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Detection of Multi-Decadal Variabilities Using Coupled Climate Models and Data

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Employing the GFDL's coupled data assimilation system, a 25-year data assimilation has been done using the ocean temperature observational network in the last quarter of the 20th century for a climate detection purpose. The assimilation system is a super-parallelized ensemble filter with the GFDL's coupled climate models (ocean/atmophere/land/ice, CM2), implemented in a multi-variate analysis scheme.The modeled temperature of the coupled model integration with the temporally-varying green house gas (GHG) and natural aerosol (NA) radiative forcings is projected onto the ocean temperature observational network in the last quarter of the 20th century, and a white noise is imposed on the projected temperature to form observations. The created idealized observations are assimilated into a set of ensemble model integrations (6, in this case) that only uses the time-invariate (1860) GHGNA radiative forcings and starts from the ensemble initial conditions formed by imposing yearly atmospheric states on an ocean state on the begining of the 20th century.

With contrasts to the control reference, a model integration at the first quarter of the 20th century with the 1860 time-invariate GHGNA radiative forcings, the assimilation improves the heat uptake of ocean in the Pacific and the Atlantic that the time mean thermoclines and the seasonal cycle of upper ocean temperature at tropics are reconstructed as data expect. The ENSO variabilities on the tropical Pacific, including extremly warm/cold events and their decadal frequency, are retrieved by the assimilation. The time mean precipitation and Walker circulations of the atmosphere over these oceans are improved due to a better estimate of sea surface temperature in the assimilation. Using temporally-varying cross-covariances between temperature and salinity evaluated by ensemble model integrations, the multi-variate assimilation system is able to construct the temperature/salinity properties of the upper portion of the north Atlantic thermohaline circulation. Results in this study suggest that although the 20th century ocean temperature observational network be adequate to detect the multi-decadal variabilities described above, utilization of the salinity observations be expected to improve the estimate of ocean states at high latitudes and deep oceans that may help detect larger timescale (centennial or beyond) variabilities in climate change.