Northeast Pacific News

by William Crawford and Stewart (Skip) McKinnell

Temperatures of coastal waters of the northeast Pacific are very sensitive to anomalies in the direction and strength of regional winds. Prevailing currents have none of the inertia of western boundary currents such as the Kuroshio and Oyashio, and instead are driven by local winds and respond within days to changes in their direction. Wind anomalies that persist through an entire season will impose major changes in local water temperature and salinity, and even shift the composition of ecosystems. The past three winters have experienced huge shifts in wind speed and direction due to changes in intensity and position of the Aleutian Low (AL) pressure system.

Figure 1 presents maps of sea level pressure (SLP) and sea surface temperature anomaly (SSTA) for the North Pacific in February and March of 2009, 2010 and 2011. We chose to plot SLP for February because this month was the extreme of the general conditions in these winters. Normally, the AL pressure system forms in winter in the Gulf of Alaska and extends across much of the North Pacific Ocean. In 2010, AL air pressure was extremely low, falling to 994 mbar, and the system was centred in the Gulf of Alaska. By contrast, the panels of February 2009 and 2011 reveal almost no region where SLP fell below 1008 mbar, marked by a white contour in the left panels, and this contour was centred far to the west and did not even reach the Gulf of Alaska.

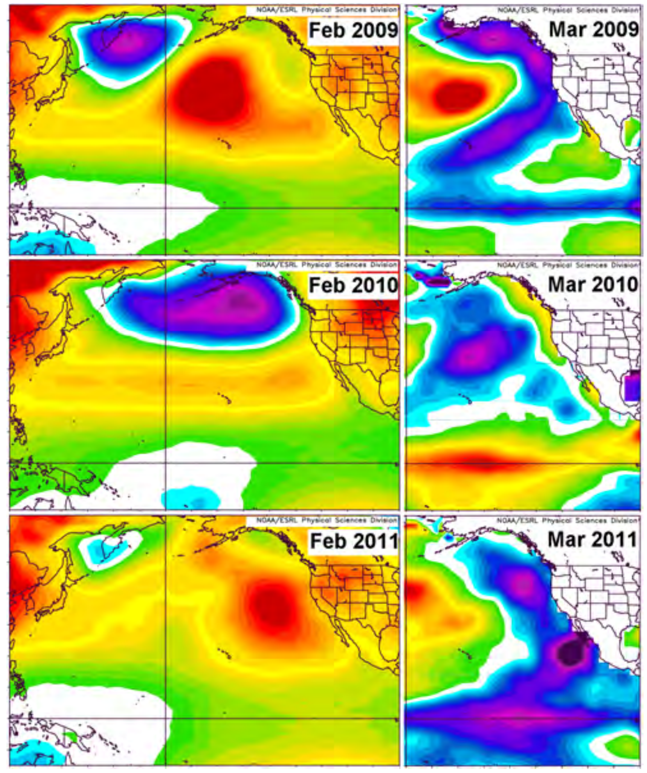

Fig. 1 Contours of sea level pressure (SLP, left) and sea surface temperature anomaly (SSTA, right) for February and March, respectively, of the past three winters. Pressure contours extend from a low of 992 mbar (purple) to 1024 mbar (red). Temperature anomalies run from –1.5°C (dark purple) to +1.5°C (red). Solid black lines denote the Equator and 180°W. Image plotted by on-line software of NOAA/ESRL Physical Sciences Division.

The temperature panels of Figure 1 reveal a classic oceanic response to ENSO (El Niño Southern Oscillation). El Niño winters in the Northern Hemisphere generally bring warm southerly winds along the west coast of Oregon to British Columbia, followed by positive SSTA. These winds are part of the cyclonic airflow around the intensified AL. By contrast, La Niña winters generally see stronger westerly winds in the subarctic northeast Pacific, due either to a weakening of the AL, or in extreme cases, as in February of 2009 and 2011, to anticyclonic flow around the rare winter extension of the North Pacific High into the Gulf of Alaska. These winds are followed by cooler waters along the west coast of U.S. and Canada. Although La Niña had diminished in the Equatorial Pacific by June 2011, SST of the eastern Gulf of Alaska remained cooler than normal.

The Aleutian Low Integral Index (ALII) is a measure of the intensity of the AL. It is formed by calculating the integral of SLP inside the 1008.5 mbar contour. Whereas the Aleutian Low Pressure Index (ALPI) is simply the area inside the 1005 mbar contour, ALII represents both the surface areal coverage and intensity of the AL by computing a "volume" of area times air pressure anomaly. The time series of ALII (Fig. 2) reveals just how extreme the past three winters have been.

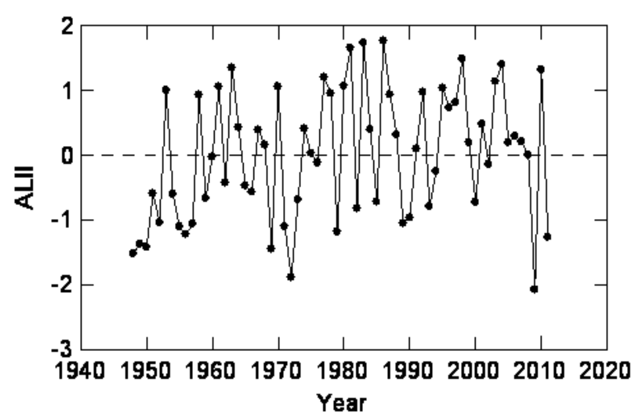

Fig. 2 Time series of the Aleutian Low Integral Index (ALPI) for December to February of winters from 1948 to 2011.

The winter of 2009 experienced the lowest ever value of ALII, followed by an extreme high in 2010 and another low in 2011. In general, ALII is high in El Niño winters and low in La Niña winters, especially since the late 1990s.

Figure 3 illustrates the changing nature of both ALII and the Oceanic Niño Index (ONI) over the winters of 1950 to 2011. ONI is determined by the anomaly of ocean surface temperature in Niño 3.4 region, which lies between 5°N and 5°S and 120°W to 170°W.

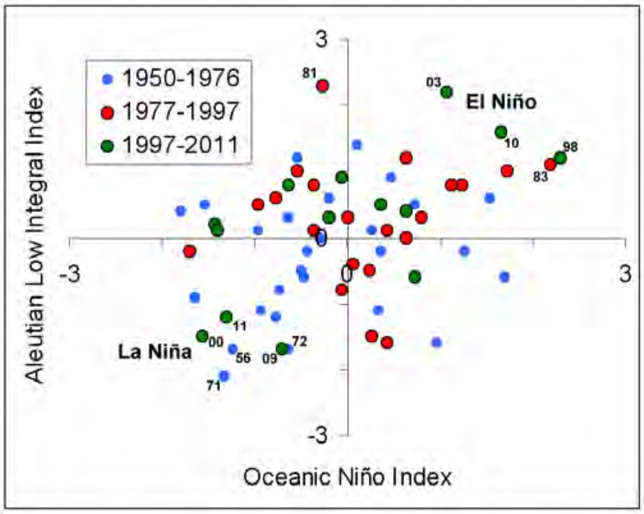

Fig. 3 Scatter plot of Aleutian Low Integral Index (ALII) and Oceanic Niño Index (ONI), each computed annually for December to February. Three eras are distinguished to reveal changes in the winter Pacific teleconnection from tropics to Gulf of Alaska. Labels indicate the last two digits of a few extreme winters.

Figure 3 reveals more negative values of both ONI and ALII from 1950 to 1976, and many more positive values from 1977 to 1997. The winters of 1976 to 1977 marked a shift in the northeast Pacific, with more intense Aleutian Lows following 1976. During the era of 1977 to 1997, only two winters had negative values for both ONI and ALII, indicating the general dominance of El Niño winters and intense Aleutian Lows. These two decades are considered to be dominated by a positive Pacific Decadal Oscillation (PDO), and the magnitude of ONI was generally a poor predictor of ALII and associated weather conditions in the Gulf of Alaska. By contrast, winters of 1950 to 1976 saw very few intense El Niño events, and no values of ALII greater than 1.2.

Green symbols of Figure 3 denote winters of 1997 to 2011. These winters cover the full range of El Niño to La Niña, with two of the most intense Aleutian Lows in the top right quadrant and three of the least intense Aleutian Lows in the bottom left quadrant. The correlation coefficient (*R*) between ONI and ALII for 1998–2011 is 0.66, compared to 0.24 for 1950–1977, and even lower *R* for 1950–1976 and 1977–1997. With such strong coupling between ONI and ALII since 1998, seasonal forecasting of winter weather along the west coast of British Columbia to Oregon has been more reliable in ENSO years.

Although the winters of 1983 and 1998 saw the most extreme warming in the ONI region, with ONI values greater than +2, these were not the winters of most intense Aleutian Lows. Instead, the more recent winters of 2003 and 2010 brought stronger Aleutian Lows whose intensity, as measured by ALII, was exceeded only in the winter of 1981.

Will these recent wide swings in ENSO and in the intensity of AL continue into future years? As of June 2011, the ensemble of El Niño models are predicting ENSO neutral conditions for the next few months, but cool surface ocean waters are still present in the eastern Gulf of Alaska. Perhaps, we may experience a "normal' winter in 2011 to 2013, with a gradual return to normal ocean temperatures.

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