1. Introduction

What numbers characterize topography? How can we reduce a complex landscape to a few numbers that let us easily and robustly compare different regions at different scales, perhaps with different data coverage available? Mean and variance might be an obvious starting point, but this implies some rather strong assumptions—that the topography is a stationary, white, Gaussian process. A common alternative assumption is that the covariance is taken to be exponential, rather than Gaussian form—an equally strong, if different, assumption.

Here, we instead use a Matrix parametisation to let us build, rather than assume, the shape of the covariance function. This form uses three parameters to characterize the topography: (1) $\sigma$, the variance; (2) $\rho$, the smoothness or differentiability; and (3) $\delta$, the correlation length or range. Building on Simons & Olhede (2003), we use a spectral domain Whittle–matern likelihood-based estimation procedure to estimate these three parameters across sample regions of the Atlantic and Pacific Oceans. The results highlight the need to explicitly account for anisotropy in analysis of oceanic structures, even in low-amplitude areas and focusing on only to k=1 low-wavenumber features (data that has been filtered to $k=20$ km).

2. Sample Topography Analyses

Analyzing the data (Fig. 1), we report estimates of the covariance parameters obtained using a variety of different parameterizations. For example, these parameterizations can be used to directly compare different regions at different scales, perhaps with different data coverage available? Mean and variance might be an obvious starting point, but this implies some rather strong assumptions— that the topography is a stationary, white, Gaussian process. A common alternative assumption is that the covariance is taken to be exponential, rather than Gaussian form—an equally strong, if different, assumption.

(See Fig. 2 for samples of the covariance parameters used.)

3. Stability of the Estimates

The histograms in Fig. 3 show the distribution of the estimates of the parameters $\sigma$, $\rho$, and $\delta$ across the eight different regions, for different starting guesses and different data coverage. The estimates are largely consistent across the eight regions, and there is little indication that the final estimate is significantly determined by the starting guess or of a bi- or multi-model estimation procedure.

(See Fig. 4 for samples of the covariance parameters used.)

4. Spatial Variation in Roughness and Covariance

Fig. 5: Maps of the mean $\nu$ and $\rho$ across the central and northern Atlantic (Ocean using a range of starting guesses and a 4000 km window. Dot size is inversely scaled with standard deviation. Cage in the central Atlantic near the Sverdrup, Polar, and Antarctic Circumpolar Currents show varying amounts of divergence from the 1:1 line, and can fall either above or below it, but generally corresponded to a straight line.

5. Future Work

- Extend the method to explicitly account for and estimate anisotropy in oceanic topography, with different parameterizations used to directly compare different regions at different scales, perhaps with different data coverage available.
- Use the model to estimate the smoothness or differentiability; and the correlation length or range, and the covariance parameters across the world's ocean basins.