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Investigating forced ocean change using a neutral density framework

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The ocean stores 93% of the heat due to climate change. Knowing where this heat is distributed within the interior of the ocean is key to detect and attribute local changes. Climate models are unique tools for investigating the role of cause and effect and relating these to the limited observational record of ocean change. Using a suite of CMIP5 results, and a number of the externally forced (1pctCO_2, historical, historicalNat) and unforced (piControl) experiments, has enabled us to better quantify the forced signal from unforced climate variability "noise". In addition, mapping the model data into a neutral density framework allows for a clear separation of the diabatic effects due to air-sea fluxes and changes due to the vertical movement of isopycnals associated to circulation shifts and ocean reorganization in response to forcing.
Using this simulation suite, we can compute a time of emergence (ToE) of the forced temperature/salinity signal from the "noise" in the ocean interior, both globally and regionally. When we focus on the pure CO_2 forcing, we find a distribution of ToE ranging from 45 to 110 years for various oceanic regions. Using the historical and RCP8.5 21st century extension simulations, which also include the non-anthropogenic forcing agents such as volcanic eruptions, we find a ToE of 120 to 180 years, corresponding to an emergence of the anthropogenic signal from late 20th century into the first decades of the 21st century. The regional differences are then discussed where the signal is robust across simulations.