

2013 Annual Ocean Review

Prepared by
Climate Prediction Center, NCEP/NOAA
February 7, 2014

<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 Ocean Climate Observation Program (OCO)

Global SST Anomaly in 2013

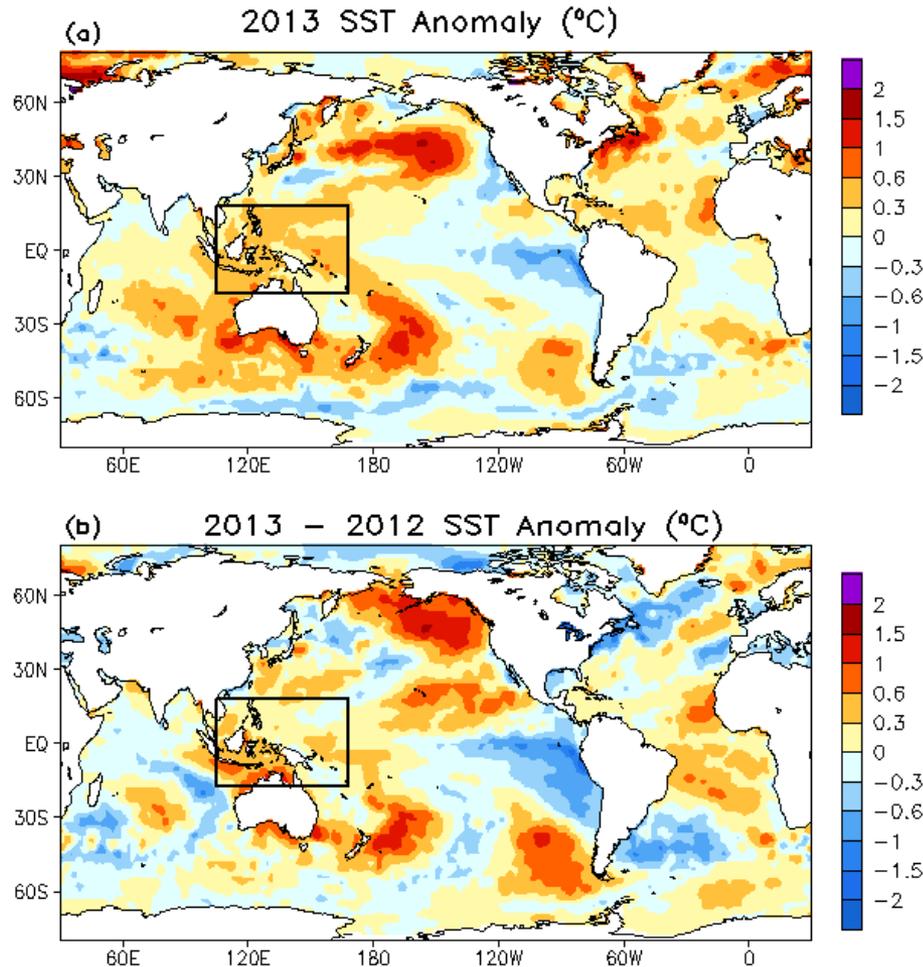
- The 2013 SST anomaly (SSTA) was characterized by positive SSTA in the central North Pacific, Indo-Pacific warm pool (IPWP), North Atlantic and negative SSTA in the eastern equatorial Pacific (EPAC).
- The positive SSTA over IPWP exceeding +1 STD persisted throughout 2013. Negative SSTA exceeding -1 STD emerged in EPAC during summer and persisted into fall 2013. Based upon the NINO3.4 index, the tropical Pacific was in ENSO-neutral conditions in 2013.
- The North Pacific SSTA was characterized by a negative phase of PDO which has persisted from May 2010 to present (3.7 years).
- The positive SSTA over IPWP has persisted since 2000 favoring persistent La Nina-like atmospheric circulations.

Historical Perspective of 2013 SST Anomaly

- The mean SST in the **tropical Pacific** changed little from 2012 to 2013, ranking the 14th warmest year since 1982.
- The mean SST in the **tropical Indian Ocean** changed little from 2012 to 2013, ranking the 7th warmest year since 1982.
- The mean SST in the **tropical Atlantic** warmed up by 0.13°C in 2013, becoming the 13th warmest year since 1982.
- The mean SST in the **North Atlantic** decreased substantially (-0.21°C) from the 2012 historical high, becoming the 8th warmest year since 1982.
- The mean SST in the **North Pacific** increased substantially ($+0.28^{\circ}\text{C}$), becoming the **warmest year since 1982**.
- The **global ocean SST** warmed by about $+0.03^{\circ}\text{C}$, becoming the 3rd warmest year since 1982.

Yearly Means

2013 Yearly Mean SST Anomaly and Tendency

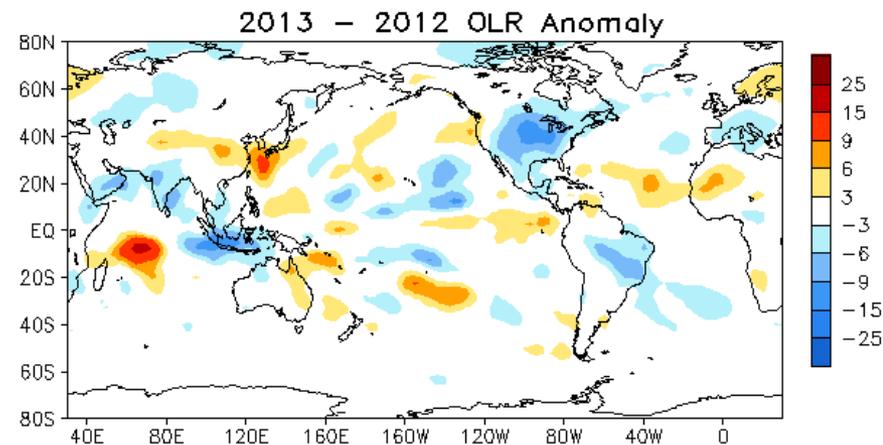
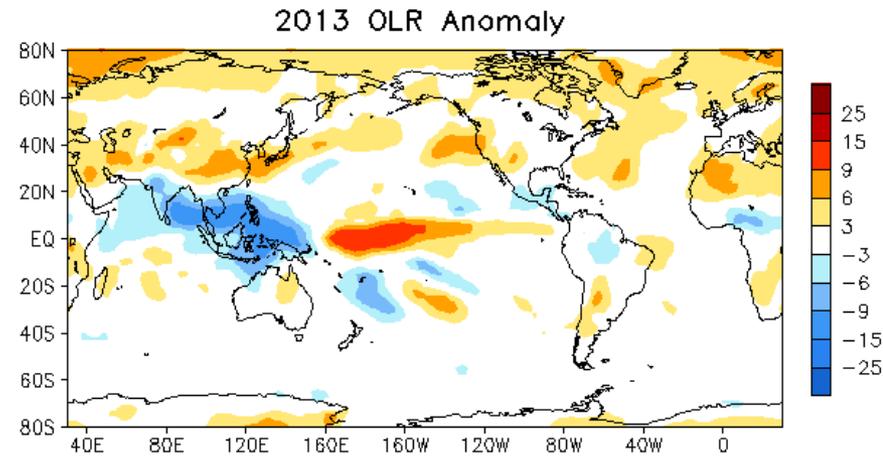
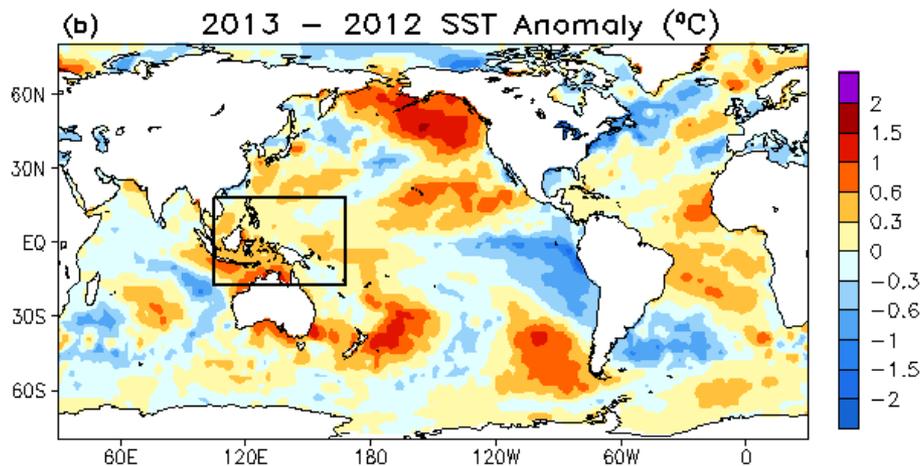
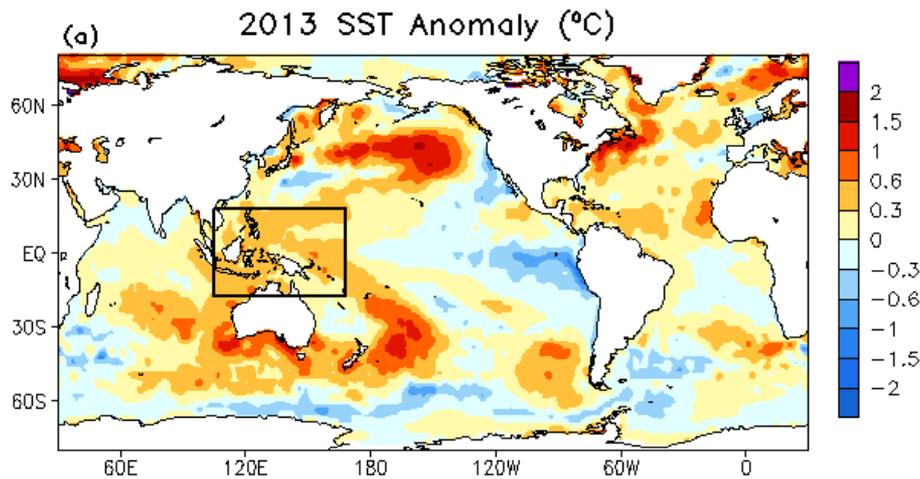


- Negative PDO pattern
- Overall warm ocean with positive SSTA over Indo-Pacific warm pool, in the eastern Indian Ocean, southwest Pacific, N. Atlantic and along the east coast of N. America
- Negative SSTA in the southeastern tropical Pacific

- Warming tendency extending from south of Bering Strait to Gulf of Alaska to northeast Pacific
- Warming tendency over Indo-Pacific warm pool
- Warming in the tropical Atlantic
- Cooling in the southeast Pacific

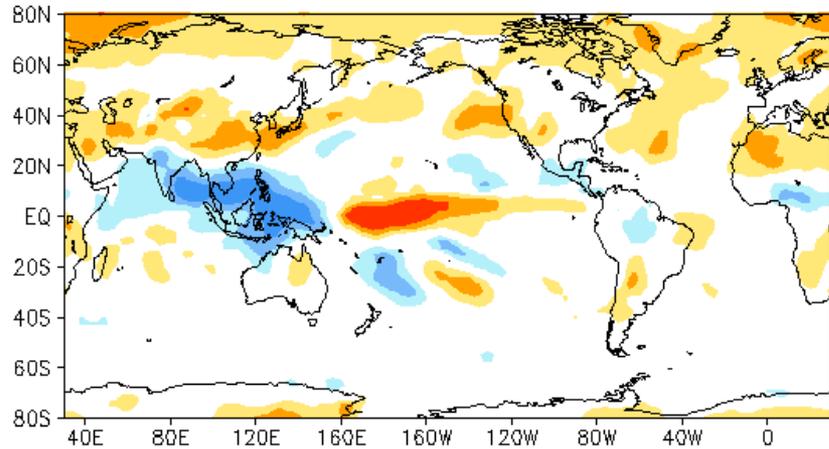
Fig. 3.1. (a) Yearly mean OISST anomaly ($^{\circ}\text{C}$, relative to 1981-2010 average) in 2013, (b) 2013 minus 2012 OISST anomaly. The box shows the area in which the normalized average SSTA is shown in Fig. 3.3a,b.

From Xue et al. (2014) to appear in the BAMS State of the Climate in 2013

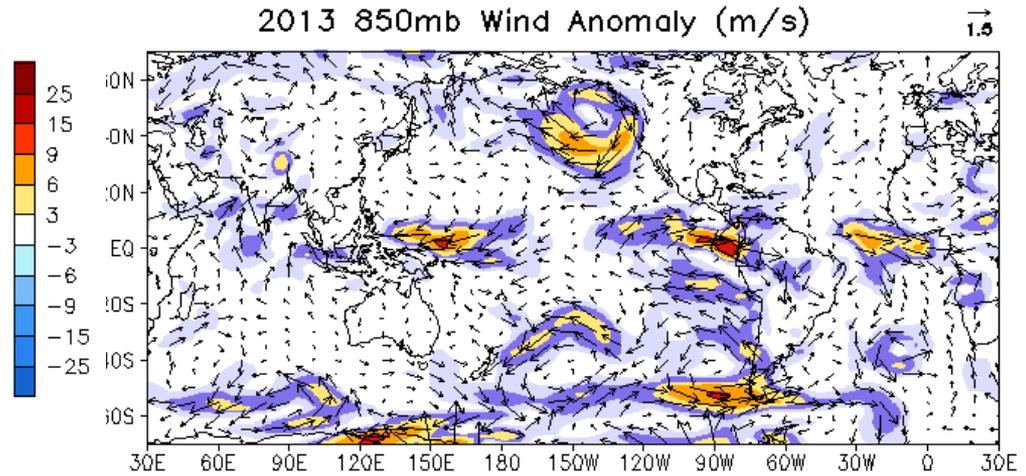


- In 2013 the OLR anomaly pattern, indicating enhanced (suppressed) convection over Indonesia (near Dateline), was associated with the west-east SSTA gradient.
- In 2013, the northward shift of ITCZ in the eastern Pacific was probably associated with the south-north SSTA gradient.
- The 2013 minus 2012 OLR anomaly has a dipole pattern in the tropical Indian Ocean, which seems related to the warming in the eastern Indian Ocean.

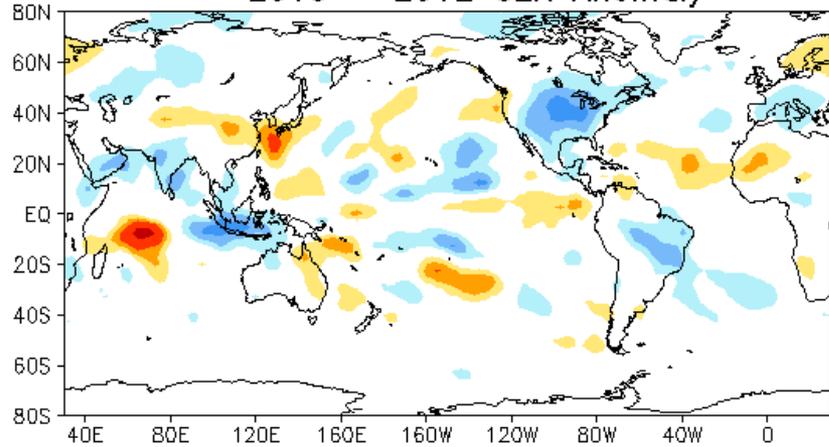
2013 OLR Anomaly



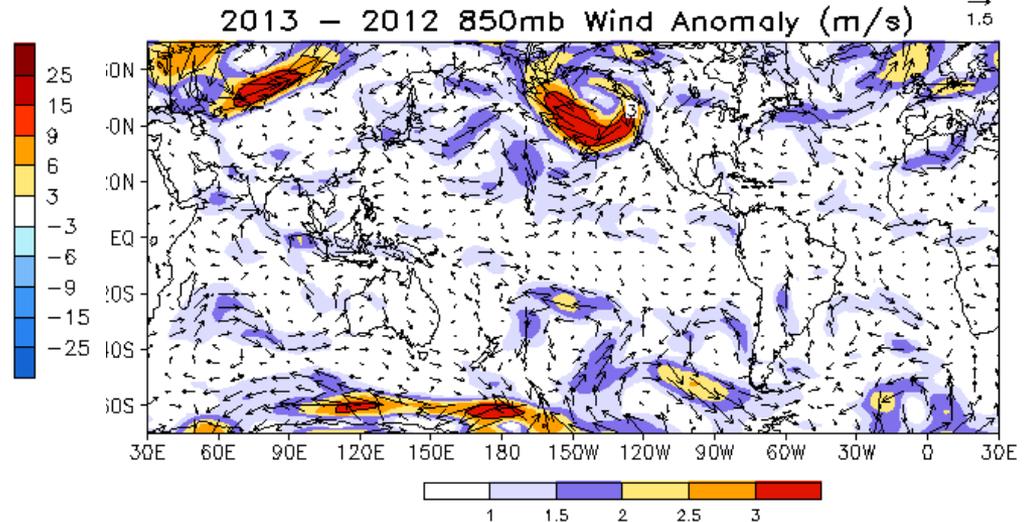
2013 850mb Wind Anomaly (m/s)



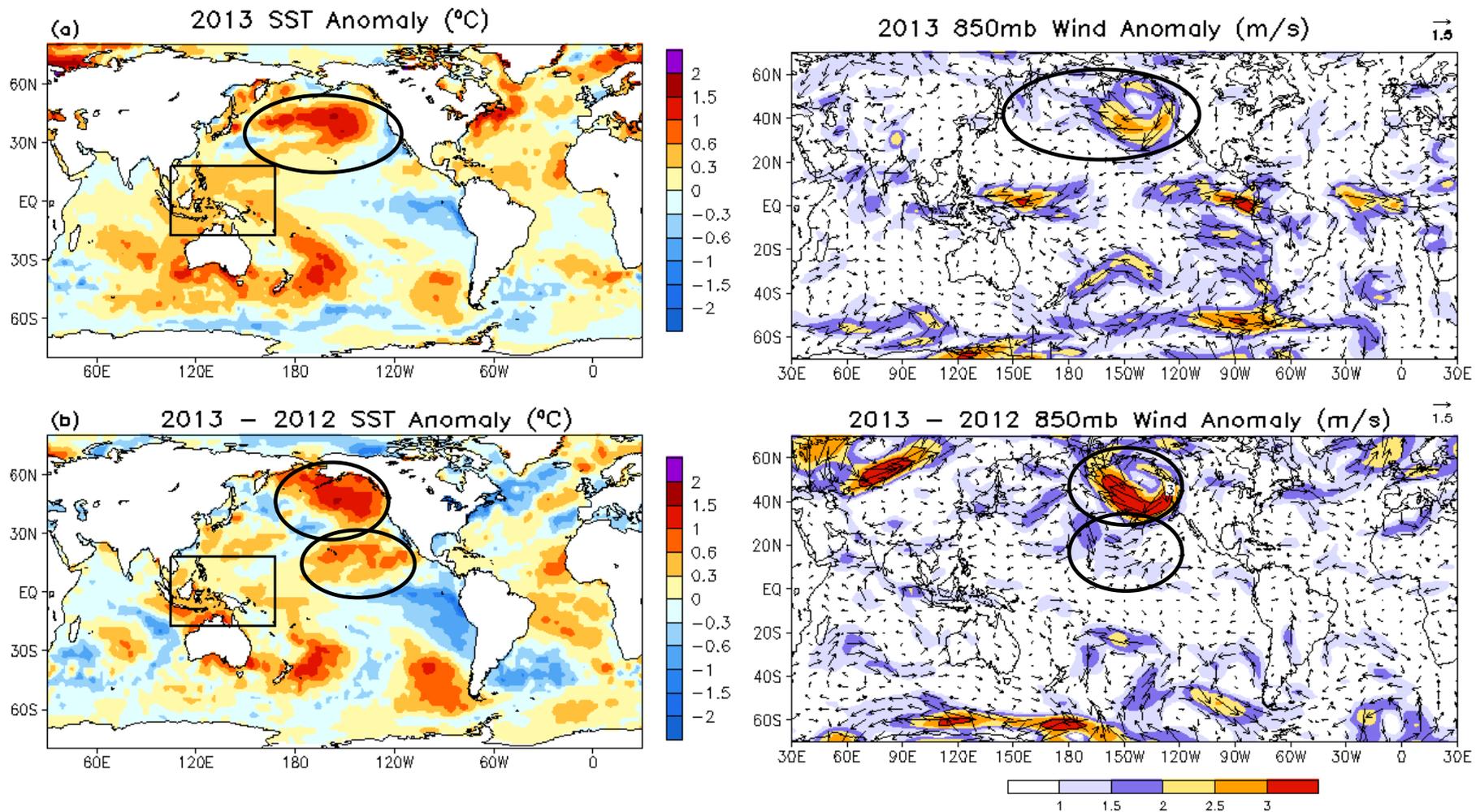
2013 - 2012 OLR Anomaly



2013 - 2012 850mb Wind Anomaly (m/s)



- In 2013 the easterly wind anomaly between 120E-180E corresponds well with the 2013 OLR anomaly pattern.
- In 2013 the cross-equatorial wind anomaly in the eastern Pacific corresponds well with the northward shift of ITCZ.



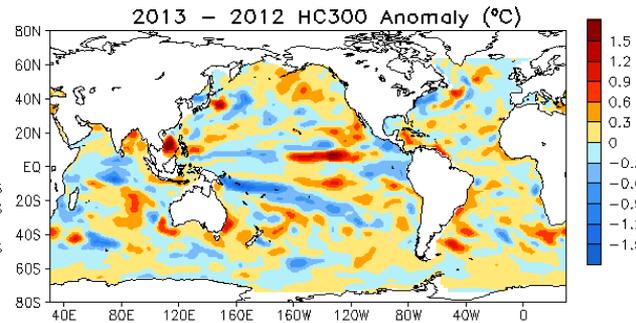
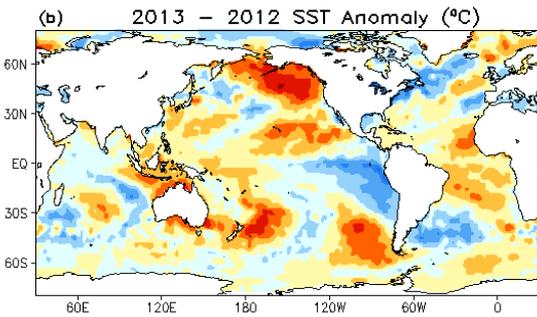
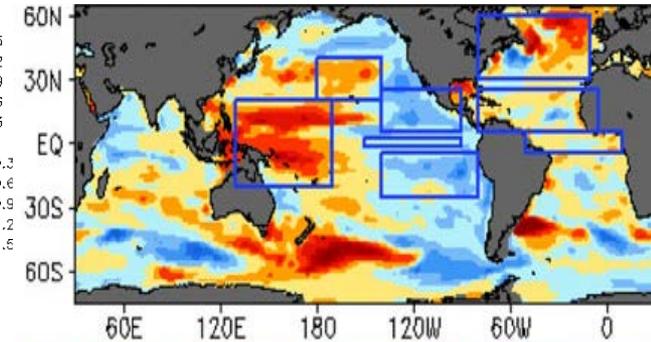
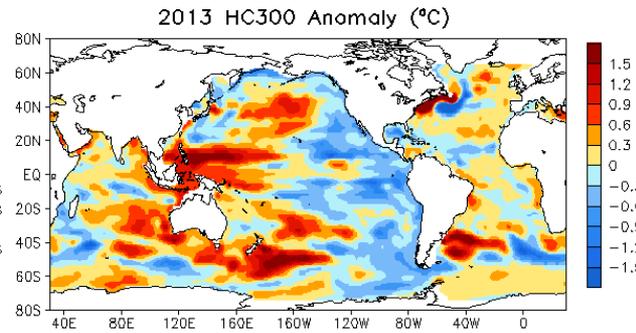
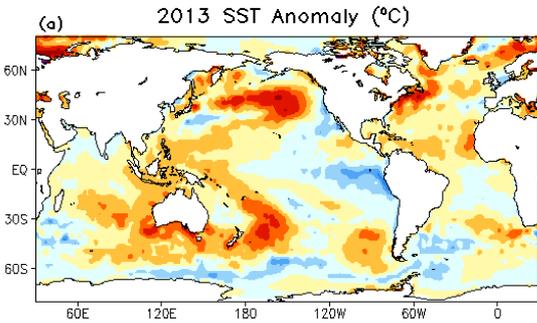
- The positive SSTA in the N. Pacific and the negative PDO pattern is consistent with easterly wind anomalies in central N. Pacific and anomalous anti-cyclonic circulations near Gulf of Alaska.
- The positive 2013-2012 SSTA difference near Gulf of Alaska is consistent with the anti-cyclonic wind anomaly.
- The positive 2013-2012 SSTA difference in the northeast subtropical Pacific is consistent with the westerly wind anomaly.

OI SST

GODAS HC300

Linear Trend in 1993-2008

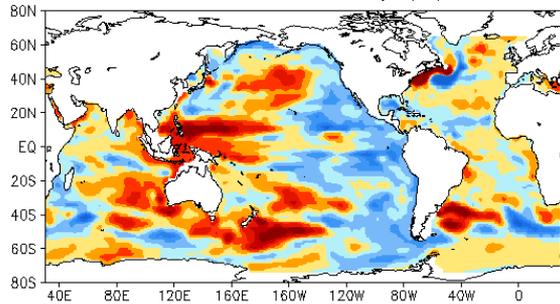
(Xue et al. 2011, Clim. Dyn.)



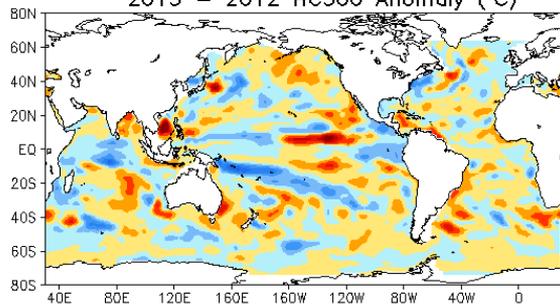
- The negative PDO pattern in SSTA corresponds well with the negative PDO pattern in HC300A.
- Both positive SSTA and HC300A extended from the central N. Pacific to the western tropical Pacific, and then to the eastern Indian Ocean and western South Pacific near Australia.
- Negative HC300A dominated in the subtropical and extra-tropical eastern Pacific.
- The HC300A pattern is partially attributed to the linear trend.

GODAS HC300

2013 HC300 Anomaly (°C)

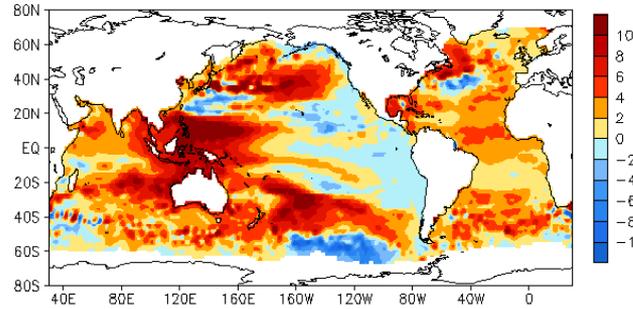


2013 - 2012 HC300 Anomaly (°C)

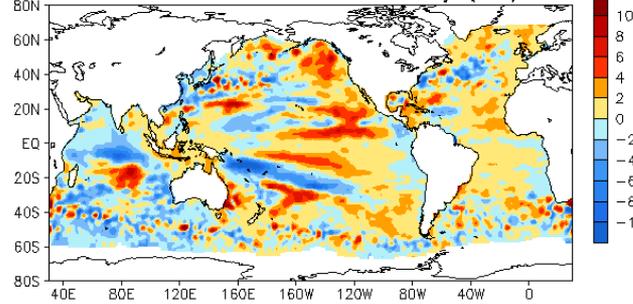


AVISO SSH

2013 SSH Anomaly (cm)

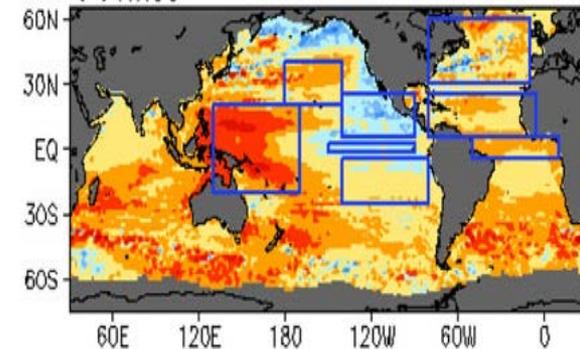


2013 - 2012 SSH Anomaly (cm)



Linear Trend

(Xue et al. 2011, Clim. Dyn.)



- The negative PDO pattern in HC300A corresponds well with the negative PDO pattern in SSH anomaly (SSHA).
- Both positive HC300A and SSHA extended from the central N. Pacific to the western tropical Pacific, and then to the eastern Indian Ocean and western South Pacific near Australia.
- HC300 was below-normal in the subtropical and extra-tropical eastern Pacific, while SSH was near-normal in the eastern Pacific.
- The SSHA pattern is partially attributed to the linear trend.
- The HC300A tendency is consistent with the SSHA tendency, indicating warming off the equator in the central-eastern Pacific.

Indo-Pacific SSTA and ENSO

Seasonal Mean SST Anomaly in 2013

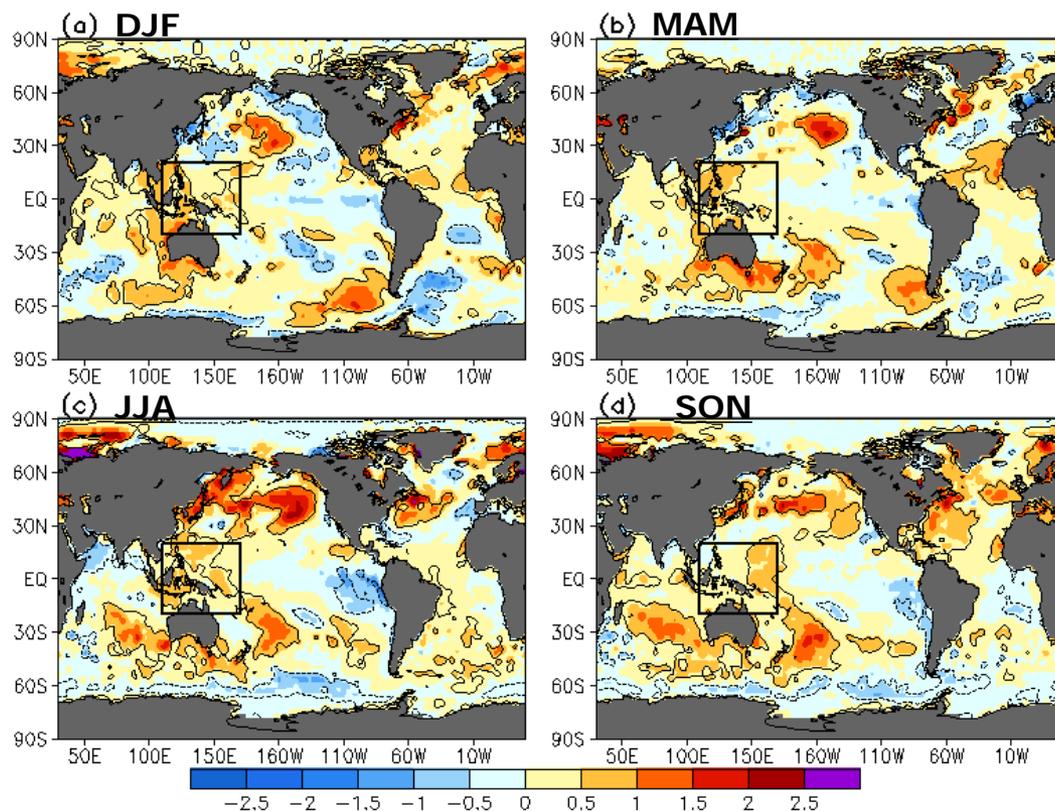


Fig. 3.2. Seasonal mean SSTA from OISST (shading, °C, relative to 1981-2010 average) for (a) December 2012 to February 2013, (b) March to May 2013, (c) June to August 2013 and (d) September to November 2013. The contours are +1 and -1 normalized seasonal mean SSTA based on seasonal mean standard deviation over 1981-2010.

From Xue et al. (2014) to appear in the BAMS State of the Climate in 2013

- The winter 2012/2013 (December-February) was characterized by a negative PDO pattern in the North Pacific, and ENSO-neutral conditions in the tropical Pacific. Both ENSO-neutral and negative PDO conditions persisted throughout 2013.

- The positive SSTA over Indo-Pacific warm pool exceeding +1 STD persisted throughout 2013. Negative SSTA of more than -1 STD emerged in the eastern Pacific during summer and persisted into fall 2013.

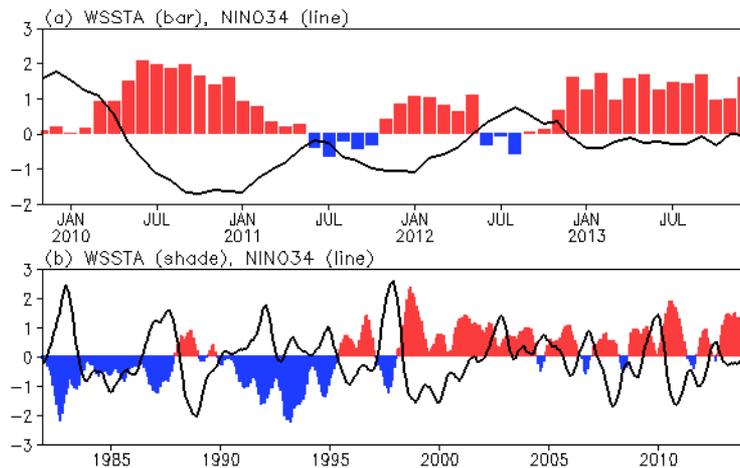
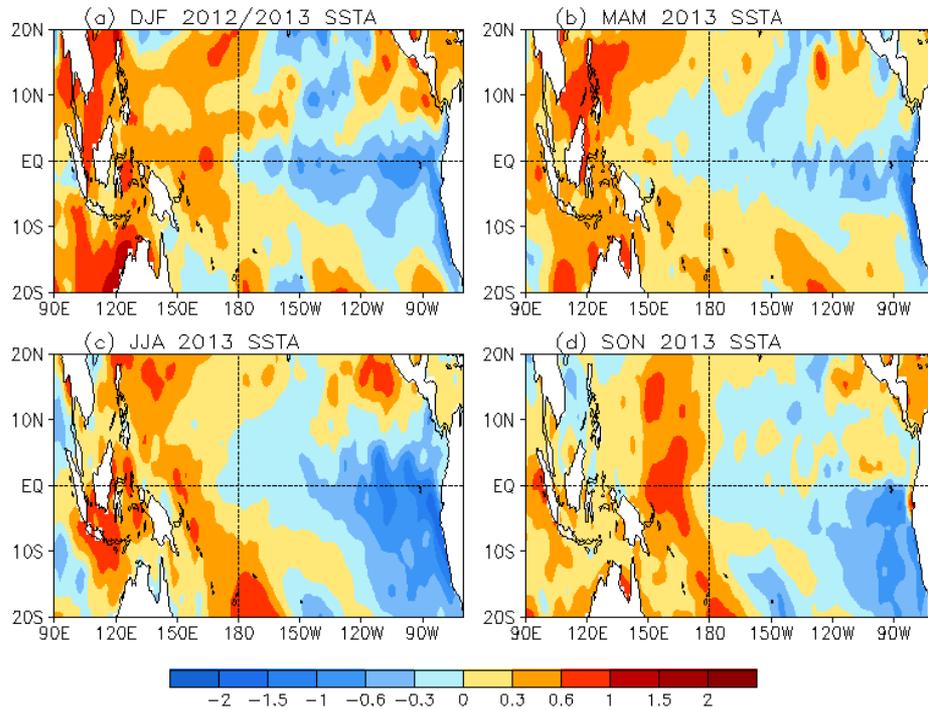


Fig. 3.3. (a) Monthly normalized average SSTA over Indo-Pacific warm pool in the box shown in Fig. 3.1, labeled as WSSTA (bar) and monthly normalized NINO3.4 index (average SSTA in 170°W-120°W, 5°S-5°N) (line) in 2010-2013 and; (b) 5-month running mean of SSTA indices in 1982-2013

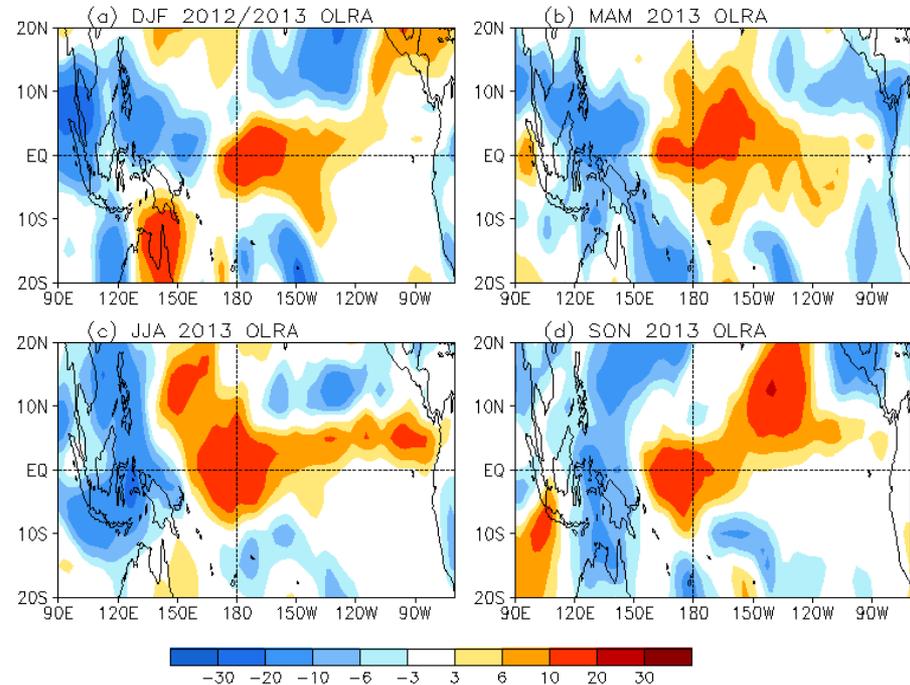
From Xue et al. (2014) to appear in the BAMS State of the Climate in 2013

- WSSTA exceeded +1 STD during most of 2013 and 2010.
- The time series since 1982 shows that WSSTA (shading) was mostly negative before 1999 and positive after 1999, which is related to a multidecadal shift that happened around 1999 (Lyon et al. 2013).
- WSSTA is generally out-of-phase with NINO3.4 with a correlation -0.45 in 1982-2013, but a correlation -0.53 before 1999 and -0.31 after 1999.
- The weakened out-of-phase relationship between WSSTA and NINO3.4 after 1999 is probably related to the weakened ENSO variability after 1999 (Hu et al. 2013).
- The persistent positive WSSTA after 1999 favors persistent La Nina-like atmospheric circulations with enhanced convections over Indonesia and suppressed convections near the dateline.

Seasonal Mean SST Anomaly

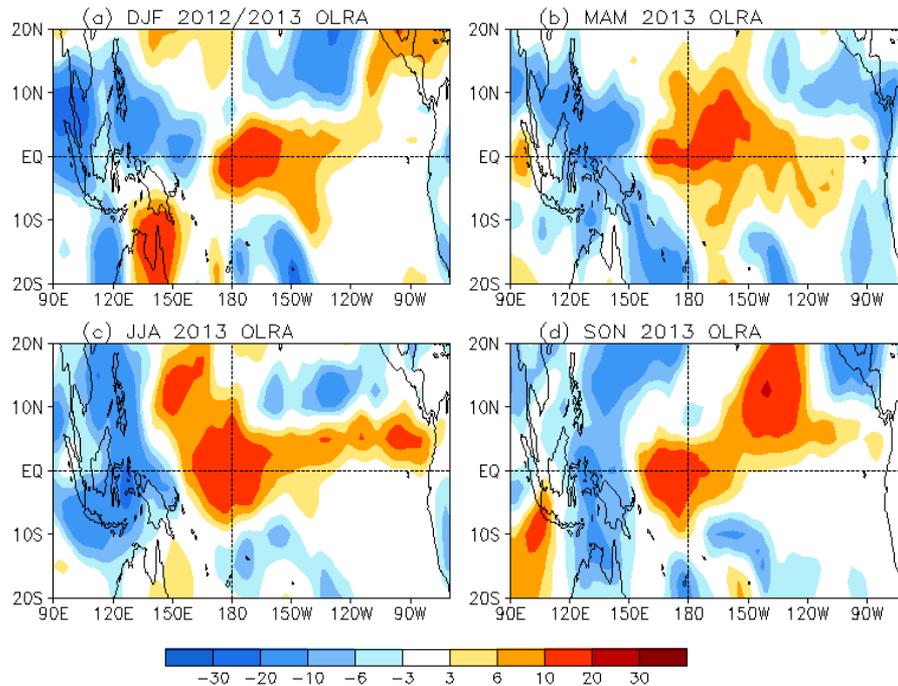


Seasonal Mean OLR Anomaly

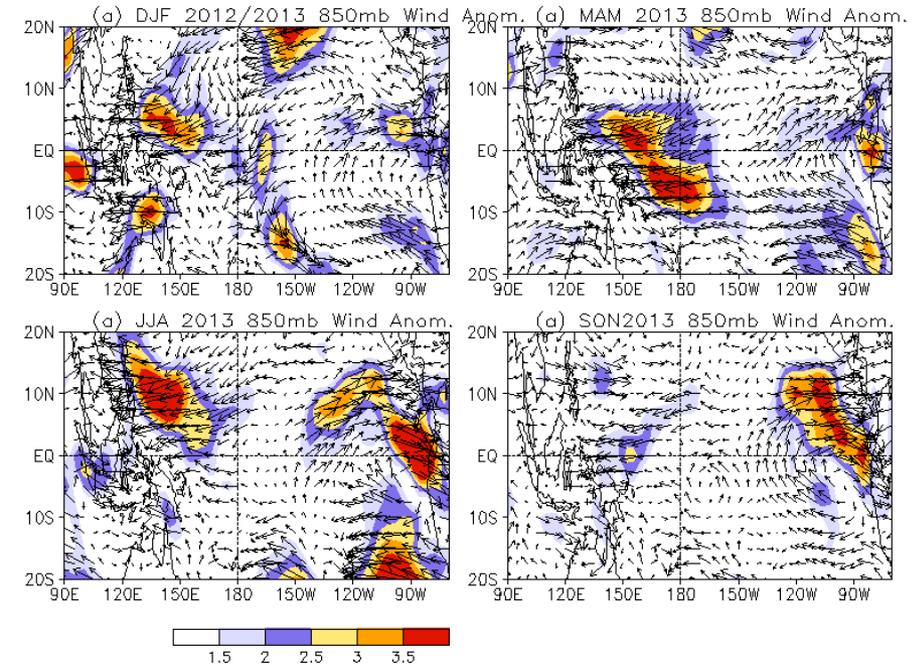


- **Positive (negative) SSTA has persisted in the western (eastern) tropical Pacific.**
- **Consistent with the west-east SSTA gradient, convection has been persistently enhanced (suppressed) over Indonesia (near Dateline) through out the year.**

Seasonal Mean OLR Anomaly

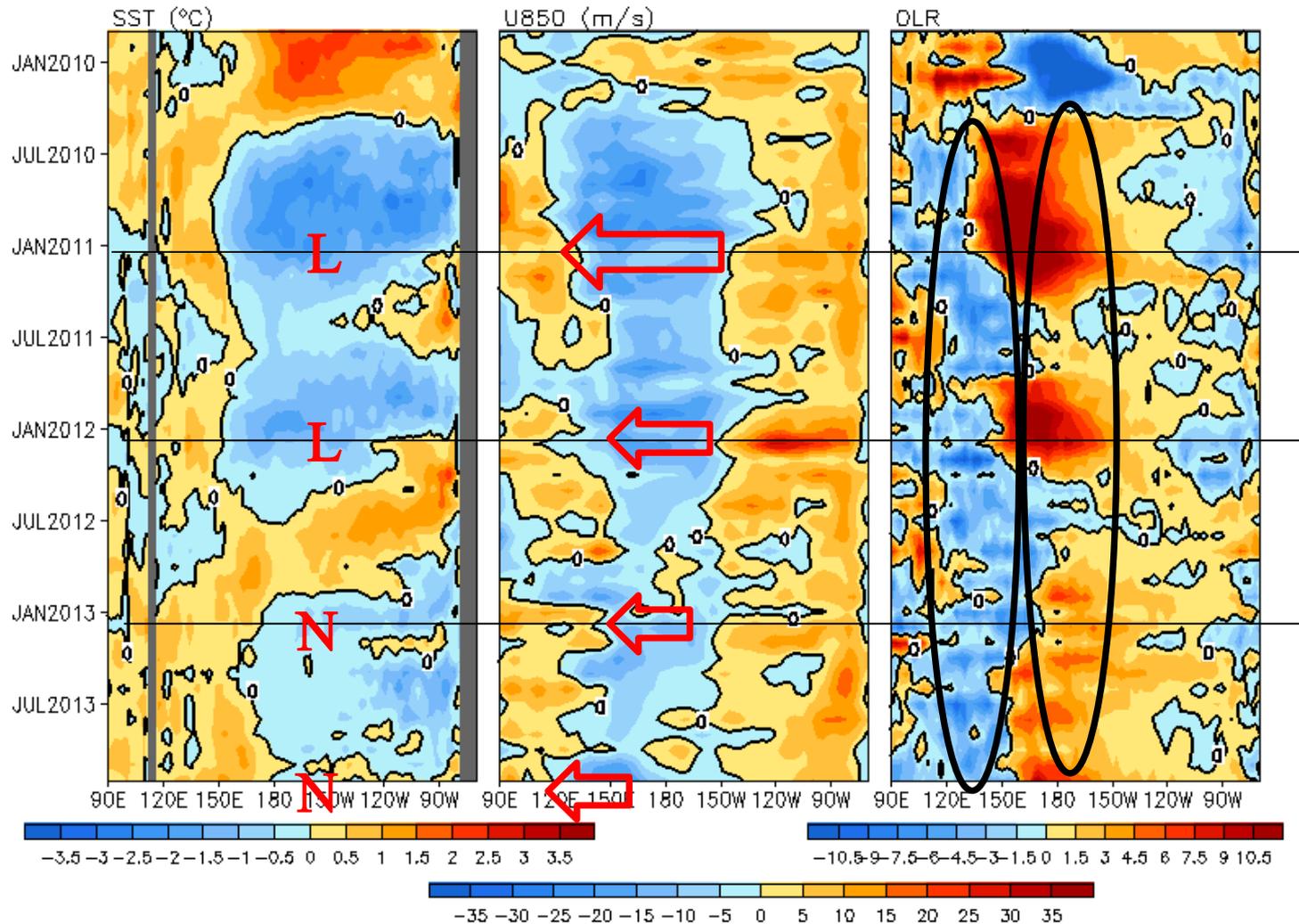


Seasonal Mean 850mb Wind Anomaly



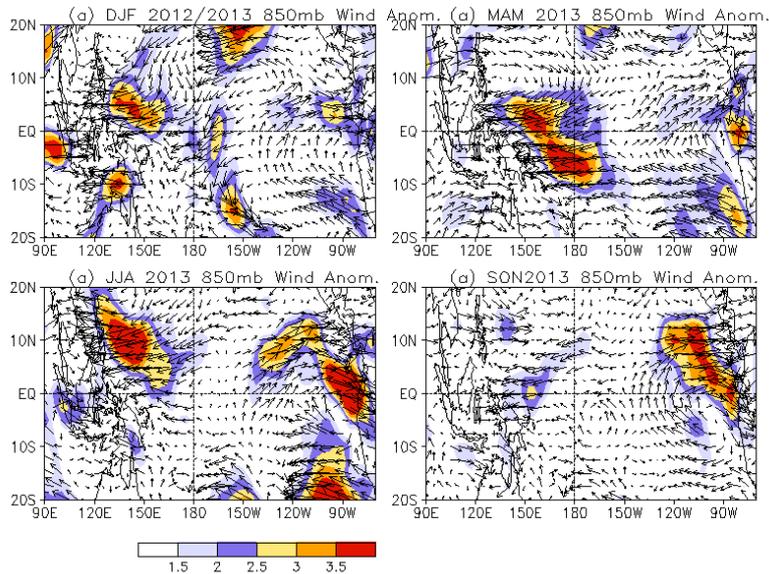
- Consistent with the enhanced (suppressed) convection over Indonesia (near Dateline), easterly wind anomalies dominated in the western tropical Pacific through out the year.
- Cross-equatorial wind anomaly, consistent with the northward shift of ITCZ, also persisted through out the year.

Indo-Pacific, 2°S–2°N Average, Monthly Anomaly

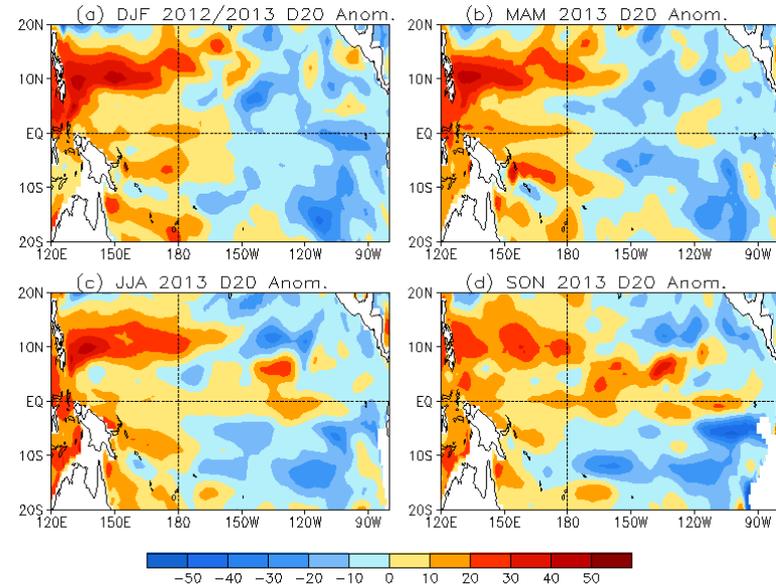


- Easterly wind anomalies persisted in the central Pacific during ENSO-neutral year of 2012 and 2013, resembling those during La Nina year of 2010 and 2011.
- Convection was enhanced (suppressed) in the western Pacific (near Dateline) during ENSO-neutral 2012 and 2013, resembling those during La Nina 2010 and 2011.

Seasonal Mean 850mb Wind Anomaly

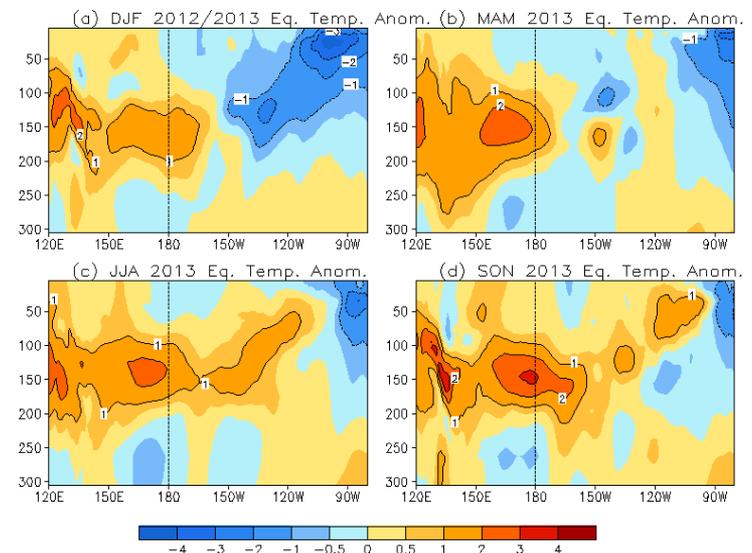


Seasonal Mean Depth of 20C Anomaly

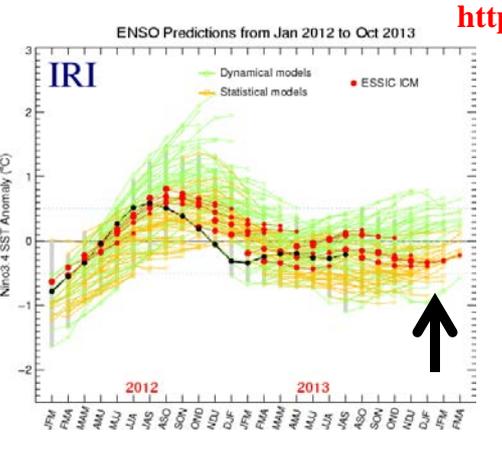
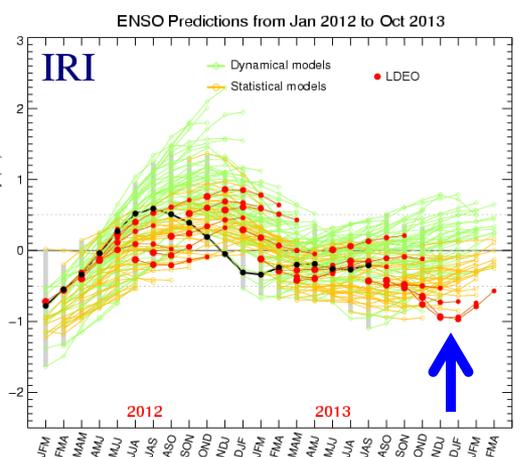
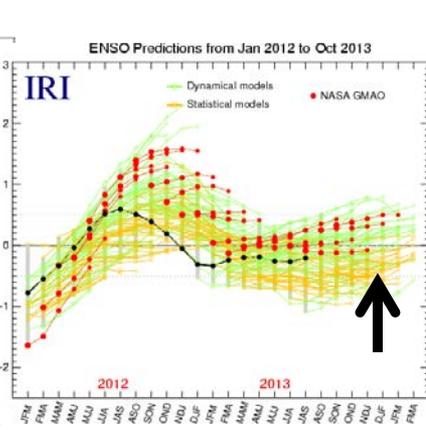
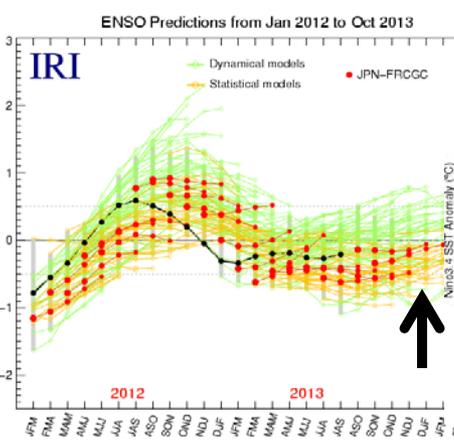
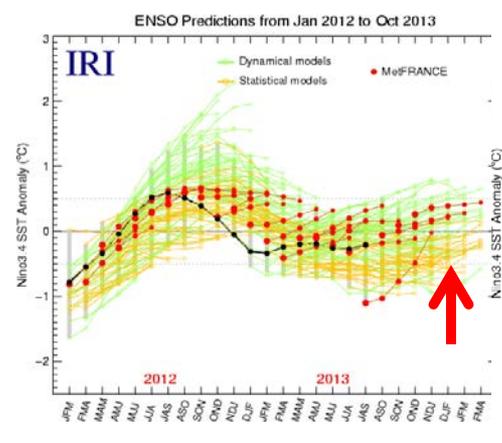
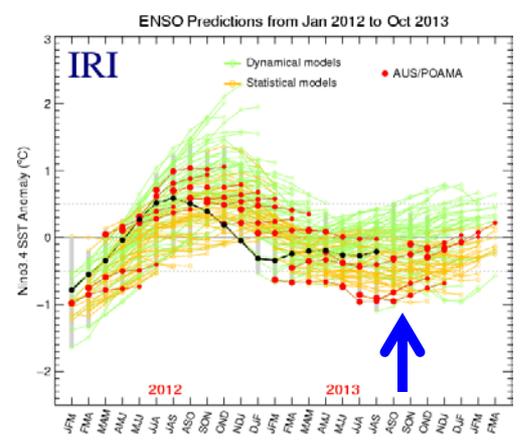
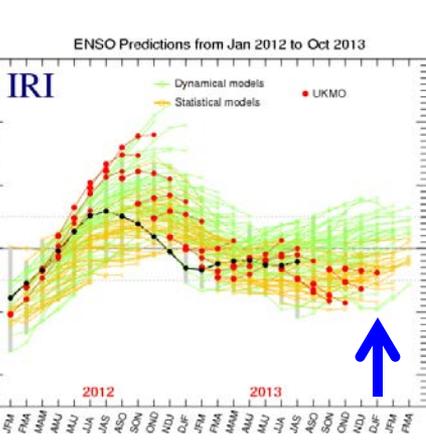
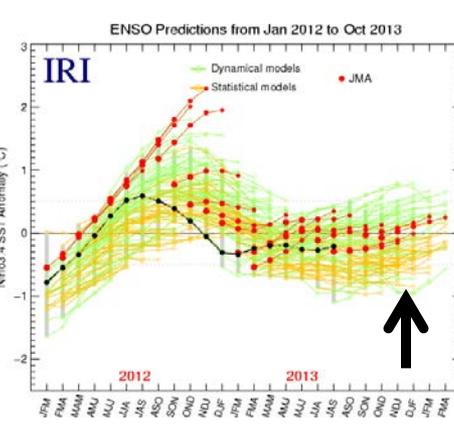
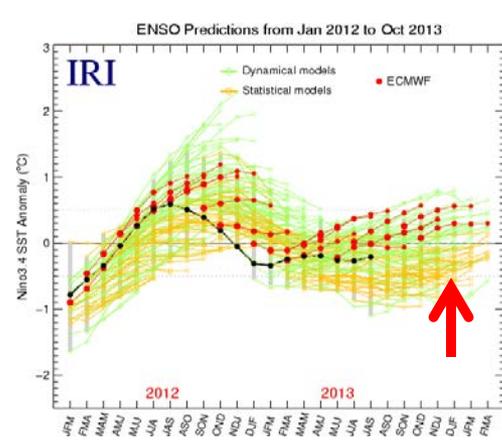
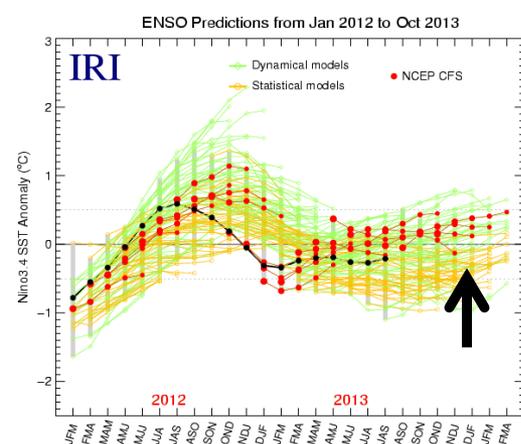


- Easterly wind anomalies were consistent with the above-normal (below-normal) depth of 20C (D20) in the western (eastern) Pacific during DJF 2012/13.
- Positive D20 anomaly (D20A) persisted in the western Pacific, while negative D20A appeared in off-equatorial eastern Pacific in MAM 2013.
- Positive D20A propagated to the eastern Pacific due to weakening of easterly wind anomalies in JJA 2013.
- Positive D20A strengthened across the equatorial belt in SON 2013.

Seasonal Mean Eq. Temp. Anomaly

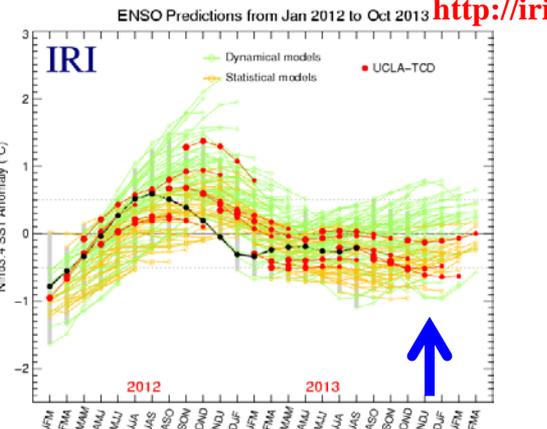
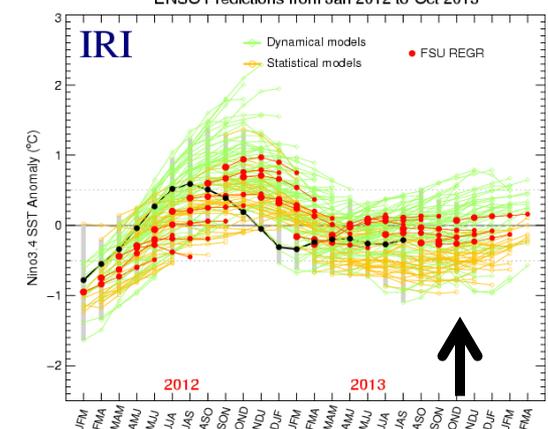
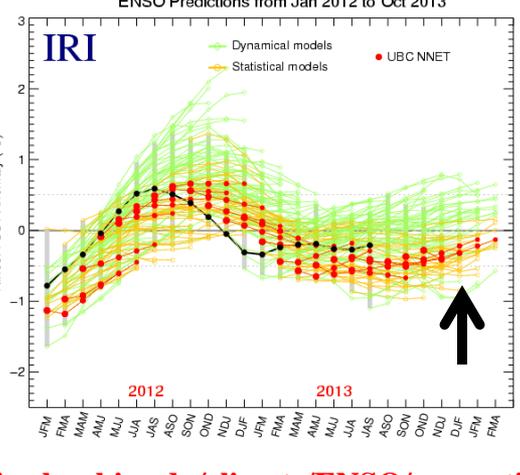
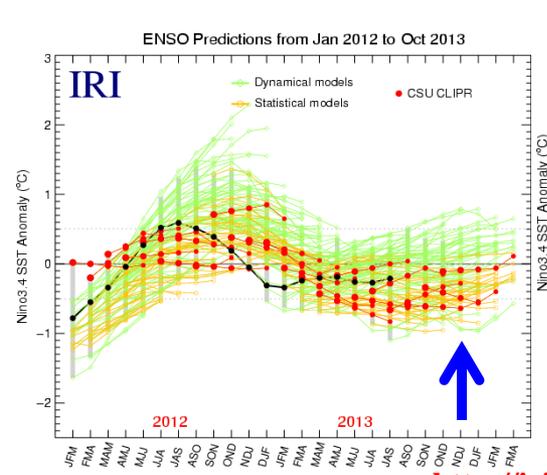
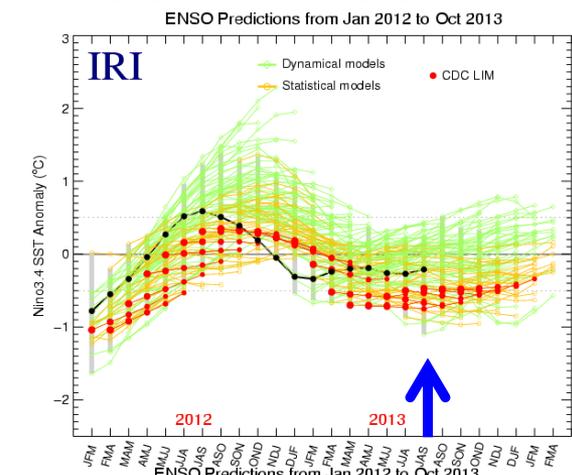
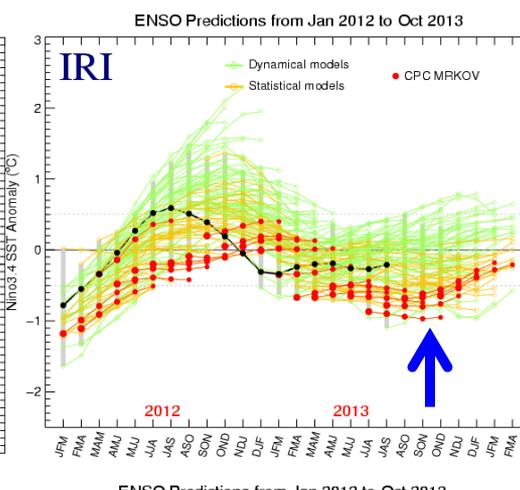
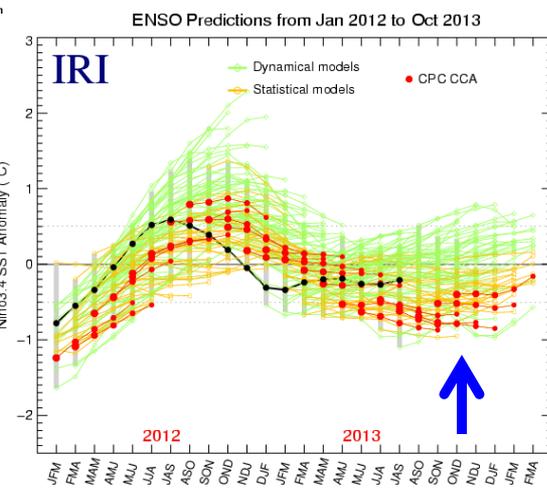
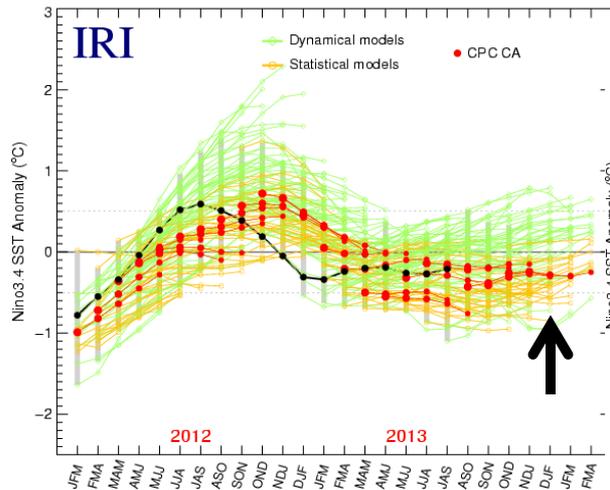


Prediction of ENSO-neutral 2012/13 Winter



http://iri.columbia.edu/climate/ENSO/currentinfo/SST_table.html

- Some dynamical models, i.e. CFS, JMA, FRCGC, GMAO, ESSIC, forecast the ENSO-neutral 2012/13 winter very well.
- Some dynamical models, i.e. ECMWF, MetFRANCE, have weak warm biases.
- Some dynamical models, i.e. LDEO, UKMO, AUS, have weak cold biases.

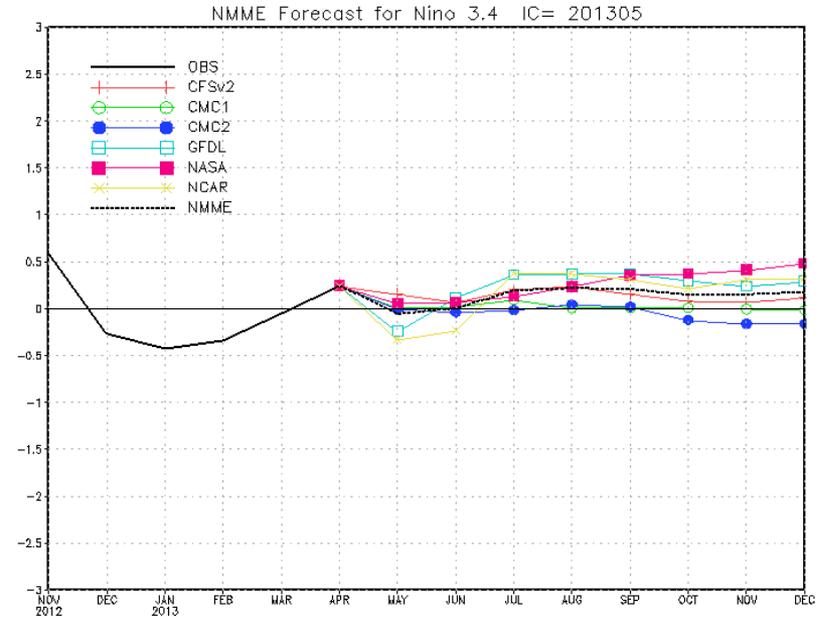
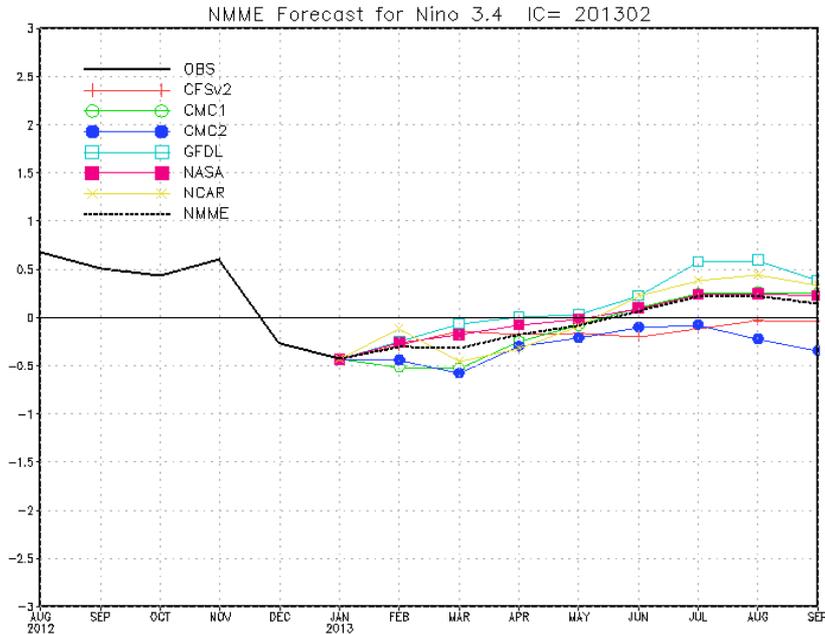


http://iri.columbia.edu/climate/ENSO/currentinfo/SST_table.htm

- Some statistical models, i.e. CPC CA, UBC NNET, and FSU REGR, forecast the ENSO-neutral 2012/13 winter very well.
- Some statistical models, i.e. CPC CAC, CPC MARKOV, CDC LIM, CSU CLIPR, have weak cold biases.

The North America Multi-Model Ensemble (NMME)

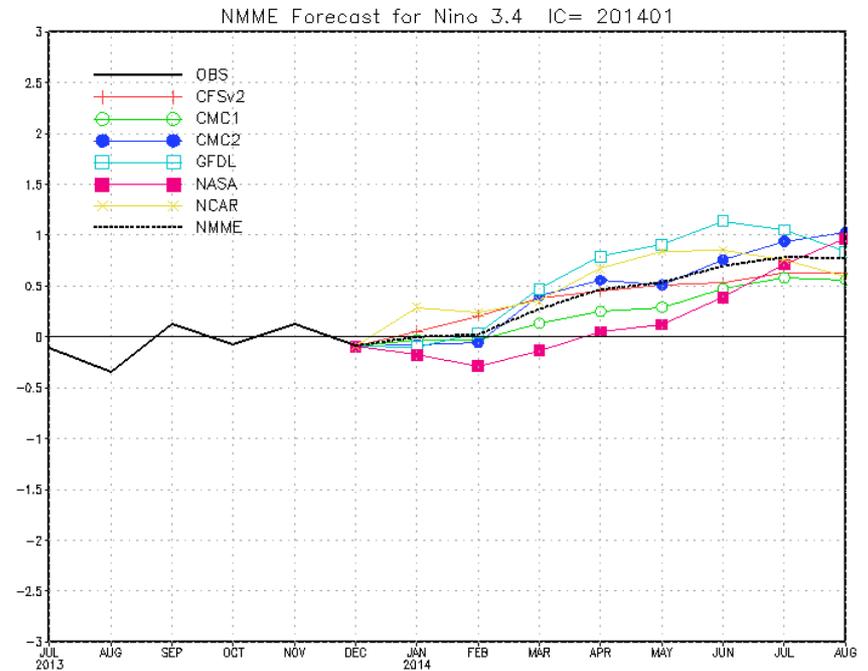
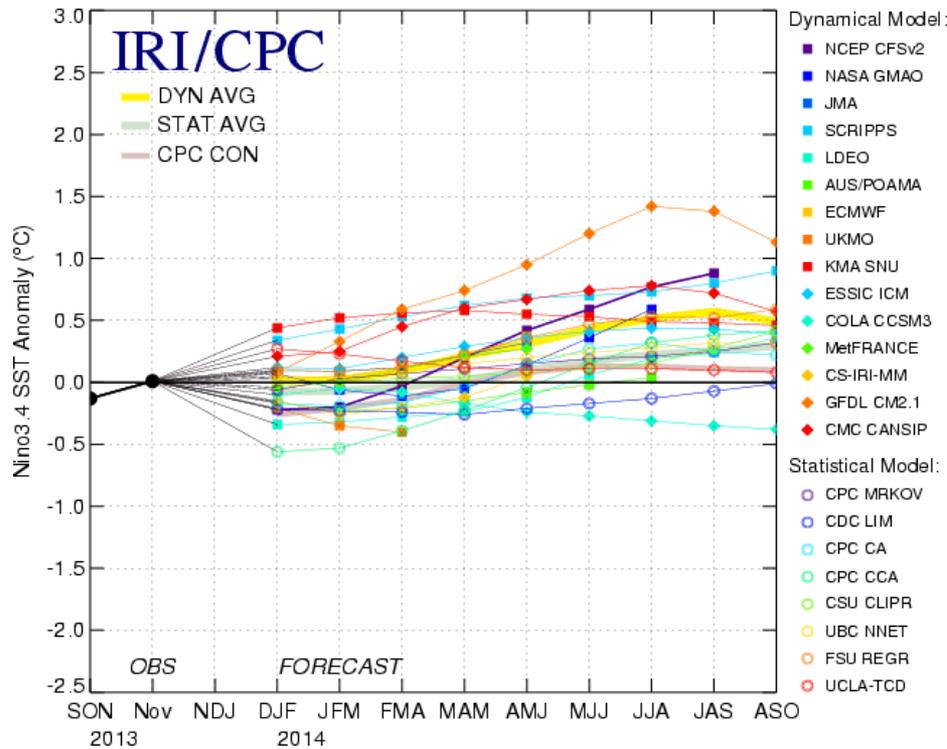
<http://www.cpc.ncep.noaa.gov/products/NMME/>



- All models from NMME forecast the ENSO-neutral 2012/13 winter well.

The Latest ENSO Forecasts

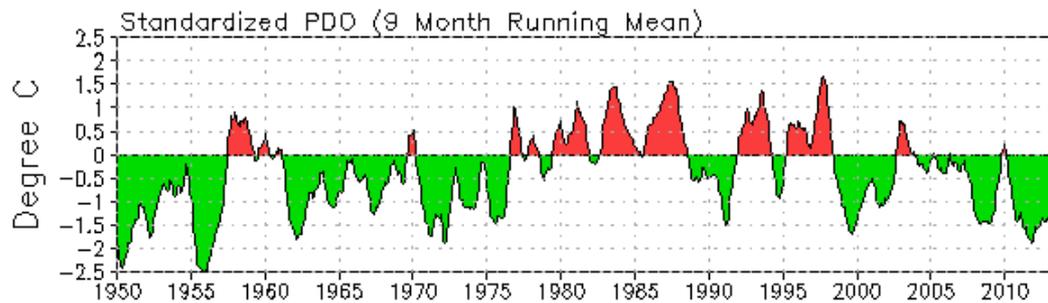
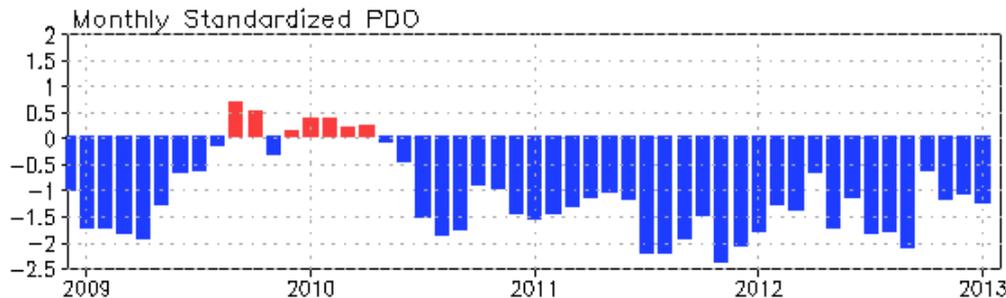
Mid-Dec 2013 Plume of Model ENSO Predictions



- All statistical models except FSU REGR indicate ENSO-neutral conditions will continue into summer 2014.
- Some dynamical models, i.e. CFS, NASA, GFDL, CMC1, CMC2, NCAR, indicate weak El Nino conditions will emerge in summer 2014.

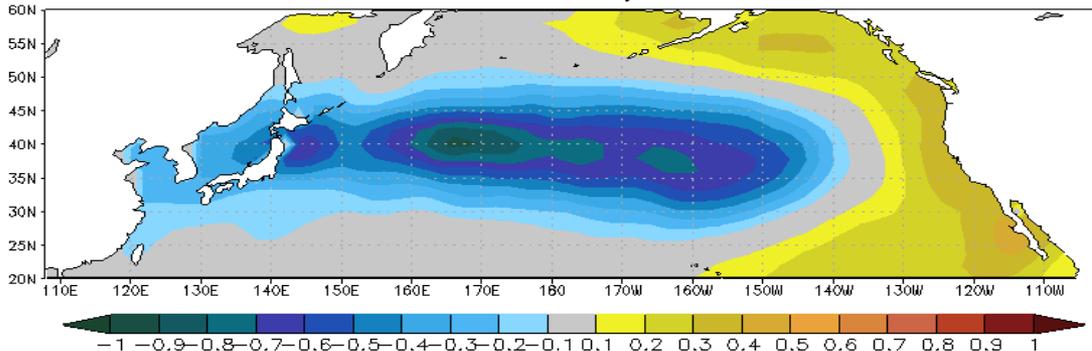
Pacific Decadal Oscillation (PDO)

Pacific Decadal Oscillation



- Negative PDO phase has persisted from May 2010 to Jan 2014, lasting for 45 months now.
- Negative (positive) PDO phase was prevalent during 1950-1975 and 1999-2012 (1976-1998).

1st EOF of monthly ERSST v3b



- 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.

PDO and NINO3.4

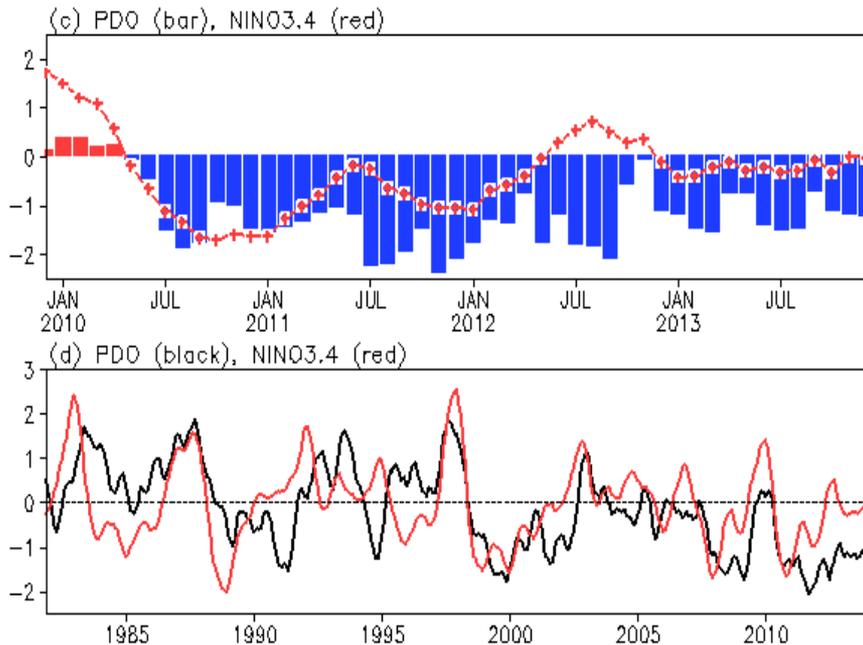


Fig. 3.3. (c) monthly normalized PDO index (bar) and NINO3.4 index (line) in 2010-2013; (d) 5-month running mean of PDO and NINO3.4 index in 1982-2013. SSTA is relative to 1981-2010 average.

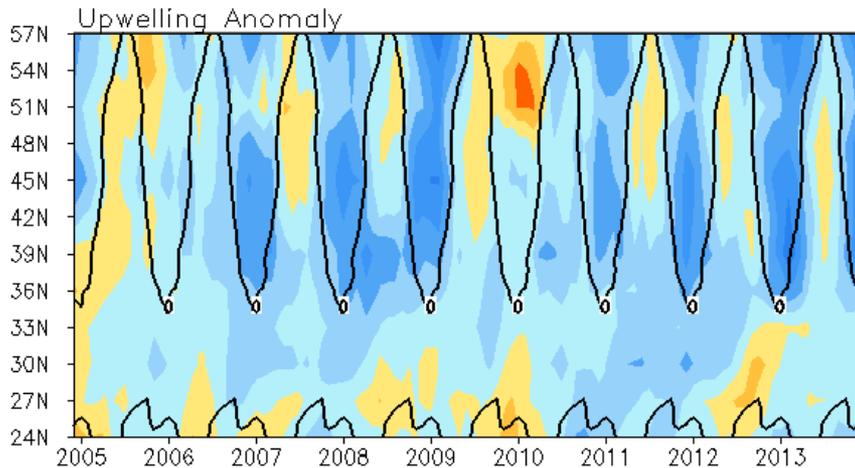
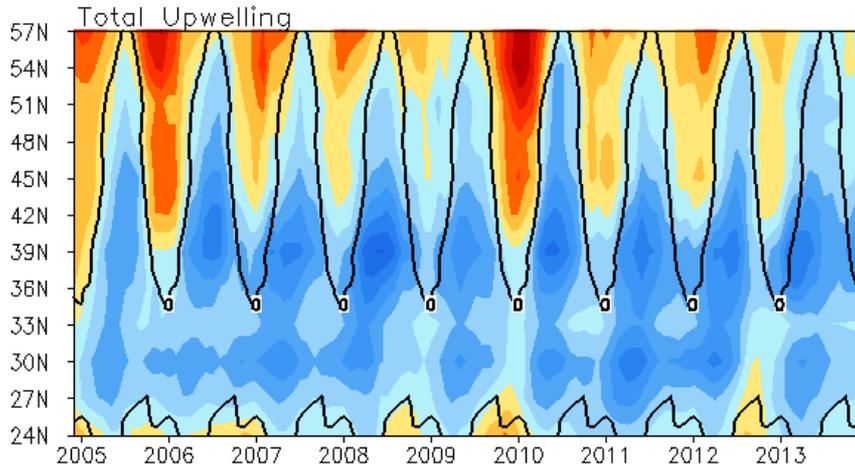
From Xue et al. (2014) to appear in the BAMS State of the Climate in 2013

- There was a regime shift of PDO around 1999. After 1999 negative PDO was more frequent than the positive PDO, while before 1999 positive PDO was more frequent. During the positive phase of the PDO, PDO either lagged NINO3.4 (1983-84, 1993-1994) or was in phase with NINO3.4 (1986-87, 1997-98). The correlation between monthly PDO and NINO3.4 at zero lag is 0.3 in 1982-1998 and 0.56 in 1999-2013. The higher correlation since 1999 is partly attributed to the fact that both PDO and NINO3.4 were in prevalent negative phase since 1999.

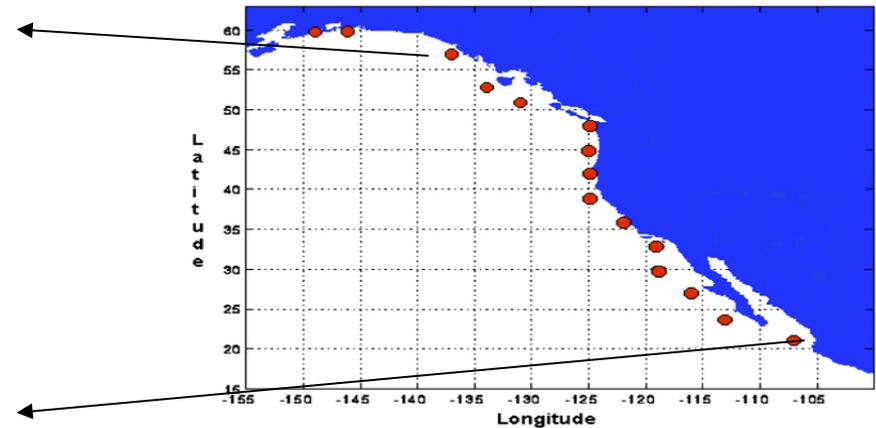
- PDO was less than -1 standard deviation in 2013 although NINO3.4 was zero.

North America Western Coastal Upwelling

Monthly Coastal Upwelling for West Coast North America
($\text{m}^3/\text{s}/100\text{m coastline}$)



Standard Positions of Upwelling Index Calculations



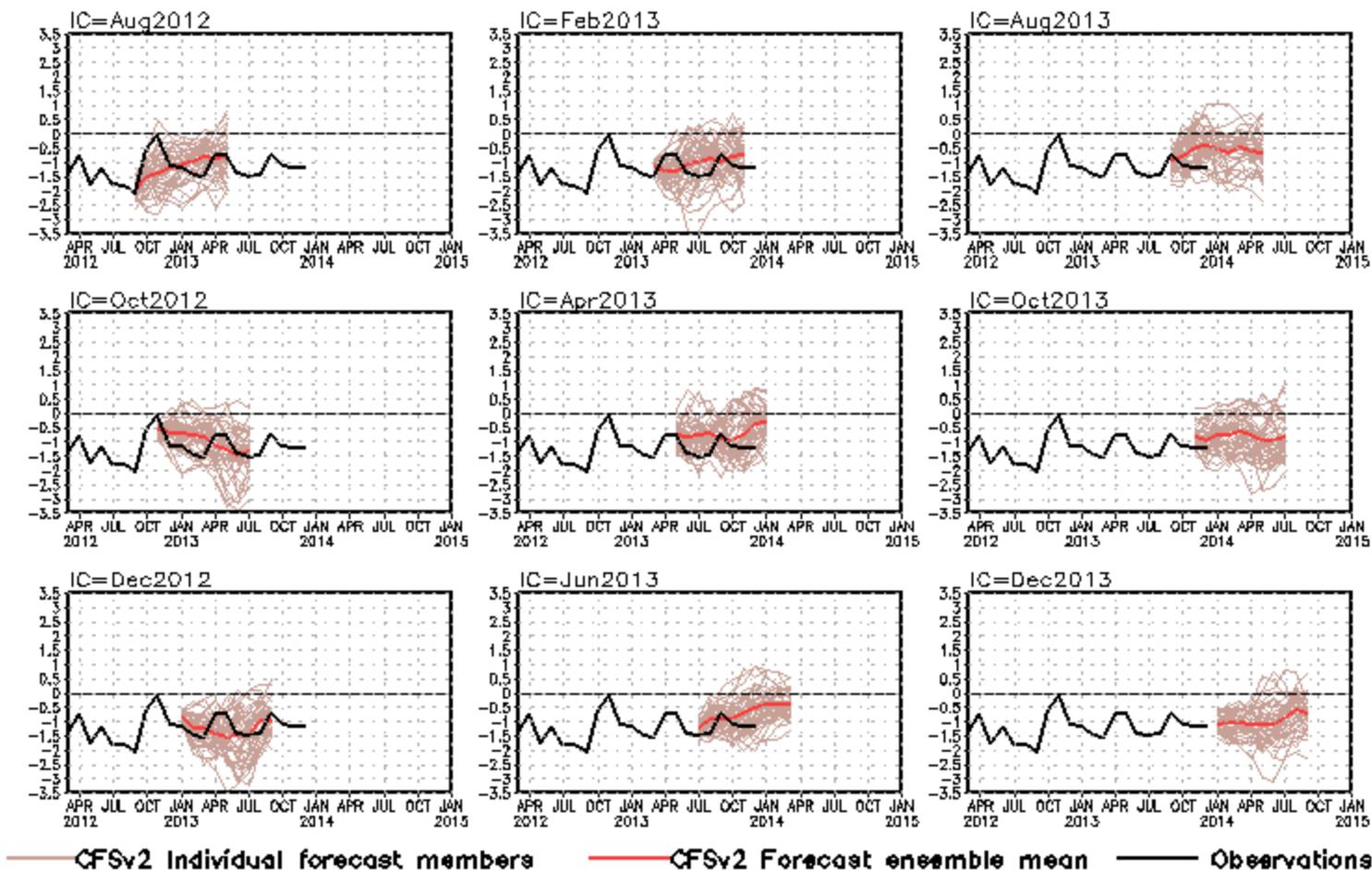
- Downwelling in mid-high latitudes was suppressed during winter of 2006 (El Niño winter), 2007-2008, 2010-2011 (La Niña winters), 2012-2013 (ENSO-neutral winters).

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 ($\text{m}^3/\text{s}/100\text{m coastline}$). 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.

standardized PDO index



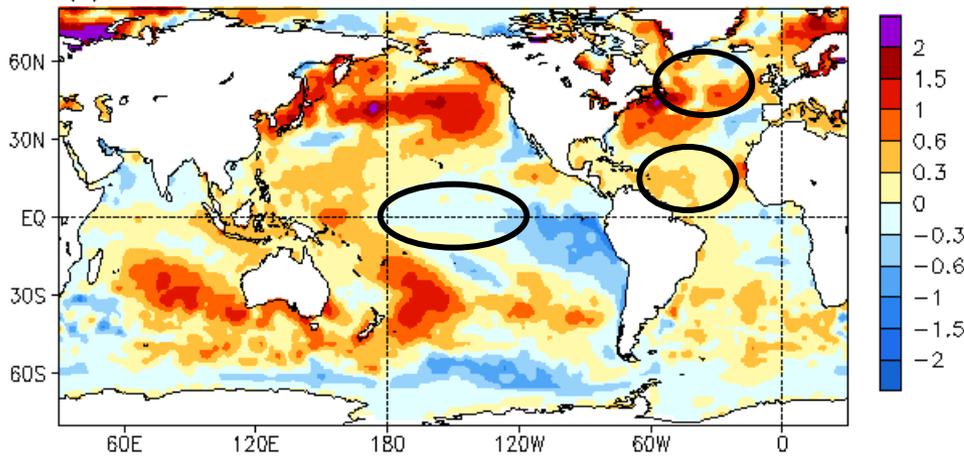
- CFSv2 has forecast the negative PDO phase in 2013 up to 9 month lead time.

2013 Atlantic Hurricane Season

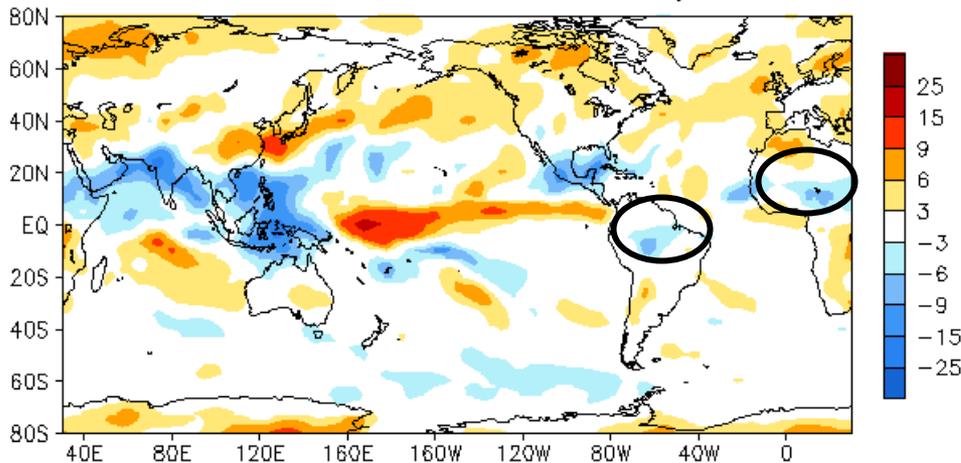
2013 Atlantic Hurricane Season

(ACE=35%, Below-normal season with the fewest number of hurricanes since 1982)

(a) Jun–Nov 2013 SST Anomaly (°C)



Jun–Nov 2013 OLR Anomaly



The Multi-Decadal Signal since 1995

The combination of warmer Atlantic waters, an enhanced West African monsoon system, and suppressed convection over the Amazon Basin has been in place during August–October since 1995. Similar conditions were also present during the active Atlantic hurricane period 1950–1970. Opposite conditions were associated with the below-normal hurricane era 1971–1994.

Factors influencing **2013** seasonal hurricane outlooks:

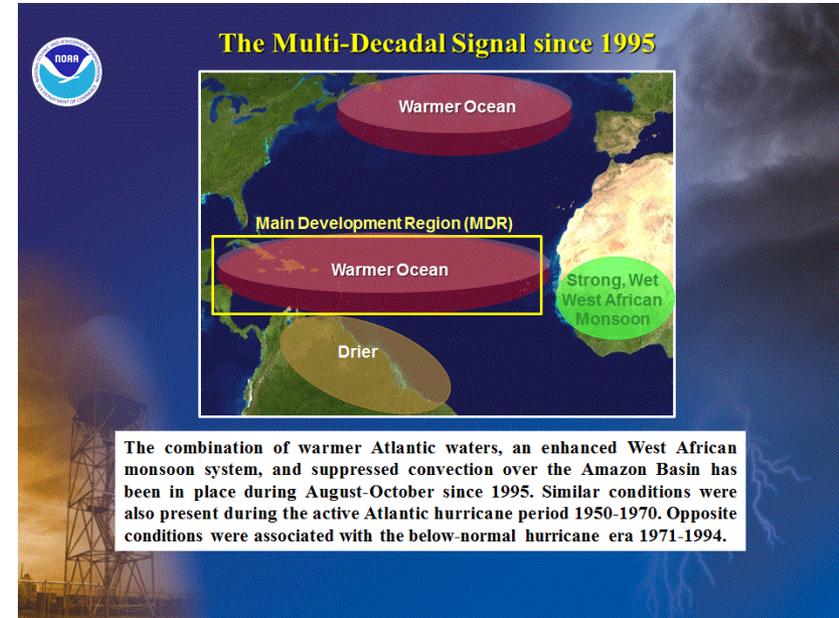
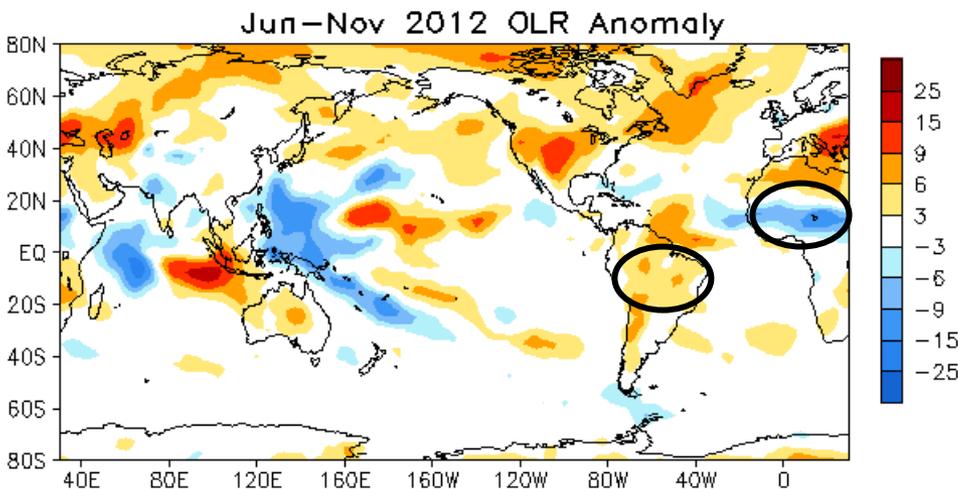
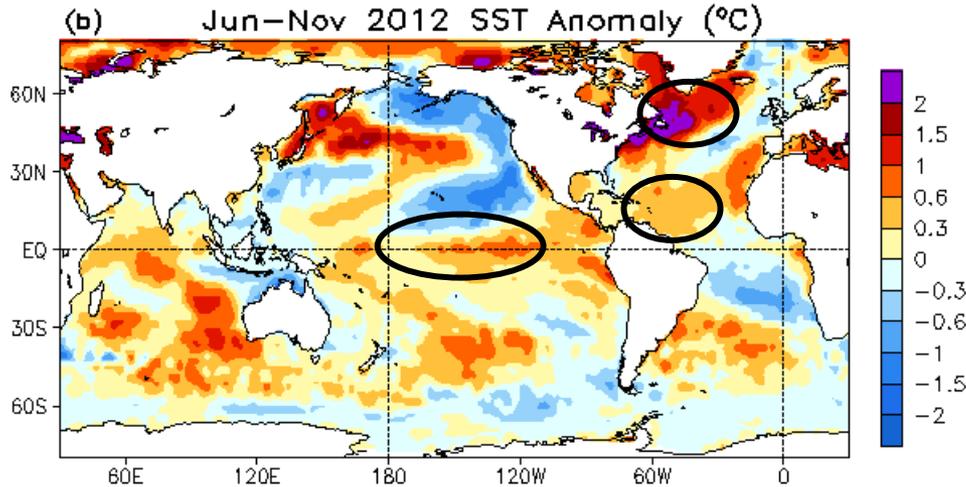
1. The multi-decadal signal since 1995 –Yes, but West African monsoon not enhanced
2. Above-average SST in tropical Atlantic and Caribbean Sea, and warmer than global tropics - Yes
3. ENSO-neutral conditions – Yes, but with east-west dipole SSTA

See details in

http://www.cpc.ncep.noaa.gov/products/GODAS/ocean_briefing_gif/global_ocean_monitoring_2014_01.ppt

2012 Atlantic Hurricane Season

(ACE=139%, Above-normal season, tied with the third-largest number of named storms (19))

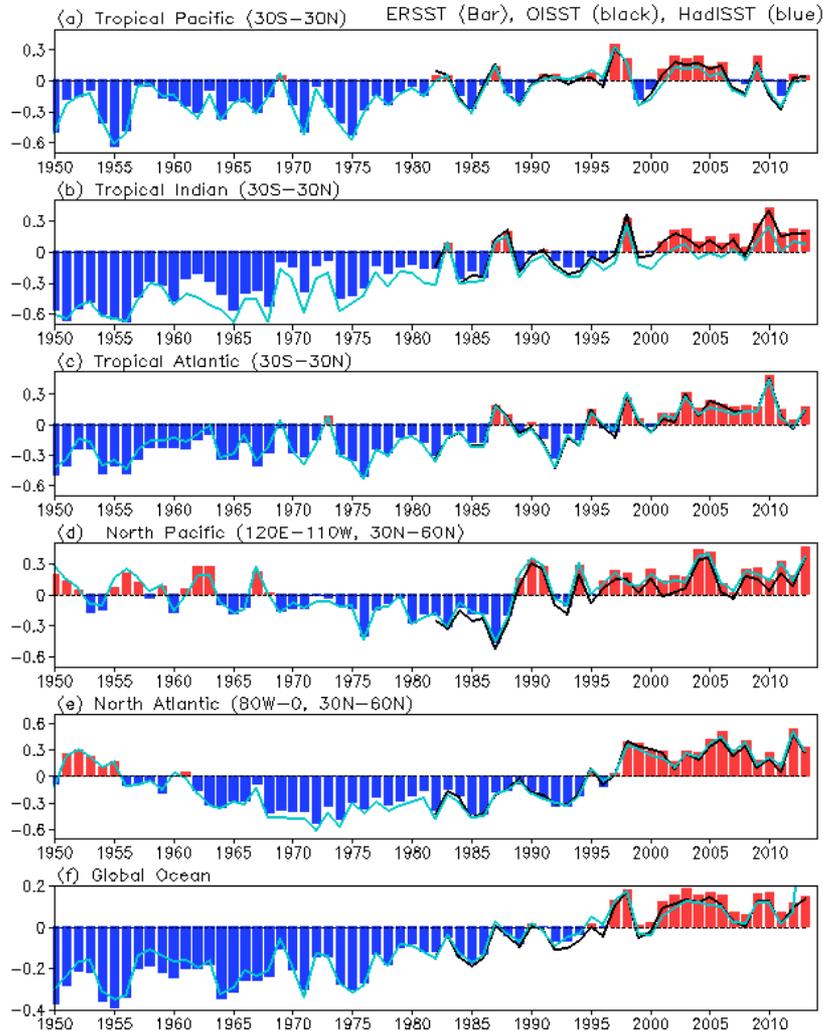


Factors influencing 2012 seasonal hurricane outlooks:

1. The multi-decadal signal since 1995 – Yes
2. Above-average SST in tropical Atlantic and Caribbean Sea, and warmer than global tropics - Yes
3. ENSO-neutral conditions – Yes but with above-average SST in central equatorial Pacific.

Basin Average of SSTA

Yearly Mean SST Anomaly Indices



-The mean SST in the **tropical Pacific** changed little from 2012 to 2013, ranking the 14th warmest year since 1982.

-The mean SST in the **tropical Indian Ocean** changed little from 2012 to 2013, ranking the 7th warmest year since 1982.

-The mean SST in the **tropical Atlantic** warmed up by 0.13°C in 2013, becoming the 13th warmest year since 1982.

-The mean SST in the **North Atlantic** decreased substantially (-0.21°C) from the 2012 historical high, becoming the 8th warmest year since 1982.

-The mean SST in the **North Pacific** increased substantially ($+0.28^{\circ}\text{C}$), becoming the **warmest year since 1982**.

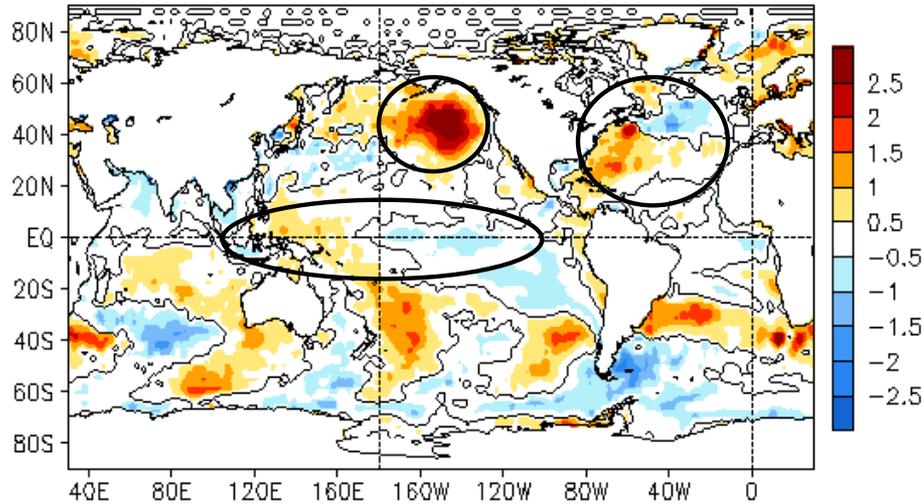
-The **global ocean SST** warmed by about $+0.03^{\circ}\text{C}$, becoming the 3rd warmest year since 1982.

Fig. 3.4. Yearly mean SSTA ($^{\circ}\text{C}$, relative to 1981-2010 average) from ERSST (bar) and HadISST (blue line) for 1950-2013 (bar) and OISST for 1982-2013 (black line) averaged over the (a) tropical Pacific, (b) tropical Indian Ocean, (c) tropical Atlantic, (d) North Pacific, (e) North Atlantic, and (f) global ocean.

Highlights in January 2014

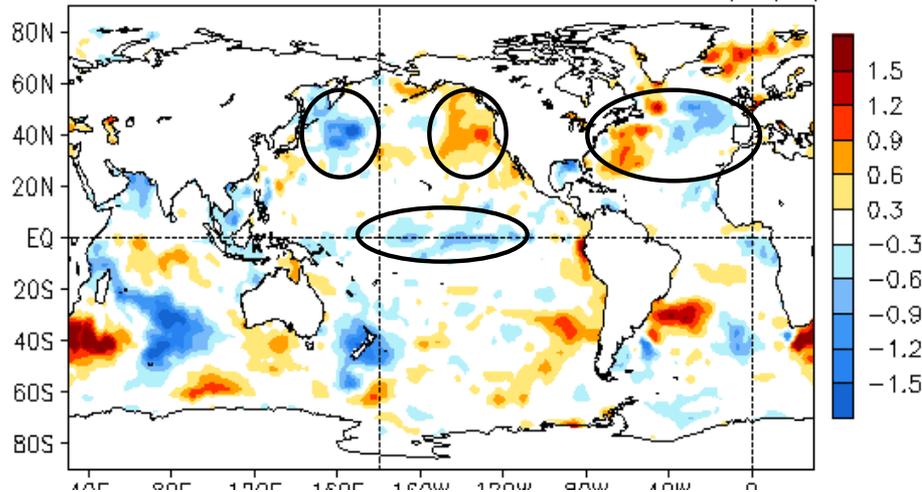
Global SST Anomaly ($^{\circ}\text{C}$) and Anomaly Tendency

JAN 2014 SST Anomaly ($^{\circ}\text{C}$)
(1981–2010 Climatology)



- SST was above-normal (below-normal) in the western (central-eastern) tropical Pacific.
- A negative PDO pattern in the N. Pacific.
- A north-south dipole of SSTA presented in the N. Atlantic.

JAN 2014 – DEC 2013 SST Anomaly ($^{\circ}\text{C}$)

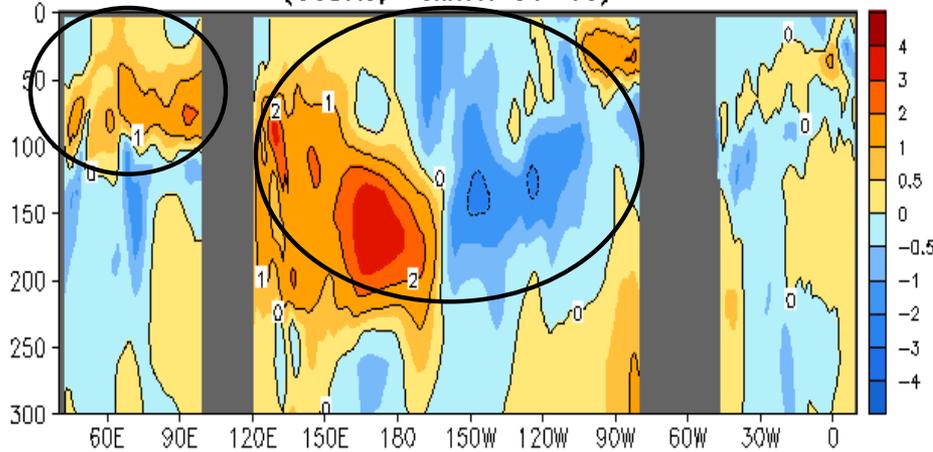


- A cooling (warming) tendency presented in the western (eastern) N. Pacific.
- A cooling tendency was observed in the central-eastern equatorial Pacific.
- A north-south dipole of SSTA tendency presented in the N. Atlantic.

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.

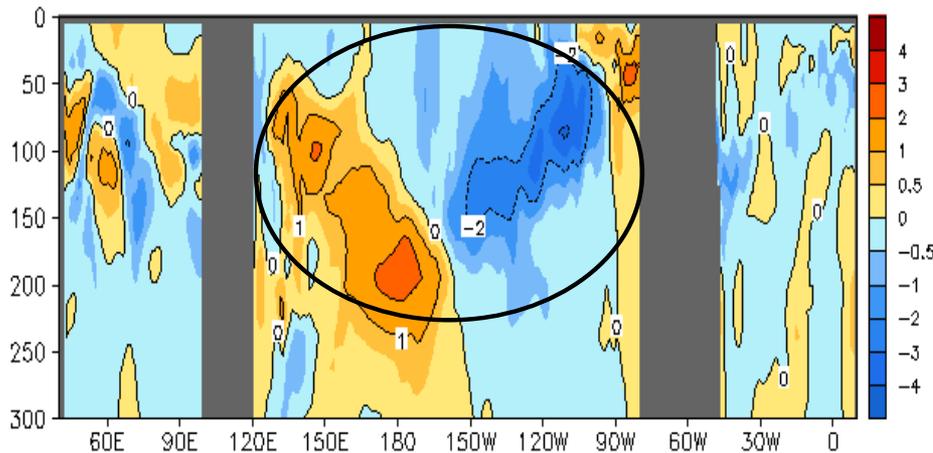
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

JAN 2014 Eq. Temp Anomaly (°C)
(GODAS, Climo. 81-10)



- Positive (negative) temperature anomalies dominated in the western (central) equatorial Pacific.
- Positive temperature anomalies dominated at the upper 100m of equatorial Indian Ocean.

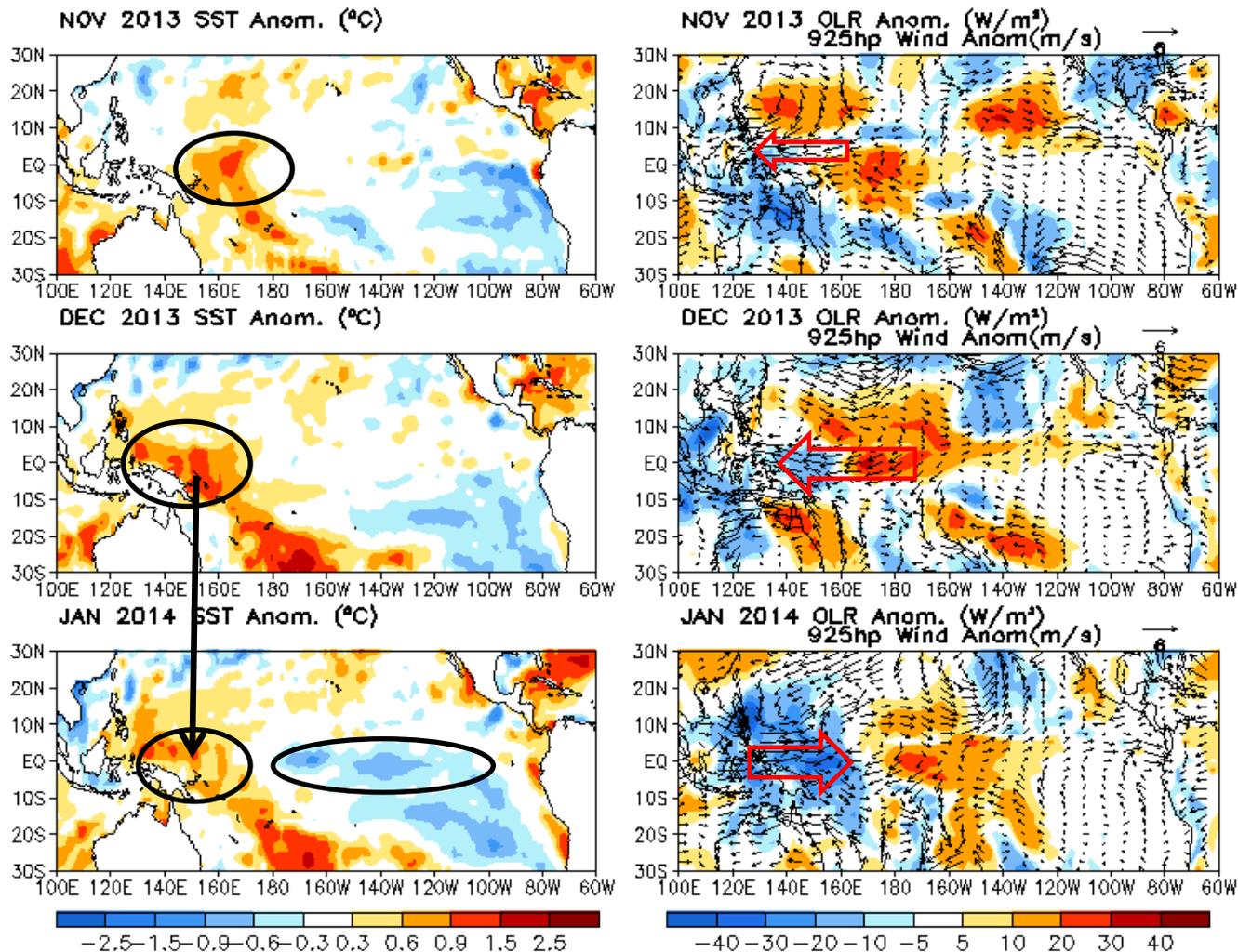
JAN 2014 – DEC 2013 Eq. Temp Anomaly (°C)



- A cooling (warming) tendency was observed in the western (central-eastern) Pacific near the thermocline, largely due to propagation of downwelling and upwelling oceanic Kelvin waves (slide 37).

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.

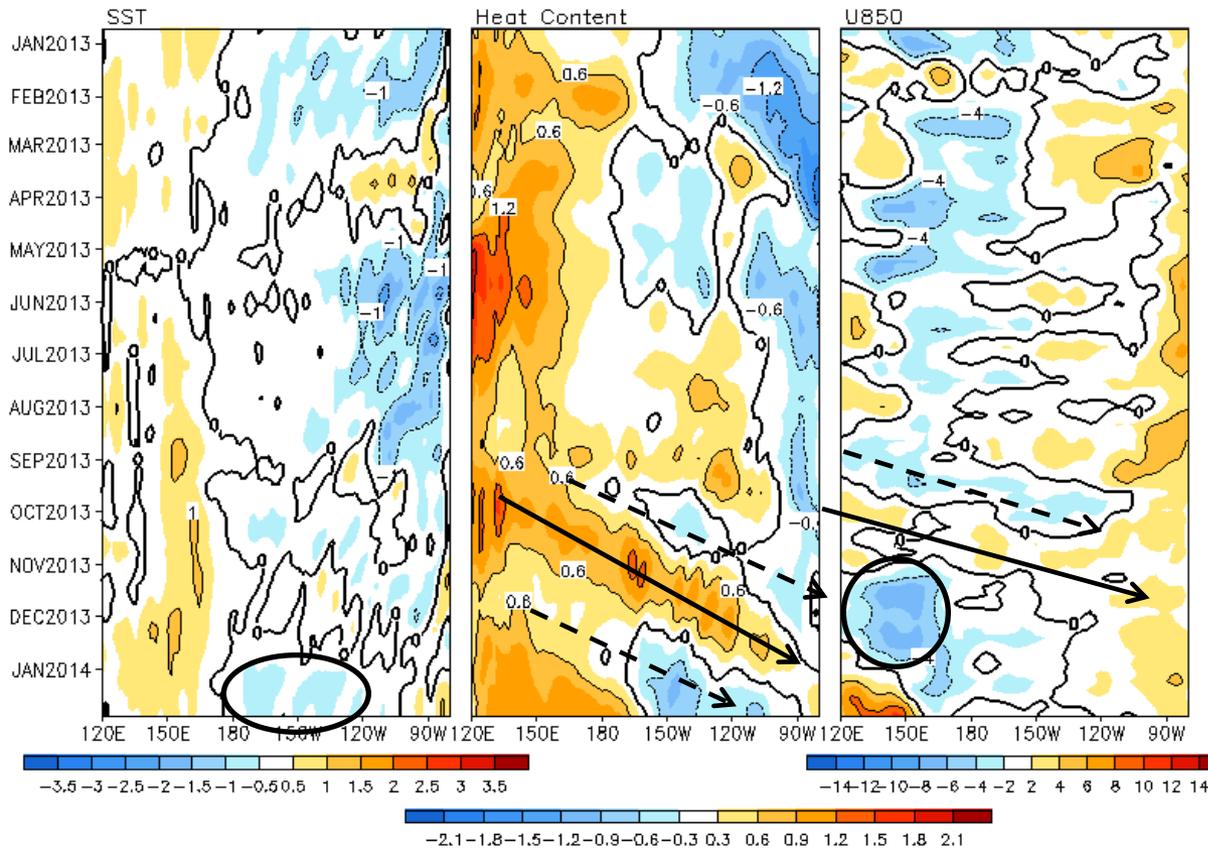
Last Three Month SST, OLR and 925hp Wind Anom.



- The positive SSTA in the western tropical Pacific persisted, while negative SSTA emerged in the central-eastern Pacific.
- Strong westerly wind anomalies developed in the western tropical Pacific in Jan 2014.

Equatorial Pacific SST ($^{\circ}\text{C}$), HC300 ($^{\circ}\text{C}$), u850 (m/s) and OLR(W/m^2) Anomalies

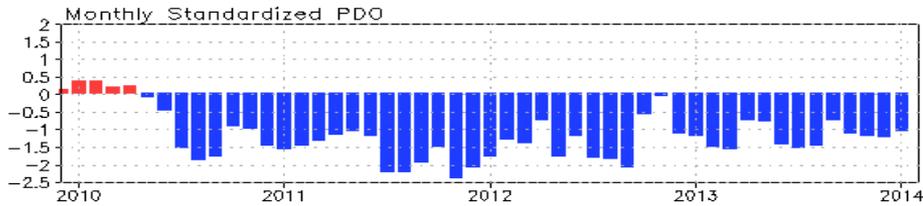
2 $^{\circ}\text{S}$ –2 $^{\circ}\text{N}$ Average, 3 Pentad Running Mean



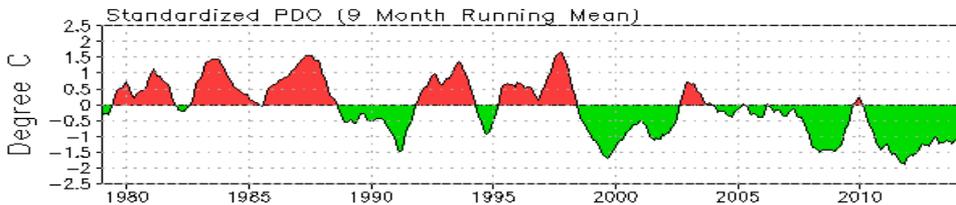
- Ocean heat content anomaly decreased (increased) in the eastern (western) equatorial Pacific following the passage of upwelling oceanic Kelvin waves.
- Easterly wind anomalies dominated in the western equatorial Pacific in Nov-Dec, which probably forced the upwelling oceanic Kelvin waves.
- Westerly wind anomalies emerged in the far western eq. Pacific in Jan, which would likely force downwelling oceanic Kelvin waves that will propagate across the eq. Pacific in next 2 months.

Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2 $^{\circ}\text{S}$ -2 $^{\circ}\text{N}$ and Outgoing Long-wave Radiation (OLR, right) averaged in 5 $^{\circ}\text{S}$ -5 $^{\circ}\text{N}$. SST is derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, U850 from the NCEP CDAS. Anomalies for SST, heat content and U850/OLR are departures from the 1981-2010 base period pentad means respectively.

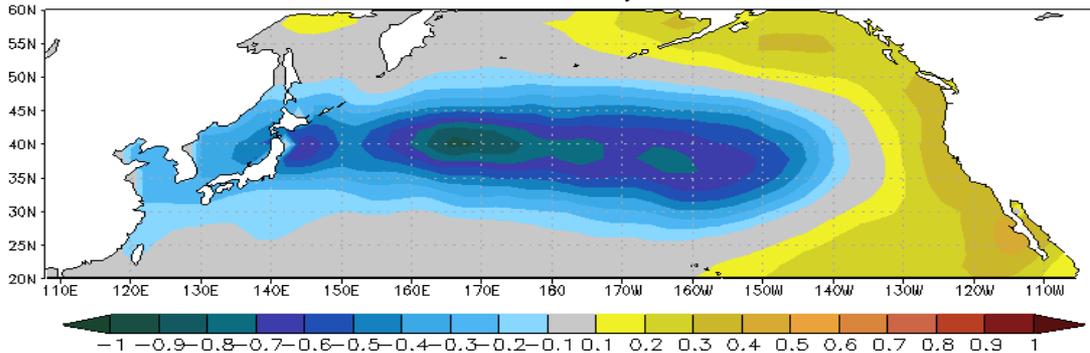
Pacific Decadal Oscillation Index



- Negative PDO phase since May 2010 has persisted for 45 months now, and the PDO index weakened slightly with PDO index = -1.0
- PDO has been in prevalent negative phase since 1999.

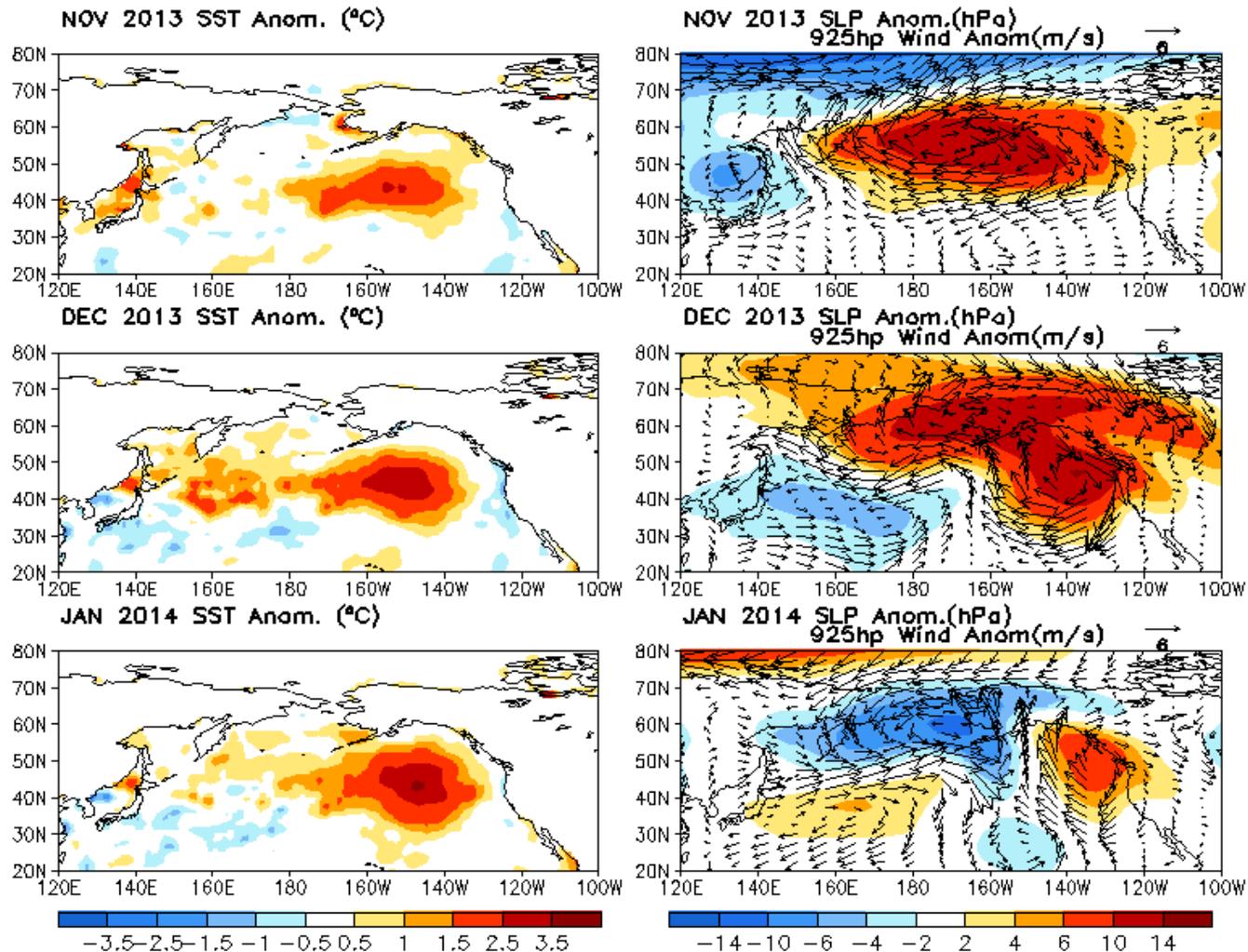


1st EOF of monthly ERSST v3b



- 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.

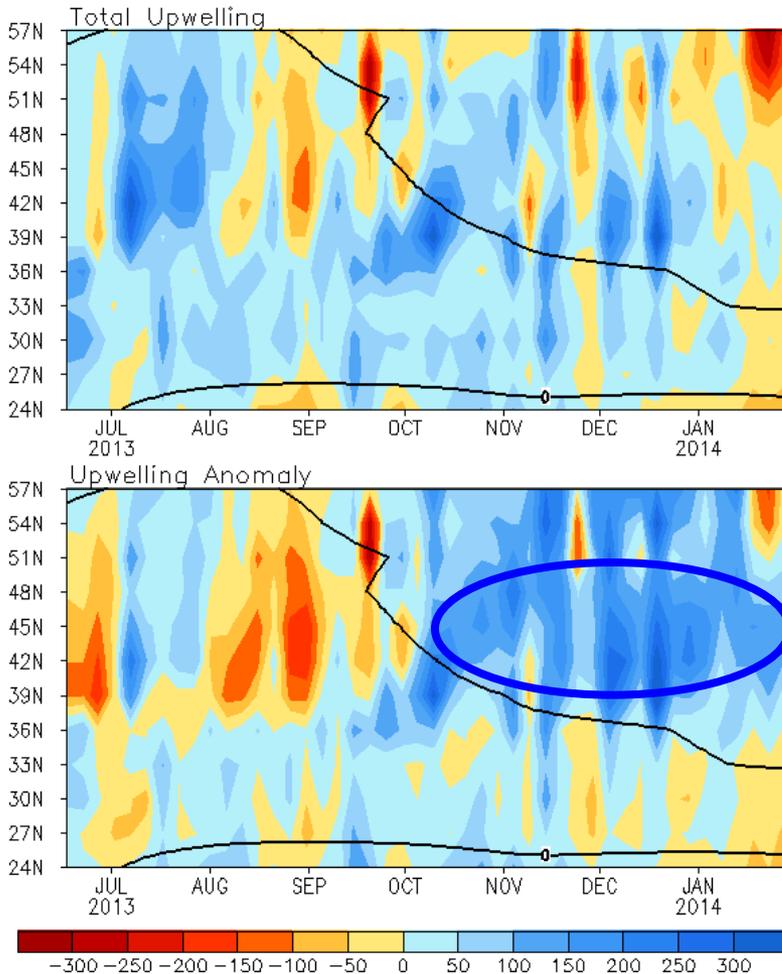
Last Three Month SST, SLP and 925hp Wind Anom.



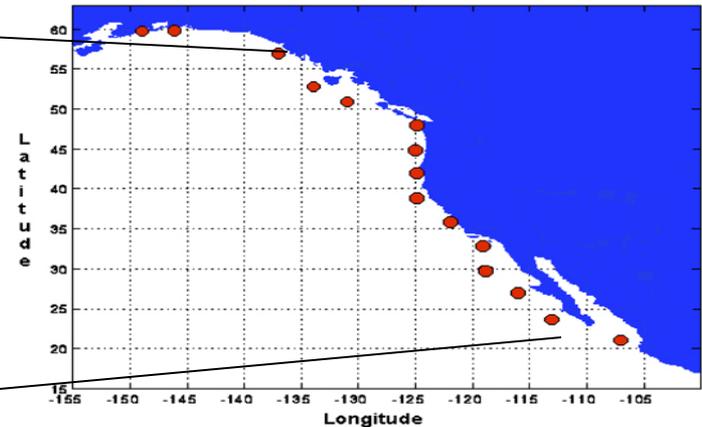
- Positive SSTA in the western N. Pacific shifted eastward slightly and reached +4°C in Jan. 2014.
- Anomalous anti-cyclone was observed near the coast of Pacific Northwest, favoring for upwelling.

North America Western Coastal Upwelling

Pentad Coastal Upwelling for West Coast North America
(m³/s/100m coastline)



Standard Positions of Upwelling Index Calculations



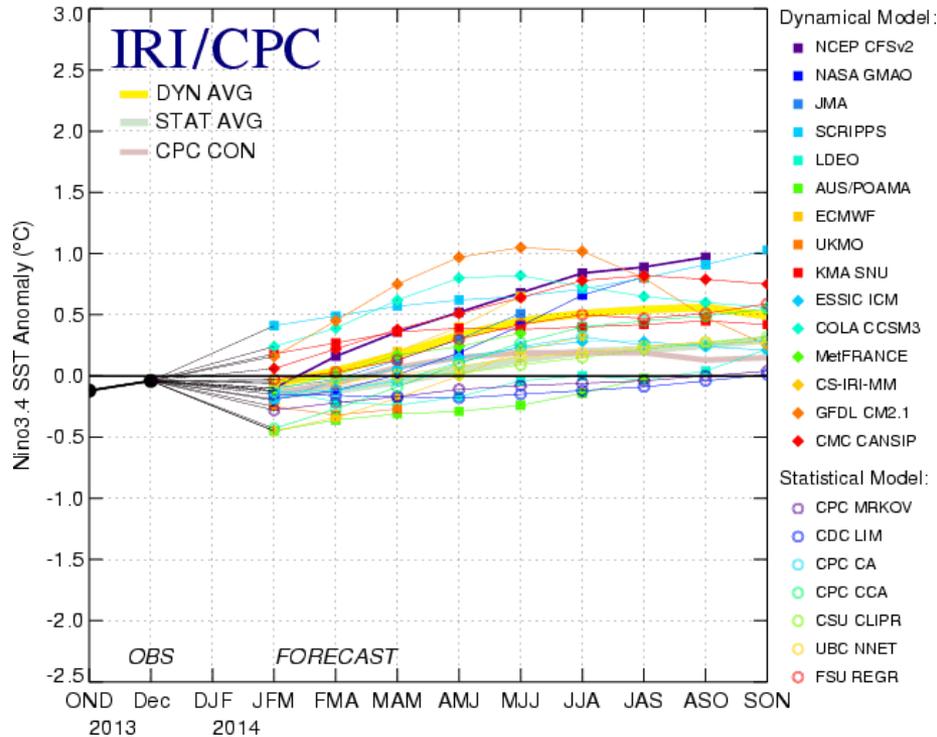
- Downwelling in mid-high latitudes has been persistently suppressed since Oct 2013.

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.

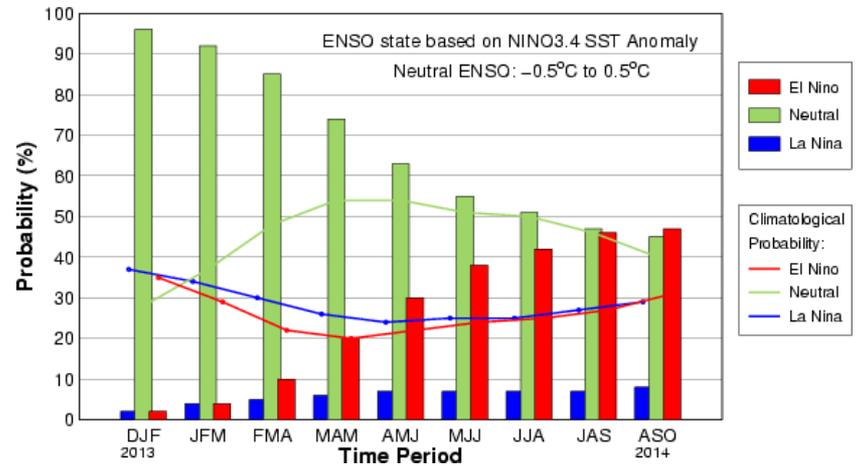
- Area below (above) black line indicates climatological upwelling (downwelling) season.
- Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.

IRI /CPC NINO3.4 Forecast Plume

Mid-Jan 2014 Plume of Model ENSO Predictions



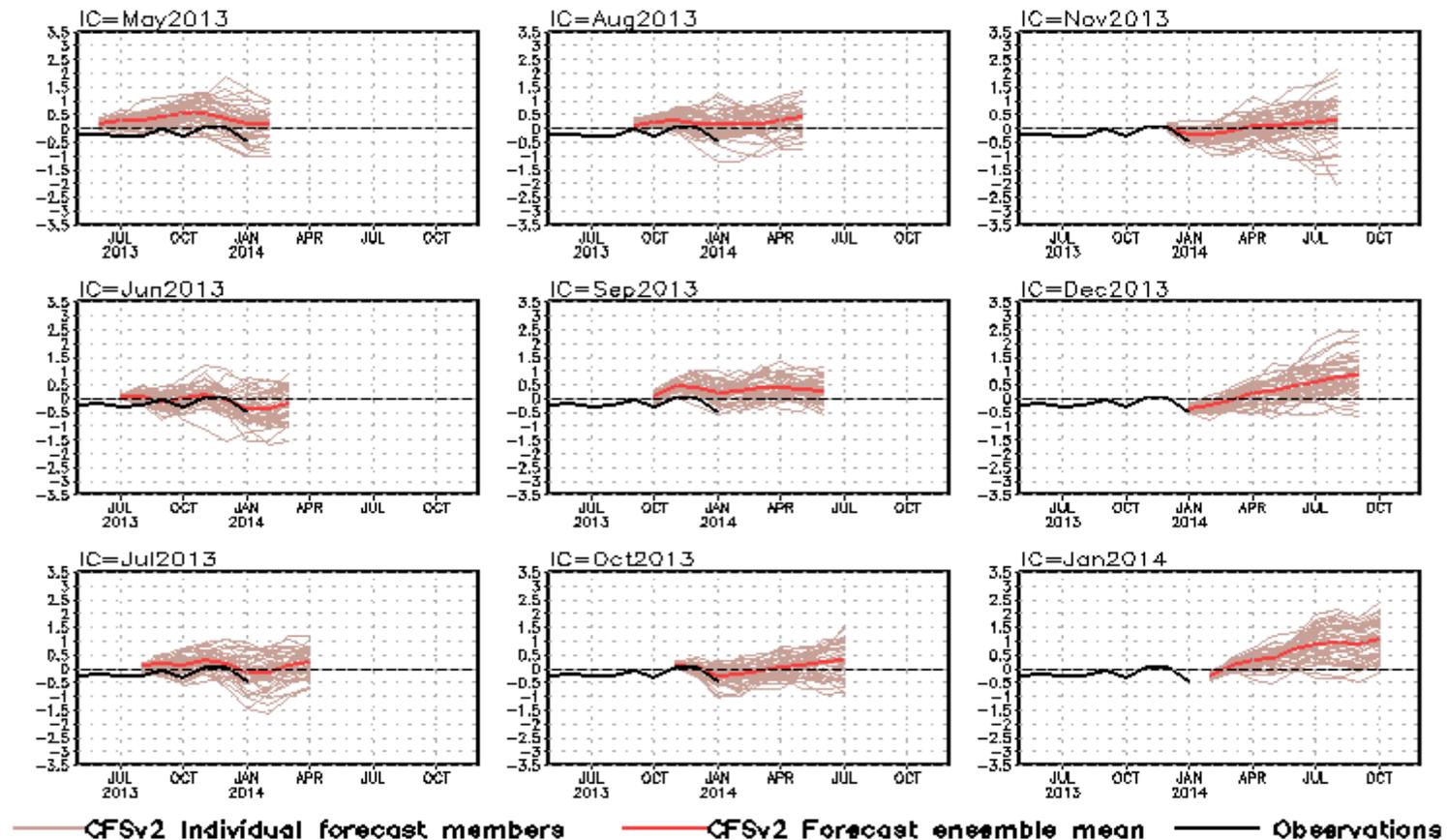
Early-Jan CPC/IRI Consensus Probabilistic ENSO Forecast



- Most of the models predicted ENSO-neutral to continue into the Northern Hemisphere spring, but some models suggest El Nino will emerge during summer.
- The consensus forecast favors ENSO-neutral conditions in spring, and the probability for ENSO-neutral and El Nino is equal in summer.

NCEP CFSv2 NINO3.4 Forecast

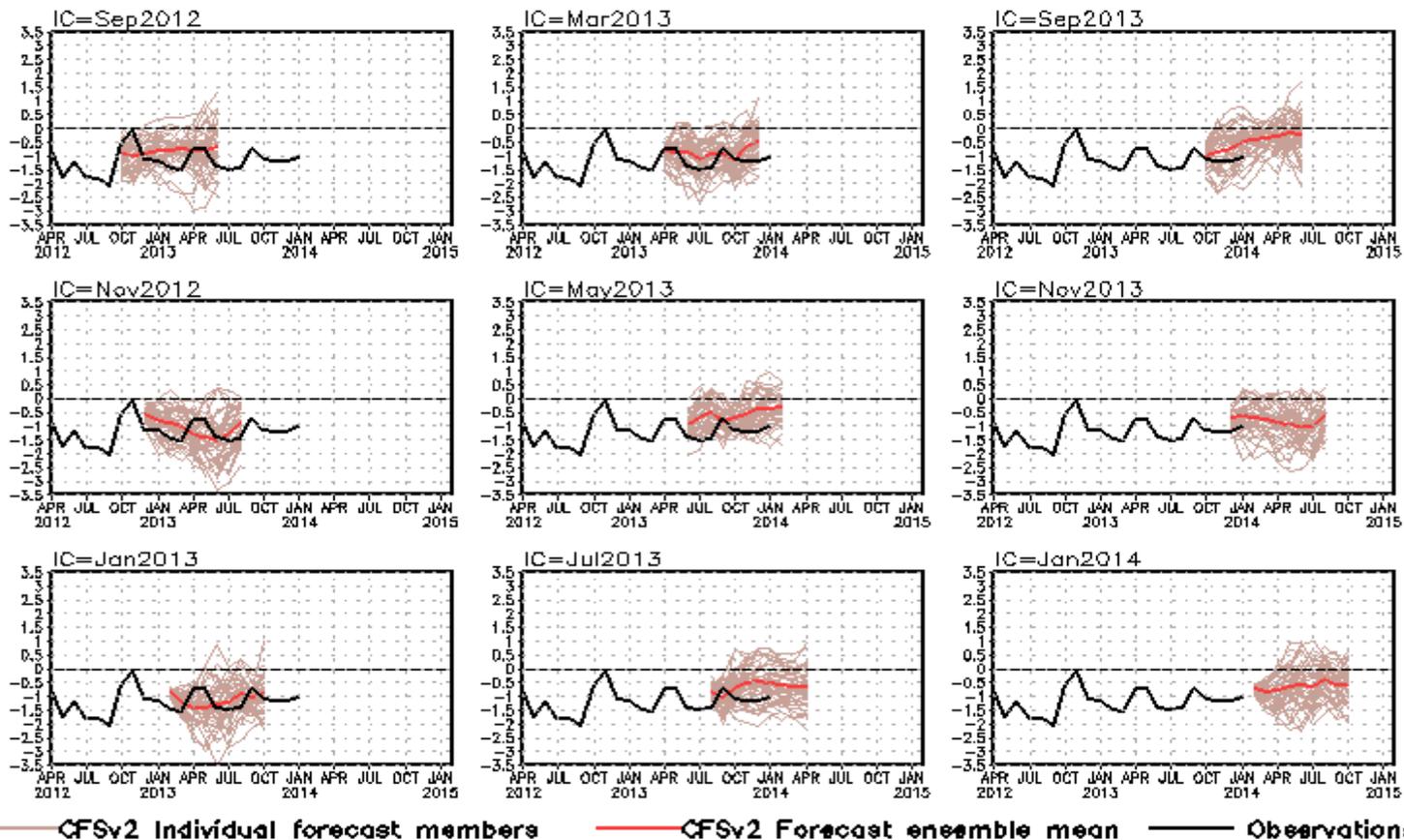
NINO3.4 SST anomalies (K)



- Latest CFSv2 prediction suggests El Nino conditions will emerge in summer 2014.

NCEP CFSv2 Pacific Decadal Oscillation (PDO) Forecast

standardized PDO index



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.

- Latest CFSv2 prediction suggests weak negative PDO phase will be likely in the coming spring and summer.

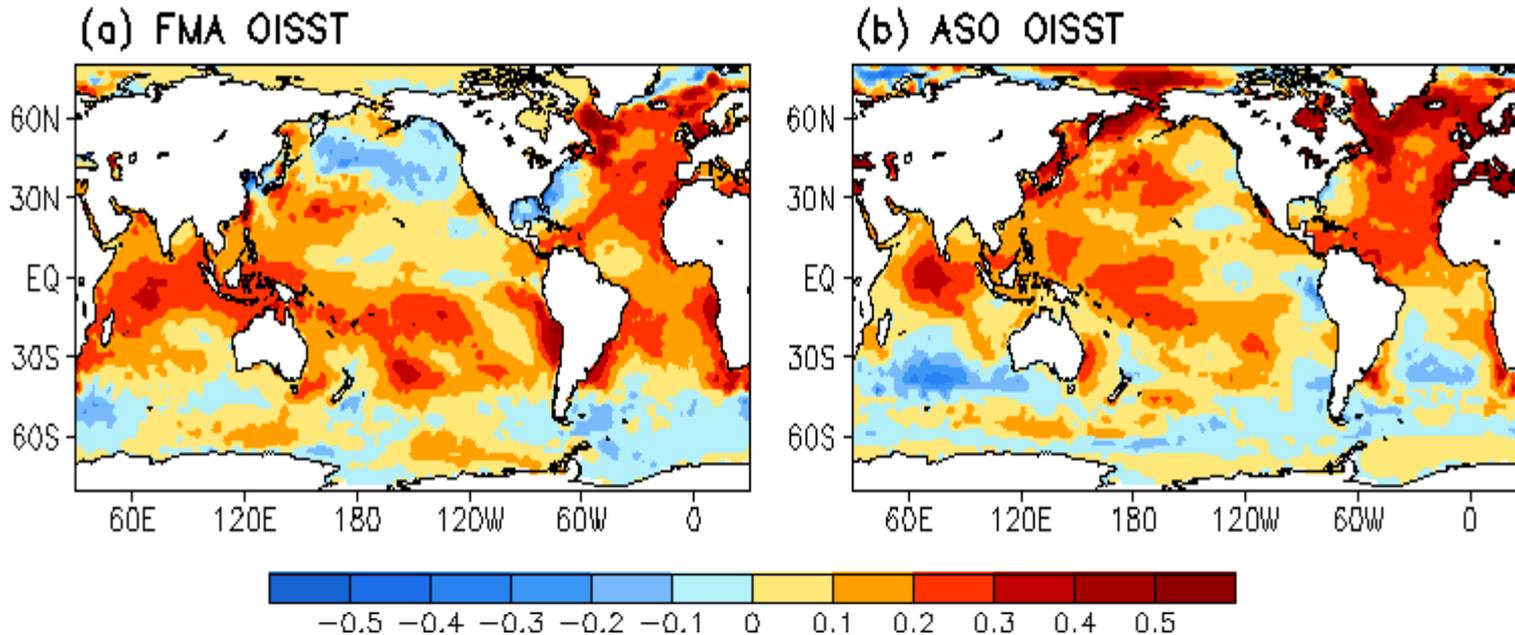
Backup Slides

Switch to 1981-2010 Climatology

- **SST from 1971-2000 to 1981-2010**
 - Weekly **OISST.v2**, monthly ERSST.3b
- **Atmospheric fields from 1979-1995 to 1981-2010**
 - NCEP CDAS **winds**, sea level pressure, 200mb velocity potential, surface shortwave and longwave radiation, surface latent and sensible fluxes, relative humidity
 - Outgoing Long-wave Radiation
- **Oceanic fields from 1982-2004 to 1981-2010**
 - GODAS temperature, **heat content**, depth of 20°C, sea surface height, mixed layer depth, tropical cyclone heat potential, surface currents, upwelling
- **Satellite data climatology 1993-2005 unchanged**
 - Aviso Altimetry Sea Surface Height
 - Ocean Surface Current Analyses – Realtime (OSCAR)

Be aware that new climatology (1981-2010) was applied since Jan 2011

SST Climatology Diff. ($^{\circ}\text{C}$): (1981–2010) – (1971–2000)



1971-2000 SST Climatology (Xue et al. 2003):

http://www.cpc.ncep.noaa.gov/products/predictions/30day/SSTs/sst_clim.htm

1981-2010 SST Climatology: <http://origin.cpc.ncep.noaa.gov/products/people/yxue/sstclim/>

- The seasonal mean SST in February-April (FMA) increased by more than 0.2°C over much of the Tropical Oceans and N. Atlantic, but decreased by more than 0.2°C in high-latitude N. Pacific, Gulf of Mexico and along the east coast of U.S.

- Compared to FMA, the seasonal mean SST in August-October (ASO) has a stronger warming in the tropical N. Atlantic, N. Pacific and Arctic Ocean, and a weaker cooling in Gulf of Mexico and along the east coast of U.S.

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.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!