Improvements in Global Bathymetry with US Multibeam and CryoSat Altimetry Data

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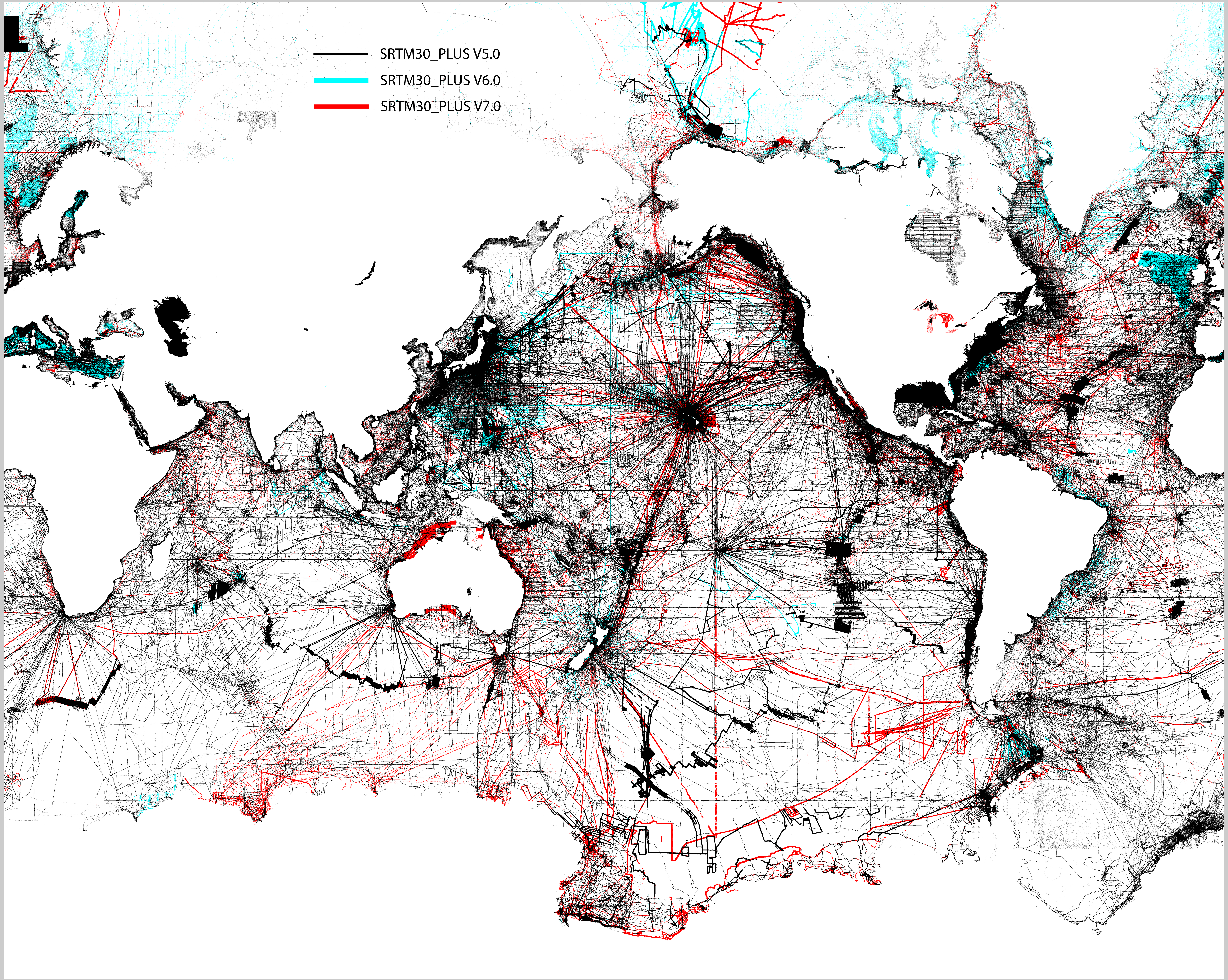
1. Background

SRTM30_PLUS is a global 30 arc second topography/bathymetry grid based on the SRTM mapping of the land topography of the Earth [Farr et al., 2007] and the best available, mostly public domain, global bathymetric information. Predicted depths at 1 minute resolution [Smith and Sandwell, 1997] are refined using edited soundings [Becker et al., 2009]. This grid forms the basis for the bathymetry in Google Earth The SRTM30_PLUS bathymetry continues to undergo significant improvements as new multibeam and altimetry data are assimilated. Over this past year we have processed 669 cruises of US Multibeam data archived at NGDC into 500-m blockmedian averages (Figure 1, red). This results in a 32% increase in cells that are constrained by depth soundings. Most of the multibeam cruises have outliers and blunders. All the data were hand-edited through comparisons with predicted depths and visual inspection of trial grids. Many of the blunders in the V6 grid were corrected although the new multibeam data introduce a new set of blunders and subtle errors that are difficult to correct or eliminate. We will present the new SRTM30_PLUS V7 global grid at the meeting. In addition to adding more sounding data, we are currently developing new marine gravity models based on altimeter data from CryoSat and Envisat which will provide factors of 2-4 improvement in gravity accuracy. Over the next few years these combined improvements in gravity accuracy and sounding coverage will translate into improvements in predicted depth. Although this development is parallel to, and overalpping with, the GEBCO grid development, we feel independent research is needed for cross checking and stimulation of new methods during this period of rapid data growth.



2. Editing of Blunders, Outliers, and Atlantis-type Anomalies

The editing of the cm-files involves 5 basic steps that are repeated until the final product is blunder free and visually appealing. The decision on which data need editing and when to stop the process is somewhat subjective. We strive for the most scientifically useful product even though the results are sometimes confusing to ordinary users. The most notable example is the discovery of the lost city of Atlantis as shown in Figure 2. This seafloor feature was caused by a sound velocity error in a single cruise. This error was corrected in SRTM30_PLUS V6.0 but remains in the bathymetry currently being used by Google Earth. The editing steps are:

Figure 2. Illustration of the presumed Atlantis discovery

1) Construct a global bathymetry and matching SID grid at 1 minute resolution. The bathymetry is based on all the available data but the SID grid only has the new data.

2) Display the bathymetry and SID grids side-by-side using the window-locking feature in ER-Mapper (Figure 3 (a) shows an ermapper editing session and (b) a cmEditor session). One can pan, zoom, and change the colormap and shading of the bathymetry in real time.

3) Identify the SID number of the trackline that will need to be edited to remove outliers and note the location and type of anomaly.

4) Use a custom visual editor called cmEditor to flag individual points based on a comparison with a previous global grid that did not include this track. Statistical and sound velocity tools are used as well.

Repeat steps 1 – 4 until the results are acceptable or funding runs out. The editing for the 30-arcsecond grid follows the same basic approach, but normally only a few outliers appear in the 30-arcsecond grid after the data were edited at 1 minute resolution.

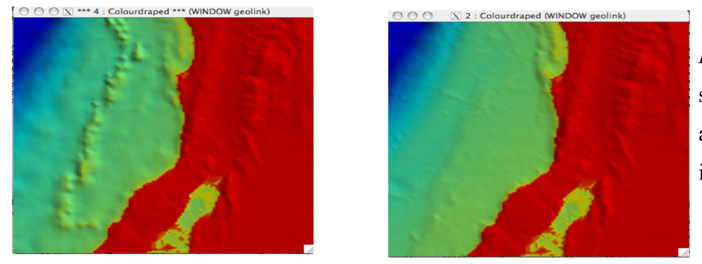


Figure 3a. ERmapping session illustrating before (*left*) and after (*right*) the bad data is removed.

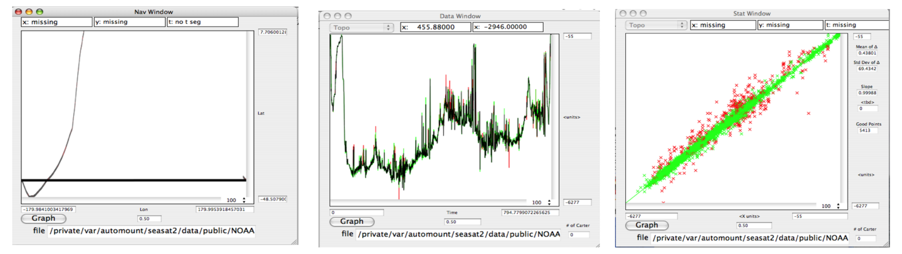


Figure 3b. Images illustrating a cmEditor session with windows for the coordinates of the data (*left*), the comparison between the ship tracks and satellite derived gravity values (*center*) and statistical comparison (*right*).

3. Common Format and Source Identification Number

The raw sounding data arrive in a variety of formats, resolution, and map projections/datums. The raw soundings are archived in their original format, assigned a unique source identification number (SID), blockmedianed at 500 m resolution, and converted to a common format.

```
NAVO-NGA-NOAA-SIO DATA EXCHANGE FORMAT
     time           time since an epoch (sec) or record sequence number
     longitude      decimal degrees (+/- 180.)
     latitude       decimal degrees (+/- 90.)
     depth          depth (-) below sea level  (corrected meters)
     sigma_h        estimated uncertainty in navigation (m)      (0-no estimate; -N data from grid meters)
     sigma_d        depth uncertainty (m)      (-1-no estimate yet; 9999-flagged data)
     source_id      unique ID number for each source (0-65535).
     pred_depth     predicted depth estimate (m) used for flagging outliers    (used internally at SIO for editing)

Example from an NGA cruise TR210634.cm:
     1 -48.37825 49.02105 -2189 0 -1 17450 -2208
     2 -48.33550 49.04571 -2203 0 -1 17450 -2222
     3 -48.28750 49.06690 -2218 0 -1 17450 -2251
     4 -48.24750 49.09137 -2229 0 -1 17450 -2262
     5 -47.84600 49.08103 -2358 0 9999 17450 -2412
     6 -47.89125 49.05984 -2339 0 9999 17450 -2392
     7 -47.93350 49.03502 -2320 0 9999 17450 -2351
     8 -47.97875 49.01381 -2300 0 9999 17450 -2339
     9 -46.99350 49.00707 -2784 0 9999 17450 -2733

Each file has a unique SID that is used as a pointer to the local location of the cm-file as well as a link to the original data
source.
SID    filename           directory                  source_location                                  year    cruise_name
00018 MR00-K01.cm /seasat2/data/public/JAMSTEC http://www.jamstec.go.jp/cruisedata/mirai/e/index.html 2000 JAMSTEC_MIRAI
00019 MR00-K02.cm /seasat2/data/public/JAMSTEC http://www.jamstec.go.jp/cruisedata/mirai/e/index.html 2000 JAMSTEC_MIRAI
00020 MR00-K04.cm /seasat2/data/public/JAMSTEC http://www.jamstec.go.jp/cruisedata/mirai/e/index.html 2000 JAMSTEC_MIRAI
00021 MR00-K05.cm /seasat2/data/public/JAMSTEC http://www.jamstec.go.jp/cruisedata/mirai/e/index.html 2000 JAMSTEC_MIRAI
00022 MR00-K06.cm /seasat2/data/public/JAMSTEC http://www.jamstec.go.jp/cruisedata/mirai/e/index.html 2000 JAMSTEC_MIRAI
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4. Seamount Discovery

In order for researchers to plan surveys of remote areas, they must first be able to determine which areas are not charted, and then be able to determine the likelihood of observing a seamount of interest in a particular location. If this information was readily available, then scientists, ship captains, and even recreational sailors could make important discoveries with minimal cost and effort. We have developed an easy to use survey tool based on Google Earth software to be installed on research and other vessels having deep-water (> 3000 m) echo sounders. The tool requires only a laptop computer, a handheld GPS (or more accurate shipboard GPS when available) and the current seafloor mapping data, as described below. This tool will enable scientists and sailors to plan a survey of new uncharted seafloor and discover major undersea features with little or no impact on their scheduled activities. The design of a survey will depend on the available ship time and the size of the feature. A single profile or swath over the summit has the highest priority. Additional surveying will depend on the distribution of prior sounding data as well as the shape of the features as predicted from satellite gravity. Figure 4 is an example where a transit cruise of RV Melville was diverted to survey the uncharted summits of six 4 km tall seamounts in the South Atlantic.

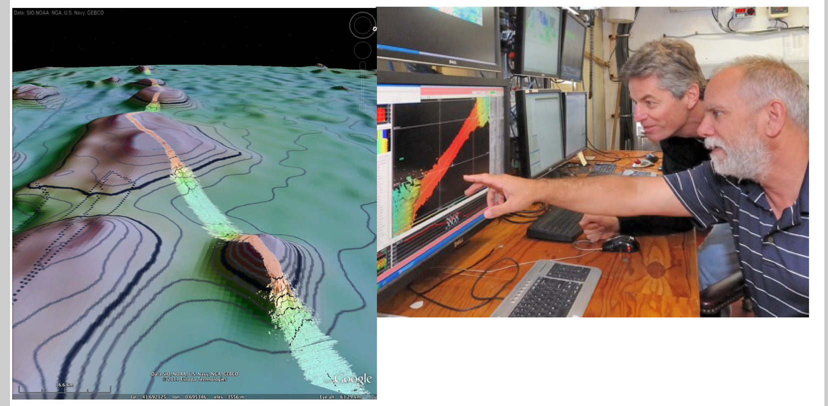

Figure 4 (left) Bathymetry of the Discovery Tablemount region of the South Atlantic. The new multibeam trackline was acquired in February, 2011 during a transit cruise of the RV Melville across the South Atlantic. (right) Dr. J.J. Becker and Captian Kurl monitoring the multibeam system during the survey.

5. What is next at SIO?

Improve global marine gravity using data from CryoSAT-2 and Jason-1.

Develop new predicted depth grid using new gravity and edited soundings.

Develop metadata tool for Google Earth so each sounding will link back to data provider.

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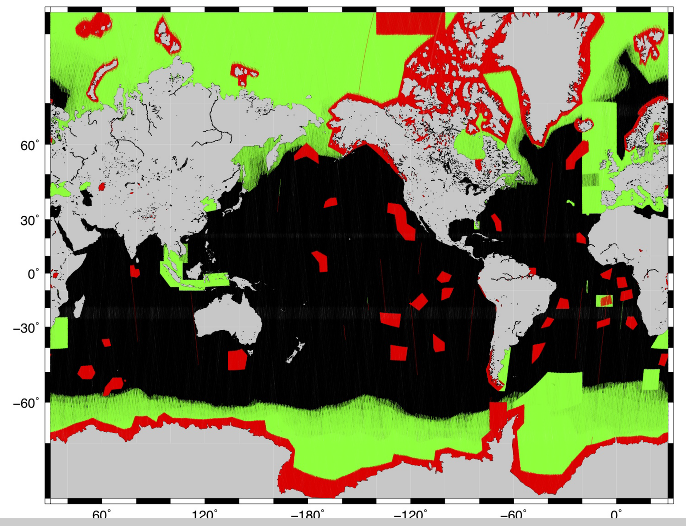
6. Tracks of CryoSat Altimetry



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