Geophysical Research Abstracts
Vol. 19, EGU2017-6389, 2017
EGU General Assembly 2017
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Mechanisms of the Indian Ocean Dipole influence on El Niño/Southern Oscillation

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Despite the tremendous socio-economic and environmental impacts of the El Niño-Southern Oscillation (ENSO), its forecasts at lead times longer than a few months remain challenging, as recently evidenced by the unexpected 2014-2015 El Niño sequence. Recent studies have suggested that negative (postive) Indian Ocean Dipole events may favour the development of El Niño (La Niña) events peaking one year later, hence possibly improving ENSO predictability and explaining ENSO biennal variability. These studies essentially show that this IOD influence on ENSO evolution is indeed robust in observations and most CMIP climate models. Accounting for the IOD influence in linear ENSO forecasts based on the tropical Pacific recharge-discharge process increases the explained variance by $\sim$10-30% at $\sim$14 months lead. This IOD influence on the ENSO forecast skill appears stronger than that of the Indian Ocean Basin-wide warming/cooling or ENSO itself. However, its underlying mechanisms are still debated.

Here we use dedicated experiments from atmospheric and oceanic numerical models, and a conceptual approach based on the Pacific ocean linear response to a wind pulse, to investigate the mechanisms by which the IOD influences ENSO evolution. Our results suggest that: (1) the atmospheric bridge (through atmospheric teleconnections) dominates the oceanic bridge (through the Indonesian throughflow); (2) the temporal change of west Pacific zonal wind stress over a six month period (e.g. related to IOD demise) matters as much as the wind seasonal anomaly for the dynamical response of the equatorial Pacific; (3) the IOD eastern pole, and its demise, is the main driver of this wind change. The abrupt demise of the IOD eastern pole favours a fast temporal change of the zonal wind in the western Pacific between fall and winter–spring, thereby favouring ENSO phase transition. Revisiting statistical approaches by using relative sea surface temperature (i.e. with tropical mean removed) confirms these modelling results both in observations and CMIP database. Better simulating the IOD demise, and its related atmospheric signature over the western Pacific, may hence yield additional long-lead ENSO prediction skill in dynamical seasonal forecasting systems.