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Identify Foot of Continental Slope by singular spectrum and fractal singularity analysis

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Identifying the Foot of Continental Slope (FOCS) plays a critical role in the determination of exclusive economic zone (EEZ) for coastal nations. The FOCS is defined by the Law of the Sea as the point of maximum change of the slope and it is mathematically equivalent to the point which has the maximum curvature value in its vicinity. However, curvature is the second derivative and the calculation of second derivative is a high pass and noise-prone filtering procedure. Therefore, identification of FOCS with curvature analysis methods is often uncertain and erroneous because observed bathymetry profiles or interpolated raster maps commonly include high frequency noises and artifacts, observation errors, and local sharp changes. Effective low-pass filtering methods and robust FOCS indicator algorithms are highly desirable.
In this approach, nonlinear singular spectral filtering and singularity FOCS-indicator methods and software tools are developed to address this requirement.
The normally used Fourier domain filtering methods decompose signals into Fourier space, composed of a fixed base that depends only on the acquisition interval of the signal; the signal is required to be stationary or at least weak stationary. In contrast to that requirement, the developed singular spectral filtering method constructs orthogonal basis functions dynamically according to different signals, and it does not require the signal to be stationary or weak stationary. Furthermore, singular spectrum analysis (SSA) can assist in designing suitable filters to carefully remove high-frequency local or noise components while reserving useful global and local components according to energy distribution.
Geoscientific signals, including morphological ocean bathymetry data, often demonstrate fractal or multifractal properties. With proper definition of scales in the vicinity of a certain point and related measures, it is found that 1-dimensional bathymetry profiles and 2-dimensional raster maps all demonstrate excellent fractal behavior with the power-law relationship. Subsequently, singularity can be estimated and it is a robust indicator of the signal's intrinsic concave or convex property within certain vicinity of the current point and without the disadvantage of the sensitivity of curvature analysis.
As an example, bathymetry profiles and raster maps from the Canadian east coast, extracted from the publically available GEBCO-2008 collection, are processed with the developed algorithms. The results are compared with ordinary curvature and Maximum Curvature results. It is found that the developed methods outperform currently available methods in compressing noise and indicating FOCS with more certainty and clarity. The representative marginal morphological profiles and raster maps of the study area have been processed effectively using this new method.

Key words: Foot of continental slope; Experimental orthogonal function; Singular spectral analysis; Singularity, Slope, Curvature; Law of the Sea; Robust low-pass filtering