A Review of Monthly/ Seasonal Climate Variability for 2005-2006: The ENSO Cycle

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This article based on a presentation by Dr. Kousky, Chief of the Development Branch at NOAA's Climate Prediction Center, that was made at the recent 31st Climate Diagnostics and Prediction workshop in Boulder, Colorado. Kousky's full presentation, and many others, can be found at the Workshop website: http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw31_proceedings.

The seasonal climate of calendar year 2006 has been an interesting one because it began with weak La Niña conditions in the first part of the year, and is ending with weak but strengthening El Niño conditions. This article summarizes the recent El Niño evolution, and describes the various indicators that seasonal forecasters use to assess ENSO conditions and place this event in historical perspective compared to events in the past half-century. Finally, we discuss the outlook for ENSO into the spring 2007 and its likely magnitude.

Recent Evolution of Conditions in the ENSO Region

During late 2005-early 2006 sea surface temperature (SST) anomalies decreased and below-average temperatures developed throughout most of the central and eastern equatorial Pacific (Figure 1a). This figure is called a Hovmöller diagram, after Swedish scientist and meteorologist, Ernest Hovmöller, who first demonstrated its usefulness for visualizing data in time and space in a paper published in 1949. These plots are commonly used by seasonal climate forecasters to look at the evolution of a variable over time, such as SST across the equatorial Pacific Ocean. In February 2006 positive SST anomalies developed in the extreme eastern equatorial Pacific, similar to what occurred during the La Niña years 1999, 2000 and 2001. Since May 2006, positive SST anomalies have increased across the equatorial Pacific between 160E and the South American coast.

NOAA's definition of an ENSO anomaly requires anomalies of 0.5ºC or greater for three months in the area of the equatorial Pacific from 120º to 170ºW (between green lines in Figure 1a) and between 5ºN and 5ºS (known as the "Niño 3.4 region"), based on the 1971-2000 base period. This three-month running average is called the "Oceanic Niño Index" (ONI), which recently has reached the threshold of the El Niño definition and is expected to remain above it into the spring of 2007 (Figure 1b).

Other Indicators of a Developing El Niño

Seasonal climate forecasters look at a suite of variables

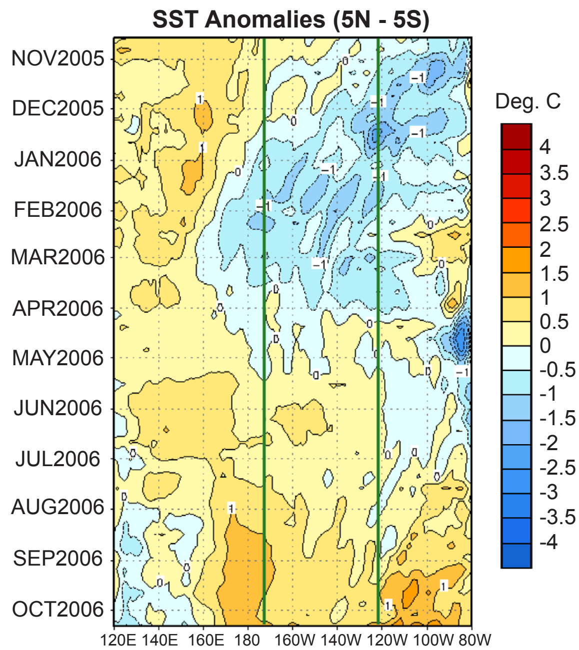

Figure 1a. Equatorial SST anomalies November 2005-October 2006. Time is on the vertical axis and longitude across the Pacific is on the horizontal axis. Cool temperatures (blue shades) dominated the eastern Pacific from November 2005 through around April 2006 (upper area of the graphic), then conditions shifted to warmer temperatures (lower area). The labeling is somewhat counterintuitive because longitudes are measured relative to Greenwich, England: eastern Pacific longitudes are 80-180W and western Pacific longitudes are 120-180E. 180E and 180W are the same, and are often referred to as the "date line," because it is the imaginary line on the Earth that separates two consecutive calendar days.

indicating the state of ENSO conditions. In addition to SSTs, these include outgoing longwave radiation (OLR), winds, and the heat content in the upper ocean. OLR is a measure of the radiative character of energy radiated from the warmer earth surface to cooler space, derived from polar-orbiting satellites. This measurement provides information on cloud-top temperature, which indicates convection or raining clouds that can then be used to estimate tropical precipitation amounts. Recently, OLR anomalies have been negative, indicating enhanced convection and precipitation, between 180W (the date line) and Papua/ New Guinea, and over the southwest North Pacific (Figure 1c). Posi-

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tive OLR anomalies (suppressed convection and precipitation) were observed over western Indonesia, portions of Malaysia and the eastern Indian Ocean. The pattern of anomalous OLR over the equatorial Pacific during the last 30 days reflects the early stages of El Niño.

Wind anomalies (not shown) also indicate the early stages of El Niño. In the early part of 2005, there were easterly wind anomalies in the equatorial Pacific, i.e., stronger than average winds from the east to the west. Recent winds, however, have shown westerly anomalies (weaker-than-average easterly winds near the equator between Papua New Guinea and the Date Line (180W). Equatorial low-level winds were near average east of the Date Line.

Finally, the heat content in the equatorial upper ocean (0-300 m depth) is a key indicator of the energy available to support a developing El Niño (Figure 1d). Heat anomalies are measured as a function of depth, by buoys anchored in the ocean with temperature sensors down to 300m or deeper. As a precursor to weak La Niña conditions that developed in late 2005 (a year ago), the upper-ocean heat content gradually decreased across the eastern and central Pacific Basin in mid-2005, while the heat content increased in the extreme western equatorial Pacific. Then during March-April 2006 the upper-ocean heat content increased as La Niña conditions weakened and ENSO-neutral conditions became established. During August-September 2006 positive subsurface temperature anomalies were observed throughout the equatorial Pacific, as upper-ocean heat content continued to build along the equator. A pattern of basin-wide positive subsurface temperature departures along the equator is usually observed prior to and in the early stages of El Niño, and in fact, the most recent analysis shows positive anomalies, between the surface and 200 m depth, across most of the equatorial Pacific (not shown).

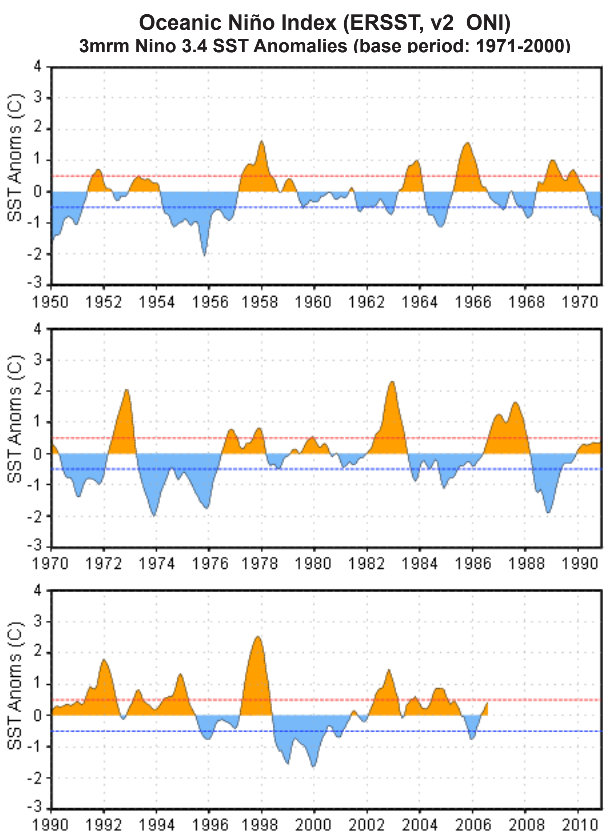

Figure 1b. Oceanic Niño Index, 1950-2006. ONI is the three-month running average (3mrm) for satellite-derived (ERSST.v2) SST in the Nino 3.4 region. Orange indicates a positive SST anomaly, blue a negative anomaly. The thresholds for the definition of ENSO anomalies are shown by red (El Niño) and blue (La Niña) lines.

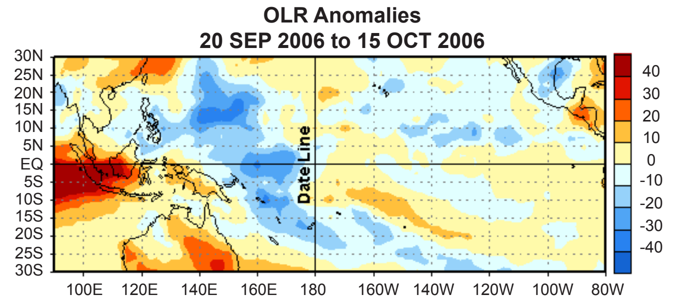

Figure 1c. Outgoing longwave radiation anomalies, Sep. 20 - Oct. 15, 2006. Positive OLR anomalies (orange/red shading, suppressed convection and precipitation) were observed over western Indonesia, portions of Malaysia and the eastern Indian Ocean. Negative OLR anomalies (blue shading, enhanced convection and precipitation) were observed between the date line and Papua/ New Guinea, and over the southwest North Pacific.

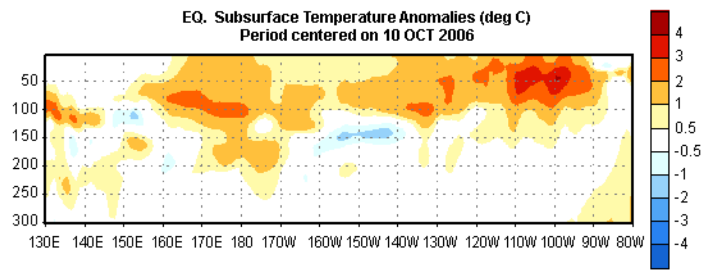

Figure 1d. Equatorial (EQ) Upper ocean temperature anomalies, 0-300m depth on the vertical axis. Warm anomalies (orange/red shades) are observed across most of the Pacific for a recent 5-day period (pentad), centered on 10 October 2006, with few areas of cool anomalies (blue shades).

Historical Perspective and Pacific SST Outlook

This event appears to be relatively weak compared to others in the past. Recent SST values for the Niño 3.4 region, compared to values for 14 historical El Niño episodes show that this event lies in the lower half of the distribution of historical El Niño episodes since 1950 (Figure 1e) which indicates that this event is likely to be of weak or moderate intensity.

Seasonal forecasters also think that this event is getting started too late in the year and the upper ocean heat content is too small for this event to become a strong El Niño. The strongest El Niño events began in the northern hemisphere's spring season (March-May) and featured much greater upper-ocean temperature anomalies than those currently being observed.

NOAA Climate Forecast System calculates SSTs and other variables across the globe. These model runs indicate that weak or moderate El Niño conditions will likely continue through April-June 2007 (Figure 1f). When this event will end is less certain, because the forecast techniques used have a difficult time with transitions between warm, neutral, and cold states of ENSO, especially 6 months or more in advance. However, El Niño events usually die away within 12 months of onset.The ENSO status outlook is also described on page 16. The bottom line is, based on recent trends and a majority of the statistical and coupled model forecasts, including those by other climate centers, NOAA/CPC forecasts that El Niño conditions should intensify during the next 2-3 months, and continue through April-July of 2007.

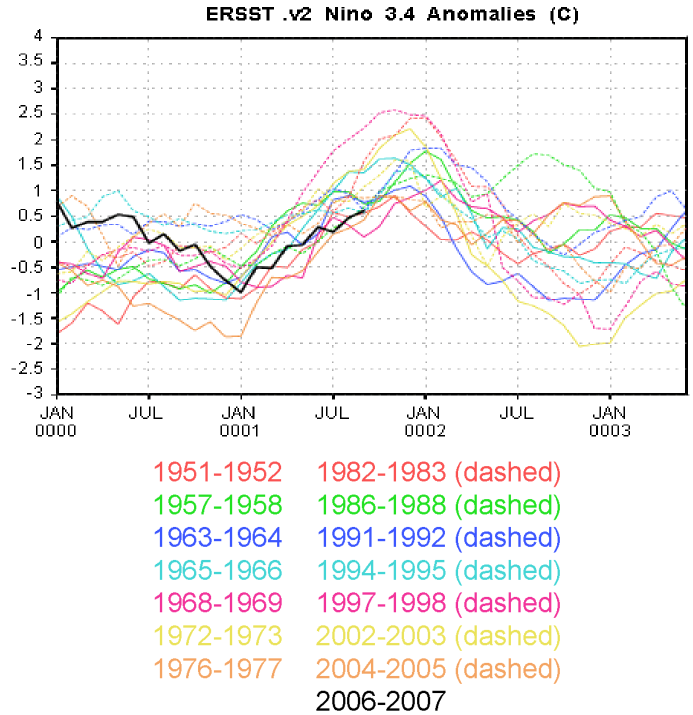

Figure 1e. 2006 event in historical perspective degrees Celsius on the vertical axis. Most recent Niño 3.4 values for the 2006 event (heavy black line) compared to 14 historical El Niño events since 1950. On the time axis year 0001 is the first year that ended up having a warm episode.

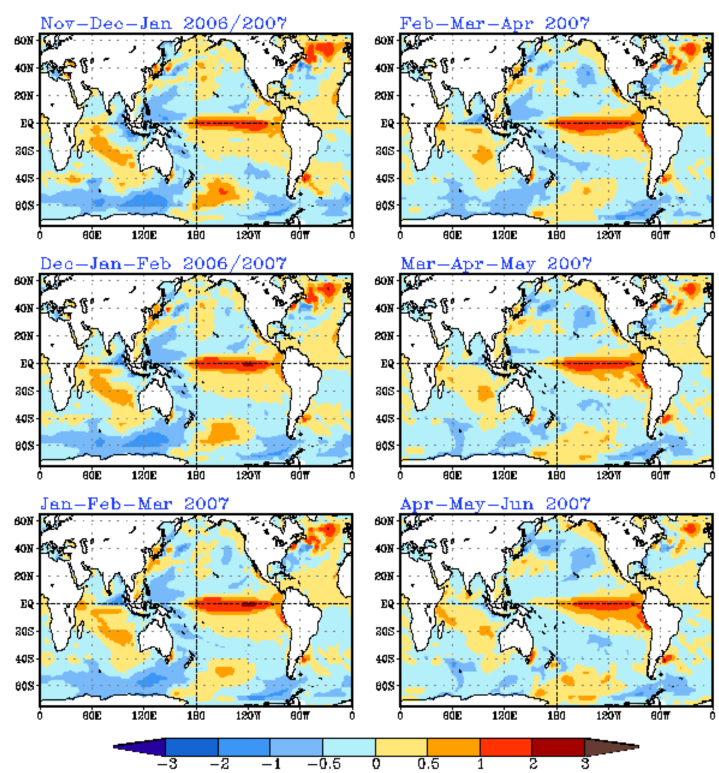

Figure 1f. SST outlook. SST's forecast based on the mean of NOAA Climate Forecast System runs. The Nino 3.4 region and other areas of the eastern tropical Pacific are likely to continue to have anomalously warm SSTs through the period April-June 2007

References

Hovmöller, E. 1949. The trough and ridge diagram. Tellus 1, 62-66. Kousky, V. 2006. A review of monthly/seasonal climate variability for 2005-2006. Available at: http://www.cpc.ncep.noaa.gov/products/outreach/proceedings/cdw31_proceedings