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Understanding and modeling the emerging Central-Pacific El Niño

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The recent identification of two distinct types (or flavors) of El Niño offers a new way to consider how El Niño and its global impacts may change as the climate changes. These two El Niño types are the Eastern-Pacific (EP) type that produces sea surface temperature (SST) anomalies near the South American coast and the Central-Pacific (CP) type that produces anomalies near the international dateline. While the EP El Niño used to be the most frequently occurring type of El Niño it has come to people's attention that the CP El Niño has gradually increased in occurrence over the past three decades. The intensity of El Niño in the CP region has doubled in the past three decades. Three of the four El Niño events in the 21st century (the 2002/03, 2004/05, and 2009/10 events) have been of the CP type. CMIP3 models project that the CP type may become the prevailing type of El Niño in a future warmer world. These studies indicate that the CP El Niño is an emerging mode of climate variability related to global warming. More importantly, recent studies suggest that the generation mechanism of the CP El Niño is different from that of the EP El Niño. The CP El Niño was argued to result not from basin-wide interactions between the tropical Pacific Ocean and the Walker circulation, which is the generation mechanism for the EP El Niño. Rather, the CP El Niño was suggested to grow via interactions between the tropical Pacific and the Hadley circulation. CP El Niño events are excited by extratropical atmospheric forcing (via the lower returning branch of the Hadley circulation) and then intensify in the central equatorial Pacific via local air-sea interactions. The connection with the Hadley circulation implies that the CP El Niño may produce a stronger impact on higher-latitude climate than the EP El Niño. This may be a reason why extreme weather conditions prevailed in the North America during the 2009 El Niño event, which was a well-recognized CP event. A record warming in the South Central Pacific and western Antarctica were also observed during the 2009 CP El Niño. Several other studies have also indicated that the CP El Niño can affect global climate differently from the EP El Niño. For example, the CP El Niño tends to increase (rather than decrease) the frequency of Atlantic hurricanes; the CP El Niño's impact on North America temperature tends to be more of an east-west contrast pattern than a north-south patter that is typically associated with the EP El Niño. These studies suggest that we cannot use our existing understanding of the conventional EP El Niño to anticipate the climate impacts and teleconnections associated with the CP El Niño. A better understanding of the emerging CP El Niño is important to climate change studies. In this talk, I will first briefly review the recent processes on understanding the impacts and dynamics of the CP El Niño. Then I will present my works on the dynamics of the CP El Niño and its interaction with the EP El Niño. The performance of the CMIP3 models in the simulation of the CP El Niño will also be evaluated. Major findings to be reported include: (1) tropical-extratropical interactions are examined to show the CP ENSO is excited by extratropical atmospheric forcing, which is different from the generation mechanism of the EP ENSO; (2) three decaying patterns of the CP ENSO are identified and their associated thermocline depth that can be used to predict how a CP ENSO event will evolve are also revealed; and (3) CMIP3 pre-industry integrations were analyzed to determine how well the CP and EP types of ENSO are captured in each of the CMIP3 models, and (4) an extratropical channeling mechanism is suggested to explain how certain transition patterns were found between the EP and CP ENSOs, during which the demise of one ENSO type can lead to the development of the other type.