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

Update prepared by
Climate Prediction Center / NCEP
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Outline

- Overview
- Recent Evolution and Current Conditions
  - ✓ Pacific Ocean
  - ✓ Indian Ocean
  - ✓ Atlantic Ocean
- SST Predictions by NCEP Climate Forecast System

Overview

• During the last few months, tropical Pacific SST anomalies evolved toward a La Nina condition. The negative SST anomalies in the far eastern equatorial Pacific from March to May 2007 are consistent with local negative heat content anomalies, which are associated with persistent easterly wind anomalies since December 2006 (slides 1, and 13-14).

• Positive SST anomalies developed in the equatorial Indian Ocean in May 2007 in association with suppressed convections in the region (slides 20, 22 and 23).

• Positive SST anomalies increased in the far eastern equatorial Atlantic in May 2007, which are associated with positive (negative) subsurface temperature anomalies in the eastern (western) equatorial Atlantic and weak westerly wind anomalies in the central equatorial Atlantic (slides 2 and 30).

• The persistent negative SST anomalies over the Gulf of Alaska during the last six months weakened slightly in May 2007 (slide 11).

• The triple-pole SST pattern in North Atlantic has been persistent since February 2007 (slide 28).

Data Sources

- Optimal Interpolation SST version 2
- NCEP/NCAR Reanalysis-1 850 mb winds
- Outgoing Long Wave Radiation
- NCEP's Global Ocean Data Assimilation System (GODAS)
- Aviso Altimetry Sea Surface Height
- Ocean Surface Current Analyses – Realtime (OSCAR)

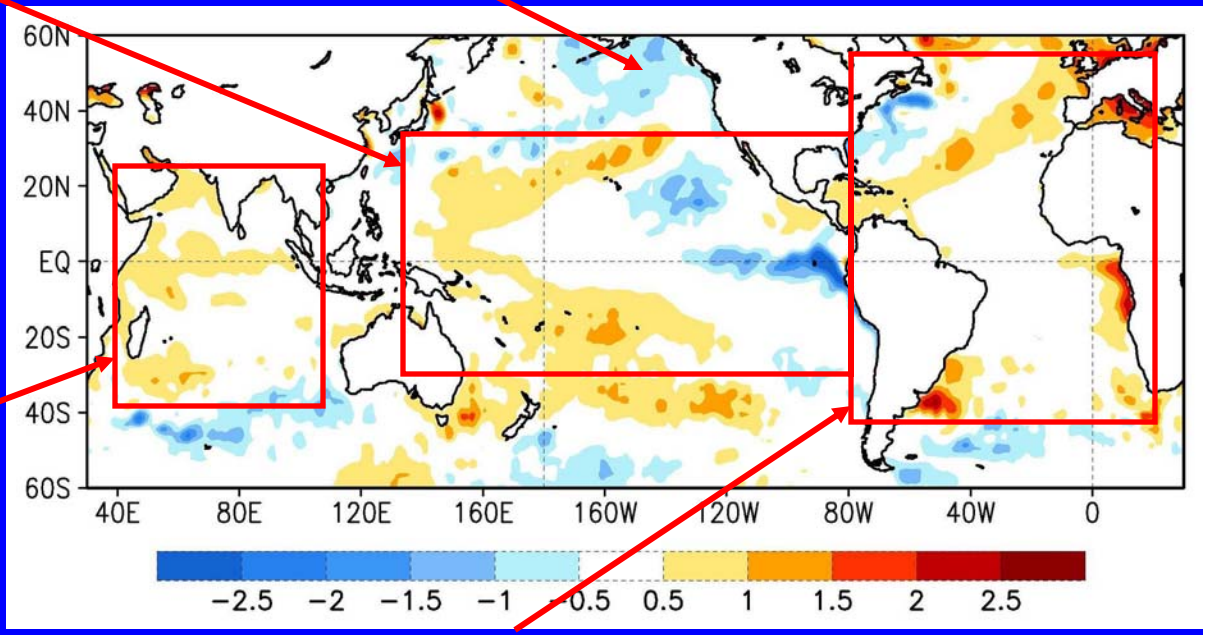
Global Ocean SST Departures (°C)

(Climatology 1971-2000)

May 2007

Positive SST departures are observed in the western equatorial Pacific, western-central subtropical Pacific, and negative SST departures are present in the eastern equatorial Pacific.

Negative SST departures are present over the Gulf of Alaska.



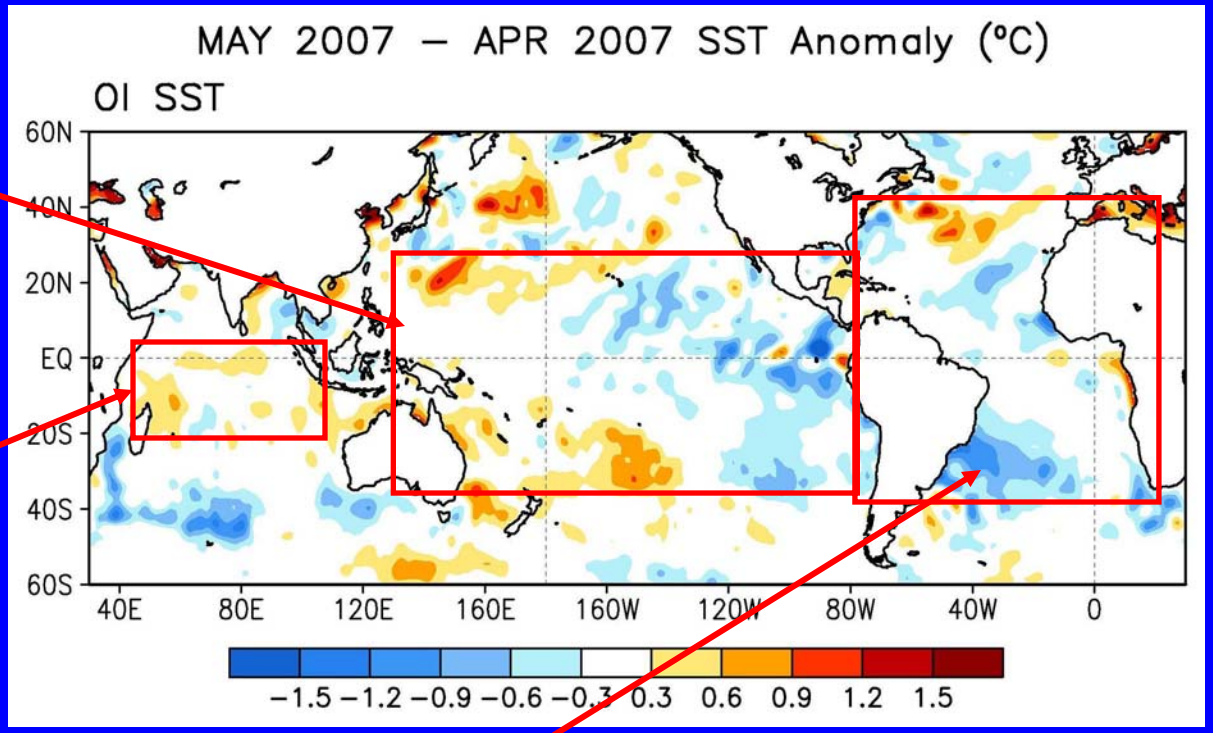
Positive SST departures are present in the equatorial Indian Ocean, southeast of Madagascar, and near the coast of Somali and Arabia.

Positive SST departures extend from the coast of Spain to Caribbean Sea, near the coast of Argentina, western coast of Africa and far eastern equatorial Atlantic. Negative SST departures are present along the eastern coast of North America.

Global Ocean SST Departure Tendency (°C)

(Climatology 1971-2000)

SST anomalies decreased in the eastern Pacific, and increased in the subtropical western-central Pacific.



SST anomalies increased in the central equatorial Indian Ocean and northeast of Madagascar.

SST decreased substantially near the southeastern coast of Brazil, and increased in the eastern equatorial Atlantic.

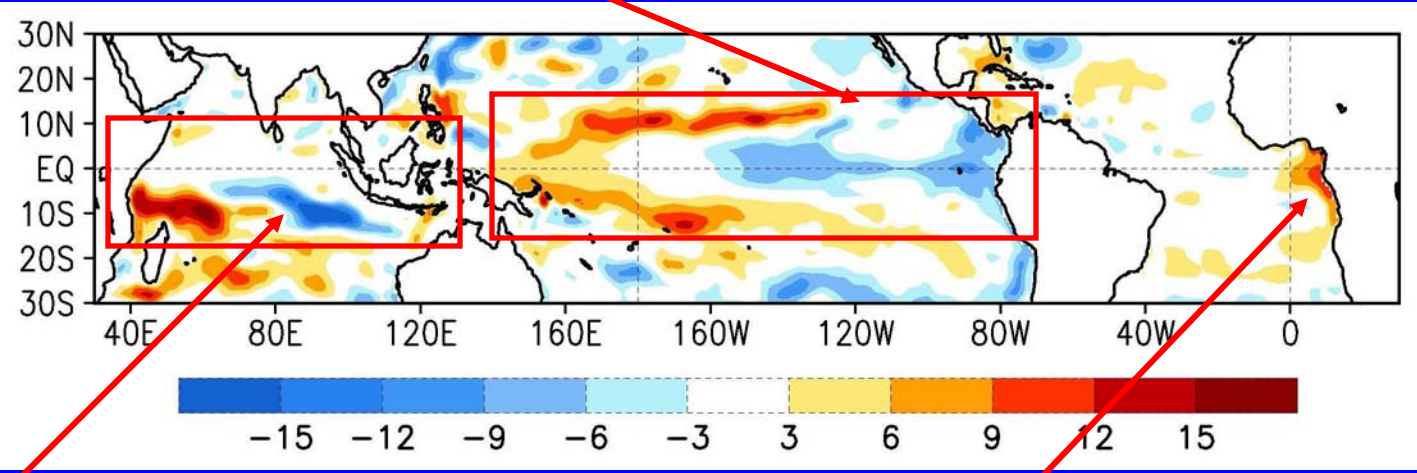
Tropical Sea Surface Height Departures (cm)

(Climatology 1982-2004)

May2007

SSH is from the Global Ocean Data Assimilation System (GODAS) (http://www.cpc.ncep.noaa.gov/products/GODAS)

Negative SSH departures are present in the eastern equatorial Pacific, and positive SSH departures in the western equatorial Pacific and subtropical Pacific.



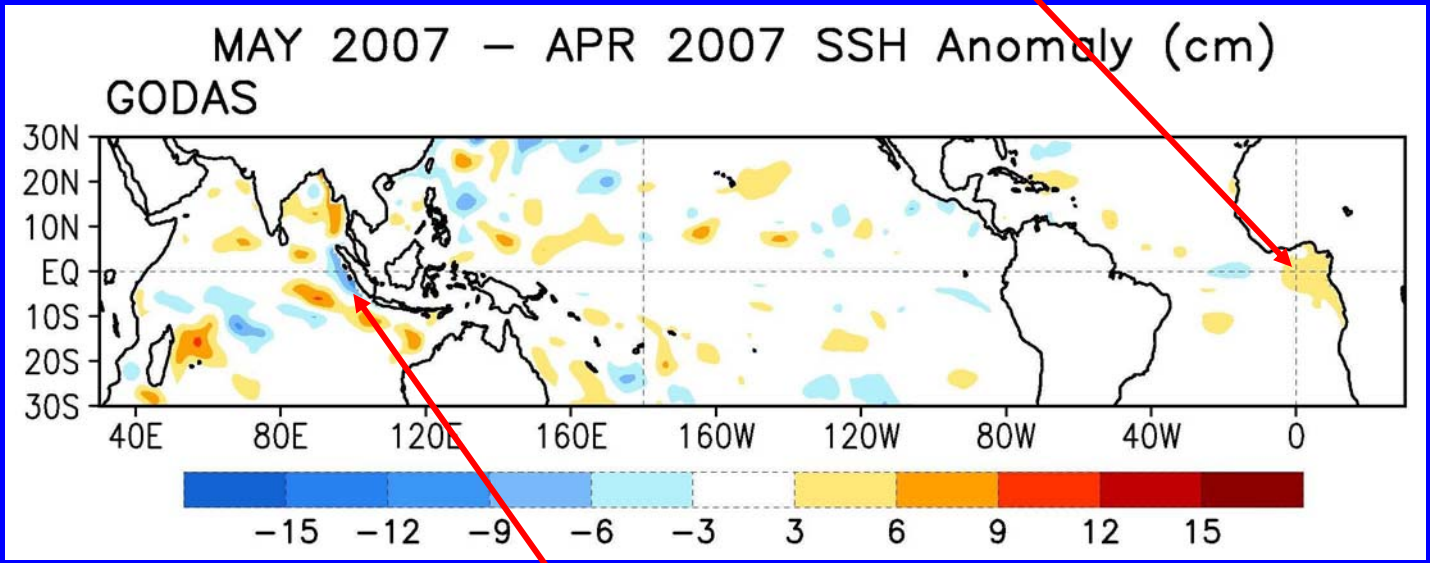
Positive (negative) SSH departures are present in the west-southern (east-southern) subtropical Indian Ocean.

Positive SSH departures are present in the Gulf of Guinea.

Sea Surface Height Departure Tendency (cm)

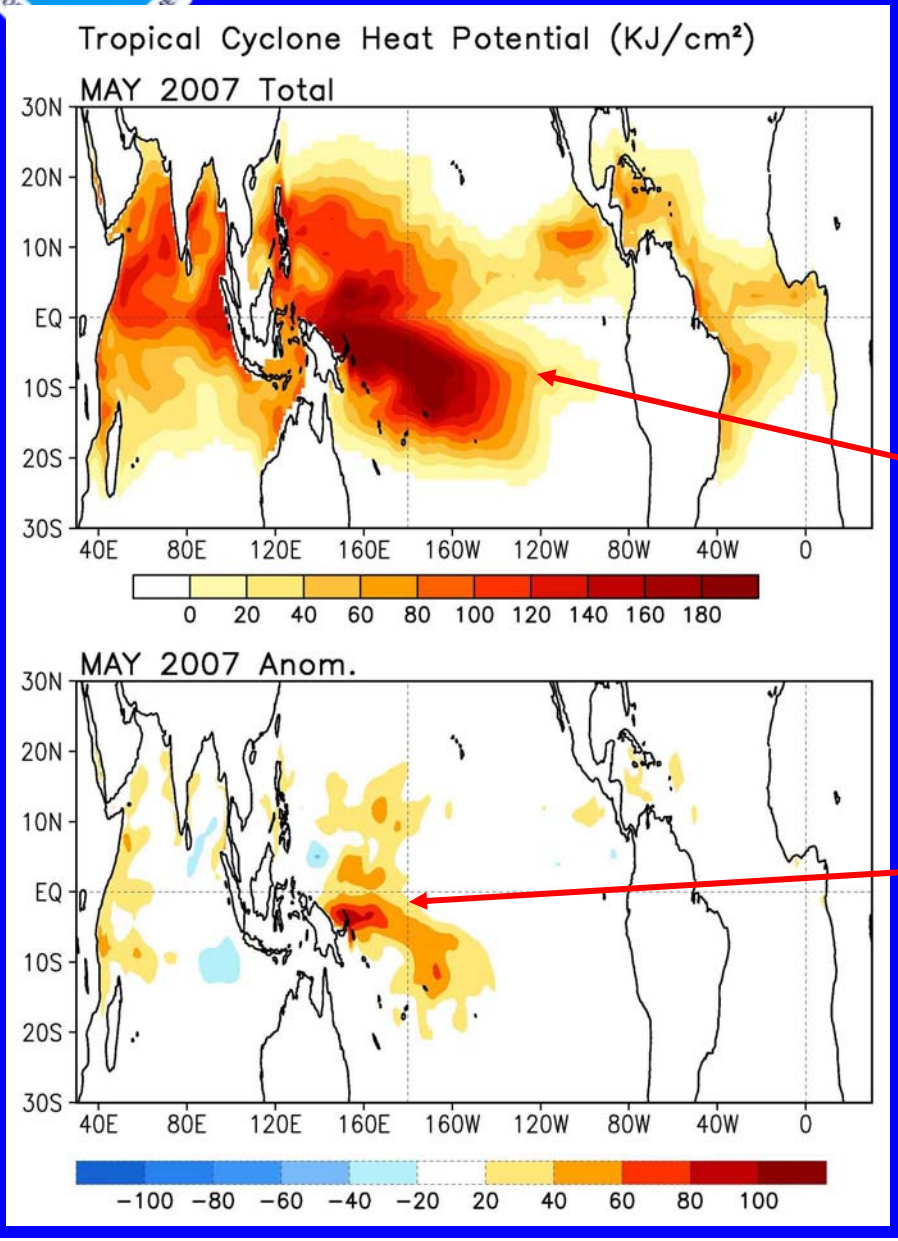
(Climatology 1982-2004)

SSH increased in the Gulf of Guinea.



SSH decreased in the far eastern equatorial Indian Ocean.

Tropical Cyclone Heat Potential



Climatology: TCHP 1982-2004
Tropical Cyclone Heat Potential (TCHP), which measures potential energy stored from the surface to the depth of 26ºC isotherm, is derived from the Global Ocean Data Assimilation System (GODAS) (http://www.cpc.ncep.noaa.gov/products/GODAS)

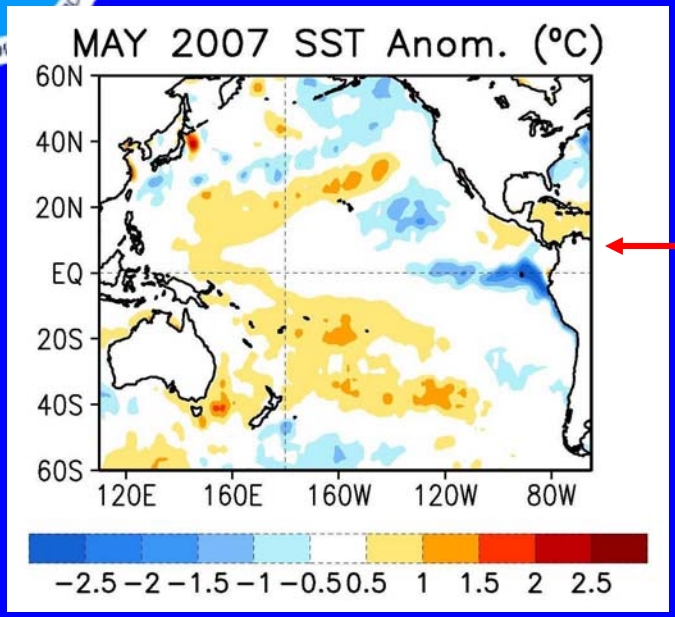
TCHP has the largest amplitude in the tropical Indian Ocean and western tropical Pacific Ocean.

Currently, TCHP is above-average in the western tropical Pacific with a maximum extending from east of New Guinea to 160ºW and 10ºS. A weak east-west dipole of TCHP anomalies is located along 10ºS in the Indian Ocean. The tropical Atlantic is close to normal conditions in May 2007.

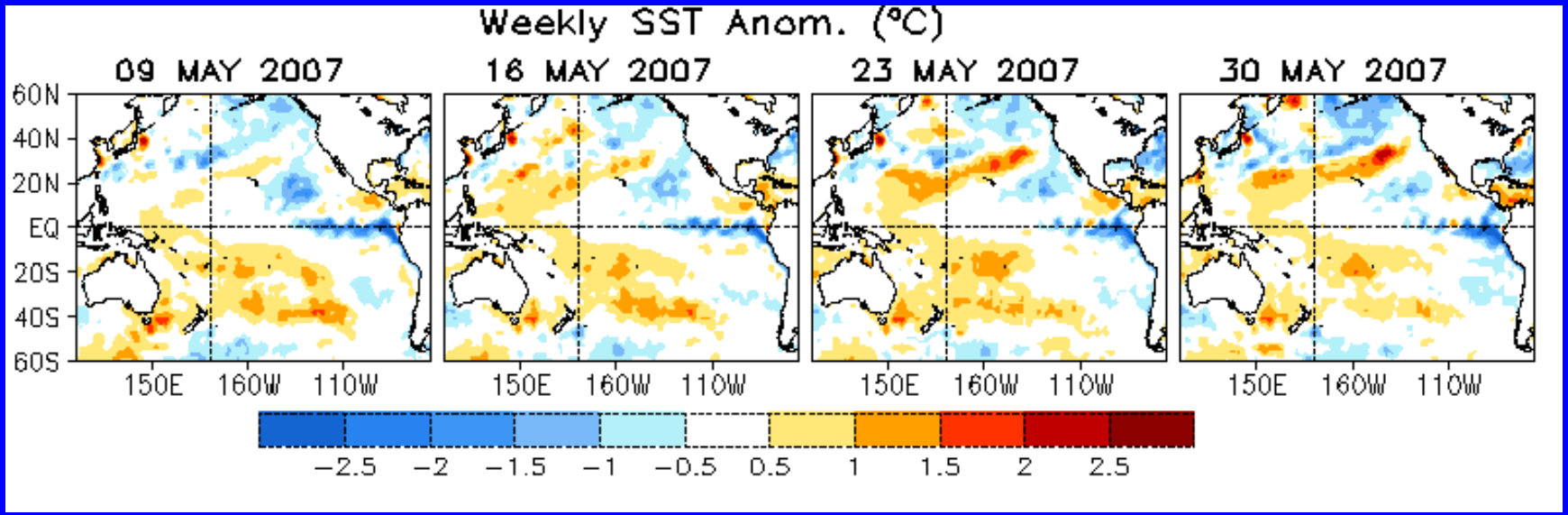
Pacific Ocean

Pacific Ocean SST Departures (°C)

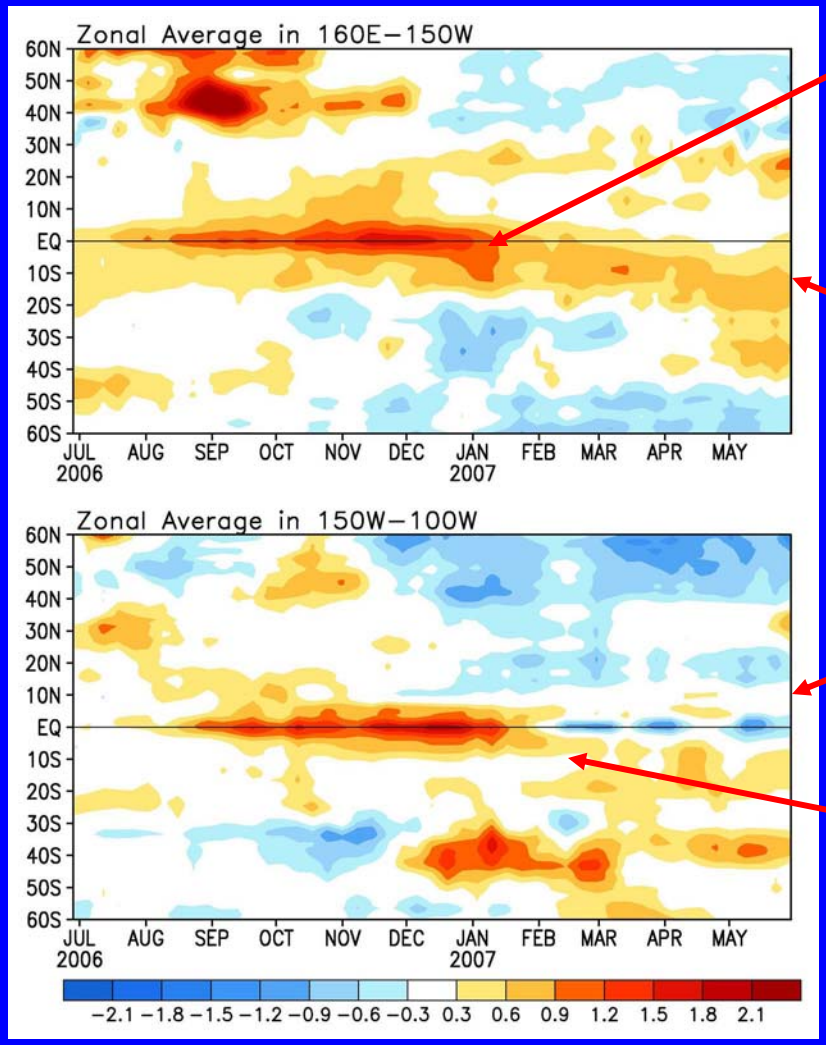
(Climatology 1971-2000)



Positive SST departures are present in the western equatorial Pacific, western-central subtropical Pacific, and negative SST departures are present in the eastern equatorial Pacific and over the Gulf of Alaska.



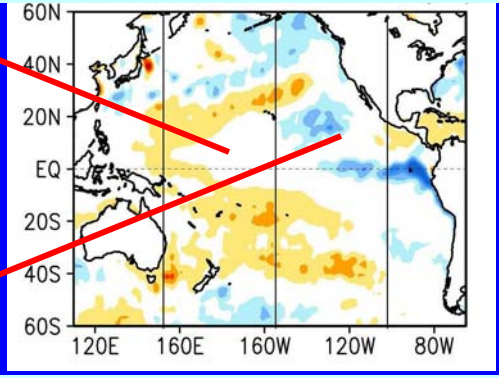
Recent Evolution of SST Departures in the Central and Eastern Pacific



Latitude

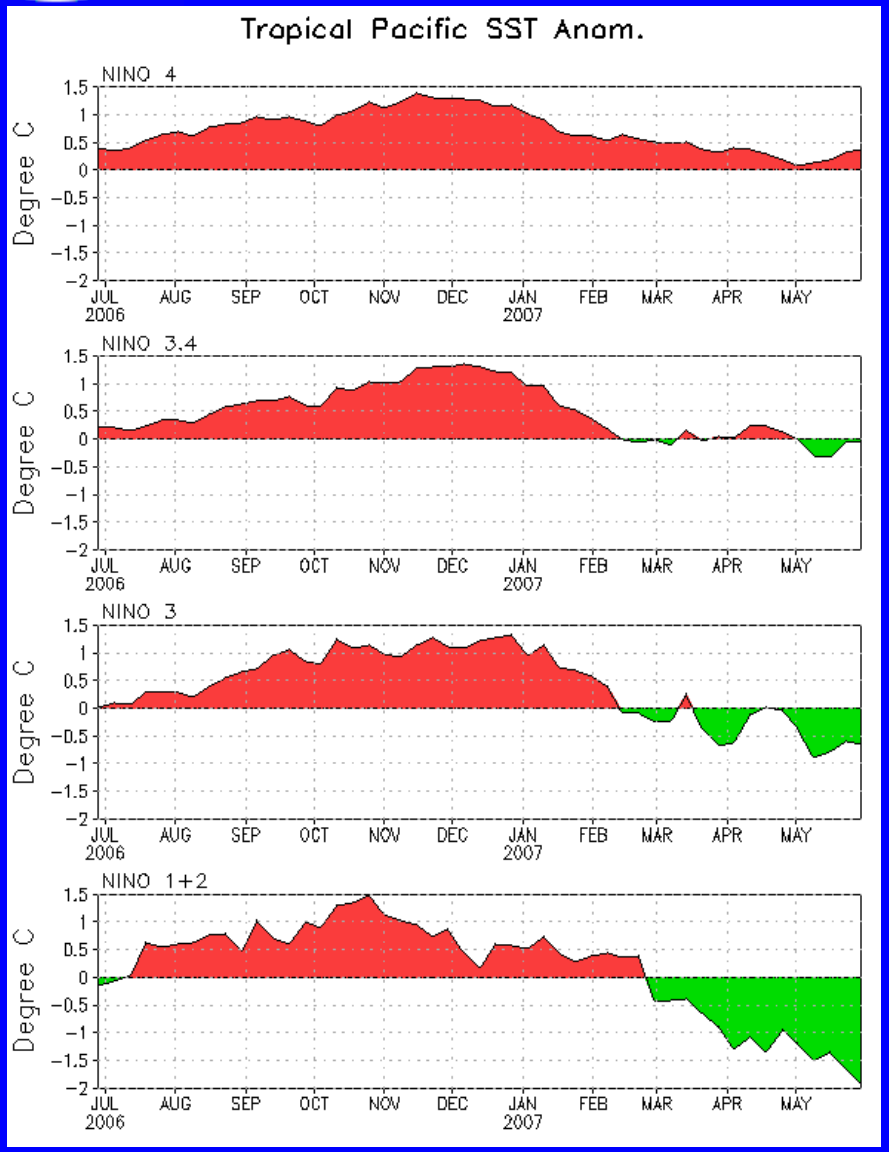
Time

During the past 12 months, the zonal average SSTs in 160ºE-150ºW have been above-average between 20ºS and 5ºN with anomalies greater than +1º during September to December 2006. The center of anomalies shifted from the equator to about 10ºS in January/February 2007, and persisted since then.



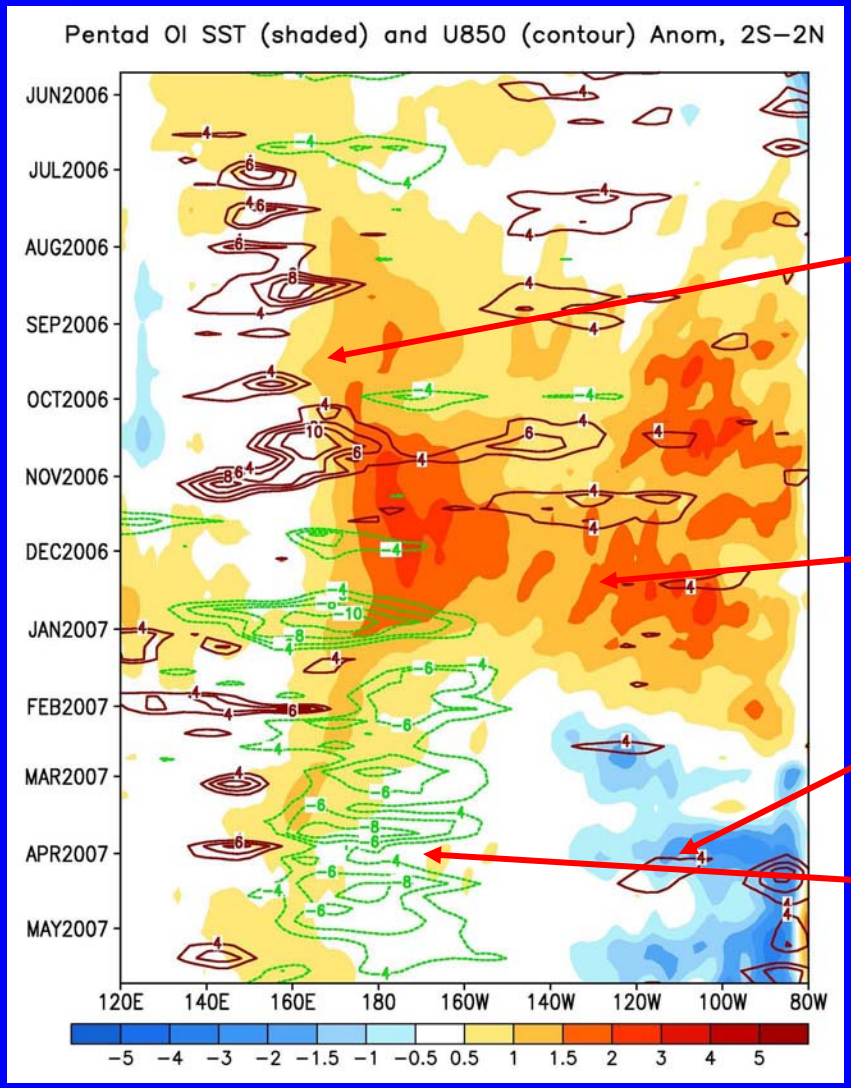
During the past 12 months, the zonal average SSTs in 150ºW-100ºW have been above-average between 10ºS and 5ºN during September 2006 to January 2007, and below-average afterwards. The negative SST anomalies between 40ºN and 60ºN over the Gulf of Alaska and positive SST anomalies in South Pacific have persisted from December 2006 to May 2007.

Recent Evolution of Pacific NINO SST Indices



- **NINO 4 SST increased gradually from 0.5ºC in August to 1.4ºC in November-December, decreased rapidly in January 2007 to about 0.5ºC, and then slowly to near zero by May 2007.**
- **NINO 3.4 increased from near neutral in July to about 1.3ºC in November-December, and then decreased rapidly to near neutral in February 2007, and remained neutral since then.**
- **NINO 3 increased from near neutral in July to about 1.1ºC in November-December, and then decreased rapidly to below-average in March 2007. It is below -0.5ºC in May 2007.**
- **NINO 1+2 increased from near neutral conditions in June to about 1.4ºC in October, and then decreased gradually. It became below-average since March 2007.**

Recent Evolution of Equatorial Pacific SST (shaded) and Surface Zonal Wind (contour) Departures



Time

Longitude

Climatology: SST 1971-2000

Reanalysis-2 850 mb winds 1979-1995

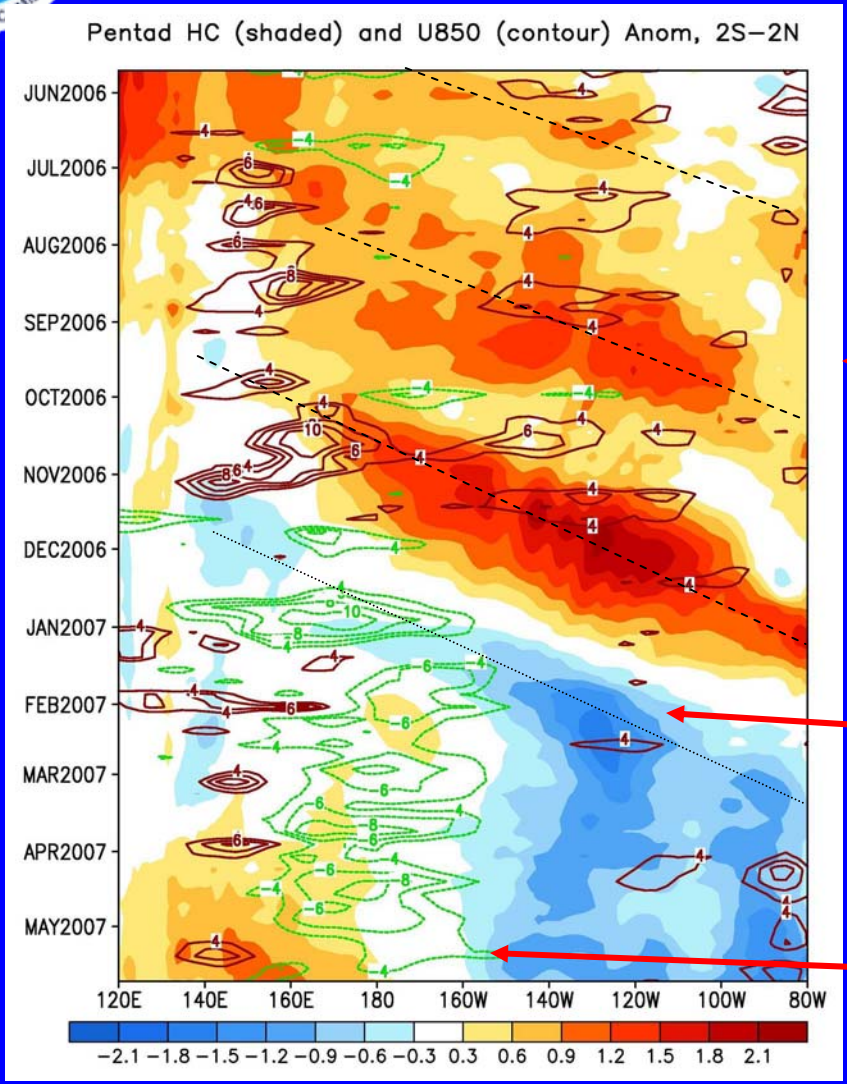
Above-average SST departures are accompanied by westerly wind anomalies to the west of SST anomalies.

Between July 2006 and December 2006, positive SST anomalies increased across the equatorial Pacific between 160ºE and the South American coast.

During January-February 2007, SST anomalies decreased everywhere east of the Date Line.

During December 2006 -May 2007, easterly wind anomalies are present between 160ºE and 160ºW.

Recent Evolution of Equatorial Pacific Upper Ocean (0-300m) Heat Content and Surface Zonal Wind Departures



Time

Longitude

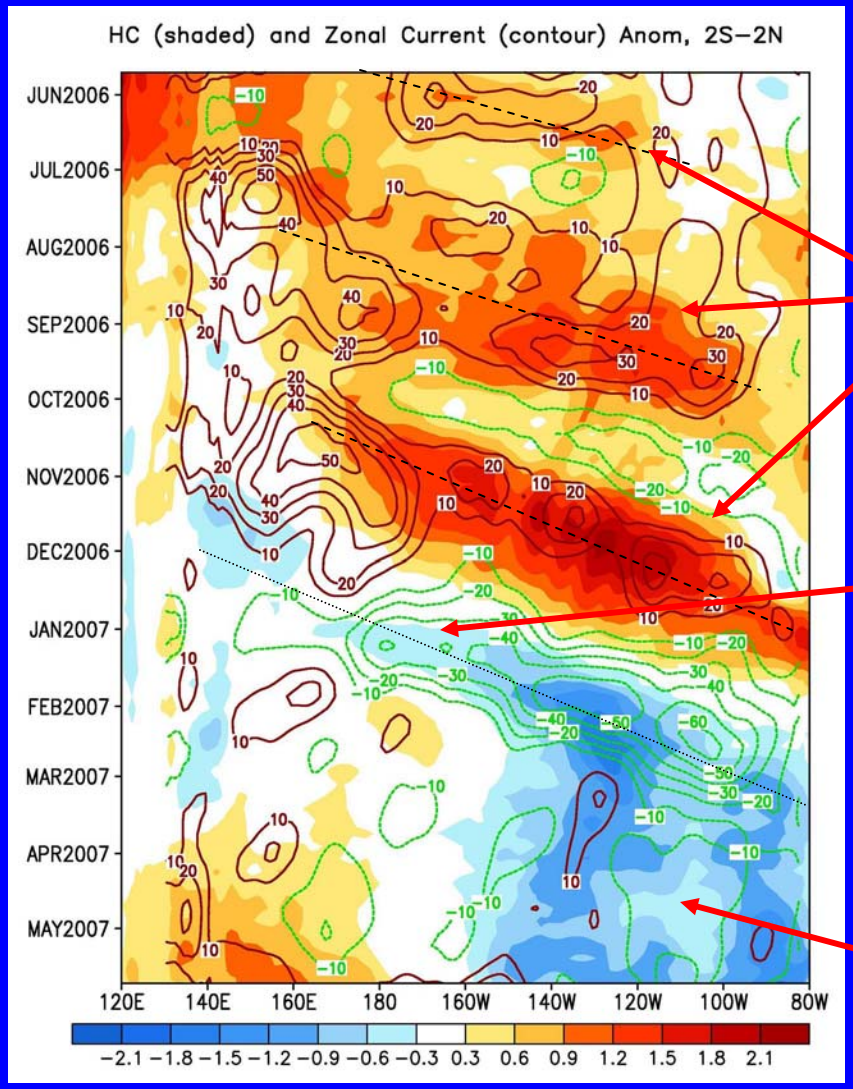
Climatology: Heat Content 1982-2004
Reanalysis-2 850 mb wind 1979-1995
Heat Content is from the Global Ocean Data Assimilation System (GODAS) (http://www.cpc.ncep.noaa.gov/products/GODAS)

Three episodes of Kelvin waves, the warm phases of which are indicated by the dashed lines, were evident in heat content departures during May to December 2006. They were forced by westerly wind anomalies (contour) in the western-central Pacific.

One Kevin wave episode, the negative phase of which is indicated by the dotted line, was initiated in late December 2006 by strong easterly wind anomalies.

During January-May 2007, easterly wind anomalies were present between 160ºE-160ºW, consistent with the negative heat content anomalies in the eastern Pacific.

Recent Evolution of Equatorial Pacific Upper Ocean (0-300m) Heat Content and Surface Zonal Current Departures



Time

Longitude

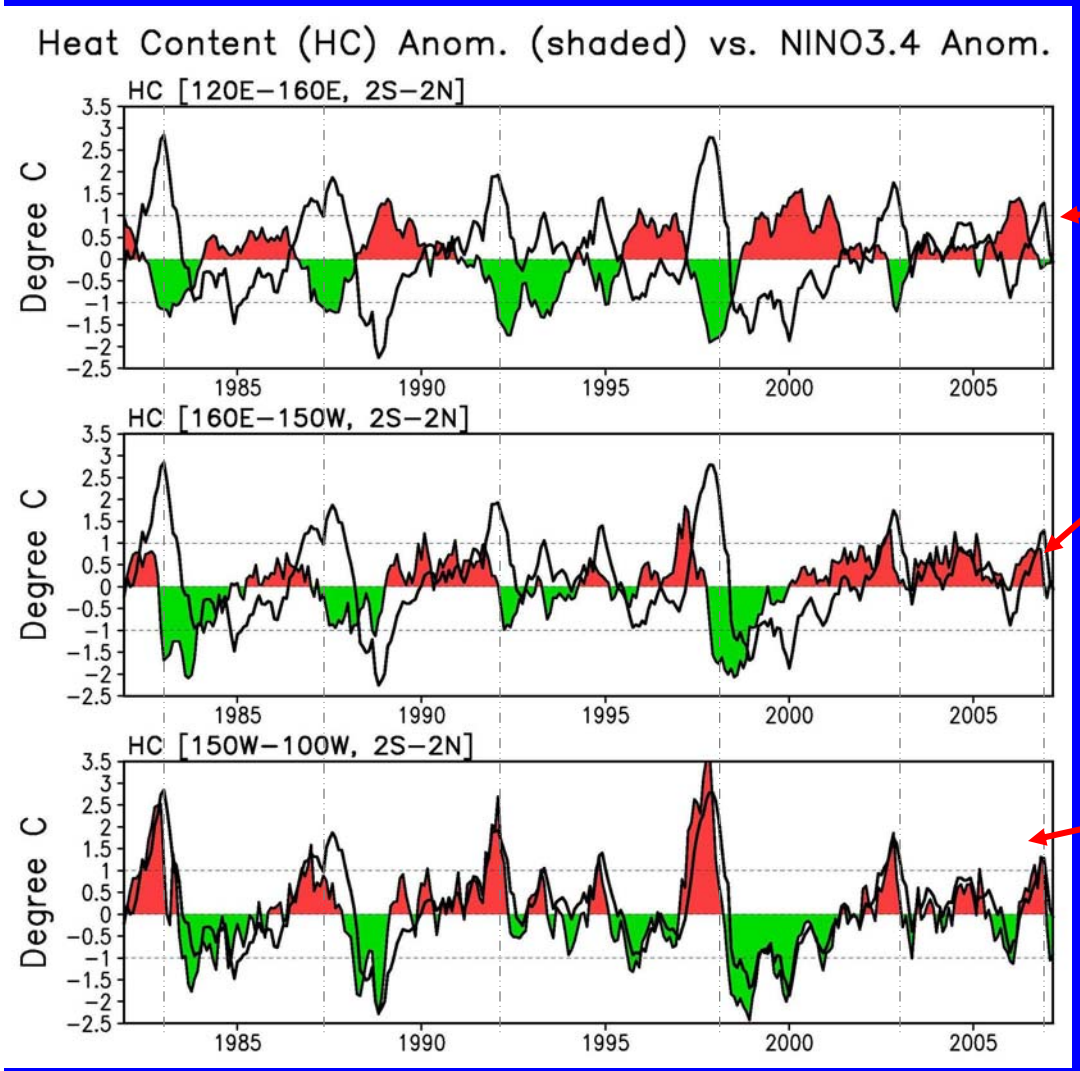
Climatology: Heat Content 1982-2004
Surface Zonal Current 1979-1995
Surface zonal currents are from Ocean Surface Current Analyses – Realtime (http://www.oscar.noaa.gov)

Three episodes of Kelvin waves, the warm phases of which are indicated by the dashed lines, were evident in not only heat content (shaded) but also surface zonal current (contour) departures during May to December 2006.

One Kevin wave episode, the negative phase of which is indicated by the dotted line, was initiated in late December 2006 and had signatures in both heat content and surface zonal current anomalies.

During January-May 2007, negative heat content anomalies are persistent in the eastern Pacific, while negative surface zonal current anomalies decreased substantially in early March.

Historical Evolution of Western, Central and Eastern Equatorial Pacific Heat Content and NINO3.4 SST Departures

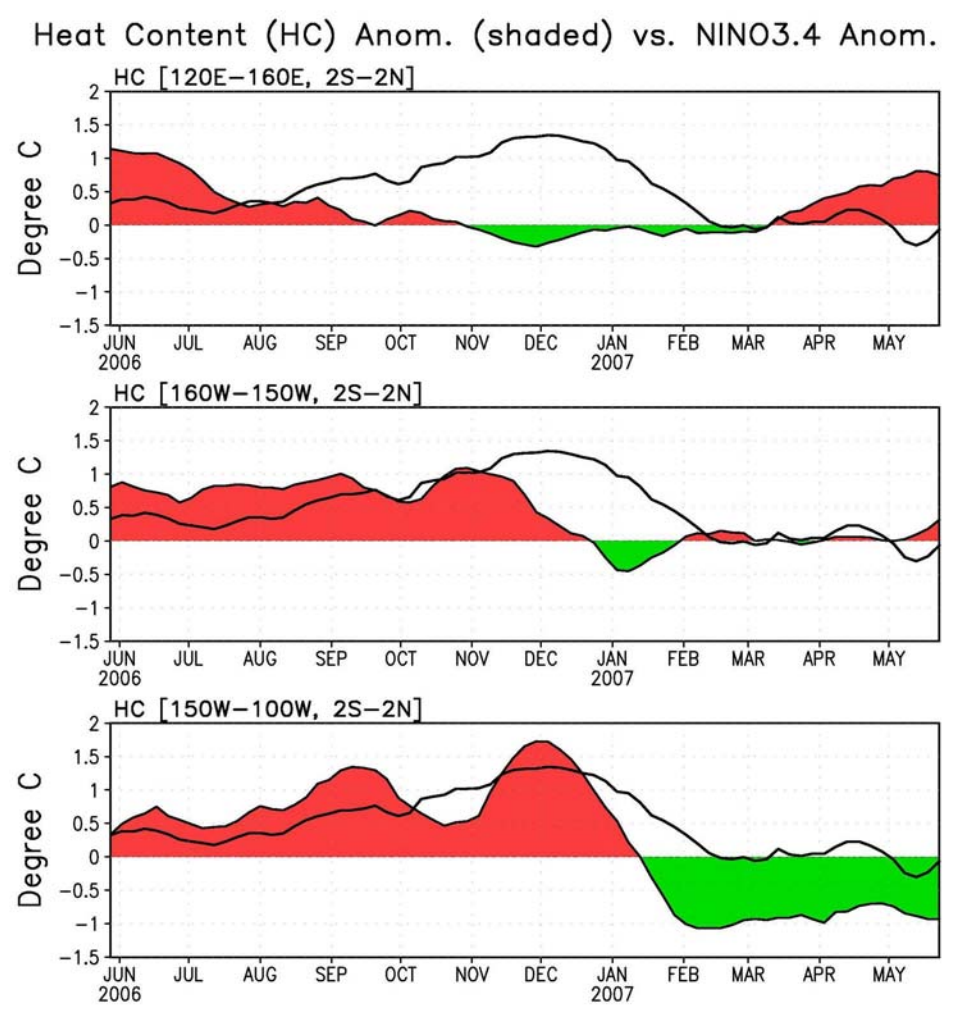


Climatology: SST 1971-2000

Heat Content 1982-2004

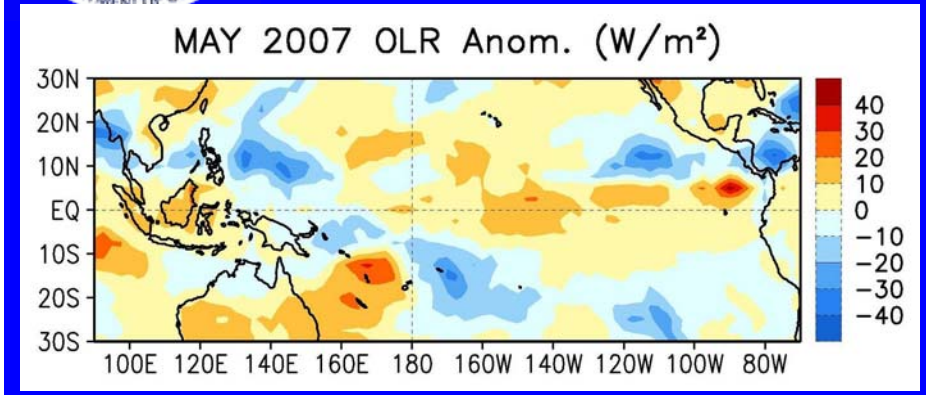
- **The western equatorial (120ºE-160ºE, 2ºS-2ºN) upper ocean (0-300 m) heat content anomalies (shaded) are out of phase with NINO3.4 (curve). But the 2004/05 and 2006/07 El Ninos are exceptions.**
- **The central equatorial (160ºE-150ºW, 2ºS-2ºN) heat content anomalies are greatest prior to and during the early stages of a Pacific warm (El Niño) episode and least prior to and during the early stages of a cold (La Niña) episode.**
- **The eastern equatorial (150ºW-100ºW, 2ºS-2ºN) heat content anomalies are largely in phase with NINO3.4, but leads the latter by a few months during onsets of La Nina and decays of El Nino.**

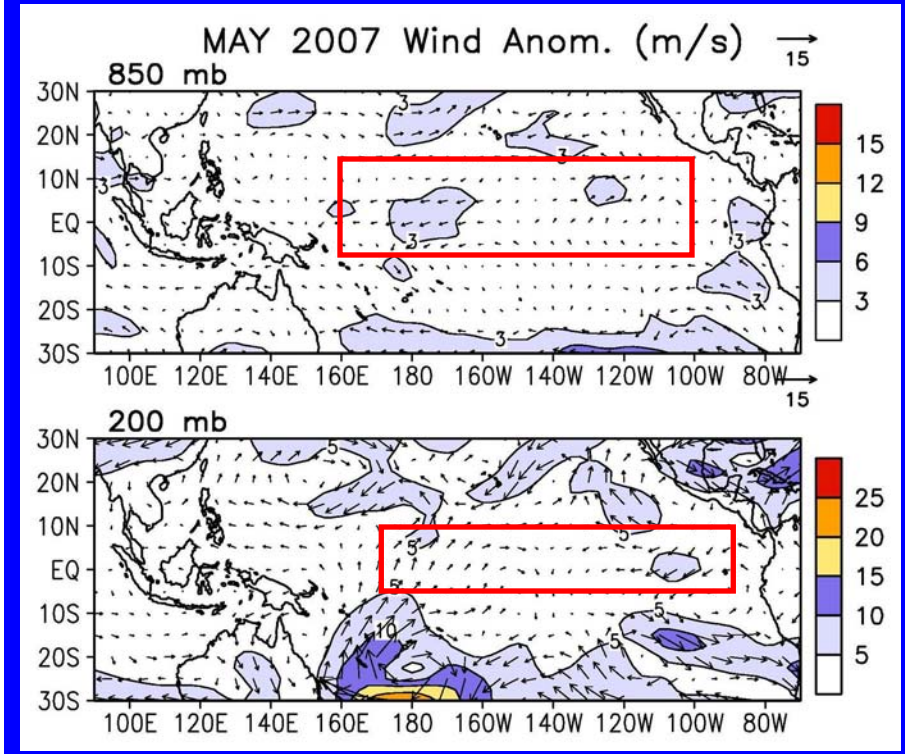
Recent Evolution of Western, Central and Eastern Equatorial Pacific Heat Content and NINO3.4 SST Departures



- **The western equatorial (120ºE-160ºE, 2ºS-2ºN) upper ocean (0-300 m) heat content anomalies declined from Jun to December 2006, and then increased slowly to +0.7ºC in May 2007.**
- **The central equatorial (160ºE-150ºW, 2ºS-2ºN) heat content anomalies remained above 0.5ºC increased slowly from Jun to November 2006 and then decreased rapidly during November-December 2006. It has been close to normal conditions since February 2007.**
- **The eastern equatorial (150ºW-100ºW, 2ºS-2ºN) heat content anomalies had increased from Jun to December 2006 with a few large fluctuations and then decreased rapidly to -1ºC in February 2007. Note that negative heat content anomalies have not lead to substantial negative NINO3.4 anomalies yet.**

Tropical Pacific OLR and Wind Anomalies





Climatology: OLR 1979-1995
Winds 1979-1995

Negative OLR anomalies (enhanced convection and precipitation, blue shading) were observed in the far eastern Pacific north of the equator, while positive OLR anomalies (suppressed convection, orange shading) were present in the equatorial central-eastern Pacific.

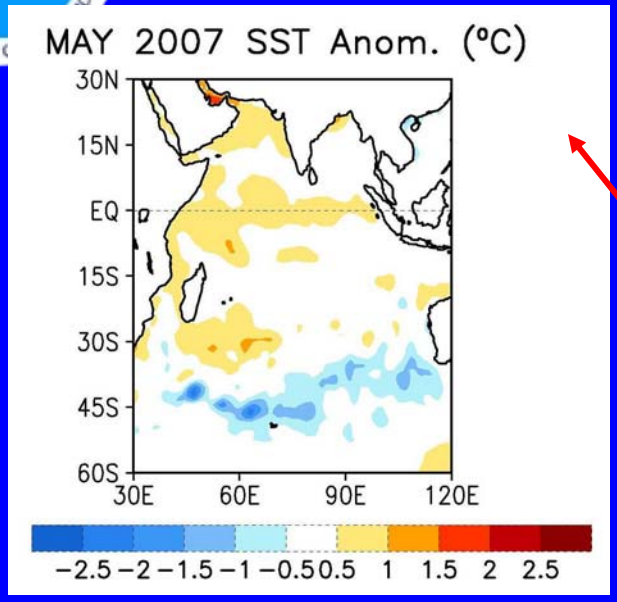
Weak low-level (850-hPa) easterly wind anomalies were observed across the central equatorial Pacific, and weak lower-level westerly wind anomalies were observed in the subtropical North Pacific.

Equatorial upper-level (200-hPa) wind anomalies are weak.

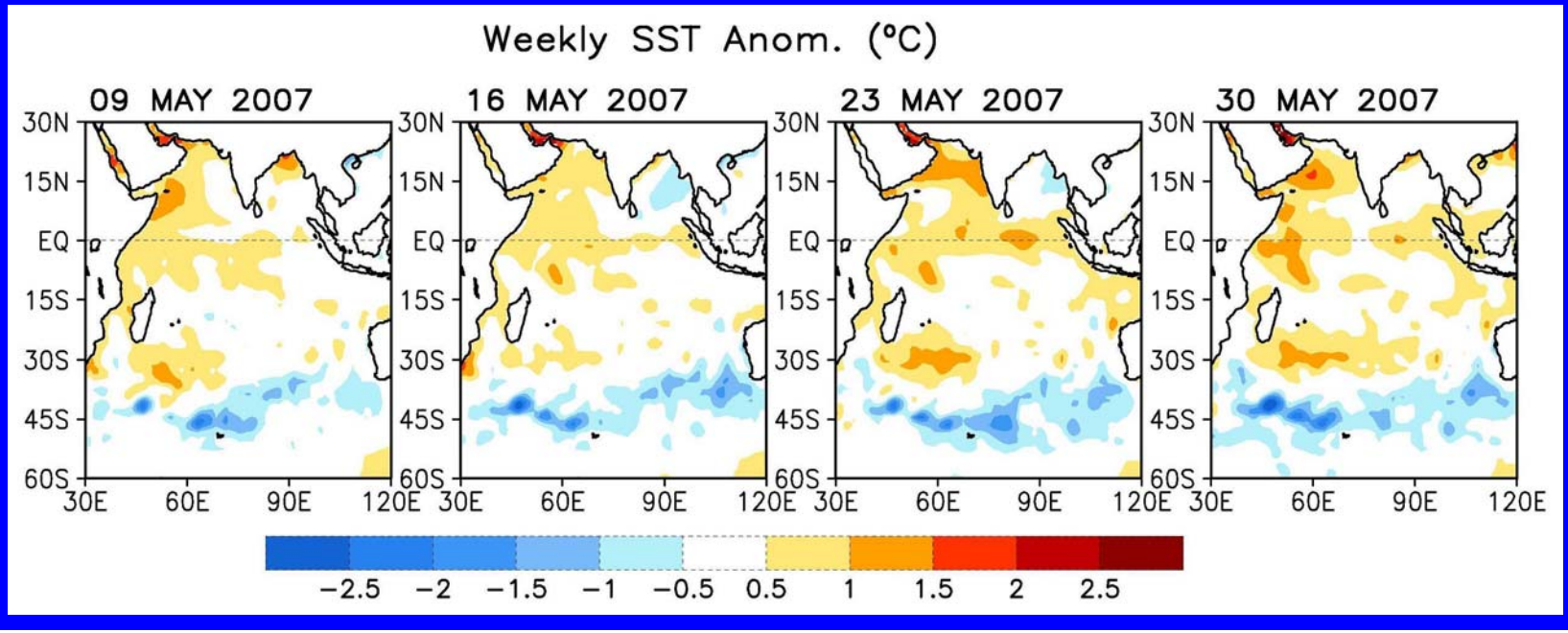
Indian Ocean

Indian Ocean SST Departures (°C)

(Climatology 1971-2000)

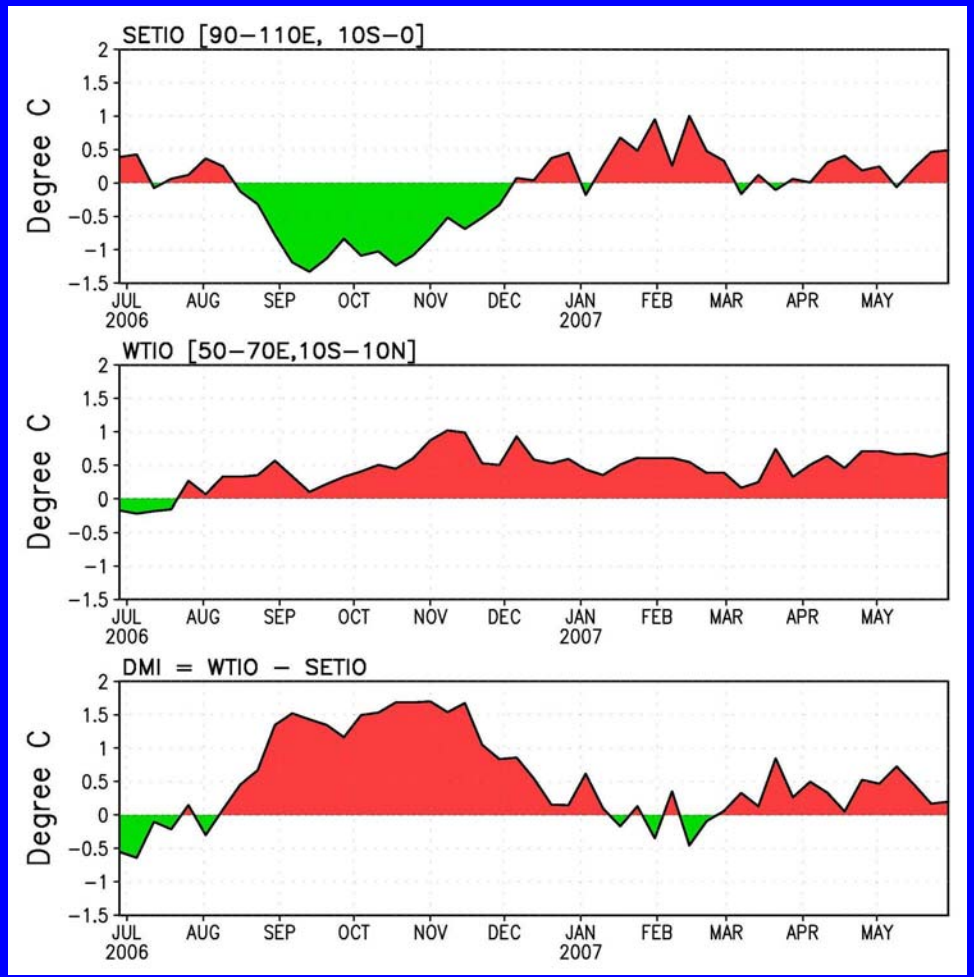


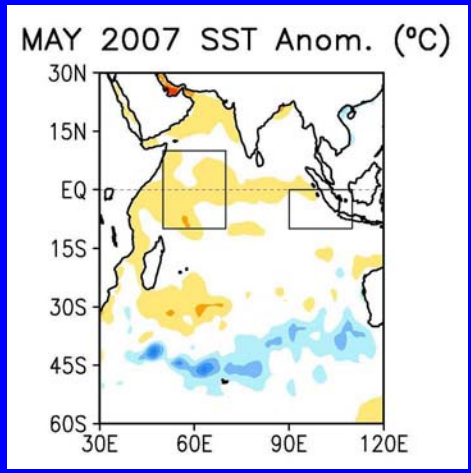
Positive SST departures are present in the equatorial Indian Ocean, southeast of Madagascar, and near the coasts of Somali and Arabia.



Recent Evolution of Indian Ocean Dipole Indices

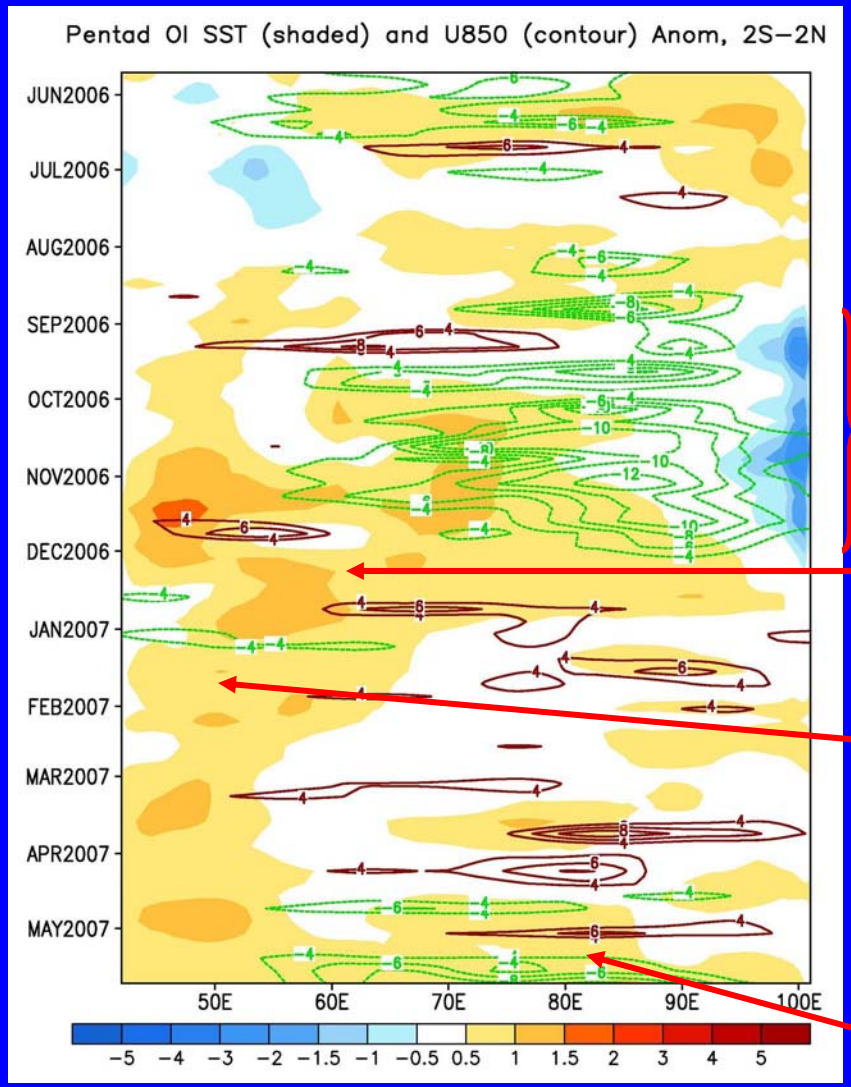
SETIO: SST anomaly in 90ºE-110ºE, 10ºS-0.
WTIO: SST anomaly in 50ºE-70ºE, 10ºS-10ºN.
DMI = WTIO - SETIO





- **Negative SETIO was observed in September-November-December 2006. It has been weakly positive (< 0.5ºC) since December 2006.**
- **WTIO has been about 0.5ºC above average since November 2006.**
- **DMI increased rapidly from neutral to +1.5ºC in August 2006, persisted during September-October, and then decreased rapidly in November-December 2006. It has been close to normal conditions since January 2007.**

Recent Evolution of Equatorial Indian SST (shaded) and Surface Zonal Wind (contour) Departures



Time

Longitude

Climatology: SST 1971-2000
850 mb winds 1979-1995

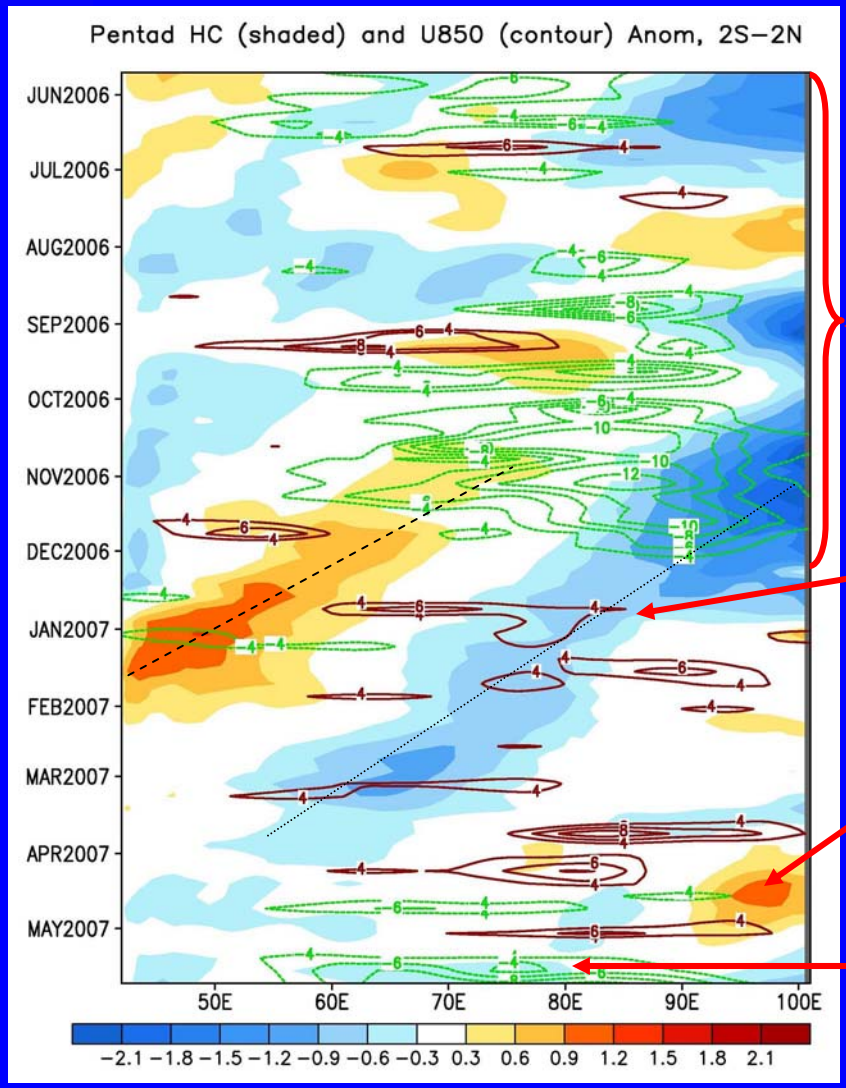
Between September and November 2006, negative SST anomalies developed in the far eastern equatorial Indian Ocean, accompanied by easterly wind anomalies in the central-eastern Indian Ocean.

During Jun-December 2006, SSTs in the central Indian Ocean were mostly above-average, and warm anomalies extended to the western Indian Ocean during August-December 2006.

Since January 2007, SSTs are above-average in the western Indian Ocean, accompanied by weak westerly wind anomalies in the central-eastern Indian Ocean.

Positive SST anomalies extended into the central Indian Ocean with appearance of easterly wind anomalies in May 2007.

Recent Evolution of Equatorial Indian Upper Ocean (0-300m) Heat Content and Surface Zonal Wind Departures



Time

Longitude

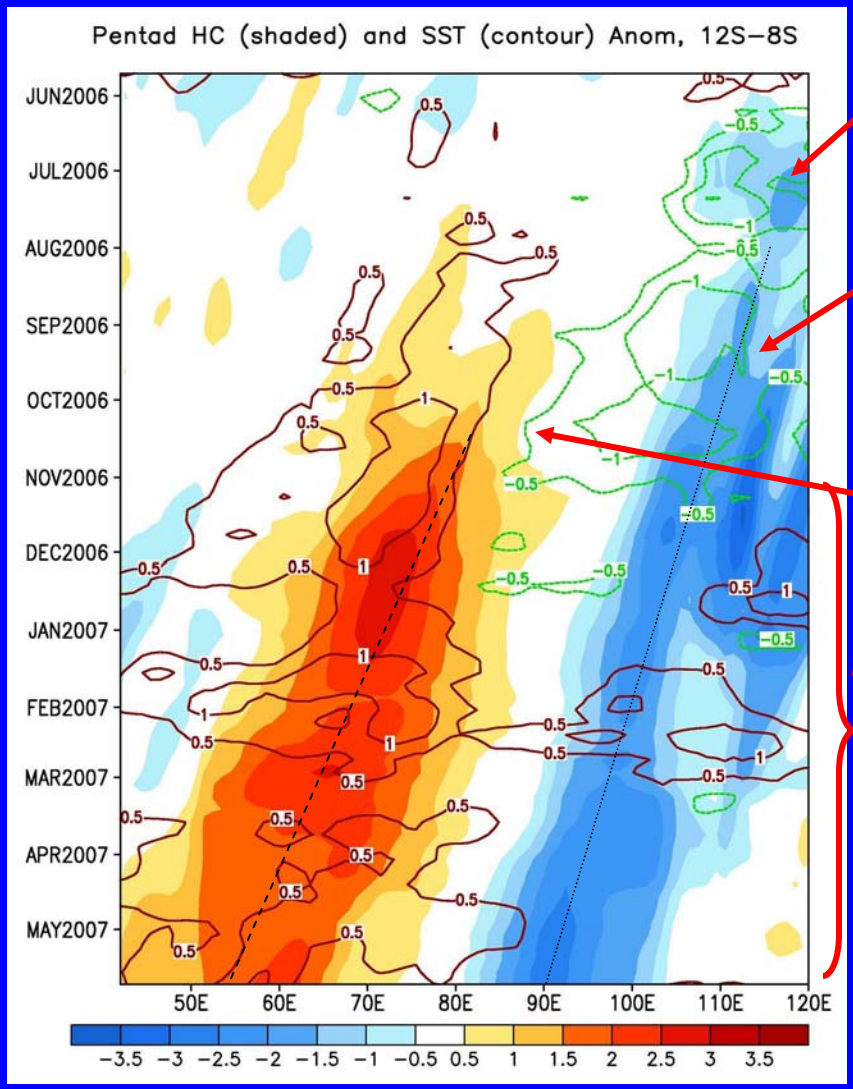
Climatology: Heat Content 1982-2004
850 mb wind 1979-1995
Heat Content is from the Global Ocean Data Assimilation System (GODAS) (http://www.cpc.ncep.noaa.gov/products/GODAS)

Negative heat content anomalies in the eastern Indian Ocean were accompanied by easterly wind anomalies in the central Indian Ocean in June 2006, and during August to November 2006.

Westward propagating Rossby waves, indicated by dashed and dotted lines for positive and negative phases, were observed between November 2006 and March 2007.

In response to the westerly wind anomalies since late March 2007, positive heat content anomalies developed in the far eastern Indian Ocean in April.

Recent Evolution of Heat Content (shaded) and SST (contour) Departures along 10°S in the Indian Ocean



Time

Longitude

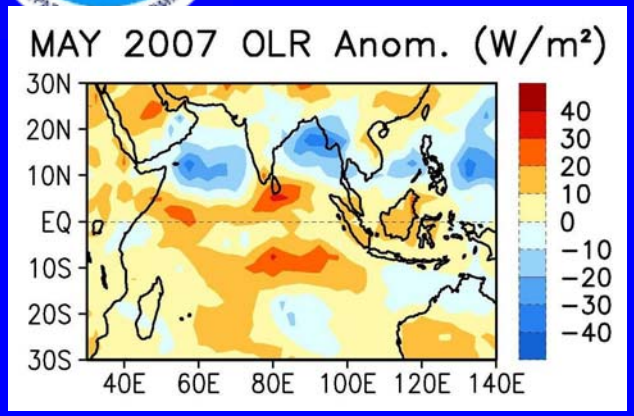
Negative SST anomalies less than -1°C collocated with negative heat content anomalies near the coast of Java during June-July 2006.

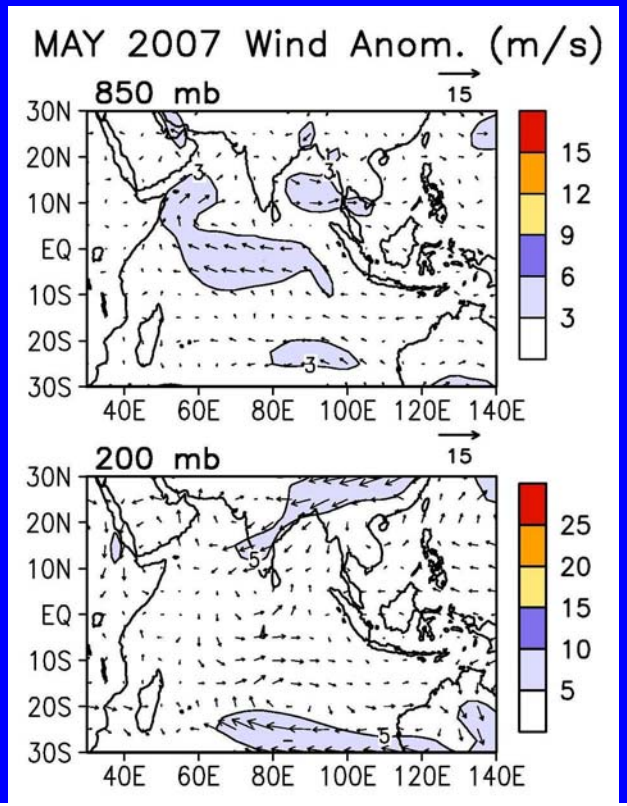
Pronounced westward propagating Rossby waves, indicated by dashed and dotted lines for positive and negative phases, were observed during August 2006 to May 2007.

Positive SST anomalies in the central Indian Ocean and negative SST anomalies in the eastern Indian Ocean propagated westward along with westward propagating heat content anomalies during August – October 2006.

SST departures in the eastern Indian Ocean transitioned from negative to positive in middle November, while positive SST departures in the central Indian Ocean persisted since November 2006.

Tropical Indian OLR and Wind Anomalies





Climatology: OLR 1979-1995
Winds 1979-1995

Negative OLR anomalies (enhanced convection and precipitation, blue shading) were observed in the Bay of Bengal and Arabian Sea. Positive OLR anomalies (suppressed convection, orange shading) were observed in the tropical Indian Ocean.

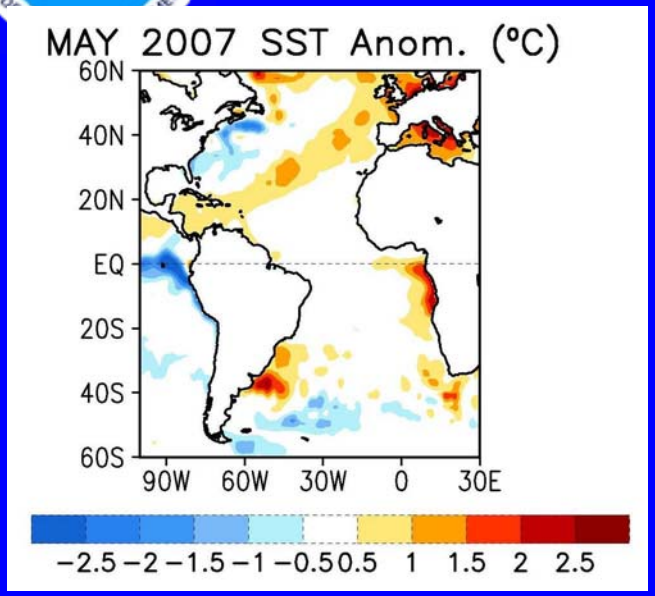
Anomalous lower-level (850-hPa) easterlies, southwesterlies, and westerlies were observed in the central equatorial Indian Ocean, western Arabian Sea, and the Bay of Bengal.

Upper-level (200-hPa) winds are near normal in the tropical Indian Ocean.

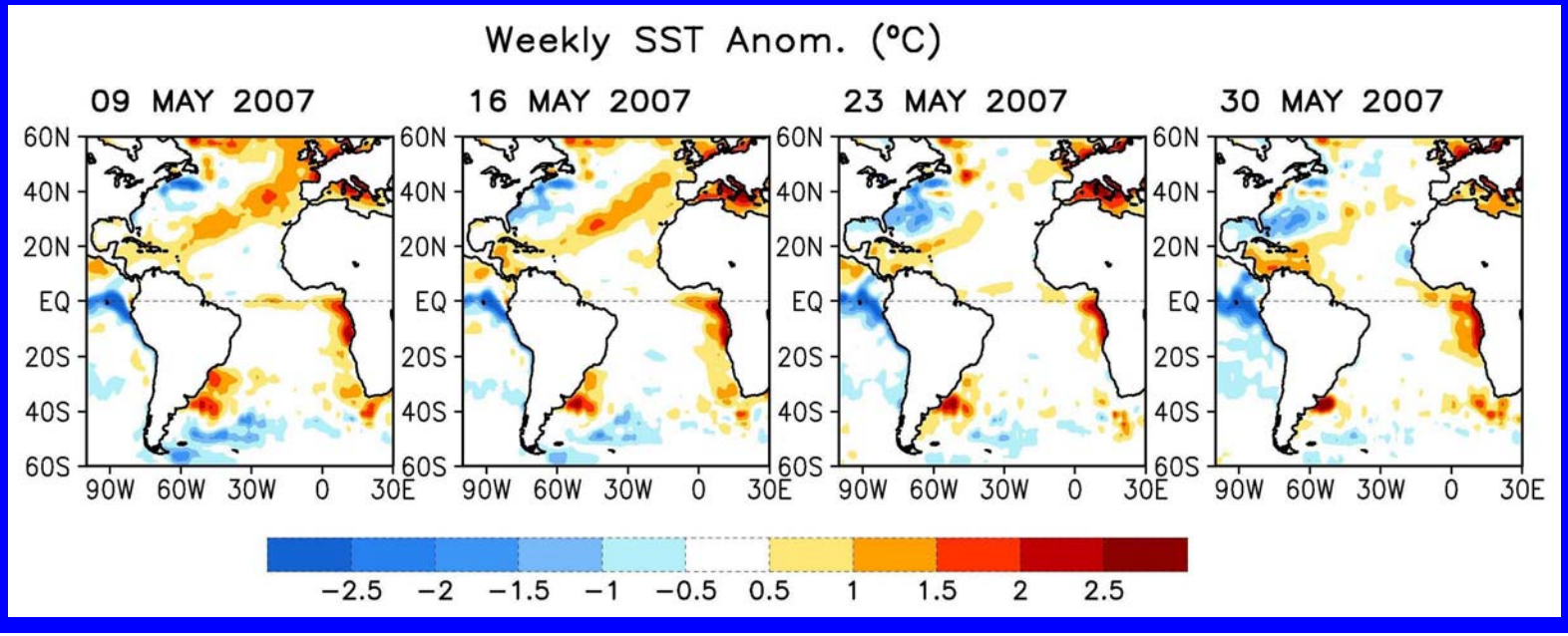
Atlantic Ocean

Atlantic Ocean SST Departures (ºC)

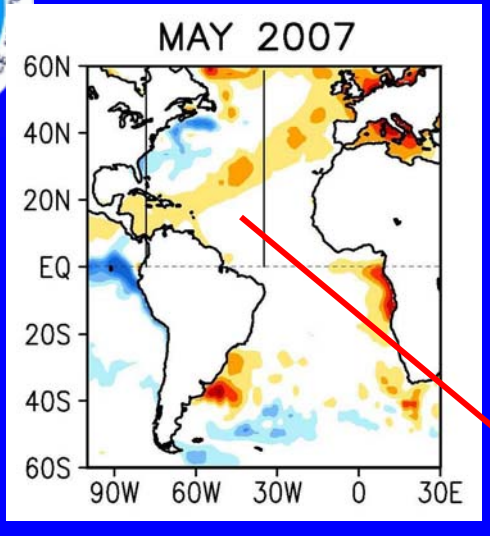
(Climatology 1971-2000)

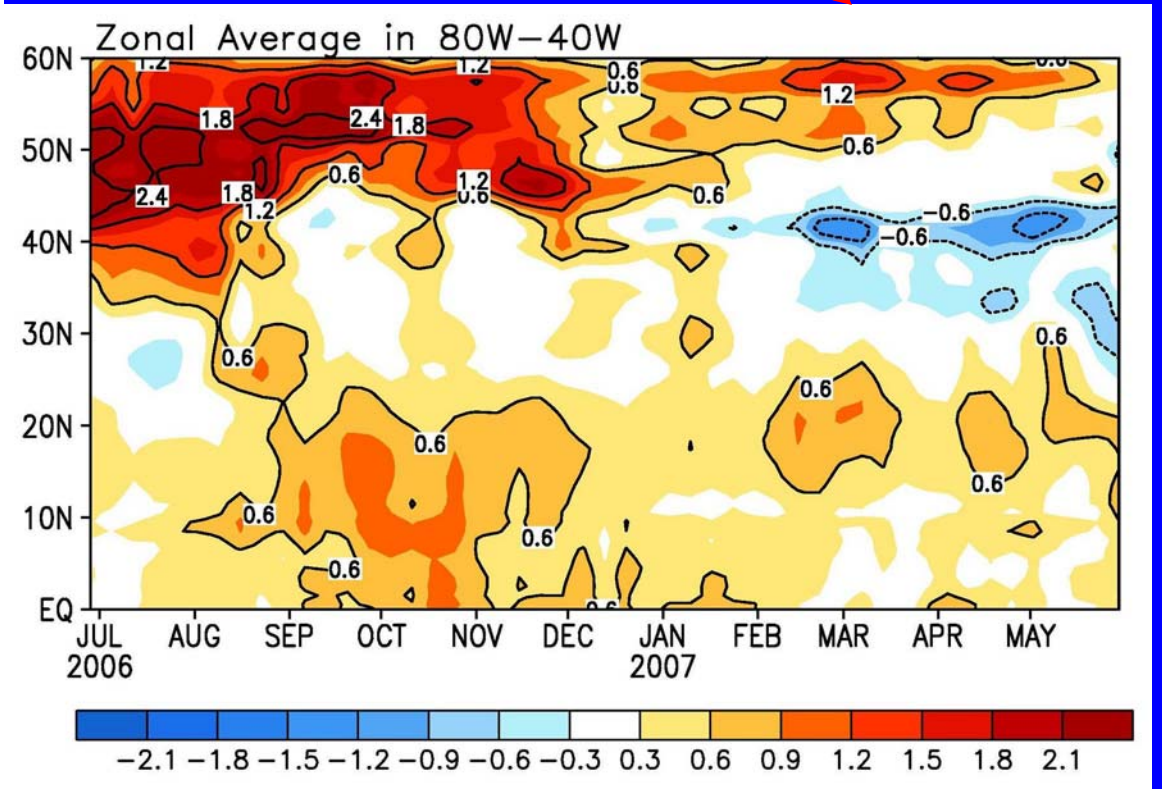


Positive SST departures extend from the west coast of Spain to Caribbean Sea, near the coast of Argentina, western coast of Africa and eastern equatorial Atlantic Ocean. Negative SST departures are present along the eastern coast of North America.



Recent Evolution of SST Departures in the North-western Atlantic





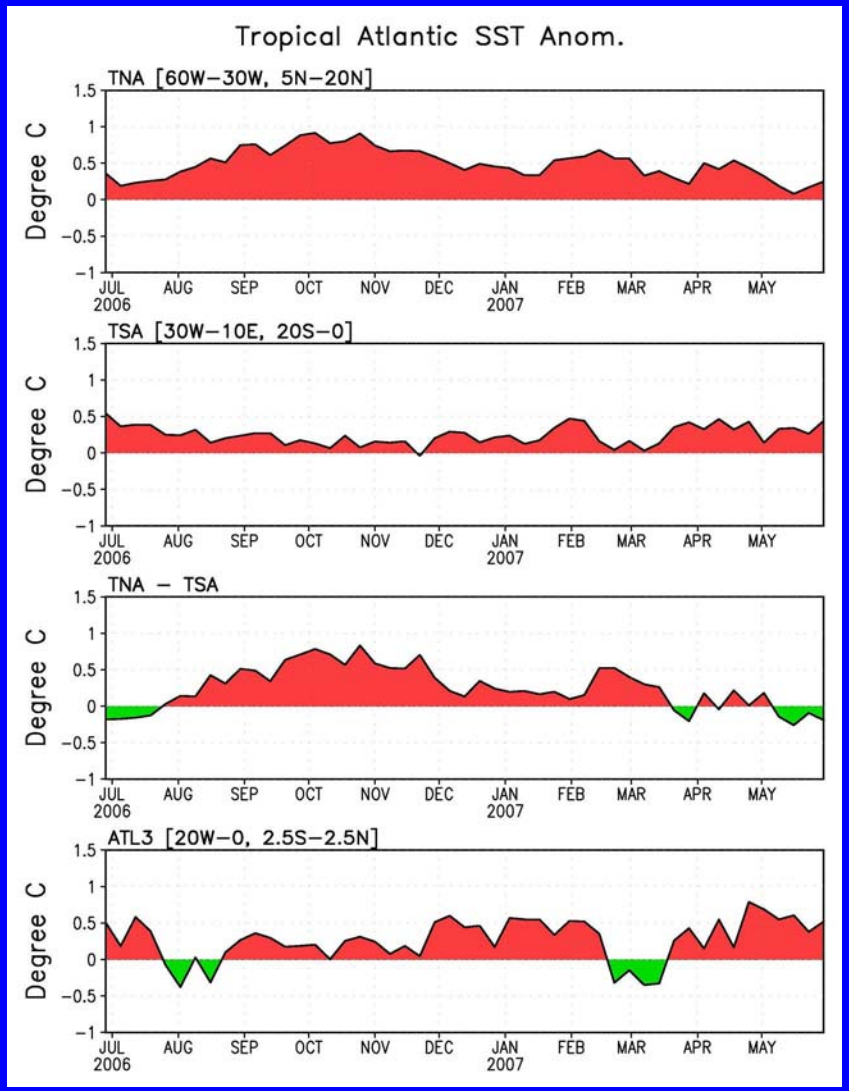
During the past 12 months, the zonal average SSTs in 80ºW-40ºW between 0 and 25ºN have been mostly above-average.

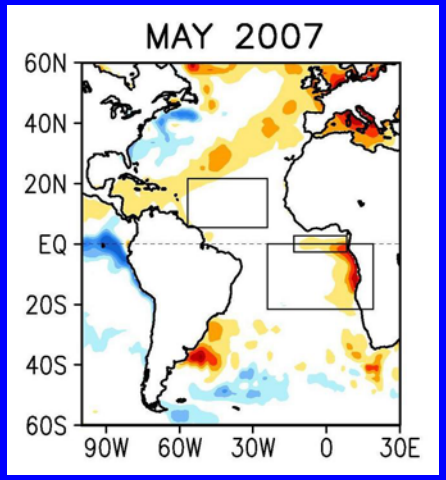
Above-average SSTs greater than +2ºC were observed between 40ºN and 60ºN during May to November 2006. Starting December 2006, the anomalies decreased to about +1ºC in 50ºN-60ºN, but switched to negative anomalies near 40ºN.

The triple-pole SST pattern persisted since February 2007.

Recent Evolution of Tropical Atlantic SST Indices

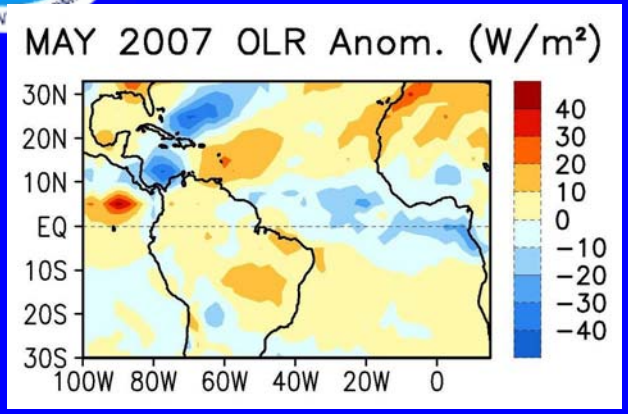
(Climatology 1971-2000)

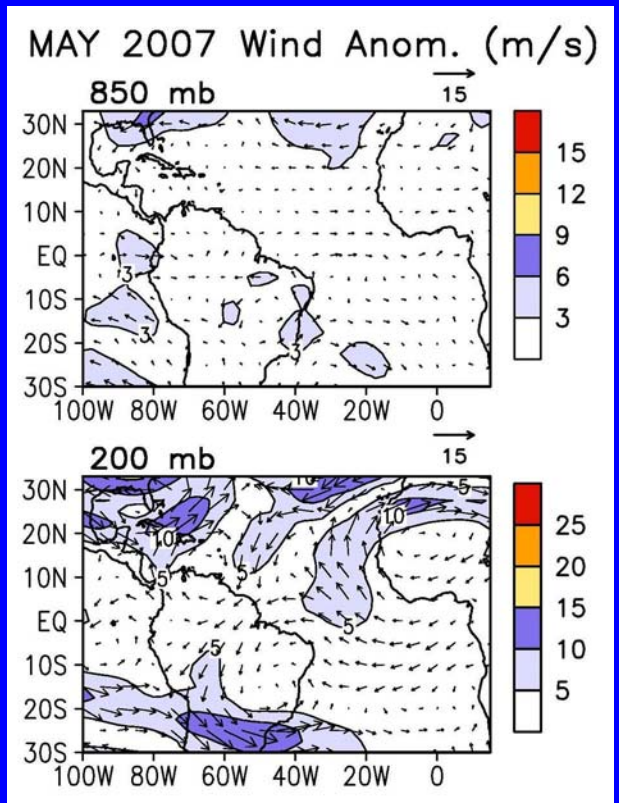




- **During the past 12 months, TNA has been above-average. TNA decreased to near normal in May 2007**
- **TSA is about 0.4ºC in May 2007.**
- **The north-south gradient mode is near normal in May 2007.**
- **Atlantic NINO is about 0.5ºC in May 2007.**

Tropical Atlantic OLR and Wind Anomalies





Climatology: OLR 1979-1995
Winds 1979-1995

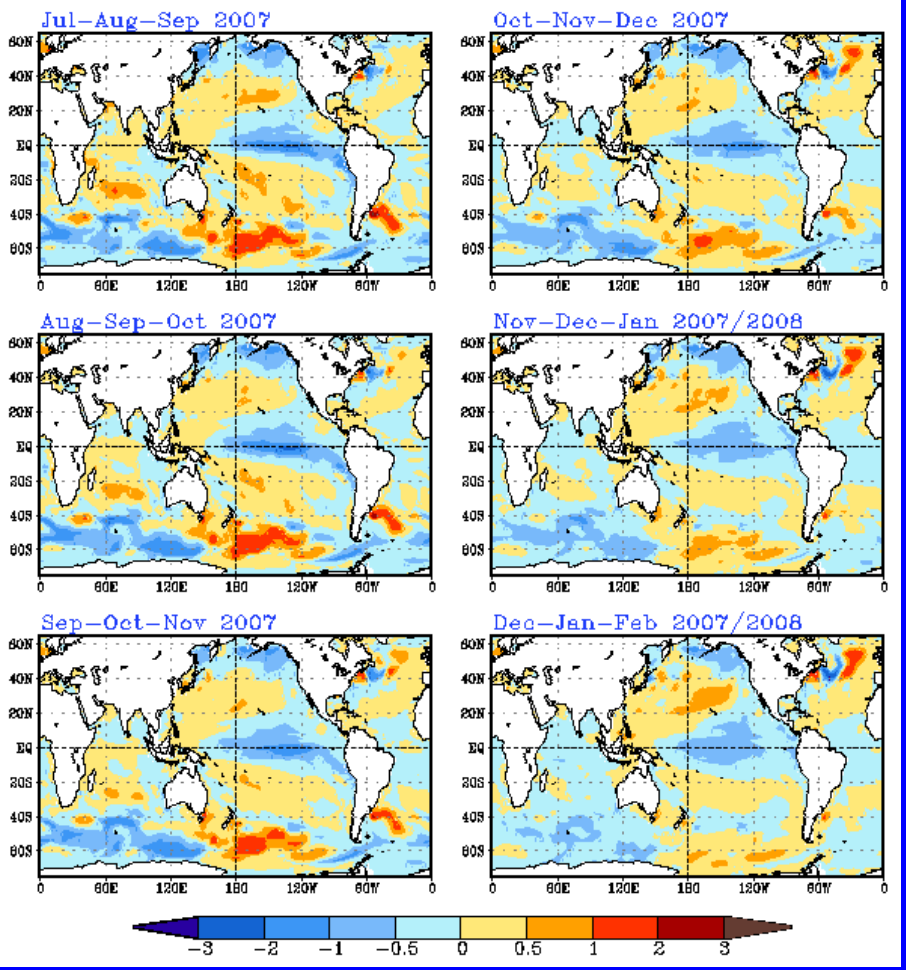
Negative OLR anomalies less than -20 W/m^2 (enhanced convection and precipitation, blue shading) were observed in the equatorial Atlantic Ocean.

Lower-level (850-hPa) wind anomalies are weak westerly in the central equatorial Atlantic.

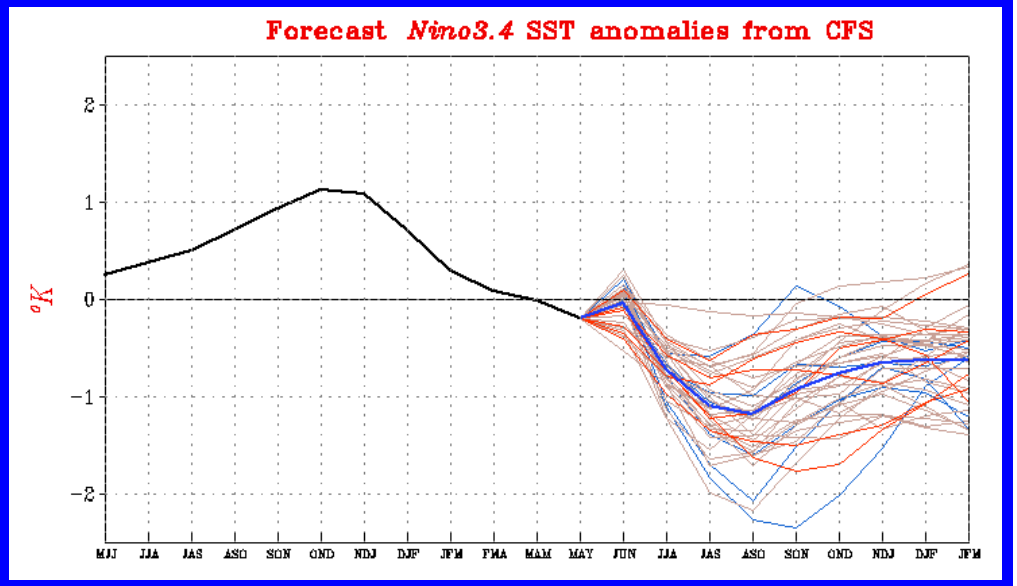
Anticyclonic upper-level (200-hPa) wind anomalies were observed in the northern subtropical Atlantic.

SST Predictions by NCEP Climate Forecast System

SST Outlook: NCEP CFS Forecast
Issued 6 Jun 2007

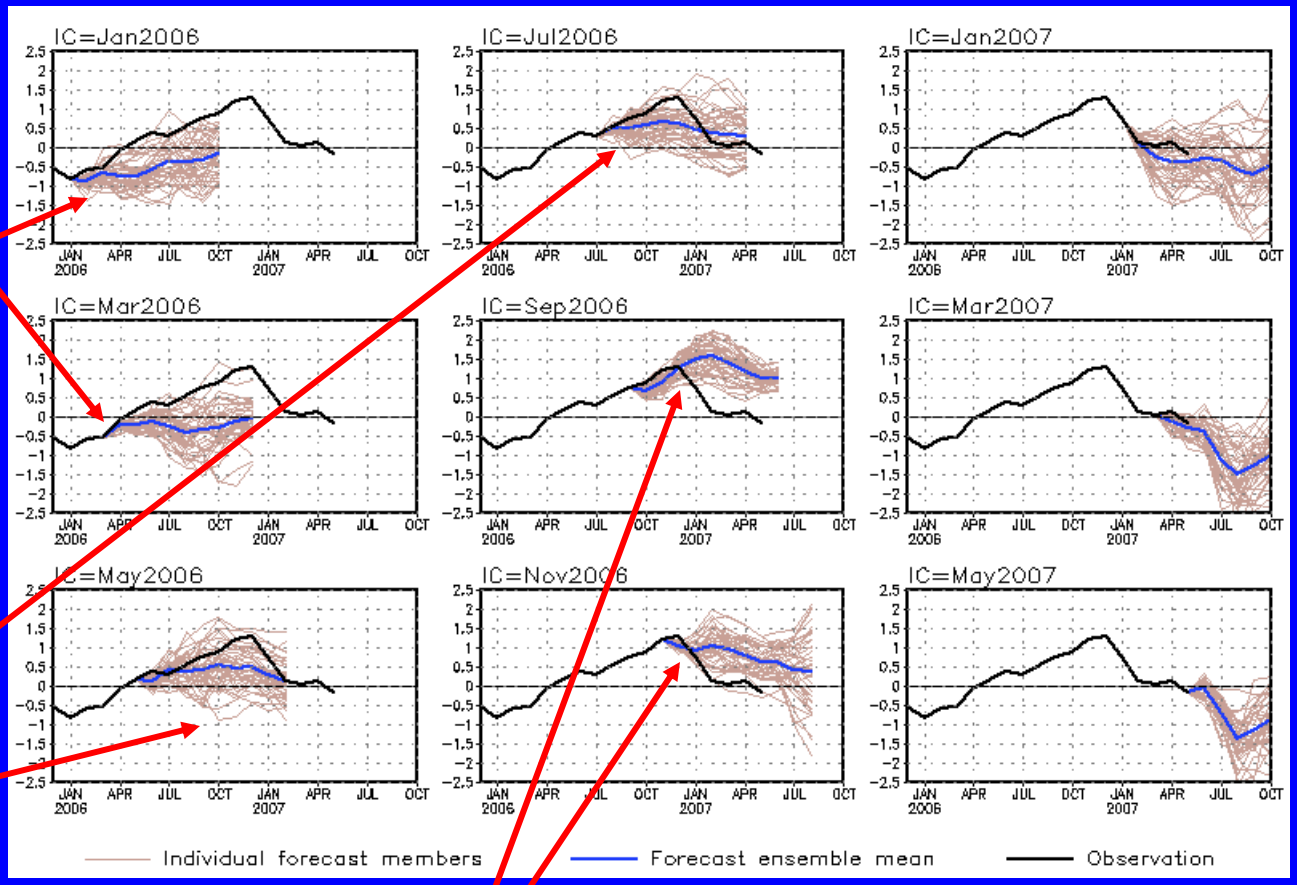


The CFS ensemble mean (thick blue line) indicates a transition from neutral to La Niña conditions during the next 2-3 months.



Nino3.4 Forecasts from Different Initial Months

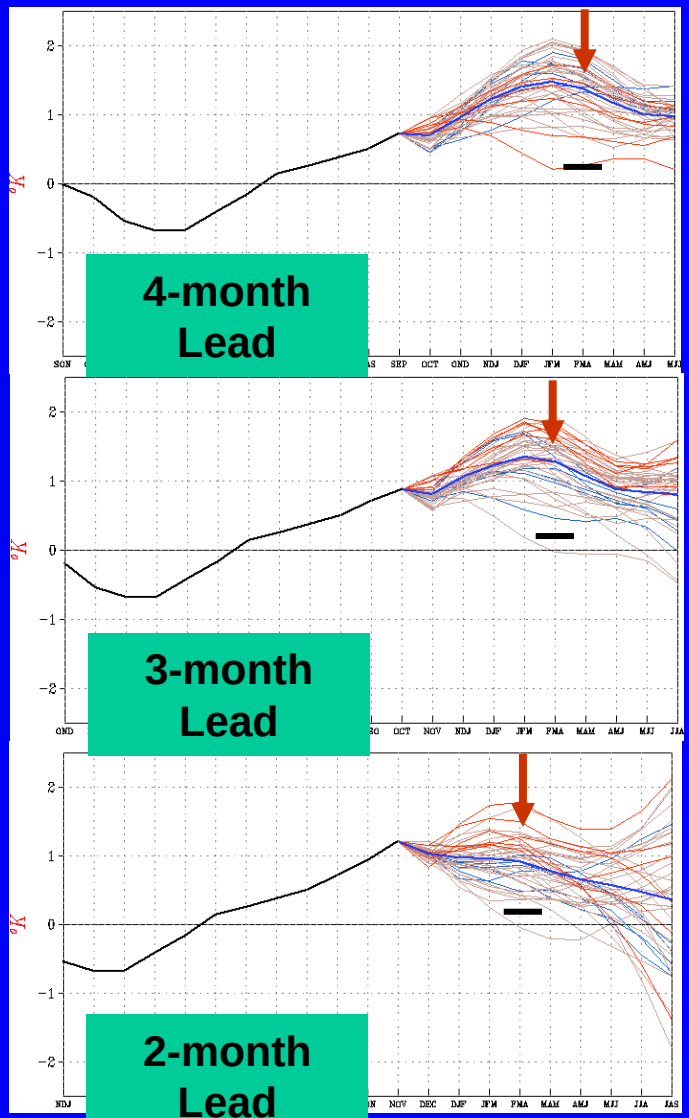
Missed the onset of the 2006/07 El Nino from January-March 2006 I.C.

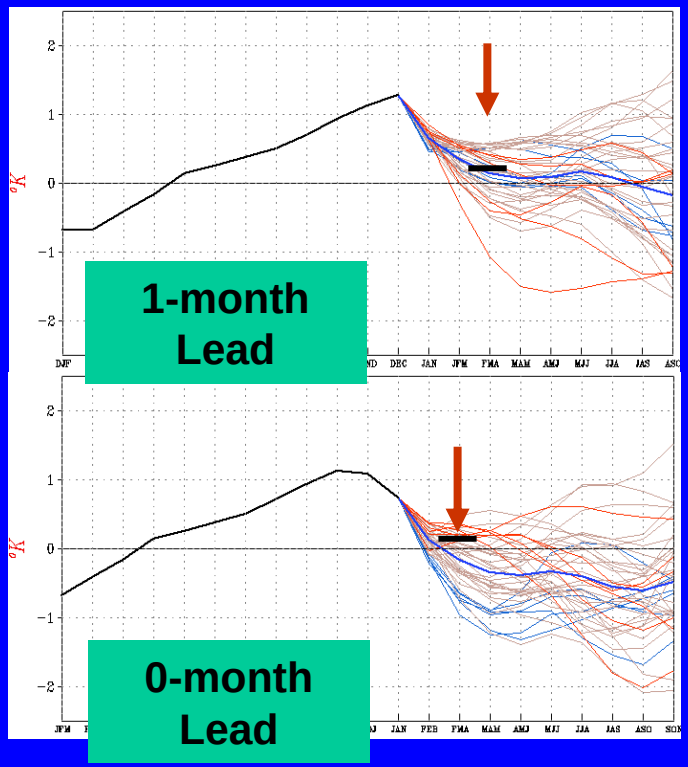


Underestimated the amplitude of the 2006/07 El Nino from May-July 2006 I.C.

Missed the fast termination of the 2006/07 El Nino from September-November 2006 I.C.

NINO3.4 Forecasts for FMA 2007 at Different Lead Times





The FMA 2007, an ENSO-neutral winter season, was forecasted accurately from December 2006 initial condition with one month lead time.

Summary

• During the last few months, tropical Pacific SST anomalies evolved toward a La Nina condition. The negative SST anomalies in the far eastern equatorial Pacific from March to May 2007 are consistent with local negative heat content anomalies, which are associated with persistent easterly wind anomalies since December 2006 (slides 1, and 13-14).

• Positive SST anomalies developed in the equatorial Indian Ocean in May 2007 in association with suppressed convections in the region (slides 20, 22 and 23).

• Positive SST anomalies increased in the far eastern equatorial Atlantic in May 2007, which are associated with positive (negative) subsurface temperature anomalies in the eastern (western) equatorial Atlantic and weak westerly wind anomalies in the central equatorial Atlantic (slides 2 and 30).

• The persistent negative SST anomalies over the Gulf of Alaska during the last six months weakened slightly in May 2007 (slide 11).

• The triple-pole SST pattern in North Atlantic has been persistent since February 2007 (slide 28).