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Reduced Space Interpolation of Subsurface Ocean Properties with Dynamical Constraints

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Subsurface ocean data are very sparse, especially in the pre-ARGO period, and more so before 1970s. Yet, subsurface ocean temperature and salinity variations are crucial for understanding the wide range of climate phenomena: ocean response to the atmospheric increase in greenhouse gases, sea level rise, subsurface dynamics of ENSO events, and changes in the ocean circulation. Existing estimates of major integral characteristics of subsurface ocean, like upper ocean heat content of the top 700 m from 1950s to present, produced by different authors disagree with each other even in their annually-averaged global means. Counterintuitively, using ocean models for interpolating over missing data has been making the spread between different estimates even larger, which compounds the problem. Here, reduced space approach is used as the main methodological framework, as it is successful in extracting large-scale climate variability from sparse and erroneous observations in earlier applications and produces verifiable uncertainty estimates. The method is augmented by using potential density as a vertical coordinate and including a "weak" dynamical constraint in the form of approximate conservation of the Bernoulli function. Subsampled data from ocean reanalyses and ARGO observations are used to determine the appropriate spatial and temporal resolution and the corresponding temporal extent for applying the modified reduced space objective analysis method to the global data set of the temperature and salinity profiles. Comparisons are made with the existing subsurface reconstructions and surface analyses.