Quantifying rhythmic bedforms from bathymetric surfaces

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INTRODUCTION
Recent advances in the quality and affordability of geophysical mapping technologies mean a resurgence in quantitative analysis of subaerial geomorphology. New techniques for studying bedforms are developing. Application of these new methods is well suited to a range of applications, including sediment transport and hydrodynamic modelling, habitat mapping, geological sequence interpretation, and bedform classification. Analysis is split into spectral and spatial approaches. The former gives orientation, wavelength and height; the latter, height only. Discrete Fourier Transform (DFT) techniques are used, with different windowing and filtering techniques, to quantitatively and objectively measure bedform height, orientation and wavelength. Spatial analysis (3D) recovers bedform heights through the identification of crests and troughs.

RESULTS I
- Spectral analysis of the synthetic surface in Figure 2A allows measurement of wavelength (λ) and height (h) from the position of the spectral power (P) and its magnitude (S^2) in Figure 2B.
- Spatial analyses identify peaks and troughs from raw spatial data (Figure 2A), or bandpass filtered spectra, from which heights are calculated.
- Uncertainties can be calculated based on spectral resolution and potential variability in the source data.
- Radon Transform (Figure 2C) projects the raw data through 180° to identify crest orientation.

RESULTS II
- Application of each technique to a simple observed surface tests its suitability for further use.
- The DFT with a spatial Flat Top window and the spatial 2nd Derivative under-report height. The 2nd Derivative and zero-crossing analyses of the Butterworth filtered surfaces are in good agreement with one another and heights from an analytical relationship (8).
- DFT picked orientations agree with each other, but the Radon Transform has picked a stronger signal from the misaligned data.

RESULTS III
A range of increasingly complex environments are tested, including a bed with regional morphological depth variability of 10 m (Figure 4A), irregularly spaced bedforms (Figure 4B) and finally a bed of cuspy bedforms (Figure 4C).

RESULTS IV
- Analysis of a large (70 km²) bank with 300 m subsets in order to analyse bedforms with L > 30 m.
- Wavelet orientation and height analysis takes 3 minutes for the bathymetry of the entire bank.

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REFERENCES

CONCLUSIONS
- A range of quantitative, automated bedform analysis techniques is tested on a series of small- and large-scale bathymetric surfaces.
- Measurements of orientation, wavelength and height are successfully extracted across a range of environments.
- Some commonly employed techniques prove ineffective at identifying parameters when real-world surfaces are analysed.
- Seafloor classification is enhanced through height and bedform orientation analysis.
- A large number of results allow statistical analysis of potentially very large data sets.
- Application of the techniques are suitable for analysis of any spatially contiguous data (e.g. LIDAR, Side-scan Sonar, Back-scanning sonar etc.).