NGA Depth Data and Bathymetry Model V13

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Background

- Recent paper:
  - Analyzes errors in S&S bathymetry models through V12
  - Chronicles development of models through V12
- V13 released after paper was published
- V13 includes NGA depths
- Overview of V13 errors presented here

Evolution of errors in the altimetric bathymetry model used by Google Earth and GEBCO

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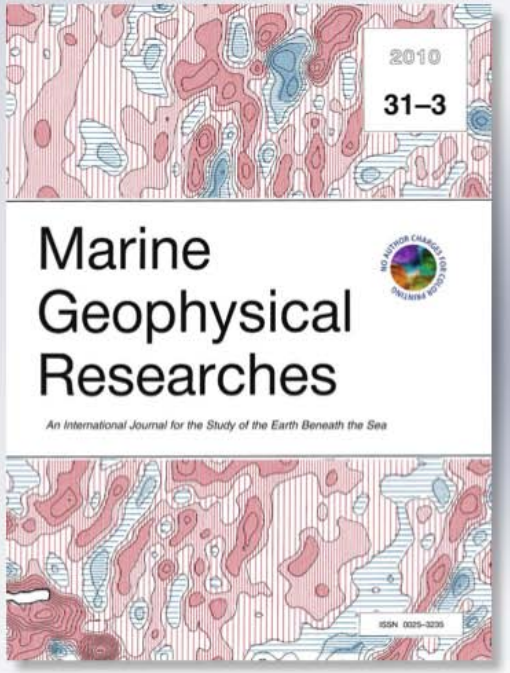


Springer

- Paper by Marks, Smith, and Sandwell, published Nov. 2010
- Analyzed errors in S&S global bathymetry models through V12
- V13 released after paper was published

Version	Released	Spacing	Node	Projection	Coverage	Gravity	Notes
S&S 7.2	June 1997	2' longitude	pixel	Mercator	± 72°	7.2	Smith and Sandwell (1997)
S&S 8.2	Nov. 2000	2' longitude	pixel	Mercator	± 72°	9.2	Refined transfer function
S2004[a]	Apr. 2004	1'	grid	geographic	global	9.2*	8.2 below 1000 m and equatorward of 72°, GEBCO[b] in shallow water and polar regions
S&S 9.2	Apr. 2007	2' longitude	pixel	Mercator	± 80.738°	16.1	New data added, NOAA, NGA, NAVO, SIO effort
S&S 9.1	Aug. 2007	1' longitude	pixel	Mercator	± 80.738°	16.1	Changed to 1' grid
S&S 10.1	May 2008	1' longitude	pixel	Mercator	± 80.738°	16.1	Bad track editing
SRTM30_Plus V4.0	May 2008	30 arc-seconds	pixel	geographic	global	16.1*	Based on S&S 10.1, limited data editing, used in Google Earth
S&S 11.1	Sept. 2008	1' longitude	pixel	Mercator	± 80.738°	16.1	Editing and new data added
SRTM30_Plus V5.0	Sept. 2008	30 arc-seconds	pixel	geographic	global	16.1*	Based on S&S 11.1, includes IBCAO[c] V2.0 north of 80°N
GEBCO_08[d] V20081212	Dec. 2008	30 arc-seconds	pixel	geographic	global	16.1*	SRTM30_Plus V5.0 and other data
GEBCO_08[d] V20090130	Jan. 2009	30 arc-seconds	pixel	geographic	global	16.1*	Artifacts removed
GEBCO_08[d] V20090202	Feb. 2009	30 arc-seconds	pixel	geographic	global	16.1*	Artifacts removed
GEBCO_08[d] V20091120	Nov. 2009	30 arc-seconds	pixel	geographic	global	16.1*	SRTM30_Plus V5.0, combined with IBCAO[c] V2.23 north of 64°N and other data
S&S 12.1	Aug. 2009	1' longitude	pixel	Mercator	± 80.738°	18.1	Scaling correction and initialization from S2004[a]
SRTM30_Plus V6.0	Nov. 2009	30 arc-seconds	pixel	geographic	global	18.1*	Based on S&S 12.1, includes IBCAO[c] V2.23 north of 80°N

* Only Smith and Sandwell (S&S) bathymetry models derive depths from satellite gravity data and combine them with acoustic data soundings and shorelines. Geographic bathymetry grids are resampled from S&S Mercator projection models.

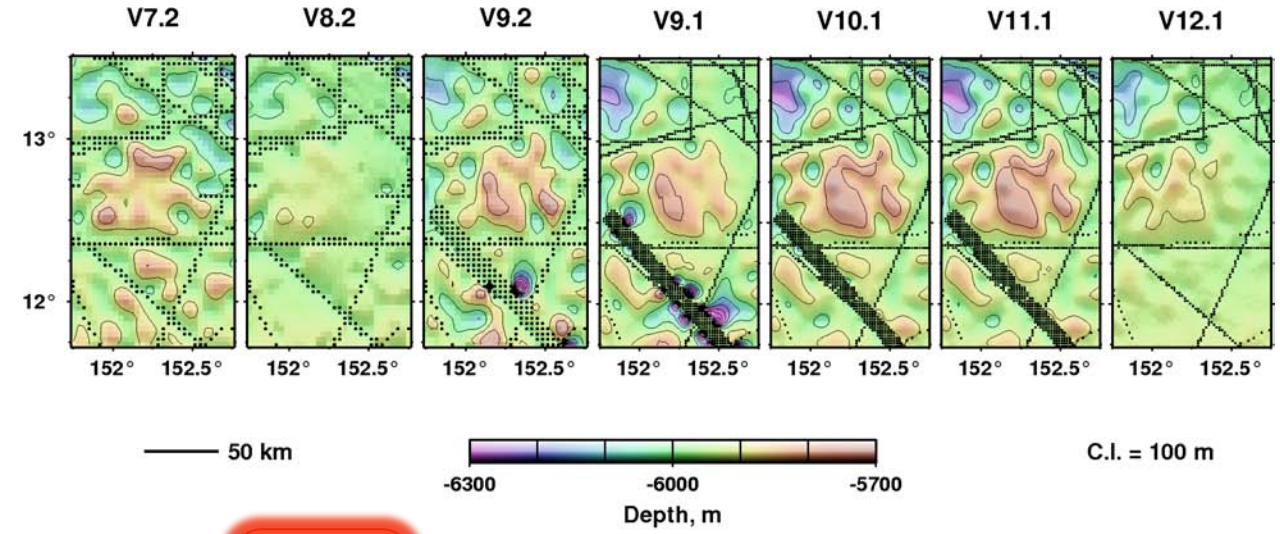
[a] Smith (unpublished); ftp://falcon.grdl.noaa.gov/pub/walter/Gebco_SandS_blend.bi2

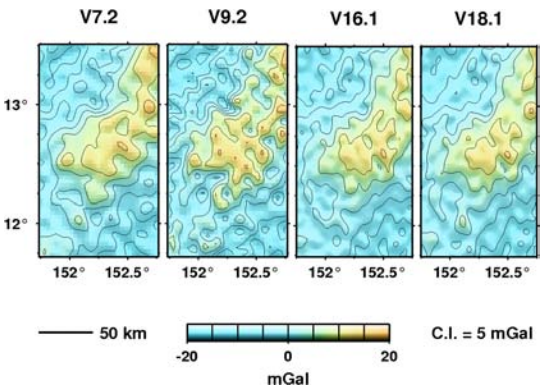
[b] British Oceanographic Data Center (2003)

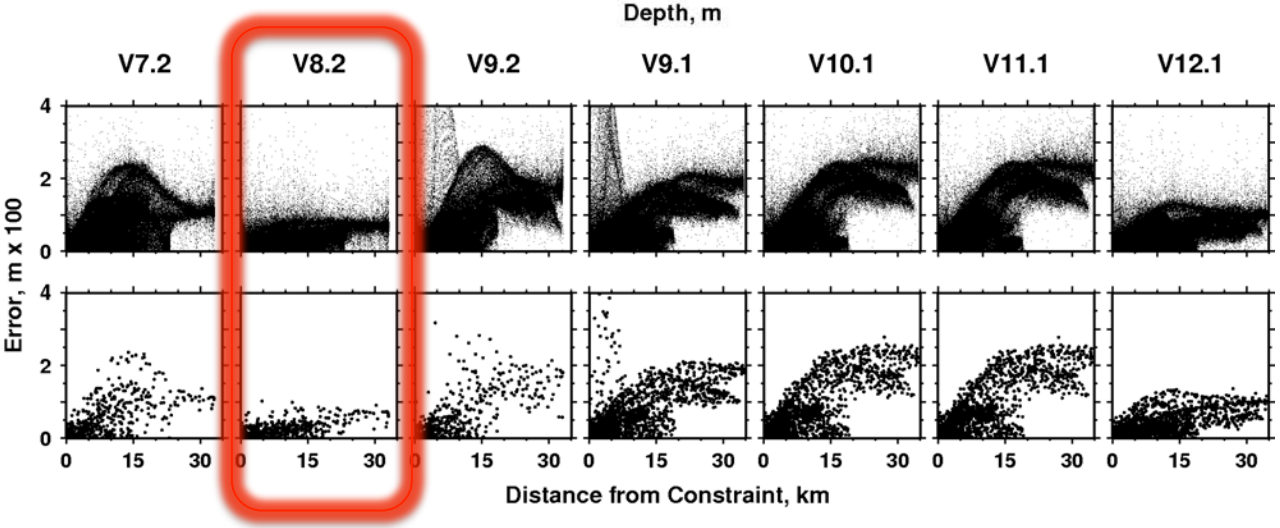
[c] Jakobsson et al. (2008)

[d] http://www.gebco.net

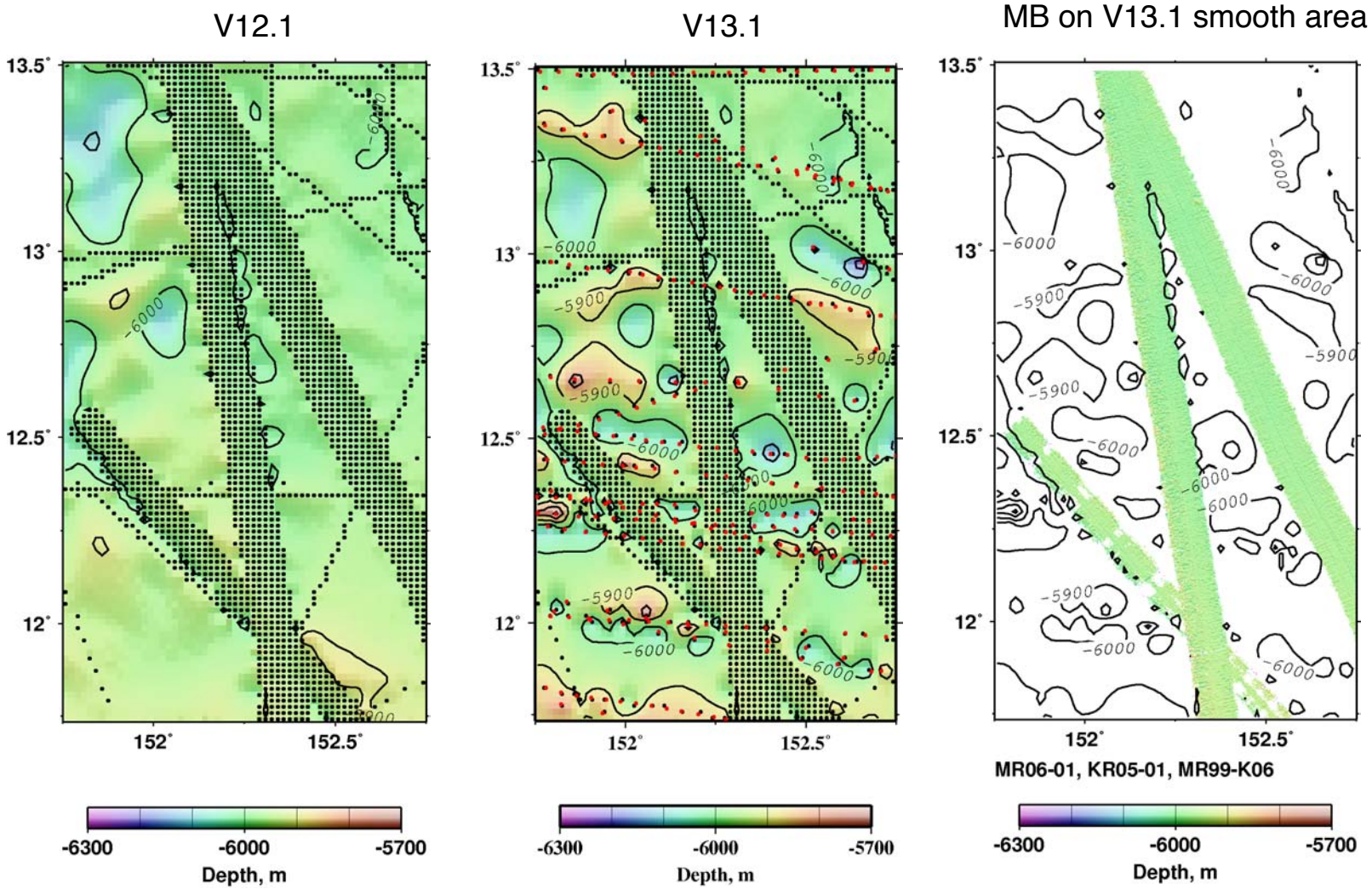
- Published table chronicles S&S bathymetry model through V12
- Lists grid attributes
- Notes development milestones
- Table needs update for V13





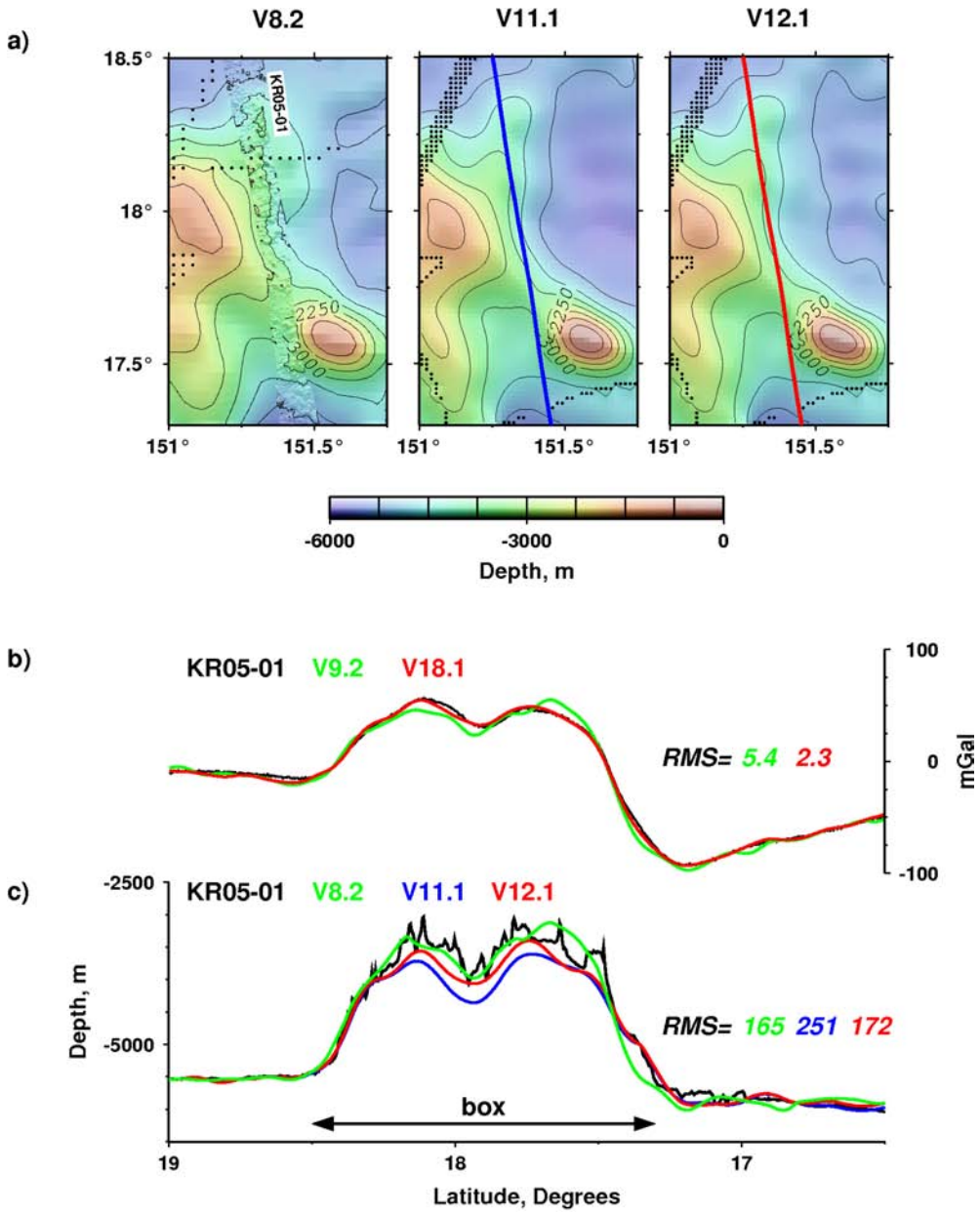


- As model evolved, new depth observations were added and prediction algorithms were improved
- We found a gravity-to-topography scaling error in V9-V11, which was fixed in V12
- Older version 8.2 had the smallest errors over smooth seafloor. It used a non-linear thresholding approach which ought to be incorporated into future versions



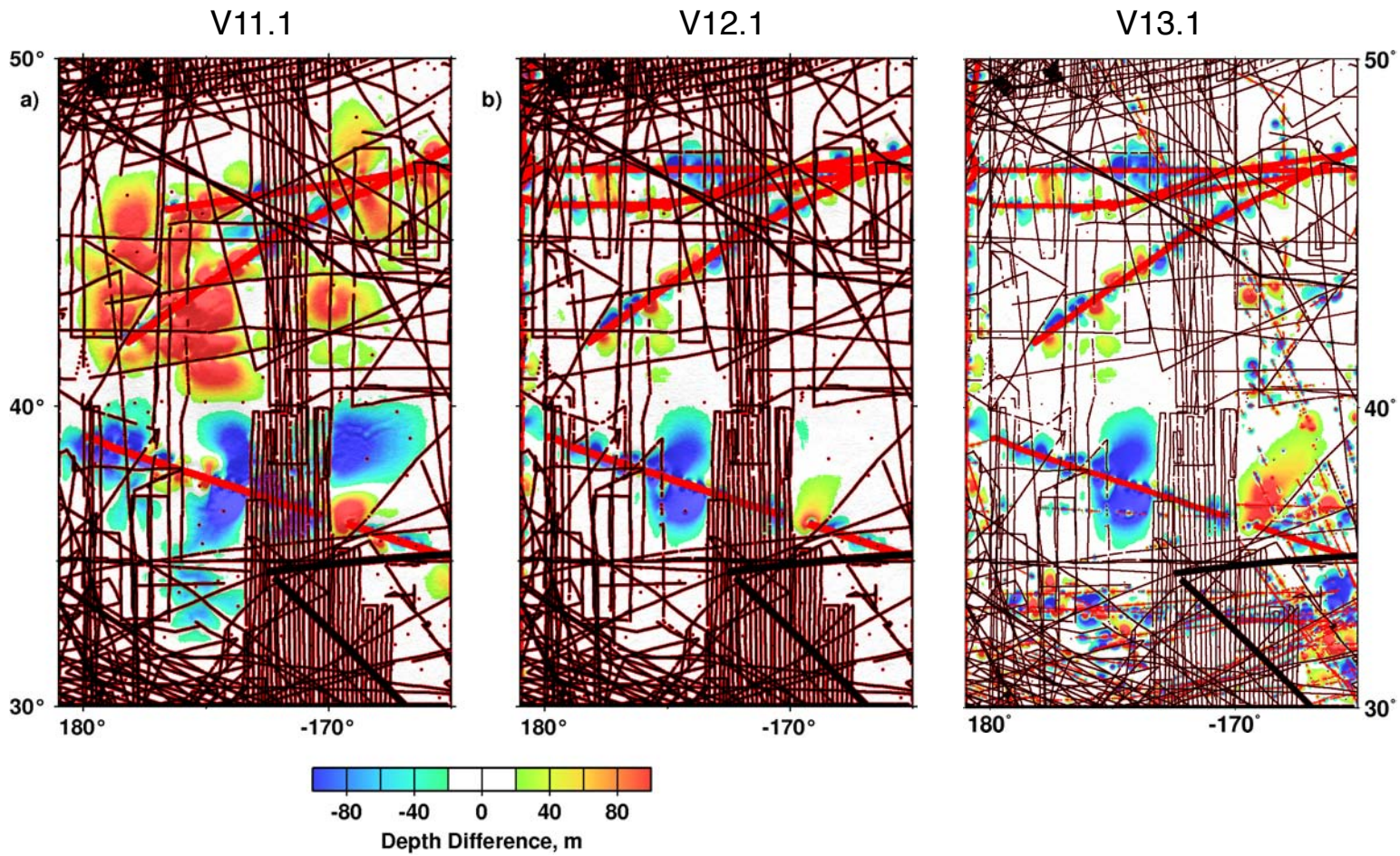
- Black dots are topography model controls, red dots are NGA points used in V13
- The addition of NGA depths to V13 makes smooth seafloor look rough
- MB shows seafloor is smooth
- Contours on MB plot (right panel) are from V13 (middle panel)

Rough Seafloor Area



- Non-linear prediction algorithm used in V8 captures seamount amplitude

- Seamount amplitude is attenuated in V11 and 12 that did not include non-linearity between gravity and topography in their prediction algorithms



- Depth differences are between version with JAMSTEC (controls are red dots) and without (controls are black dots), V13 is compared to V12 without JAMSTEC
- In V11, the impact of new data was allowed to diffuse over long distances, while in V12, it was not
- The long-wavelength component of V12 is based on S2004, which traces its heritage to V8.
- V13 incorporates NGA depths which may introduce errors

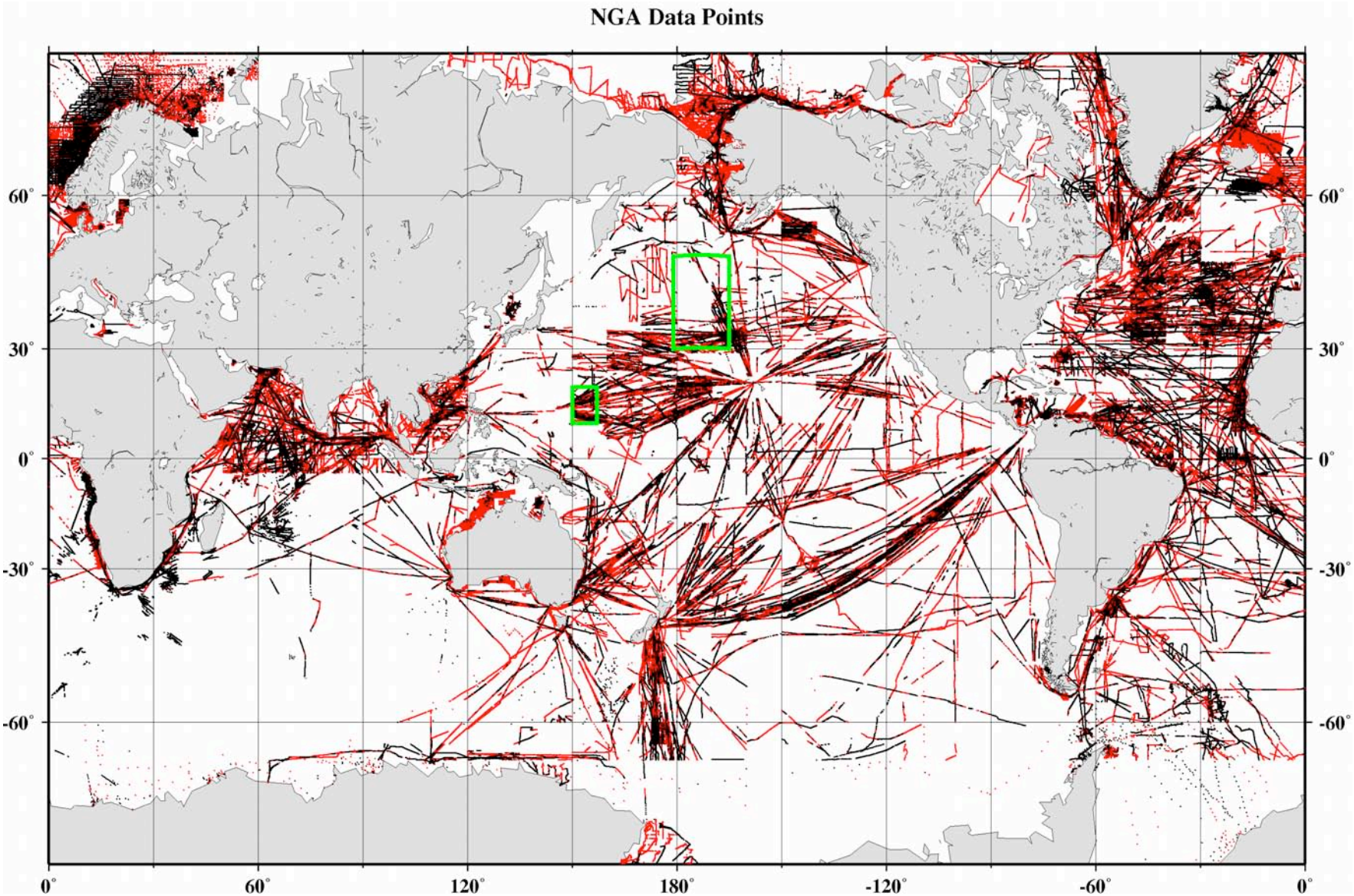
Sample NGA Data Records

Depth uncertainty

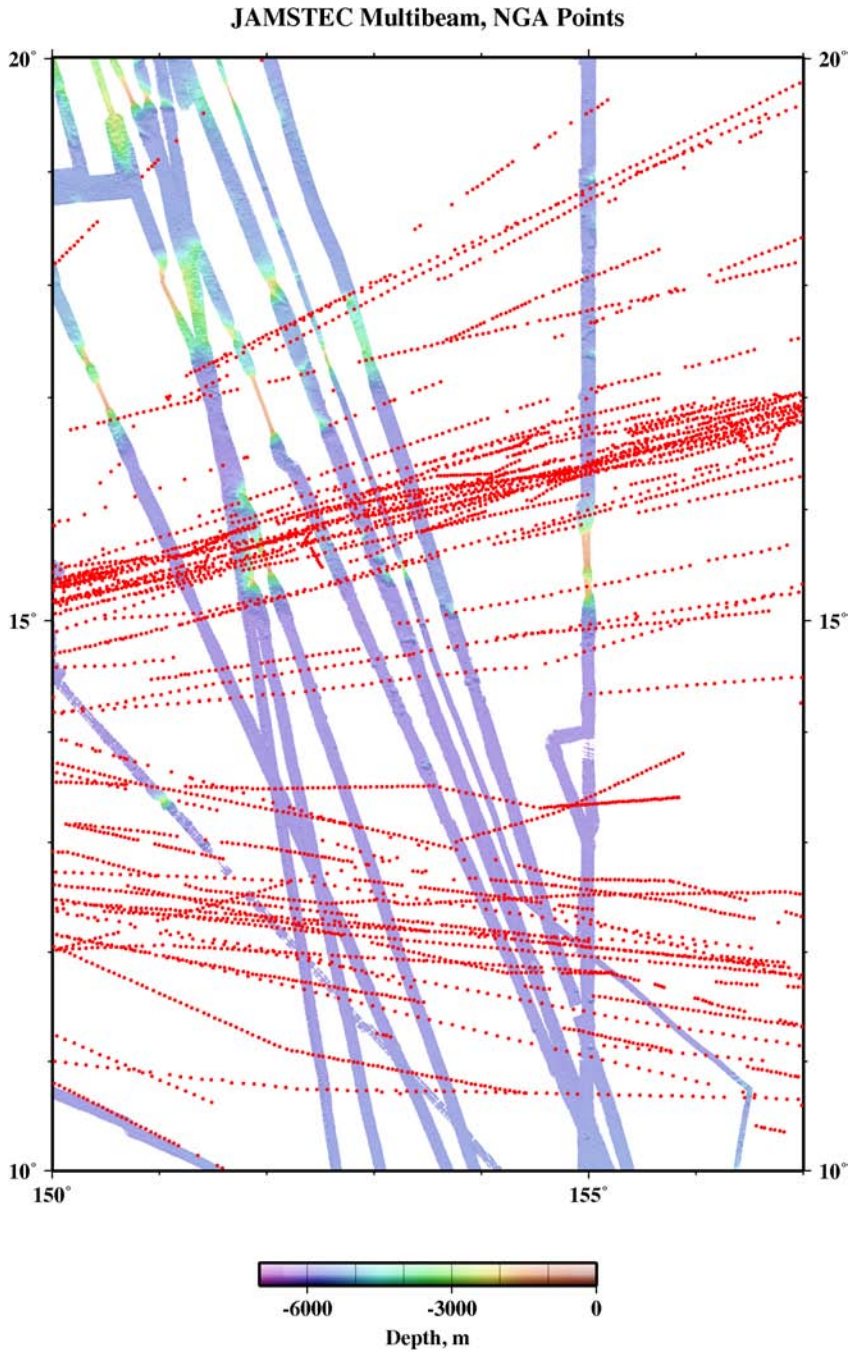
SID

```
74 -45.98025 51.02503 -4323 0 9999 16500 -3944
75 -41.57025 52.99506 -3789 0 9999 16500 -3582
76 -43.28325 52.50980 -4313 0 9999 16500 -4067
77 -44.86200 50.10982 -4284 0 9999 16500 -4021
78 -38.05325 51.08664 -3649 0 9999 16500 -3791
79 -38.11200 52.12663 -3563 0 -1 16500 -3564
80 -37.90350 50.00005 -4371 0 -1 16500 -4254
81 -38.05825 53.05983 -3832 0 -1 16500 -3649
```

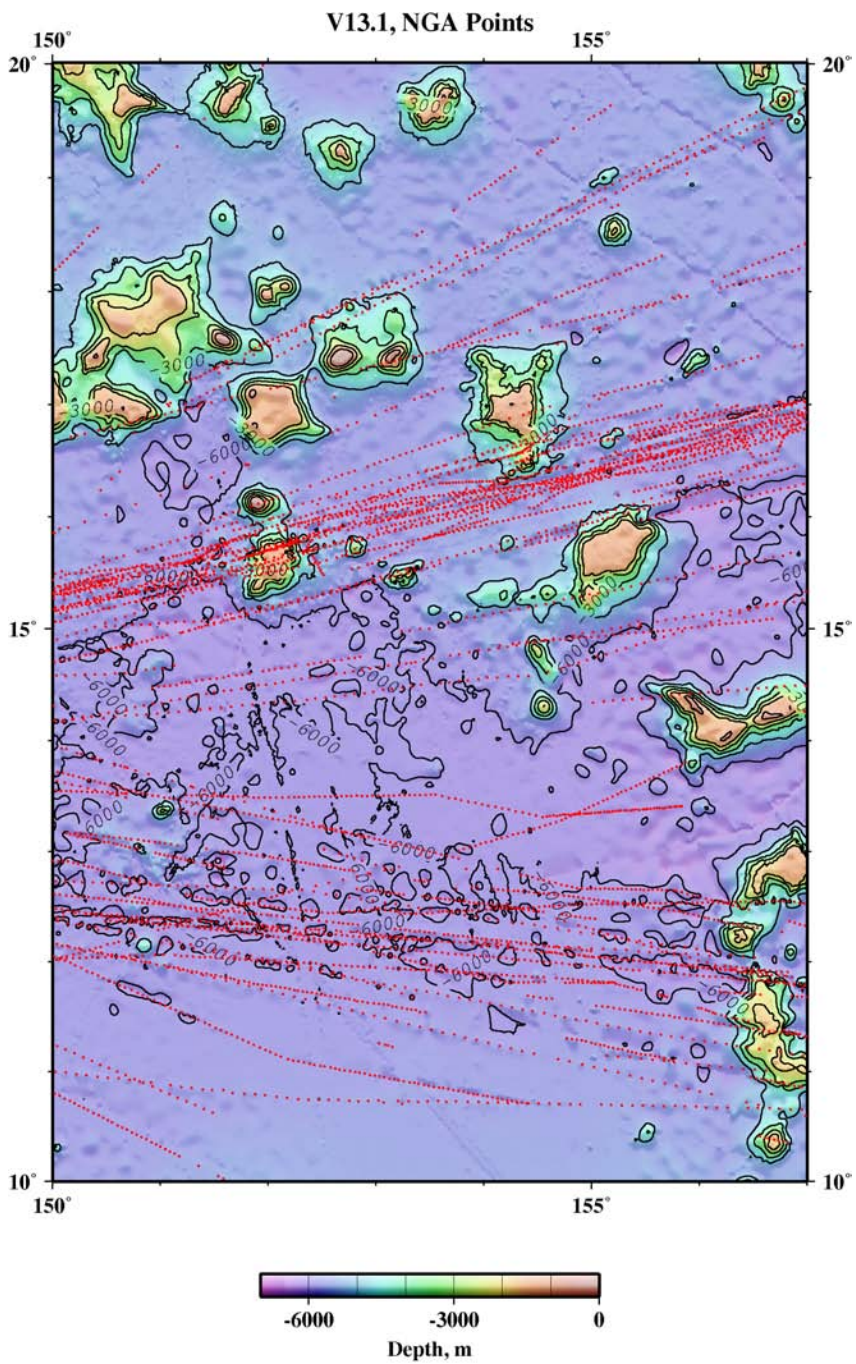
- “Bad” NGA data have depth uncertainties flagged 9999, and/or source IDs on a list of bad tracks
- “Good” NGA data are those remaining after the bad data are excluded
- Sandwell provided these editing criteria
- In our analysis, we examine “good” NGA data and all NGA data “(good” + “bad”)



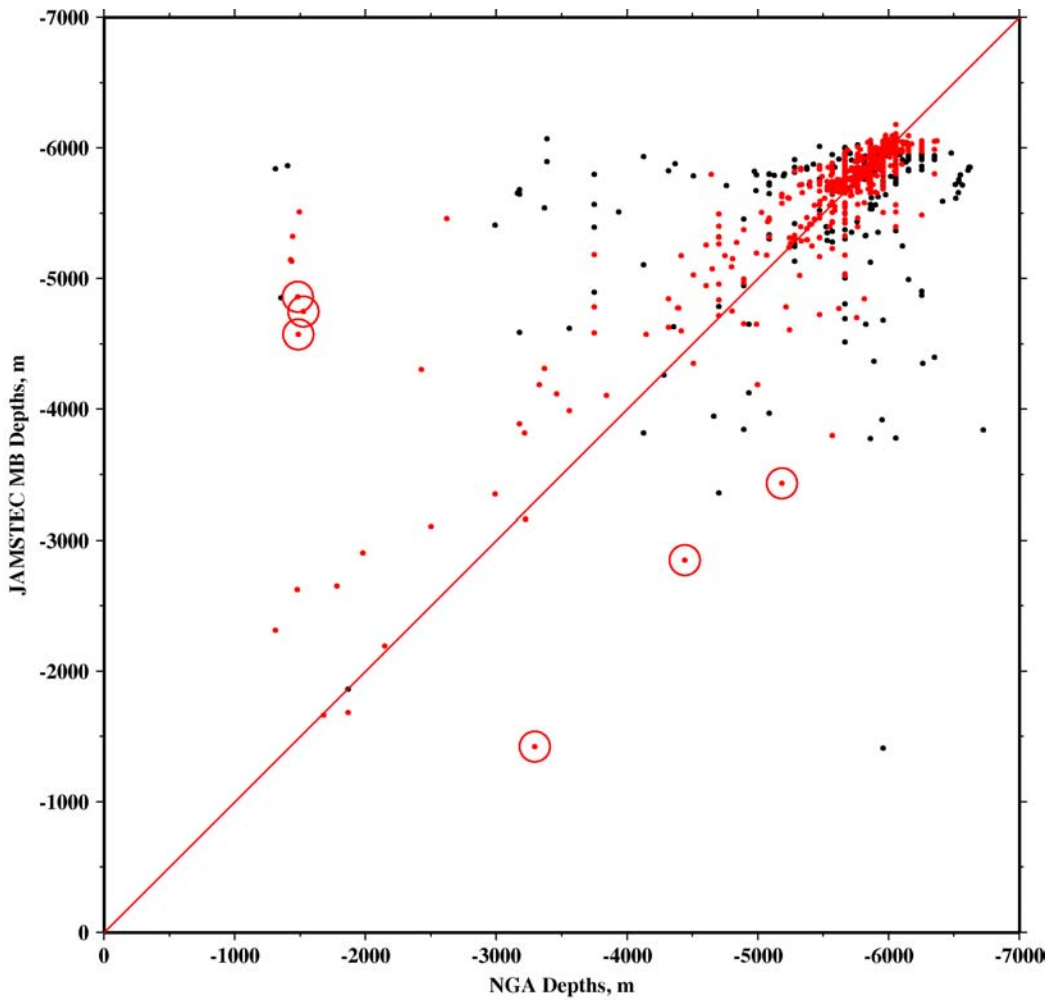
- “Bad” NGA points (black dots) and “good” NGA points (red)
- Green boxes are areas in this study



- 780 “good” NGA points (red dots) on JAMSTEC Multibeam
- We compare NGA depths to JAMSTEC depths



- “Good” NGA points (red dots) on V13
- CI = 1000 m
- In smooth area to south, contours follow NGA tracks
- Large errors in NGA depths make smooth seafloor look rough



•NGA depths plotted against JAMSTEC MB depths

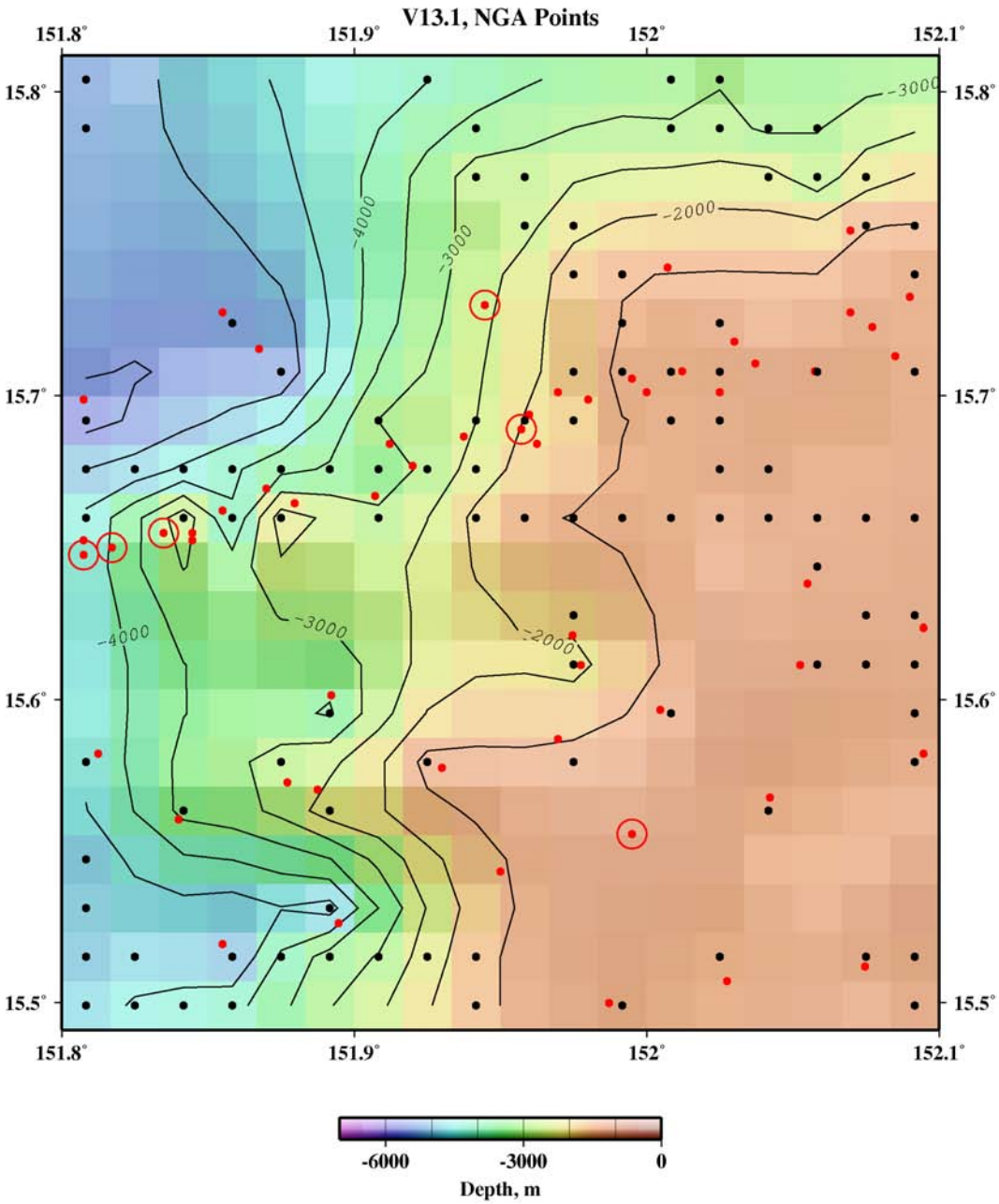
- Red dots (“good” NGA points) and black dots (“bad” NGA points)

- Numerous large outliers far from 1:1 line

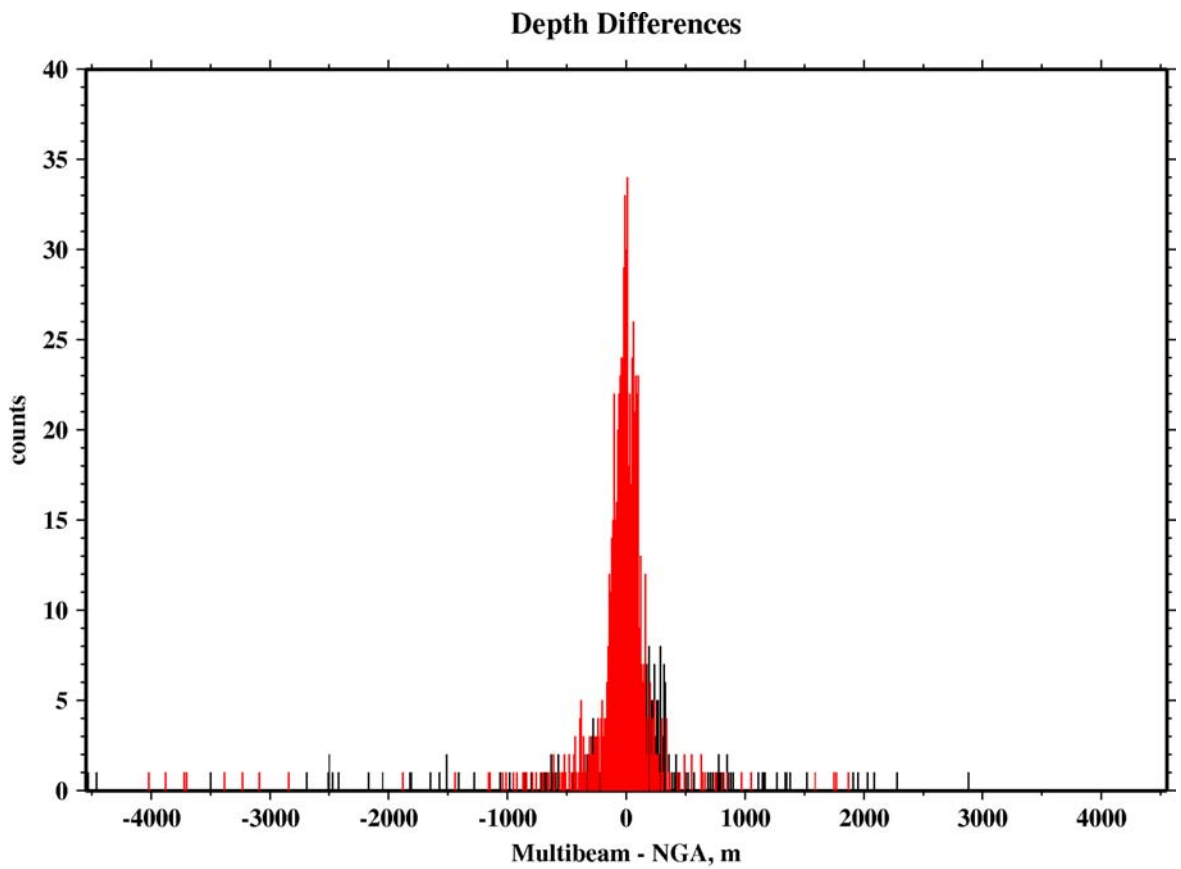
- Circled outliers examined in next slide

- If multibeam depths are “ground truth,” then NGA depths display large errors

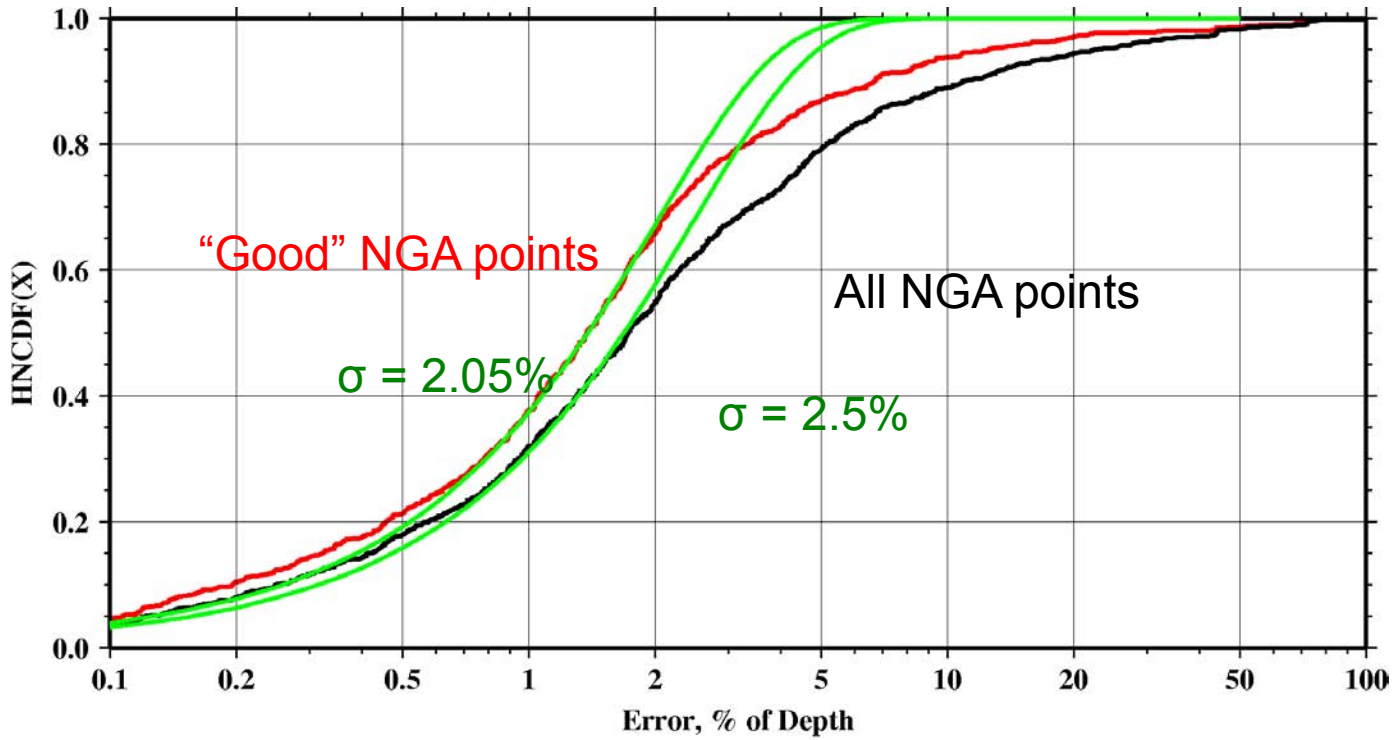
- NGA depths show striping at ~100 m intervals



- Red dots are “good” NGA points
- Black dots are V13 control points
- Circled NGA points are selected large outliers from previous slide
  - Selected because they did not lie on MB ingested into V13
  - Not on source ID list of bad tracks
  - Not flagged for depth uncertainty
- These outliers were not used in V13 so they don’t impact contours
- Other large outliers lie on MB ingested into V13 so their wrong depths are swamped by correct MB depths



- Depth differences are JAMSTEC MB depths – NGA depths
- Red = “good” NGA points, black = “bad” NGA points
- Differences in depth are “errors”
- σ = 437 m (“good” NGA points), which is more than 3 times the IHO S-44 standard
- MAD (Median Absolute Deviation) is 122 m for “good” NGA data, but IHO S-44 requires 95%, not 50%, of data within standard



- Black and red lines are cumulative absolute error as % of depth, i.e., (MB – NGA)/MB
- Green line is theoretical Gaussian function (HNCDF), i.e., $\mathrm{erf}(|x|/\sqrt{(2*\sigma^2)})$, where σ = % of depth
- If data follow Gaussian distribution, then least squares fitting is justified and gives good results, if not Gaussian, results can be seriously biased
- ~35-50% of errors are not modeled by Gaussian distribution
- Errors of 2.5% may be attributable to sound velocity correction, fathoms-to-meters (Smith, 1993)

Remarks

- ~35-50% of NGA data are not modeled by Gaussian distribution and so are bad

- NGA data have errors of 2.05-2.5% of depth

- An improved altimeter prediction algorithm that allows weighting for error, and robust fit for outliers, is needed

- The algorithm used in V8 produced a superior bathymetric prediction than even more recent versions

- Predictions initialized from S2004 long wavelengths are superior