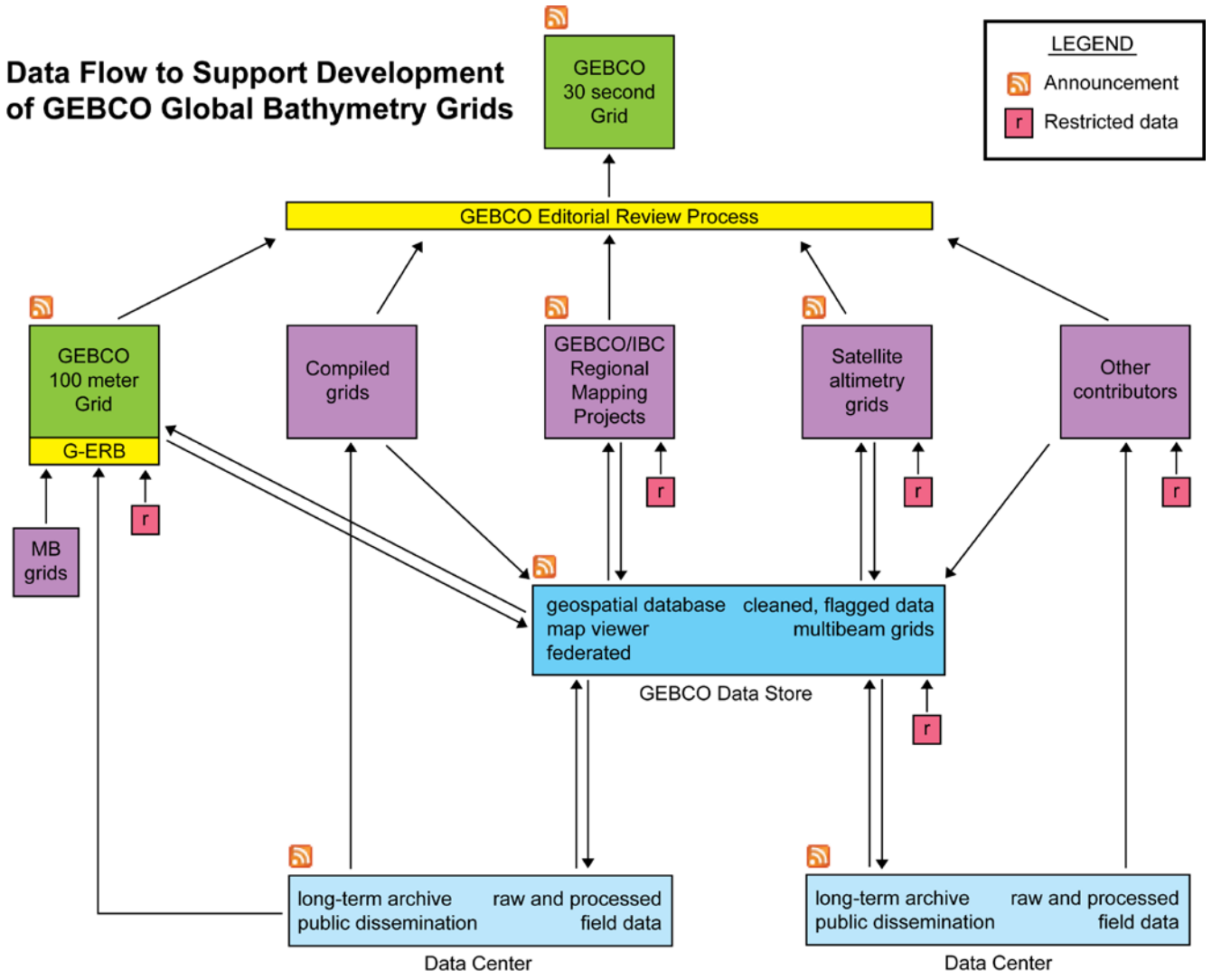
Data Flow to Support Development of GEBCO Global Bathymetry Grids
GEBCO 30 second Grid
LEGEND
Announcement
r
Restricted data
GEBCO Editorial Review Process
GEBCO 100 meter Grid
G-ERB
Compiled grids
GEBCO/IBC Regional Mapping Projects
Satellite altimetry grids
Other contributors
MB grids
geospatial database
map viewer
federated
cleaned, flagged data
multibeam grids
GEBCO Data Store
long-term archive
public dissemination
raw and processed
field data
Data Center
long-term archive
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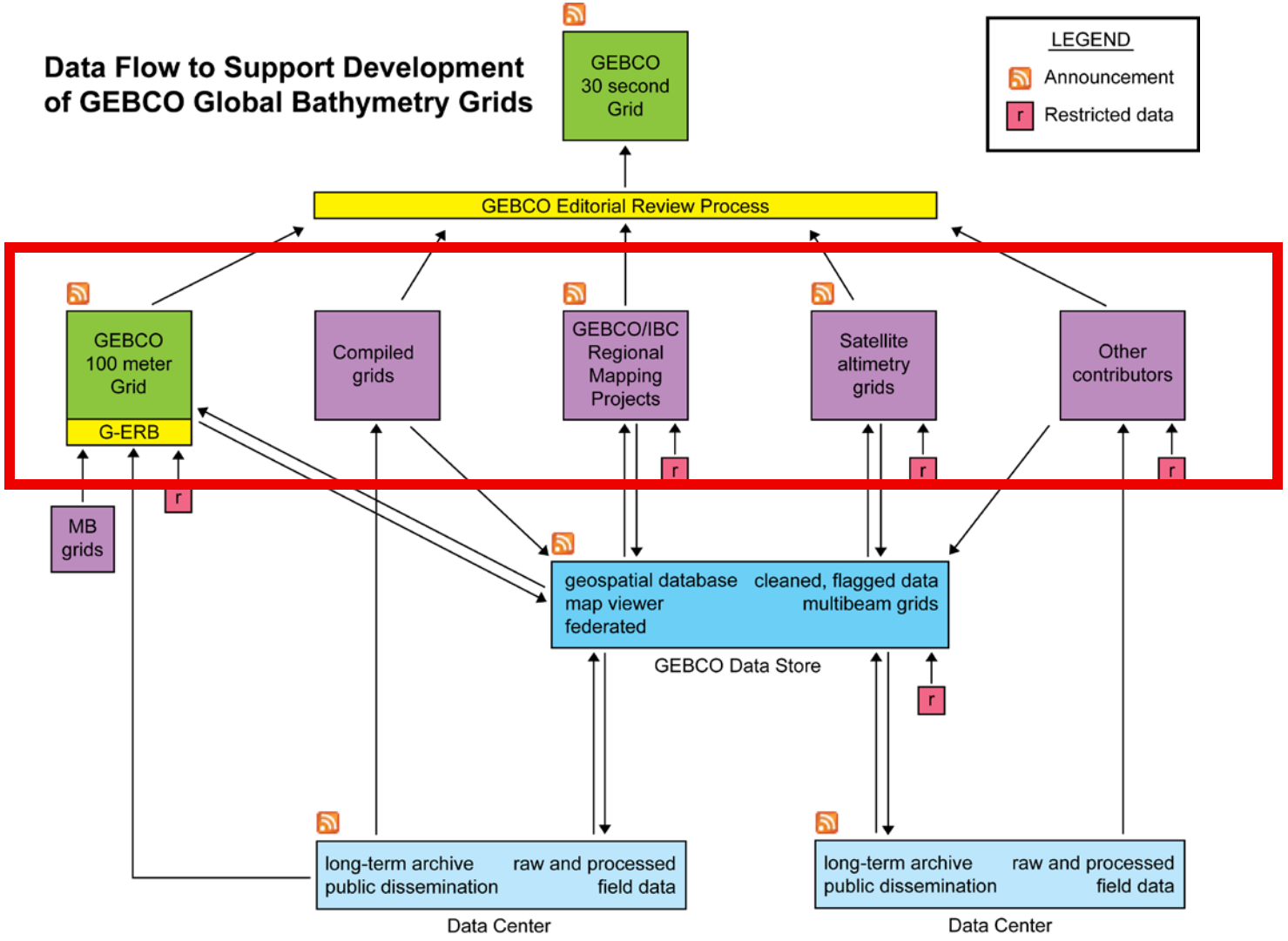
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applications of radar altimetry and ship soundings

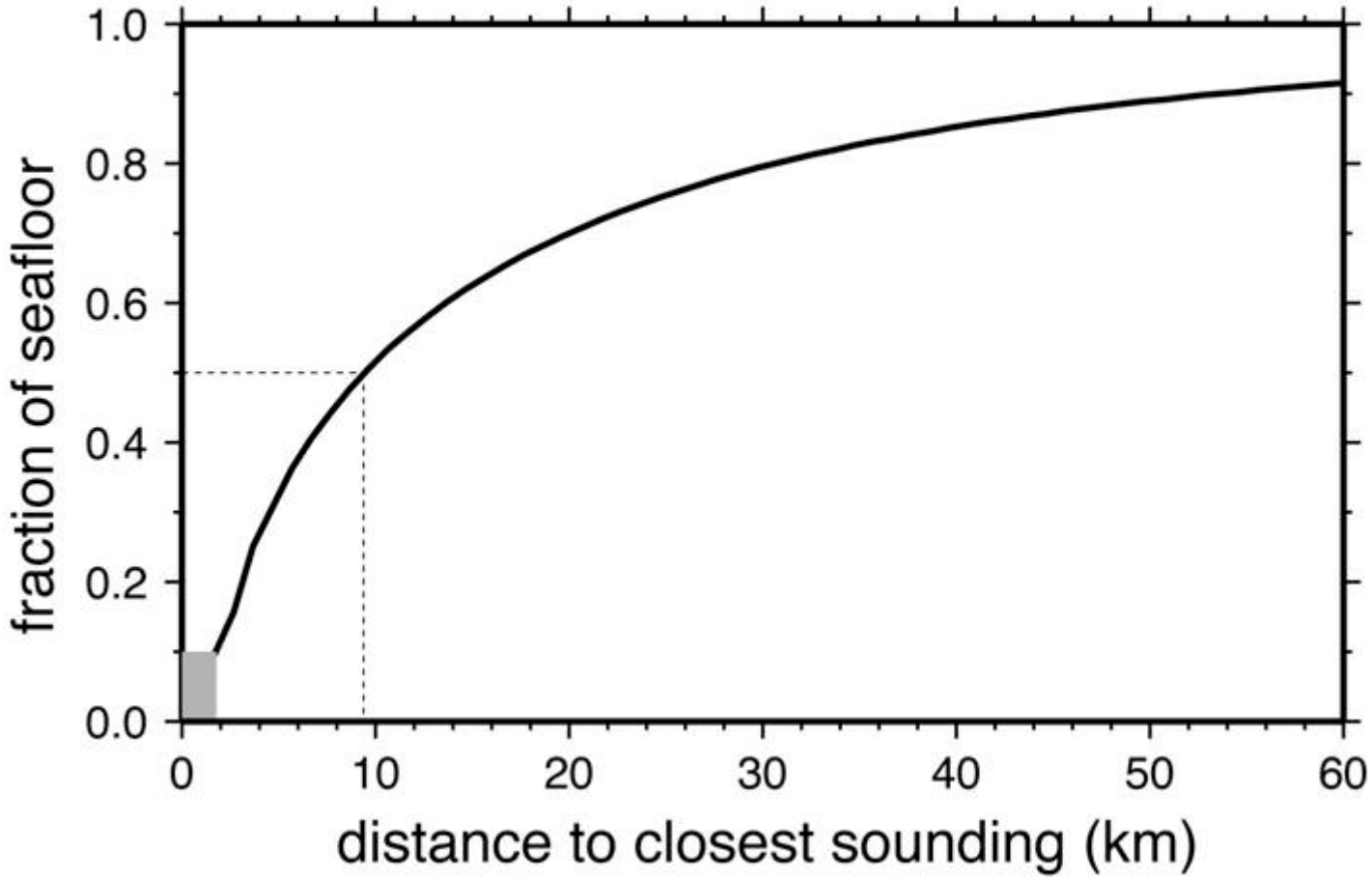
Gravity:

- plate tectonics
- planning ship surveys
- inertial guidance (mostly military)
- petroleum exploration

Topography:

- seafloor roughness
- seamounts
- tsunami models
- tide models, tidal friction, thermohaline circulation
- planning undersea cables
- law of the sea
- education and outreach

1/2 of global seafloor bathymetry not resolved at 10 km resolution



[Smith and Marks, 2009]

Bathymetry from Gravity and Ship Soundings: Inverse Nettleton Method

1. Grid available depth soundings.

1. Separate into low-pass and high-pass filtered components (~160 km).

1. High-pass filter gravity and downward continue to low-pass filtered depths.

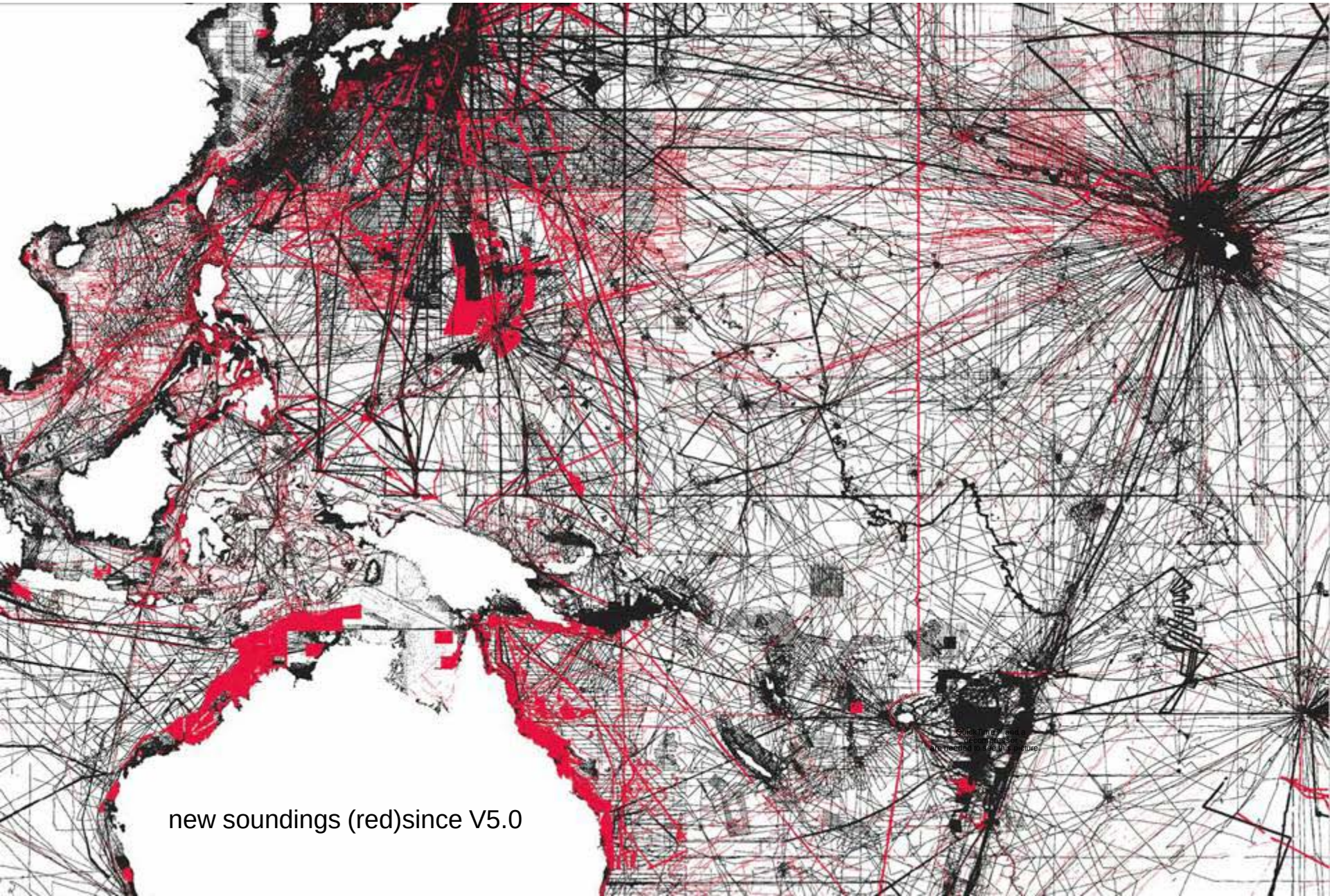
1. Perform a robust linear regression of high-pass topography and high-pass, downward-continued gravity in small regions.

1. Multiply gravity by topography/gravity slope to predict topography in pass band.

1. Add original low-pass filtered depth.

1. Force agreement with soundings.

Where does your organization obtain data?



What tools and methods do you use to clean and disseminate your data?
cm_Editor and www/ftp

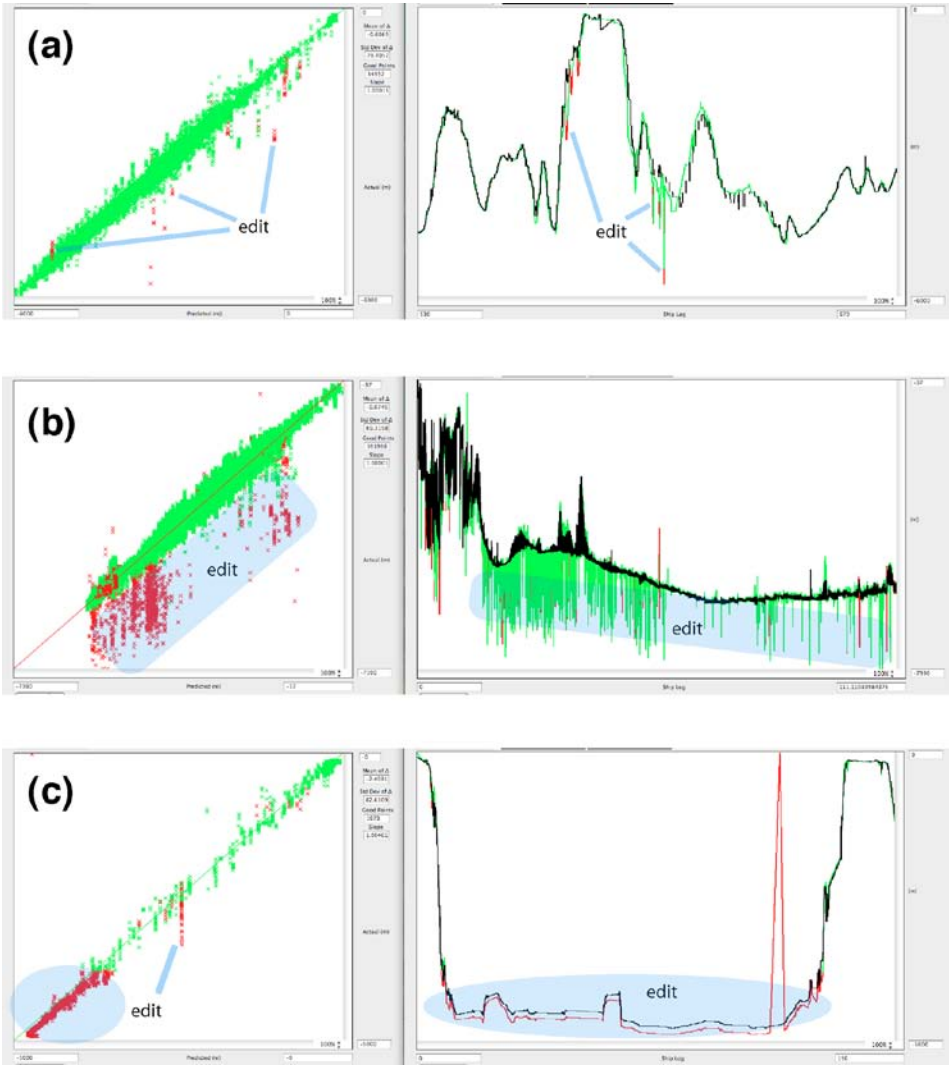
CM FORMAT

The common file (filename.cm) consists of ASCII text with variable precision depending on the precision of the original data. There are 7 columns as follows:

time	time since an epoch (sec), or record sequence number
longitude	decimal degrees (+/- 180.)
latitude	decimal degrees (+/- 90.)
depth	depth; below sea level is negative (corrected meters)
sigma_h	estimated uncertainty in navigation (m) (0=no estimate)
sigma_d	depth uncertainty (m) (9999=edited data; -1= no estimate)
source_id	unique ID number for each source (0-65535).
pred_depth	predicted depth estimate (m) (used internally at SIO for editing)

1 59.39518 23.25101 -2693 0 -1 54627 -2662
2 59.42965 23.23397 -2722 0 -1 54627 -2587
3 59.46411 23.21693 -2598 0 -1 54627 -2571
4 59.49880 23.20098 -2645 0 -1 54627 -2605
5 59.53434 23.18941 -2750 0 -1 54627 -2836

6 59.56989 23.17783 -2893 0 -1 54627 -2923



What tools and methods do you use to clean and disseminate your data?
cm_Editor and www/ftp

SID start	SID end	directory	data type	status - raw	status - cm
0	0		---predicted---		
1	16	data/public/NAVO	NAVO multibeam	16 files Mbformat 121	16 files not edited
18	78	data/public/JAMSTEC	JAMSTEC multibeam		some files edited
100	101	data/private/GEBCO	GEBCO Contours Antarctica	contours digitized from GEBCO sheet	not edited
200	269	data/public/JAMSTEC	JAMSTEC multibeam		
16,387	16403	data/private/NGA	NGA DNC soundings < 300 m (3 deep no	11 files-shallow	11 files not edited
16,500	17875	data/public/NGA/xyz	NGA trackline data	1376 unique files	
32,768	32774	data/public/NOAA	large grids, various sources		7 cm some edited
32,775	32812	data/public/CCOM	Law of Sea surveys - offshore US	multibeam - xyz	38 files not edited
32,813	32857	data/public/GEBCO	UK Hydrographic Office	mulibeam - xyz	45 files not edited
32,858	32865	data/public/NOAA	Pacific Islands + Inland lakes	grids - xyz	8 files not edited
32,866	32881	data/public/CCOM	Law of Sea surveys - part 2	multibeam - xyz	16 files
32,900	32916	data/private/GEBCO	ENC -GEBCO	Elactronic Navigation Charts ENC	16 files
32,900	32922	data/private/GEBCO	MBES from Colin Jacobs, and OLEX	grd and xyz files	7 files, OLEX not yet edited or used
48,000	48174	data/public/NOAA_geodas	NGDC trackline added July 9, 2009	new mgd77 files	175 files edited
49,152	53907	data/public/NOAA_geodas	NGDC trackline edited	4756 edited dat files	4756 edited
53,909	54165	data/public/SIO_multi	grids from SIO multibeam	grd files at 250m res	edited, some bad not used
54,166	54187	data/public/SIO	various grids		18 files, edited
54,188	54288	data/private/IFREMER	IFREMER and VML	100 files	all files edited
54,289	54335	data/public/SIO	various grids		all files, edited
54,336	54377	data/public/SIO_multi	grids from SIO multibeam - part 2	42 files	
54,498	54572	data/public/SIO	WHOI GLOBEC		some edited
54,573	54673	data/public/SIO	Polar programs and prop		not edited
54,674	55084	/data/private/3DGBR	Rob Beaman	441 files of Great Barrier Reef	edited
55,085	55129	/data/public/SIO	Australia multibeam	45 files of Antarctic data	edited
65,400	65403	/data/public/lakes	large inland bodies of water		derived from grids
65,500	65503	data/public/IBCAO/cm	Blockmedianed IBACO points	From Martin J, orig in stereo xy	edited
65,535	65535	data/public/IBCAO/cm	IBCAO 1 minute grid V2.23		not edited

What tools and methods do you use to clean and disseminate your data?
cm_Editor and www/ftp

```
54153 WEST01MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html YEAR no_metadata_found
54154 WEST03MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1994 Scripps_Institution_of_Oceanography
54155 WEST04MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html YEAR no_metadata_found
54156 WEST05MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1994 Scripps_Institution_of_Oceanography
54157 WEST06MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1994 Scripps_Institution_of_Oceanography
54158 WEST08MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1994 Scripps_Institution_of_Oceanography
54159 WEST09MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1994 Scripps_Institution_of_Oceanography
54160 WEST10MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1995 Scripps_Institution_of_Oceanography
54161 WEST11MV.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html 1995 Scripps_Institution_of_Oceanography
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54165 WSFL01WT.cm /seasat2/data/public/SIO_multi http://nsdl.sdsc.edu/beta/expeditions.html YEAR no_metadata_found
54166 SWIR_e.cm /seasat2/data/public/SIO
54170 atalante_97_found_e.cm /seasat2/data/public/SIO
54171 foundation_block_e.cm /seasat2/data/public/SIO
54174 spanish_shackleton_e.cm /seasat2/data/public/SIO
54175 vol1_e.cm /seasat2/data/public/SIO
54176 vol10_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54177 vol2_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54178 vol3_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54179 vol4_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54180 vol5_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54181 vol6_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54182 vol7_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54183 vol8_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54184 vol9_e.cm /seasat2/data/public/SIO http://ocean-ridge.ldeo.columbia.edu/general/html/home.html 2000
54185 whoi_globec_e.cm /seasat2/data/public/SIO
54186 CentAm_1000_1000_z.cm /seasat2/data/public/SIO
54187 Chile_all_1000_1000_z.cm /seasat2/data/public/SIO
54188 90012211.bat.cm /seasat2/data/private/IFREMER http://www.ifremer.fr/anglais/produits/base.htm
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54192 91004111.bat.cm /seasat2/data/private/IFREMER http://www.ifremer.fr/anglais/produits/base.htm
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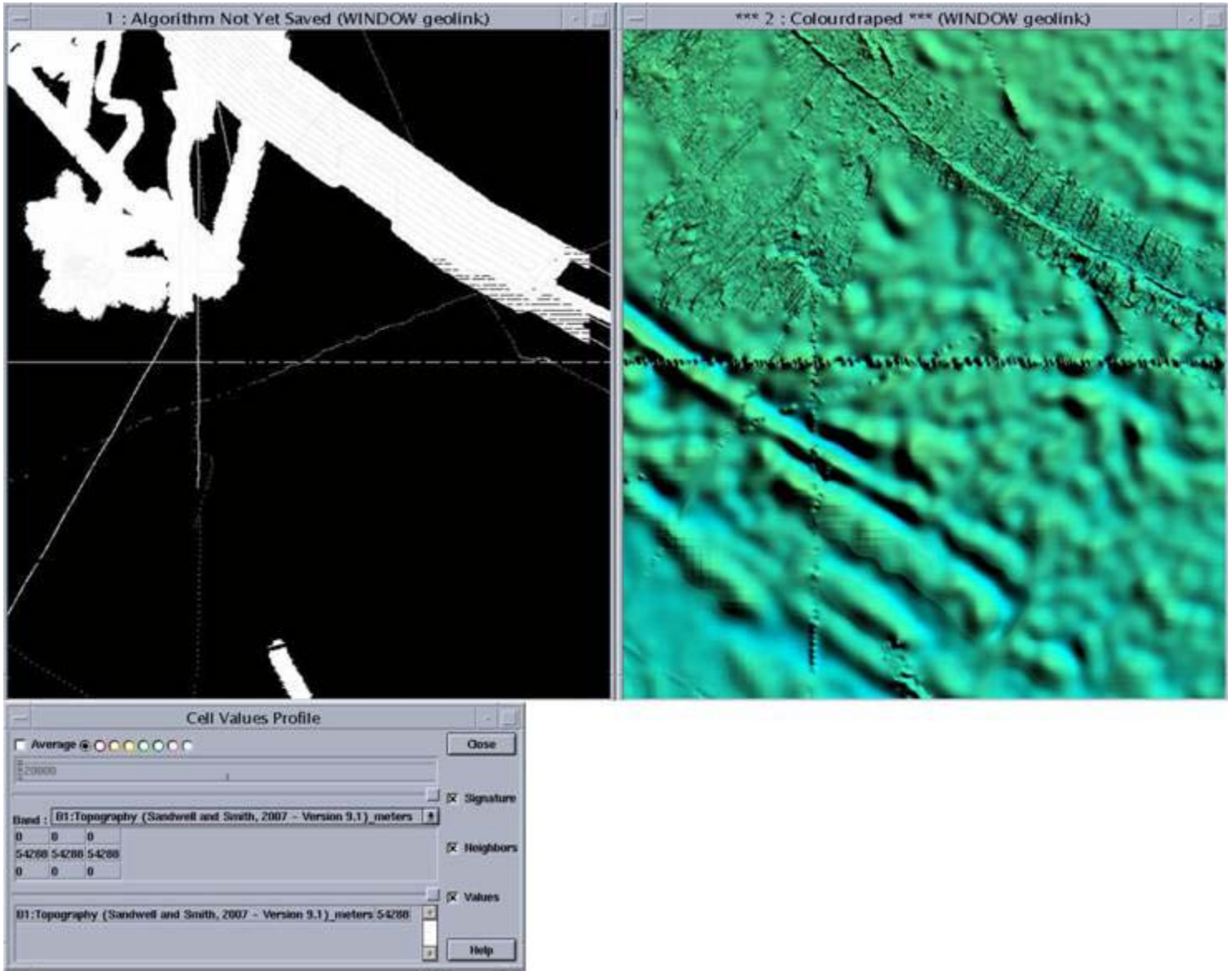
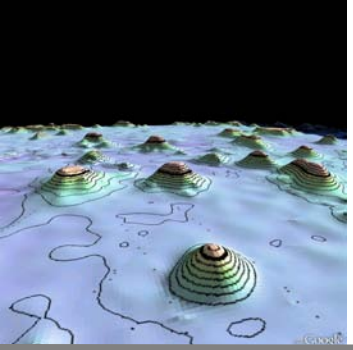
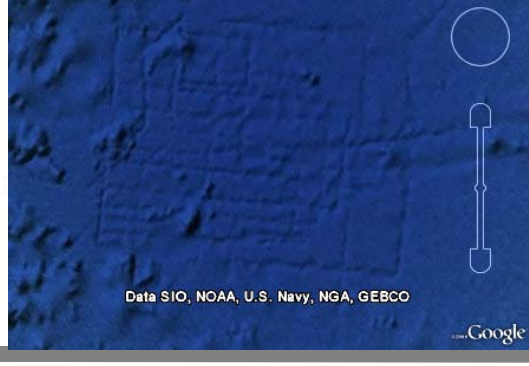
What tools do you use? ER_Mapper





Why make SRTM30_PLUS when we have GEBCO08?



Need best available matching bathymetry **and** gravity for marine tectonics and other deep ocean applications.

Predicted depths are sometimes useful and sometimes not so the grid needs to contain masking information.

Accurate predicted depths depend on **both** accurate topography and accurate gravity.

Gaps in bathymetry coverage > 80 km cause large uncertainties in the gravity/topography calibration.

Need to include all deep ocean data which means we need careful data editing od some really bad data.

The GEBCO data store is a place to share cleaned soundings.

It is easier to make a new global grid (SRTM30_PLUS) than try to add subgrids to an existing grid.

GEBCO08 is mostly SRTM30_PLUS V5.0 we are on V7.0 now.

Proposal for Distributed Archive of Cleaned Ship Soundings

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 data 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 format(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)

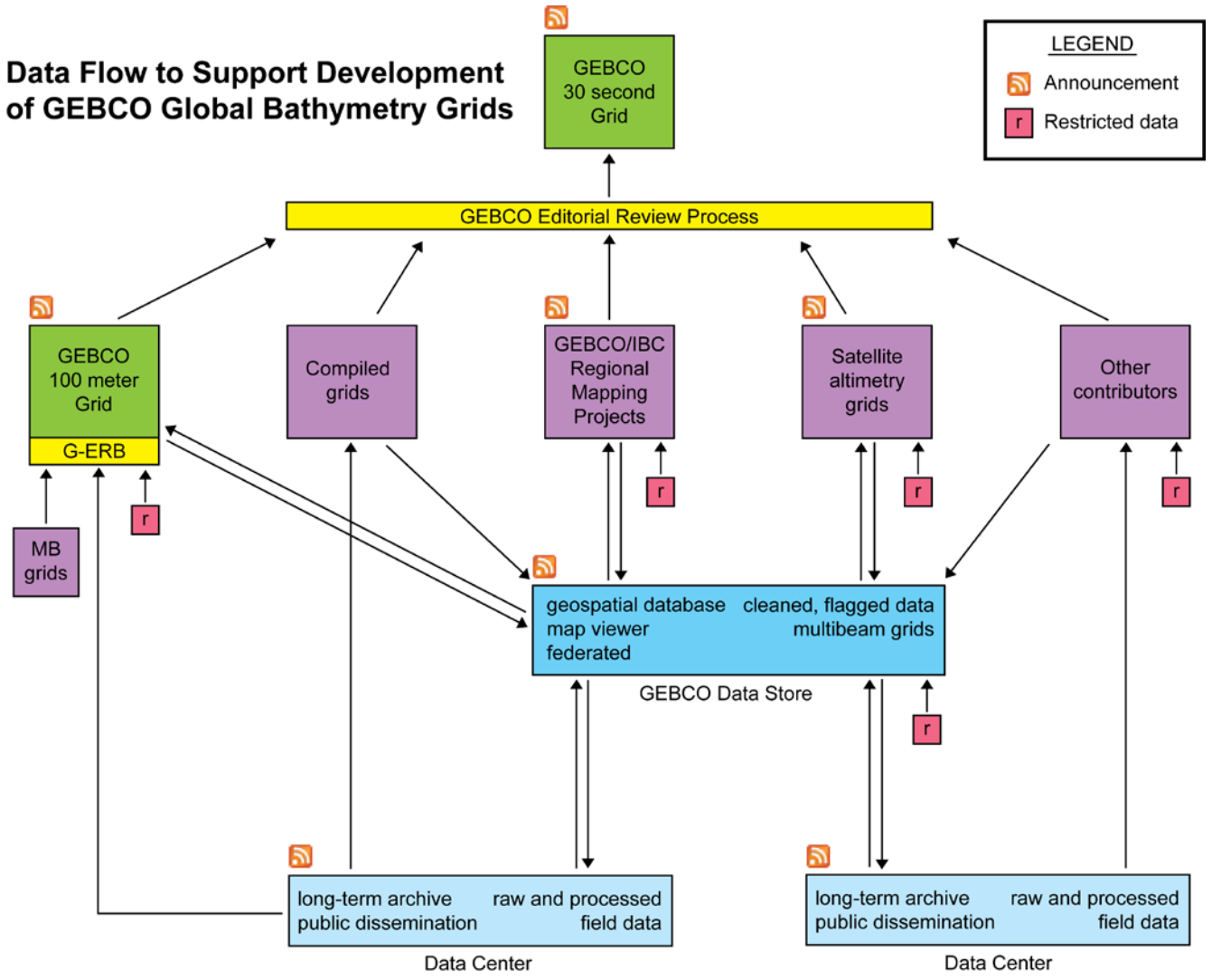
What is next at SIO?

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.

(This research was funded by the National Science Foundation. *High-Resolution Marine Gravity, Seafloor Topography, and Seafloor Roughness*; Sandwell; OCE0326707; $166,505 09/01/2008 - 02/31/2011)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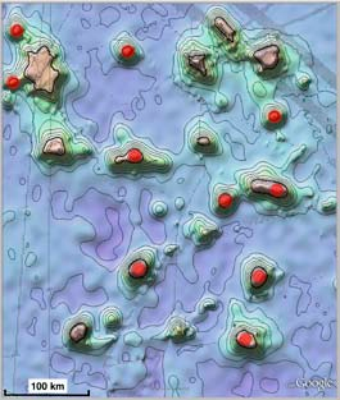
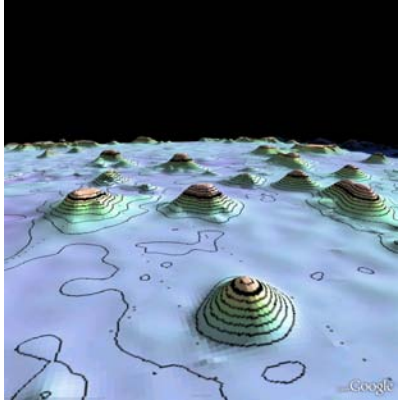


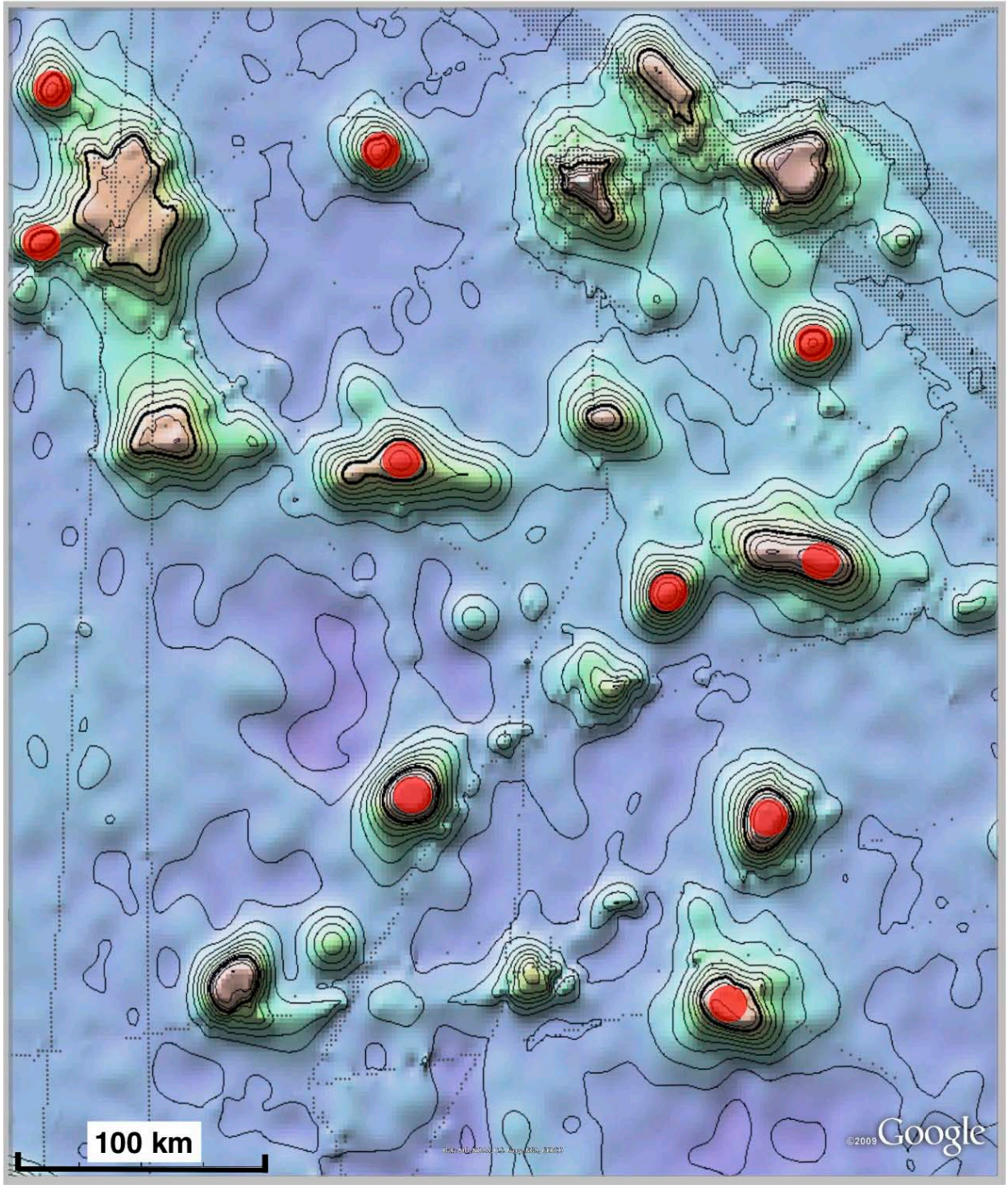
Seamount Discovery Tool



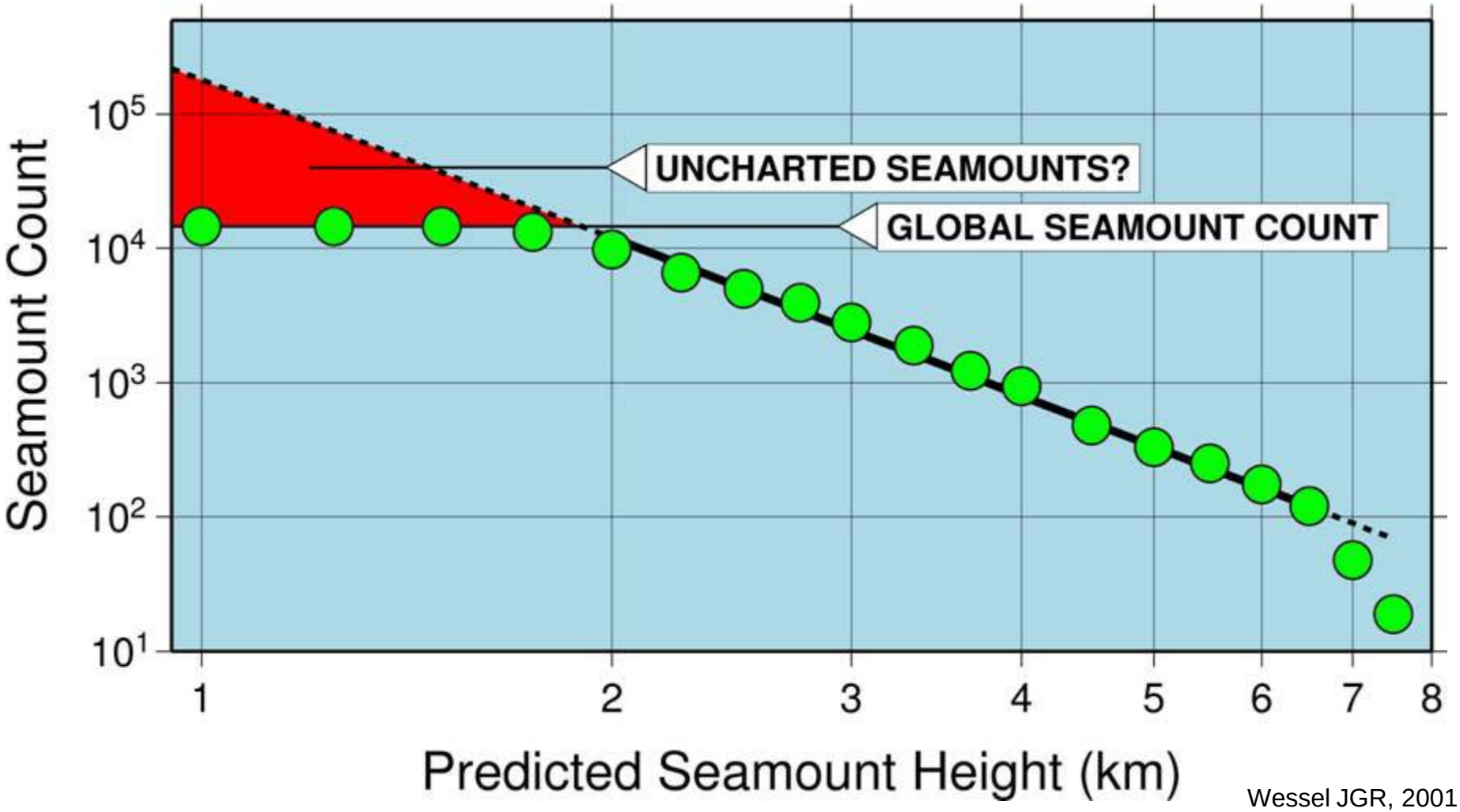
- Created as an efficient way for ships of opportunity to plan routes that travel over uncharted seamounts.
- Most seamounts < 2 km tall are uncharted
- Seamount exploration strategies
  - acquire and edit existing data
  - ships of opportunity and Google Earth
  - satellite altimetry
- Discovery tool uses Google Earth and a GPS

Wessel, P., D. T. Sandwell and S-S. Kim, The global seamount census, Oceanography, 23:1 p. 24-33, 2010.
Sandwell, D. T., and P. Wessel, Seamount discovery tool aids navigation to uncharted seafloor features, Oceanography, 23:1 , p. 24-26, 2010.

uncharted seamounts > 3 km tall



size distribution of seamounts



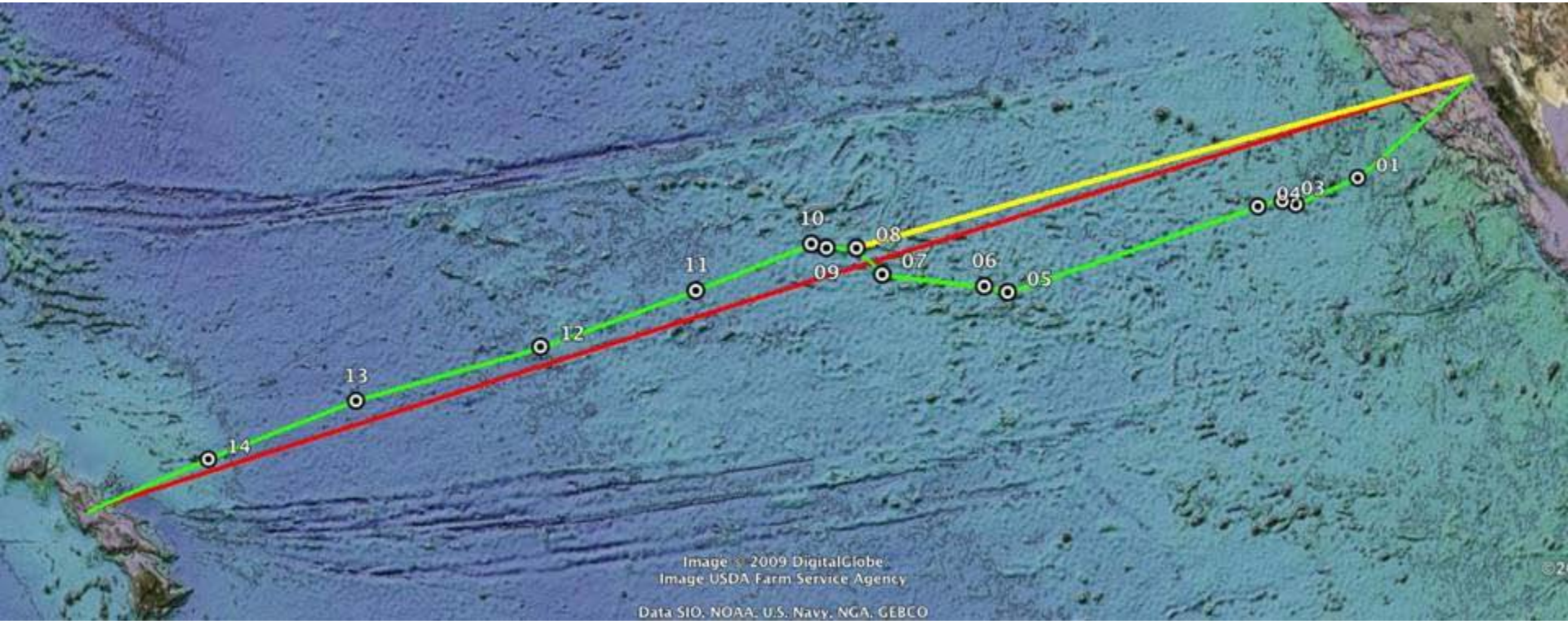
Wessel JGR, 2001

Seamount Exploration Strategies

- Existing data
- Ships of opportunity and Google Earth (GE)
  - GE to encourage data sharing
  - **GE as a real-time survey tool**
- Satellite altimetry
  - Cryosat II
  - Other non-repeat orbit altimeters

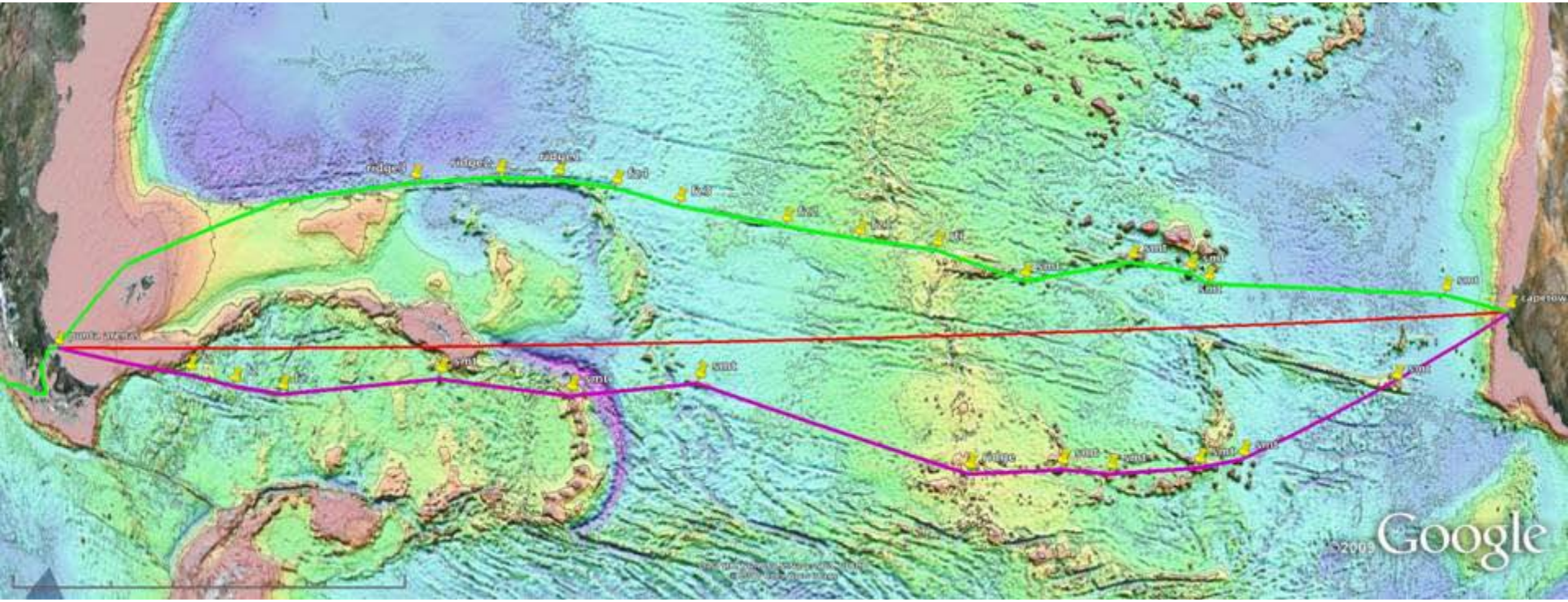
San Diego to Honolulu - White Holly - May 2009

red - great circle = 4180 km
green – 14 new seamounts = 4300.1 km (1.028)
yellow - 7 new seamounts = 4189.7 km (1.0023)

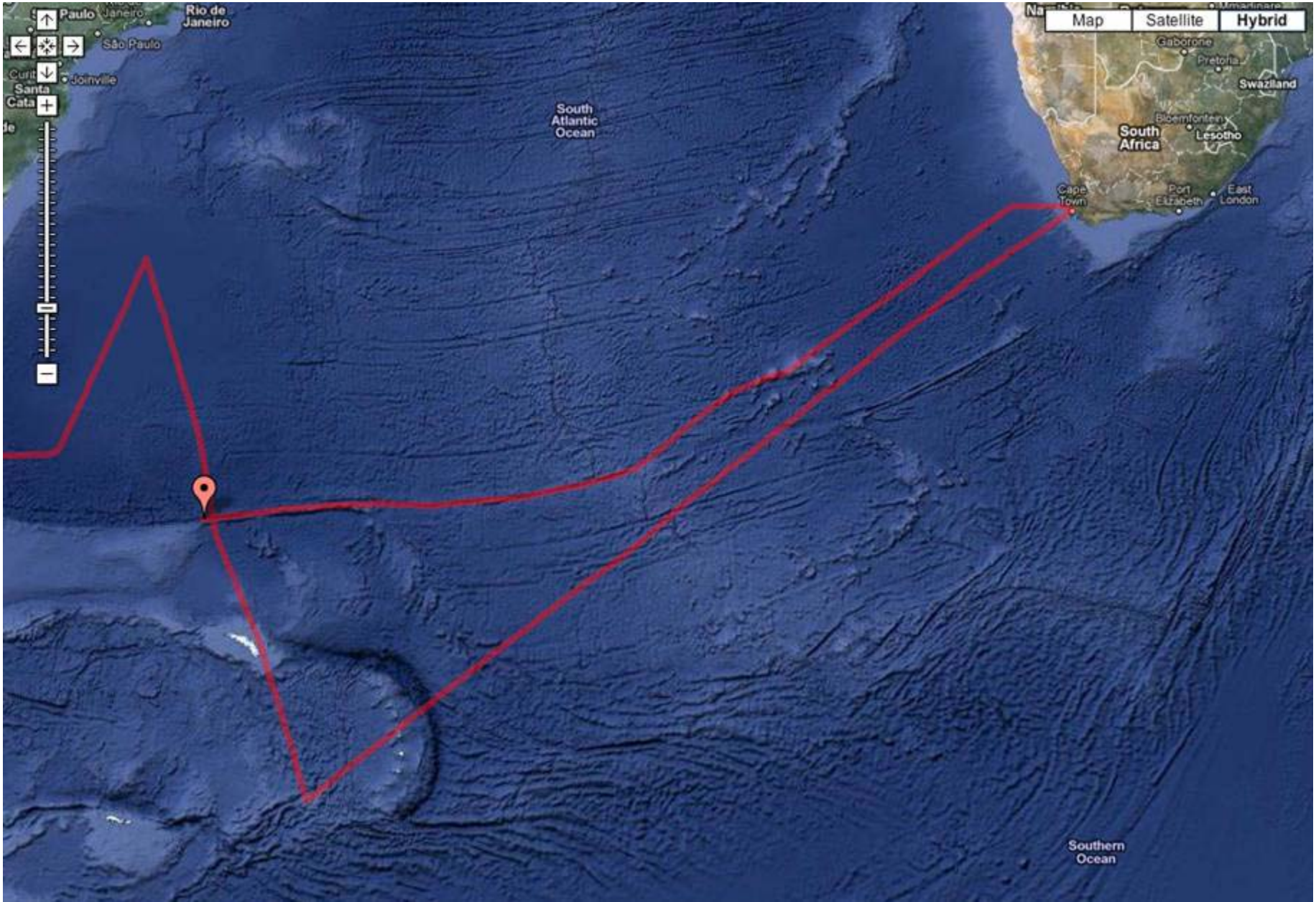


Cape Town to Punta Arenas - Melville - Feb, 2011

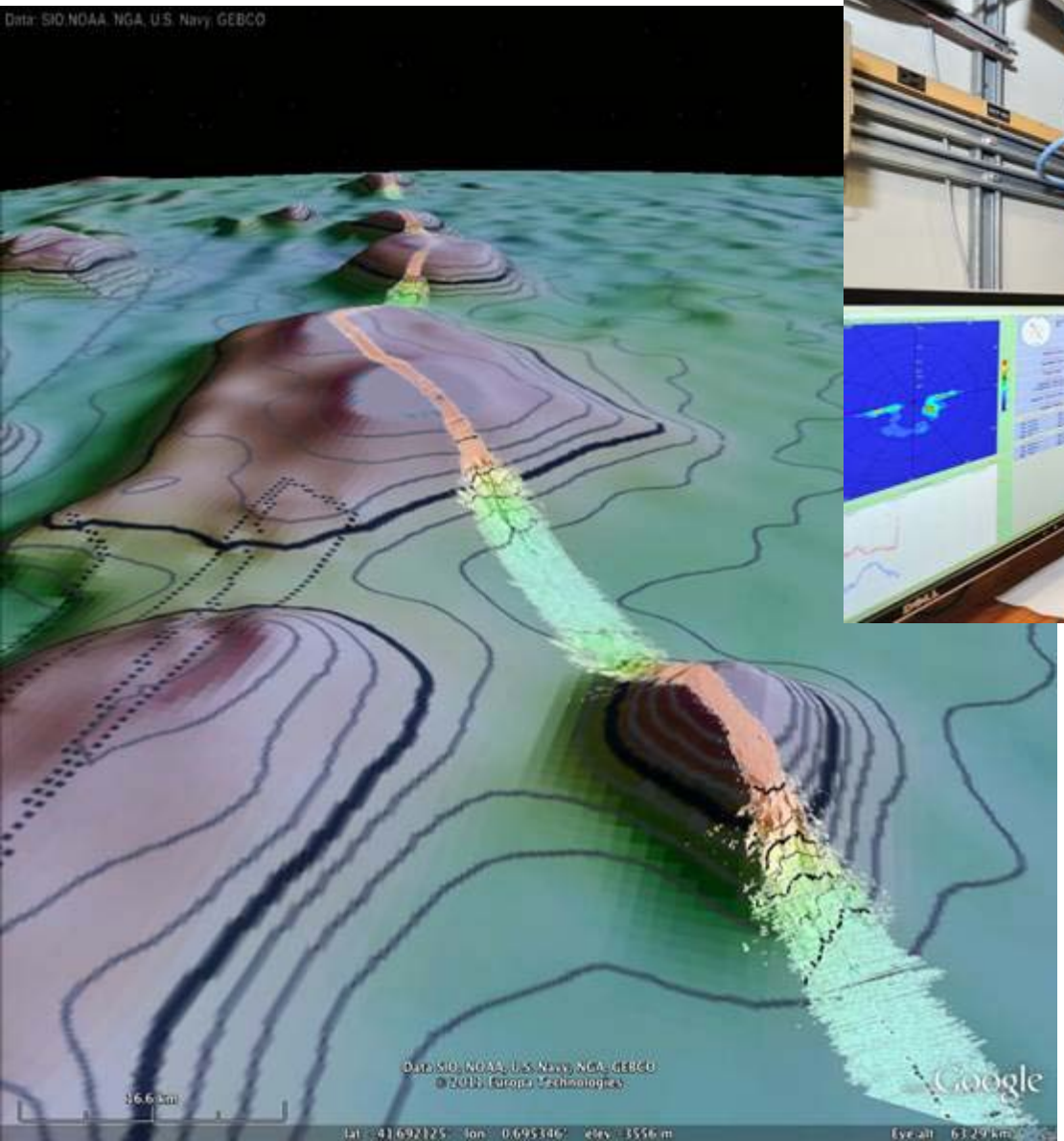
red - great circle = 6896 km
green - 10 new seamounts = 7130 km (1.034)
violet - 11 new seamounts = 7069 km (1.025)



Cape Town to Punta Arenas - Melville - Feb, 2011

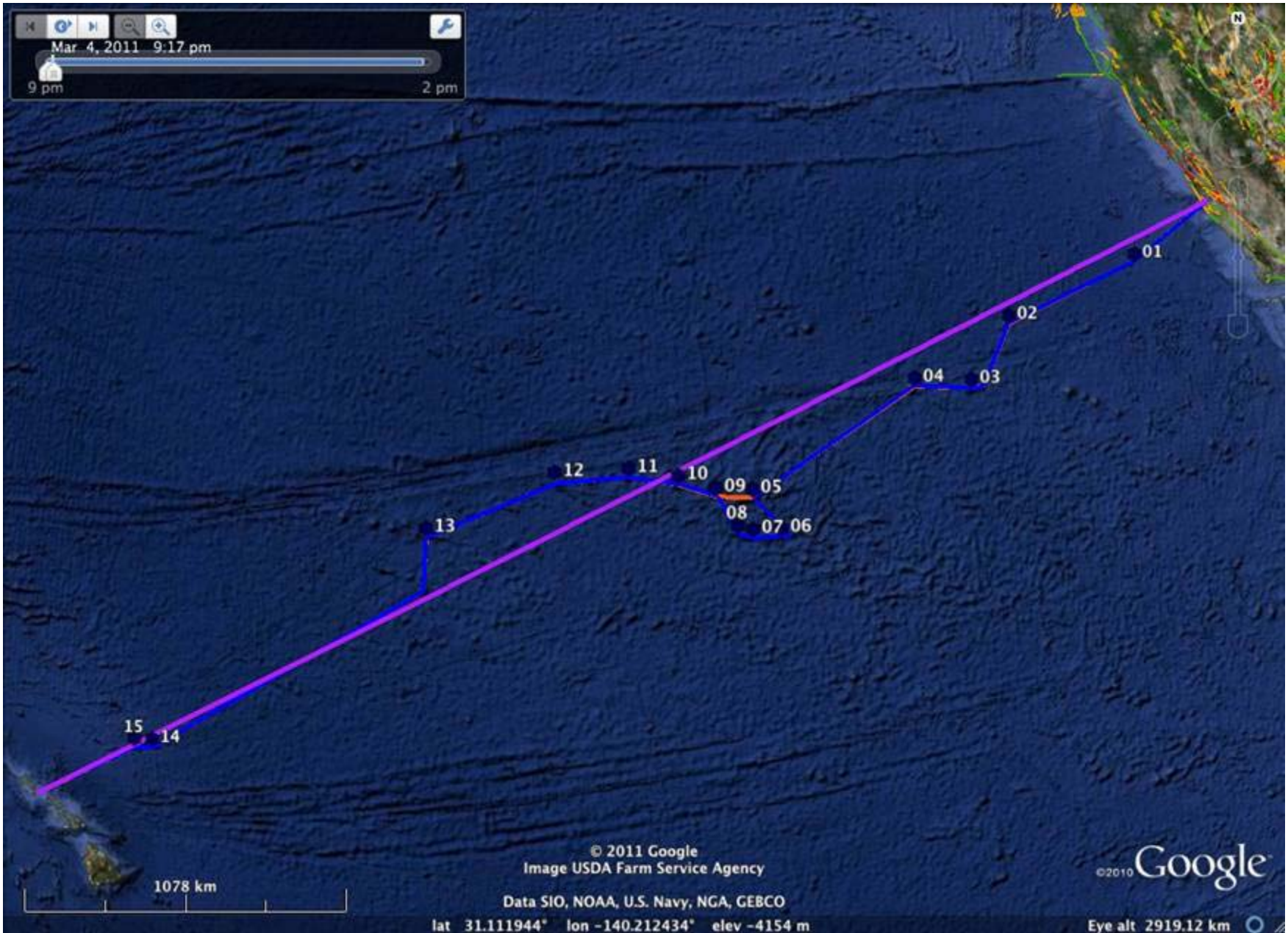


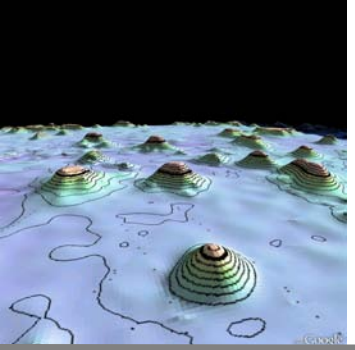
Cape Town to Punta Arenas - Melville - Feb, 2011



Okeanos Explorer - Monterey Bay to Honolulu - soon

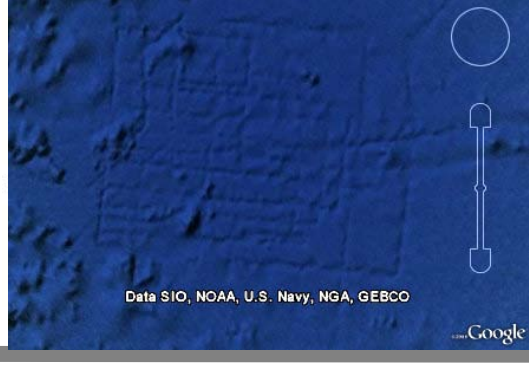
Elizabeth Lobecker





Global Edited Soundings for Gravity/Bathymetry Calibration

David Sandwell, Walter Smith, JJ Becker, Karen Marks,
Megan Jones, Adrienne Apacile, Seung-Hee Kim, Scott Nelson
Rob Beaman, . . .



- Objective - construct global bathymetry at 1-10 km resolution for scientific research

- Where does your organization obtain data? — anywhere - focus on single beam soundings

- How do you manage your data? — (not very well)
  - What tools and methods do you use to clean and disseminate your data? cm_Editor and www/ftp
  - How do you assess the quality of your data? — visual (undergrad students) and statistical
  - How do you describe and document your data? — online docs and occasional journal article
- How do you grid your data? — gravity to topography recipe
  - What is your gridding process? — high-pass G&T, estimate T/G, add long-λ T, remove/restore ΔT
  - What tools do you use? — GMT, ER_Mapper, C-programs, csh, awk, . . .
  - How do you evaluate your grid? — visual
  - How do you update your grid? — regrid globally
  - How do you document your grid development? — version number and README

- What are the limitations of the methodologies and tools that you currently use? not portable

- What capabilities and functionalities are on your wish list? — ER_Mapper for Mac

- Where do you see your efforts going in the future? — Improved gravity from Cryosat

- What issues do you face that complicate your effort? — **Classified and proprietary data**