Christmas, El Niño, and SMOS

Christmas is surely an appropriate moment to talk about the "El Niño / Southern Oscillation" (ENSO). Today there is no doubt that ENSO is the largest source of inter-annual climate variability at regional and planetary scales. Although its ocean-atmosphere coupled nature was postulated in 1969, the quasi-periodic oceanic and atmospheric anomalous behavior has been observed for centuries. For more than five hundred years, Peruvian fishermen and farmers have been aware that a periodic warm surface counter-current off the Peruvian Coast reduces the anchovy catch, while, at the same time, increased rainfalls transform barren lands onto fertile ones. This counter-current was termed as the current of the "El Niño" (the Child Jesus) because it usually appears around Christmas. On the other hand, several tens of thousands of kilometers to the west, over the Asian continent, other climate events also have a strong impact on society. For example, the failure of monsoons resulted in the Great Drought (1876-1877) that contributed to cause more than seven million deaths in the British-controlled India. Since then, various efforts were made to predict the interannual variability of the Indian monsoons. In 1904 Sir Gilbert Walker was appointed as the director-general of Observatories in India to lead such task. Although Walker was not aware of the El Niño current, he did know about the existence of synchronized interannual pressure fluctuations over the Indian Ocean and eastern tropical Pacific (fluctuations that Walker called the "Southern Oscillation"). His research team evidenced that monsoons are part of a global phenomenon, and that the Southern Oscillation is correlated with major changes in the rainfall patterns and wind vents over the tropical Pacific and Indian Oceans.

Briefly described, an El Niño event is characterized by an anomalous warming of the eastern equatorial Pacific. This eastern ocean warming happens together with a low atmospheric surface pressure in the east and a high pressure in the west. This anomalous pattern of surface pressures weakens the trade winds in the central and eastern tropical Pacific and increase the amount of rainfall over the east. An observed complementary phase, called La Niña, is characterized by high atmospheric pressure over the east, low pressure over the west, intensification of the trade winds, and reduced rainfall in the central and eastern tropical Pacific.

Schematic depiction of La Niña conditions (intensified normal conditions) displaying the longitude gradient of SST (warm in the west and col surface in the east) together with the Walker Convective Cell over the Pacific Ocean. Similar convective cells are found over the Atlantic and Indian Oceans. (From Wikipedia, public released by its author: http://en.wikipedia.org/wiki/File:LaNina.png).

The oscillation between El Niño and La Niña conditions exposes a back and forth zonal displacement of the various Walker convective cells that cover the planet along its tropical belt. Such displacements modify the regional cloud coverage, solar irradiance, and precipitation, triggering a set of world-wide tele-connections.

Several historians have argued that ENSO is a powerful force shaping tropical habitats. In peninsular India, every major drought between 1526 and 1900 has been associated with El Niño events. Similarly, correlations between malaria cycles in Asia and South America with ENSO have been detected. Therefore, prediction of ENSO, and its relation with global climate anomalies, continues to be an important research effort in short-term climate forecasting. This task has become even more challenging as researchers are becoming more and more convinced that there is not a single archetypical El Niño (or La Niña) pattern, but several. During some events (called now *Standard* or *East Pacific*), the largest temperature anomalies are located at the eastern part of the Pacific. However, during some of the most recent events, the largest anomalies are restricted to the central part of the Pacific Ocean, and are now called *Central Pacific* or *Modoki* (a Japanese word for “almost”) events.

Although the role of salinity in operational ENSO forecasting was initially neglected (in contrast with temperature, sea level, or surface winds), recent studies have shown that salinity does play a role in the preconditioning of ENSO. Moreover, some researchers suggest that sea surface salinity might play a role (through the modulation of the western Pacific barrier layer) to favor the *Standard* or the *Modoki* nature of each event. To be able to routinely use salinity in ENSO operational forecasts, there was the need of a systematic source of salinity observations.

The SMOS and Aquarius missions represent the first essay to elucidate the actual capability of satellite imaging to determine sea surface salinity from microwave measurements of the brightness temperatures at the L-band (1.4 GHz). The main advantages of satellite measurements over in situ data (as the one provided by the TOGA/TAO array or by the Argo automatic profilers) are they spatial coverage, and they systematic overpass measuring any given location every few days. Thus, satellites are the most suited component of the ocean observing system to detect and track all large-scale, and various meso-scale, features present in the ocean surface. While this had been demonstrated for surface temperature and elevation, now the scientific community is finally assessing it for surface salinity.

After three years of data, the results do show that despite the unexpected level of noise in the brightness data (due to natural and artificial sources of interferences), salinity retrievals allow to capture some of the intra-seasonal modulation of sea surface salinity in the tropical oceans as the figure below indicates, becoming already an appropriate source of complementary salinity data.

Time evolution of the monthly averaged SSS during 2011. In red the in-situ value measured by a TAO mooring. In blue, the salinity from SMOS 0.25ºx0.25º binned product. In green, the 0.25ºx0.25º fusion product. The data fusion algorithm effectively reduces the noise of the binned data maps. The plot also displays the equivalent TAO data during the 2010.

Happy New Year,

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