Towards an Error Budget for Single- and Multi-Beam Data

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Mapping the ocean basins requires a combination of single- and multi-beam depth measurements to obtain the most complete coverage. In order to give each data source proper weight, one should have a model for the expected uncertainty in each measurement. We are developing an error budget for single- and multi-beam data by comparing their values in areas where survey tracks overlap.

We present here preliminary results from some overlapping survey lines near the Caroline Islands of Micronesia, in the western Pacific Ocean. Ships proceeding between Guam and New Guinea frequently take the same course in this area, as there are only a few north-south passages between the atolls, as shown at right.

Before doing this analysis, we expected that single-beam data would be much less accurate than multi-beam data, and that single-beam would measure the shallowest point within the ensonified cone. Both assumptions seem to be wrong. We find that multibeam measurements are repeatable to within about 0.25% of depth, though errors are systematic and apparently due to roll bias. Single-beam data seem at least as accurate as multibeam.

Red dots are MR00-K08 ping points; red lines are from swath data gridted at 0.1 (roughly 200 m) spacing.

- Red dots are from MR02-K01 ping points; green lines are from swath data gridted at 0.1 spacing.
- Black star is single-beam sounding from MW9204
- 0.1 grids from swath bathymetry accurately honor ping data points here.
- The center portions of the overlapping profiles have similar depths.
- Differences in depths between MR00-K08 and MR02-K01 increase towards the outer edges of the profiles.

Red and green dots locate the profiles shown to the left.

- The image shown is the difference between MR00-K08 and MR02-K01 bathymetry grids, each made at 0.1 arc-minute.
- There is a systematic difference, an east-west tilt, which might be due to a roll bias error in one or both swaths.
- The largest differences are around 10 m. If we assume each swath system is equally in error, the error is ~0.1% of depth (here, ~9 m).

We anticipated that the reported single-beam depth would be the shallowest depth in its ensonified cone.

However, we find that single-beam depths are systematically deeper than the shallowest multibeam depth found in the cone. It is possible that the single-beam system does a rather good job of averaging the depths within the patch it samples.

Histograms of the differences show the same offsets, and a surprise in the spread of the distributions.

- There is a ~10 m median offset of MR00-K08 multibeam minus MW9204 single beam data (green error bars).
- MR00-K08 multibeam depths are about the same as single-beam depths at corresponding locations.
- MR02-K01 multibeam depths (directly beneath MW9204 locations) are systematically ~10 m deeper than the corresponding single-beam depth.
- Assuming navigation of all is good, MW9204 samples the east side of the MR00-K08 swath and near the center of the MR02-K01 swath. Do these results suggest there is no roll bias in MR00-K08?

Histograms of differences show the same offsets, and a surprise in the spread of the distributions.

- There is a ~10 m median offset of MR02-K01 multibeam minus MW9204 single beam data (green error bars). The fact that MW9204 runs nearly down the middle of the MR00-K08 swath.
- The median offset of MR02-K01 multibeam minus MW9204 single beam is only ~4 m (red line), despite the fact that MW9204 runs along the eastern edge of the MR00-K08 swath.
- The histogram of differences between multibeam depths from MR02-K01 and MR00-K08 (black bars) appears wider than the red and green histograms of differences between multibeam and single-beam depths. This suggests single-beam measurements are more accurate as multibeam measurements.

Note this implies we can use old single-beam to find errors in new multibeam data!