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A 4-dimensional spectral description of ocean variability for uncertainty determination

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Observations of climate change rely on estimates of mean quantities, such as abyssal temperature or sea level, and trends in the mean over time. In the ocean, estimates of these means are inevitably contaminated by eddy noise. Uncertainty in the mean depends on both the level of variability and the spatial-temporal covariance of the eddy noise. Thus, a thorough understanding of the structure of background noise is crucial for developing useful observations of the ocean for climate research. Eddy noise covariances can conveniently be computed from the spectrum of ocean variability and used to estimate, a priori, the uncertainty in measurements of essential climate variables. We will present an empirical model of the 4-dimensional frequency-wavenumber spectrum of ocean variability, constructed to fit a range of ocean observations including sea surface height from satellite altimetry, current meters, and hydrography, supplemented with numerical model results. This model spectrum varies geographically to match the observed spectrum. It is intended as a "first guess", to be extended and updated as record lengths increase and new observations become available. We propose that the model presented is superior to using single data sets to estimate noise covariance, and more efficient than repeated observing system evaluation experiments. To illustrate these points, we present estimated uncertainties based on the Argo network and for repeated ship tracks.