Question:

Explain what is "Modoki" El Nino and how is its evolution different from traditional El Nino?

Answer: (Based on (Yeh 2009 title: "El Nino in a changing climate Nature paper") and (Kao 2007 title:"Contrasting Eastern-Pacific and Central Pacific types of ENSO")

Definition:

Modoki El Nino is different from traditional El Nino because the SST warming is largely in the central equatorial Pacific region instead of in the eastern equatorial Pacific region. Recent studies show that the canonical El Nino has become less frequent and that a different kind of El Nino has become more common during the late twentieth century, in which warm sea surface temperatures (SSTs) in the central Pacific are flanked on the east and west by cooler SSTs. This type of El Nino, termed the central Pacific El Nino(CP-El Nino; also termed the dateline El Nino, El Nino Modoki or warm pool El Nino), differs from the canonical eastern Pacific El Nino (EP-El Nino) in both the location of maximum SST anomalies and tropical–midlatitude teleconnections. The first recorded El Niño that originated in the central Pacific and moved toward the east was in 1986. El Niño "Modoki" events occurred in 1991-92, 1994–95, 2002–03, 2004–05, and 2009-10. The El Nino Modoki was named to represent the phenomenon in 2004 that had a maximum SST anomaly in the central tropical Pacific, differing from the conventional El Nino. In addition, such modification in the structure of El Nino has implications for its teleconnection pattern in many countries surrounding the Pacific Ocean.

The number of CP-El Nino events is relatively small, its frequency increased noticeably after 1990. For the period of 1854– 2007, the occurrence ratio of the EP-El Nino before and after 1990 is 0.19 per year and 0.29 per year, respectively, whereas that of the CP-El Nino before and after 1990 is 0.01 per year and 0.29 per year, respectively. Simply put, this result indicates that anomalous warm SSTs in the central equatorial Pacific (that is, CP-El Nino) has been observed more frequently during recent decades (Yeh 2009 title: "El Nino in a changing climate Nature paper")

The large difference of anomalous mean SST between the two types of El Nino results in changes in the total SST pattern in the tropical Pacific , which determines the atmospheric response. For the EP-El Nino the centre of maximum anomalous rainfall is observed around the dateline; for the CP-El Nino it is shifted westward to around 165 deg E. The anomalous rainfall is largely enhanced in the central and eastern equatorial Pacific and reduced in the western equatorial Pacific during the EP-El Nino compared to the CP-El Nino.

In addition to the differences in their spatial structure, the EP and CP types of ENSO also show differences in their temporal evolutions

At the surface:

For the EP type of ENSO the SST anomalies emerge from the coast of South America, propagate westward to the central Pacific, and decay off the equator. The peak SST anomalies of this type of ENSO appear near the coasts, accompanied with weaker and opposite anomalies in the equatorial western Pacific. For the CP type of ENSO, SST anomalies first appear around the date line, develop and mature in a V-shaped anomaly structure extending toward the subtropics in both hemispheres (but more into the Northern Hemisphere), and then decay in the equatorial central Pacific. The CP- ENSO has greater association with SST anomalies in the subtropics than the EP-ENSO. In addition, the propagating feature of the SST anomalies in the CP type of ENSO is weaker and less clear than those of the EP type of ENSO.

Subsurface:

These two types of ENSO have even larger differences in their subsurface temperature evolutions. For the EP type of ENSO , large and out-of-phase temperature anomalies in the subsurface ocean appear on both sides of the Pacific basin. Temperature anomalies in the eastern tropical Pacific emerge from the American coasts and then propagate westward on the surface . At the same time, negative subsurface anomalies accumulated in the western Pacific. After the mature phase of the event, these subsurface temperature anomalies propagate eastward along the thermocline and eventually emerge on the surface of the eastern Pacific and reverse the phase of ENSO. In contrast, the subsurface temperature evolution of the CP-ENSO does not have a basin wide fluc- tuation pattern and shows little propagation feature. The initiation, development, and termination of the subsurface temperature anomalies all occur in the central Pacific. The anomalies appear first near the surface and then extend downward to a shallow layer of about 100 m. This depth is well above the local thermocline, which is about 150–200 m deep, indicating that thermocline variation is not involved in the evolution of the CP type of ENSO. It is important to note that there is no identifiable phase-reversal signal implying that the CP type of ENSO does not behave like a cycle/ oscillation. The CP-ENSO occurs as an event that is not driven by thermocline variations, while the EP-ENSO is driven by the delayed-oscillator type of thermocline variation and occurs as a cycle with its warm- and cold-phase events following each other

Atmosphere-Ocean Coupling:

EP type of ENSO is associated with significant wind stress anomalies covering a large part of the tropical Pacific. On the other hand, surface wind anomalies associated with the CP type of ENSO are limited to the equatorial central-to-western Pacific (1308E– 1608W) and off Australia. The differences in the wind stress patterns suggest that the EP-ENSO is related to basin-scale coupling processes along the equator, while the CP-ENSO is related to local coupling processes in the central Pacific.

For EP- ENSO , the precipitation anomalies extend from the equatorial eastern to central Pacific, where the largest SST anomalies are located. There are opposite precipitation anomalies near Indonesia and

Amazon regions. The precipitation anomaly pattern associated with this type of ENSO reflects zonal shifts of the Pacific Walker circulation. An EP type of El Nino event shifts the rising branch of the circulation from the far western Pacific to the center-to-eastern Pacific, and vice versa for a La Nina event of the same type. For CP-ENSO the precipitation anomalies are characterized by a dipole pattern within the tropical Pacific with largest anomalies located mainly in the far western and eastern Pacific. It is noticed that the positive and negative anomaly centers of this dipole pattern do not line up in the same latitude. Instead, they tend to be located slightly to the north and to the south of the equator respectively. The anomaly pattern appears related to the meridional shift of the intertropical convergence zone (ITCZ). During the warm phase of CP- ENSO, the ITCZ intensifies in the equatorial western Pacific and shifts more northward in the eastern Pacific, and vice versa for the cold phase of the CP-ENSO. The impacts of CP-ENSO events on precipitation are much less in Indonesia and are negligible in the Amazon.

Teleconnection:

These two ENSO types also exhibit different teleconnection with the Indian Ocean, with the EP-ENSO linked more closely with the tropical Indian Ocean whereas the CP-ENSO is linked more with the southern Indian Ocean.

It is widely recognized that the canonical EPW pattern associated with El Niño suppresses Atlantic cyclone activity because the anomalous atmospheric circulation associated with El Niño tends to increase the vertical wind shear over the main development region for Atlantic hurricanes [e.g.,Goldenberg and Shapiro, 1996; Shaman et al., 2009]. A study by Kim et al. [2009] claimed that "in contrast to EPW events, CPW episodes are associated with a greaterthan average frequency and increasing landfall potential along the Gulf of Mexico coast and Central America." They also stated that "compared to climatology, track density for CPW increases across the Caribbean, the Gulf of Mexico, and the U.S. east coast."

Sang-Ki Lee (2010) shows in his independent data analysis of tropical cyclone activity in the five CPW years shows that only three (1969, 2002, and 2004) are associated with significantly greater than average storm activity over the Gulf of Mexico and Caribbean Sea, whereas the other two (1991, and 1994) are associated with significantly lowerthanave rage activity.