Error Analysis of the Altimetric Bathymetry Model

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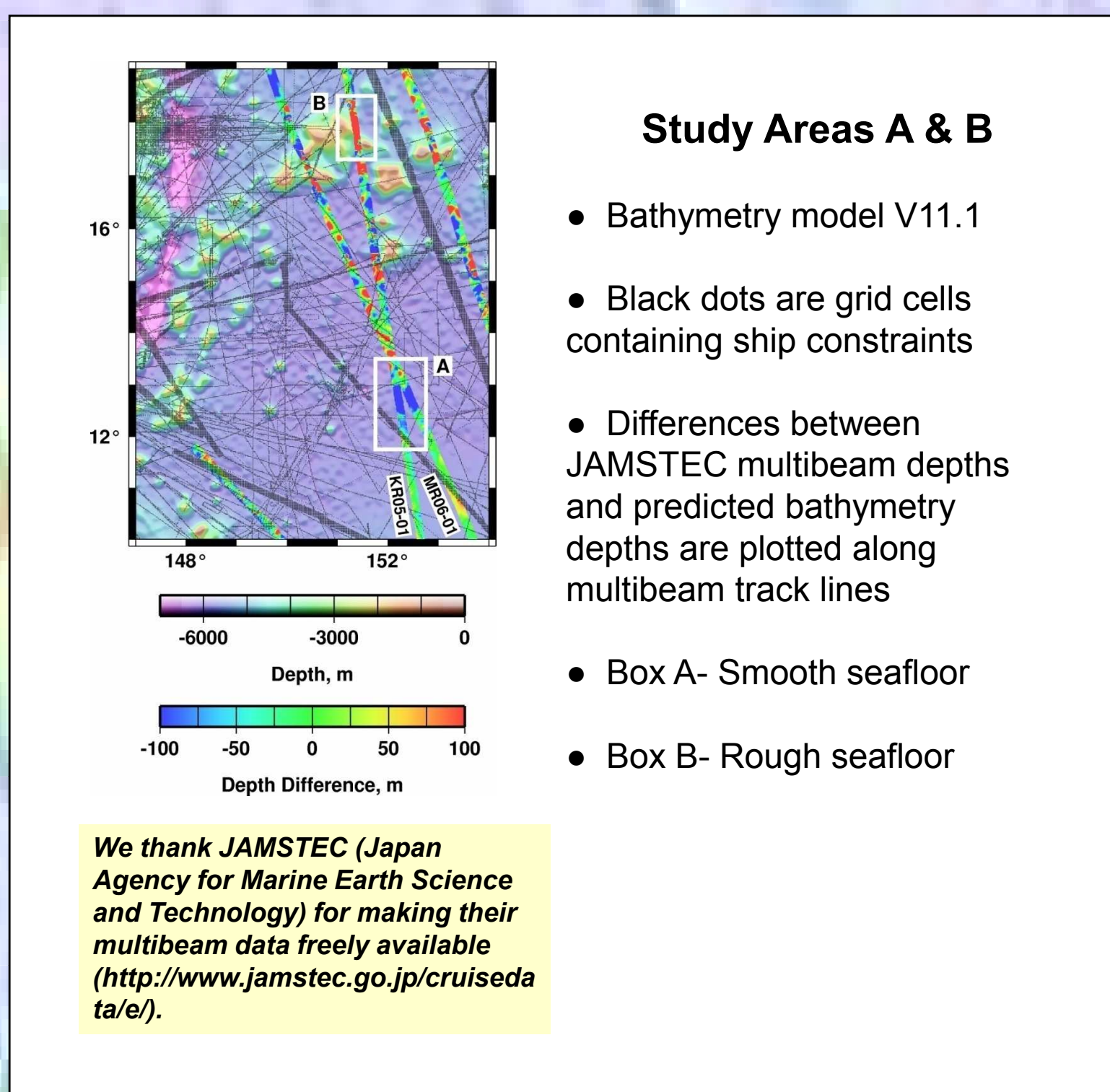[2]Scripps Institution of Oceanography, La Jolla, California, USA

Abstract. The altimetric bathymetry model combines depths derived from satellite gravity data with in-situ data such as soundings and shorelines. We used JAMSTEC multibeam surveys as "ground truth" to test versions of these models. This has revealed two kinds of problems. One is a biased scaling from gravity in milligals to topography in meters in the altimetry prediction band (15-160 km wavelengths). The other is that regionally averaged (> 160 km wavelength) depths seemed to accumulate error over successive versions of the model. These problems were not in version 8.2 but crept in subsequently, and have been mostly mitigated in version 12.1.

The prediction-band errors are particularly evident over a patch of smooth seafloor that lay in a large area unconstrained by ship observations (Box A). Bathymetry versions 9.2, 9.1, 10.1, and 11.1 show errors in depth approaching 150 m, that increase with distance from constraint, and that also increase with successive versions. The depth errors were less than 100 m in bathymetry version 8.2. After correcting the scaling problem, errors in version 12.1 are comparably small. Results are similar over a rough area of seafloor (Box B).

The long-wavelength errors are evident in a focus area in the north Pacific Ocean (Panel C), where the errors bleed even through grid cells having ship constraints. Initializing the 12.1 model to start from S2004 has mostly corrected this problem.

Our analysis of bathymetry version 12.1 (Panel D) reveals that errors are not a function of depth. We find that 50% of the depth errors are less than 50 m (or 1% of depth), and that 90% are less than 220 m (or less than 5.5% of depth).

Study Areas A & B

- Bathymetry model V11.1
- Black dots are grid cells containing ship constraints
- Differences between JAMSTEC multibeam depths and predicted bathymetry depths are plotted along multibeam track lines
- Box A- Smooth seafloor
- Box B- Rough seafloor

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

Bathymetry Grid Attributes

Version	Spacing	Node	Projection	Coverage	Released	Based on	Notes
V8.2	2' longitude	pixel	Mercator	global ± 72°	Nov. 2000	9.1 gravity	
S2004	1' longitude	grid	geographic	global	April 2004	9.1 gravity	V8.2 below 1000 m and equatorward of 72°, GEBCO in shallow water and polar regions
V9.2	2' longitude	pixel	Mercator	global ± 80.738°	April 2007	16.1 gravity	
V9.1	1' longitude	pixel	Mercator	global ± 80.738°	Aug. 2007	16.1 gravity	changed to 1 grid, new data added, NOAA, NGA, NAVO, SIO effort
V10.1	1' longitude	pixel	Mercator	global ± 80.738°	May 2008	18.1 gravity	bad track editing and refined grid
V11.1	1' longitude	pixel	Mercator	global ± 80.738°	Sept. 2008	18.1 gravity	editing and NOAA data added
V12.1	1' longitude	pixel	Mercator	global ± 80.738°	Aug. 2009	18.1 gravity	scaling correction and initialization from S2004

Box A- Smooth Seafloor

- Black dots are grid cells with ship constraints
- JAMSTEC multibeam data withheld in this V12.1 for testing purposes
- KR05-01 and MR06-01 multibeam data are plotted on V8.2 image; multibeam shows seafloor is flat, and V8.2 bathymetry is flat
- Beginning with version 9, the gravity-to-topography scaling was computed from 1-minute grids rather than 2-minute grids. 1-min sampling of ship tracks yielded increased topographic variance, causing the gravity-to-topography scale to be too large. This was corrected in version 12.
- Maps show distance to the nearest sounding used to constrain each version
- Errors are differences between KR05-01 and MR06-01 multibeam depths and predicted depths, plotted against distance to the nearest sounding constraining the prediction
- Dashed red line models V8.2 errors, solid red line models V11.1 errors
- Large errors in versions 9.2, 9.1, 10.1, and 11.1 result from scaling problem and from basing successive version on previous one
- Corrected scaling in V12.1 reduces errors to >~100 m
- Basing V12.1 on S2004 instead of preceding version also reduced long-wavelength errors

Box B- Rough Seafloor

- Black dots are grid cells with ship constraints
- JAMSTEC multibeam data withheld in this V12.1 for testing purposes
- KR05-01 multibeam data are plotted on V8.2 image; multibeam and predicted bathymetry map seamounts
- Gravity anomalies map seamounts
- Medium-wavelength anomalies associated with seamounts and ridges are correctly scaled in all bathymetry versions
- Maps show distance to the nearest sounding used to constrain each version
- Errors are differences between KR05-01 multibeam depths and predicted depths, plotted against distance from constraint
- Errors are largest (reaching ~800 m) in versions 9.1, 10.1, and 11.1
- Scaling correction reduces amplitude of errors in version 12.1
- Basing V12.1 on S2004 instead of preceding version also reduces long-wavelength errors

Panel C

Long-wavelength Errors

- Focus area located in northern Pacific Ocean
- Red dots are constraints from prediction with JAMSTEC multibeam, black dots are constraints from prediction without JAMSTEC (V11.1 on left, V12.1 on right)
- Depth differences between ± 20 m are colored white for clarity
- In V11.1 (on left), there are long-wavelength depth differences that can extend even through common constraints
- In V12.1 (on right), long-wavelength errors are greatly reduced
- Initializing from S2004 has led to improvements in V12.1
- Histograms show smaller depth differences in V12.1

Panel D

V12.1 Errors with Depth

- Global study region
- Plot shows V12.1 bathymetric prediction without JAMSTEC data, plotted against V12.1 prediction with JAMSTEC
- Errors are differences in 1-minute medians
- Dashed blue lines are the IHO S-44 95% confidence level for depth uncertainty, red line is 1:1 ideal; most depth errors are less than the S-44 standard
- Errors show no systematic correlation with depth

V12.1 Error Histograms

- Errors are depth differences between V12.1 with, and without, JAMSTEC multibeam data
- 50% of the errors are less than 50 m, or 1% of depth)
- 90% of the errors are less than 220 m, or 5.5% of depth
- 95% of the errors are less than 320 m, or 8% of depth