Detecting Very Small Seamounts in AltiKa Repeat Cycle Data

K. M. Marks and W. H. F. Smith

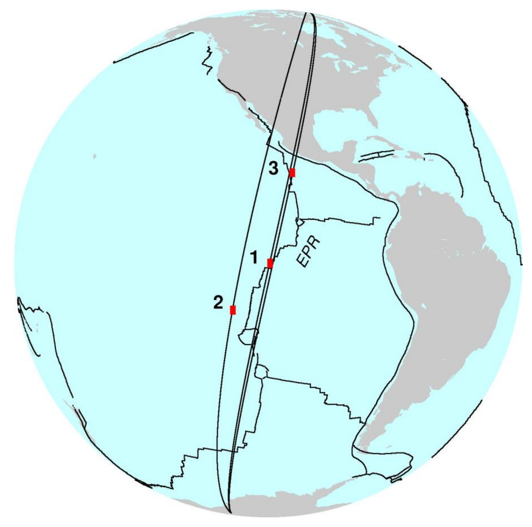
NOAA Laboratory for Satellite Altimetry, College Park, Maryland, USA

Abstract. There are hundreds of thousands of seamounts on the world's ocean floor. Even though small seamounts are much more common than large ones, it is the larger ones (taller than 2 km) that have been found in marine gravity fields derived from satellite altimetry. It is hard to find the smaller seamounts because the amplitude of their geoid anomaly decreases rapidly with seamount size.

A recent study by Smith (2015)* used single cycles of AltiKa 40 Hz sea surface height data to identify seamounts as small as 1.35 km tall. Our present study uses a method of "stacking" repeat cycles of 40 Hz AltiKa data profiles that improves the resolution of small seamount signals and lowers the noise. We find that noise variance decreases with an increase in the number of cycles stacked. The root-mean-square noise level dips below 2 cm when 12 or more repeat cycles are stacked (about 1 year of data). Seamounts smaller than ~1100 m tall are easily found in the stacked profiles, and seamounts as small as 500 m tall are perceptible. Coherence analyses between geoid height and topography shows that full wavelengths down to ~10 km are being resolved.

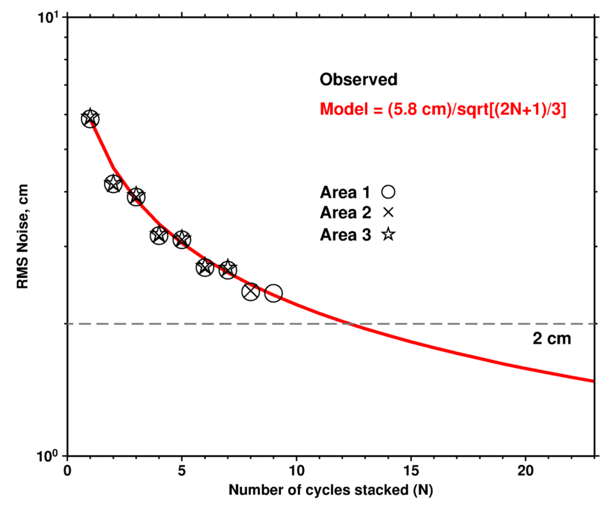
Smith, Marine Geodesy, 2015, doi 10.1080/01490419.2015.1014950

Study areas



- Three study areas are located on the flanks of the East Pacific Rise (*EPR*)
- The study areas are crossed by AltiKa tracks and have multibeam data coverage

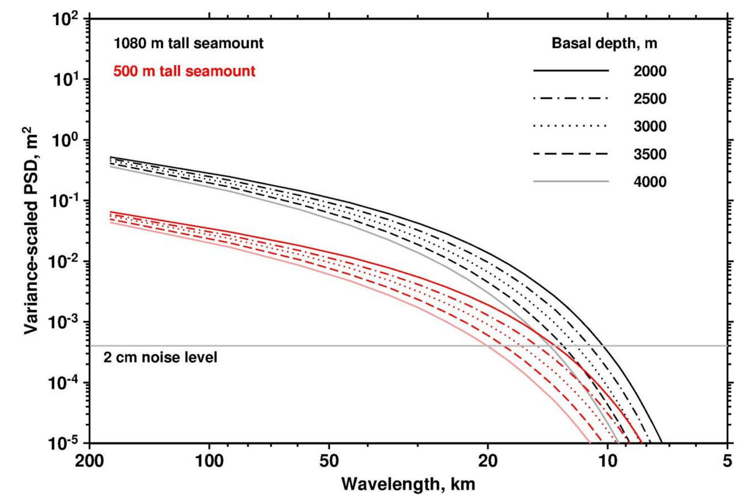
Stacking cycles lowers noise



- Noise variance decreases with an increase in the number of cycles stacked
- RMS noise level dips below 2 cm when 12 or more repeat cycles are stacked (~1 yr of data)

- Removing time-varying ocean dynamics from altimeter data leaves geoid heights
- Anomalies < 160 km in wavelength are associated with seafloor topography

Seamount size versus depth

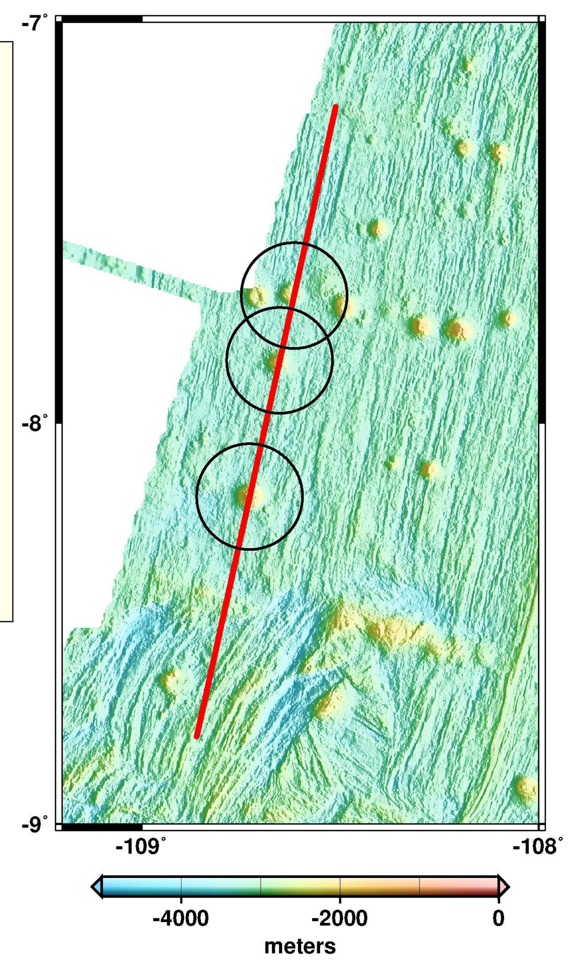


- What limits seamount detection more- depth of the seamount or small size? The answer is size.
- The power from small seamounts (red lines) is lower than the power from large seamounts (black lines)
- A lower noise level will help reveal signal from smaller seamounts

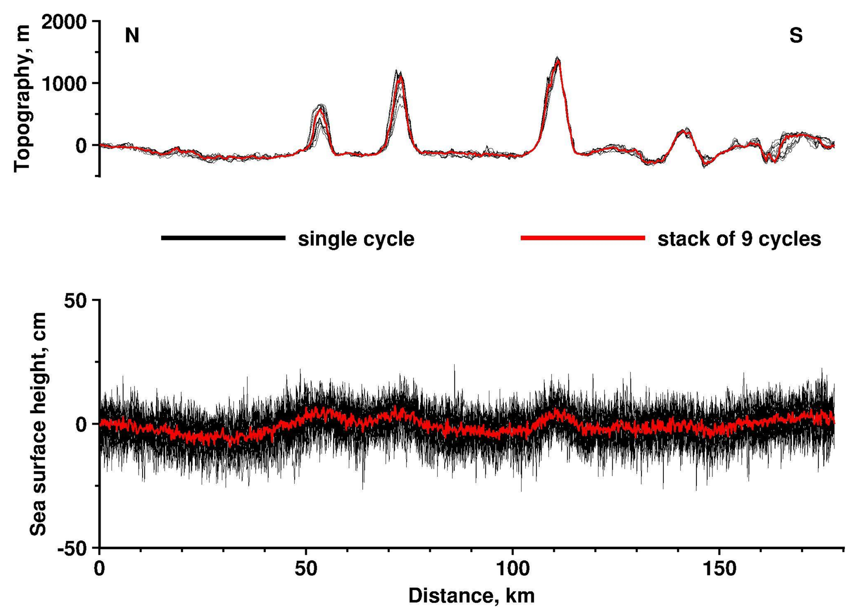
1

Wilkes FZ area

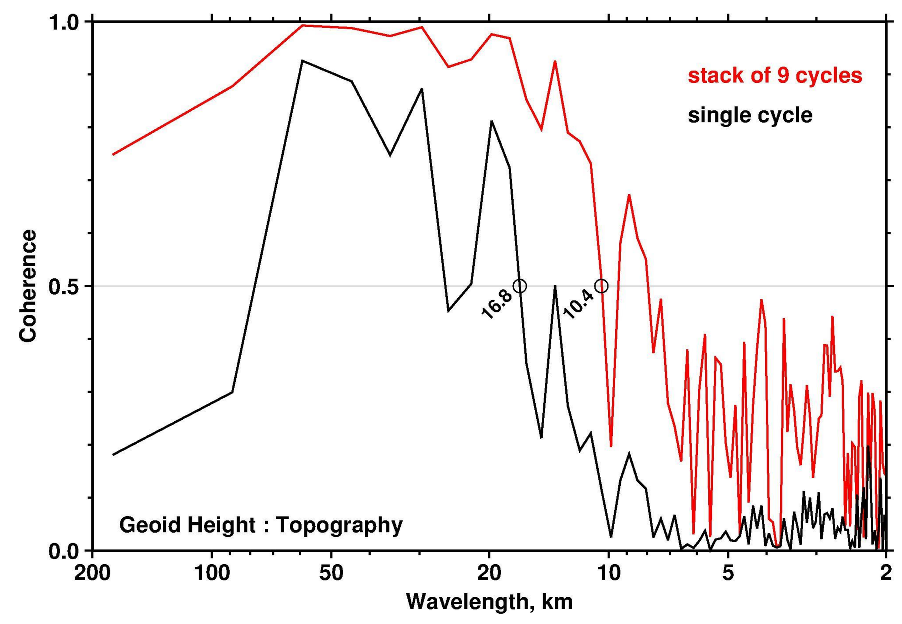
- AltiKa pass 0396 (red) crosses three seamounts (circled). The tallest is 1600 m and the track traverses its apex. The track is slightly offset from the apex of the other two.
- Depths are interpolated from multibeam data, at the locations of AltiKa observations
- Smith (2015)* used a single cycle of pass 0396 to analyze signal from these seamounts; in this study we stack 9 cycles



Stacking AltiKa repeat cycles improves resolution of small seamounts



- Every 35 days AltiKa repeats the same ground track
- 9 repeat cycles were stacked by aligning the along-track data points to the nearest common latitude and then taking the median across aligned points
- Seamounts are evident in stacked profile (red line)
- Stacking reduces noise and clarifies anomalies from seamounts

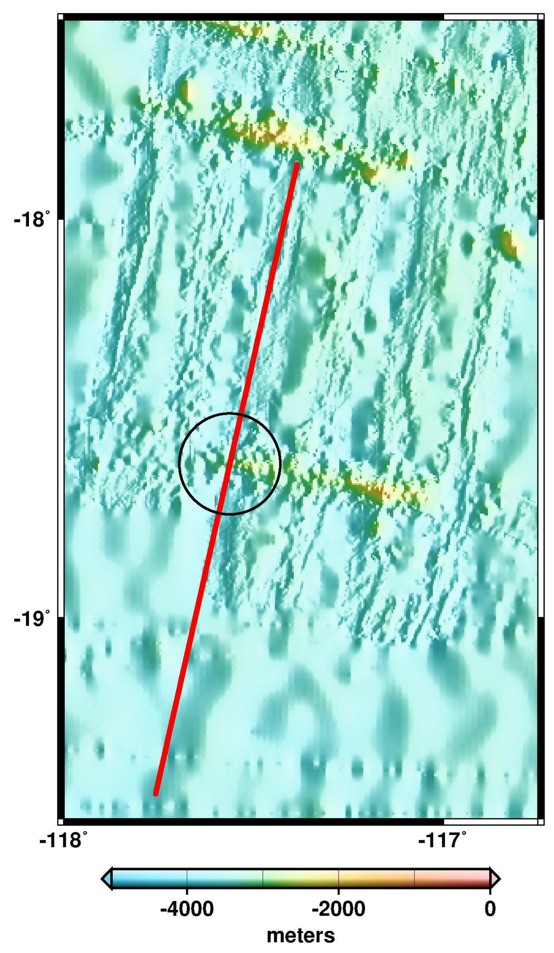


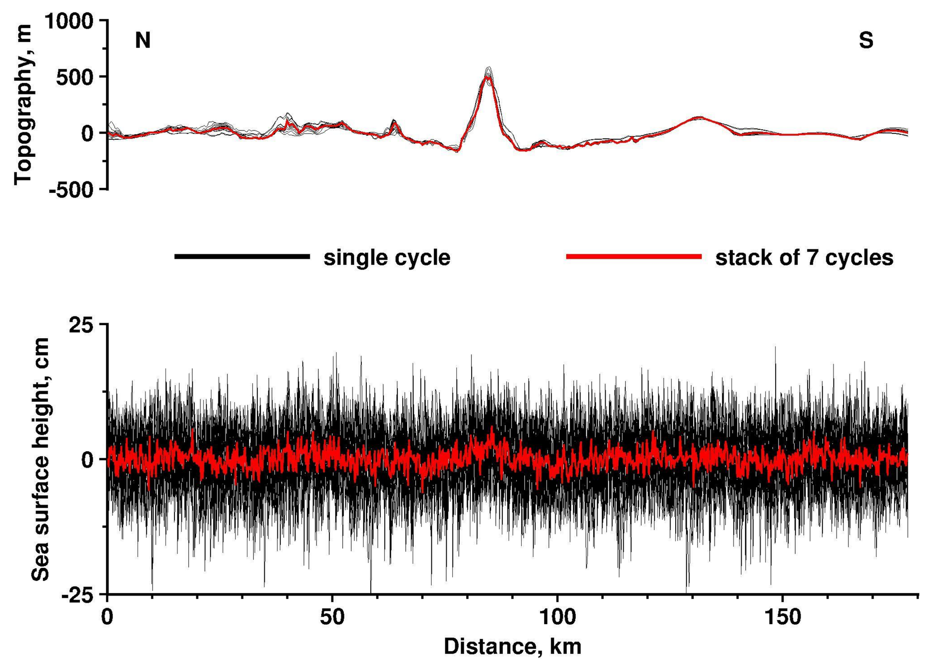
- Coherence estimates the correlation between topography and geoid height as a function of wavelength
- Coherence from one cycle of data resolves anomalies down to ~17 km full wavelength; stacking 9 repeat cycles resolves down to ~10 km
- Shorter-wavelength anomalies and hence smaller seamounts are resolved by stacking

2

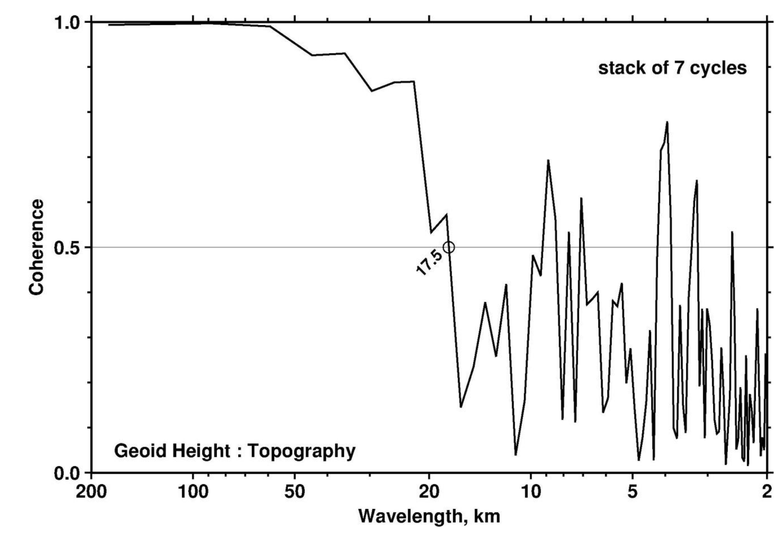
500 m tall seamount

- AltiKa pass 0282 (red) crosses seamount (circled) that is 500 m tall
- Some multibeam data were ingested into SRTM15_Plus in this study area

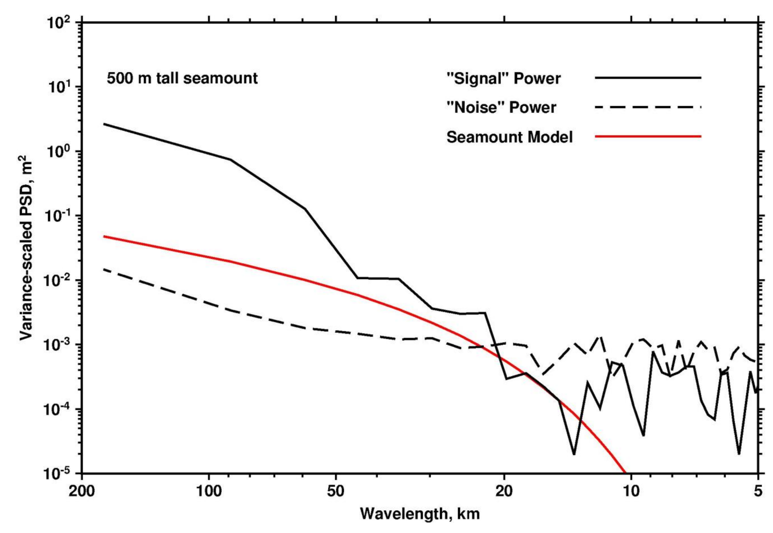




- 7 repeat cycles were stacked over 500 m tall seamount
- Noise in individual cycles (black lines) obscures seamount signal
- Seamount signal is barely perceptible in stacked profile (red line)



- Coherence from stacking 7 repeat cycles resolves anomalies down to ~17 km in full wavelength
- This seamount has a basal diameter of about 11 km, a little smaller than resolved by coherence analysis

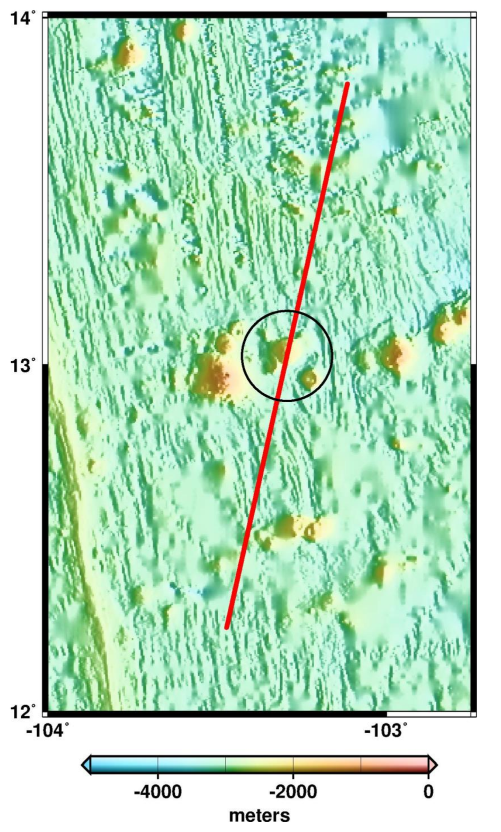


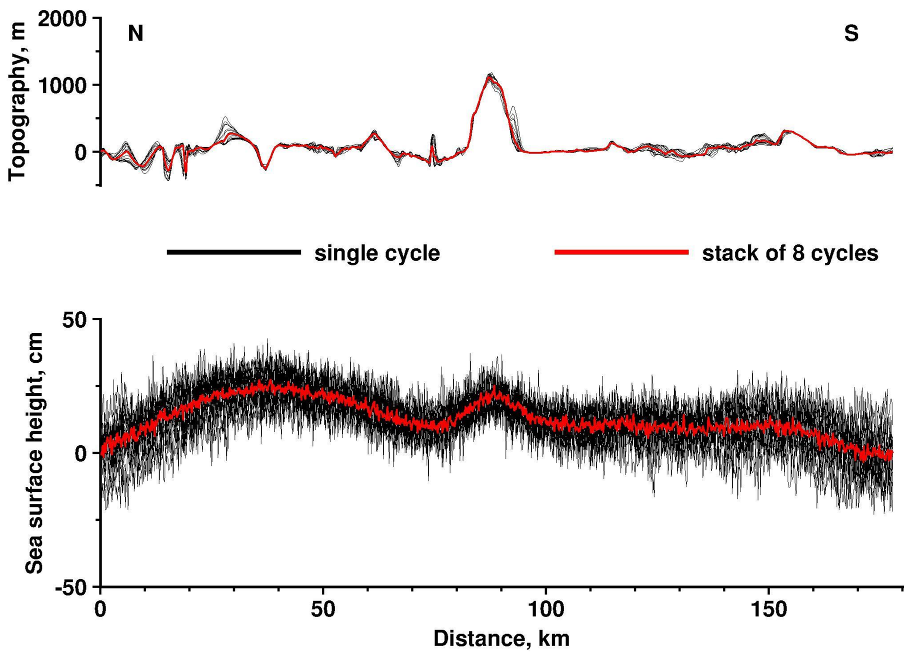
- Cross-spectral analysis from 1024 random combinations of height profile pairs
- "Signal" power is less than "noise" power at wavelengths shorter than about 20 km, making this 500 m tall seamount hard to detect

3

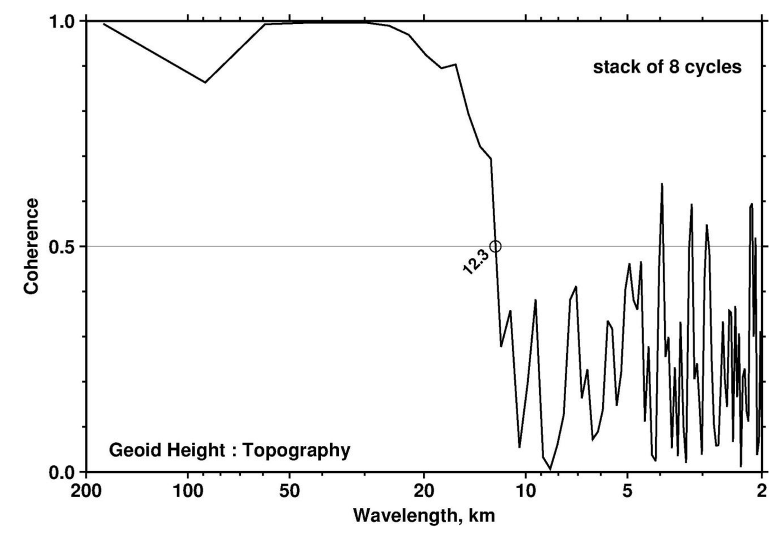
1080 m tall seamount

- AltiKa pass 0854 (red) crosses seamount (circled) that is 1080 m tall
- Multibeam data were ingested into SRTM15_Plus in this study area

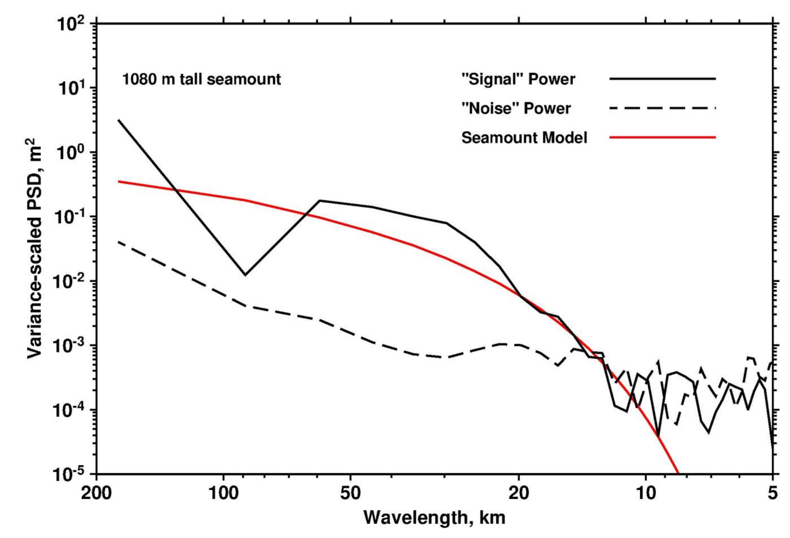




- 8 repeat cycles were stacked over 1080 m tall seamount
- Seamount signal is evident in stacked profile (red line)



- Coherence from stacking 8 repeat cycles resolves anomalies down to ~12 km in full wavelength
- This seamount has a basal diameter of about 12 km and is resolvable in coherence analysis



- Cross-spectral analysis from 1024 random combinations of height profile pairs
- "Signal" power is more than "noise" power at wavelengths longer than about 12 km, so this 1080 m tall seamount is easy to detect

GEBCO 2015 Kuala Lumpur, Malaysia