Tropical Ocean Recharge Mechanism for Climate Variability: A Unified Theory for Decadal and ENSO Modes

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Abstract

Decadal to interdecadal timescale variability in the Pacific region, commonly referred to as the Pacific Decadal Oscillation (PDO), is studied in this research using analytical and numerical models. A coupled analytical model is formulated to analyze the physical mechanism of both PDO and ENSO. It has the equatorial $\beta-$plane dynamics of a reduced-gravity model coupled with wind stress of fixed spatial patterns. The amplitude of the latter is proportional to sea surface temperature (SST) anomaly in the eastern equatorial Pacific. The SST anomaly is governed by a simple thermal dynamic equation used for ENSO modeling. The analytical eigen solutions are solved. We find that when a warm SST is coupled with cyclonic wind stress patterns in the eastern subtropical Pacific, an oscillation with timescale around 10-15 years could be generated. In contrast, when a warm SST is coupled with only a westerly wind stress in the central equatorial Pacific, an ENSO-like oscillation could be generated with timescale around 3-5 years. The PDO may be understood as a weakly coupled decadal recharge oscillator similar to the recharge oscillator dynamics of ENSO. Sensitivity of these two kinds of coupled modes to different parameters is tested. Numerical integrations with the reduced-gravity shallow-water model in a rectangular basin and a similar coupled framework confirm the results of the analytical model.

A hybrid coupled model, which couples an oceanic general circulation model with a statistical atmospheric model, is currently used to test the relevant hypotheses of PDO. The progress along this direction will also be reported.

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