Using Ocean Reanalyses to Validate CMIP5 Historical Experiments in the Tropical Pacific

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Long-term changes of El Niño/South Oscillation are studied with ensemble runs of Simple Ocean Data Assimilation (SODA 2.2.6) and the fifth coupled model intercomparison project phase 5 (CMIP5). The ocean model of SODA is based on the Parallel Ocean Program (POP) ocean model with a horizontal resolution that is on average 0.4^{o} x 0.25^{o} and with 40 levels in the vertical. Assimilation of temperature observations is carried out sequentially using a 10-day update cycle with model error covariances determined from a simulation that does not include assimilation. The error covariances evolve in time as a function of the local velocity field and mixed layer depth. Output variables are averaged every 5 days, and are then mapped onto a uniform global 0.5°x0.5° horizontal grid. The ocean model surface boundary conditions are provided from eight ensemble members from atmospheric reanalysis 20^{th} century reanalysis version 2 (20CRv2). The surface wind stress from 20CRv2 is used in the ocean model for the surface momentum fluxes. Solar radiation, specific humidity, cloud cover, 2m air temperature, precipitation and 10m wind speed from 20CRv2 are used for computing heat and freshwater fluxes. SST observations from ICOADS 2.5 are assimilated using the SODA software package.

The ensemble reanalysis shows that ENSO variability is considerably different in different ocean ensemble members. The period, location and duration of ENSO events are analyzed to explore the low frequency behavior of ENSO. To study the importance of the background state on ENSO, long-term trends of tropical Pacific SST, wind stress, subsurface temperature, the subtropical cells (STCs) and the equatorial undercurrent (EUC) are analyzed. There is a slight cooling trend of SST over the central tropical Pacific due to an enhanced tropical Pacific circulation. Subsurface temperature also has a cooling trend. The STCs consist of equatorial upwelling, Ekman transport, extra-tropical subduction and pycnocline transport from the subtropical to the tropical region, when the STCs are accelerated equatorial upwelling should increase which will bring cold water from the subsurface that will cool the surface. ENSO variability is also analyzed with the CMIP5 historical experiments, and results show that most of the models have a realistic distribution of ENSO strength when compared with SODA 2.2.6. One distinguishing difference is that while SODA 2.2.6 has prominent asymmetry between El Niño and La Niña strength, the CMIP5 models tend to have fairly symmetric El Niño and La Niña strengths. Most of the CMIP5 models generally have warming trends and the transport of the STCs has a slight decreasing trend, which is different from SODA 2.2.6.

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