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

Prepared by

Climate Prediction Center, NCEP/NOAA

January 11 , 2019

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

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

Outline

- **Overview**
- **Recent Highlights**
  - **Pacific/Arctic Ocean**
  - **Indian Ocean**
  - **Atlantic Ocean**
- **Global SST Predictions**
- **Review of El Nino development in 2018 and its comparison with historical El Nino events**
- **Characteristics of long-term changes and their footprints in the 2018 El Nino development**
- **Subsurface signature in “Warm Blob in Pacific” and “Cold Blob in Atlantic”**

Overview

- **Pacific Ocean**
  - **According to ENSO Diagnostic Discussion released on Jan 10, 2019, ENSO-neutral conditions continued in Dec 2018 although all NINO indices were above +0.8C.**
  - **Positive subsurface temperature anomalies weakened cross the equatorial Pacific, but anomalies remained above +3C near the thermocline.**
  - **Most of the models suggest El Niño conditions will develop and last through the Northern Hemisphere spring/summer 2019.**
  - **Eastward propagation of intraseasonal variability associated with Madden-Julian Oscillation were prominent in Oct-Dec 2018.**

- **Indian Ocean**
  - **A positive Indian Ocean dipole event during Sep-Nov 2018 has ended.**

- **Atlantic Ocean**
  - **Strong positive NAO index has persisted from Dec 2017 to Oct 2018, and transitioned to neutral phase in Nov-Dec 2018.**

Data Sources and References

(climatology is for 1981-2010)

- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **Extended Reconstructed Sea Surface Temperature (ERSST) v5 (Huang et al. 2017)**
- **NCEP CDAS winds, surface radiation and heat fluxes (Kalnay et al. 1996)**
- **NESDIS Outgoing Long-wave Radiation**
- **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 from CMEMS**
- **Ocean Surface Current Analyses – Realtime (OSCAR)**
- **Ensemble ocean reanalyses from Real-time Ocean Reanalysis Intercomparison Project**

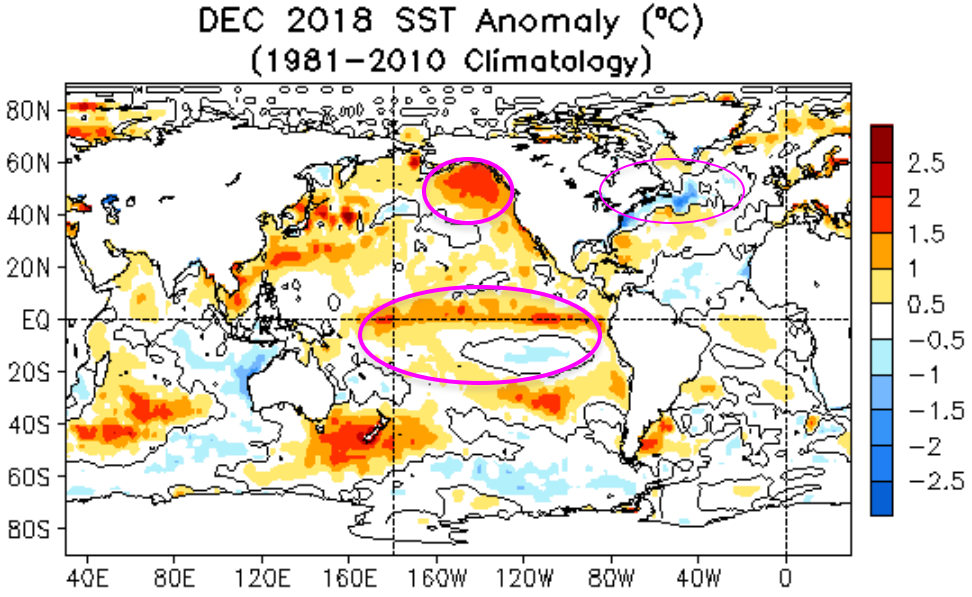
http://www.cpc.ncep.noaa.gov/products/GODAS/multiora_body.html

http://www.cpc.ncep.noaa.gov/products/GODAS/multiora93_body.html

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

Global Oceans

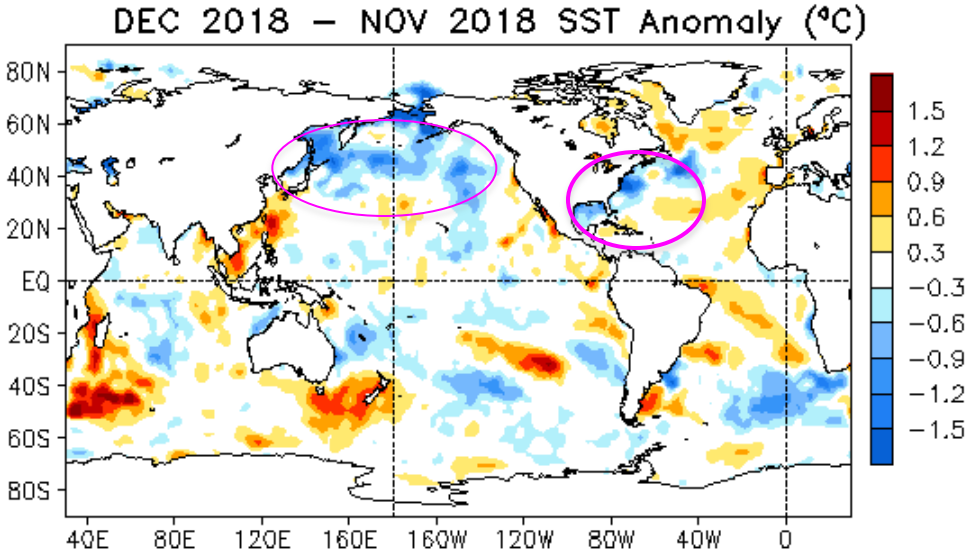
Global SST Anomaly (^{0}C) and Anomaly Tendency



- **SSTs were above average across the tropical Pacific except in the southeast Pacific.**

- **Positive SSTAs persisted in the Gulf of Alaska**

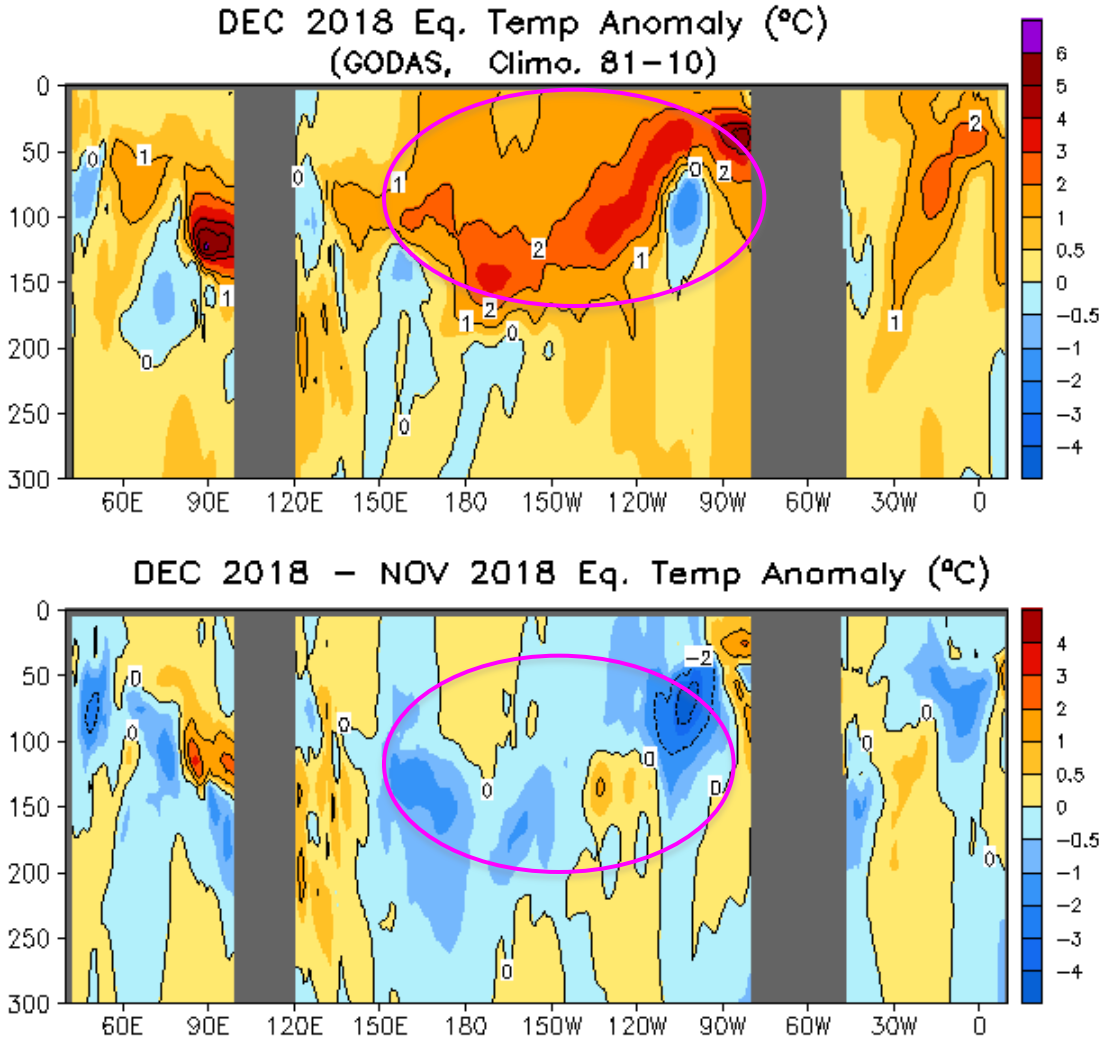
- **Negative SSTAs emerged along the Gulf Stream.**



- **SSTA tendencies were negative in the high-latitude North Pacific, Gulf of Mexico, and near the eastern coast of U.S.**

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



- **In the equatorial Pacific positive temperature anomalies continued, and were above +3°C near the thermocline.**

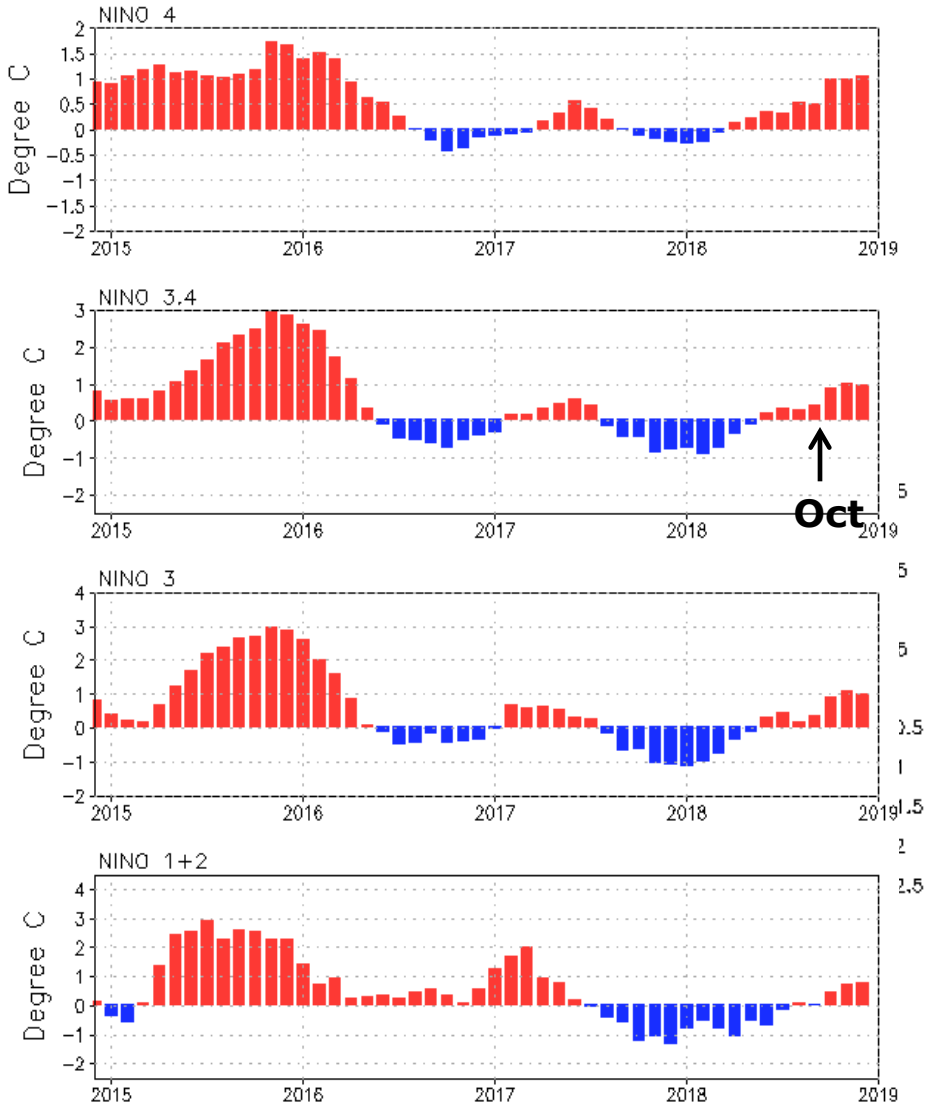
- **Positive temperature anomalies presented along the thermocline in the Atlantic and Indian Oceans.**

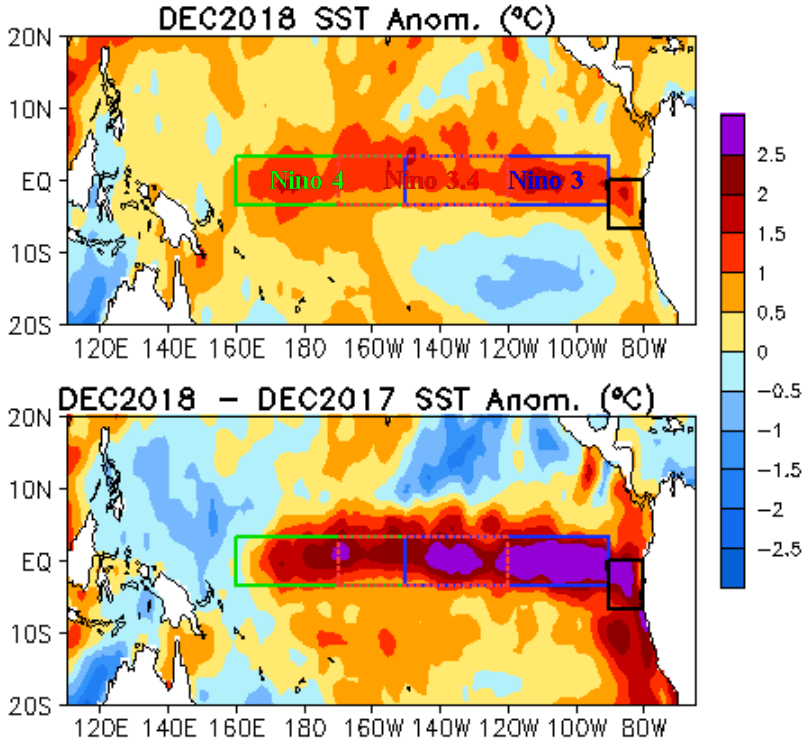
- **Temperature anomaly tendency was negative near the thermocline in the equatorial Pacific with the strongest cooling in the far eastern Pacific.**

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

Evolution of Pacific NINO SST Indices





- **All NINO indices persisted in Dec 2018, with Niño 3.4 = 1.0 C.**

- **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

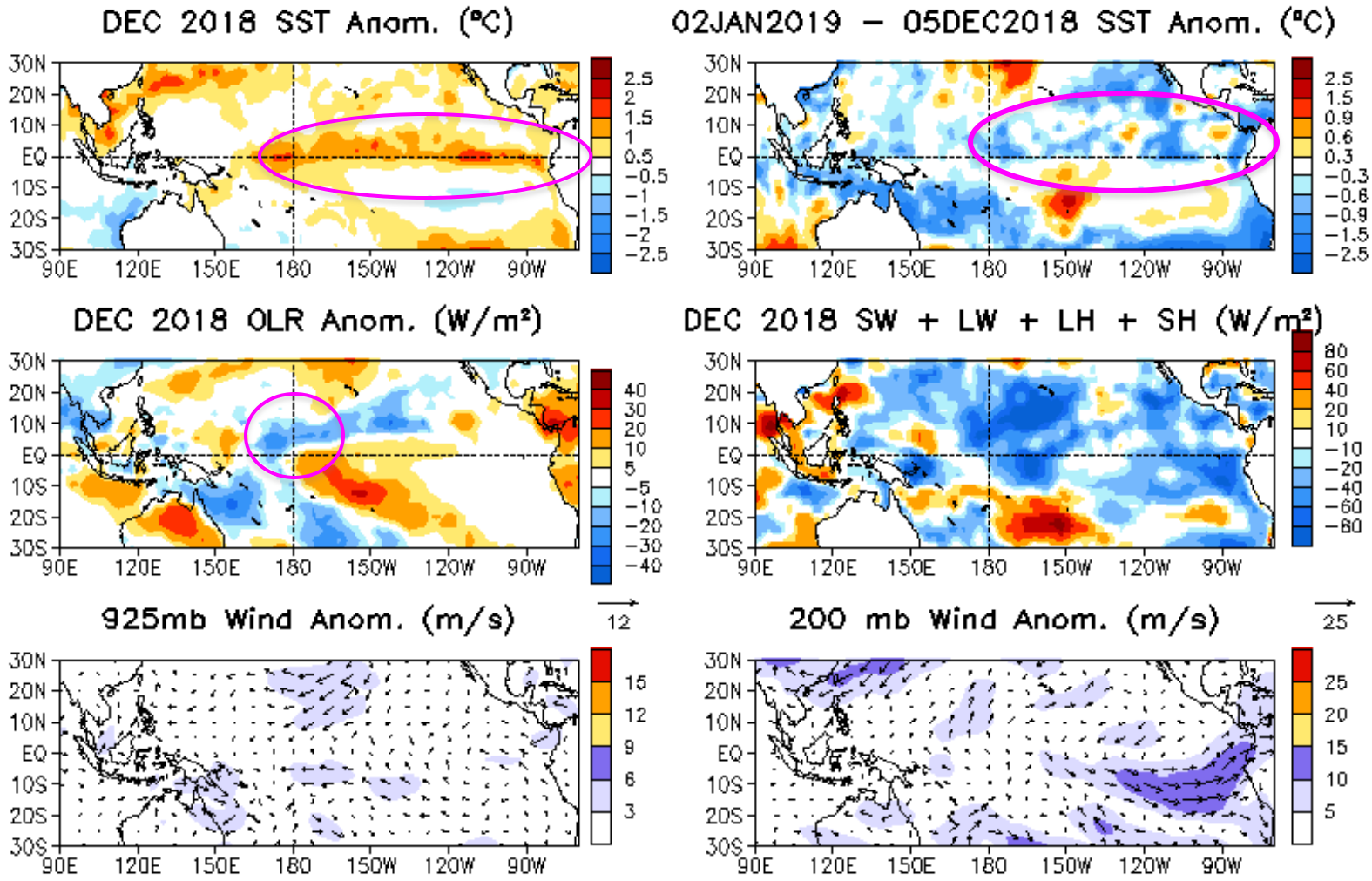
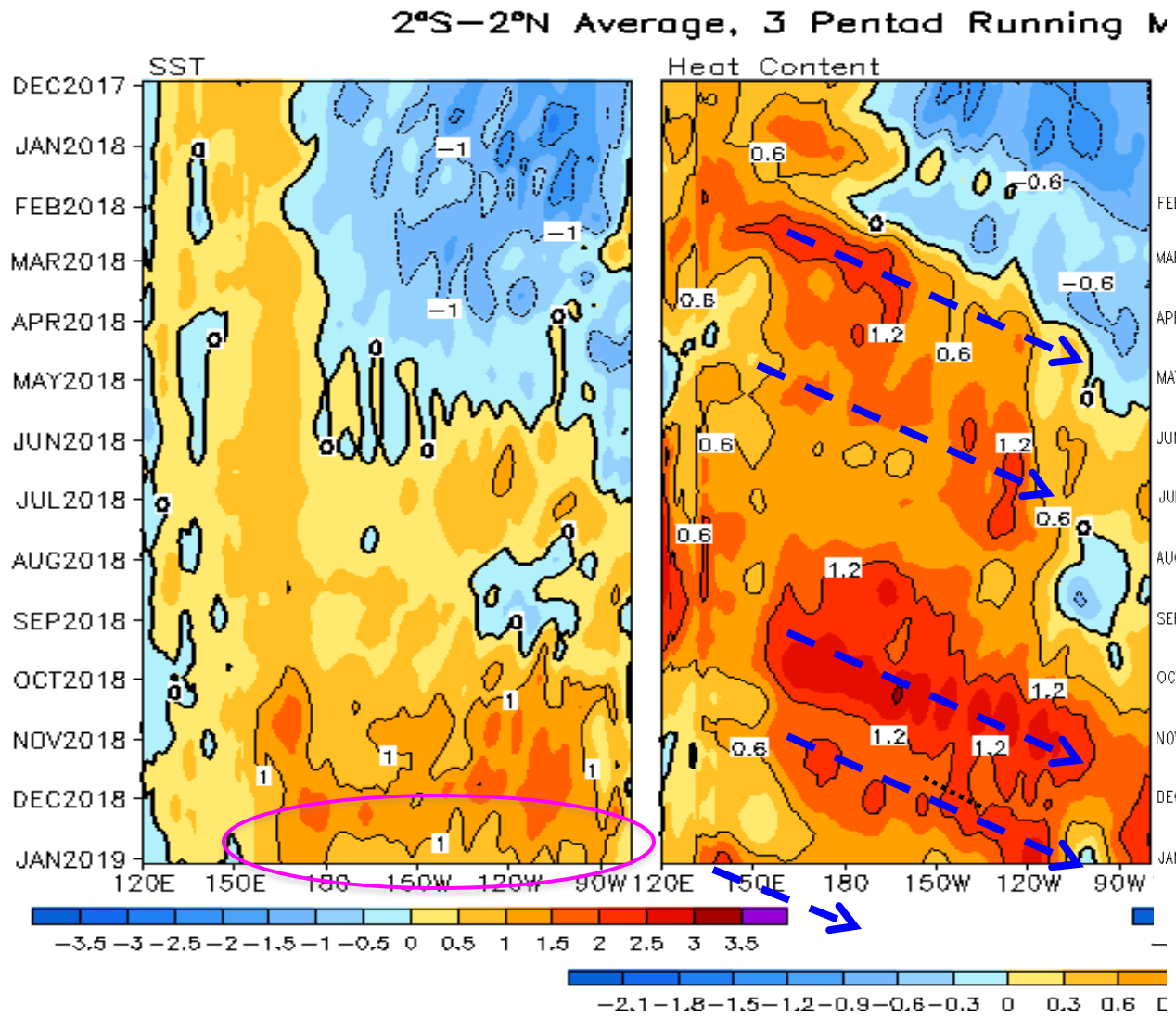
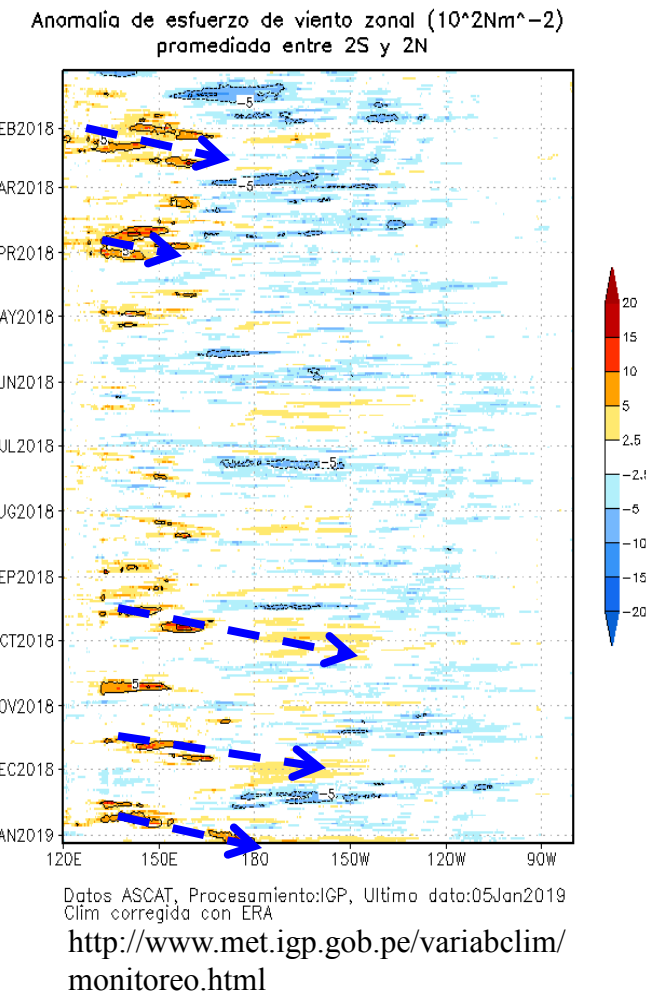


Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

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



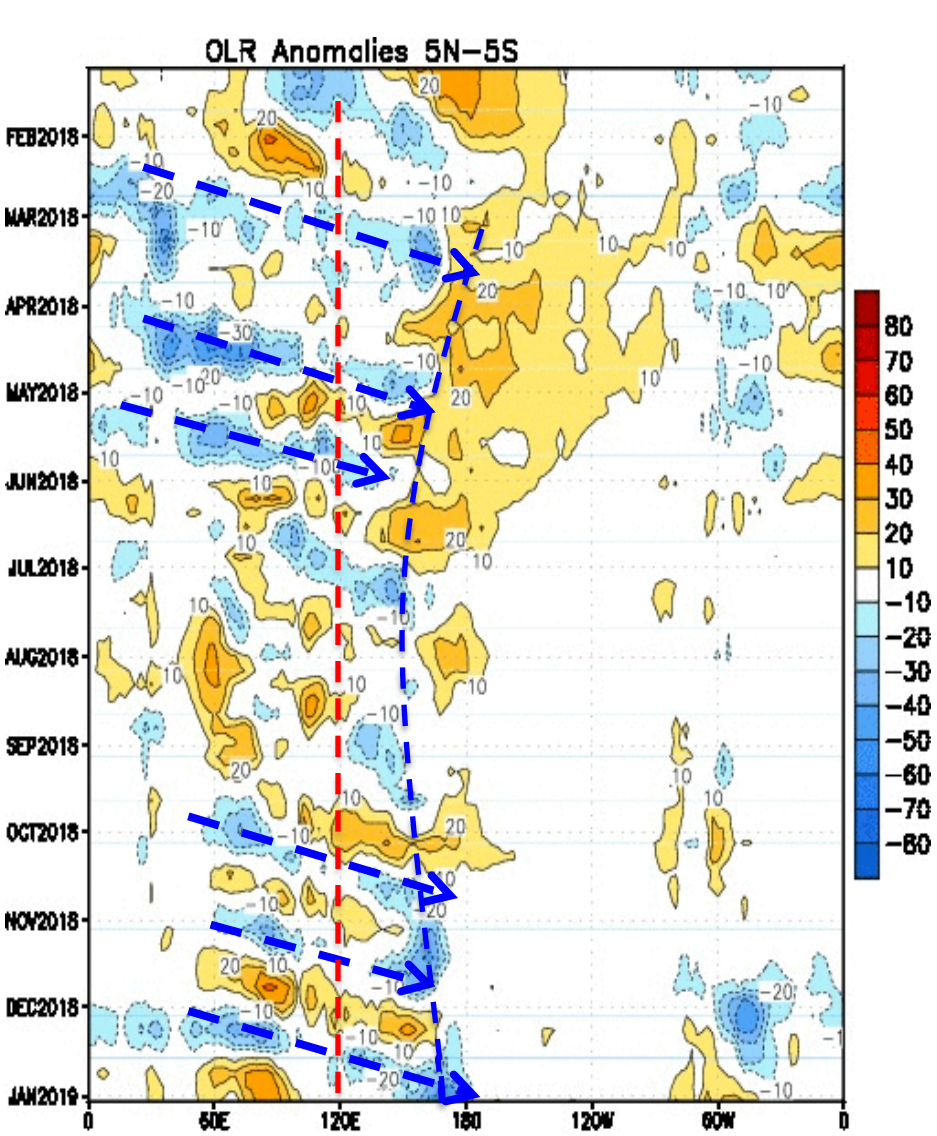
ASCAT Zonal Windstress

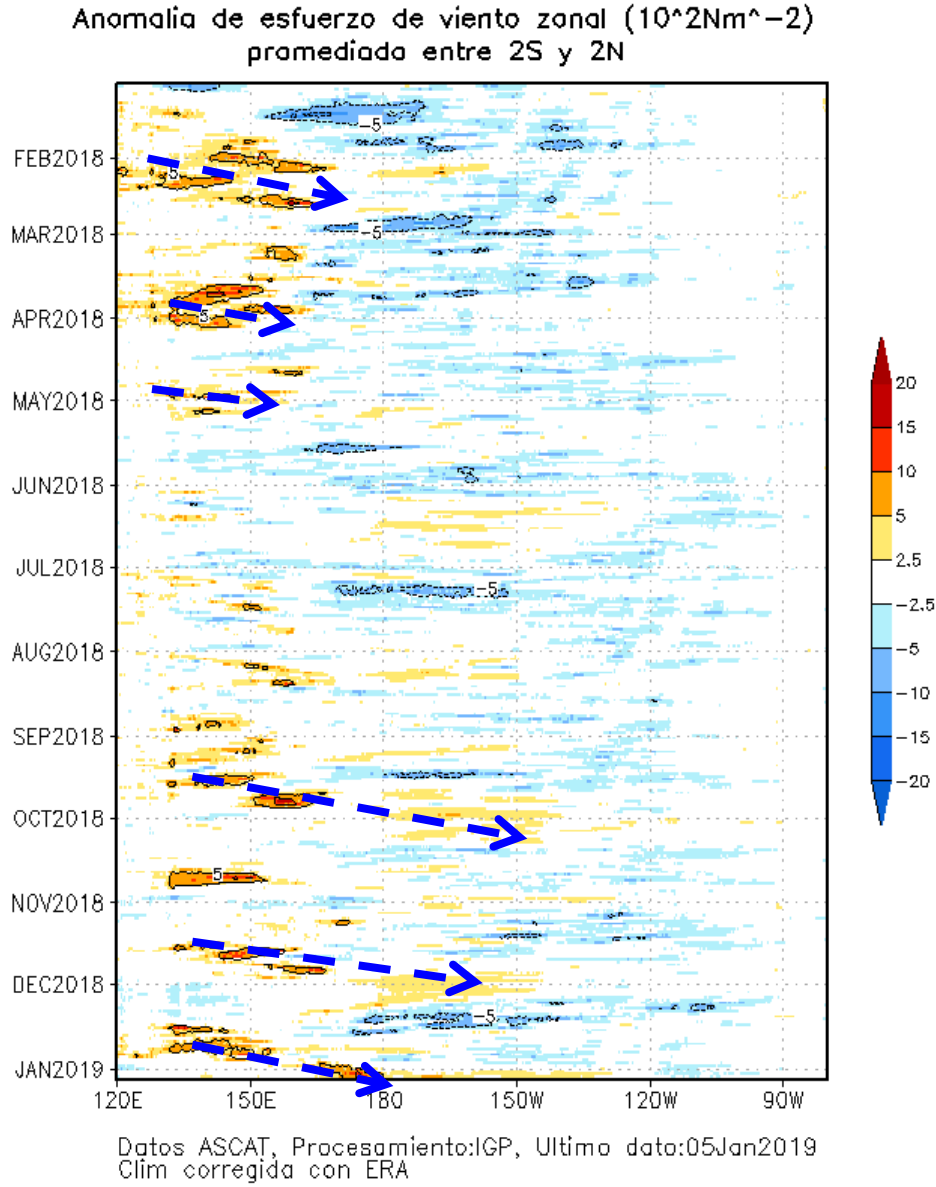


http://www.met.igp.gob.pe/variabclim/monitoreo.html

- **Positive SSTA more than +1C has persisted since Oct, but it reduced substantially in the central-eastern Pacific in late Dec 2018.**

- **A sequence of downwelling oceanic Kelvin waves were observed in spring and fall/winter, which were closely associated the sequence of Westerly Wind Bursts.**

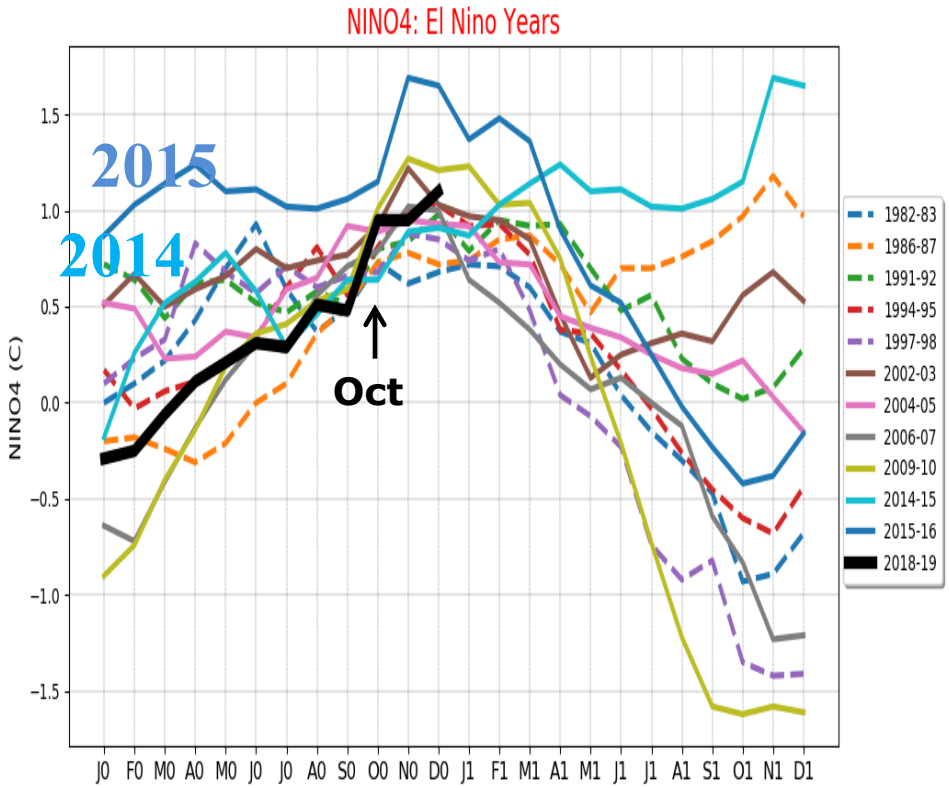


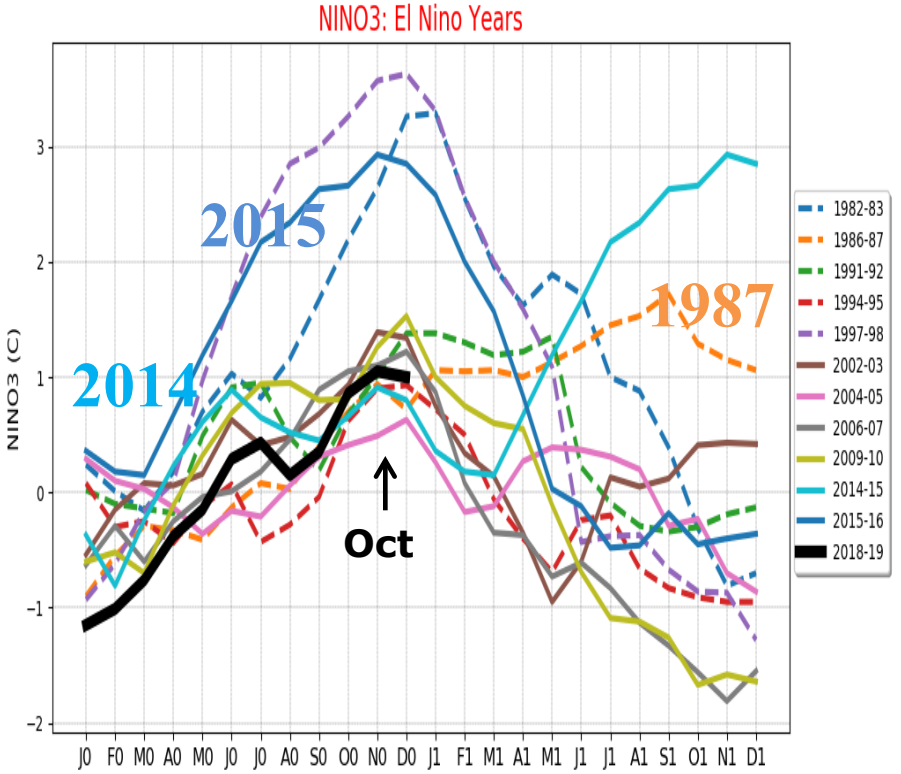


- **OLR anomalies show strong MJO activities in spring and fall/winter 2018, which appears closely associated with the sequence of Westerly Wind Bursts (WWB).**

- **Note that the absence of WWB during summer/early fall is associated with the westward retreat of deep convection during the period.**

El Nino Composites

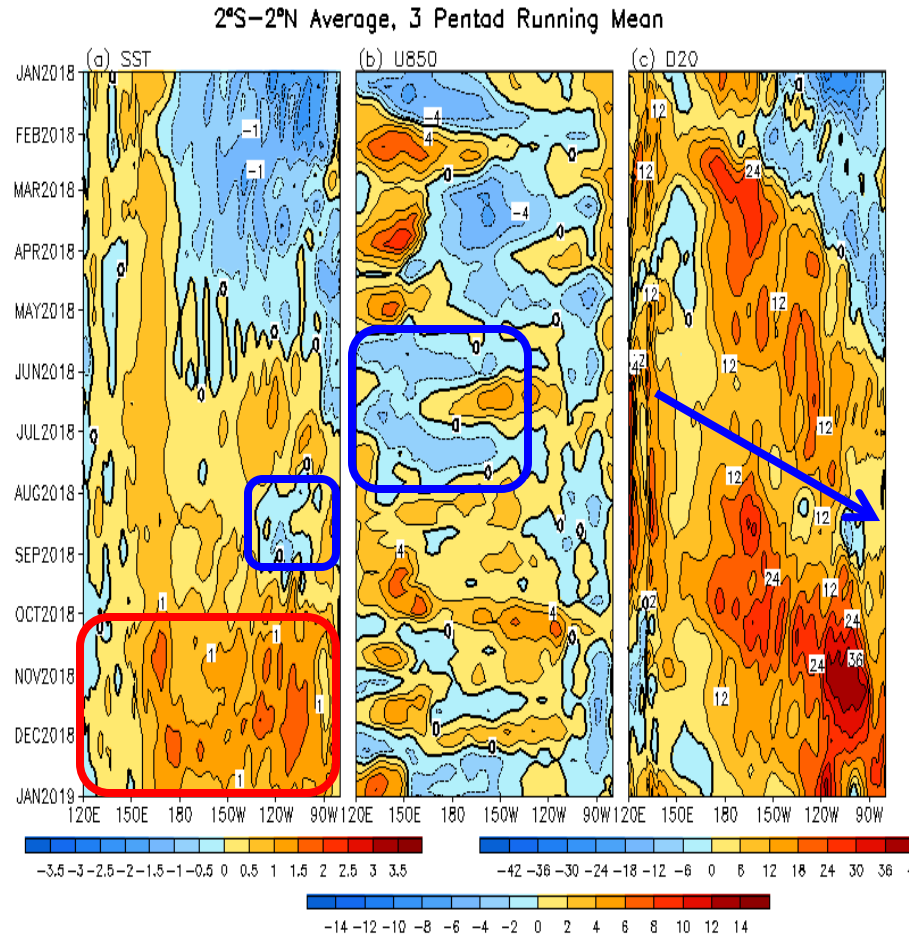




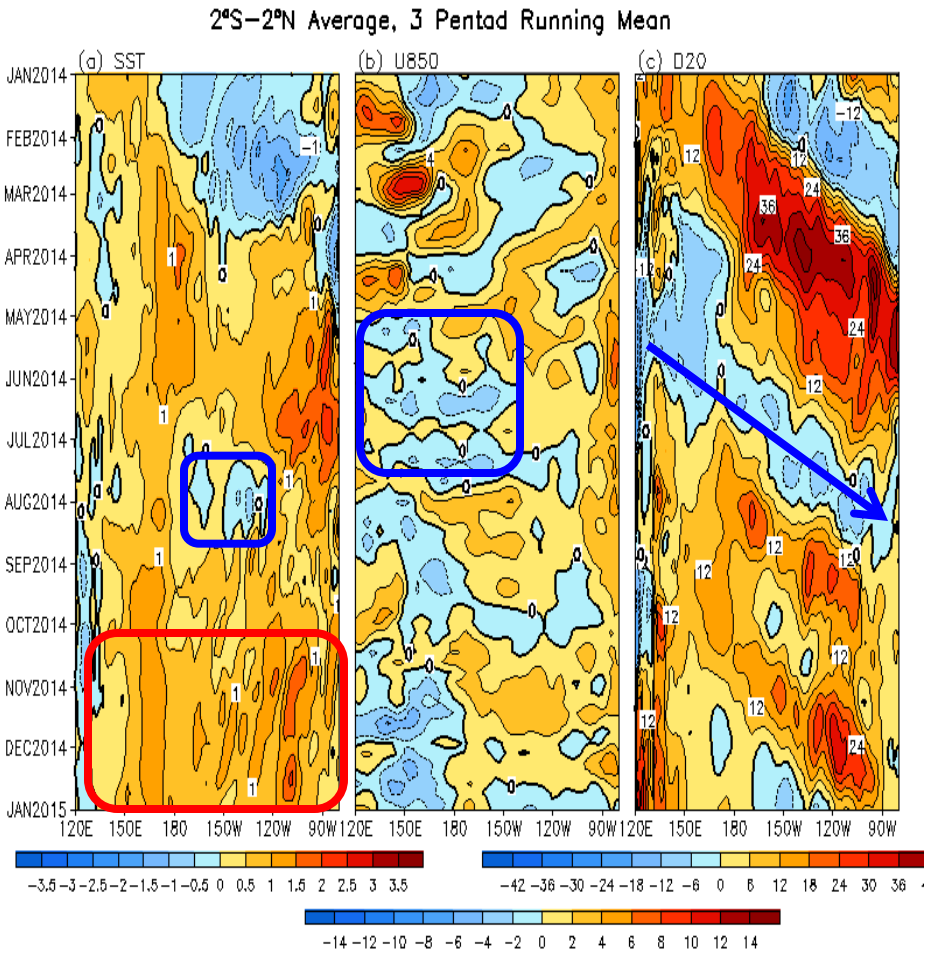
- Compared to the historical El Nino events since 1980, the El Nino development in 2018, measured by NINO3 and NINO4, started with cooler conditions, but cached up after summer, with an amplitude similar to other weak El Ninos.

- Although the evolution of NINO4 and NINO3 in 2018 is very different from that in 2014 in the first half of the year, the conditions in fall/winter are very similar in the two years.

2018



2014



The common features in the El Nino development in 2018 and 2014 include:

- easterly wind anom. and associated upwelling oceanic Kelvin waves in early summer, and SST cooling in the central-eastern Pacific in summer;

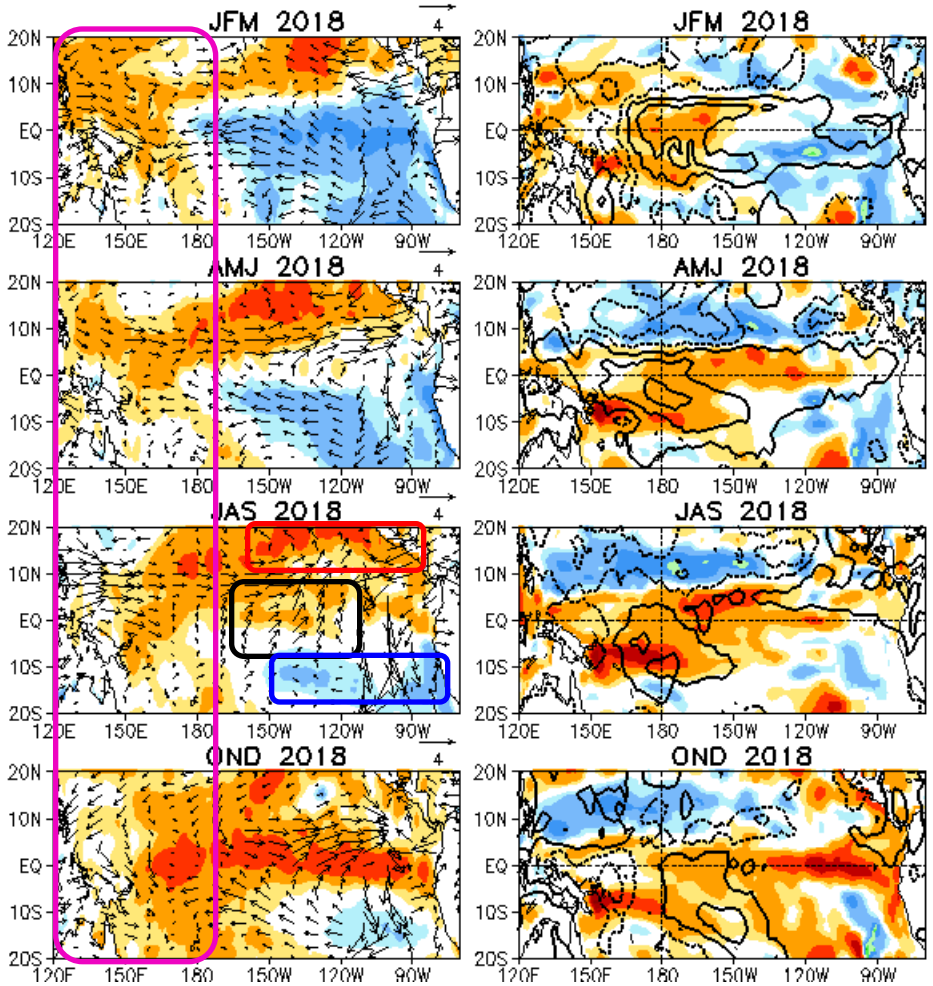
- a late onset of El Nino warming in Oct;

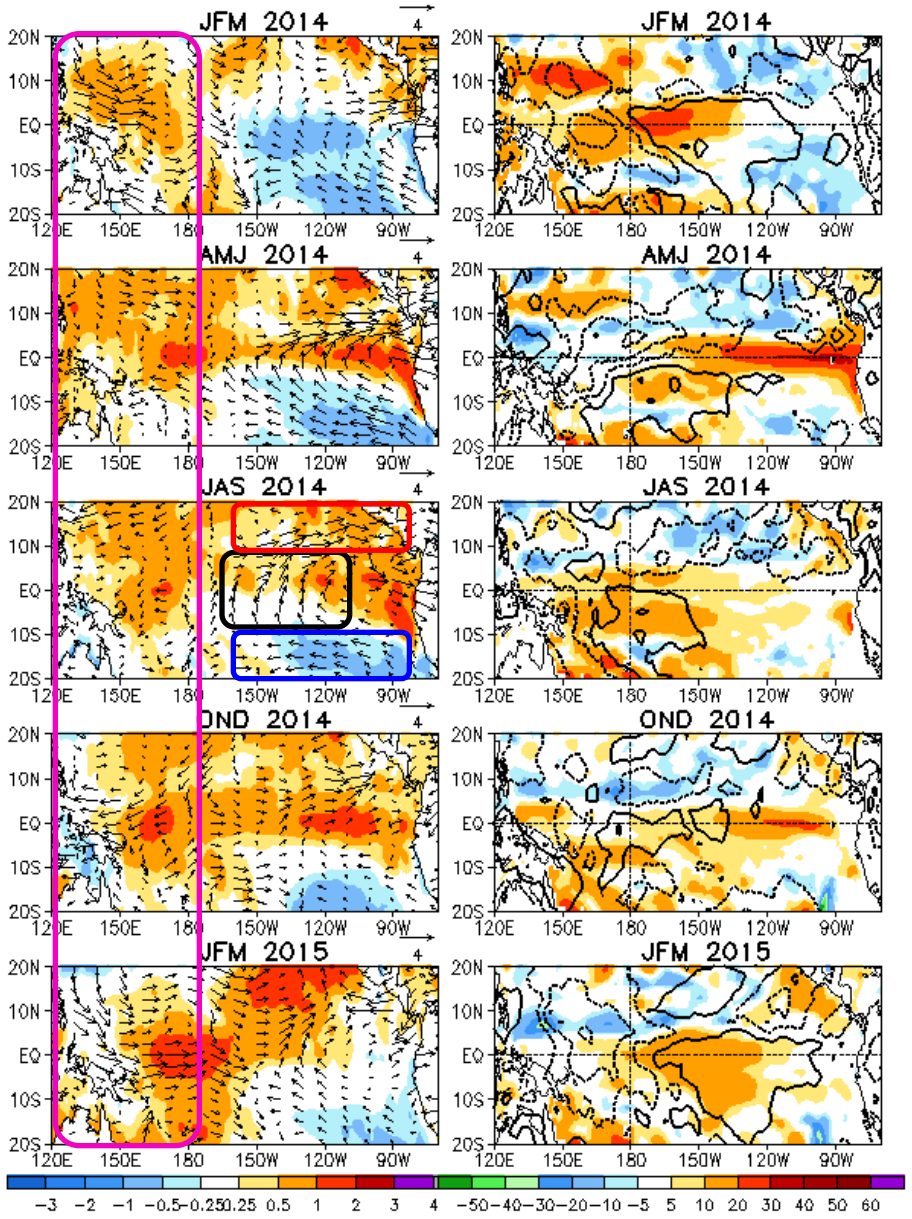
- absence of persistent westerly wind anom. associated with the warming

2018

SST (shade), Wind 850mb **OLR (contour), D20 (shade)**

2014



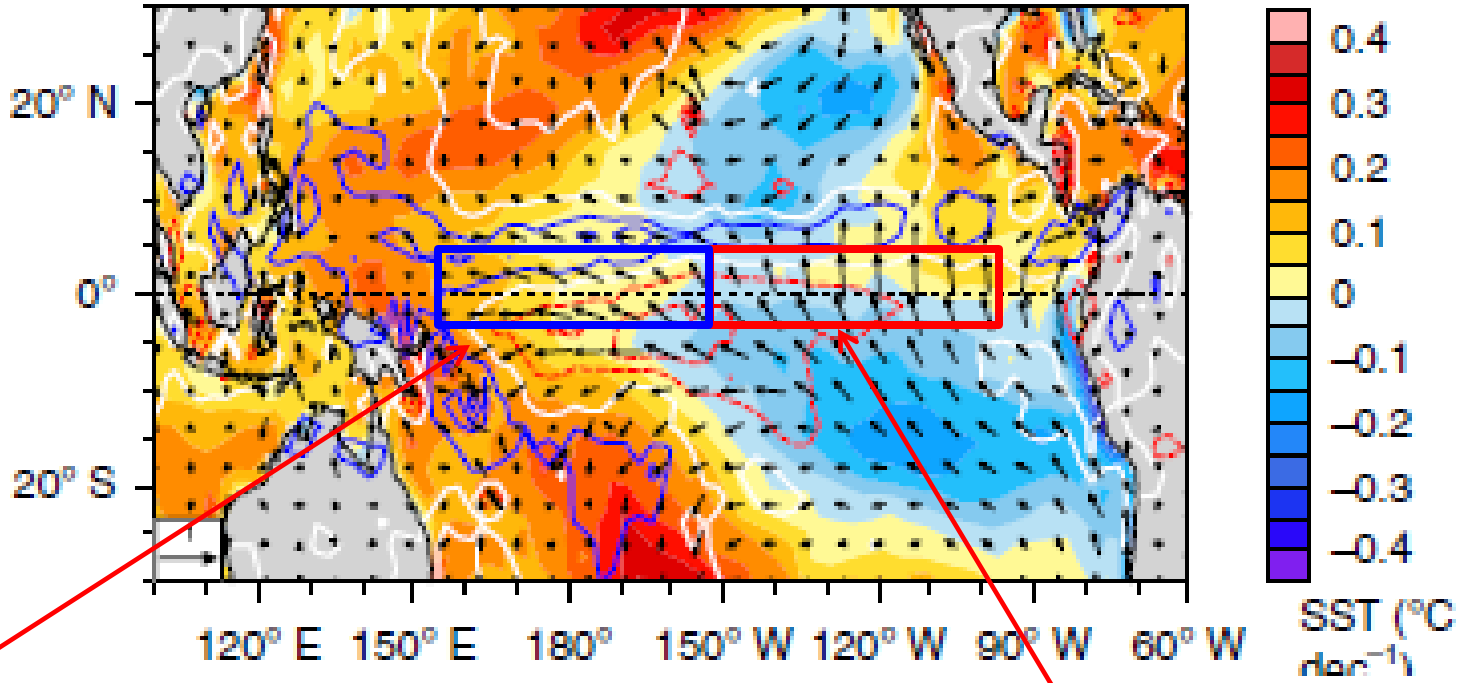


- **The common features in 2014 and 2018 include: persistent warming in the western Pacific, cross-eq. winds, north-south SST gradient, suppressed convection near the Dateline and enhanced convection near 10N**

Cross-Equatorial Winds Control El Nino Diversity and Change

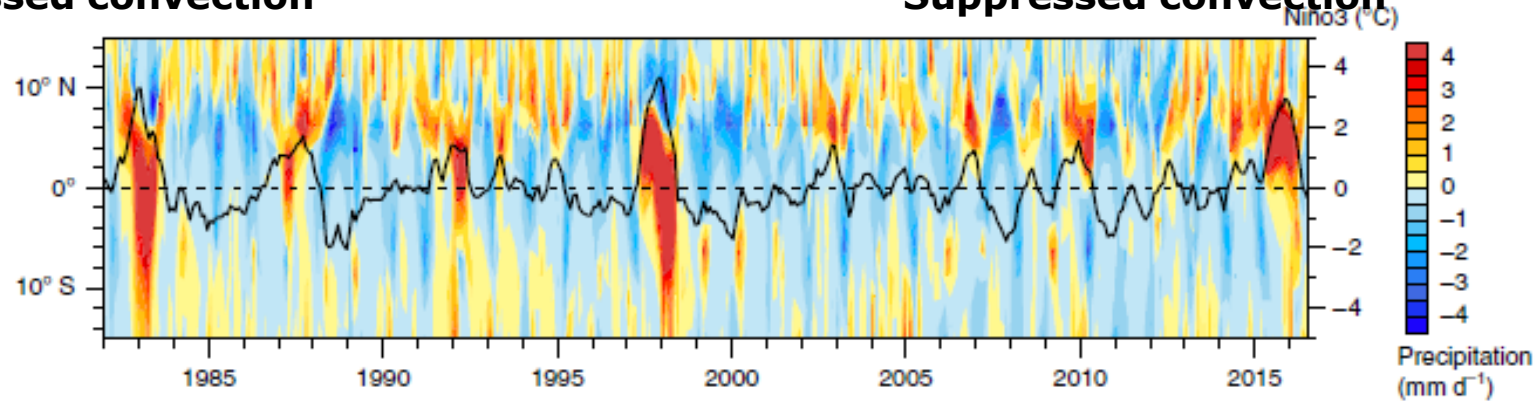
Hu and Fedorov, Nature Climate Change, 2018

Trend in 1982-2015



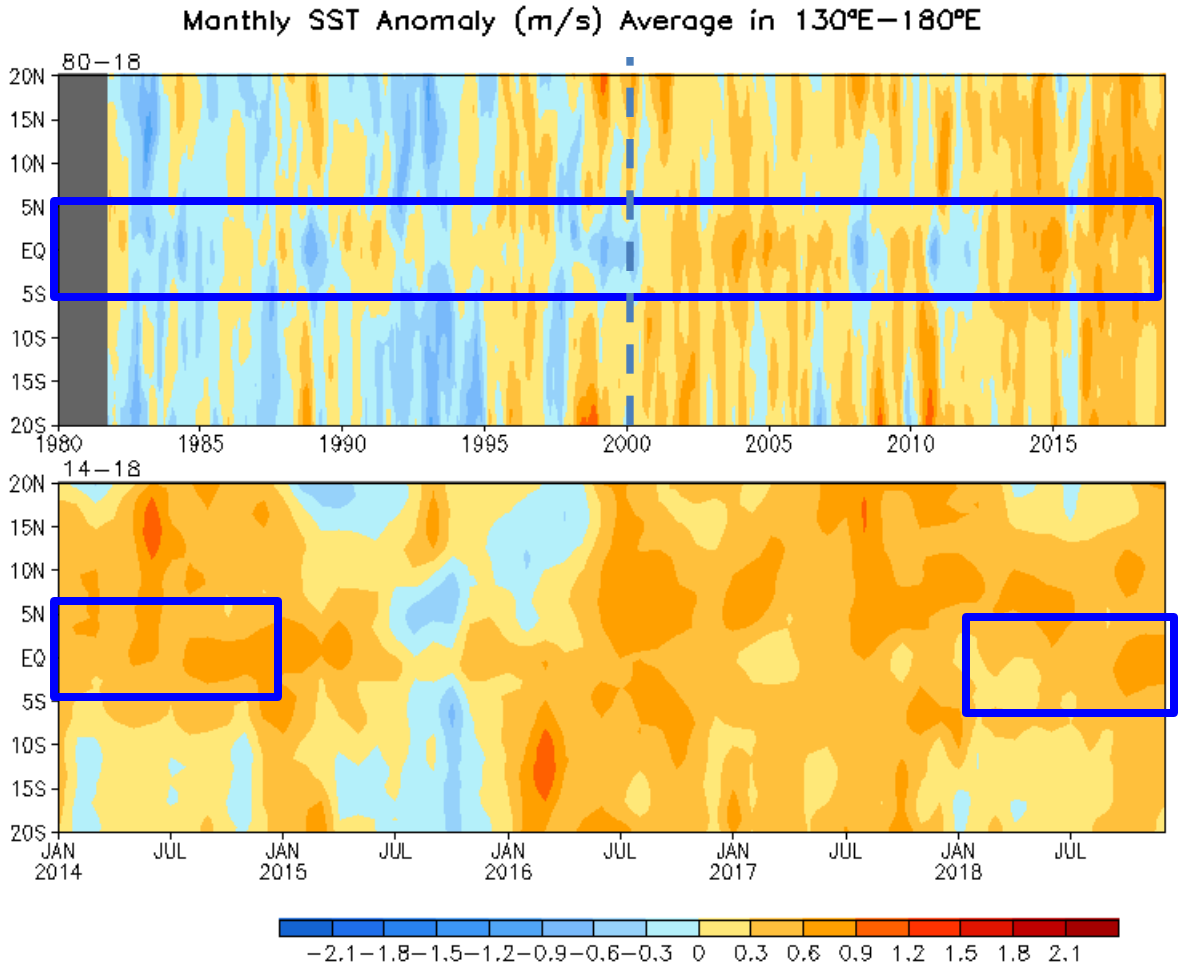
NINO4: Easterly wind anom. Suppressed convection

NINO3: Cross-eq wind anom. Suppressed convection



Positive precipitation anom. stayed north of the eq. since the 1997/98 El Nino.

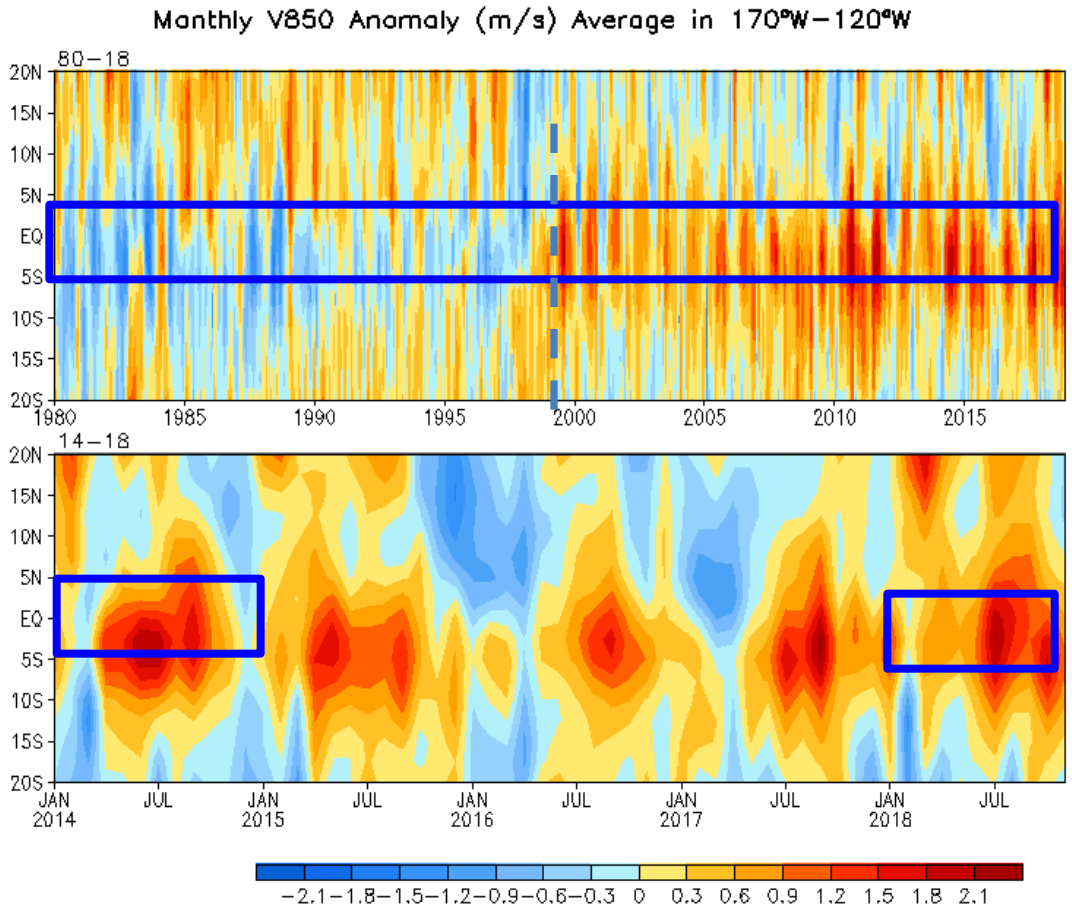
SST Anom. in the Western Pacific (130E-180E)



- **There was a shift towards positive SST anomalies in the western Pacific around 2000, which have persisted in all the years since 2000 except during the 2007-09 and 2010-2012 La Ninas cycles.**

- **The positive SST anomalies appear intensified after 2014, which enhanced the east-west SST gradient and favored easterly wind anom.**

V850mb Wind Anom. in the NINO3.4 Region

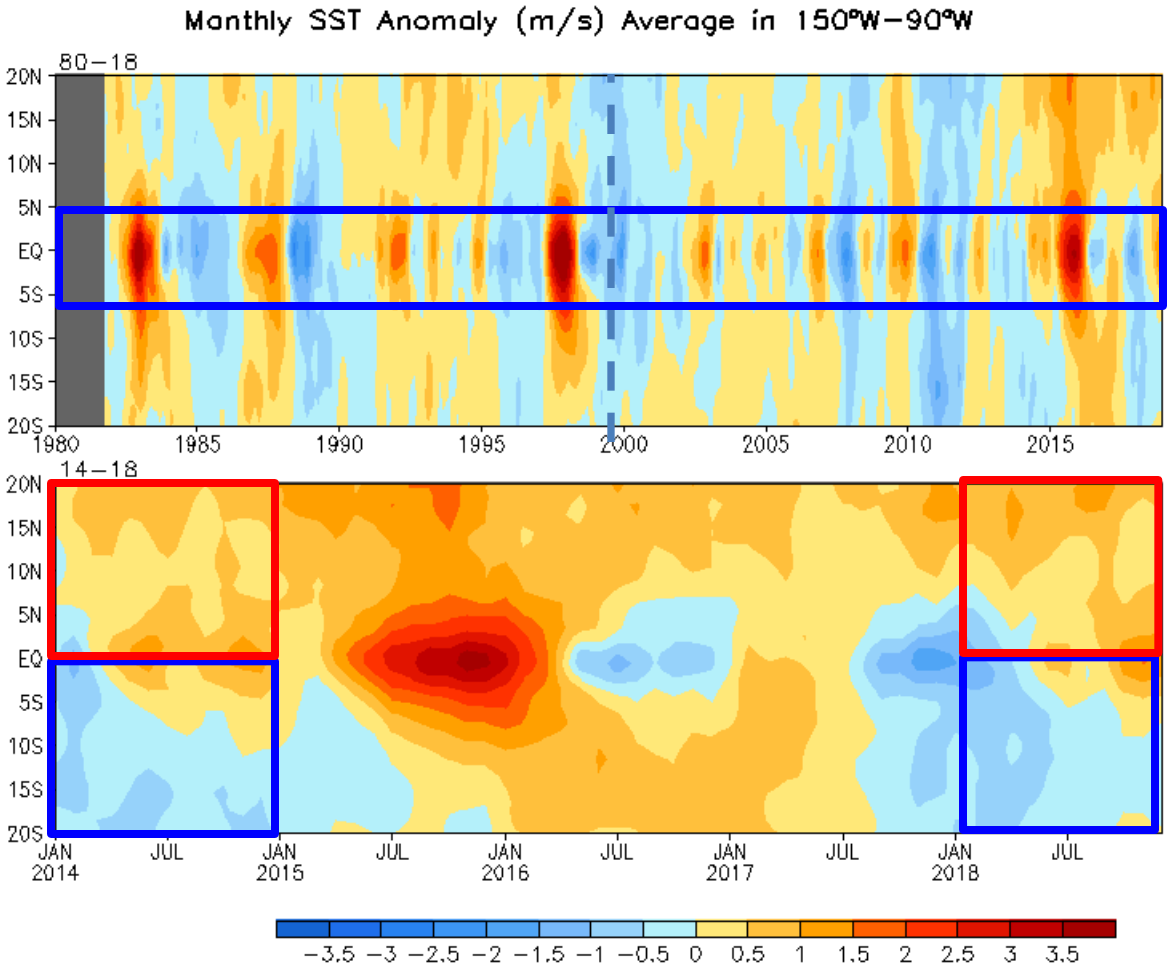


- **There was a shift towards enhanced northward cross-equatoriral wind around 2000, which have persisted since then.**

- **The enhanced cross-equatorial winds are unfavorable for development of the eastern Pacific El Nino (Hu and Fedorov 2018).**

- **The impacts of the cross-equatorial winds are largest during summer.**

SST Anom. in the NINO3 Region

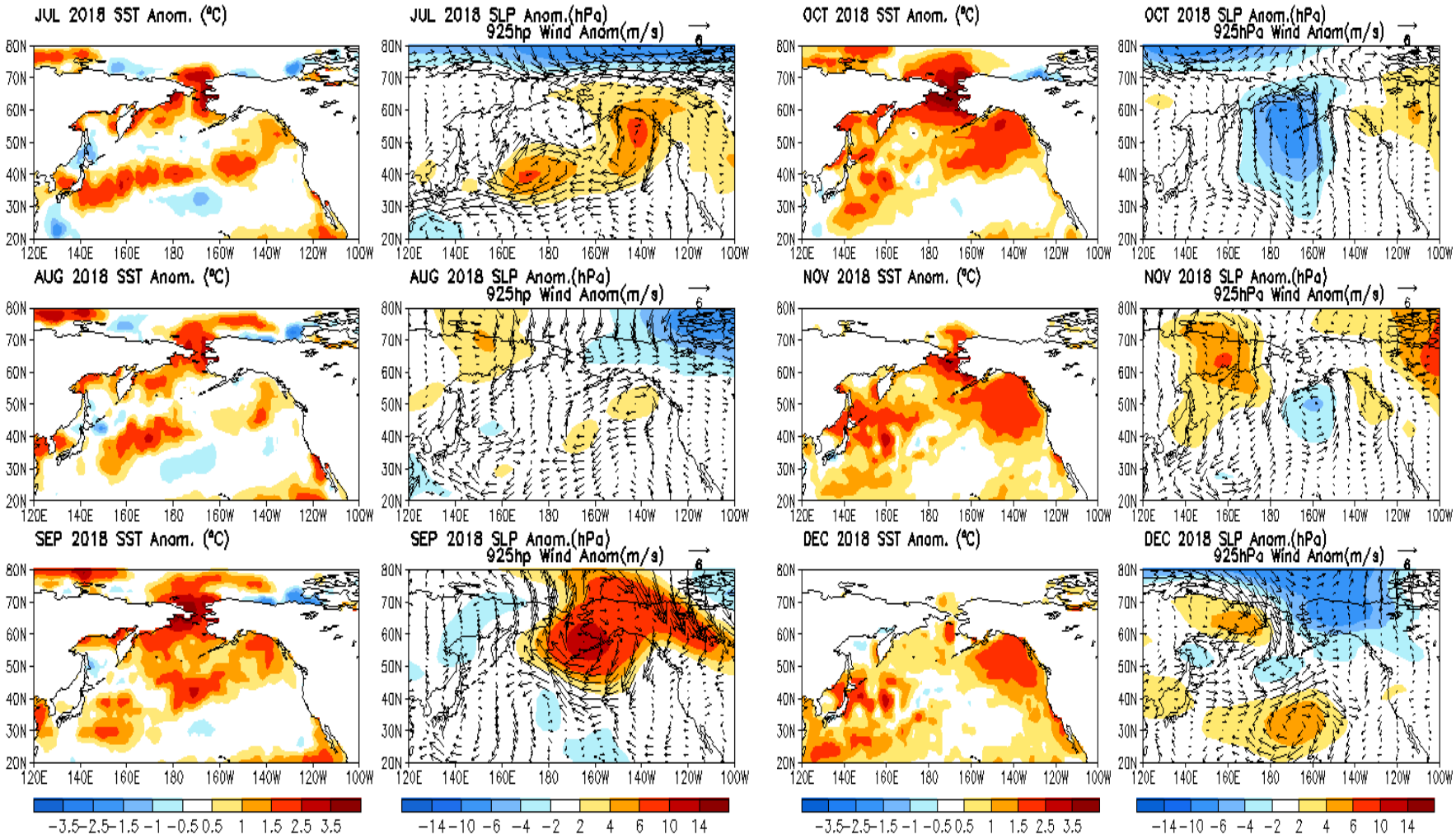


- **Positive SST anom. has persisted north of eq. in the eastern Pacific since 2014, which is probably associated with the enhanced North Pacific Mode (Hartman 2015; Peng et al. 2018).**

-In both 2014 and 2018, there was a strong meridional SST anom. gradient, positive (negative) north (south) of the equator, which is unfavorable for development of the eastern Pacific El Nino (Zhu et al. 2016; Hu and Fedorov 2018; Wu et al. 2018).

North Pacific & Arctic Oceans

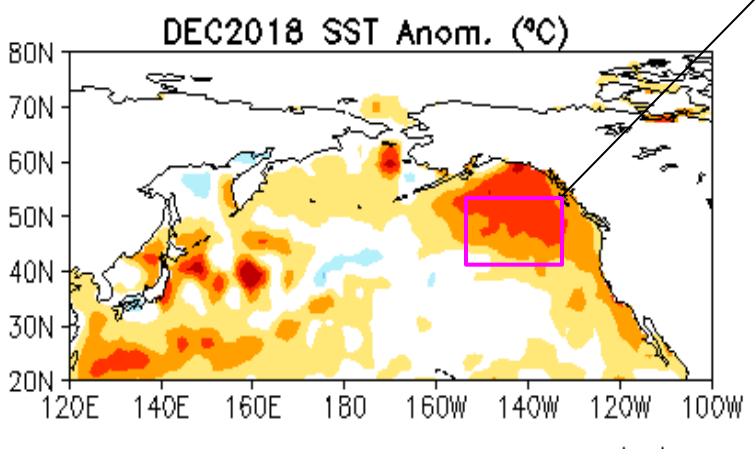
Last Six Month SST, SLP and 925hPa Wind Anomalies

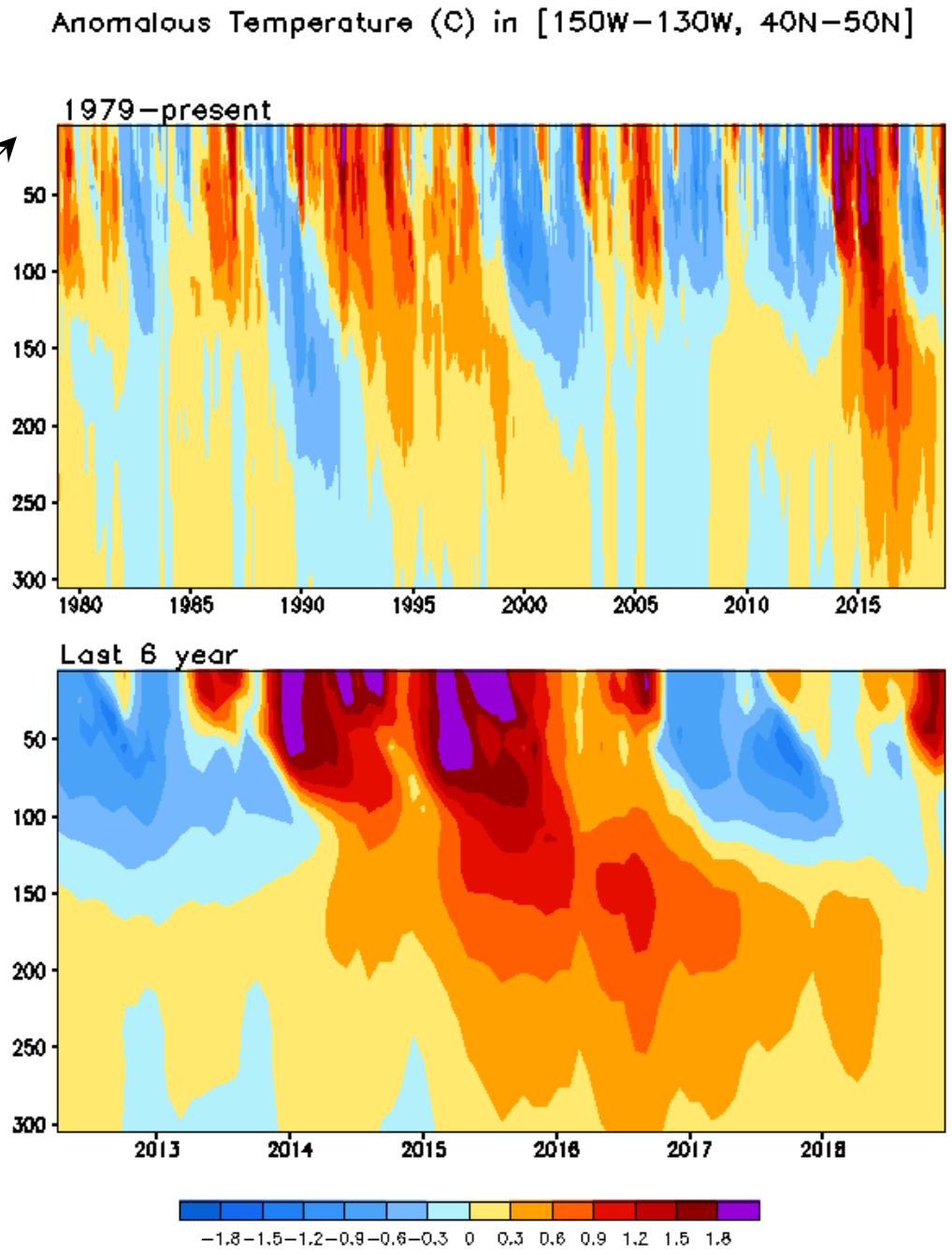


- **SST warming in the northeast Pacific (Pacific "Blob") emerged in Sep 2018, and has persisted in the last three months.**
- **The warming seems forced by the strong bridge over the Gulf of Alaska in Sep 2018.**

The "Blob" in North Pacific

https://en.wikipedia.org/wiki/The_Blob_(Pacific_Ocean)



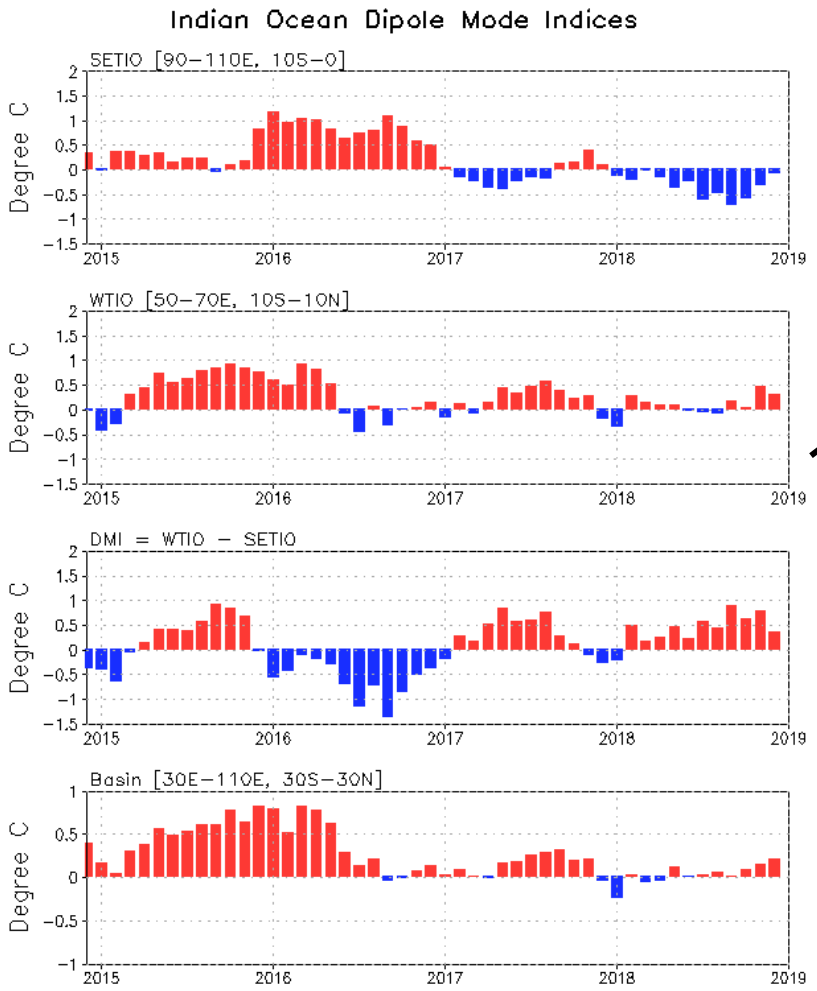


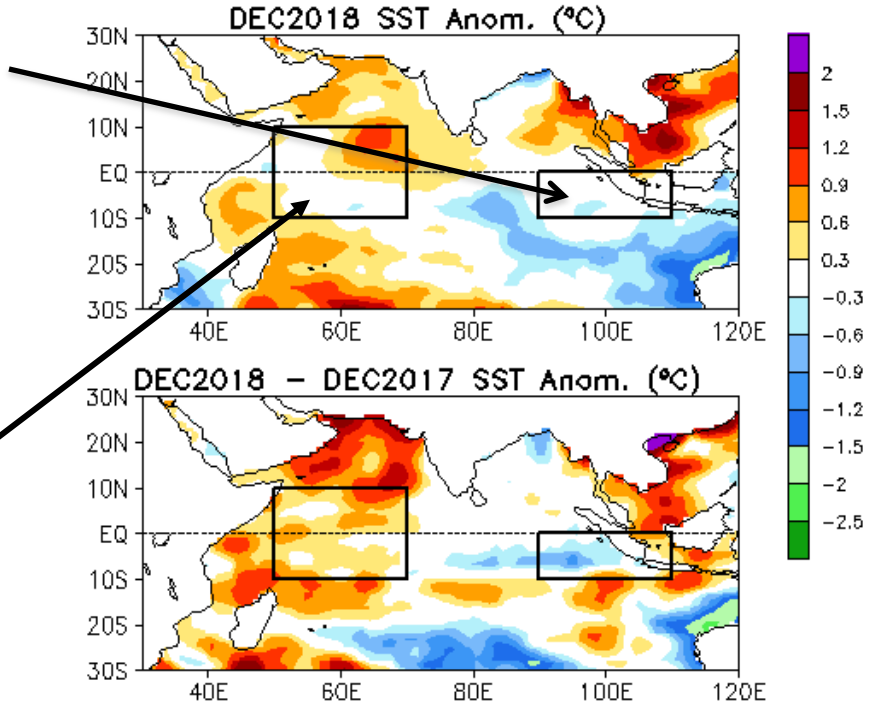
- **In 2014-2015, the northeast Pacific experienced the strongest SST warming on the record, referred to as "Pacific Blob" by Bond et al. (2015). The warming has extended to 300m depth in late 2015 and the subsurface warming has lasted into 2018.**

- **The new warming emerged in Sep 2018 was much weaker and has extended to 70m so far.**

Indian Ocean

Evolution of Indian Ocean SST Indices





- **SSTA has been weak in the tropical Indian Ocean in Dec 2018.**

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

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

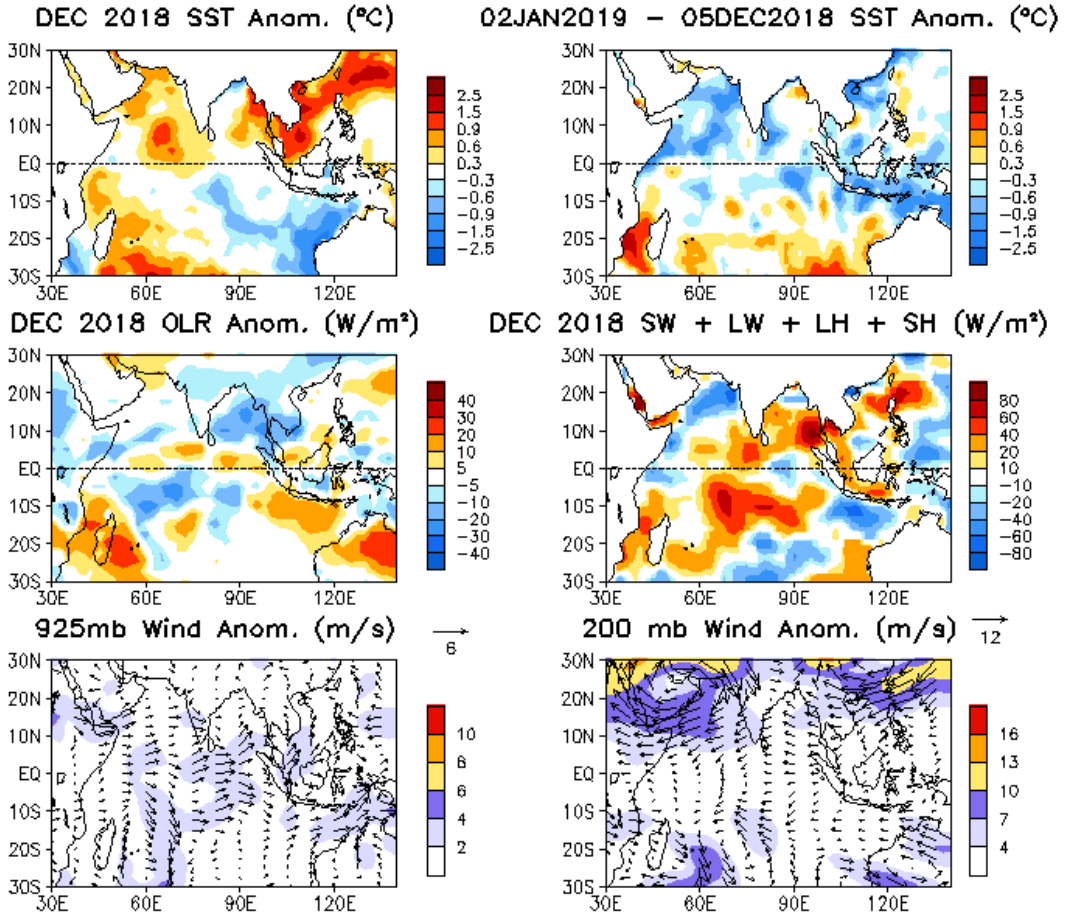
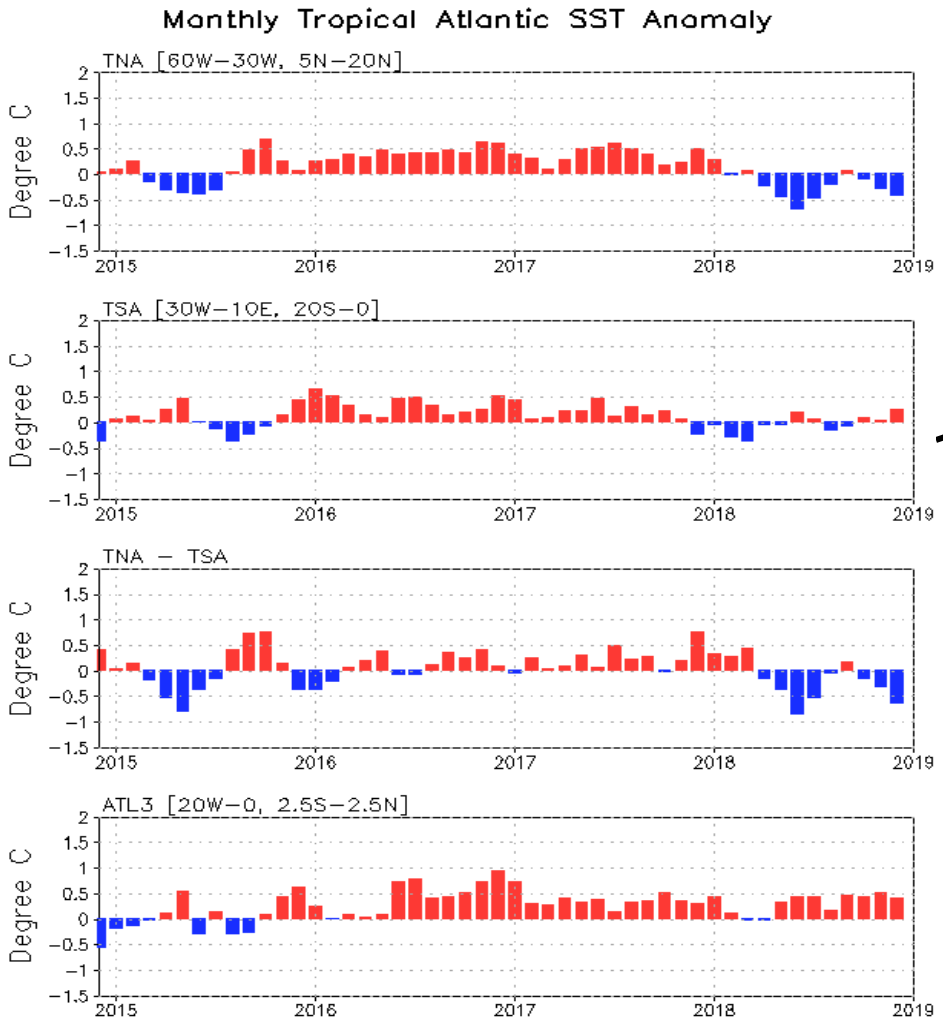
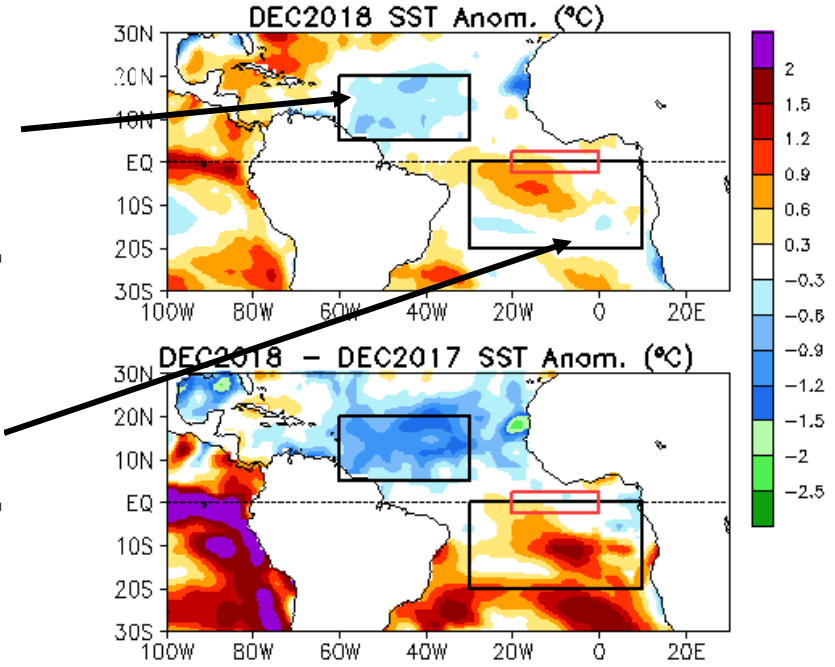


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

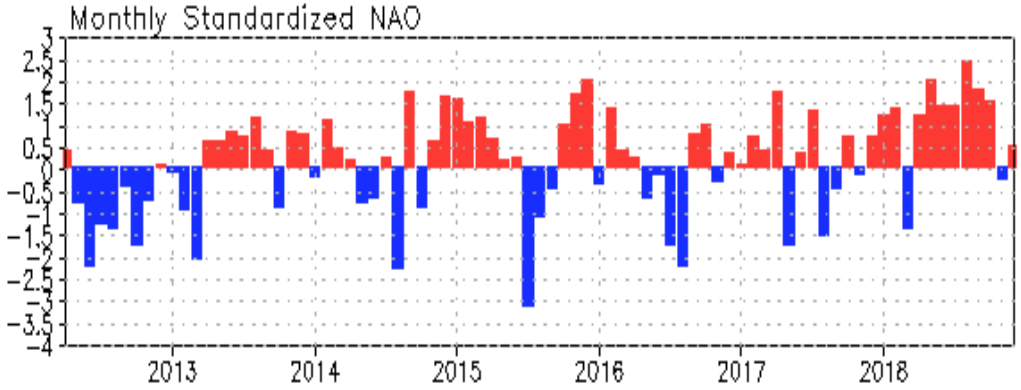


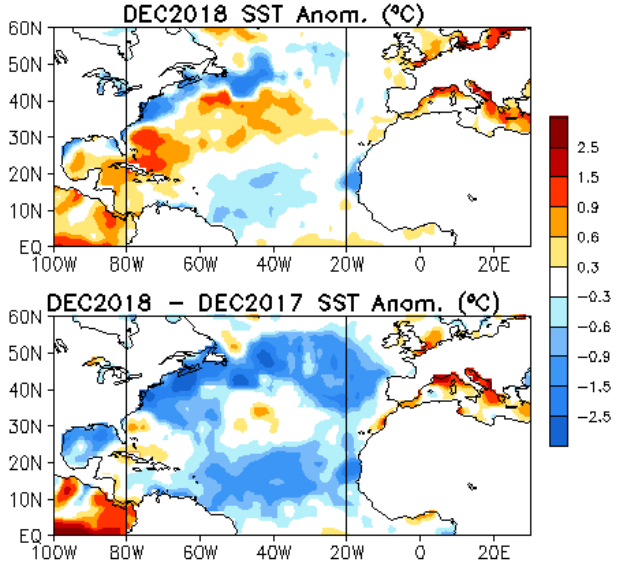


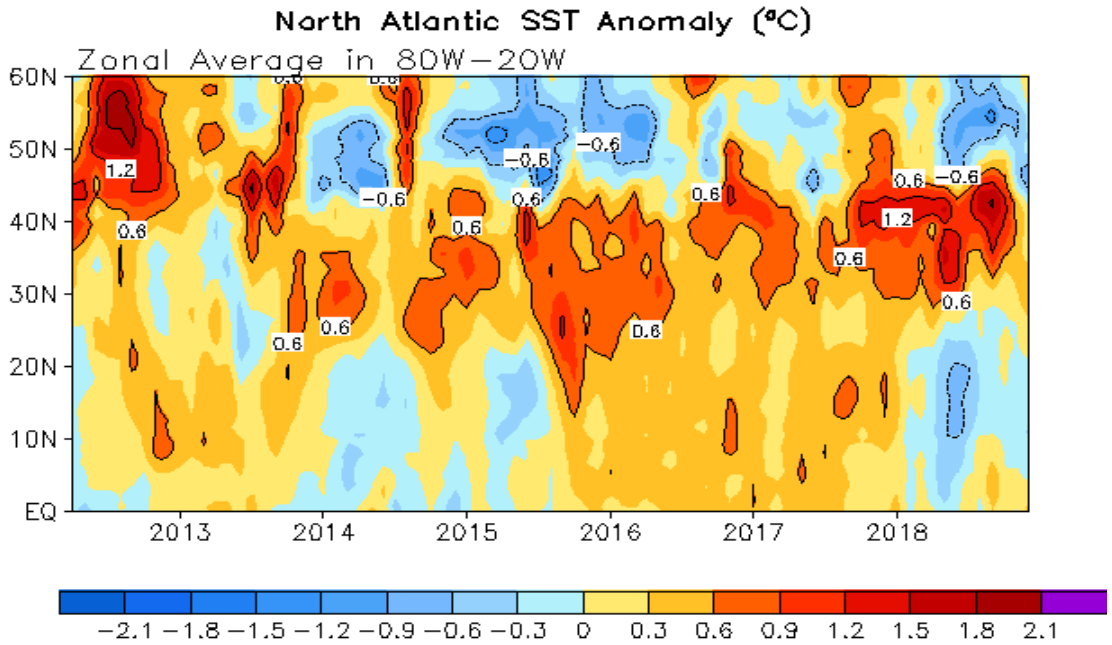
- **Negative TNA strengthened in Dec 2018, leading to a stronger negative meridional gradient mode.**
- **Positive Atl 3 continued in Dec 2018.**

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

NAO and SST Anomaly in North Atlantic



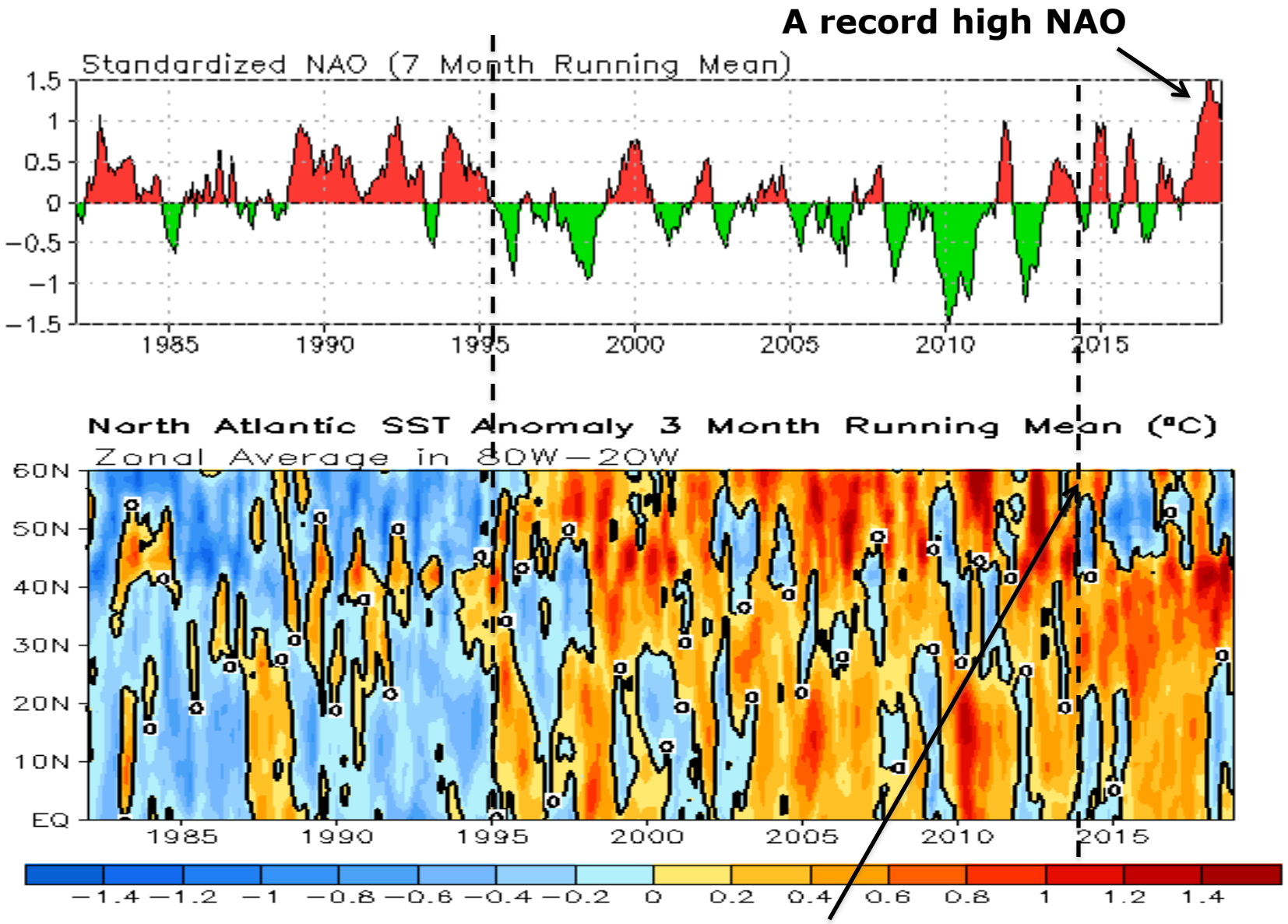




- **Strong positive NAO persisted from Dec 2017 to Oct 2018, and transitioned to neutral phase in Nov-Dec 2018.**

- **SSTA in 2018 has a tripole/horseshoe pattern with positive in the mid-latitudes and negative in lower and higher latitudes, which resembled the conditions in 2014-2015.**

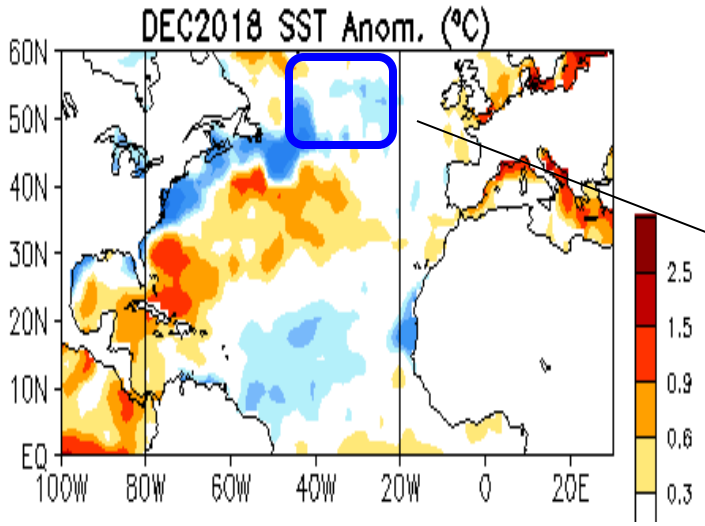
Fig. NA2. Monthly standardized NAO index (top) derived from monthly standardized 500-mb height anomalies obtained from the NCEP CDAS in 20°N-90°N (http://www.cpc.ncep.noaa.gov). Time-Latitude section of SST anomalies averaged between 80°W and 20°W (bottom). SST are derived from the NCEP OI SST analysis,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

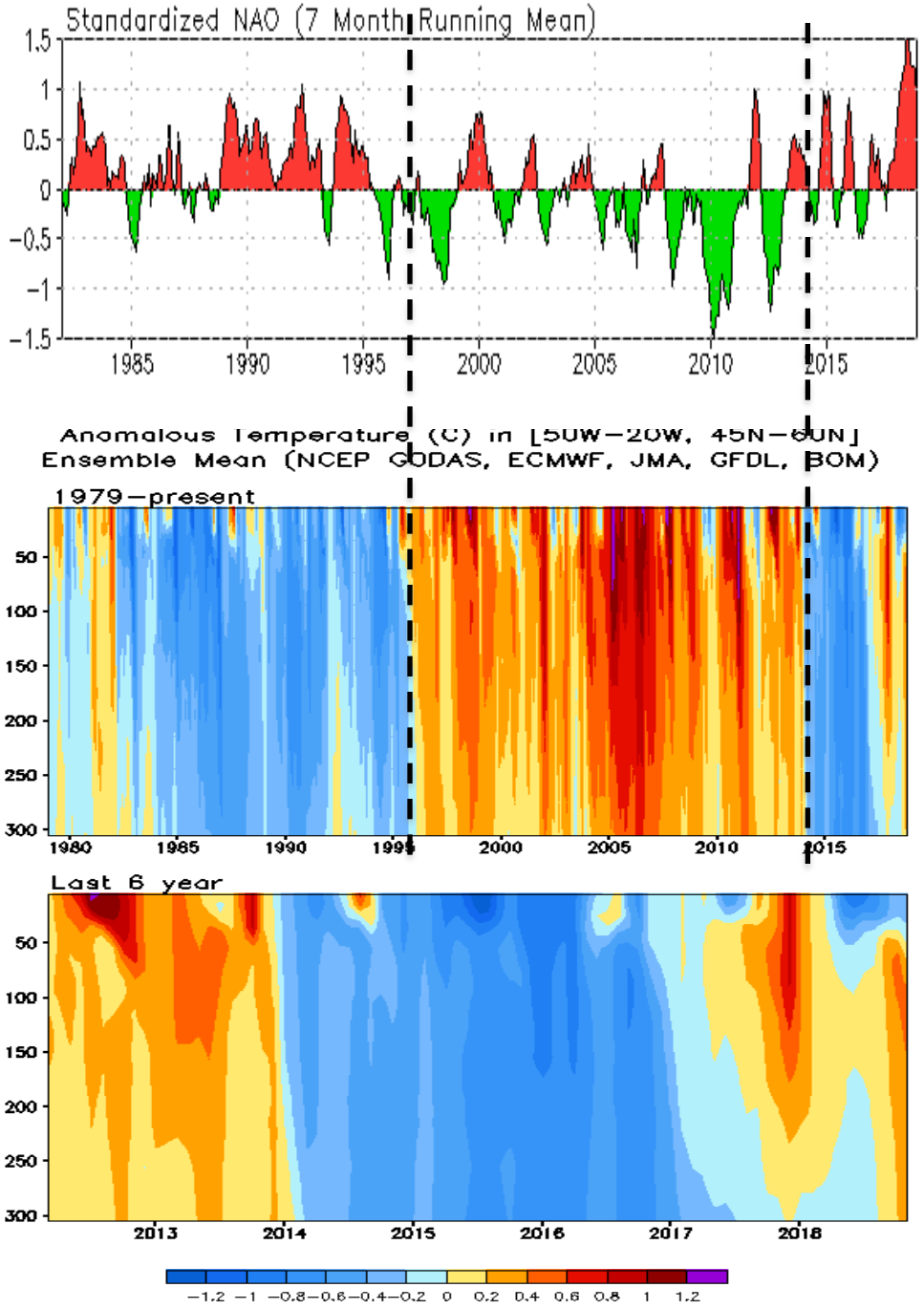


The emergence of the N. Atlantic "Cold Blob" around 2014 appears associated with the onset of positive phase of NAO.

“Cold Blob” in Subpolar N. Atlantic

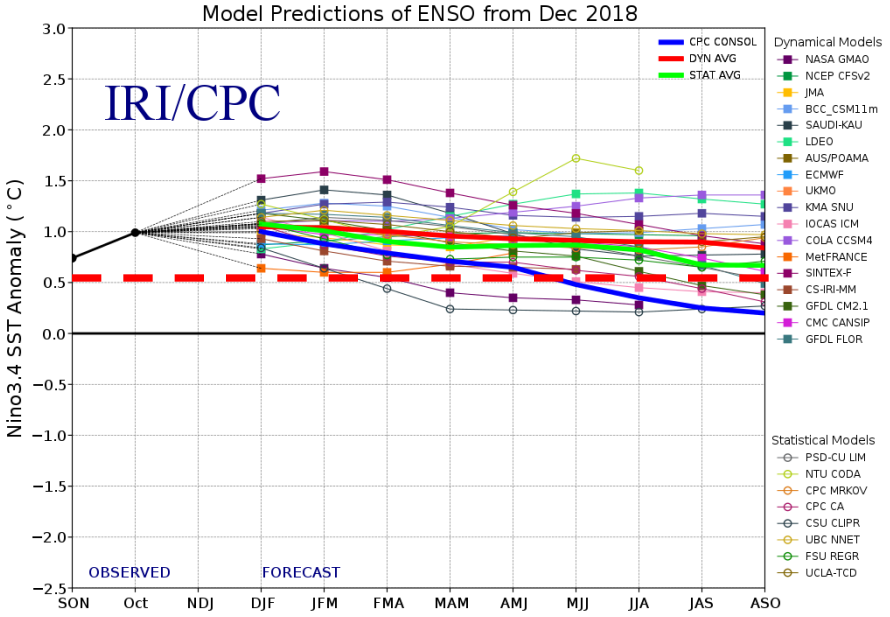
https://en.wikipedia.org/wiki/Cold_blob_(North_Atlanti

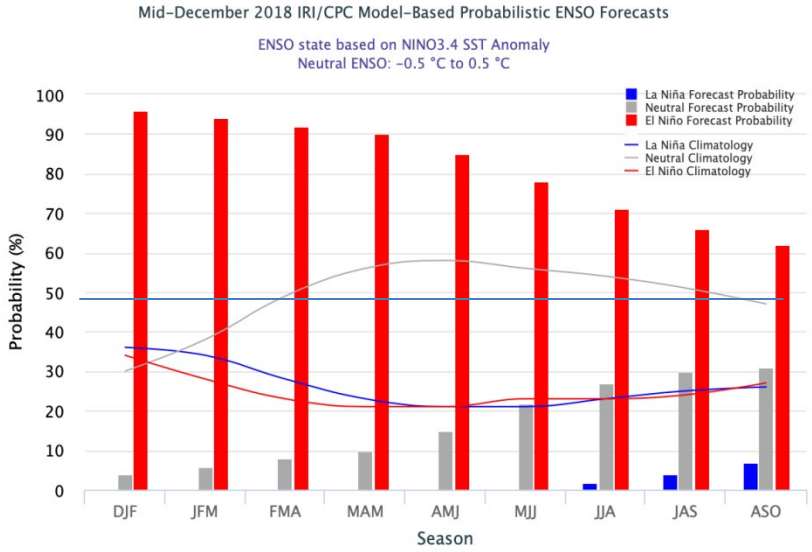




- **The “Cold Blob” in the subpolar N. Atlantic during 1981-1994 and 2014-2016 seems associated with the positive phase of NAO.**
- **The cooling in 2018 was consistent with the positive NAO, but the cooling was confined near the surface different from previous cooling events.**

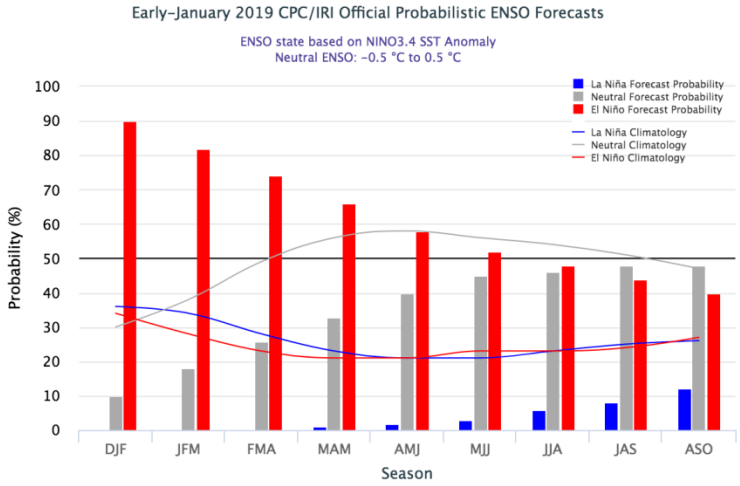
ENSO and Global SST Predictions

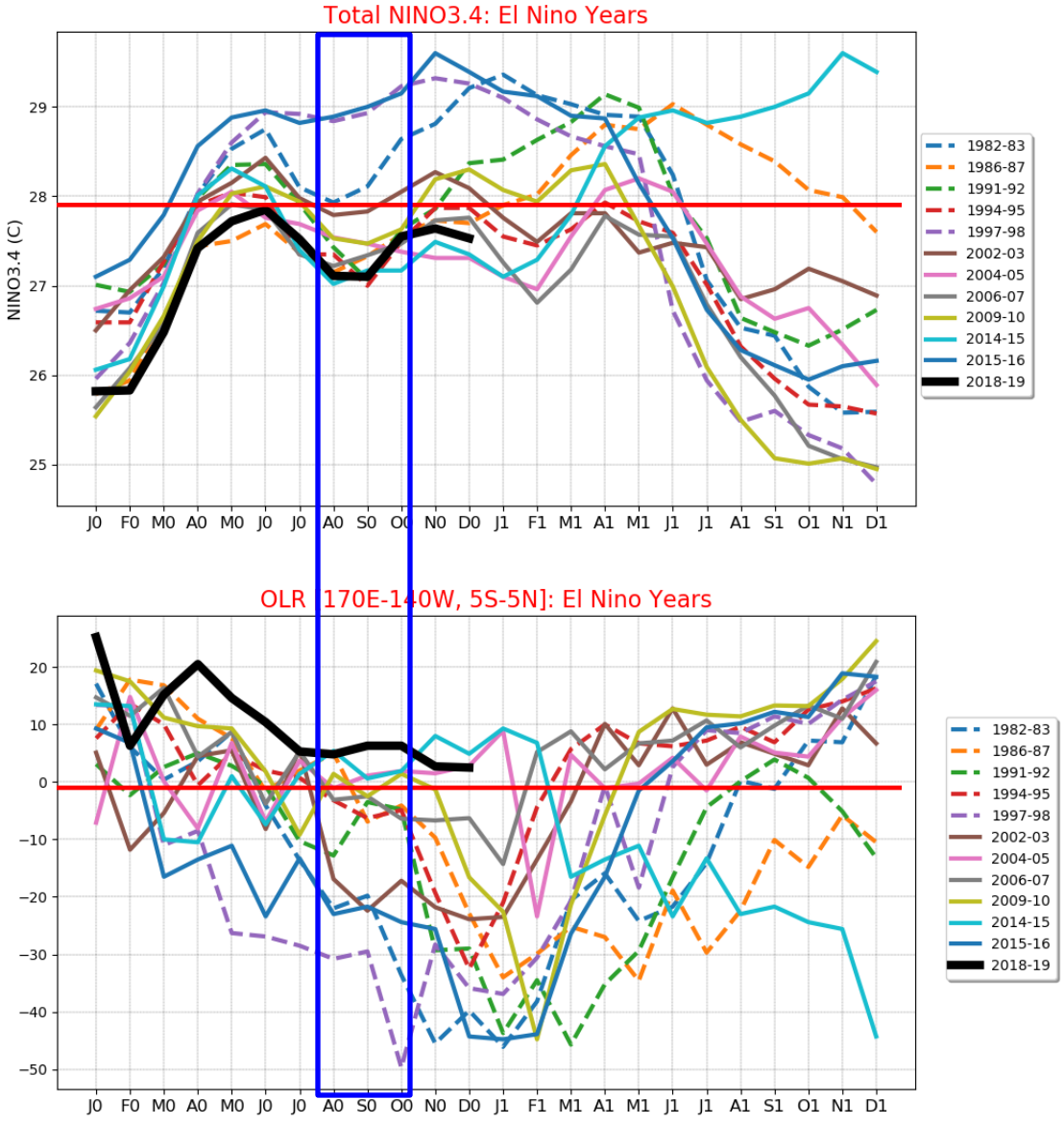




- **Most of statistical and dynamical models suggest an El Nino will develop and continue through the Northern Hemisphere summer 2019.**

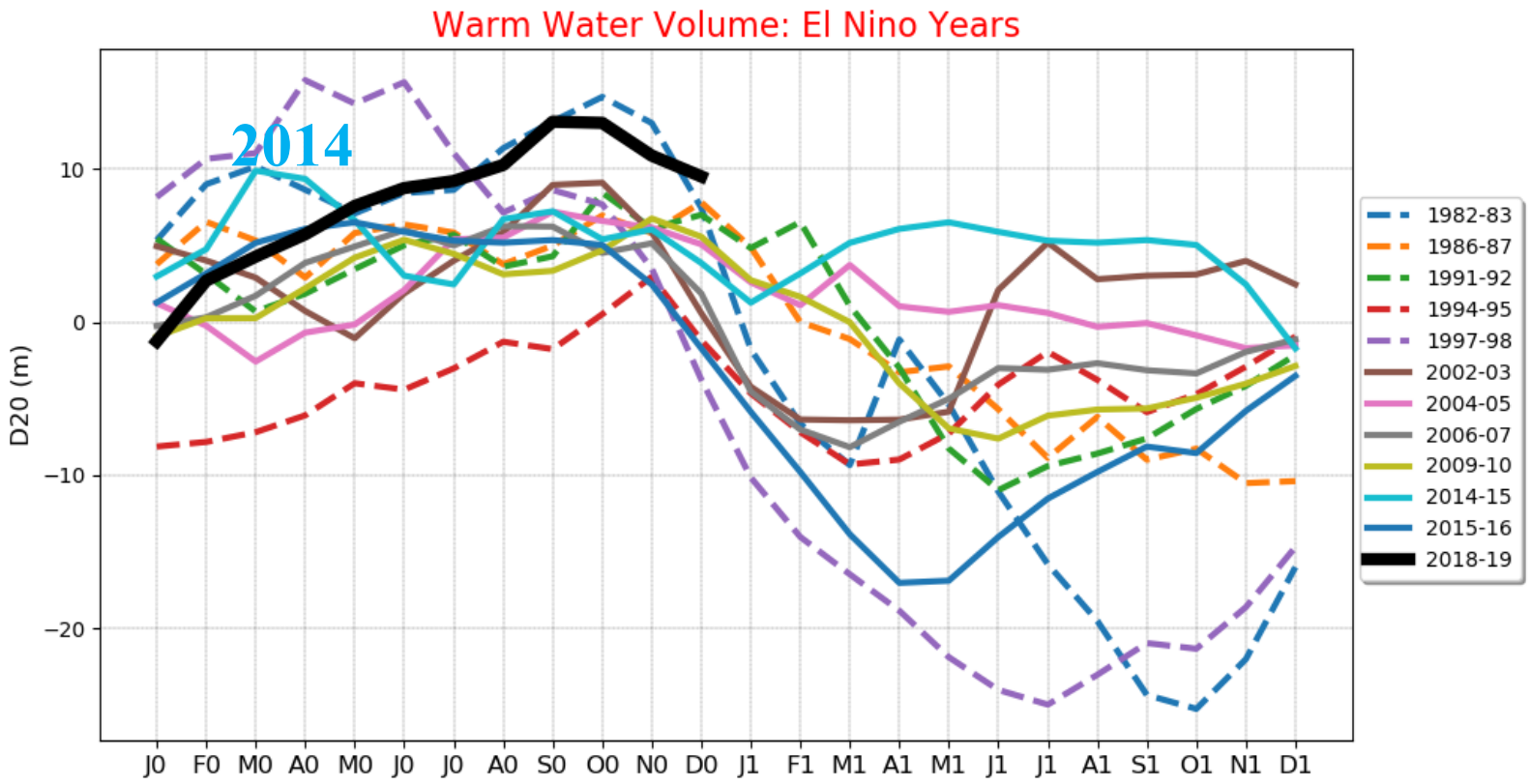
- **NOAA Official ENSO Forecast: El Niño is expected to form and continue through the Northern Hemisphere spring 2019 (~65% chance).**





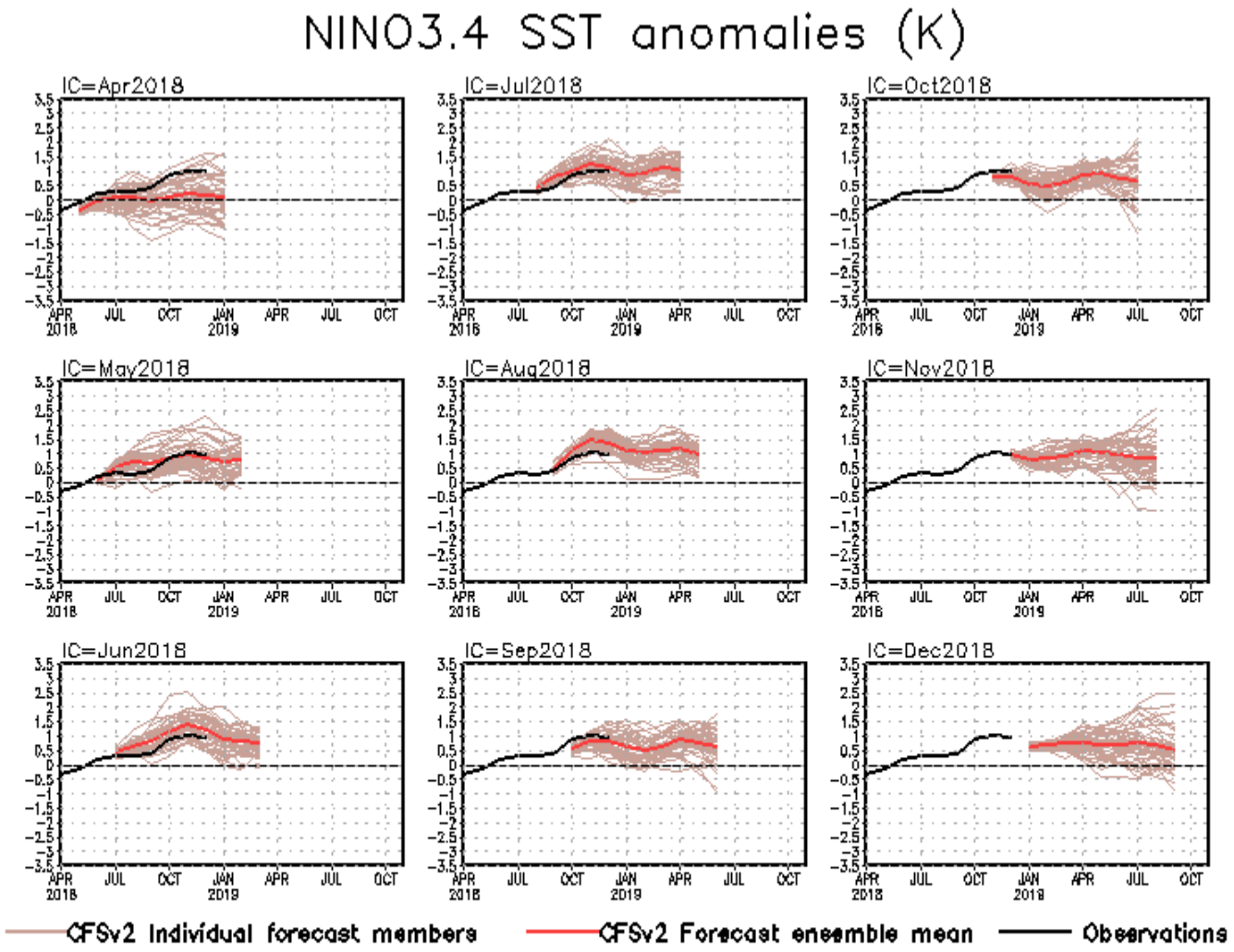
- **The total NINO3.4 index was below 28C throughout 2018, which is the threshold for deep convection. It had the lowest value in summer compared to other events.**
- **The cooler SST might explain why convection in the central-eastern Pacific was near-neutral since summer 2018, which was similar to that in 2014.**
- **The ENSO Diagnostic Discussion indicates that the late winter and early spring are the most favorable months for coupling. So forecasters believe weak El Niño conditions will emerge shortly.**
- **Enhanced convection developed in Mar 2014. Will enhanced convection develop in the central-eastern Pacific in next 2-3 months?**

El Nino Composites



- **Compared to other El Nino events, the WWV in 2018 was highest in the fall/winter of Year 0 (much higher than that in 2014), which provides the necessary conditions for development of continued warming in 2019.**

CFS Niño3.4 SST Predictions from Different Initial Months

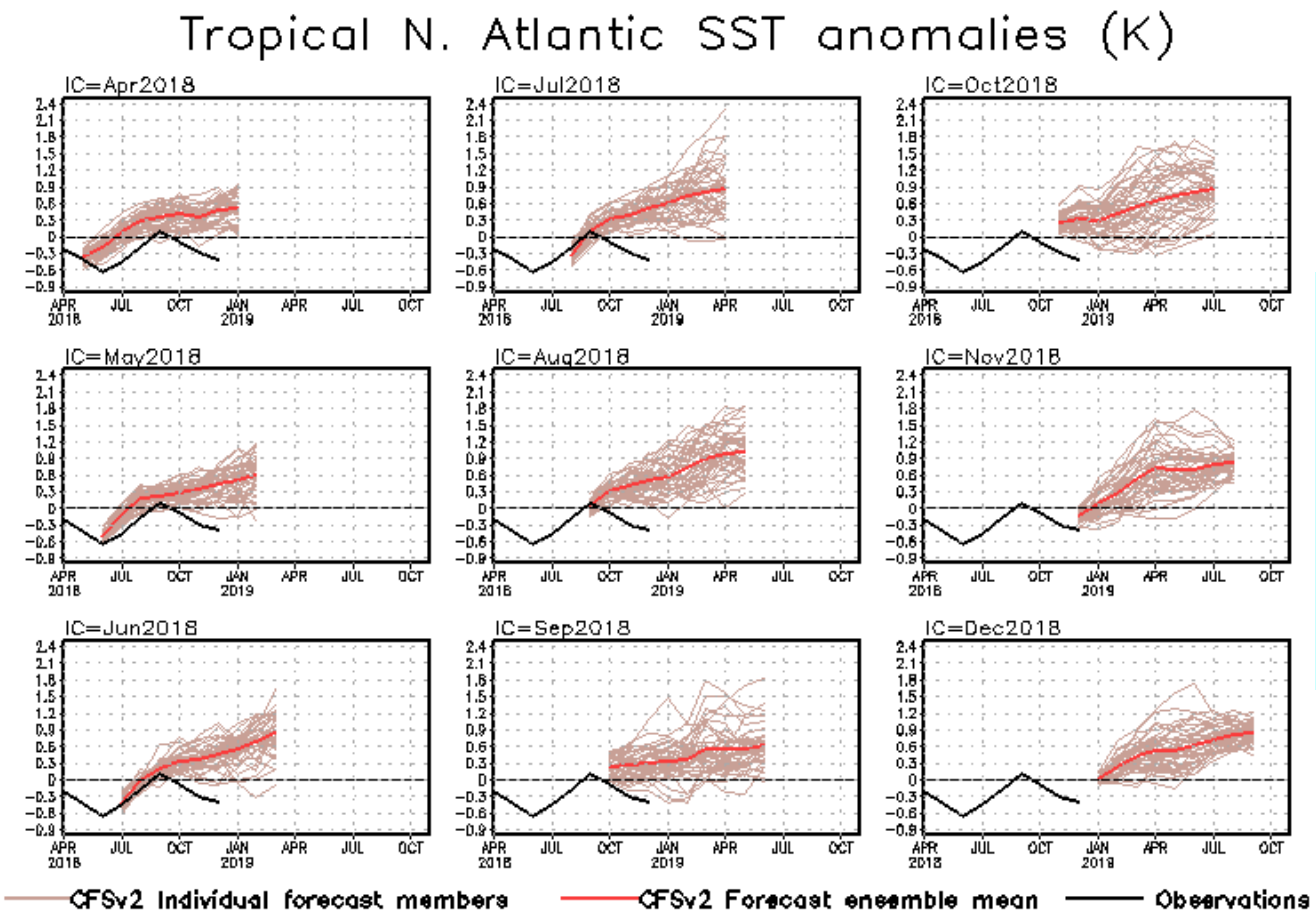


- **The latest CFSv2 forecasts call for weak El Nino conditions to continue through summer 2018.**
- **CFSv2 predictions started from May-Sep 2018 I.C. agree with observations quite well.**

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.

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].



- **CFSv2 has been forecasting a warming trend in the tropical North Atlantic since May 2018.**

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

Thanks!

Please send us your comments and suggestions