# New Soundings for SRTM30_Plus V7.0


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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 (SRTM30_PLUS V4.0) and GEBCO08 (SRTM30_PLUS V5.0). Over the past four years we have developed tools and methods for editing raw soundings at 500 m resolution. To date we have assembled 7295 files of soundings from a wide variety of sources such as the NGDC GEODAS data base (4636 files) (Figure 1 is a global map of soundings; the new soundings are in red and bold). Over the past year we have added 2039 files of data that were not available from NGDC or any other archive. Most of these data were contributed by the National Geospatial Agency (1376 files) and they randomly fill gaps in coverage in all the oceans. In addition we assembled regional surveys from the Great Barrier Reef (Figure 2, Great Barrier Reef SRTM30_PLUS V5.0 and V7.0), Mediterranean Sea, Black Sea, Caspian Sea, and Gulf of California. In addition we added gridded data from major inland Lakes. Approximately 3000 person-hours have been spent editing these mostly single-beam echo sounder data. For the past 4 years funding was provided by the National Science Foundation (OCE0326707).

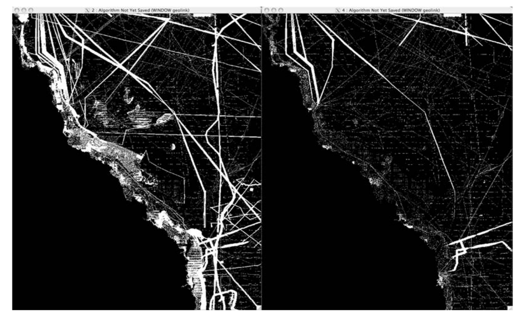

*Figure 2a.* Differences in ship track coverage of the Great Barrier Reef in V5.0 (*right*) and V7.0 (*left*)

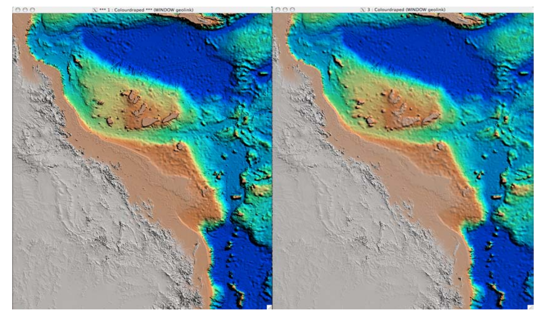

*Figure 2b.* Differences in bathymetry of the Great Barrier Reef in V5.0 (*right*) and V7.0 (*left*)

## 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 3. 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 3. 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 4 (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.

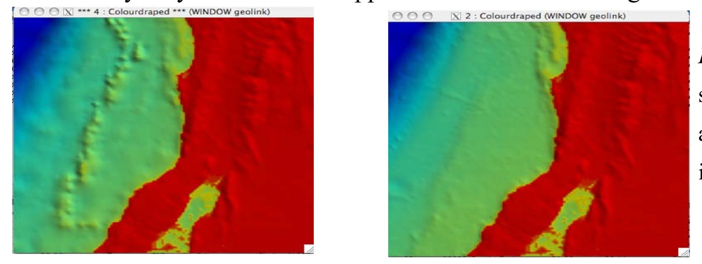

*Figure 4a.* ERmapping session illustrating before (*left*) and after (*right*) the bad data is removed.

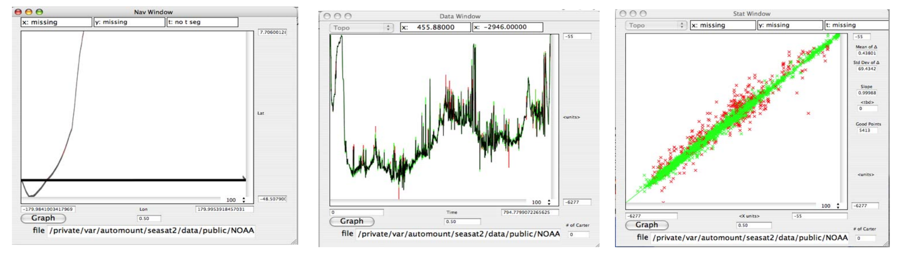

*Figure 4b.* Images illustrating a cmEditor sesion with windows for the coordinates of the data (*left*), the comparison between the ship tracks and satelite derived gravity values (*center*) and statistical comparison (*right*).

## 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 5 is an example map of a large region in the Western Pacific. Contour interval is 500 m and the thick contour is –2000 m. The small black dots show locations of existing ship soundings. Note the 10 seamounts (red dots) predicted to be more than 3000 m tall based on satellite gravity. These targets for exploration are very poorly sampled by existing ship soundings. This area is remote and it is unlikely there will be a survey ship transiting the area soon.

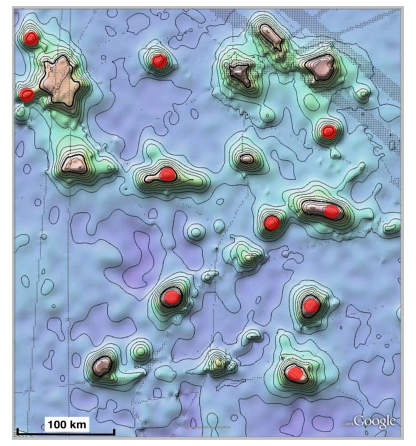


*Figure 5.* Example bathymetry overlay available as part of the Seamount Discovery Tool. Contours show depth based on the 1-minute version 12 of the Smith and Sandwell [1997] bathymetric prediction. Black dots show the soundings used as depth constraints [Becker et al., 2009]. Red dots show 10 uncharted seamounts more than 3 km tall. The overlays were made using new capabilities of the Generic Mapping Tools. The relevant GMT code is img2google.

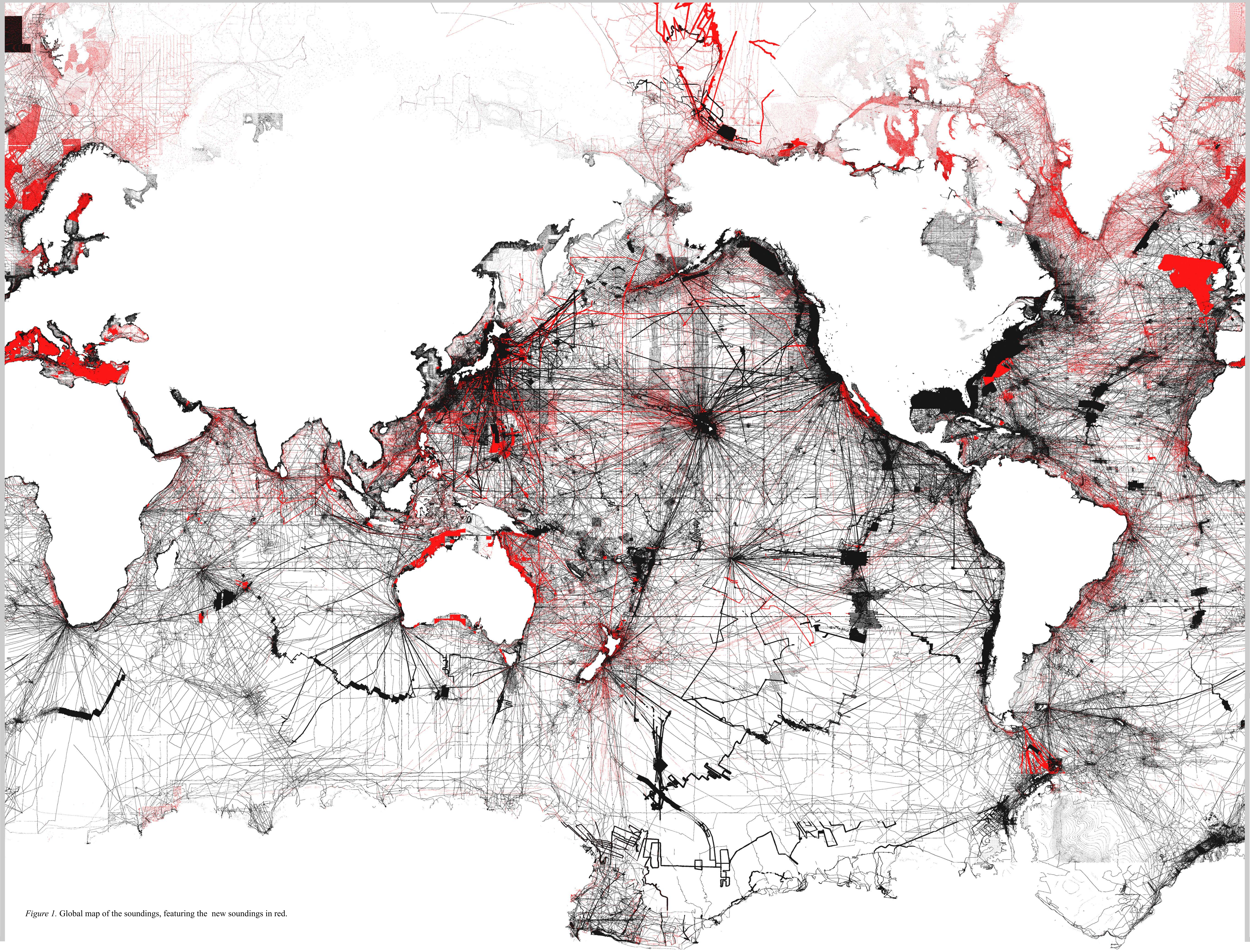

*Figure 1.* Global map of the soundings, featuring the new soundings in red.

## 5. Google Earth Overlays

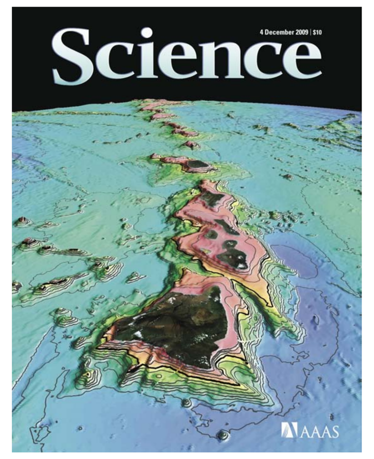


*Figure 6.* Seafloor depth based on ship soundings and satellite altimetry draped over matching seafloor in Google Earth (500 m contour interval) was used for the December 2009 cover of Science. The global kml-file is available at ftp://topex.ucsd.edu/pub/global_topo_1min/global_topo_1min_V12.1.kmz.

Using the 1-minute bathymetry grid and new tools available in GMT, we developed a small KMZ-file that links to thousands of image tiles stored on a computer at SIO. These tiles display depth contours as well as the pixels with depths constrained by soundings. An example is shown in Figure 6 which was published on the cover of Science as an overview image of the Hawaiian Swell Seismic Experiment [Wolfe et al., 2009]. These overlays also provide the basis for a Seamount Discovery Tool that we hope will become a navigational aid on UNOLS vessels [Sandwell and Wessel, 2010]

## 6. Proposal for Distributed Data Archive

**Proposal:**

Interested organizations would offer to host an L1 site: IHO (GEBCO), NGDC, UNH, SIO, JAMSTEC, UH, U. Sydney, . . .

Site includes: all public cm-files and associated metadata, global grids at 30-arc second resolution with matching grids of source_id. **These would be available to anyone without registration or agreements.**

Public data would be mirrored periodically.

**To Do:**

Populate the metadata: source_id, filename, directory location, attribution (nation, institution, ship, PI), link to provider of original data...

Prepare a data base structure for L1 data files (need professional help).

Develop a method for adding and editing data (e.g., CVS).

Develop a method for syncing the multiple data bases.

Levels of Data
L0 – raw sounding data (e.g. multibeam)
**L1 – cleaned soundings in common form t(s) (e.g. CM-files at 500 m resolution)**
L2 – global and regional grids
L3 – images and higher level products (e.g., Google Earth overlays)

## 7. 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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