Global Air-Sea Coupled Modes: Recent Evolution, Current Status and Prediction

Update prepared by
Climate Prediction Center / NCEP
August 6, 2007

Outline

- Overview
- Recent Evolution and Current Conditions
  - ✓ Pacific Ocean
  - ✓ Indian Ocean
  - ✓ Atlantic Ocean
- SST Predictions by NCEP's Climate Forecast System
- Uncertainties in NCEP's Global Ocean Data Assimilation System (GODAS)

Overview

Pacific Ocean

- Since mid-May 2007, two oceanic Kevin wave episodes have brought HC in the central-eastern Pacific from below-normal in May to near normal in June to below-normal in July. The intraseasonal variability in the ocean was associated with the intraseasonal surface wind variability related to the Madden Julian Oscillation.
- The negative SST tendency between 140°W-100°W was related to the negative SSH anom. and negative surface zonal current anom. which reduced SST by moving the cold tongue water westward.
- The positive SST tendency along the west coast of North America was associated with onshore Ekman transport due to the surface cyclonic wind anom. near the Gulf of Alaska, which suppressed coastal upwelling in June and July 2007.

Indian Ocean

- The tropical SST and low-level winds were near normal, but the convection was enhanced in the central Indian and Maritime continent due to MJO activities.

Atlantic Ocean

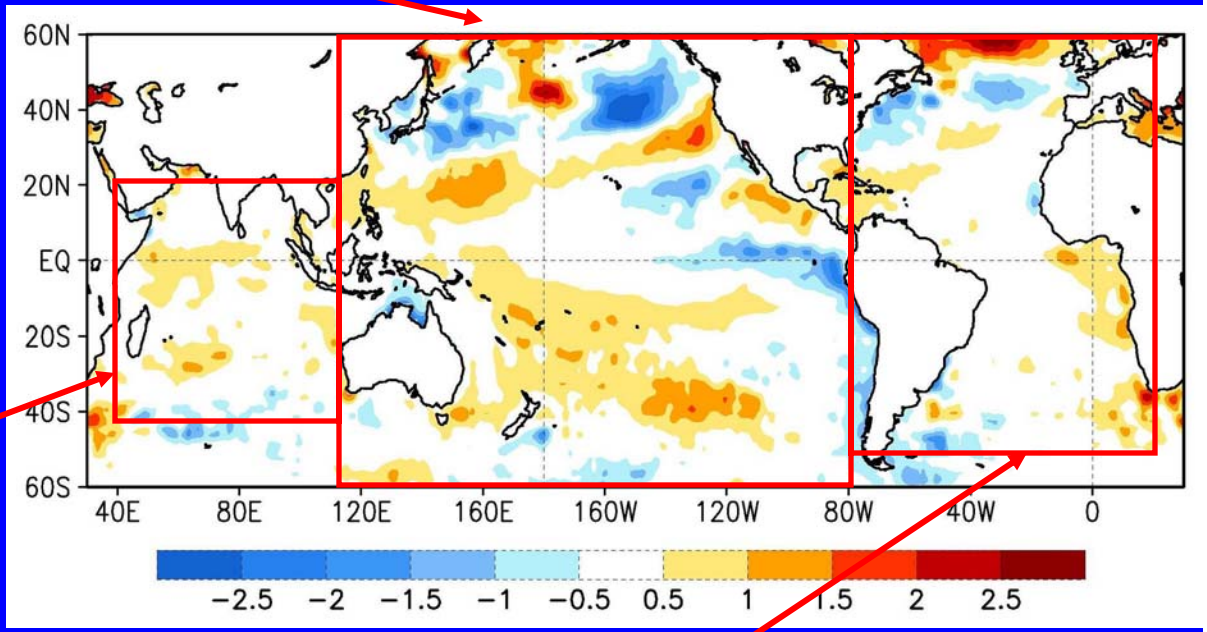
- Low-level westerly wind anom. was associated with the positive SST anom. in the eastern equatorial Atlantic. During July 2007, the Caribbean Sea was dry, and the Sahel region was wet.
- The positive SST anom. in the high-latitude North Atlantic during June-July 2007 was probably forced by the easterly wind anom. associated with the negative phase of NAO, which reduced the surface cooling by evaporation.

Global Ocean SST Anomaly (°C)

(Climatology 1971-2000)

July 2007

Positive SST anom. present in the central-western subtropical Pacific. Negative SST anom. present in the eastern equatorial Pacific, the west coasts of South America and the midlatitude North Pacific.



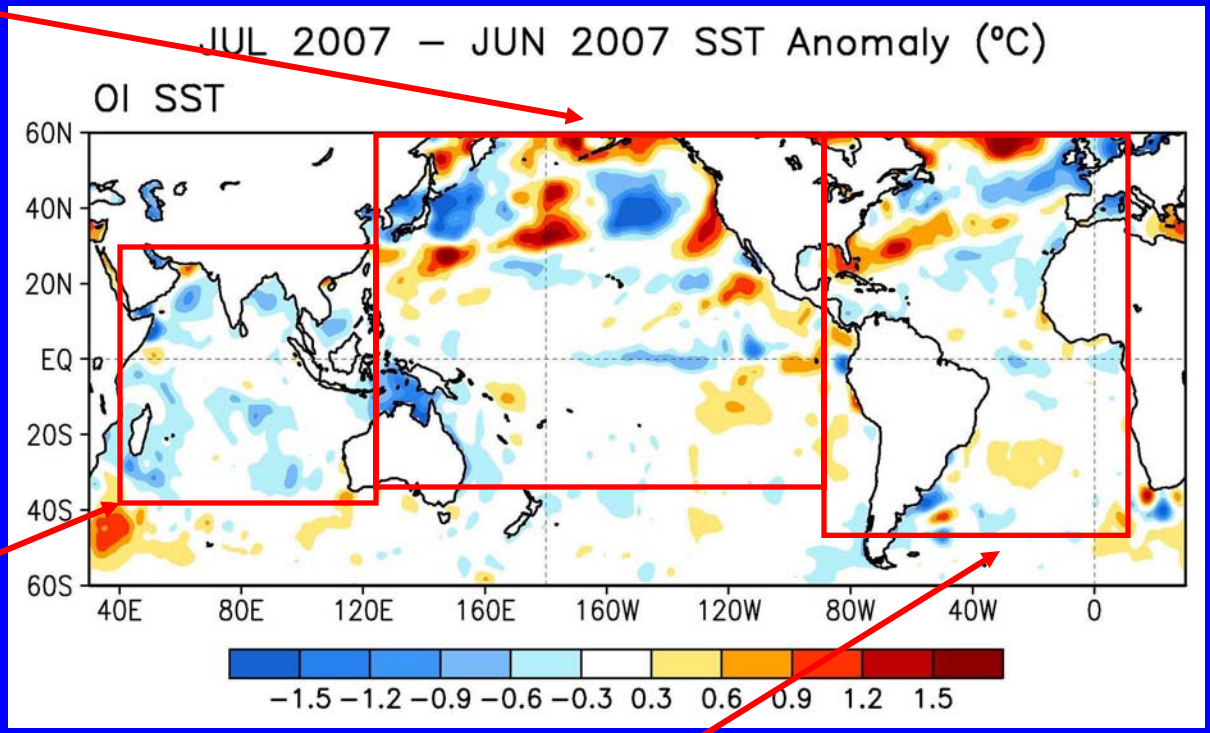
Weak positive SST anom. present in the equatorial Indian Ocean.

Positive SST anom. present in the high-latitude North Atlantic, the Caribbean Sea, the eastern equatorial Atlantic and the west coasts of Africa. Negative SST anom. present in the mid-latitude North Atlantic.

Global Ocean SST Anomaly Tendency (ºC)

(Climatology 1971-2000)

SST anom. decreased in the central-eastern equatorial Pacific between 170ºW-100ºW, portions of the mid-latitude North Pacific and north of Australia. SST anom. increased along the coast of Alaska and North America.



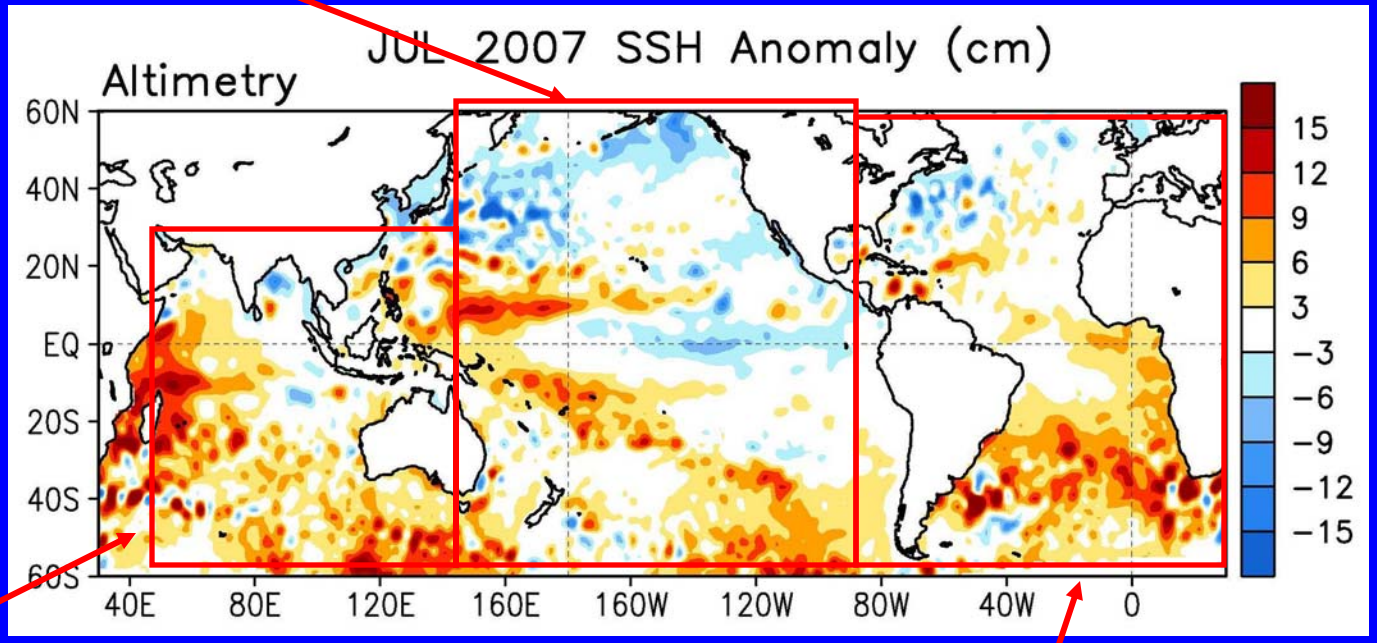
SST anom. decreased in the Arabian Sea, Bay of Bengal and South China Sea.

SST anom. increased substantially south of Greenland, the eastern Gulf of Mexico, northeast of Florida, but decreased southwest of the British Isles and the equatorial Atlantic Ocean.

Tropical Sea Surface Height Anomaly (cm)

(Climatology 1993-2005)

Positive SSH anom. present in the western subtropical Pacific, and the eastern South Pacific. Negative SSH anom. present in the eastern equatorial Pacific, the western North Pacific and the Gulf of Alaska.



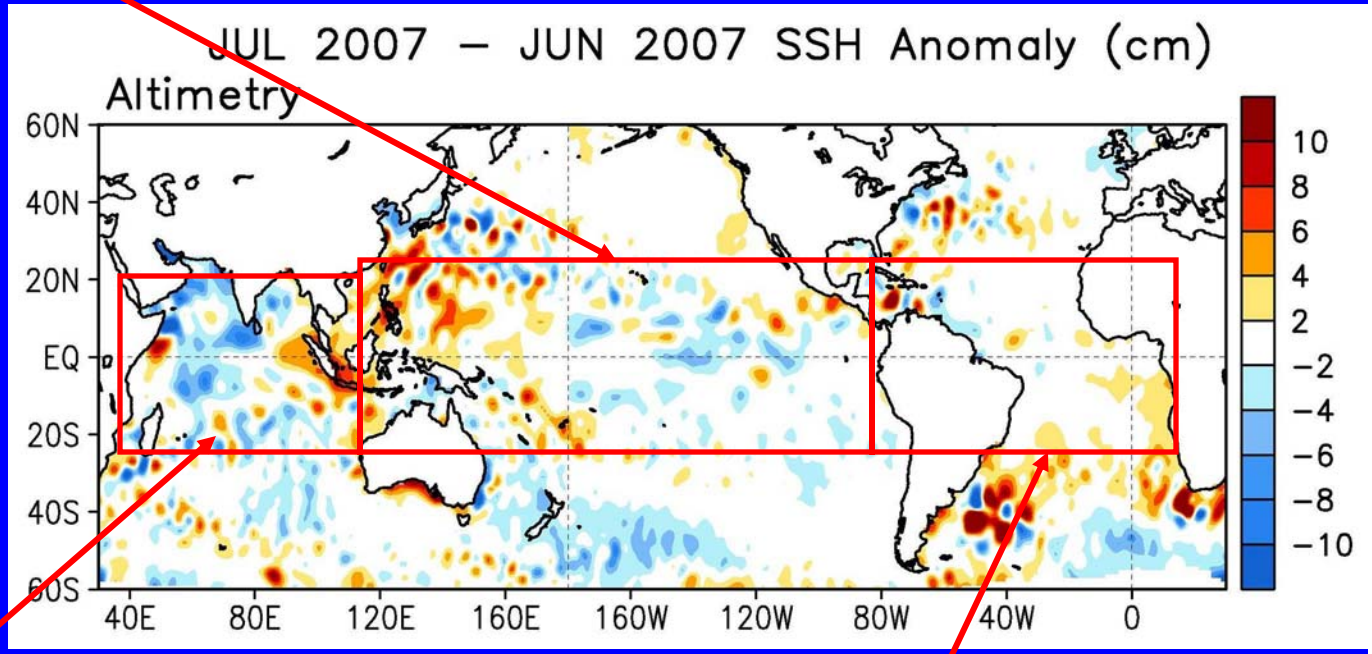
Positive SSH anom. present in the central-western tropical Indian Ocean, and South Indian Ocean.

Positive SSH anom. present in the central-eastern equatorial Atlantic and South Atlantic. Negative SSH anom. present in the western North Atlantic.

Sea Surface Height Anomaly Tendency (cm)

(Climatology 1993-2005)

SSH decreased in the eastern equatorial Pacific between 150°W and 110°W, but increased in the northwestern Pacific.

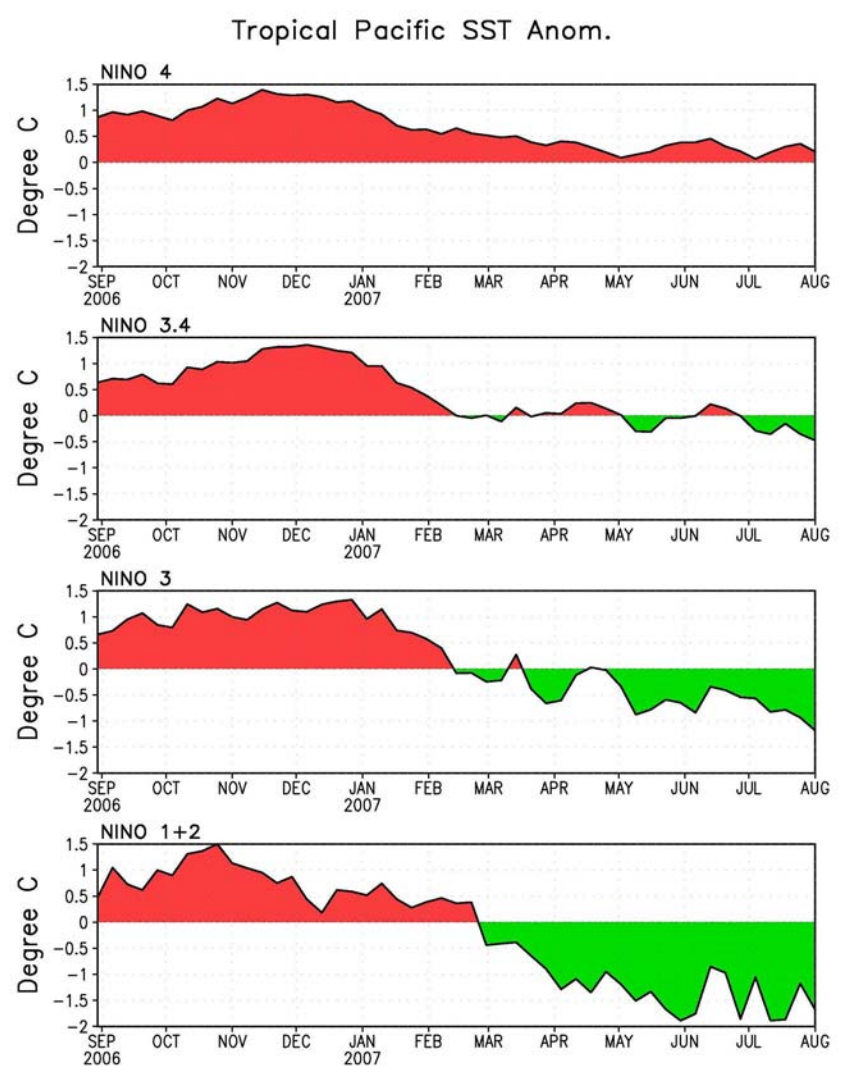


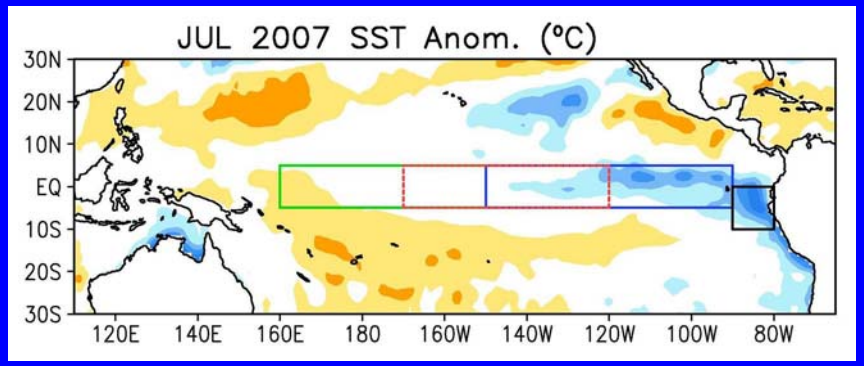
SSH increased (decreased) in the far eastern (central) equatorial Indian Ocean.

SSH changed little in the tropical Atlantic Ocean.

Pacific Ocean

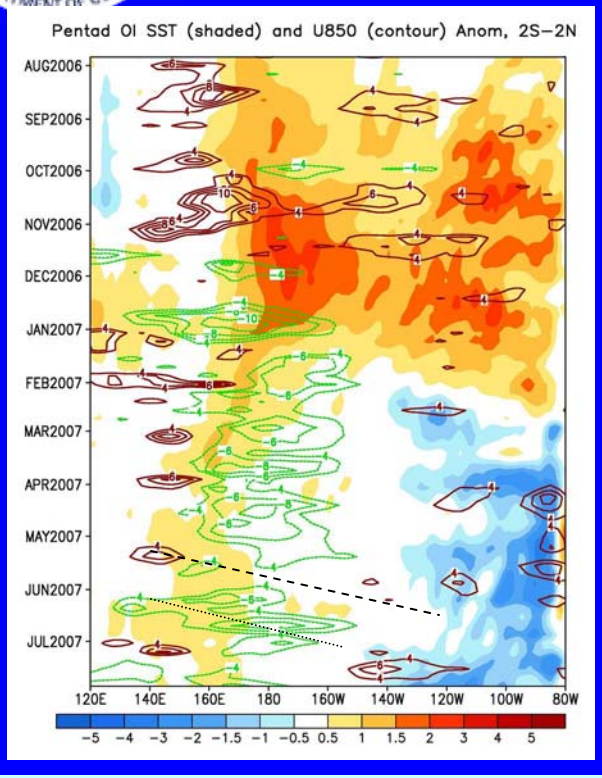
Recent Evolution of Pacific NINO SST Indices

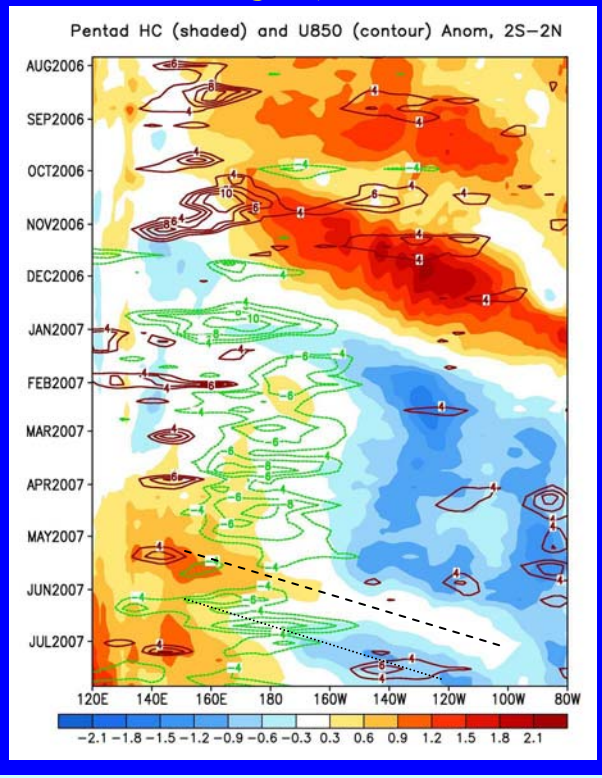


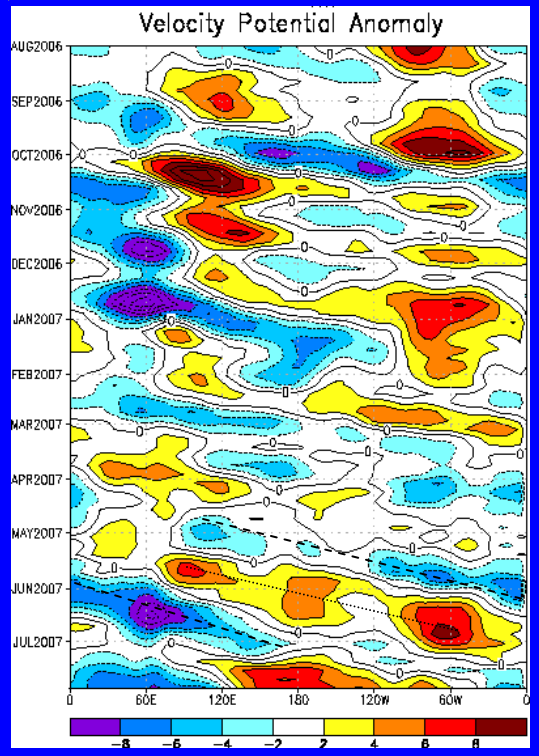


- **NINO 4 SST was near normal during April-July 2007.**
- **NINO 3.4 SST was at normal during February-June 2007, and became weak negative in July 2007.**
- **NINO 3 SST was more than 0.5ºC below-normal during May-July 2007.**
- **NINO 1+2 SST was more than 1ºC below-normal during April-July 2007.**

Recent Evolution of Equatorial Pacific SST (shaded, ºC), Surface Zonal Wind (contour, m/s) and Upper Ocean (0-300m Heat Content Anomaly (shaded, ºC) and MJO Activities

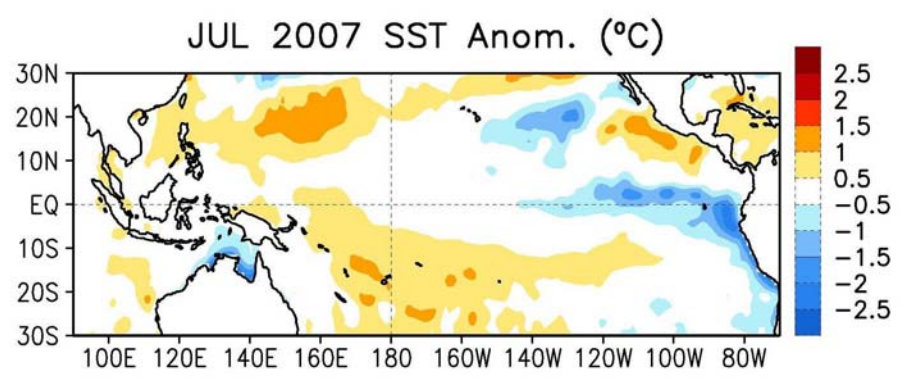


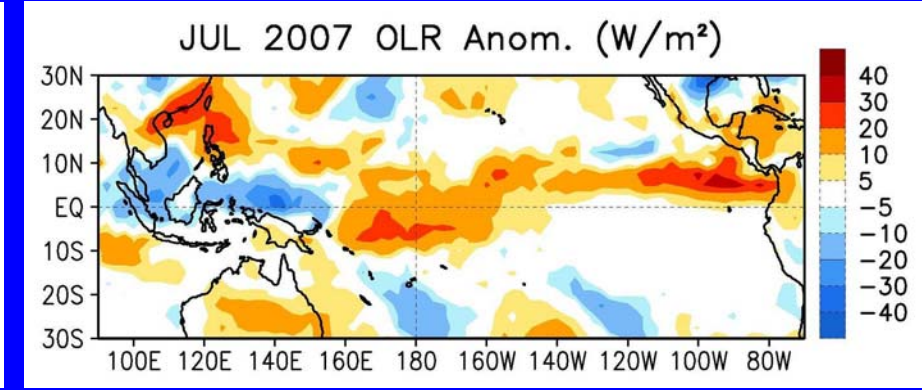


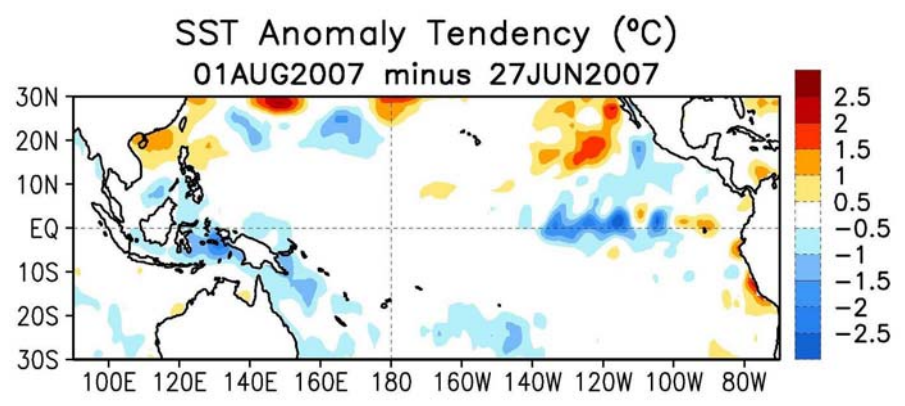


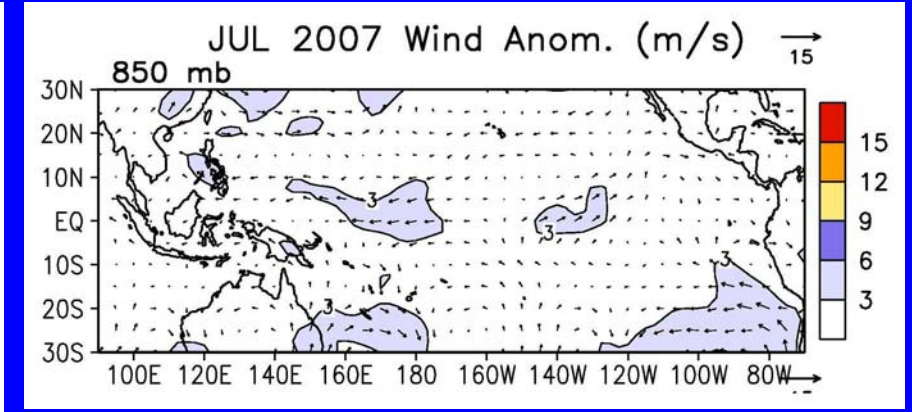
Since mid-May 2007, two oceanic Kevin wave episodes were evident in heat content (HC) anom., which have brought HC in the central-eastern Pacific from below-normal to near normal from May to June, and from near normal to below-normal from June to July. Corresponding to the recent negative HC surge , SST has transitioned from near normal to below-normal between 140ºW and 110ºW in mid-July. The intraseasonal variability in the ocean was apparently associated with the intraseasonal surface wind variability related to the Madden Julian Oscillation, which was represented by 200mb velocity potential anom.

Tropical Pacific: SST, SST Tendency, OLR, 850mb Wind



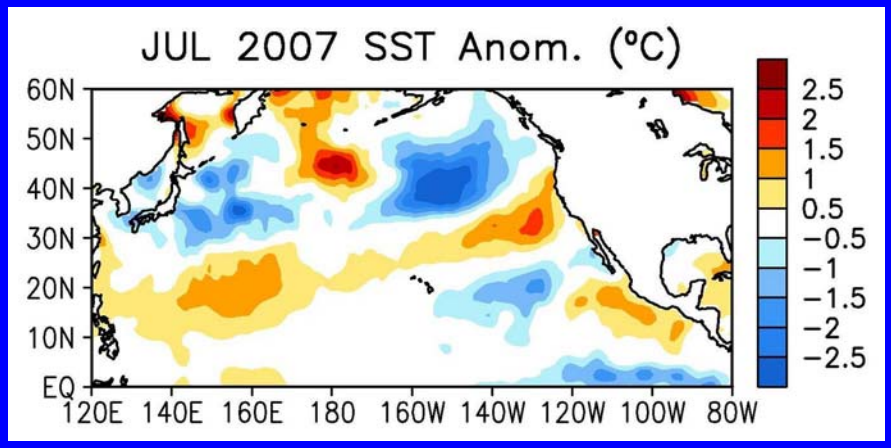


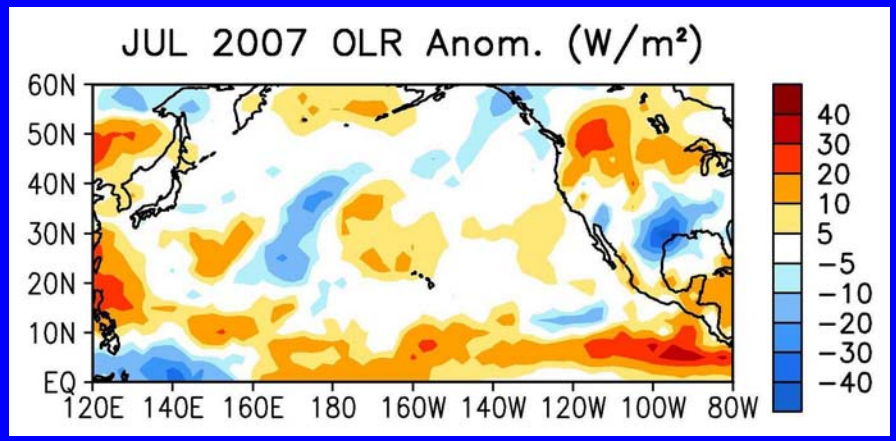


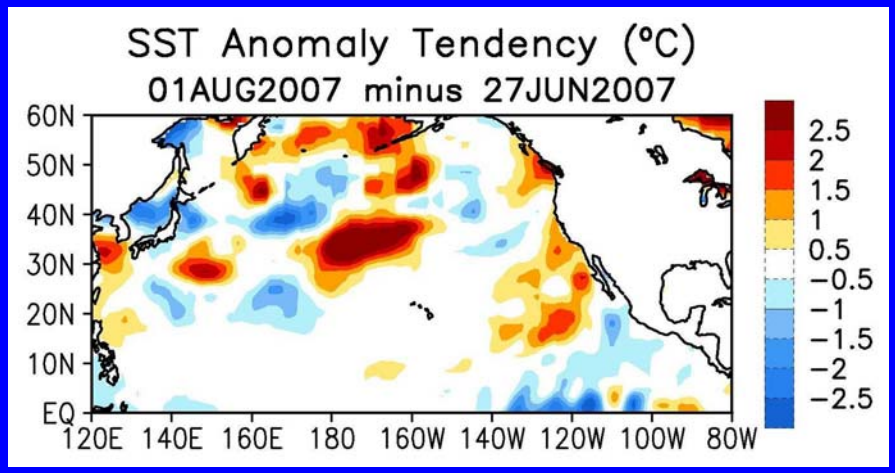


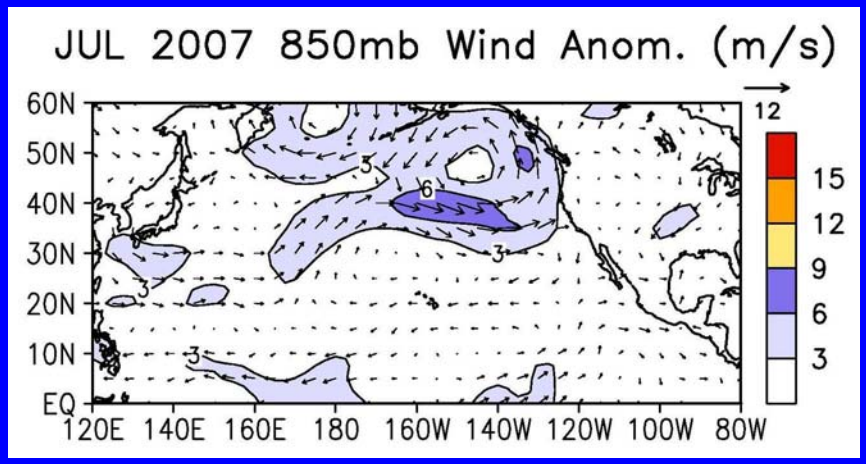
The negative SST tendency in the eastern equatorial Pacific between 140ºW-100ºW was related to the negative SSH tendency (slide 7), a reduction of subsurface temperature, and negative surface zonal current anom. (slide 27) which reduced SST by moving the cold tongue water westward. The atmospheric circulation featured La Nina-like conditions with enhanced convection (negative OLR) in the Maritime continent and suppressed convection (positive OLR) near the Date Line, and weak easterly surface wind anom. in the western tropical Pacific.

North Pacific: SST, SST Tendency, OLR, 850mb Wind





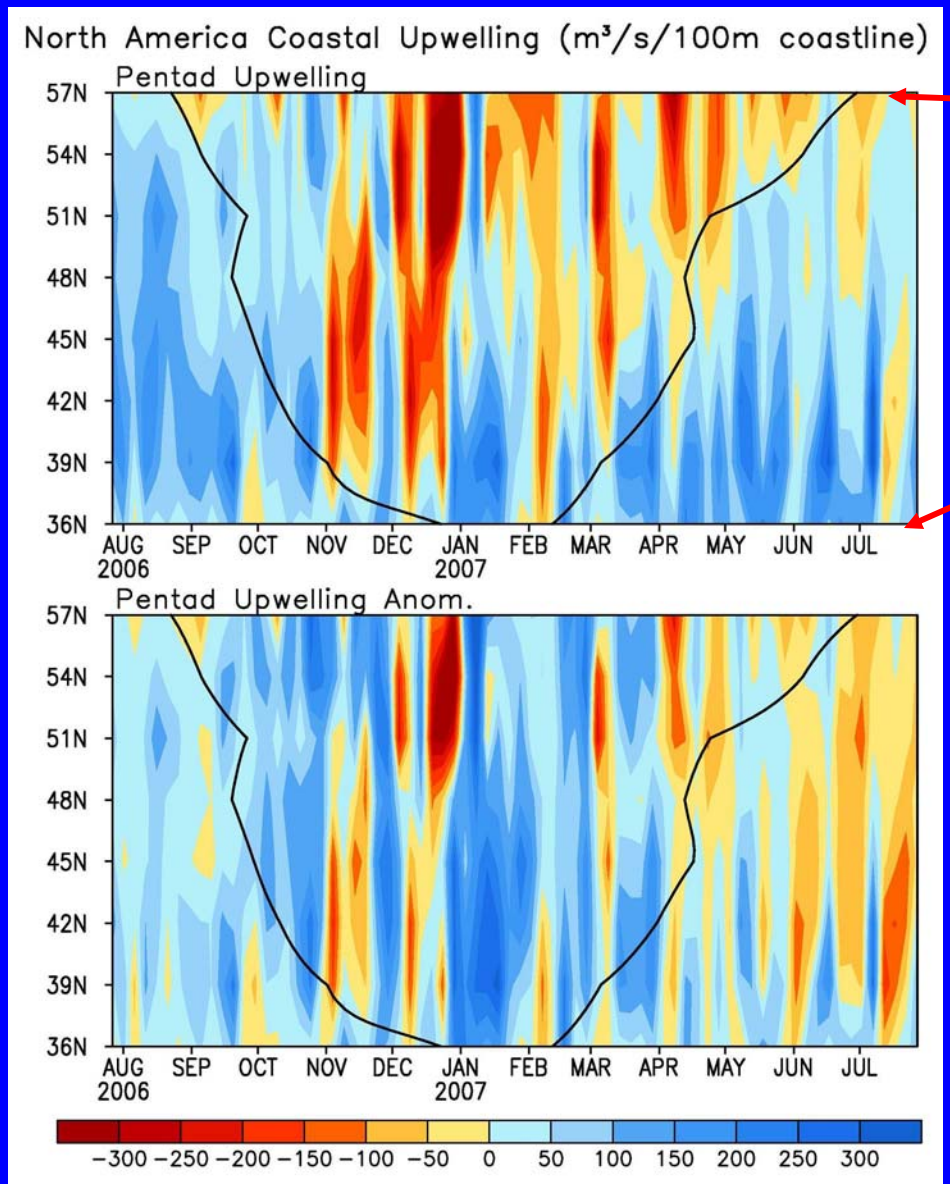


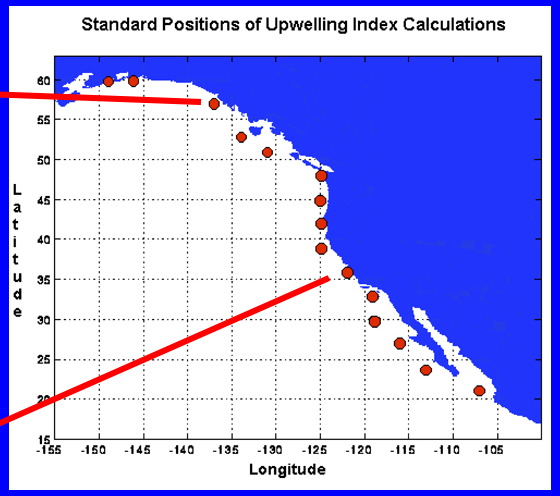


The positive SST tendency along the west coast of North America was associated with onshore Ekman transport due to the surface cyclonic wind anom. in the Gulf of Alaska.

Recent Evolution of Coastal Upwelling at 8 West Coast Sites of North America

PFEL, NOAA Fisheries Service



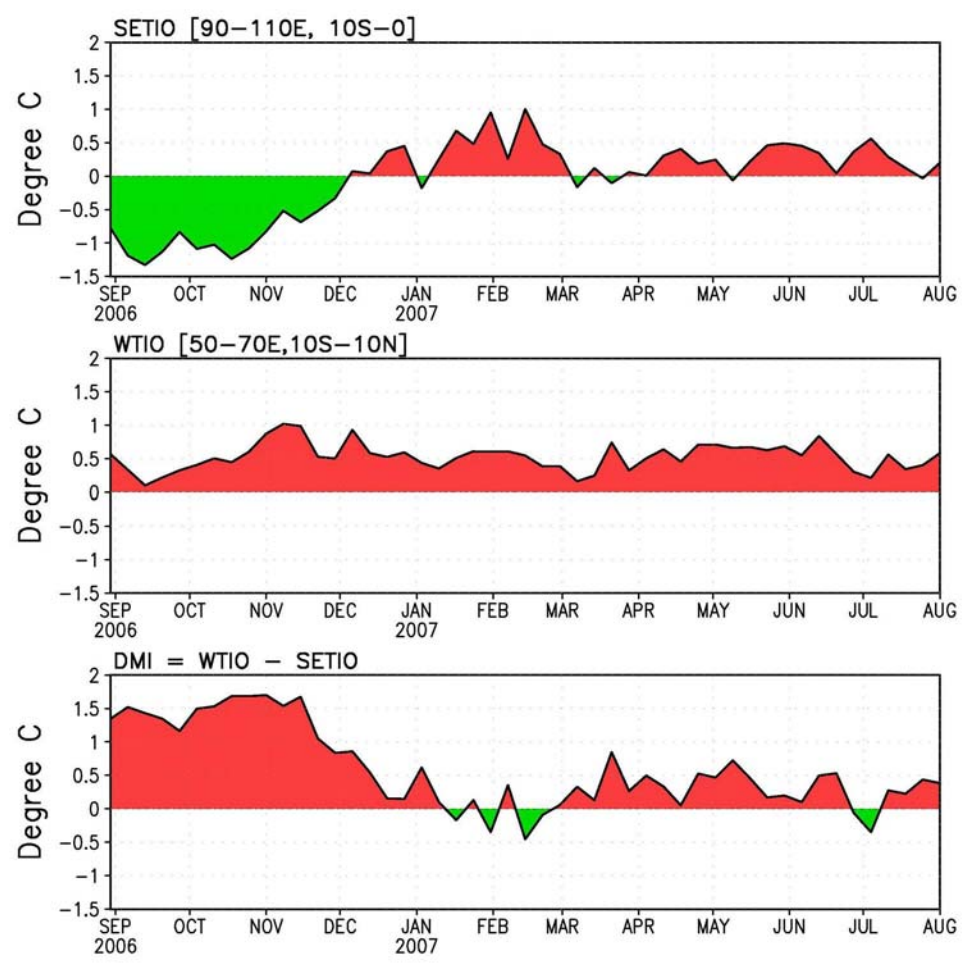


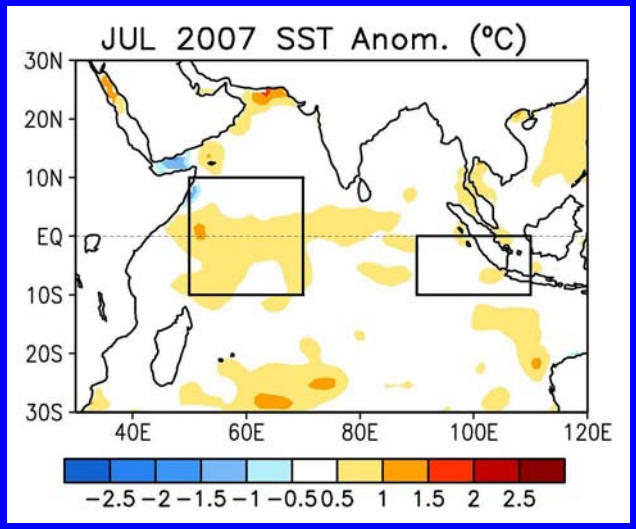
- **The climatological zero upwelling, represented by the black line, indicates that the climatological upwelling seasons progress from March to July along the west coast of North America from 36ºN to 57ºN.**
- **The coastal upwelling season of 2007 started in March, remained near normal until the end of May. It has been below-normal in June-July 2007.**

Indian Ocean

Recent Evolution of Indian Ocean Dipole Indices

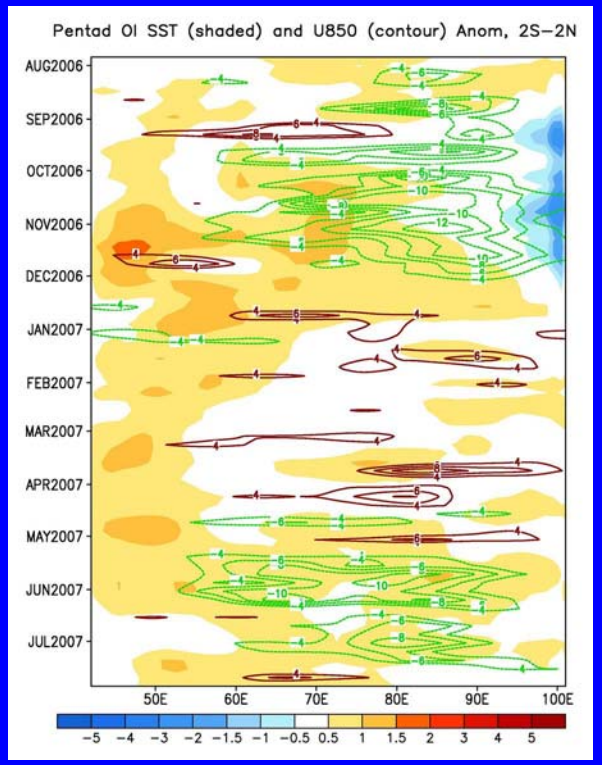
SETIO: SST anomaly in 90ºE-110ºE, 10ºS-0.
WTIO: SST anomaly in 50ºE-70ºE, 10ºS-10ºN.
DMI = WTIO - SETIO

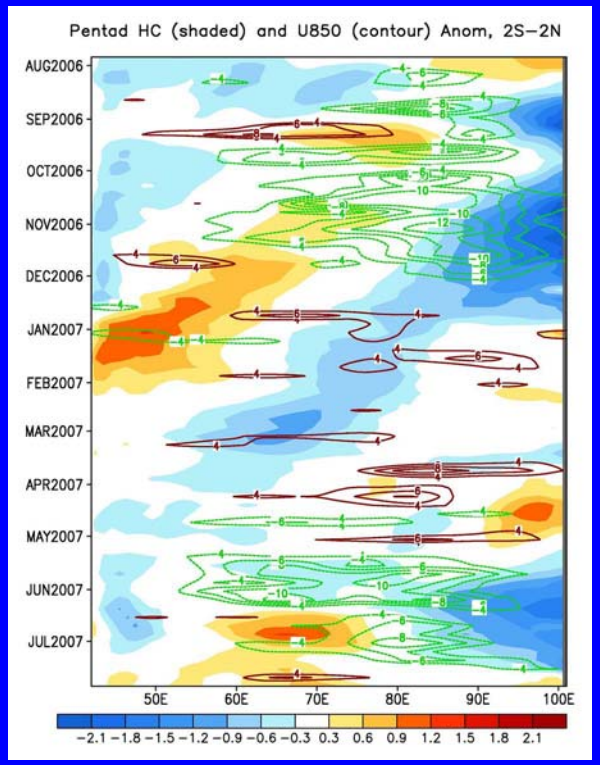


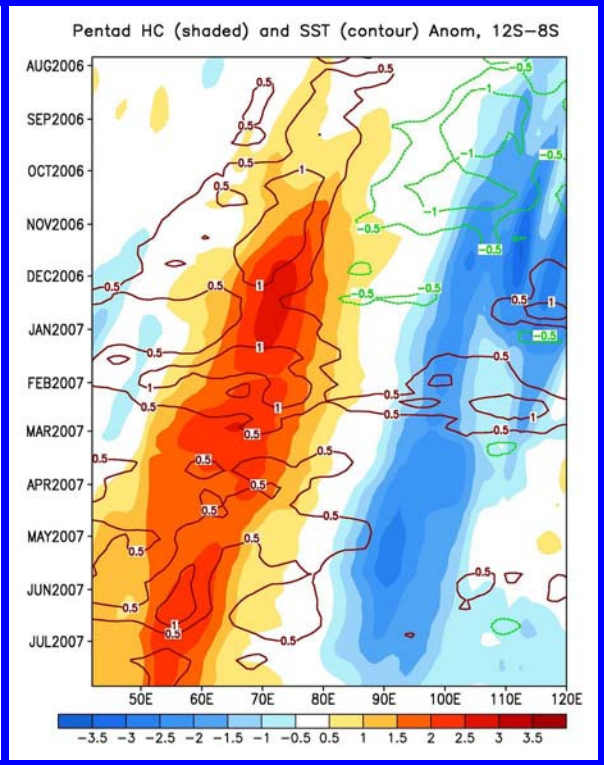


- **SETIO SST has been weak positive since December 2006, and was near normal in July 2007.**
- **WTIO SST has been about 0.5ºC above-normal since November 2006.**
- **DMI SST has been weak positive since March 2007, and was near normal in July 2007.**

Recent Evolution of Equatorial Indian SST (shaded, ºC) and Surface Zonal Wind (contour, m/s) Departures

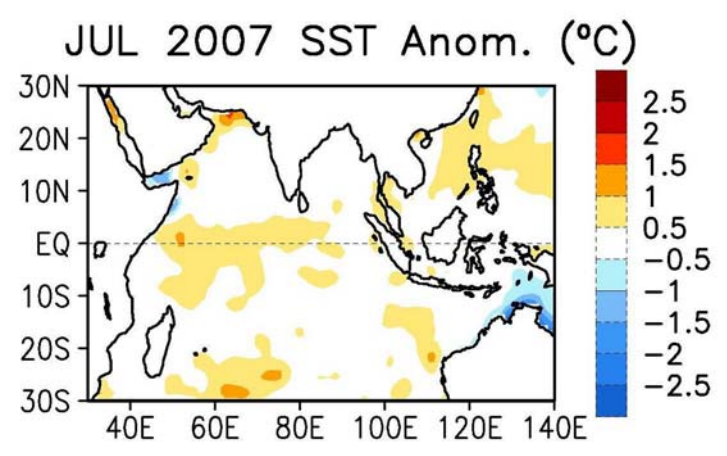


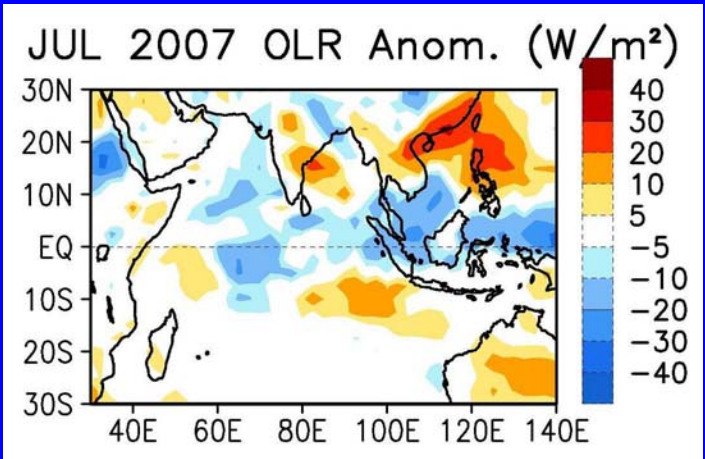


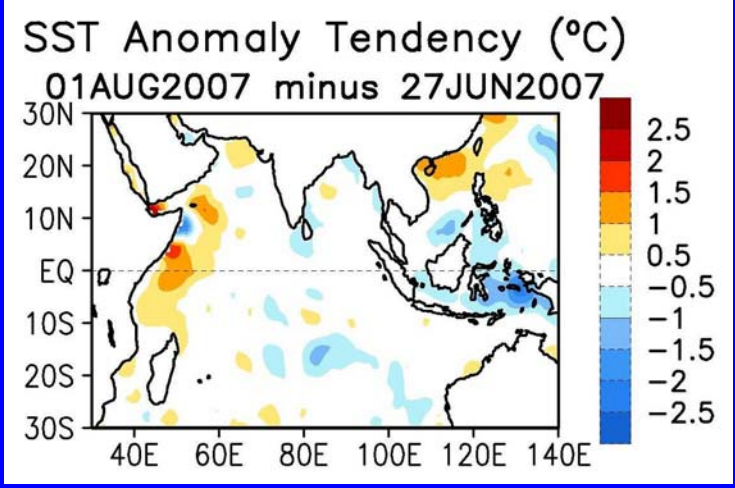


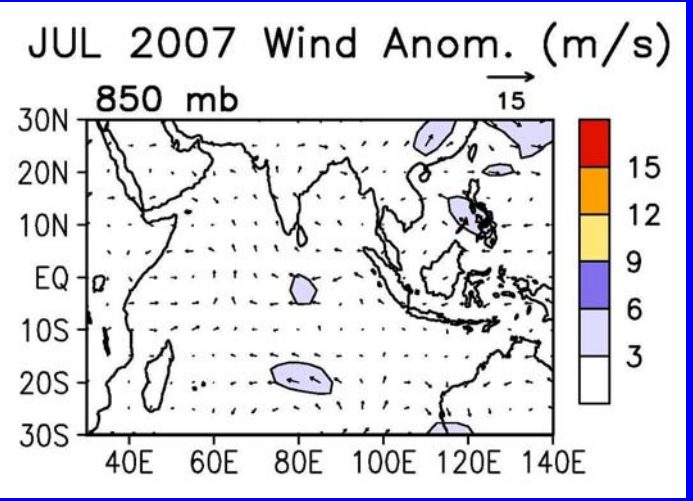
In May 2007, positive SST anom. were present across the equatorial Indian Ocean, accompanied by easterly wind anom. due to stronger than normal atmospheric monsoon circulation. In response to the easterly wind anom., negative (positive) heat content (HC) anom. developed in the eastern (central) Indian Ocean in June 2007. Westward propagation of oceanic Rossby waves were evident along 10ºS since September 2006, which were forced by wind stress curl associated with the 2006 Indian Ocean Dipole event. Note weak below-normal HC were present near the coast of Java between 110ºE-120ºE and 10ºS in June-July 2007.

Tropical Indian: SST, SST Tendency, OLR, 850mb Wind







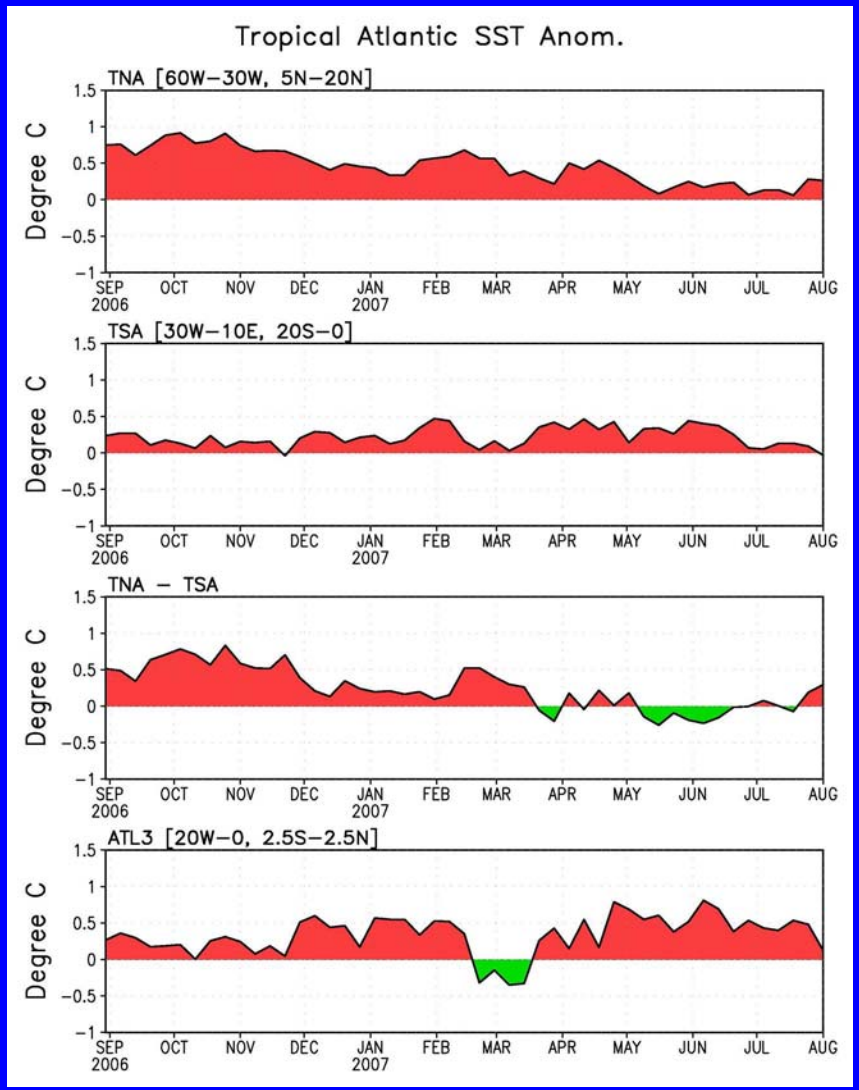


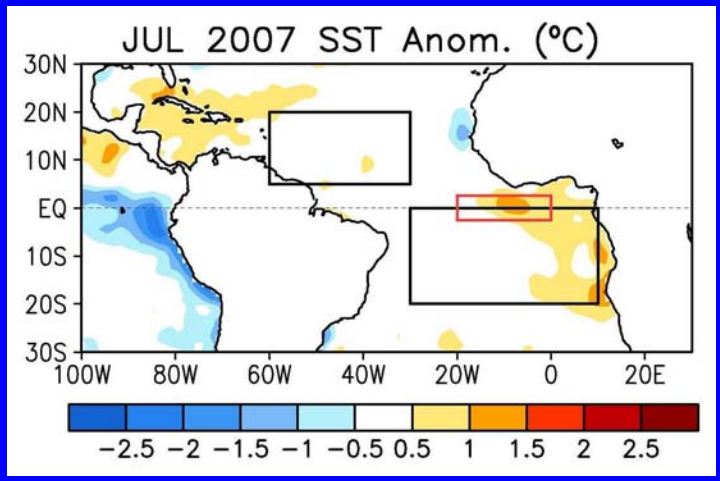
The negative (positive) SST tendency south (north) of Philippines was associated with the enhanced (suppressed) convection which reduced (increased) short wave radiation at the sea surface. Corresponding to the weak SST anom., the surface wind anom. was weak in the tropical Indian Ocean.

Atlantic Ocean

Recent Evolution of Tropical Atlantic SST Indices

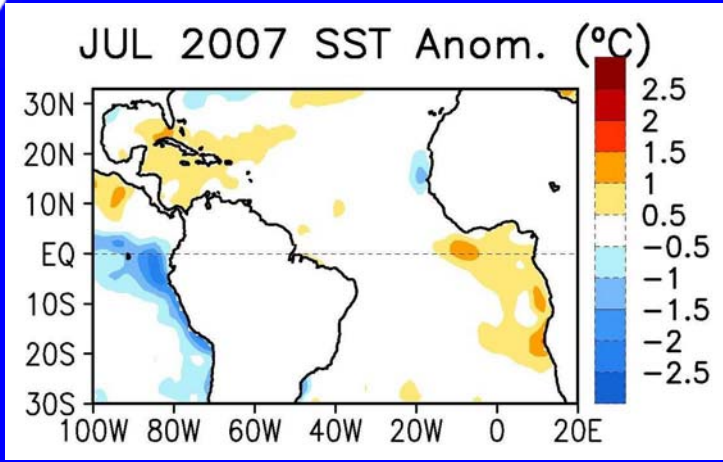
(Climatology 1971-2000)

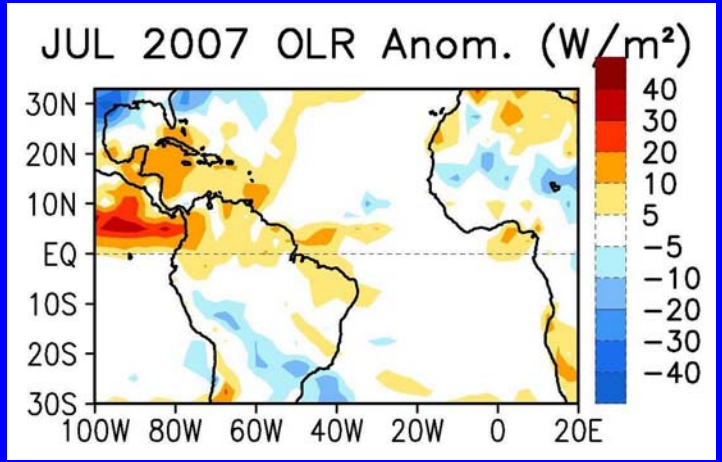


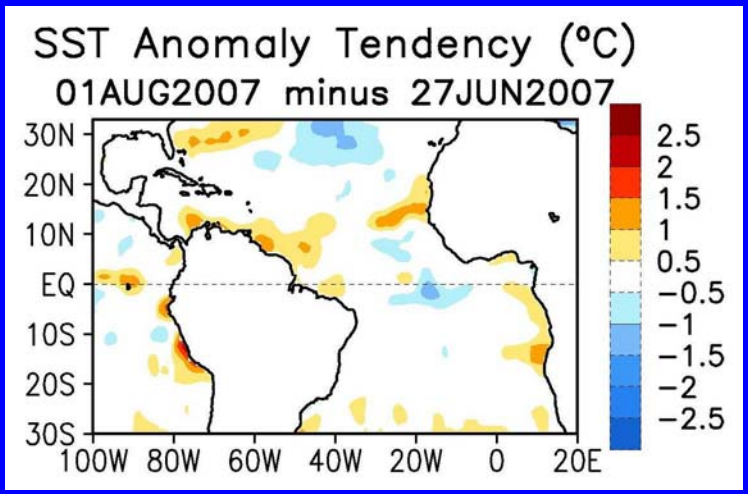


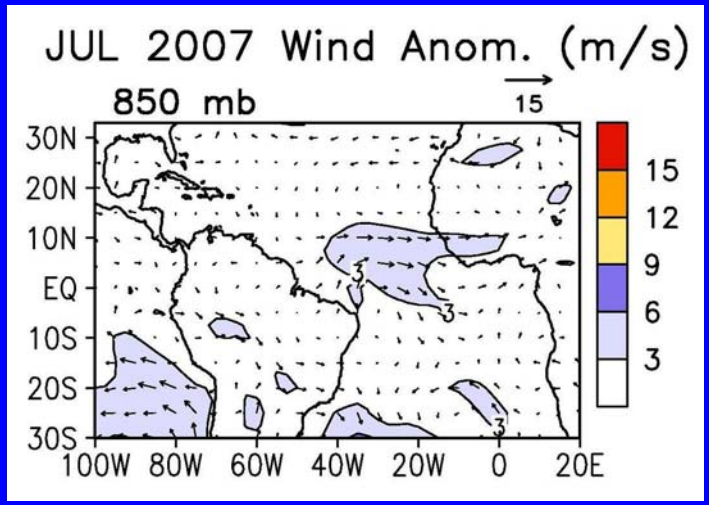
- **TNA SST was at normal in July 2007.**
- **TSA SST was at normal in July 2007.**
- **The north-south gradient mode has been near normal since April 2007.**
- **Atlantic NINO has been 0.5ºC above-normal since May 2007.**

Tropical Atlantic: SST, SST Tendency, OLR, 850mb Wind



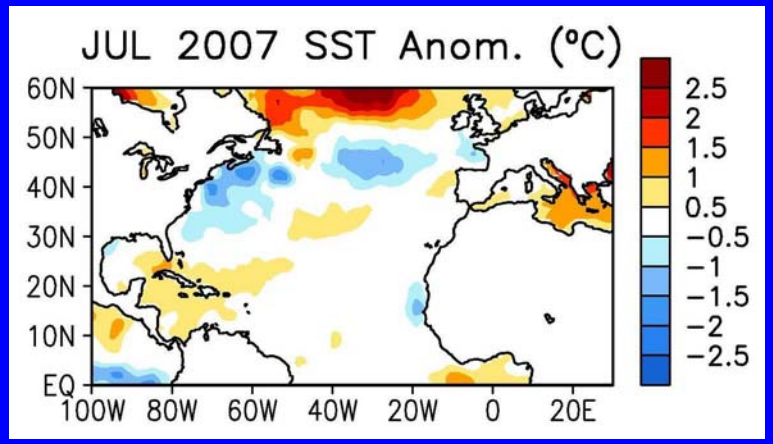


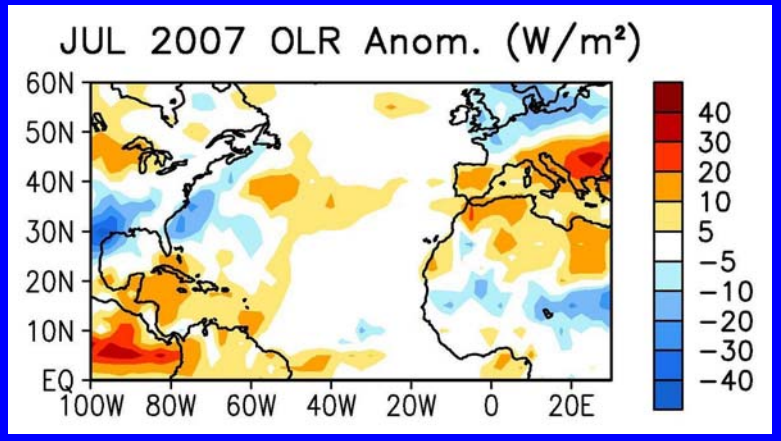


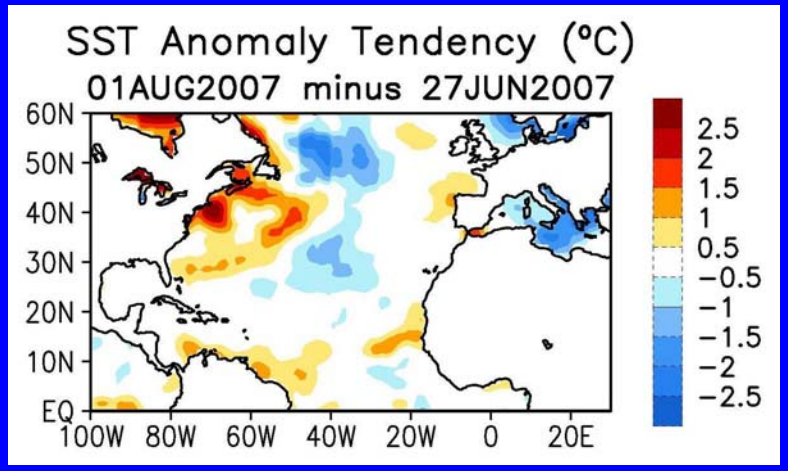


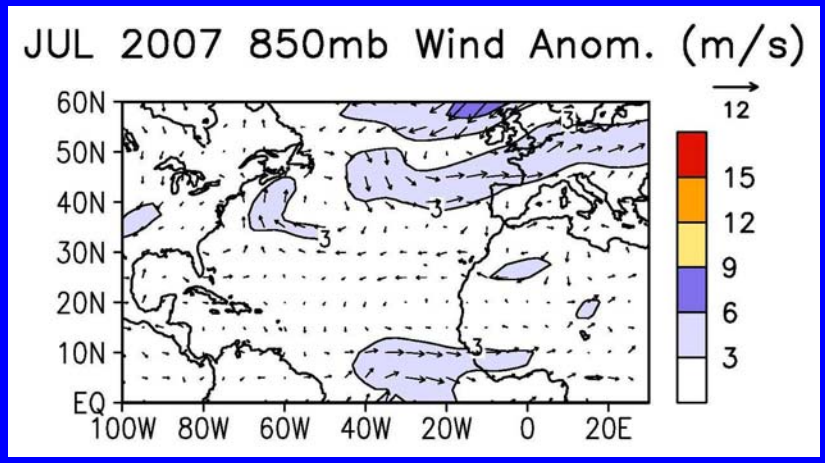
The low-level westerly wind anom. was associated with the positive SST anom. in the eastern equatorial Atlantic. During July 2007, the Caribbean Sea was dry, and the Sahel region was wet.

North Atlantic: SST, SST Tendency, OLR, 850mb Wind



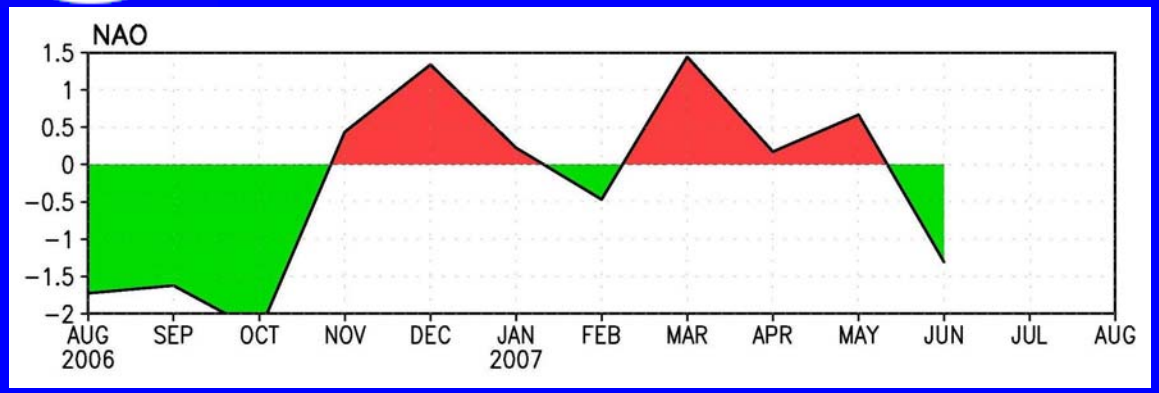


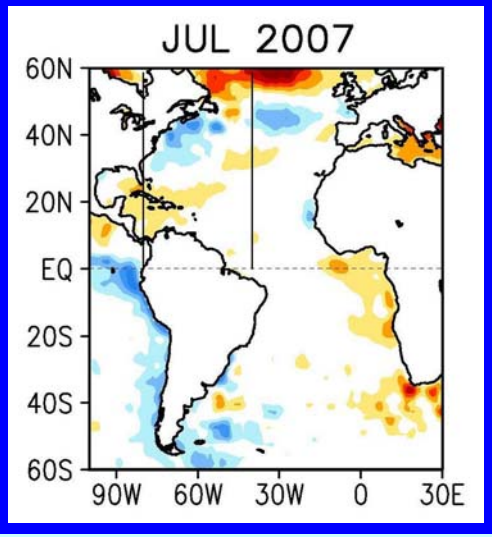


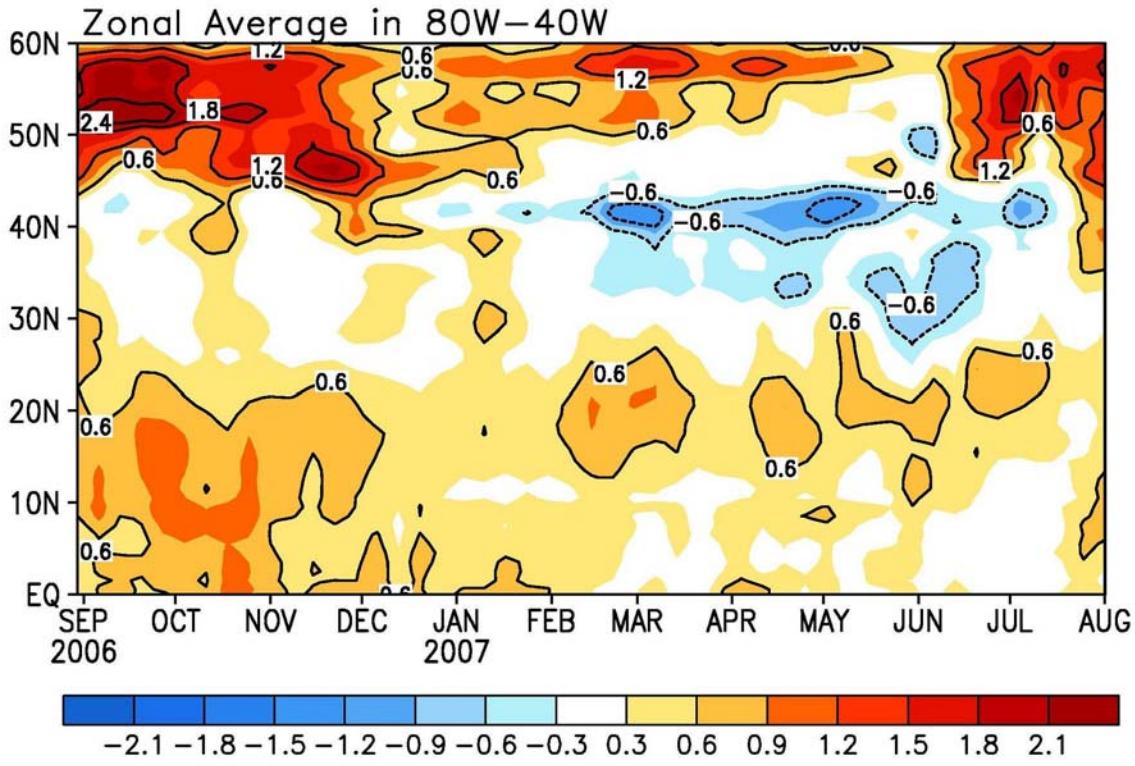


The positive SST anom. in the high-latitude North Atlantic was probably due to the easterly wind anom. which reduced the surface cooling by evaporation. The low-level cyclonic wind anom. centered on the British Isles are associated with the enhanced convection (negative OLR) over the Northern Europe.

Recent Evolution of SST Anomaly in the Northwest Atlantic







The zonal average SSTs in 80ºW-40ºW between 40ºN and 60ºN was strongly influenced by atmospheric surface winds related to NAO, being strongly positive when NAO was in a negative phase and weak positive when NAO was in a positive phase.

The zonal average SSTs in 80ºW-40ºW between 10ºN and 25ºN have been above-normal during the past 12 months, but the anom. were not as large as those last summer.

CFS ENSO Predictions and GODAS Uncertainties

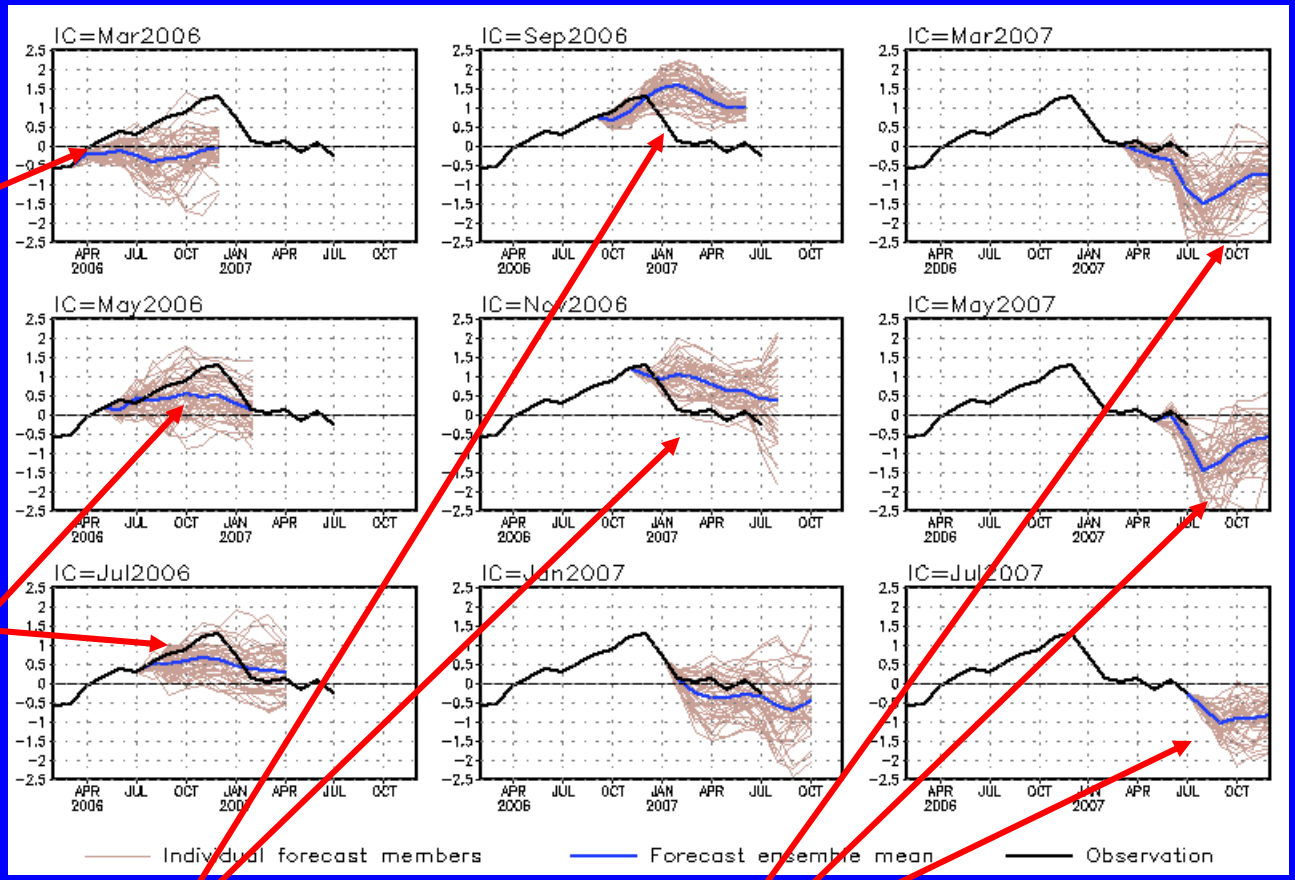
CFS Nino3.4 Forecasts from Different Initial Months

Missed the onset of the 2006/07 El Nino.

Underestimated the amplitude of the 2006/07 El Nino.

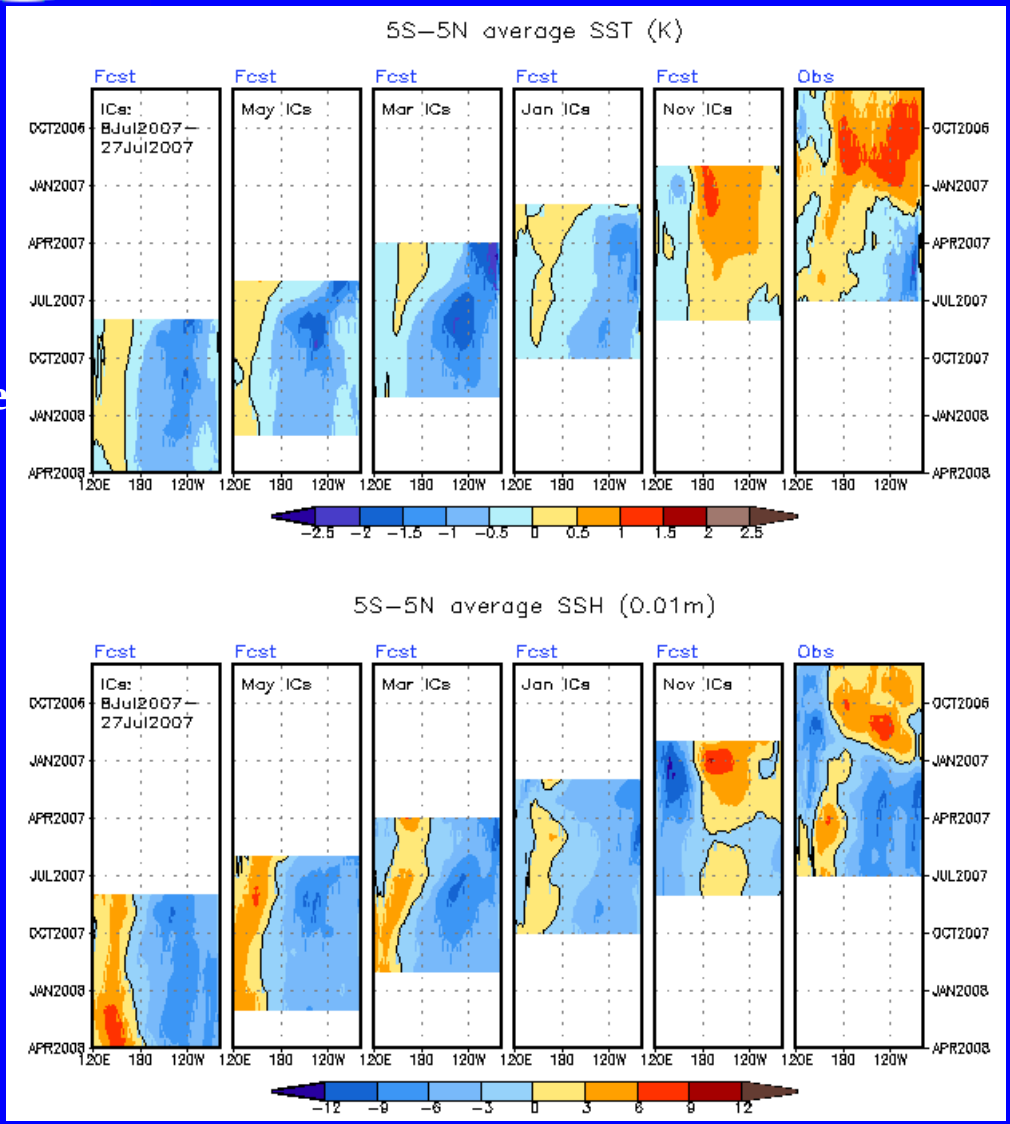
Missed the fast termination of the 2006/07 El Nino.

Forecast La Nina to be developed during summer of 2007.



Evolution of CFS SST and SSH vs. OBS in 5ºS-5ºN

JUL MAY Mar Jan Nov



Time

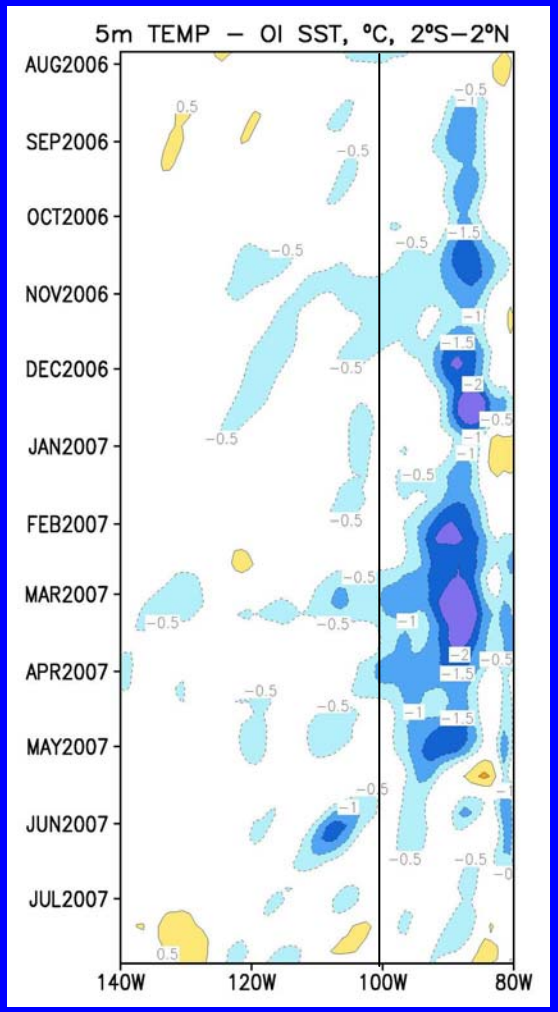
Longitude

The observed SST transitioned from positive to negative anom. during January-February 2007. CFS did not forecast the transition from Nov. I.C. when the equatorial HC anom. were positive, but it successfully forecasted the transition to negative SST anom. from Jan. I.C. when the equatorial HC anom. became negative.

From Mar-May 2007 I.C., CFS consistently predicted the negative SST anom. would grow and spread to the western Pacific, and peak during summer 2007. Compared to observations, the forecast SST anom. were too large and extend too far westward, while the forecast SSH anom. were reasonable.

Recent Evolution of GODAS Biases: Equatorial Temperature (5m) and SSH

Temp(5m) – OI SST

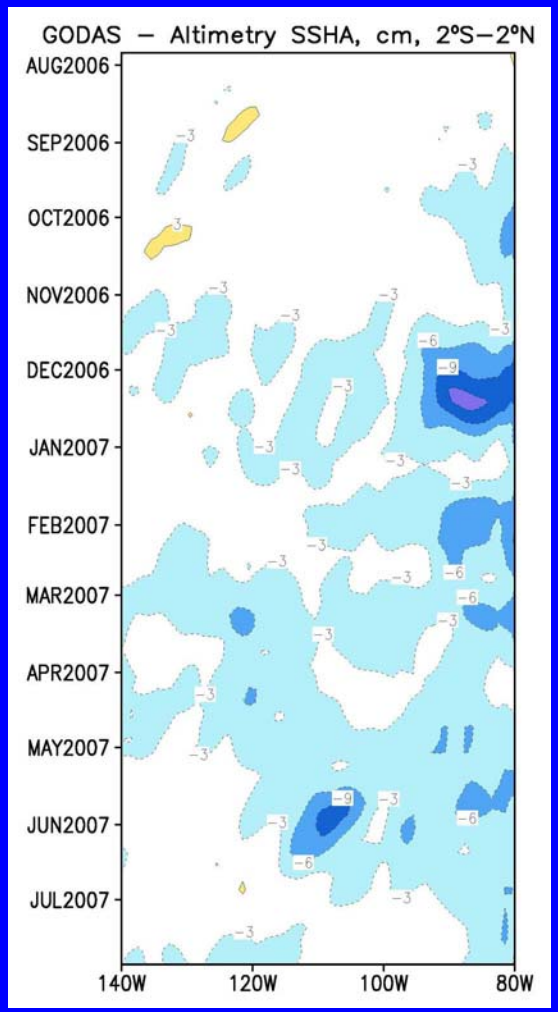


The GODAS temperature at 5 meter depth has been more than 1°C lower than the OI SST in the far eastern equatorial Pacific between 100°W and 80°W during February-April 2007.

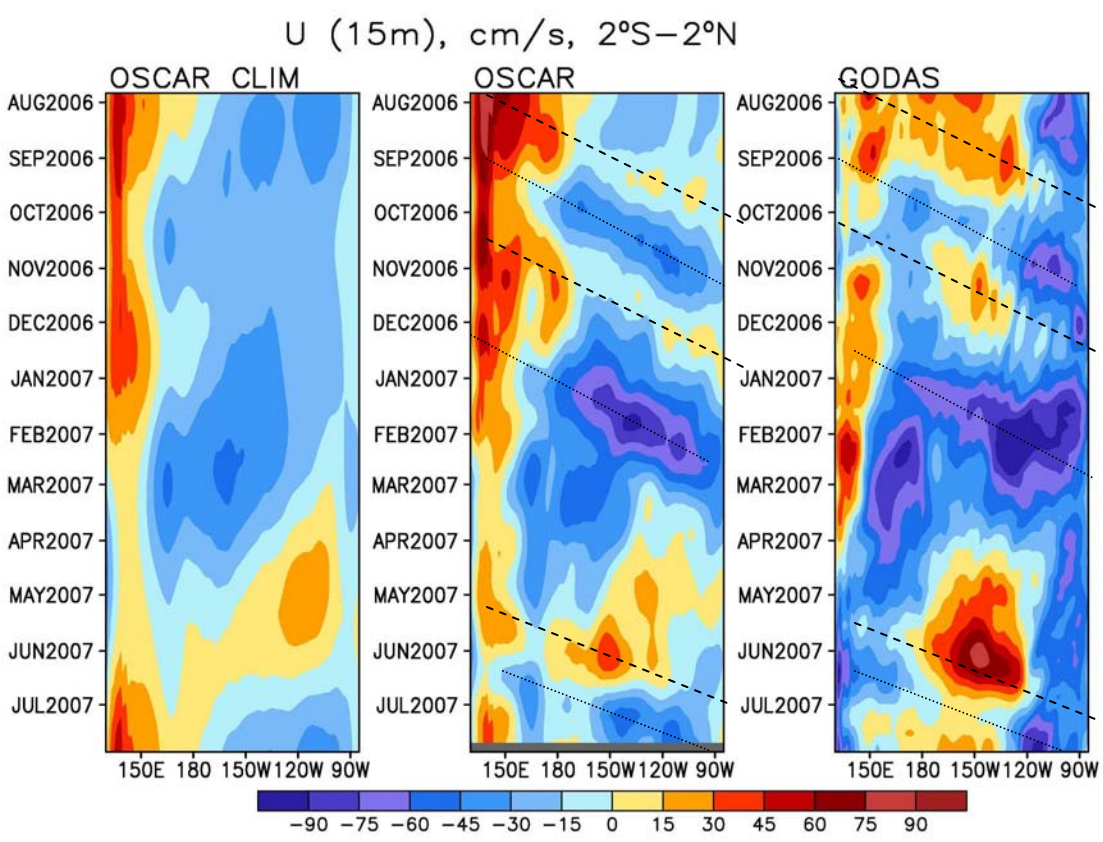
The GODAS SSH anomaly was about 3 cm lower than the Altimetry SSH anomaly in the far eastern Pacific during November 2006 to June 2007.

The negative SST and SSH biases might have contributed to the cold biases of the CFS NINO3.4 forecast from February- June I.C..

GODAS – Altimetry SSHA



Recent Evolution of GODAS Biases: Equatorial Surface (15 m) Zonal Current



A few episodes of Kelvin waves, the warm phases of which are indicated by the dashed lines, were evident in surface zonal current during August 2006 to January 2007. Since April 2007, the surface zonal current has been close to normal conditions featured by the westward propagating eastward zonal current. Since mid-May, oceanic Kelvin waves have caused positive and negative surface zonal current anom. in June and July 2007.

The GODAS surface zonal current was biased westward in the far western Pacific, eastward in the central Pacific and westward in the far eastern Pacific. The westward biases in the far eastern Pacific since February 2007 probably have contributed to the westward biases of the CFS forecast SST anomalies.

Summary

Pacific Ocean

- Since mid-May 2007, two oceanic Kevin wave episodes have brought HC in the central-eastern Pacific from below-normal in May to near normal in June to below-normal in July. The intraseasonal variability in the ocean was associated with the intraseasonal surface wind variability related to the Madden Julian Oscillation.
- The negative SST tendency between 140°W-100°W was related to the negative SSH anom. and negative surface zonal current anom. which reduced SST by moving the cold tongue water westward.
- The positive SST tendency along the west coast of North America was associated with onshore Ekman transport due to the surface cyclonic wind anom. near the Gulf of Alaska, which suppressed coastal upwelling in June and July 2007.

Indian Ocean

- The tropical SST and low-level winds were near normal, but the convection was enhanced in the central Indian and Maritime continent due to MJO activities.

Atlantic Ocean

- Low-level westerly wind anom. was associated with the positive SST anom. in the eastern equatorial Atlantic. During July 2007, the Caribbean Sea was dry, and the Sahel region was wet.
- The positive SST anom. in the high-latitude North Atlantic during June-July 2007 was probably forced by the easterly wind anom. associated with the negative phase of NAO, which reduced the surface cooling by evaporation.