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

Prepared by

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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

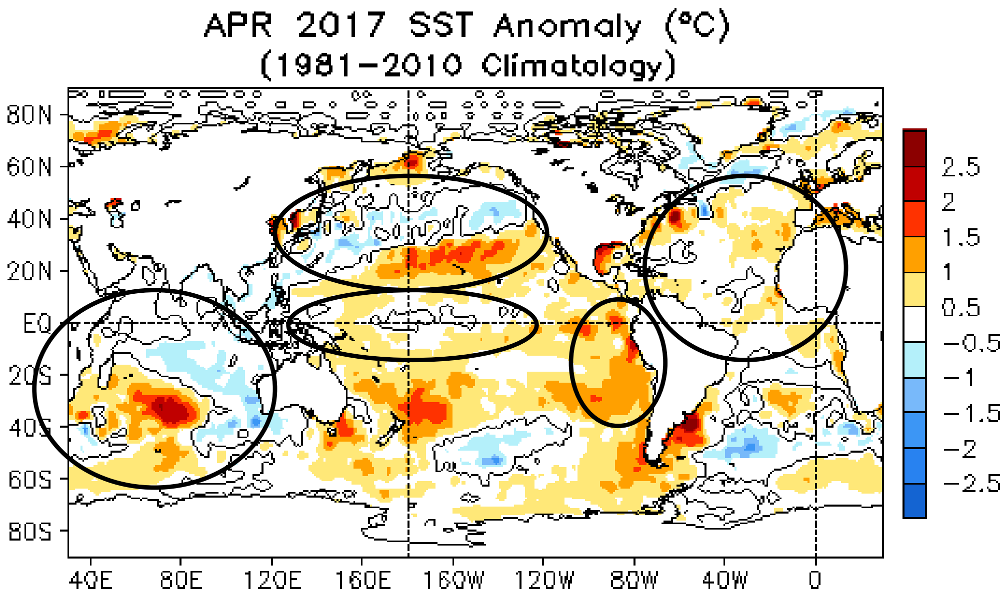
- **Overview**
- **Recent highlights**
  - ❖ **Pacific/Arctic Ocean**
  - ❖ **Indian Ocean**
  - ❖ **Atlantic Ocean**
- **Global SST Predictions**
  - ❖ **Will an El Nino emerge in 2017-18?**
  - ❖ **Which is the strongest El Nino so far, 1997/98 or 2015/16?**

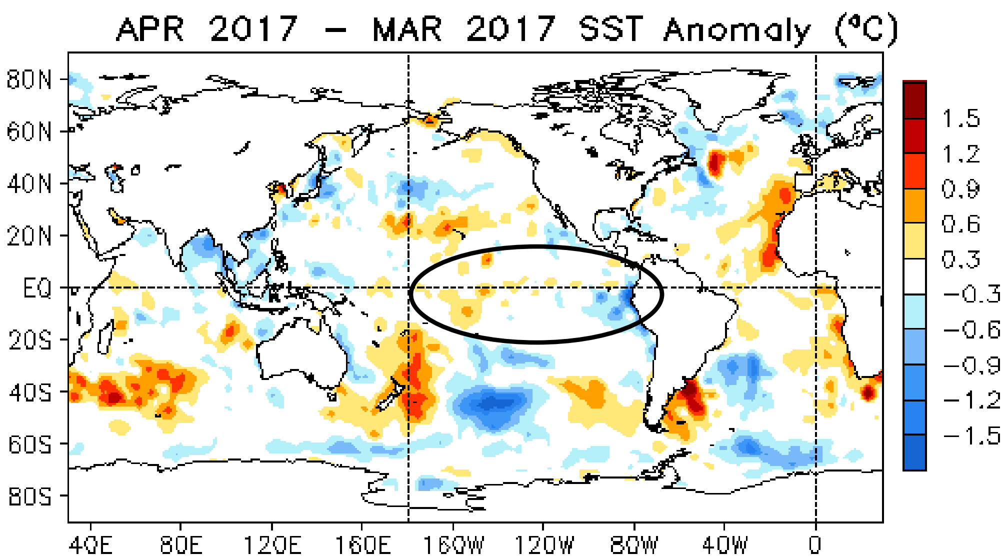
Overview

- **Pacific Ocean**
  - **NOAA "ENSO Diagnostic Discussion" on 11 May 2017 indicated *"ENSO-neutral and El Niño are nearly equally favored during the Northern Hemisphere summer and fall 2017."***
  - **Positive SSTAs expanded westward with NINO3.4=0.30^{o}C in Apr 2017.**
  - **Subsurface ocean temperature anomalies were positive in the west and east, while negative in the between along the thermocline in the equatorial Pacific in Apr 2017.**
  - **Positive phase of PDO has persisted for 6 months with PDOI=1.2 in Apr 2017.**
- **Indian Ocean**
  - **SSTAs were near average in the tropical, and large positive in the SW Indian Ocean in Apr 2017.**
- **Atlantic Ocean**
  - **NAO has been in positive phase since Dec 2016 with NAOI=1.74 in Apr 2017, and SSTAs were mainly positive, especially in the middle latitudes of N. Atlantic.**

Global Oceans

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





- Small SSTAs presented in the central tropical Pacific associated with ENSO neutral, while strong positive SSTAs were observed in the Southern American Pacific coast connected with coast El Nino.

- SSTAs in N Pacific were associated with positive phase of PDO.

- SSTAs were mostly positive in N. Atlantic.

- In the Southern Indian Ocean, SSTAs were positive in the SW and negative in NE.

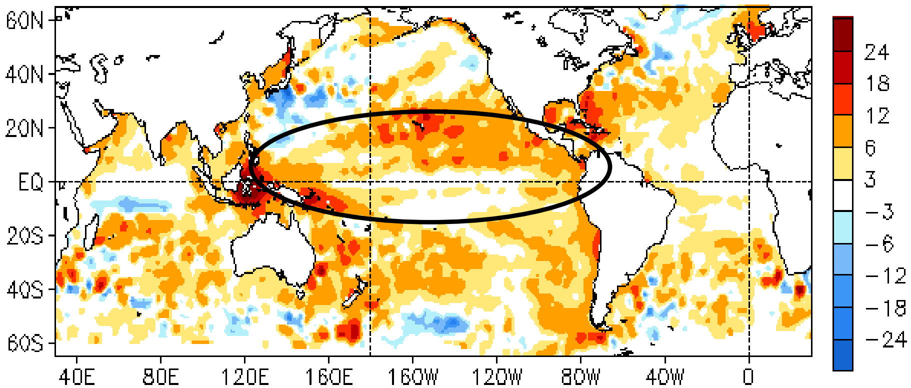
- Positive SSTA tendencies in the central equatorial Pacific and negative SSTA tendencies in the American coast were observed, implying westward propagation of positive SSTAs.

- Both negative and positive SSTA tendencies were observed in S. Oceans.

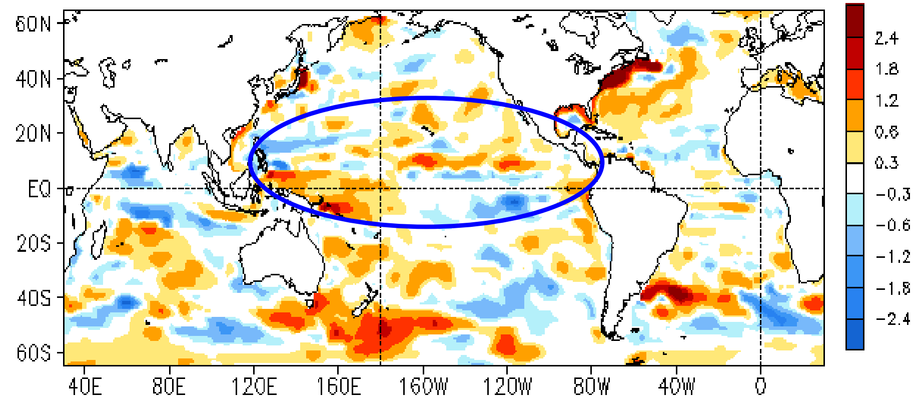
Fig. G1. Sea surface temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Global SSH and HC300 Anomaly & Anomaly Tendency

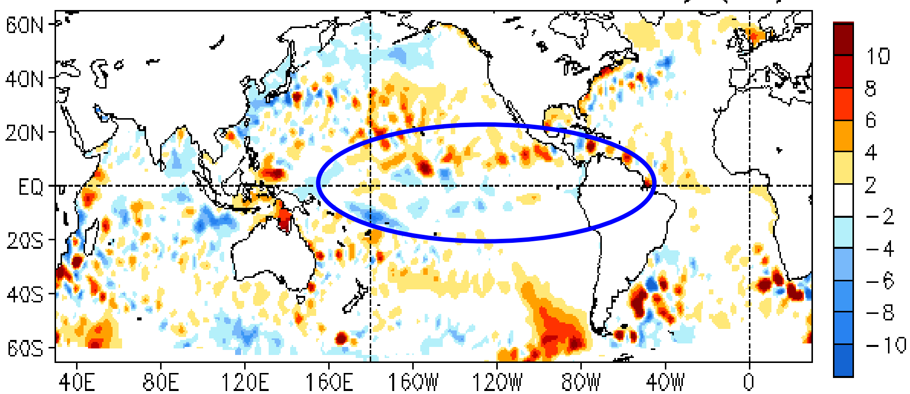
APR 2017 SSH Anomaly (cm)
(AVISO Altimetry, Climo. 93−13)



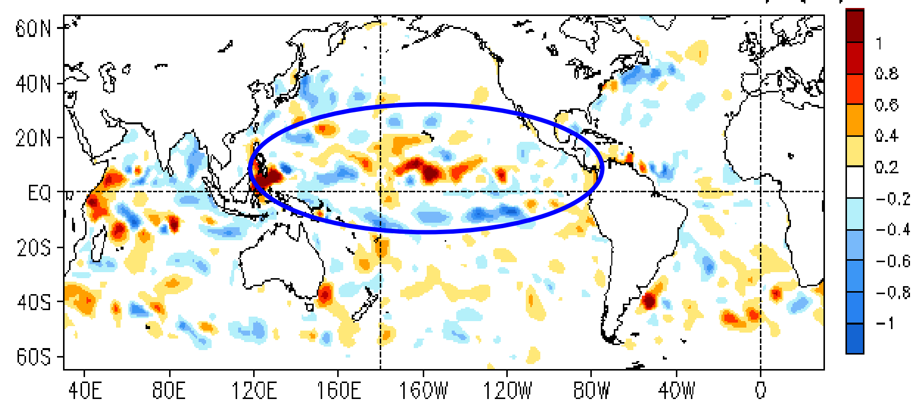
APR 2017 Heat Content Anomaly (°C)
(GODAS, Climo. 81−10)



APR 2017 − MAR 2017 SSH Anomaly (cm)

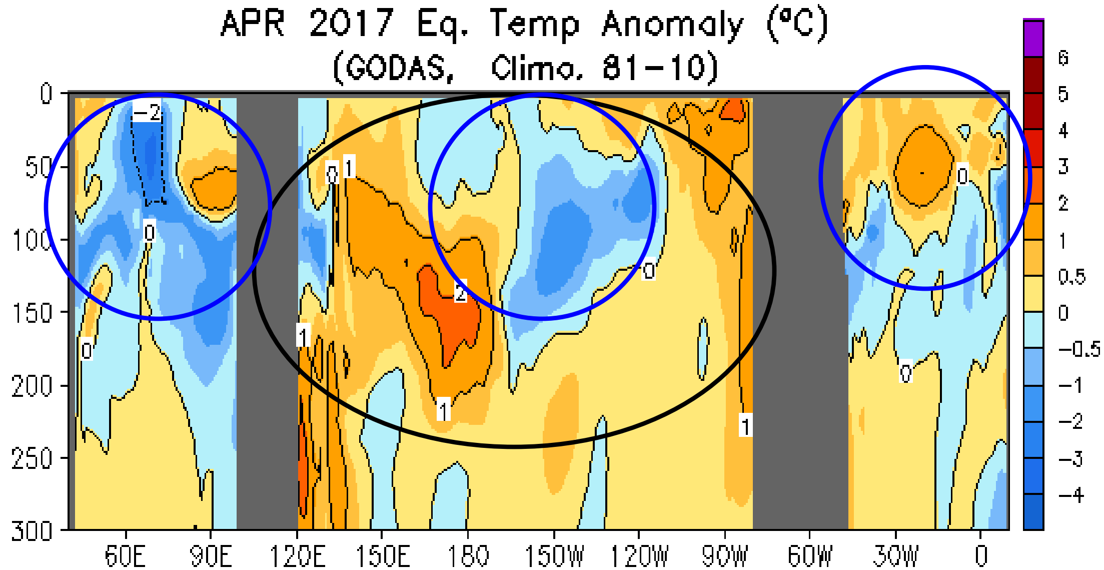


APR 2017 − MAR 2017 Heat Content Anomaly (°C)

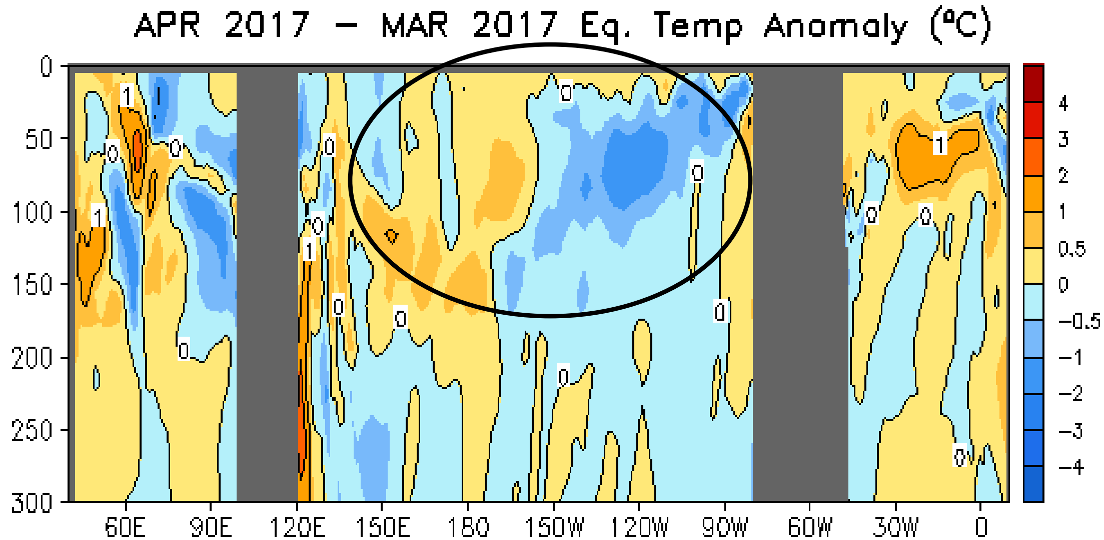


- The SSHA pattern was overall consistent with HC300A pattern, but there were many detailed differences between HC300A and SSHA.
- Overall, both SSHA and HC300A were small in the tropical Pacific, consisting with neutral phase of ENSO.

Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2ºS-2ºN



- Positive ocean temperature anomalies presented along the thermocline in the western Pacific and American coast , and negative in between.
- Both positive and negative ocean temperature anomalies were observed in the Indian and Atlantic Oceans.

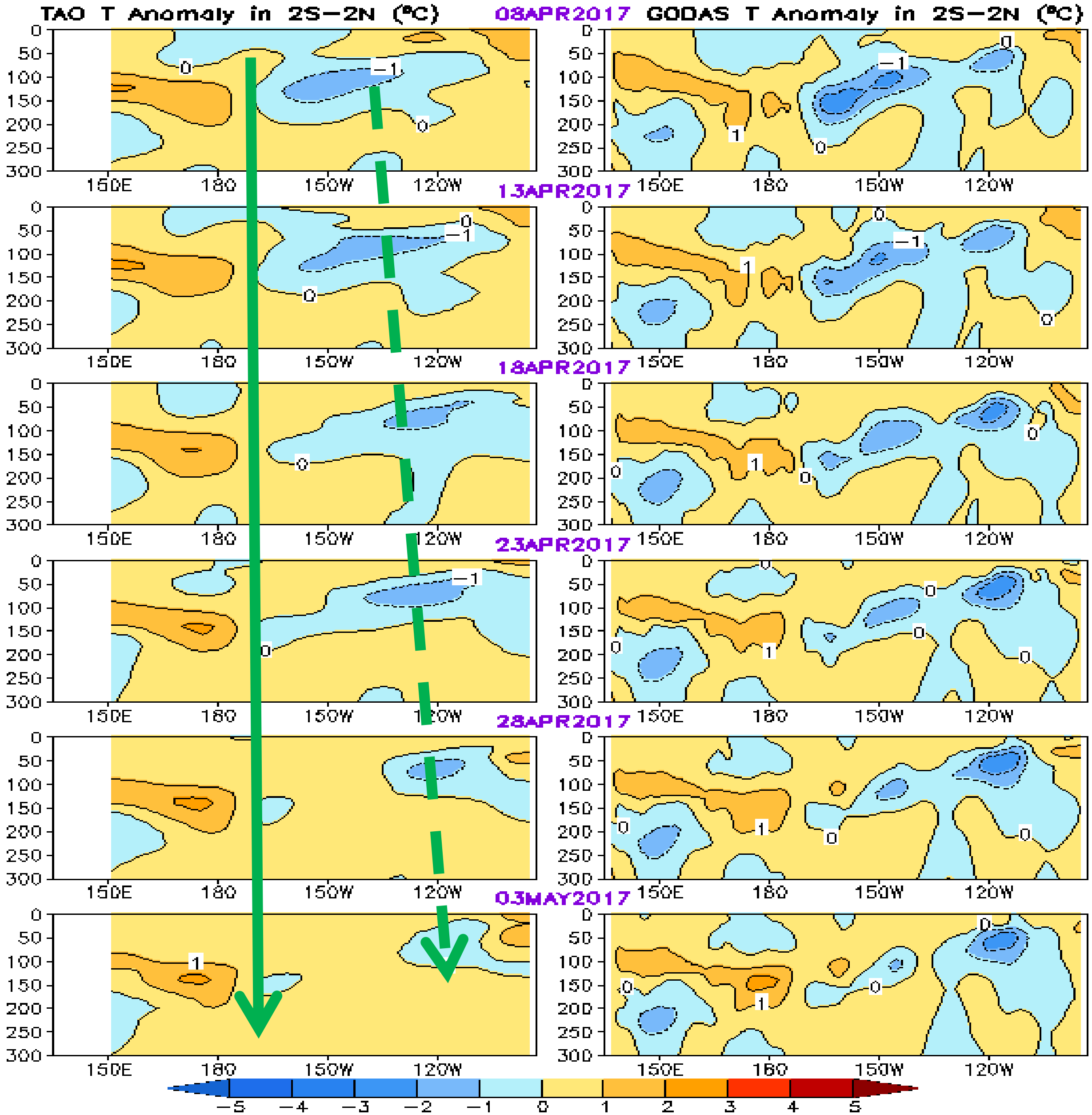


- Overall, ocean temperature anomaly tendencies were positive in the west and negative in the east.

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.

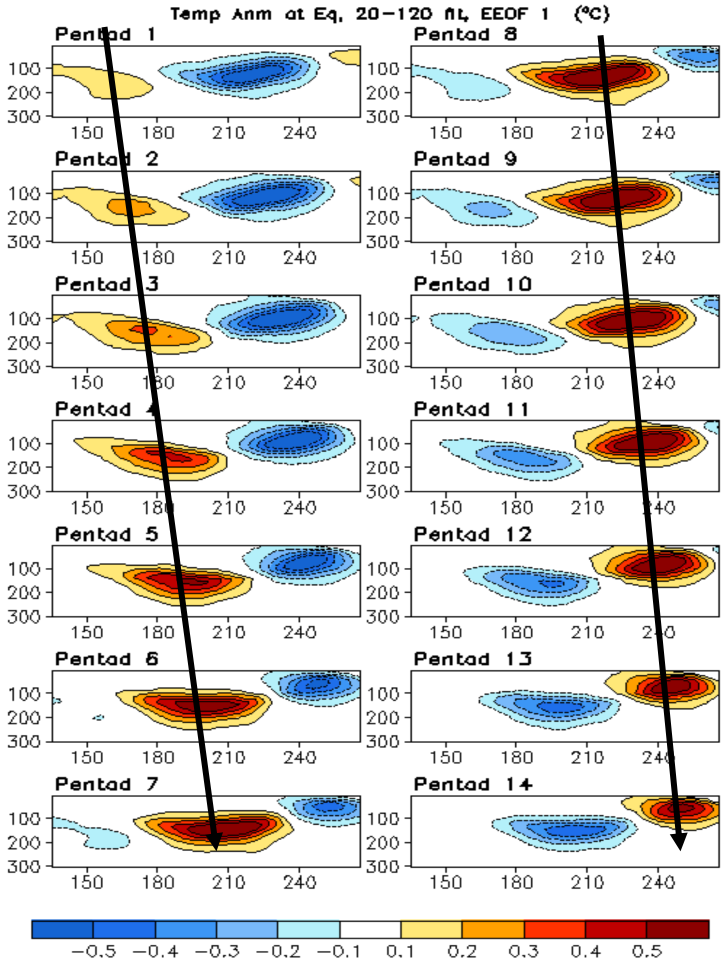
Tropical Pacific Ocean and ENSO Conditions

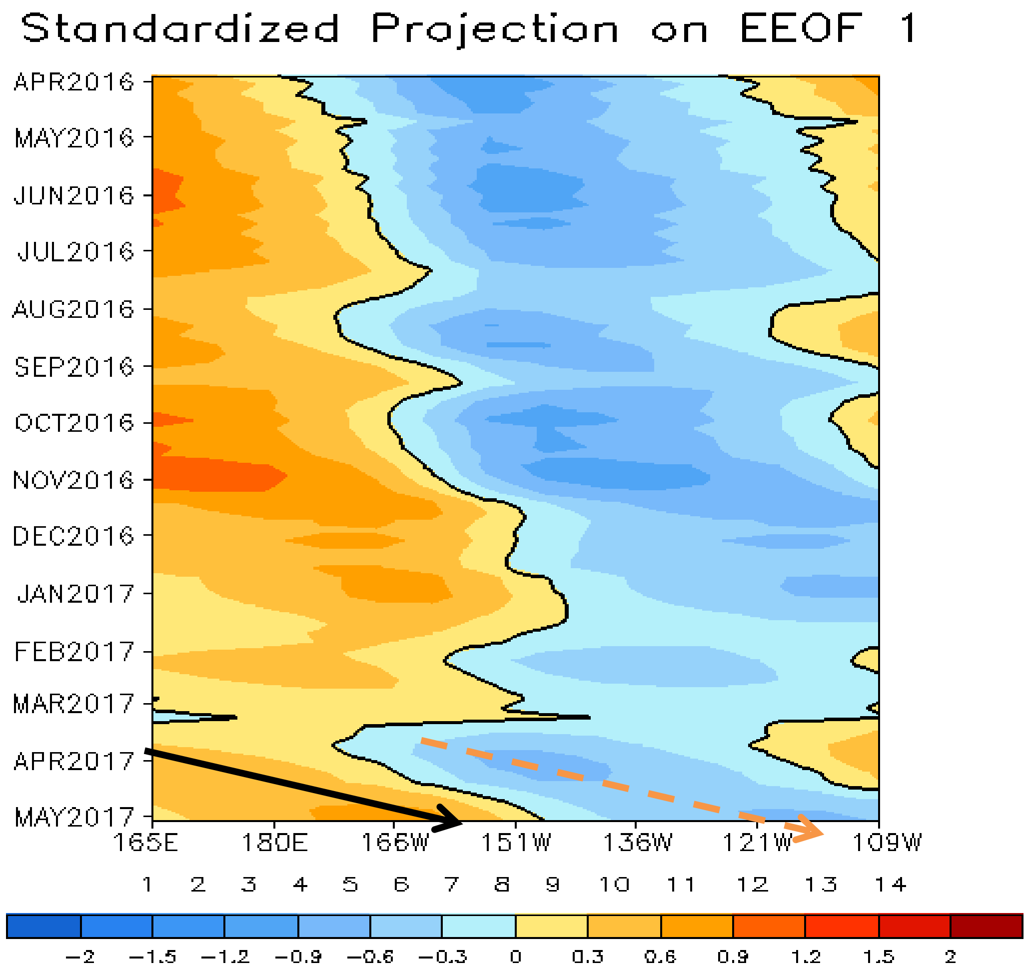
Equatorial Pacific Ocean Temperature Pentad Mean Anomaly



- Positive ocean temperature anomalies in the western Pacific Ocean persisted, and negative ones in the eastern propagated eastward during last month.
- Both the anomalous pattern, intensity, and propagation are comparable between TAO and GODAS.

Oceanic Kelvin Wave (OKW) Index



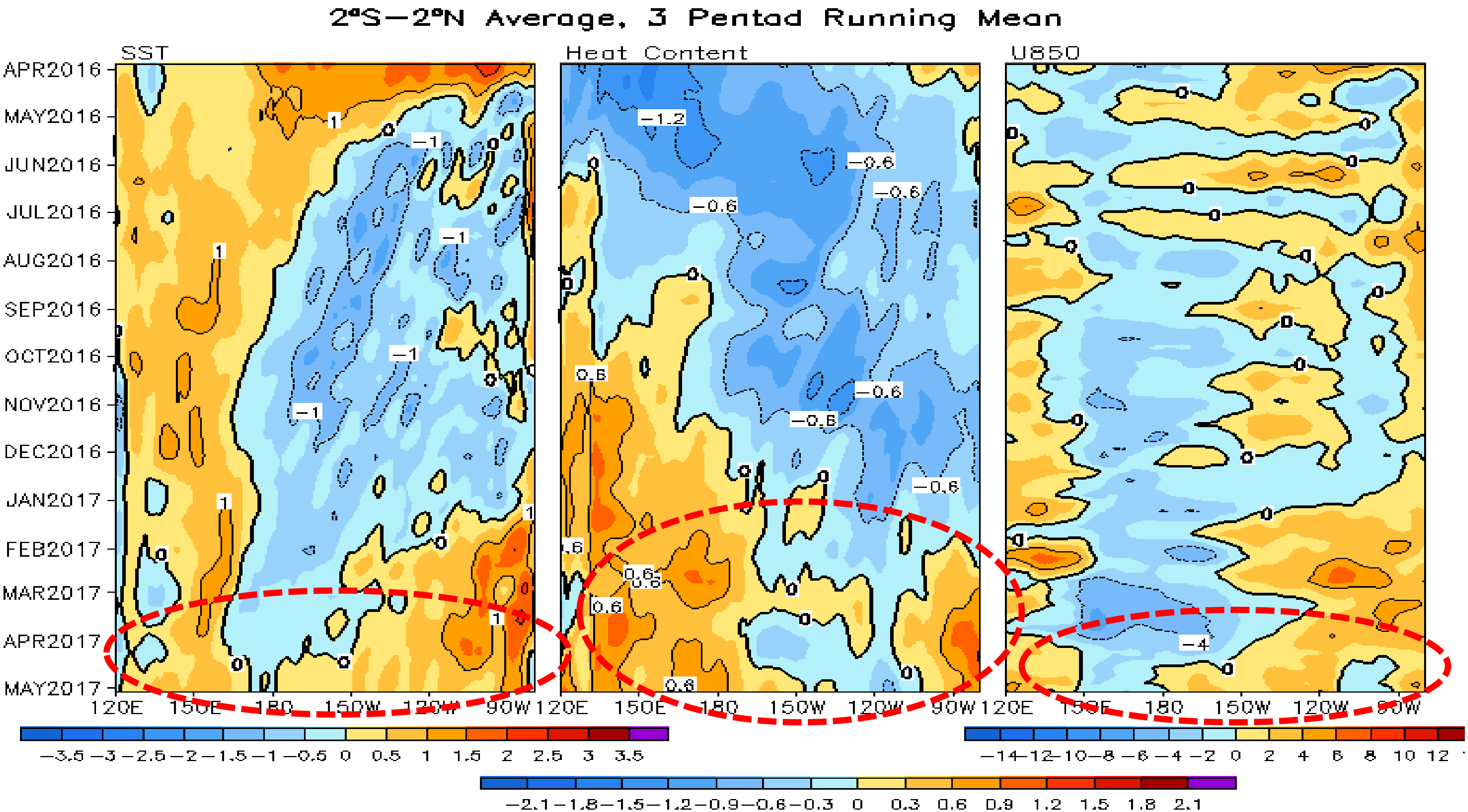


- **Negative OKW initiated in the mid-Mar and positive OKW initiated in early Apr propagated eastward.**

- **During Dec 2016-Feb 2017, stationary variations were dominant.**

(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 in the last few months.**
- **Positive HC300A in the western and central Pacific as well as in the American coast persisted in last a few months.**
- **Low-level westerly wind anomalies merged in the central-eastern equatorial Pacific Ocean in Apr 2017.**

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

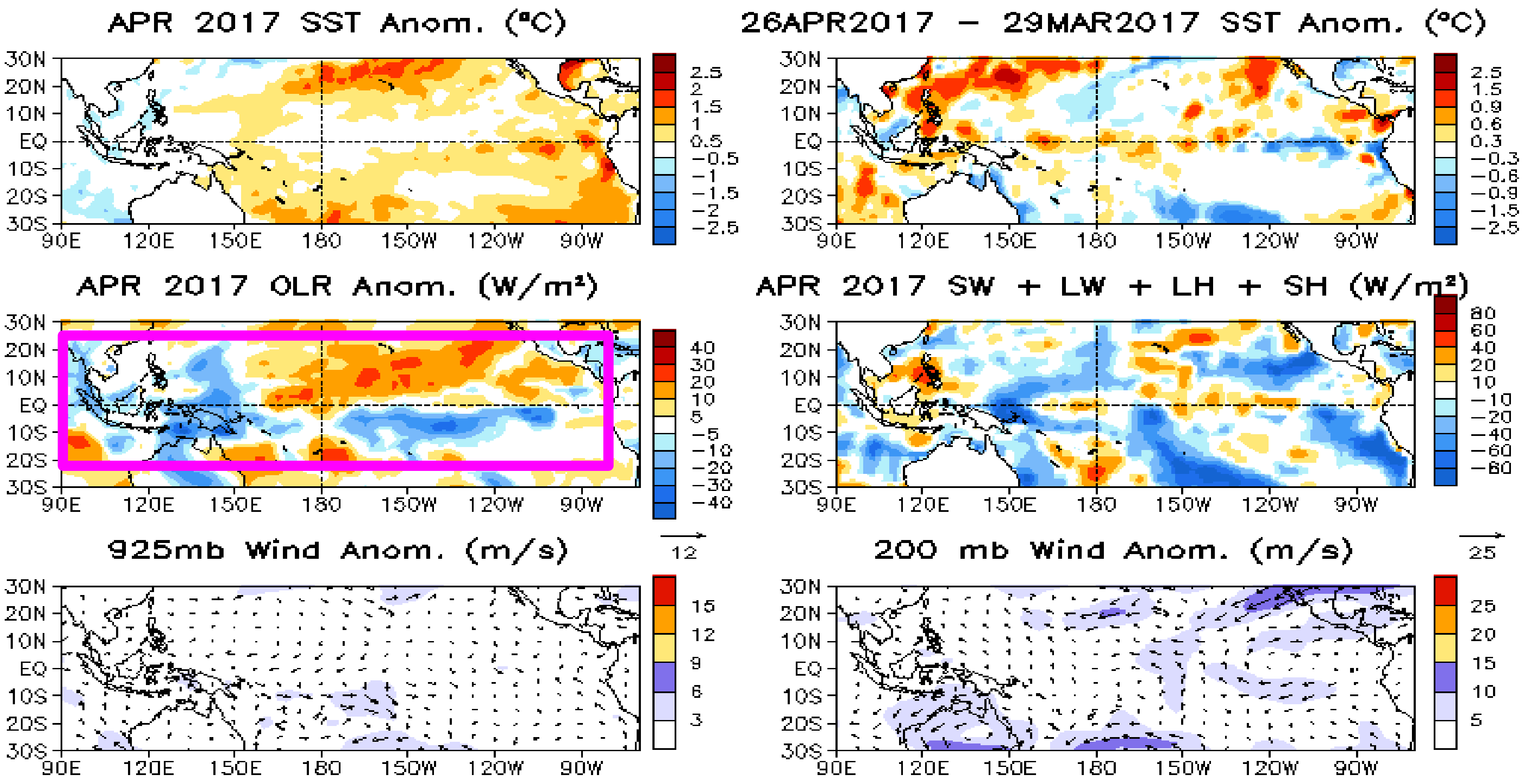
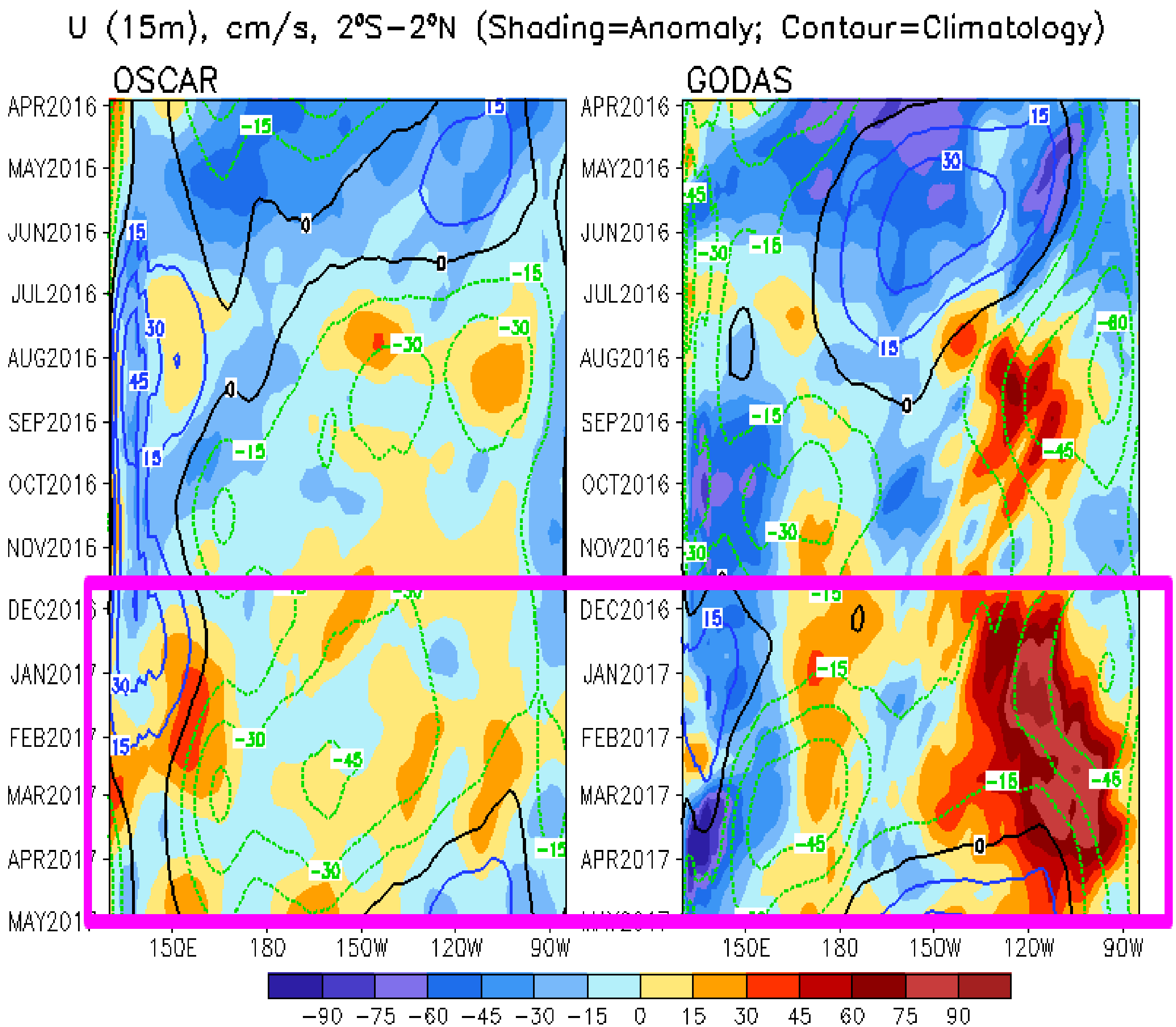


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

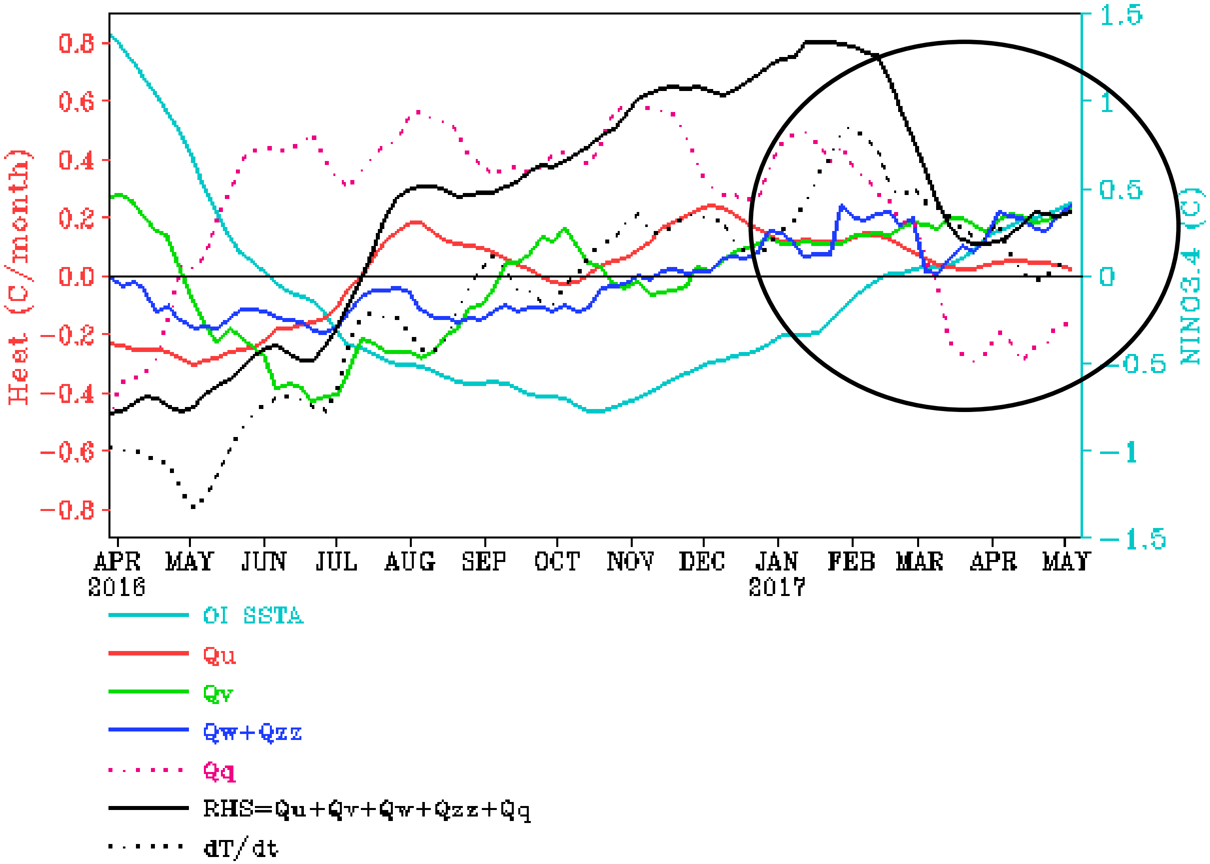
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- The anomalous currents showed large differences between OSCAR and GODAS since Nov 2016.

- 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.**

- **All dynamical terms (Qu, Qv, Qw+Qzz) were small positive, while heat flux term (Qq) was negative in Apr 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;

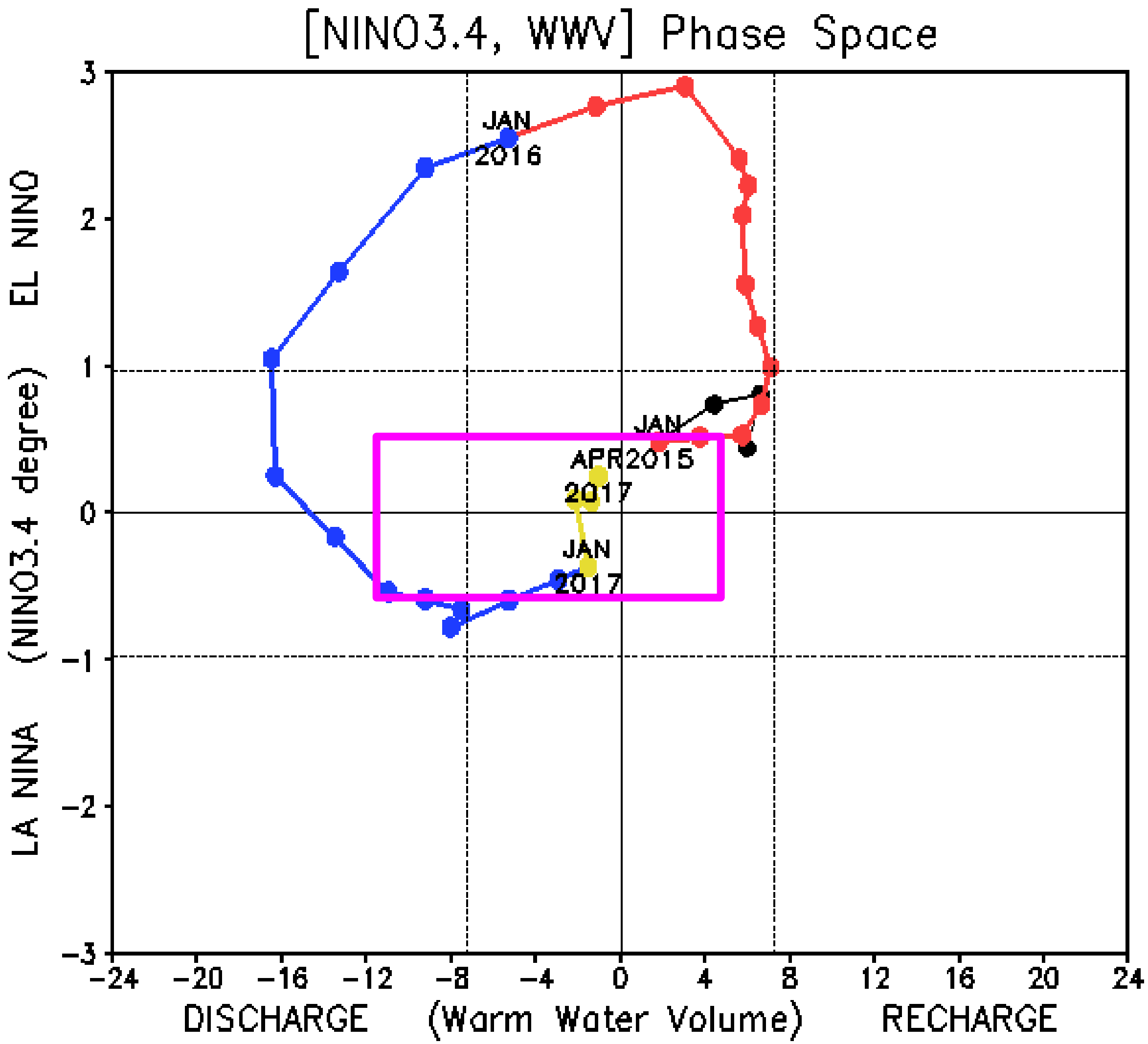
Qpen: SW penetration; Qcorr: Flux correction due to relaxation to OI SST

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).**

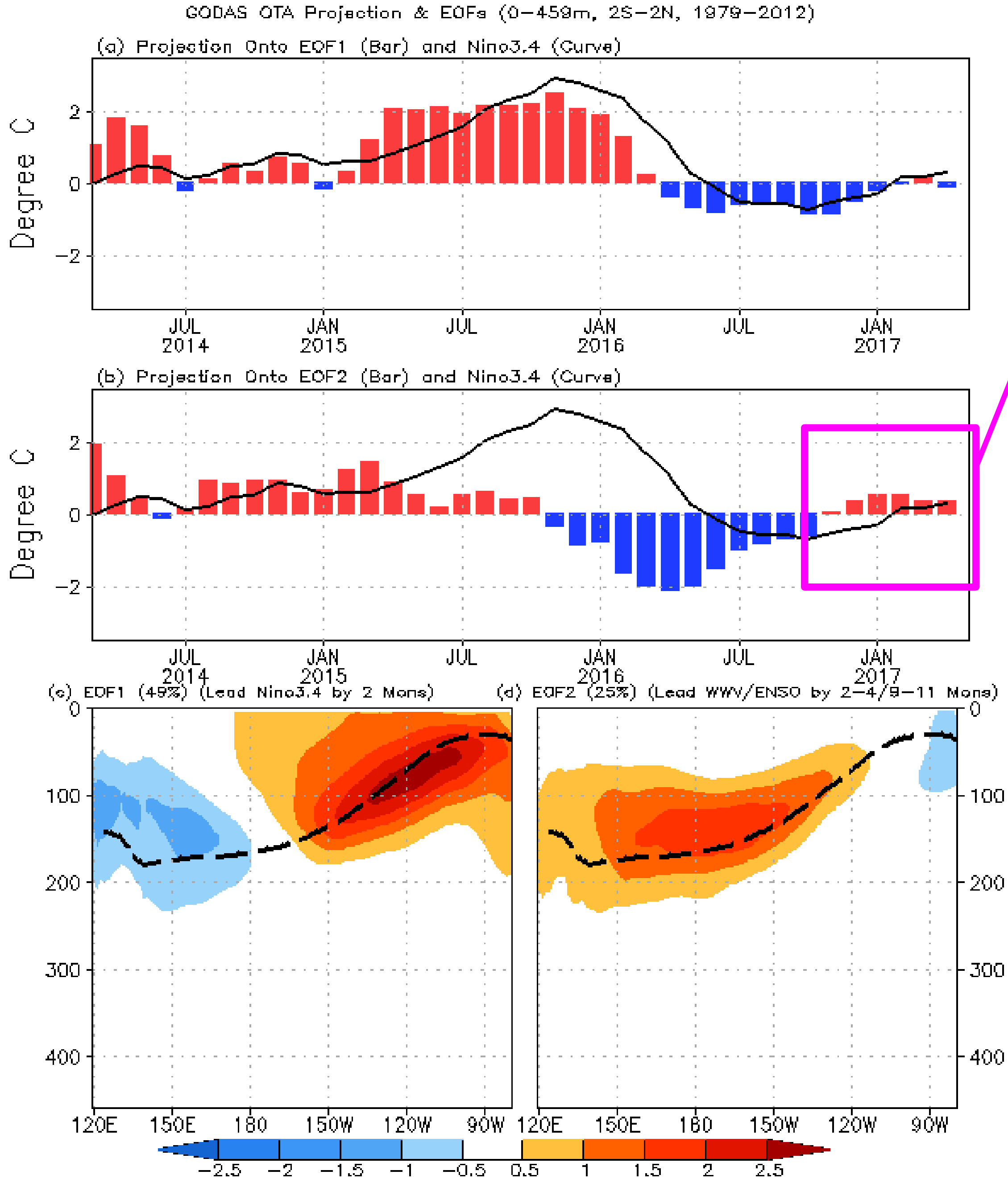
- **Since WWV is intimately linked to ENSO variability (Wyrtki 1985; Jin 1997), it is useful to monitor ENSO in a phase space of WWV and NINO3.4 (Kessler 2002).**

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



- **Equatorial Warm Water Volume (WWV) has been almost no change (small discharge) 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 20ºC in [120ºE-80ºW, 5ºS-5ºN] calculated with the NCEP's global ocean data assimilation system. Anomalies are departures from the 1981-2010 base period means.



Equatorial subsurface ocean temperature monitoring: 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).

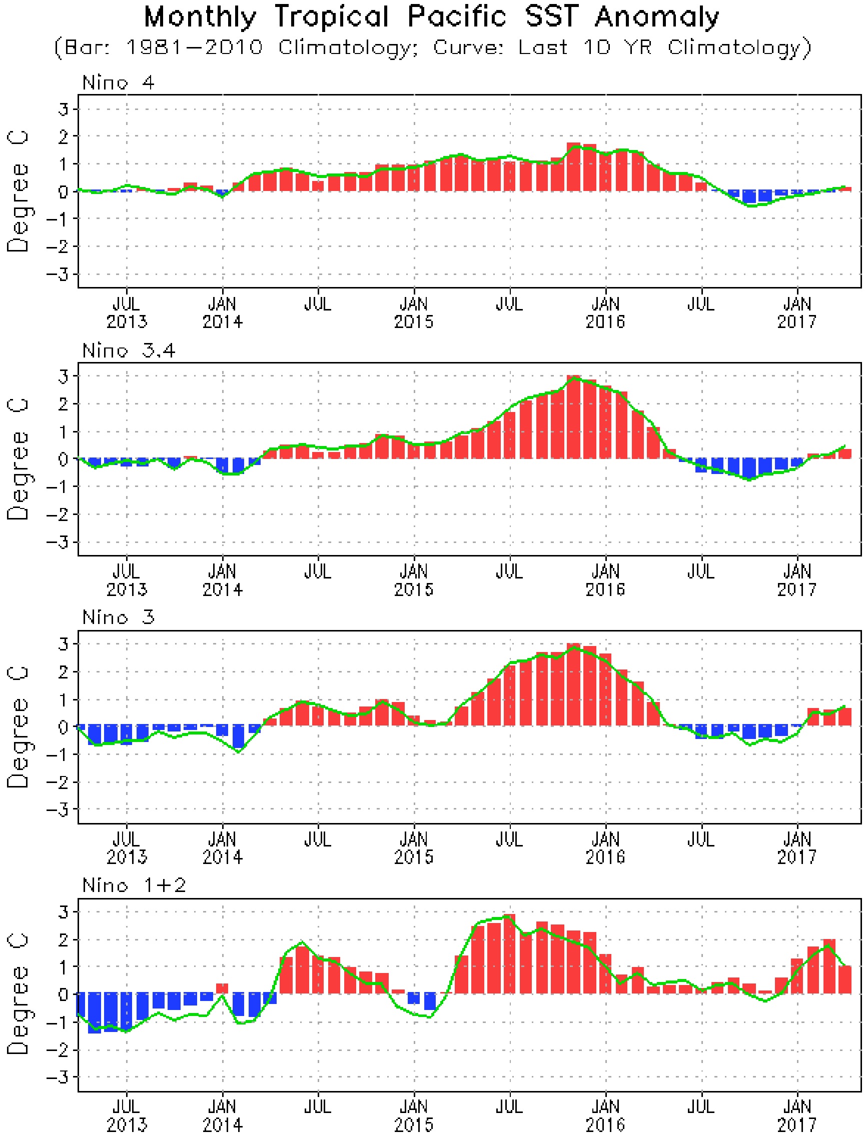
Recharge process: heat transport from outside of equator to equator : Negative -> positive phase of ENSO

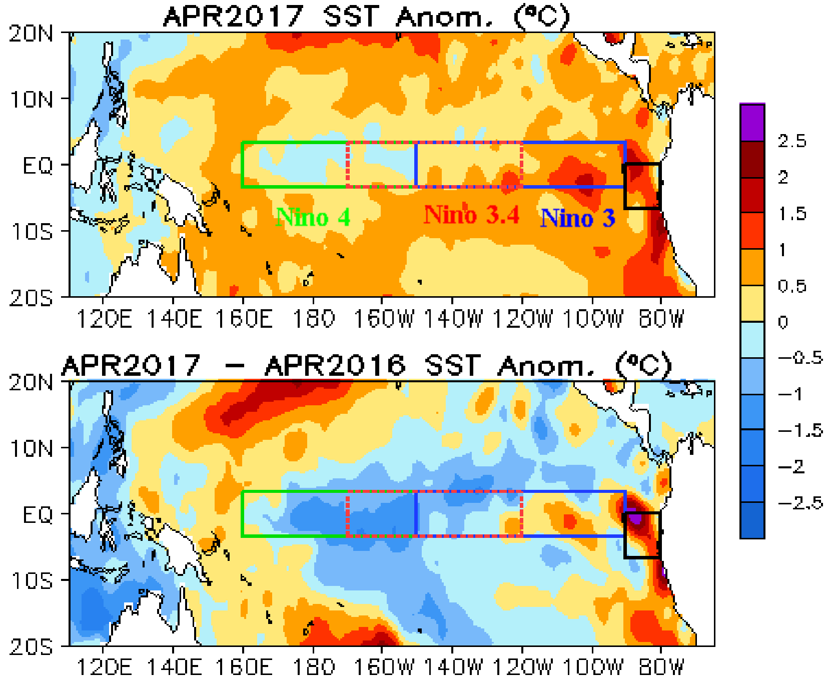
Discharge process: heat transport from equator to outside of equator: Positive -> Negative phase of ENSO

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*.

Evolution of Pacific NINO SST Indices





- **All Nino indices were positive; Nino1+2 weakened in Apr 2017.**

- **Nino3.4 = 0.30°C in Apr 2017.**

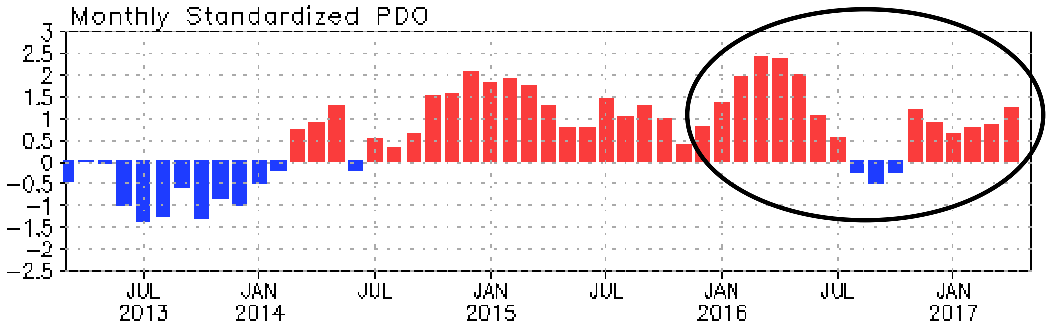
- **Compared with last Apr, the central and eastern equatorial Pacific was much cooler and American coast was much warmer in Apr 2017.**

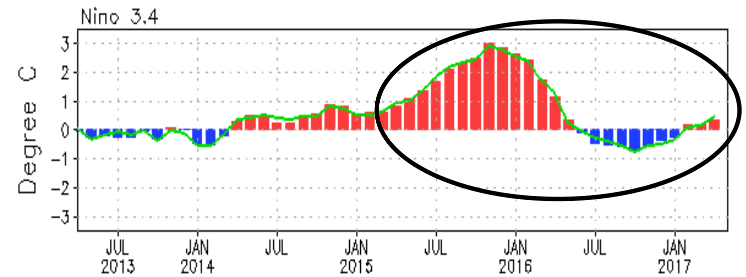
- **The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v4.**

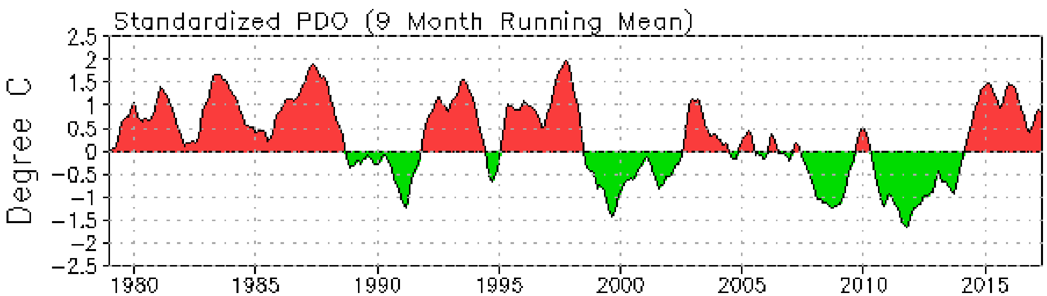
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

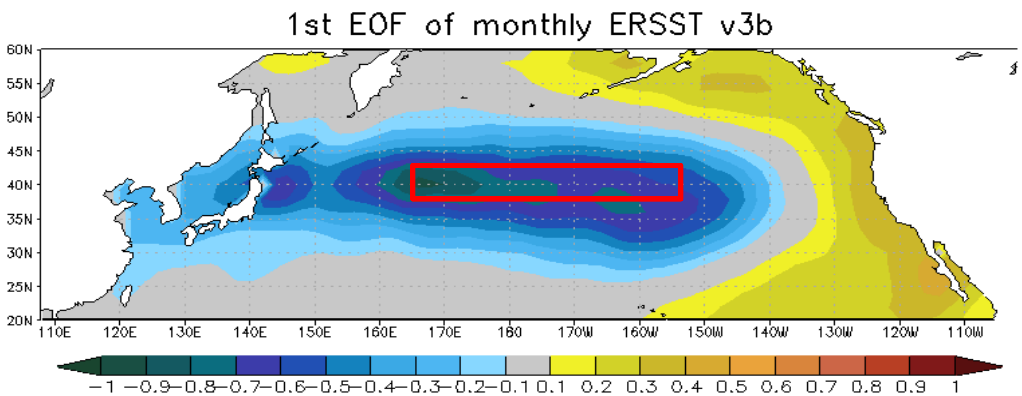
North Pacific & Arctic Oceans

PDO index









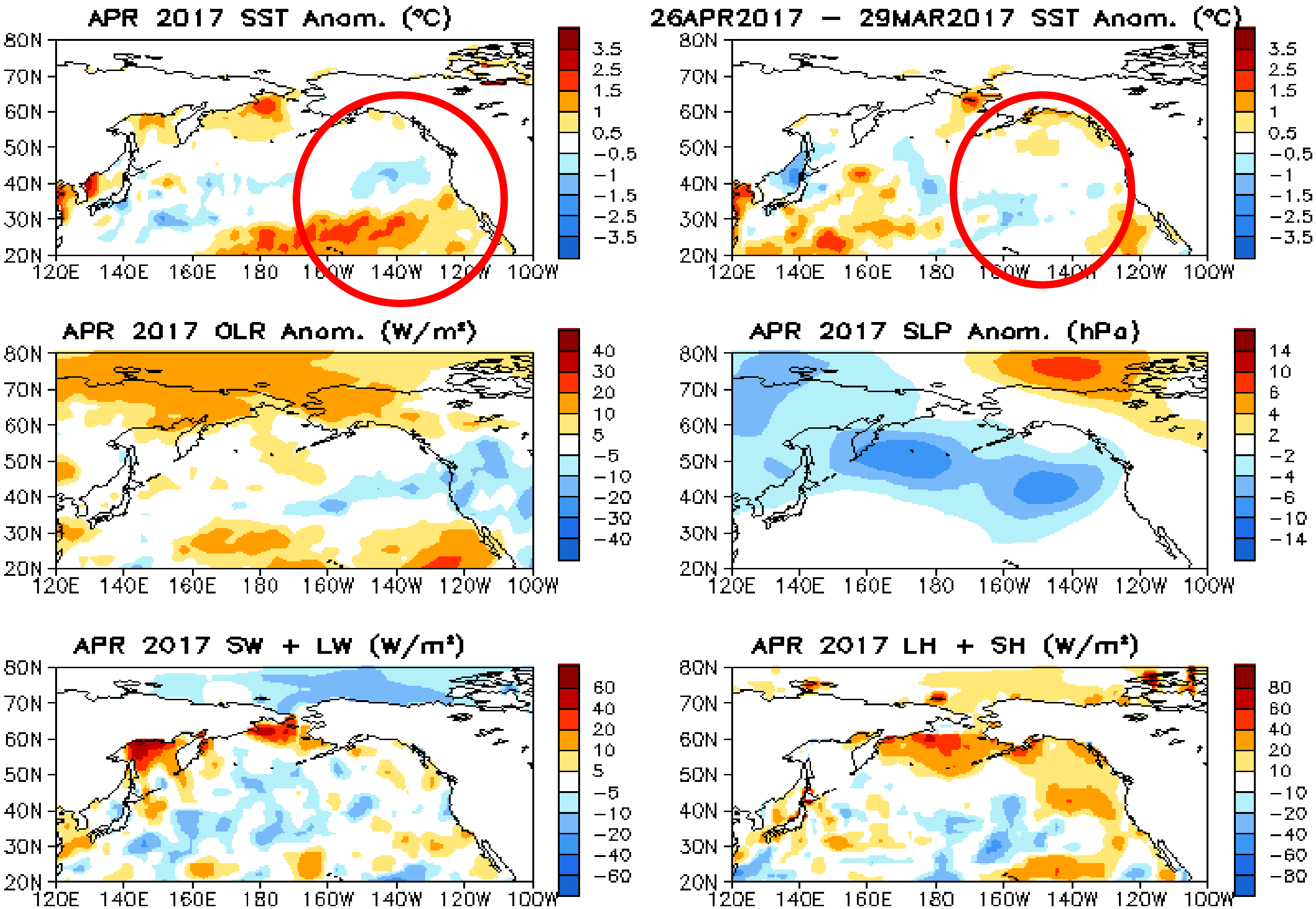
- The positive phase of PDO index has persisted 6 months since Nov 2016 with PDO index =1.2 in Apr 2017.

- 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.

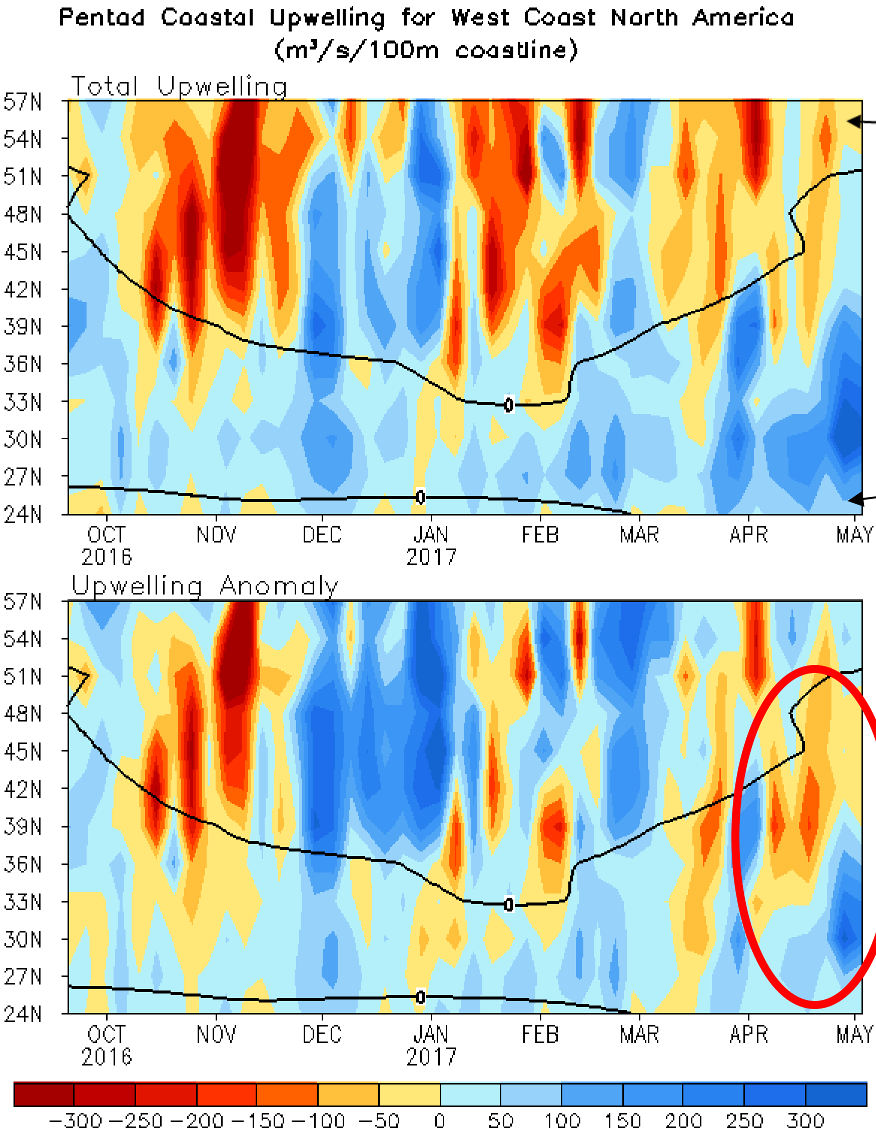
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx

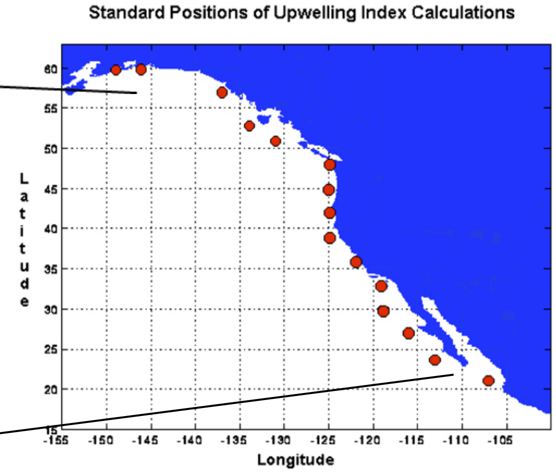


- **Positive SSTA associated with so called "Blob" in the NE Pacific disappeared.**
- **Overall, SSTA tendency was small in N. Pacific.**

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.

North America Western Coastal Upwelling





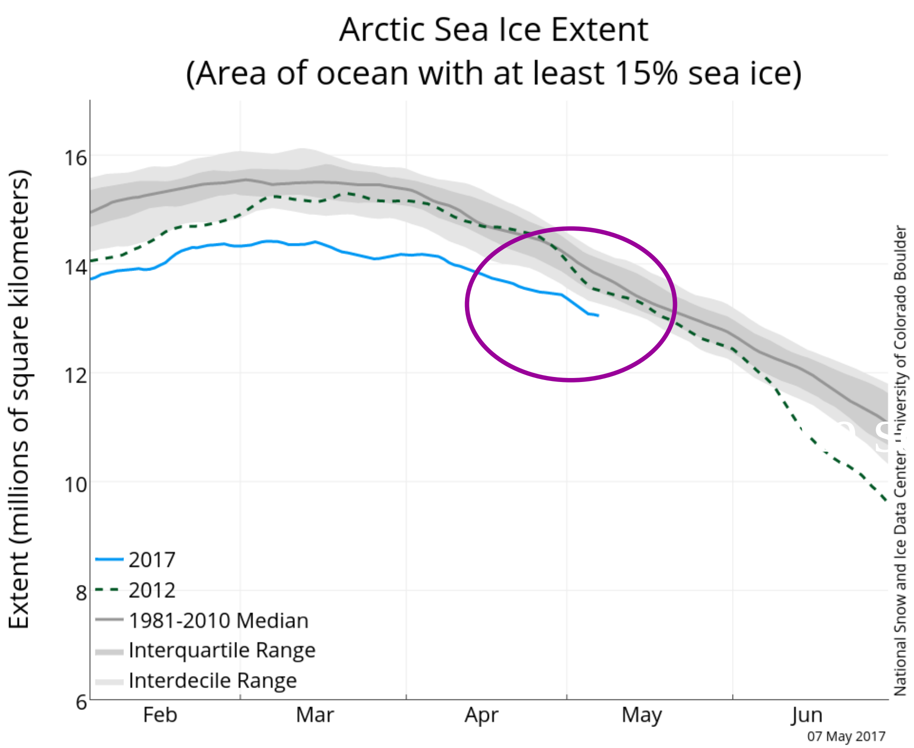
- **Recently, anomalous downwelling (upwelling) presented in mid-high (mid-) latitudes.**

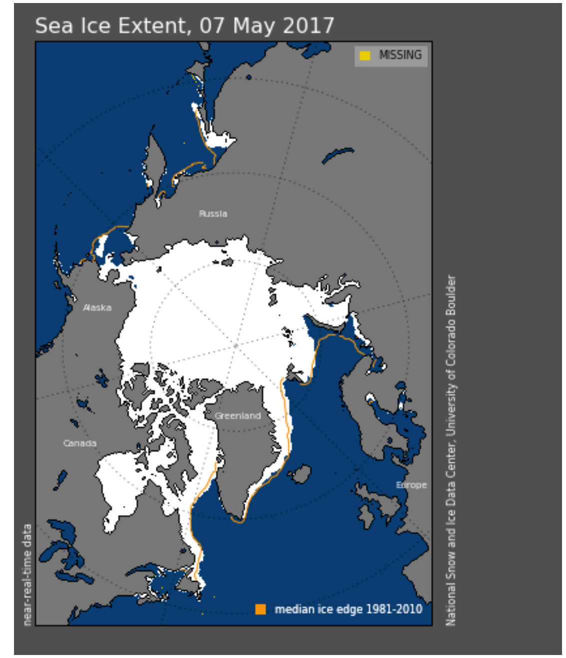
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

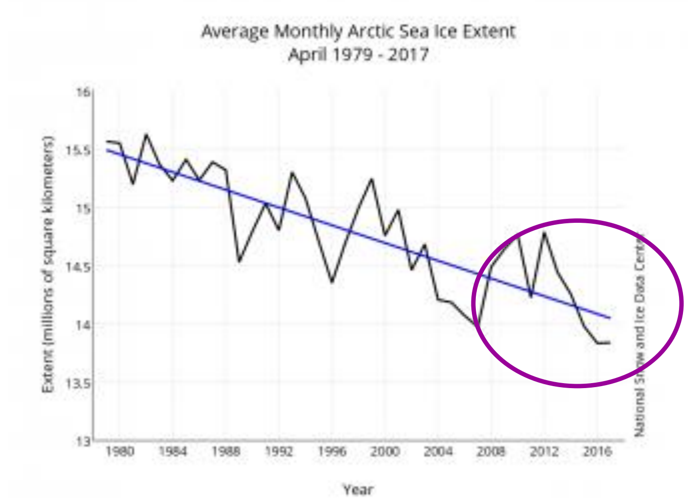
- **Area below (above) black line indicates climatological upwelling (downwelling) season.**
- **Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.**

Arctic Sea Ice

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



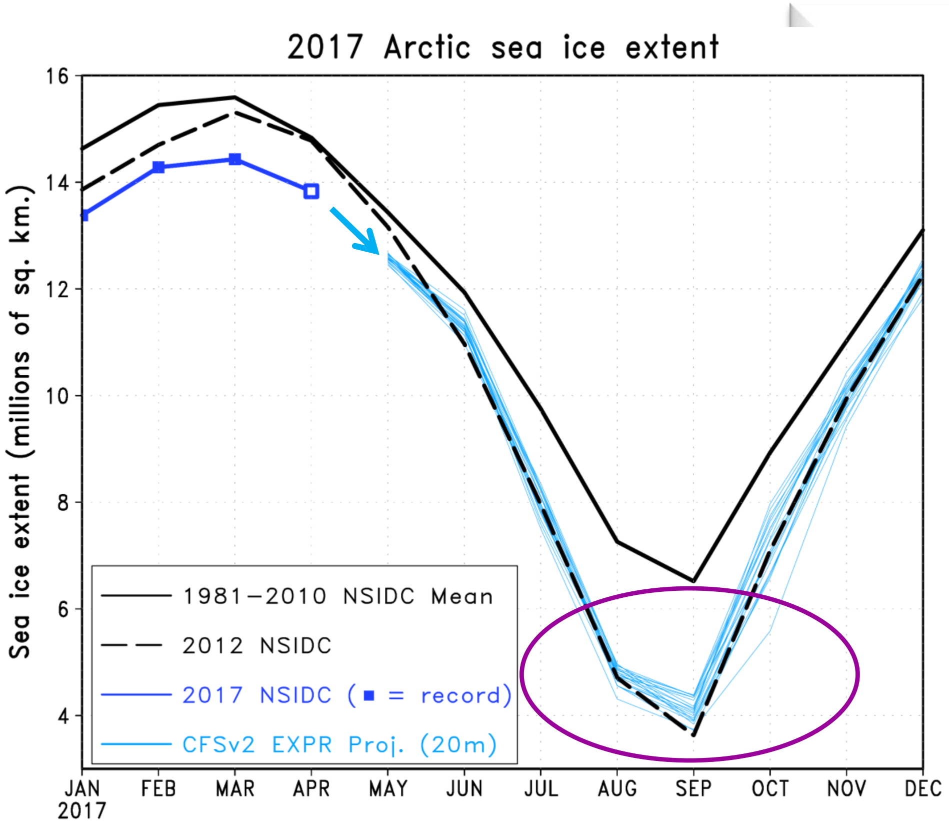


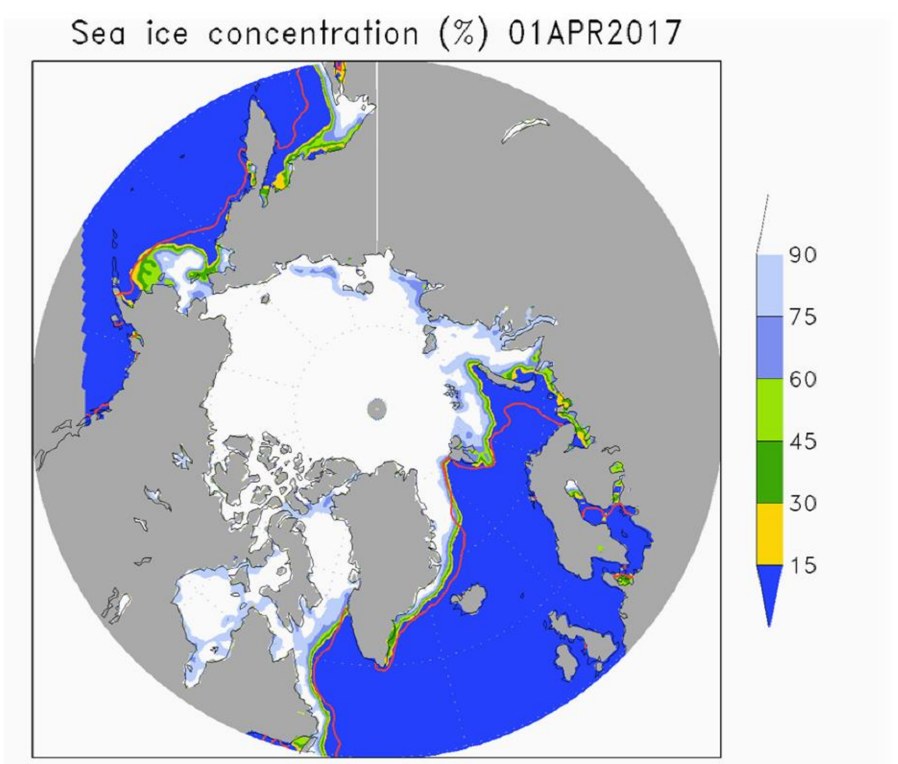


- **Arctic sea ice extent in Apr 2017 was smaller than that in 2012.**

- **Arctic sea ice extent for April 2017 tied with April 2016 for the lowest in the satellite record for the month.**

Arctic Sea Ice *(Dr. Thomas Collow)*



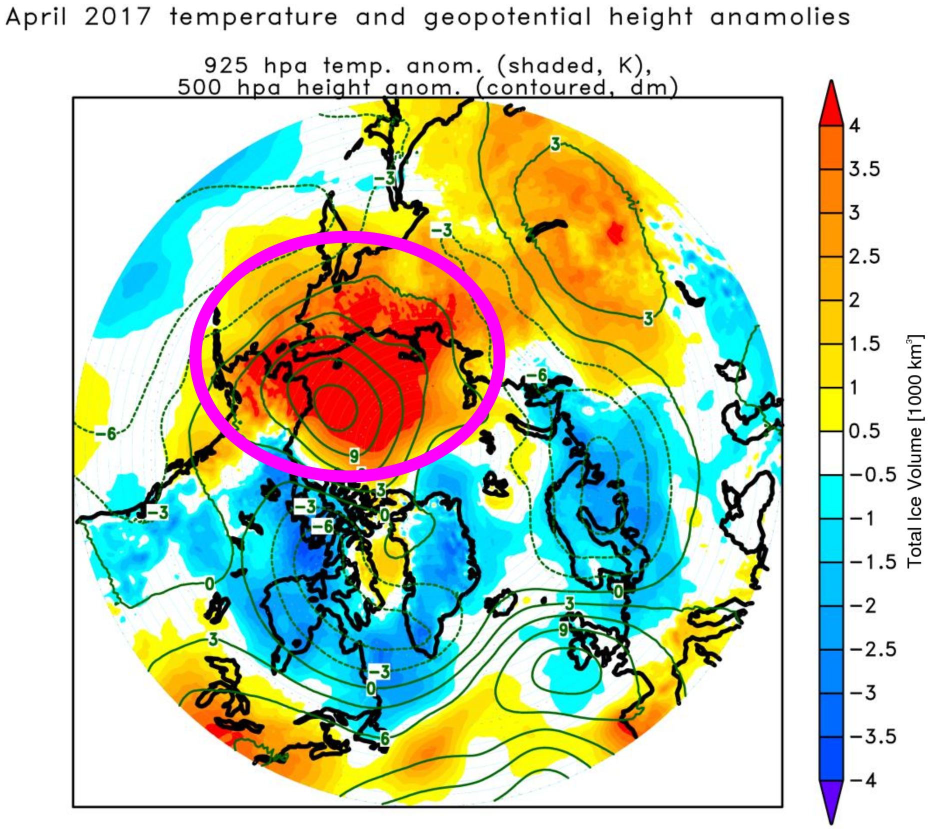


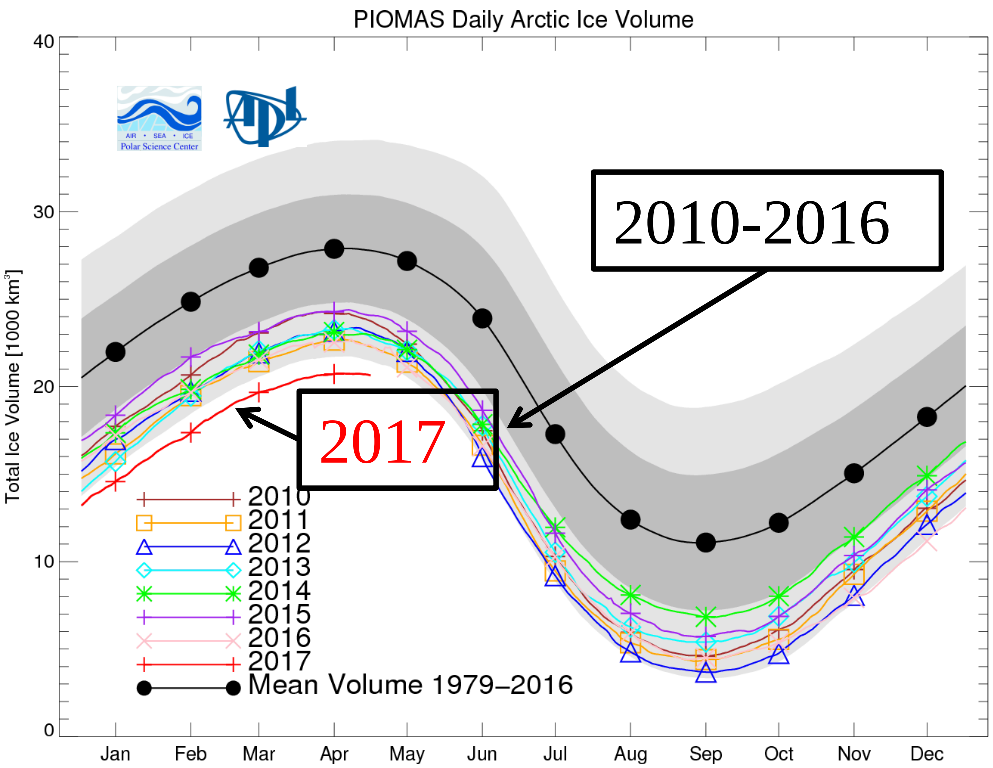
- Arctic sea ice extent has begun to steadily decrease since its March maximum with considerable melting occurring in the Bering Strait

- April 2017 sea ice extent tied April 2016 for the lowest on record

- Current projections from the CFSv2 experimental forecast system point to a near or slightly above the 2012 record minimum. However, as of now 2017, sea ice extent is greater than at this time in 2016.

(Dr. Thomas Collow)



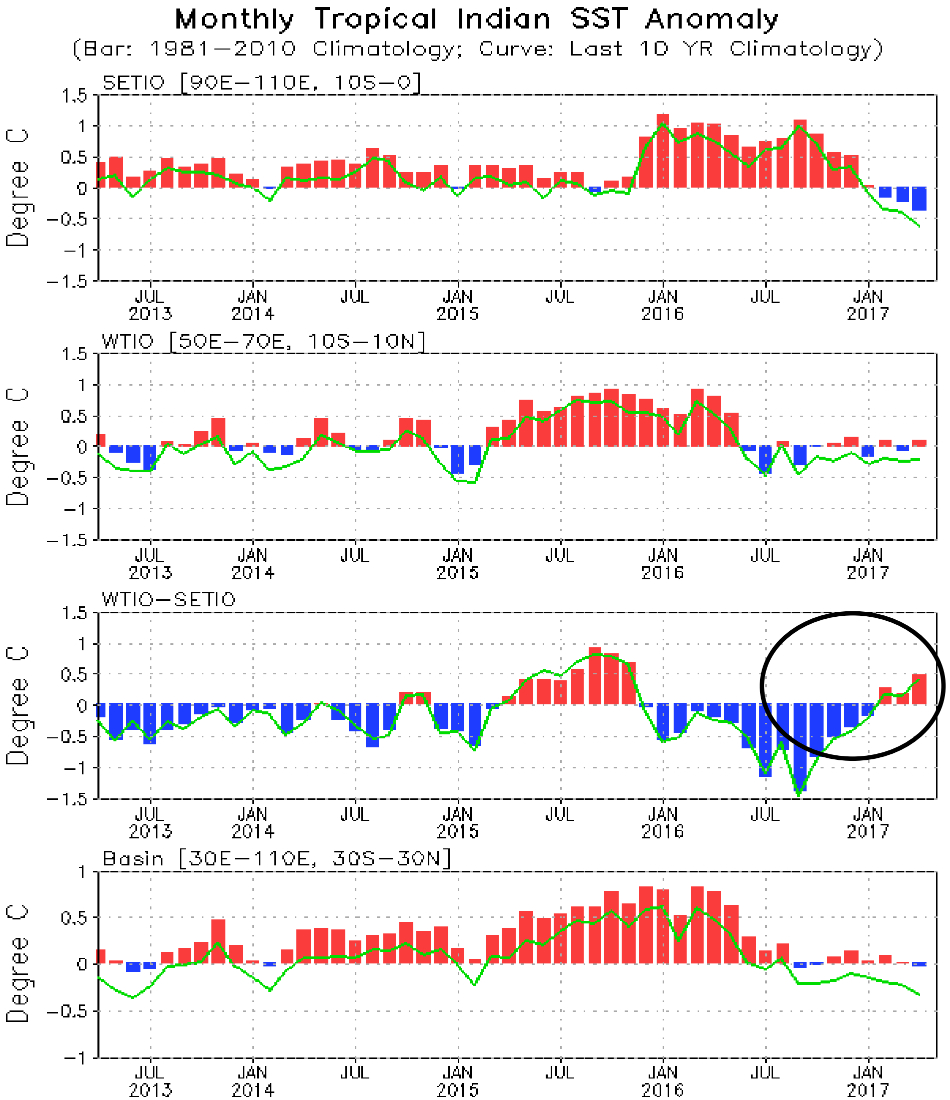


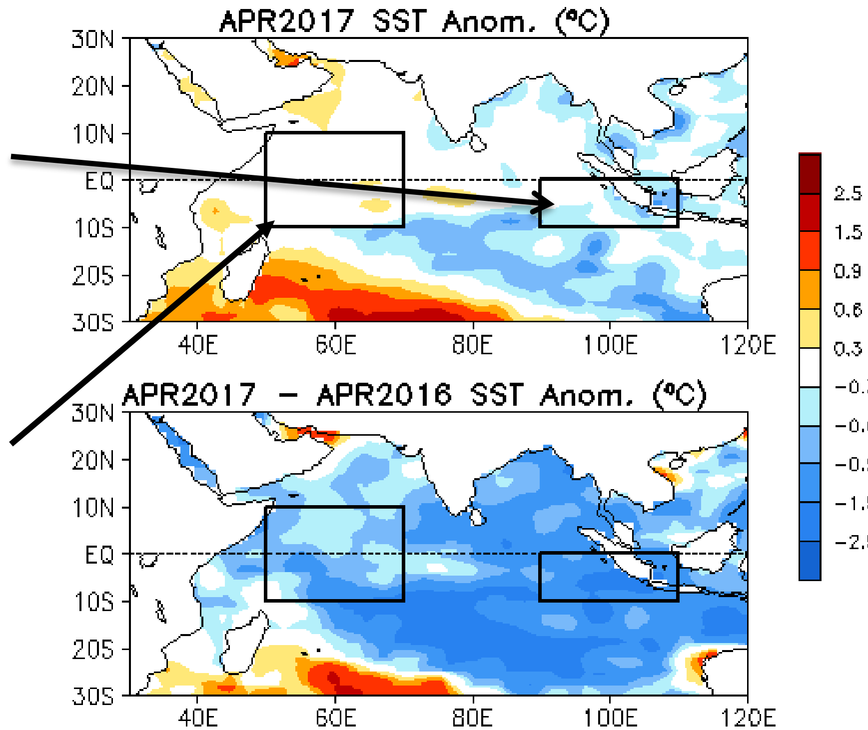
- **Warm temperature anomalies in April 2017 likely aided the quick sea ice melt over the Bering Strait. Elsewhere cooler temperature anomalies were seen along other Arctic edge regions which may have slowed the melt in these zones, placing 2017 behind 2016 in terms of current extent.**

- **Sea ice volume from the Pan-Arctic Ice Ocean and Assimilation System (PIOMAS) remains at record low levels, well below the 2010-2016 cluster.**

Indian Ocean

Evolution of Indian Ocean SST Indices



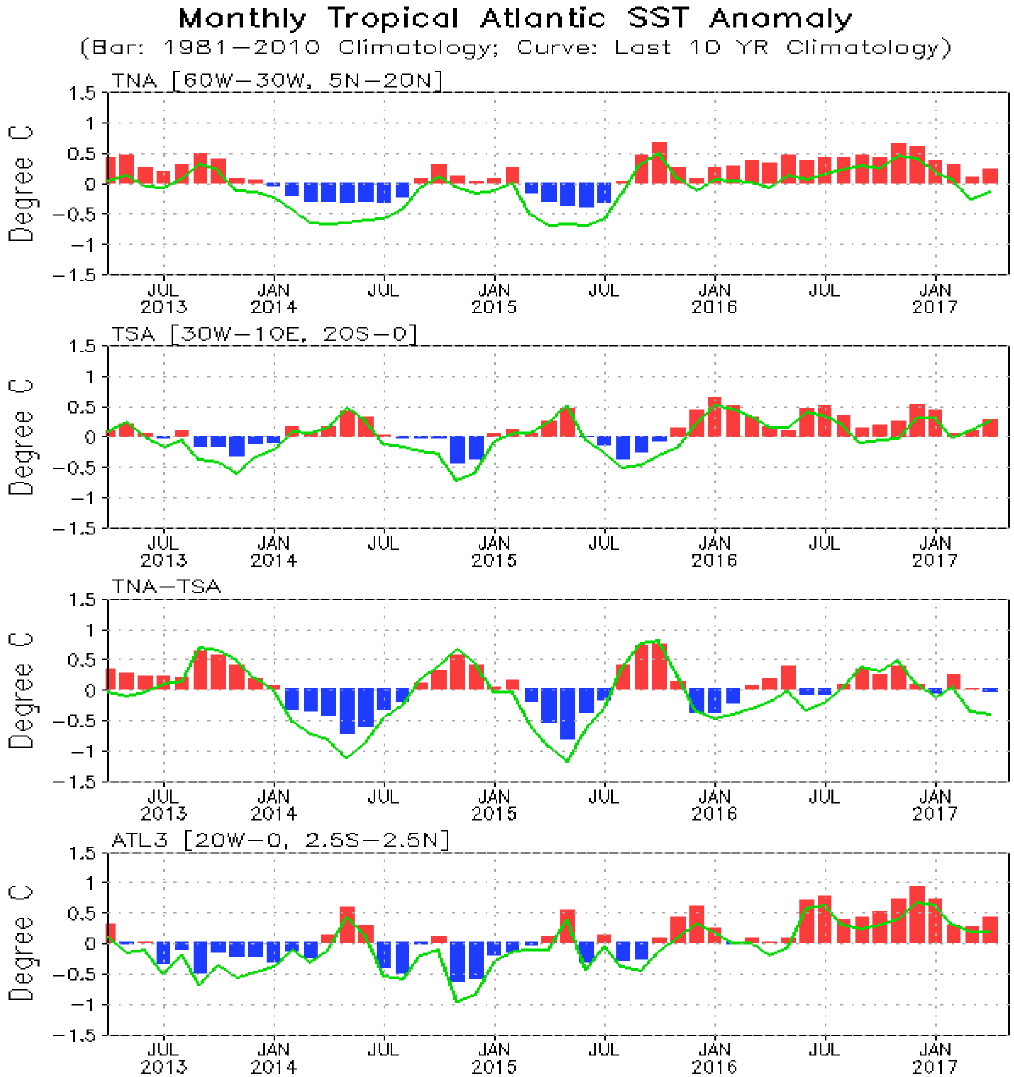


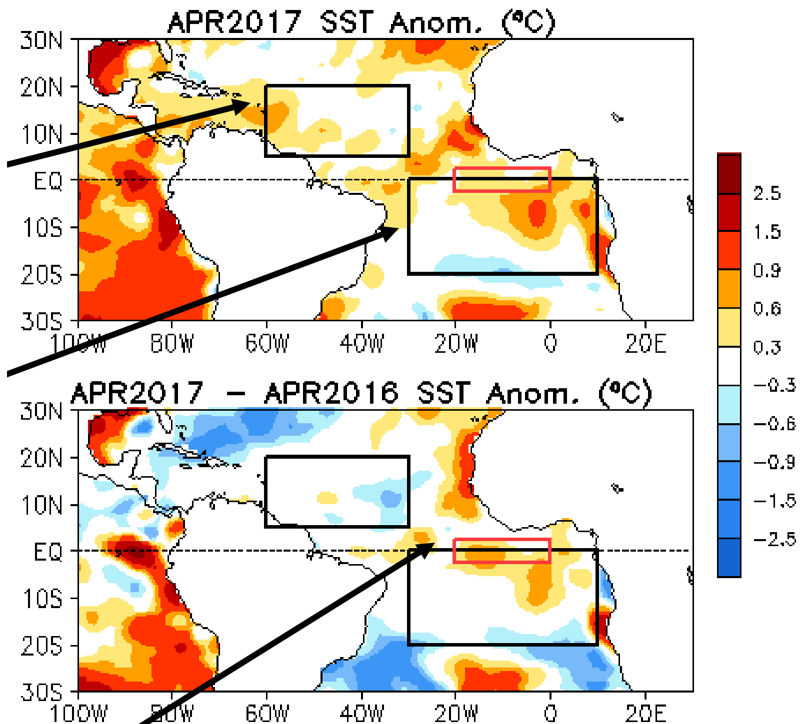
- **Overall, SSTAs were negative in NE and positive in SW Indian Ocean.**
- **Dipole index was positive during last three months, and Basin index was small since Sep 2016.**

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 and North Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

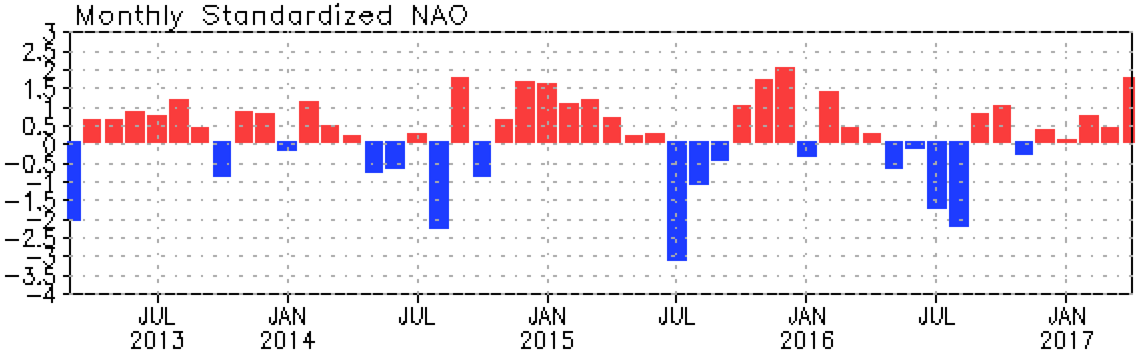


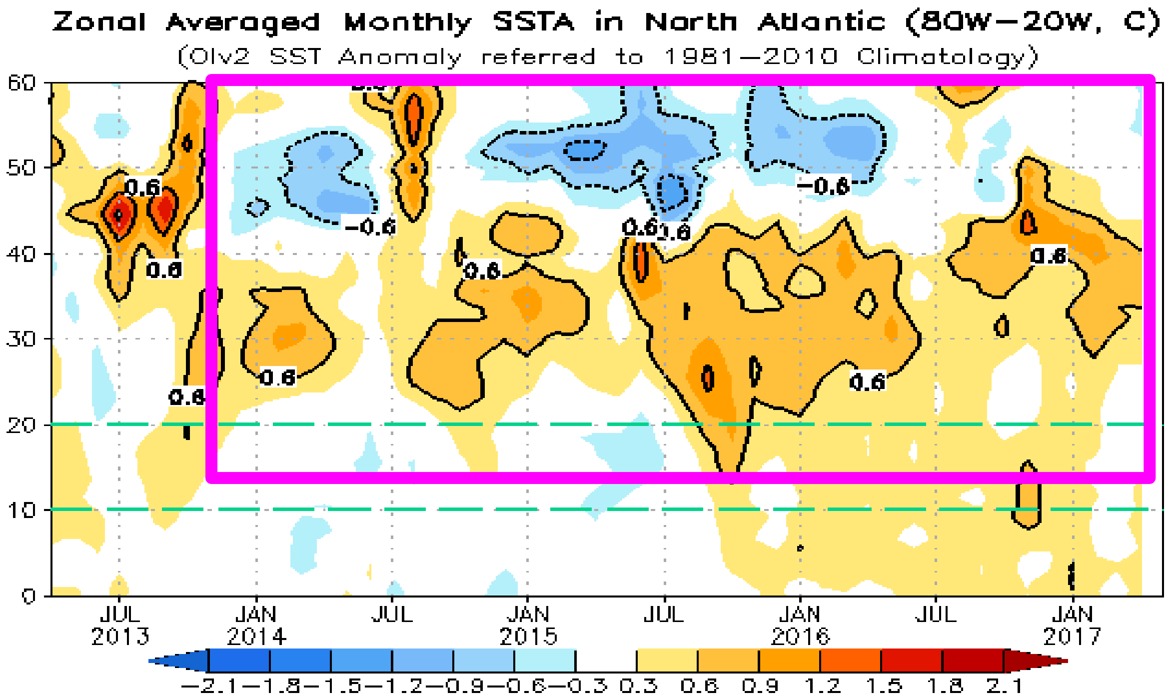


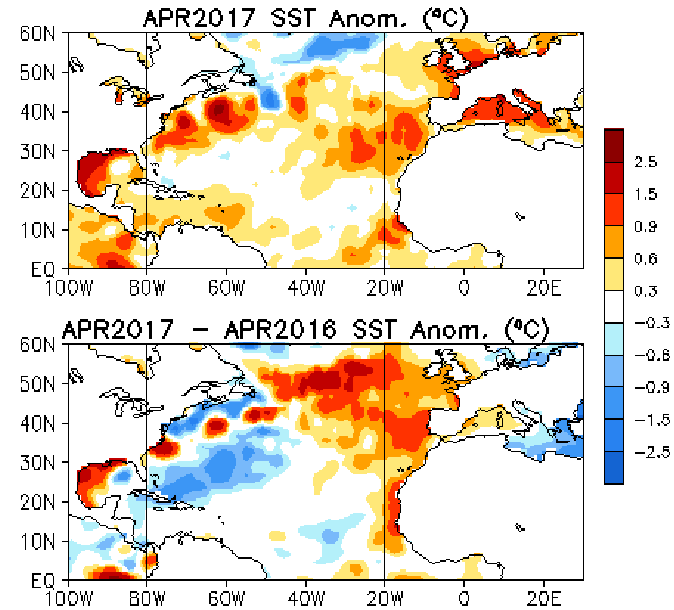
- Overall, SSTAs in the tropical Atlantic Ocean were positive.
- All indices, except TNA-TSA, were positive in Apr 2017.

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.

NAO and SST Anomaly in North Atlantic







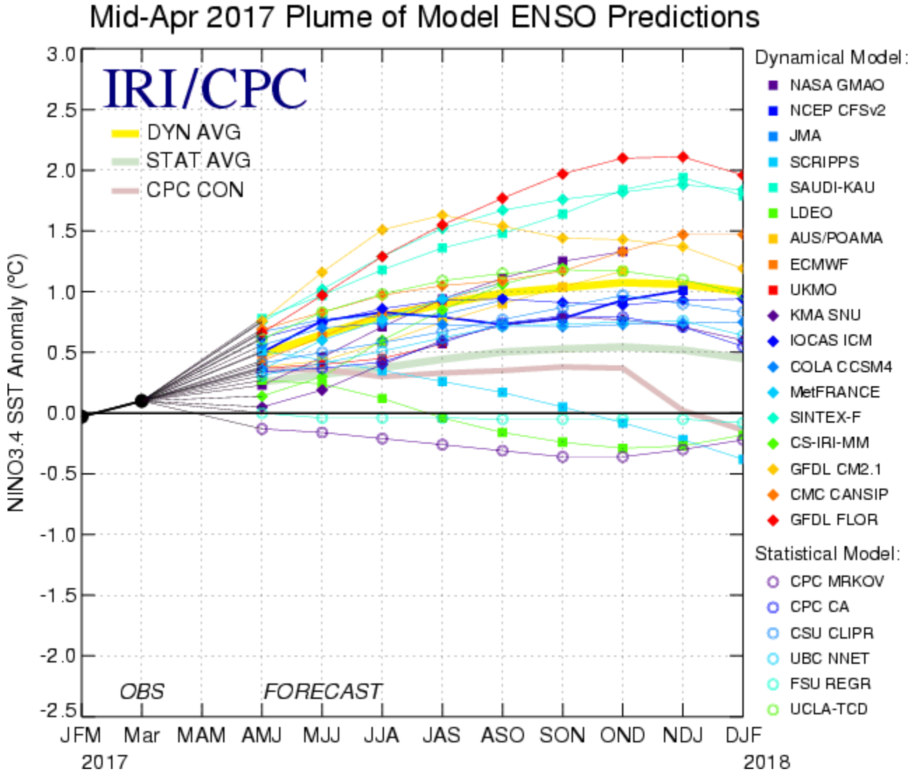
- NAO has been in positive phase since Dec 2016 with NAOI=1.74 in Apr 2017.

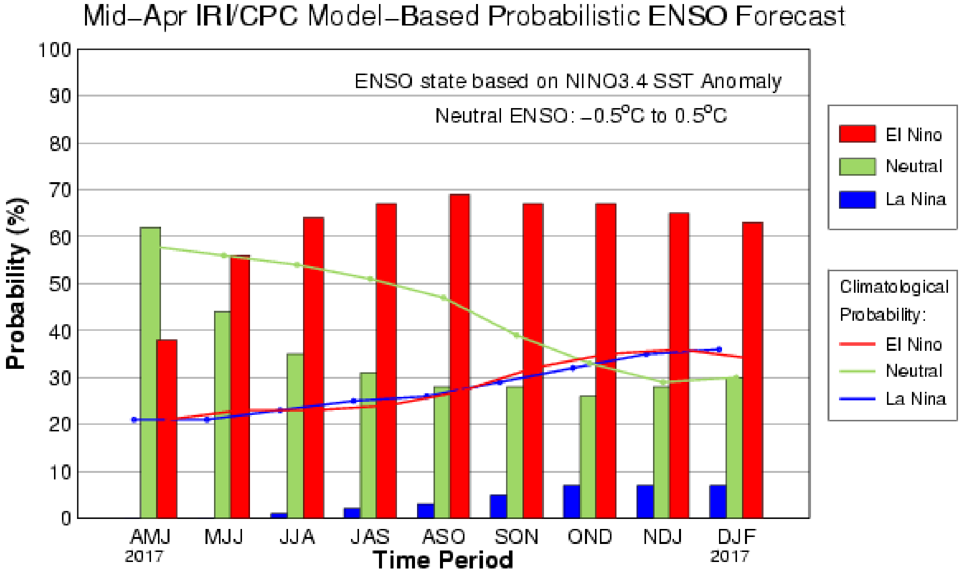
- SSTA was positive in the middle latitudes and negative in the high latitudes during last 3 years, probably due to the impact of positive phase of NAO.

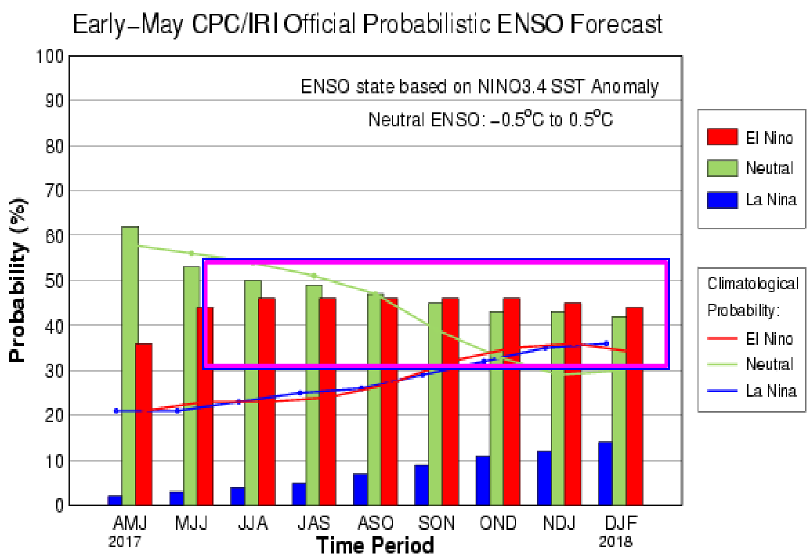
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20ºN-90ºN (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80ºW and 20ºW (bottom). SST are derived from the NCEP OI SST analysis,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

ENSO and Global SST Predictions

IRI NINO3.4 Forecast Plum

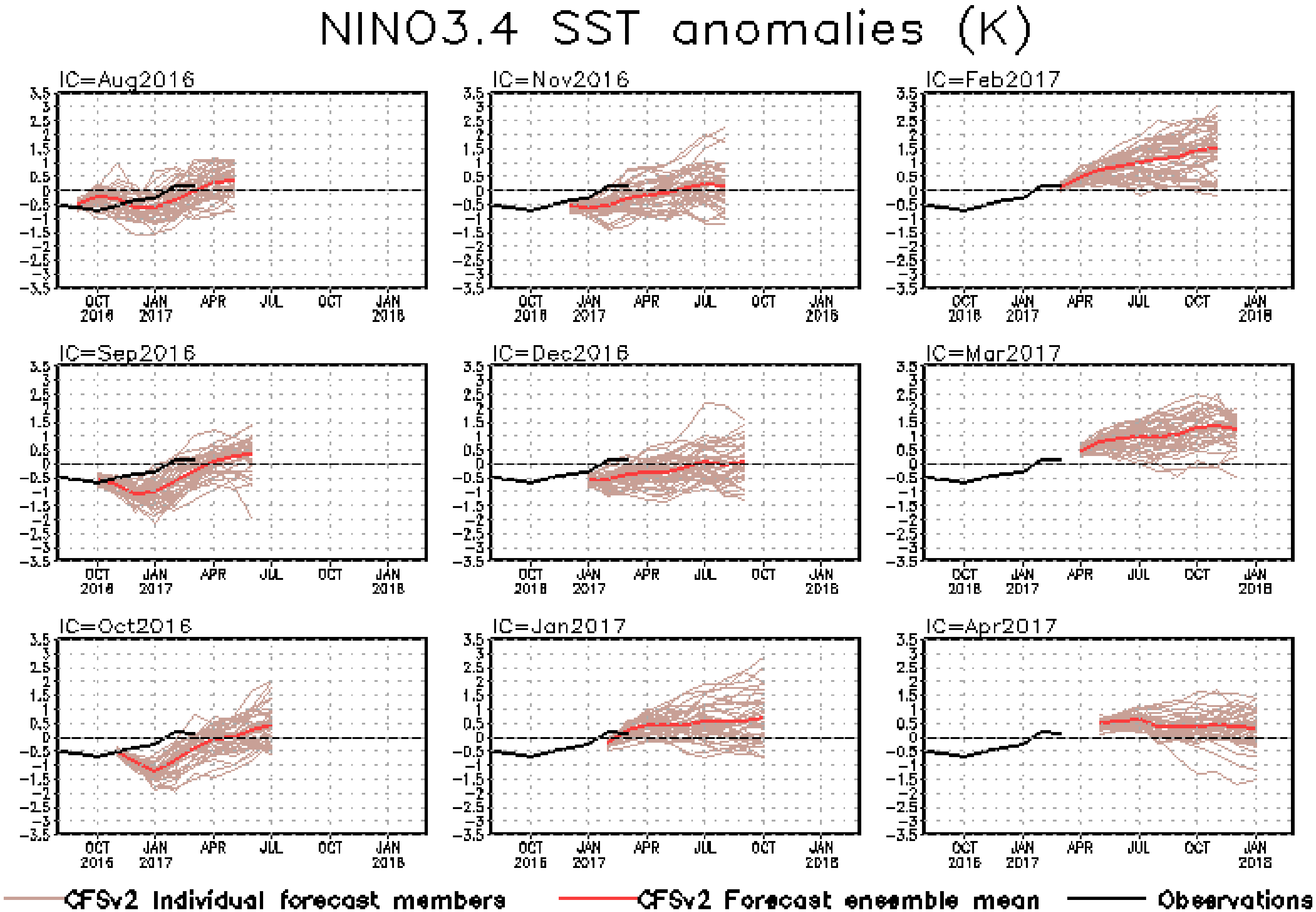






- **Majority of dynamical models call for El Nino development in summer/fall 2017, while most statistical models favor continuation of neutral conditions through 2017.**
- **NOAA "ENSO Diagnostic Discussion" on 11 May 2017 suggested that "ENSO-neutral and El Niño are nearly equally favored during the Northern Hemisphere summer and fall 2017."**

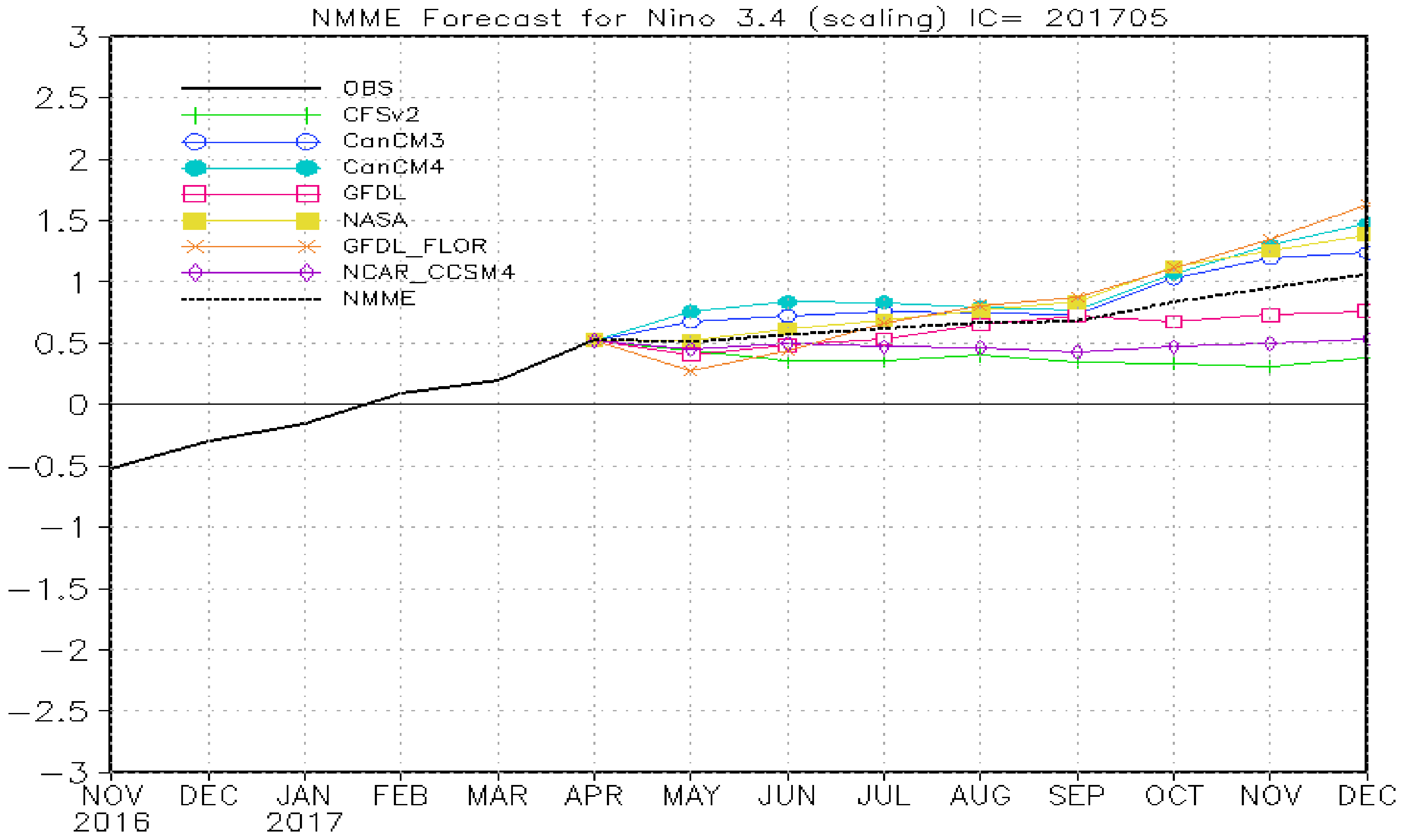
CFS Niño3.4 SST Predictions from Different Initial Months



- Latest CFSv2 forecasts call for a bordline El Nino since summer 2017.
- CFSv2 predictions had cold biases with ICs in Jun-Dec 2016.

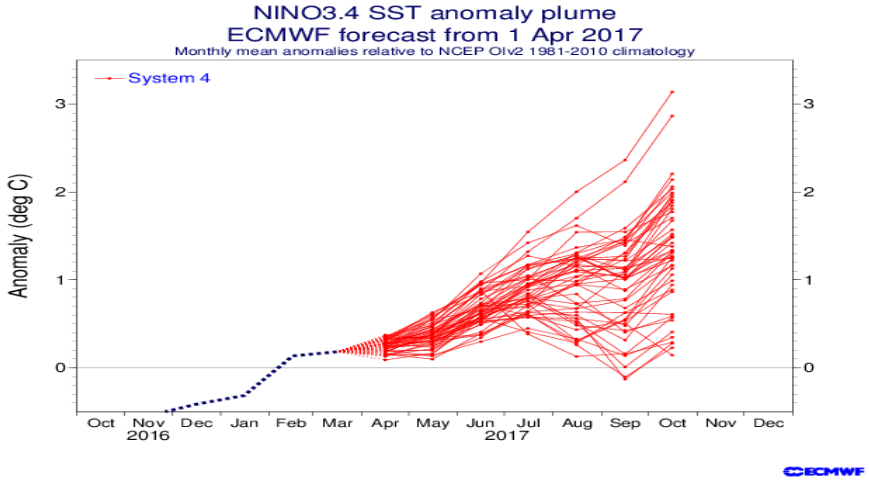
Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with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

Emily Becker: "CFSv2 and CCSM4 both respond to the CFSR re-re-adjustment with flat forecasts, while GEOS5, FLOR, and CanCM3&4 are sticking with weak-moderate El Nino. The ensemble mean of both original and PDF-adjusted call for ONI about +1C, peaking in OND/NDJ. Overall, the probabilities are confident for El Nino, but the magnitude is pretty borderline."

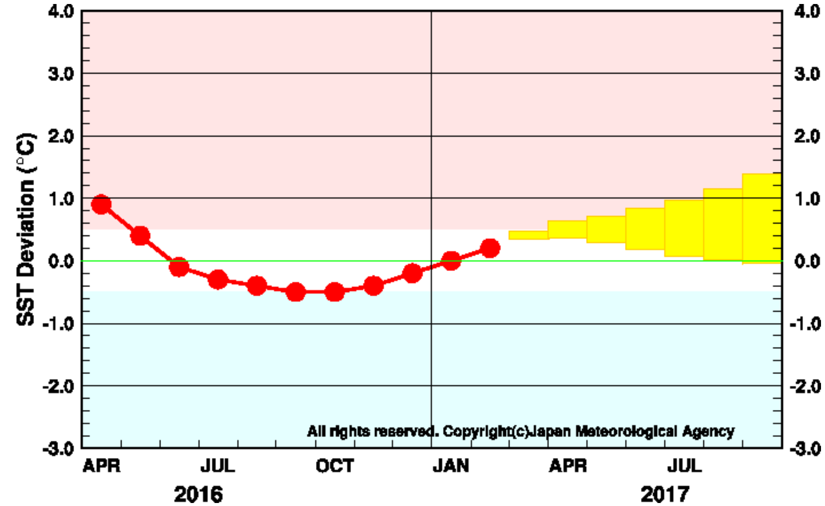


Individual Model Forecasts: neutral or (boardline) El Nino

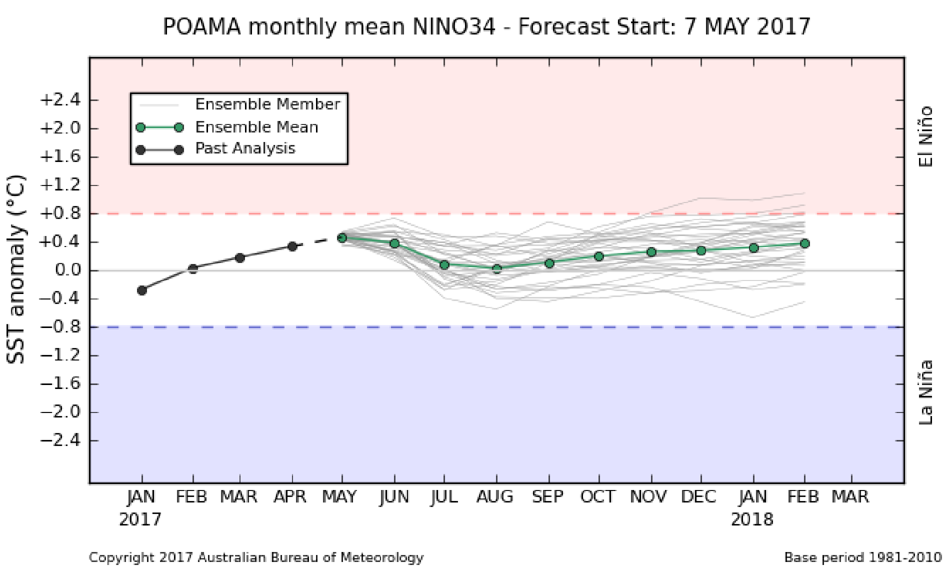
EC: Nino3.4, IC=01Apr 2017



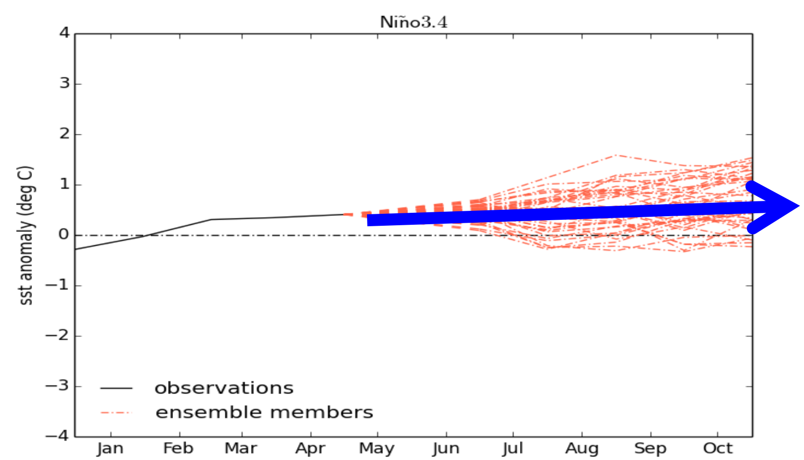
JMA: Nino3, IC=May 2017



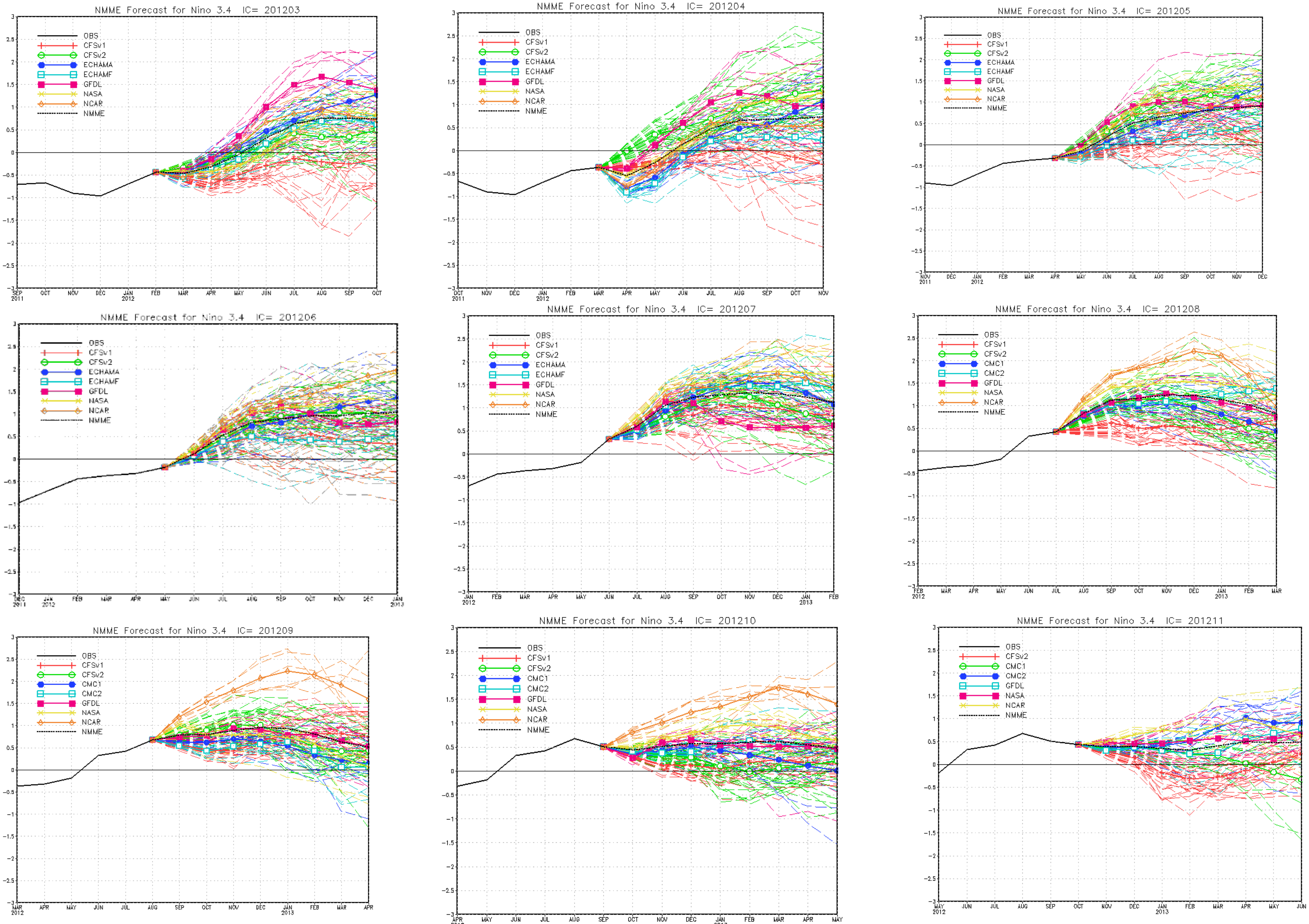
Australia: Nino3.4, IC=7May 2017



UKMO: Nino3.4, IC=May 2017

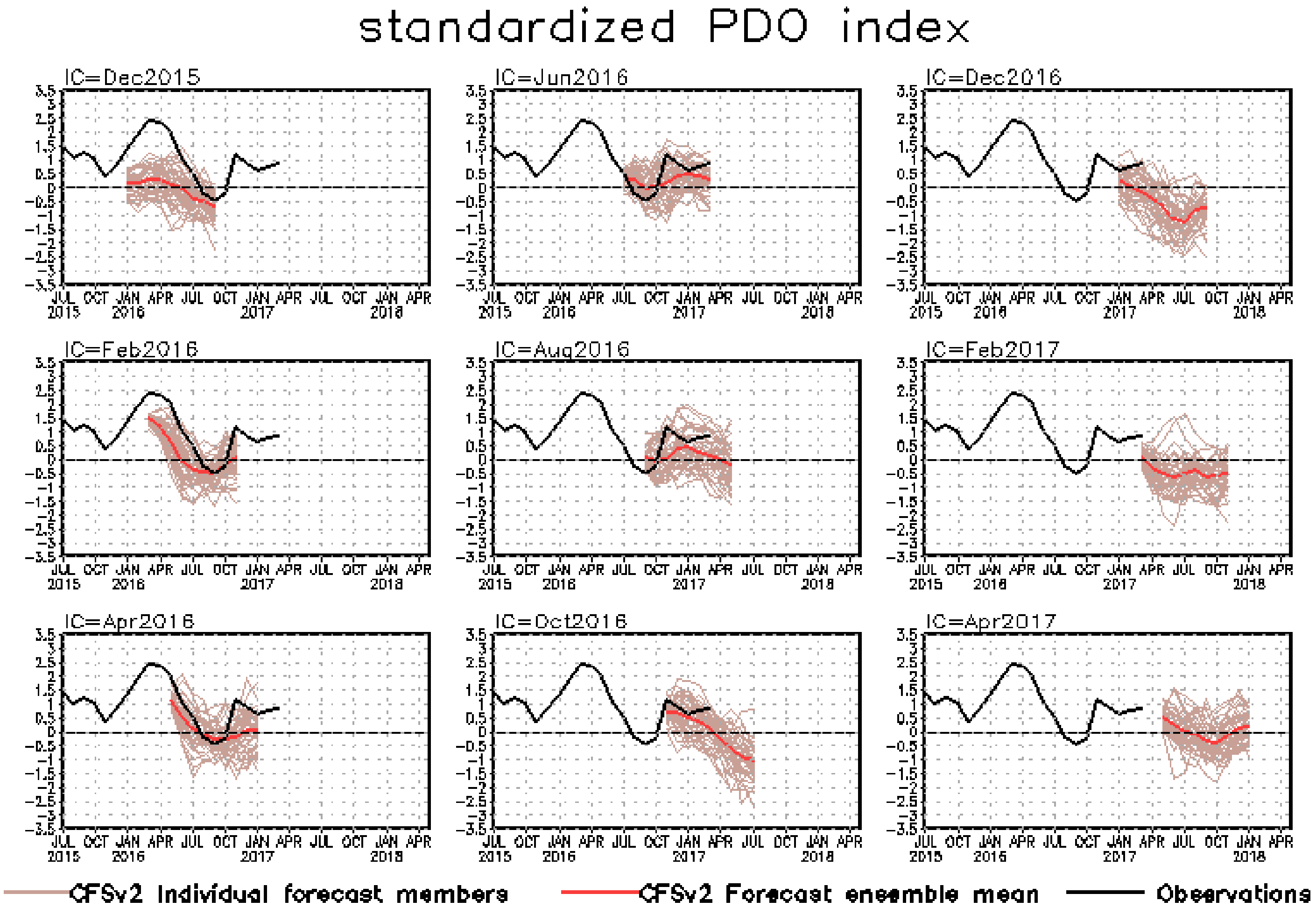


Failure Forecast in 2012 with ICs in Mar-Nov 2012



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].

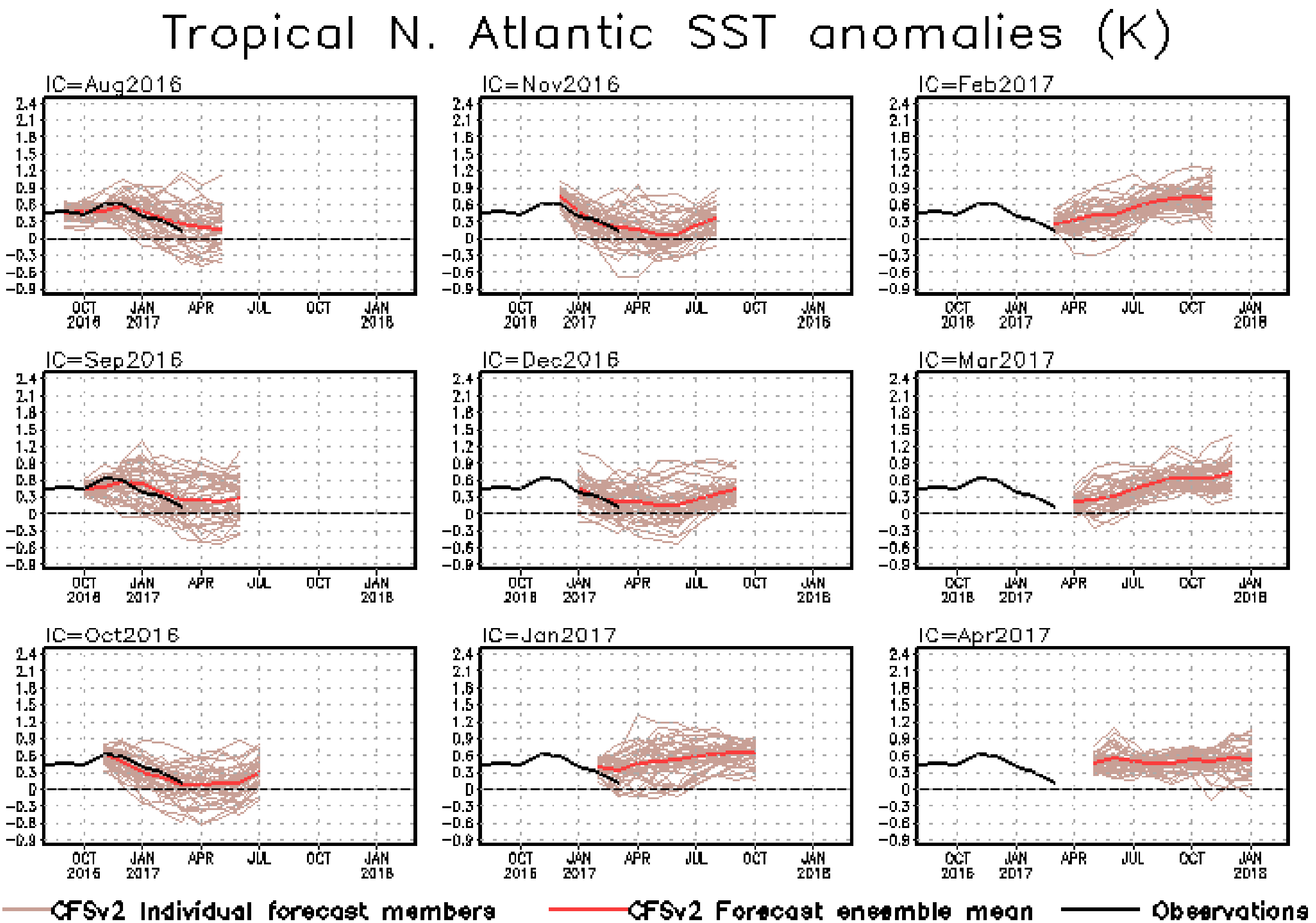
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

- CFSv2 predicts a netural 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

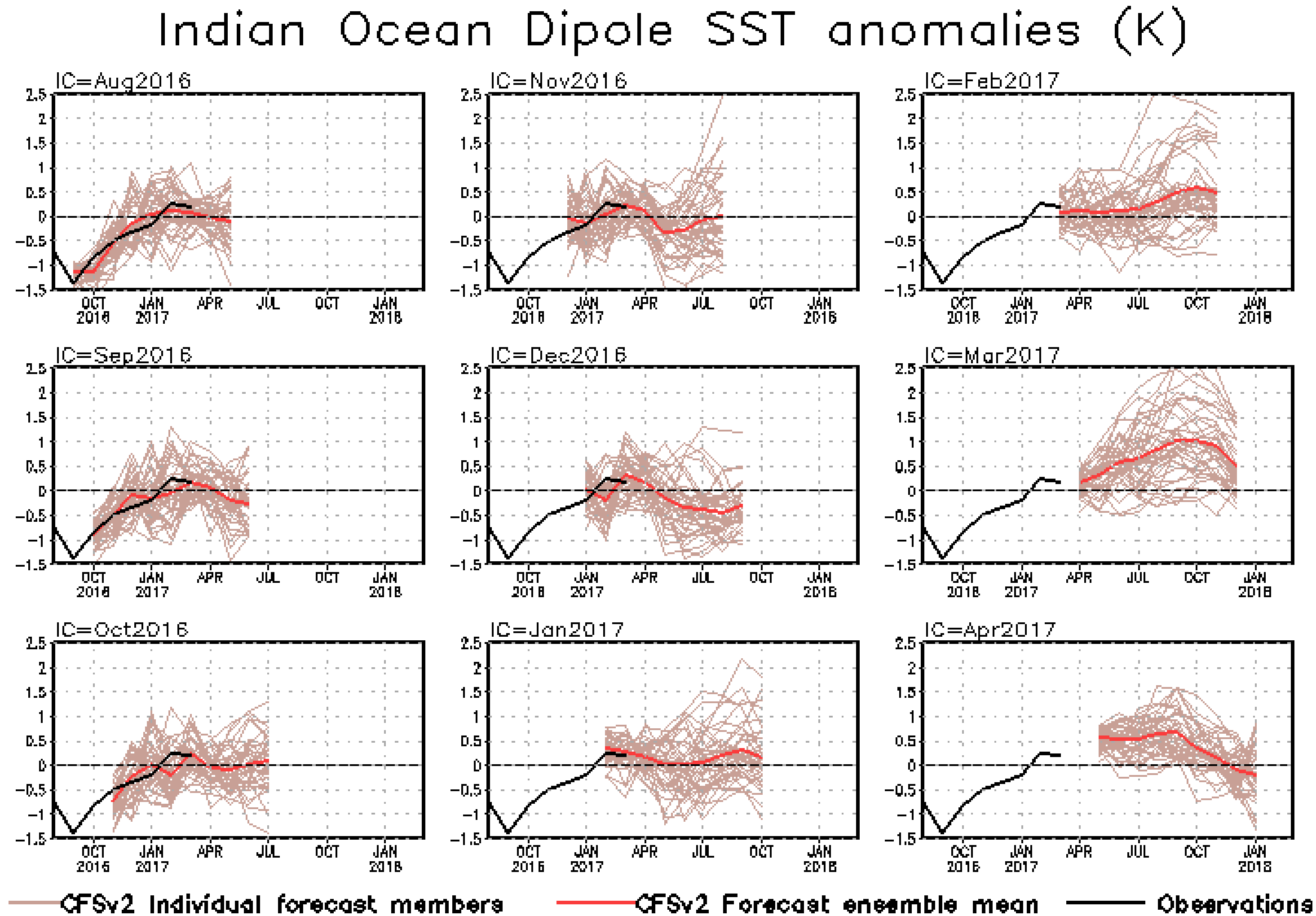
TNA is the SST anomaly averaged in the region of [60°W-30°W, 5°N-20°N].



- 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.

Which is the strongest El Nino so far, 1997/98 or 2015/16?

“On the basis of the Niño3.4 index and its uncertainty *(in ERSSTv4)*, we find that the strength of the three strongest ENSO events is not separable at 95% confidence level. The monthly peak SST anomalies in the most recent 2015–2016 El Niño is tied with 1997–1998 and 1982–1983 El Niño as the strongest.”

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

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2016GL070888

Key Points:
- The strength of the three strongest ENSO events is not separable at 95% confidence level
- The histograms of 1000-member ensemble analysis support that the strength of the three strongest ENSO events is not separable
- The ENSO ranking has to include the SST uncertainty

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Ranking the strongest ENSO events while incorporating SST uncertainty

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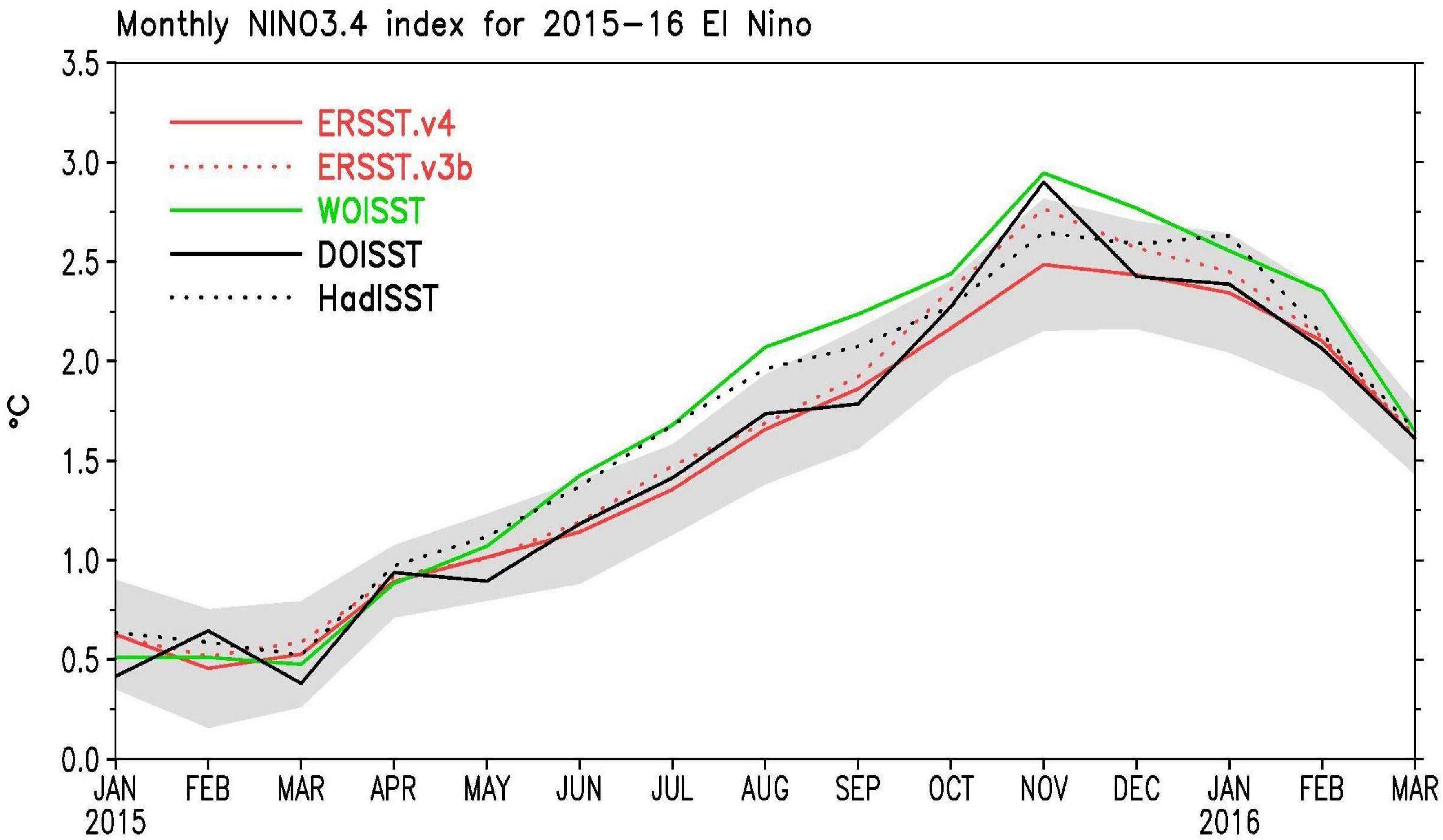
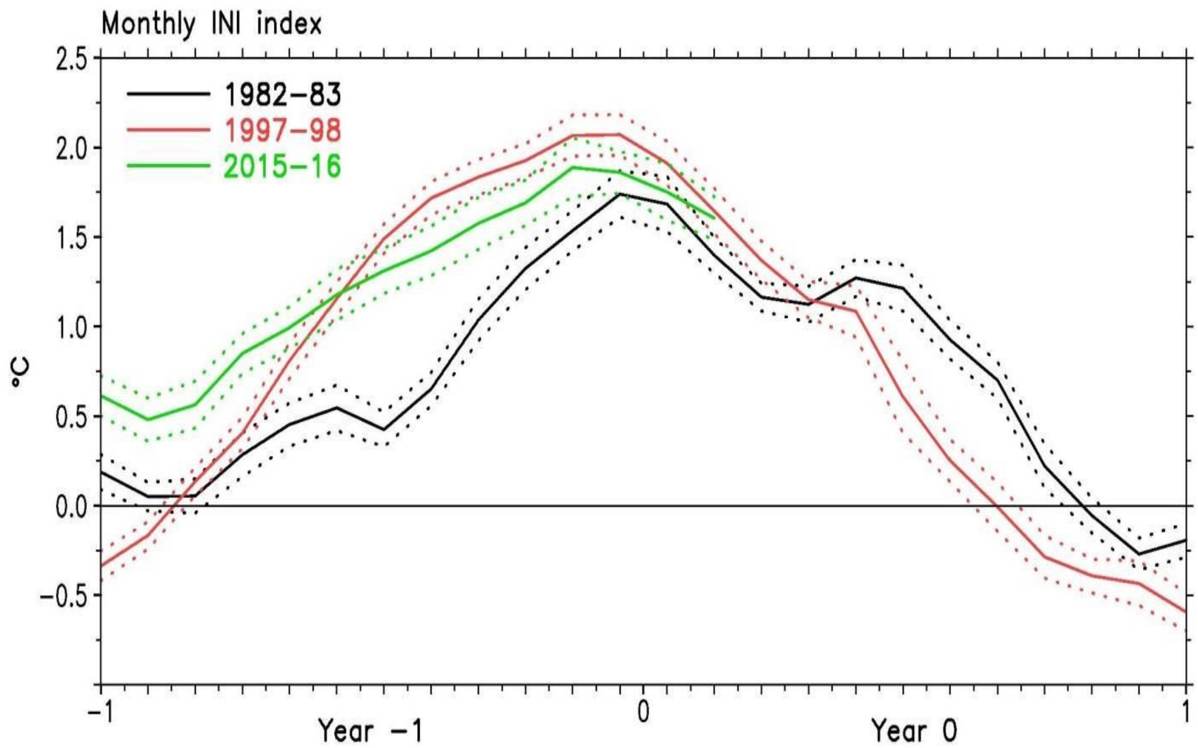
[1]National Centers for Environmental Information, NOAA, Asheville, North Carolina, USA, [2]Climate Prediction Center, NOAA, College Park, Maryland, USA

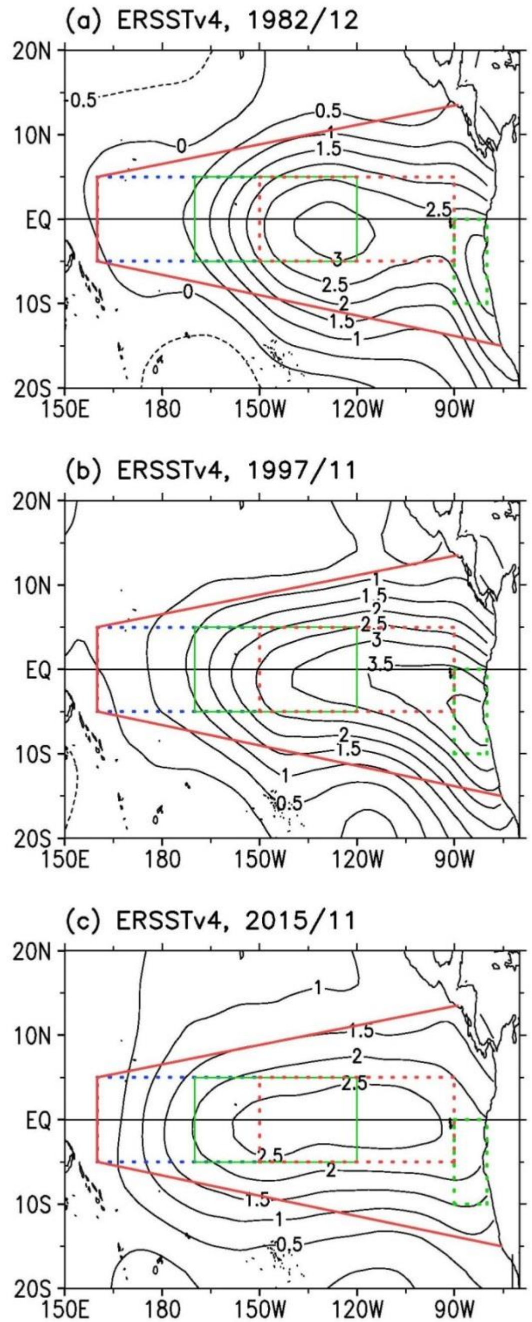
Abstract The strength of El Niño–Southern Oscillation (ENSO) is often measured using a single, discrete value of the Niño index. However, this method does not consider the sea surface temperature (SST) uncertainty associated with the observations and data processing. On the basis of the Niño3.4 index and its uncertainty, we find that the strength of the three strongest ENSO events is not separable at 95% confidence level. The monthly peak SST anomalies in the most recent 2015–2016 El Niño is tied with 1997–1998 and 1982–1983 El Niño as the strongest. The three most negative monthly Niño values occur within the 1955–1956, 1973–1974, and 1975–1976 La Niña events, which cannot be discriminated by rank. The histograms of 1000-member ensemble analysis support the conclusion that the strength of the three strongest ENSO events is not separable. These results highlight that the ENSO ranking has to include the SST uncertainty.



Monthly Niño3.4 from ERSSTv4 (solid red line), ERSSTv3b (dotted red line), WOISST (solid green line), DOISST (dotted green line), and HadISST (solid blue line) during 2015-16 El Niño. The gray shading represents the 1.96σ uncertainty of ERSSTv4 at the 95% confidence level.

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





ERSSTv4 monthly INI indices (solid lines) and their uncertainty at 95% confidence level (dotted lines) for 1982-83, 1997-98, and 2015-16 El Niños.

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

Acknowledgements

- Drs. Caihong Wen, Arun Kumar, and Yan Xue: carefully 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 NINO3.4 plume
- Drs. Thomas Collow and Wanqiu Wang: Supplied Sea ice slides
- Dr. Kathleen Dohan: updated OSCAR current

Backup Slides

Global Sea Surface Salinity (SSS)
Anomaly for April 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!
- Positive SSS anomaly appear in the most areas of the 20°S to 10°N in Indian Ocean; 20°N to 40°N in the N. Pacific Ocean, and 20°S to 40°N of the Atlantic Ocean. The salinity increase in the Indian Ocean is likely due to the decrease of the precipitation. However, the precipitation between 20°N to 40°N in the N. Pacific is increasing, so the ocean currents/entrainments and/or mixing probably contribute to the SSS increase. Large area of evaporation increase appear in the Atlantic ocean, especially the west basins of the both hemispheres, which likely cause the coherent increase of SSS in these regions. The SSS in the north region of the Bay of Bengal continues decreasing.

- **Data used**

  SSS :

  Blended Analysis of Surface Salinity (BASS) V0.Y

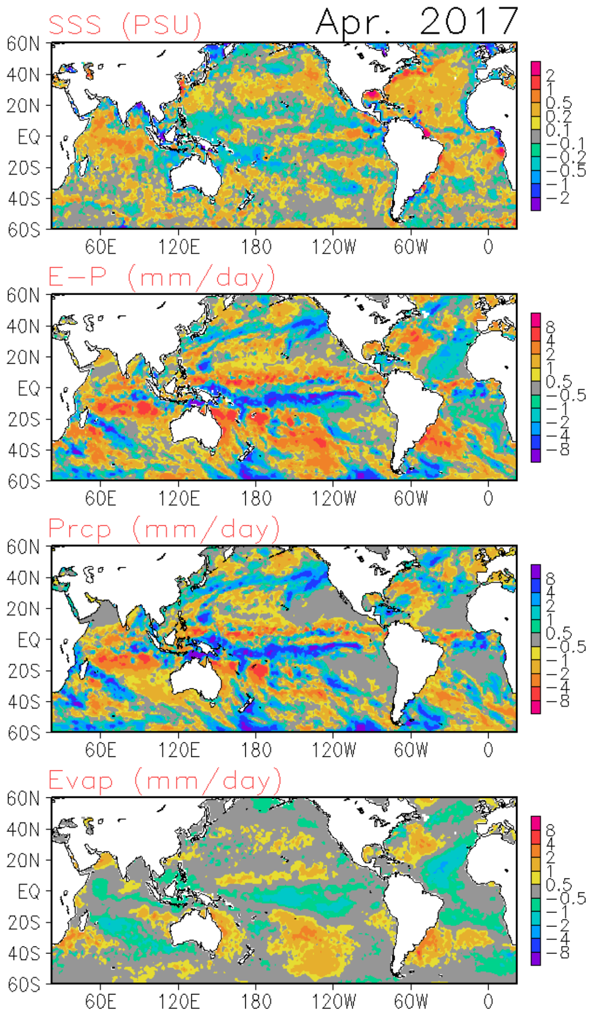
  (a CPC-NESDIS/NODC-NESDIS/STAR joint effort)

  (Xie et al. 2014)

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

  Precipitation: CMORPH adjusted satellite precipitation estimates

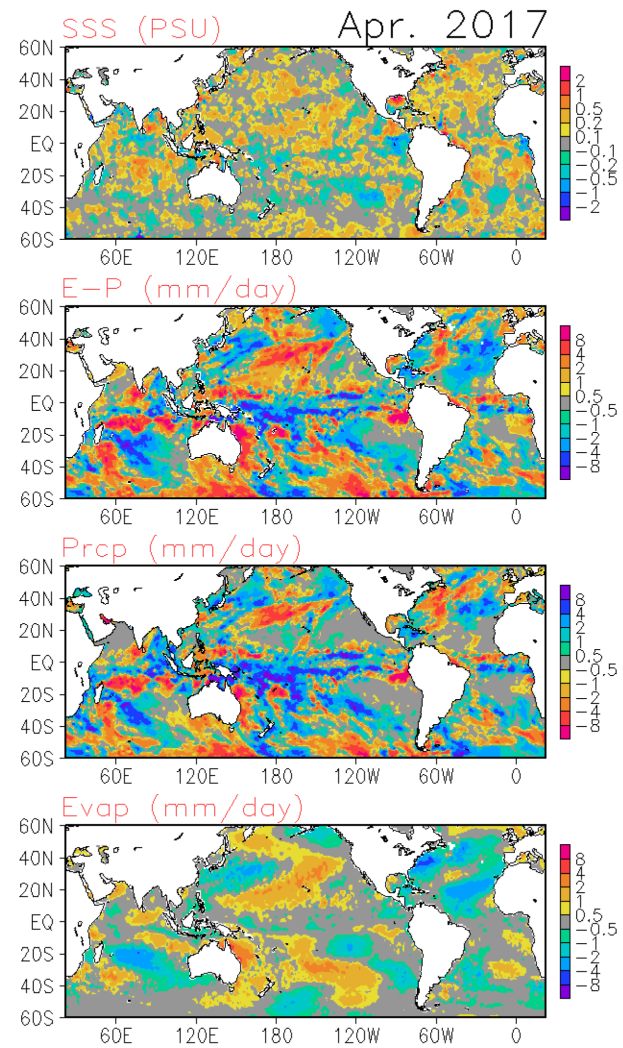
  Evaporation: CFS Reanalysis



Global Sea Surface Salinity (SSS)

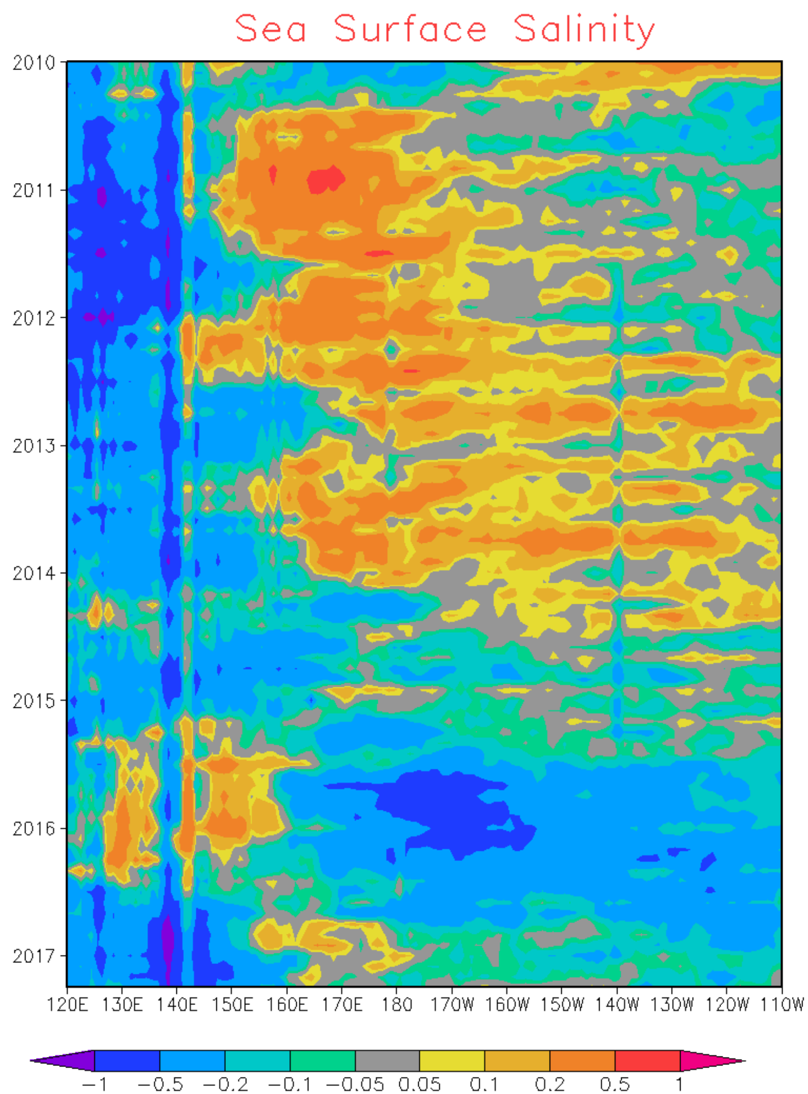
Tendency for April 2017

Compared with last month, the salinity between 20°N to 40°N in the N. Pacific Ocean and majority of 20°S to 40°N in the Atlantic Ocean shows increase. The SSS increase in the N. Pacific Ocean is probably caused by the oceanic advection, entrainment, and mixing. While, the SSS increase in the Atlantic ocean is likely due to the reduction of the freshwater flux in this region. The SSS decreases in the west basin of north of Bay of Bengal and increase in the east basin of north of Bay of Bengal.



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 continues as well. There is no significant SSS change the east 170°W.



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

- Overall SSTAs were small in the tropical, and large in the SW.
- SSTA tendency was largely determined by heat flux.
- Convections were enhanced over the northern basin.

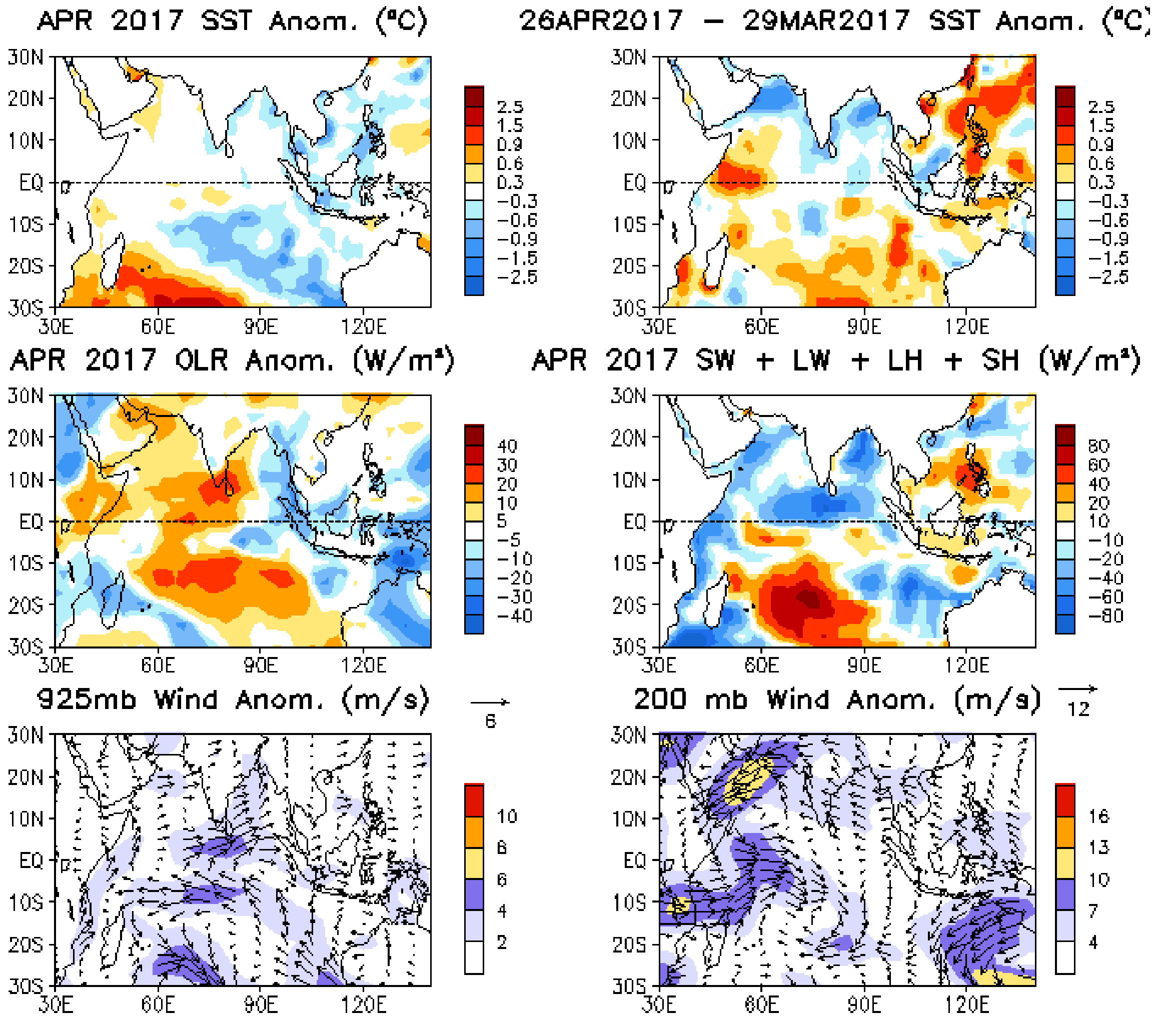
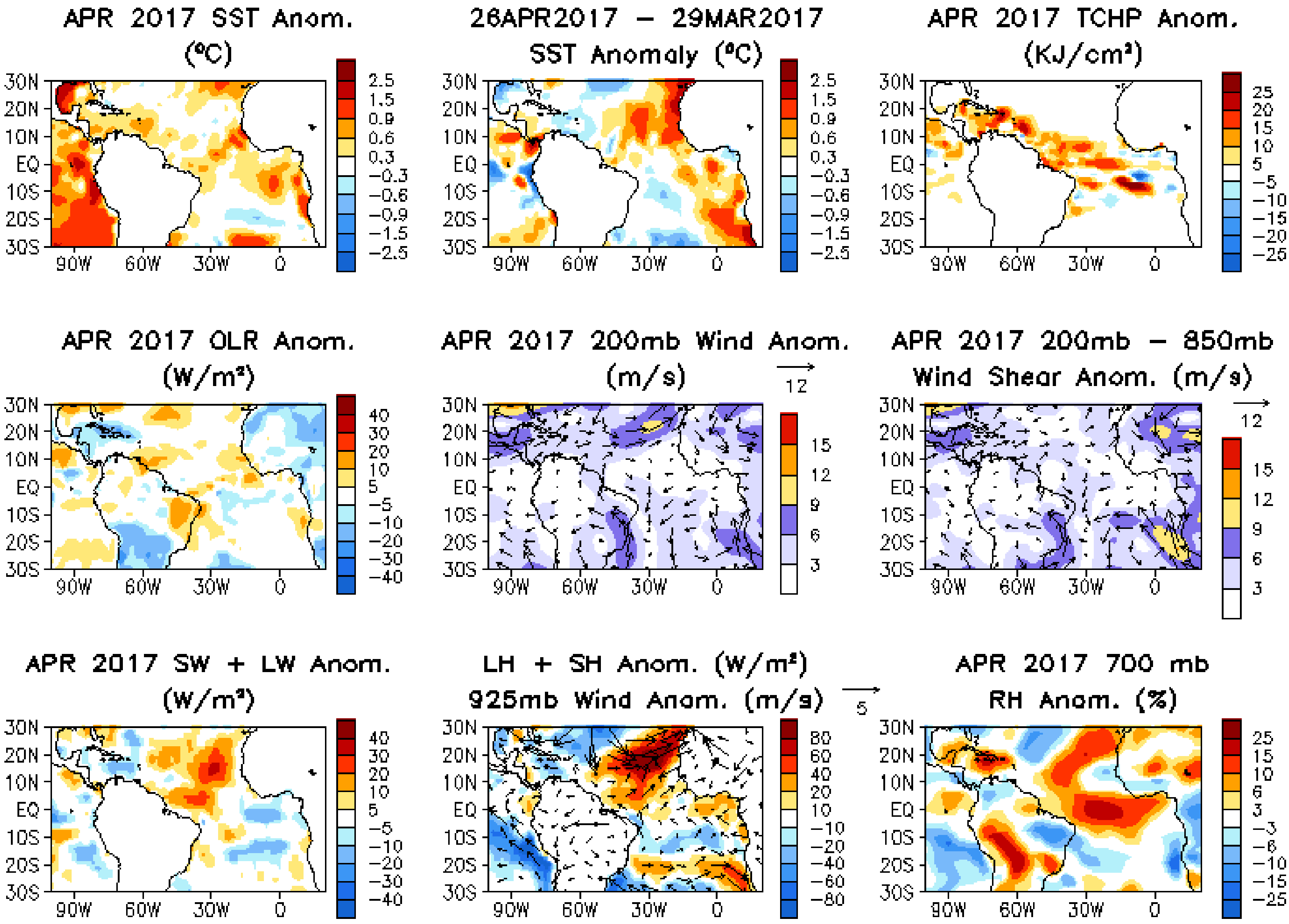


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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



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

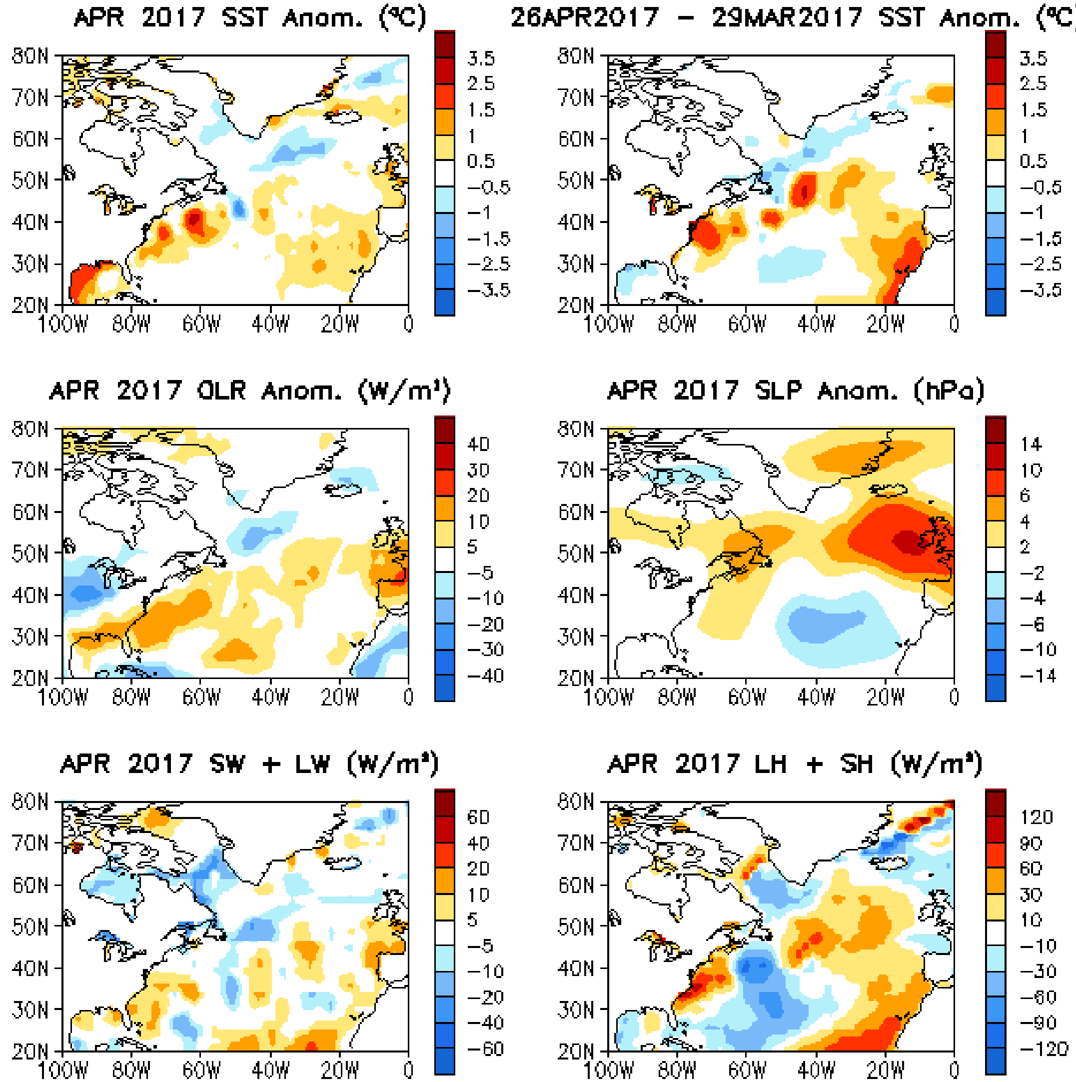
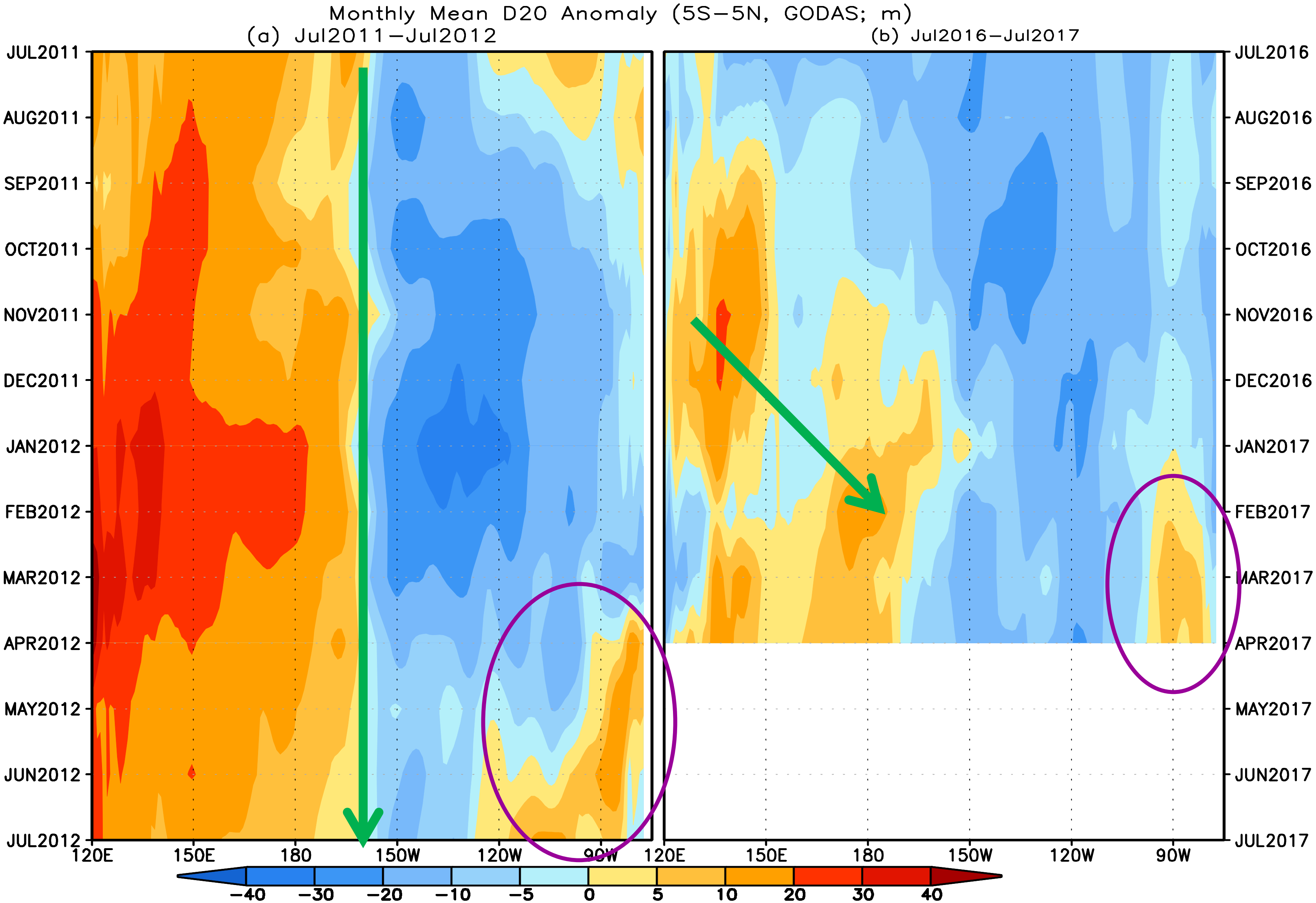
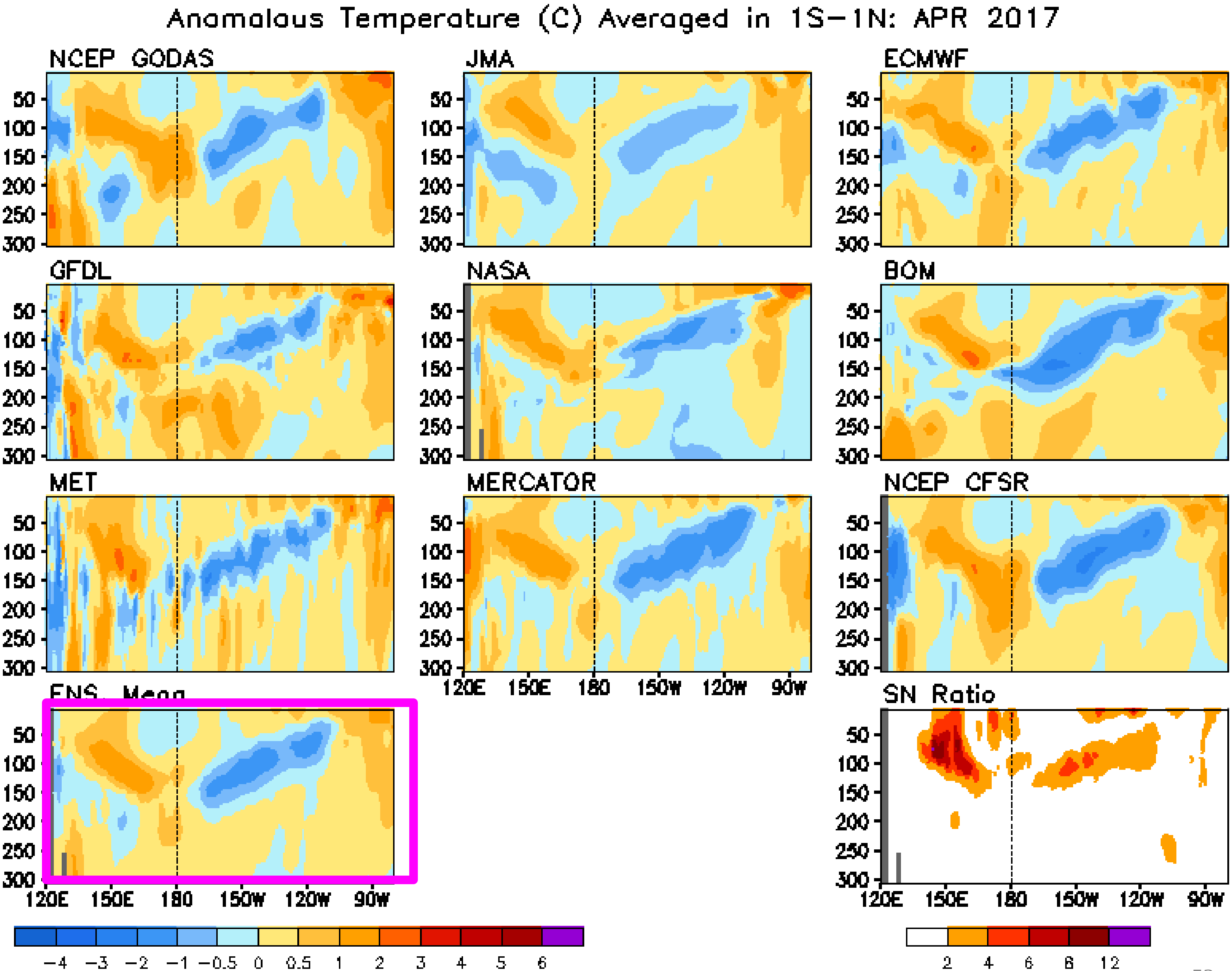


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

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





Anomalous Temperature (C) Averaged in 1S-1N: APR 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

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!