ENSO Cycle: Recent Evolution, Current Status and Predictions

Update prepared by
Climate Prediction Center / NCEP
24 August 2009

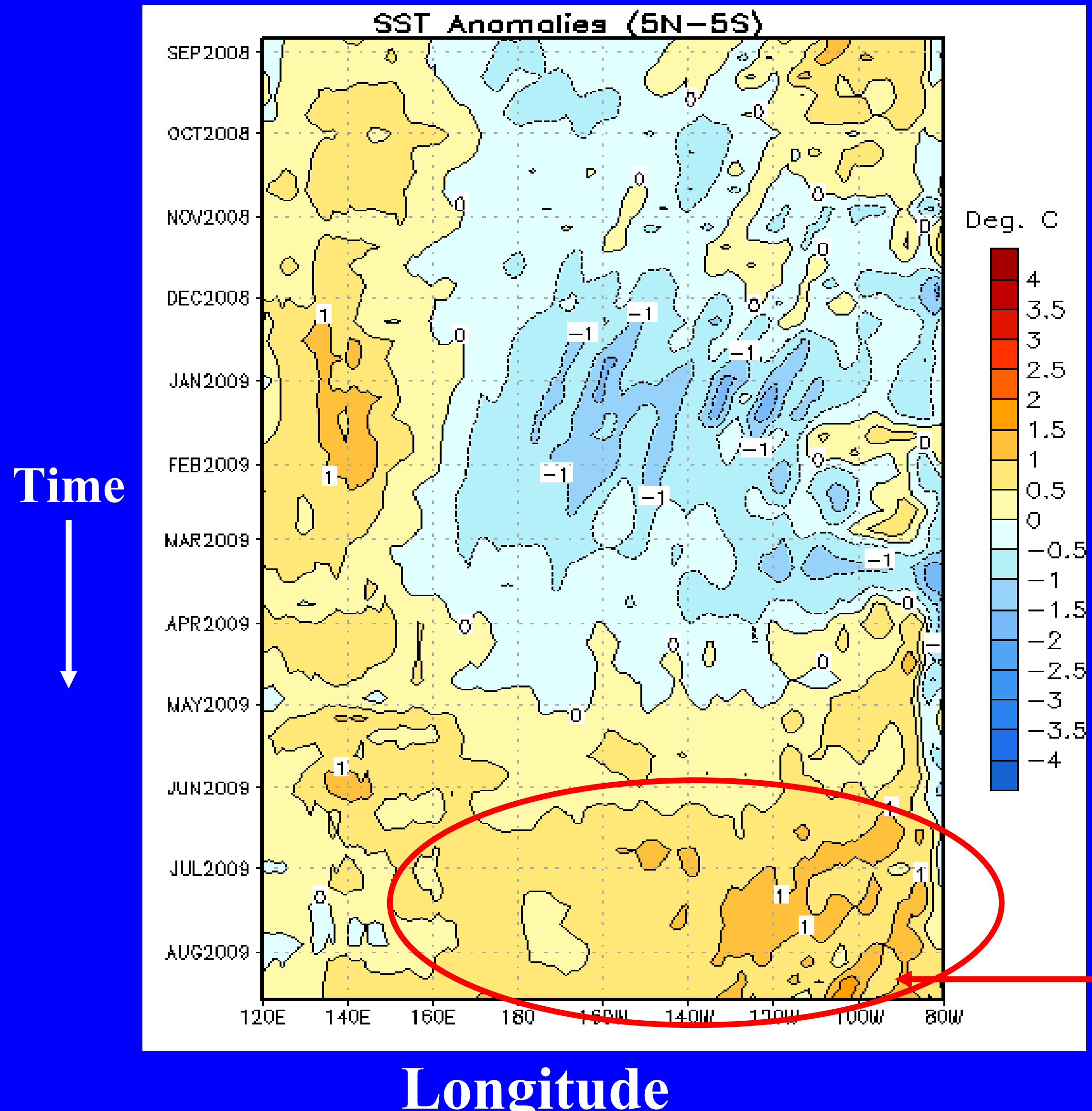
Outline

- 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

- El Niño is present across the equatorial Pacific Ocean.
- Sea surface temperatures (SST) remain +0.5 to +1.5 above-average across much of the equatorial Pacific Ocean.
- Current observations and dynamical model forecasts indicate El Niño is expected to strengthen and last through Northern Hemisphere winter 2009-10.

Recent Evolution of Equatorial Pacific SST Departures (ºC)



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

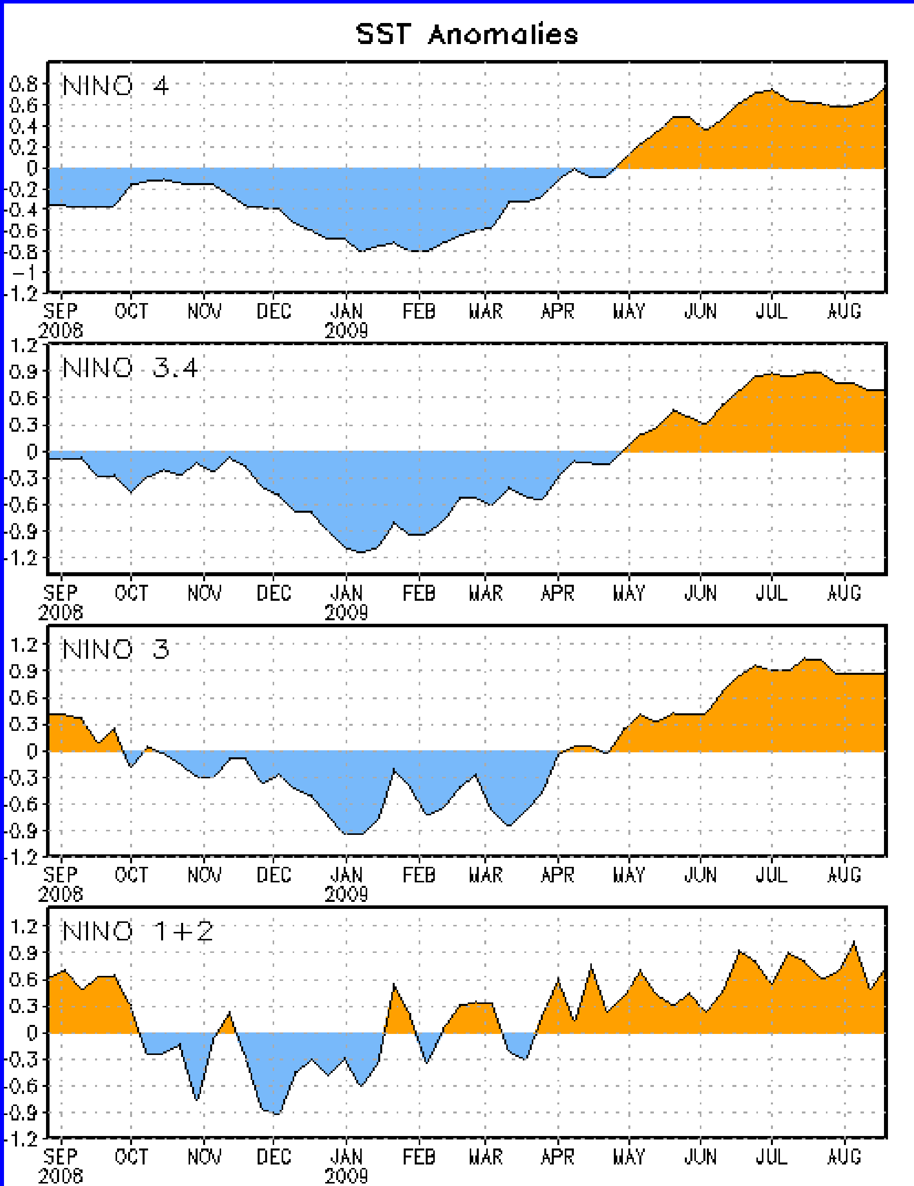
During February- April 2009, negative SST anomalies weakened across the equatorial Pacific.

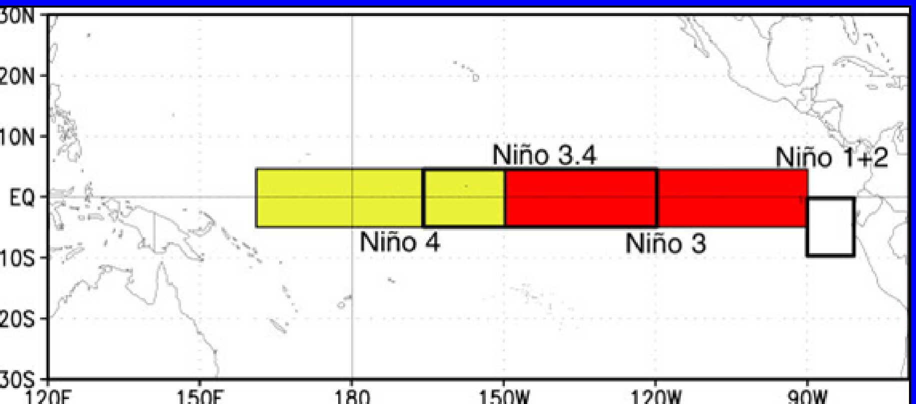
Since the beginning of June 2009, SST anomalies have been at least +0.5°C across much of the equatorial Pacific.

Niño Region SST Departures (ºC) Recent Evolution

The latest weekly SST departures are:

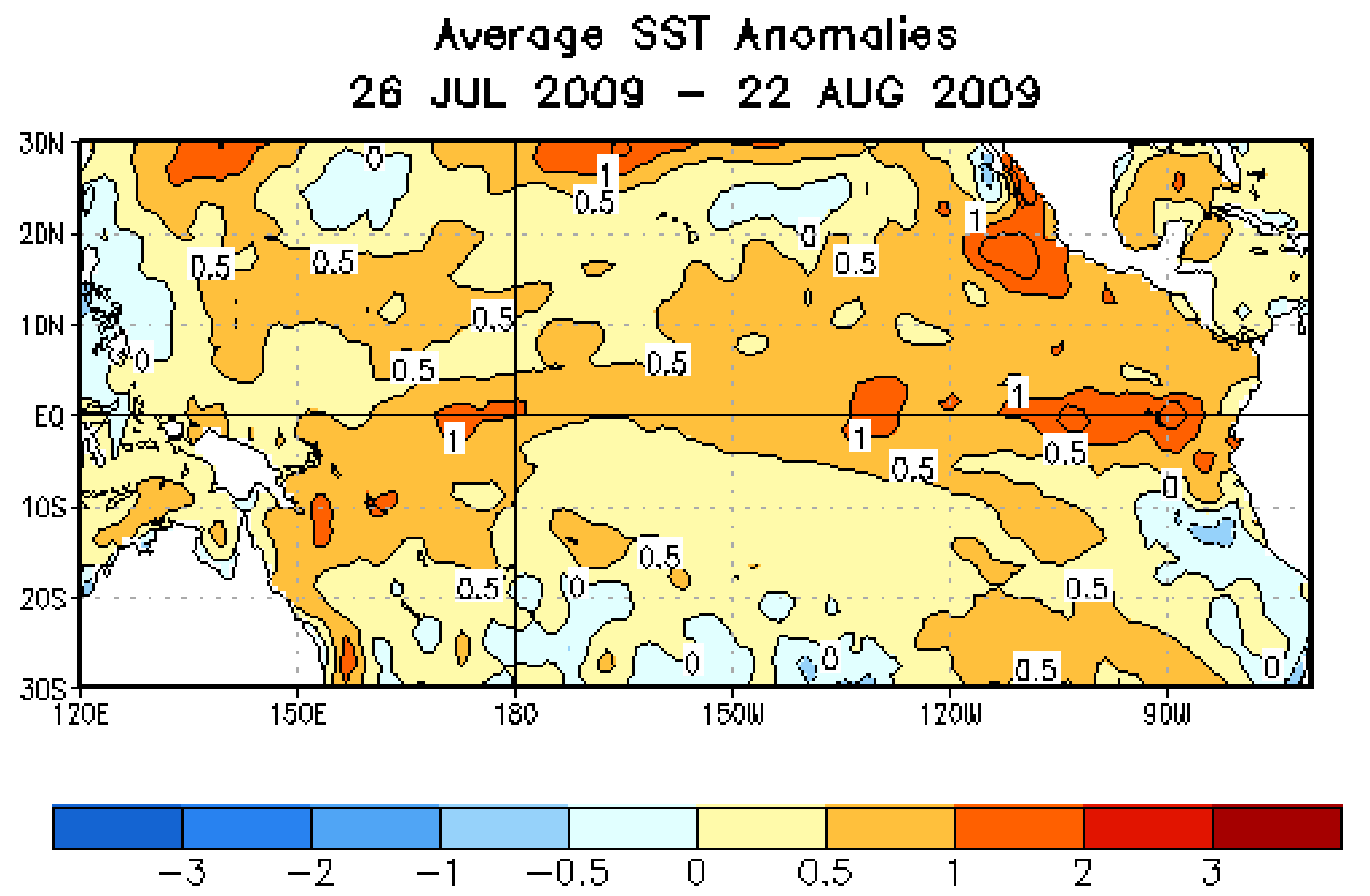
Niño 4	**0.8ºC**
Niño 3.4	**0.7ºC**
Niño 3	**0.9ºC**
Niño 1+2	**0.8ºC**



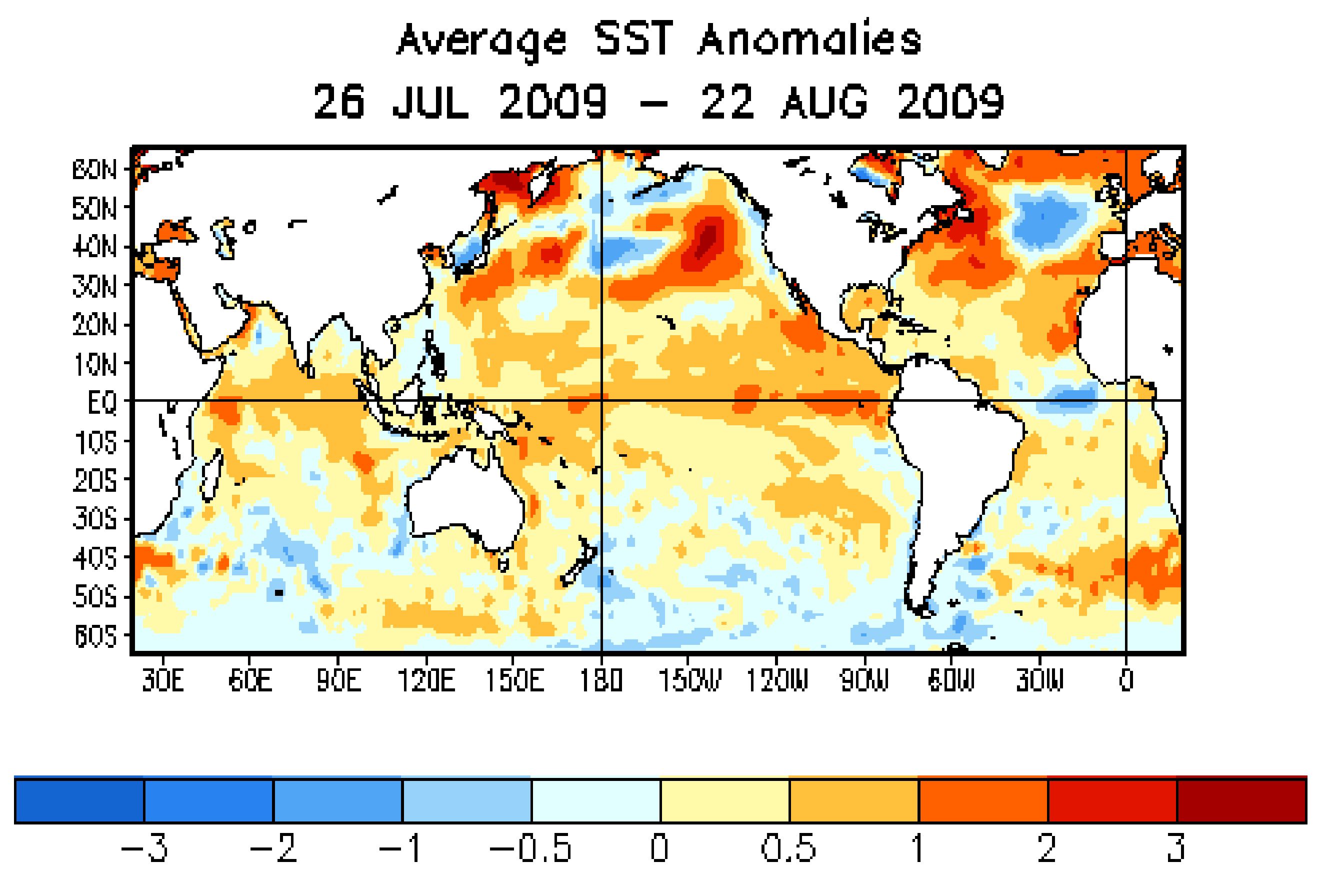


SST Departures (ºC) in the Tropical Pacific During the Last 4 Weeks

During the last 4-weeks, equatorial SSTs were at least 0.5°C above-average across the Pacific Ocean and at least 1.0°C above average near the Date Line and in the eastern Pacific.

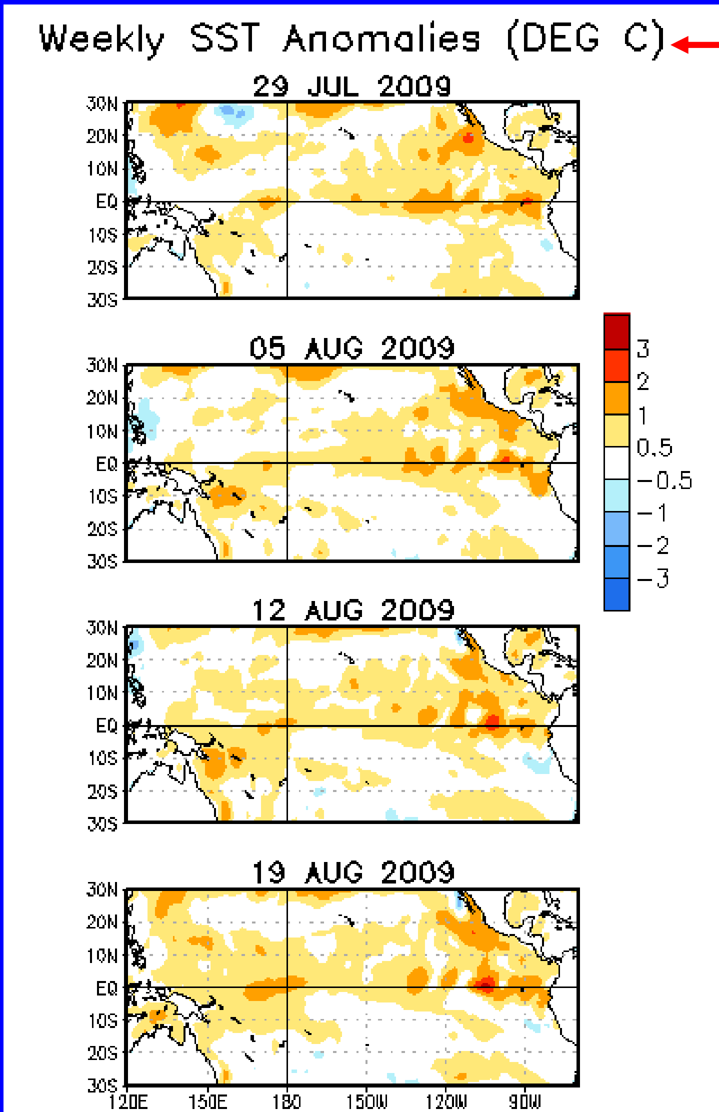


Global SST Departures (ºC)

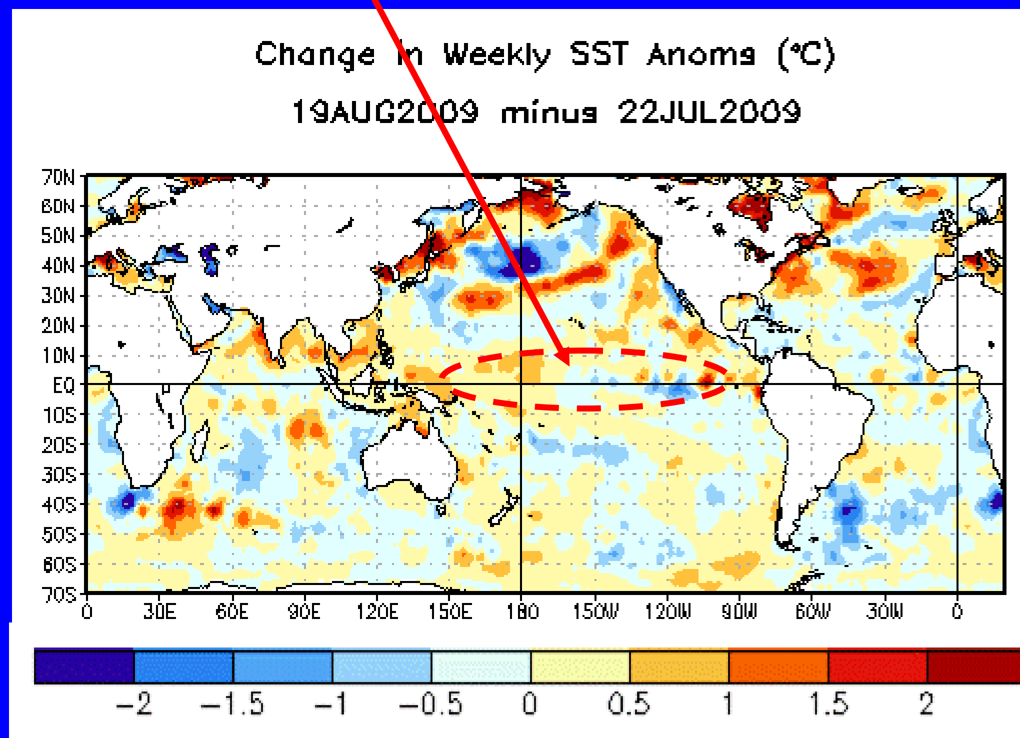


During the last four weeks, equatorial SSTs were above-average in the Pacific and Indian Oceans. Also, above-average SSTs covered large areas of the Northern Hemisphere mid-to-high latitudes.

Weekly SST Departures (ºC) for the Last Four Weeks



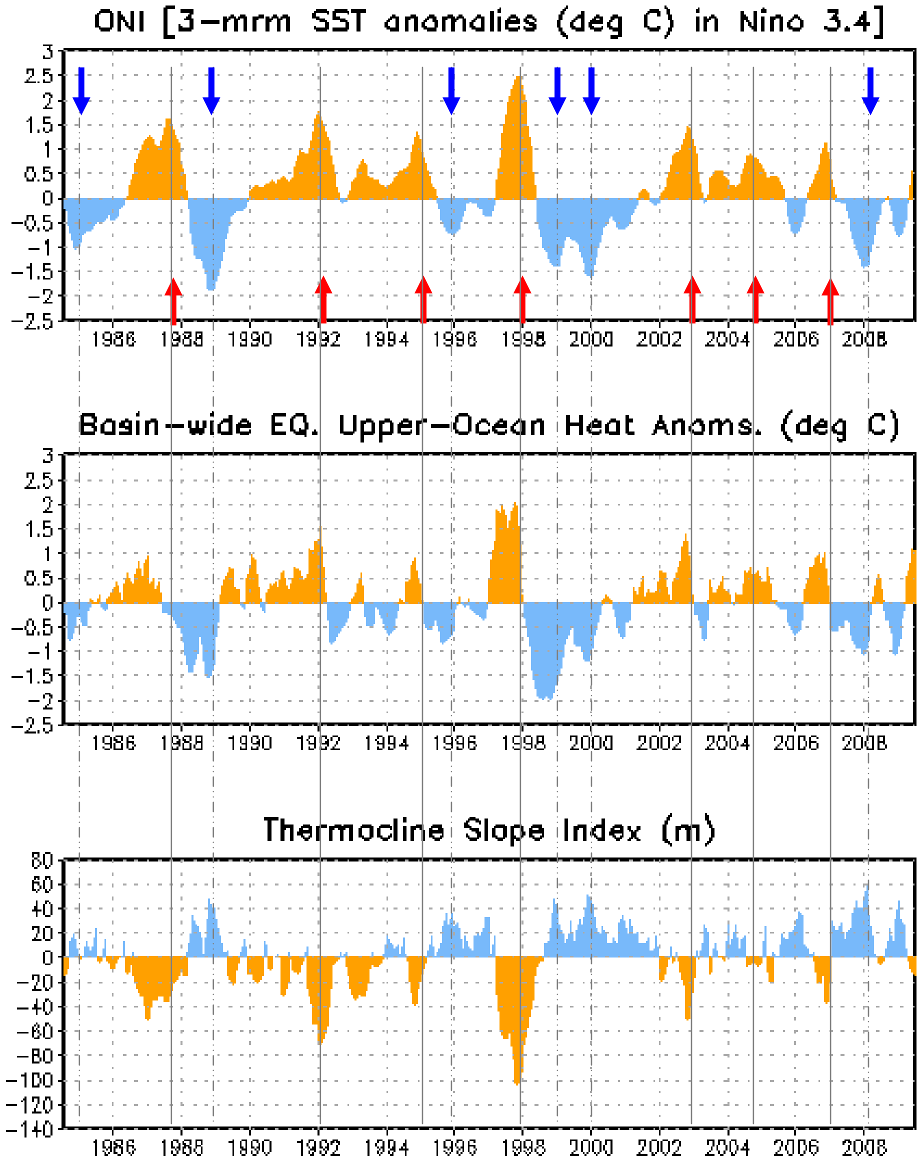
- During the last four weeks, SST anomalies have been positive across the equatorial Pacific Ocean.
- During the last month, there has been little change in SST anomalies across the equatorial Pacific Ocean.



Upper-Ocean Conditions in the Eq. Pacific

Cold Episodes

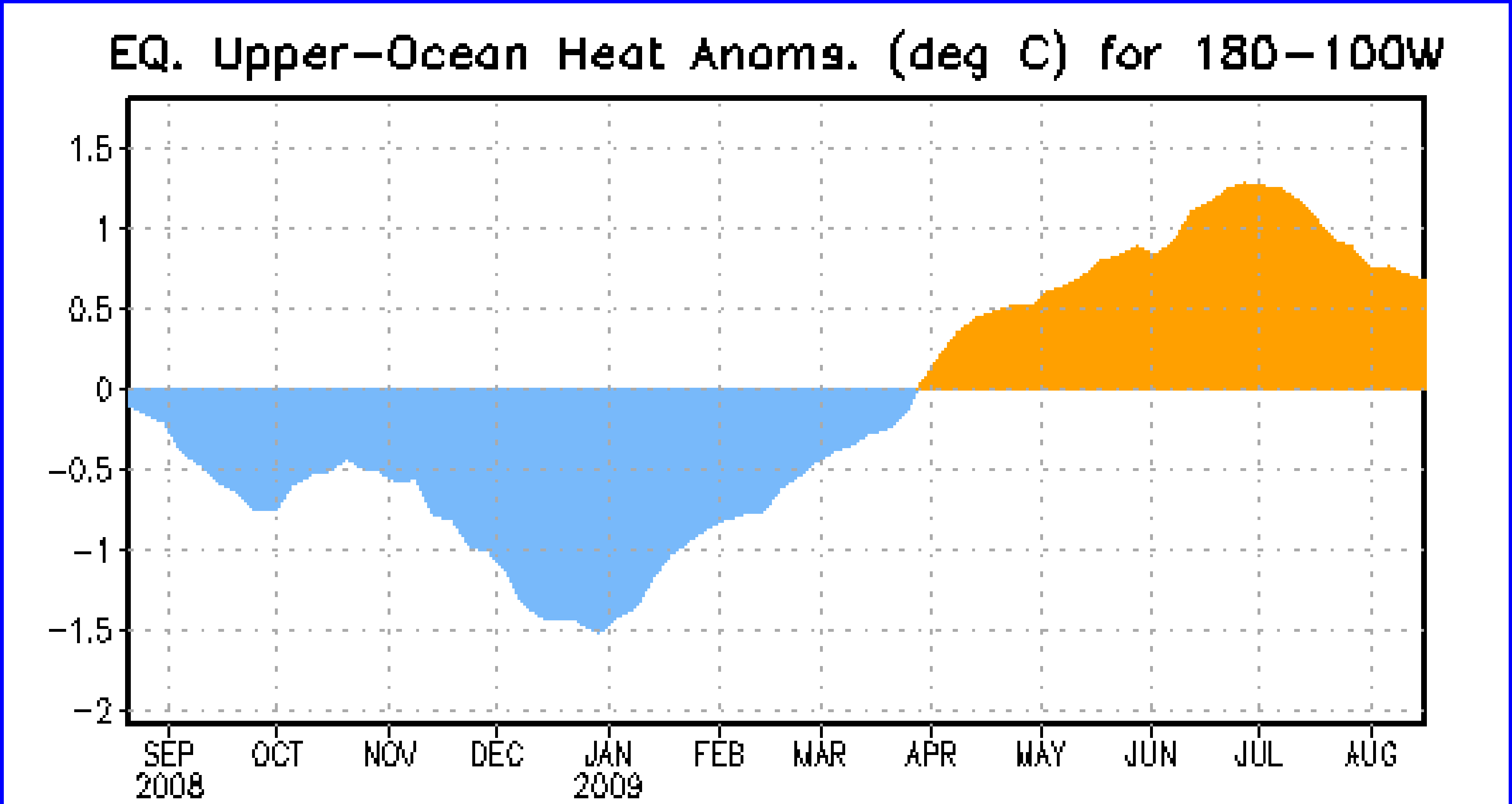
Warm Episodes



- 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 (positive) and the thermocline slope index (negative) reflect El Niño conditions.

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).

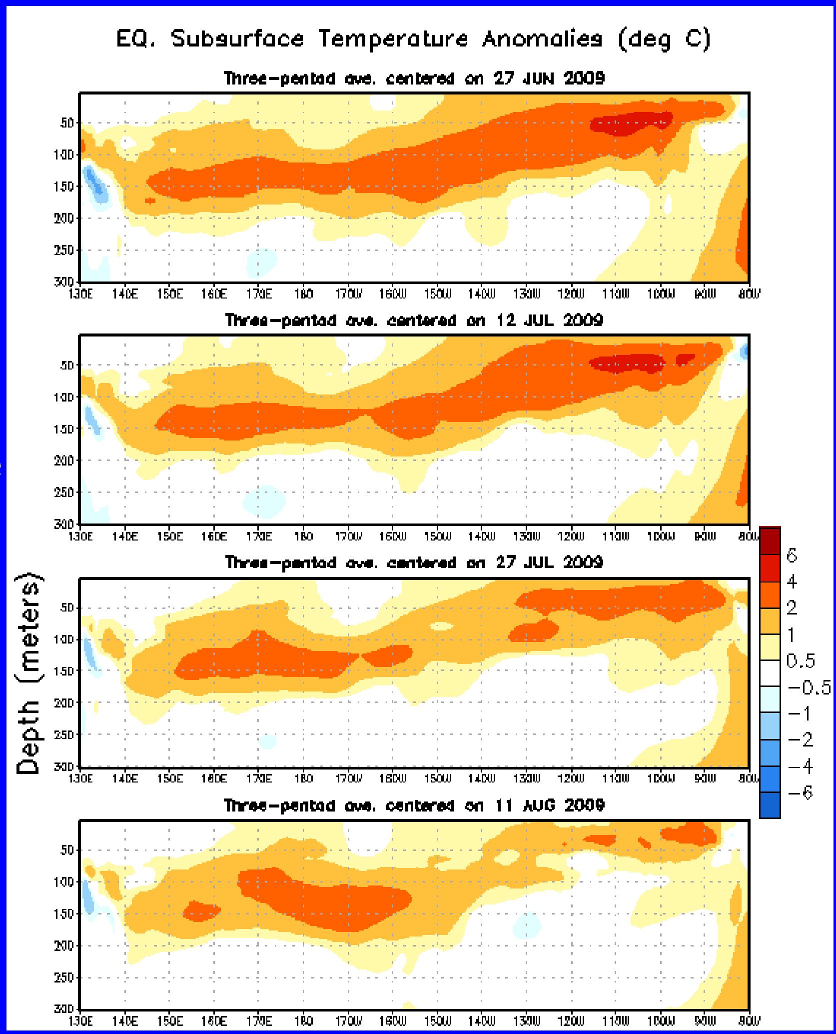
Central & Eastern Pacific Upper-Ocean (0-300 m) Weekly Heat Content Anomalies



The upper ocean heat content was below-average across the eastern half of the equatorial Pacific Ocean between mid-August 2008 and March 2009, with a minimum reached in late December 2008. The heat content anomalies have remained positive since April 2009.

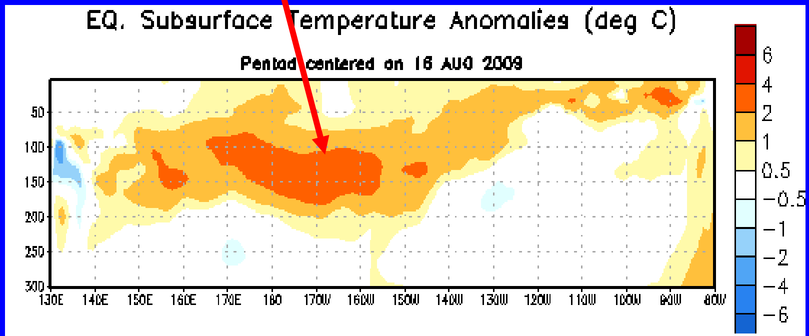
Sub-Surface Temperature Departures (°C) in the Equatorial Pacific

Time



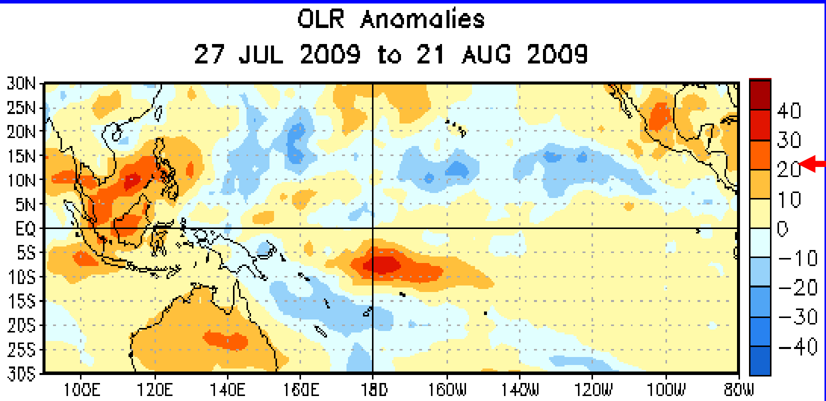
Longitude

- **During late- June through mid- August 2009, positive sub-surface temperature anomalies weakened in the eastern half of the Pacific Ocean.**
- **The most recent period (below) shows positive anomalies across the equatorial Pacific, with the largest anomalies near 125m depth in the west-central Pacific.**

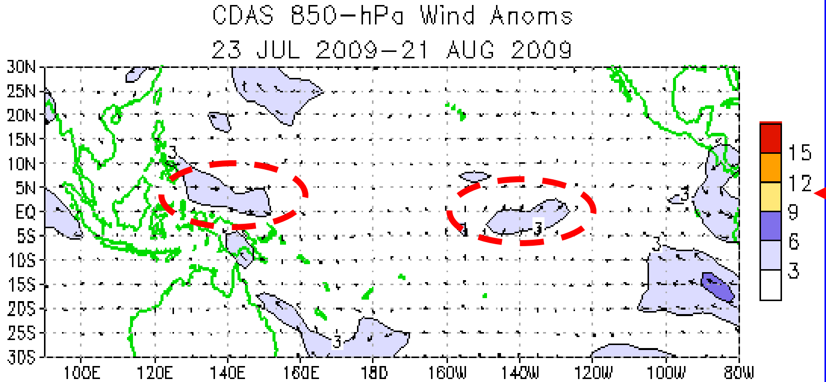


Most recent pentad analysis

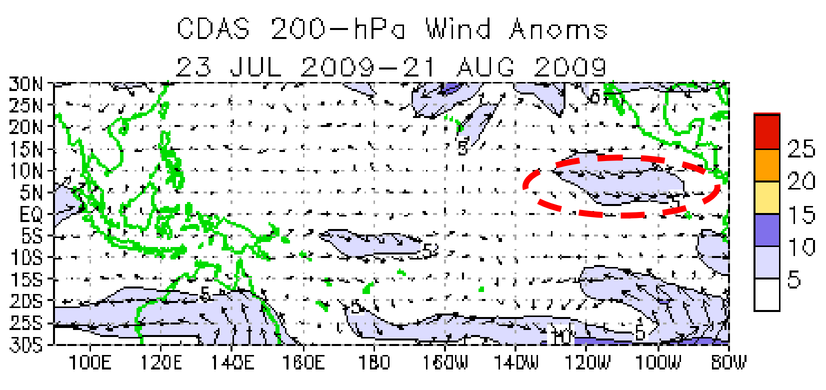
Tropical OLR and Wind Anomalies During the Last 30 Days



Positive OLR anomalies (suppressed convection and precipitation, red shading) were present over Indonesia, Malaysia, Philippines, and Australia, while small negative anomalies (enhanced convection, blue shading) covered areas in the west-central Pacific.



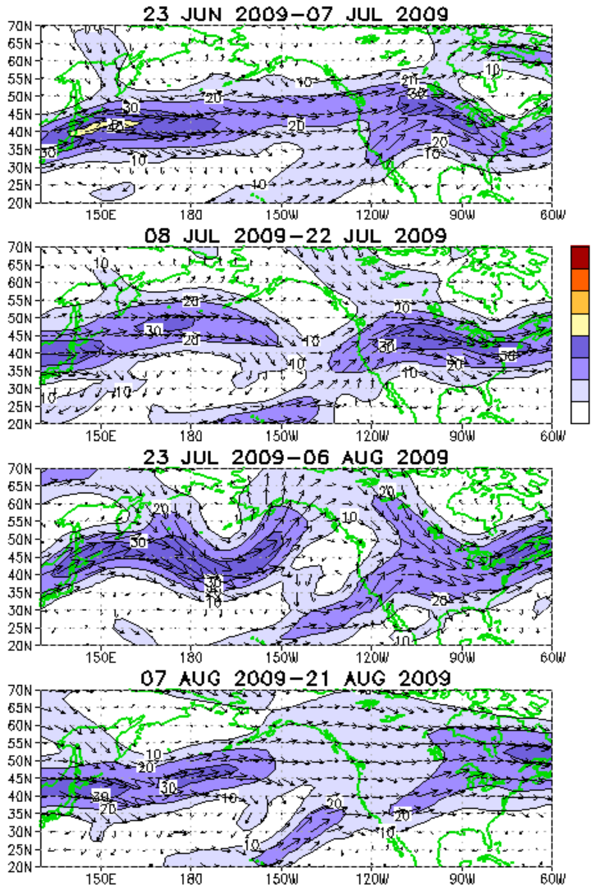
Low-level (850-hPa) equatorial winds were near-average over much of the Pacific. Weak westerly anomalies were observed in small areas in the western and east-central Pacific.



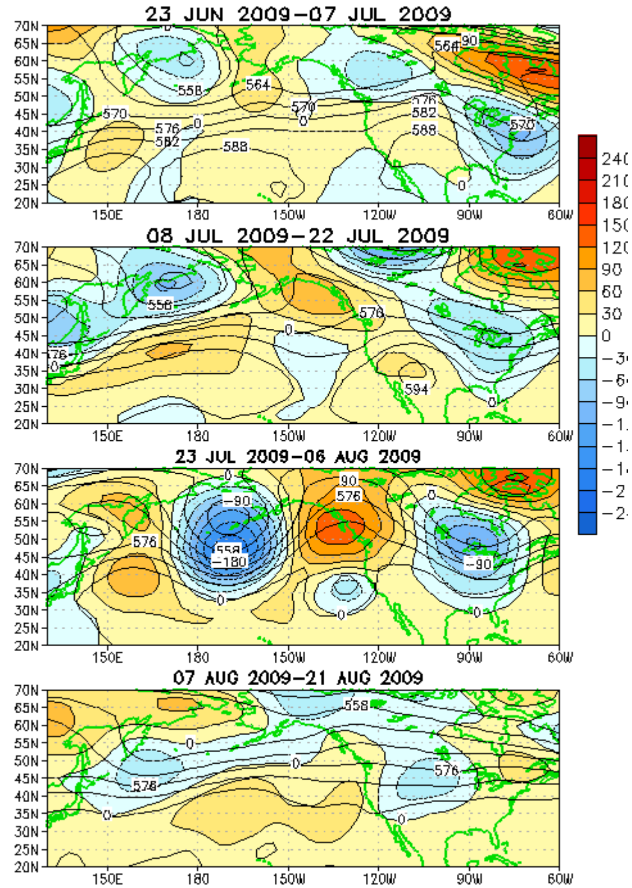
Upper-level (200-hPa) winds remained near-average across much of the Pacific, except for westerly wind anomalies in the eastern Pacific.

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

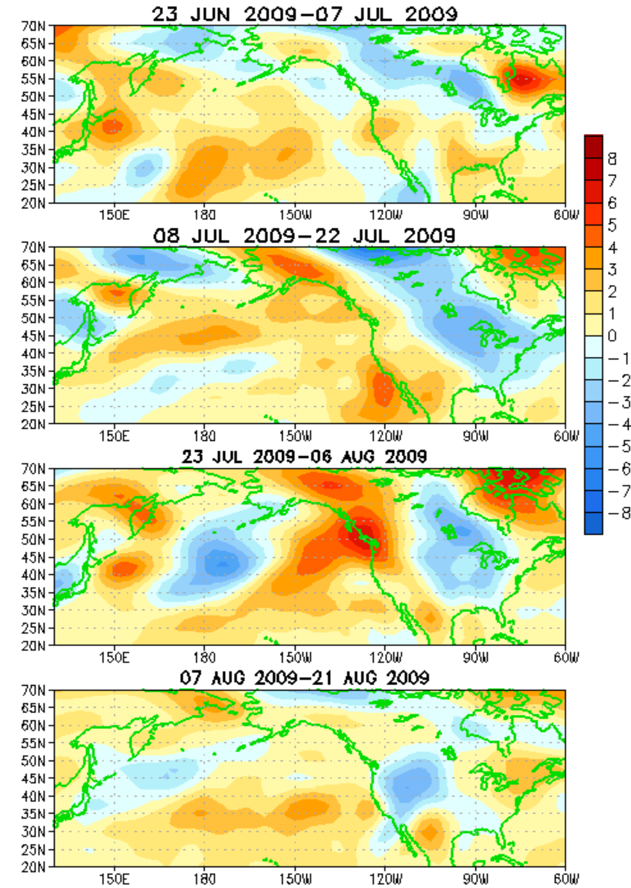
200-hPa Wind



500-hPa Height & Anoms.



925-hPa Temp. Anoms. (°C)

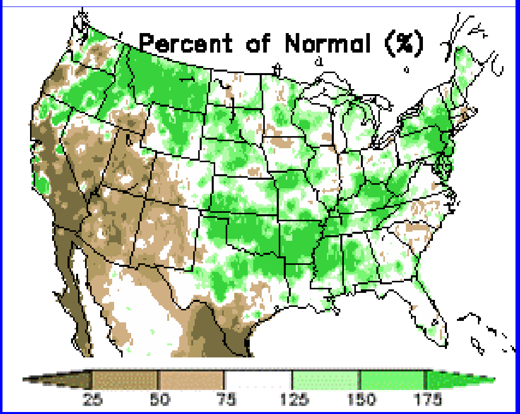


During late June to early August, an anomalous north-south dipole of height anomalies (below-average heights over the eastern U.S. and above-average heights over eastern Canada) contributed to below-average temperatures over much of the north-central and eastern U. S. and to above-average temperatures in eastern Canada. Anomalous ridging over western N. America during July contributed to above-average temperatures in the western U.S. Since early August, the anomalous height pattern was weaker over much of the country. However, below-average heights contributed to below-average temperatures in the western U.S.

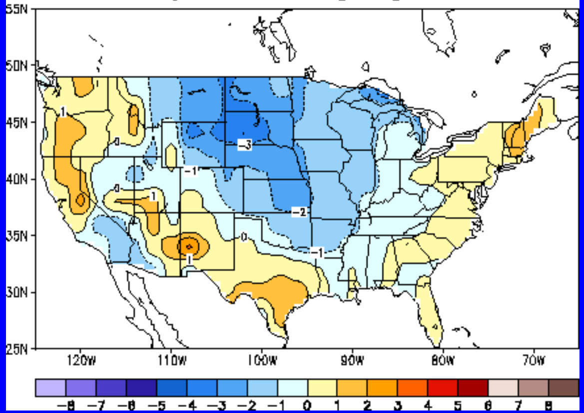
U.S. Temperature and Precipitation Departures During the Last 30 and 90 Days

Last 30 Days

30-day (ending 23 Aug 2009) % of average precipitation

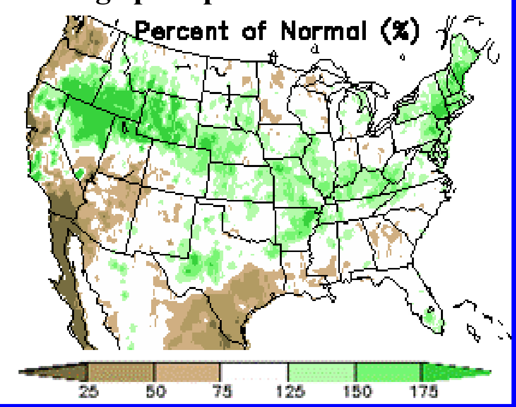


30-day (ending 22 Aug 2009) temperature departures (degree C)

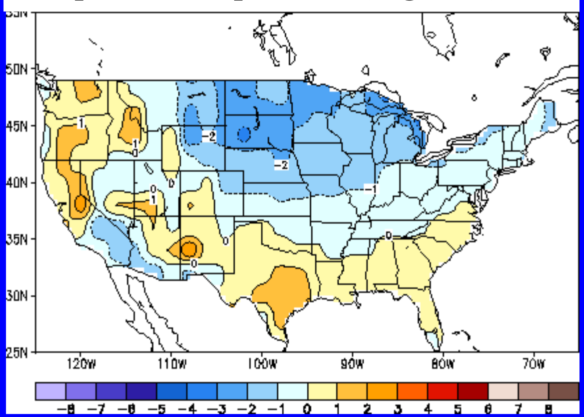


Last 90 Days

90-day (ending 23 Aug 2009) % of average precipitation



90-day (ending 22 Aug 2009) temperature departures (degree C)

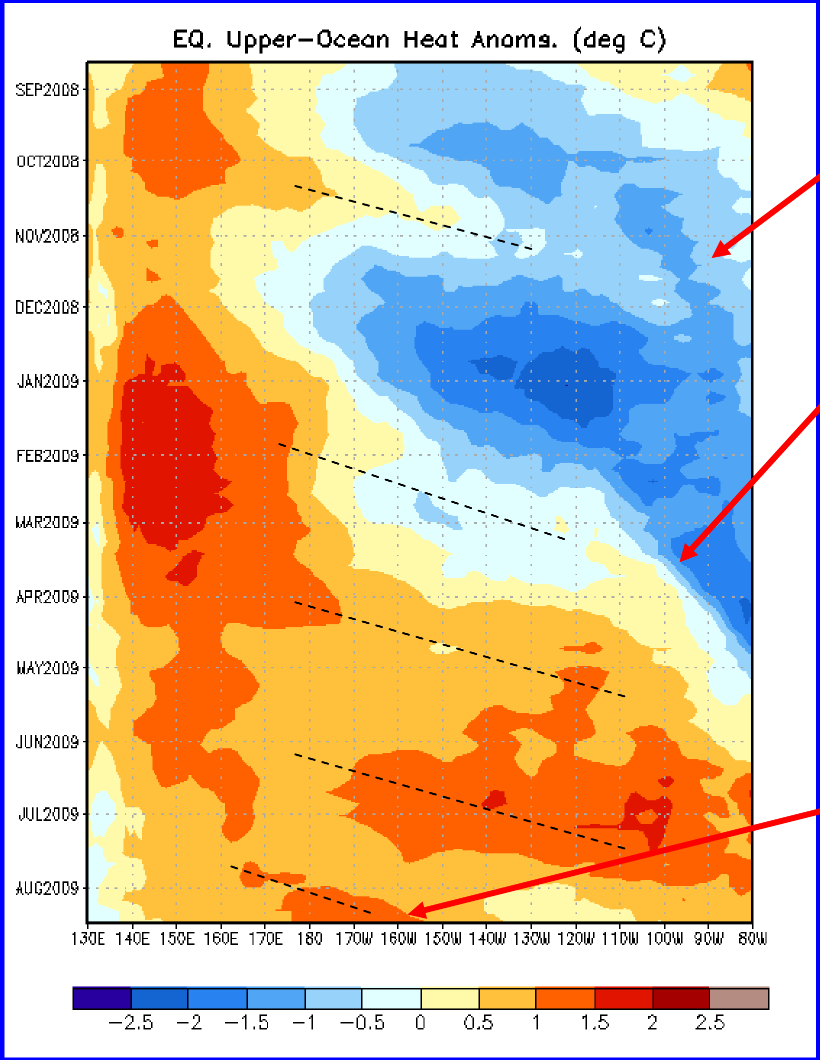


Intraseasonal Variability

- 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



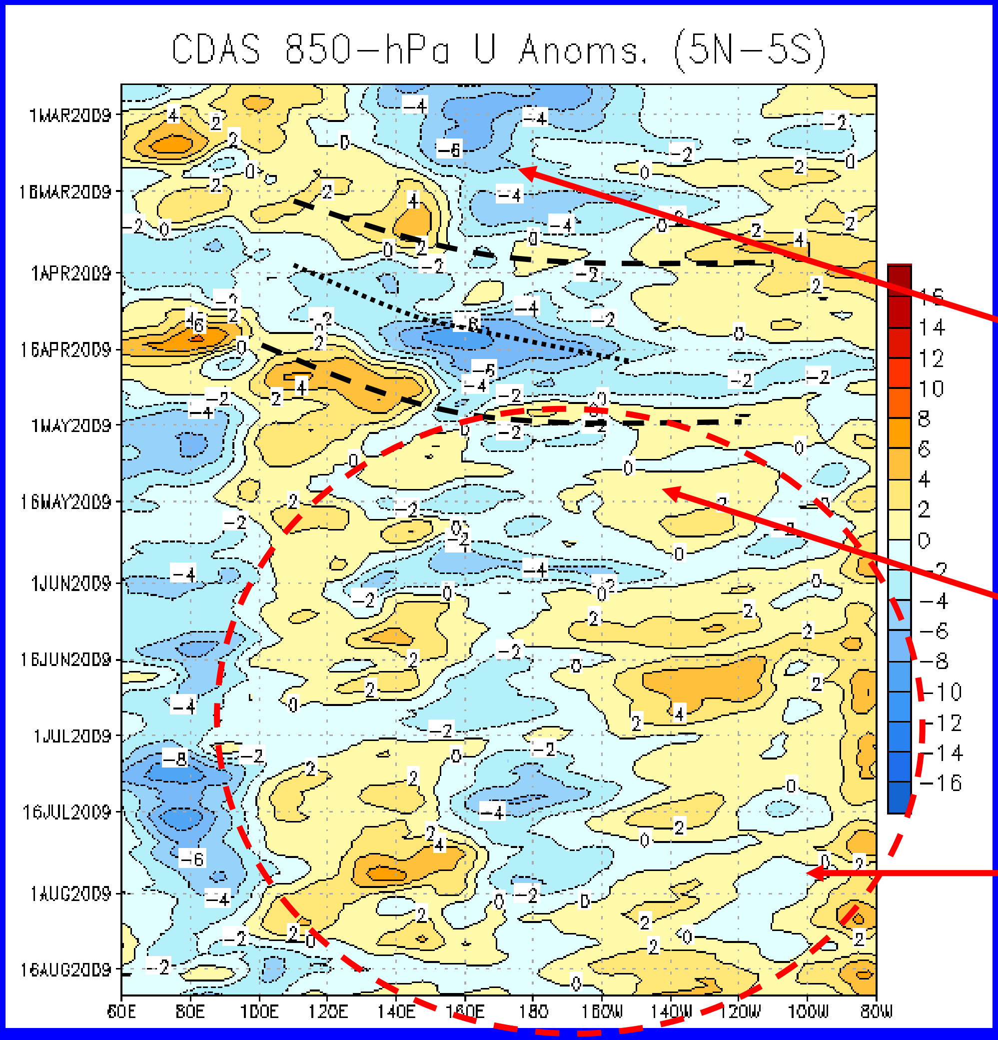
Time

Longitude

- During 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, with anomalies becoming positive since late March.
- In April 2009, the combined effects of an oceanic Kelvin wave and weaker easterly trade winds contributed to an increase in the upper-ocean heat content anomalies across the Pacific Ocean.
- Since April 2009, heat content anomalies have remained above-average.
- Recently, the downwelling phase of a Kelvin wave has shifted eastward.

•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).

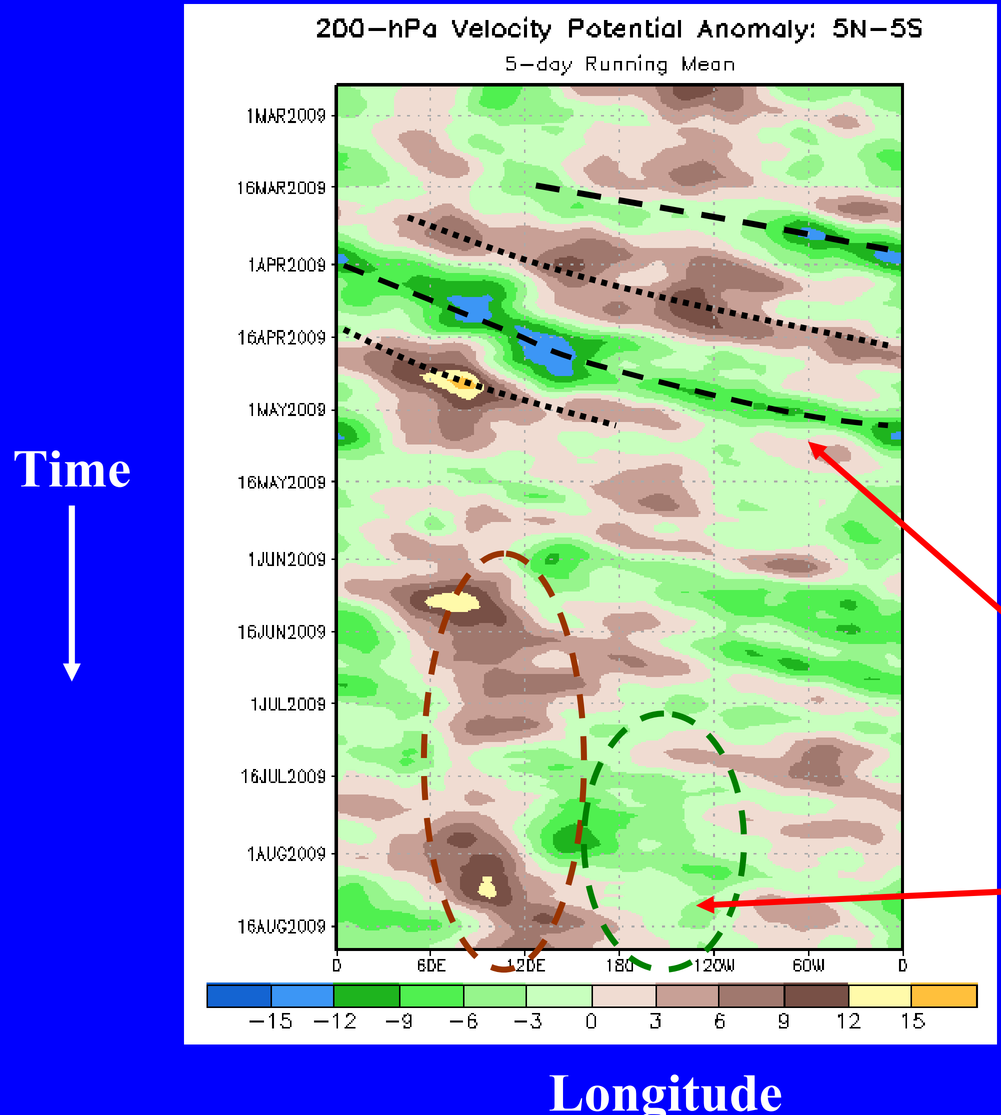
Easterly wind anomalies (blue shading).

Low-level (850-hPa) easterly wind anomalies persisted from January 2007- March 2009 over the equatorial Pacific between 150ºE and 150ºW.

During March and April 2009, a pattern of alternating anomalous westerlies and easterlies was evident, associated with the MJO. Since then, the MJO has been weak.

Since May 2009, westerly wind anomalies have covered large portions of the equatorial Pacific, except near the Date Line.

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



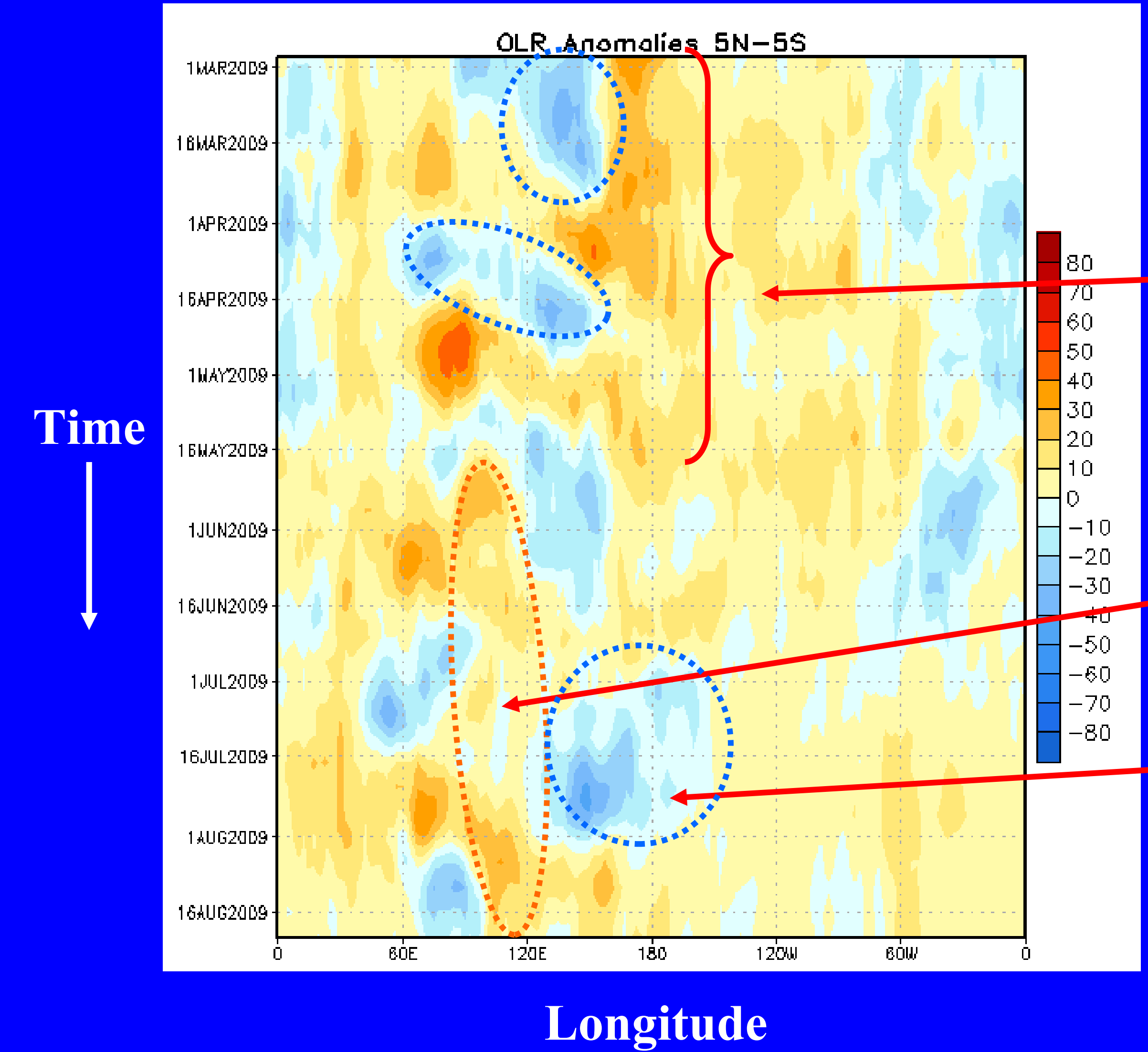
Positive anomalies (brown shading) indicate unfavorable conditions for precipitation.

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

The MJO was active from mid-March through early May 2009.

Since the beginning of July, the velocity potential pattern generally indicates anomalous upper-level divergence over the west-central Pacific, and anomalous upper-level convergence over the Indian Ocean and Maritime Continent.

Outgoing Longwave Radiation (OLR) Anomalies



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

Wetter-than-average conditions (blue shading)

From February 2007- May 2009, convection has been suppressed across the central equatorial Pacific Ocean.

Convection has occasionally been enhanced over the western equatorial Pacific and central Indian Ocean.

Since mid-May 2009, convection has remained mostly suppressed over the eastern Indian Ocean and Maritime Continent.

During July 2009, convection was enhanced near the Date Line and over the western Pacific.

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.

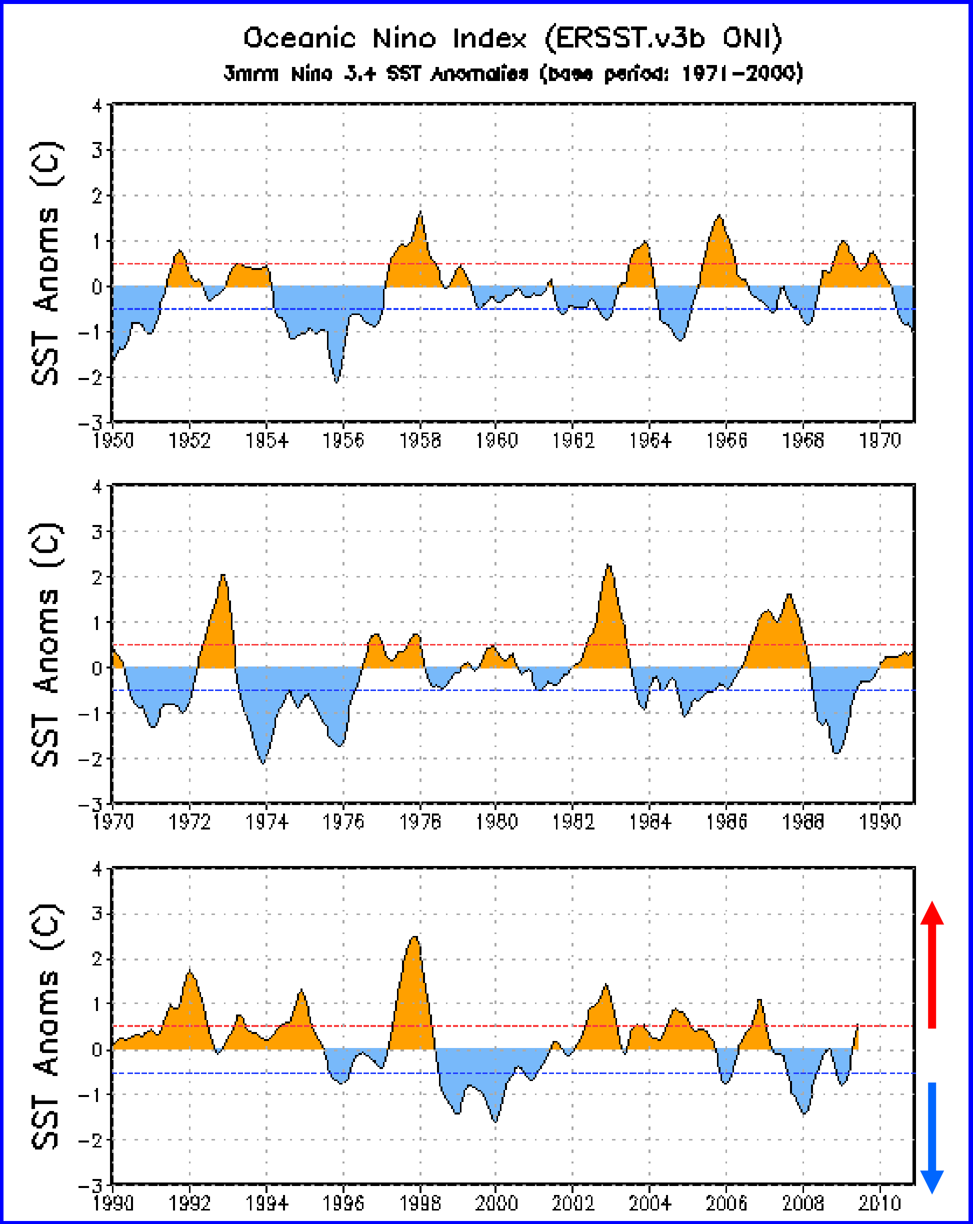
La Niña: characterized by a *negative* ONI less than or equal to -0.5°C.

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 (May – July 2009) is +0.6ºC.



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 ^{o}C 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	-0.1	0.2	0.6						
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020												
2021												
2022												
2023												
2024												
2025												
2026												
2027												

Pacific Niño 3.4 SST Outlook

• Most ENSO models indicate El Niño will continue through Northern Hemisphere winter 2009-10.

• The models disagree on the eventual strength of El Niño (SST anomalies ranging from +0.5°C to +2.0°C), but a majority of the models indicate at least a moderate strength El Niño (greater than +1.0°C) during November-December-January 2009-10.

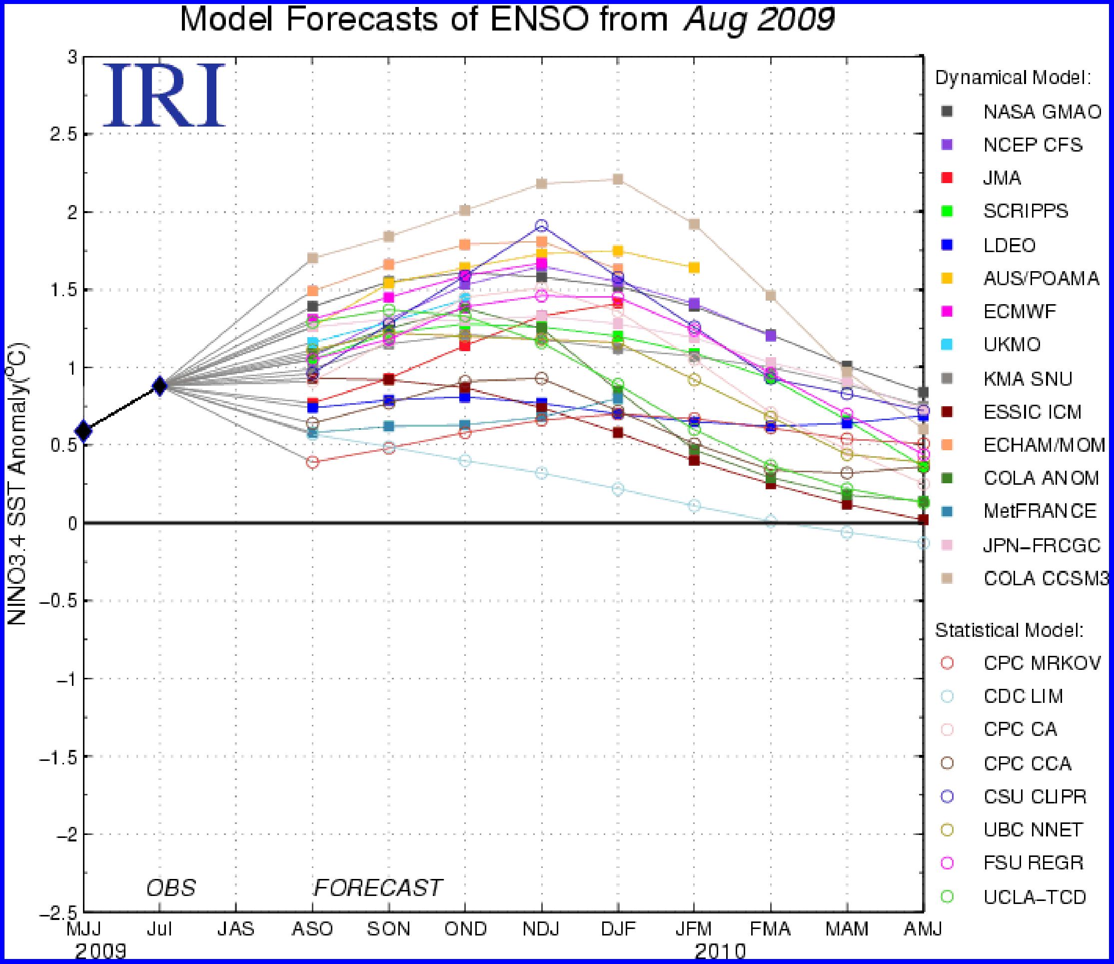
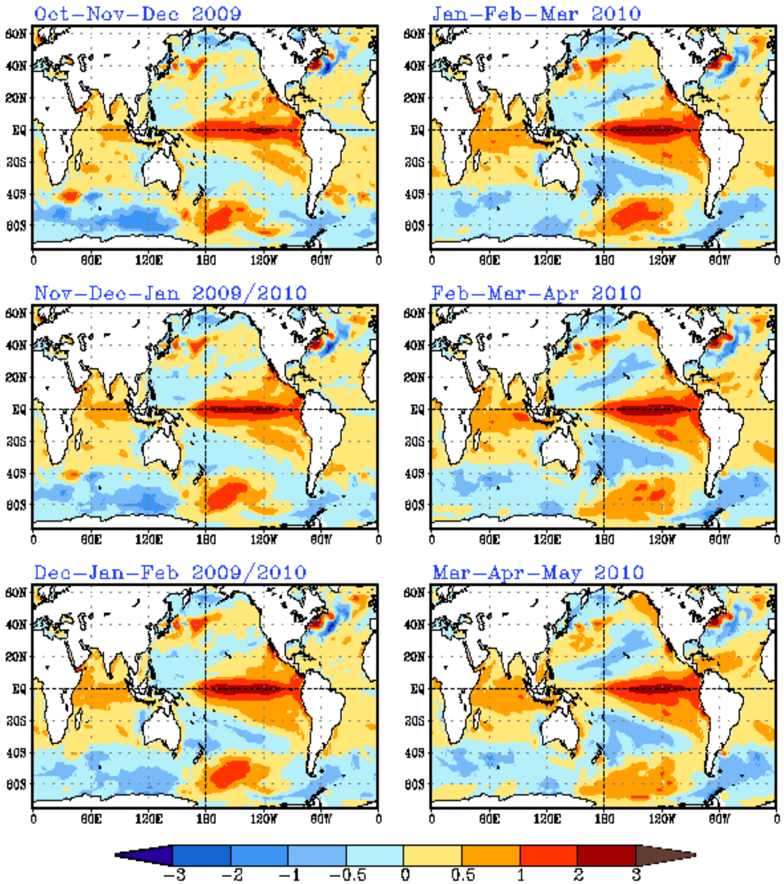
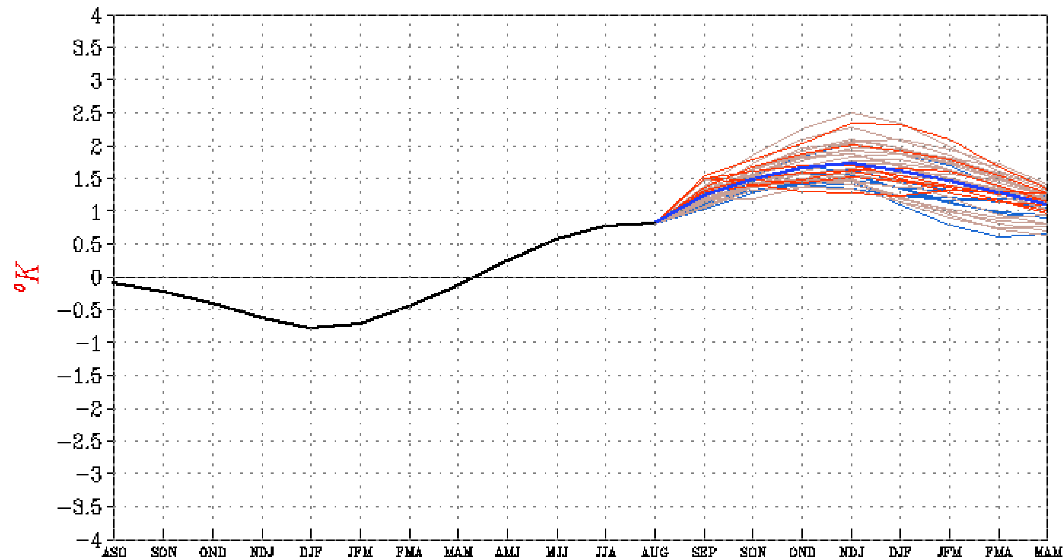


Figure provided by the International Research Institute (IRI) for Climate and Society (updated 18 Aug 2009).

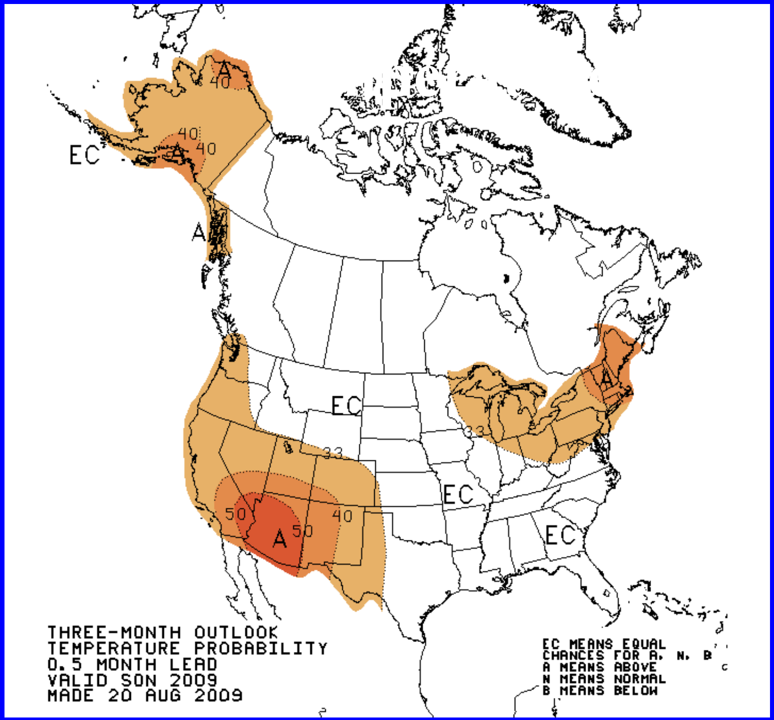
SST Outlook: NCEP CFS Forecast Issued 23 August 2009

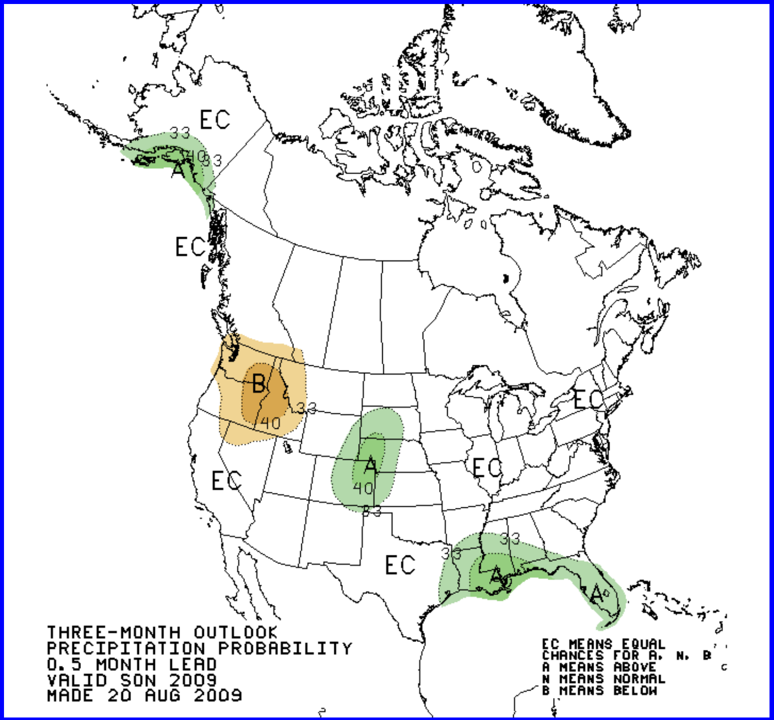


The CFS ensemble mean (heavy blue line) predicts El Niño to last through Northern Hemisphere winter 2009-10.



U. S. Seasonal Outlooks
September – November 2009





The seasonal outlooks combine the effects of long-term trends, soil moisture, and, when appropriate, the ENSO cycle.

Summary

- El Niño is present across the equatorial Pacific Ocean.
- Sea surface temperatures (SST) remain +0.5 to +1.5 above-average across much of the equatorial Pacific Ocean.
- Current observations and dynamical model forecasts indicate El Niño is expected to strengthen and last through Northern Hemisphere winter 2009-10.