Effects of Freshwater Flux (FWF) Forcing on Interannual Climate Variability in the Tropical Pacific

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Abstract

The impacts of freshwater flux (FWF) forcing on interannual variability in the tropical Pacific climate system are investigated using a hybrid coupled model (HCM), constructed from an oceanic general circulation model (OGCM) and a simplified atmospheric model, whose forcing fields to the ocean consist of three components. Interannual anomalies of wind stress and precipitation minus evaporation, (P-E), are calculated respectively by their statistical feedback models that are constructed from a singular value decomposition (SVD) analysis of their historical data. Heat flux is calculated using an advective atmospheric mixed layer (AML) model. The constructed HCM can well reproduce interannual variability associated with El Niño-Southern Oscillation (ENSO) in the tropical Pacific.

HCM experiments are performed with varying strength of anomalous FWF forcing. It is demonstrated that FWF can have a significant modulating impact on interannual variability. The buoyancy flux (Q_B) field, an important parameter determining the mixing and entrainment in the equatorial Pacific, is analyzed to illustrate the compensating role played by its two contributing parts, one is related with heat flux (Q_T) and the other with freshwater flux (Q_S), respectively. A positive feedback is identified between FWF and sea surface temperature (SST) as follows. SST anomalies, generated by El Niño, non-locally induce large anomalous FWF variability over the western and central regions, which directly influences sea surface salinity (SSS) and Q_B, leading to changes in the mixed layer depth (MLD), the upper ocean stability, the mixing and the entrainment of subsurface waters. These oceanic processes act to enhance the SST anomalies, which in turn feedback to the atmosphere in a coupled ocean-atmosphere system. As a result, taking into account anomalous FWF forcing in the HCM leads to an enhanced interannual variability and ENSO cycles. It is further shown that FWF forcing is playing a different role from heat flux forcing, with the former acting to drive a change in SST, while the latter being representing a passive response to the SST change. This HCM based modeling study presents clear evidence for the role of FWF forcing in modulating interannual variability in the tropical Pacific. The significance and implications of these results are further discussed for physical understanding and model improvements of interannual variability in the tropical Pacific ocean-atmosphere system.