The Global Distribution of Small Seamounts along SARAL/AltiKa Altimeter Tracks

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Abstract

Seamounts can be habitats and hazards to submarine navigation, and their distribution reveals the volcanic history of the oceans. As only a few percent of ocean floor has been sounded, seamount distribution must be mapped by satellite altimetry. Wessel (doi:10.1029/2000JB000083) looked at data from an earlier generation of altimeter technology and suggested that all seamounts 2 km and taller had been found, but there might be as many as 50,000 seamounts between 1–2 km tall that were not yet found. The AltiKa altimeter delivers more precise sea level measurements at a higher along-track sampling rate than previous altimeters. These data resolve small seamounts not previously resolvable (Smith, doi:10.1080/01490419.2015.1014950), particularly if repeat-track profiles are "stacked" and band-pass filtered (Marks and Smith, doi:10.1007/s11001-016-9293-0). These two studies looked at only a few isolated locations where multibeam acoustic depth sounding surveys were available for "ground truth" for tuning a band-pass filter to detect the small seamount geoid signal. In the new work we present here we have stacked 32 repeat cycles of SARAL AltiKa data world-wide, and band-pass filtered the stacks, to yield 75,208 potential seamount locations distributed between +/- 81.5 latitude throughout the global ocean. These locations are detected as local maxima in the filtered geoid at least 2 cm above background and with a full-width at half-maximum (FWHM) at least 4 km wide. Of these, 4824 detections were over multibeam surveys. We assign a proxy seamount height to each by subtracting the regional SRTM30 depths from the multibeam depths. These proxy heights follow a Poisson statistical distribution similar to that which fits acoustic bathymetry profiles over seamounts (Jordan et al., doi:10.1029/JB088iB12p10508). We are currently investigating how to derive proxy heights from anomaly amplitude and FWHM, optimizing the trade-off between false negative and false positive detections, and whether it is possible to identify potential seamounts that may pose hazards to submarine navigation.

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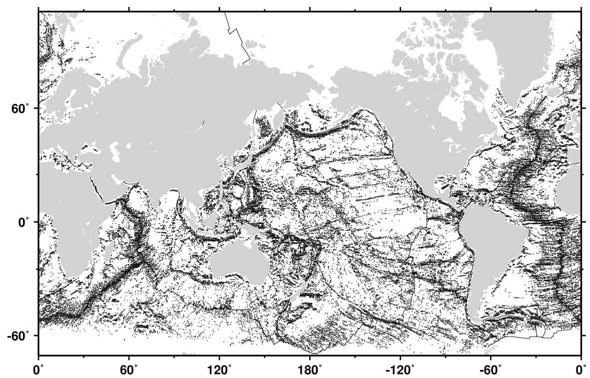
Get the stacked data

Stacked sea surface heights available from NCEI

- Download from NCEI Data Repository Assession 0174134 (http://accession.nodc.noaa.gov/0174134)
- Marks and Smith, 2018 (doi:10.25921/8hk9-fk45)
- NetCDF file records contain longitude, latitude, number of cycles, sigma, and stacked sea surface height (geoid) for all 1002 AltiKa altimeter passes

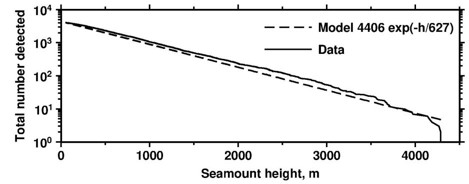
Results

75,208 Detected Features



- 32 repeat cycles of SARAL AltiKa data were stacked and band-pass filtered
- Features are detected where stacked and filtered local maxima are > 2 cm above background with a full-width at half maximum ≥ 4 km wide
- These are located in ocean basins and along tectonic features such as fracture zones and plate boundaries
- Previous seamount census study (Wessel, doi:10.1029/2000JB000083) based on gridded marine gravity data from older altimeter technology identified 14,675 seamounts taller than 2 km
- Our study that used height profiles from AltiKa detects 75,208 features down to almost 0.5 km tall

Seamount Heights follow Poisson-type Distribution



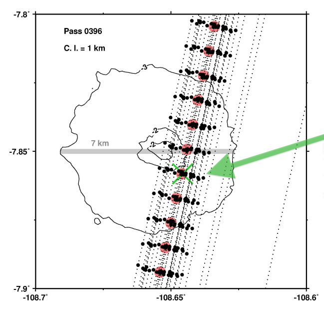
- Of the 75,208 points shown at left, only 4824 are located over multibeam depth surveys. We estimated the seafloor feature heights by subtracting regional SRTM30_PLUS depths from the multibeam depths at each of these 4824 points.
- If we plot the cumulative number of features found versus the assigned feature heights, we get the plot above
- These heights follow a statistical Poisson distribution similar to that which fits acoustic bathymetry profiles over seamounts (Jordan et al., doi:10.1029/JB088iB12p10508)
- This model suggests at least 84% are less than 2 km tall

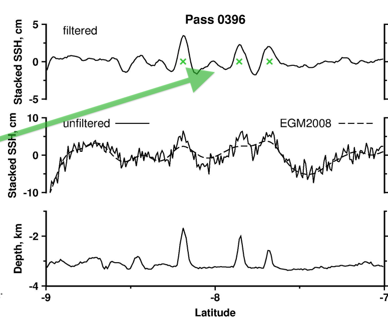
How we stacked the profiles

Method

- Create model ground tracks with samples spaced about 1 km apart (red circles) to match AltiKa repeat mission tracks
- Use sea surface height (SSH) data from the first 32 AltiKa repeat cycles at full 40 Hz along-track sampling rate (small black dots)
- Align multiple repeat cycle data points that are closest to each model sample point and less than 1 km away (heavy black dots).
- Select 1024-point long repeat cycle segments from 40 Hz data that pass quality criteria and are centered on model sample points
- Remove long-wavelength non-geoidal signals from the SSH repeat cycle segments by subtracting the differences between SSH and the EGM2008 geoid – this procedure leaves geoid anomalies
- Calculate the median (i.e., the stacked) profile from the center points of the aligned and height-adjusted repeat cycle segments
- Green "X" marks seamount detection

Filtered and Unfiltered Stacks



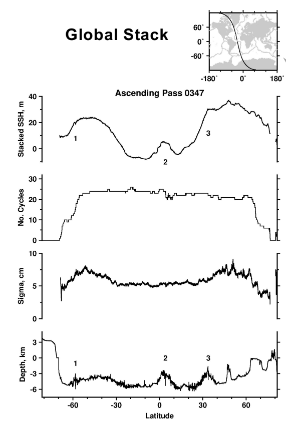


- Seamount detection filter applied to stacked repeat cycle segments sampled at 40 Hz
- Small 1280 m tall seamount (middle green "X") has 3.6 cm local maxima and is only 7 km wide (see figure to left)

- Unfiltered stacked SSH at model track points (solid line)
- Geoid from EGM2008 (dashed line) follows but does not reach unfiltered stacked SSH amplitudes, demonstrating our method essentially produces geoid anomalies, but at higher resolution
- Linear trend removed for display

- Multibeam depths (from Cochran et al., doi:10.1007/BR01204152)

Global Stack



- Pass 0347 crosses (1) North Weddell ridge, (2) Mid-Atlantic ridge near Saint Paul FZ and (3) near Hayes FZ

- Stacked sea surface height profile along model ground track
- Number of cycles used in stack
- Sigma, the expected error in a single measurement
- Bathymetry from SRTM30_PLUS

- Manuscript published in AGU's Earth and Space Science (Marks and Smith, 2018, doi:10.1029/2018EA000440)

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