Interpolating Across Gaps in Bathymetric Surveys: The Value of Altimetry

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Abstract. Ship surveys of ocean depths are sparse, unevenly spaced, and there are gaps as large as 10^5 km^2 between ship tracks. These gaps may be filled in by various interpolation schemes or by more sophisticated methods that combine depths derived from satellite gravity data with ship measurements to produce altimetric bathymetry models.

We examine a small area in the western Pacific Ocean that encompasses a number of seamounts and has large gaps in ship survey coverage. Ship depth measurements from these surveys were interpolated using GMT routines “surface” and “nearneighbor” and the results are compared to swath multibeam data made available by the Japan Agency for Marine Earth and Science Technology (JAMSTEC) and to the Smith and Sandwell altimetric bathymetry model (version 12.1*). The GEBCO_08 grid is based on Smith and Sandwell model version 11.1 and other data.

Seamounts located in the gaps between ship surveys are not detected by interpolation schemes. But the altimetric bathymetry model detects these seamounts because the gaps are filled in with depths predicted from satellite gravity anomalies that reflect the underlying seafloor topography.

Our comparisons yield “errors” that we define as the difference between JAMSTEC multibeam depths and the interpolated (or modeled) depths. These errors are plotted against distance from ship controls. Interpolation results from the GMT routine “surface” with a tension set to 0 have the largest errors (> 2250 m), and when the tension is 1, the errors are smaller (< 1250 m). Interpolation results from the “nearneighbor” routine are intermediate (< 2000 m). The smallest (mostly < 500 m) errors are from the differences between the JAMSTEC multibeam depths and the altimetric bathymetry model.

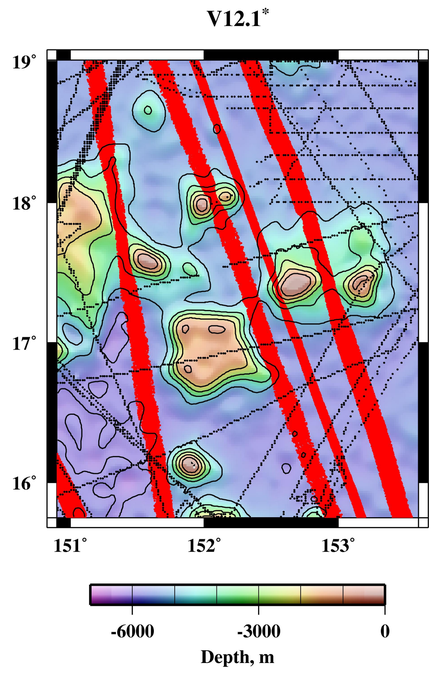
Histograms of the errors reveal more details. The negative errors (interpolated depths are deeper than multibeam depths) of “surface” with tension set to 0 are due to the elongated shapes in the interpolation, when in fact the shapes of seamounts are more circular.

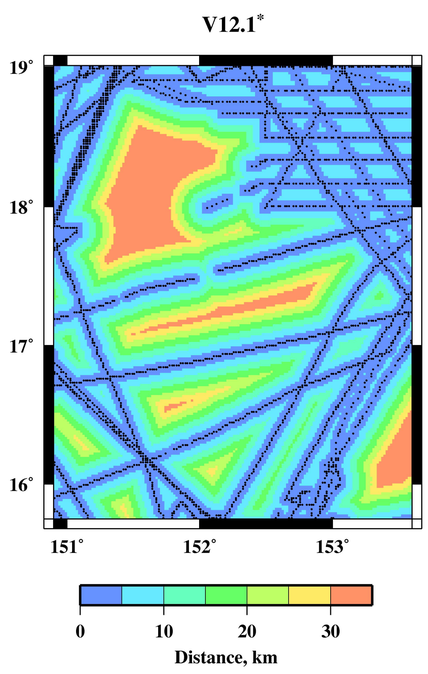
The altimetric bathymetry model matches JAMSTEC multibeam better than gap-filing by interpolation routines.

Study Area

- Short-wavelength (<160 km) marine gravity anomalies reflect underlying seafloor topography
- Altimetric bathymetry model combines depths derived from satellite gravity data with ship soundings
- Black dots are model grid cells constrained by ship soundings
- Bathymetry model V12.1* was constructed without JAMSTEC multibeam data for testing purposes; publicly released V12.1 included JAMSTEC data
- Red dots are locations of selected JAMSTEC multibeam swaths
- Bathymetry derived from satellite gravity detects seamounts that are located in gaps between ship tracks

We thank JAMSTEC (Japan Agency for Marine Earth Science and Technology) for making their multibeam data freely available (http://www.jamstec.go.jp/cruisedata/e/).





Distance to Control

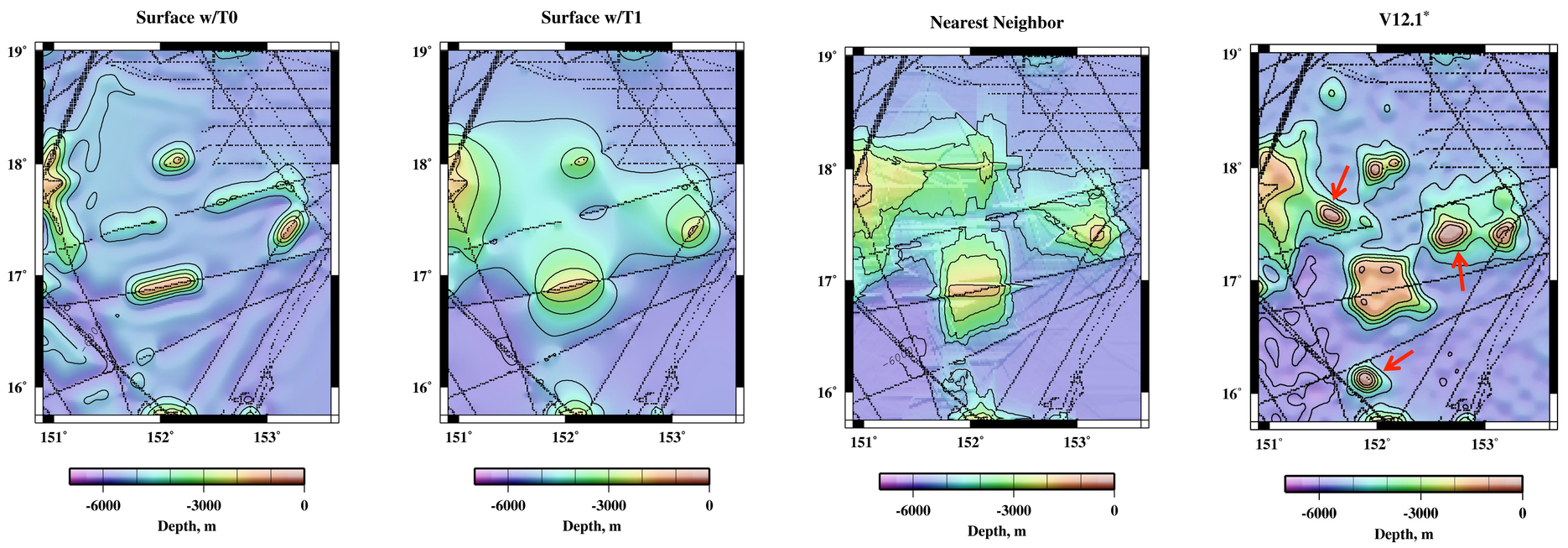
- Map shows distance to nearest sounding used to constrain bathymetric model V12.1*
- Black dots are model grid cells constrained by ship soundings
- Distance to control can exceed 30 km
- There are large gaps between ship surveys

Filling the Survey Gaps

- Gaps can be filled using interpolation schemes
- Interpolating only from surrounding ship soundings may not detect features in gaps
- Some interpolation schemes may perform better than others
- Altimetric models fill the gaps with depths estimated from satellite gravity data

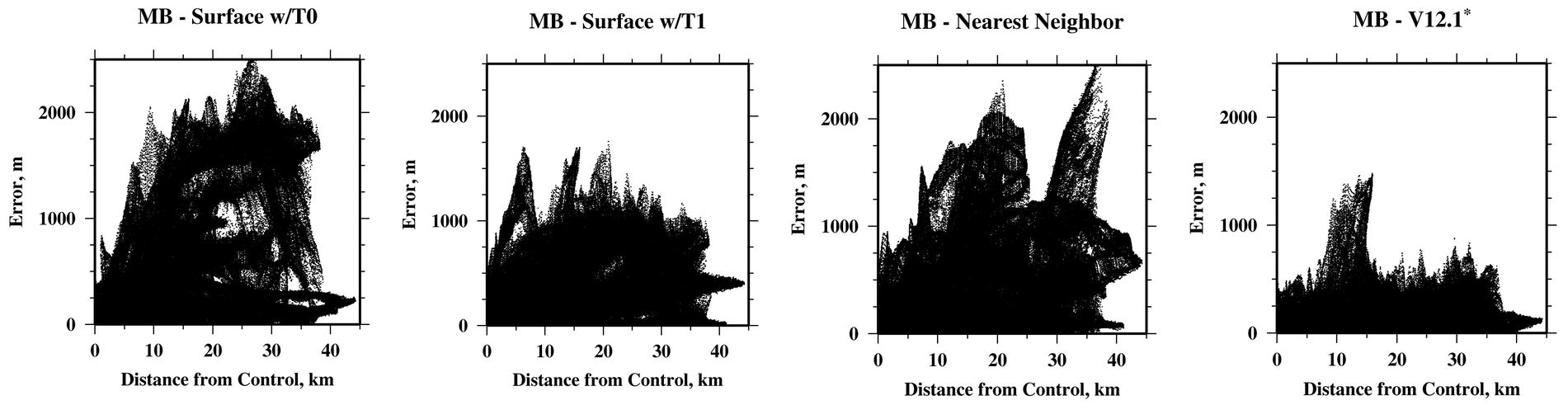
Interpolation Schemes

- We use GMT routines “surface” and “nearneighbor” to grid ship soundings in V12.1
- We set “surface” tension (T) to “0” (minimum curvature solution) and “1” (harmonic surface where minima and maxima are only possible at control points)
- “Nearneighbor” uses nearest neighbor algorithm to assign distance-weighted average value within radius (100 km) centered on a node
- No interpolated solution detects seamounts in gaps between ship soundings
- Altimetric bathymetry model V12.1* detects seamounts in gaps between ship soundings (red arrows)



Interpolation Errors

- Errors are differences between JAMSTEC multibeam depths and interpolated (or model) depths, plotted against distance from control
- “Surface” with tension of 0 has largest (>~2250 m) errors, tension of 1 has smaller (<~1250 m) errors
- “Nearneighbor” errors are intermediate (mostly <~2000 m)
- Bathymetry model V12.1* has smallest (mostly <~500 m) errors
- Different interpolation schemes produce different solutions (and errors) even with same depth controls
- V12.1* detects seamounts because satellite gravity anomalies reflect underlying seafloor topography



Error Histograms

- Errors are depth differences between JAMSTEC multibeam depths and interpolated (or model) depths
- “Surface” with tension of 0 has the largest errors and they are generally negative (interpolated depths are deeper than multibeam depths)
- Errors in “surface” with tension of 1 and nearneighbor solutions are smaller partly because interpolated features are more circular in shape (not elongated as for tension of 0)