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 Climate Observation Division (COD)

Outline

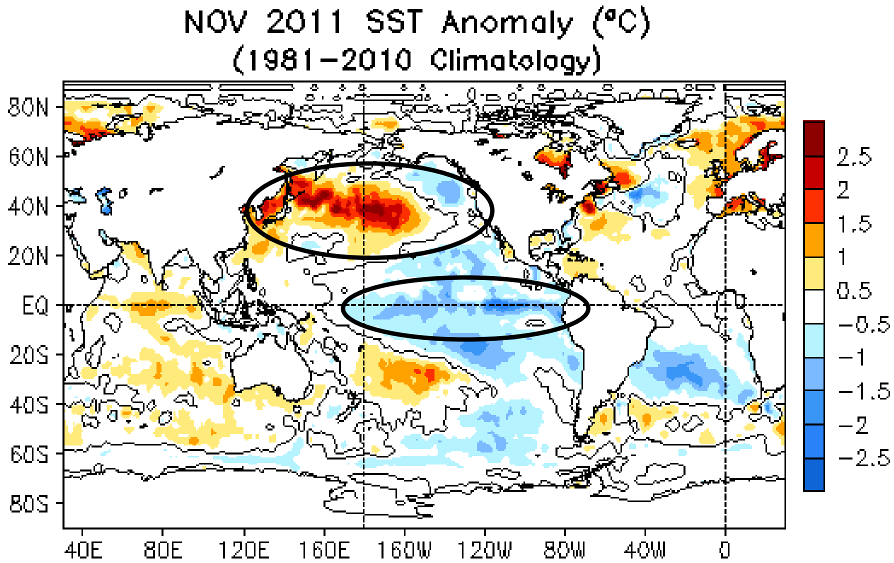
- Overview
- Recent highlights
  - Pacific/Arctic Ocean
  - Indian Ocean
  - Atlantic Ocean
- CFS SST Predictions

Overview

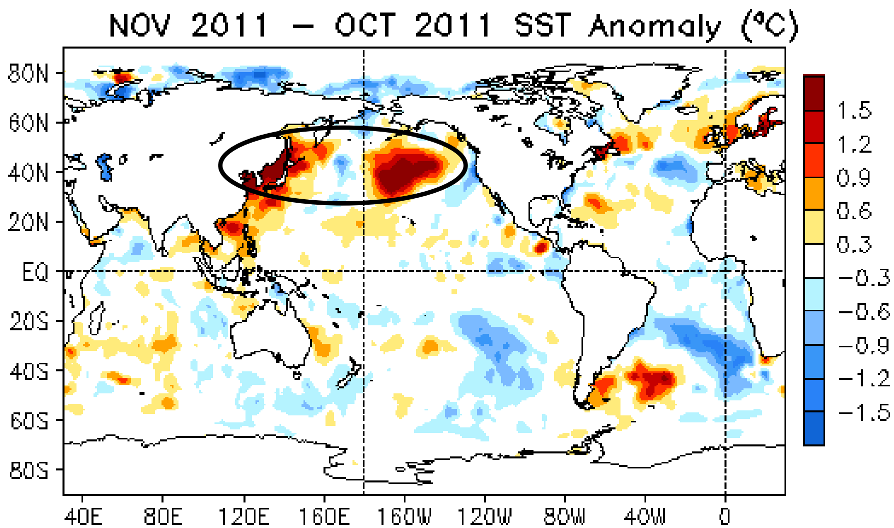
- **Pacific Ocean**
  - La Nina conditions persisted with NINO3.4=-0.97^{o}C in Nov 2011.
  - NOAA "ENSO Diagnostic Discussion" suggests weak-to-moderate strength La Niña is expected to continue through the Northern Hemisphere winter 2011-12.
  - Negative PDO enhanced, with PDOI=-2.4 in Nov 2011.
  - Both CFSv1 and CFSv2 predicted negative PDO to last through the Northern Hemisphere winter and continue into spring/summer 2012.
- **Indian Ocean**
  - Easterly wind anomalies have persisted in the east-central tropical Indian Ocean since May 2011, and weak positive IOD conditions emerged with DMI=0.56^{o}C in Aug-Oct 2011.
- **Atlantic Ocean**
  - Positive SSTA and below-normal vertical wind shear in the Atlantic Hurricane Main Development Region in JJASON 2011 are much weaker than those in JJASON 2010.
  - In JJASON 2011, similar to JJASON 2010, North Atlantic Subtropical High retreated eastward, which helps steer tropical cyclones northward and away from the land.

Global Ocean

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



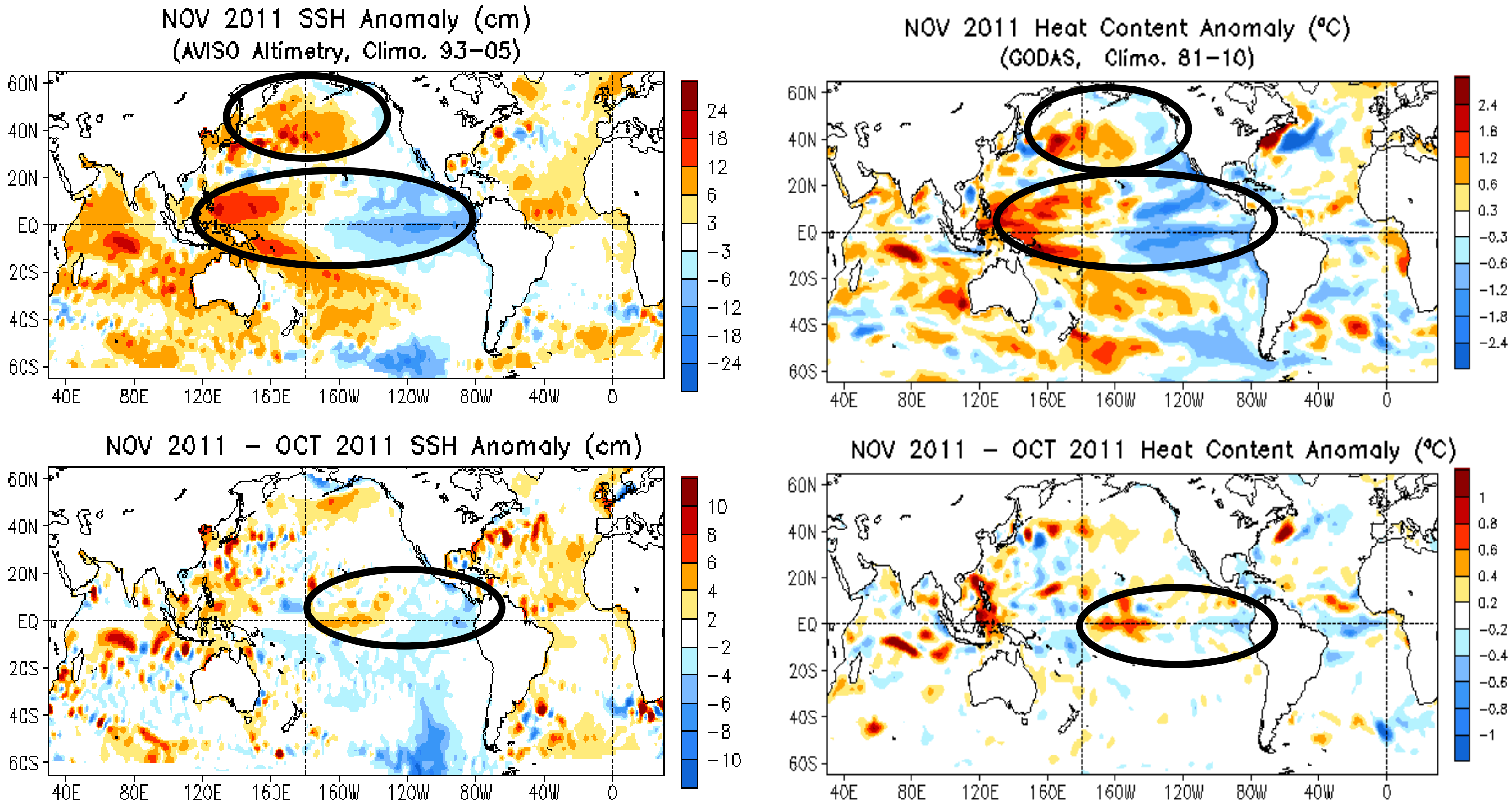
- La Nina conditions prevailed in the tropical Pacific.
- Negative PDO pattern dominated in the North Pacific.



- SST increased substantially near 160W, 40N and along the coasts of China and Japan.

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.

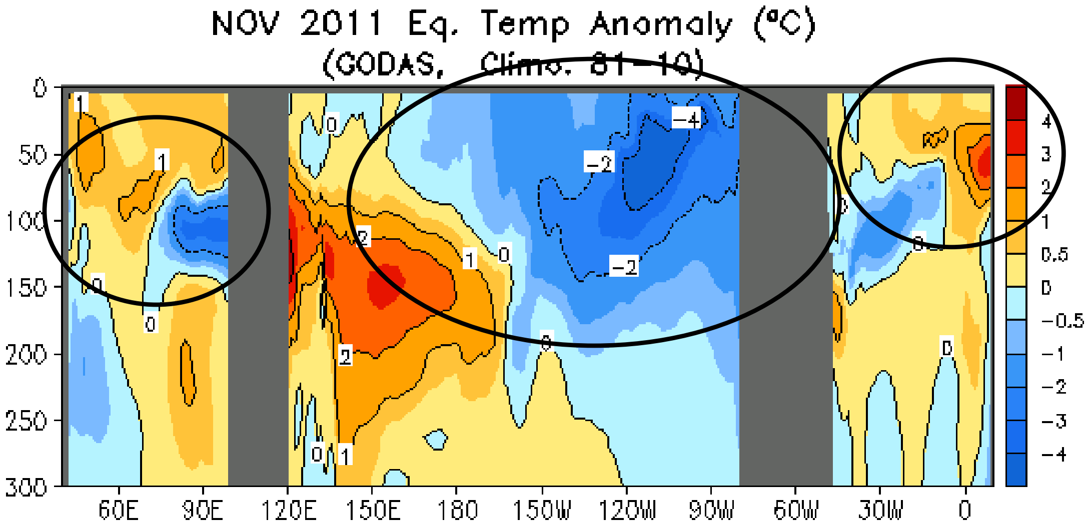
Global SSH / HC Anomaly (cm / °C) and Anomaly Tendency



- SSH and HC anomalies in the tropical Pacific resemble the mature phase of La Nina.
- SSH and HC anomalies in the North Pacific have a negative PDO pattern, consistent with that of SST anomalies.
- SSH and HC anomalies as well as their tendencies were largely consistent, except in the Southern Ocean where biases in GODAS climatology are large (not shown).

Fig. G2. Sea surface height anomalies (SSHA, top left), SSHA tendency (bottom left), top 300m heat content anomalies (HCA, top right), and HCA tendency (bottom right). SSHA are derived from http://www.aviso.oceanobs.com, and HCA from GODAS.

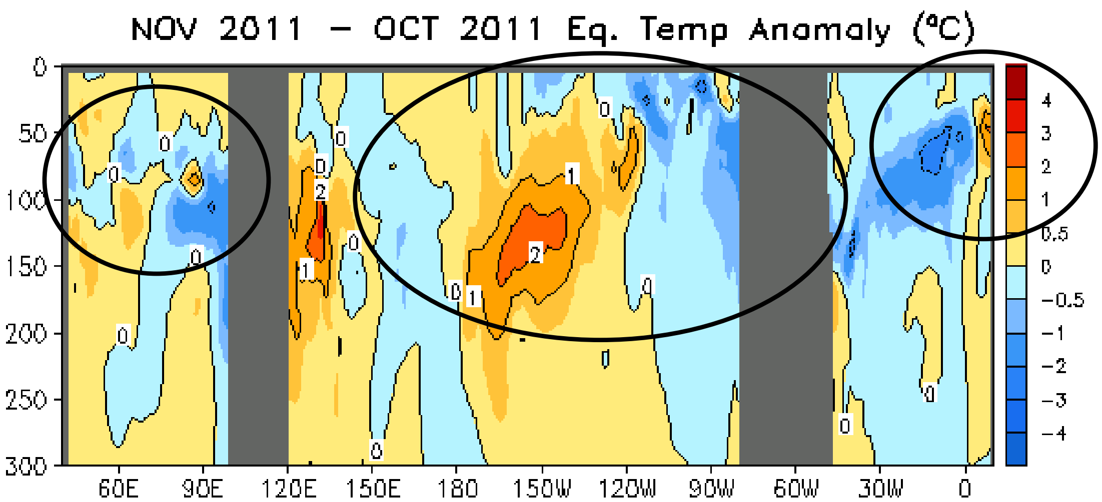
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N



- Dipole temperature anomalies, warm (cold) in the west (east), are consistent with La Nina conditions.

- Dipole temperature anomalies near depth 100m in the equatorial Indian Ocean are associated with positive IOD conditions.

- Dipole temperature anomalies were observed in the equatorial Atlantic Ocean.



- Temperature increased (decreased) in the western and central (eastern) tropical Pacific in Nov 2011.

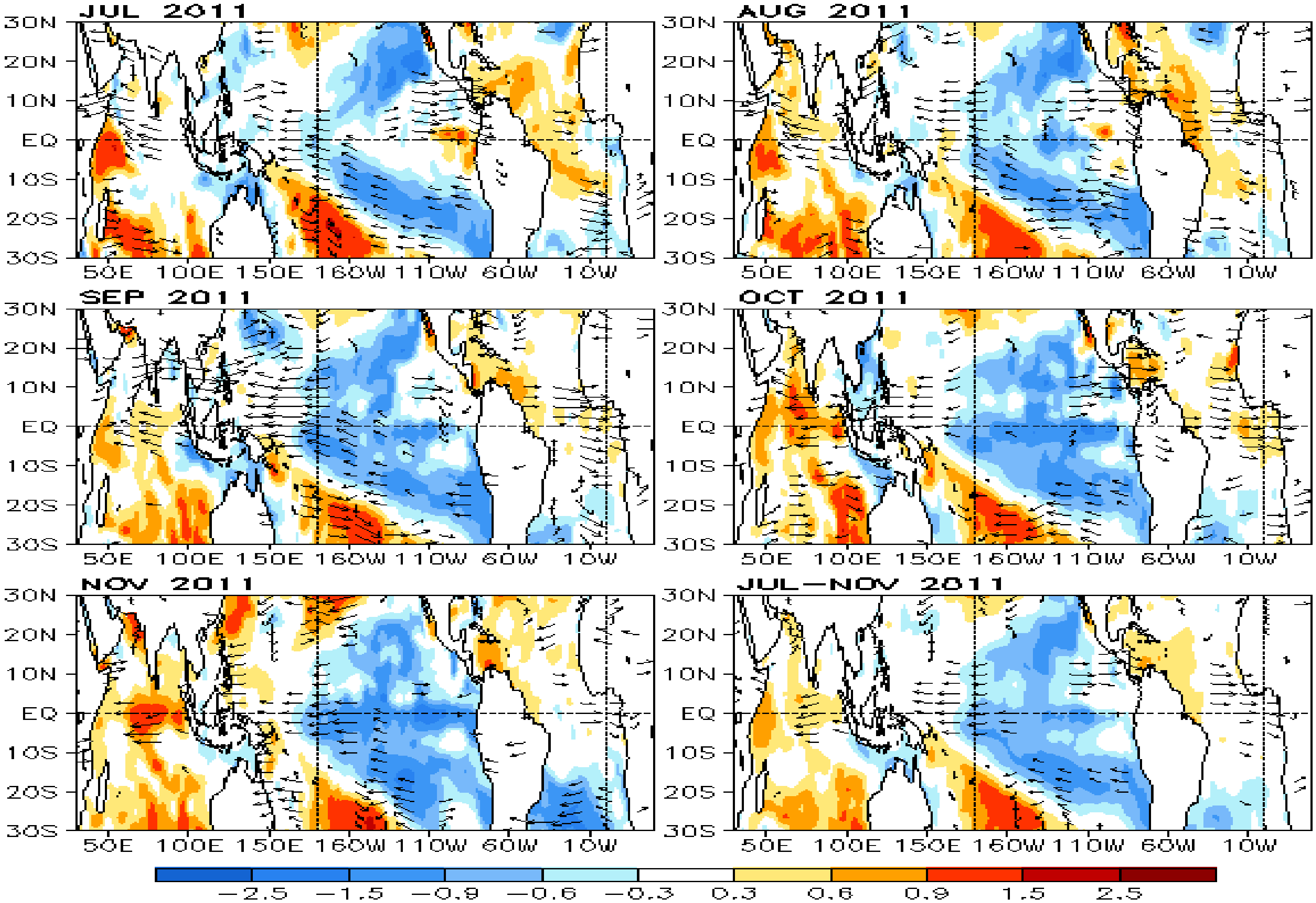
- Temperature decreased near depth 100m in the eastern equatorial Indian Ocean.

- Temperature decreased near the thermocline in the equatorial Atlantic Ocean.

Fig. G3. Equatorial depth-longitude section of ocean temperature anomalies (top) and anomaly tendency (bottom). Data are derived from the NCEP's global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM. Anomalies are departures from the 1981-2010 base period means.

Global Tropical Ocean

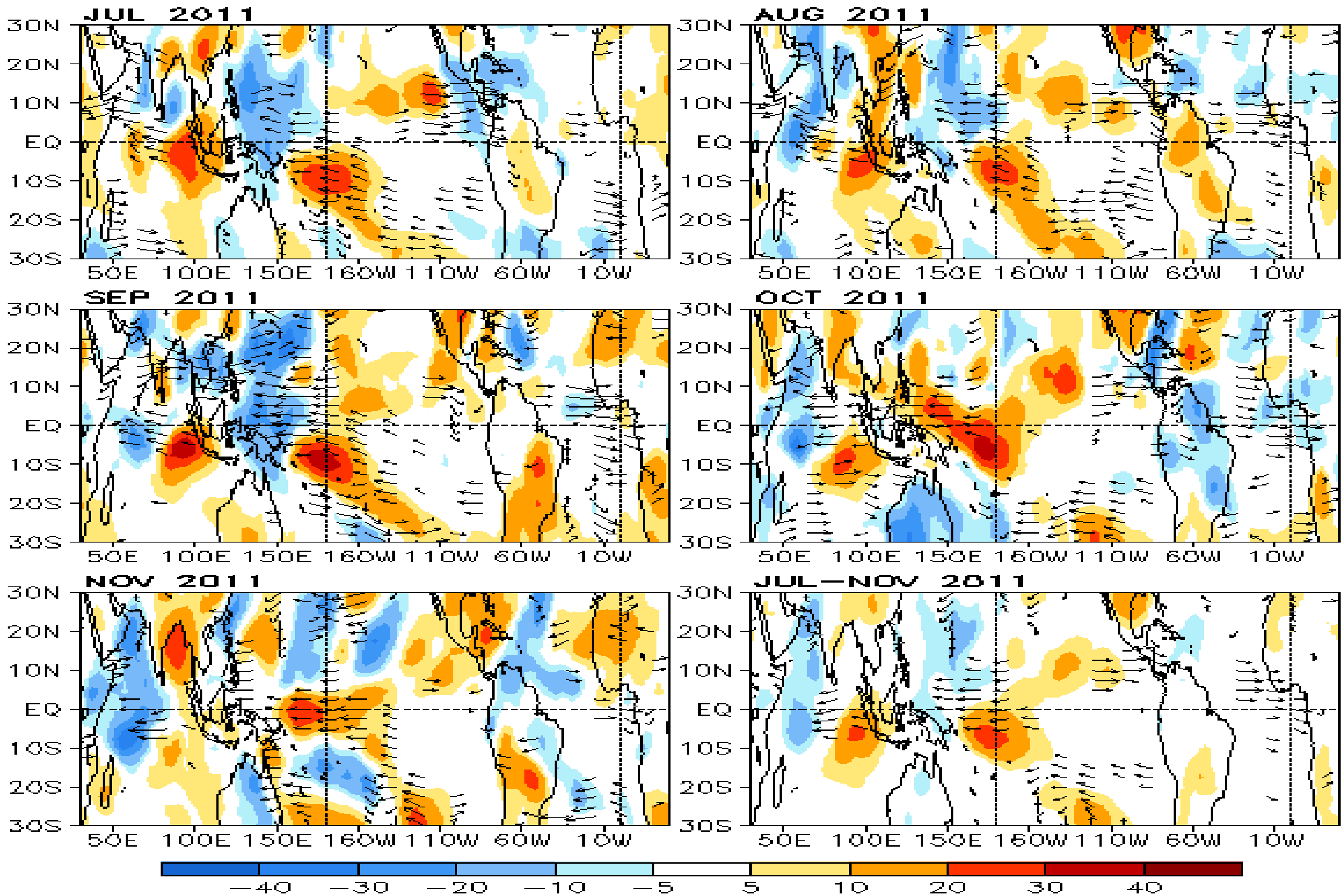
Evolution of SST and 850mb Wind Anom.



- Persistent SST anom. (SSTA): Negative SSTA in trop. Pacific, positive SSTA in trop. N. Atlantic, positive (negative) SSTA in W. and C. trop. Indian Ocean (north of Australia).

- Persistent surface wind anom.: easterly in W. and C. trop. Pacific and trop. Indian Ocean, westerly in N.E. trop. Pacific and tropical Atlantic.

Evolution of OLR and 850mb Wind Anom.

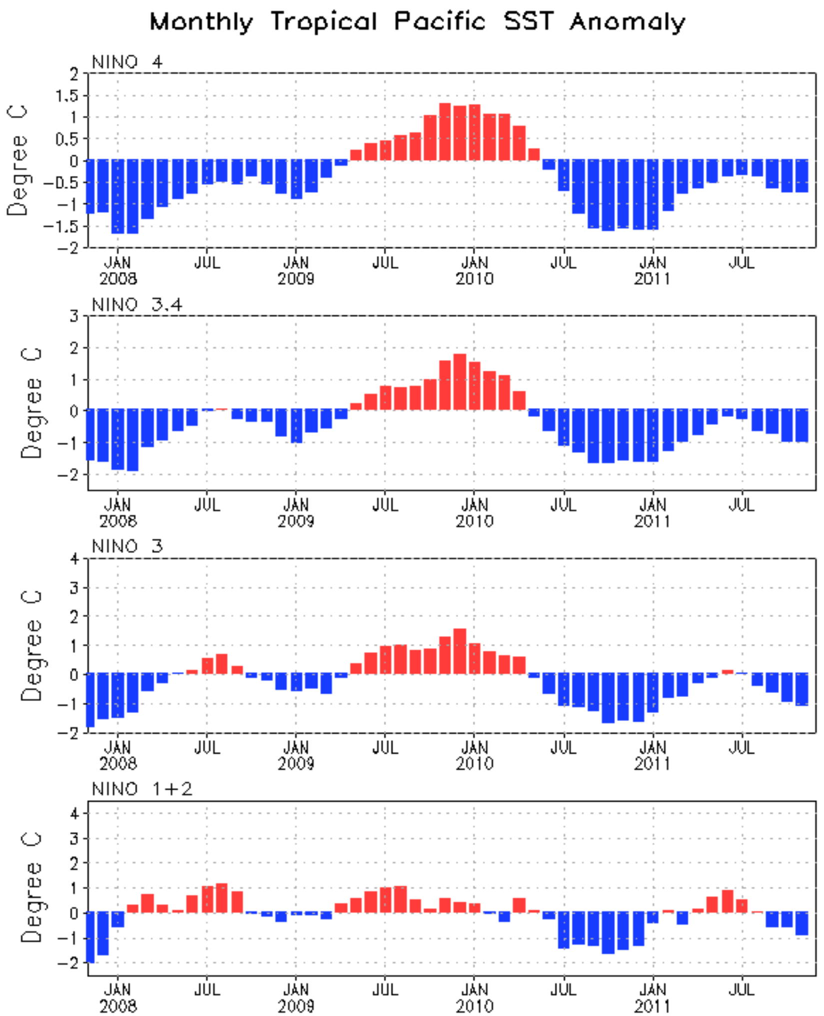


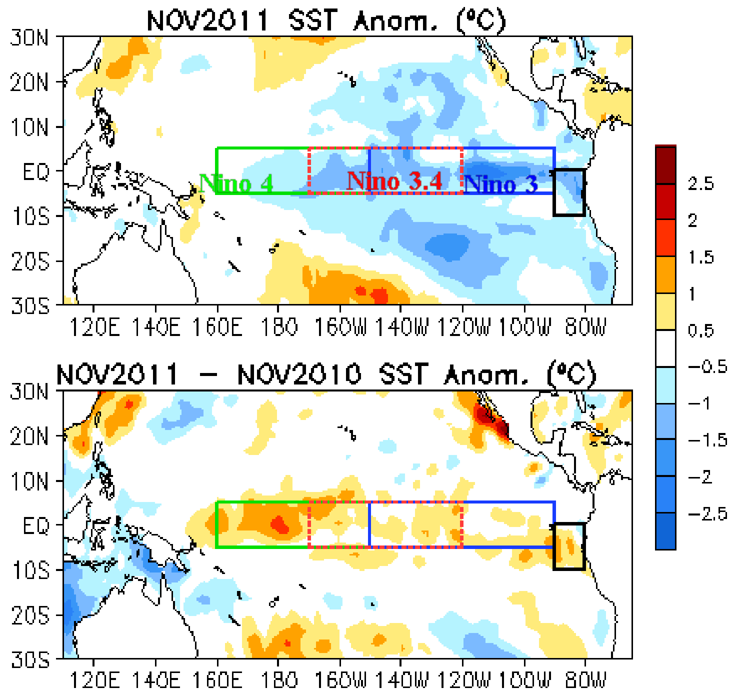
- Persistent OLR anom.: Suppressed (enhanced) convection in C. trop. Pacific and S.E. Indian Ocean (W. trop. Indian Ocean and N.W. trop. Pacific). Convection modulated by MJO activities in Oct-Nov 2011 (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml).

- Surface wind anomalies converged to (diverged from) the center of enhanced (suppressed) convection.

ENSO Conditions

Evolution of Pacific NINO SST Indices





- All NINO indices were negative and persisted.

- Nino3.4 = -0.97°C in Nov 2011.

- The indices were calculated based on OISST. They may have some differences compared with those based on ERSST.v3b.

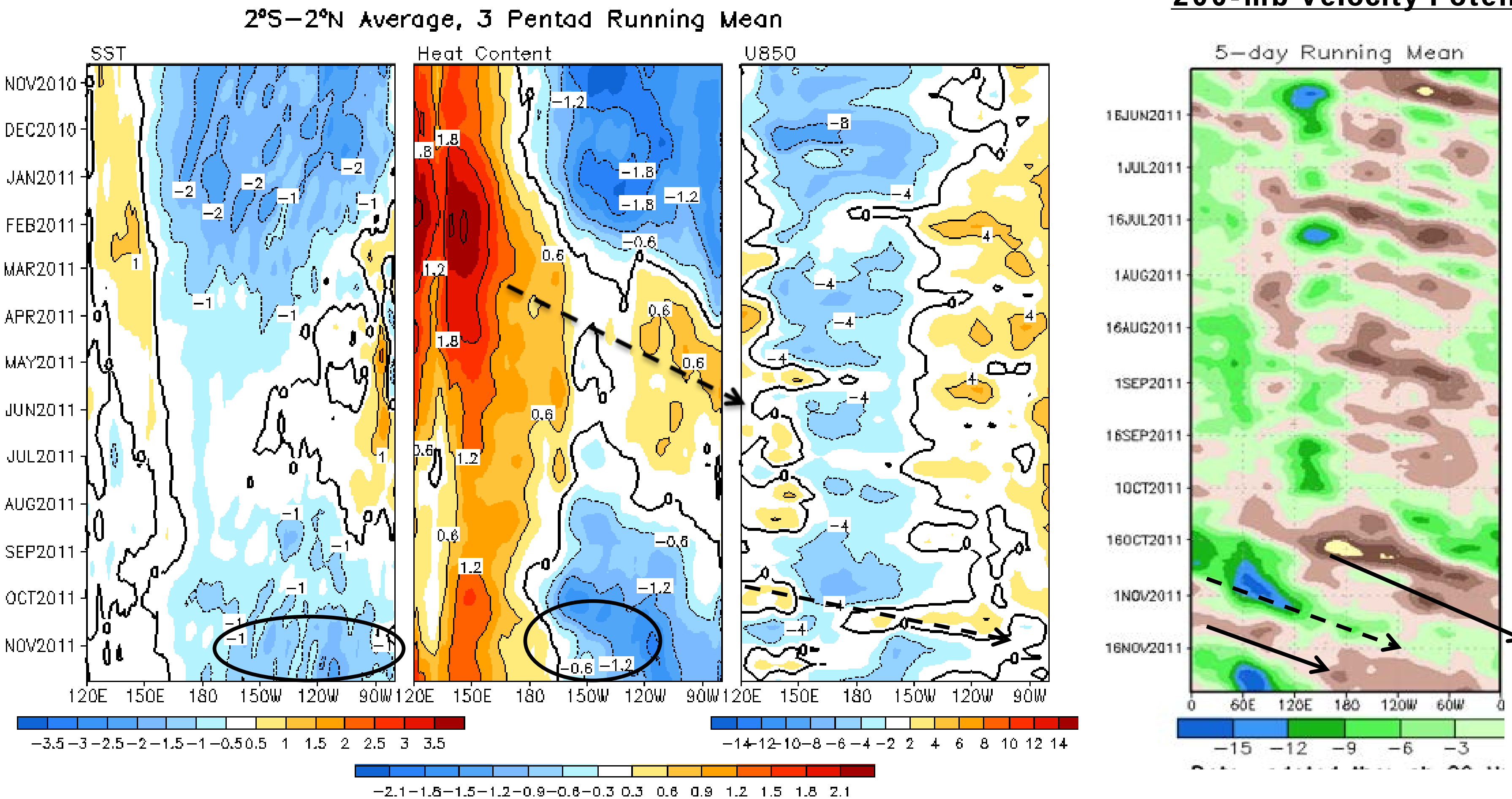
Fig. P1a. Nino region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the specified region. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1981-2010 base period means.

Evolution of Equatorial Pacific SST (°C), 0-300m

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

Heat Content (°C), 850-mb Zonal Wind (m/s) Anomaly

200-mb Velocity Potential



- Negative SST anomalies persisted in the central and eastern equatorial Pacific in Nov 2011.
- Negative HC anomalies weakened in the central Pacific in response to MJO-related westerly wind anomalies.
- 200mb velocity potential shows continuous MJO activities from early Oct to the end of Nov.

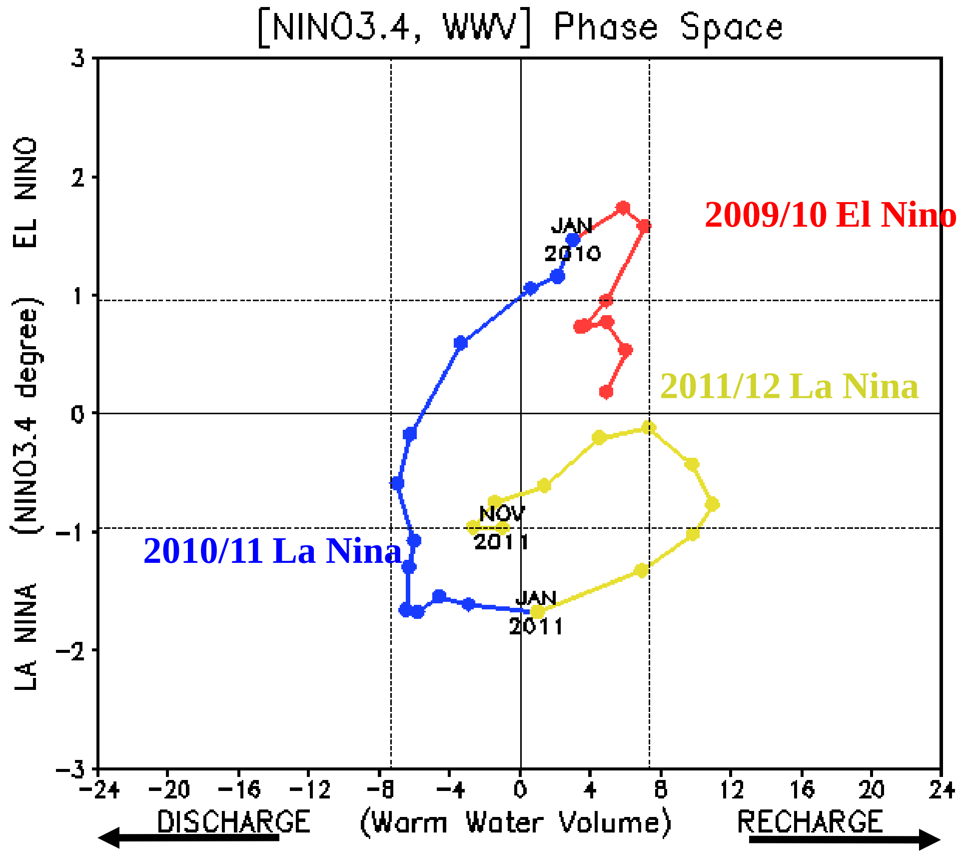
Fig. P4. Time-longitude section of anomalous pentad sea surface temperature (left), upper 300m temperature average (heat content, middle-left), 850-mb zonal wind (U850, middle-right) averaged in 2°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST is derived from the NCEP OI 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.

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).

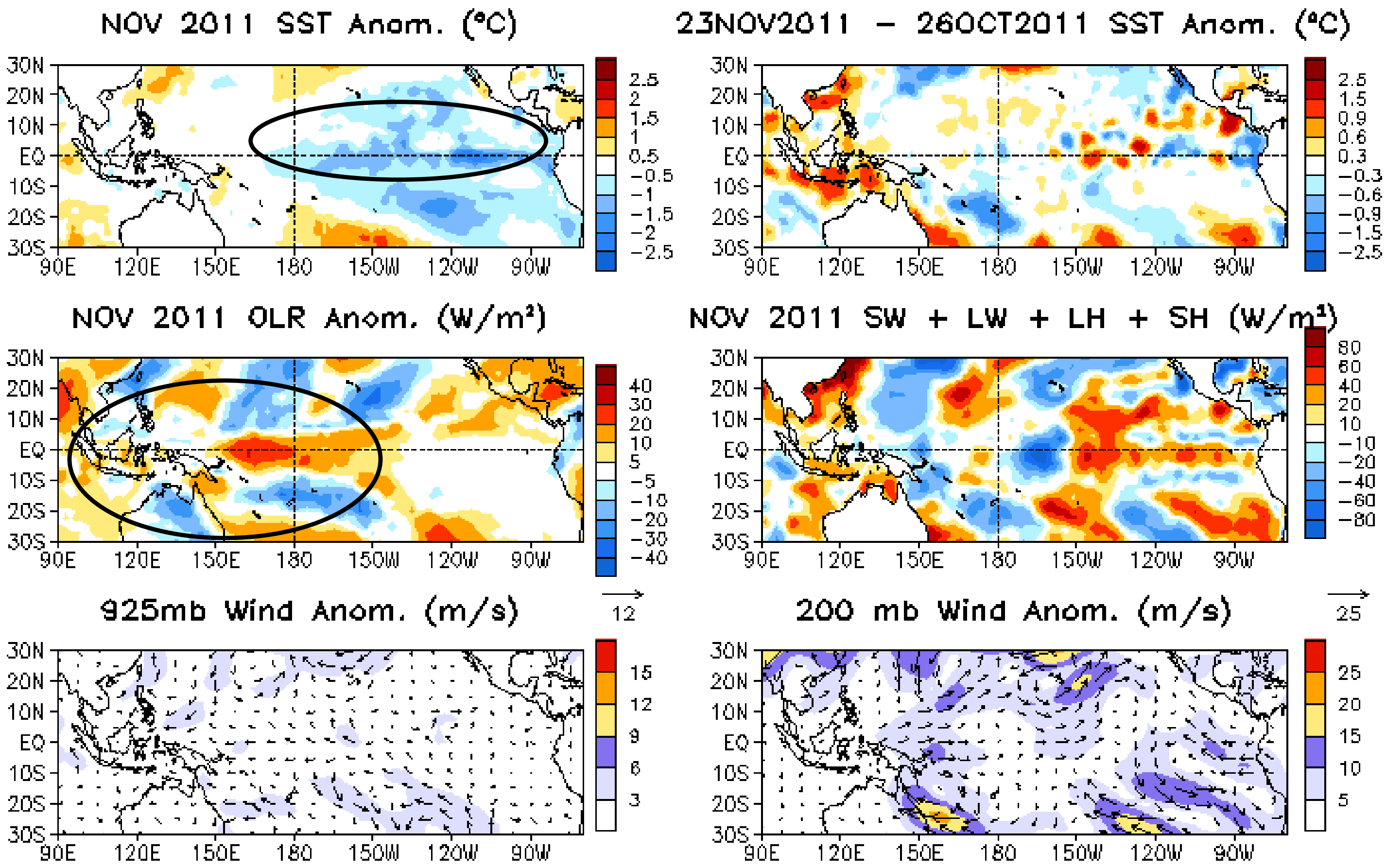
- Increase (decrease) of WWV indicates recharge (discharge) of the equatorial oceanic heat content.



- La Nina conditions (NINO3.4 < -0.5C) were established in Aug 2011.
- WWV has been decreasing since Apr 2011, reached minimum in Oct 2011, and started to increase in Nov 2011.
- NINO3.4 has been decreasing since Jun 2011, and reached minimum in Oct-Nov 2011.

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

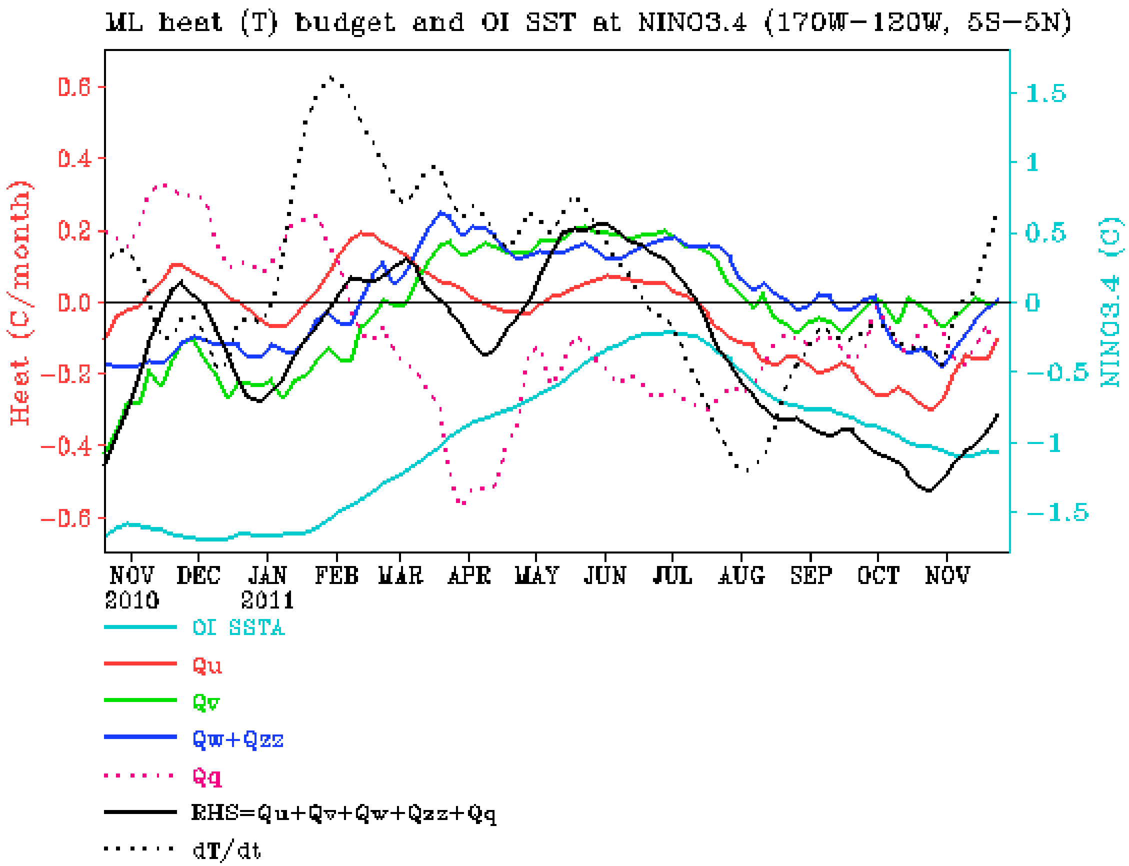
Tropical Pacific: SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb & 200-mb Winds



- Negative SSTA prevailed in the tropical Pacific.
- Convection was suppressed near the Dateline and enhanced over northern Australia.
- Low- and upper-level wind anomalies were modulated by MJO activities in Nov.

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.

NINO3.4 Heat Budget



- SSTA tendency (dT/dt) in NINO 3.4 (dotted line) increased rapidly, and switched from negative to positive in Nov, indicating weakening of La Nina conditions.

- Qu and Qw+Qzz, zonal advection and vertical entrainment/diffusion, were the dominant cooling terms with the former leading the latter by two months.

- Both Qu and Qw+Qzz reached minimum in late Oct and started to increase rapidly and reached near zero by the end of Nov.

- The total heat budget term (RHS) has large cold biases compared with the tendency (dT/dt) since early Sep 2011.

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;

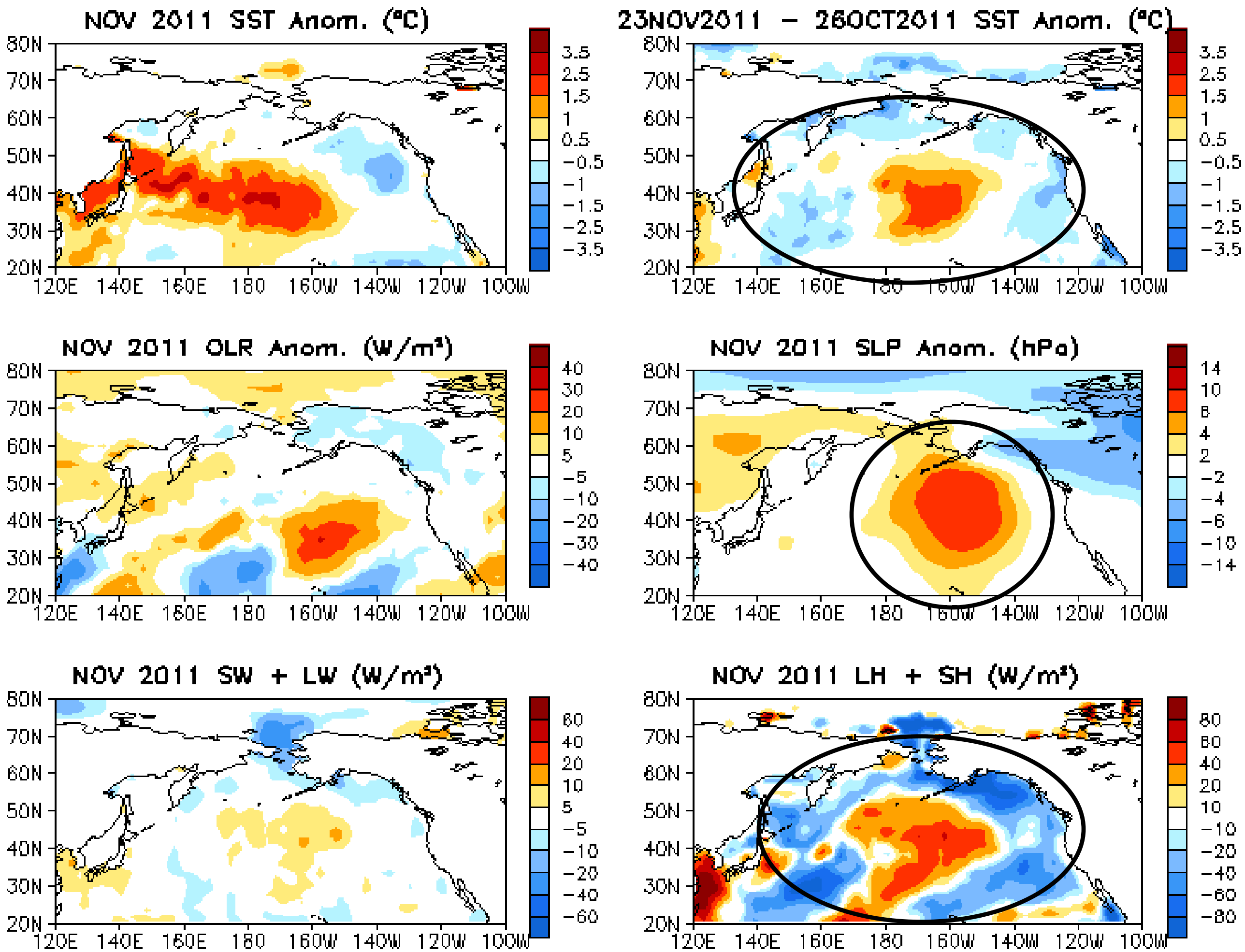
Qw: Vertical entrainment; Qzz: Vertical diffusion

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

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

North Pacific & Arctic Ocean

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



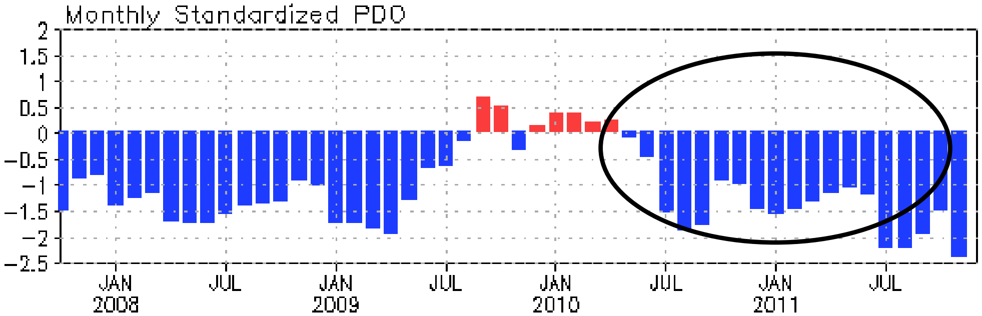
- Positive (negative) SSTA presented in the western and central (eastern) North Pacific, consistent with the negative PDO index (next slide).

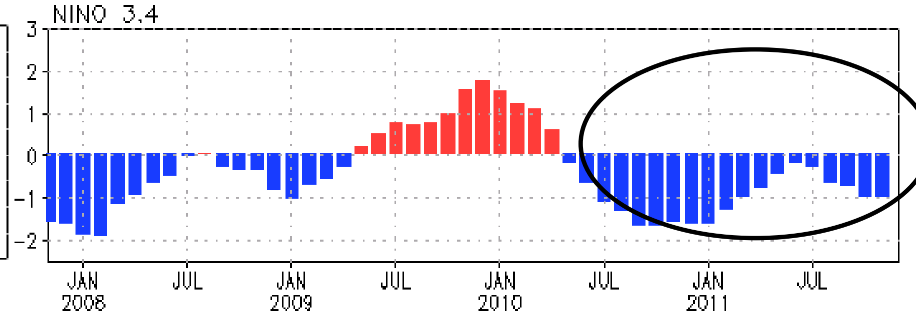
- Net surface heat flux anomalies contributed to the SST tendency in the North Pacific.

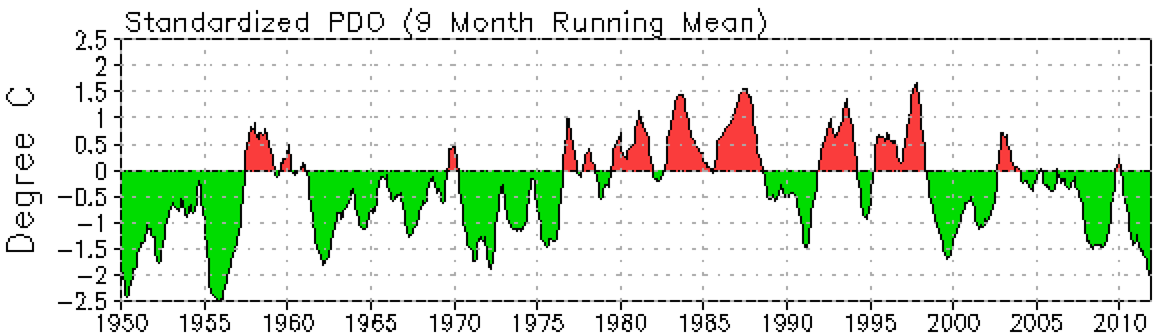
- Above-normal sea level pressure and associated northerly wind anomalies along the coast were favourable for upwelling.

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.

PDO index

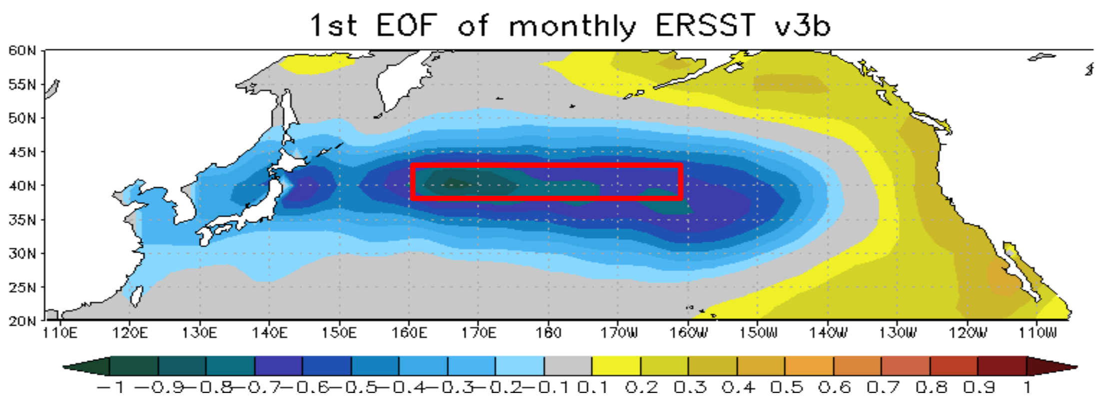






- The negative PDO index enhanced substantially in Nov with PDO =-2.4.

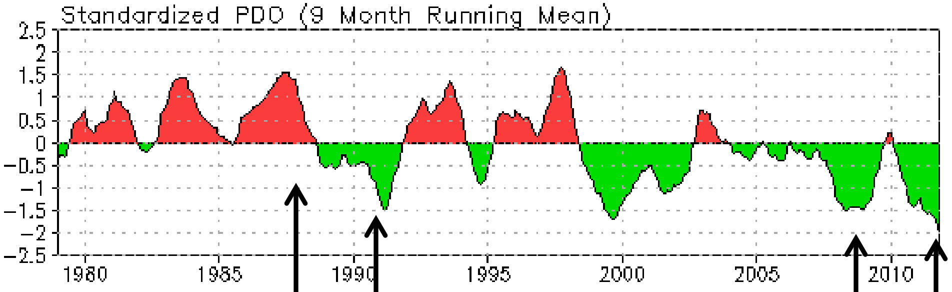
- The apparent positive correlation between NINO3.4 and PDO index suggests strong influences of the La Nina on the North Pacific SST variability through atmospheric bridge.

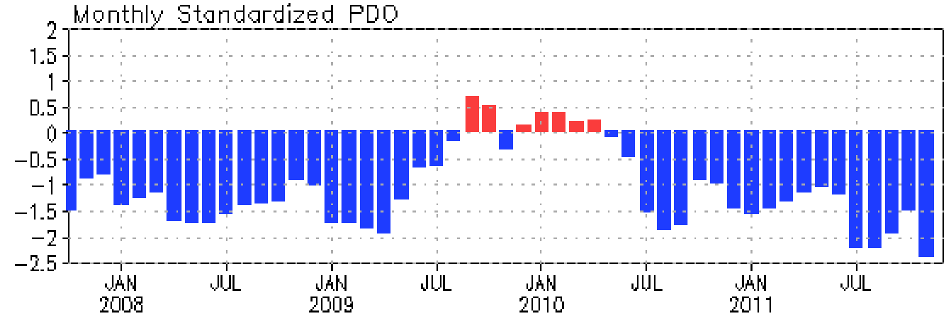


- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

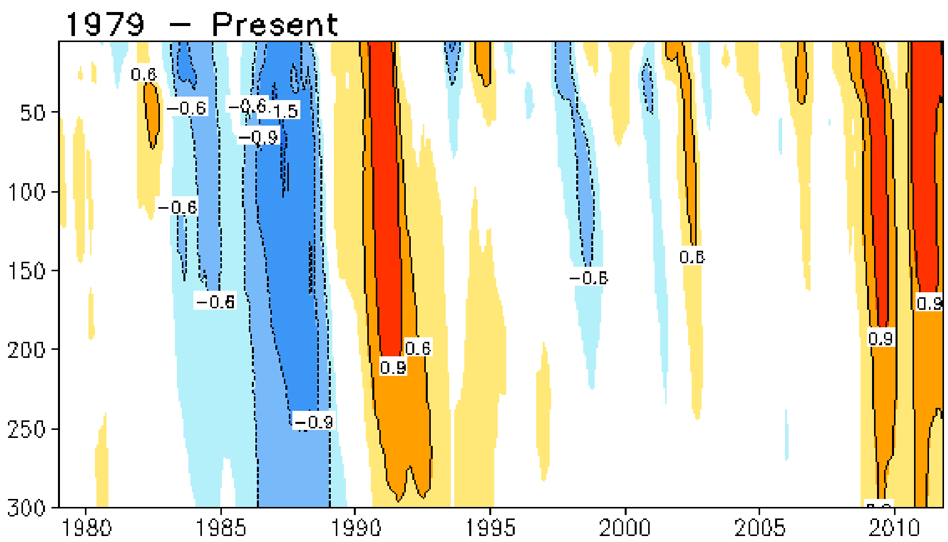
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

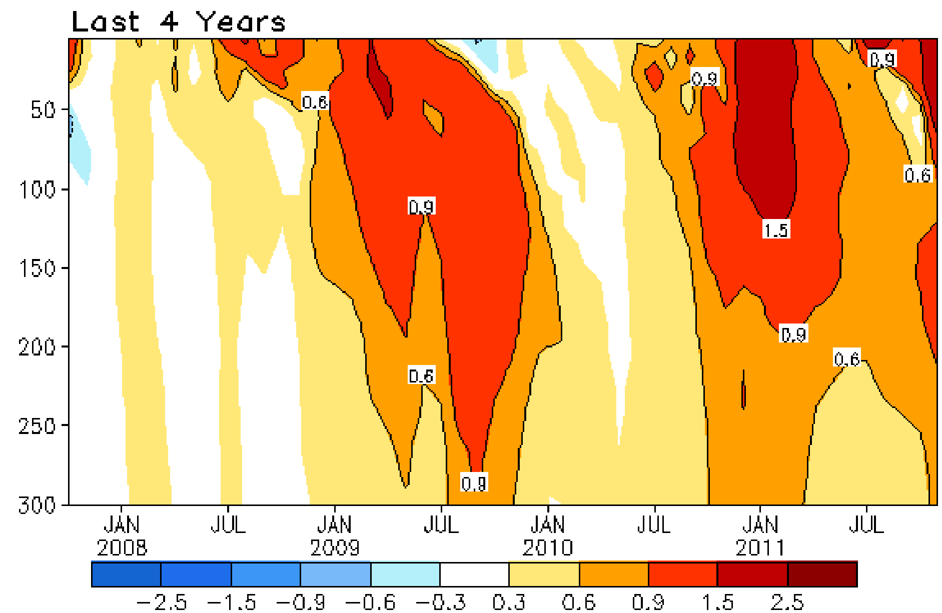
Subsurface Temperature Anom. in Central North Pacific





Central North Pacific Temp. Anomaly
Average in [160E−160W, 38N−42N] (°C)





- PDO has strong signature of subsurface temperature anomalies that can penetrate to below 300m.
- Deep ocean warming in the central N. Pacific (160E-160W, 38N-42N) was particularly strong during the negative phases of PDO in 2009, 2010 and 2011.
- Positive temperature anomalies more than 0.9C penetrated to 200m depth, indicating strong vertical mixing in Nov 2011.

Seasonal Re-emergence of Temperature Anomaly

PDO=-1.7 NINO3.4=-1.0

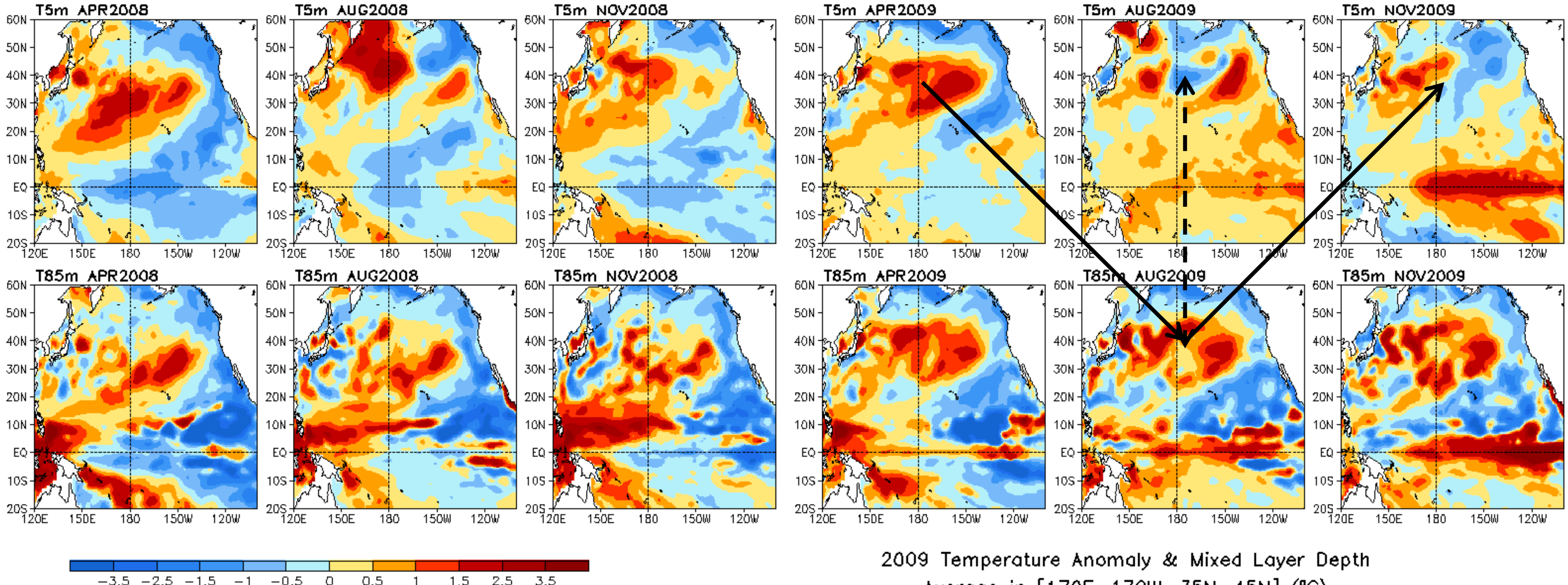
PDO=-1.4 NINO3.4=+0.0

PDO=-0.9 NINO3.4=-0.4

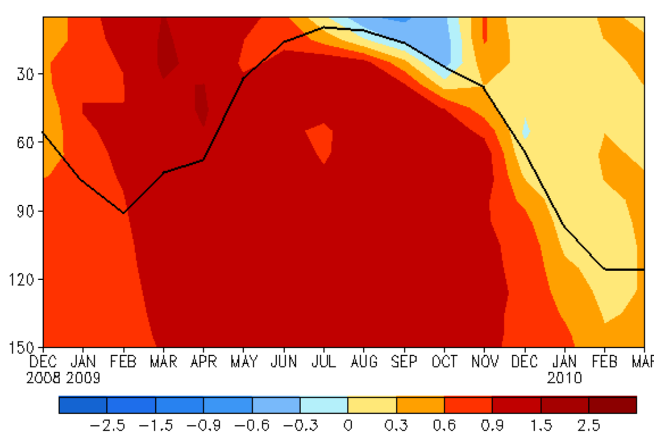
PDO=-2.0 NINO3.4=-0.3

PDO=-0.2 NINO3.4=+0.7

PDO=-0.3 NINO3.4=+1.5



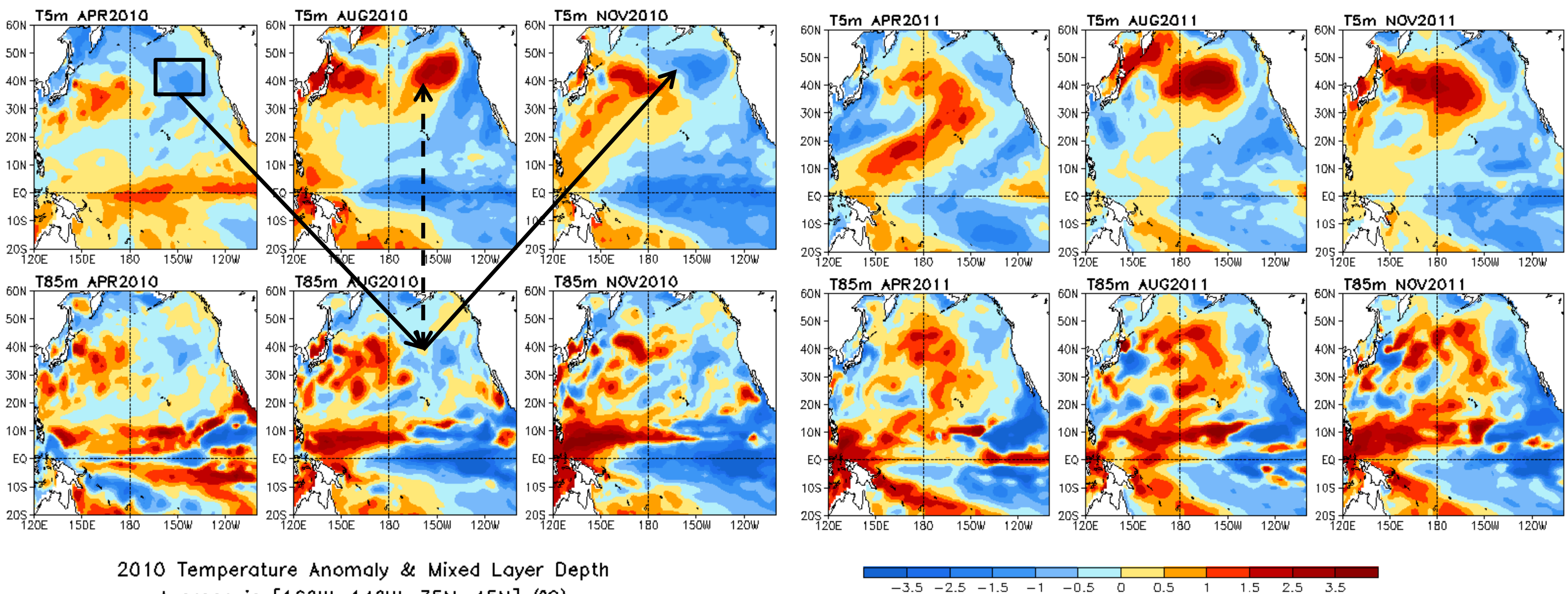
2009 Temperature Anomaly & Mixed Layer Depth
Average in [170E−170W, 35N−45N] (°C)

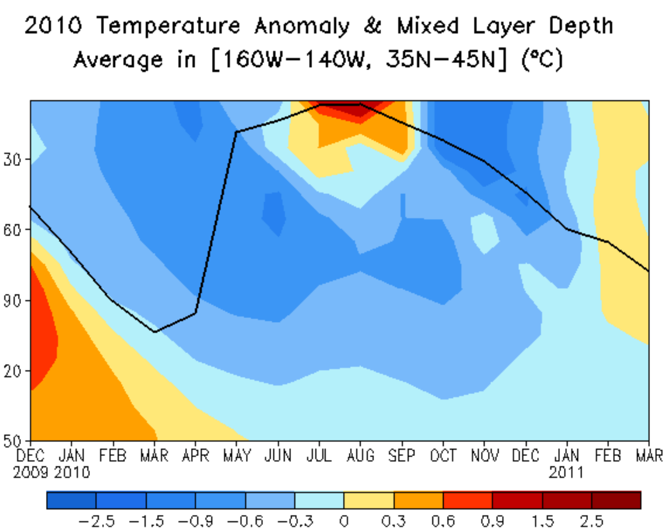


- **In 2008, temperature anomalies at depth 5m and 85m were largely consistent, indicating seasonal re-emergence mechanism was not very important.**
- **In 2009, seasonal re-emergency mechanism was evident near 180W, 40N as discussed by Alexander et al. (1999).**

Seasonal Re-emergence of Temperature Anomaly

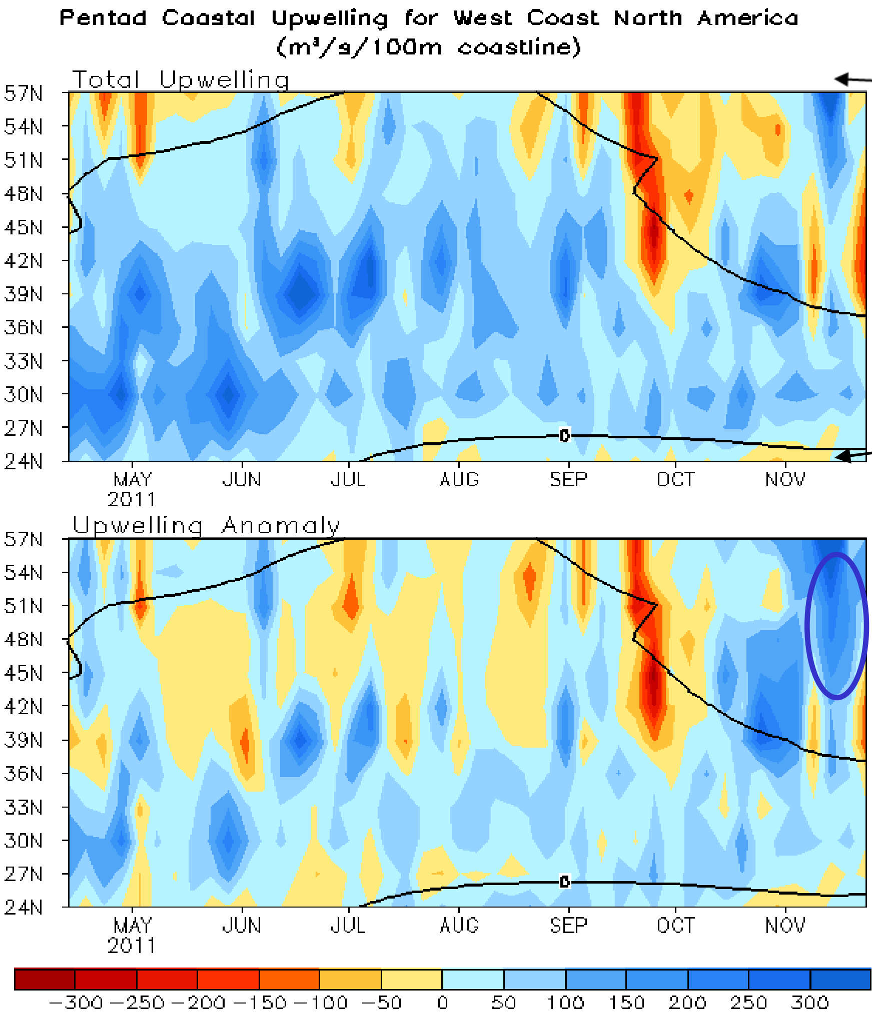
PDO=+0.2	PDO=-1.9	PDO=-1.0	PDO=-1.2	PDO=-2.2	PDO=-2.4
NINO3.4=+0.6	NINO3.4=-1.3	NINO3.4=-1.6	NINO3.4=-0.8	NINO3.4=-0.6	NINO3.4=-1.0

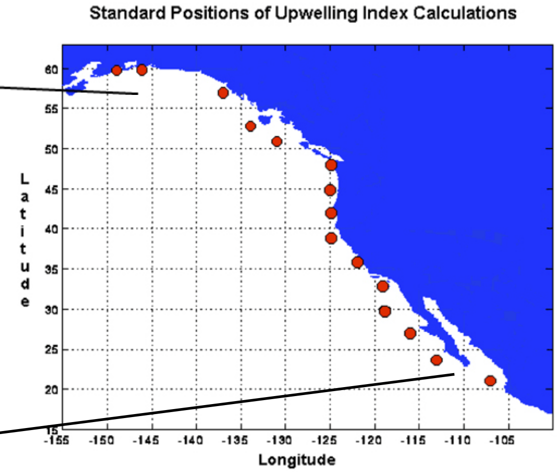




- In 2010, seasonal re-emergency mechanism was evident near 150W, 40N as that discussed by Alexander et al. (1999).
- In 2011, temperature anomalies at depth 5m and 85m were largely consistent , indicating seasonal re-emergence mechanism was not very important.
- La Nino conditions (NINO3.4 < -0.5) were largely in phase with negative PDOs.

North America Western Coastal Upwelling





- Seasonal downwelling north of 42N was weaker than climatology in Nov 2011.

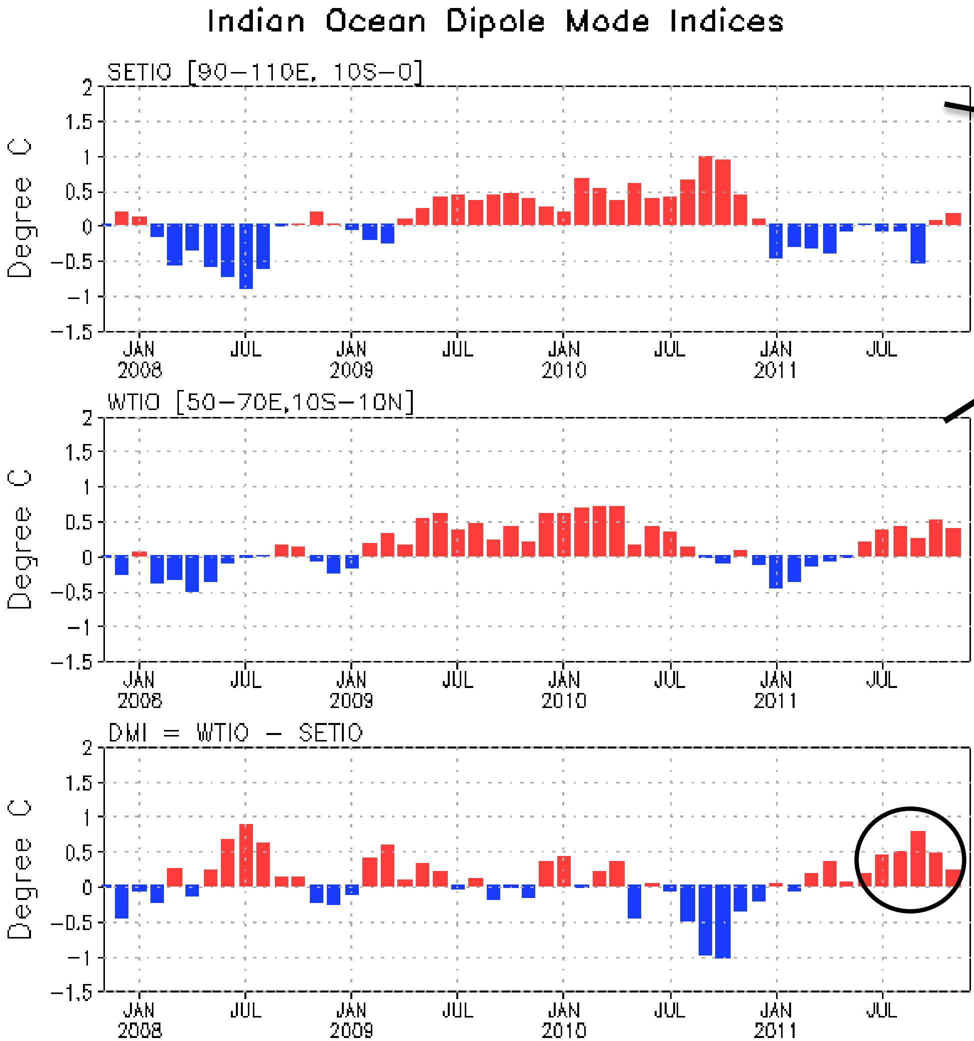
Fig. NP2. Total (top) and anomalous (bottom) upwelling indices at the 15 standard locations for the western coast of North America. Upwelling indices are derived from the vertical velocity of the NCEP's global ocean data assimilation system, and are calculated as integrated vertical volume transport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

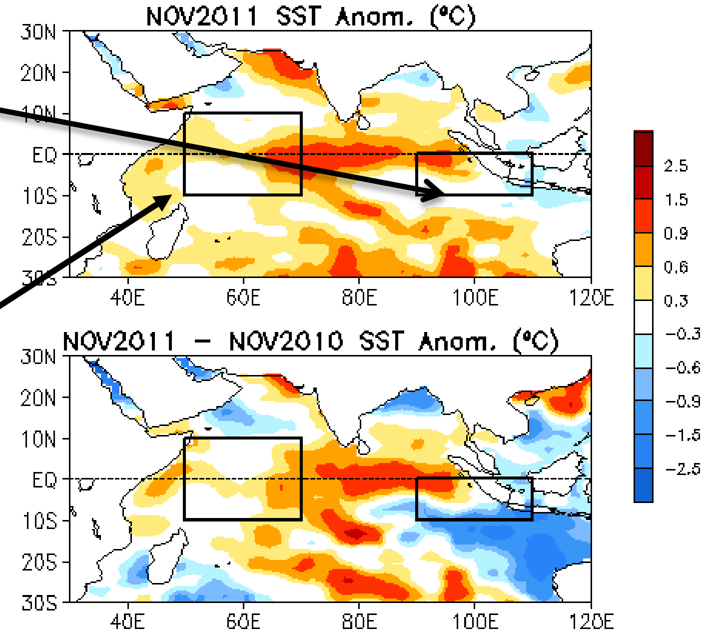
- Area below (above) black line indicates climatological upwelling (downwelling) season.

- Climatologically upwelling season progresses from March to July along the west coast of North America from 36°N to 57°N.

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices

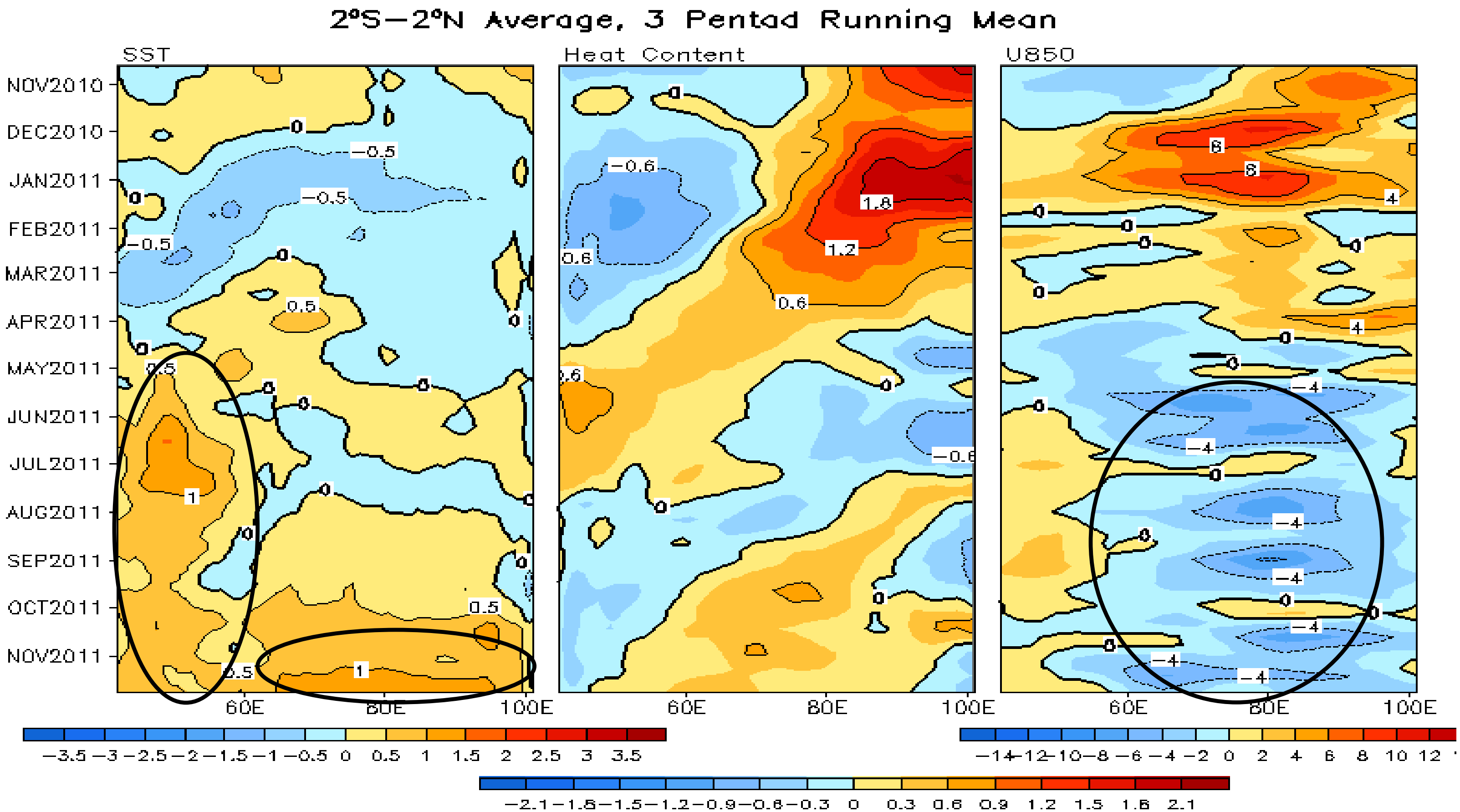




- **SETIO was near-zero in Nov.**
- **DMI was 0.43, 0.48, 0.76 and 0.45 in Jul, Aug, Sep and Oct 2011.**
- **DMI=0.56°C in Aug-Oct 2011, indicating positive IOD conditions.**

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.

Recent Evolution of Equatorial Indian SST (°C), 0-300m Heat Content (°C), and 850-mb Zonal Wind (m/s) Anomalies



- Positive SSTA has persisted in the western tropical Indian Ocean from May 2011 to Nov 2011.
- Positive SSTA enhanced in the central-eastern tropical Indian Ocean in Nov 2011.
- Easterly wind anomalies have persisted in the central-east tropical Indian Ocean since May 2011.

Fig. 13. 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°S-2°N and Outgoing Long-wave Radiation (OLR, right) averaged in 5°S-5°N. SST are derived from the NCEP OI SST, heat content from the NCEP's global ocean data assimilation system, and U850 from the NCEP CDAS. Anomalies are departures from the 1981-2010 base period pentad means.

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

- Positive SSTA was observed in the central and eastern equatorial Indian Ocean.
- Convection was enhanced (suppressed) over the western and central tropical Indian Ocean (Bay of Bengal).
- Low level easterly wind anomalies were located over positive SSTA.

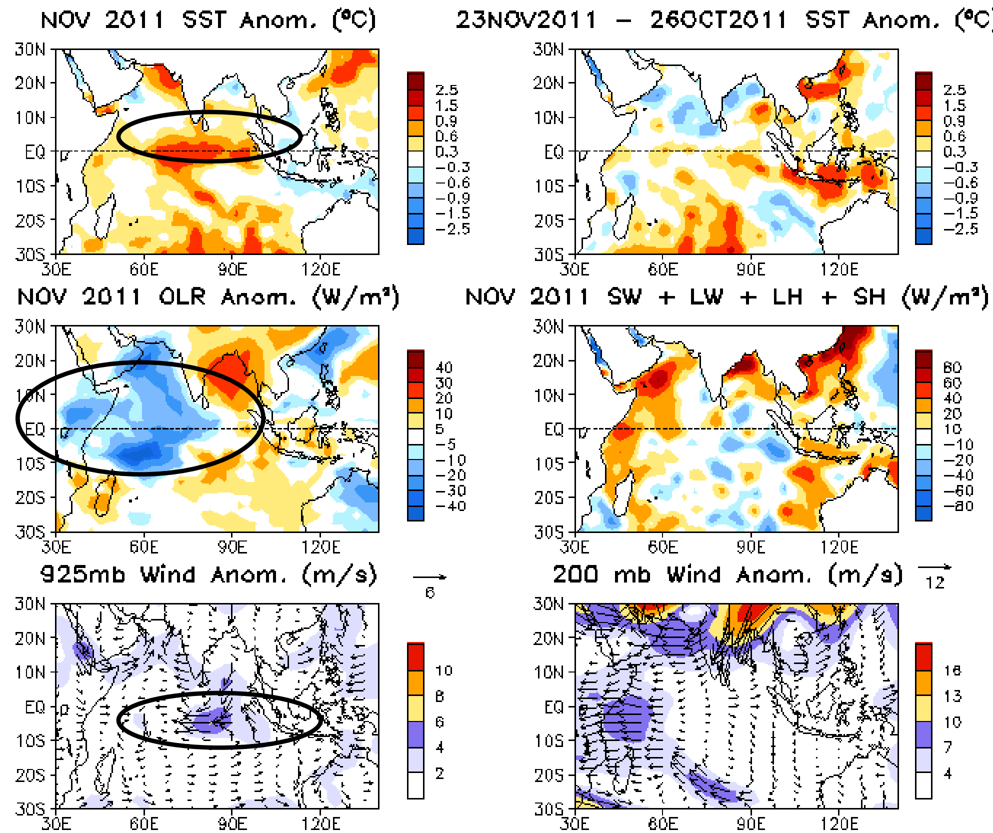
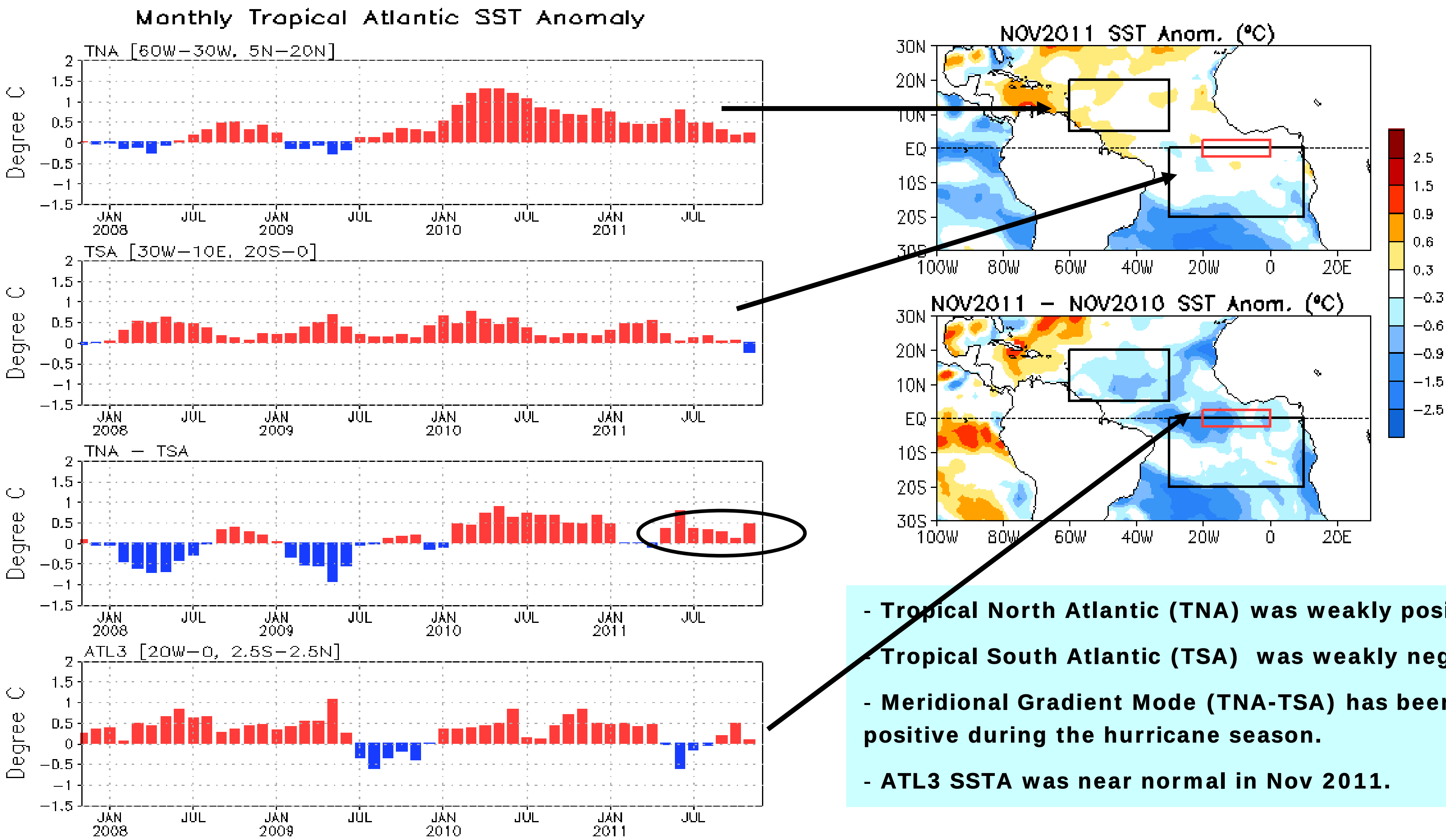


Fig. I2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude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

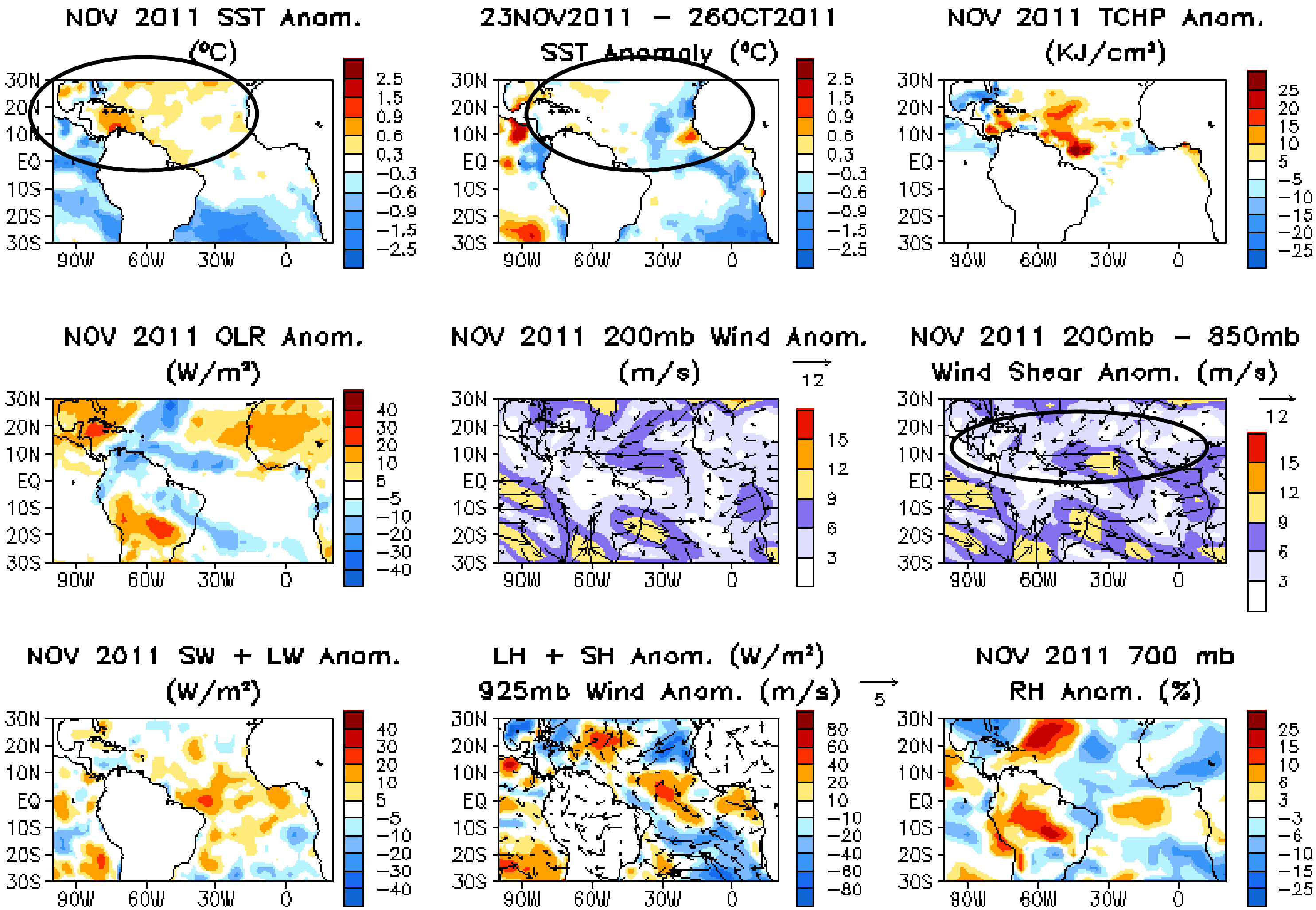
Evolution of Tropical Atlantic SST Indices



- Tropical North Atlantic (TNA) was weakly positive.
- Tropical South Atlantic (TSA) was weakly negative.
- Meridional Gradient Mode (TNA-TSA) has been positive during the hurricane season.
- ATL3 SSTA was near normal in Nov 2011.

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

Tropical Atlantic:

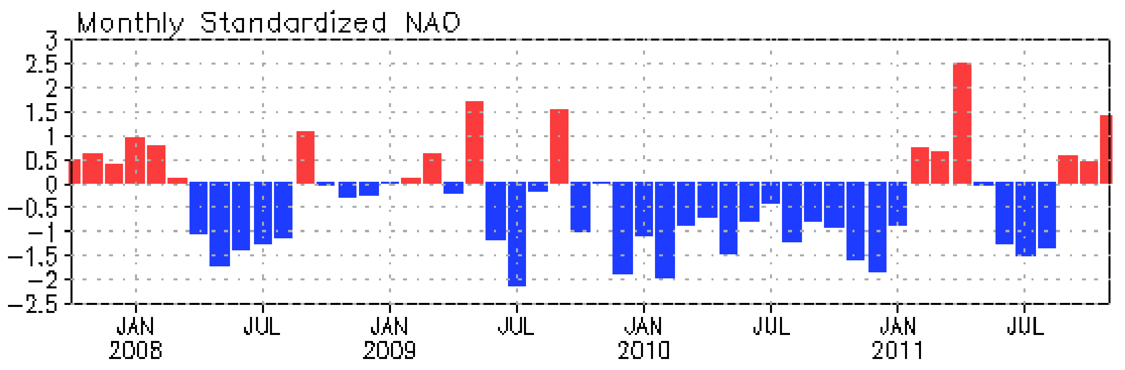


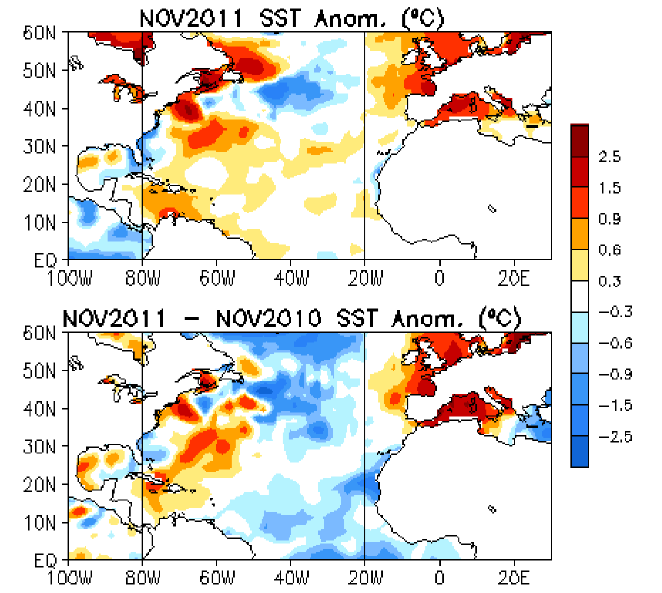
- **Positive SSTA persisted in Caribbean Sea, but dissipated in the eastern tropical North Atlantic and equatorial Atlantic.**

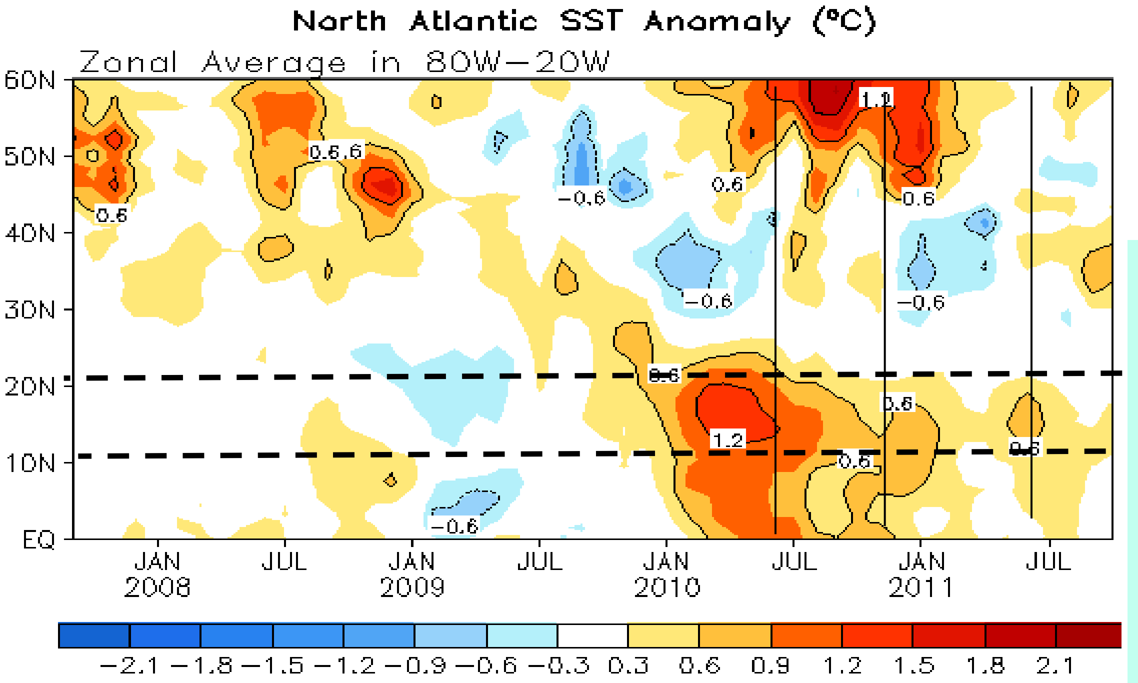
- **Below-normal vertical wind shear persisted in the tropical North Atlantic.**

North Atlantic Hurricane Season

NAO and SST Anomaly in North Atlantic



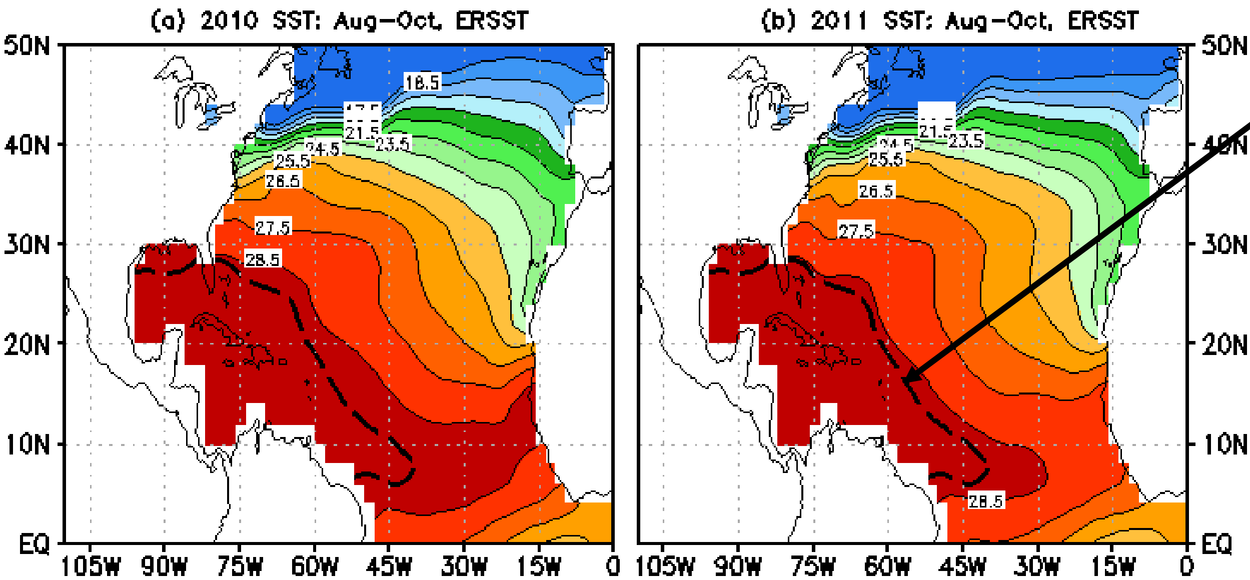




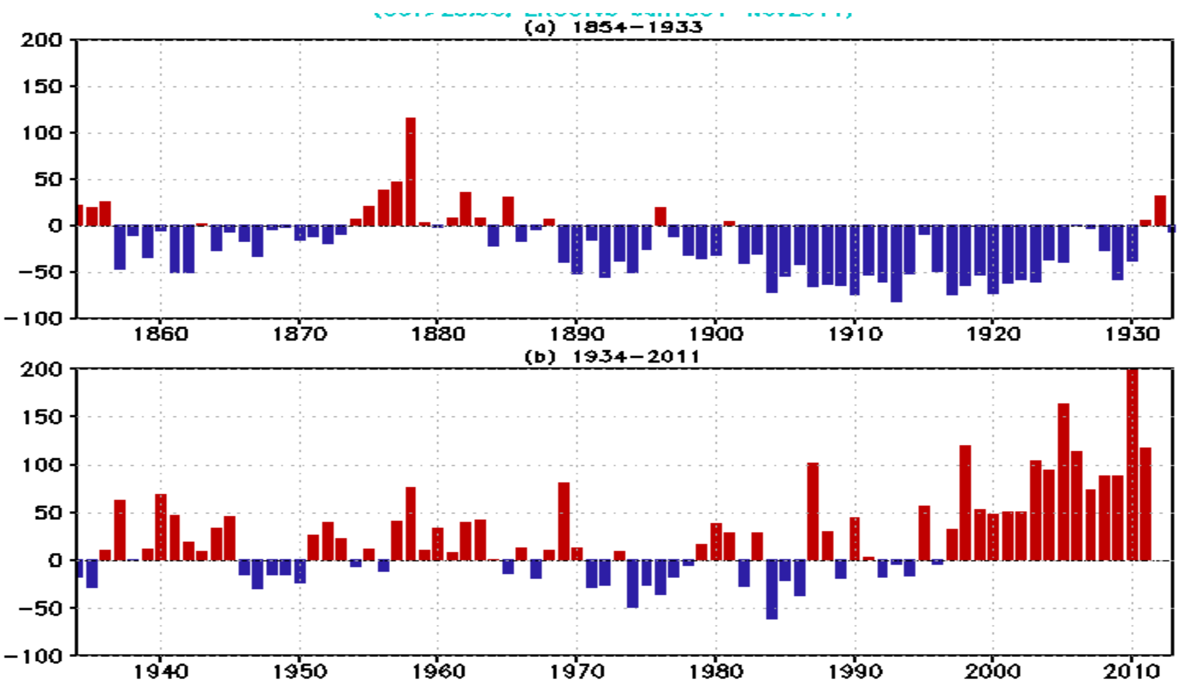
- Positive NAO persisted in Sep-Nov 2011.
- SST in high-latitudes was much cooler in summer/fall 2011 than in summer/fall 2010, probably related to opposite phase of NAO in spring 2010 and 2011.
- SST in low-latitudes was much cooler in summer/fall 2011 than in summer/fall 2010, probably due to the contrary of the delayed impacts of El Nino in spring 2010 and La Nina in spring 2011.

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.

Atlantic Warm Pool (AWP) Index



The black dash line is the climatological 28.5ºC isotherm for Aug-Oct .

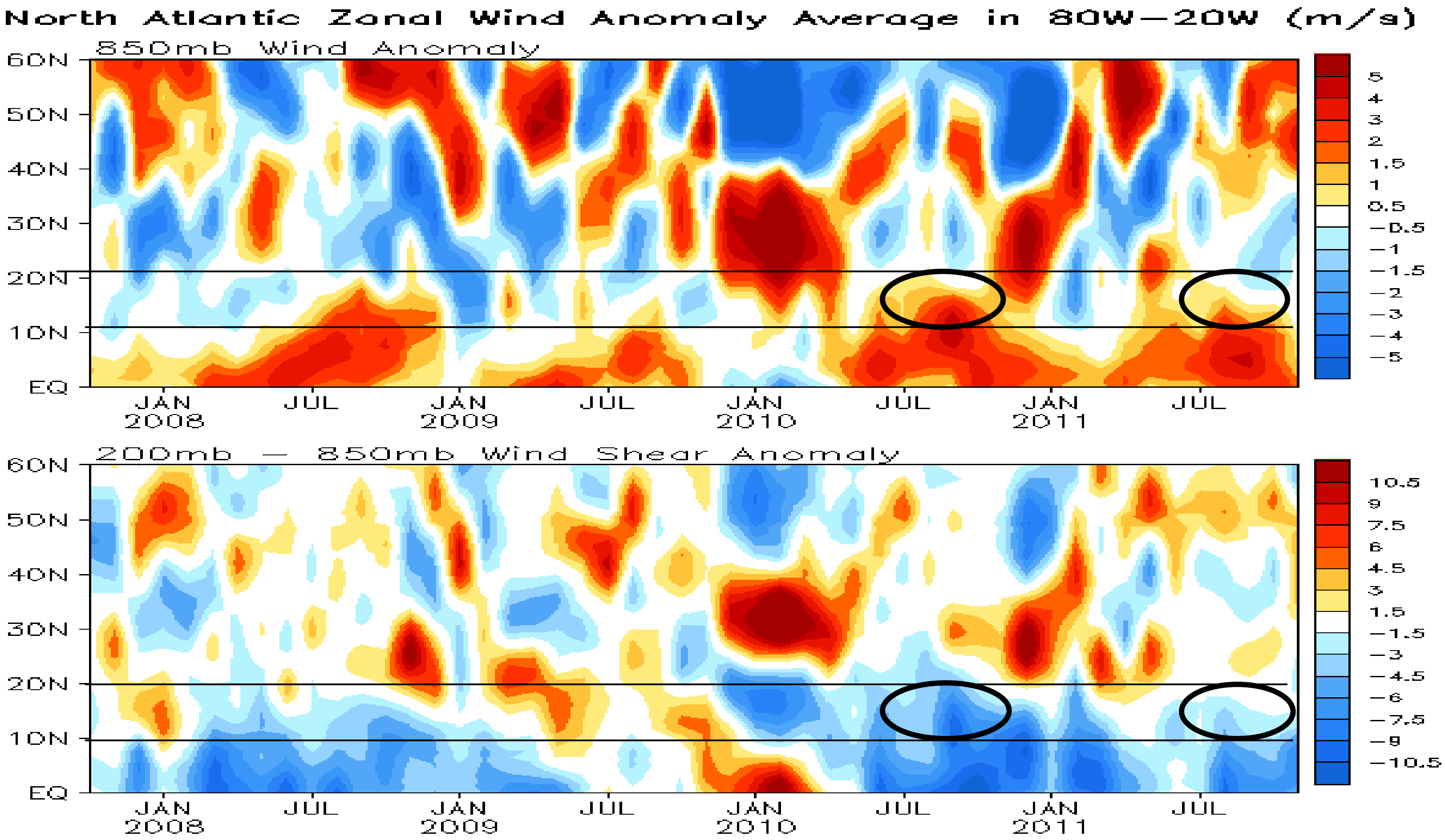


- Atlantic Warm Pool (AWP) index is defined as JJASON anomalies of the area with SST > 28.5ºC in the tropical North Atlantic from 15ºW westward divided by climatology (unit %) (Wang et al. G3 2008). The index was calculated using ERSSTv3.

- A large (small) AWP is unfavorable (favorable) for hurricanes to make landfall in the United States; The mechanisms are due to (1) the shift of tropical cyclone (TC) genesis location & (2) the change of TC steering flow (Wang et al. GRL 2011).

- The AWP in 2010 and 2011 was about 200% and 120% climatology respectively.

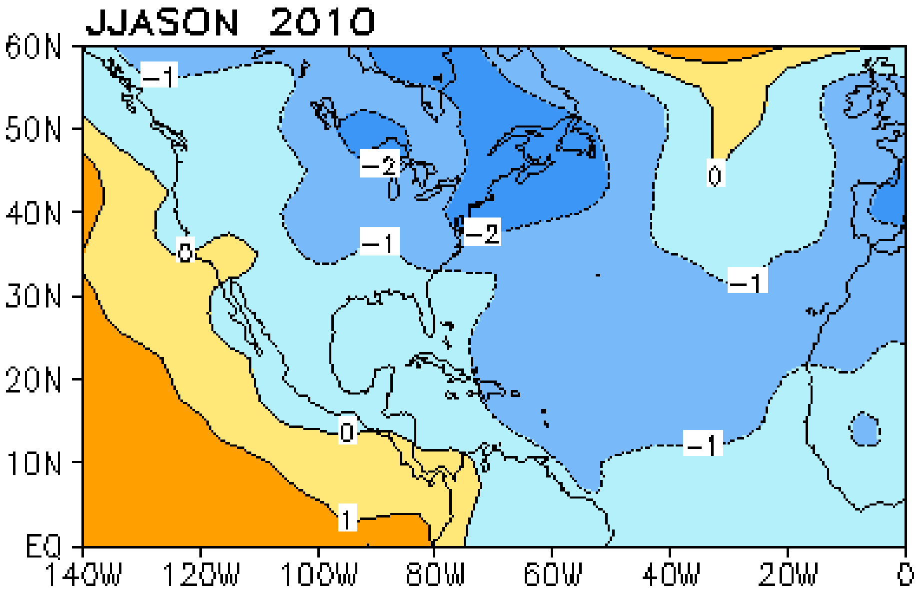
North Atlantic U850 and U200-U850



- In the Hurricane Main Development Region (80W-20W, 10N-20N), low-level easterly (upper panel) and vertical wind shear (lower panel) were below-normal in JJASON 2011, which is favorable for hurricane development.

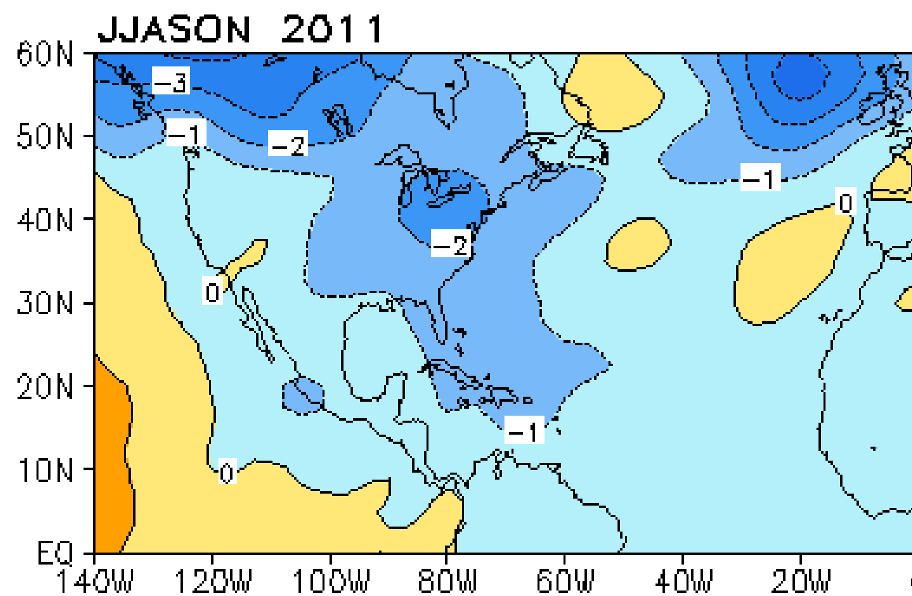
- However, anomalies in JJASON 2011 were much weaker than those in JJASON 2010.

North Atlantic Subtropical High (NASH)

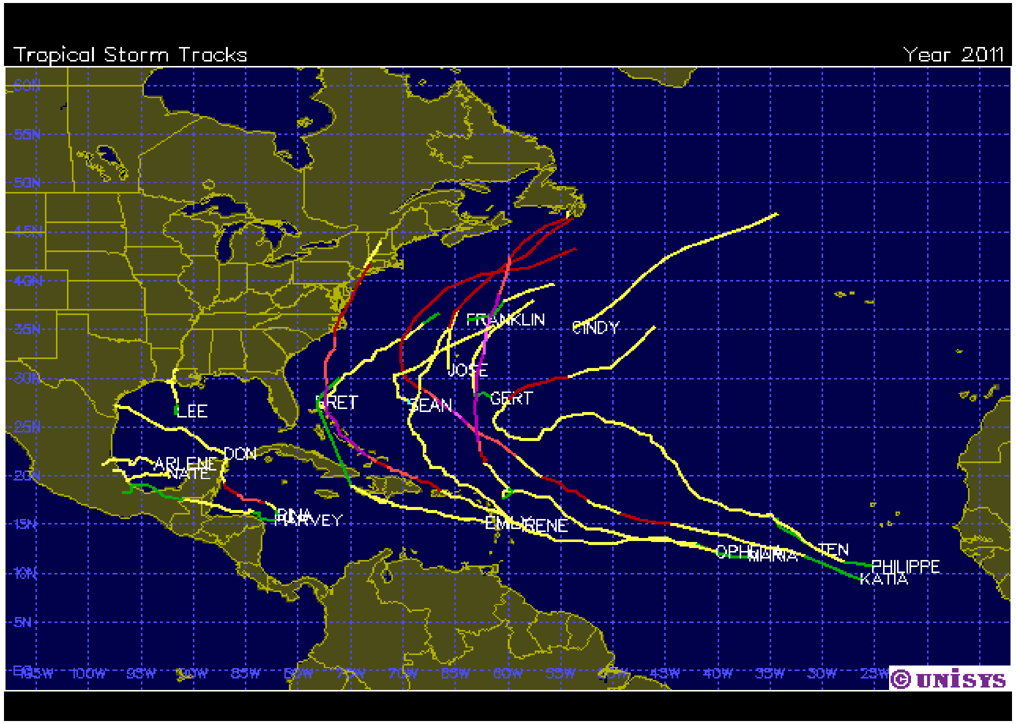


Models & data show that a large AWP is associated with a smaller, weakened North Atlantic subtropical high (NASH) that retreats eastward toward Europe and that SLP weakens off the east coast of the US creating a weakness where tropical cyclones (TCs) can be steered northward and away from land (Wang et al. 2011). The situation in 2010 (left) is an illustrative case in point.

In 2011, like in 2010, the high pressure of the NASH has retreated eastward leaving an area of weakness off the east coast where TCs can recurve, as we have observed. The next slide shows how the storm tracks in 2011 have generally avoided making landfall in the US. Even Irene, which narrowly made landfall, was diverted northward by the pressure distribution (personal communication, David Enfield).



NOAA Predicts an Active Atlantic Hurricane Season in 2011



- By Dec. 1, 2011, 19 tropical storms, 7 hurricanes and 3 major hurricanes (category 3, 4) formed in the North Atlantic Ocean.

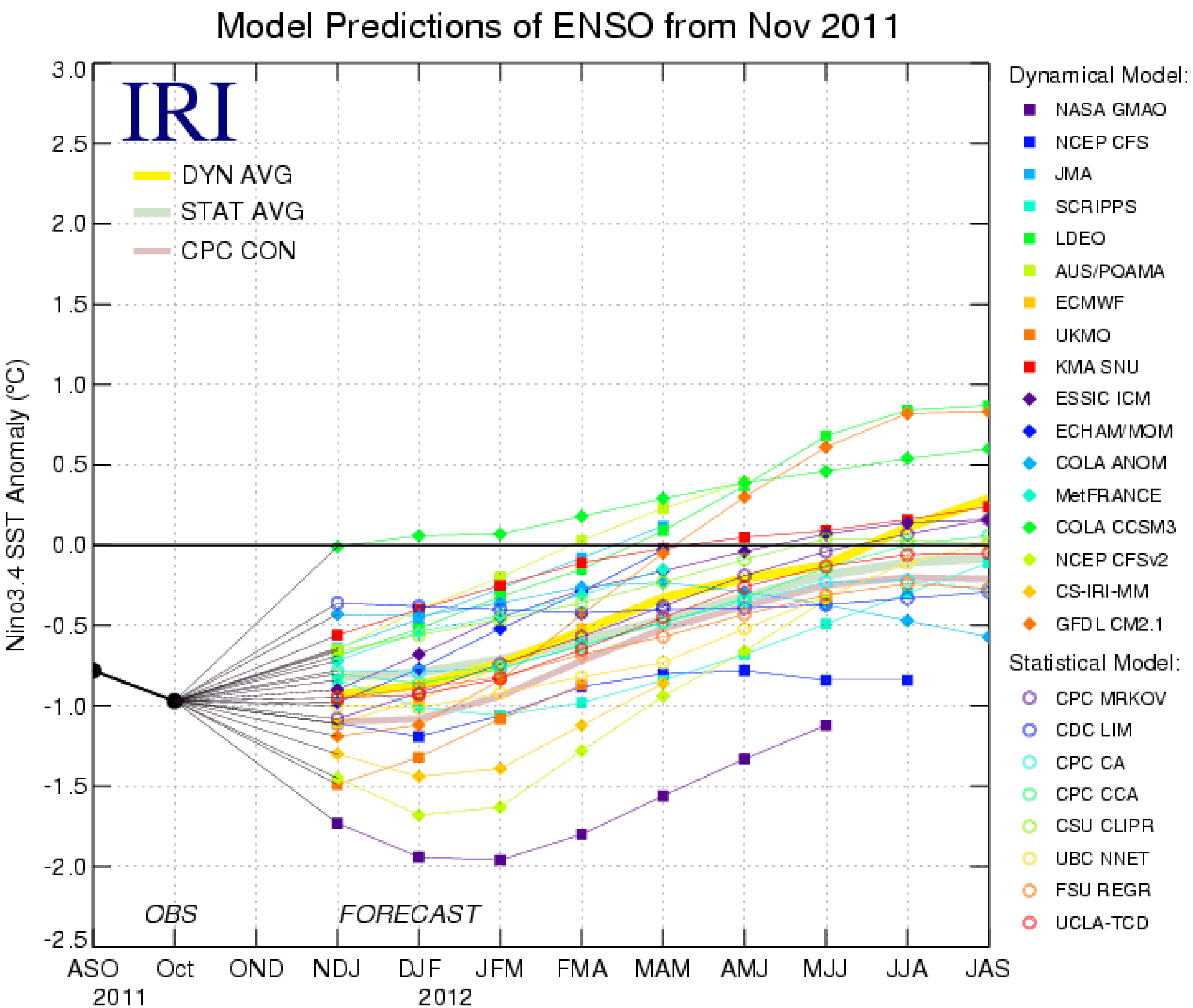
- The NOAA's Atlantic Hurricane Outlook verified very well.

http://en.wikipedia.org/wiki/2011_Atlantic_hurricane_season

	Normal	May 19	Aug. 4	*Obs. by Dec. 1*
Named storms	11	12-18	14-19	19
Hurricanes	6	6-10	7-10	7
Major hurricanes	2	3-6	3-5	3
ACE (% median)	100	105-200	135-215	119

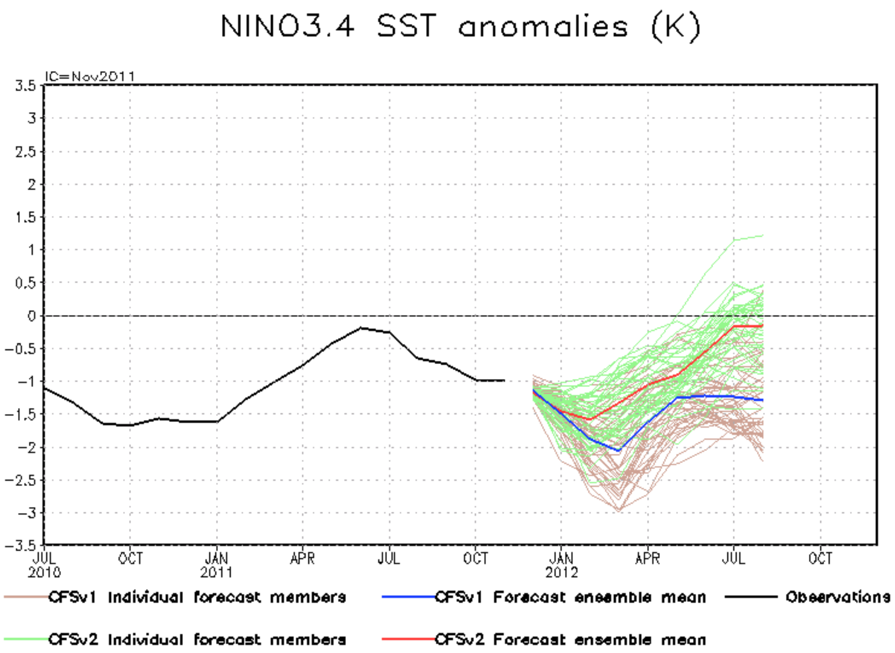
SST Predictions

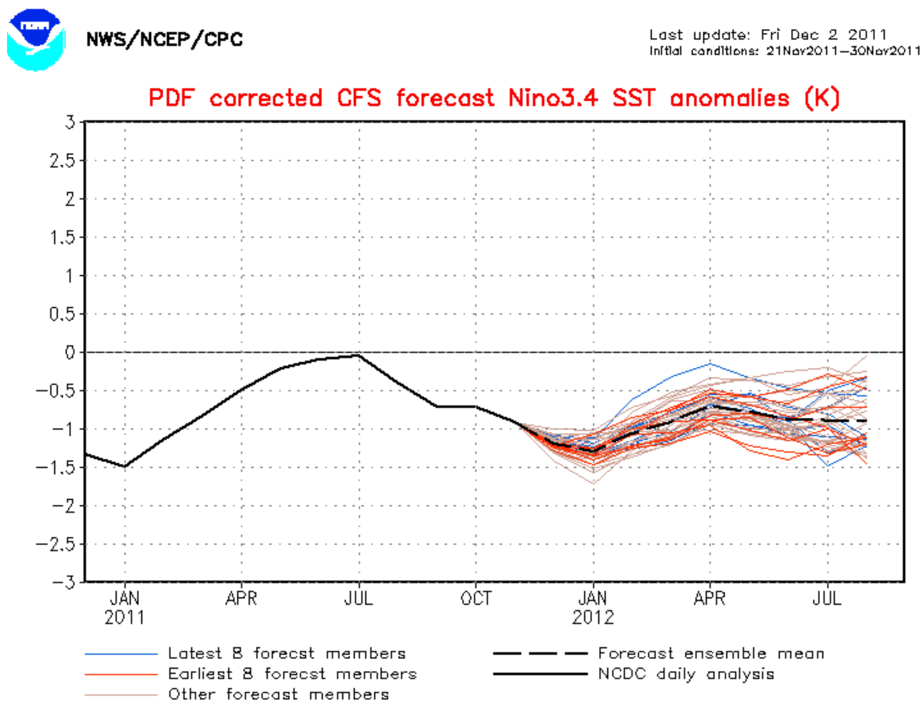
IRI NINO3.4 Forecast Plum



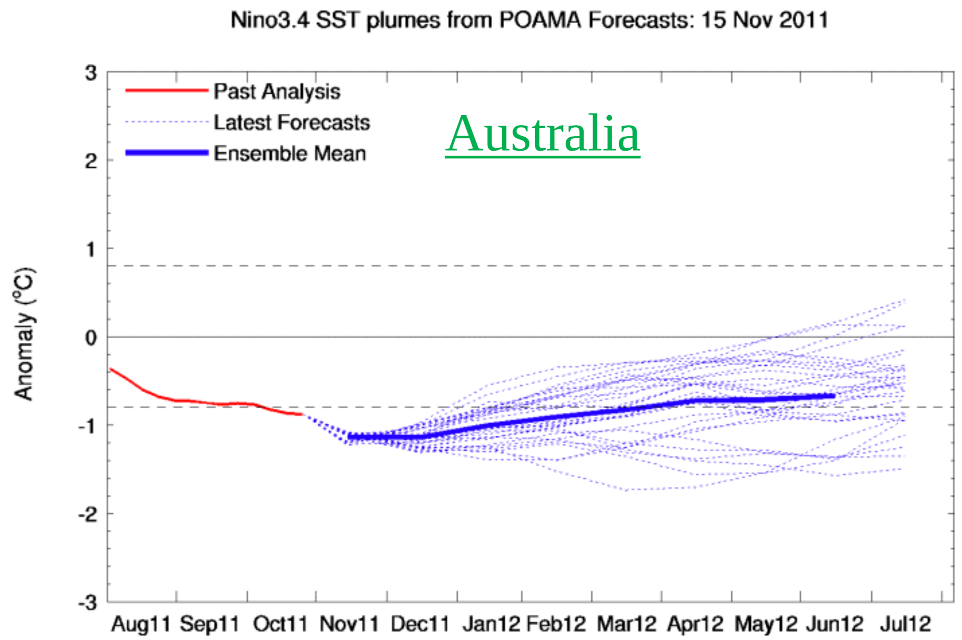
- The majority of models predicted that weak to moderate La Nina conditions peak in the winter 2011/12, dissipate in spring and return to normal-conditions by late spring and summer.

NCEP CFSv1 and CFSv2 NINO3.4 Forecast

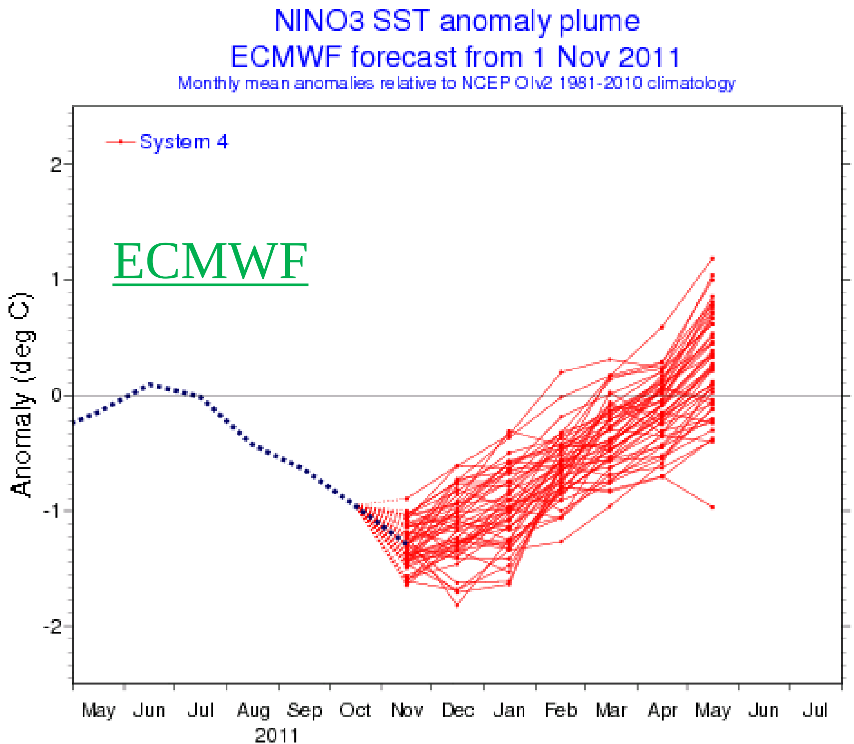


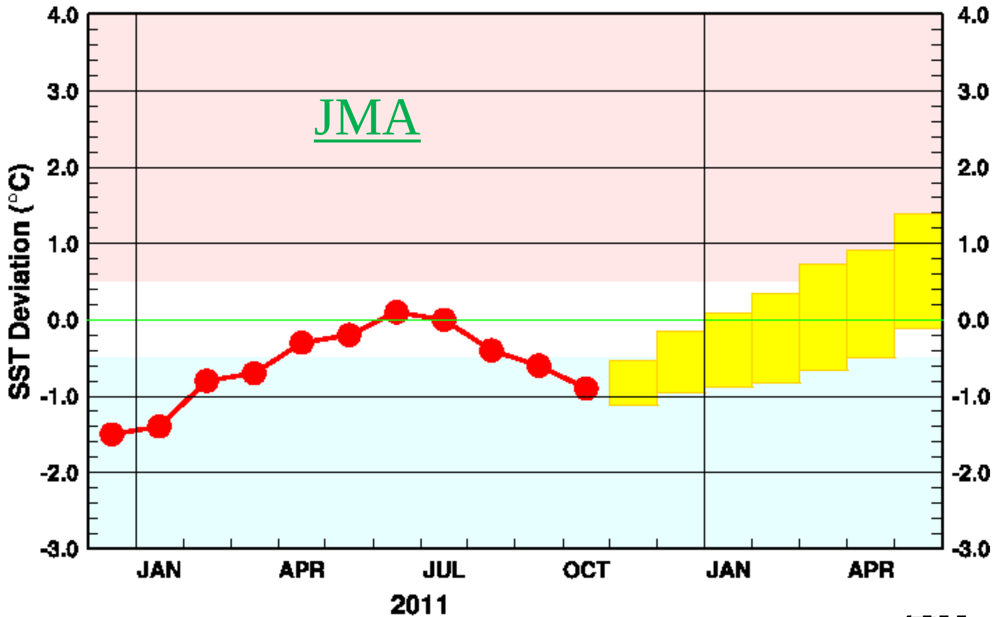


- Both CFSv1 and CFSv2 predicted that strong La Nina conditions (NINO3.4 less than -1.5°C) would peak in Mar 2012 and Feb 2012 respectively.
- CFSv2 predicted the La Nina would dissipate and return to normal-conditions by summer 2012, while CFSv1 predicted the La Nina to last through summer 2012.
- PDF corrected CFSv1 forecast favors moderate La Nina conditions to peak in Jan 2012.
- NOAA "ENSO Diagnostic Discussion" suggests weak-to-moderate strength La Niña is expected to continue through the Northern Hemisphere winter 2011-12.

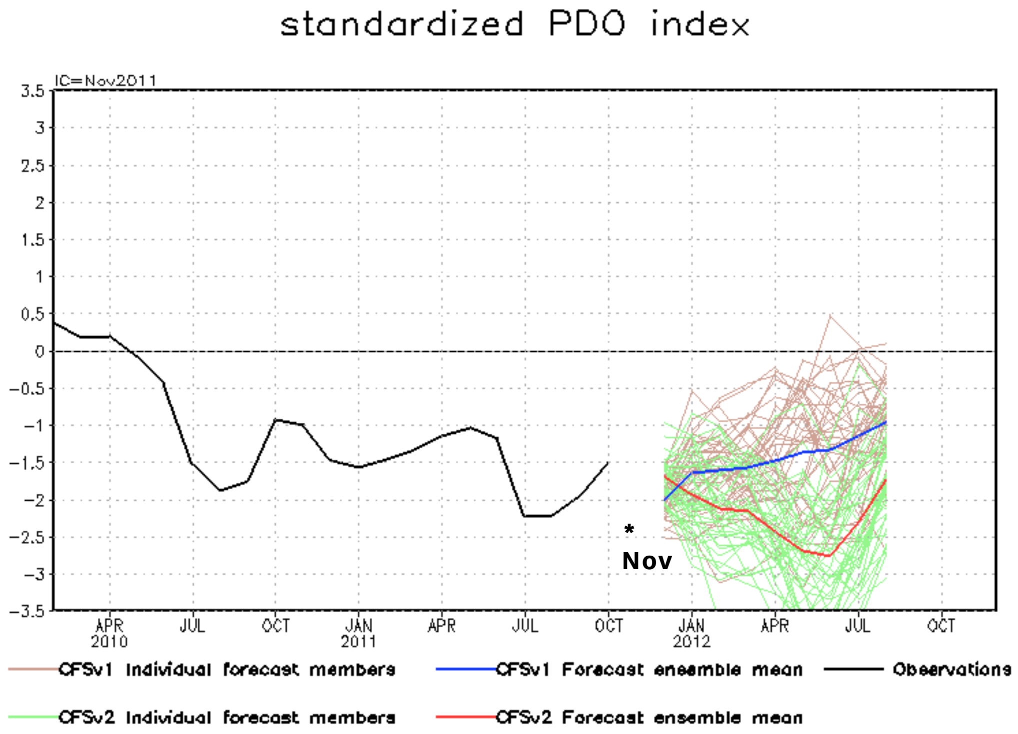


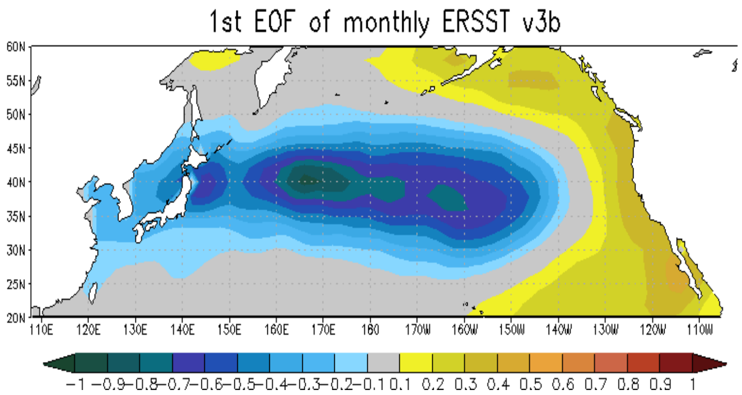
- **Large spread in NINO3.4 forecast was evident among models: some examples here.**





NCEP CFSv1 and CFSv2 PDO Forecast

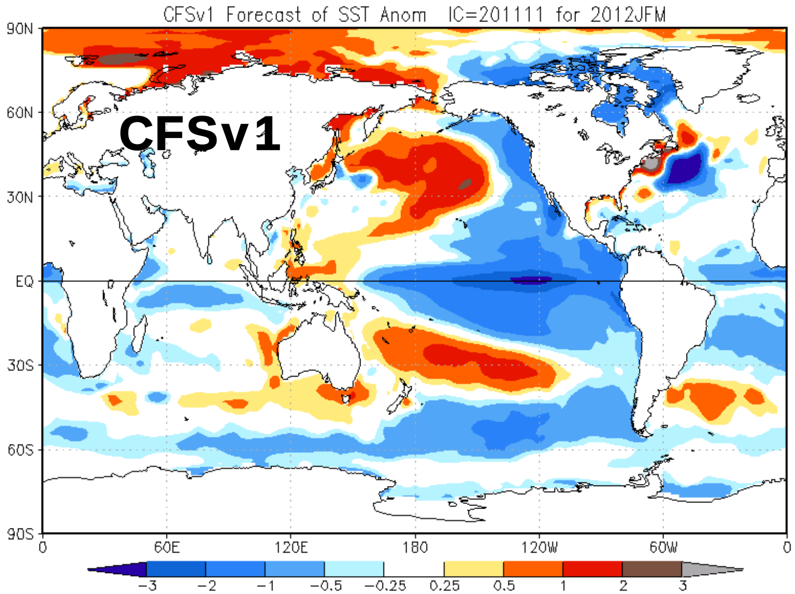


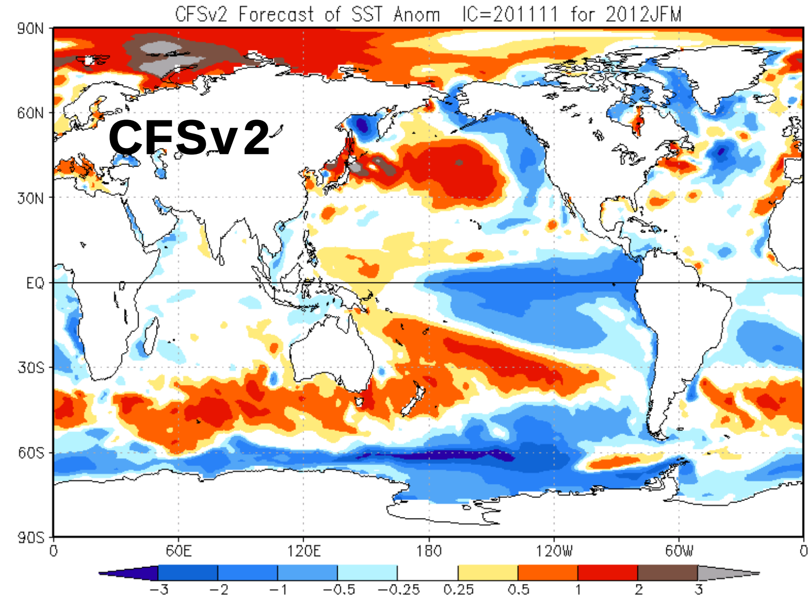


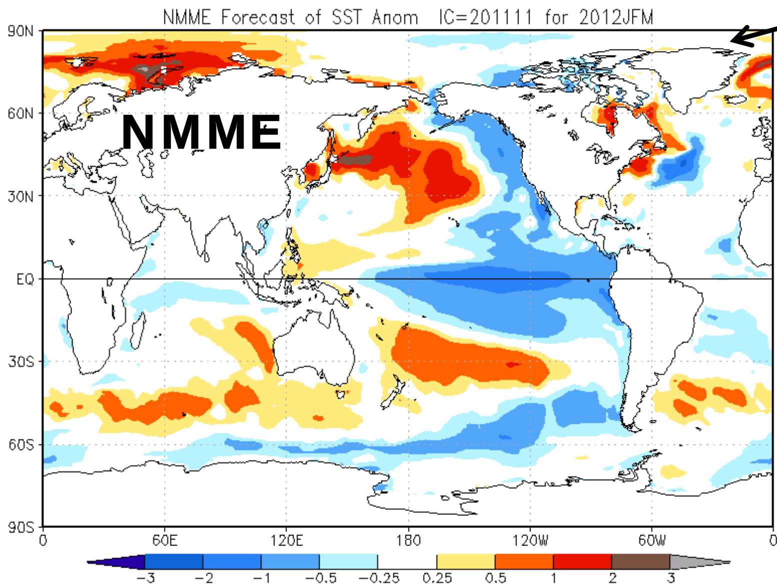
- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSSTv3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.

- Both CFSv1 and CFSv2 predicted that negative PDO would last through the Northern Hemisphere winter 2011/12, and continue into spring and summer 2012.
- CFSv2 (CFSv1) predicted negative PDO to strengthen (weaken) in spring 2012.

National Multi-Model Ensemble (NMME) SST Forecast for JFM 2011 (Oct 2011 I.C.)







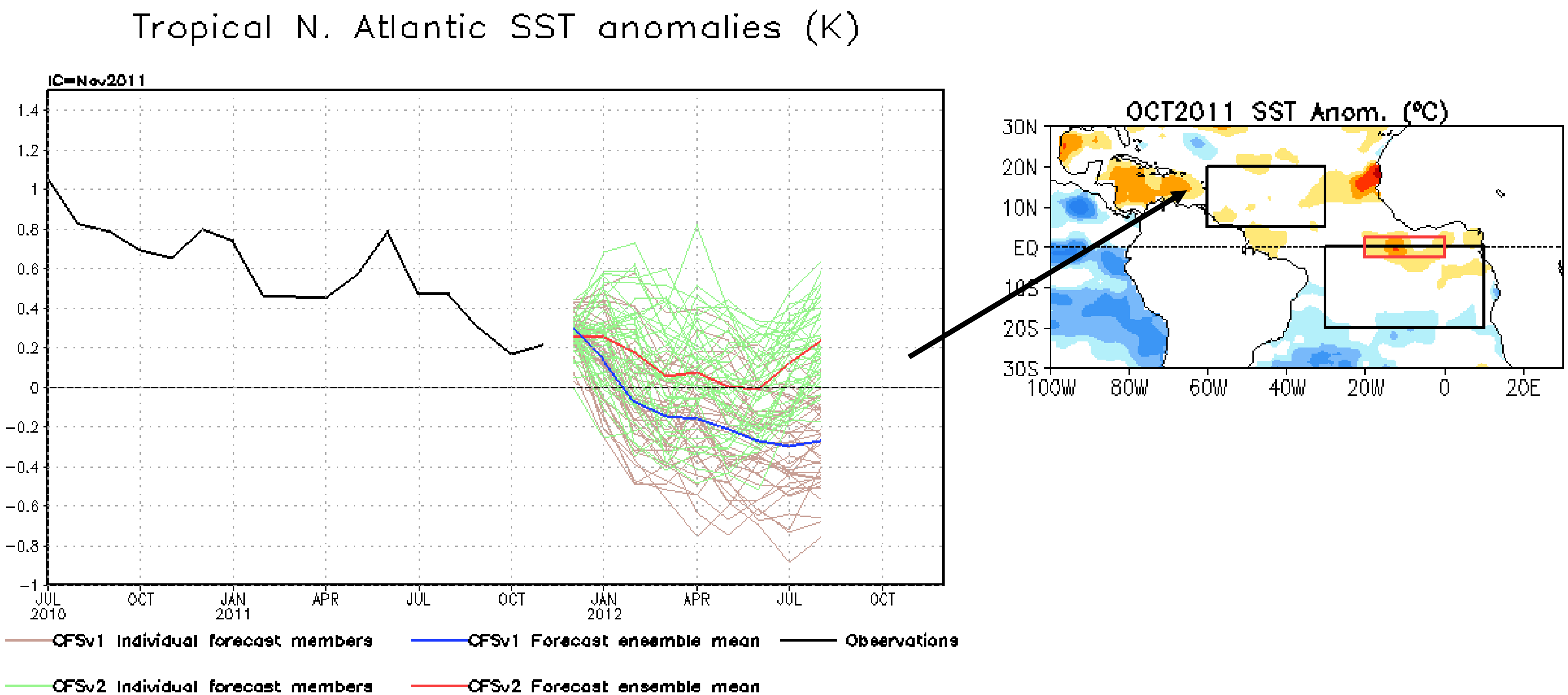
Ensemble Mean of 7 Models
(CFSv1, CFSv2, ECHAMA, ECHAMF, GFDL, NCAR, NASA)

http://www.cpc.ncep.noaa.gov/products/people/wd51yf/NMME
experimental product

Thanks Qin Zhang, Huug van den Dool, Suru Saha, Malaquias Pena Mendez, Patrick Tripp, Peitao Peng and Emily Becker plus the originators at NASA, NCAR, GFDL, IRI (all coupled models)

- **National Multi-Model Ensemble (NMME) forecast favors La Nina conditions and negative PDO in JFM.**
- **CFSv2 forecast agrees well with NMME forecast.**
- **Compared to NMME forecast, CFSv1 forecast SST is too cold and has too broad meridional extent in the tropical Pacific, too cold near the Kuroshio Extension, tropical Indian and tropical Atlantic Ocean.**

NCEP CFSv1 and CFSv2 Tropical North Atlantic SST Forecast

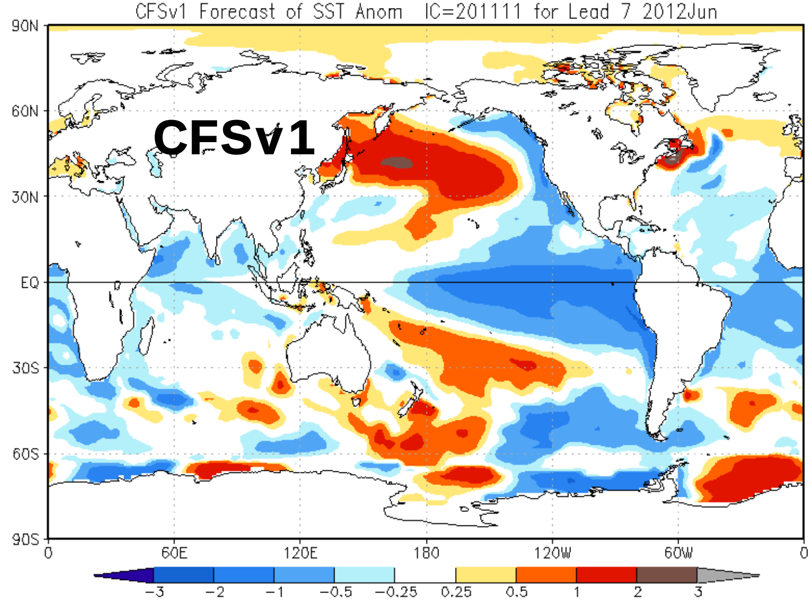


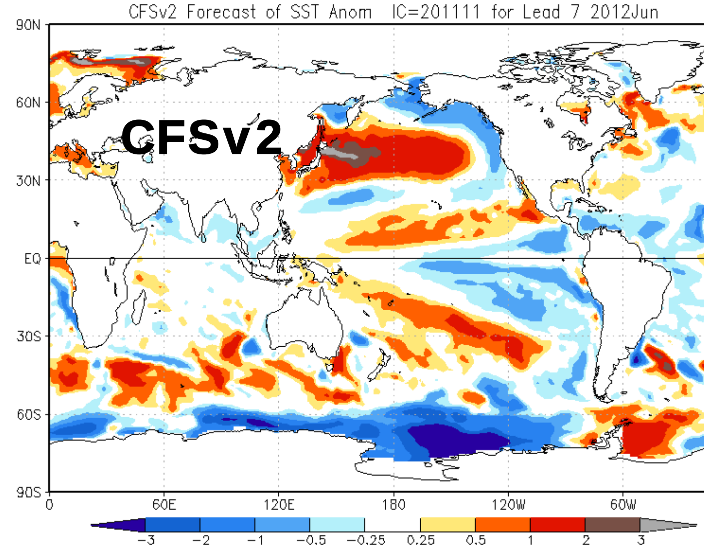
- CFSv1 suggested positive TNA would weaken rapidly, switch to negative in mid-winter, and continue to cool in spring 2012, becoming below-normal in summer 2012.

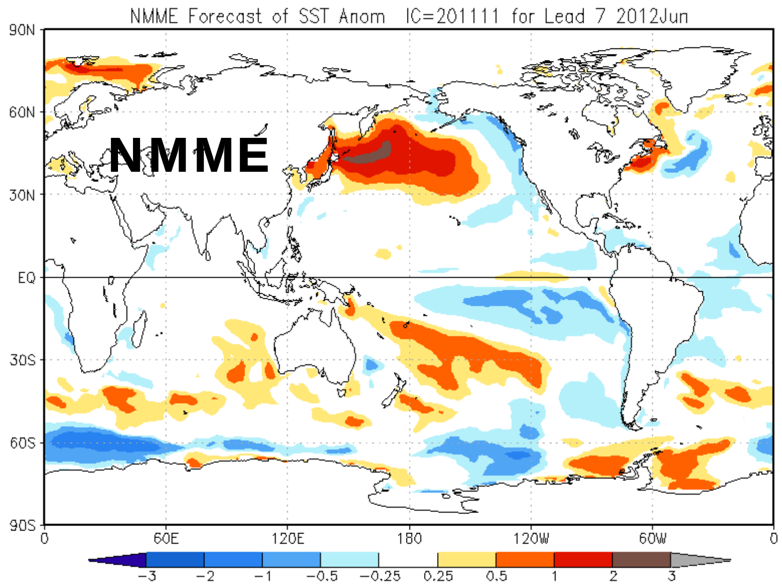
- However, CFSv2 forecast positive TNA would weaken slowly, return to near normal in spring 2012, and then increase and become above-normal in summer 2012.

National Multi-Model Ensemble (NMME) SST Forecast for Jun 2012

(Oct 2011 I.C.)







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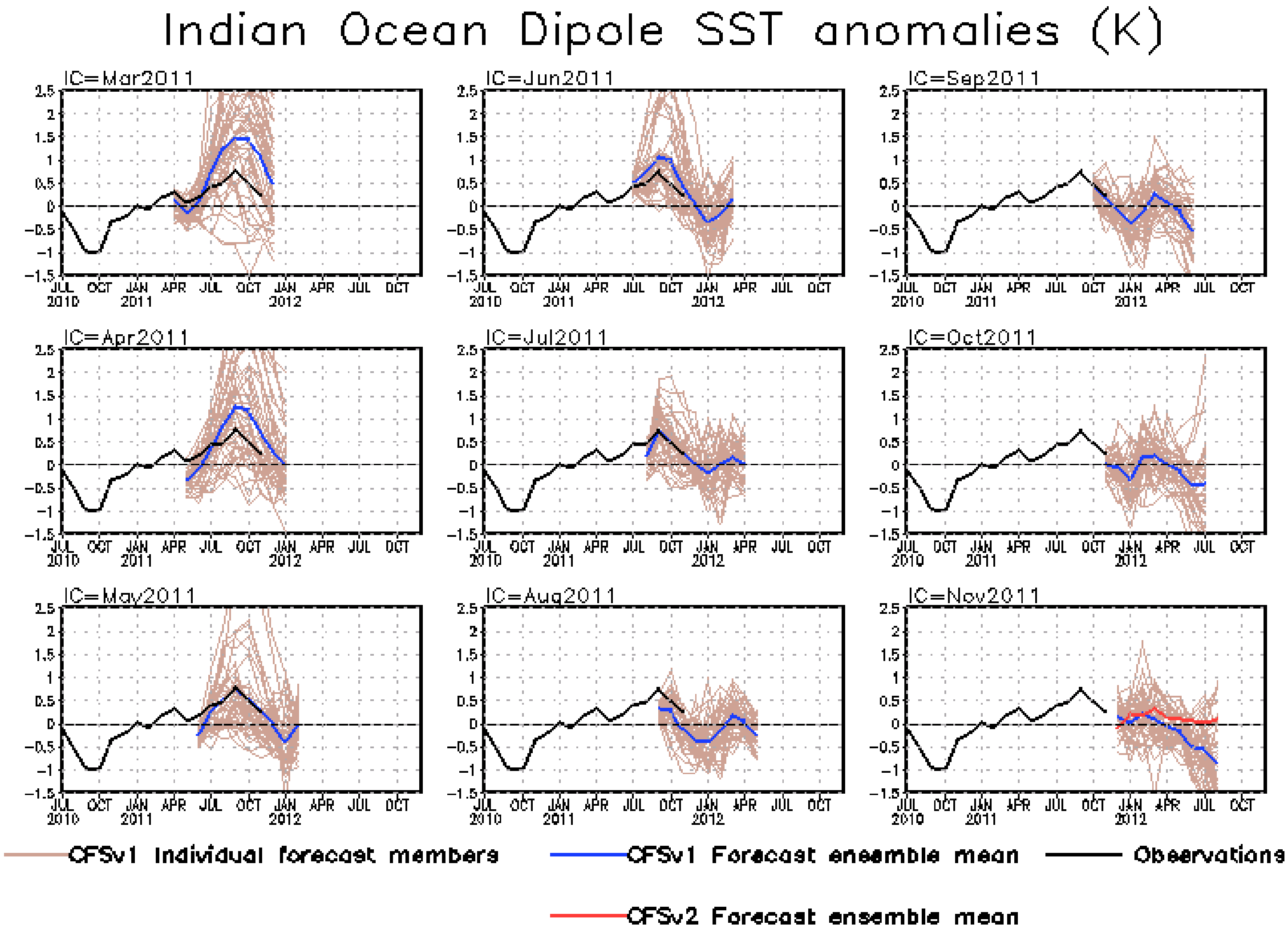
experimental product

Thanks Qin Zhang, Huug van den Dool, Suru Saha, Malaquias Pena Mendez, Patrick Tripp, Peitao Peng and Emily Becker plus the originators at NASA, NCAR, GFDL, IRI (all coupled models)

- **National Multi-Model Ensemble (NMME) forecast favors ENSO-neutral conditions and neutral tropical North Atlantic SST in Jun 2012.**
- **CFSv2 forecast agrees with NMME forecast better than CFSv1 forecast.**
- **All models predicted negative PDO phase in Jun 2012.**

NCEP CFS DMI SST Predictions from Different Initial Months



DMI = WTIO- SETIO

SETIO = SST anomaly in [90°E-110°E, 10°S-0]

WTIO = SST anomaly in [50°E-70°E, 10°S-10°N]

- **The onset of positive IOD in fall 2011 was forecast well by CFSv1 since Feb 2011.**
- **However, the spread among ensemble members is quite large.**

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.

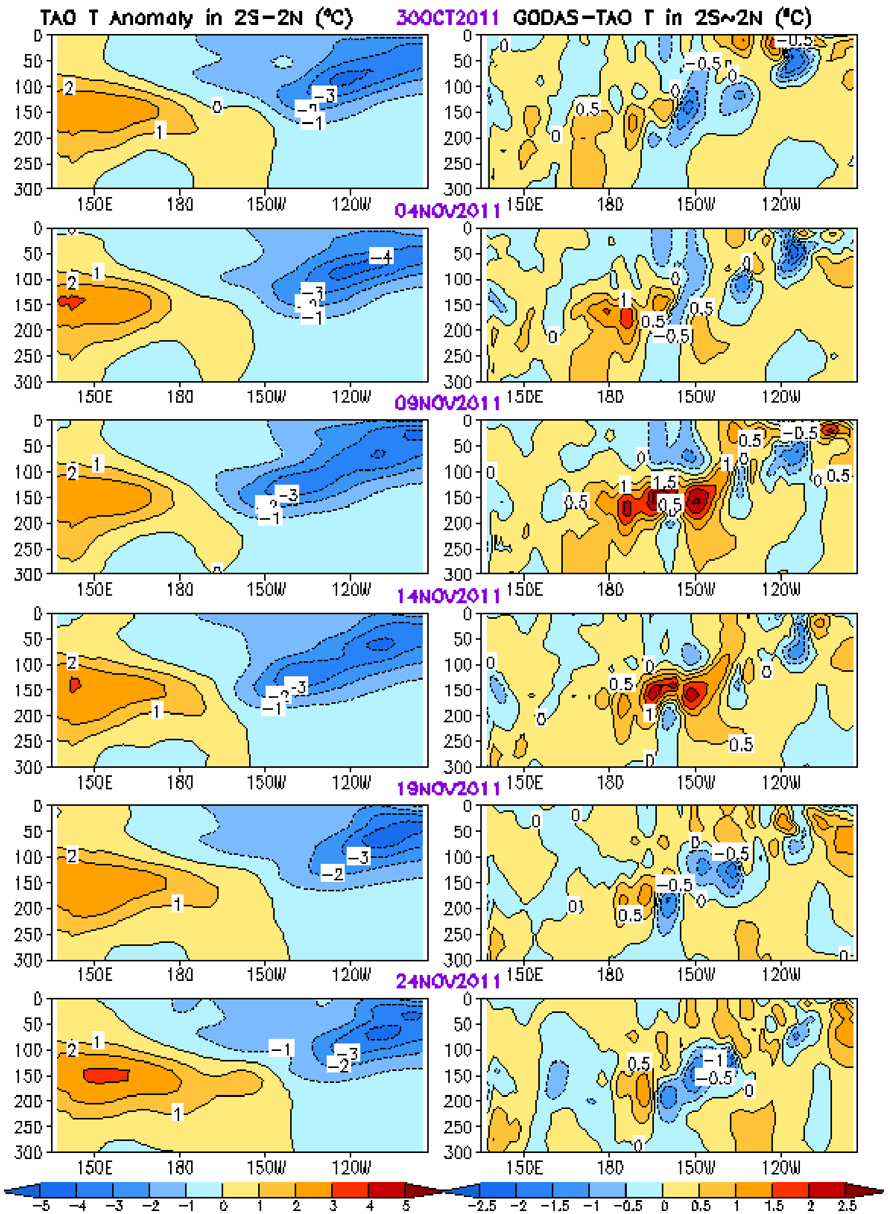
Overview

- **Pacific Ocean**
  - La Nina conditions persisted with NINO3.4=-0.97°C in Nov 2011.
  - NOAA "ENSO Diagnostic Discussion" suggests weak-to-moderate strength La Niña is expected to continue through the Northern Hemisphere winter 2011-12.
  - Negative PDO enhanced, with PDOI=-2.4 in Nov 2011.
  - Both CFSv1 and CFSv2 predicted negative PDO to last through the Northern Hemisphere winter and continue into spring/summer 2012.
- **Indian Ocean**
  - Easterly wind anomalies have persisted in the east-central tropical Indian Ocean since May 2011, and weak positive IOD conditions emerged with DMI=0.56°C in Aug-Oct 2011.
- **Atlantic Ocean**
  - Positive SSTA and below-normal vertical wind shear in the Atlantic Hurricane Main Development Region in JJASON 2011 are much weaker than those in JJASON 2010.
  - In JJASON 2011, similar to JJASON 2010, North Atlantic Subtropical High retreated eastward, which helps steer tropical cyclones northward and away from the land.

Backup Slides

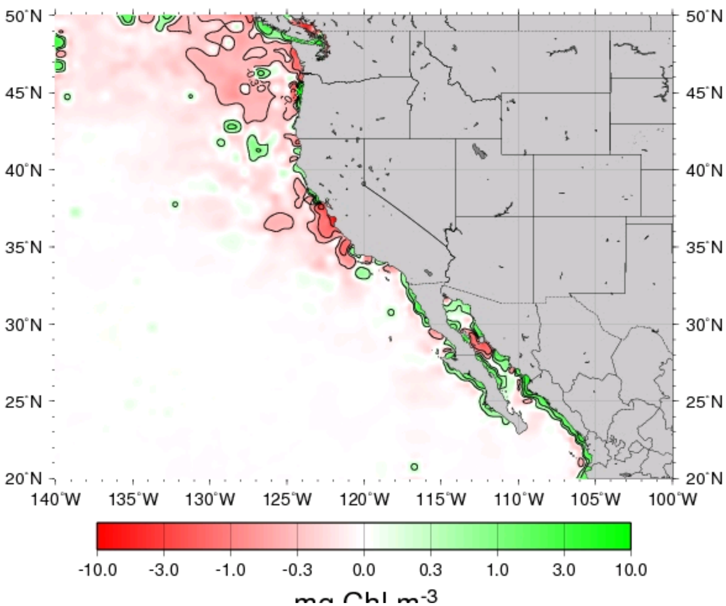
Equatorial Pacific Temperature Anomaly

TAO GODAS-TAO

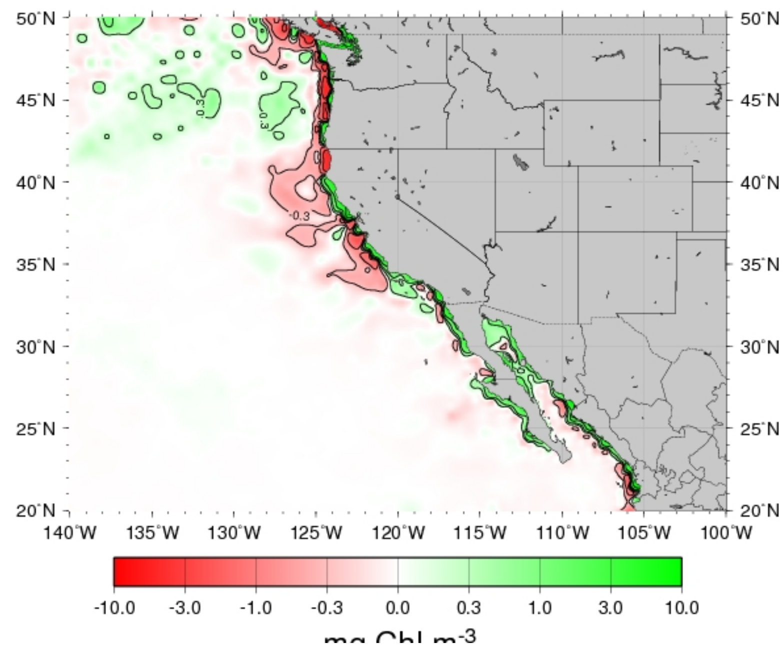


Monthly Chlorophyll Anomaly

MODIS Aqua Chlorophyll a Anomaly for November, 2011



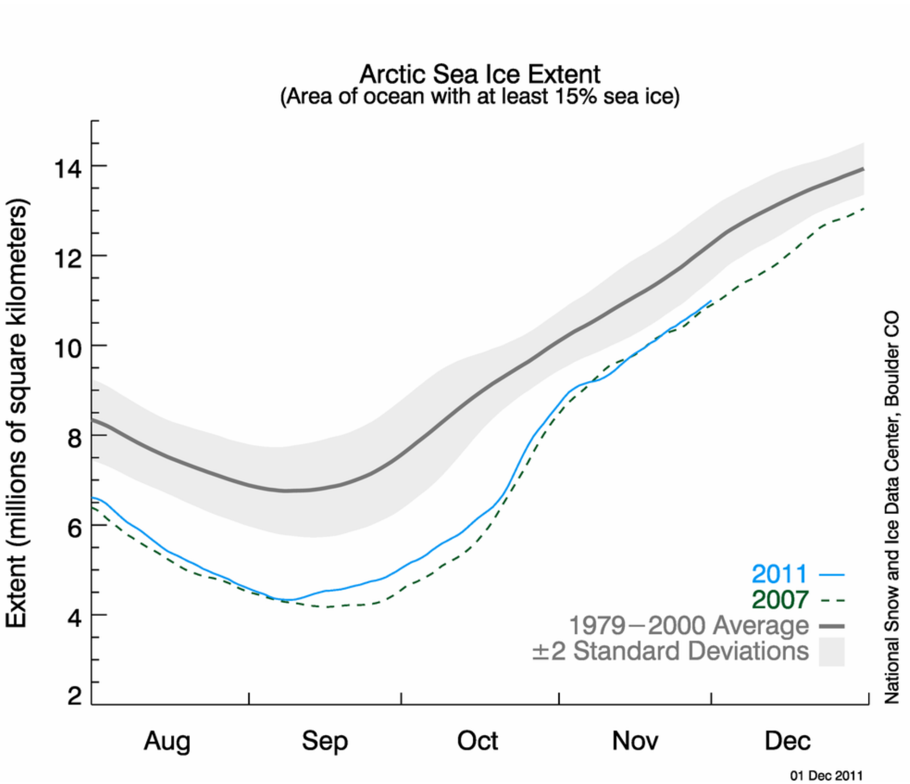
MODIS Aqua Chlorophyll a Anomaly for October, 2011

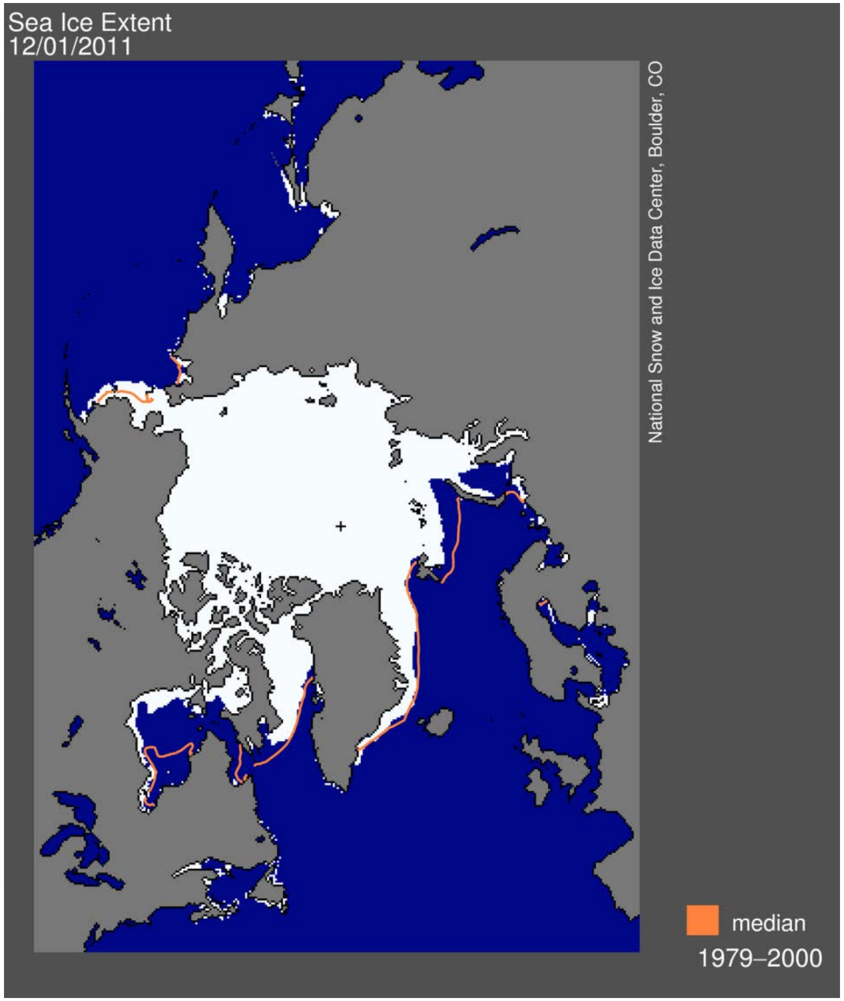


http://coastwatch.pfel.noaa.gov/FAST

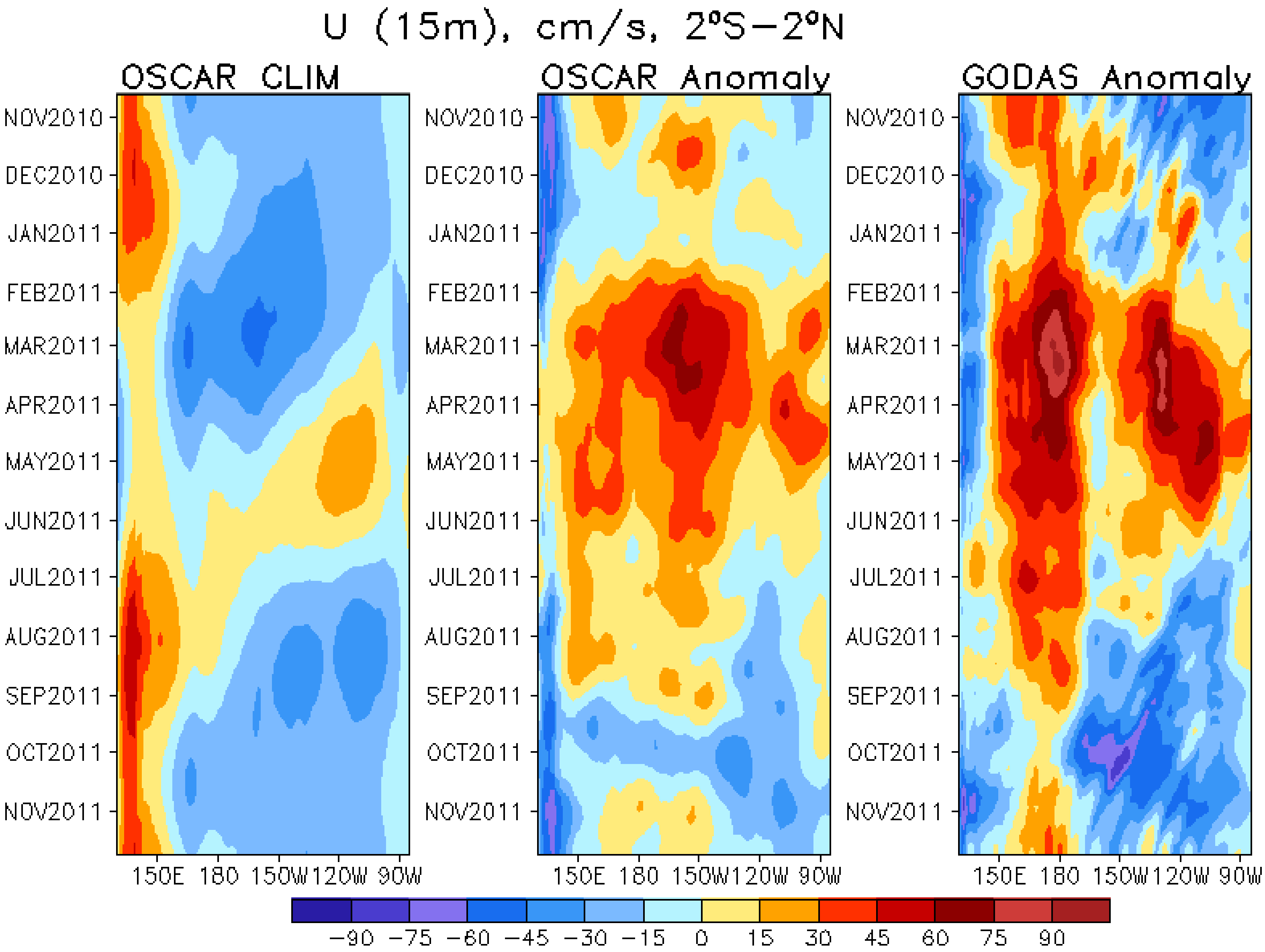
Arctic Sea Ice

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





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



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

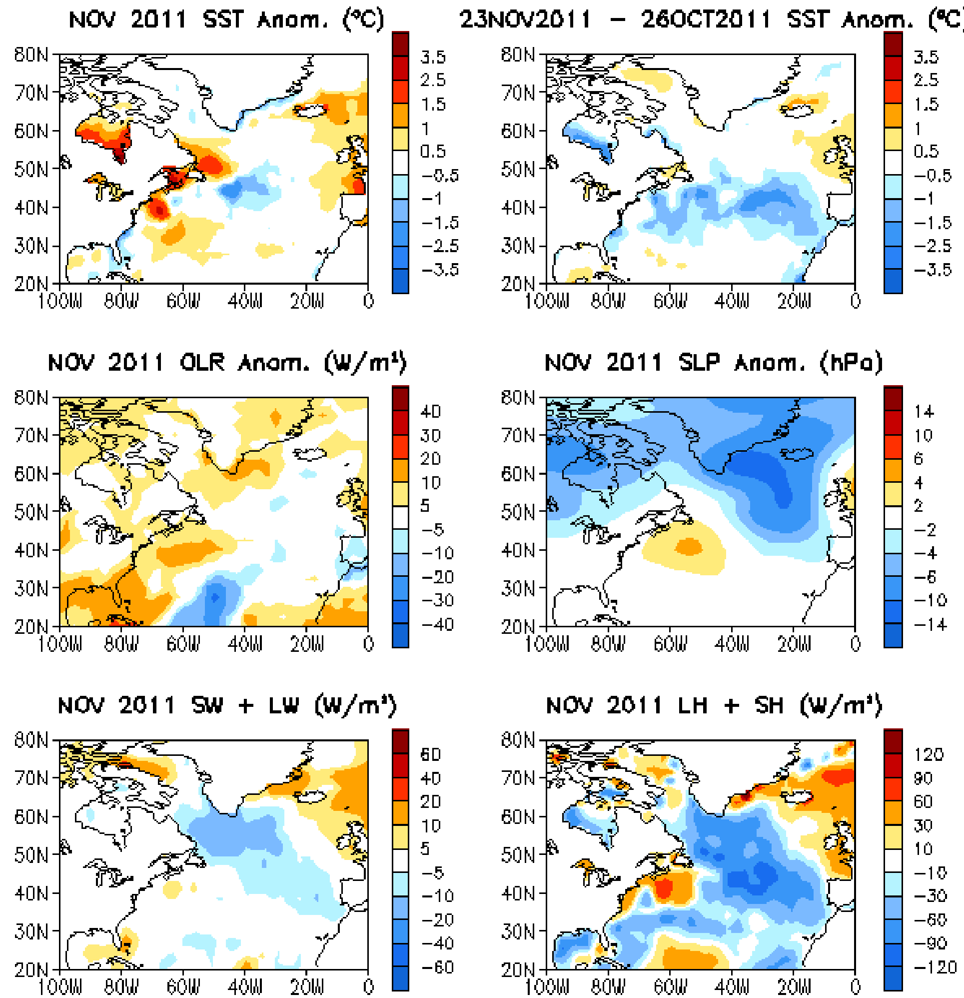


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible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

CFS Niño3.4 SST Predictions from Different Initial Months

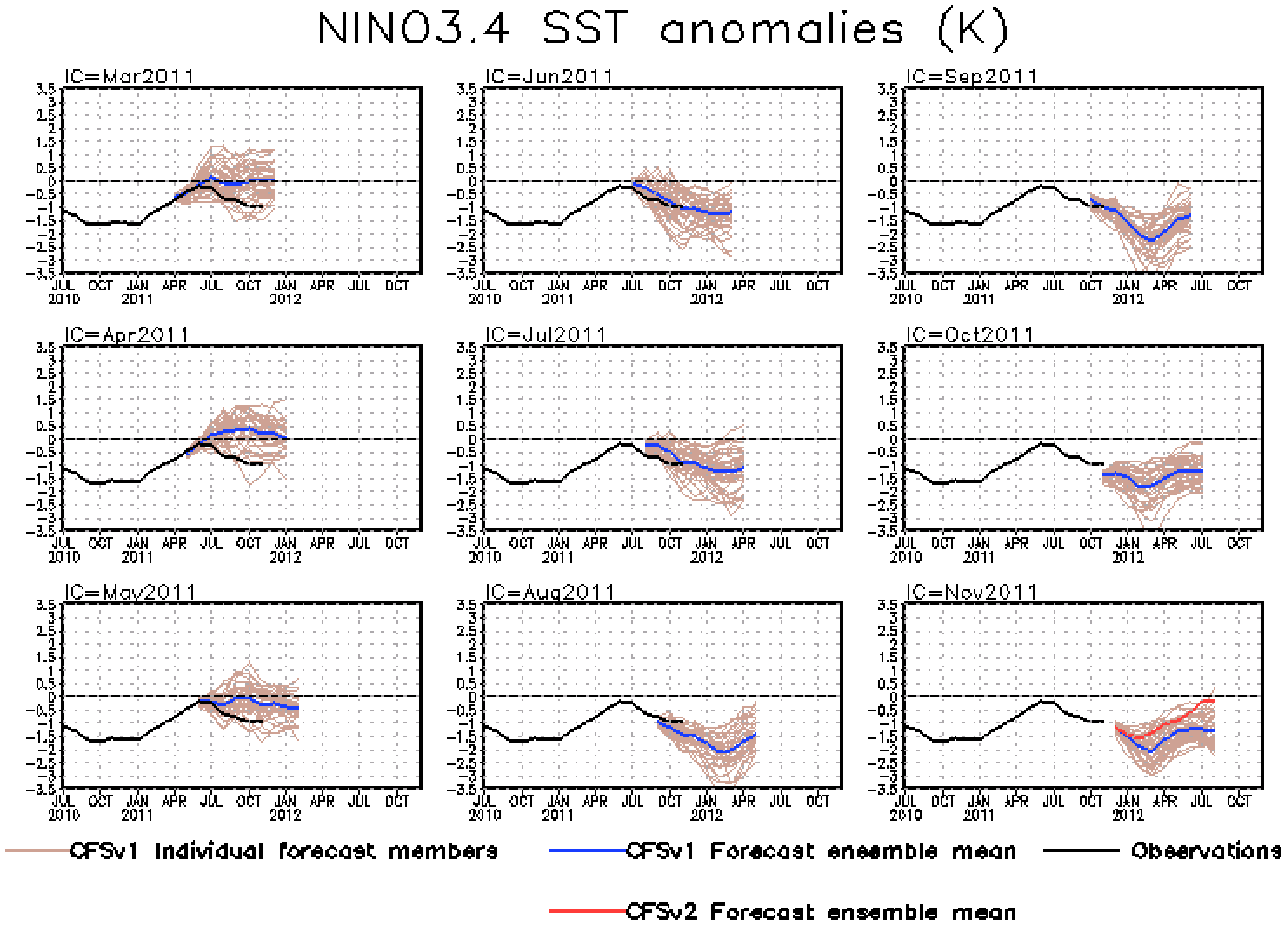


Fig. M1. CFS Nino3.4 SST prediction from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies were computed with 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 , 5°N-20°N].

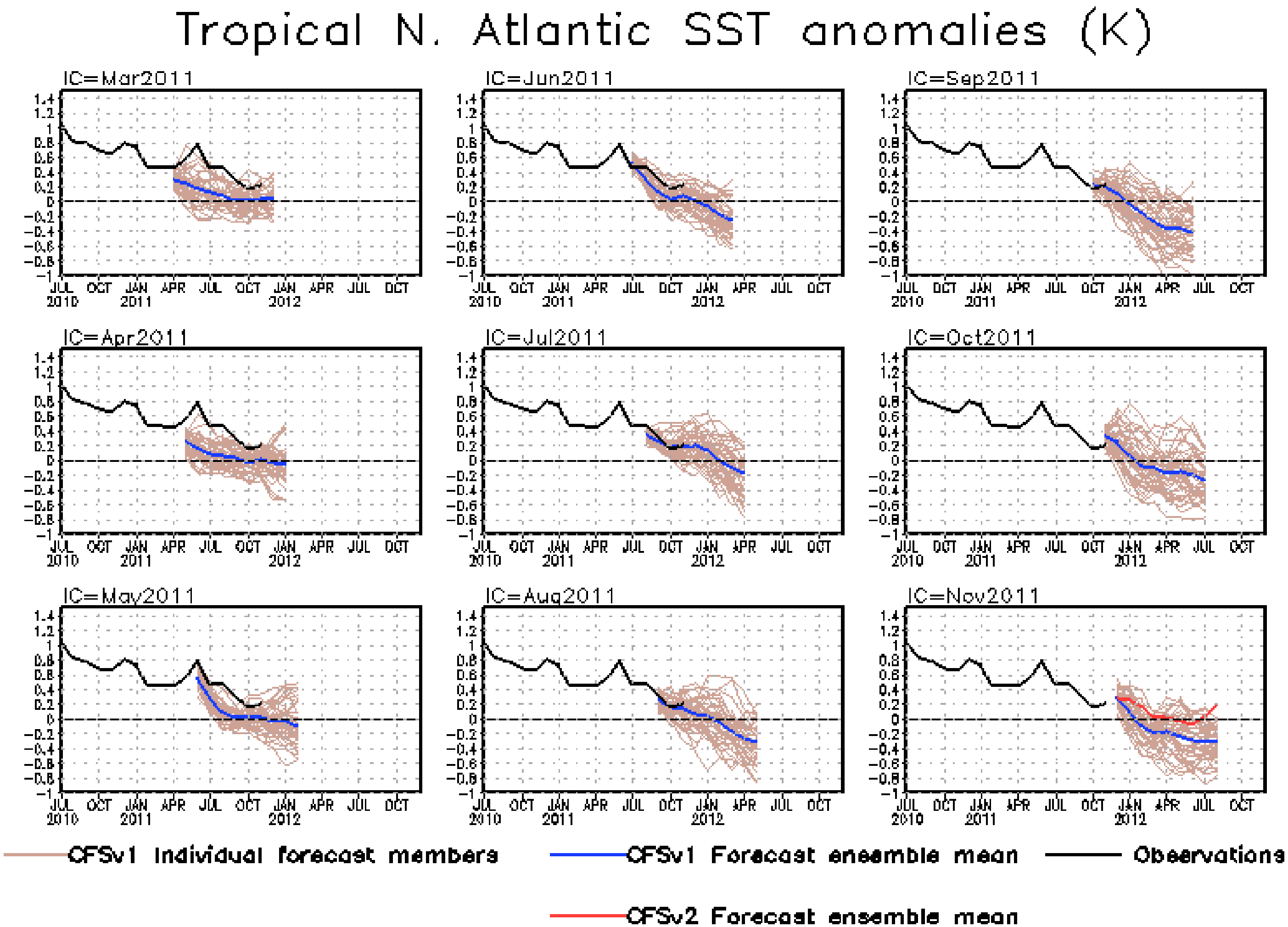
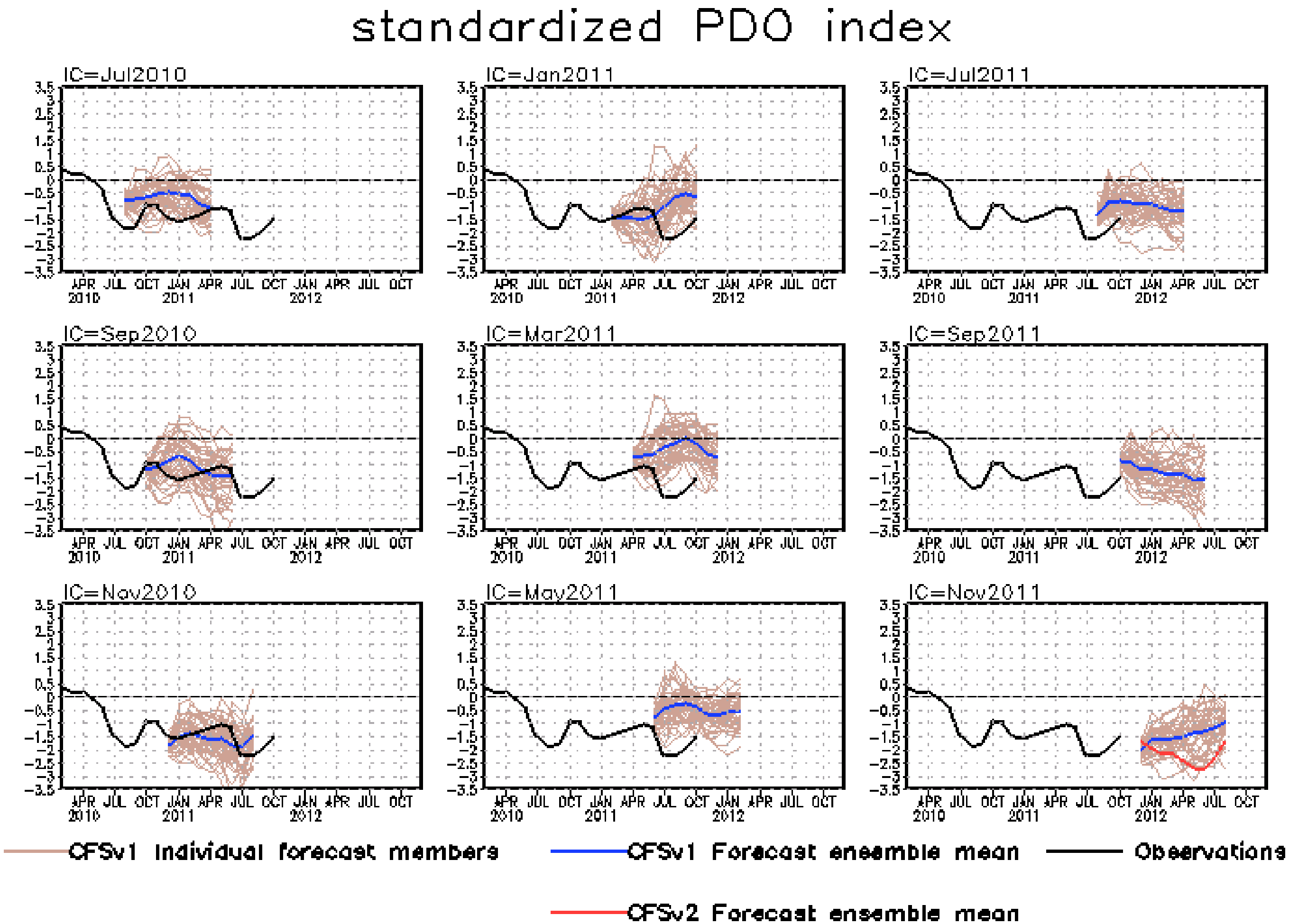


Fig. M3. CFS Tropical North Atlantic (TNA) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labelled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). Anomalies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

CFS Pacific Decadal Oscillation (PDO) Index Predictions from Different Initial Months



PDO is the first EOF of monthly ERSSTv3b anomaly in the region of [110°E-100°W, 20°N-60°N].

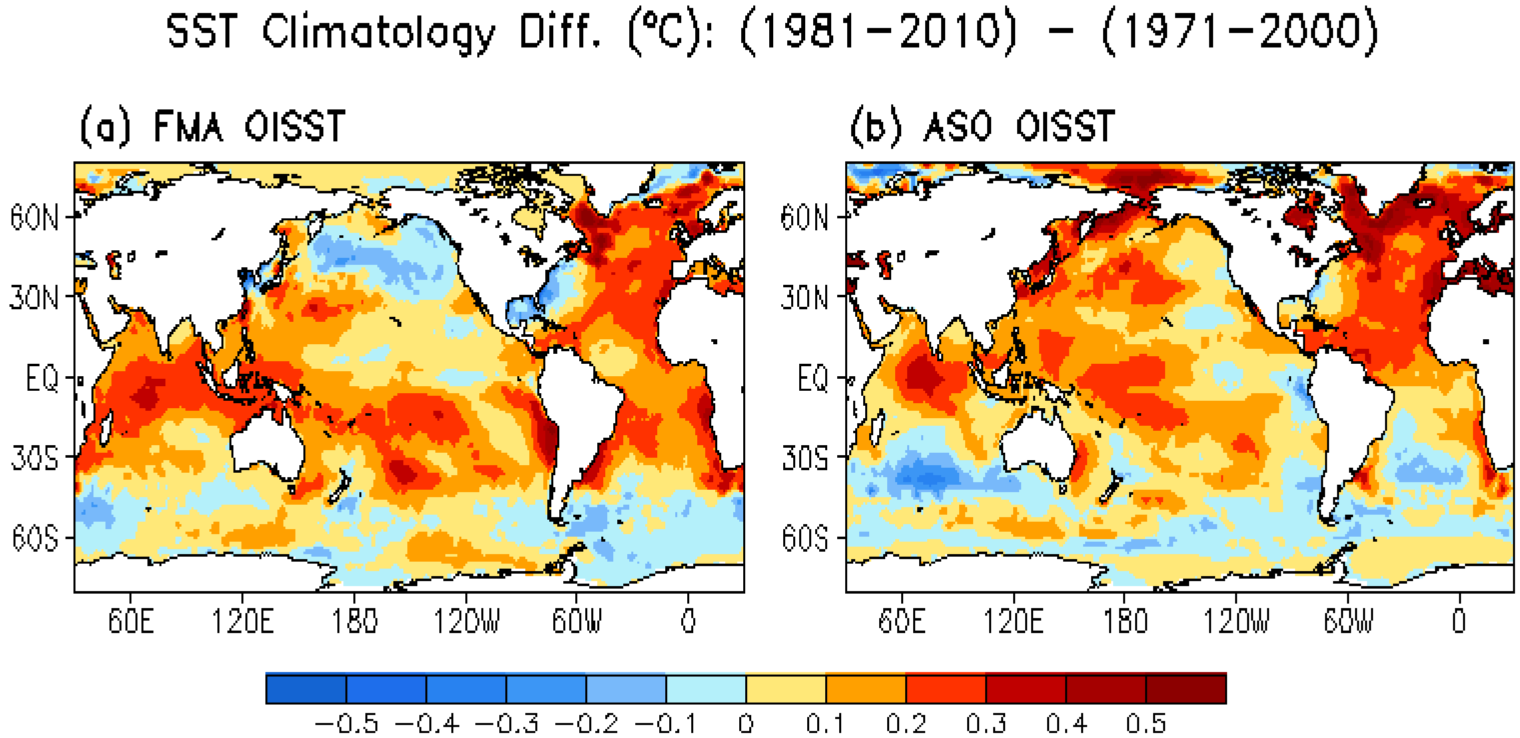
CFS PDO index is the standardized projection of CFS SST forecast anomalies onto the PDO EOF pattern.

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

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



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!