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Spatial Variation and Anisotropy in the Morphology and Structure of Oceanic Lithosphere

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The shape, structure, and strength of the oceanic lithosphere exert major controls on geodynamic processes. Variations initiated by regional spreading regimes go on to have a global influence, from intraplate volcanism to subduction dynamics.

To understand the surface morphology of the oceans, we use a frequency-domain maximum-likelihood procedure to map the roughness of the seafloor and its bathymetric covariance. This covariance is often assumed to be Gaussian or exponential in form, but using a Matérn parameterisation (variance, range, and differentiability) lets us solve for, rather than assume, the shape of the covariance. Because high-resolution, directly measured bathymetry data is not available for most of the deep ocean, we apply the same technique to the vertical gravity gradient, which is measured by satellite and contains more short-wavelength information than the free-air gravity anomaly.

To examine the deeper lithospheric structure, we also analyse the relationship between gravity and bathymetry through their coherence and admittance, particularly the anisotropy in the relationship. In particular, we separate out measurements of anisotropy that are significant and occur at wavelengths associated with the long-term mechanical strength of the lithosphere. Some of these directions are aligned with anisotropy in the gravity and/or bathymetry data; these may simply reflect this input anisotropy, or they may still reflect anisotropy in lithospheric strength that is aligned with anisotropy in the surface structure or density structure.

Our overarching goal is to use statistical analyses to link variations in lithospheric surface morphology and strength to the key geological processes that affect it from formation (e.g., spreading rate and direction) to modification (e.g., level of later volcanic activity), and eventually destruction (e.g., patterns of faulting and seismicity at subduction zones).