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

Prepared by

Climate Prediction Center, NCEP/NOAA

June 9, 2017

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

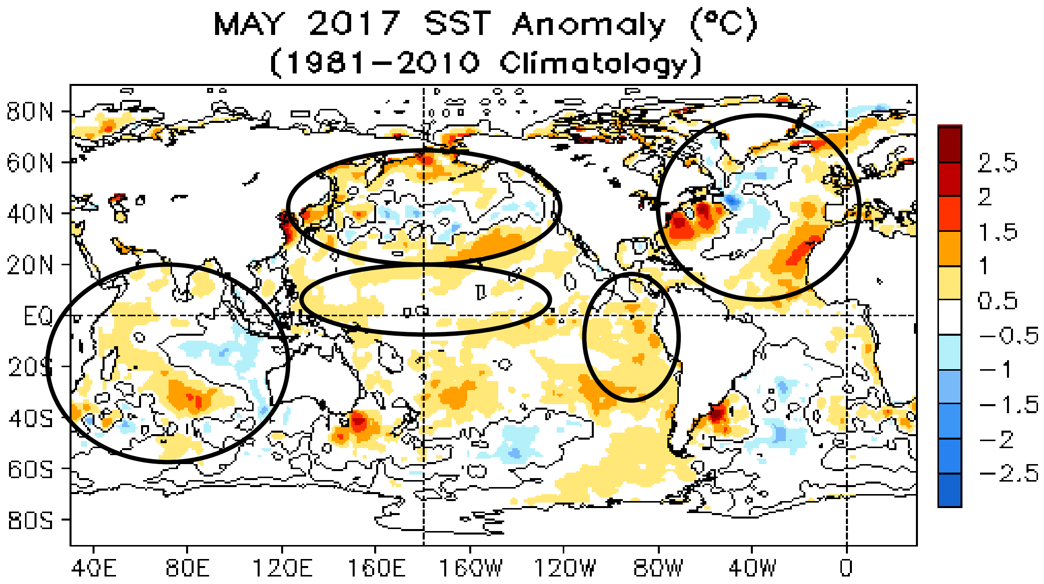
- Overview
- Recent highlights
  - ❖ Pacific/Arctic Ocean
  - ❖ Indian Ocean
  - ❖ Atlantic Ocean
- Global SST Predictions
  - ❖ NOAA 2017 Hurricane Outlooks
  - ❖ Evolution and Prediction of Coastal El Nino in 2017

Overview

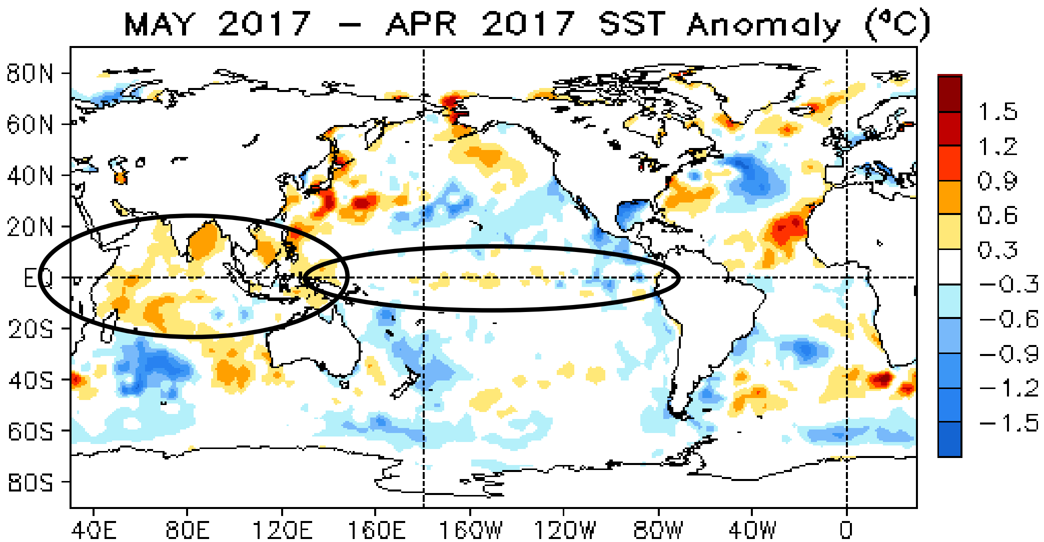
- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 8 June 2017 indicated *"ENSO-neutral is favored (50 to ~55% chance) through the Northern Hemisphere fall 2017."***
  - **Positive SSTAs persisted in the equatorial Pacific Ocean with NINO3.4=0.46^{o}C in May 2017.**
  - **Subsurface ocean temperature anomalies were positive along the thermocline in the equatorial Pacific in May 2017.**
  - **Positive phase of PDO has persisted for 7 months with PDOI=0.96 in May 2017.**
- **Indian Ocean**
  - **SSTAs were positive in the west and negative in the east in May 2017.**
- **Atlantic Ocean**
  - **NAO switched to negative phase with NAOI=-1.72 in May 2017, and SSTAs were positive in the tropical N. Atlantic.**

Global Oceans

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



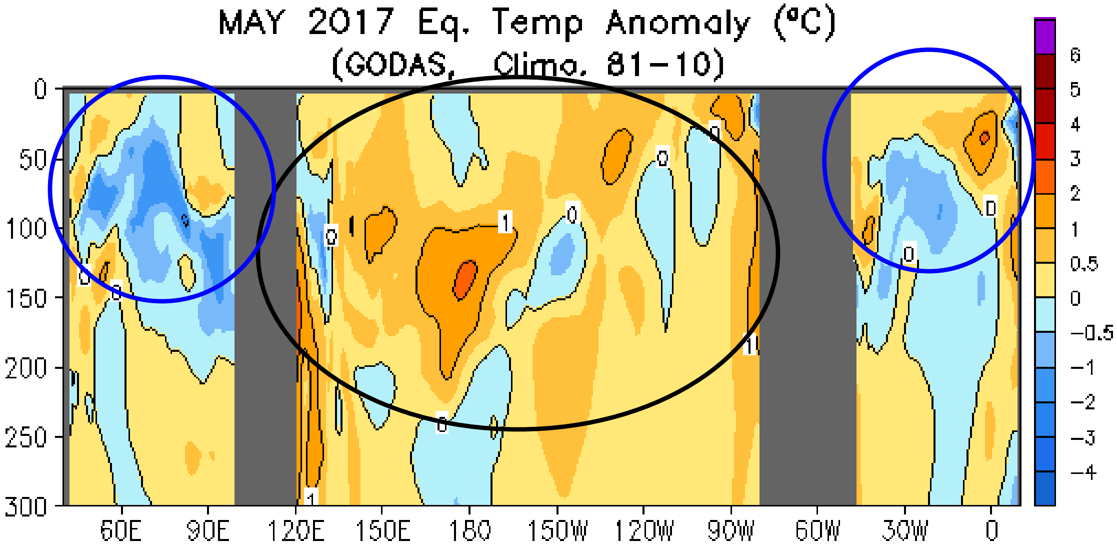
- Small SSTAs persisted in the central tropical Pacific associated with ENSO neutral, while positive SSTAs presented in the Southern American Pacific coast connected with coastal El Nino.
- SSTAs in N Pacific were associated with positive phase of PDO.
- Both positive and negative SSTAs were observed in N. Atlantic.
- In the Indian Ocean, SSTAs were positive in the west and negative in the east.



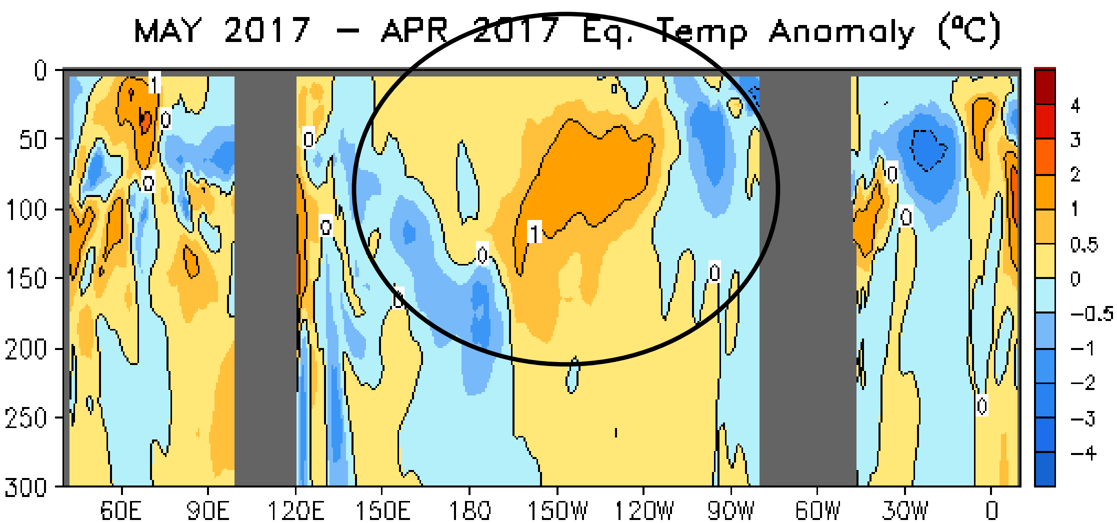
- SSTA tendencies in the central and eastern equatorial Pacific and along the American coast were small.
- Positive SSTA tendencies were dominant in the tropical Indian Ocean.
- Negative SSTA tendencies presented in the subtropical N. Pacific and central N. Atlantic.

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 ocean temperature anomalies presented along the thermocline.**
- **Both positive and negative ocean temperature anomalies were observed in the Indian and Atlantic Oceans.**



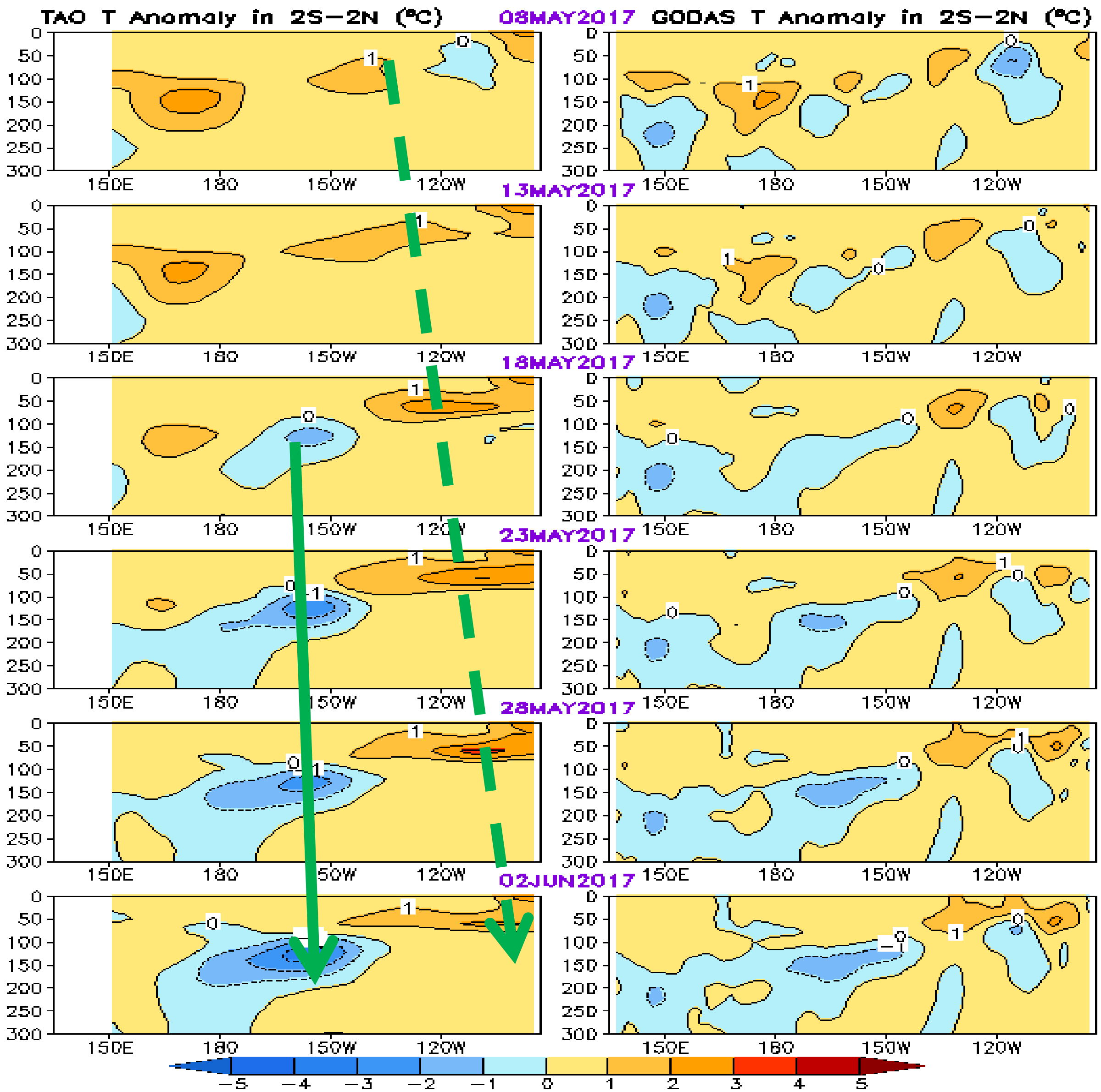
- **Ocean temperature anomaly tendencies were negative in the western-central Pacific and near the American coast, positive in the central-eastern Pacific, suggesting an eastward propagation of the positive anomalies.**

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

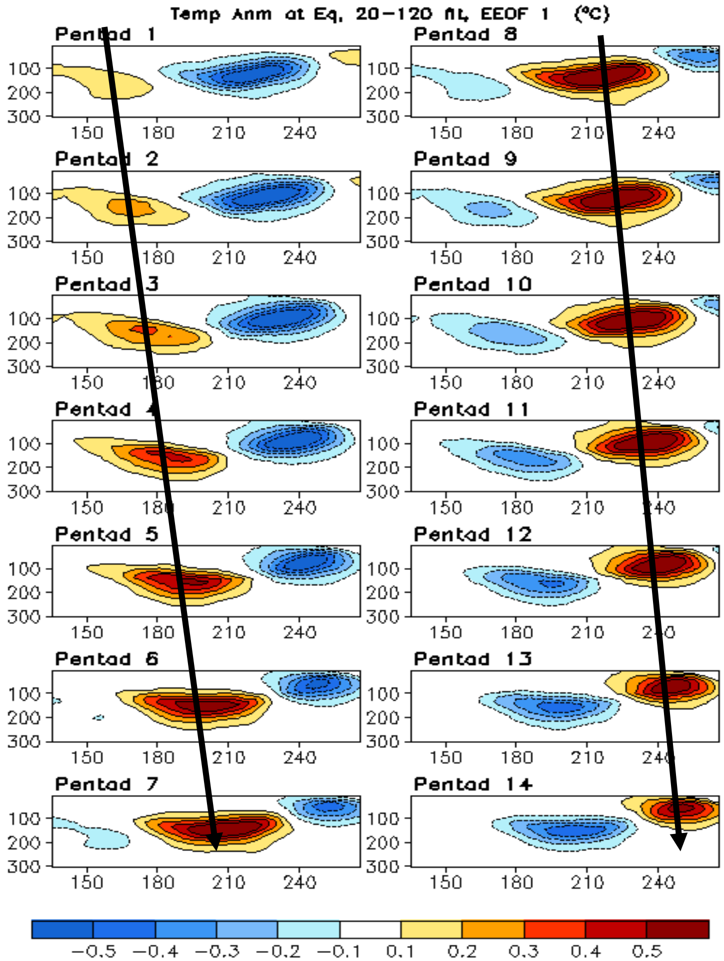
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly

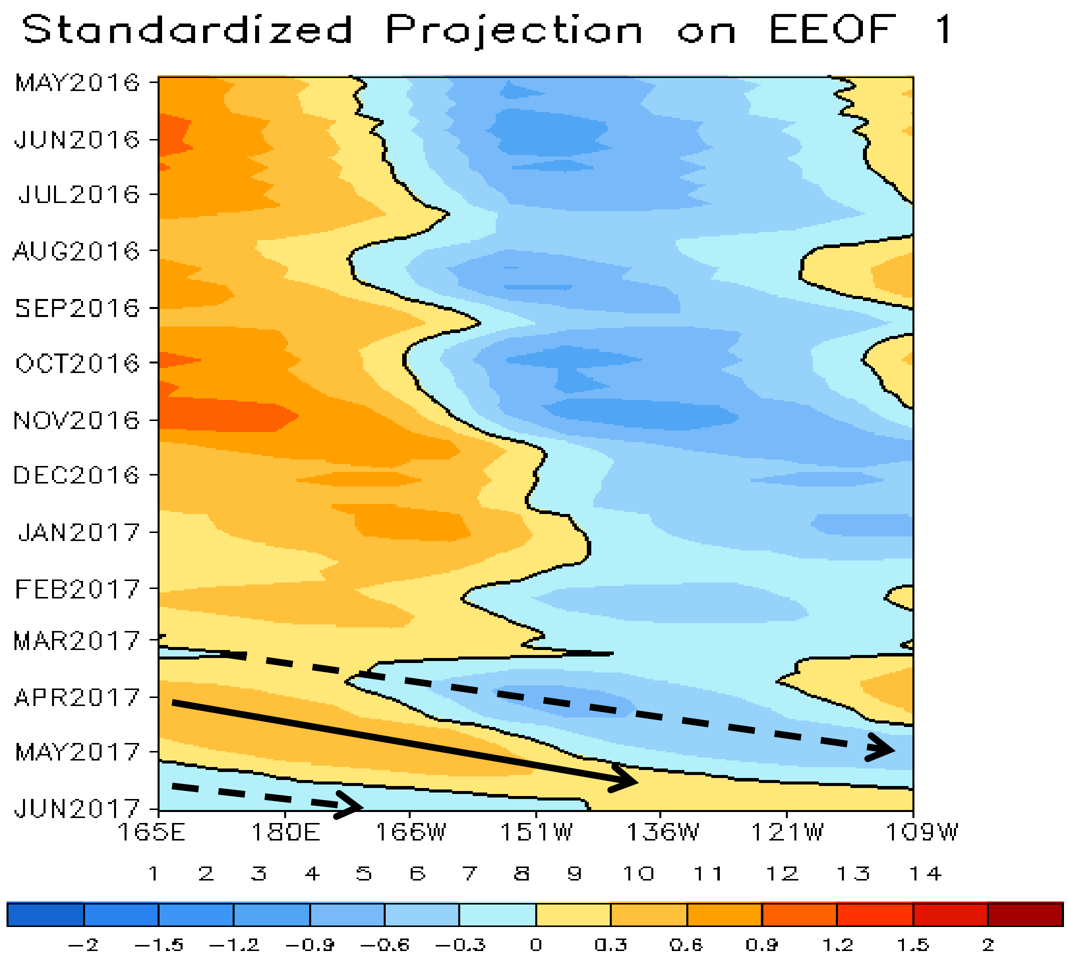
TAO GODAS



- **Positive ocean temperature anomalies propagated eastward and reached the eastern Pacific, while negative ones emerged in the central Pacific during last month.**
- **There were some differences between TAO and GODAS.**

Oceanic Kelvin Wave (OKW) Index

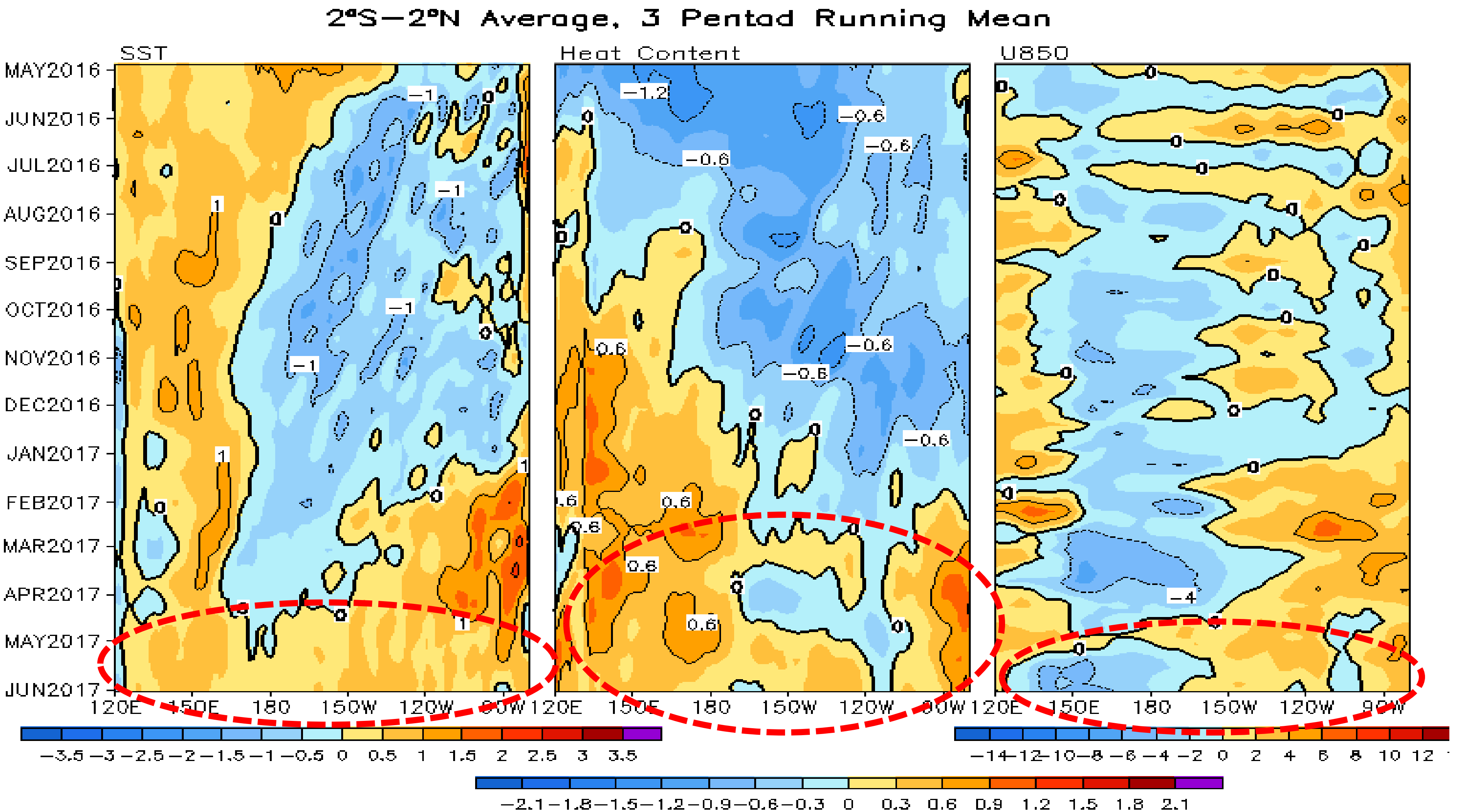




- **Negative OKW initiated in the mid-Mar and mid-May and positive OKW initiated in Apr propagated eastward.**

- *(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



- **Positive SSTA in the eastern Pacific expanded westward and weakened in the last few months.**
- **Positive HC300A in the western and central Pacific as well as along the American coast weakened in last month.**
- **Basically, easterly (westerly) low-level wind anomalies presented in the western-central (eastern) equatorial Pacific Ocean in May 2017.**

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

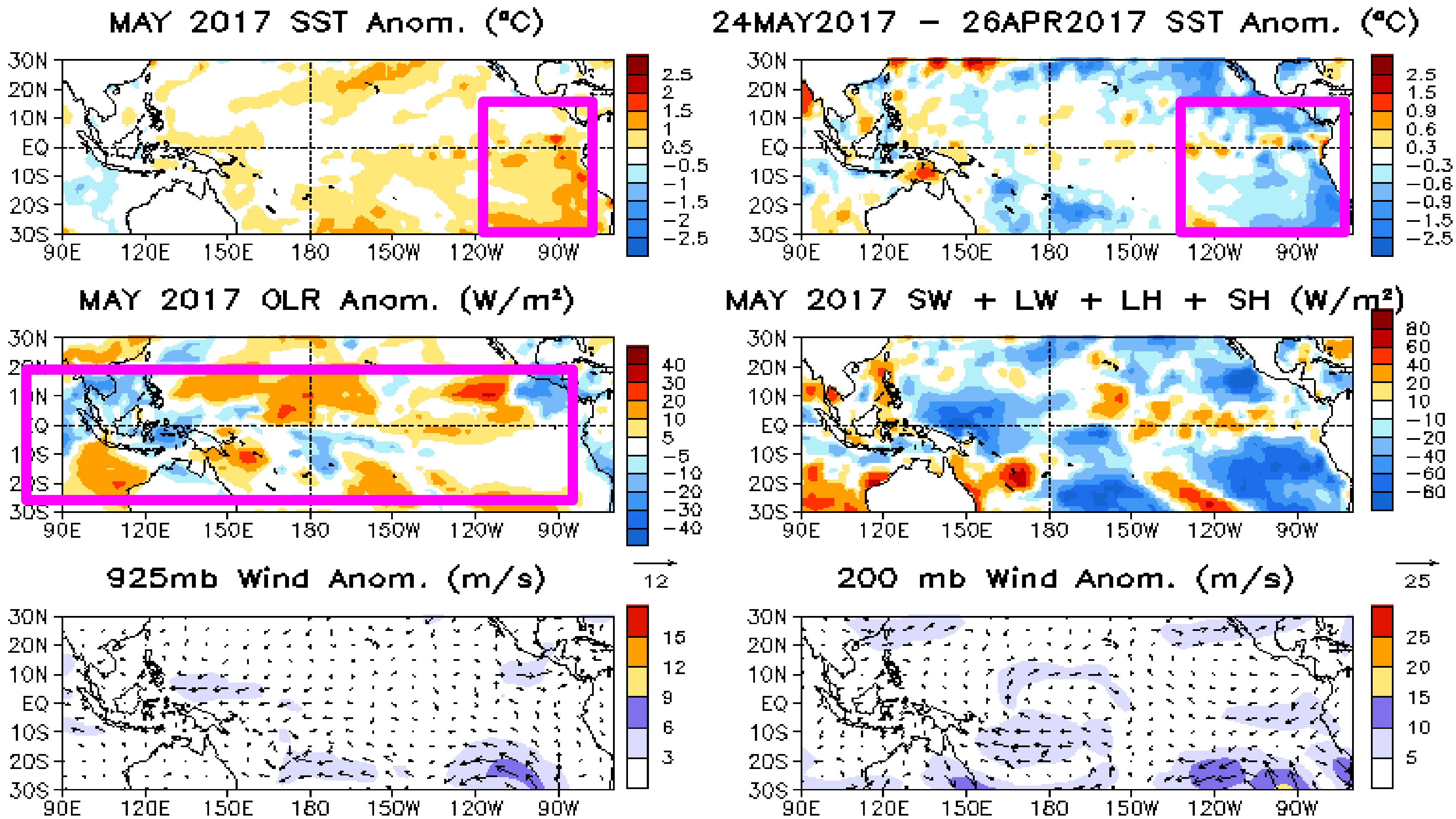
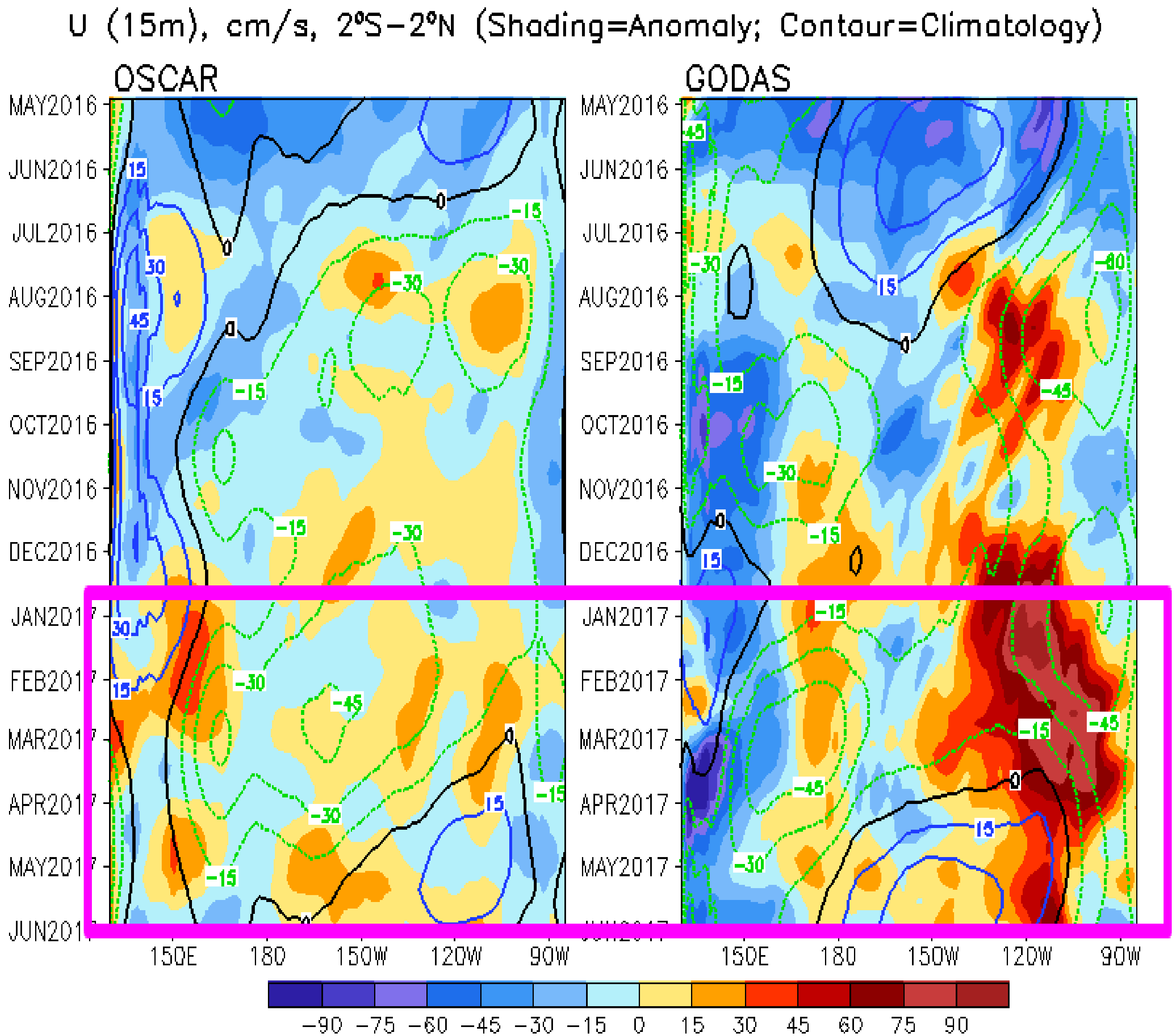


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

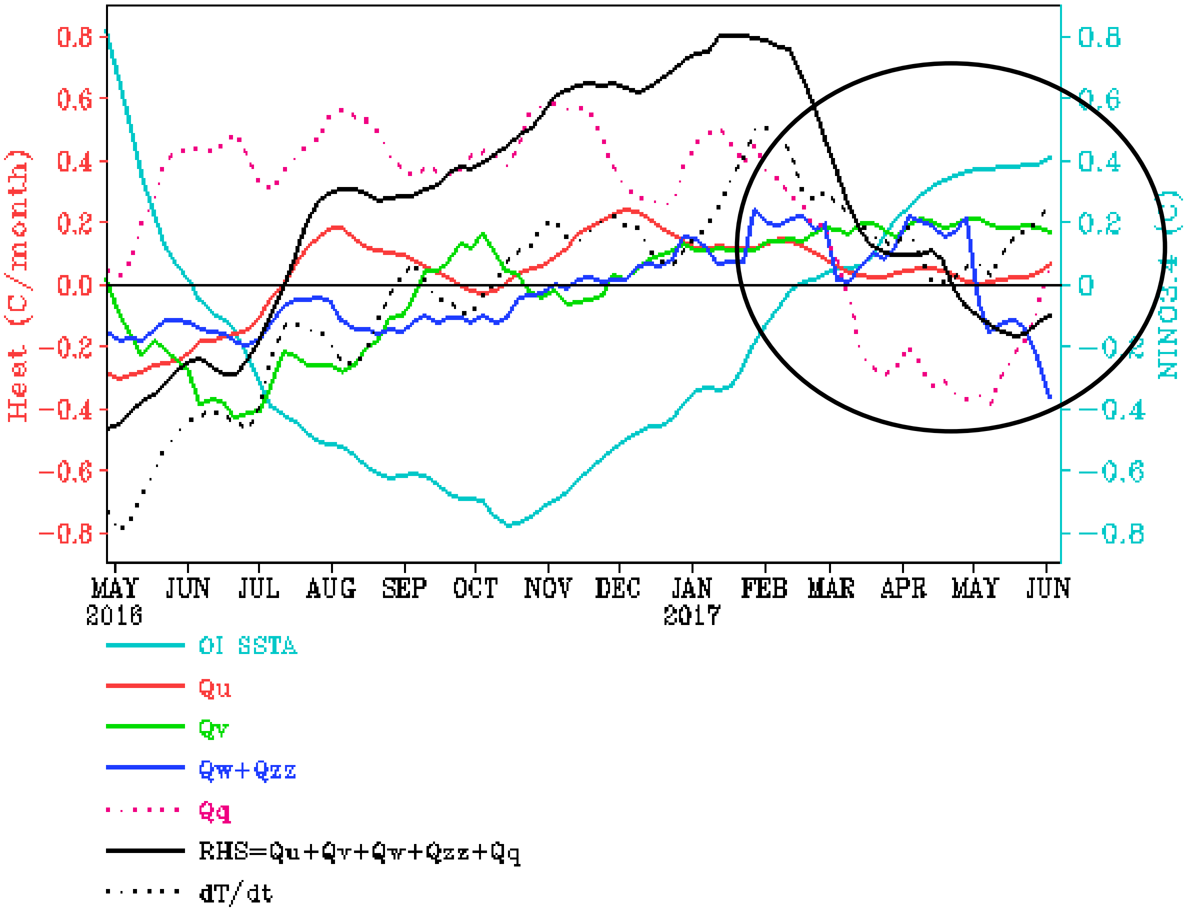
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- The anomalous currents showed large differences between OSCAR and GODAS during Nov 2016 – Apr 2017.

- Current anomalies were small in last month.

NINO3.4 Heat Budget



- **Observed SSTA tendency (dT/dt) in Nino3.4 region (dotted black line) was positive since Oct 2016, consisting with the decay of La Nina and transition to ENSO neutral condition. But total budget tendency (solid black line) was negative in May 2017.**

- **Zonal advection(Qu) was near zero, meridional advection (Qv) was positive, while vertical terms (Qw+Qzz) and heat flux term (Qq) were negative in May 2017.**

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

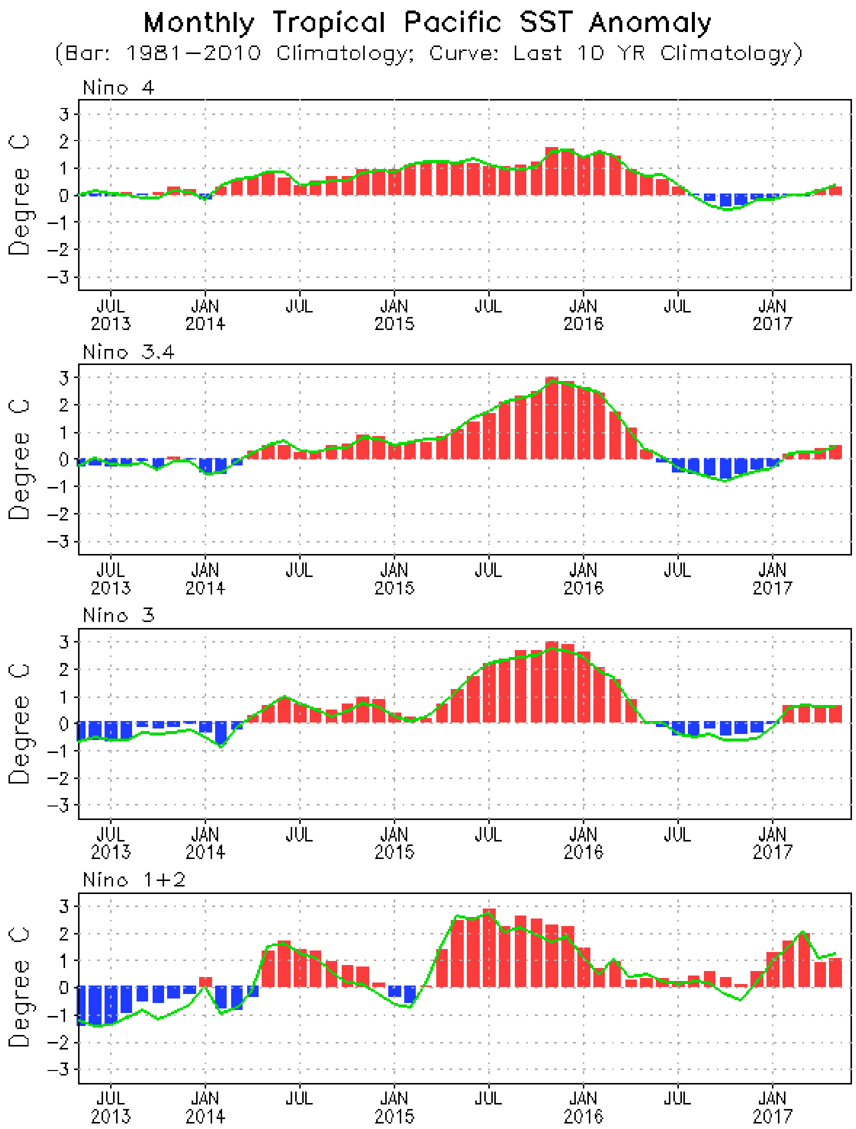
Qu: Zonal advection; Qv: Meridional advection;

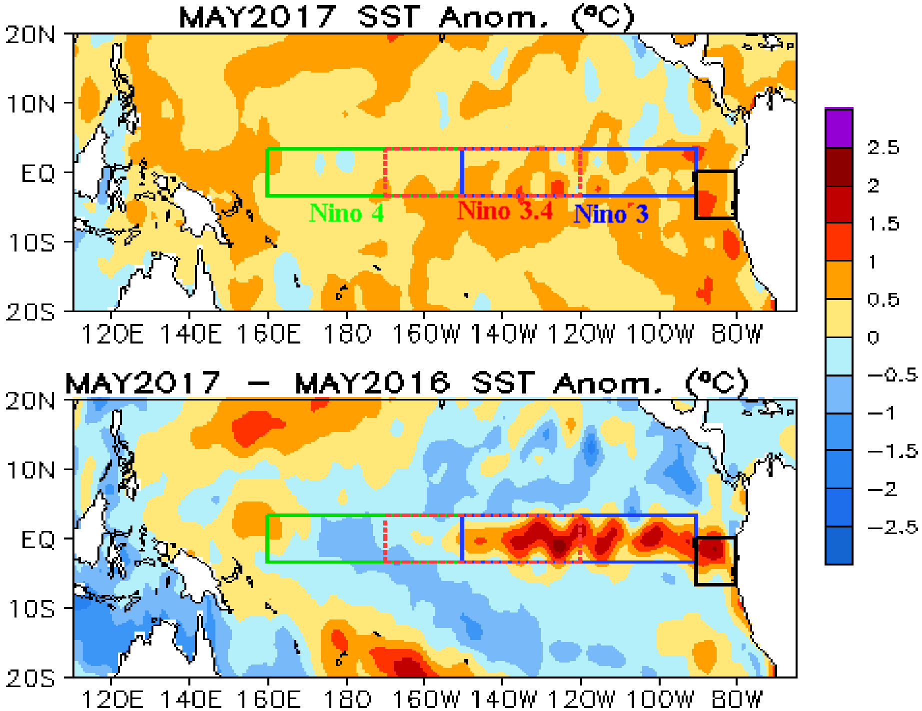
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

Evolution of Pacific NINO SST Indices





- **All Nino indices were positive in May 2017.**

- **Nino3.4 = 0.46ºC in May 2017.**

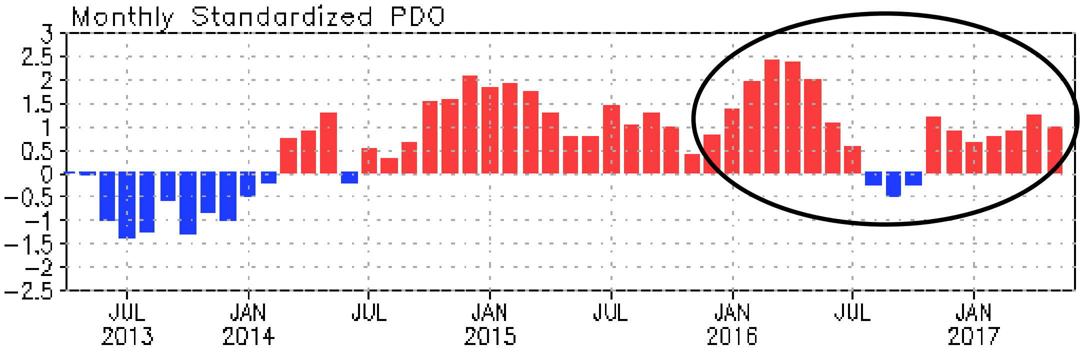
- **Compared with last May, the central and eastern equatorial Pacific was much warmer in May 2017.**

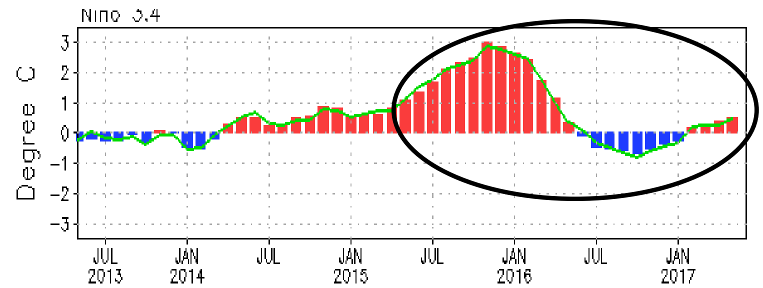
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v4.**

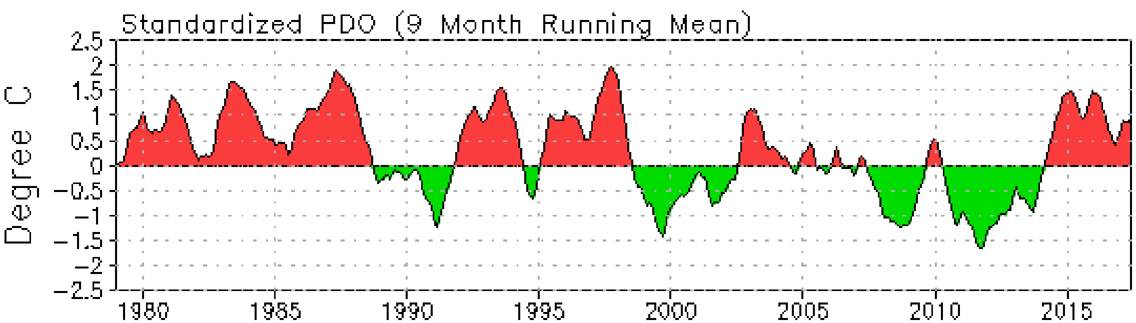
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

North Pacific & Arctic Oceans

PDO index

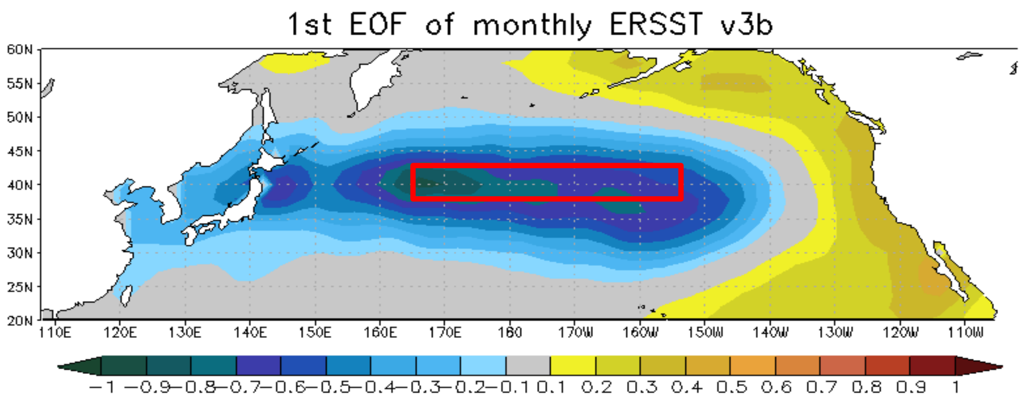






- **The positive phase of PDO index has persisted 7 months since Nov 2016 with PDO index =0.96 in May 2017.**

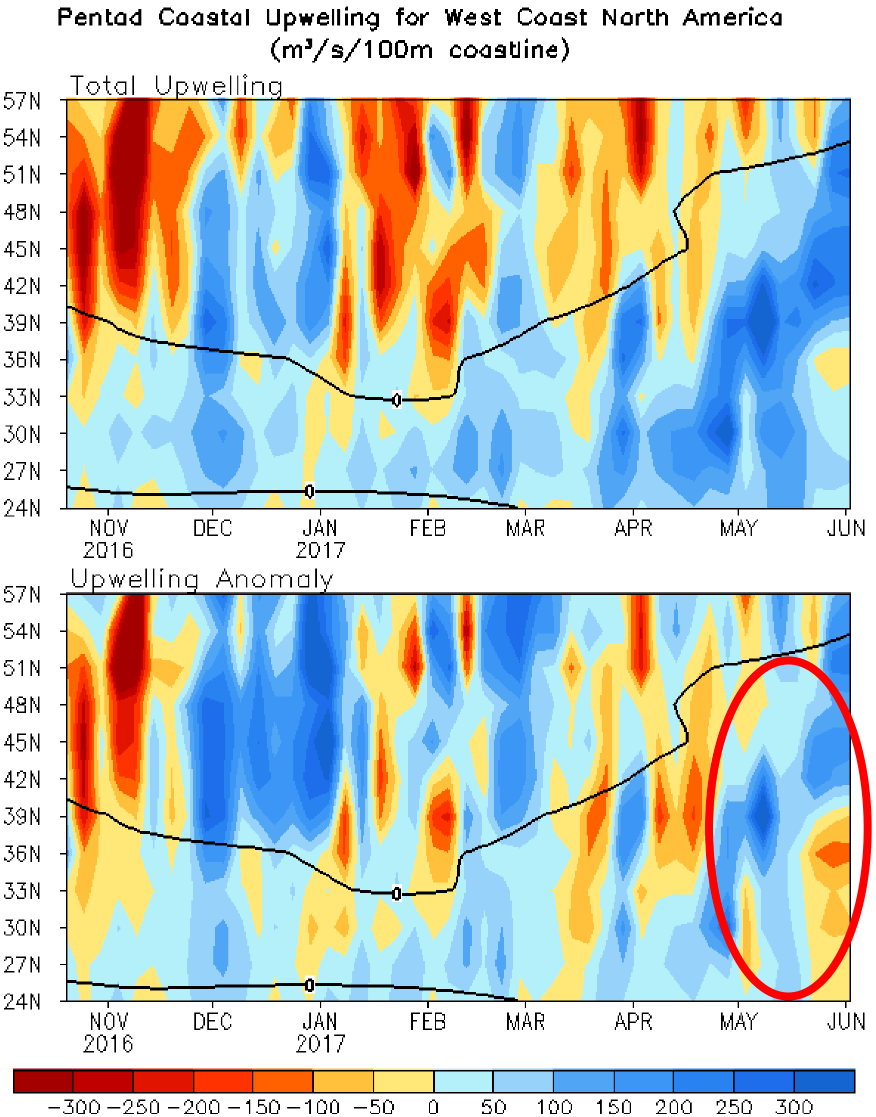
- **Statistically, ENSO leads PDO by 3-4 months, may through atmospheric bridge.**

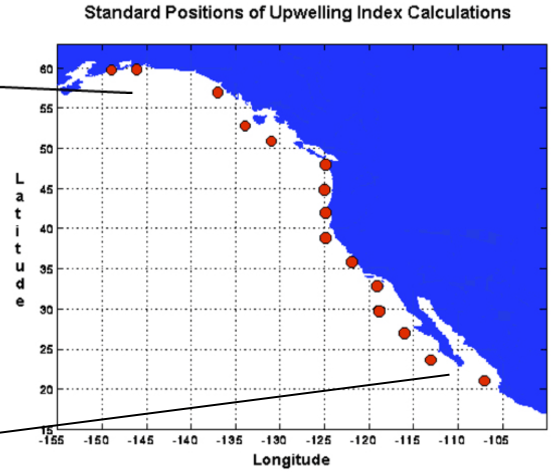


- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

- 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





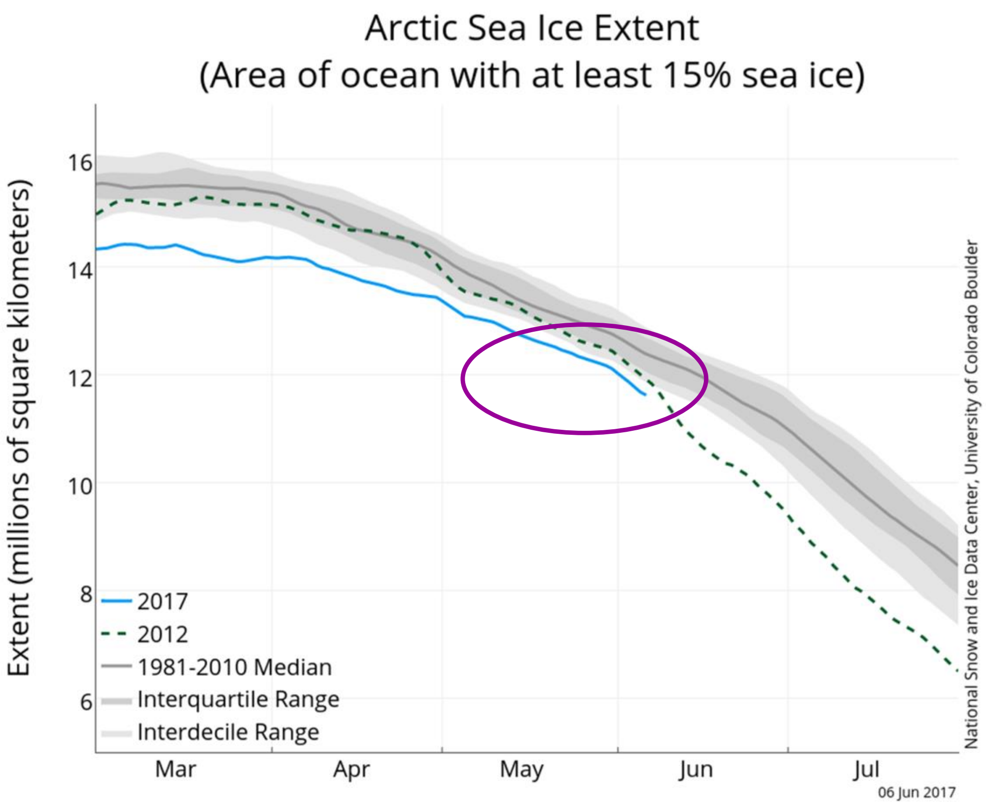
- **Both anomalous downwelling and upwelling presented along the coast in May 2017.**

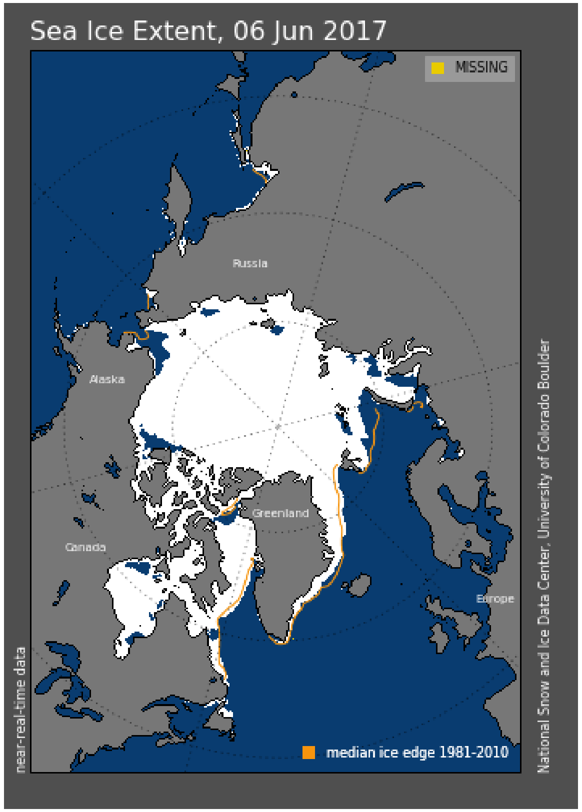
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

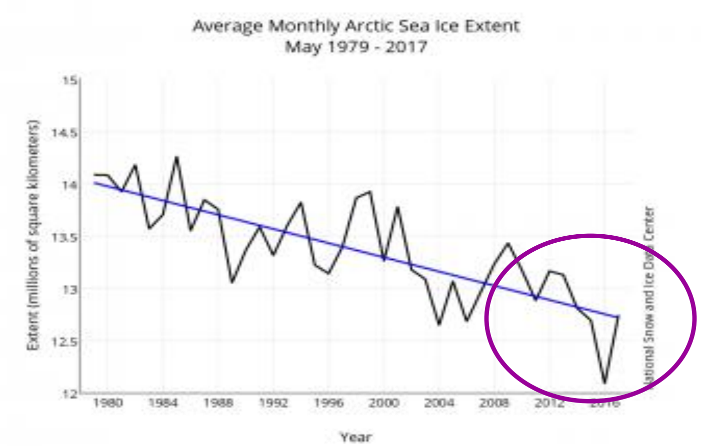
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

Arctic Sea Ice

National Snow and Ice Data Center
http://nsidc.org/arcticseaicenews/index.html



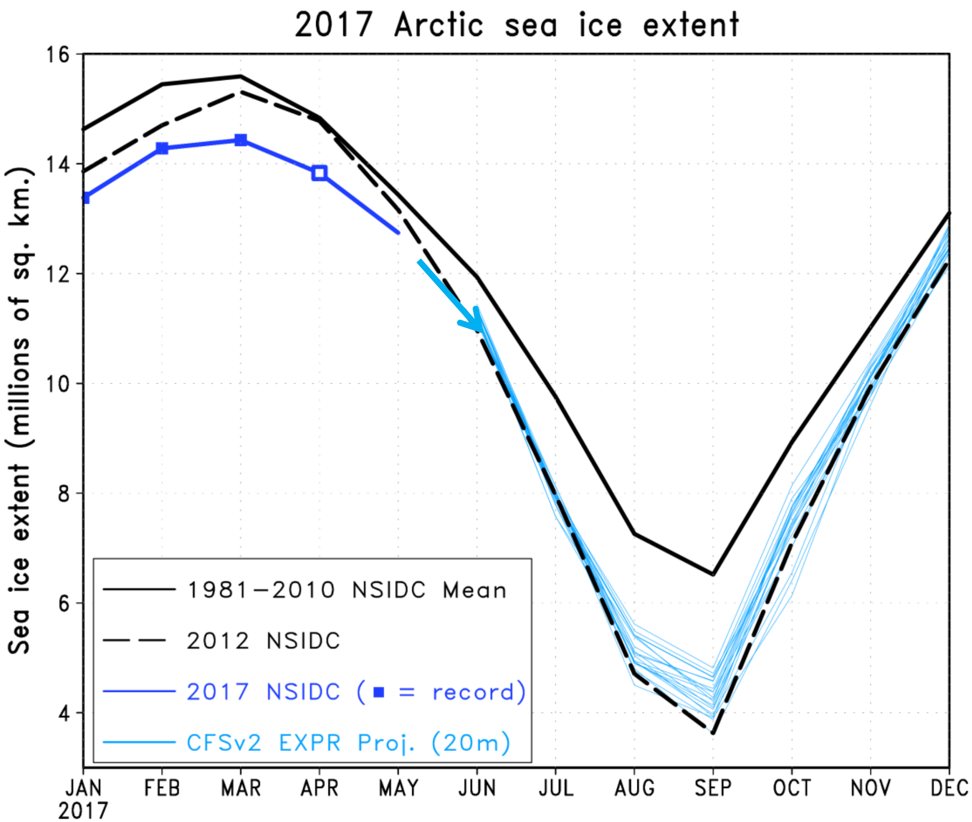


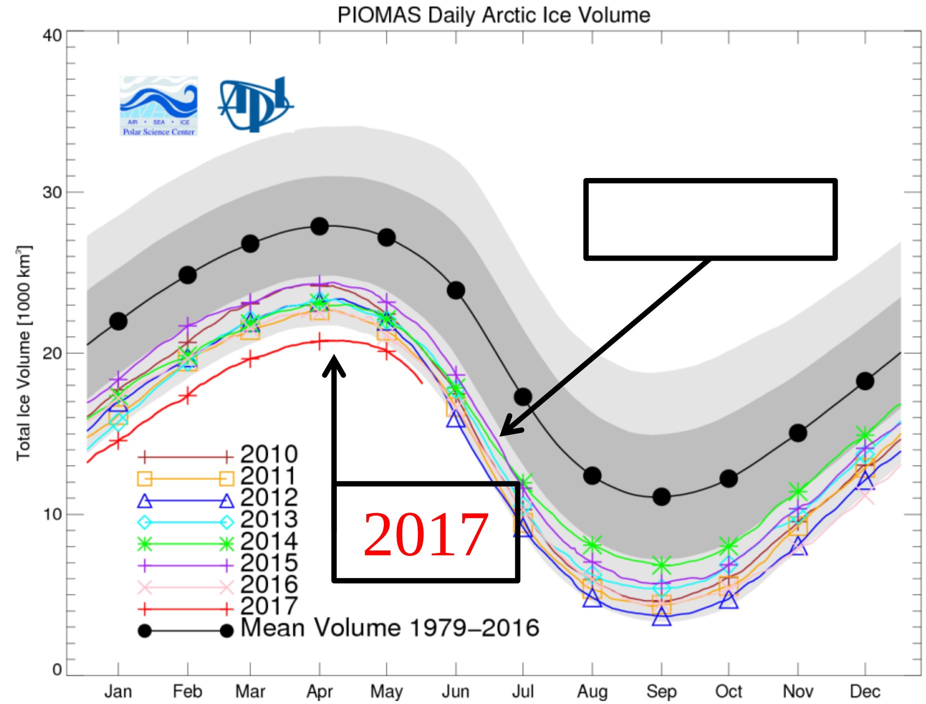


- **Arctic sea ice extent in May 2017 was smaller than that in 2012.**

- **Arctic sea ice extent for May 2017 was the fourth lowest in the 1979 to 2017 satellite record for the month.**

Arctic Sea Ice





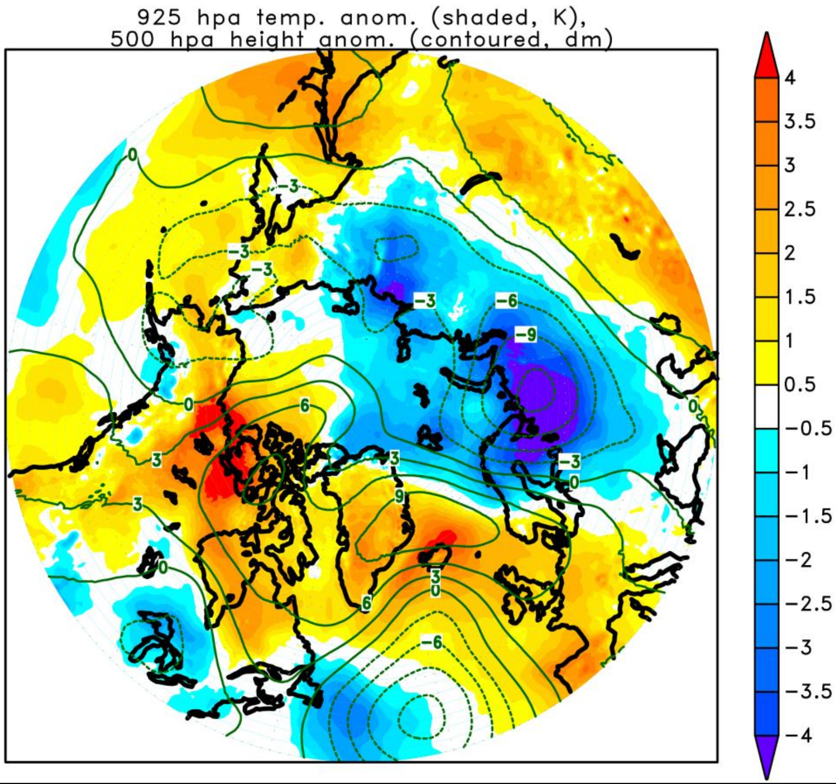
- **Arctic sea ice melting has slowed this past month.**

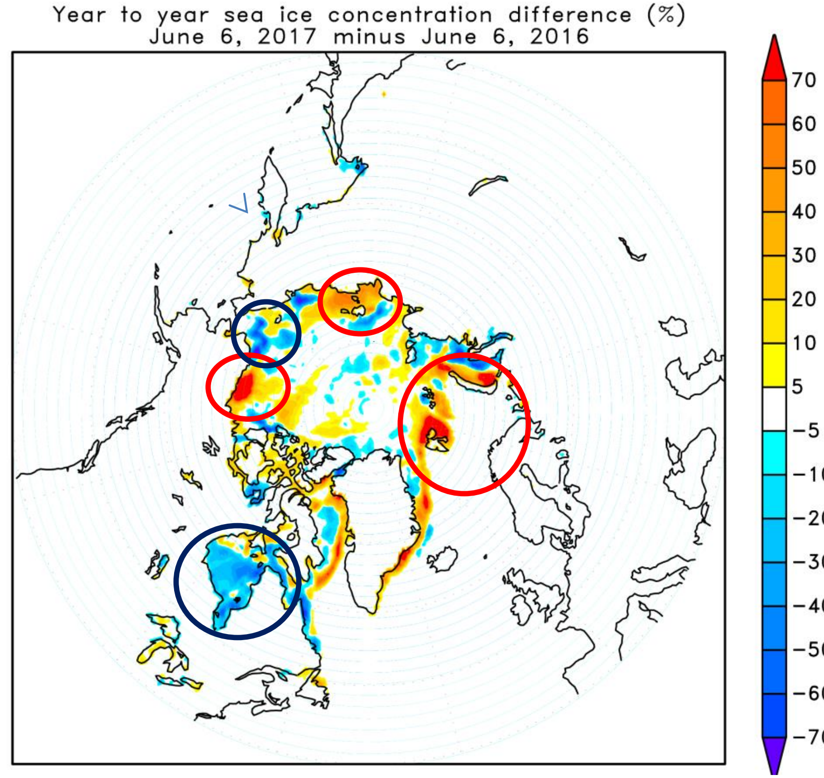
- **May 2017 sea ice extent was the 4th lowest in the satellite record which began in 1979**

- **Sea ice volume from PIOMAS remains at a record low**

- **Signs still point to a very low upcoming September minimum but experimental forecast is no longer suggesting a new record. Summertime atmospheric conditions will ultimately determine how fast the sea ice melts (note May 2017 extent is still less than May 2012).**

May 2017 temperature and geopotential height anamolies





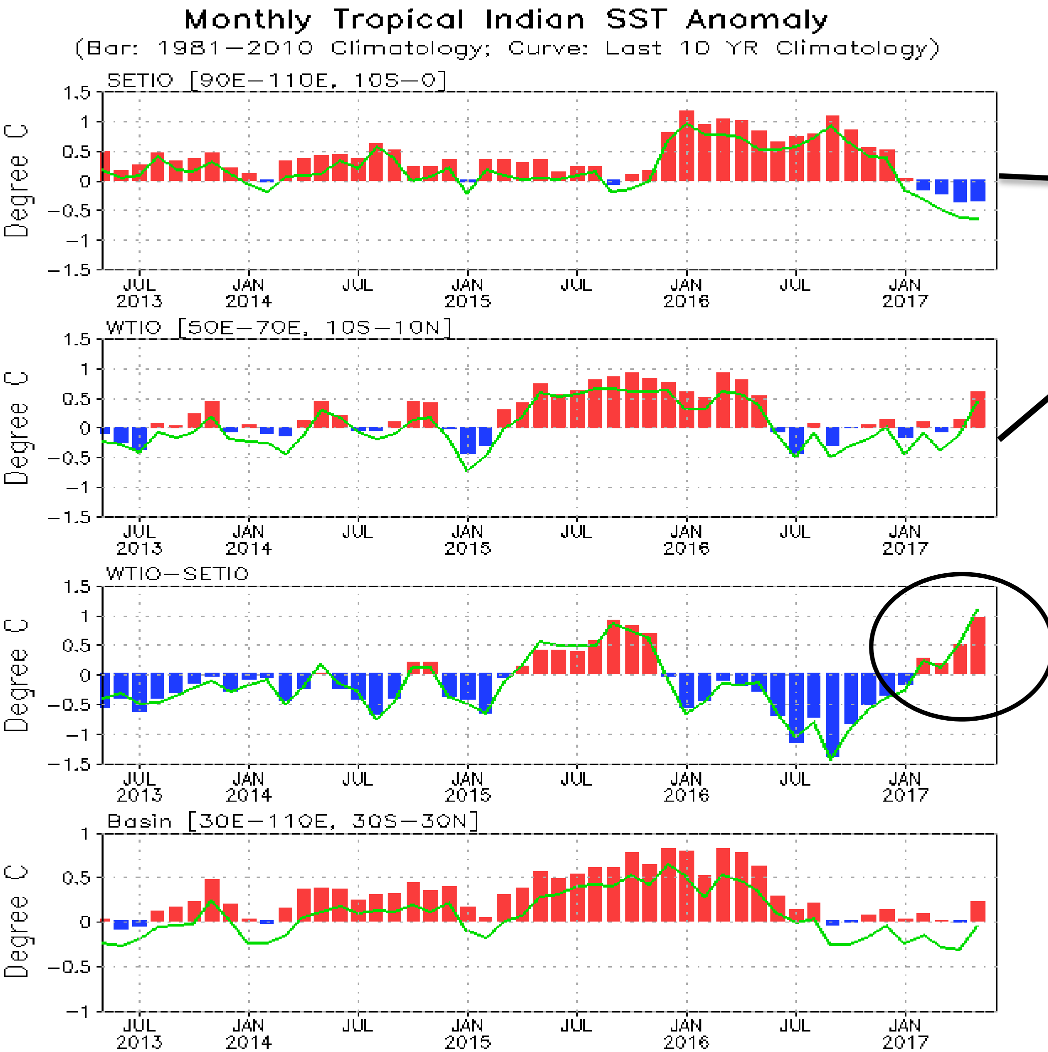
- **May 2017 925 hPa temperature anomalies were generally negative on the Asian side of the Arctic and positive on the North American/Atlantic side.**

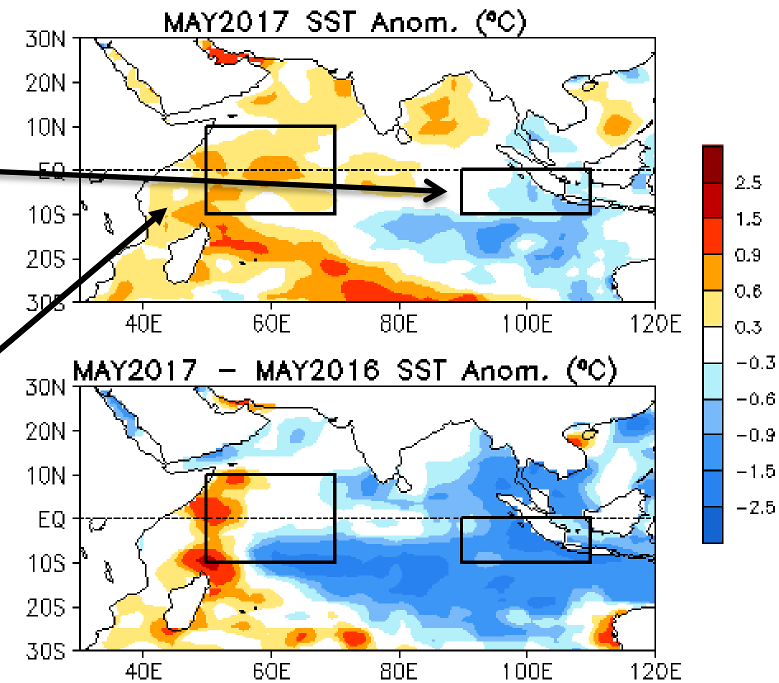
- **There was less sea ice melt in the North Atlantic, Kara Sea, and East Siberian Sea as compared to last year. There is also more ice currently in the Beaufort Sea than last year (2016 saw record early melt in this region).**

- **Ice concentration in the Chukchi Sea and Hudson Bay is lower than last year. The rapid melt in the Chukchi Sea is “unprecedented” according to a recent NOAA report**

Indian Ocean

Evolution of Indian Ocean SST Indices





- **Overall, SSTAs were positive in the west and negative in the east.**
- **Dipole index was positive during last four months and strengthened in last two months, and Basin index was positive in May 2017.**

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

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

- Overall, SSTAs were positive in the west and negative in the east.
- SSTA tendency was small along the equator.
- Convections were enhanced over the northern basin.

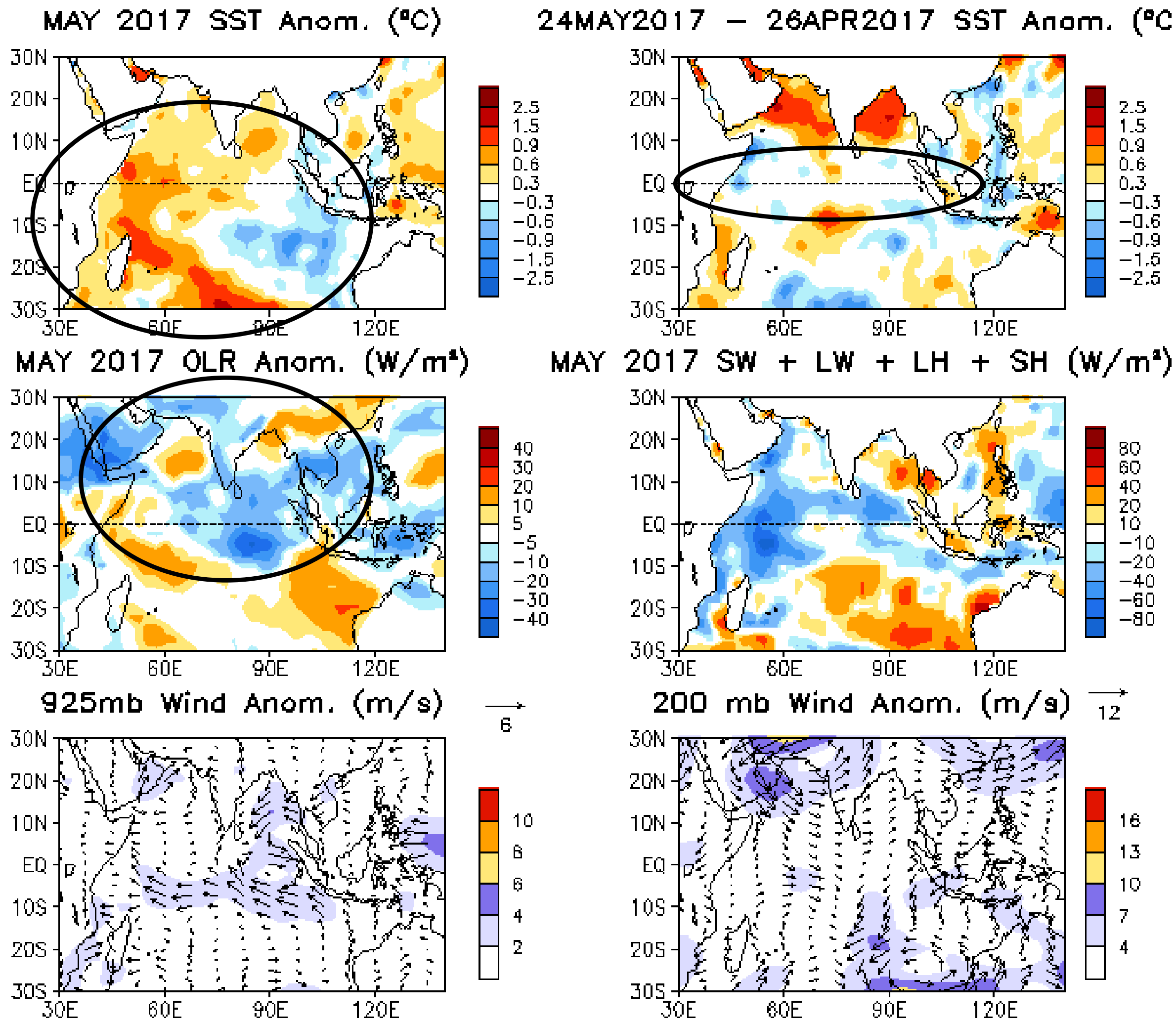
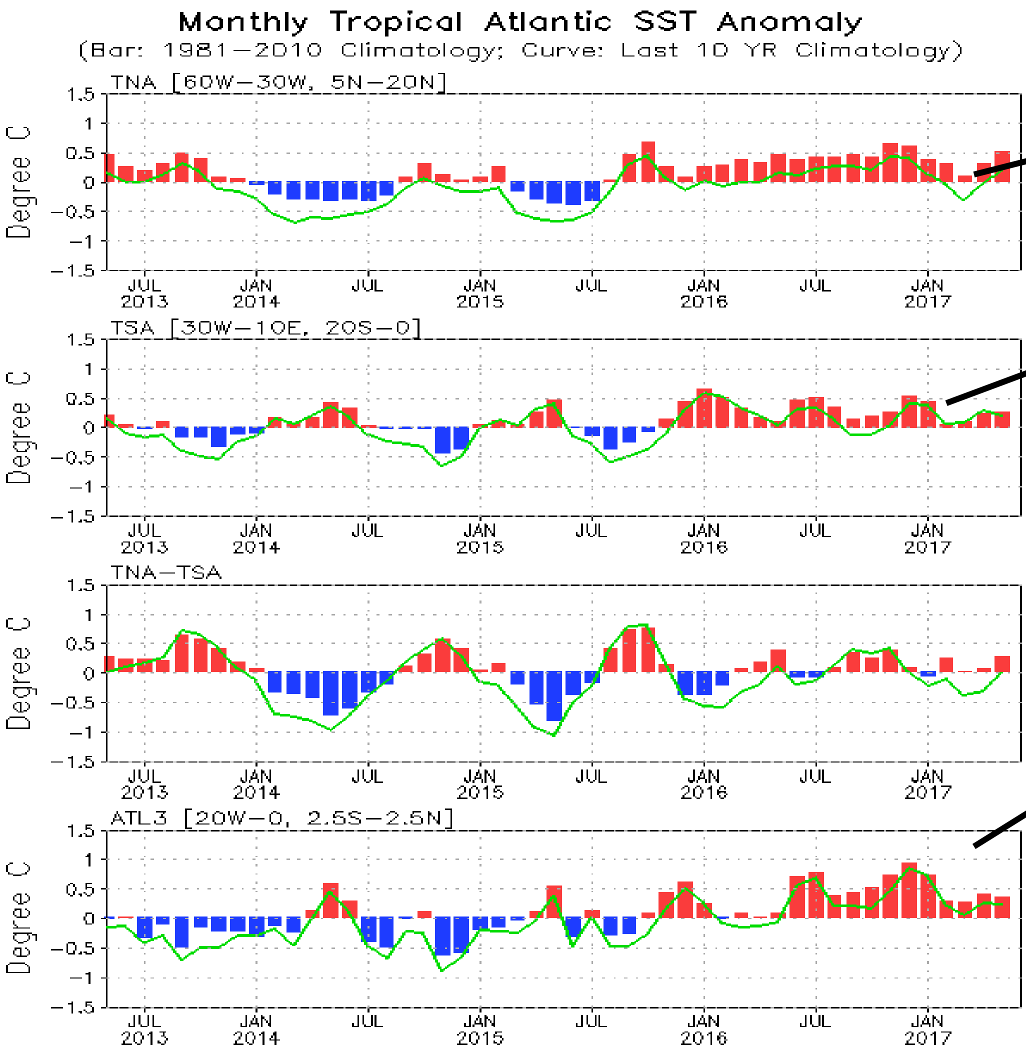
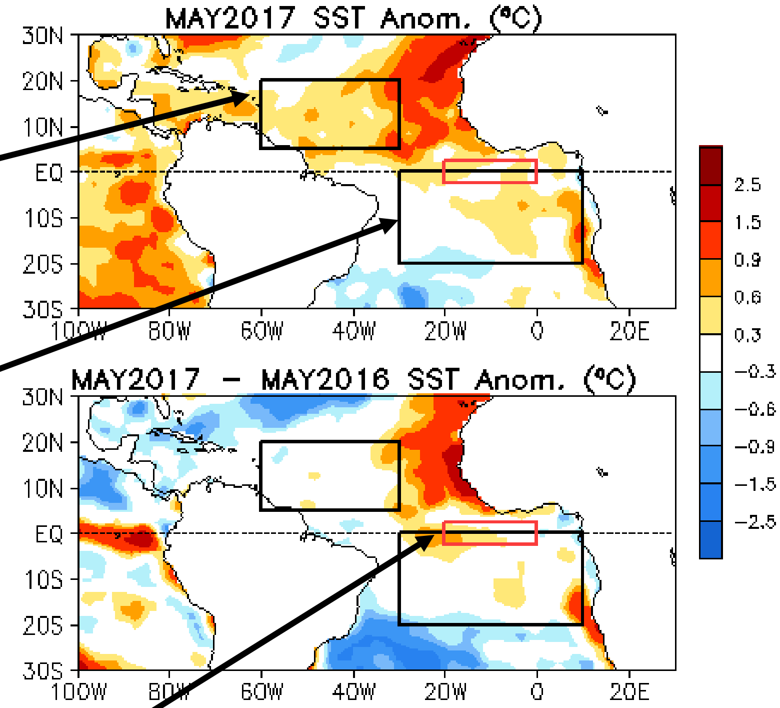


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

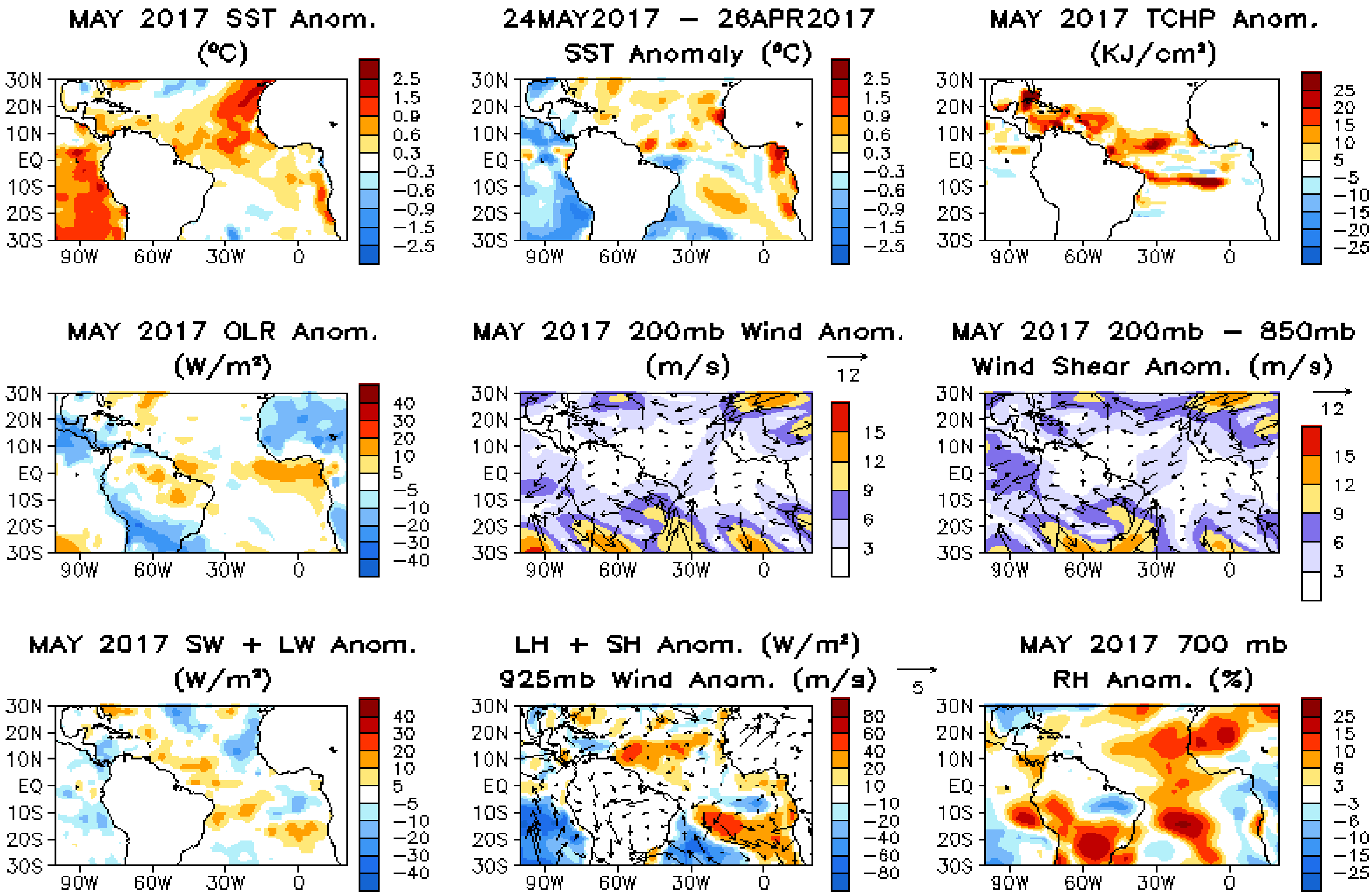




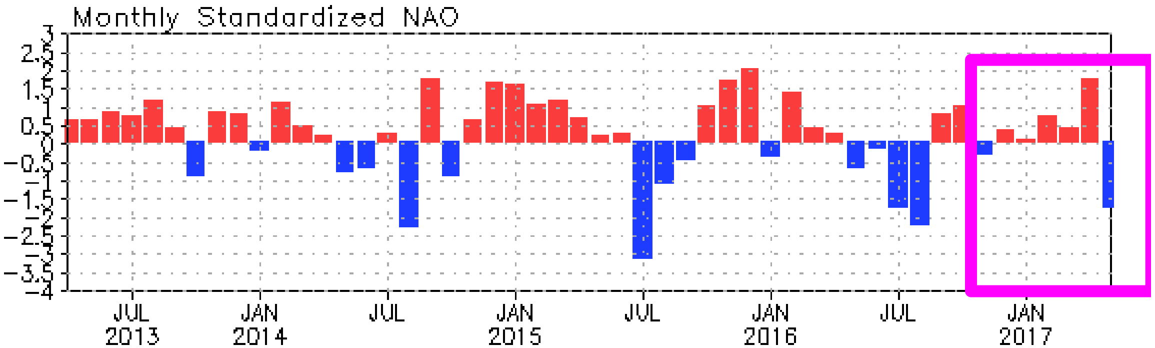
- Overall, SSTAs in the tropical Atlantic Ocean were positive.
- All indices were positive in May 2017.

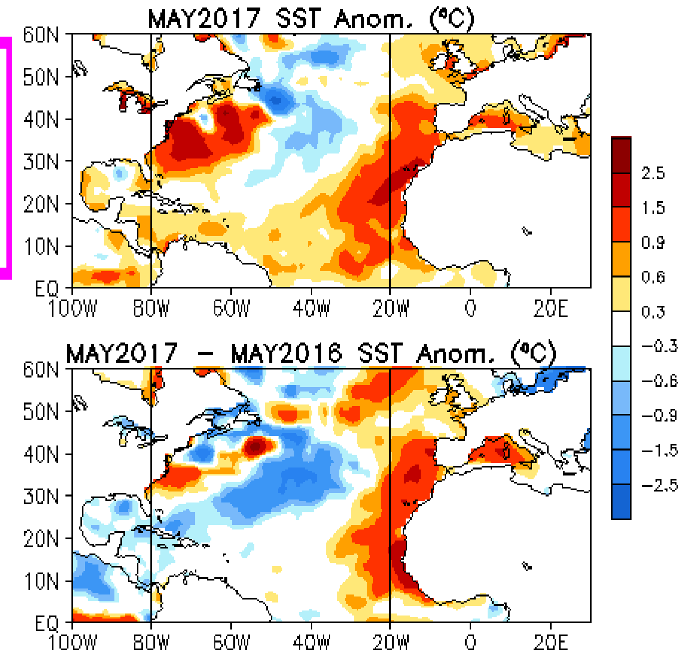
Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (ºC) for the TNA [60ºW-30ºW, 5ºN-20ºN], TSA [30ºW-10ºE, 20ºS-0] and ATL3 [20ºW-0, 2.5ºS-2.5ºN] regions, and Meridional Gradient Index, defined as differences between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

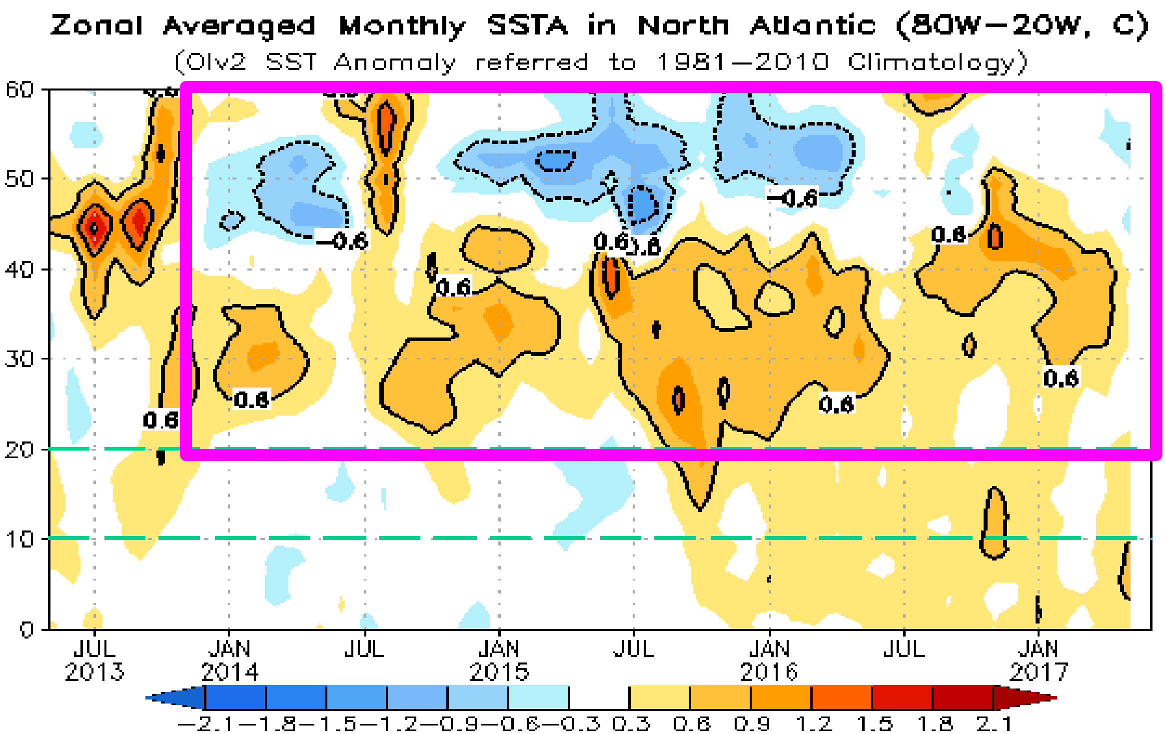
Tropical Atlantic:



NAO and SST Anomaly in North Atlantic







- NAO switched to negative phase with NAOI=-1.72 in May 2017.

- SSTA was positive in the middle latitudes and negative in the high latitudes during last 3 years, probably due to the impact of positive phase of NAO.

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

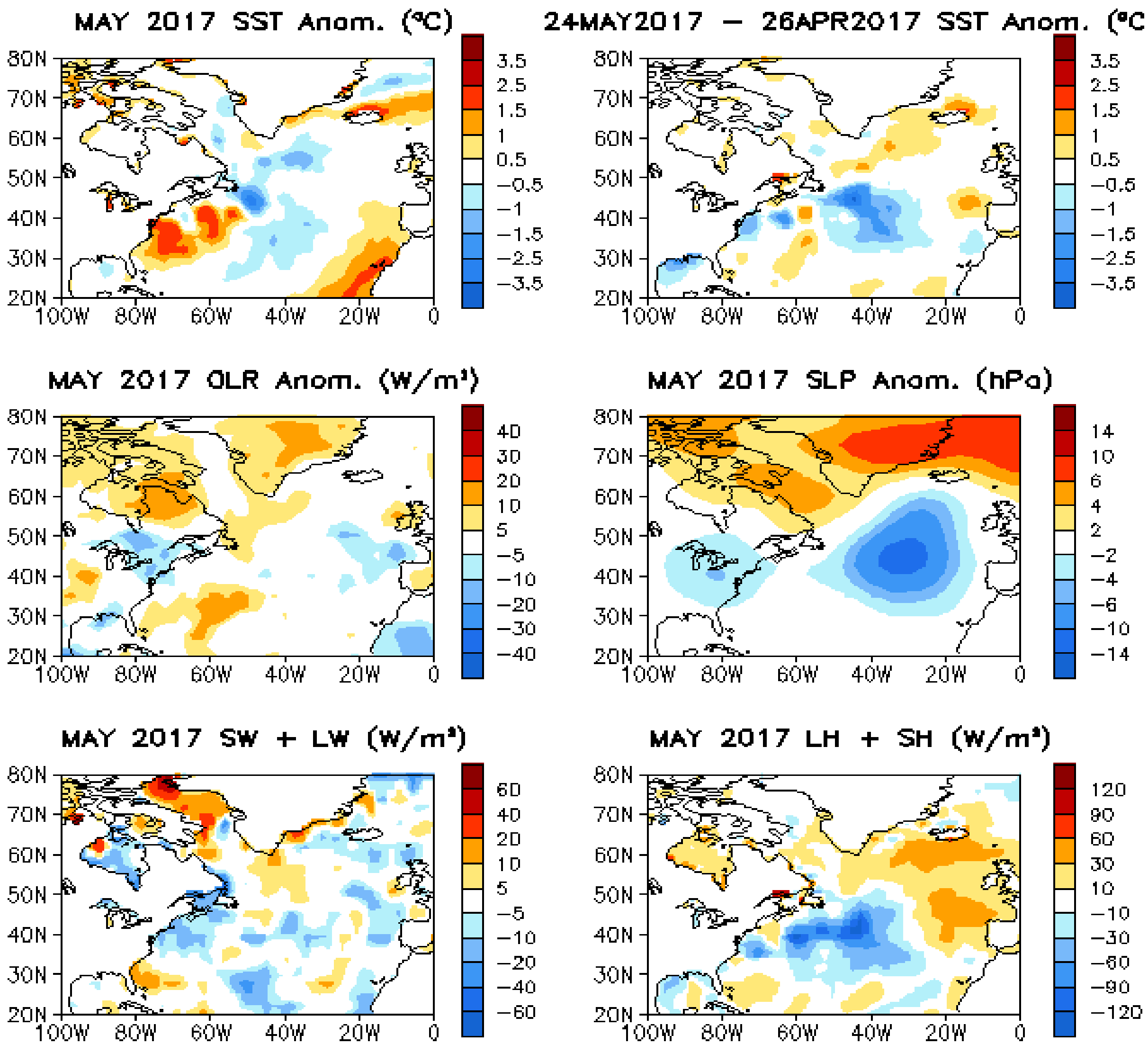
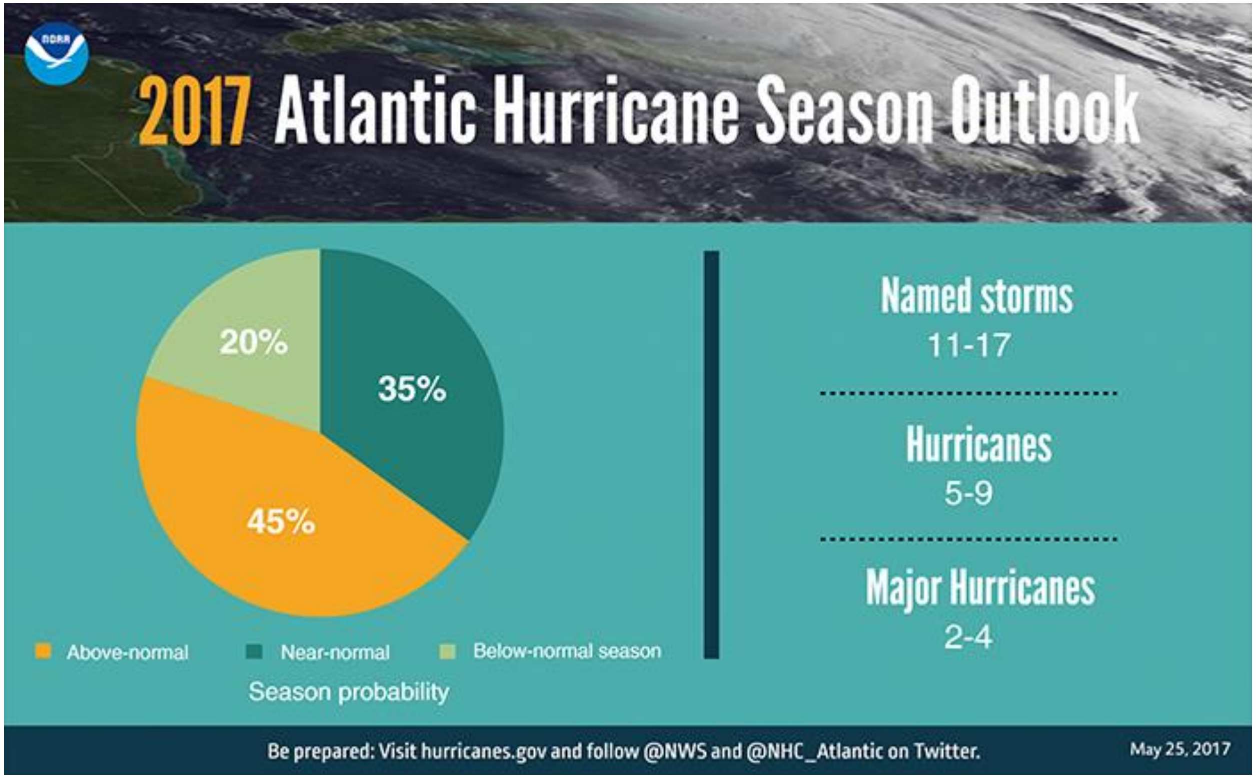


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

NOAA Outlooks of Hurricane Season in 2017

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)



Atlantic	2017 prediction (issued on May 25)	1981-2010
Named storms	11-17	12.1
Hurricanes	5-9	6.4
Major hurricanes	2-4	2.7
ACE range of the median, which includes Arlene in Apr	75%-155%	

Reasoning behind the outlook

NOAA's 2017 Atlantic hurricane season outlook reflects three main factors during August-October:

(1) Either ENSO-neutral or weak El Niño conditions are expected over the tropical Pacific Ocean (*unfavorable*),

(2) Near- or above-average sea-surface temperatures (SSTs) across much of the Atlantic hurricane Main Development Region (*favorable*), and

(3) Near-average or weaker-than-average vertical wind shear in the MDR (*favorable*).

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)

NOAA's 2017 Hurricane Season Outlooks

For 2017 the probabilities of each season type are:

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

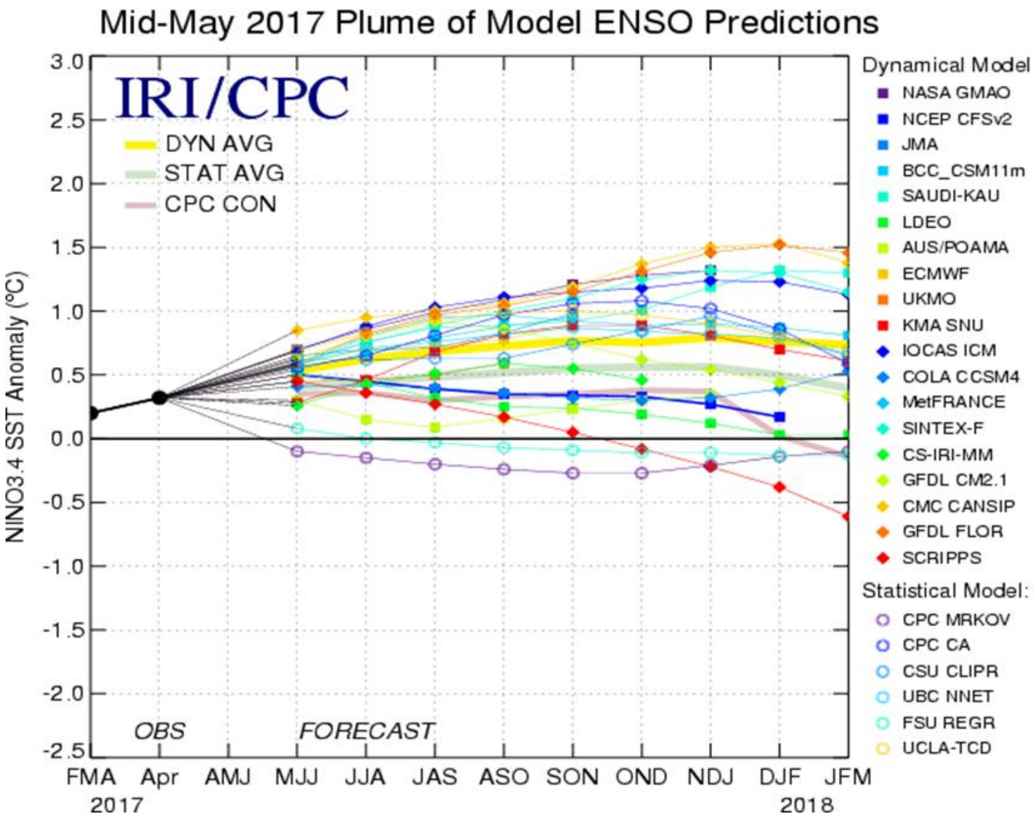
NOAA's 2017 Atlantic and eastern Pacific seasonal hurricane outlooks indicate the likely ranges (each with a 70% chance) of Named Storms, Hurricanes, Major Hurricanes and percentage of the median Accumulated Cyclone Energy (ACE).

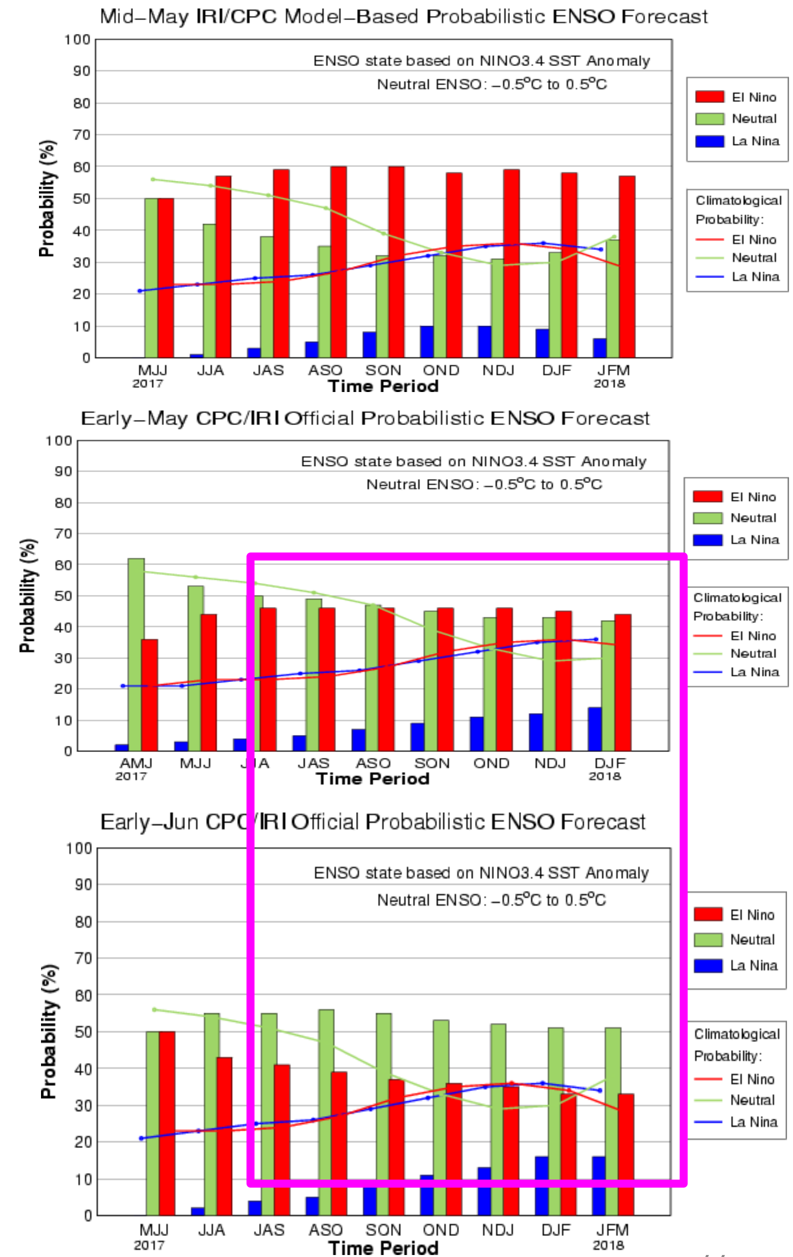
NOAA's 2017 Central Pacific seasonal hurricane outlook indicates the likely range of Tropical Cyclones (TCs), with a 70% chance. TC's include tropical depressions, tropical storms and hurricanes.

(http://www.cpc.ncep.noaa.gov/products/outlooks/hurricane.shtml)

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum

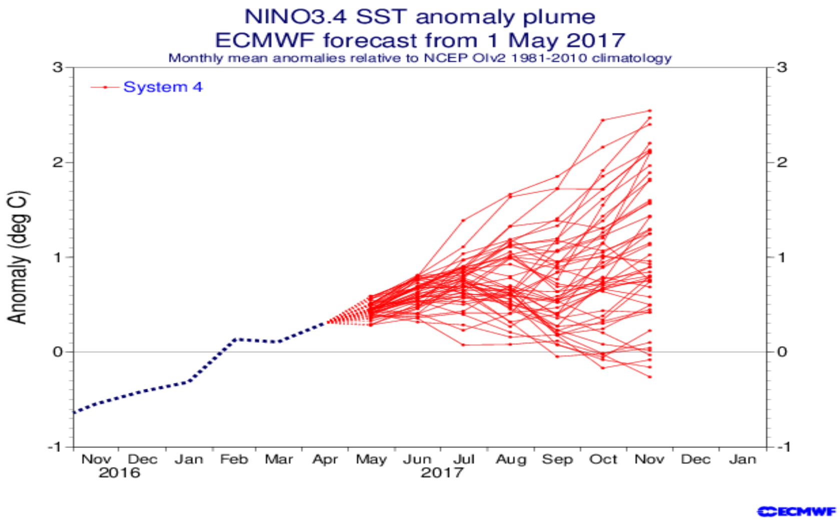




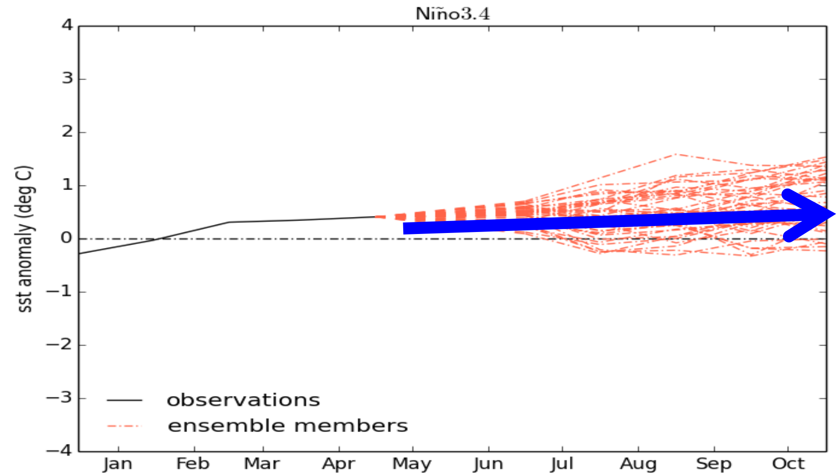
- **Many models with ICs in May 2017 favor a weak El Niño by the Northern Hemisphere summer 2017, continuing through winter 2017-18.**
- **NOAA "ENSO Diagnostic Discussion" on 8 June 2017 suggested that "ENSO-neutral is favored (50 to ~55% chance) through the Northern Hemisphere fall 2017."**

Individual Model Forecasts: neutral or (boardline) El Nino

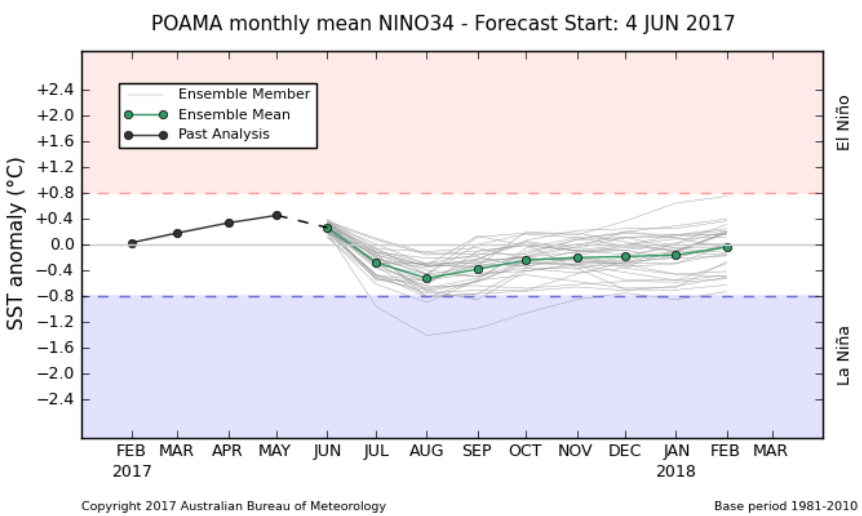
EC: Nino3.4, IC=01May 2017



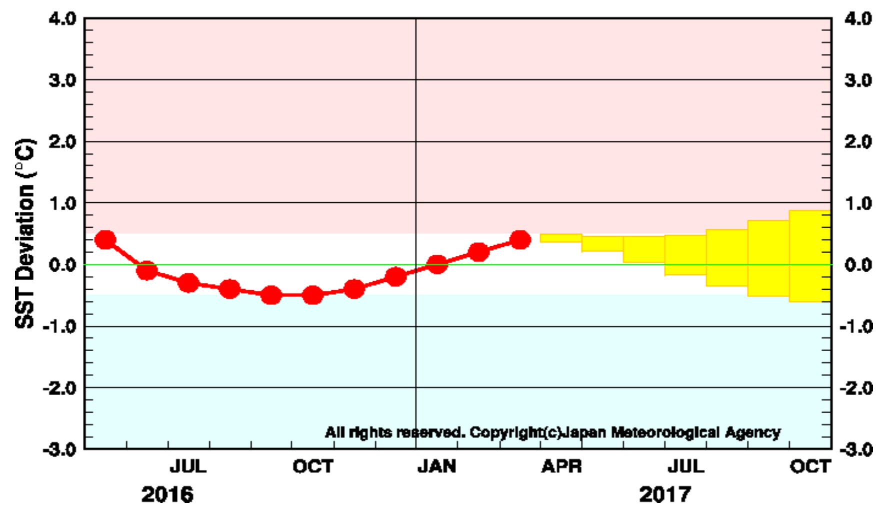
UKMO: Nino3.4, IC=May 2017



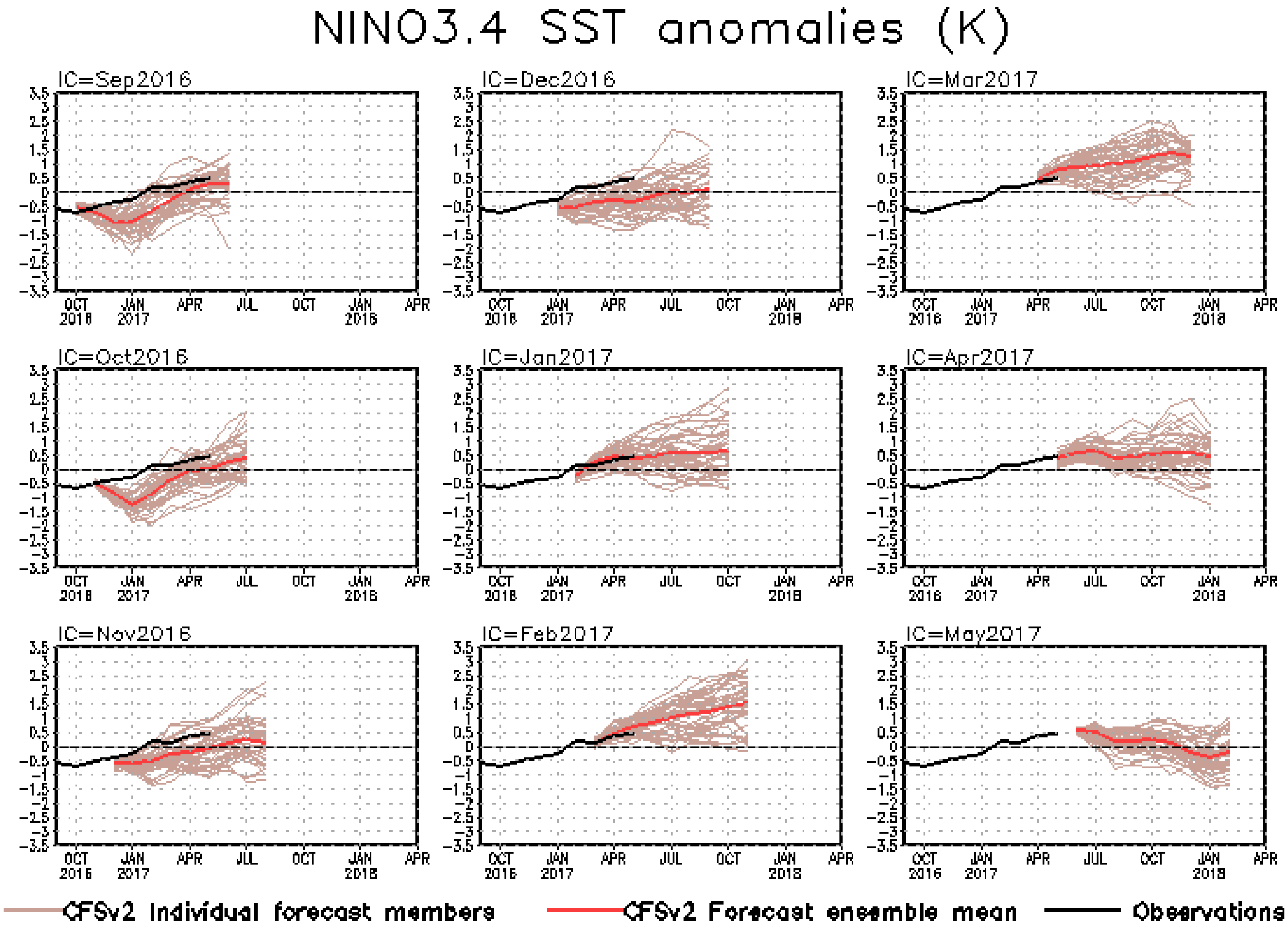
Australia: Nino3.4, IC=4 June 2017



JMA: Nino3, IC=June 2017



CFS Niño3.4 SST Predictions from Different Initial Months

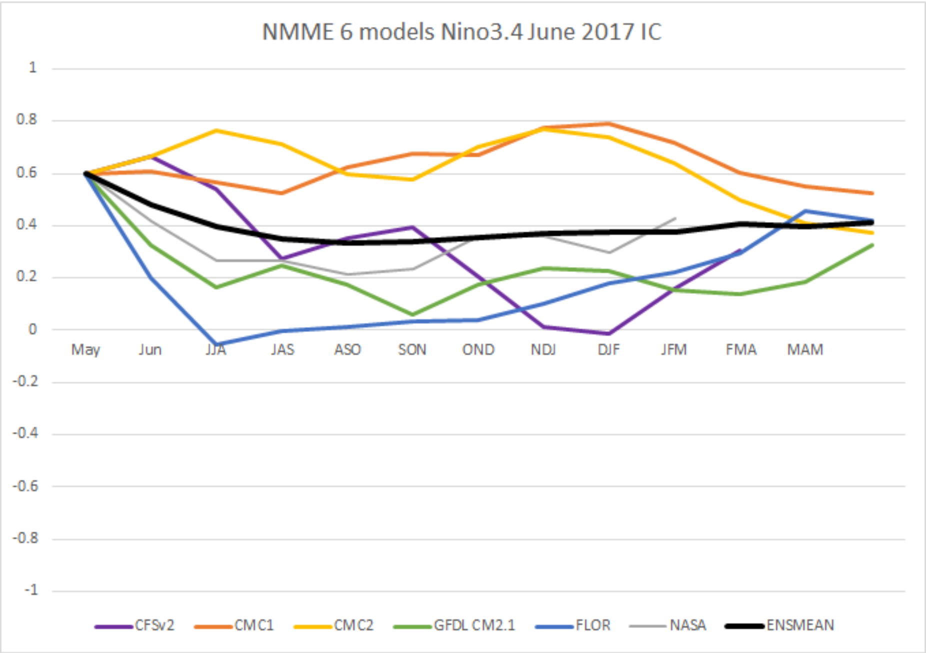


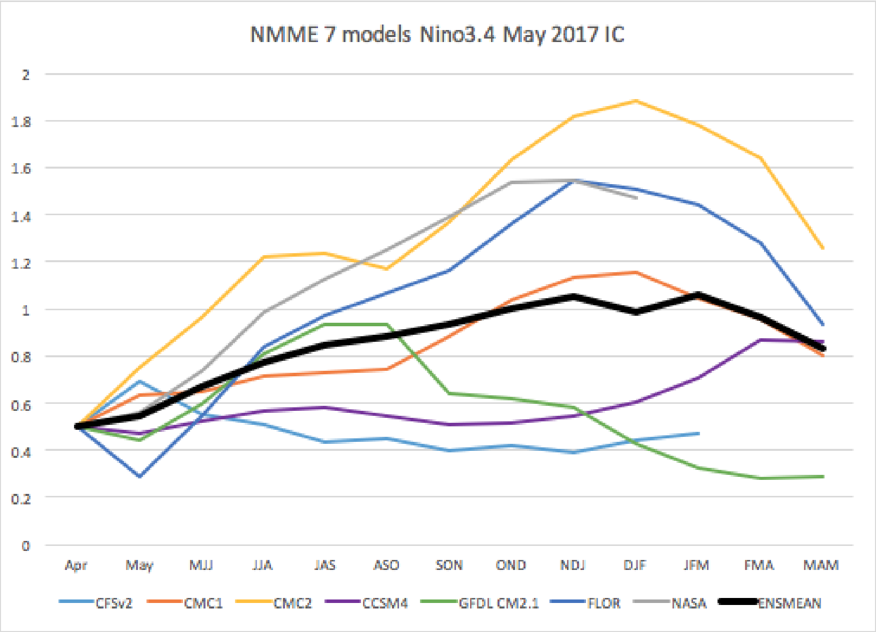
- Latest CFSv2 forecasts call for ENSO neutral in 2017.
- CFSv2 predictions had cold biases with ICs in Jun-Dec 2016.

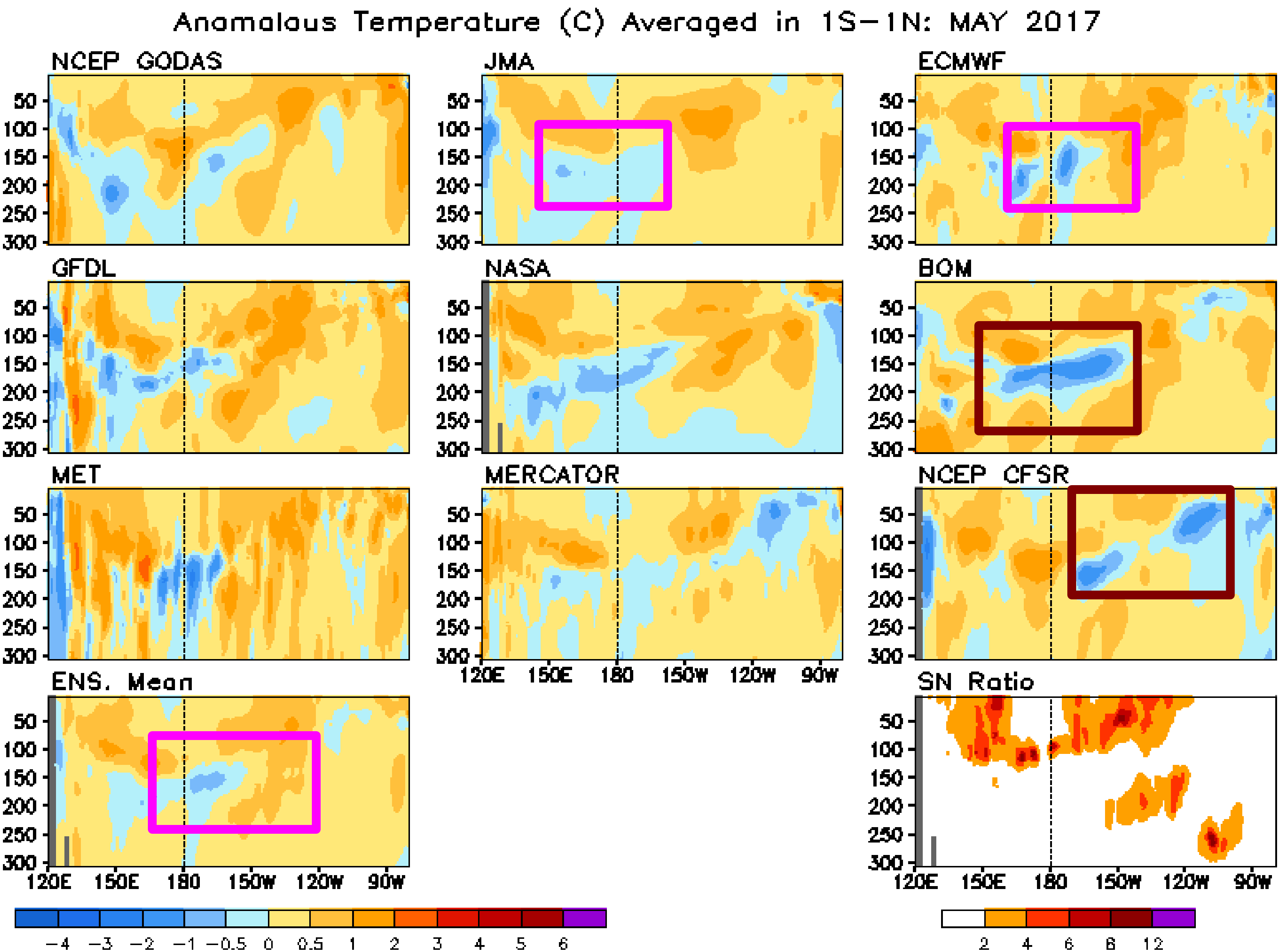
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

Large Uncertainty: 6 NMME Models with ICs in June 2017

(provided by Dr. Emily Becker)

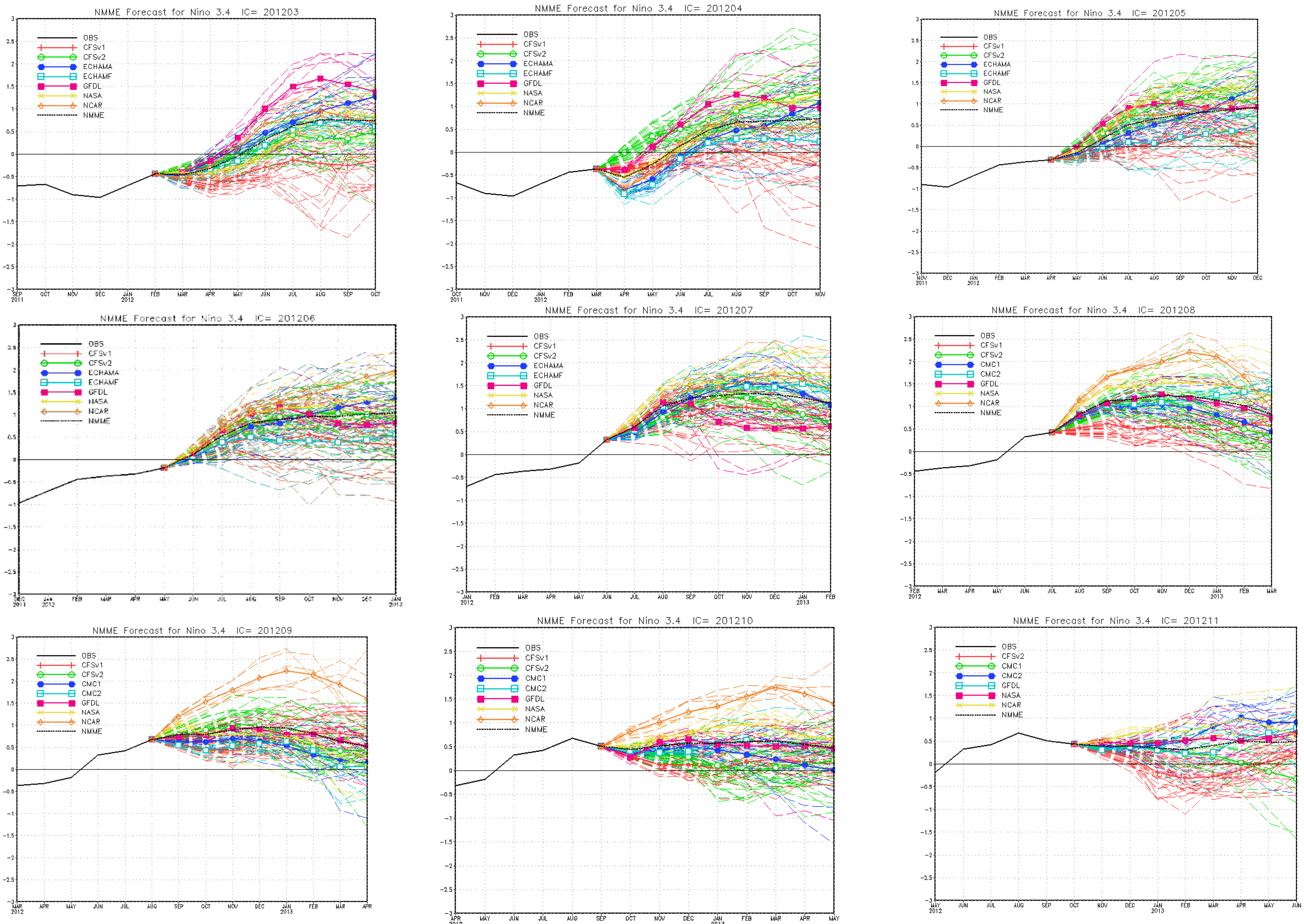






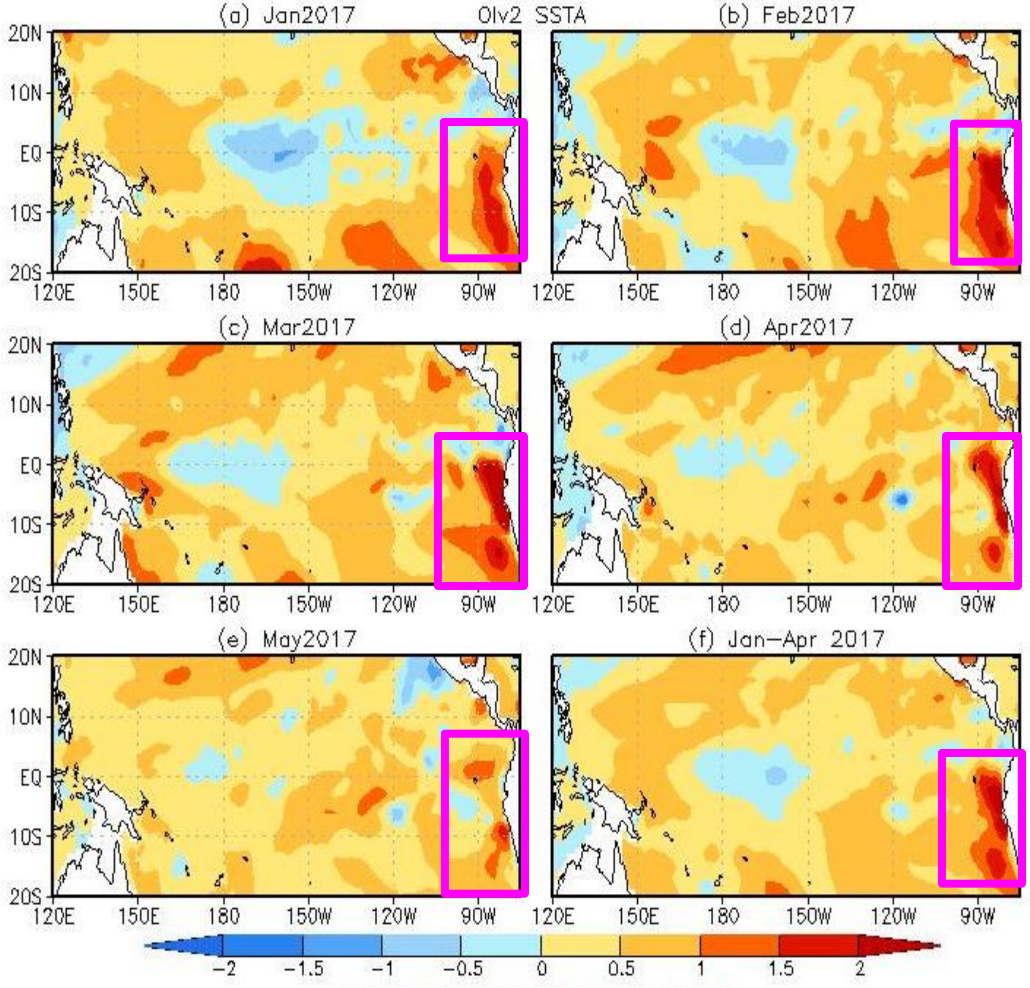
Anomalous Temperature (C) Averaged in 1S-1N: MAY 2017
NCEP GODAS
JMA
ECMWF
GFDL
NASA
BOM
MET
MERCATOR
NCEP CFSR
ENS. Mean
SN Ratio
50
100
150
200
250
300
120E
150E
180
150W
120W
90W
−4 −3 −2 −1 −0.5 0 0.5 1 2 3 4 5 6
2 4 6 8 12

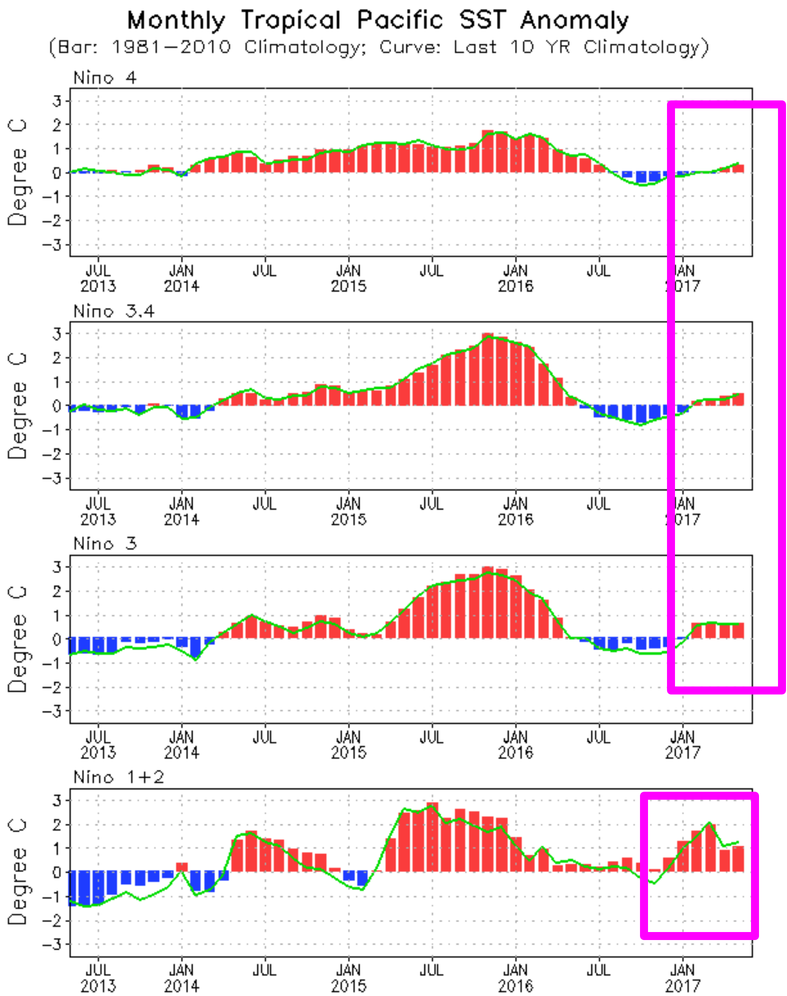
Failure Forecast in 2012 with ICs in Mar-Nov 2012



Evolution and Forecast of Coastal El Nino 2017

Evolution of Coastal El Nino 2017



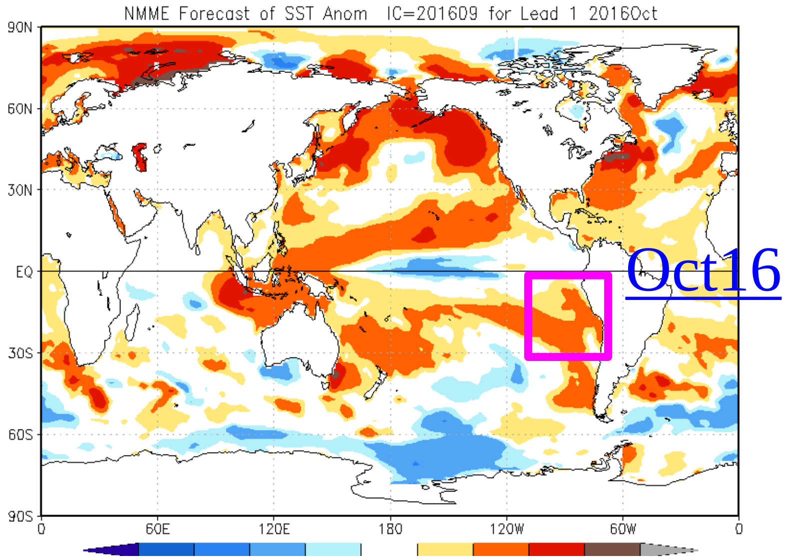


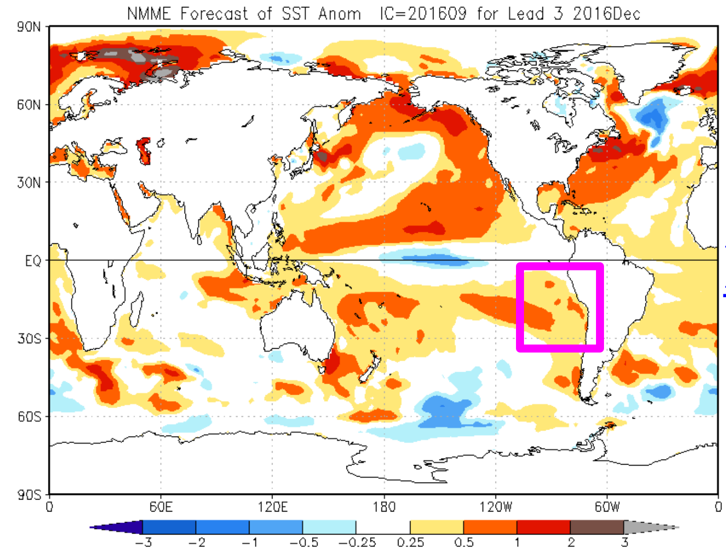
Impact of Coastal El Nino 2017

https://www.google.com/search?q=coastal+el+nino+in+peru&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiNr_P16Y3UAhVJJ8AKHau_DnkQ_AUIBygC&biw=1258&bih=878#imgrc=r2ed0xhKxnztgM

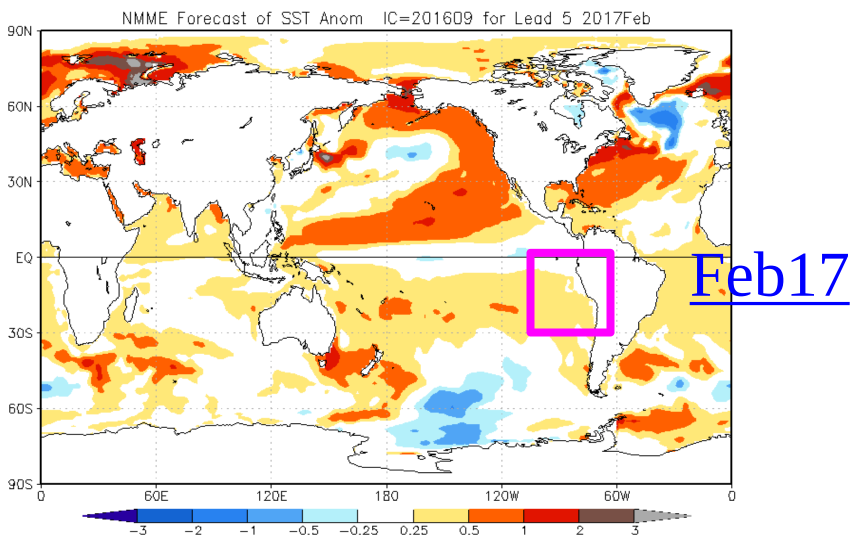
Unsuccessful Prediction of the Coastal SSTA

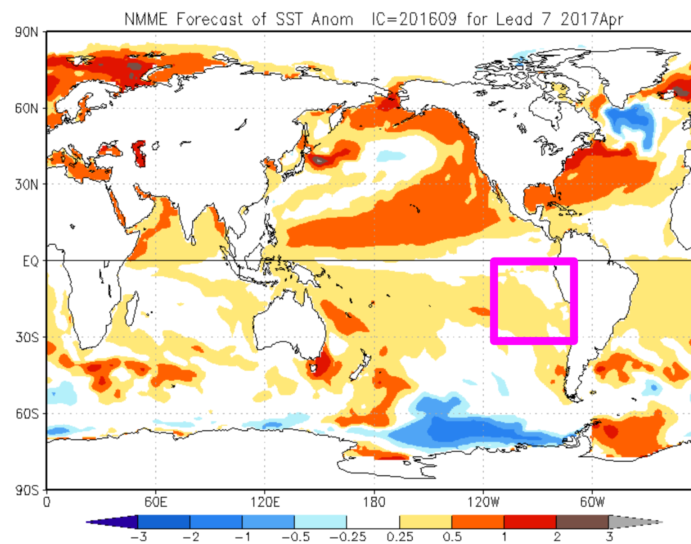
(NMME: IC=Sep2016, Lead 1, 3, 5, and 7 Months)





Dec16



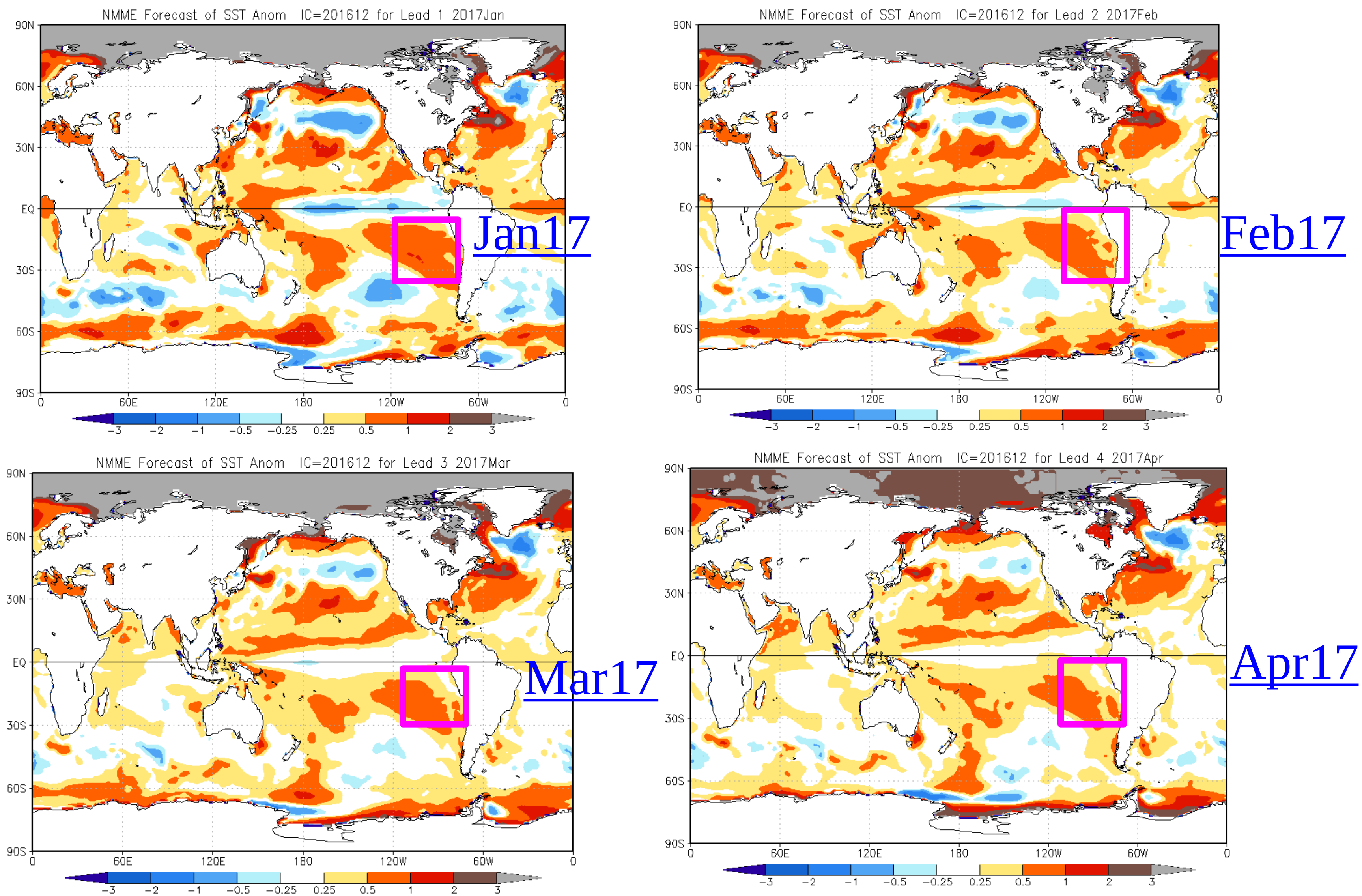


Apr17

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

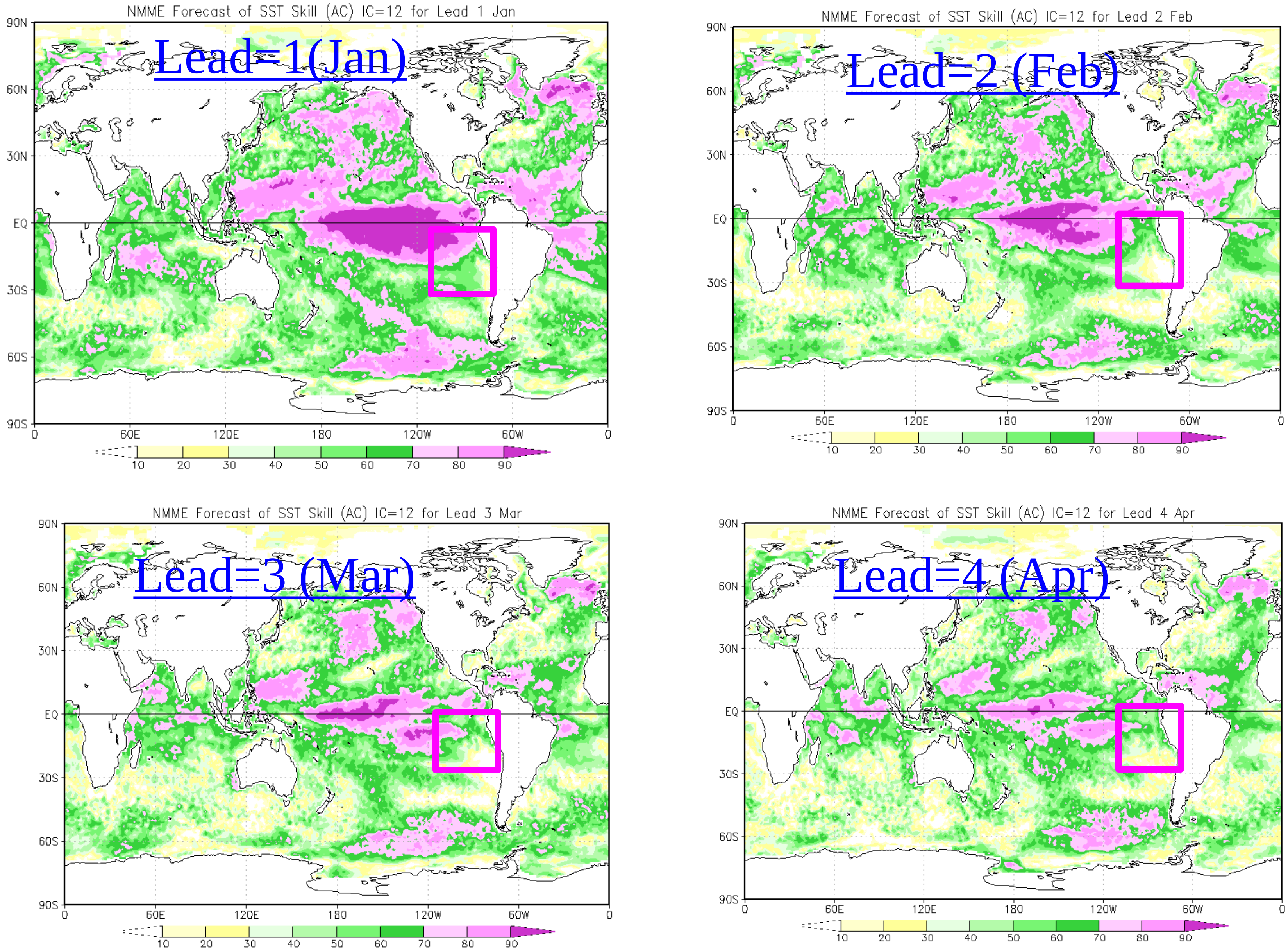
Unsuccessful Prediction of the Coastal SSTA

(NMME: IC=Dec2016, Lead 1-4 Months)



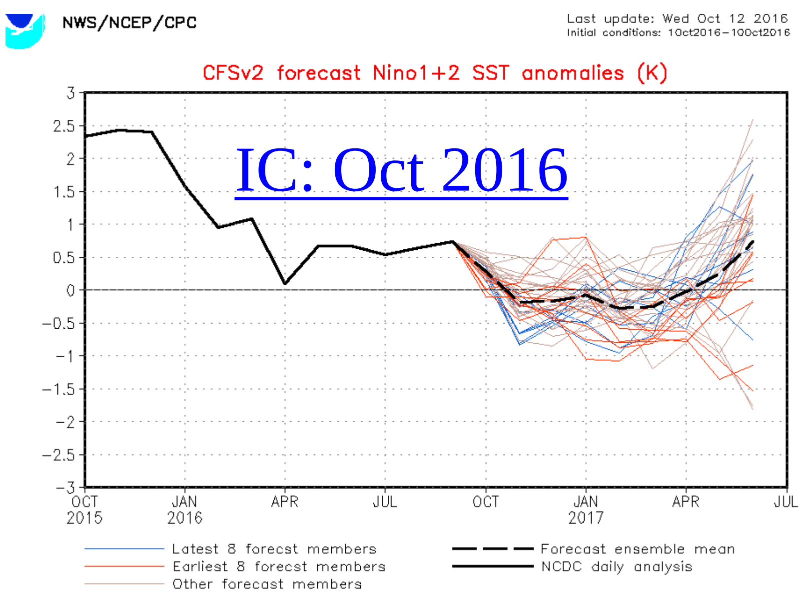
(http://www.cpc.ncep.noaa.gov/products/NMME/archive/)

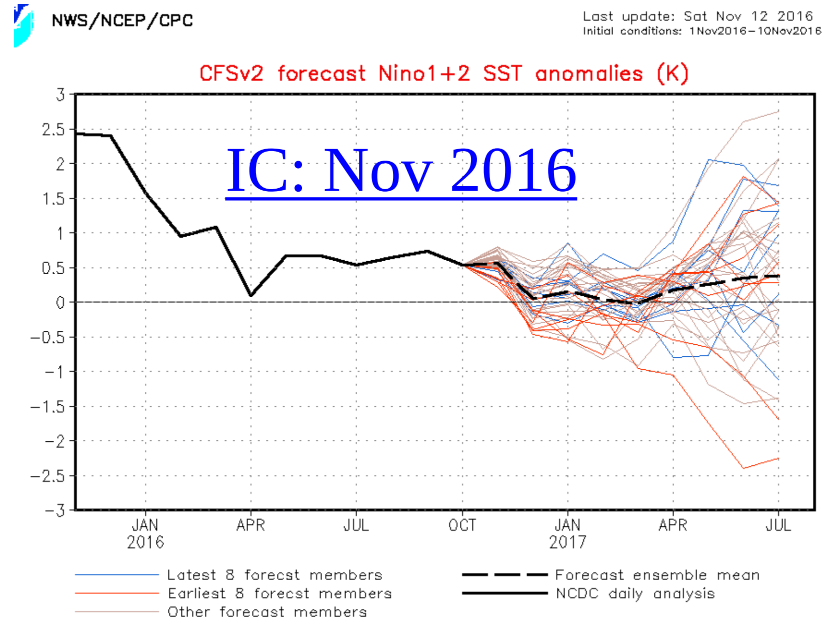
Low Skill of Predicting Coastal SSTA (NMME: AC; IC=Dec)

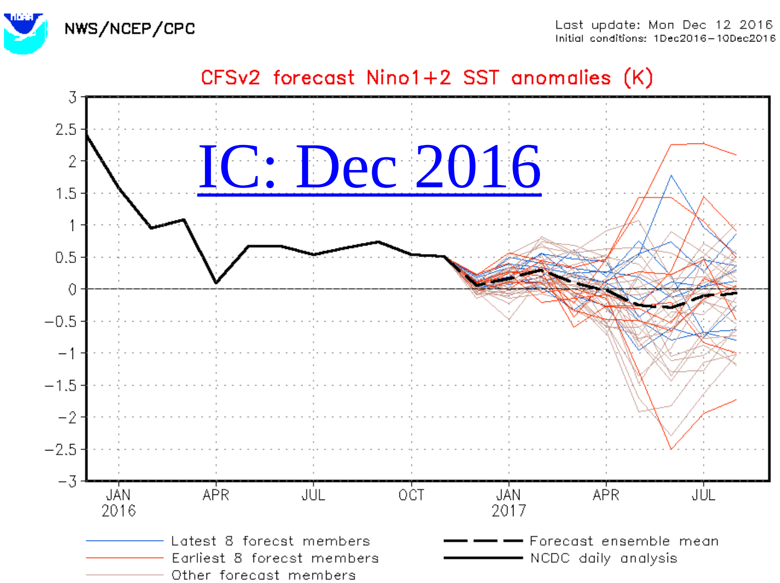


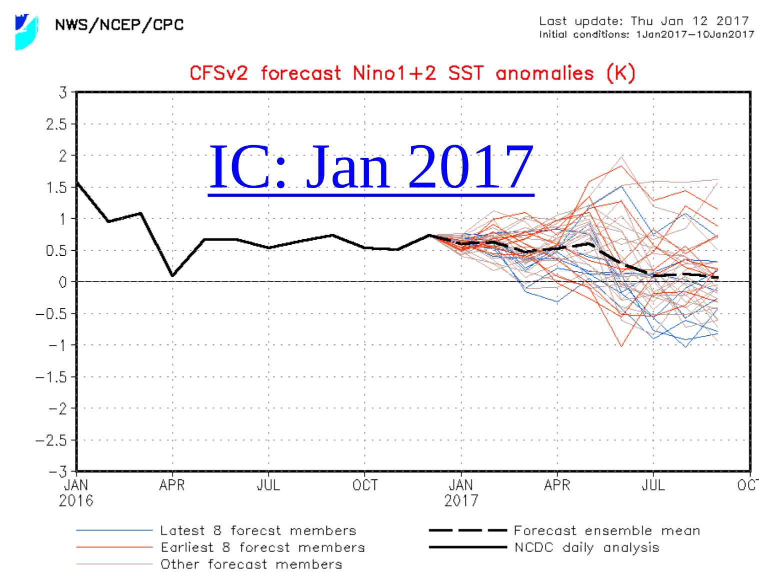
(http://www.cpc.ncep.noaa.gov/products/people/wwang/cfsv2_fcst_history/)

Unsuccessful Prediction of the Coastal SSTA (CFSv2: Nino1+2)

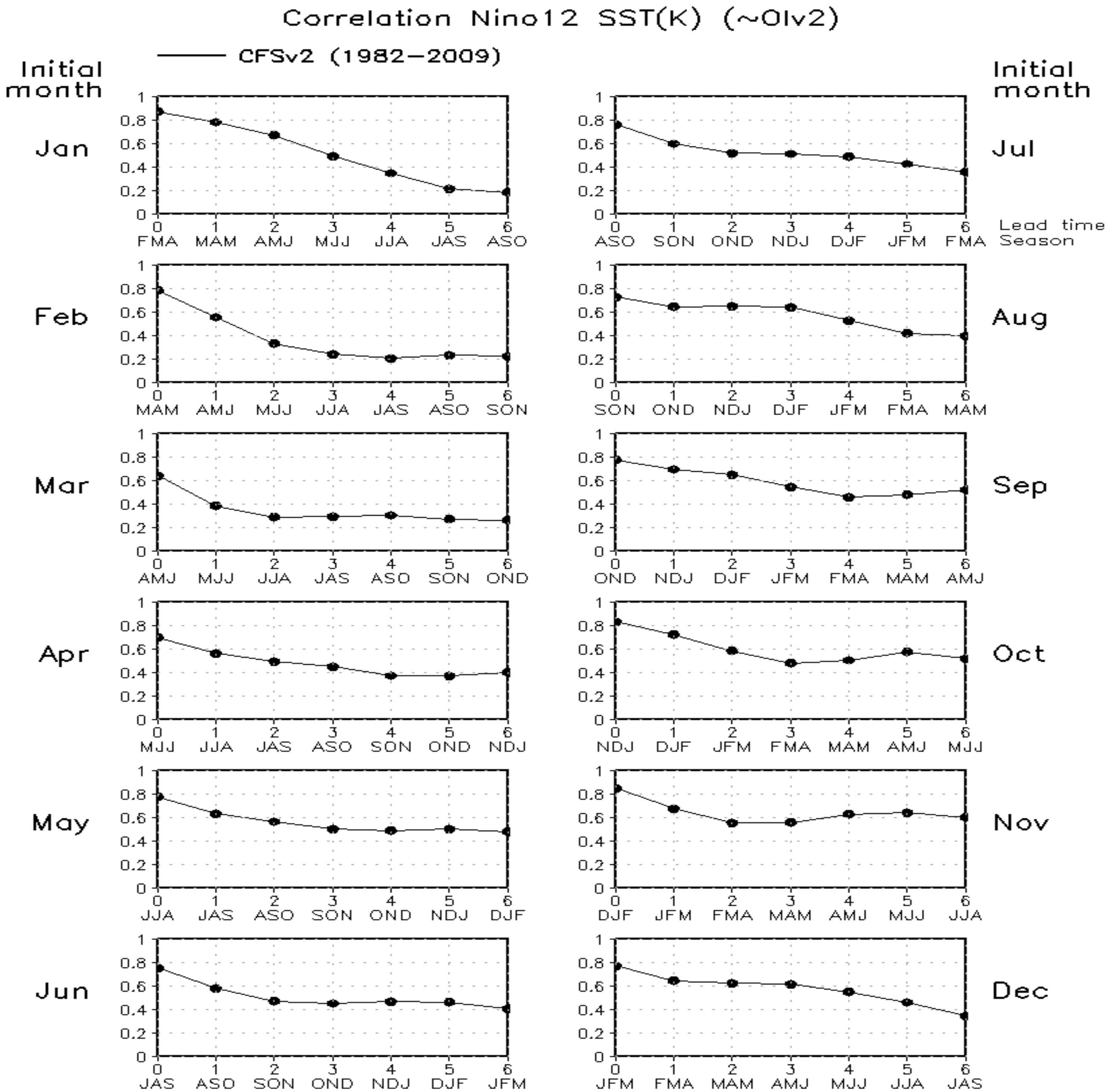








(http://www.cpc.ncep.noaa.gov/products/people/wwang/cfsv2_fcst_history/)

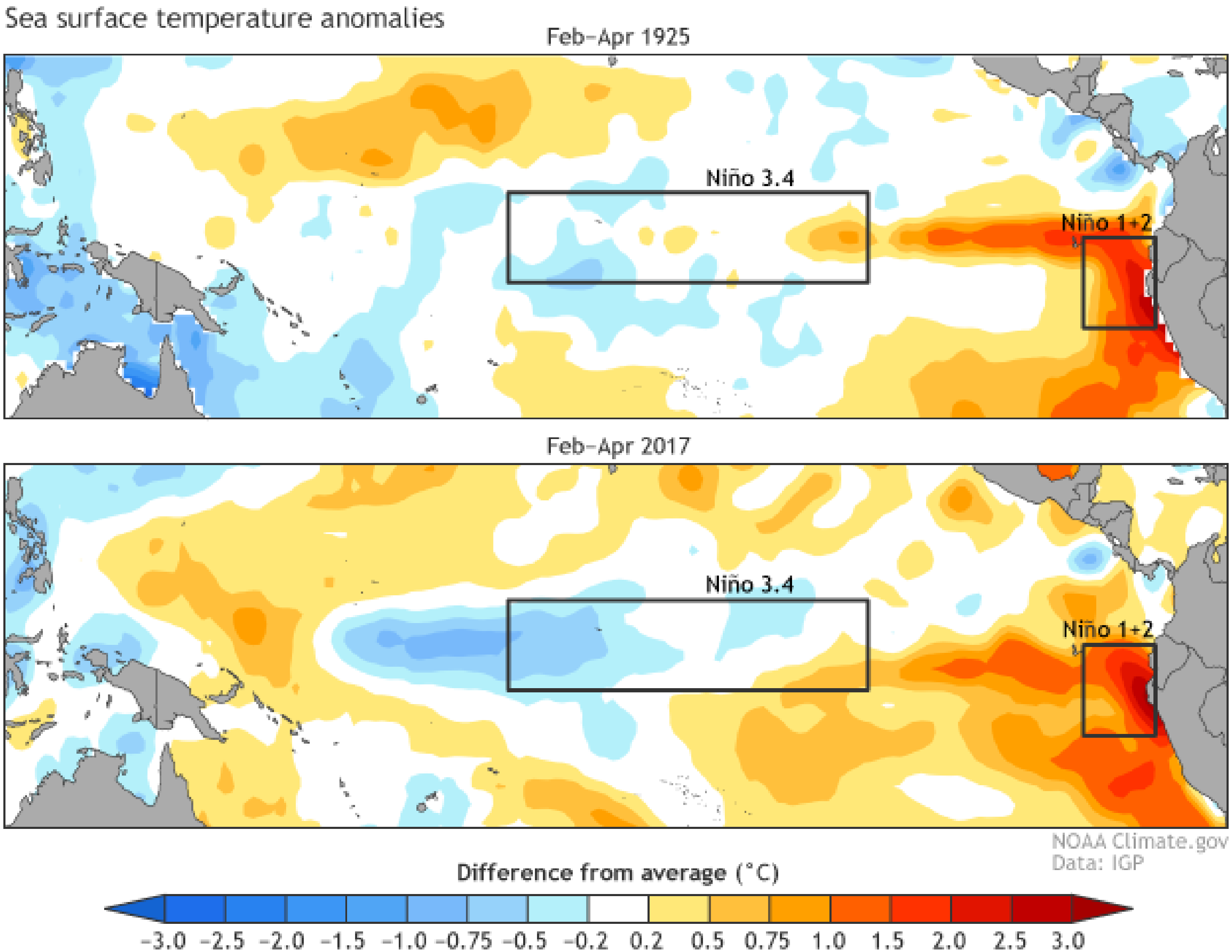


[Low Skill of Predicting Coastal SSTA](#)

(CFSv2: Nino1+2)

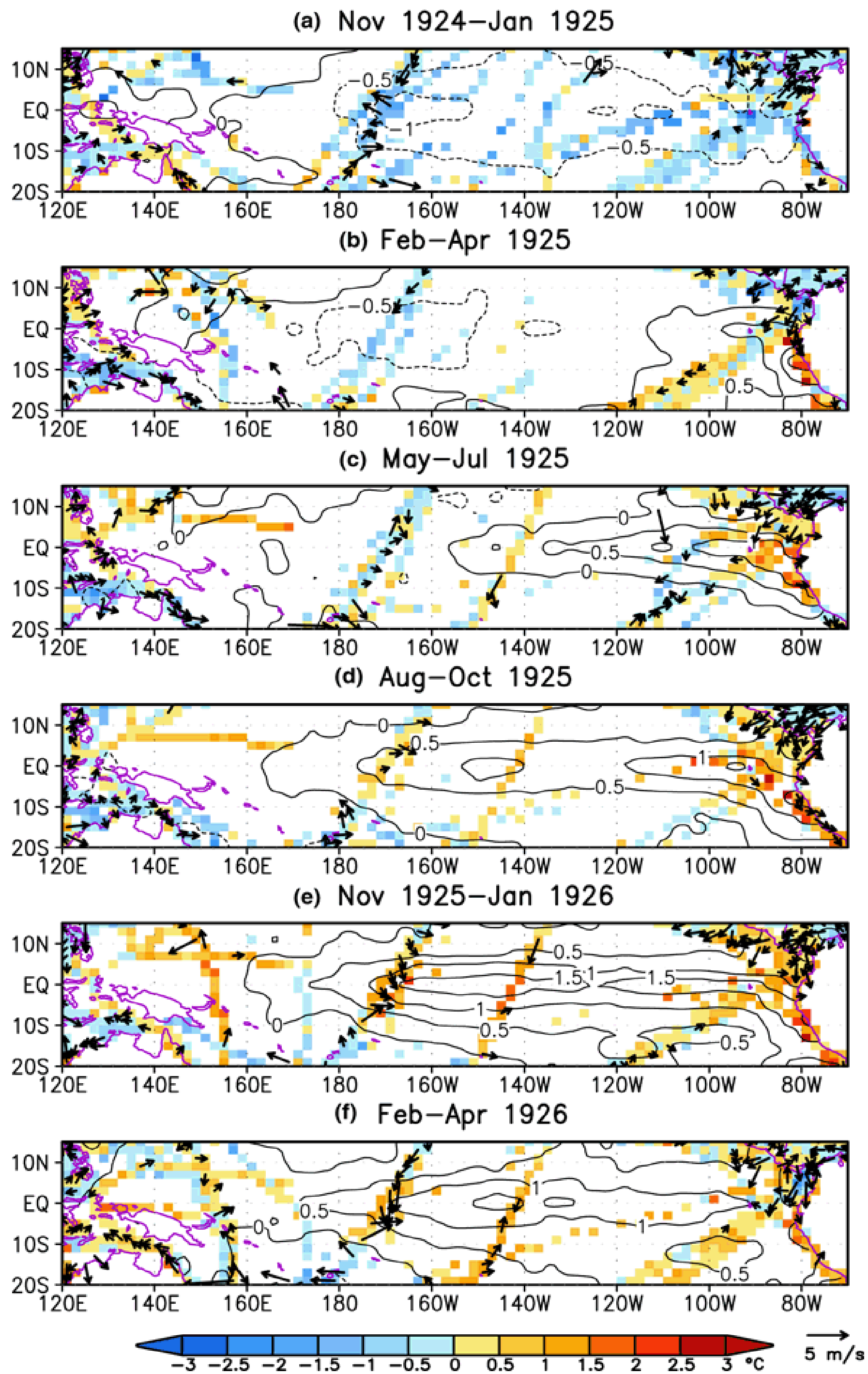
(http://www.cpc.ncep.noaa.gov/products/people/mchen/CFSv2HCST/metrics/corl/CFSv2corl_nino12_ssn.gif

Coastal El Nino in 1925 and 2017



ENSO forecasters in offices getting coffee (Author: Michelle L'Heureux)

(https://www.climate.gov/news-features/blogs/enso/enso-forecasters-offices-getting-coffee)



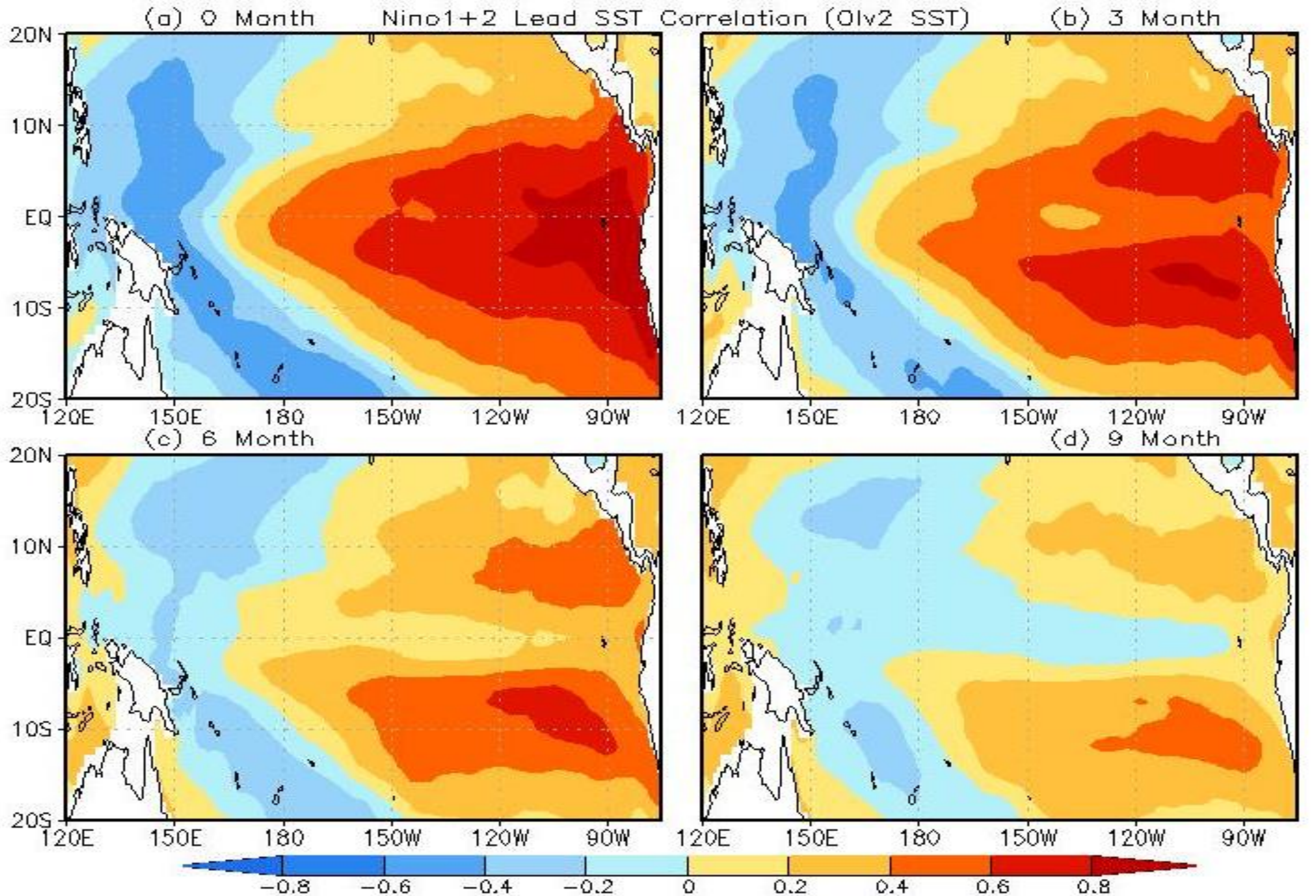
"…… In contrast to the extreme 1982–1983 and 1997–1998 events, this very strong "coastal El Niño" in early 1925 was characterised by warm conditions in the far-eastern Pacific (FEP), but cool conditions elsewhere in the central Pacific.

… downwelling equatorial Kelvin waves had little role in its initiation. Instead, ship data indicate an abrupt onset of strong northerly winds across the equator and the strengthening/weakening of the intertropical convergence zones (ITCZ) south/north of the equator.

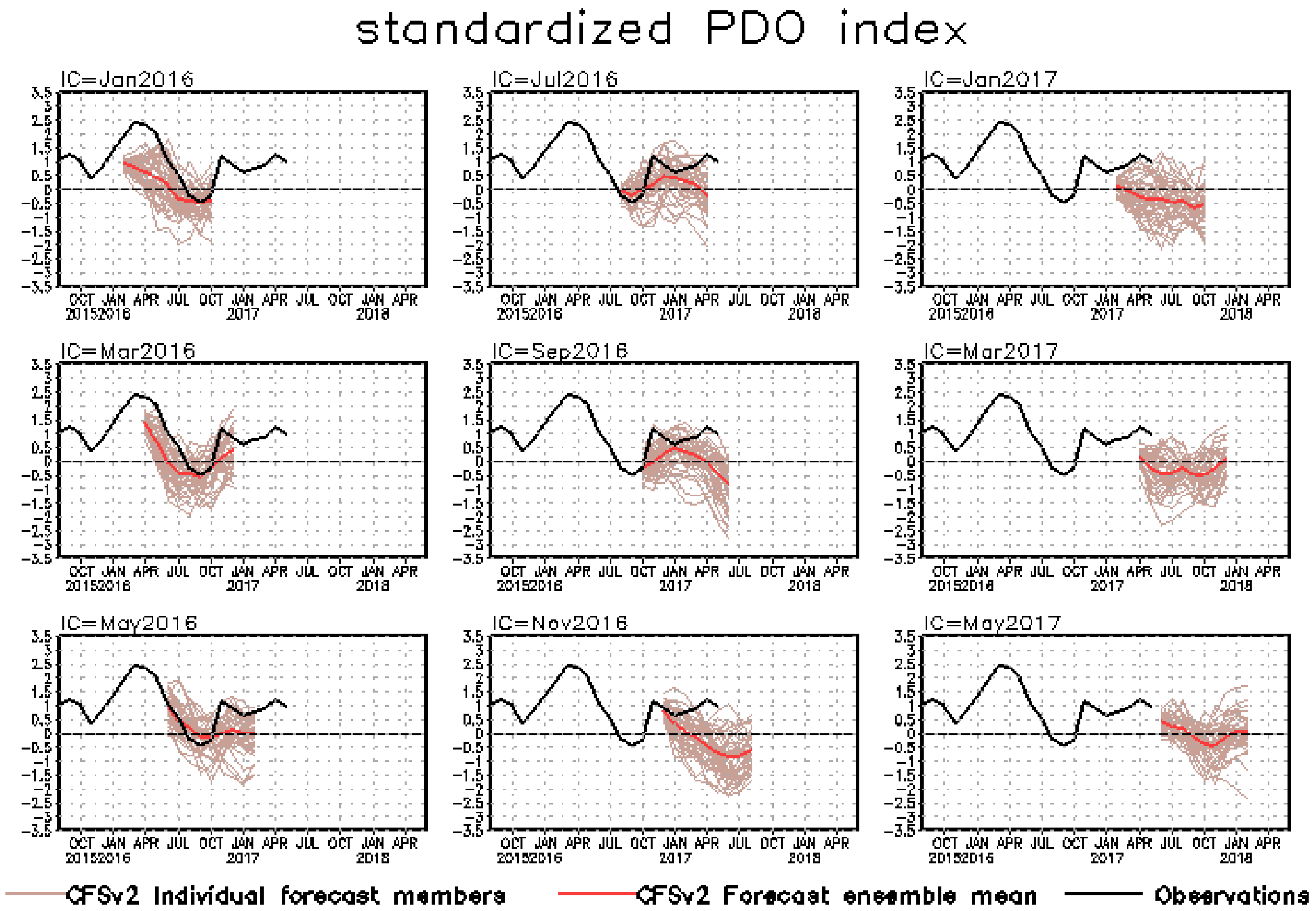
…. In summary, there are two types of El Nino events with very strong impacts in the FEP, both apparently associated with nonlinear convective feedbacks but with very different dynamics: the very strong warm ENSO events like 1982–1983 and 1997–1998, and the very strong "coastal" EN events like 1925."

Fig. 2: Seasonal mean SST (°C) from ICOADS (colors, shown only for at least three observations per grid cell) and surface wind vectors anomalies (shown only for at least ten observations per grid cell and a minimum magnitude of 1 m/s). Also shown is the SST anomaly reconstruction HadISST 1.1 (contours; interval: 0.5 °C, slight smoothing). The averaging periods are indicated in each panel. *(Takahashi, K. and Martínez, A. G., 2017: The very strong coastal El Niño in 1925 in the far-eastern Pacific. Climate Dynamics, http://doi.org/10.1007/s00382-017-3702-1).*

Statistically, coastal El Nino doesn't lead to canonical El Nino



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].

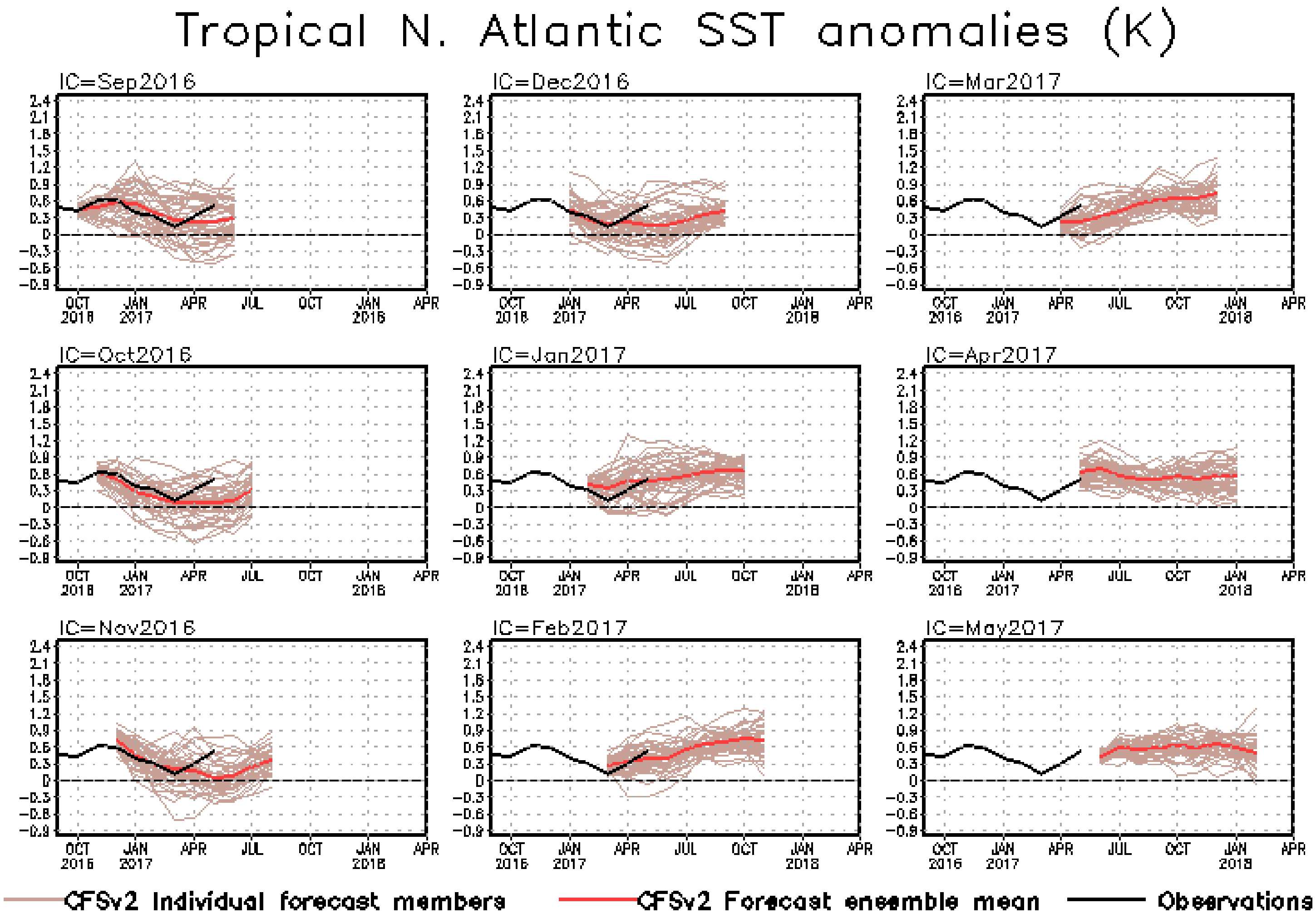
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

- CFSv2 predicts a neutral phase of PDO in 2017.

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

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

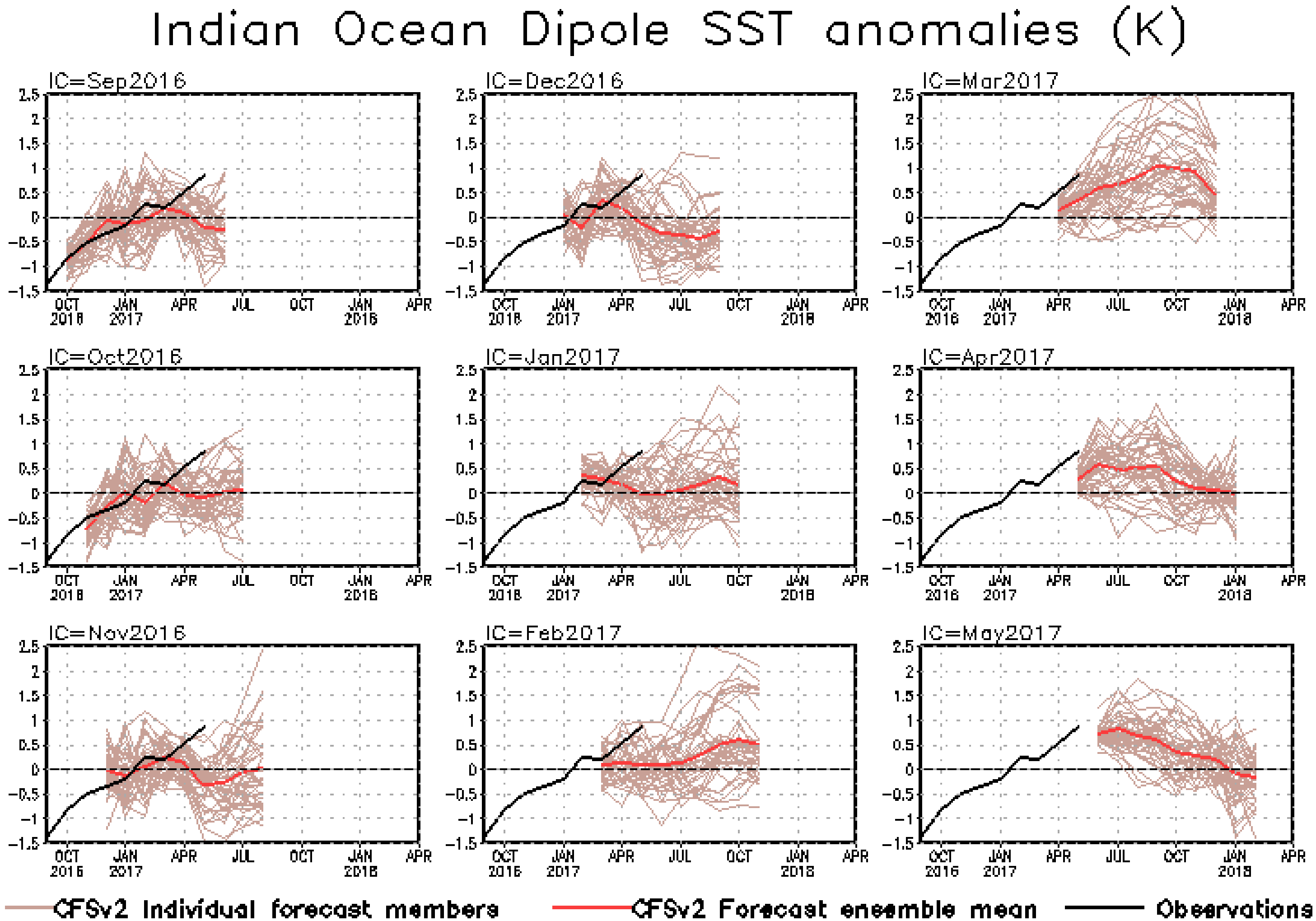
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].



- **Latest CFSv2 predictions call persistently above normal SSTA in the tropical N. Atlantic in 2017.**

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

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

SETIO = SST anomaly in [90ºE-110ºE, 10ºS-0]

WTIO = SST anomaly in [50ºE-70ºE, 10ºS-10ºN]

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.

Acknowledgements

- Drs. Caihong Wen, Arun Kumar, and Yan Xue: 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: Supplied Sea ice slides
- Dr. Wanqiu Wang: Provided the plots about Nino1+2 prediction skills and forecasts
- Dr. Kathleen Dohan: updated OSCAR current

Backup Slides

Global Sea Surface Salinity (SSS)

Anomaly for May 2017

- NOTE: Since Aquarius terminated operations, the blended SSS analysis is from in situ and SMOS only from June 2015. Please report to us any suspicious data issues!
- The negative SSS anomaly is in most area between 40°N and 60°N of the N. Pacific Ocean with the increase of the freshwater flux in these region. The positive SSS anomaly between 20°S to 10°N in most areas of the Indian Ocean continues, especially in the central and west basin. However, the precipitation increases in this region. Therefore, such salinity increase is likely due to the ocean currents/entrainments and/or mixing. The SSS anomaly in the north region of Bay of Bengal is still negative. The SSS in the north and east region of Arabian Sea becomes fresher.

- **Data used**

  SSS :

  Blended Analysis of Surface Salinity (BASS) V0.Y

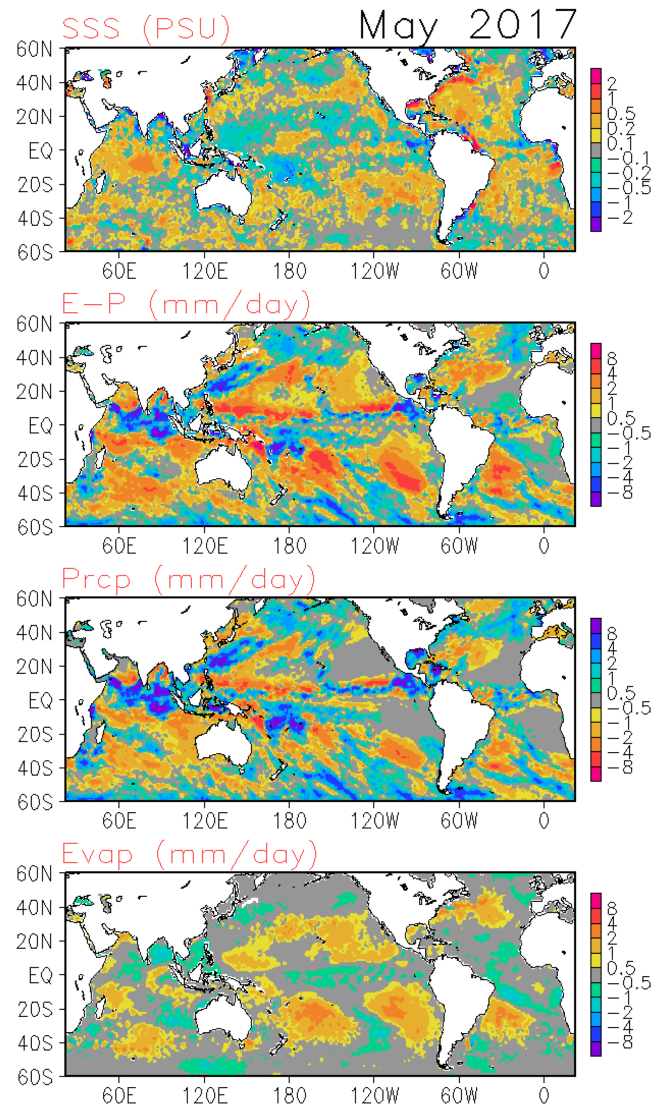
  (a CPC-NESDIS/NODC-NESDIS/STAR joint effort)

  (Xie et al. 2014)

  ftp.cpc.ncep.noaa.gov/precip/BASS

  Precipitation: CMORPH adjusted satellite precipitation estimates

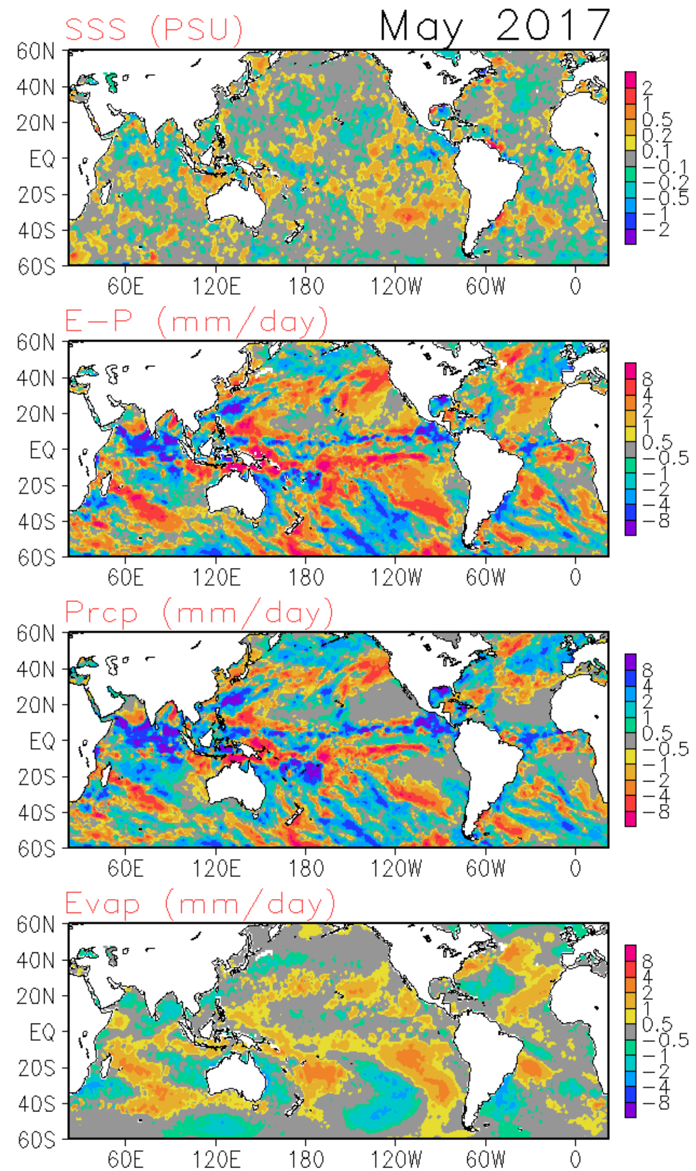
  Evaporation: CFS Reanalysis



Global Sea Surface Salinity (SSS)

Tendency for May 2017

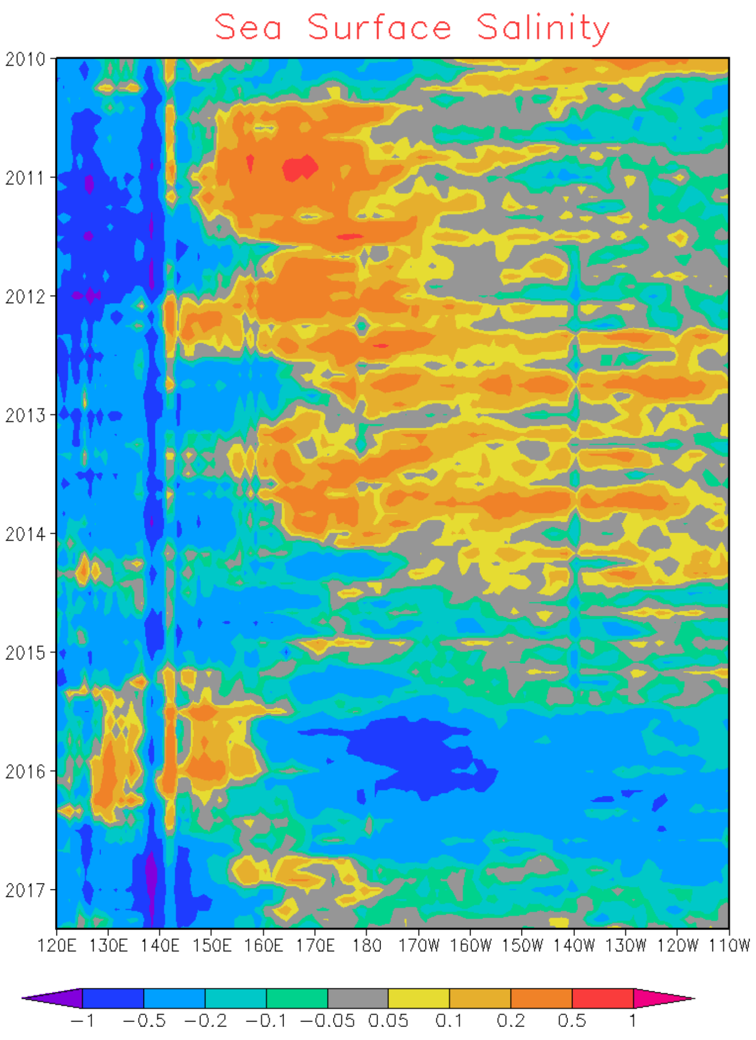
Compared with last month, the salinity between 20°N to 40°N in the N. Pacific ocean and in the eastern of N. Atlantic Ocean shows decrease. The SSS decrease in the eastern N. Atlantic Ocean is probably caused by the increase of precipitation. While, the SSS decrease in the N. Pacific ocean is likely due to the oceanic advection since the freshwater flux is decrease in this region. The SSS increases in the north of Bay of Bengal and decreases in the north of Arabian Sea.



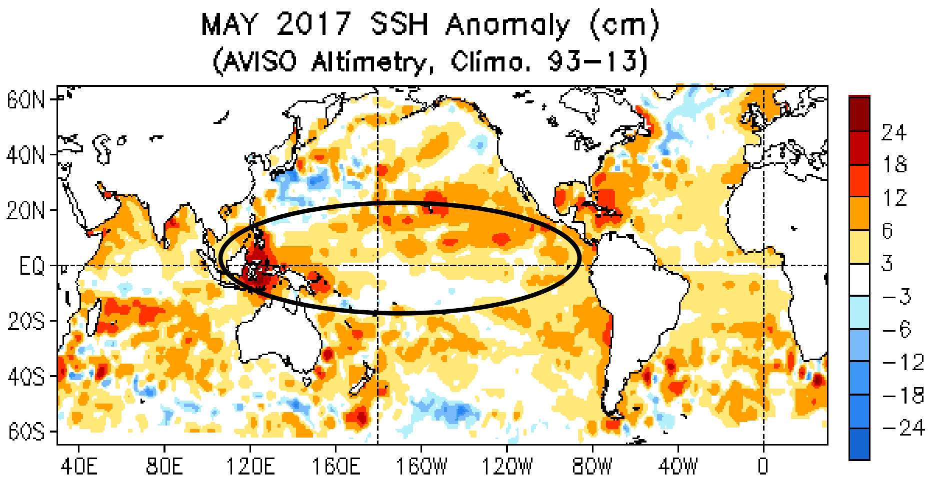
Global Sea Surface Salinity (SSS)
Anomaly Evolution over Equatorial Pacific

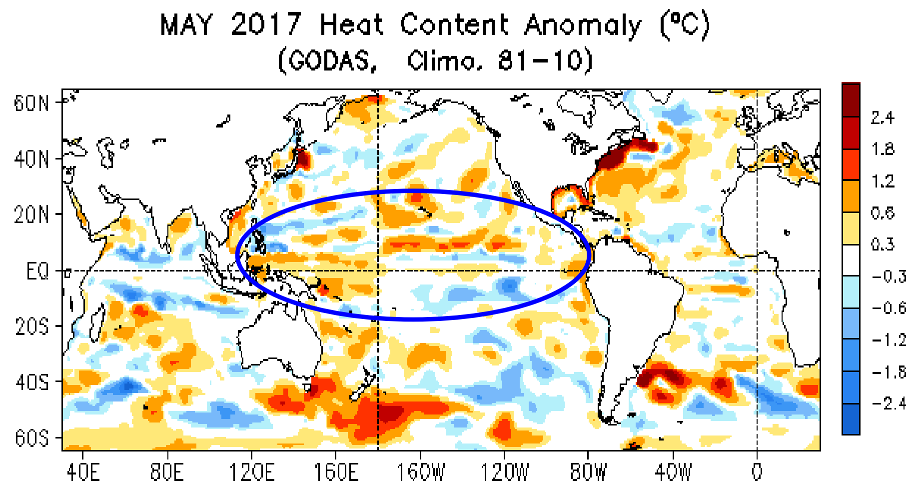
- Hovemoller diagram for equatorial SSS anomaly **(10ºS-10ºN);**

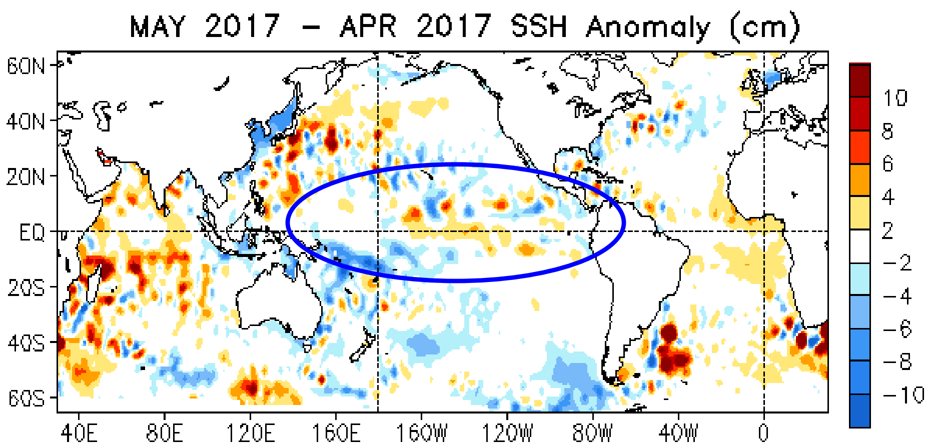
- In the western equatorial Pacific Ocean, from 120°E to 150°E, the negative SSS signal continues. At the meantime, the positive SSS anomaly in the central equatorial Pacific region between 155°E to 170°W is changing to neutral condition this month. There is no significant SSS change east of 170°W.

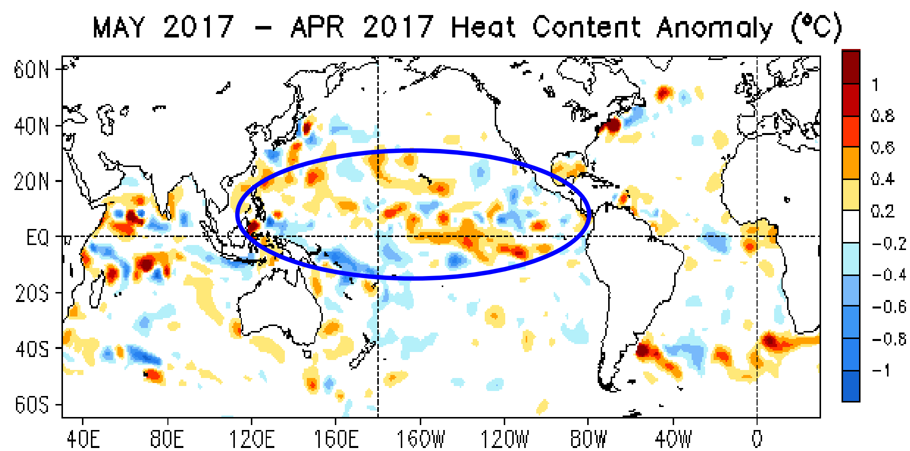


Global SSH and HC300 Anomaly & Anomaly Tendency









- The SSHA pattern was overall consistent with HC300A pattern, but there were many detailed differences between HC300A and SSHA.
- Overall, both SSHA and HC300A were small in the tropical Pacific, consisting with neutral phase of ENSO.

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) has been small since Dec 2016.

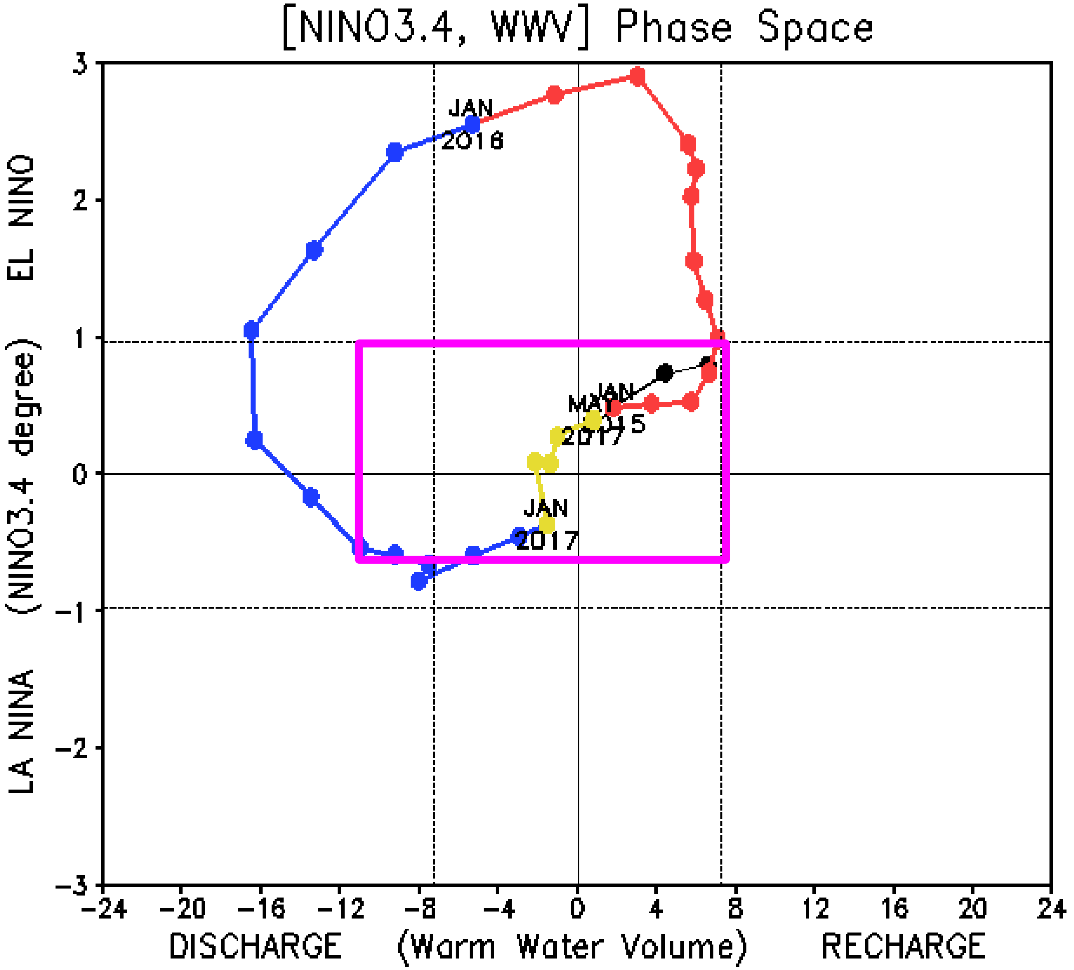
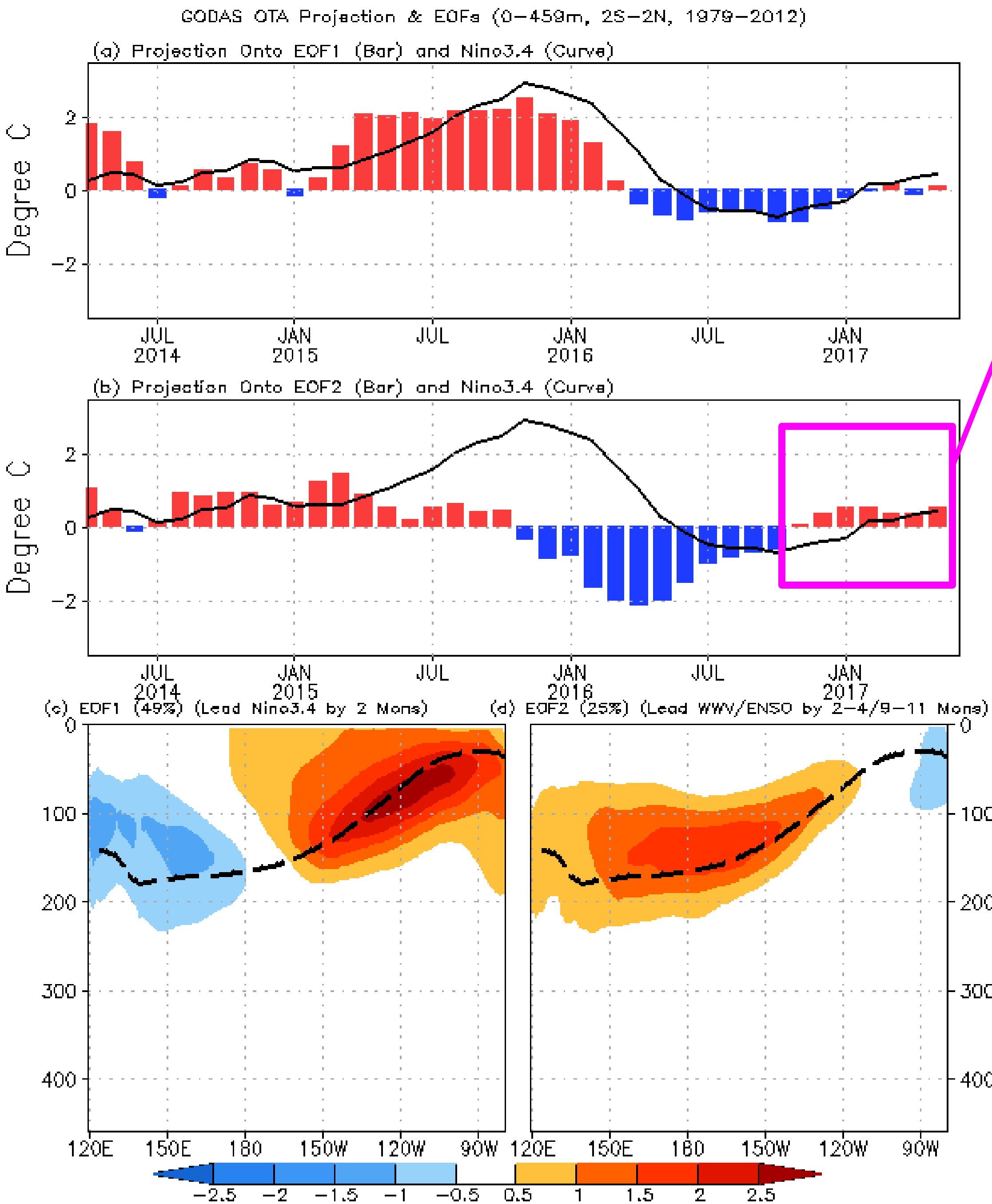


Fig. P3. Phase diagram of Warm Water Volume (WWV) and NINO 3.4 SST anomalies. WWV is the average of depth of 20°C in [120°E-80°W, 5°S-5°N] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



Equatorial subsurface ocean temperature monitoring: Right now, ENSO was in recharge phase since Nov 2016.

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).

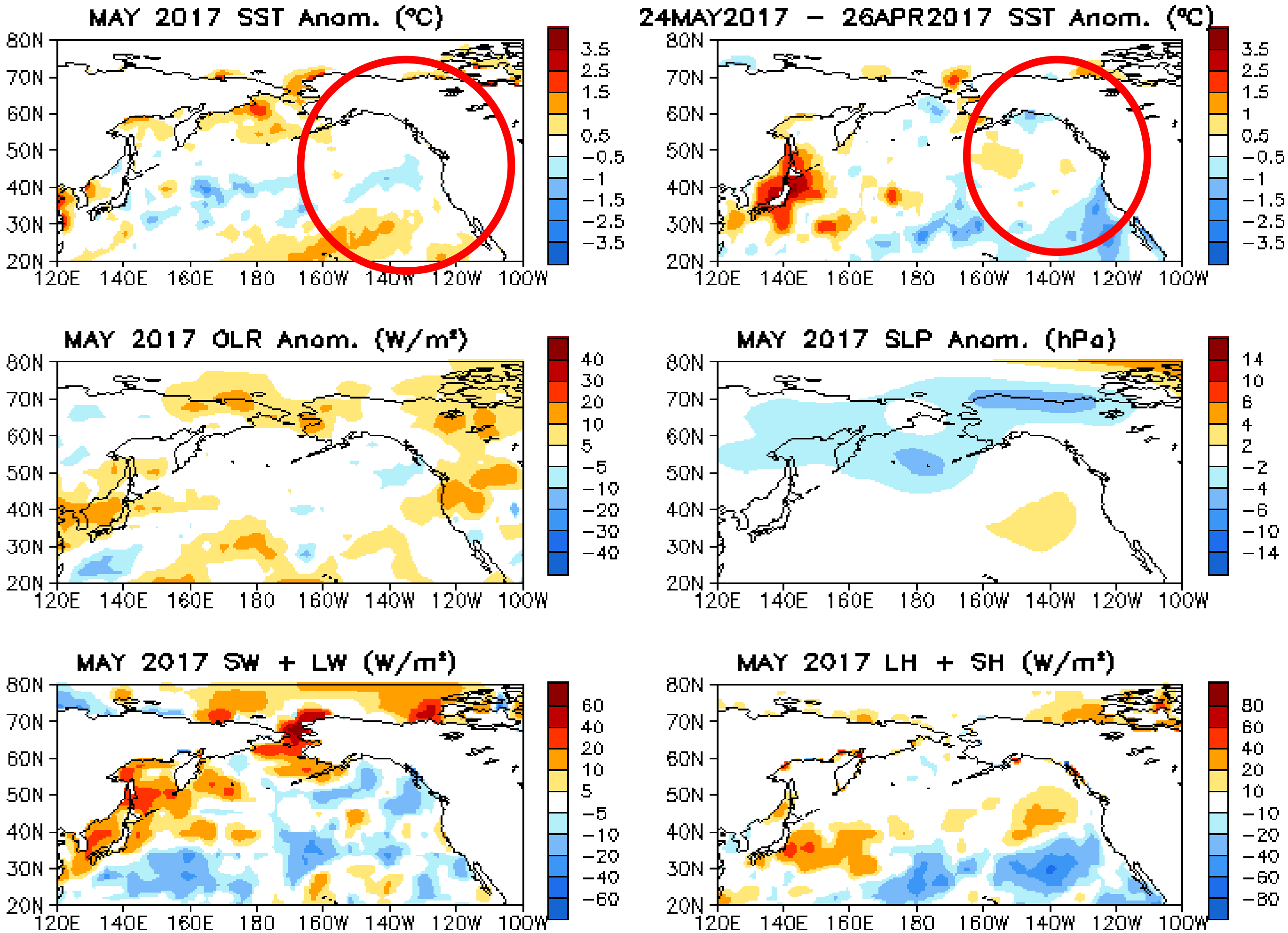
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

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*.

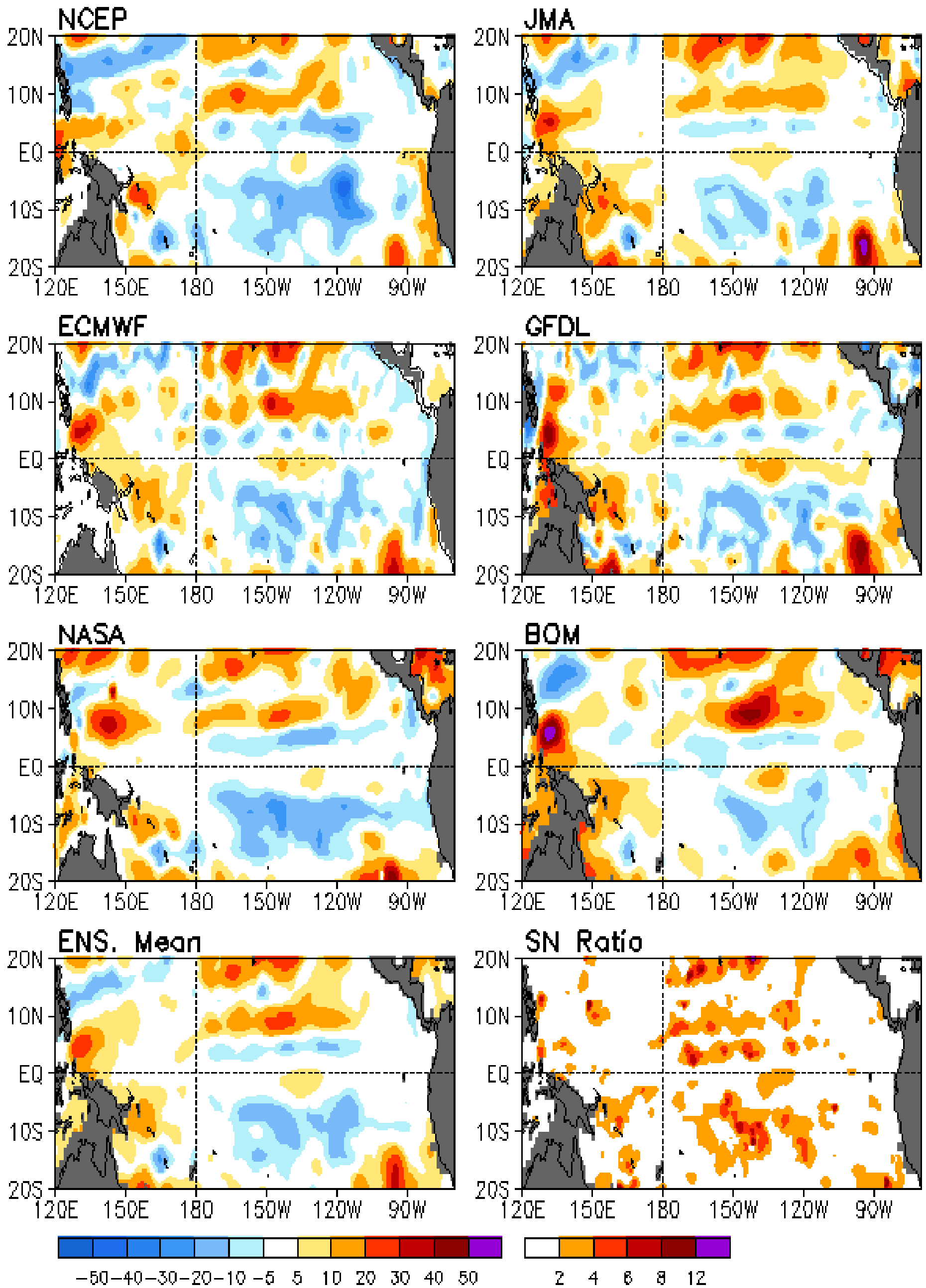
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx



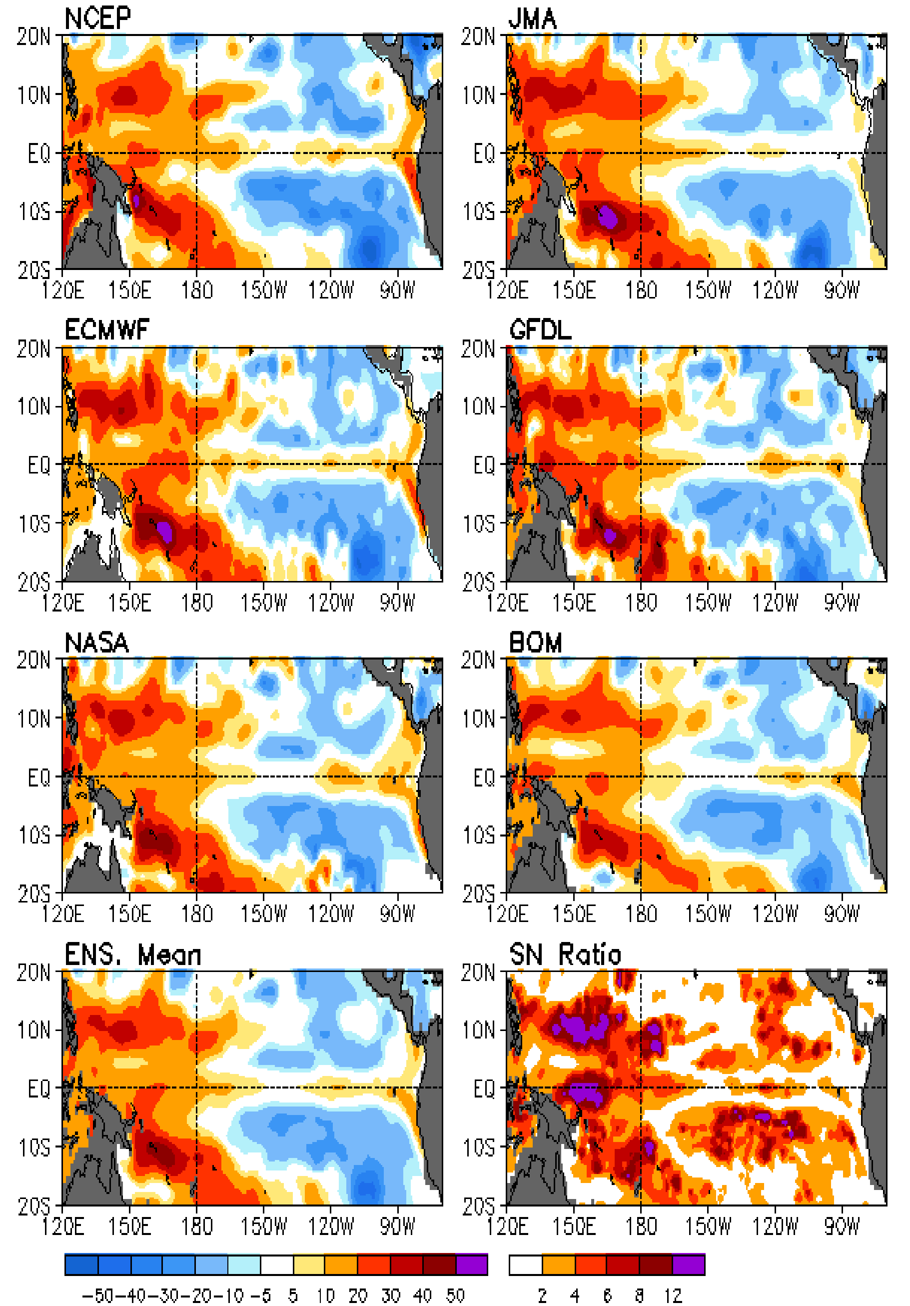
- Positive SSTA associated with so called "Blob" in the NE Pacific disappeared.

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.

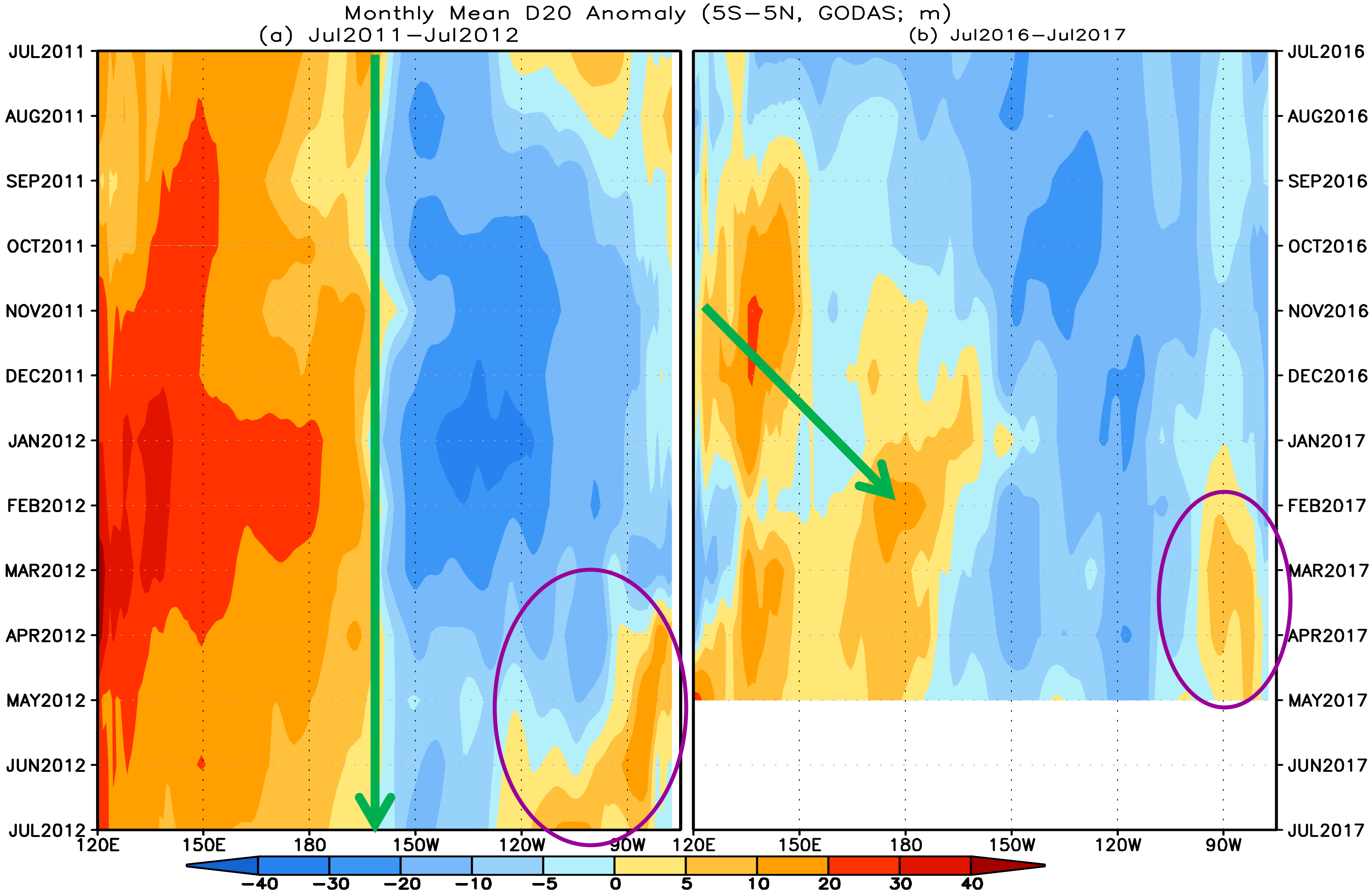
Anomalous Depth (m) of 20C Isotherm: MAY 2017

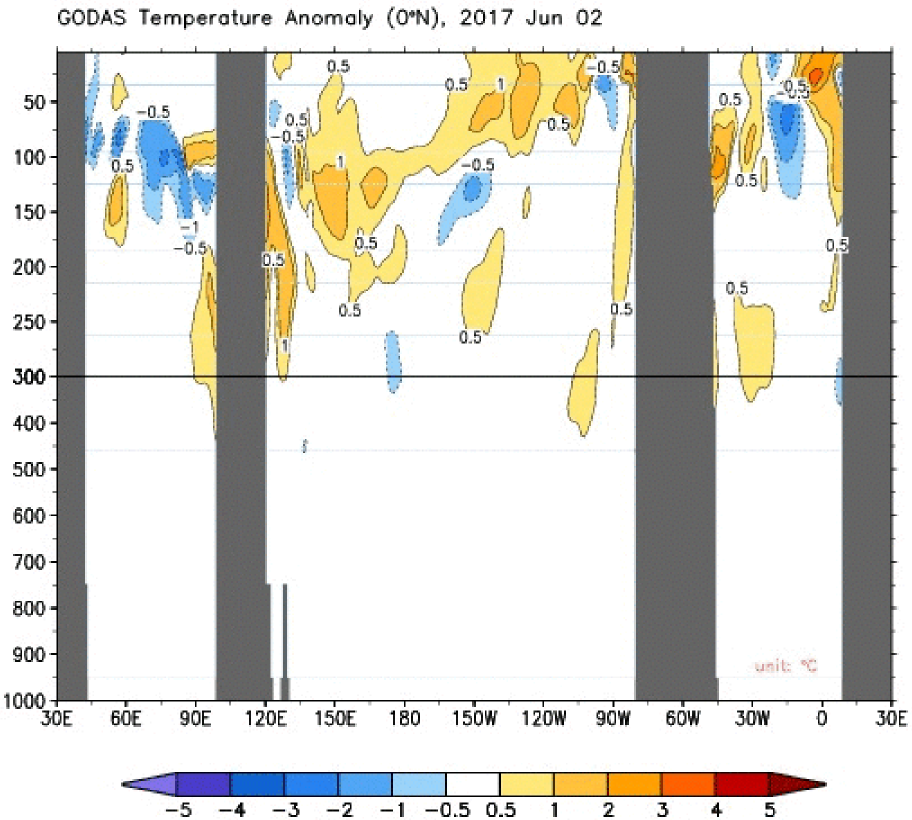


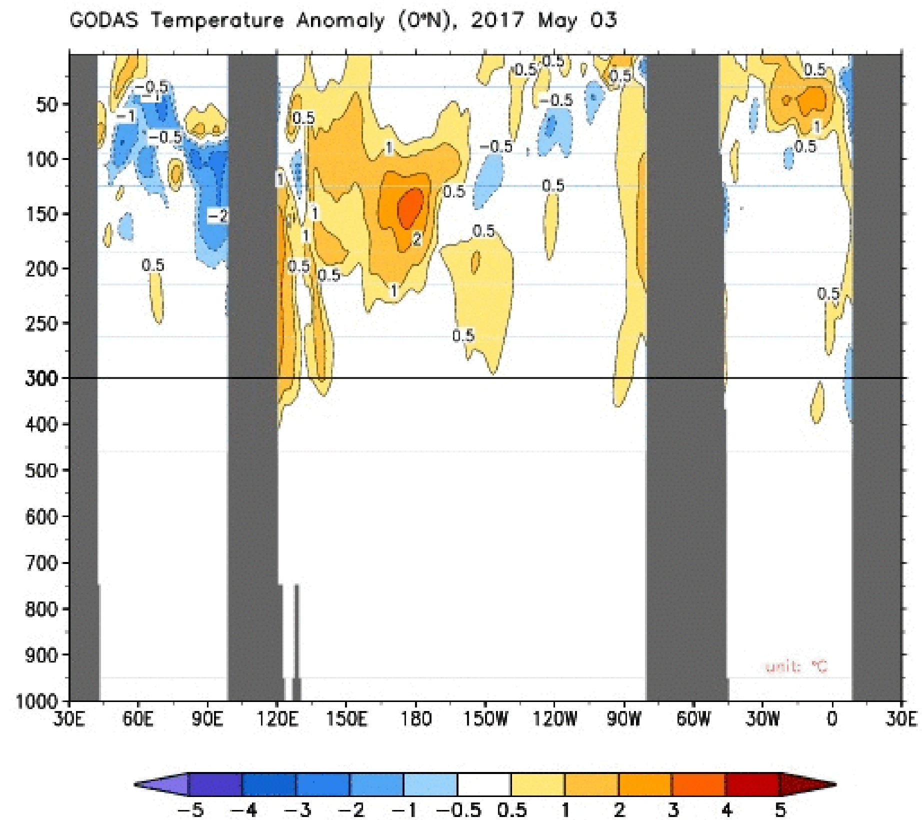
Anomalous Depth (m) of 20C Isotherm: MAY 2012

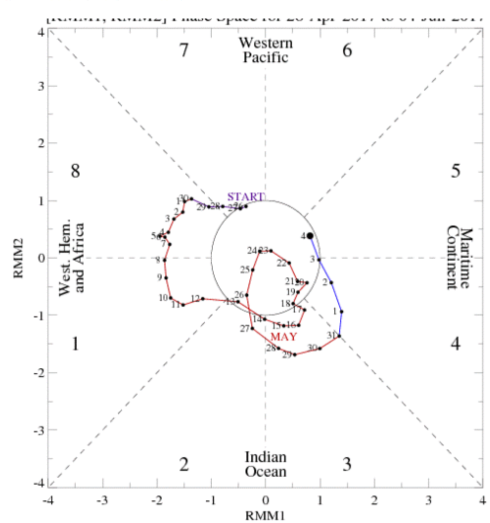


Differences of D20 Evolution in 2011/12 and 2016/17




GODAS Temperature Anomaly (0°N), 2017 Jun 02
unit: °C
30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0 30E
−5 −4 −3 −2 −1 −0.5 0.5 1 2 3 4 5


GODAS Temperature Anomaly (0°N), 2017 May 03
unit: °C
30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0 30E
−5 −4 −3 −2 −1 −0.5 0.5 1 2 3 4 5


Western Pacific
West. Hem. and Africa
Maritime Continent
Indian Ocean
START
MAY
RMM1
RMM2

Data Sources and References

- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **NCEP CDAS winds, surface radiation and heat fluxes**
- **NESDIS Outgoing Long-wave Radiation**
- **NDBC TAO data (http://tao.ndbc.noaa.gov)**
- **PMEL TAO equatorial temperature analysis**
- **NCEP's Global Ocean Data Assimilation System temperature, heat content, currents (Behringer and Xue 2004)**
- **Aviso Altimetry Sea Surface Height**
- **Ocean Surface Current Analyses – Realtime (OSCAR)**

Please send your comments and suggestions to Yan.Xue@noaa.gov. Thanks!