

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 Office of Climate Observation (OCO)

Outline

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

Overview

- **Pacific Ocean**

- Surface and subsurface temperature has warmed up steadily since March 09, and a transition from ENSO-neutral to El Niño conditions occurred in June 2009.
- Negative PDO phase since September 2007 has persisted for 22 months now; however it weakened substantially and became weakly below-normal in June 2009. Upwelling was below-normal in June 09.

- **Indian Ocean**

- Since mid-March 09, zonal wind anomalies were persistently easterly and SST was persistently 0.5°C above-normal.
- SST was 1.5°C (0.5 °C) above-normal in the western (eastern) tropical Indian Ocean, while Dipole Mode Index was near-normal.

- **Atlantic Ocean**

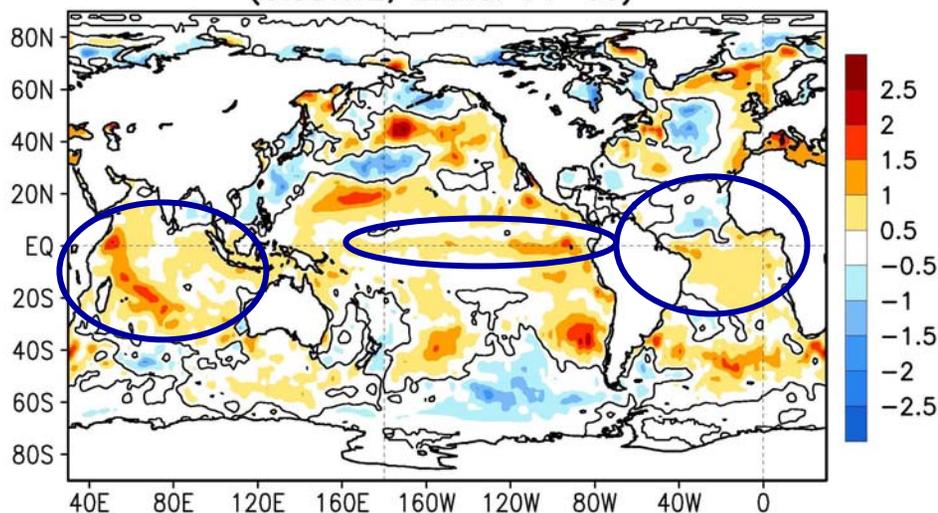
- Tropical North Atlantic SST (TNA) was slightly below-normal, while tropical South Atlantic SST (TSA) was about 0.7°C above-normal.
- ITCZ was shifted southward in responding to the negative Meridional Gradient Mode (TNA-TSA).

- **Arctic Ocean**

- Sea ice extent decreased rapidly in May, and was close to the 2007 historical low in June 09.

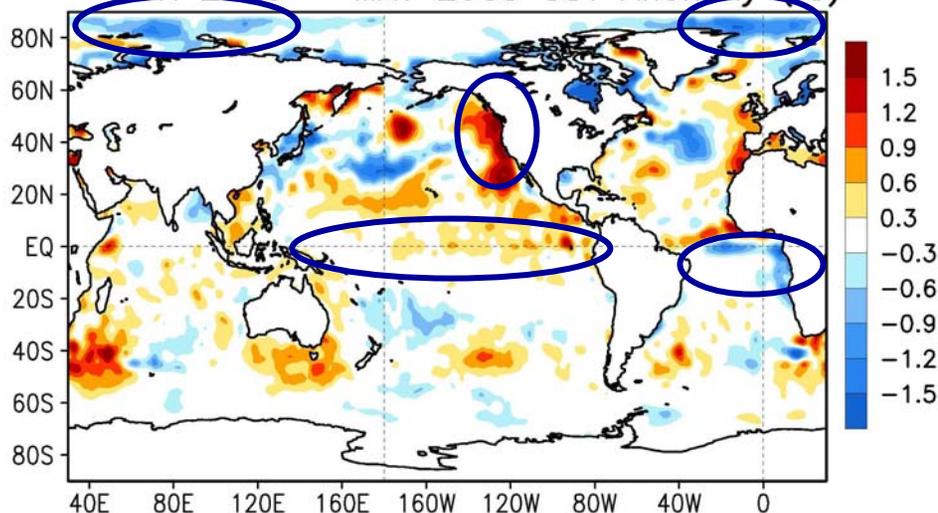
Global SST Anomaly ($^{\circ}\text{C}$) and Anomaly Tendency

JUN 2009 SST Anomaly ($^{\circ}\text{C}$)
(OISST.v2, Climo. 71-00)



- Negative PDO-like SST pattern in North Pacific weakened substantially, but the PDO index remained negative (slide 17).
- El Nino conditions (NINO 3.4 > 0.5 $^{\circ}\text{C}$) presented in the tropical Pacific.
- Positive SSTA in the tropical Indian Ocean persisted.
- Negative meridional gradient of SSTA in the tropical Atlantic persisted.

JUN 2009 - MAY 2009 SST Anomaly ($^{\circ}\text{C}$)



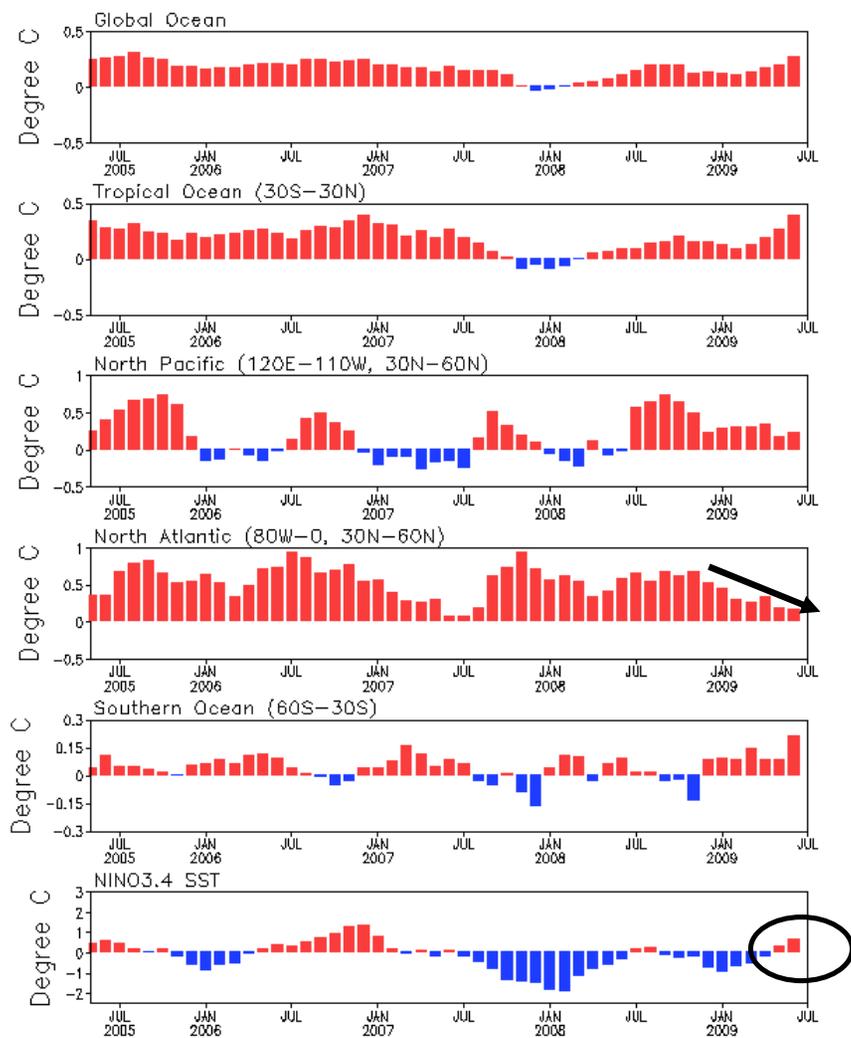
- SSTA increased in the central-eastern equatorial Pacific.
- SSTA increased substantially along the west coast of North America.
- SSTA decreased in the Arctic Ocean, and equatorial Atlantic Ocean.

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 1971-2000 base period means.

Monthly Time Series

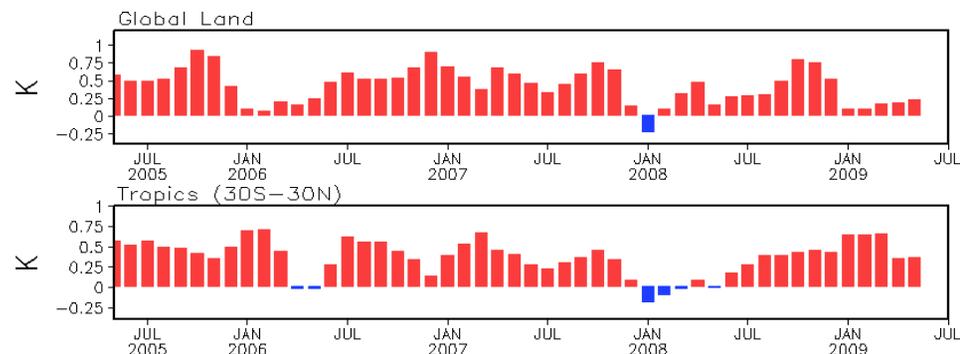
Sea Surface Temperature

Monthly SST Time Series (OISST.v2, Climo. 1971–2000)



CAMS Land Temperature

CAMS Temperature (Climo. 1982–2004)
(3–Month running mean)

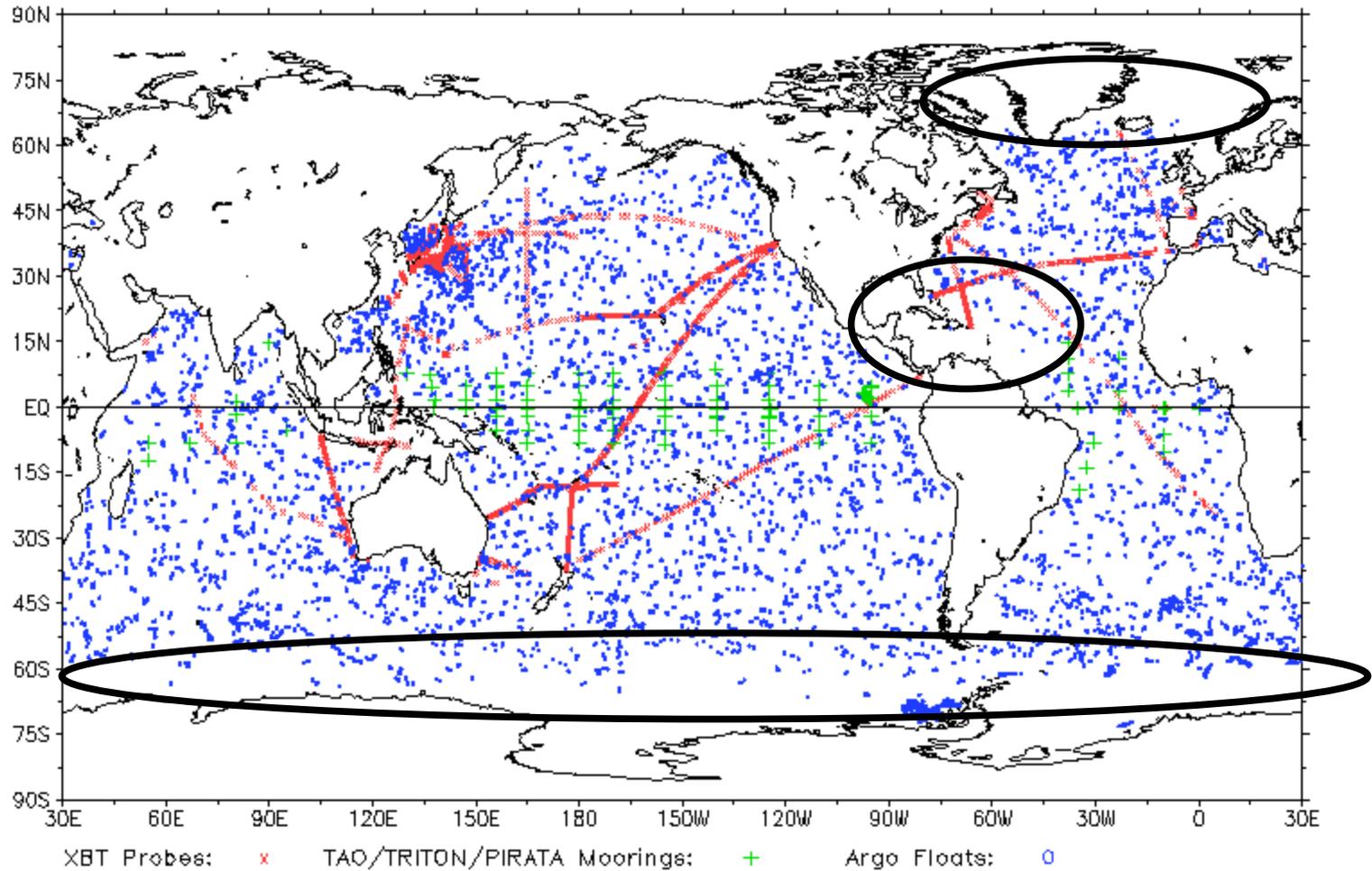


- Global mean SSTA increased slightly.
- Global mean seasonal land temperature was weakly above-normal, and persisted.
- Tropical land temperature anomalies persisted, while tropical ocean SSTA increased.
- SSTA in North Atlantic continued a downward trend since November 08.
- Southern oceans warmed up substantially.
- NINO 3.4 SST became 0.5°C above-normal, satisfying the NOAA's El Niño definition.

Fig. BU. Sea surface temperature (SST) anomalies (left) and surface air temperature anomalies (right) average for selected regions. Due to larger variability, the surface air temperature anomalies have a 3-month running mean applied. Anomalies were computed with respect to the 1971-2000 base period means.

In Situ Observation Distribution (quality controlled)

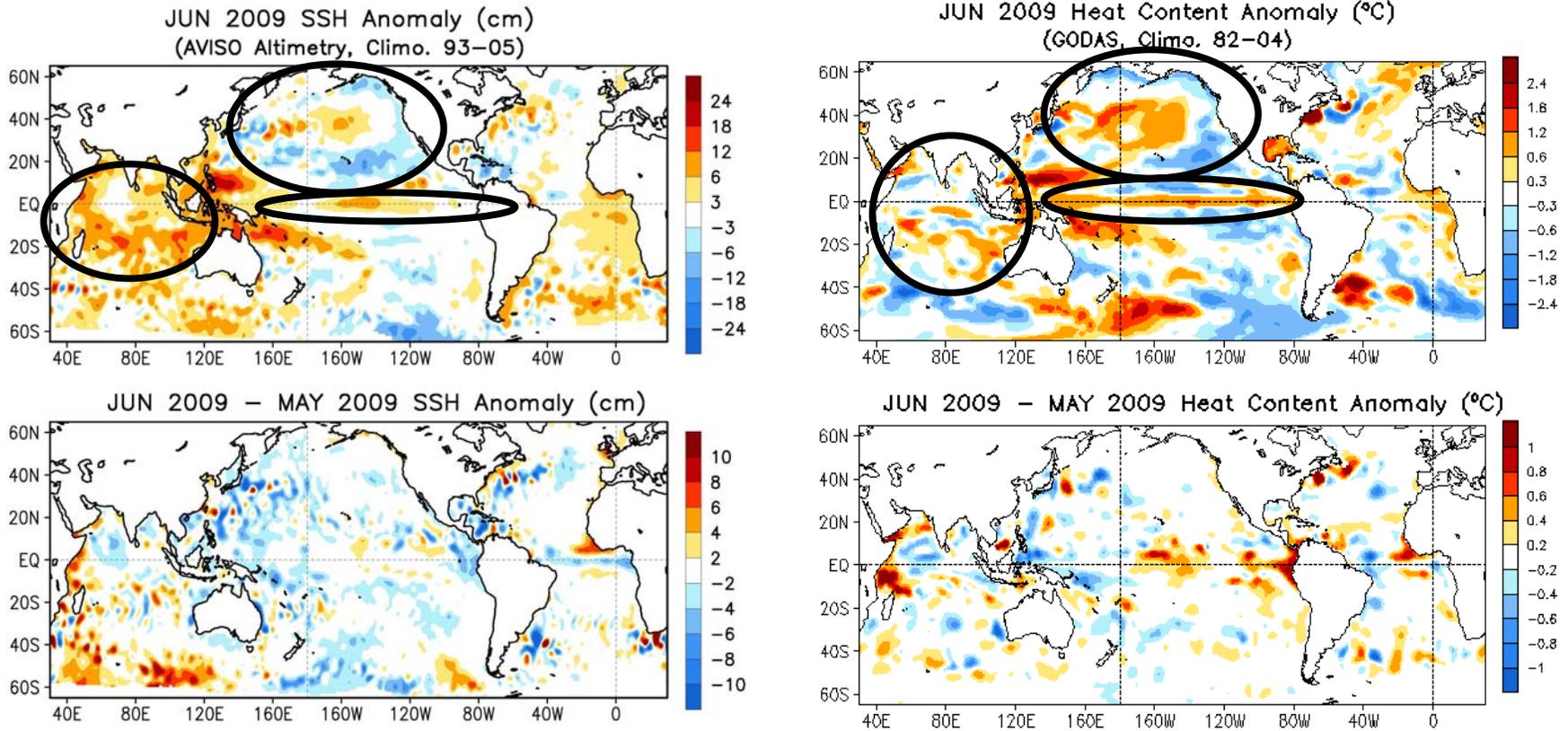
Temperature profiles (0–250m), 2009 Jun



- Data coverage was poor in

- Gulf of Mexico, the Caribbean Sea and western tropical North Atlantic
- South of 60°S and ice-covered regions
- North of 60°N and ice-covered regions

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

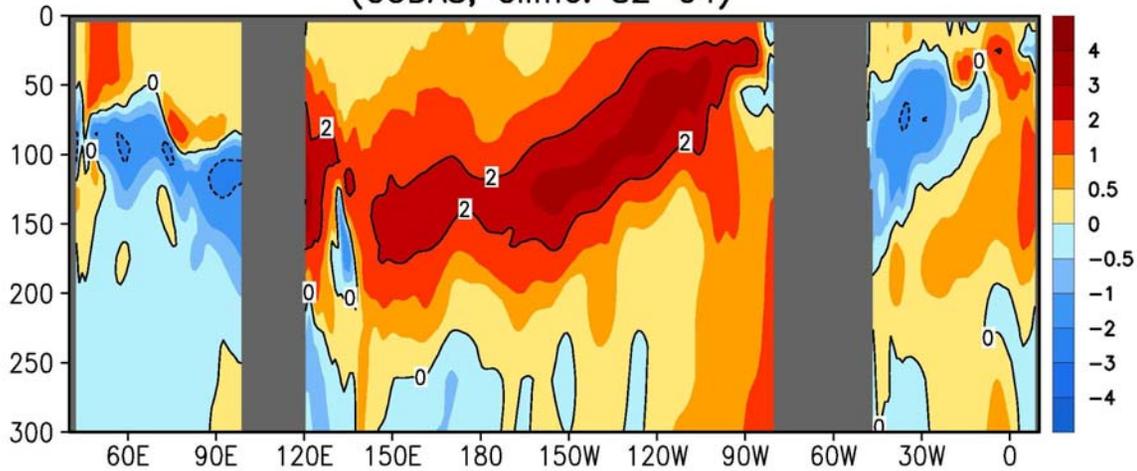


- Negative PDO-like pattern presented in SSHA and HCA in the North Pacific.
- Positive SSHA and HCA presented in the equatorial Pacific, consistent with the weak El Niño conditions.
- Patterns of SSHA and HCA were largely consistent except in the tropical Indian Ocean where biases in GODAS HCA were large.

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.avisioceanobs.com>, and HCA from GODAS.

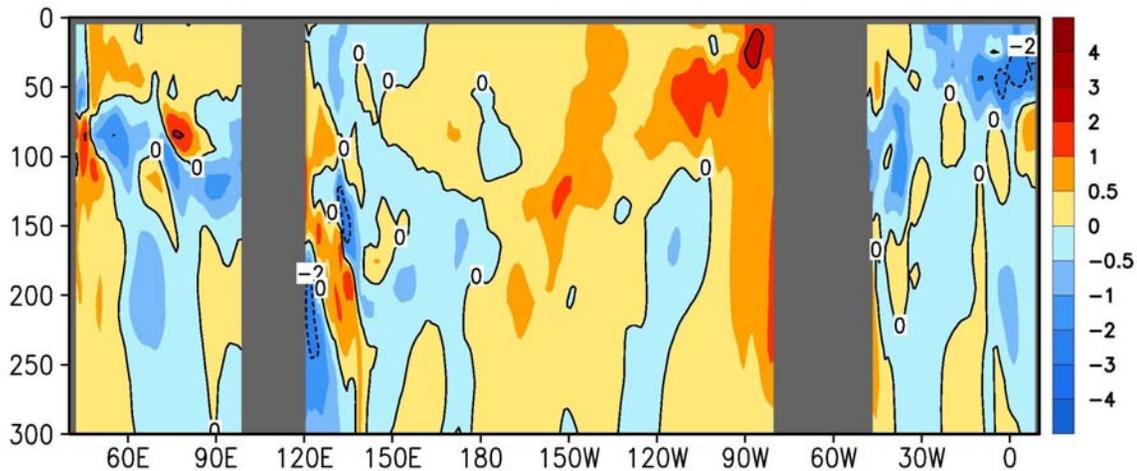
Longitude-Depth Temperature Anomaly and Anomaly Tendency in 2°S-2°N

JUN 2009 Eq. Temp Anomaly (°C)
(GODAS, Climo. 82-04)



- Positive subsurface temperature anomalies about 3°C presented near the thermocline in the eastern equatorial Pacific.

JUN 2009 – MAY 2009 Eq. Temp Anomaly (°C)

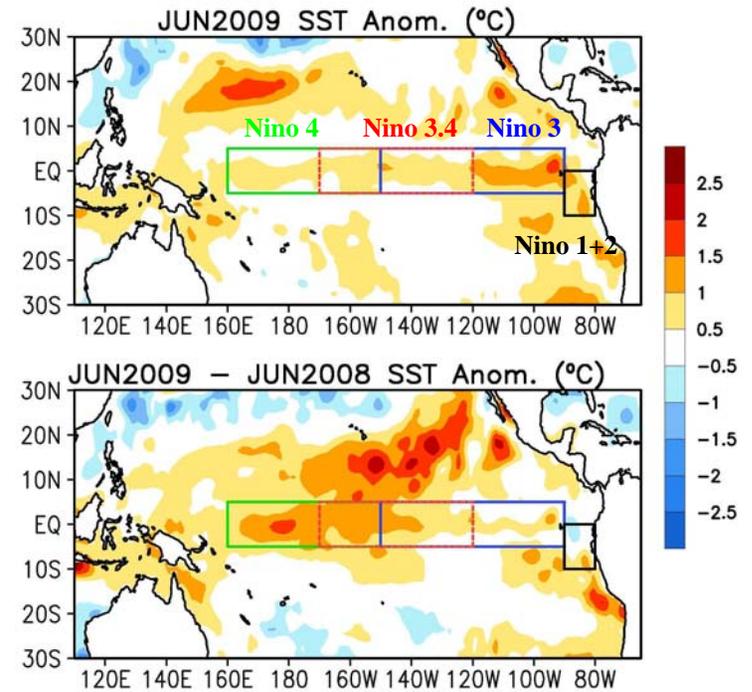
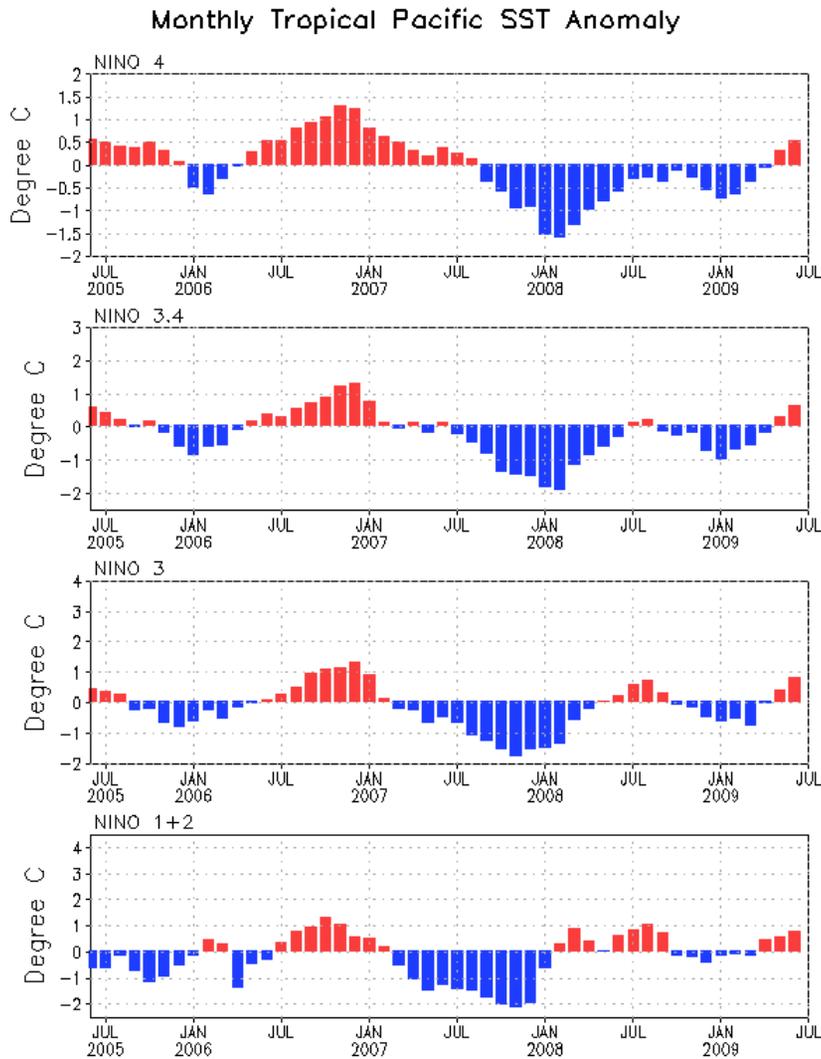


- Positive subsurface temperature anomalies in the eastern equatorial Atlantic weakened substantially.

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 1982-2004 base period means.

Tropical Pacific Ocean

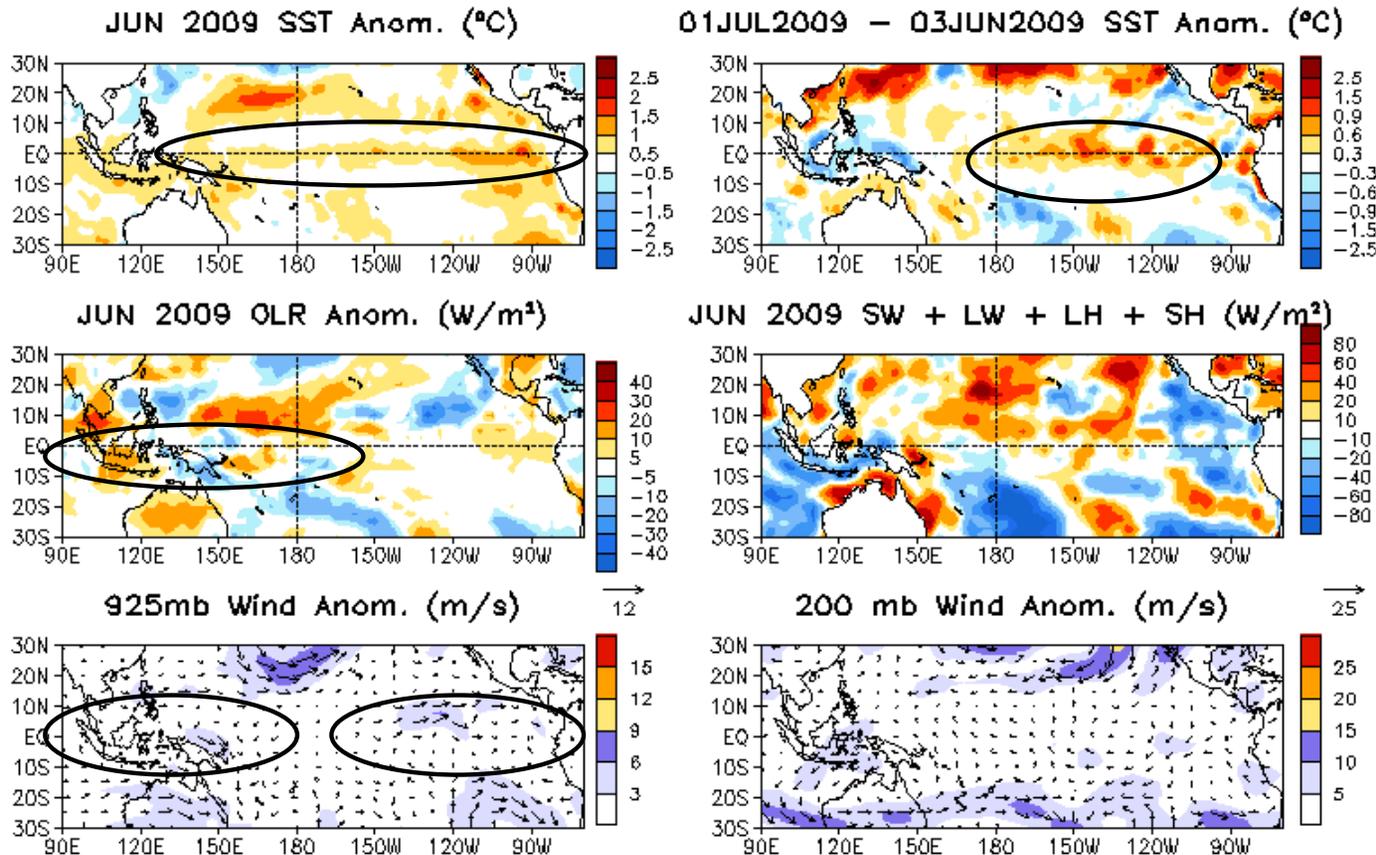
Evolution of Pacific NINO SST Indices



- El Niño conditions (NINO 3.4 > 0.5°C) were satisfied in June 09, and are expected to last through the Northern Hemisphere Winter – NOAA's "ENSO Diagnostic Discussion".
- All NINO indices were 0.5°C above-normal in June 09.

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 1971-2000 base period means.

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



- Positive SSTA presented along the equatorial Pacific.
- SST warmed up (cooled down) in the central-eastern (far western) tropical Pacific.
- Convection was suppressed (enhanced) over the Maritime Continent (in the western Pacific).
- Low-level westerly wind anomalies presented in the far western and eastern Pacific.

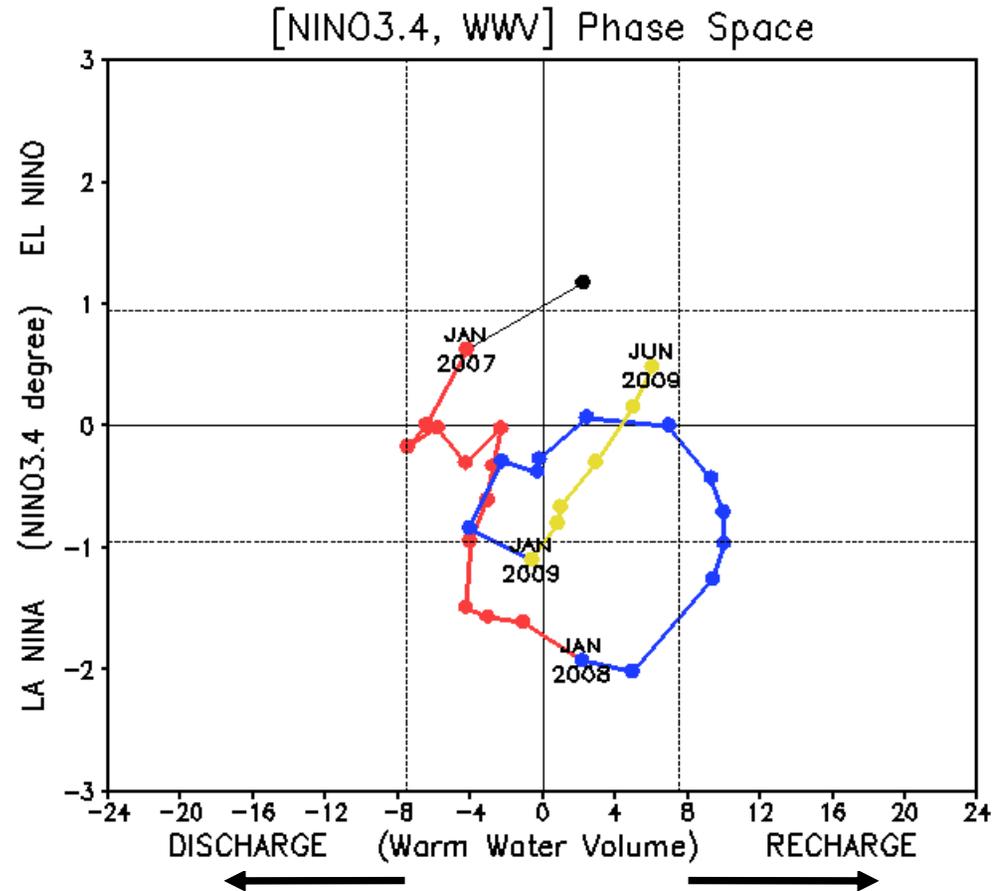
Fig. P2. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sum of net surface short- and long-wave radiation, latent and sensible heat flux anomalies (middle-right), 925-mb wind anomaly vector and its amplitude (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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

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] (Meinen and McPhaden, 2000).

- Since WWV is intimately linked to ENSO variability (Wyrтки 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.



- Both NINO3.4 and Warm Water Volume (WWV) have been increasing steadily since March 09.
- Compared to last June, NINO3.4 was much warmer, but subsurface warm water volume was slightly lower.
- However, the trend of the trajectory suggests NINO3.4 will likely increase in next 1-2 months.

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 for WWV (NINO 3.4) are departures from the 1982-2004 (1971-2000) base period means.

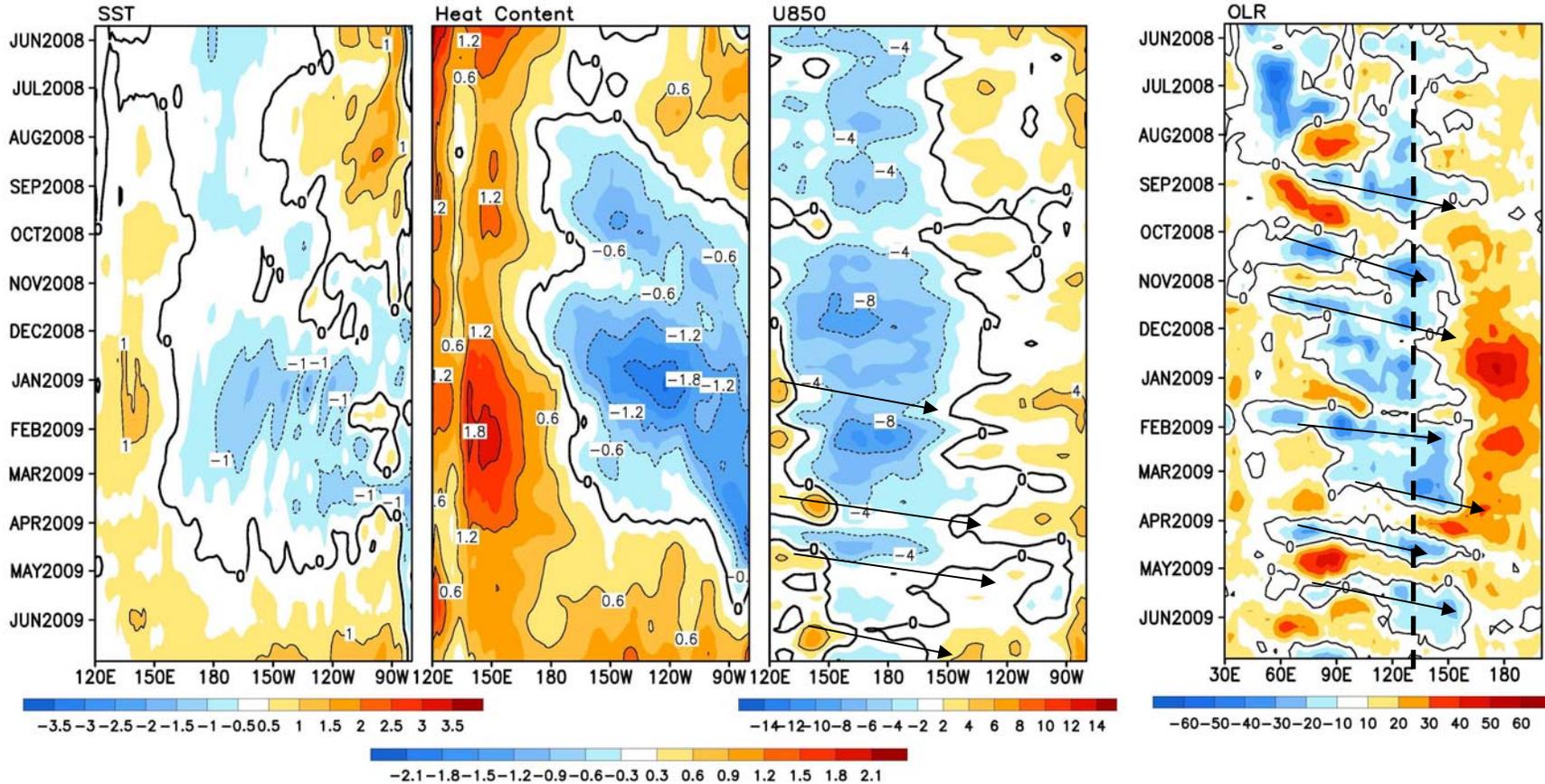
Evolution of Equatorial Pacific SST ($^{\circ}\text{C}$), 0-300m Heat Content ($^{\circ}\text{C}$),

850-mb Zonal Wind (m/s), and OLR (W/m^2) Anomaly

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

5 $^{\circ}\text{S}$ –5 $^{\circ}\text{N}$ Average
(3 Pentad Running Mean)

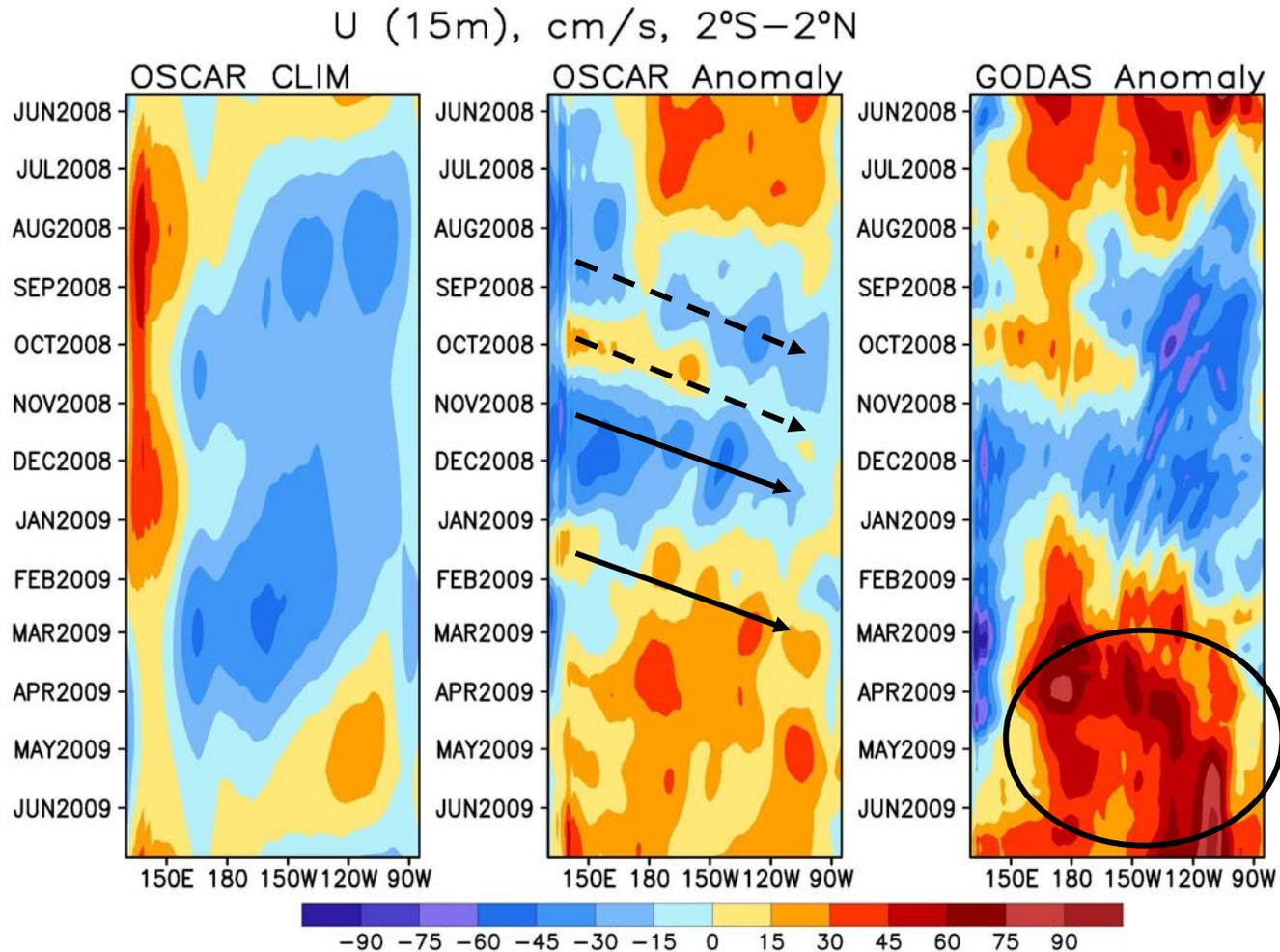
La Nina



- SST was 0.5C above-normal across the equatorial Pacific in June 09.
- Positive heat content anomalies strengthened in June due to westerly wind anomalies in the far western and eastern Pacific.
- MJO was very active during Jan-Jun 09, and MJO-related westerly wind anomalies contributed to the onset of the 2009 El Niño.

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 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

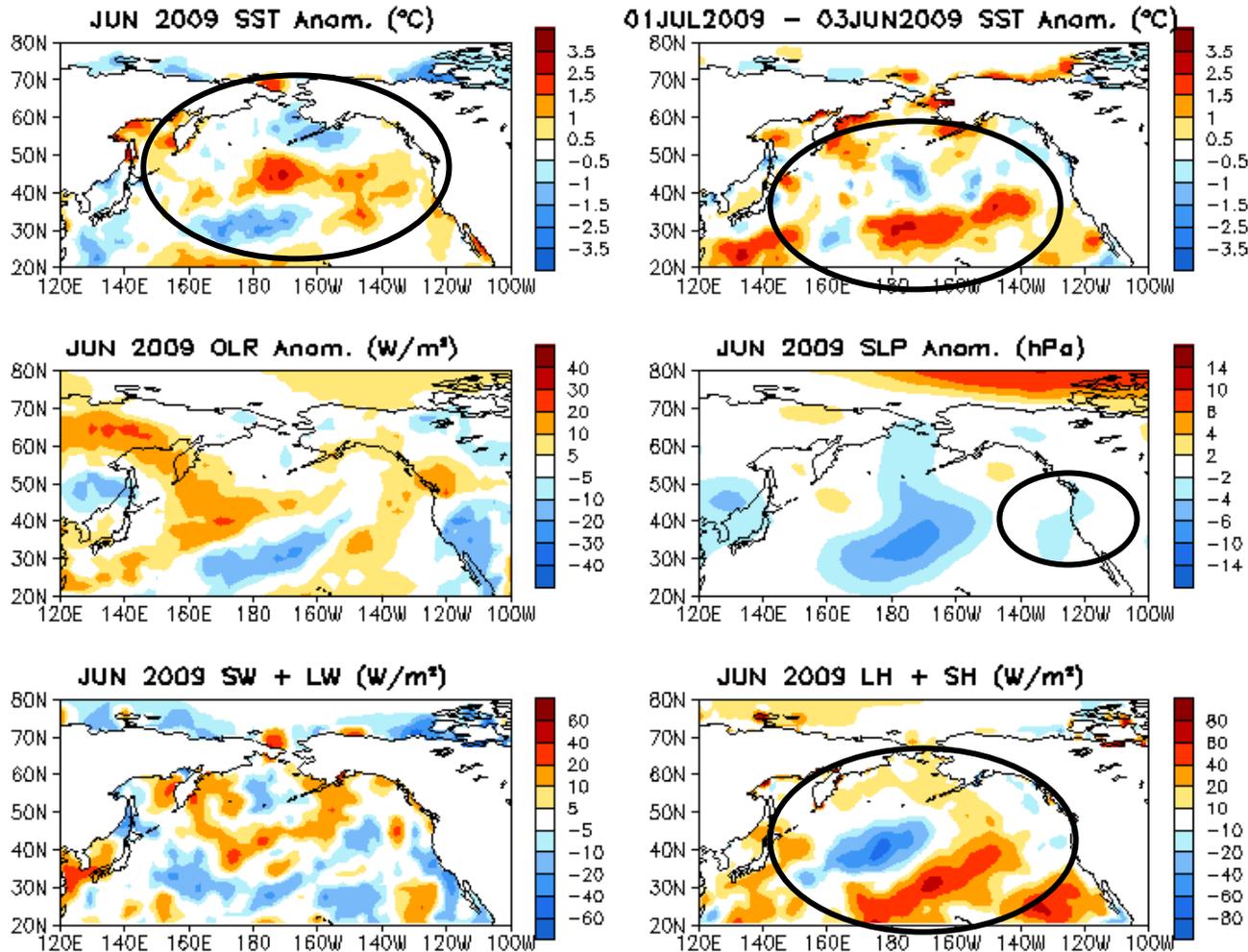
Evolution of Equatorial Pacific Surface Zonal Current Anomaly (cm/s)



- Eastward propagation of negative (positive) surface zonal current anomalies were associated with upwelling (downwelling) oceanic Kelvin waves.
- Surface zonal current anomaly has been positive since mid-Jan 09, consistent with the transition from La Nina to ENSO-neutral conditions in April 09 and the transition to El Nino conditions in June 09.
- Positive surface zonal current anomalies simulated by GODAS were too strong compared with those of the OSCAR currents.

North Pacific & Arctic Ocean

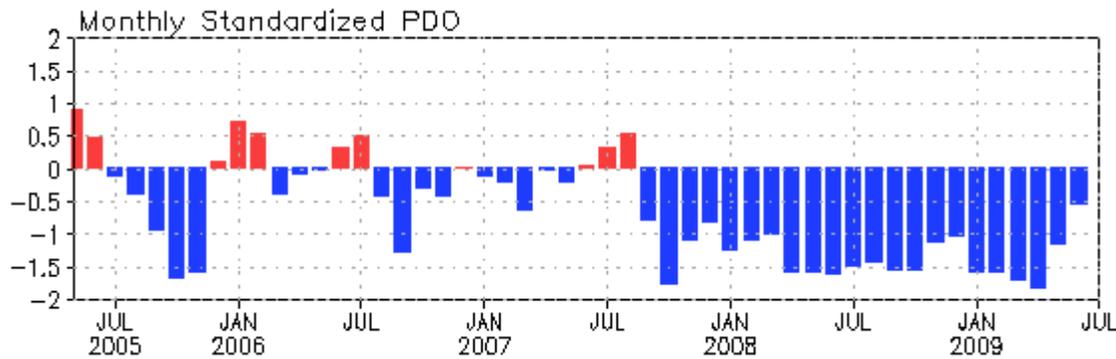
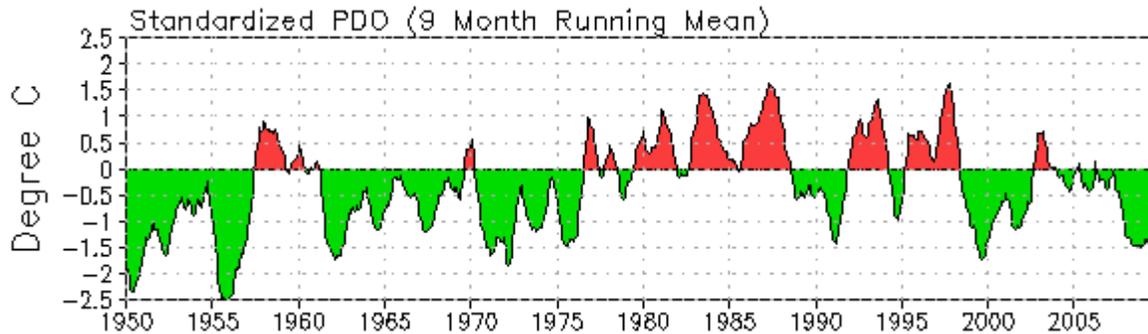
North Pacific & Arctic Ocean: SST Anom., SST Anom. Tend., OLR, SLP, Sfc Rad, Sfc Flx



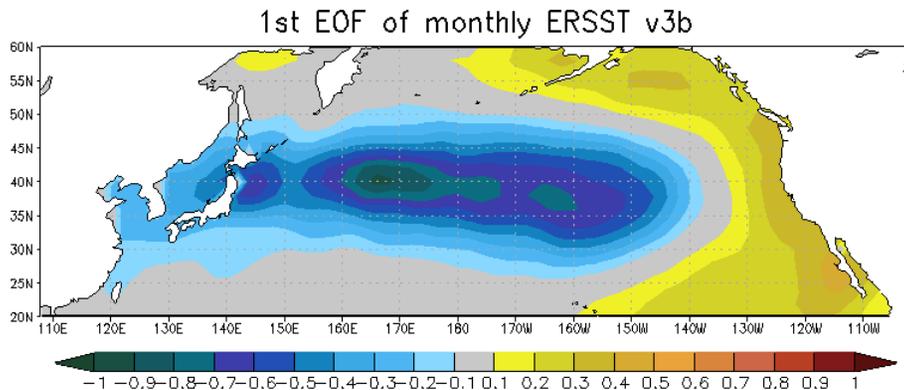
- Negative PDO-like SST pattern in the North Pacific weakened.
- SSTA tendencies were consistent with the net surface heat flux anomalies.
- Below-normal sea level pressure implicated southerly wind anomalies along the west coast of North America, unfavourable for coastal upwelling.

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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

PDO index



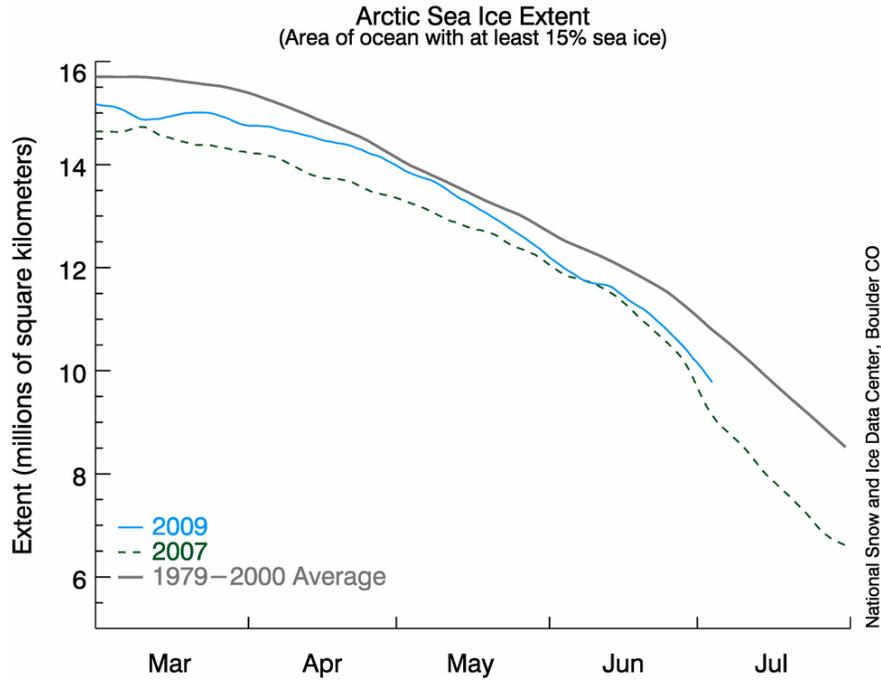
- Negative PDO index started in September 2007, and has persisted for 22 months.
- Negative PDO index weakened substantially, and became -0.6 in June 09.



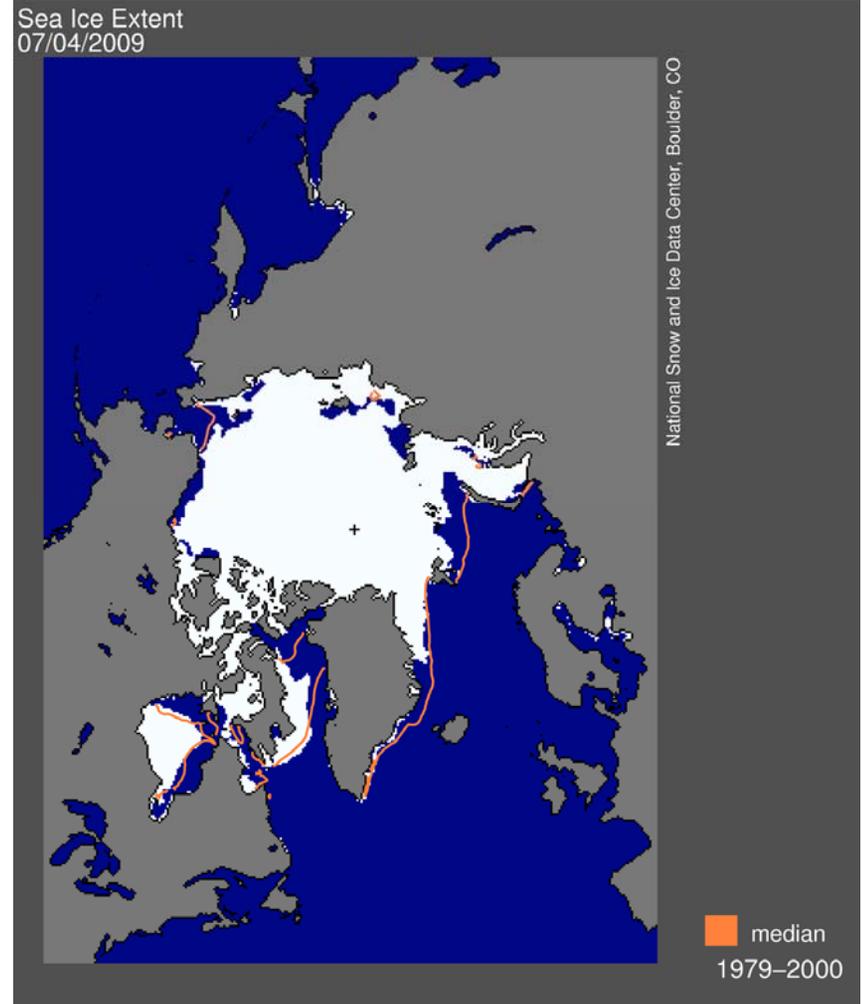
- Pacific Decadal Oscillation is defined as the 1st EOF of monthly ERSST v3b in the North Pacific for the period 1900-1993. PDO index is the standardized projection of the monthly SST anomalies onto the 1st EOF pattern.
- The PDO index differs slightly from that of JISAO, which uses a blend of UKMET and OIv1 and OIv2 SST.

Arctic Sea Ice

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

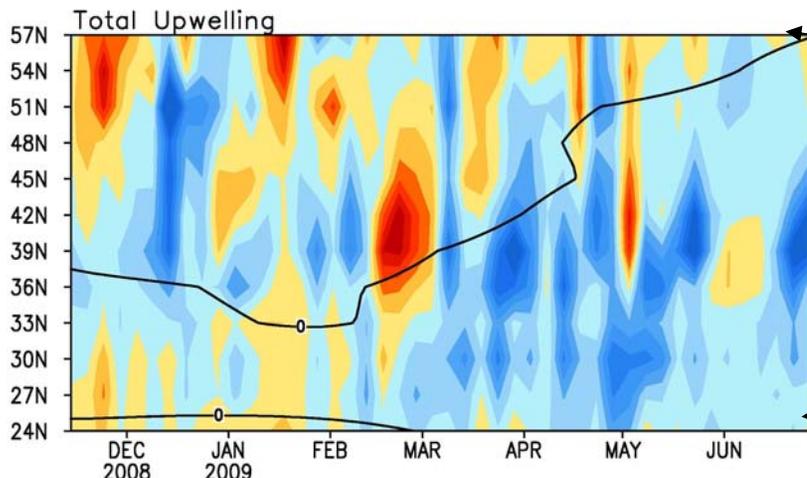


- Sea ice extent decreased rapidly in May and was close at the 2007 historical low during June 09.

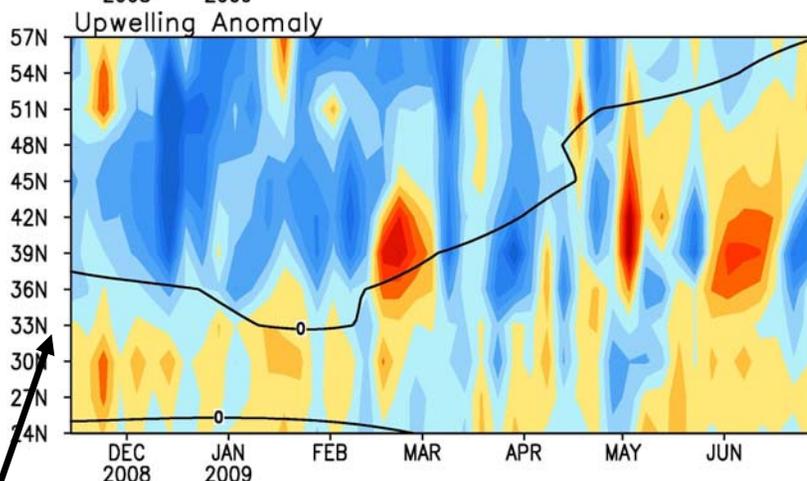
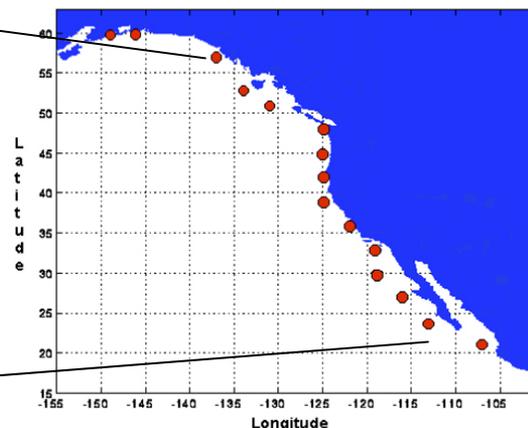


North America Western Coastal Upwelling

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



Standard Positions of Upwelling Index Calculations



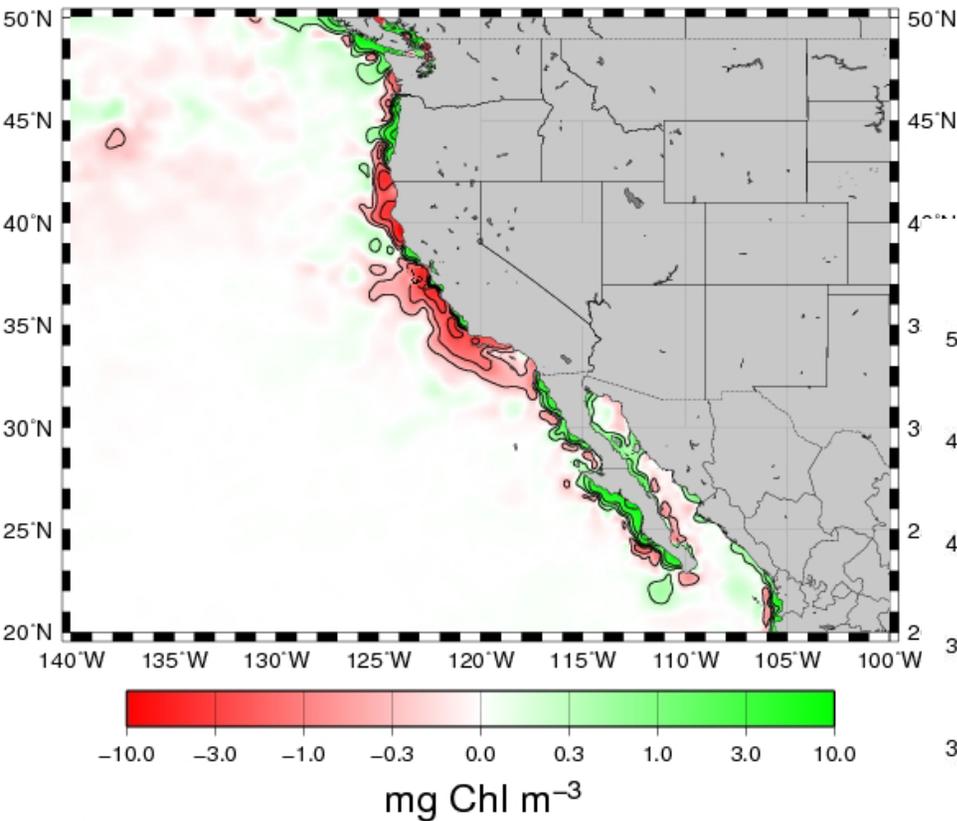
- Upwelling had large week-to-week variability.
- The monthly mean was below-normal in June 09.

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 1982-2004 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.

Monthly Chlorophyll Anomaly

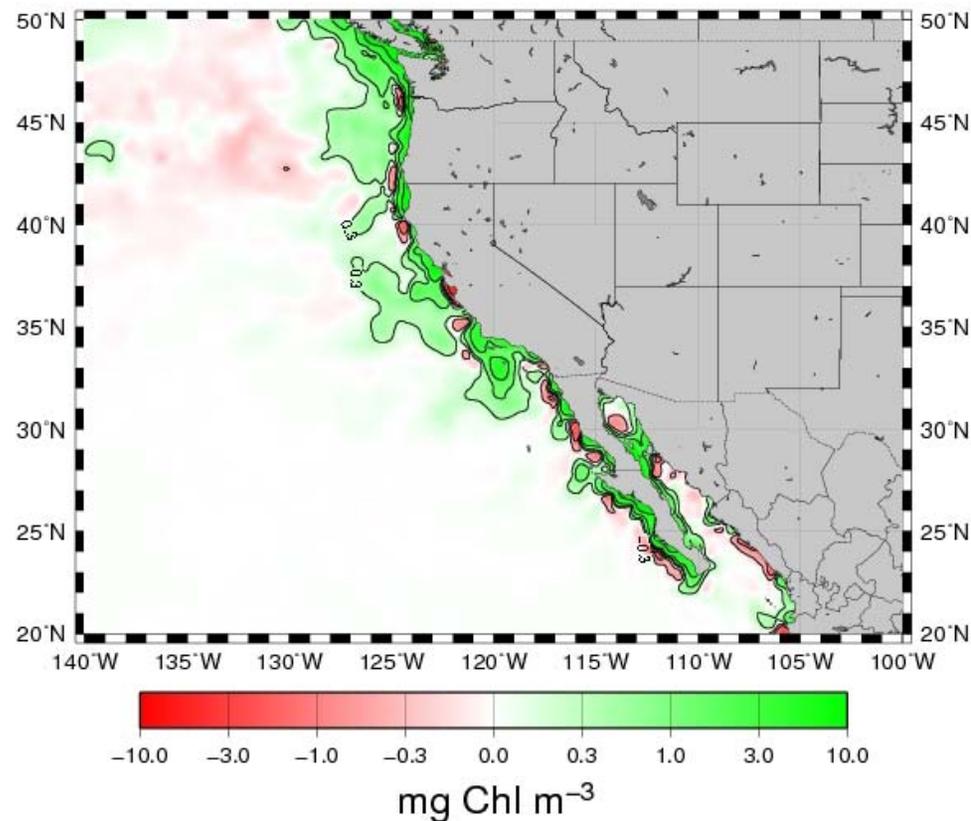
MODIS Aqua Chlorophyll a Anomaly for June, 2009



2009 Jul 1 11:51:14 Data courtesy of NASA GSFC

- Negative Chlorophyll anomalies presented along the west coast of North America between 32N-42N, which were consistent with below-normal upwelling from late May to late June.

MODIS Aqua Chlorophyll a Anomaly for May, 2009

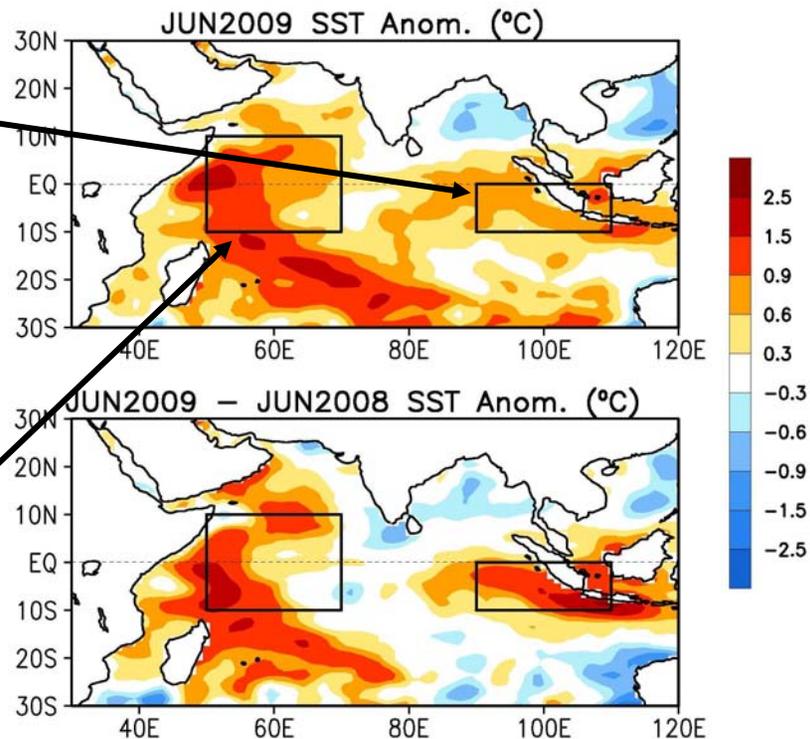
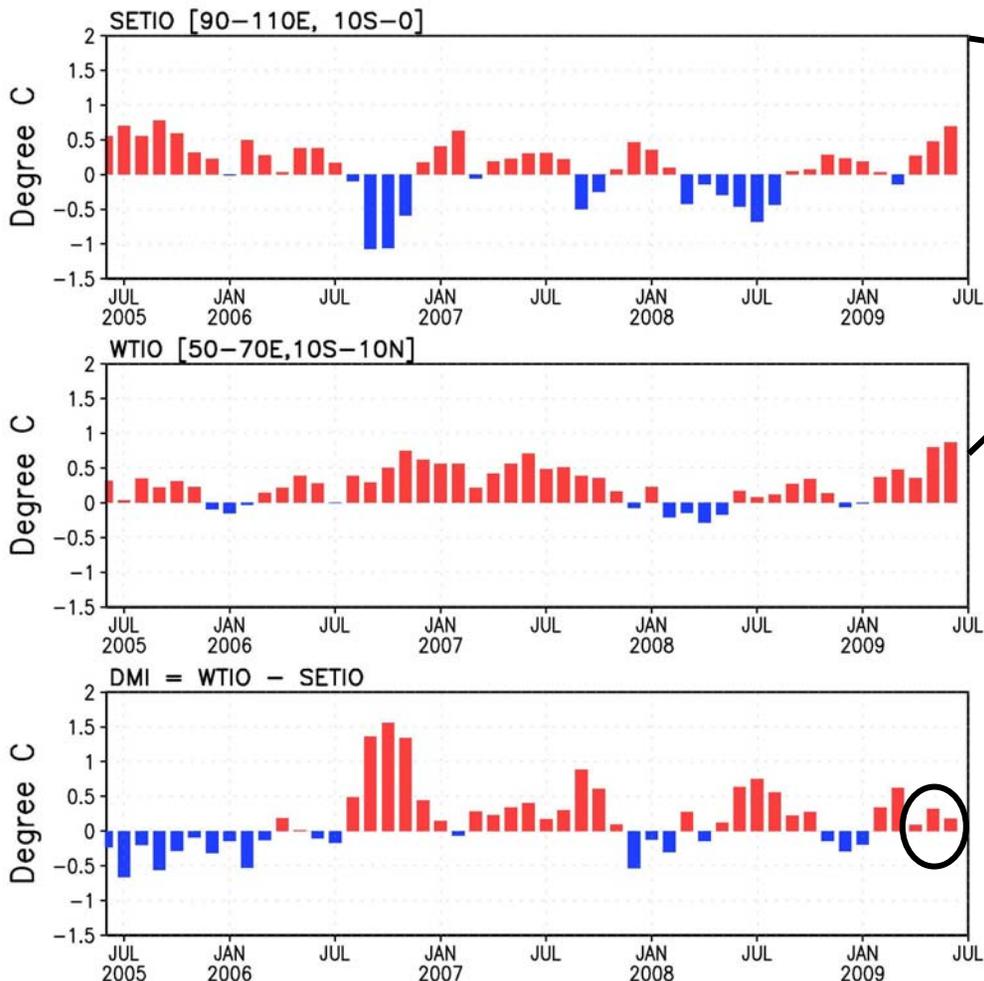


2009 Jun 2 12:52:40 Data courtesy of NASA GSFC

Tropical Indian Ocean

Evolution of Indian Ocean SST Indices

Indian Ocean Dipole Mode Indices



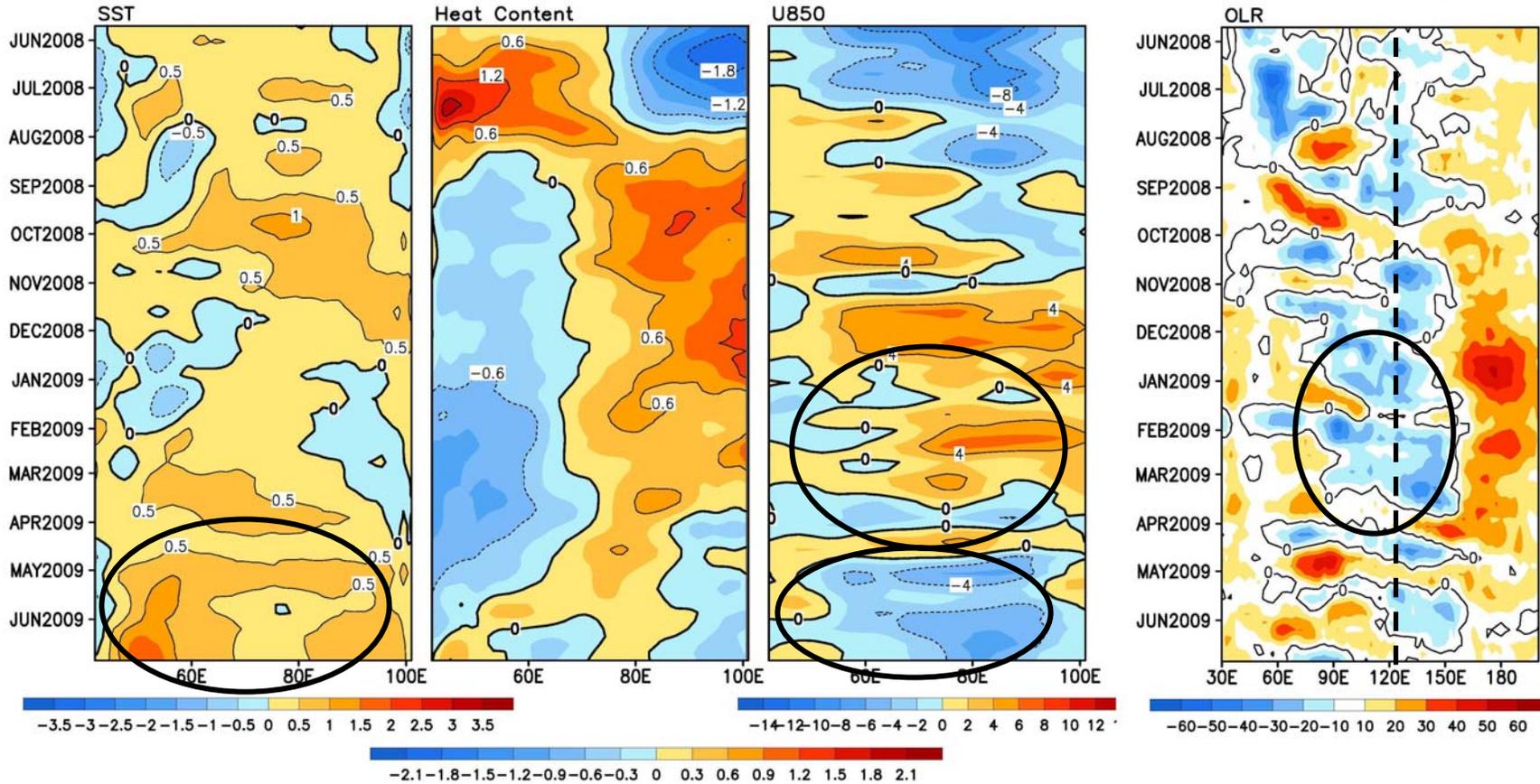
- Positive eastern pole SSTA (SETIO) strengthened.
- Positive western pole SSTA (WTIO) persisted.
- DMI was weakly above-normal.
- Large positive SSTA (> 1.5 °C) presented in the western tropical Indian Ocean.

Fig. 11a. 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 1971-2000 base period means.

Recent Evolution of Equatorial Indian SST ($^{\circ}\text{C}$), 0-300m Heat Content ($^{\circ}\text{C}$), 850-mb Zonal Wind (m/s) and OLR (W/m^2) Anomalies

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

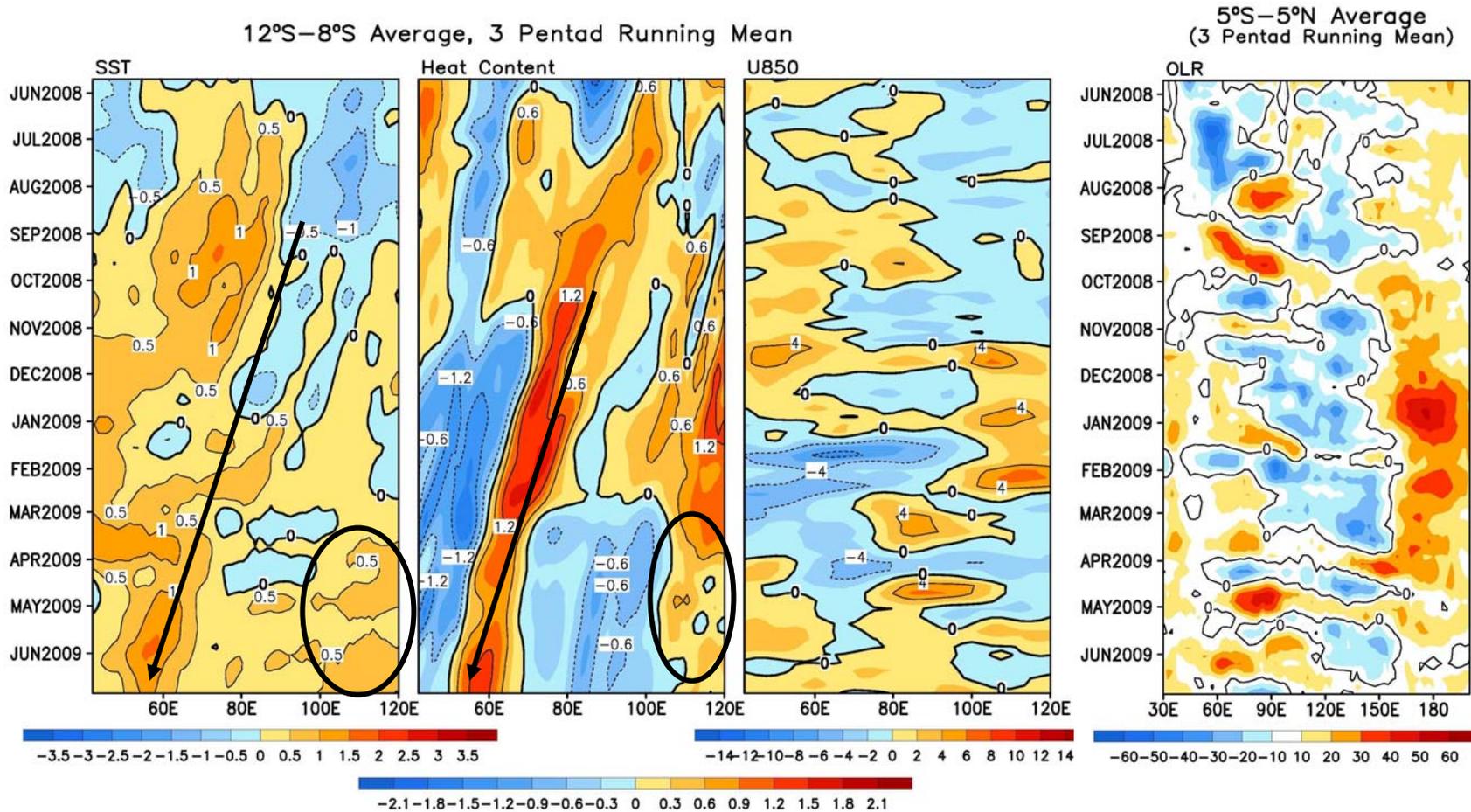
5 $^{\circ}\text{S}$ –5 $^{\circ}\text{N}$ Average
(3 Pentad Running Mean)



- Westerly wind anomalies from Nov 08 to Feb 09 were associated with the La Nina conditions in the tropical Pacific.
- Since mid-March 09, easterly wind anomalies were dominant,, and SST was about 0.5 $^{\circ}\text{C}$ above-normal.
- Were the easterly wind anomalies associated with the positive SSTA in the tropical Indian Ocean?

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 $^{\circ}\text{S}$ -2 $^{\circ}\text{N}$ and Outgoing Long-wave Radiation (OLR, right) averaged in 5 $^{\circ}\text{S}$ -5 $^{\circ}\text{N}$. SST 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 for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

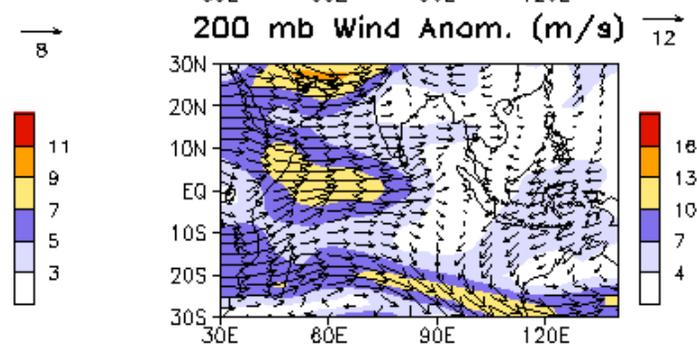
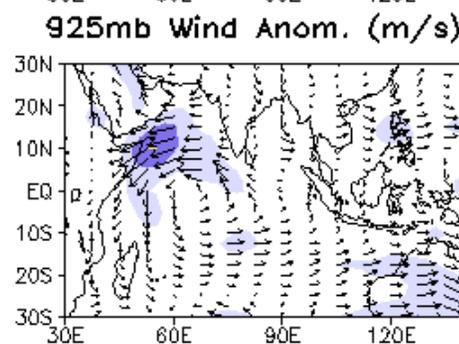
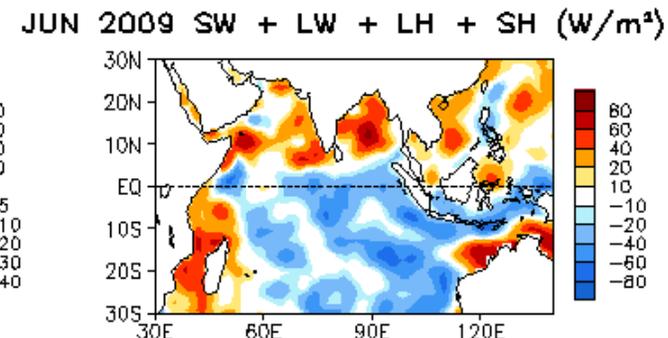
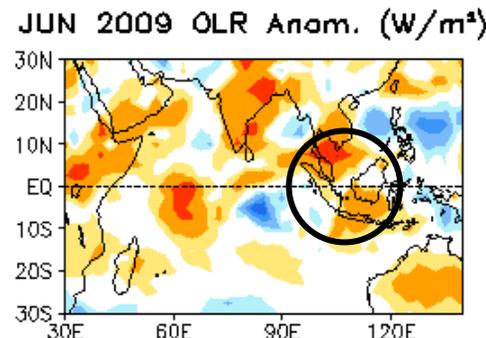
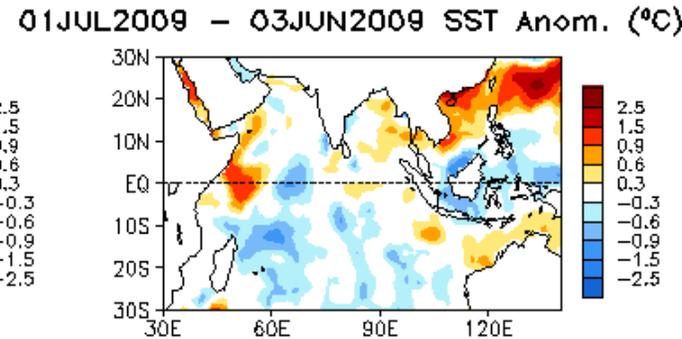
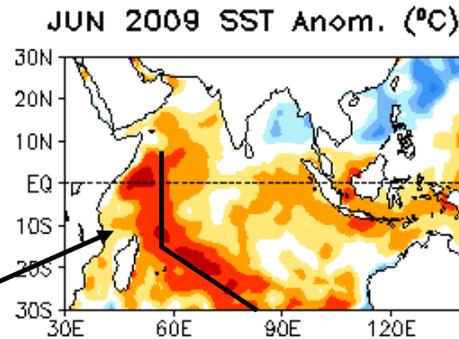
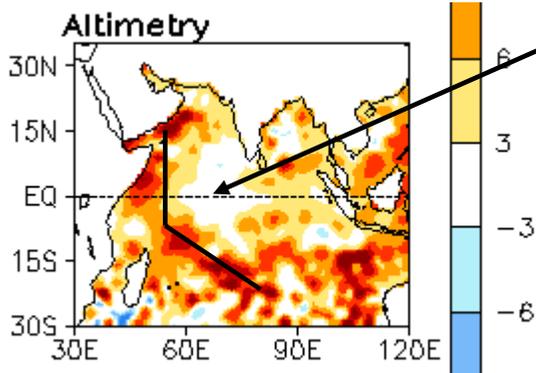
Recent Evolution of 10°S Indian SST (°C), 0-300m Heat Content (°C), 850-mb Zonal Wind (m/s)



- Westward propagation of positive HCA near 10°S probably contributed to the recent warming in SST near 60°E.
- Positive SSTA east of 100°E was consistent with positive HCA there.

Fig. 14. 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 12°S-8°S 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 for SST, heat content and U850/OLR are departures from the 1971-2000, 1982-2004, 1979-1995 base period pentad means respectively.

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



- Positive SSTA was associated with positive SSHA in the western tropical Indian and subtropical southern Indian Ocean.

- Convection was suppressed in the central tropical Indian Ocean, and Maritime Continent.

Fig. 12. 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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

Tropical Atlantic Ocean

Evolution of Tropical Atlantic SST Indices

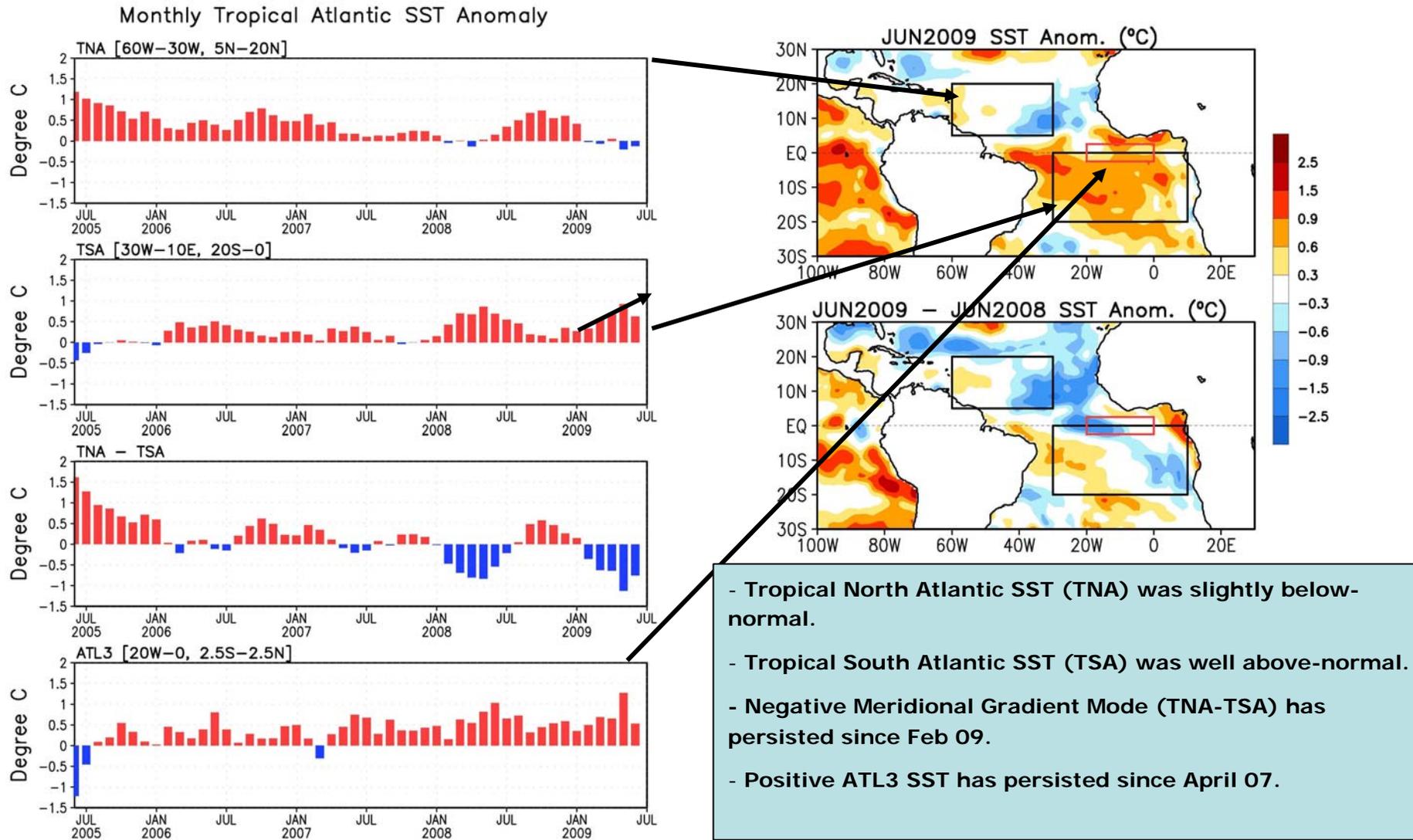
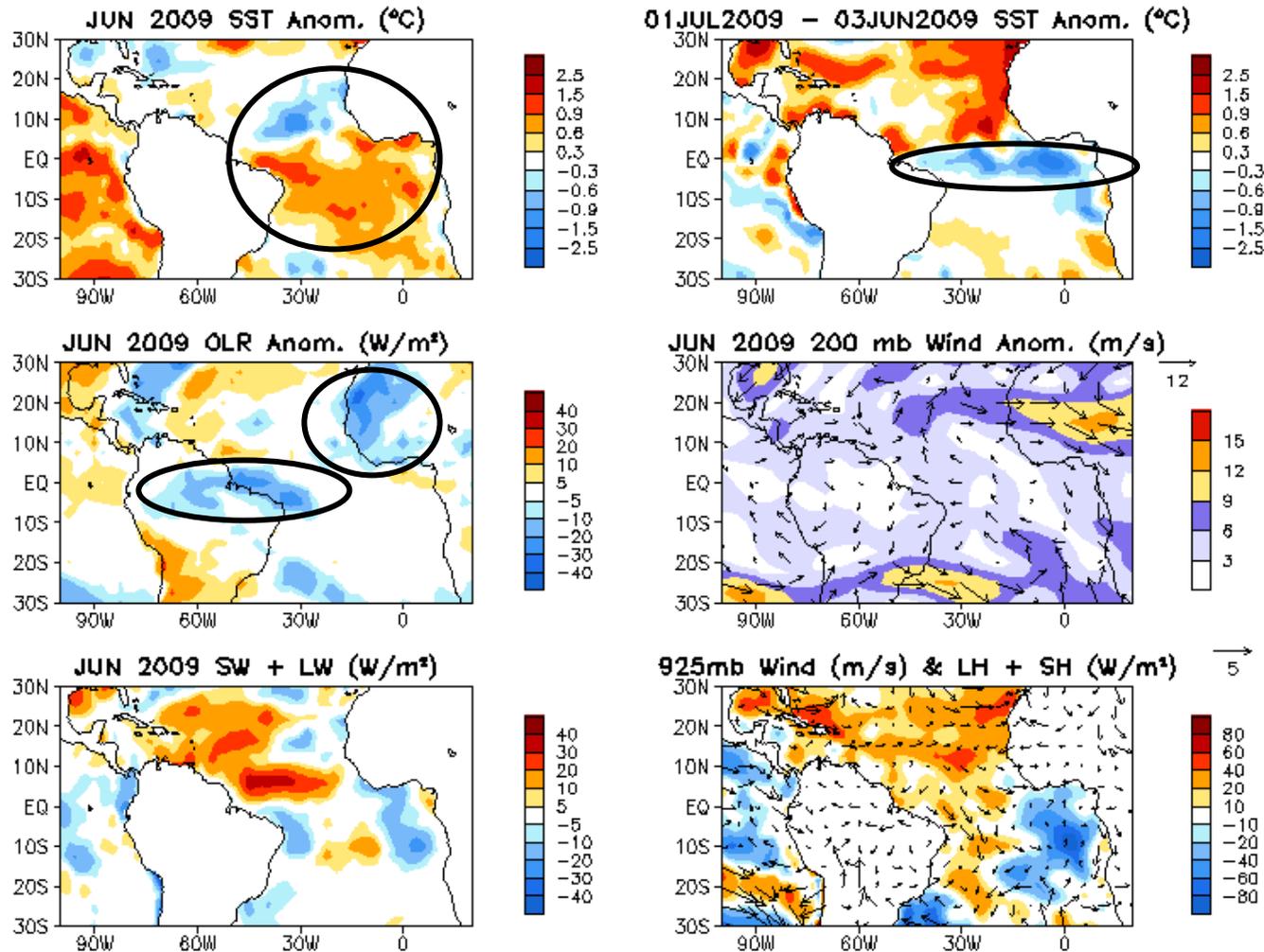


Fig. A1a. Tropical Atlantic Variability region indices, calculated as the area-averaged monthly mean sea surface temperature anomalies (°C) for the TNA [60°W-30°W, 5°N-20°N], TSA [30°W-10°E, 20°S-0] and ATL3 [20°W-0, 2.5°S-2.5°N] regions, and Meridional Gradient Index, defined as differences between TNA and TSA. Data are derived from the NCEP OI SST analysis, and anomalies are departures from the 1971-2000 base period means.

Tropical Atlantic:

SST Anom., SST Anom. Tend., OLR, Sfc Rad, Sfc Flx, 925-mb/200-mb Winds



- SSTs warmed up (cooled down) significantly in the tropical and subtropical North Atlantic (equatorial Atlantic).
- ITCZ was shifted southward in responding to the negative meridional gradient of SSTA.
- Surface wind anomalies were north-westerly (westerly) in the western (central) tropical Atlantic, consistent with the SSTA.

North Atlantic Ocean

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

- Negative NAO pattern in SLP anomalies.
- SSTA tendencies were largely consistent with net surface heat flux anomalies except in the Norwegian Sea.

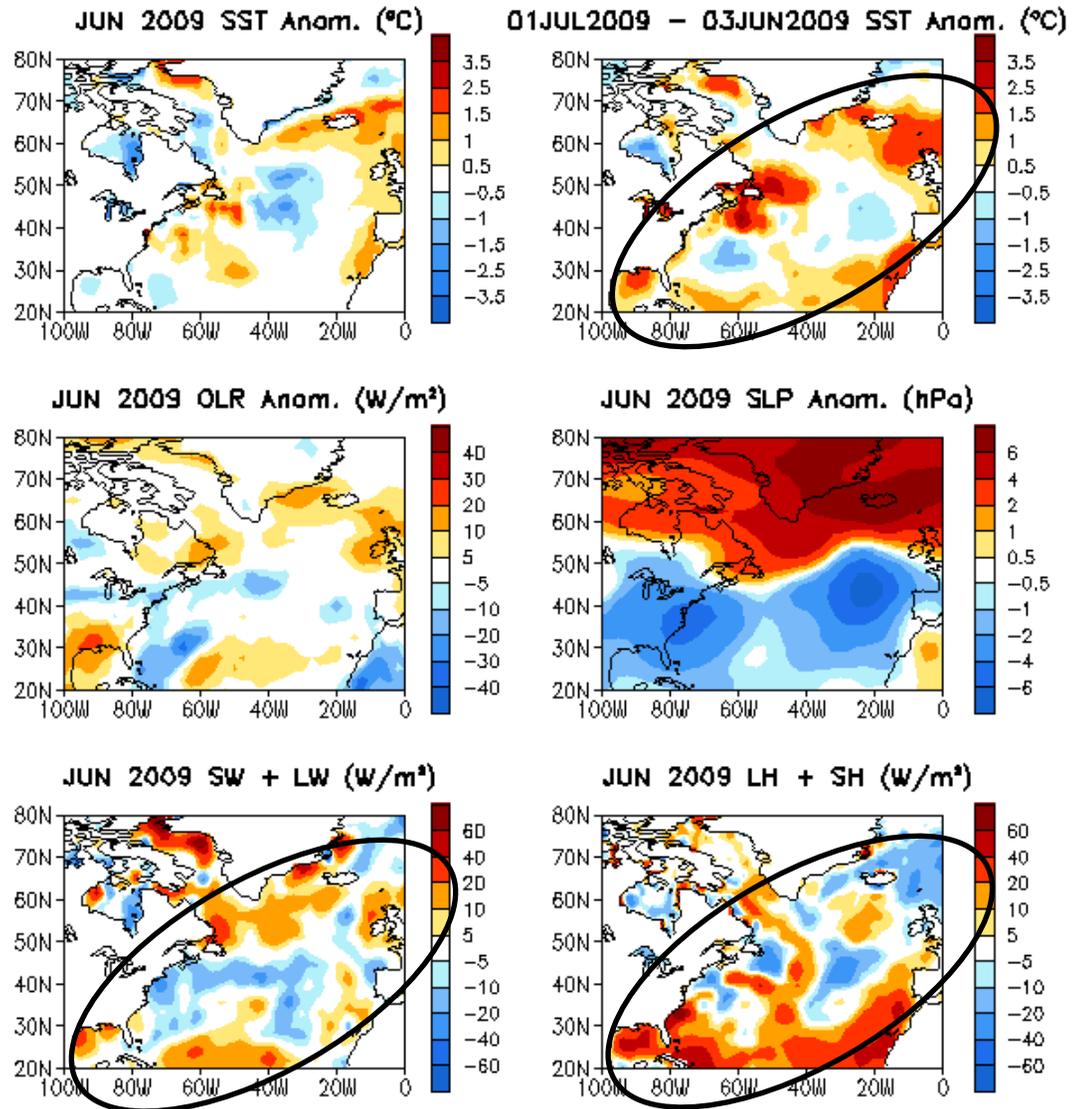
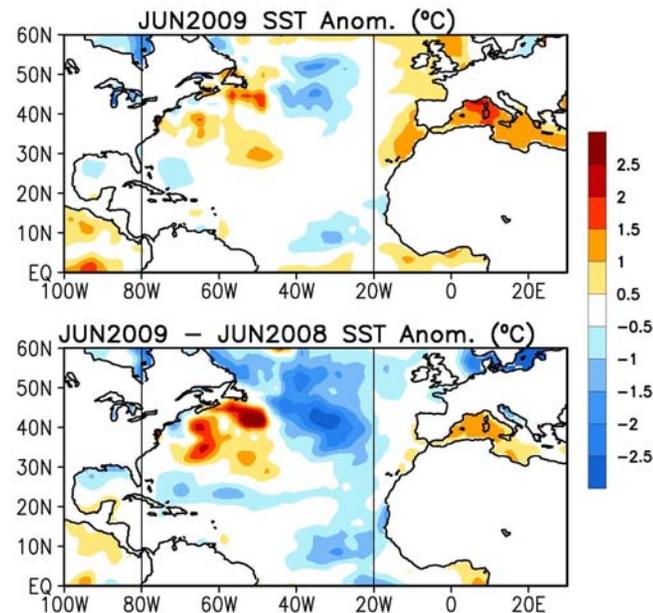
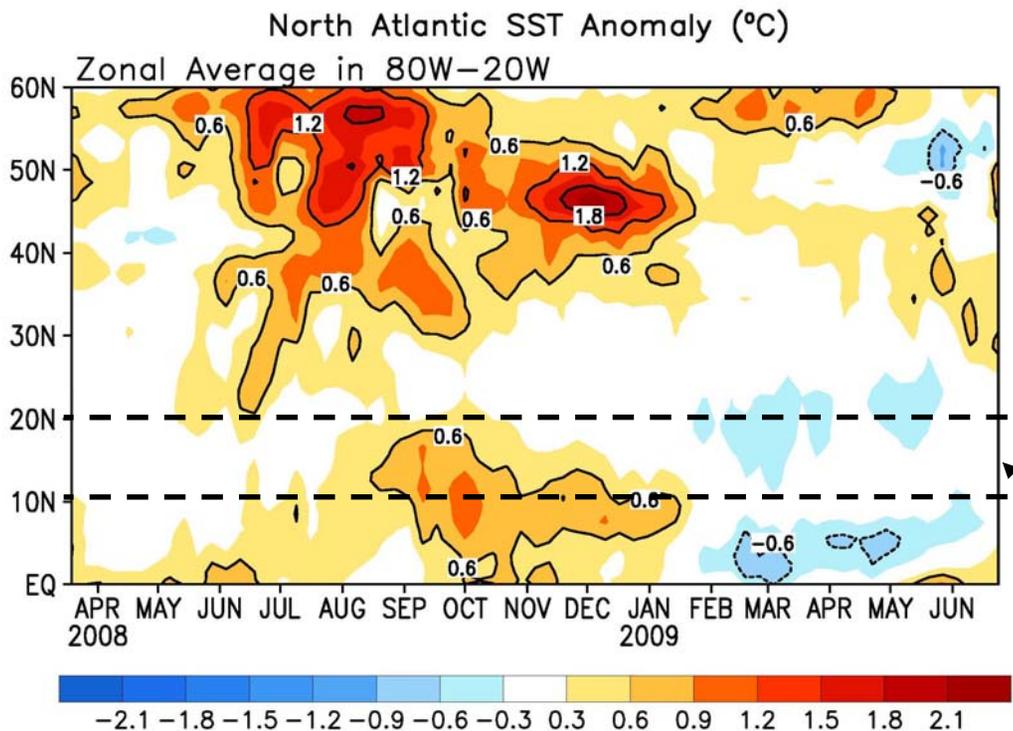
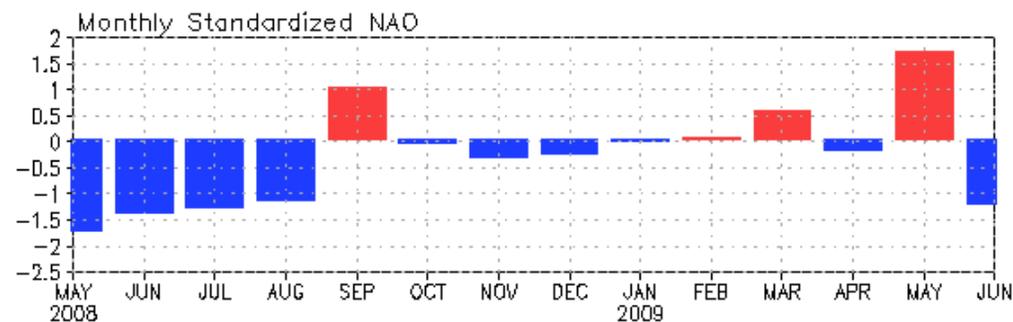


Fig. NA1. Sea surface temperature (SST) anomalies (top-left), anomaly tendency (top-right), Outgoing Long-wave Radiation (OLR) anomalies (middle-left), sea surface pressure anomalies (middle-right), sum of net surface short- and long-wave radiation anomalies (bottom-left), sum of latent and sensible 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 1979-1995 base period means except SST anomalies are computed with respect to the 1971-2000 base period means.

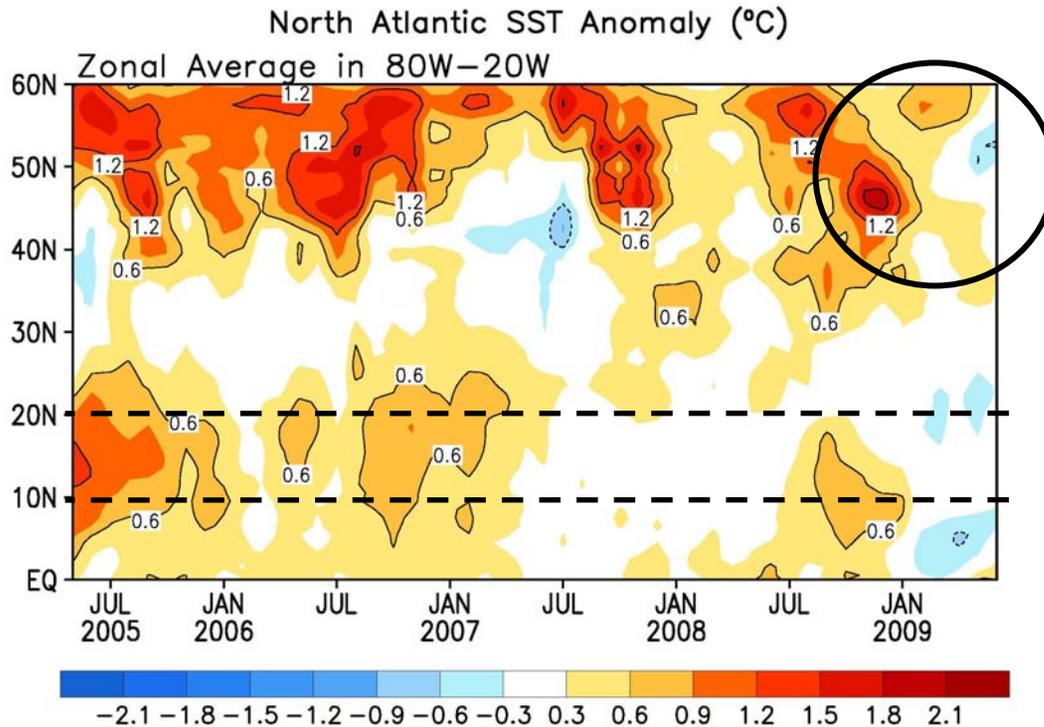
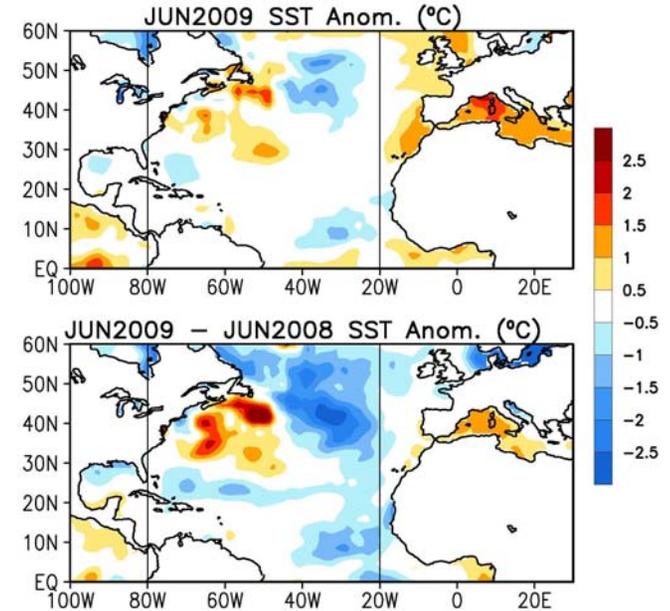
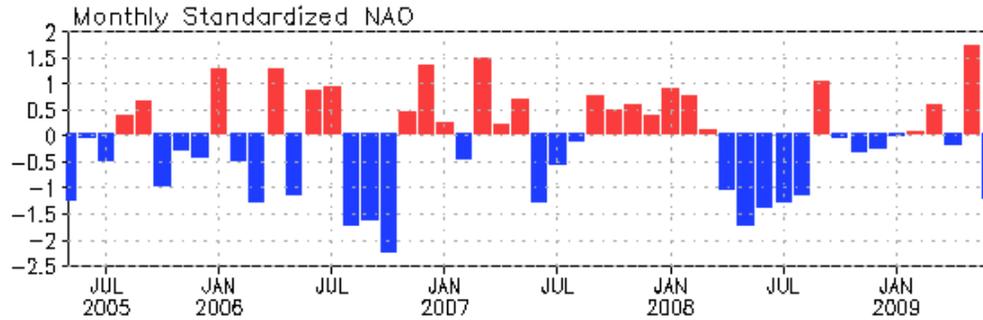
NAO and SST Anomaly in North Atlantic



- High-latitude North Atlantic SSTA are closely related to NAO index – negative (positive) NAO leads to SST warming (cooling).
- NAO was about 1.2 below-normal in June 09.
- SST in the Hurricane Main Development Region was near-normal in June 09.

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 1971-2000 base period means.

NAO and SST Anomaly in North Atlantic



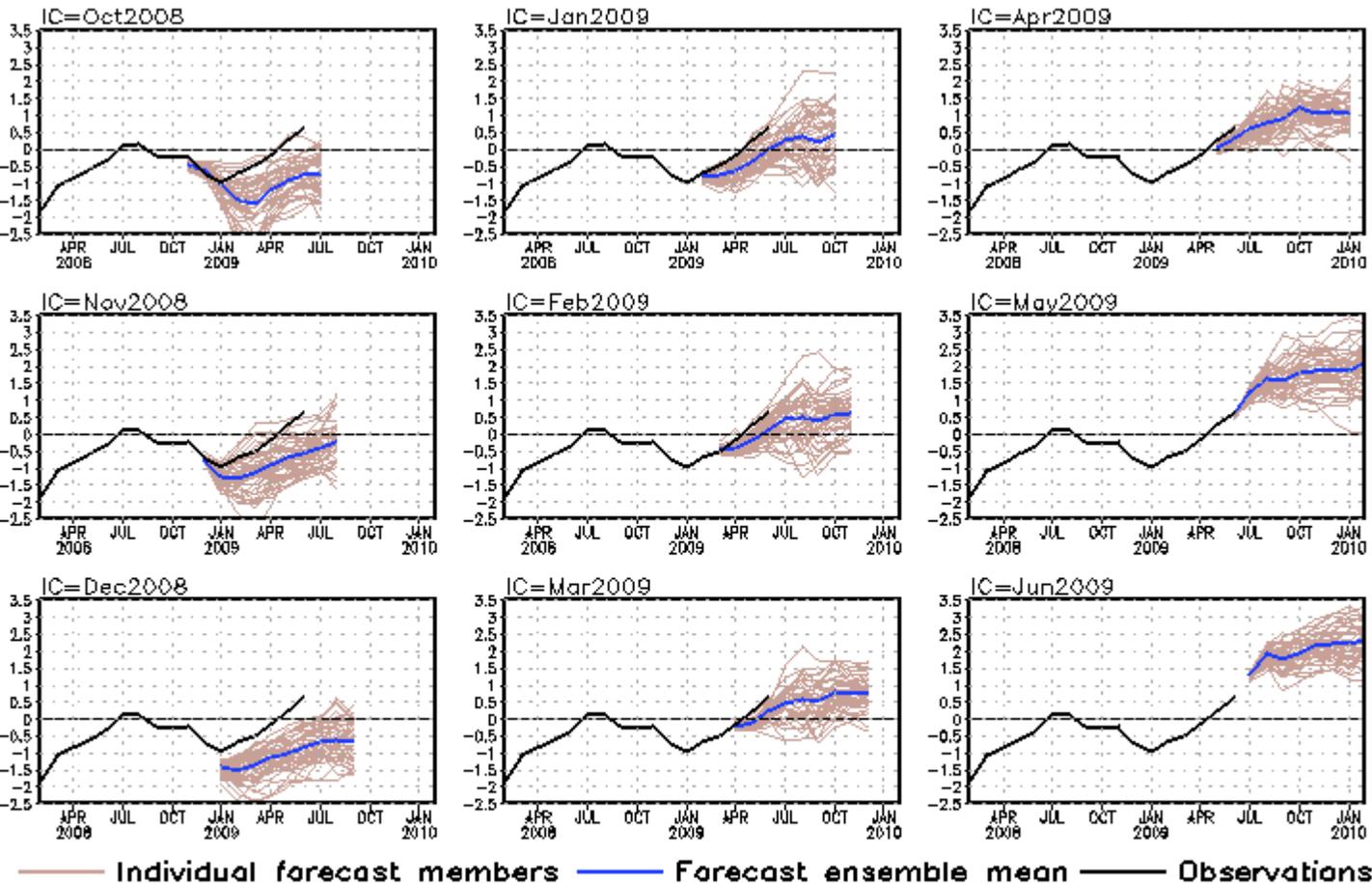
- North Atlantic SSTs cooled down and became near-normal during the past few months due to near-normal or above-normal NAO index.

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 1971-2000 base period means.

CFS SST Predictions and Ocean Initial Conditions

CFS Niño3.4 SST Predictions from Different Initial Months

NINO3.4 SST anomalies (K)

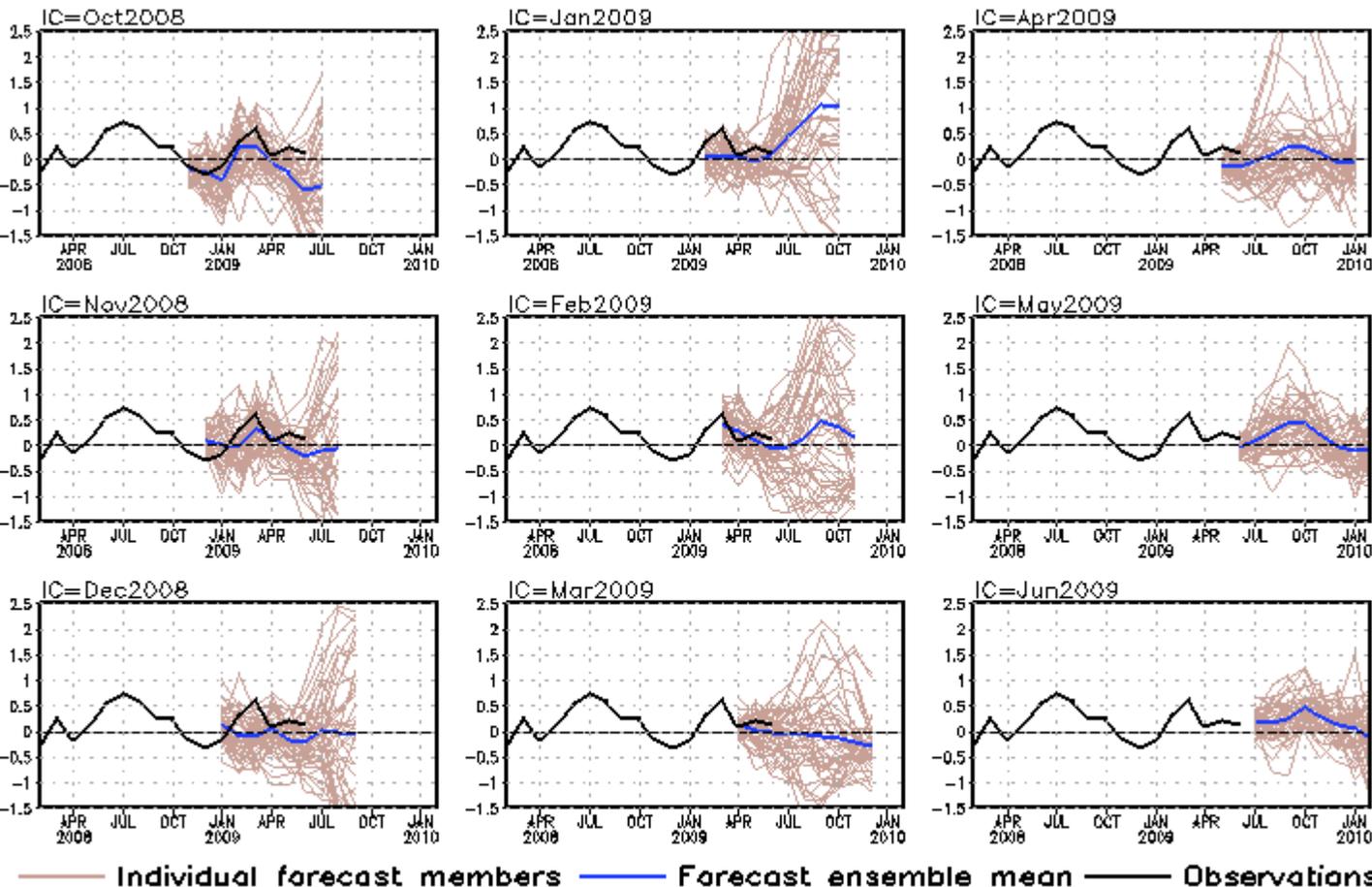


- Latest forecasts suggested a strong El Niño (NINO 3.4 > 1.5C) would develop during summer/fall 2009.

Fig. M1. CFS Niño3.4 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 (labeled 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 1971-2000 base period means.

CFS DMI SST Predictions from Different Initial Months

Indian Ocean Dipole SST anomalies (K)



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]

- Latest forecasts called for a weakly above-normal Dipole Mode Index in the fall 09.

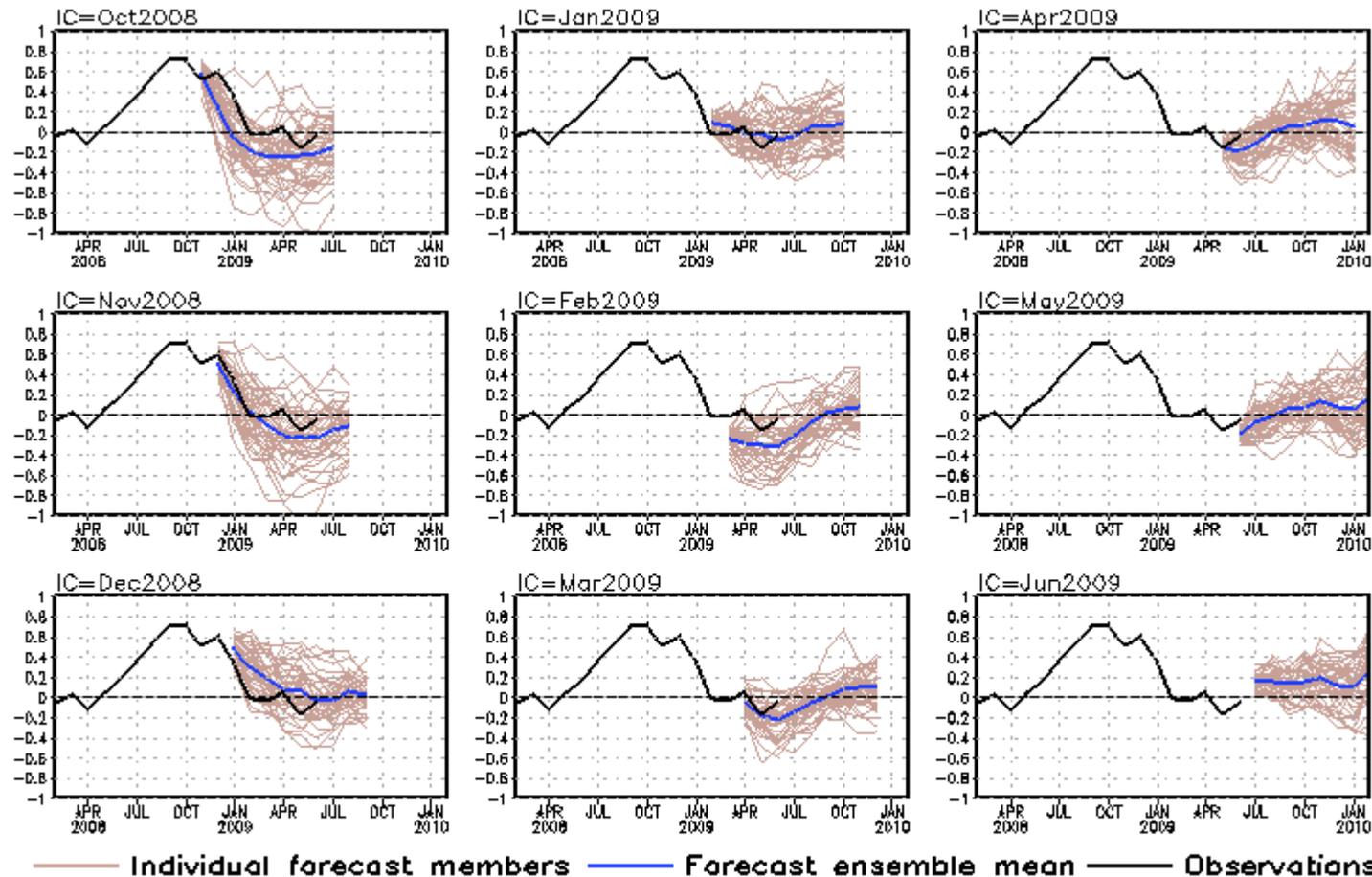
Fig. M2. CFS Dipole Model Index (DMI) SST predictions from the latest 9 initial months. Displayed are 40 forecast members (brown) made four times per day initialized from the last 10 days of the initial month (labeled as IC=MonthYear) as well as ensemble mean (blue) and observations (black). The hindcast climatology for 1981-2006 was removed, and replaced by corresponding observation climatology for the same period. Anomalies were computed with respect to the 1971-2000 base period means.

CFS Tropical North Atlantic (TNA) SST Predictions

from Different Initial Months

Tropical N. Atlantic SST anomalies (K)

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



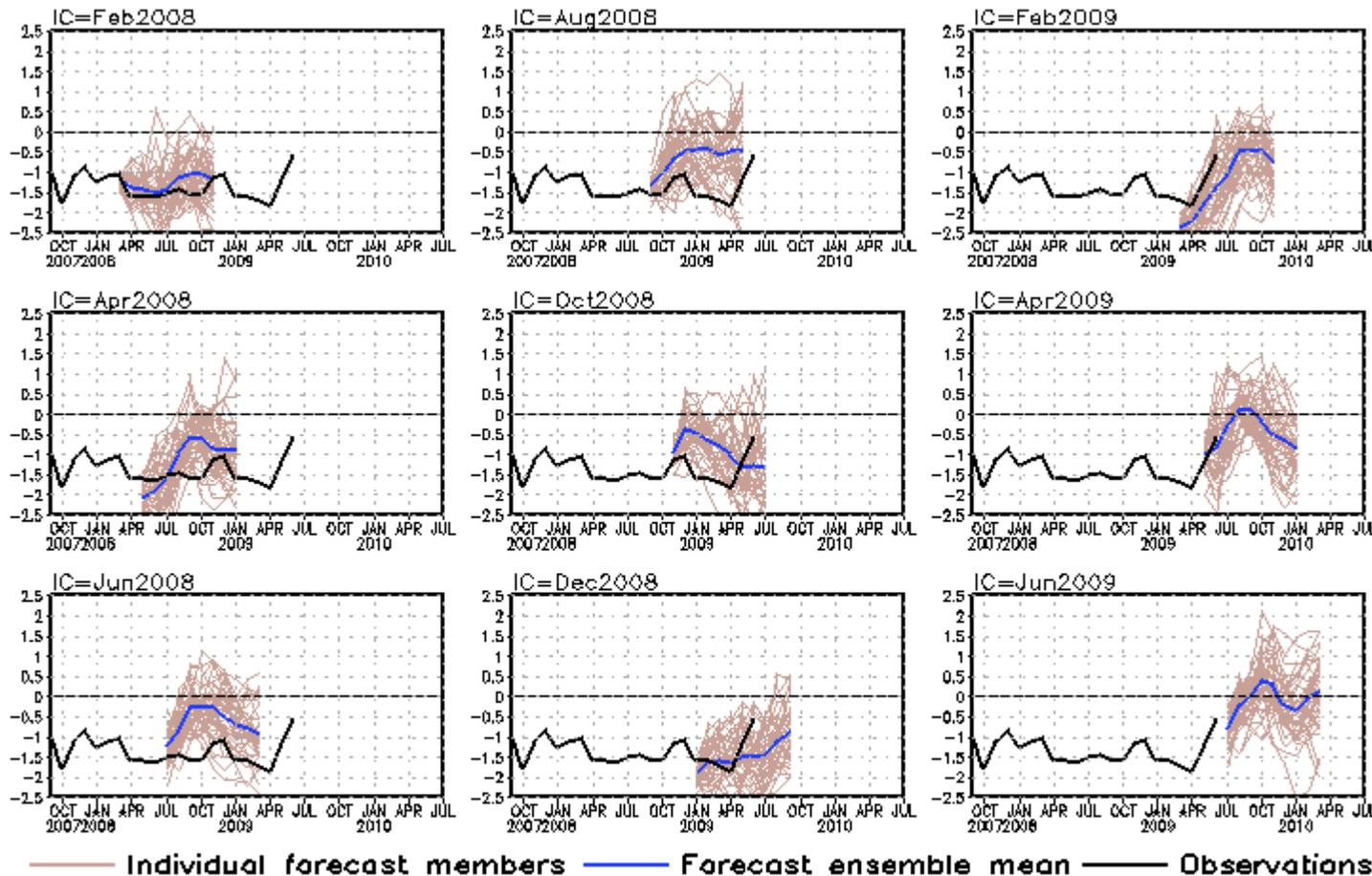
- Latest forecasts suggested that the tropical North Atlantic SST would be near-normal in next 3-6 months.

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 (labeled 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 1971-2000 base period means.

CFS Pacific Decadal Oscillation (PDO) Index Predictions

from Different Initial Months

standardized PDO index



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

- CFS SST anomalies are projected onto the PDO SST pattern (slide 16).
- CFS has forecasted the recent negative PDO phase since Dec 07 I.C.
- Latest forecasts suggested that the current negative PDO would weaken rapidly and return to near-normal during summer/fall 09.

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 (labeled 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 1971-2000 base period means.

Summary

- **Pacific Ocean**

- Surface and subsurface temperature has warmed up steadily since March 09, and a transition from ENSO-neutral to El Niño conditions occurred in June 2009.
- Negative PDO phase since September 2007 has persisted for 22 months now; however it weakened substantially and became weakly below-normal in June 2009. Upwelling was below-normal in June 09.

- **Indian Ocean**

- Since mid-March 09, zonal wind anomalies were persistently easterly and SST was persistently 0.5°C above-normal.
- SST was 1.5°C (0.5 °C) above-normal in the western (eastern) tropical Indian Ocean, while Dipole Mode Index was near-normal.

- **Atlantic Ocean**

- Tropical North Atlantic SST (TNA) was slightly below-normal, while tropical South Atlantic SST (TSA) was about 0.7°C above-normal.
- ITCZ was shifted southward in responding to the negative Meridional Gradient Mode (TNA-TSA).

- **Arctic Ocean**

- Sea ice extent decreased rapidly in May, and was close to the 2007 historical low in June 09.

Backup Slides

Data Sources and References

- **Optimal Interpolation SST (OI SST) version 2 (Reynolds et al. 2002)**
- **SST 1971-2000 base period means (Xue et al. 2003)**
- **NCEP CDAS winds, surface radiation and heat fluxes**
- **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**
- **Ocean Surface Current Analyses – Realtime (OSCAR)**

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