pacific ENSO update

A Quarterly Bulletin of the Pacific El Niño/Southern Oscillation Applications Climate (PEAC) Center
Providing Information on Climate Variability for the U.S.-Affiliated Pacific Islands

Special Edition Sea-Level Bulletin

Issued: July 10, 2008

ENSO and Sea-level Variability in the U.S.-Affiliated Pacific Islands: An Overview of 2006-2008 ENSO Events

Introduction

The El Niño-Southern Oscillation (ENSO) climate cycle is an important factor in providing a diagnostic outlook on sea-level variability for the U.S-Affiliated Pacific Islands (USAPI). Several studies at the Pacific ENSO Applications Climate (PEAC) Center have established that the sea-level variations in the tropical Pacific Islands are sensitive to the ENSO cycle, with low sea-level observed during moderate to strong El Niño events and high sea-level observed during moderate to strong La Niña events.

During the 2006-08 ENSO events, many Pacific Islands experienced high sea-levels continuously for a period of 12 to 18 months. From July 2006 to January 2007, weak El Niño conditions influenced the ocean and atmosphere; then, after a brief transition through ENSO-neutral conditions, a weak to moderate La Niña persisted from July 2007 through June 2008. All USAPI tide stations recorded elevated sea levels from July 2006 to June 2008, which, from an historical perspective is quite significant; no other El Niño event on record has resulted in observed sea level rise in the USAPIs. The elevated sea level during the El Niño period (July-August-September and October-November-December of 2006) was somewhat of an anomaly, and therefore it was reasoned that factors other than ENSO may have influenced this rise.

Using the criteria identified by the Multivariate ENSO Index, (http://www.cdc.noaa.gov/people/klaus.wolter/MEI/mei.html), the 2007-08 La Niña event is classified as "moderately strong"; when comparing the 2007-08 event to two other historic La Niña events in 1998-99 and 1988-89, the observed rise of sea-level during 2007-08 was considerably higher at most locations. In addition to La Niña, the role of other oceanic and atmospheric factors contributing to this high sea-level has been investigated. Despite uncertainties in sea level science, our immediate observation is that the extreme high-water levels have increased in some USAPI locations within recent decades. Based on global and regional climate dynamics, thorough research on this issue is necessary.

Links Between ONI, SOI, and Sea-level

Two common methods used for determining the intensity of an ENSO event are the Oceanic Niño Index (ONI) and the Southern Oscillation Index (SOI).

The ONI is based upon the sea surface temperature (SST) anomalies in the Niño 3.4 region. ONI values between 0 and ±0.5ºC indicate ENSO-neutral conditions; +(-)0.5ºC to +(-)1.0ºC indicate weak El Niño (La Niña) conditions; +(-)1.0 to +(-)1.5 indicate moderate El Niño (La Niña) conditions, and values greater than +(-)1.5ºC indicate strong El Niño (La Niña) conditions.

The SOI is based on the difference in Sea Level Pressure (SLP) between Tahiti (in the eastern Pacific) and Darwin, Australia (in the western Pacific). SOI values less than -1.0 (greater than +1.0) indicate a moderate-to-strong El Niño (La Niña), and values between -0.5 to -1.0 (+0.5 to +1.0) correspond to a weak-to-moderate El Niño (La Niña) event. Thus the ONI and SOI maintain an inverse relationship to each other. Based on both ONI and SOI values, the intensity of three similar ENSO events are shown (by season) in **Table 1** (right). The corresponding seasonal SOI and ONI values for each event are shown in **Figure 1** (below).

Table 1: Ranks of El Niño/ La Niña seasons

Year/ Season	2006-07	1997-98	1987-88
JAS	Weak El Niño	Strong El Niño	Strong El Niño
OND	Moderate El Niño	Strong El Niño	Strong El Niño
JFM	Neutral	Strong El Niño	Neutral
AMJ	Neutral	Neutral	**Moderate La Niña**
JAS	**Weak La Niña**	**Weak La Niña**	**Moderate La Niña**
OND	**Moderate La Niña**	**Moderate La Niña**	**Strong La Niña**
JFM	**Moderate La Niña**	**Moderate La Niña**	**Strong La Niña**
AMJ	**Moderate La Niña**	**Moderate La Niña**	**Moderate La Niña**

A comparison of Oceanic Niño Index (ONI) values and seasonal sea-level variations at three Pacific Island locations are shown in Figure 2 (a-c) on the next page. The primary objectives of this analysis are to (i) evaluate the role of the major climate indices in driving the variability picture during extreme events, and to (ii) explore the role of other natural and climatic factors in this sea-level rise scenario.

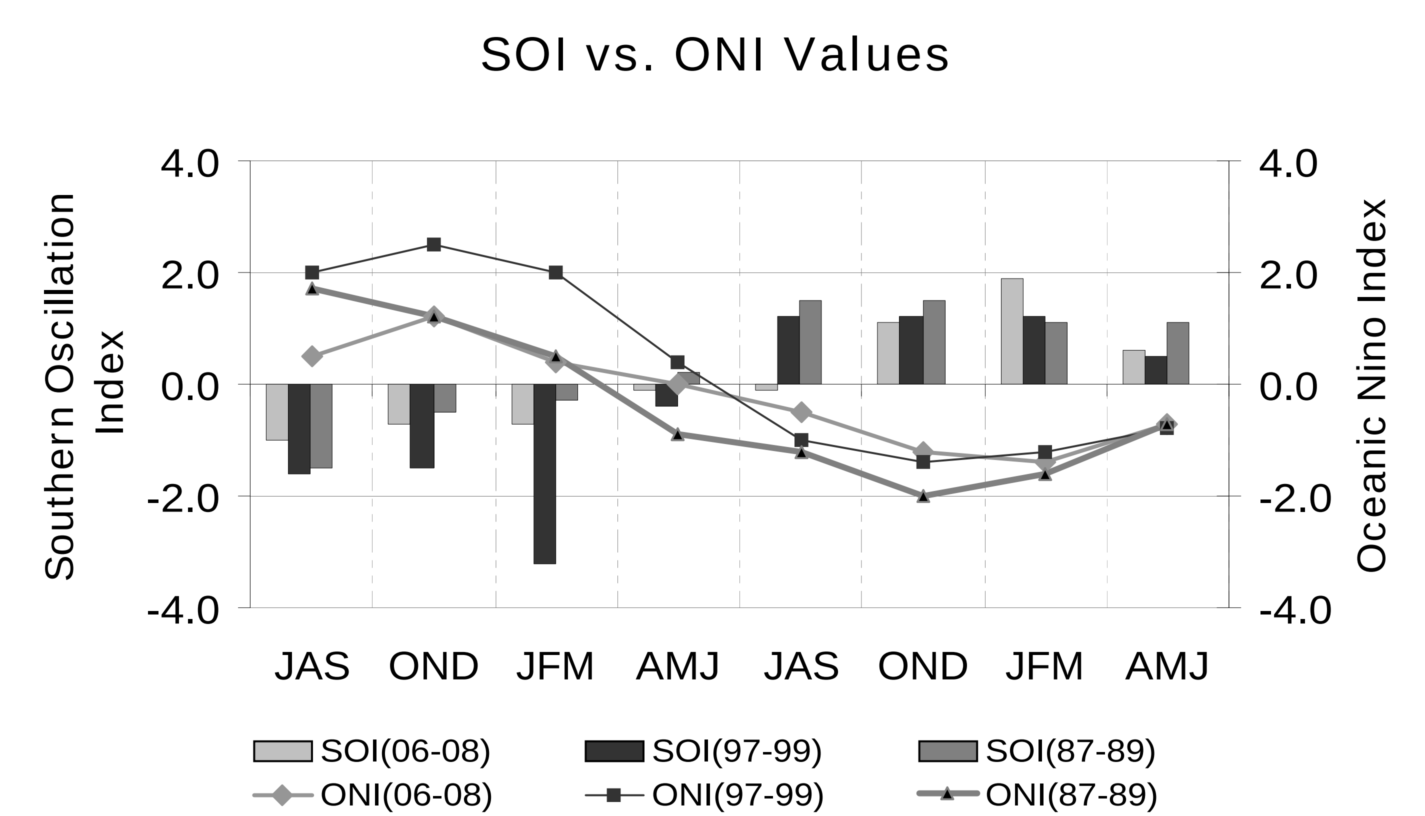


Figure 1 (above): A comparison of SOI and ONI values during three La Niña events (1987-98, 1997-99 and 2006-08).

Links Between ONI, SOI, and Sea-level

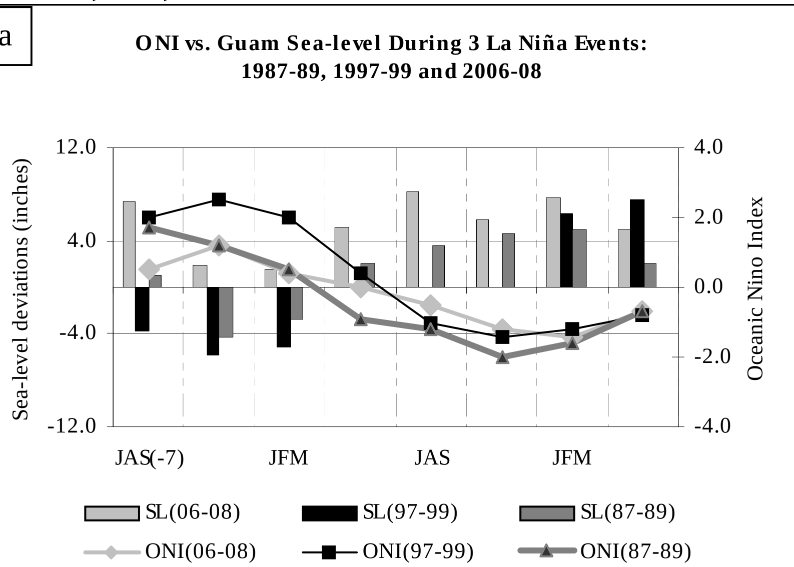
Figure 2 (right): Seasonal variations of sea-level and Oceanic Niño Index (ONI) at (a) Guam, (b) Pohnpei and (c) Pago Pago. *Note that for ONI, Warm (+) and cold (-) episodes are based on a threshold of +/- 0.5°C for the Oceanic Niño Index (ONI) [3 month running mean of ERSST.v3 SST anomalies in the Niño 3.4 region], based on the 1971-2000 base period. For historical purposes cold and warm episodes are defined when the threshold is met for a minimum of 5 consecutive overlapping seasons.*

A comparative picture between ONI and sea-level deviations for selected stations is presented in **Table 2** (page 4). In all three years (2007, 1998, and 1988) the La Niña event is established by the JAS season (see Fig. 2), and therefore only seasons JAS - AMJ of 2007-08, 1998-99, and 1988-89 are examined in this analysis. This analysis primarily focuses on tide-gauge locations that tend to show the most vulnerability, while still presenting a general view of the region.

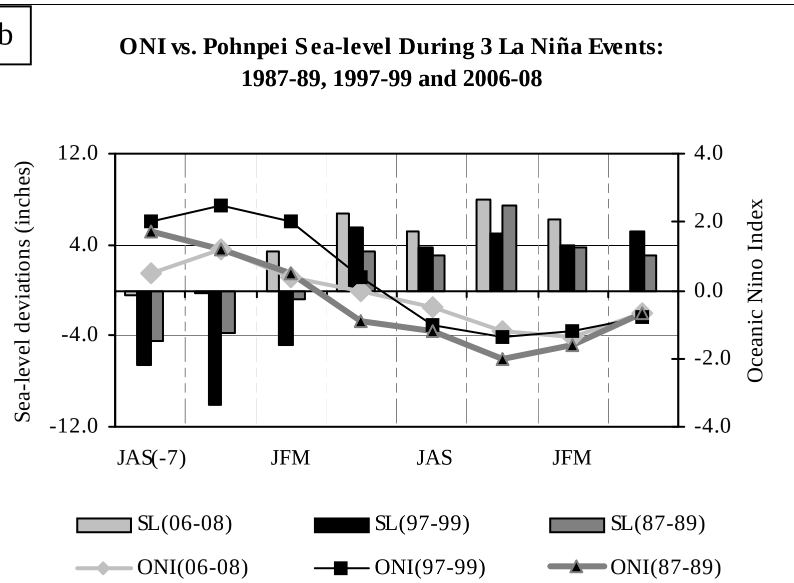
Among these, the Micronesian Islands of Yap, Pohnpei, Kapingamarangi, and Chuuk displayed an alarming picture. (Since Chuuk does not currently have a tide-gauge station, a comprehensive data analyses was not possible at this stage; however, findings reveal that sea-level variability in Chuuk is highly correlated to Yap.) During the 2007-08 La Niña event, Chuuk and Pohnpei sustained serious damage from high tides, and both states declared a state of emergency. Significant damage to crops (taro, breadfruit, banana, and coconut) and infrastructure greatly impacted the economy, agriculture, and general livelihood of these island communities.

Recent sea-level rise has been observed in Guam, Palau and Pago Pago as well, but because of higher elevation has not caused any serious damage there. The Marshall Islands (Majuro and Kwajalein) also recorded sea-level rise, with some reports of minimal damage there. Due to the severity of damage caused in the Micronesia, those islands are the primary focus in the following section; however, we have also included Guam and Pago Pago to help provide a comprehensive regional perspective.

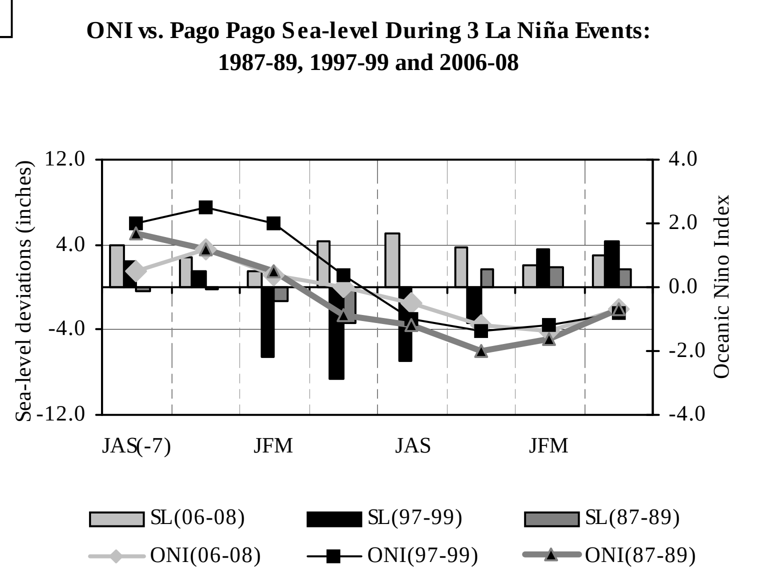
2a



2b



2c



Data source: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Table 2: ONI and Seasonal Sea-level Deviations (in inches) During Three ENSO Events						
Season:	**ONI**	**Guam**	**Yap**	**Pohnpei**	**Kapingamarangi**	**Pago Pago**
JAS 07	-0.5	+8.2	+11	+5.1	+2.1	+5.1
JAS 98	-1.0	*	+6.6	+3.7	-2.9	-6.9
JAS 88	**-1.2**	**+3.6**	**+6.3**	**+3.0**	**-1.3**	**0**
OND 07	-1.2	+5.9	+7.3	+8.0	+4.1	+3.8
OND 98	-1.4	*	+6.3	+5.0	-0.1	-3.3
OND 88	**-2.0**	**+4.6**	**+6.4**	**+7.5**	**+2.2**	**+1.7**
JFM 08	-1.4	+7.8	+7.2	+6.2	+4.7	+2.0
JFM 99	-1.2	+6.4	+5.5	+3.9	+2.4	+3.5
JFM 89	**-1.6**	**+5.0**	**+6.4**	**+3.8**	**+4.1**	**+1.8**
AMJ 08	-0.7	+4.9	+4.9	0	+1.6	+3.0
AMJ 99	-0.8	+7.5	+9.1	+5.1	+0.6	+4.3
AMJ 89	**-0.7**	**+2.0**	**+1.4**	**+3.1**	**+1.9**	**+1.7**
* Indicates missing data due to broken tide gage.						

Long-term Sea-level Trends

As evident from Table 2 (above), the sea-level rise recorded in 2007-08 was considerably high at several locations. Despite weaker ONI values (indicating a weaker La Niña), when compared to the ONI values during the 1997-98 and 1987-88 events (relatively stronger La Niña events), most of the islands recorded higher rise during the 2007-08 event. The ONI and SOI efficiently determine the strength of the El Niño/ La Niña event; less sea-level rise is expected in a weaker La Niña year than in a stronger La Niña year. Based on this loosely proportional relationship between ENSO strength and sea-level variation, scientific reasoning suggests that, in addition to the La Niña of 2007-08, there must be other factors responsible for this rise — a reasonable hypothesis, considering that sea-level in several locations was elevated above normal before the onset of the 2007-08 La Niña (Figure 1). Atmospheric circulation might have significantly influenced the whole process, but no solid evidence is available at this time. Another explanation could be that since sea-level was originally elevated even during the El Niño (JAS and OND of 2006), the ensuing La Niña further elevated these levels. But the underlying question remains: why were sea-levels higher than average during an El Niño year to begin with? Further study is certainly needed here, and we are actively working to examine all the causes.

One immediate answer to this question appears to be in the tide gauge records, which reveal that sea-levels at all stations have displayed a rising trend, to some degree, over the past 15 to 20 years. This evidence supports the many anecdotal assertions that global extreme high-water levels have increased within recent decades. According to the Intergovernmental Panel for Climate Change (IPCC)*, global average sea-level rose at an average rate of 1.8 [1.3 to 2.3] mm per year over the period from 1961 to 2003. The rate of sea-level rise was even faster from 1993 to 2003, with an average rate of about 3.1 [2.4 to 3.8] mm per year. This 3.1 mm (or 0.13 inches) per year rising trend shows a close correlation with the rise that has been observed in some of the USAPI locations, particularly within the Federated States of Micronesia. *(Please note that we are not making any future projections of sea-level rise at this time, but rather providing a synthesis of observed values from the data record.)*

Whether the faster rate of rise from 1993 to 2003 reflects decadal variability or an increase in the longer-term trend remains unclear. However, the scientific community asserts with *high confidence* that the rate of observed sea level rise has increased from the 19th to the 20th century. Despite looming uncertainties in sea-level science, these latest findings are significant and continue to gain credibility; meanwhile, skeptical counter-arguments refuting the gravity of sea-level rise are steadily losing ground.

* For full IPCC 4th Assessment Synthesis Report, go to: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf