Geophysical Research Abstracts
Vol. 16, EGU2014-14572, 2014
EGU General Assembly 2014

Characterizing the statistical structure of bathymetry and topography as a Matérn process

Frederik J. Simons (1), Sofia C. Olhede (2), Gabe L. Eggers (1), and Kevin W. Lewis (1)

(1) Princeton University, Geosciences, Princeton, United States (fjsimons@gmail.com, +1 (609) 258 2593), (2) University College London, Statistical Science, United Kingdom (s.olhede@ucl.ac.uk)

Describing and classifying the statistical structure of topography and bathymetry is of much interest across the geophysical sciences. Oceanographers are interested in the roughness of seafloor bathymetry as a parameter that can be linked to internal-wave generation and mixing of ocean currents. Tectonicists are searching for ways to link the shape and fracturing of the ocean floor to build detailed models of the evolution of the ocean basins in a plate-tectonic context. Geomorphologists are building time-dependent models of the surface that benefit from sparsely parameterized representations whose evolution can be described by differential equations. Geophysicists seek access to parameterized forms for the spectral shape of topographic or bathymetric loading at various (sub)surface interfaces in order to use the joint structure of topography and gravity for inversions for the effective elastic thickness of the lithosphere. Planetary scientists are in need of robust terrain-classification models to help unravel the cratering history and tectonic evolution of planetary surfaces, for the selection of suitable landing sites, and for purposes as mundane as the prediction of wear and tear on rover wheels. Finally, statisticians, mathematicians and computer scientists are interested in the analysis of texture for purposes of out-of-sample prediction, extension, and in-painting for application in fields as diverse as computer graphics and medical imaging. A unified geostatistical framework for the description, characterization and study of surfaces of these various kinds and for such a multitude of applications is via the Matérn process, a theoretically well justified and mathematically attractive parameterized form for the spectral-domain covariance of Gaussian processes, both in isotropic form and considering various geometrical kinds anisotropy. We discuss a constructive new estimation technique to find the parameters of the Matérn forms of topography and bathymetry from small and possibly irregularly shaped pieces of terrestrial and planetary real estate, via maximum-likelihood optimization. We discuss whether the Matérn form is appropriate (it is), how to find the parameters and their associated uncertainties, how well the models fit the data, and, finally, what they can tell us about the surfaces in question. We present results that are analytical as well as numerical, backed by extensive testing on simulated data, and with examples for the terrestrial planets Venus and Mars, as well as for the seafloor- and subseafloor expression of tectonic and geomorphic processes on Earth, where we hope that our new methodology will lead to new paradigms.