Geophysical Research Abstracts
Vol. 21, EGU2019-19160, 2019
EGU General Assembly 2019
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Low-frequency variability of the Pacific Subtropical Cells and their effect on tropical climate

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The importance of subtropical and extratropical zonal wind stress anomalies on the Pacific Subtropical Cells (STCs) strength is assessed through several idealized and realistic numerical experiments, performed using a global ocean model. Different zonal wind stress anomalies are employed, and their intensity is strengthened or weakened with respect to the climatological value throughout a suite of simulations. Subtropical strengthened (weakened) zonal wind stress anomalies result in increased (decreased) STCs meridional mass and energy transport. Upwelling of subsurface water into the tropics is intensified (reduced), a distinct cold (warm) anomaly appears in the equatorial thermocline and up to the surface, resulting in significant tropical sea surface temperature anomalies. The remotely-driven response is compared with a set of simulations where an equatorial zonal wind stress anomaly is imposed. A dynamically distinct response is achieved, whereby the equatorial thermocline adjusts to the wind stress anomaly resulting in significant equatorial sea surface temperature anomalies as in the remotely-forced simulations, but with no role for STCs. Significant anomalies in Indonesian Throughflow transport are generated only when equatorial wind stress anomalies are applied, leading to remarkable heat content anomalies in the Indian Ocean. Equatorial wind stress anomalies do not involve modifications of STCs transport, but could set up the appropriate initial conditions for a tropical-extratropical teleconnection involving Hadley cells, exciting a STCs anomalous transport which ultimately feeds back on the Tropics. Experiments performed with both time-constant and time-varying realistic wind stress anomalies also suggest a potential impact of midlatitude atmospheric modes of variability on tropical climate through STCs dynamics. Large temperature trends are found in the subsurface ocean at the Subtropics, as well as in the equatorial thermocline. Instead, results obtained from pre-industrial and future-scenario simulations, performed by a subset of state-of-the-art ocean-atmosphere coupled models, do not provide a coherent picture of natural STCs variability and future changes. Several mass transport diagnostics are compared for pre-industrial simulations, showing agreement among models about equatorward mass transport in the Southern Hemisphere, but disagreement in the Northern Hemisphere. Also a general degradation of linear correlation coefficients between different STCs metrics is found when moving toward the Equator. According to future scenario simulations, STCs meridional energy transport is expected to decrease (increase) in the Northern (Southern) Hemisphere under warmer climate conditions. On the other hand, our observational estimate could underestimate STCs meridional energy transport in the Southern Hemisphere with respect to models. A further evaluation using several ocean reanalysis is therefore performed. Furthermore, our analysis also include historical simulations of the last century, which are a more consistent comparison with observations-derived computations.