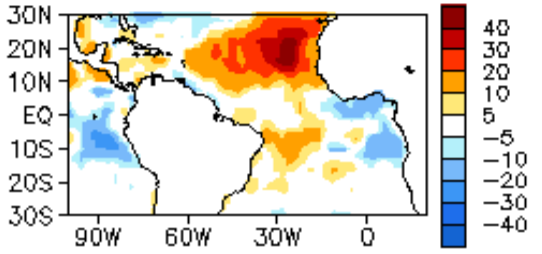
JUL 2018 200mb Wind Anom. (m/s)



JUL 2018 200mb – 850mb Wind Shear Anom. (m/s)

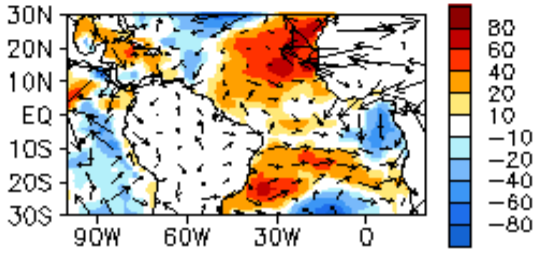


JUL 2018 SW + LW Anom. (W/m²)

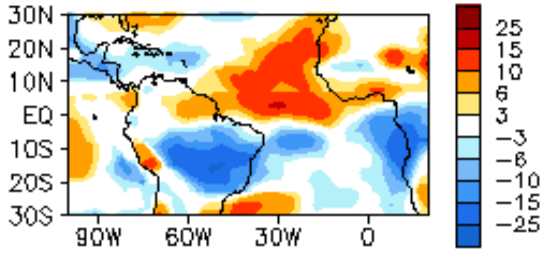


LH + SH Anom. (W/m²)

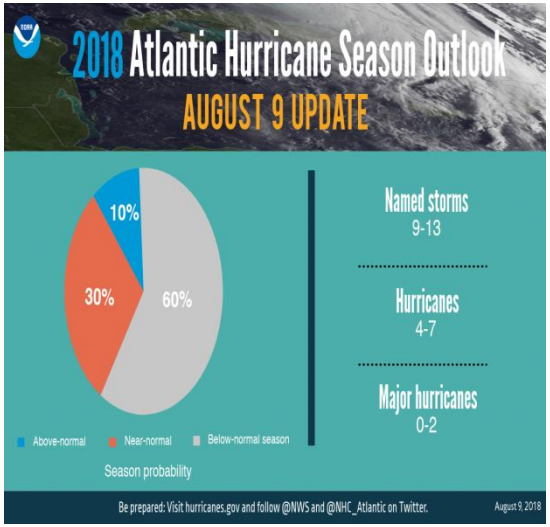
925mb Wind Anom. (m/s)

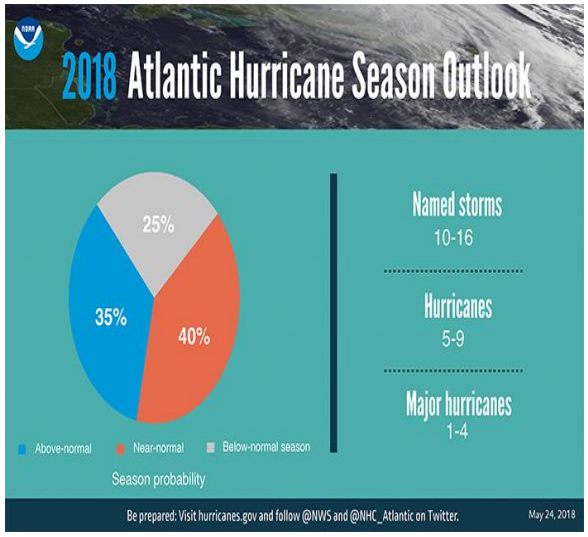


JUL 2018 700 mb RH Anom. (%)



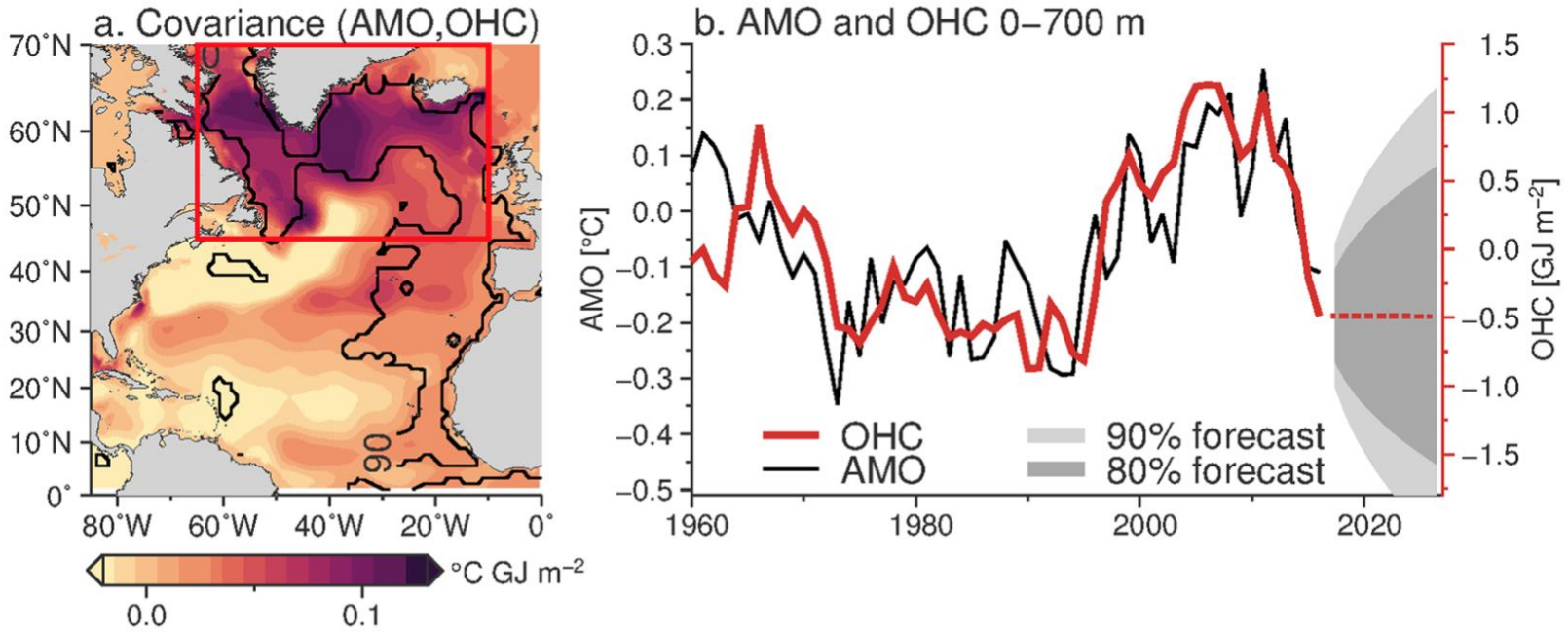
2018 Atlantic Hurricane Season Outlook Update





https://en.wikipedia.org/wiki/2018_Atlantic_hurricane_season

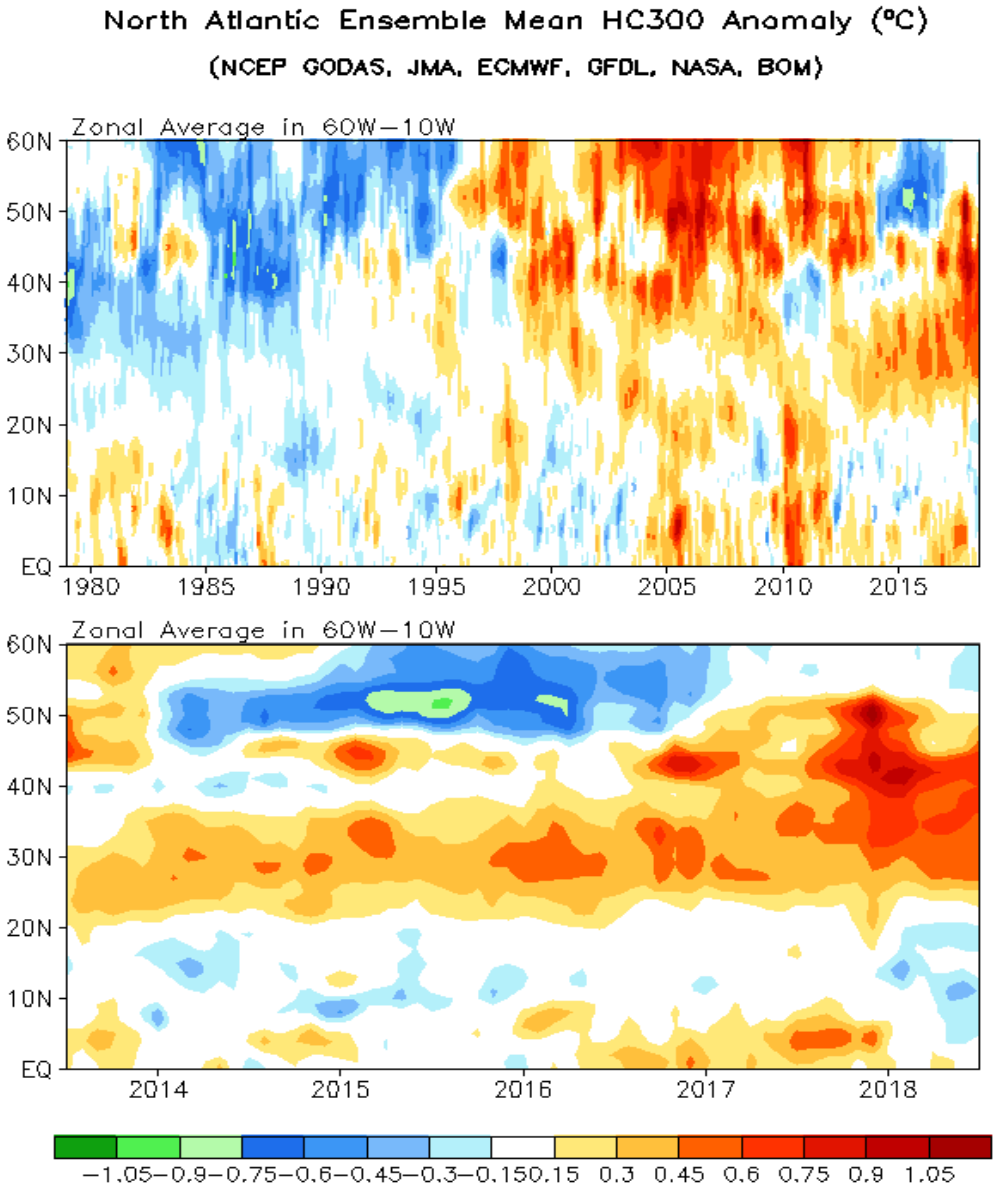
Atlantic	2018 prediction (issued on May 24) Updated on Aug 9	1981-2010	Observations (By Aug 9)
Named storms	(10-16) 9-13	12	4
Hurricanes	(5-9) 4-7	6	2
Major hurricanes	(1-4) 0-2	3	0

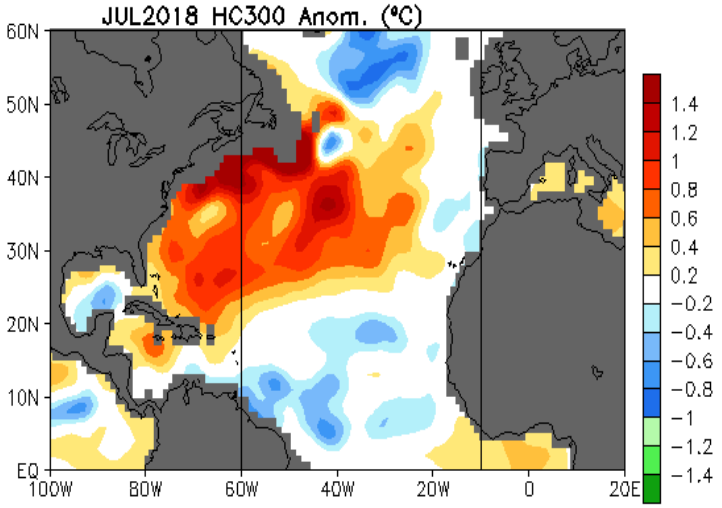


(Adapted from Frajka-Williams et al. 2018)

- High correlation between AMO index and the north Atlantic ocean heat content .

Frajka-Williams et al. 2018: Emerging negative Atlantic Multidecadal Oscillation index in spite of warm subtropics, Scientific Reports.

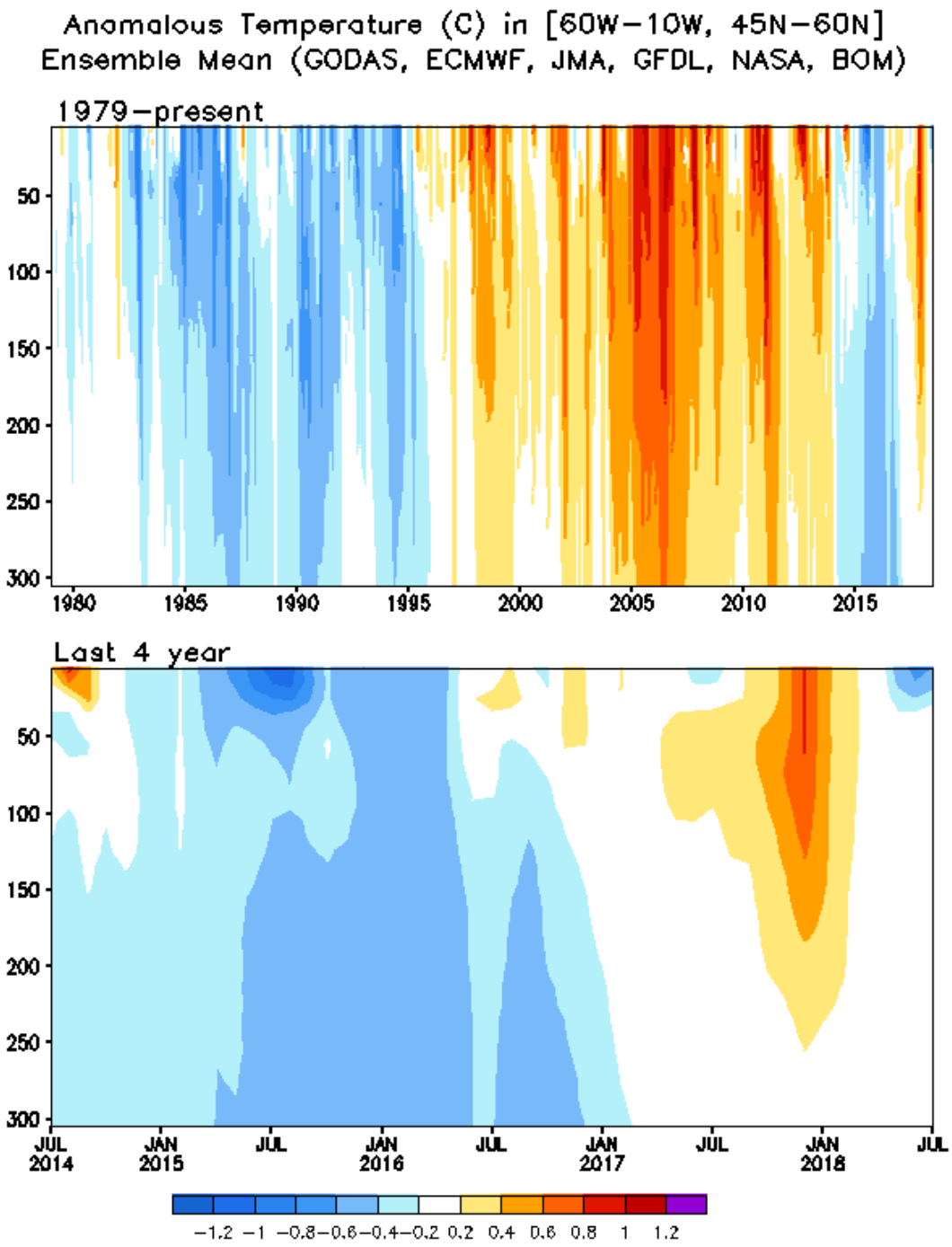


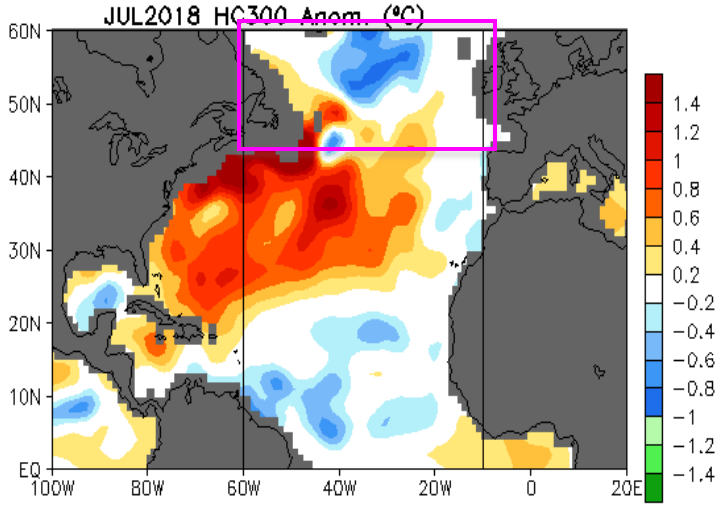


- HC300 anomaly has a tripole/horseshoe pattern with positive in the mid- latitudes and negative in lower and higher latitudes.

-The "cold blob" in the subpolar gyre in 2014-2016 was comparable to that before 1996.

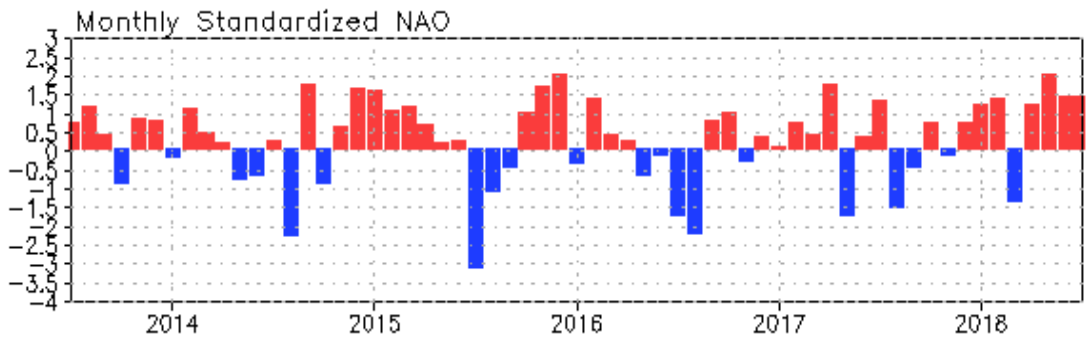
- The "cold blob" weakened substantially during 2017-2018.

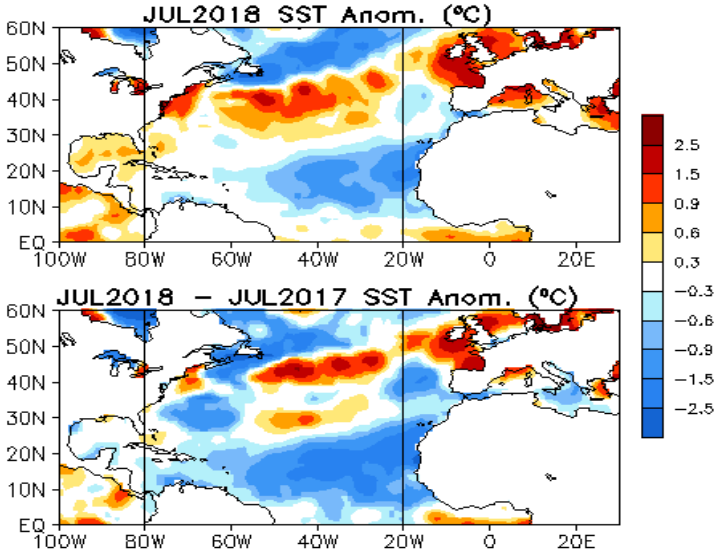


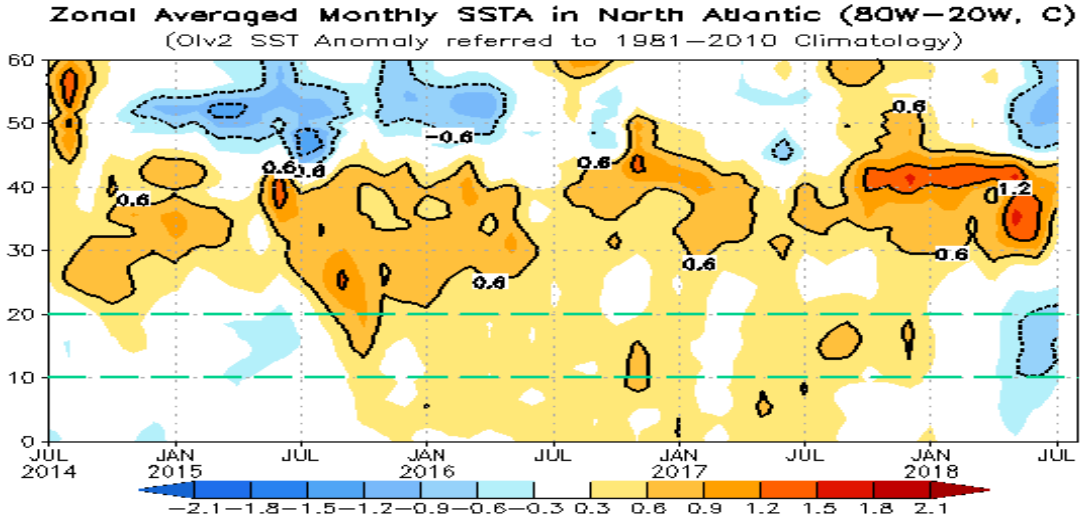


- Negative temperate anomaly in the subpolar North Atlantic was only observed near the surface since Mar 2018.

NAO and SST Anomaly in North Atlantic





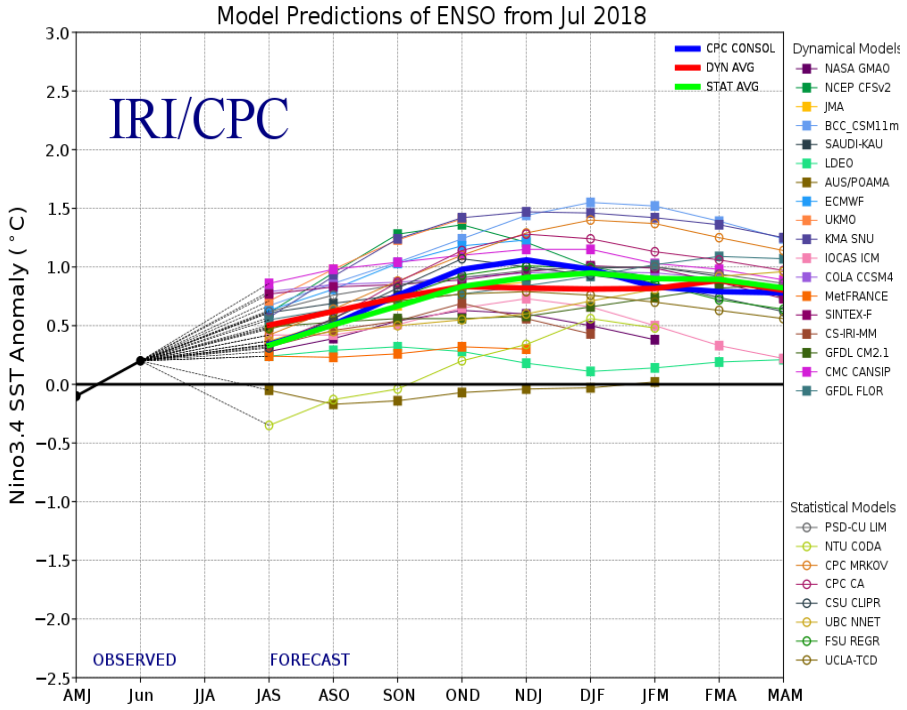


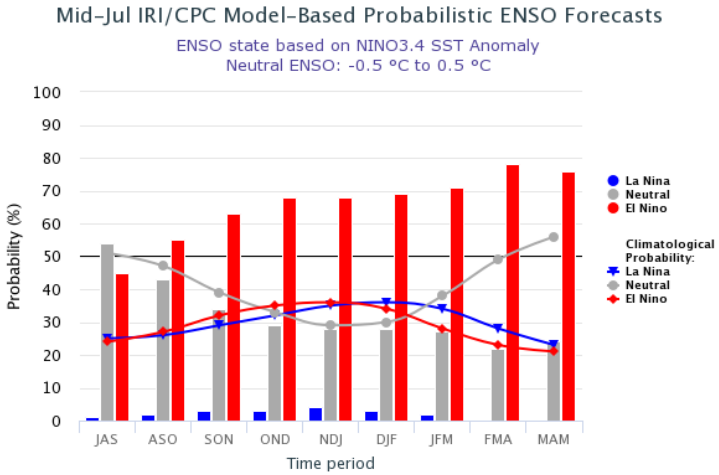
- **NAO was in a positive phase with NAOI= +1.4 in Jul 2018.**

- **SSTA has a tripole/horseshoe pattern with positive in the mid- latitudes and negative in lower and higher latitudes, which resembled the late 2014 and 2015 period.**

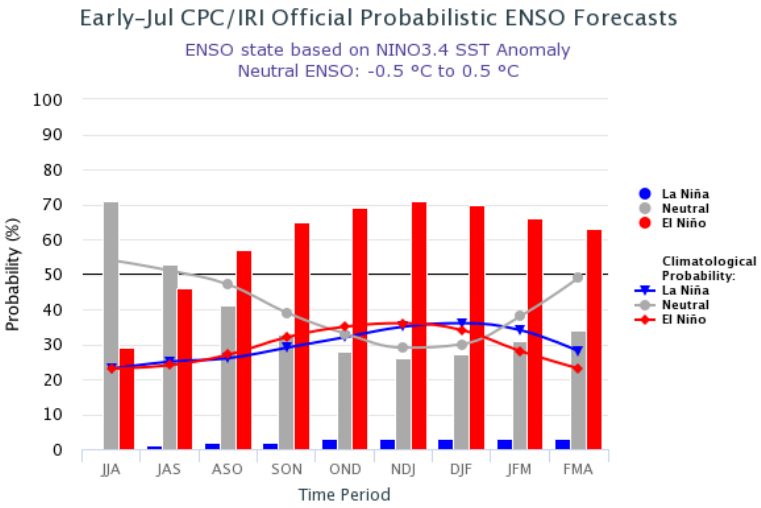
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80°W and 20°W (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

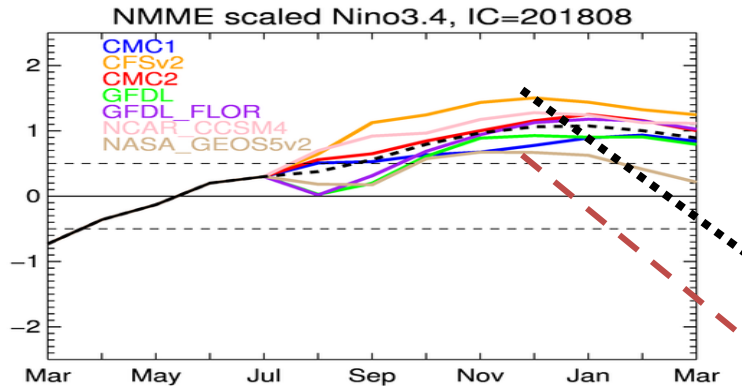




- **The majority of models favor El Nino development by early fall with about 65% chance.**
- **NOAA "ENSO Diagnostic Discussion" on 9 Aug 2018 continuously issue El Nino watch and state "There is ~60% chance of El Niño in the Northern Hemisphere fall 2018 (September-November), increasing to ~70% during winter 2018-19. "**

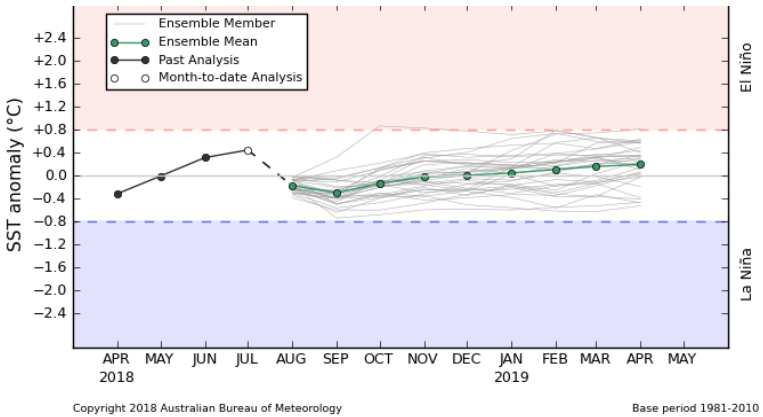


Individual Model Forecasts and Oceanic IC conditions

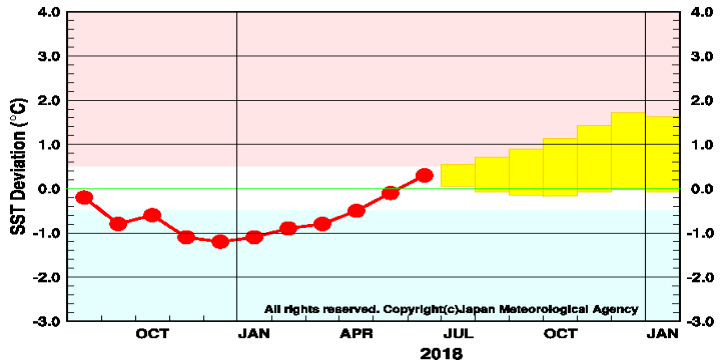


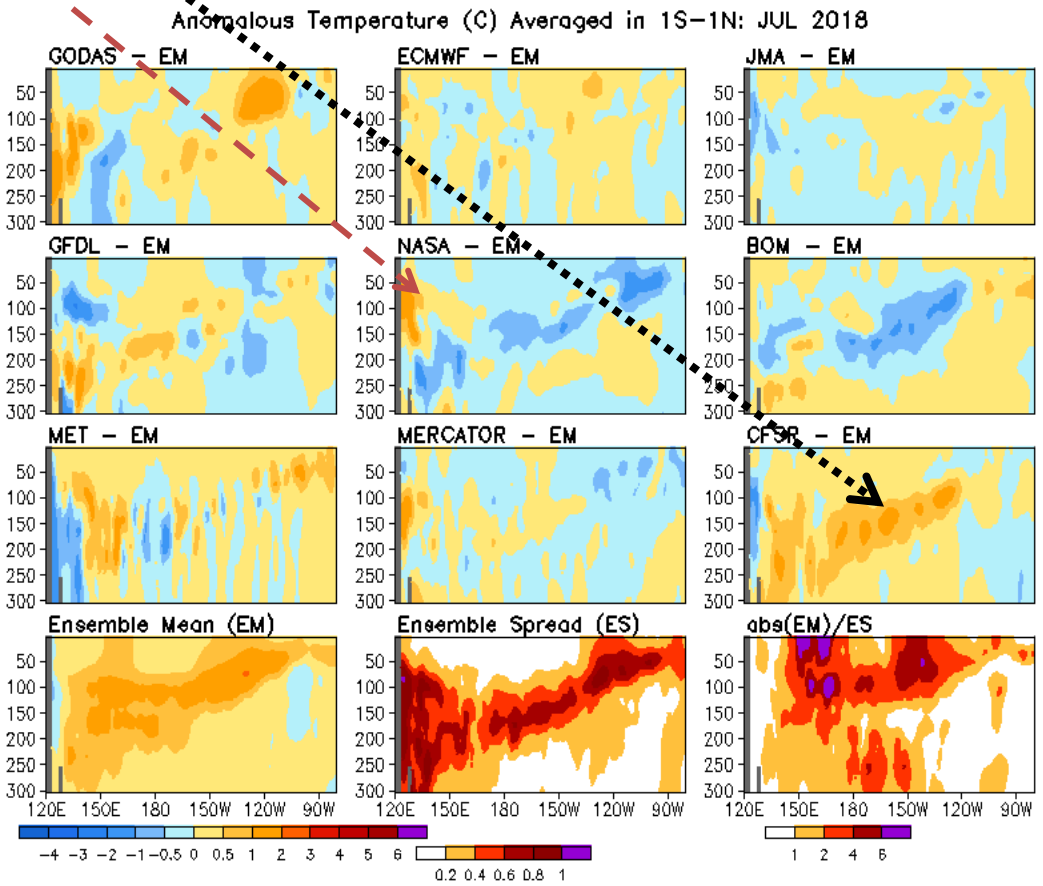
- **NASA, BOM ocean initial conditions had cold biases along the thermocline in the equatorial western-central Pacific, which are consistent with their ENSO-neutral predictions.**

Australia: Nino3.4, IC= 29 Jul 2018

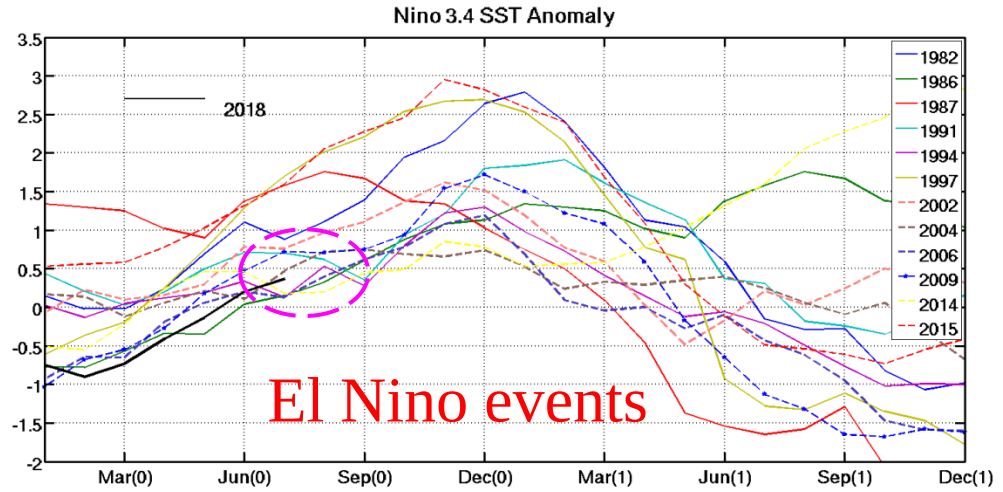


JMA: Nino3, IC/updated = 10 Jul 2018





SST,D20 and 925hp Wind anomalies in July



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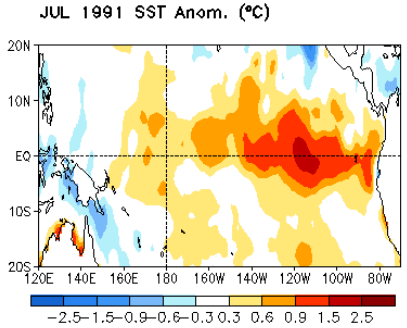
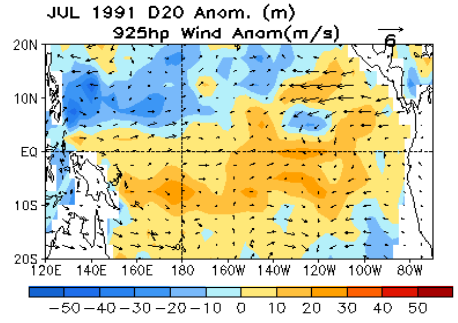
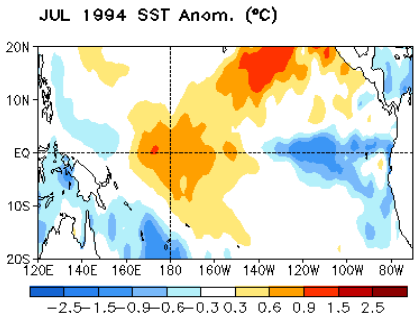
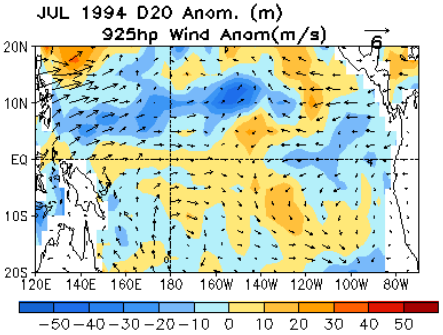




1994





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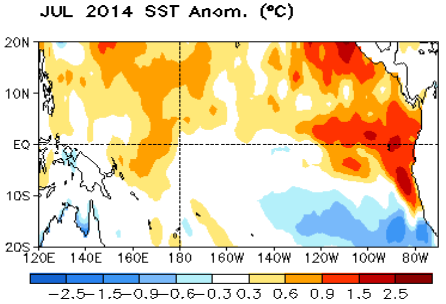
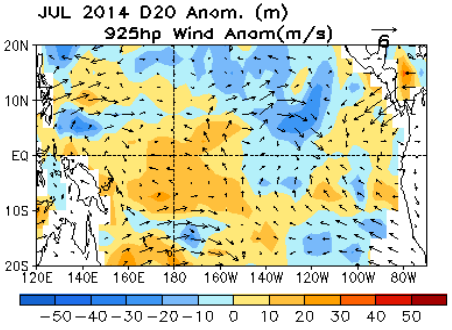
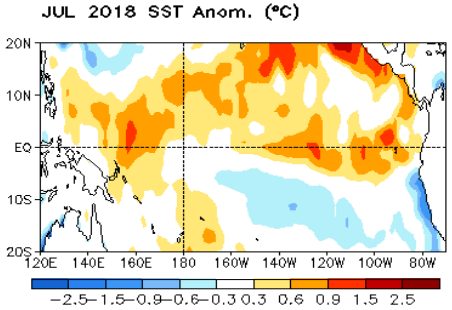
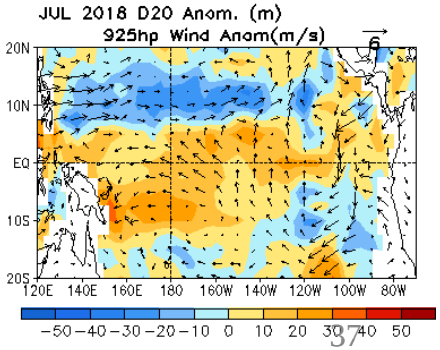


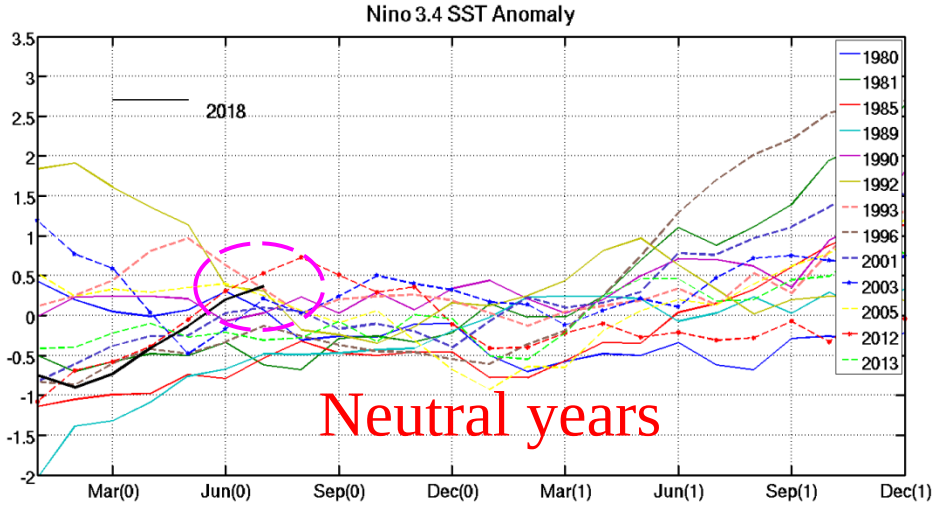


2018

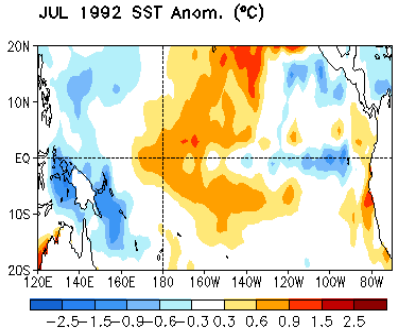


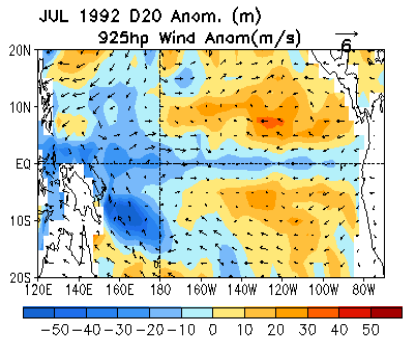


SST,D20 and 925hp Wind anomalies in July

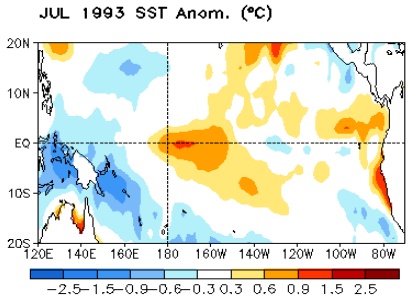


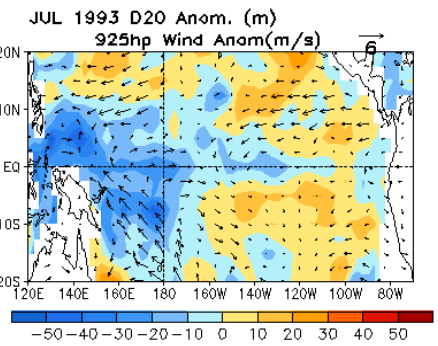
1992



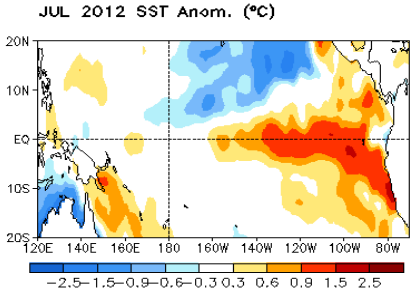


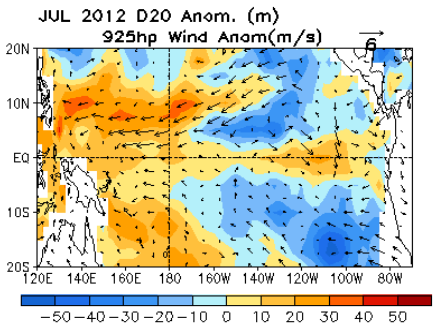
1993



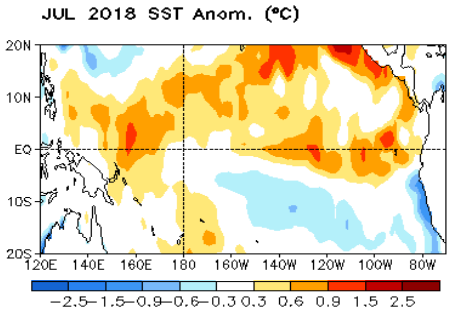


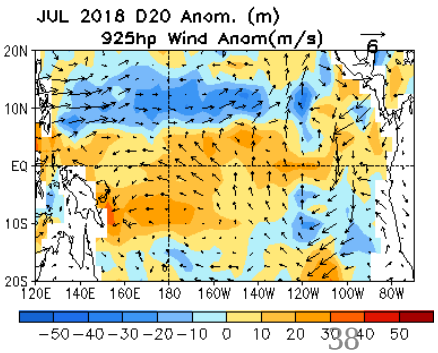
2012



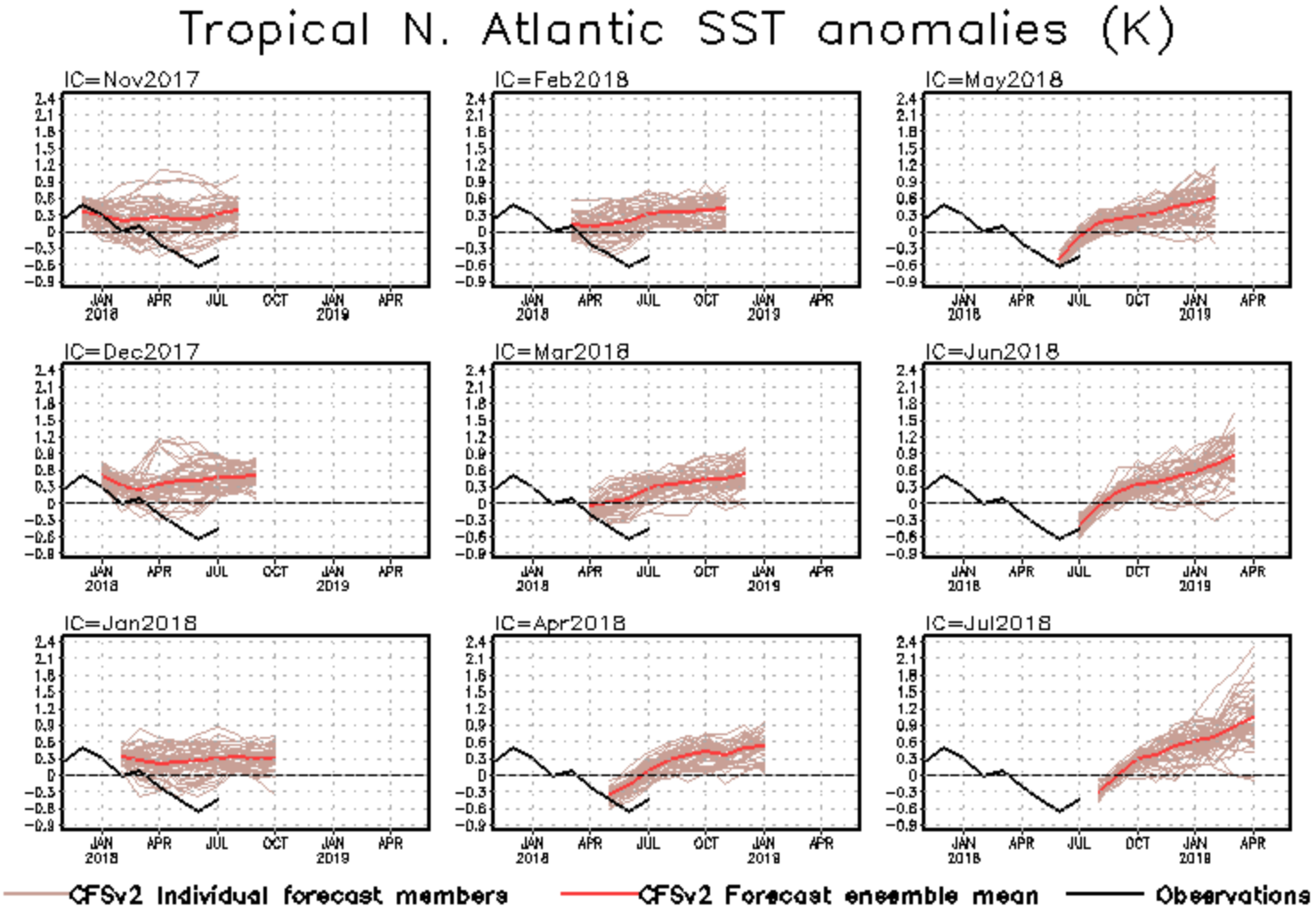


2018





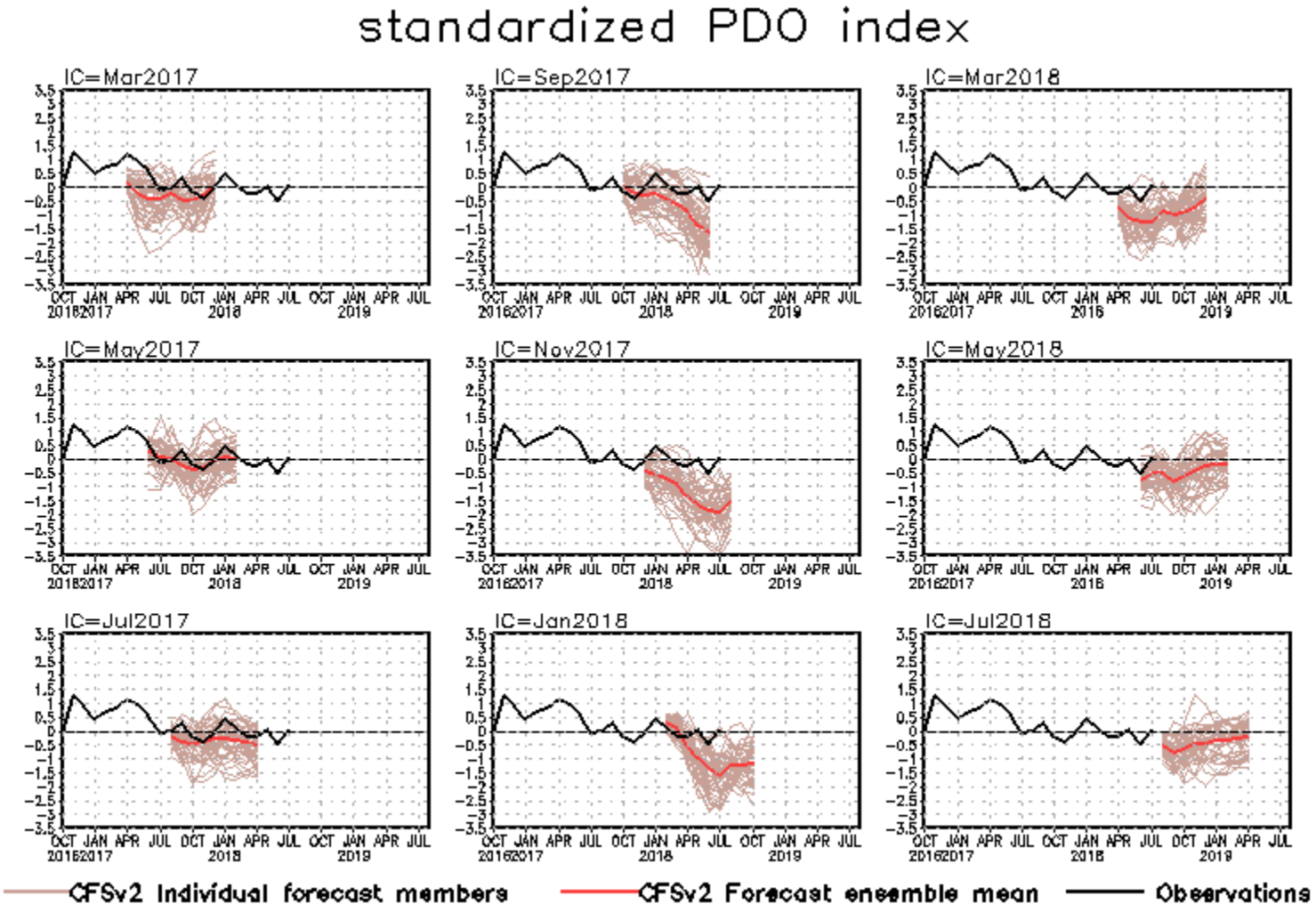
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



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

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.

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.

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.

Acknowledgements

- Dr. Zeng-Zhen Hu and Arun Kumar: reviewed PPT, and provided insight and constructive suggestions and comments
- Drs. Li Ren and Pingping Xie: Provided SSS slides
- Dr. Emily Becker: Provided NMME plot
- Dr. Wanqiu Wang: Provided Sea Ice prediction slides

Back up

CPC's Sea Surface Salinity (SSS) Monitoring Products

- **Monthly SSS**
  - *BASS (Blended Analysis of Surface Salinity, Xie et al. 2014)*
  - *Combining information from in situ measurements and satellite retrievals*
  - *1.0^{o} over the global ocean, monthly from January 2010*
  - *Supporting CPC's Monthly Ocean Briefing in real-time*
- **Pentad SSS**
  - *Resolving SSS variations associated with MJO and oceanic mesoscale processes and interactions with ENSO*
  - *In situ pentad mean salinity data from NCEI*
  - *Satellite retrievals from multiple satellites (*NASA/SMAP, ESA/SMOS, NASA/Aquarius)
  - *OI-based blending technique developed for monthly analysis revised for pentad applications*

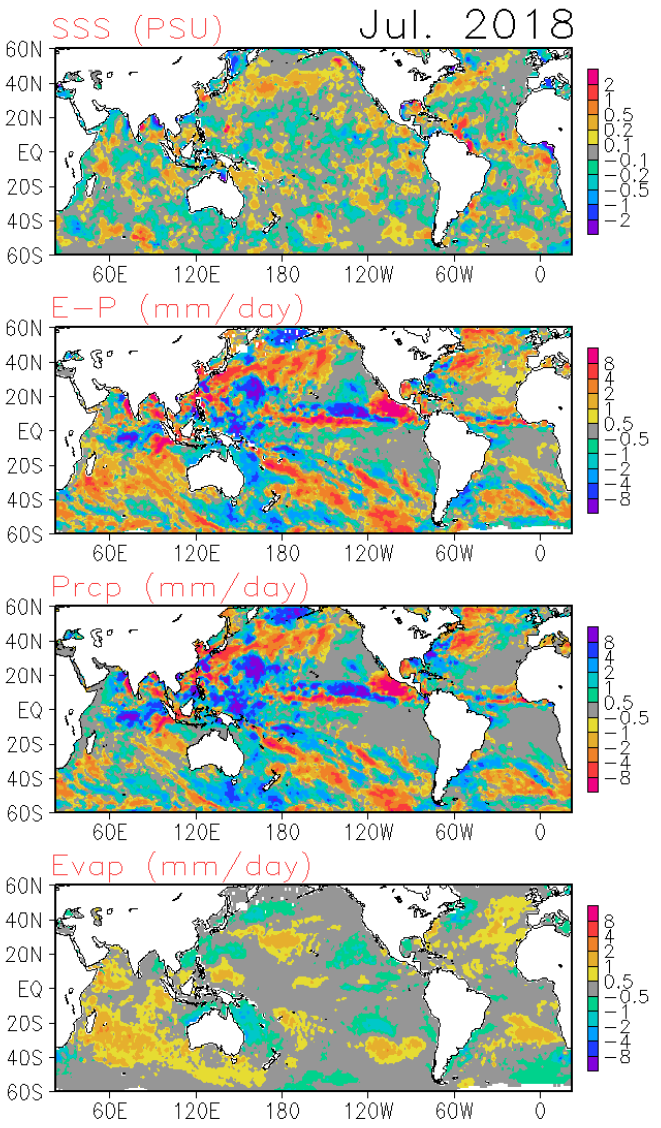
Primary Features of the Pentad Global SSS Monitoring Package

- Refined Resolution
  - *daily updated pentad*
  - *Spatial resolution kept at 1.0^{o}lat/lon due to restriction in inputs*
- Reduced Production Latency
  - *2 days after the ending date for each pentad*
- Composed of SSS , E, P, and E-P
  - *SSS: BASS/Pentad (in situ – Satellite Blended Analysis)*
  - *E: CFSR Evaporation adjusted against OAFlux*
  - *P: Bias Corrected CMORPH satellite precipitation estimates*

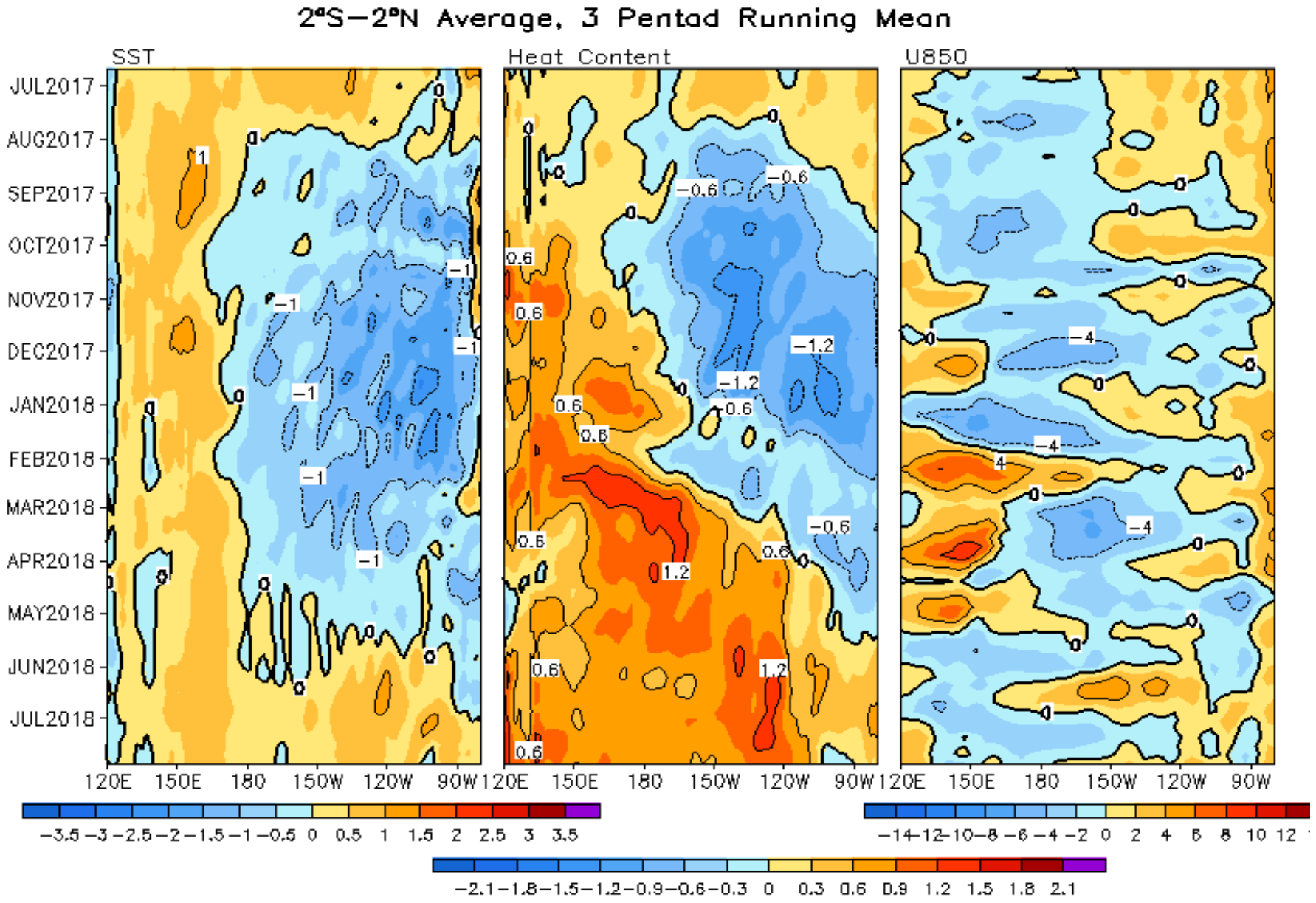
Global Sea Surface Salinity (SSS)

Tendency for July 2018

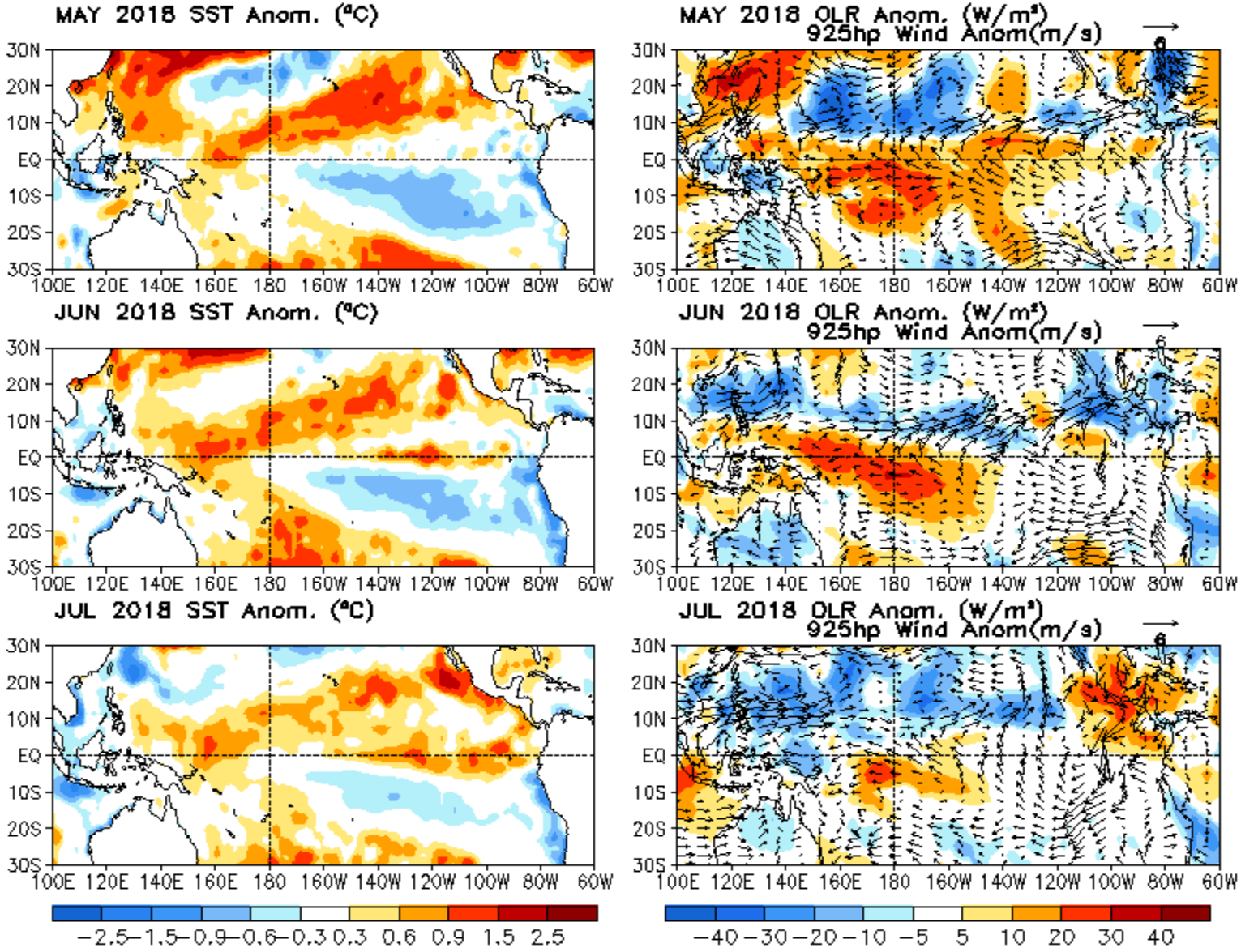
Compared with last month, the SSS in the subarctic N. Pacific Ocean increases with the precipitation being reduced. In the similar latitudes of the Atlantic Ocean, the SSS also increases with the precipitation being reduced. The SSS in the subtropical N. Pacific ocean decreases with increased precipitation. The SSS in the Sea of Okhotsk decreases while the precipitation increases which suggests that the SSS change is possibly dominated by the oceanic advection/entrainments.



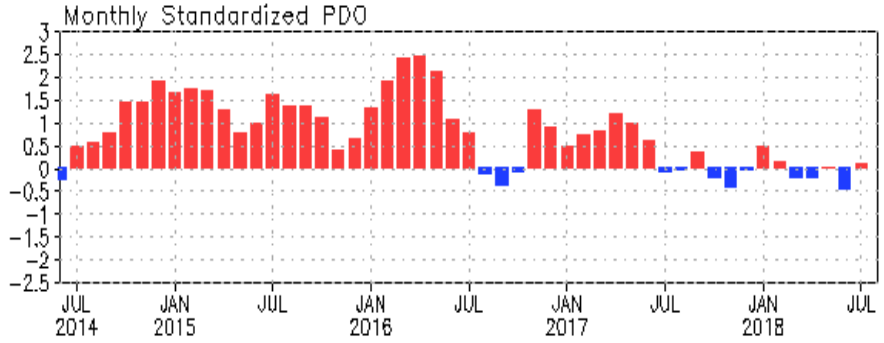
Equatorial (2S-2N) Pacific SST (°C), Surface Zonal Wind (m/s) and HC300 (°C) Anomalies

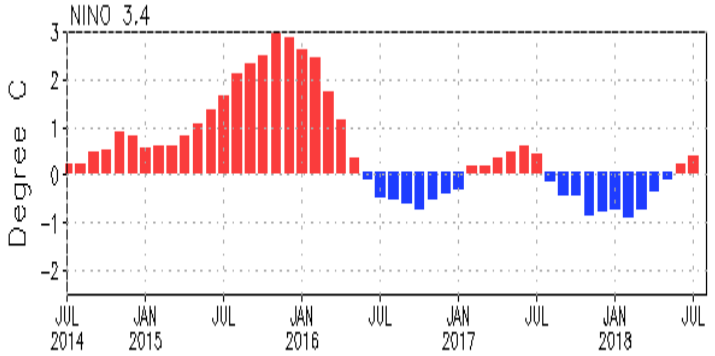


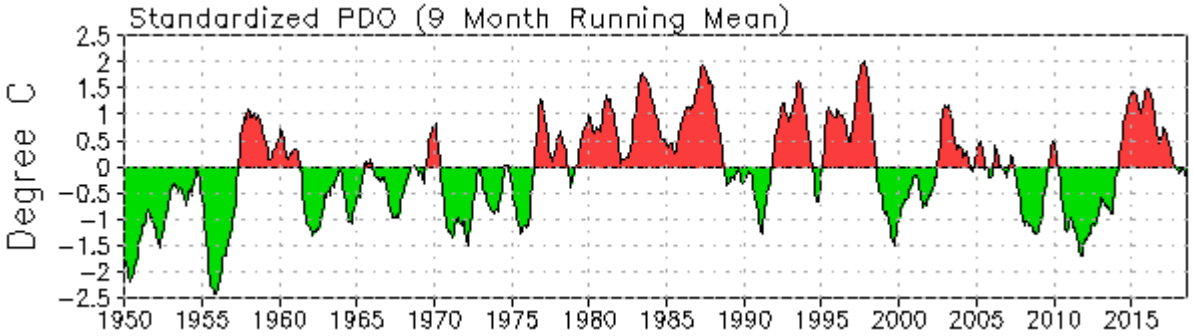
Last Three Month SST, SLP and 925hp Wind Anomalies

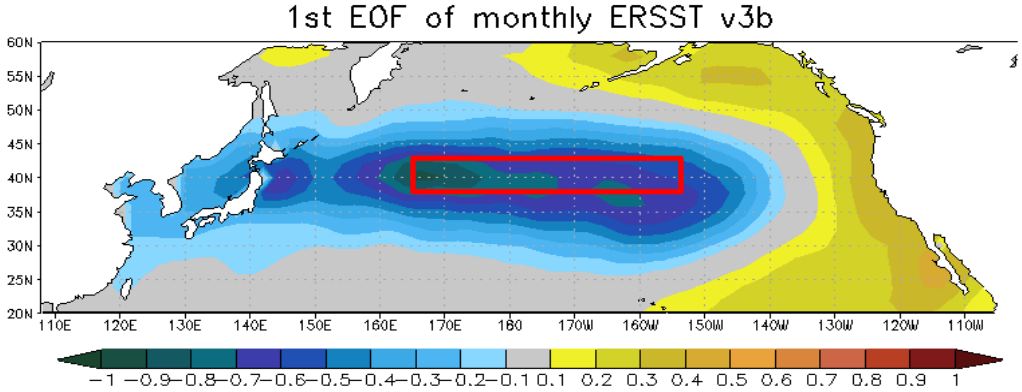


PDO index









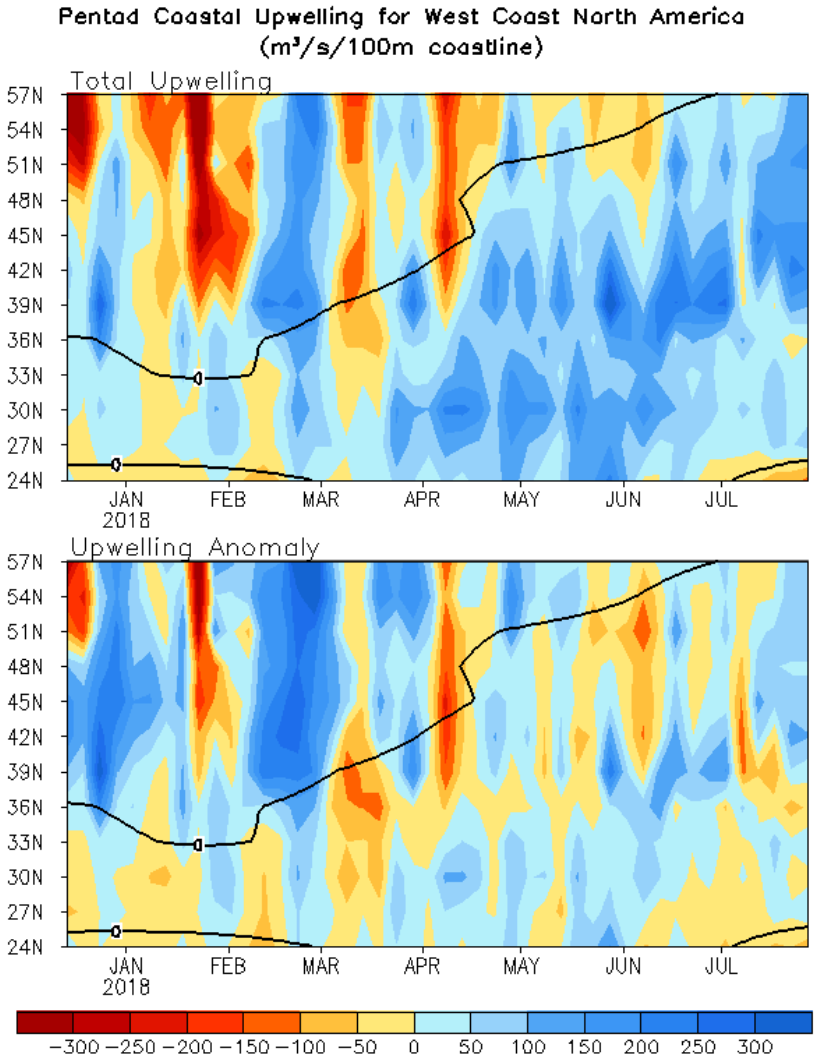
- Positive SSTAs presented in the central North Pacific with PDO index =0.1 in Jul 2018.

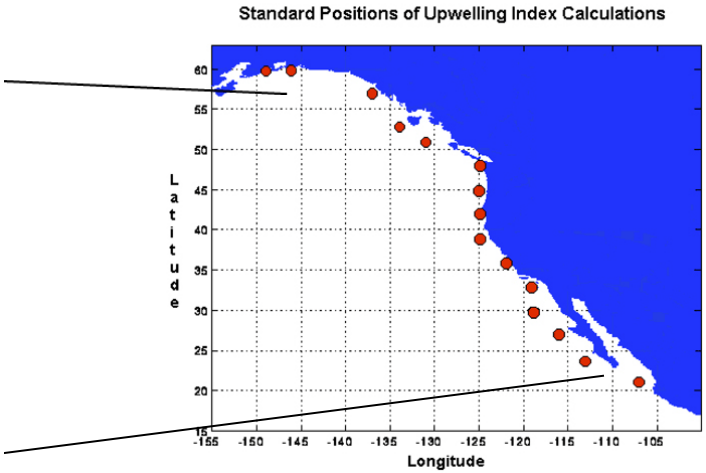
- Statistically, ENSO leads PDO by 3-4 months, may through atmospheric bridge.

- 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





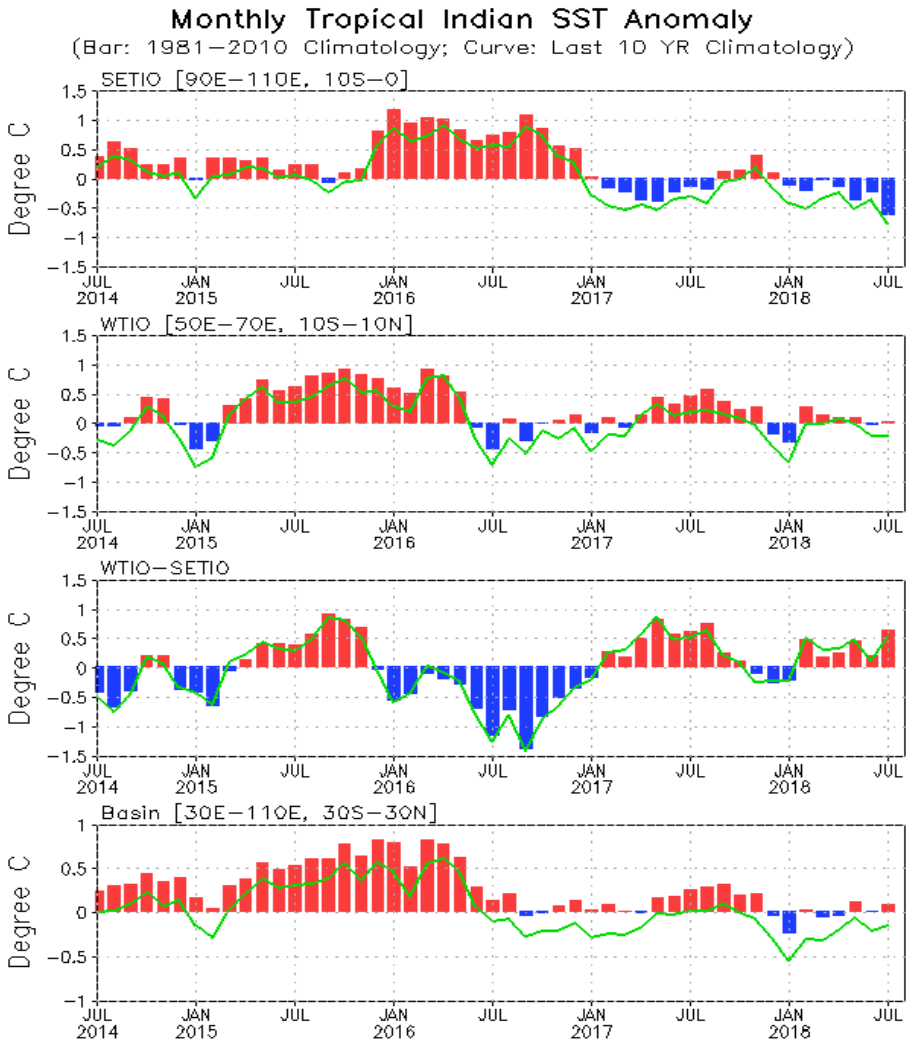
- Both anomalous upwelling and downwelling were small.

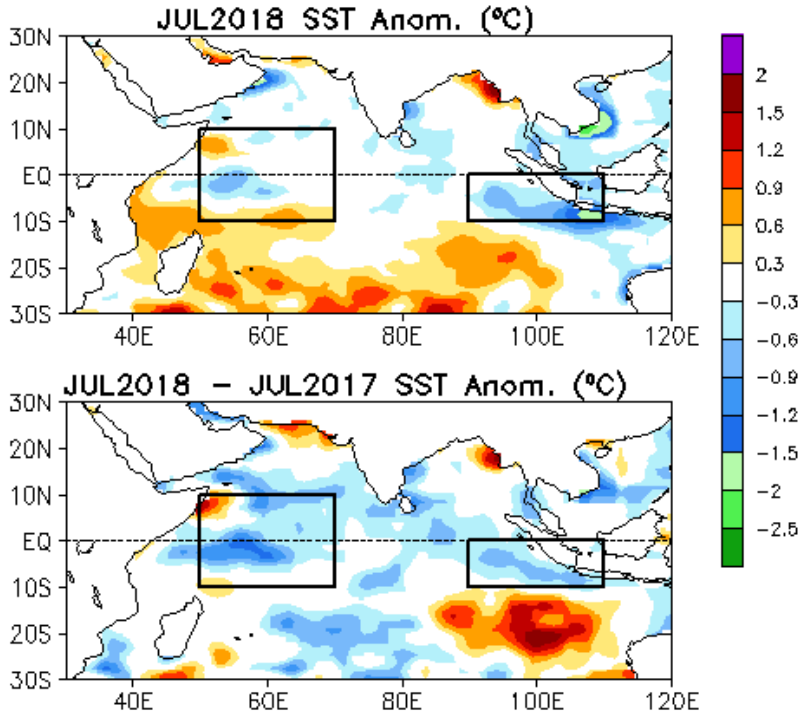
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport 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 Mayil to July along the west coast of North America from 36ºN to 57ºN.

Evolution of Indian Ocean SST Indices





- Positive Dipole index strengthened in Jul 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.

CPC's Markov Model NINO3.4 Forecast

(http://www.cpc.ncep.noaa.gov/products/people/yxue/ENSO_forecast_clim81-10_godas.html)

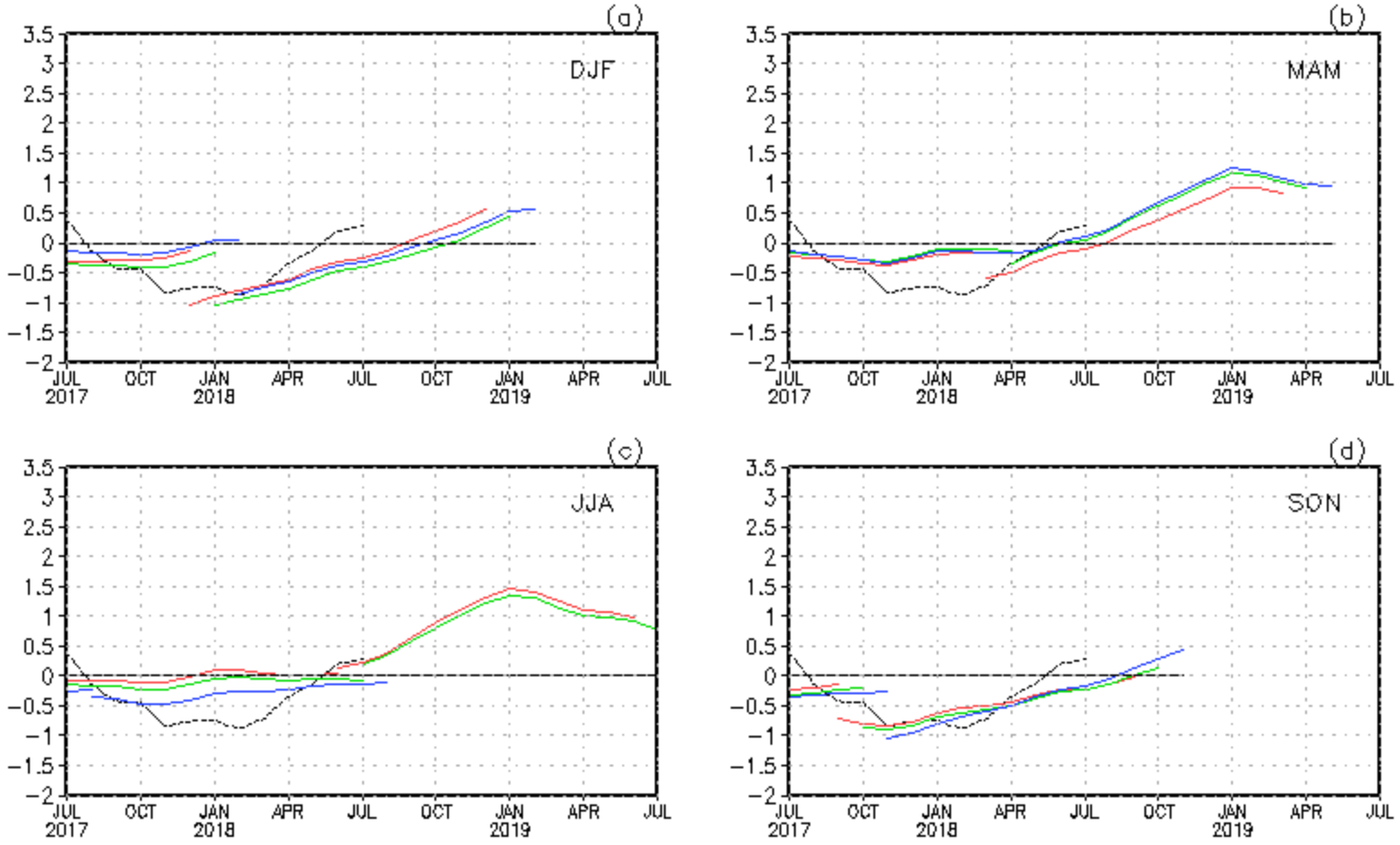
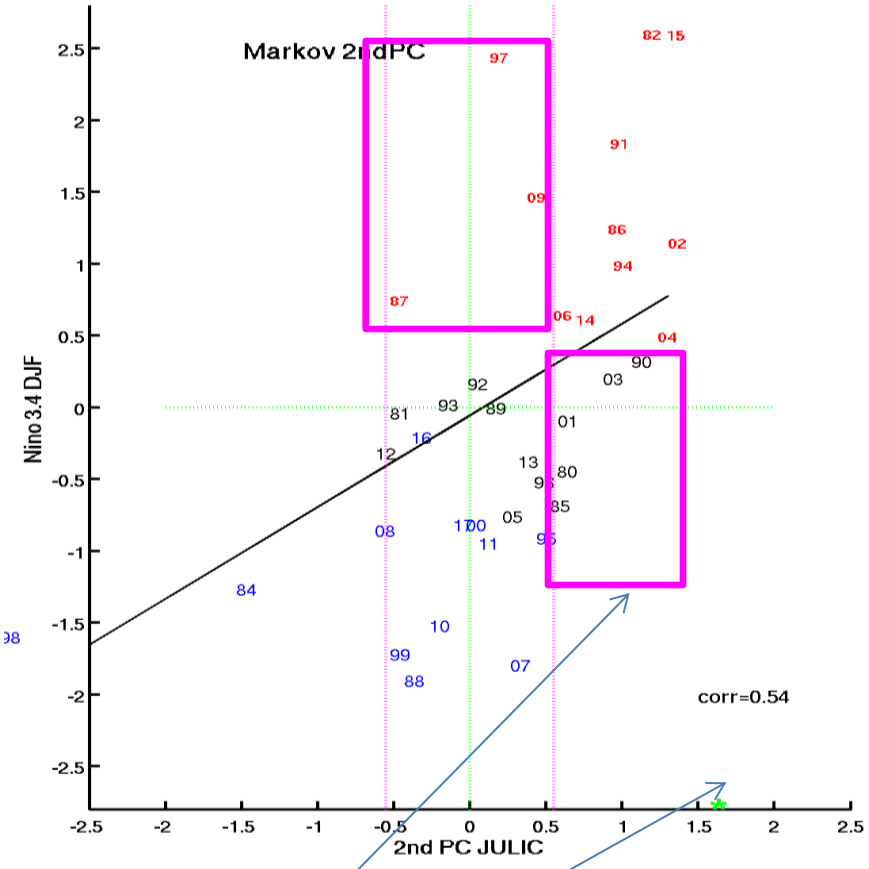


Fig. 4. Time evolution of NINO3.4 forecasts up to 12 lead months by the Markov model initiated monthly up to July 2018 . Shown in each panel are the forecasts grouped by three consecutive starting months: (a) is for December, January and February, (b) is for March, April and May, (c) is for June, July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

ENSO Precursor: Markov PC2 vs. NINO3.4 in DJF

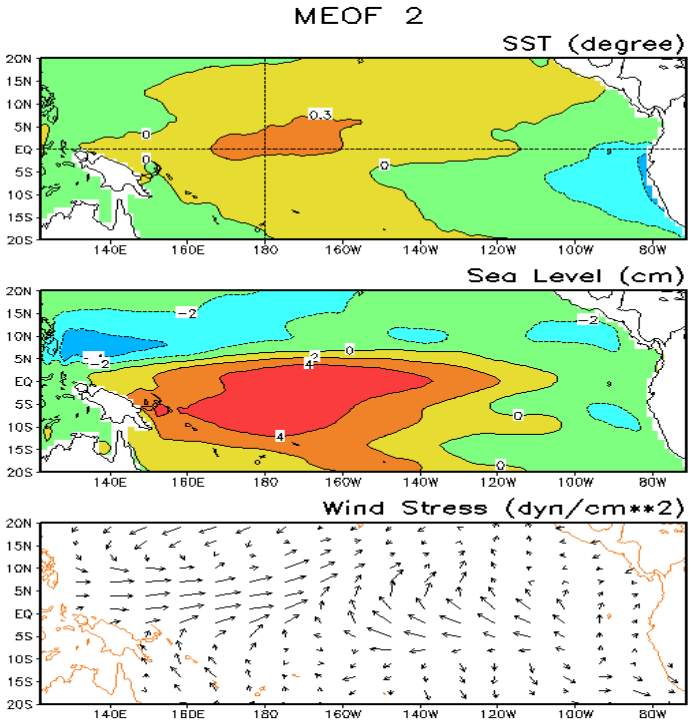


False alarms:

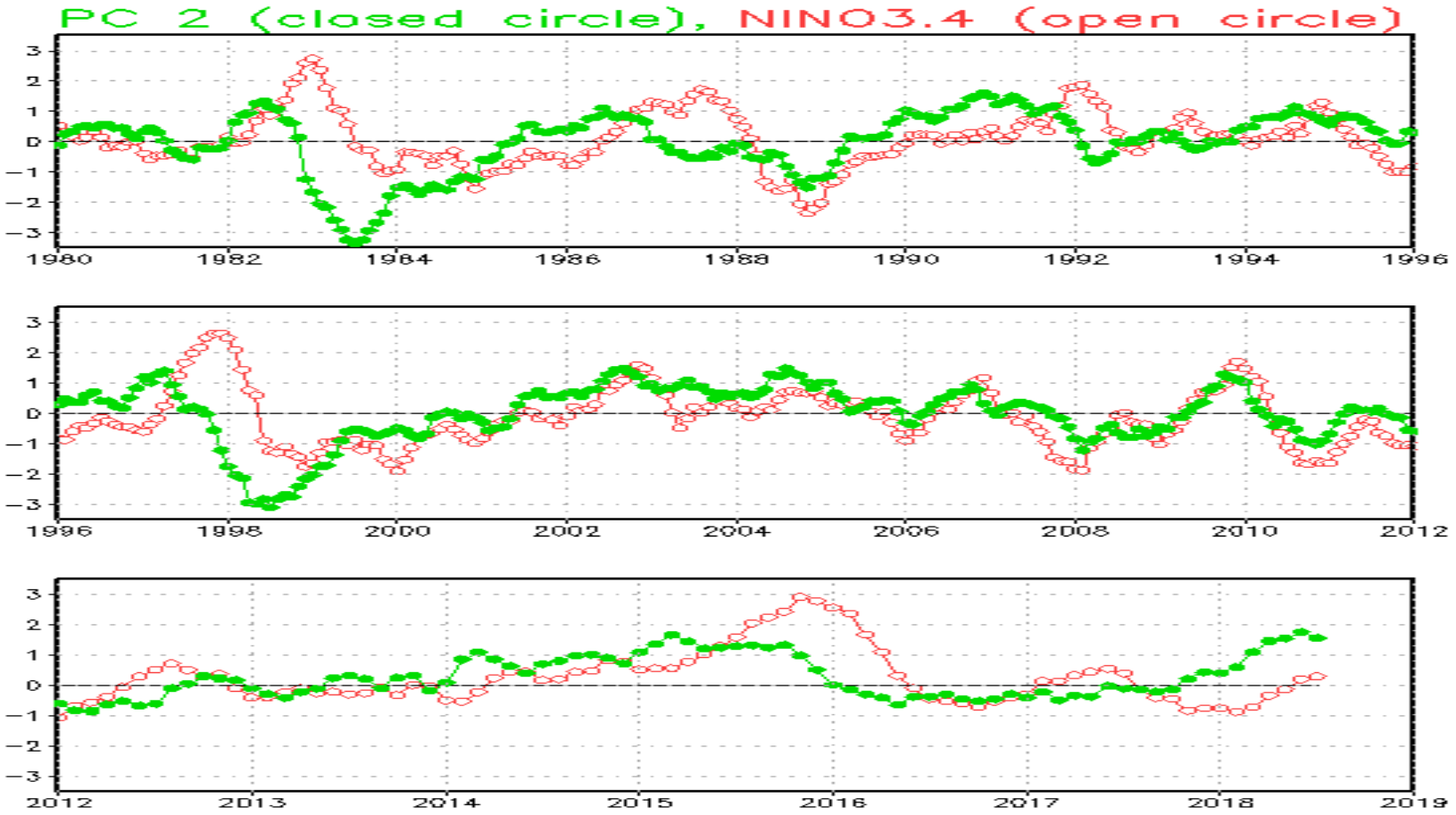
80
90
01
03

* Markov 2nd PC in July 2018

2x2 contingency table El Nino Case (1980-2017)	July Criterion: 0.55=0.5 STD
Percent correct rate	0.8 (30/38)
Hit rate	0.67 (8/12)
False alarm rate	0.33 (4/12)

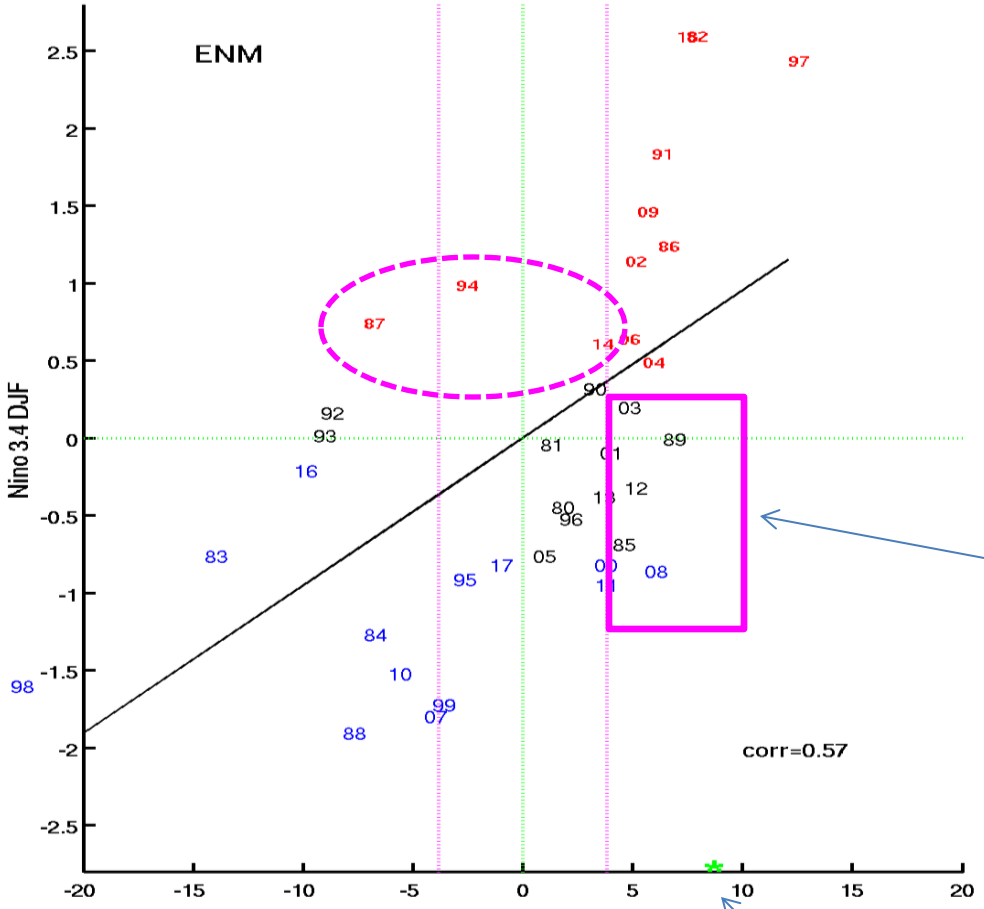


http://www.cpc.ncep.noaa.gov/products/people/yxue/ENSO_forecast_clim81-10_godas.html



PC2	82	86	91	94	97	02	04	06	09	14	15	18
Apr	1.0	0.8	1.5	0.8	1.4	0.8	0.6	0.1	-0.1	0.9	1.5	1.4
May	1.3	0.8	1.4	0.8	1.0	0.8	0.8	0.3	0.1	0.6	1.2	1.5
Jun	1.3	1.1	1.2	0.8	0.6	1.1	1.3	0.5	0.3	0.4	1.2	1.7
Jul	1.1	0.9	0.9	0.9	0.1	1.3	1.2	0.6	0.4	0.7	1.3	1.6

ENSO Precursor: Warm Water Volume (WWV) vs. NINO3.4 in DJF



2x2 contingency table El Nino Case (1980-2017)	July Criterion: 3.83 = 0.5 STD
Percent correct rate	0.8 (30/38)
Hit rate	0.75 (9/12)
False alarm rate	0.36(5/14)

False alarms:

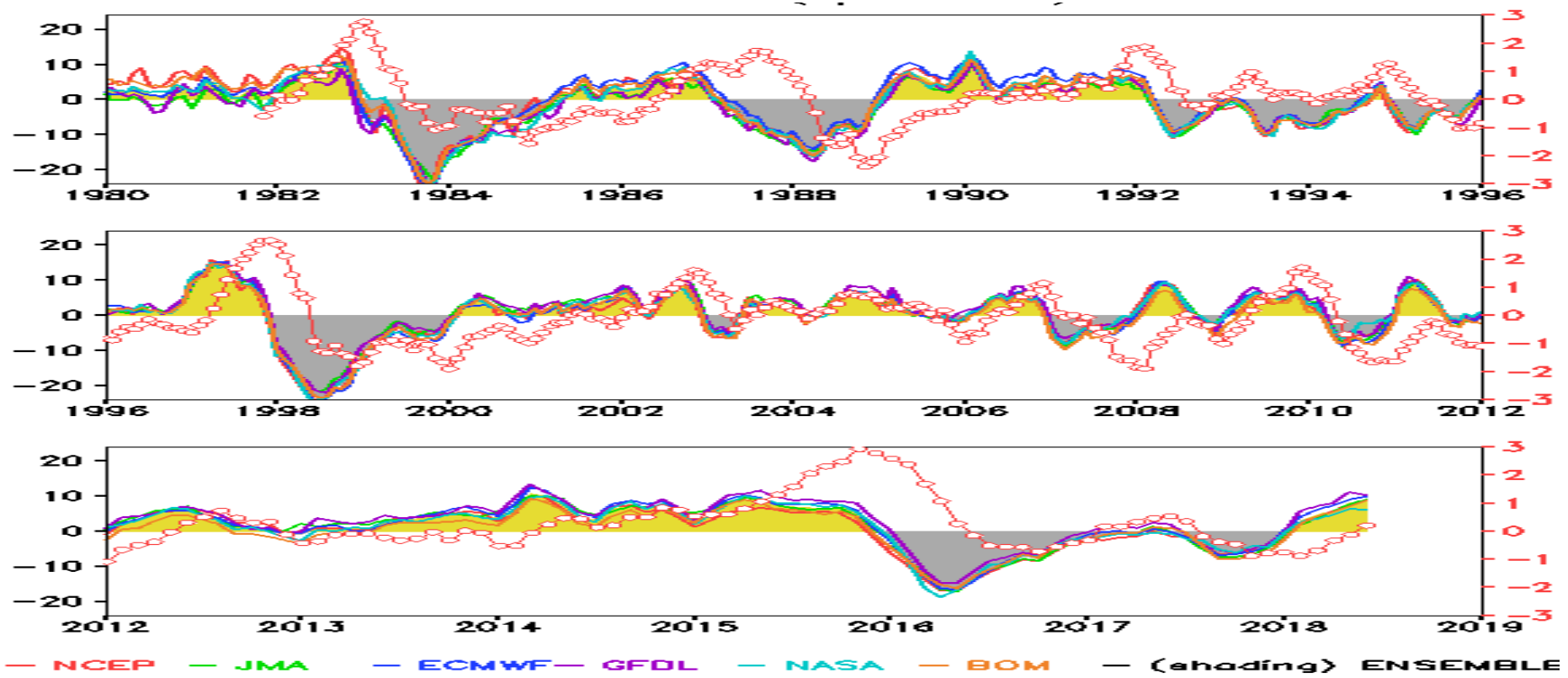
85
89
03
08
12

WWV in July

* **WWV in July 2018**

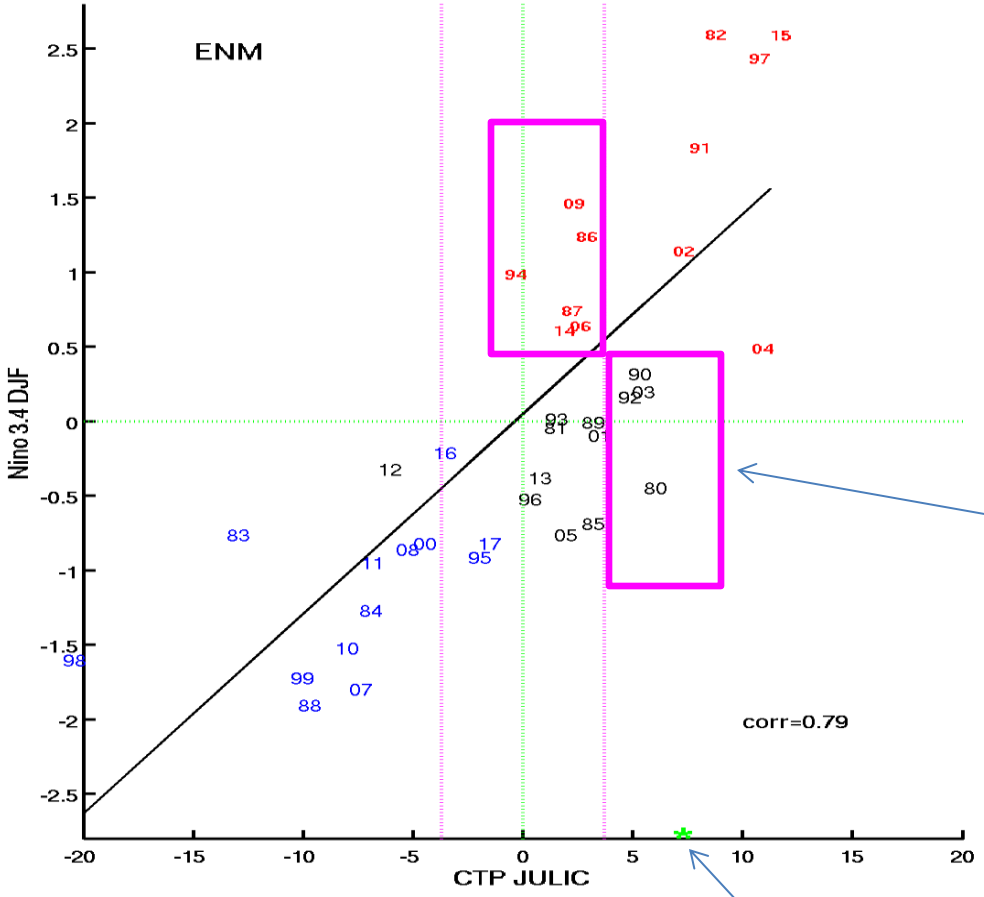
Data downloadable from http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

Warm Water Volume (WWV) & NINO3.4 (open circles)



ENM WWV	82	86	87	91	94	97	02	04	06	09	14	15	18
Apr	7.2	2.5	-2.8	3.8	-5.3	14.7	1.8	0.2	3.0	4.1	9.9	9.2	6.1
May	7.3	4.7	-3.1	6.0	-3.5	14.4	0.6	0.5	4.8	5.8	8.1	9.0	8.1
Jun	7.2	6.6	-5.7	5.5	-3.3	14.8	3.5	1.6	5.5	6.5	4.2	7.4	8.8
Jul	7.4	6.2	-7.2	5.9	-3.1	12.1	4.7	5.5	4.4	5.2	3.1	7.0	8.2

ENSO Precursor: Central Tropical Pacific D20 (CTP) vs. NINO3.4 in DJF



2x2 contingency table El Nino Case (1980-2017)	July Criterion: 3.7 = 0.5 STD
Percent correct rate	0.74 (28/38)
Hit rate	0.5 (6/12)
False alarm rate	0.4 (4/10)

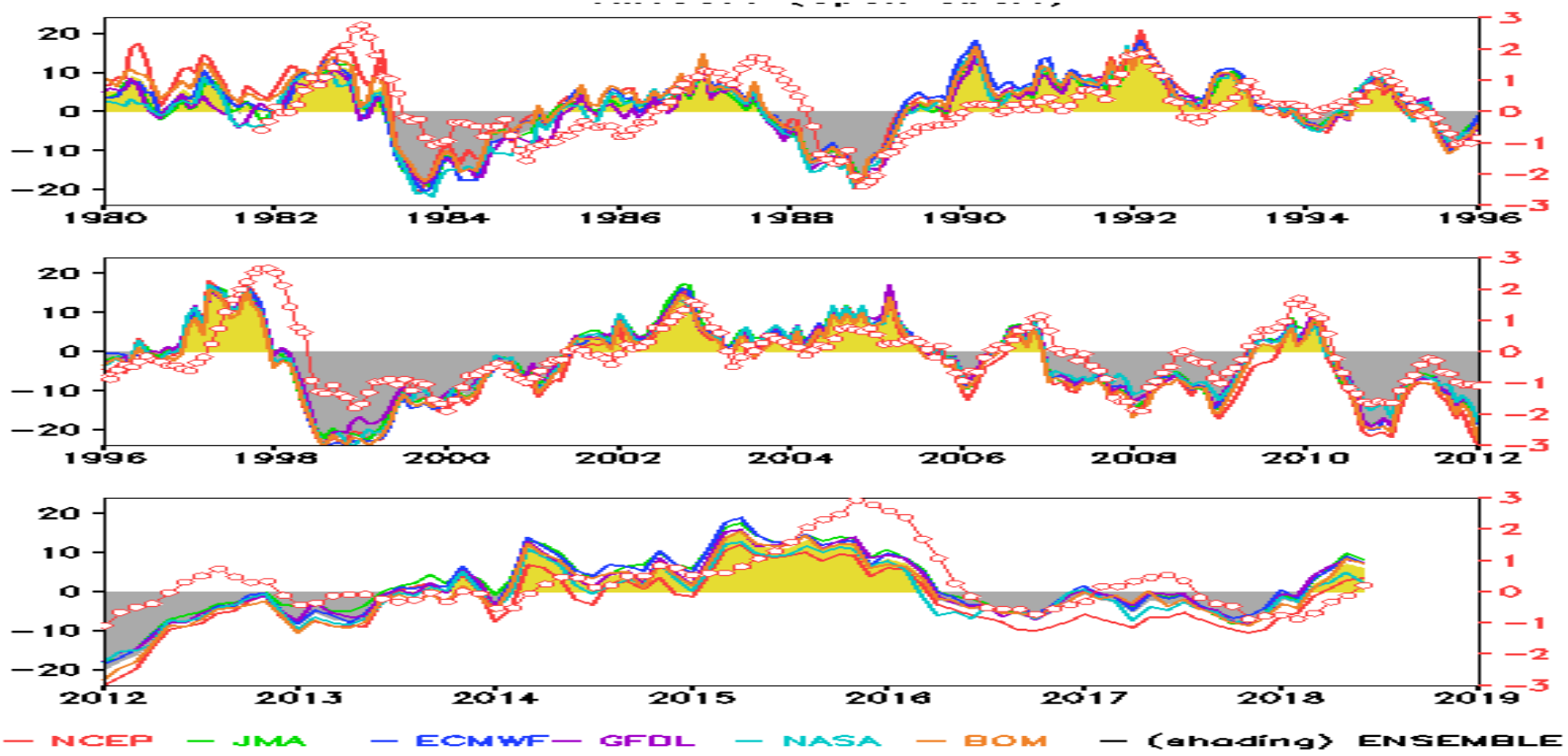
False alarms:
80
90
92
03

CTP in July

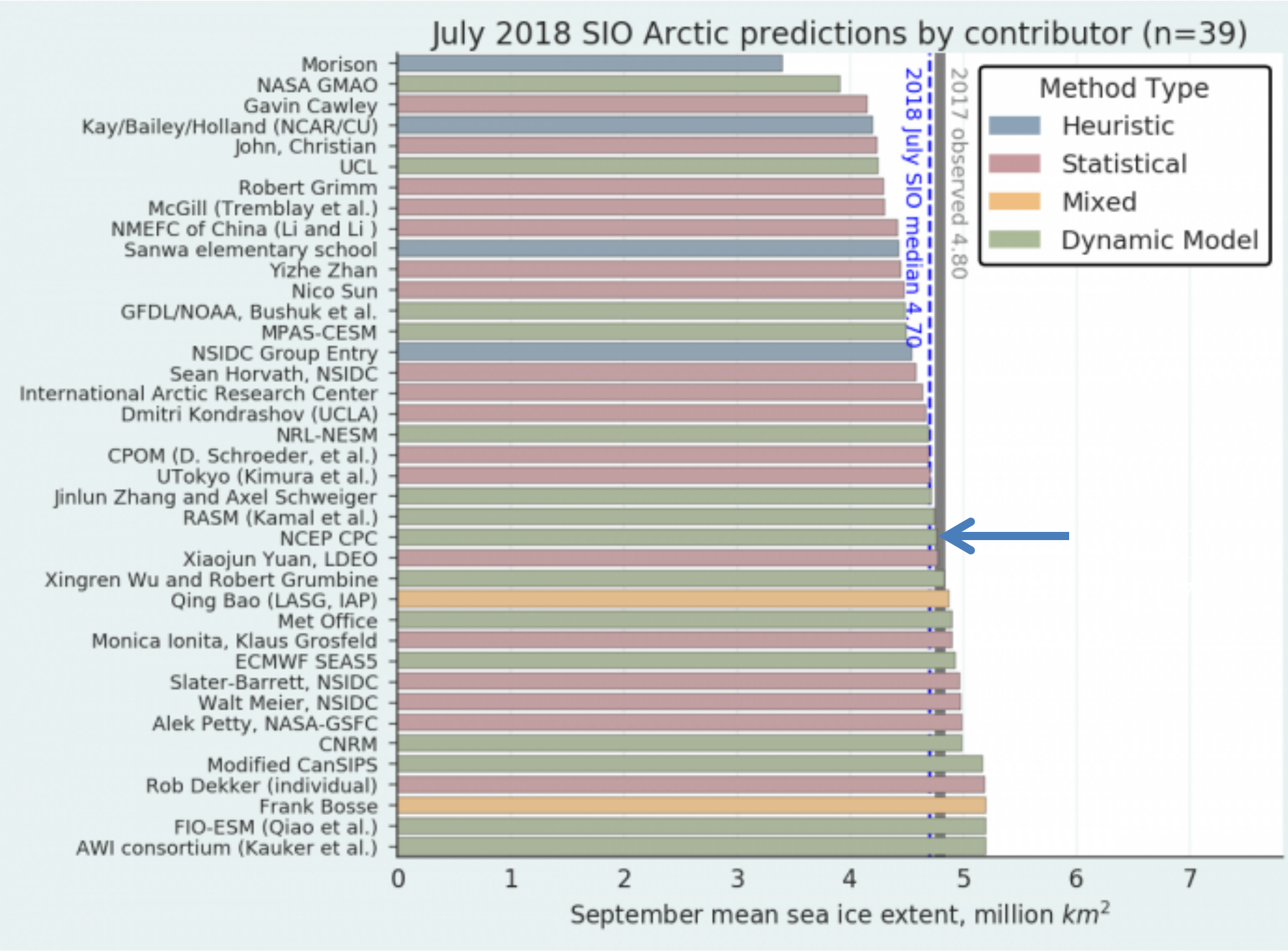
* **CTP in July 2018**

Data downloadable from http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

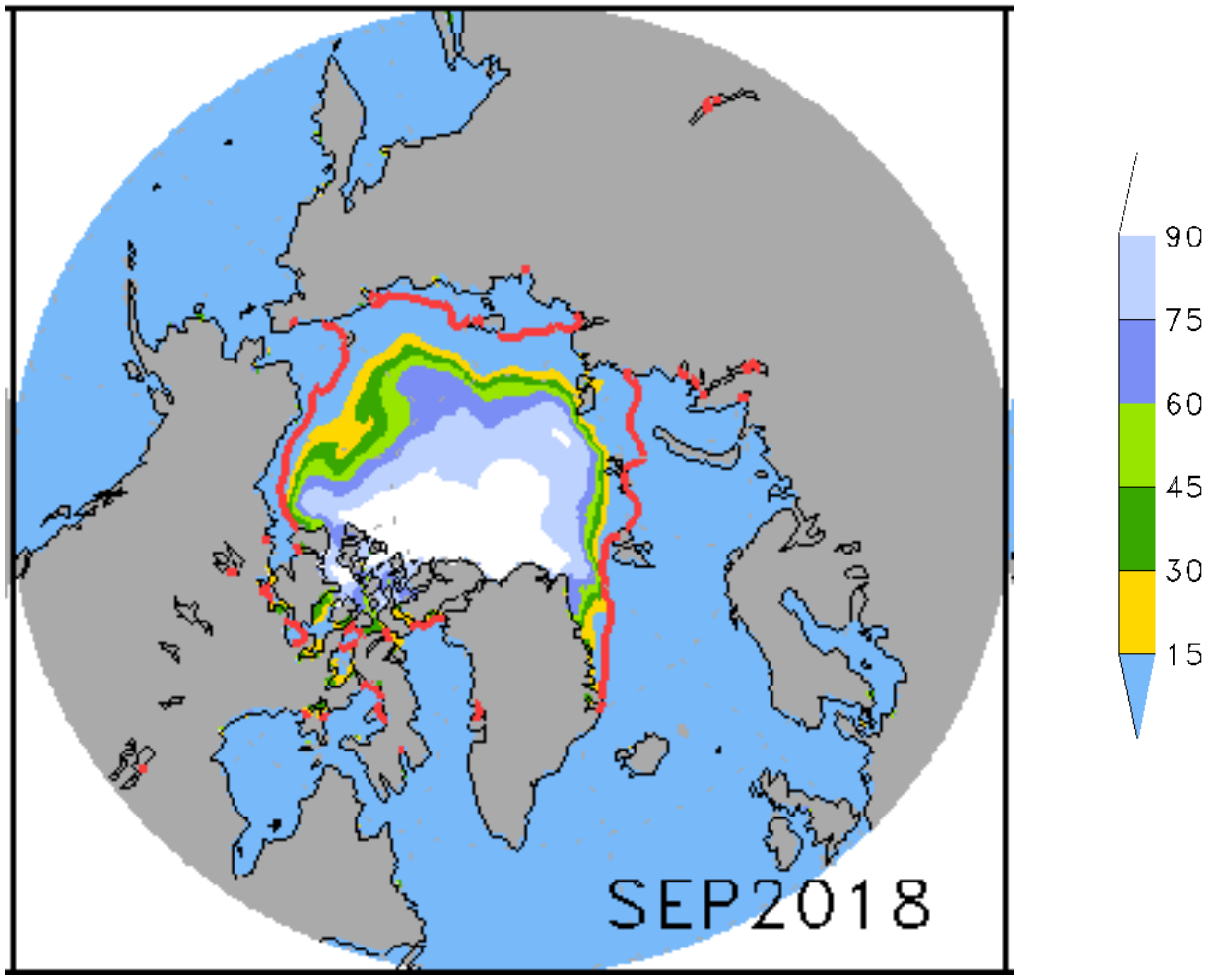
Central Tropical Pacific (CTP) Index & NINO3.4 (open circles)



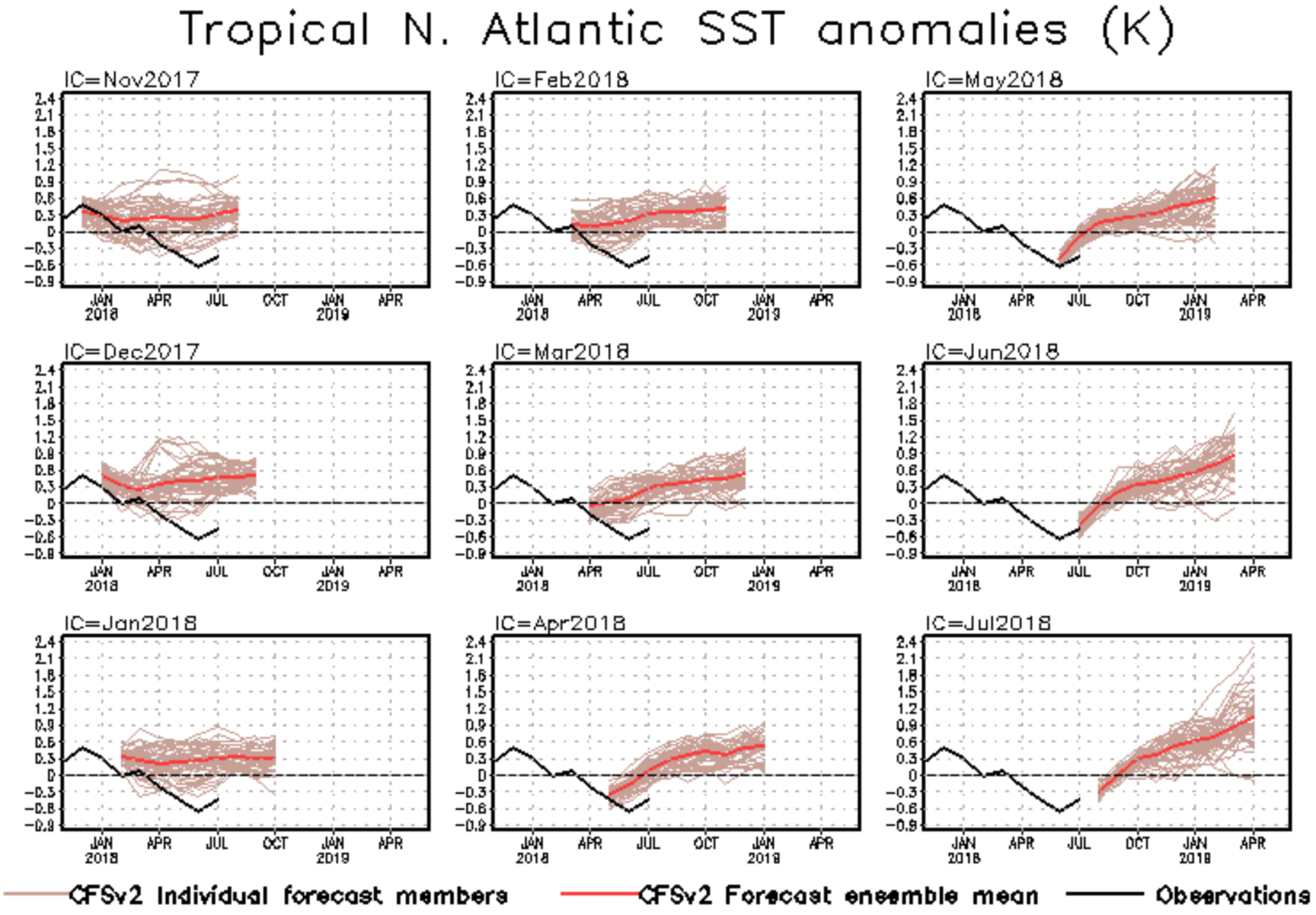
ENM CTP	82	86	91	94	97	02	04	06	09	14	15	18
Apr	**8.9**	0.9	**9.8**	-3.6	**16.3**	2.7	3.2	-2.5	-5.3	**9.7**	**15.4**	**4.1**
May	**9.3**	1.8	**8.9**	-1.1	**15.7**	3.0	**6.2**	-1.0	-2.5	**7.4**	**11.9**	**7.2**
Jun	**8.6**	**5.0**	**7.6**	-0.6	**14.2**	**5.5**	**4.6**	0.4	0.9	2.9	**11.0**	**6.0**
Jul	**8.3**	**2.4**	**7.6**	-0.8	**10.3**	**6.8**	**10.4**	2.1	1.8	1.4	**11.2**	**6.8**


July 2018 SIO Arctic predictions by contributor (n=39)
Morison
NASA GMAO
Gavin Cawley
Kay/Bailey/Holland (NCAR/CU)
John, Christian
UCL
Robert Grimm
McGill (Tremblay et al.)
NMEFC of China (Li and Li)
Sanwa elementary school
Yizhe Zhan
Nico Sun
GFDL/NOAA, Bushuk et al.
MPAS-CESM
NSIDC Group Entry
Sean Horvath, NSIDC
International Arctic Research Center
Dmitri Kondrashov (UCLA)
NRL-NESM
CPOM (D. Schroeder, et al.)
UTokyo (Kimura et al.)
Jinlun Zhang and Axel Schweiger
RASM (Kamal et al.)
NCEP CPC
Xiaojun Yuan, LDEO
Xingren Wu and Robert Grumbine
Qing Bao (LASG, IAP)
Met Office
Monica Ionita, Klaus Grosfeld
ECMWF SEAS5
Slater-Barrett, NSIDC
Walt Meier, NSIDC
Alek Petty, NASA-GSFC
CNRM
Modified CanSIPS
Rob Dekker (individual)
Frank Bosse
FIO-ESM (Qiao et al.)
AWI consortium (Kauker et al.)
2018 July SIO median 4.70
2017 observed 4.80
Method Type
Heuristic
Statistical
Mixed
Dynamic Model
0
1
2
3
4
5
6
7
September mean sea ice extent, million km^2

September 2018 SIC forecast



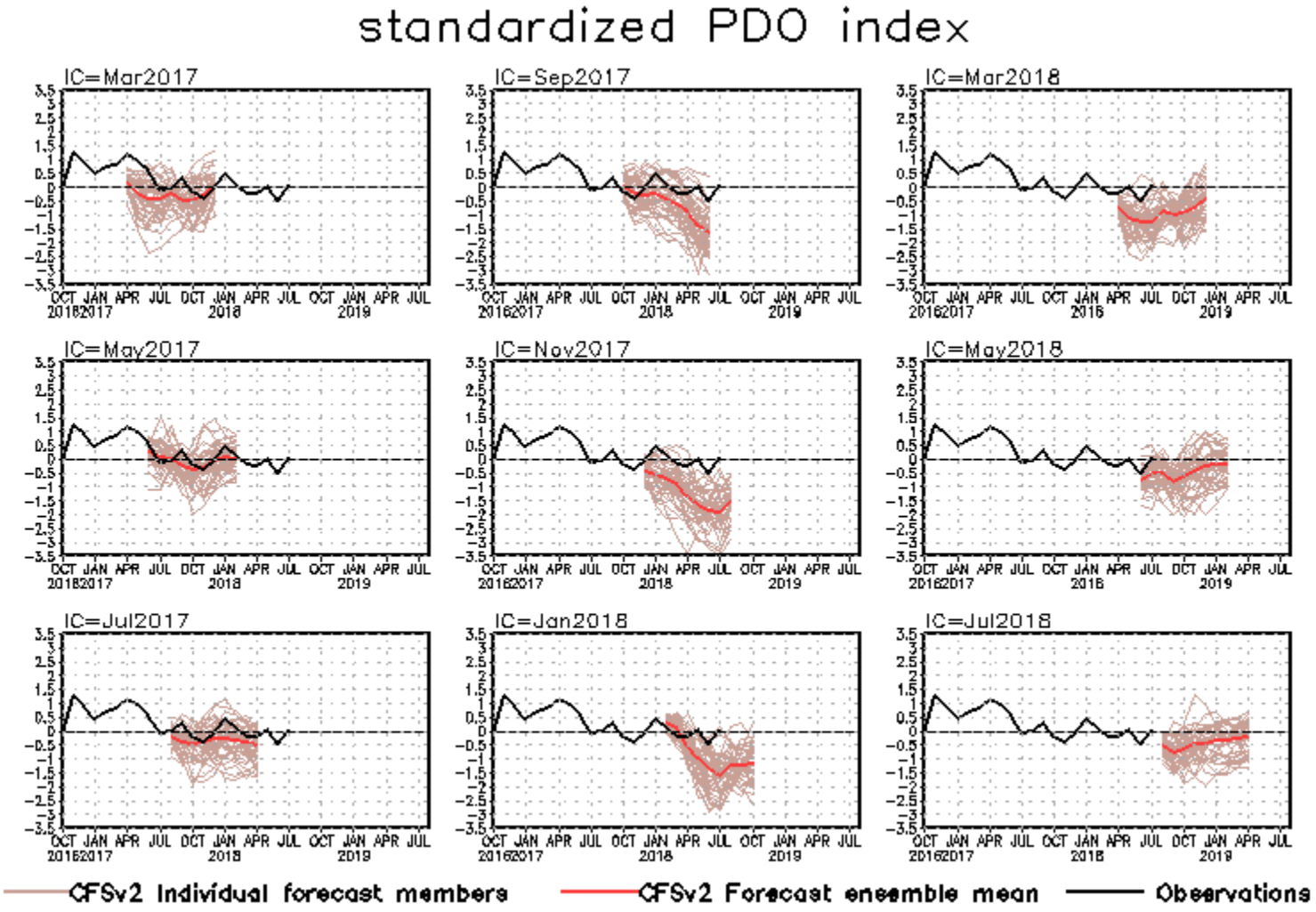
CFS Tropical North Atlantic (TNA) SST Predictions from Different Initial Months



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

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.

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.

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.