ENSO Cycle: Recent Evolution, Current Status and Predictions

Update prepared by
Climate Prediction Center / NCEP
4 May 2009

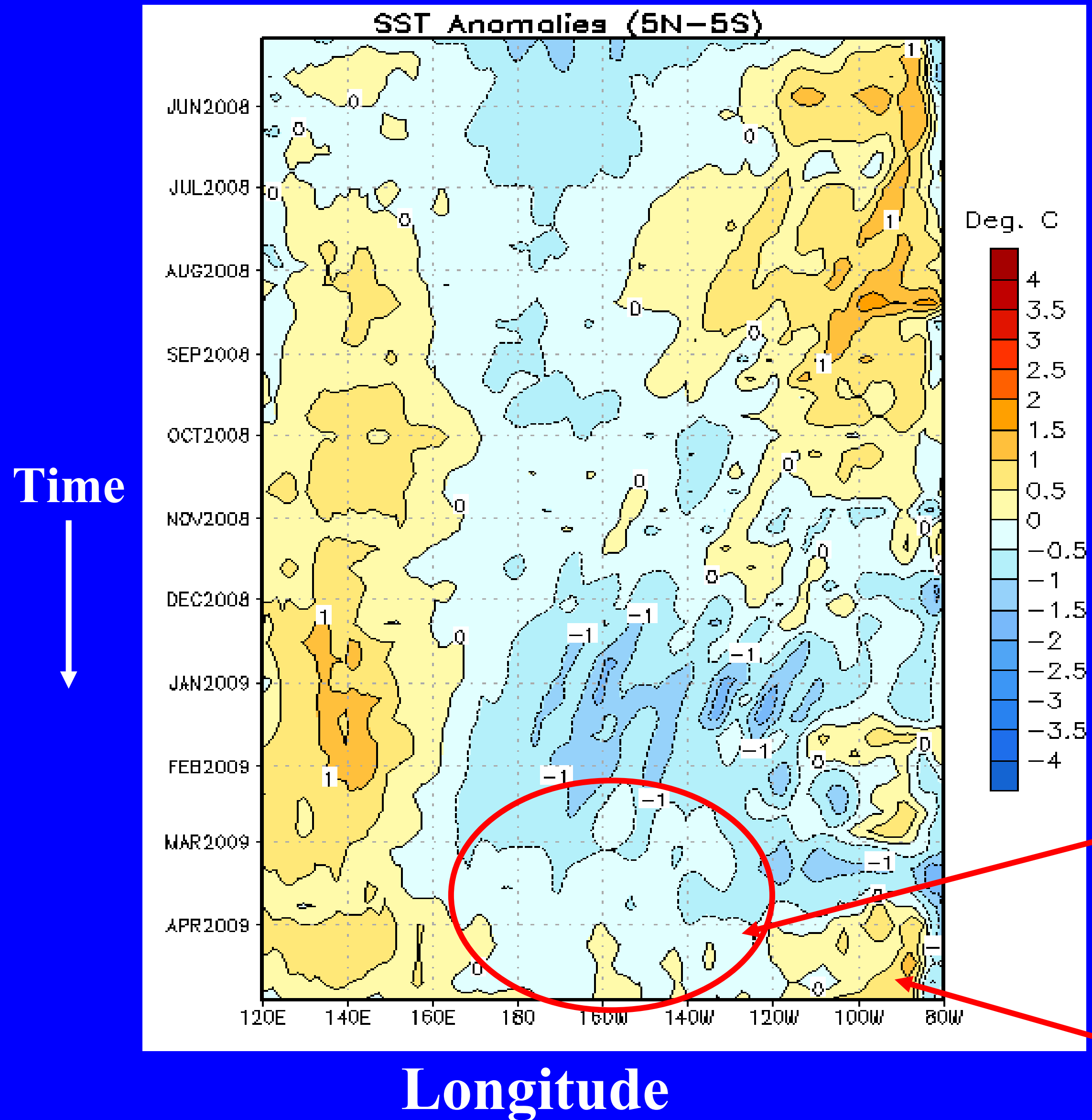
Outline

- Overview
- Recent Evolution and Current Conditions
- Oceanic Niño Index (ONI) – “Revised December 2008”
- Pacific SST Outlook
- U.S. Seasonal Precipitation and Temperature Outlooks
- Summary

Summary

- A transition from La Niña to ENSO-neutral is underway in the equatorial Pacific Ocean.
- Negative equatorial SSTs have weakened considerably since February 2009.
- The patterns of tropical convection and winds continue to reflect weak La Niña conditions.
- Based on recent trends in the observations and model forecasts, a transition to ENSO-neutral conditions will continue.

Recent Evolution of Equatorial Pacific SST Departures (ºC)



During October 2008- February 2009, negative sea surface temperature (SST) anomalies dominated across the central and east-central equatorial Pacific Ocean.

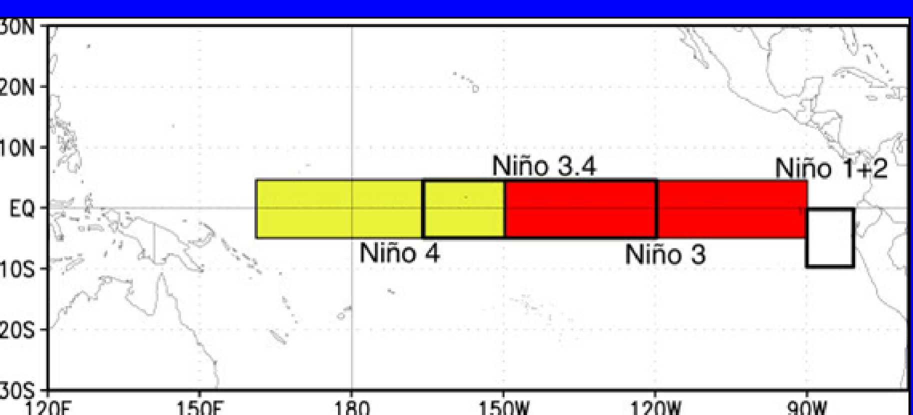
Since February 2009, negative SST anomalies have weakened in the central and east-central Pacific.

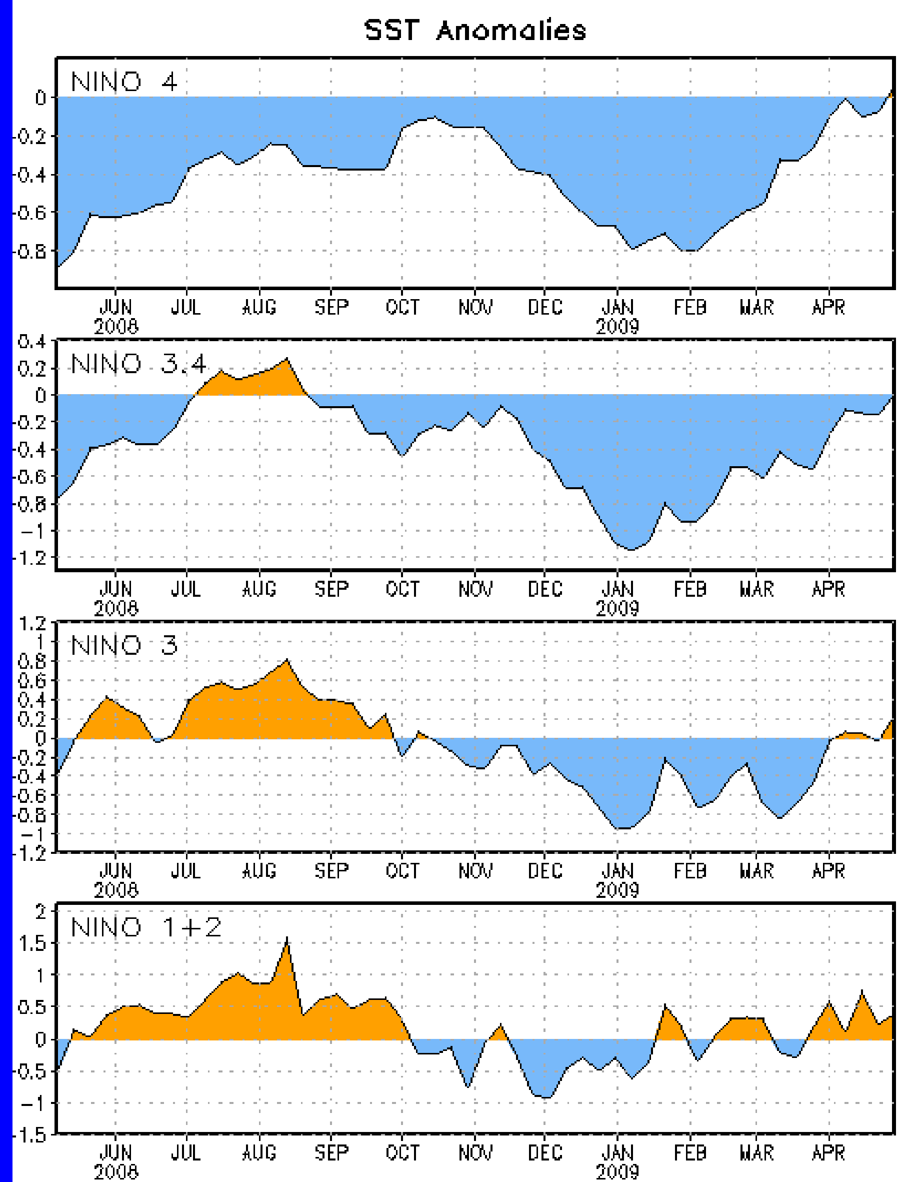
Recently, SST anomalies in the eastern Pacific have increased.

Niño Region SST Departures (ºC) Recent Evolution

The latest weekly SST departures are:

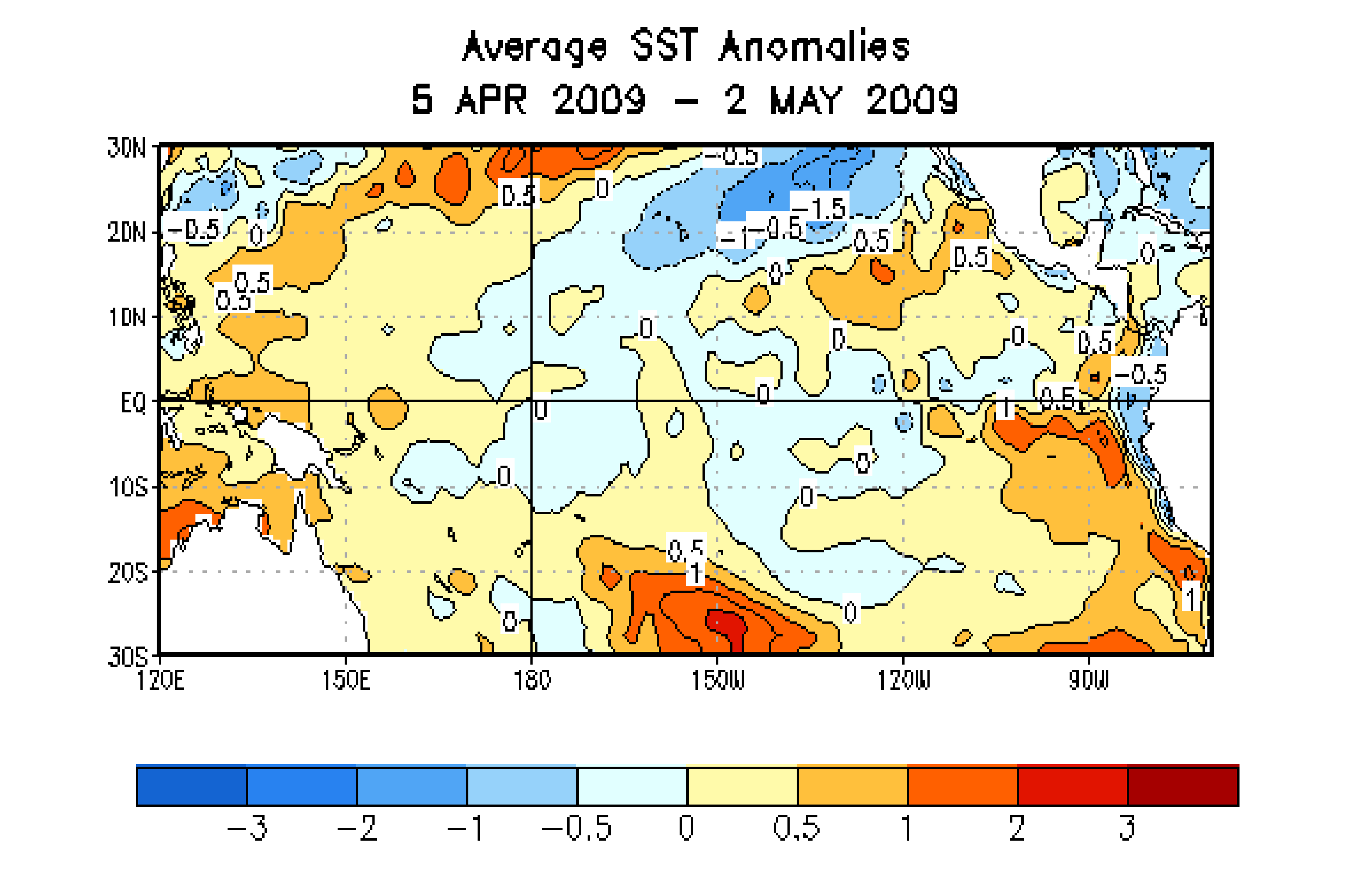
Niño 4	0.1ºC
Niño 3.4	0.0ºC
Niño 3	0.3ºC
Niño 1+2	0.4ºC



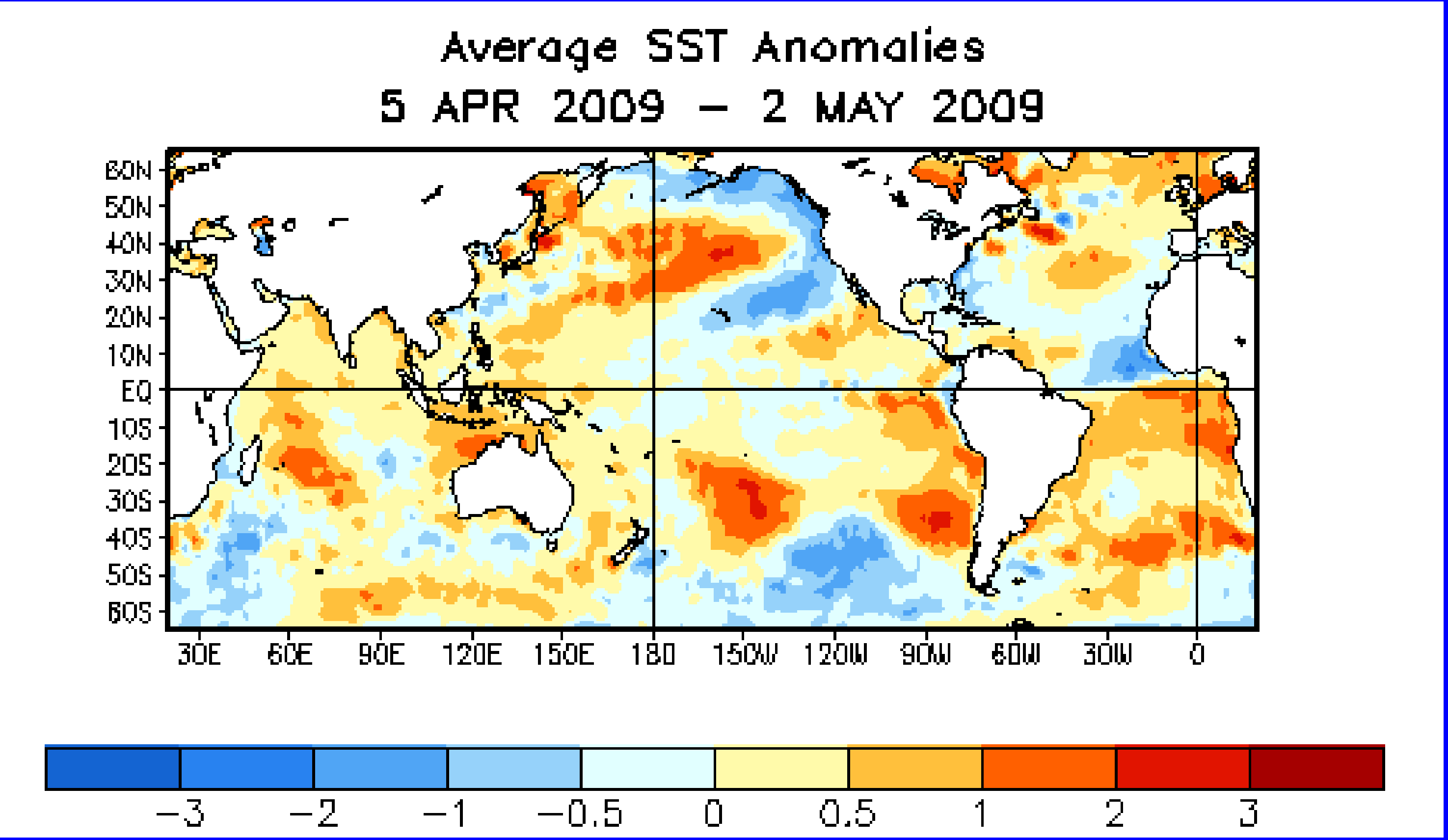


SST Departures (ºC) in the Tropical Pacific During the Last 4 Weeks

During the last 4-weeks, equatorial SSTs were near-average across the central and east-central Pacific Ocean, with larger anomalies evident in the far eastern Pacific.

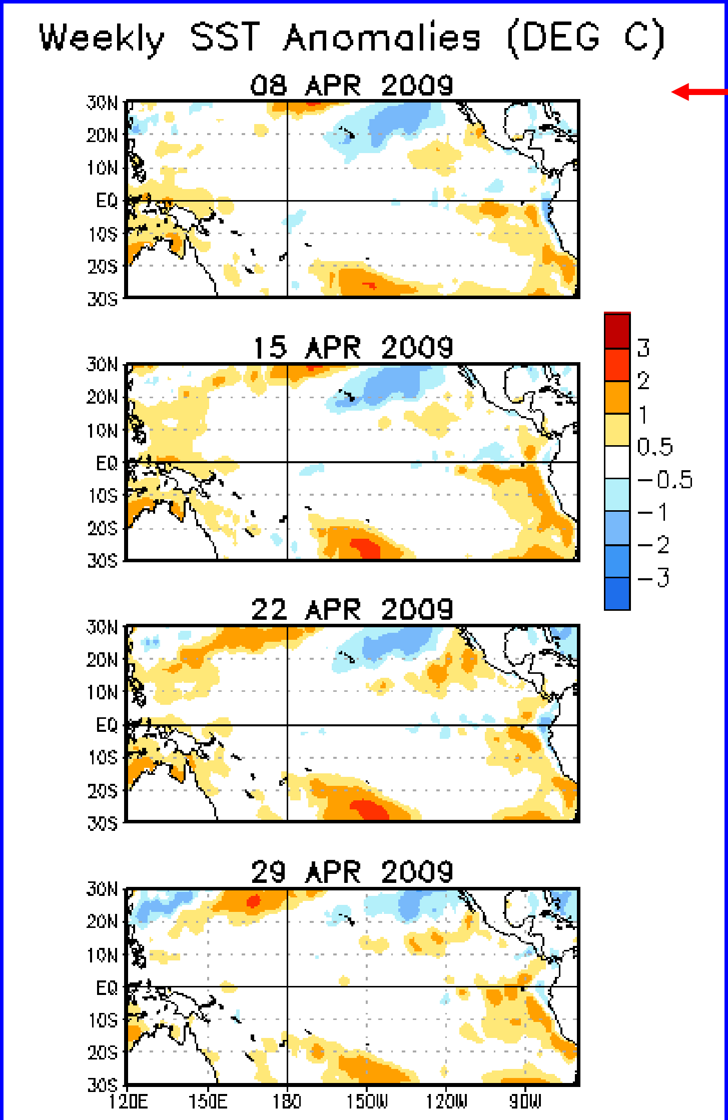


Global SST Departures (ºC)



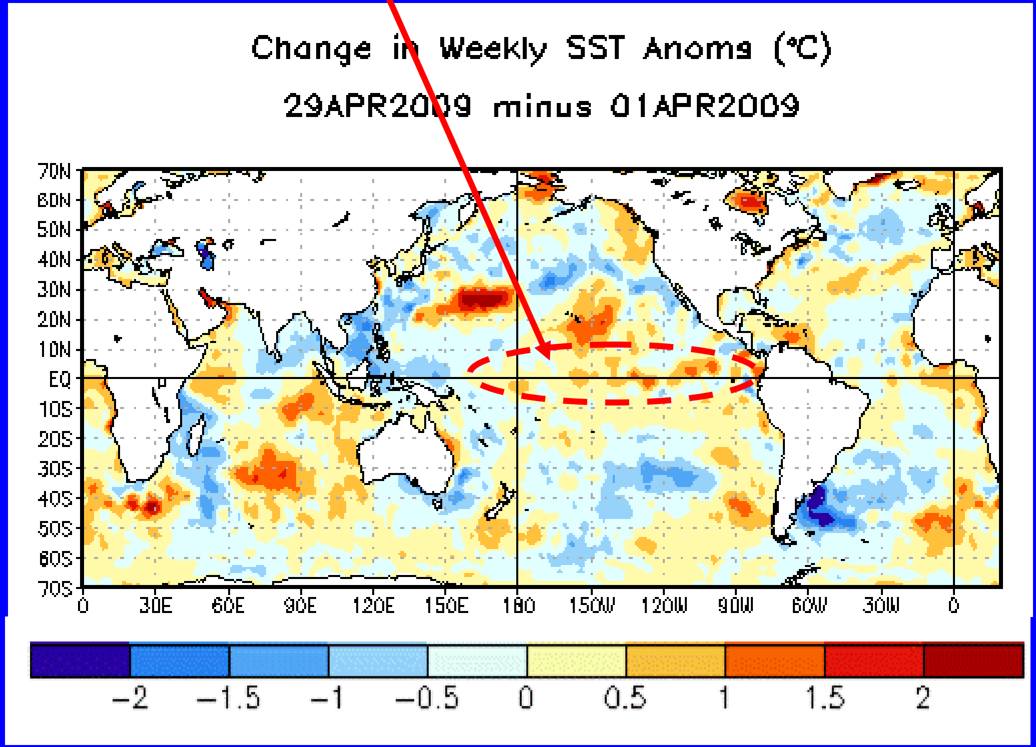
During the last four weeks, equatorial SSTs were above-average in parts of the eastern Pacific, western Indian, and eastern Atlantic Oceans. Positive anomalies extended in a horseshoe pattern from the central North Pacific to the central South Pacific, and also covered much of the high latitudes in the North Atlantic Ocean. Negative anomalies extended from the west coast of North America to the Gulf of Alaska.

Weekly SST Departures (ºC) for the Last Four Weeks

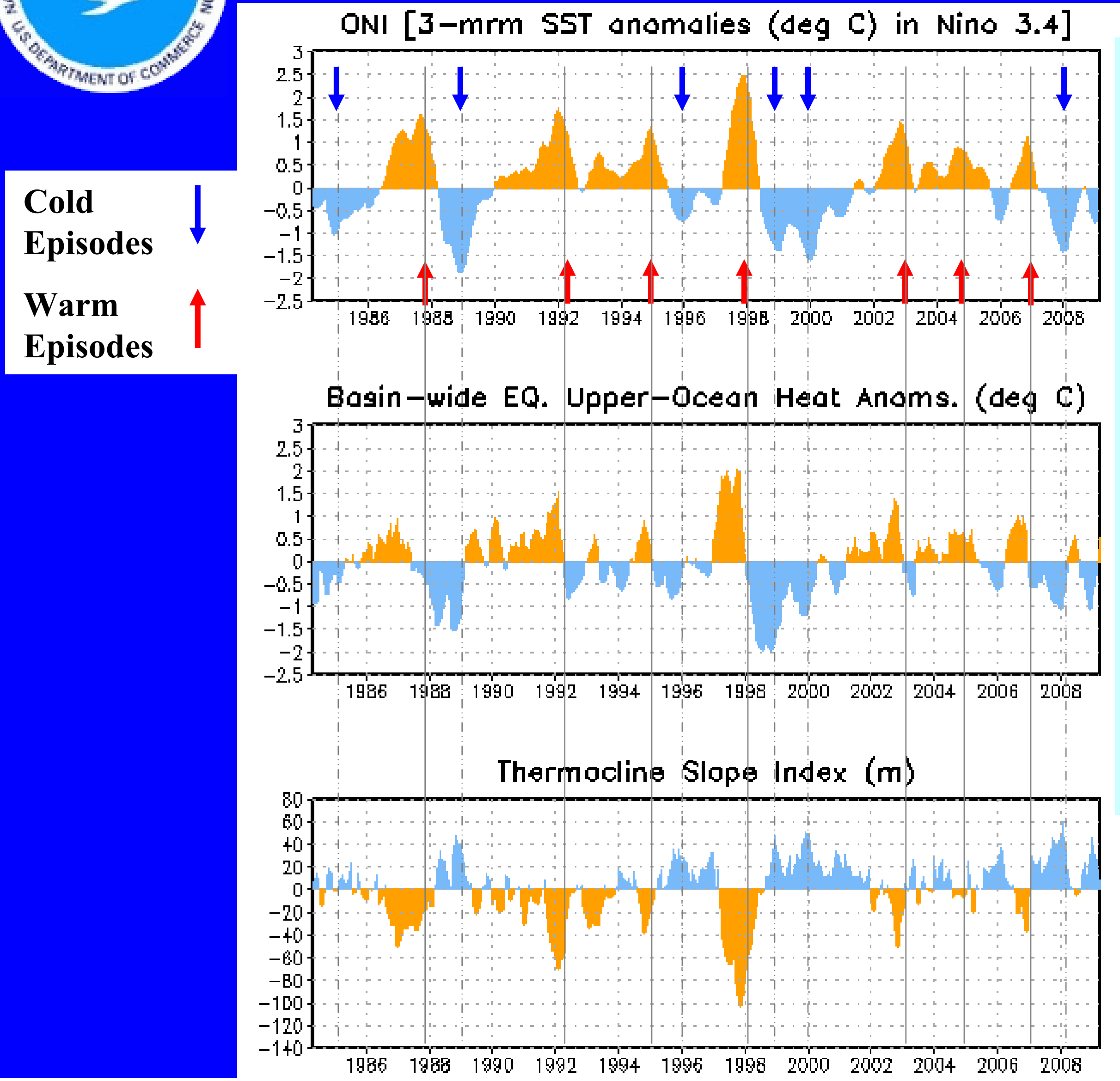


- During the last four weeks SST anomalies have exhibited little change across the equatorial Pacific, with near-average SSTs covering the central and east-central Pacific.

- The change in SST anomalies was mainly positive across the equatorial Pacific Ocean.



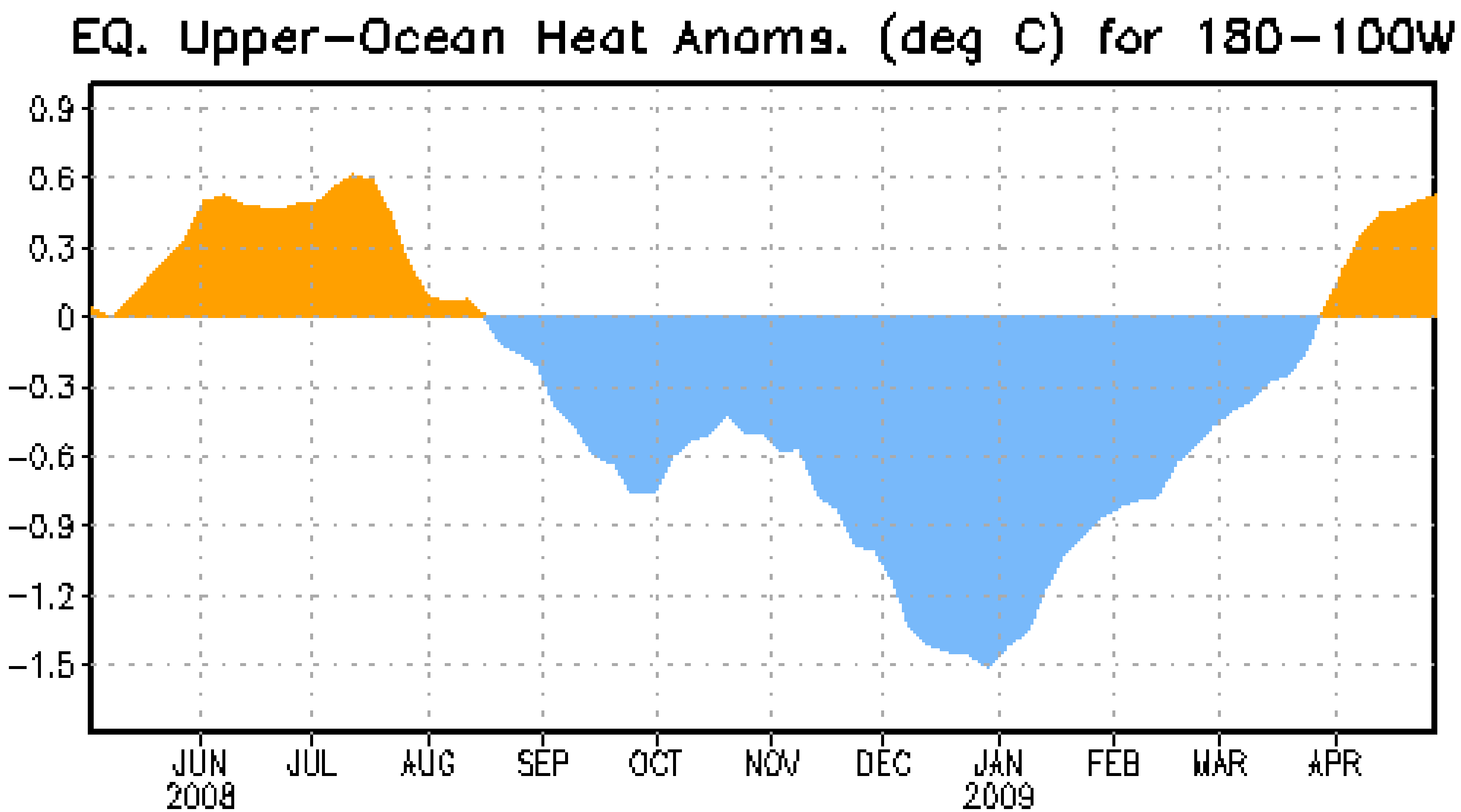
Upper-Ocean Conditions in the Eq. Pacific



- The basin-wide equatorial upper ocean (0-300 m) heat content is greatest prior to and during the early stages of a Pacific warm (El Niño) episode (compare top 2 panels) and least prior to and during the early stages of a cold (La Niña) episode.
- The slope of the oceanic thermocline is least (greatest) during warm (cold) episodes.
- Recent values of the upper-ocean heat anomalies (negative) and the thermocline slope index (positive) indicate La Niña.

The monthly thermocline slope index represents the difference in anomalous depth of the 20ºC isotherm between the western Pacific (160ºE-150ºW) and the eastern Pacific (90º-140ºW).

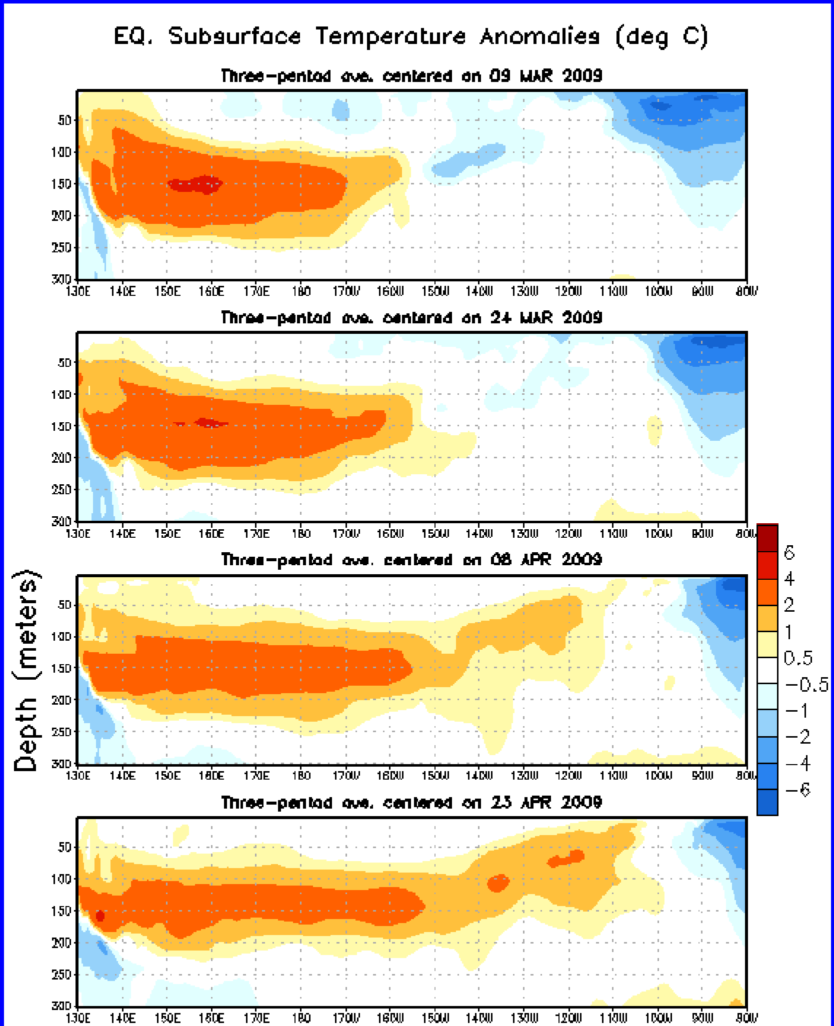
Central & Eastern Pacific Upper-Ocean (0-300 m) Weekly Heat Content Anomalies



The upper ocean heat content was below-average across the eastern half of the equatorial Pacific Ocean between mid-August and March 2009. The heat content anomaly was most negative in late December 2008, and has since trended upward, becoming positive in late March 2009.

Sub-Surface Temperature Departures (ºC) in the Equatorial Pacific

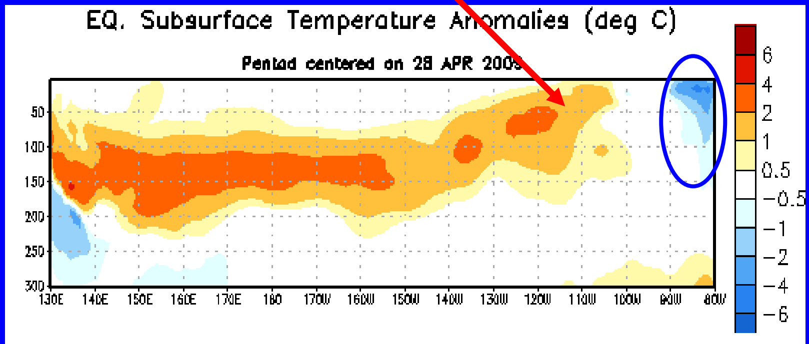
Time



Longitude

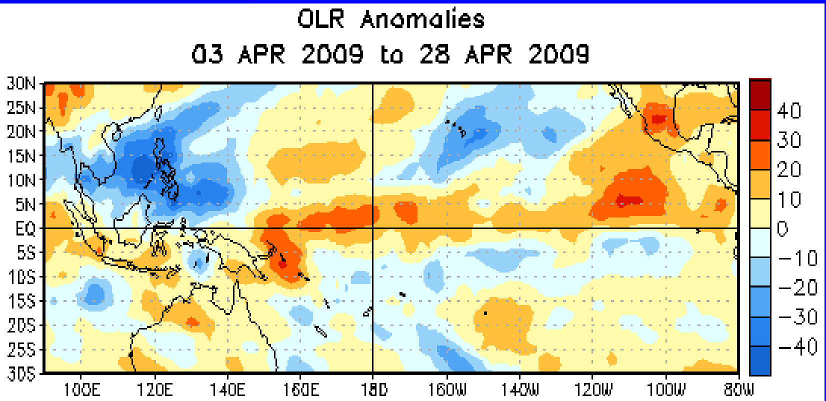
- During March through mid-April 2009, negative sub-surface temperature departures weakened east of the Date Line, while positive departures expanded eastward.

- The most recent period (below) shows negative subsurface temperature anomalies confined to the far eastern Pacific (blue oval), while positive anomalies have shifted east to near 100°W.

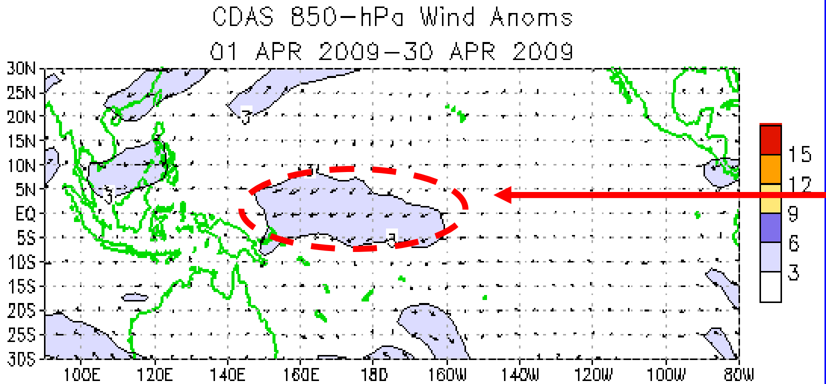


Most recent pentad analysis

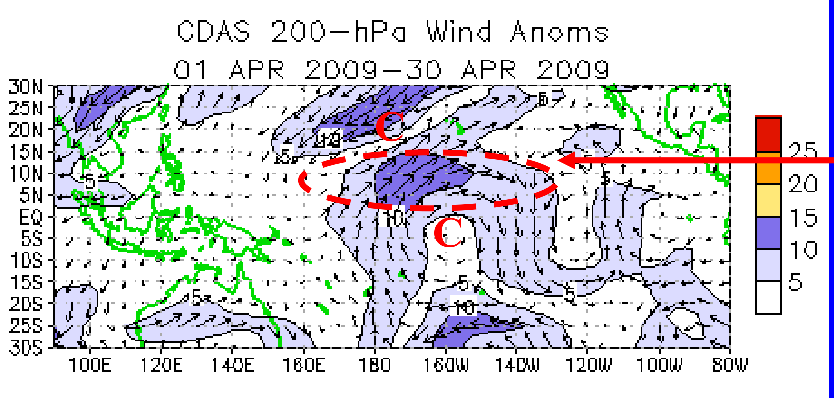
Tropical OLR and Wind Anomalies During the Last 30 Days



Positive OLR anomalies (suppressed convection and precipitation, red shading) were centered just north of equator and over Indonesia and Papua New Guinea, while negative anomalies (enhanced convection, blue shading) were present over Southeast Asia and the Philippines.



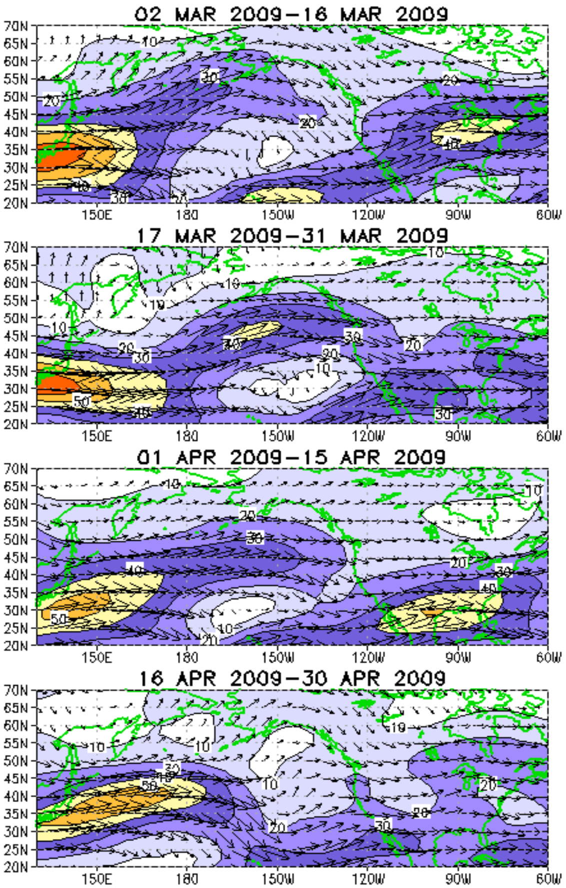
Low-level (850-hPa) easterly wind anomalies have weakened over the western and central tropical Pacific Ocean.



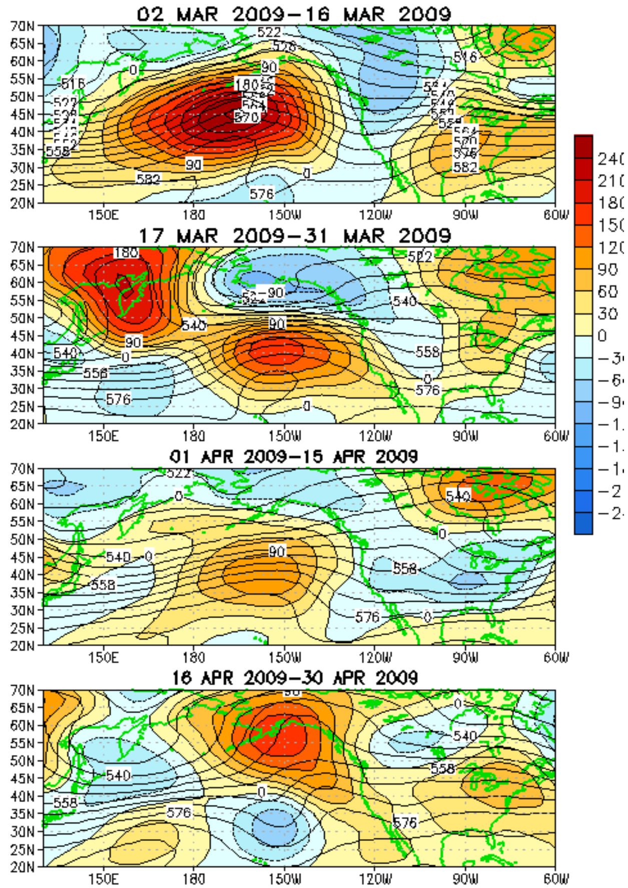
Just north of the equator, upper-level (200-hPa) westerly wind anomalies continued over the central and east-central tropical Pacific. An anomalous cyclonic couplet is evident in the subtropics.

Atmospheric Circulation over the North Pacific & North America During the Last 60 Days

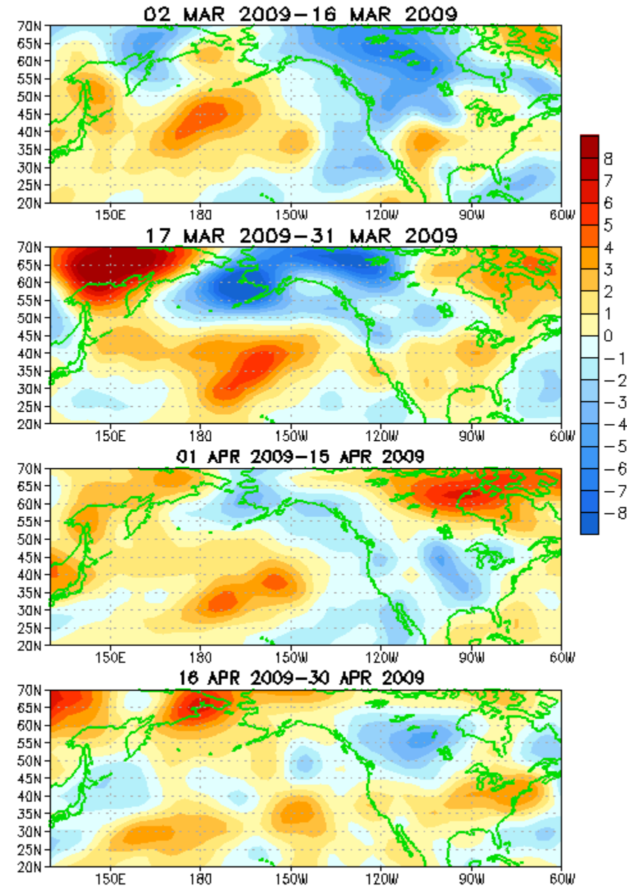
200-hPa Wind



500-hPa Height & Anoms.



925-hPa Temp. Anoms. (^{o}C)

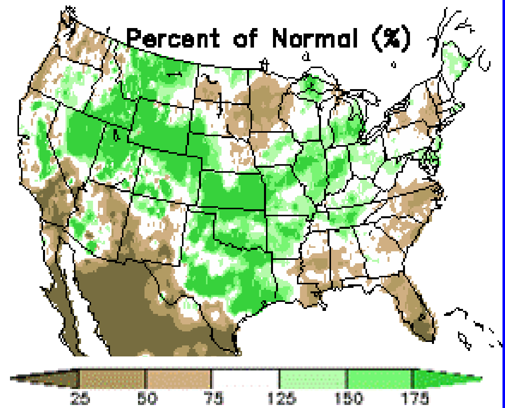


From March until mid- April, an anomalous ridge gradually weakened over the central North Pacific Ocean. Downstream of the ridge, an anomalous trough fluctuated in strength and position near western North America. Associated with the anomalous trough, below-average temperatures were evident throughout parts of the U.S. During late April, ridges strengthened over the Gulf of Alaska and over eastern North America. This pattern contributed to near to above-average temperatures over much of the United States.

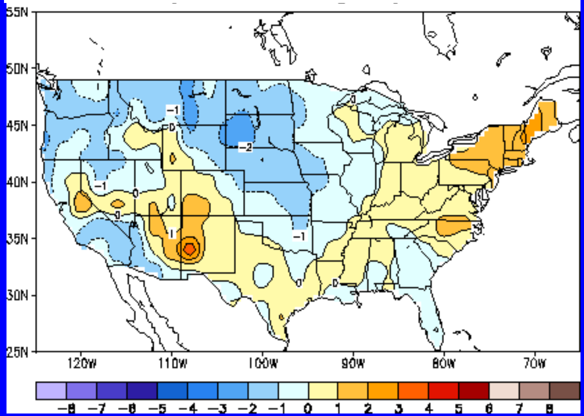
U.S. Temperature and Precipitation Departures During the Last 30 and 90 Days

Last 30 Days

30-day (ending 3 May 2009) % of average precipitation

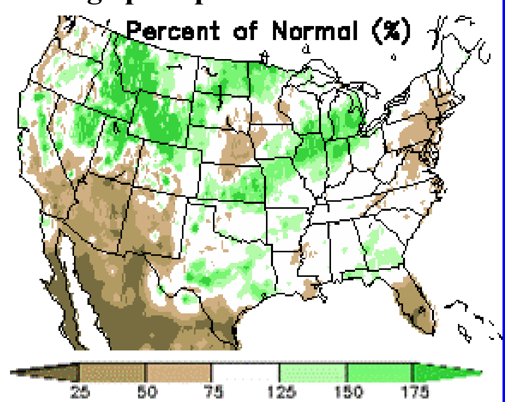


30-day (ending 2 May 2009) temperature departures (degree C)

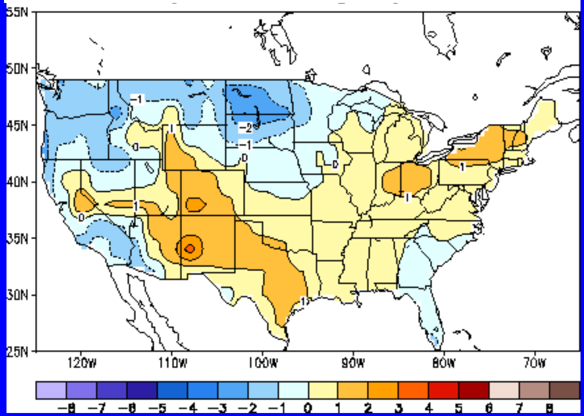


Last 90 Days

90-day (ending 3 May 2009) % of average precipitation



90-day (ending 2 May 2009) temperature departures (degree C)

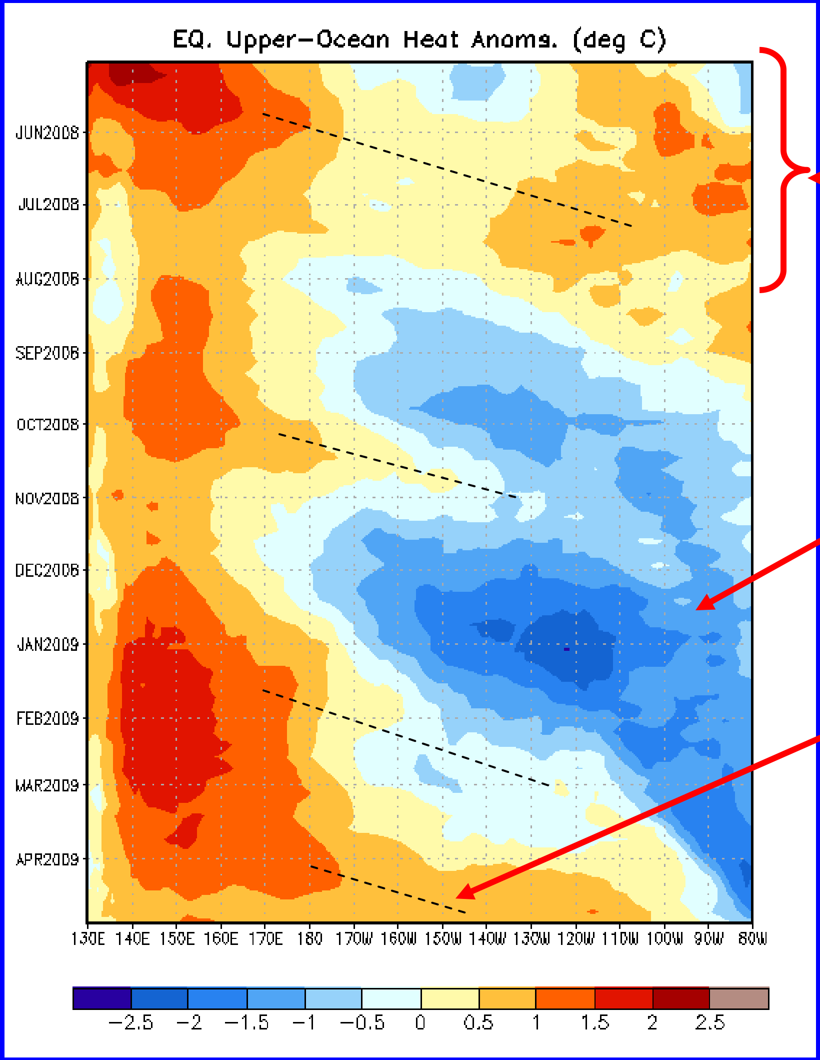


Intraseasonal Variability

- Intraseasonal variability in the atmosphere (wind and pressure), which is often related to the Madden-Julian Oscillation (MJO), can significantly impact surface and subsurface conditions across the Pacific Ocean.

- Related to this activity
  - significant weakening of the low-level easterly winds usually initiates an eastward-propagating oceanic Kelvin wave.
  - Several Kelvin waves have occurred during the last year (see next slide).

Weekly Heat Content Evolution in the Equatorial Pacific



Time

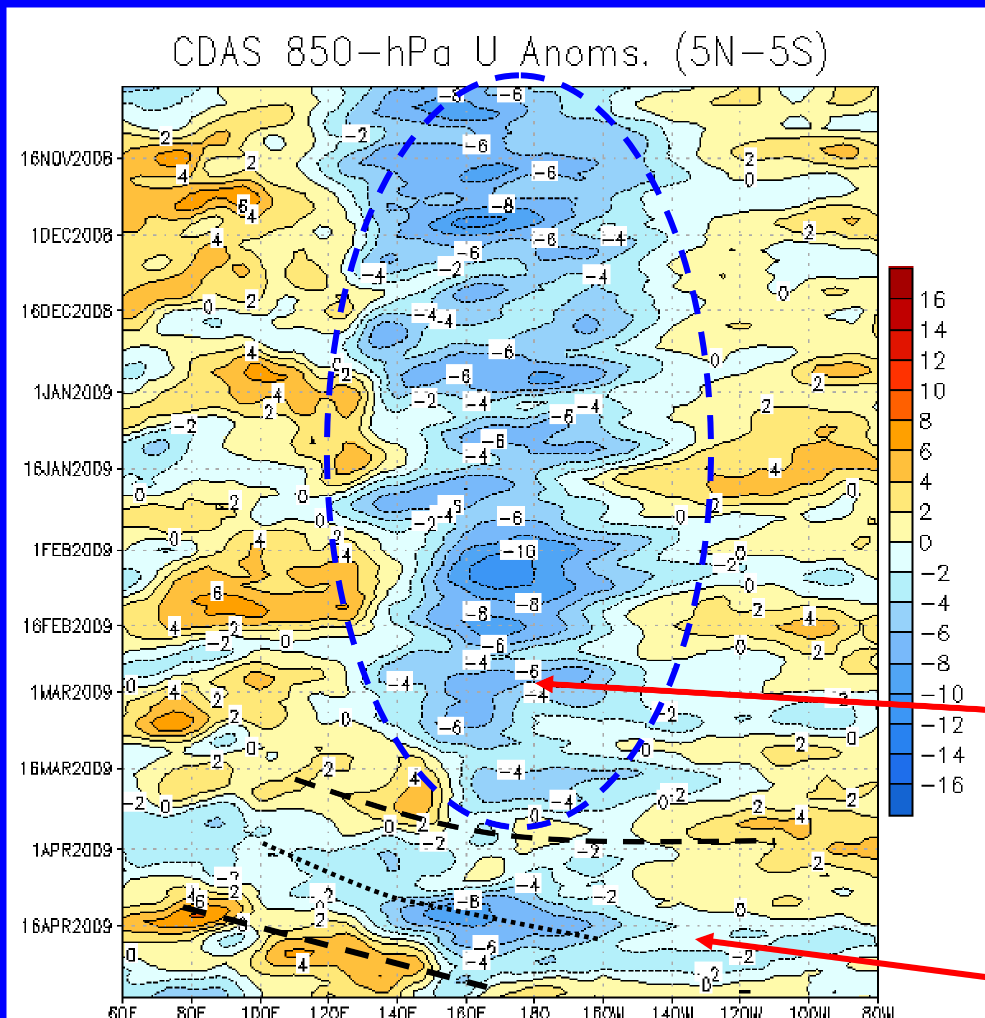
Longitude

- During May - July 2008, positive heat content anomalies developed across the central and eastern equatorial Pacific Ocean. This warming reflected the combination of an oceanic Kelvin wave (dashed line) and the dissipation of La Niña.
- During September 2008 – January 2009, negative heat content anomalies returned and then strengthened in the central and eastern equatorial Pacific as La Niña conditions redeveloped.
- The negative anomalies weakened during January-March 2009, becoming positive since late March.
- Recently, an oceanic Kelvin wave has increased the heat content anomalies across the eastern half of the Pacific Ocean.

- Oceanic Kelvin waves have alternating warm and cold phases. The warm phase is indicated by dashed lines. Down-welling and warming occur in the leading portion of a Kelvin wave, and up-welling and cooling occur in the trailing portion.

Low-level (850-hPa) Zonal (east-west) Wind Anomalies (m s^{-1})

Time



Longitude

Westerly wind anomalies (orange/red shading).

Easterly wind anomalies (blue shading).

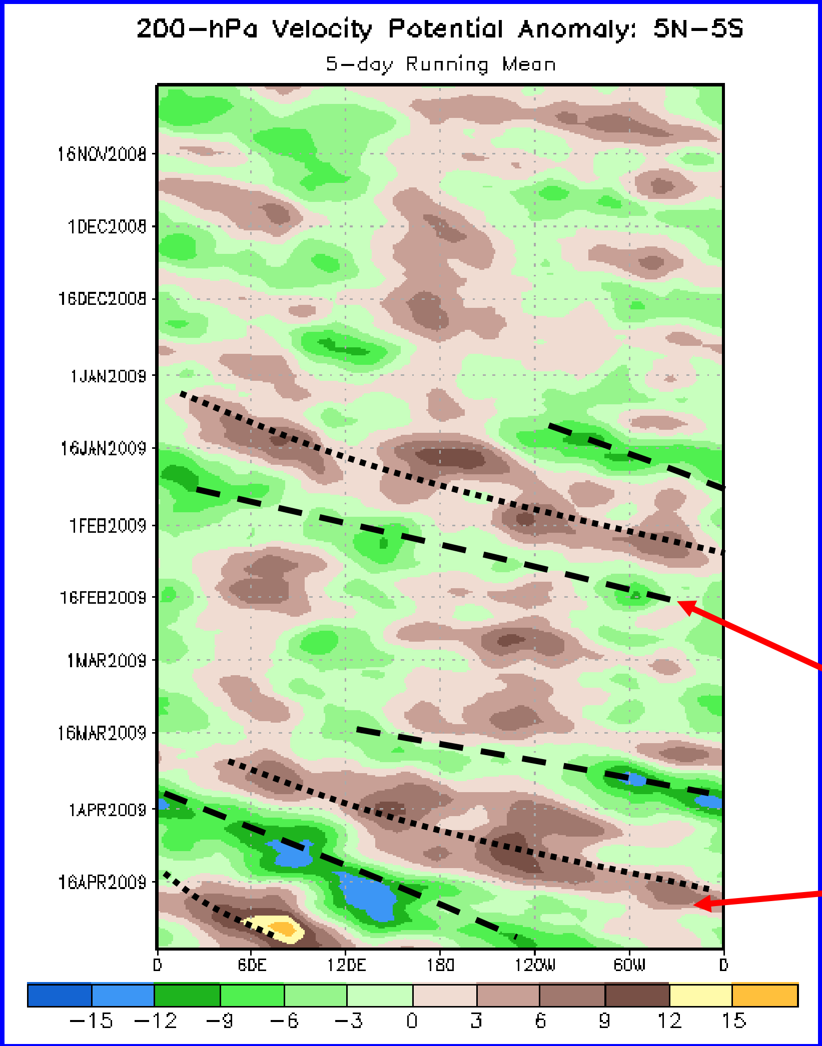
Low-level (850-hPa) easterly wind anomalies have persisted since January 2007 over the equatorial Pacific between 150ºE and 150ºW.

Brief periods of weaker easterlies (anomalous westerlies) have been associated with intraseasonal (MJO) activity.

From October through mid-March, strong easterly anomalies dominated the central equatorial Pacific (blue circle).

In association with an MJO, a pattern of alternating anomalous westerlies and easterlies is evident across the equatorial Indian and Pacific Oceans.

200-hPa Velocity Potential Anomalies (5ºN-5ºS)



Time

Longitude

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation.

Negative anomalies (green shading) indicate favorable conditions for precipitation.

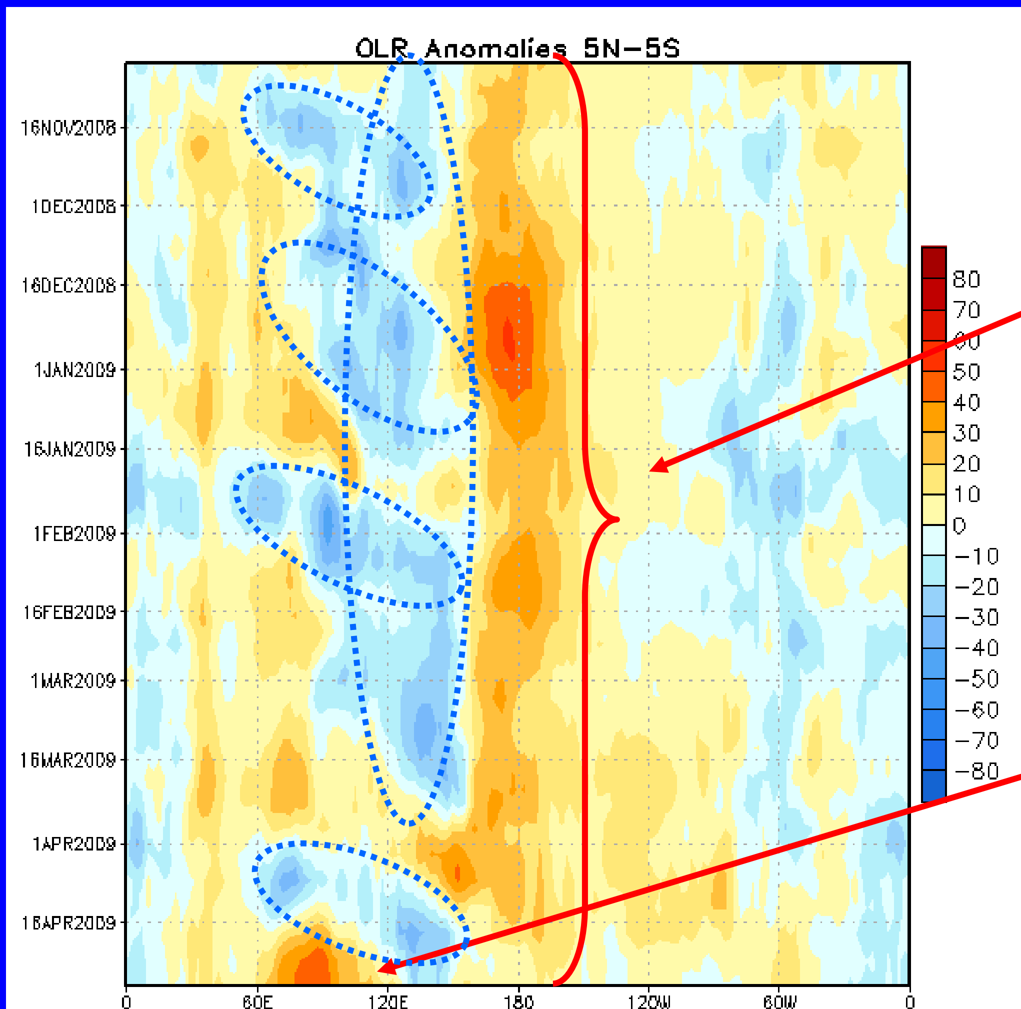
Positive velocity potential anomalies (associated with suppressed convection) have been dominant near the Date Line.

The MJO was active from mid-January to mid-February 2009.

The MJO has also been active since mid-March 2009.

Outgoing Longwave Radiation (OLR) Anomalies

Time



Longitude

Drier-than-average conditions (orange/red shading)

Wetter-than-average conditions (blue shading)

Since February 2007, convection has been suppressed across the central equatorial Pacific Ocean.

Convection has occasionally been enhanced over the western equatorial Pacific and central Indian Ocean. Between November 2008- March 2009, convection was persistent over Indonesia.

Recently, suppressed convection has shifted from the Indian Ocean to Indonesia in association with MJO activity.

Oceanic Niño Index (ONI)

- The ONI is based on SST departures from average in the Niño 3.4 region, and is a principal measure for monitoring, assessing, and predicting ENSO.
- Defined as the three-month running-mean SST departures in the Niño 3.4 region. Departures are based on a set of improved homogeneous historical SST analyses (Extended Reconstructed SST – ERSST.v3b). The SST reconstruction methodology is described in Smith et al., 2008, *J. Climate*, vol. 21, 2283-2296.)
- Used to place current events into a historical perspective
- NOAA's operational definitions of El Niño and La Niña are keyed to the ONI index.

NOAA Operational Definitions for El Niño and La Niña

El Niño: characterized by a *positive* ONI greater than or equal to +0.5°C.

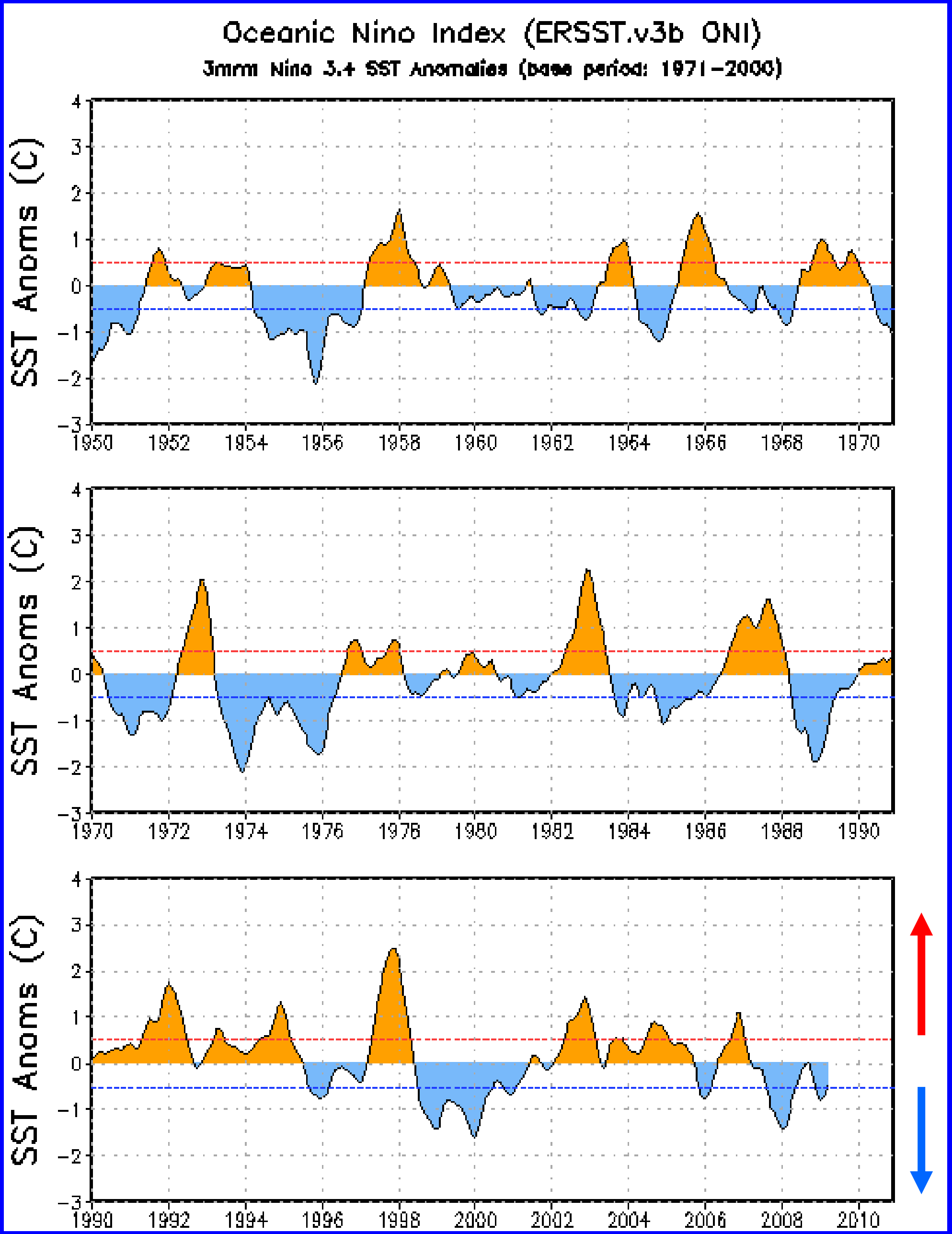
La Niña: characterized by a *negative* ONI less than or equal to -0.5°C.

By historical standards, to be classified as a full-fledged El Niño or La Niña episode, these thresholds must be exceeded for a period of at least 5 consecutive overlapping 3-month seasons.

CPC considers El Niño or La Niña conditions to occur when the monthly Niño3.4 SST departures meet or exceed +/- 0.5°C along with consistent atmospheric features. These anomalies must also be forecasted to persist for 3 consecutive months.

ONI (ºC): Evolution since 1950

The most recent ONI value (February – April 2009) is −0.5ºC.



El Niño

neutral

La Niña

Historical El Niño and La Niña Episodes

Based on the ONI computed using ERSST.v3b

NOTE:

After updating the ocean analysis to ERSST.v3b, a new La Niña episode was classified (ASO 1962-DJF 1962/63) and two previous La Niña episodes were combined into one single episode (AMJ 1973- MAM 1976).

El Niño	Highest ONI Value
JAS 1951 - NDJ 1951/52	0.8
MAM 1957 – MJJ 1958	1.7
JJA 1963 – DJF 1963/64	1.0
MJJ 1965 – MAM 1966	1.6
OND 1968 – MJJ 1969	1.0
ASO 1969 – DJF 1969/70	0.8
AMJ 1972 – FMA 1973	2.1
ASO 1976 – JFM 1977	0.8
ASO 1977 - DJF 1977/78	0.8
AMJ 1982 – MJJ 1983	2.3
JAS 1986 – JFM 1988	1.6
AMJ 1991 – JJA 1992	1.8
AMJ 1994 – FMA 1995	1.3
AMJ 1997 – AMJ 1998	2.5
AMJ 2002 – FMA 2003	1.5
MJJ 2004 – JFM 2005	0.9
JAS 2006 - DJF 2006/07	1.1

La Nina	Lowest ONI Value
ASO 1949 – FMA 1951	-1.7
MAM 1954 – DJF 1956/57	-2.1
ASO 1962 – DJF 1962/63	-0.8
MAM 1964 – DJF 1964/65	-1.1
NDJ 1967/68 – MAM 1968	-0.9
JJA 1970 – DJF 1971/72	-1.3
AMJ 1973 – MAM 1976	-2.0
SON 1984 – ASO 1985	-1.0
AMJ 1988 – AMJ 1989	-1.9
ASO 1995 – FMA 1996	-0.7
JJA 1998 – MJJ 2000	-1.6
SON 2000 – JFM 2001	-0.7
ASO 2007 – AMJ 2008	-1.4

Historical Pacific warm (red) and cold (blue) episodes based on a threshold of +/- 0.5 ºC for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v3b SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)], calculated with respect to the 1971-2000 base period. For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1950	-1.7	-1.5	-1.3	-1.4	-1.3	-1.1	-0.8	-0.8	-0.8	-0.9	-0.9	-1.0
1951	-1.0	-0.9	-0.6	-0.3	-0.2	0.2	0.4	0.7	0.7	0.8	0.7	0.6
1952	0.3	0.1	0.1	0.2	0.1	-0.1	-0.3	-0.3	-0.2	-0.2	-0.1	0.0
1953	0.2	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4
1954	0.5	0.3	-0.1	-0.5	-0.7	-0.7	-0.8	-1.0	-1.2	-1.1	-1.1	-1.1
1955	-1.0	-0.9	-0.9	-1.0	-1.0	-1.0	-1.0	-1.0	-1.4	-1.8	-2.0	-1.9
1956	-1.3	-0.9	-0.7	-0.6	-0.6	-0.6	-0.7	-0.8	-0.8	-0.9	-0.9	-0.8
1957	-0.5	-0.1	0.3	0.6	0.7	0.9	0.9	0.9	0.9	1.0	1.2	1.5
1958	1.7	1.5	1.2	0.8	0.6	0.5	0.3	0.1	0.0	0.0	0.2	0.4
1959	0.4	0.5	0.4	0.2	0.0	-0.2	-0.4	-0.5	-0.4	-0.3	-0.2	-0.2
1960	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.1	0.0	-0.1	-0.2	-0.2	-0.2
1961	-0.2	-0.2	-0.2	-0.1	0.1	0.2	0.0	-0.3	-0.6	-0.6	-0.5	-0.4
1962	-0.4	-0.4	-0.4	-0.5	-0.4	-0.4	-0.3	-0.3	-0.5	-0.6	-0.7	-0.7
1963	-0.6	-0.3	0.0	0.1	0.1	0.3	0.6	0.8	0.9	0.9	1.0	1.0
1964	0.8	0.4	-0.1	-0.5	-0.8	-0.8	-0.9	-1.0	-1.1	-1.2	-1.2	-1.0
1965	-0.8	-0.4	-0.2	0.0	0.3	0.6	1.0	1.2	1.4	1.5	1.6	1.5
1966	1.2	1.0	0.8	0.5	0.2	0.2	0.2	0.0	-0.2	-0.2	-0.3	-0.3
1967	-0.4	-0.4	-0.6	-0.5	-0.3	0.0	0.0	-0.2	-0.4	-0.5	-0.4	-0.5
1968	-0.7	-0.9	-0.8	-0.7	-0.3	0.0	0.3	0.4	0.3	0.4	0.7	0.9
1969	1.0	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.6	0.7	0.8	0.7
1970	0.5	0.3	0.2	0.1	0.0	-0.3	-0.6	-0.8	-0.9	-0.8	-0.9	-1.1
1971	-1.3	-1.3	-1.1	-0.9	-0.8	-0.8	-0.8	-0.8	-0.8	-0.9	-1.0	-0.9
1972	-0.7	-0.4	0.0	0.2	0.5	0.8	1.0	1.3	1.5	1.8	2.0	2.1
1973	1.8	1.2	0.5	-0.1	-0.6	-0.9	-1.1	-1.3	-1.4	-1.7	-2.0	-2.1
1974	-1.9	-1.7	-1.3	-1.1	-0.9	-0.8	-0.6	-0.5	-0.5	-0.7	-0.9	-0.7
1975	-0.6	-0.6	-0.7	-0.8	-0.9	-1.1	-1.2	-1.3	-1.5	-1.6	-1.7	-1.7

Historical Pacific warm (red) and cold (blue) episodes based on a threshold of +/- 0.5 ºC for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v3b SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)], calculated with respect to the 1971-2000 base period. For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1976	**-1.6**	**-1.2**	**-0.8**	**-0.6**	**-0.5**	-0.2	0.1	0.3	**0.5**	**0.7**	**0.8**	**0.7**
1977	**0.6**	**0.5**	0.2	0.2	0.2	0.4	0.4	0.4	**0.5**	**0.6**	**0.7**	**0.7**
1978	**0.7**	0.4	0.0	-0.3	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.2	-0.1
1979	-0.1	0.0	0.1	0.1	0.1	-0.1	0.0	0.1	0.3	0.4	0.5	0.5
1980	0.5	0.3	0.2	0.2	0.3	0.3	0.2	0.0	-0.1	-0.1	0.0	-0.1
1981	-0.3	-0.5	-0.5	-0.4	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.1	-0.1
1982	0.0	0.1	0.1	0.3	**0.6**	**0.7**	**0.7**	**1.0**	**1.5**	**1.9**	**2.2**	**2.3**
1983	**2.3**	**2.0**	**1.5**	**1.2**	**1.0**	**0.6**	0.2	-0.2	-0.6	-0.8	-0.9	-0.7
1984	-0.4	-0.2	-0.2	-0.3	-0.5	-0.4	-0.3	-0.2	-0.3	**-0.6**	**-0.9**	**-1.1**
1985	**-0.9**	**-0.8**	**-0.7**	**-0.7**	**-0.7**	**-0.6**	**-0.5**	**-0.5**	**-0.5**	-0.4	-0.3	-0.4
1986	-0.5	-0.4	-0.2	-0.2	-0.1	0.0	0.3	**0.5**	**0.7**	**0.9**	**1.1**	**1.2**
1987	**1.2**	**1.3**	**1.2**	**1.1**	**1.0**	**1.2**	**1.4**	**1.6**	**1.6**	**1.5**	**1.3**	**1.1**
1988	**0.7**	**0.5**	0.1	-0.2	**-0.7**	**-1.2**	**-1.3**	**-1.2**	**-1.3**	**-1.6**	**-1.9**	**-1.9**
1989	**-1.7**	**-1.5**	**-1.1**	**-0.8**	**-0.6**	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1
1990	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4
1991	0.4	0.3	0.3	0.4	**0.6**	**0.8**	**1.0**	**0.9**	**0.9**	**1.0**	**1.4**	**1.6**
1992	**1.8**	**1.6**	**1.5**	**1.4**	**1.2**	**0.8**	**0.5**	0.2	0.0	-0.1	0.0	0.2
1993	0.3	0.4	0.6	0.7	0.8	0.7	0.4	0.4	0.4	0.4	0.3	0.2
1994	0.2	0.2	0.3	0.4	**0.5**	**0.5**	**0.6**	**0.6**	**0.7**	**0.9**	**1.2**	**1.3**
1995	**1.2**	**0.9**	**0.7**	0.4	0.3	0.2	0.0	-0.2	**-0.5**	**-0.6**	**-0.7**	**-0.7**
1996	**-0.7**	**-0.7**	**-0.5**	-0.3	-0.1	-0.1	0.0	-0.1	-0.1	-0.2	-0.3	-0.4
1997	-0.4	-0.3	0.0	0.4	**0.8**	**1.3**	**1.7**	**2.0**	**2.2**	**2.4**	**2.5**	**2.5**
1998	**2.3**	**1.9**	**1.5**	**1.0**	**0.5**	0.0	**-0.5**	**-0.8**	**-1.0**	**-1.1**	**-1.3**	**-1.4**
1999	**-1.4**	**-1.2**	**-0.9**	**-0.8**	**-0.8**	**-0.8**	**-0.9**	**-0.9**	**-1.0**	**-1.1**	**-1.3**	**-1.6**
2000	**-1.6**	**-1.4**	**-1.0**	**-0.8**	**-0.6**	**-0.5**	-0.4	-0.4	-0.4	**-0.5**	**-0.6**	**-0.7**
2001	**-0.6**	**-0.5**	-0.4	-0.2	-0.1	0.1	0.2	0.2	0.1	0.0	-0.1	-0.1

Historical Pacific warm (red) and cold (blue) episodes based on a threshold of +/- 0.5 ºC for the Oceanic Nino Index (ONI) [3 month running mean of ERSST.v3b SST anomalies in the Nino 3.4 region (5N-5S, 120-170W)], calculated with respect to the 1971-2000 base period. For historical purposes El Niño and La Niña episodes are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2002	-0.1	0.1	0.2	0.4	**0.7**	**0.8**	**0.9**	**1.0**	**1.1**	**1.3**	**1.5**	**1.4**
2003	**1.2**	**0.9**	**0.5**	0.1	-0.1	0.1	0.4	0.5	0.6	0.5	0.6	0.4
2004	0.4	0.3	0.2	0.2	0.3	**0.5**	**0.7**	**0.8**	**0.9**	**0.8**	**0.8**	**0.8**
2005	**0.7**	**0.5**	0.4	0.4	0.4	0.4	0.4	0.3	0.2	-0.1	-0.4	-0.7
2006	-0.7	-0.6	-0.4	-0.1	0.1	0.2	0.3	**0.5**	**0.6**	**0.9**	**1.1**	**1.1**
2007	**0.8**	0.4	0.1	-0.1	-0.1	-0.1	-0.1	-0.4	**-0.7**	**-1.0**	**-1.1**	**-1.3**
2008	**-1.4**	**-1.4**	**-1.1**	**-0.8**	**-0.6**	-0.4	-0.1	0.0	0.0	0.0	-0.3	-0.6
2009	-0.8	-0.7	-0.5									
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020												
2021												
2022												
2023												
2024												
2025												
2026												
2027												

Pacific Niño 3.4 SST Outlook

A majority of ENSO forecasts indicate near-average SSTs (−0.5°C to +0.5°C) in the central equatorial Pacific through the remainder of 2009.

The dynamical model forecasts (solid boxes) are predicting warmer SSTs than the statistical forecasts (open circles), with several dynamical models predicting EL Niño to develop in the next few months.

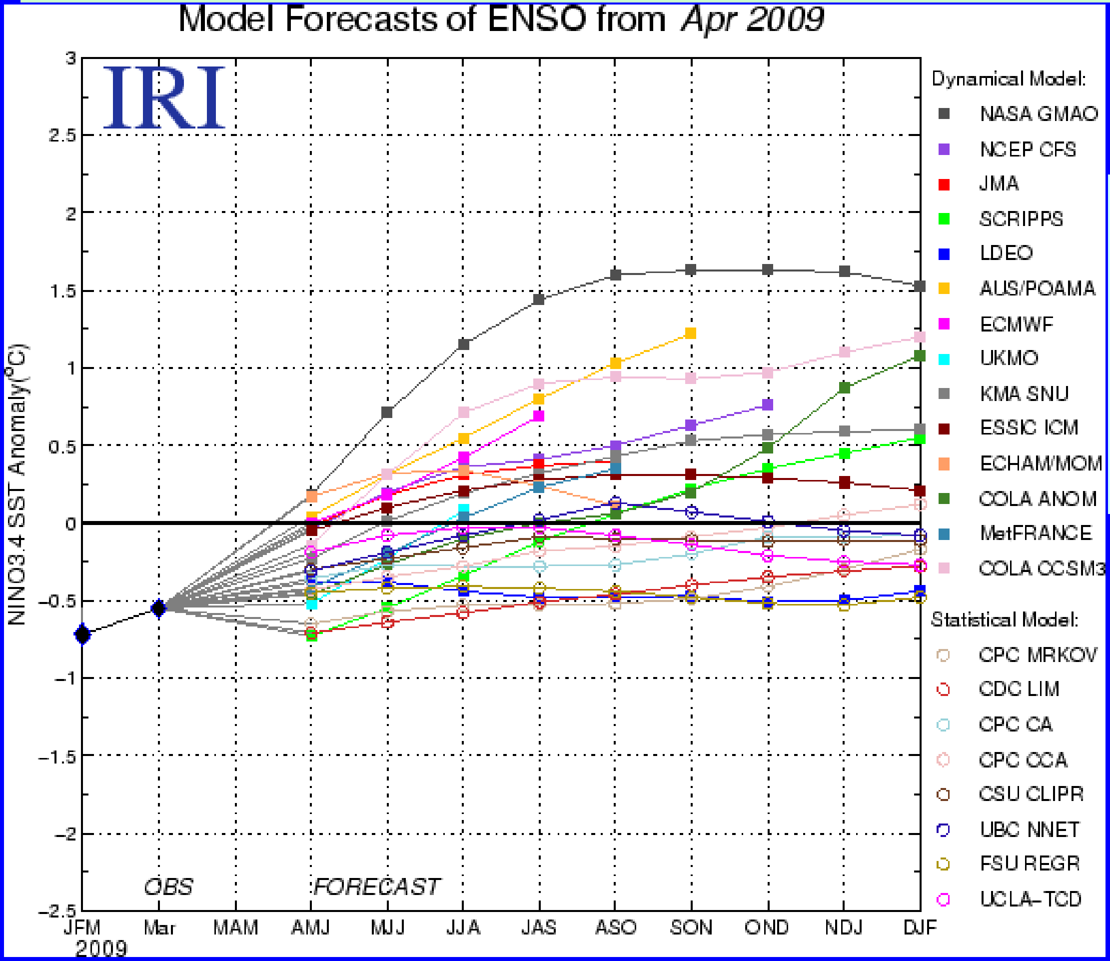
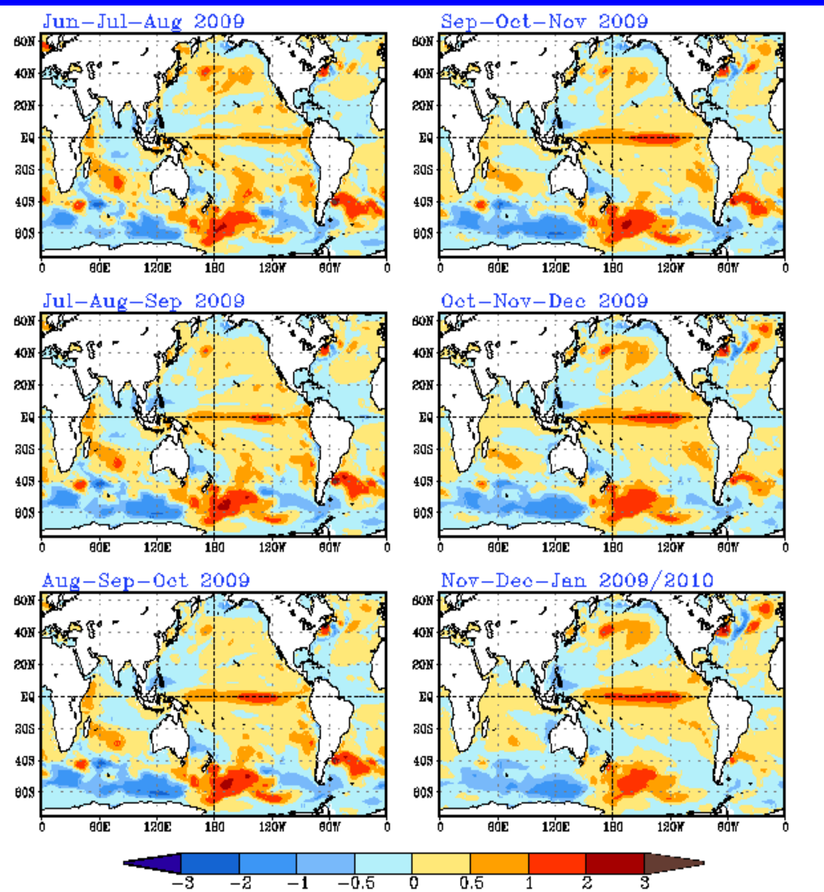
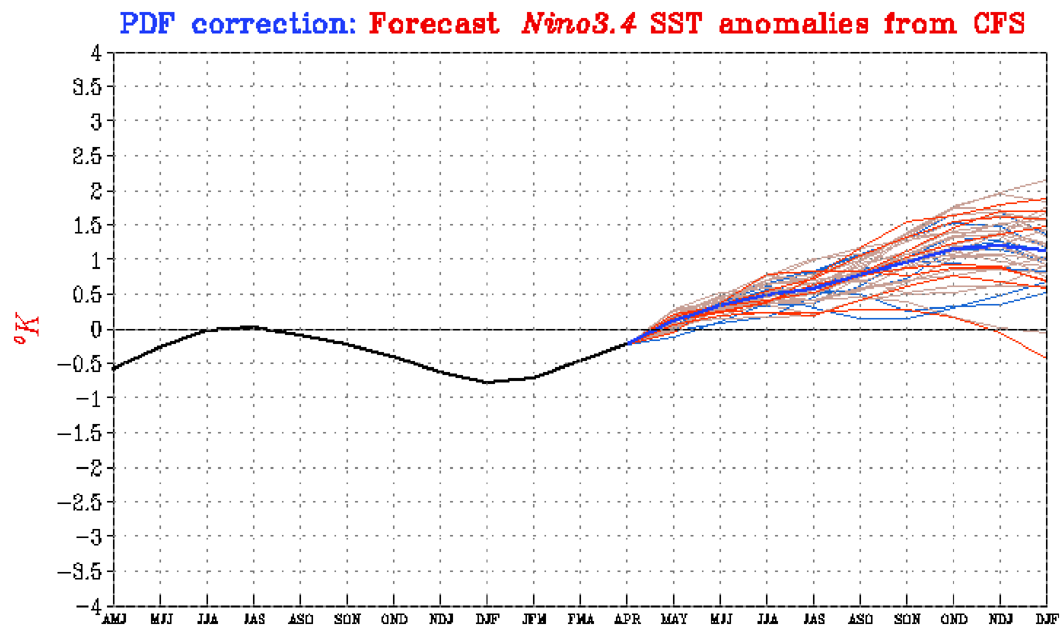


Figure provided by the International Research Institute (IRI) for Climate and Society (updated 15 April 2009).

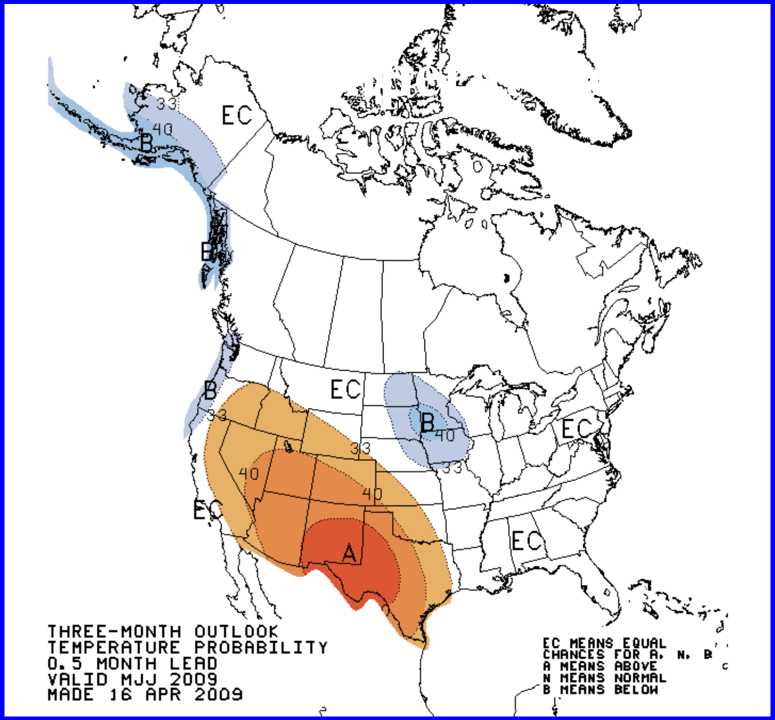
SST Outlook: NCEP CFS Forecast Issued 2 May 2009

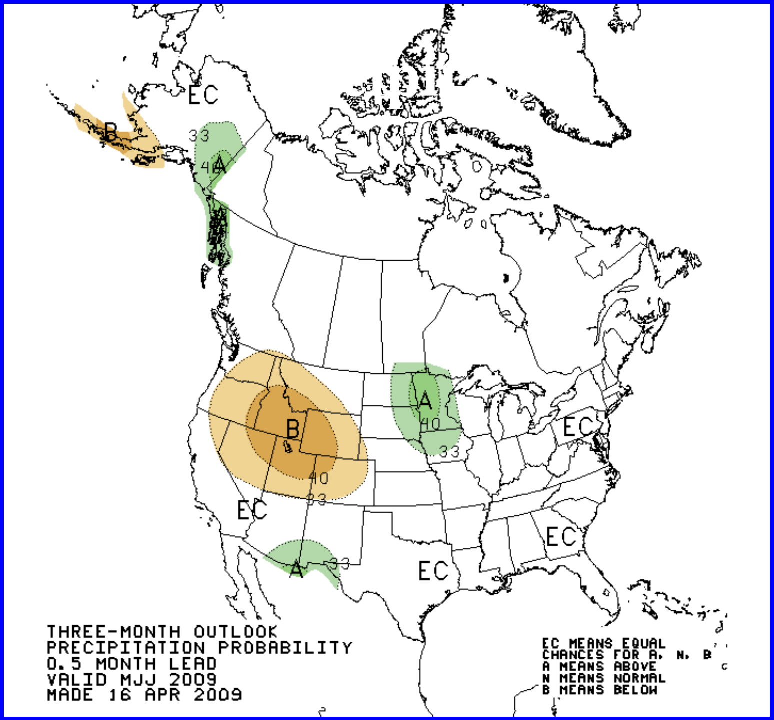


The CFS ensemble mean (heavy blue line) predicts near-average SSTs through July-August 2009.



U. S. Seasonal Outlooks
May – July 2009





These seasonal outlooks combine long-term trends and soil moisture.

Summary

- A transition from La Niña to ENSO-neutral is underway in the equatorial Pacific Ocean.
- Negative equatorial SSTs have weakened considerably since February 2009.
- The patterns of tropical convection and winds continue to reflect weak La Niña conditions.
- Based on recent trends in the observations and model forecasts, a transition to ENSO-neutral conditions will continue.