

Mapping the Gaps with Academic Research Fleet Vessels

Vicki Ferrini, PhD

Lamont-Doherty Earth Observatory of Columbia University

ferrini@ldeo.columbia.edu



GMRT

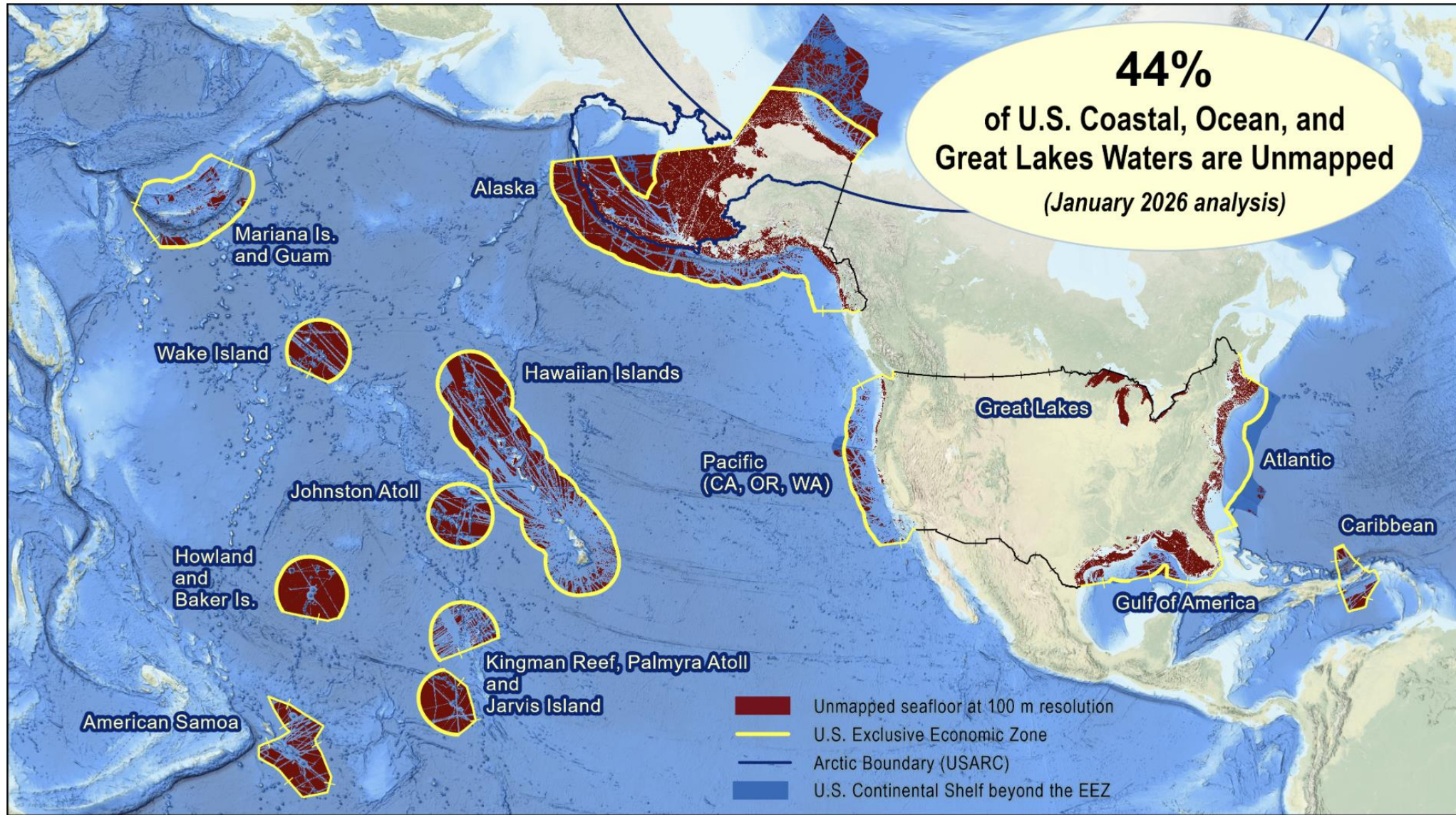


GeoMapApp

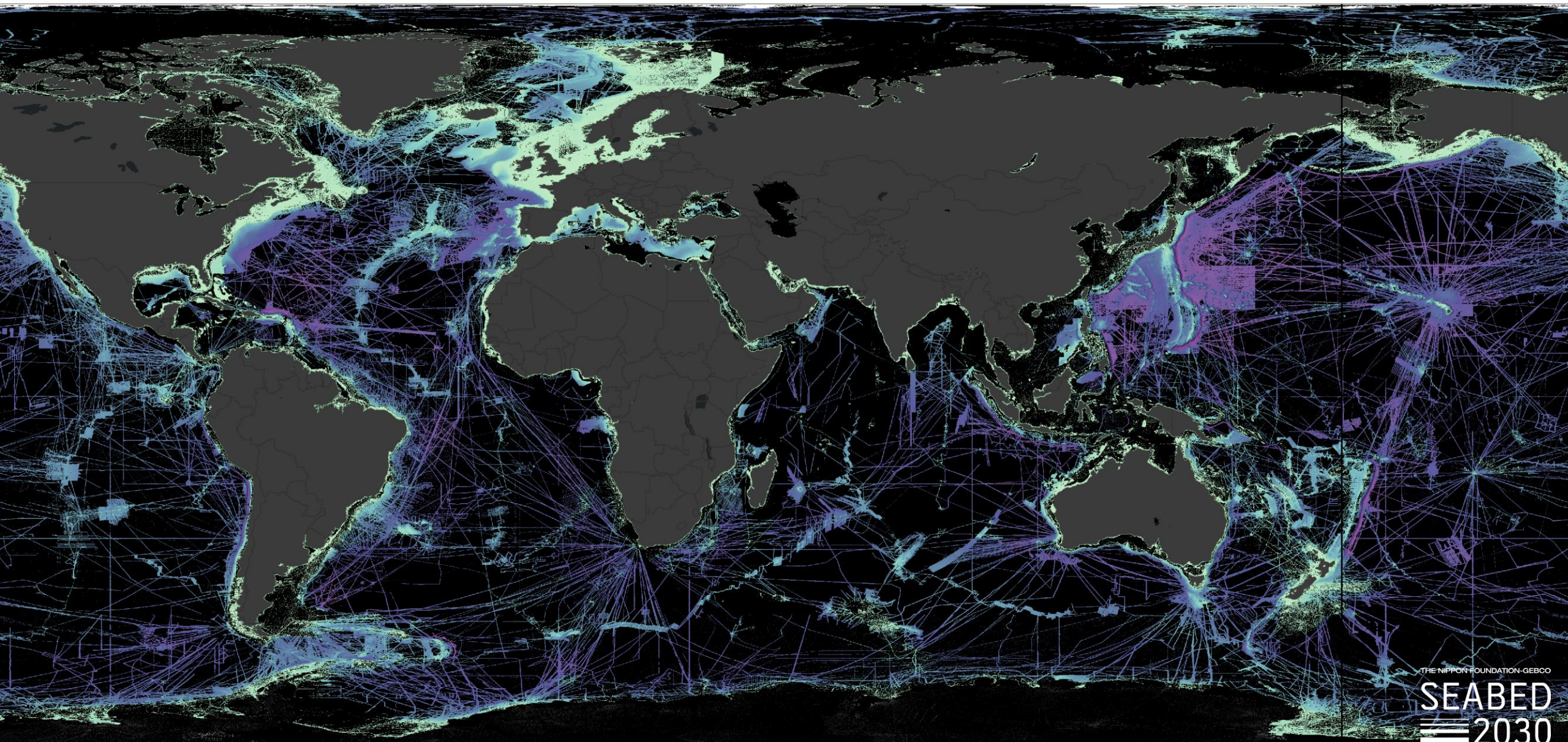
THE NIPPON FOUNDATION-GEBCO

SEABED
2030

US Bathymetry Gap Analysis



GEBCO 2026: 28.7% world ocean mapped



How will we map the gaps?

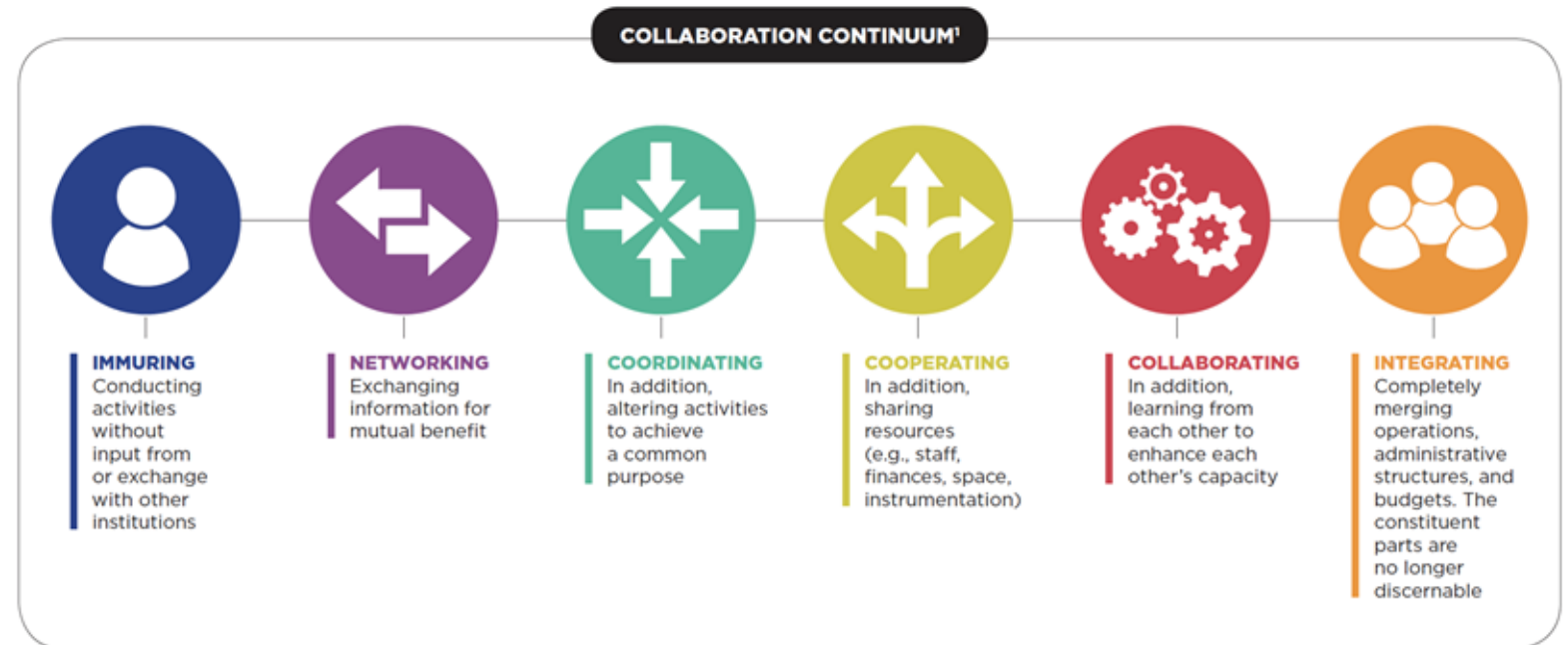
- Collaboration/Coordination

- Knowledge sharing
- Data sharing
- Global movement

- Technical Innovation

- Acquisition
- Data Processing & Integration

- **Transit Mapping**



¹The original Collaboration Continuum, which included Networking, Coordinating, Cooperating, and Collaborating, comes from Arthur T. Himmelman, *Collaboration for a Change: Definitions, Decision-making Models, Roles, and Collaboration Process Guide*. January 2002, Himmelman Consulting, Minneapolis, MN.



Barrie

- T
- R
- C

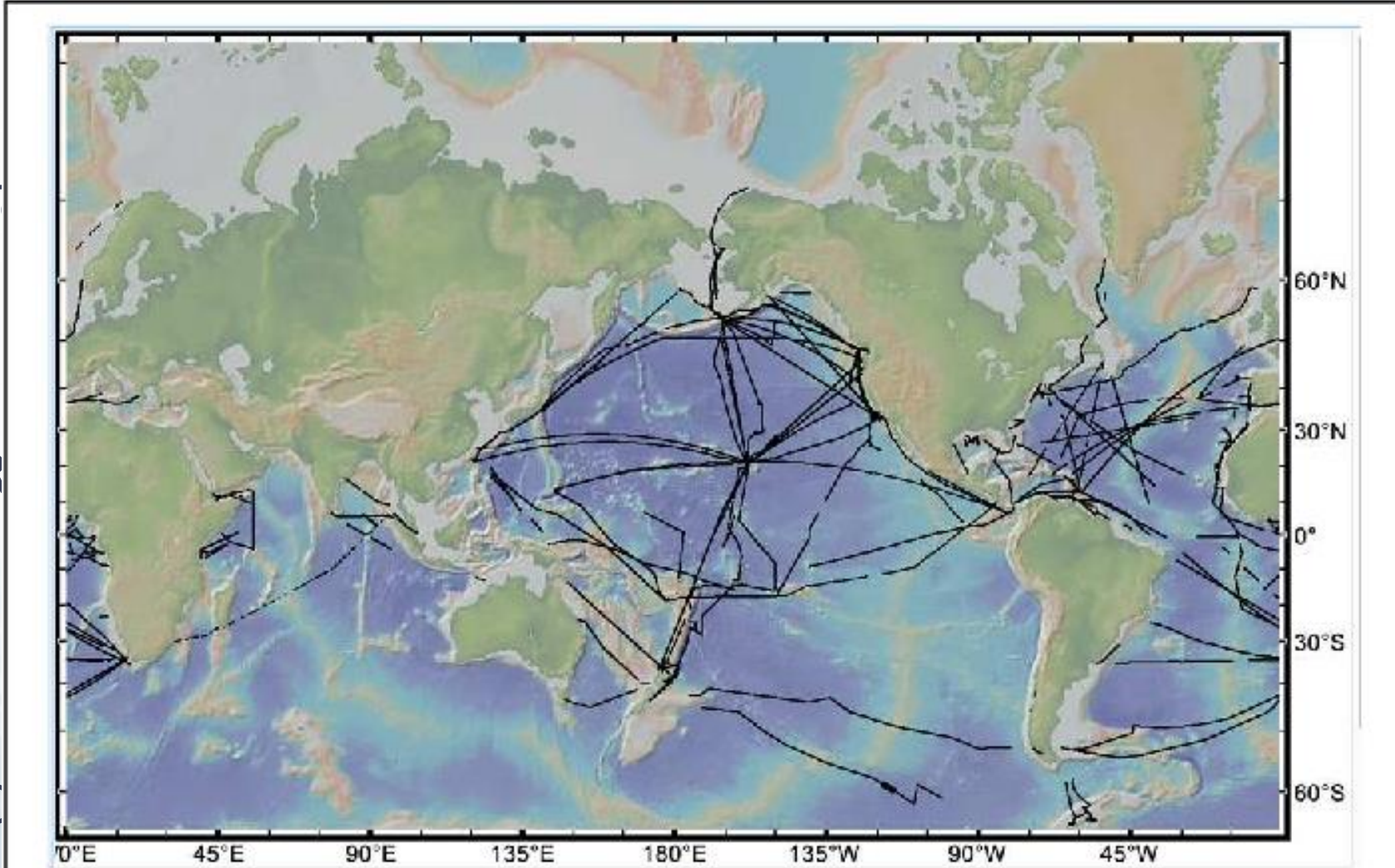


Fig. 3. An example of multibeam data coverage acquired during transit legs of research vessels in the US Academic Research Fleet (ARF). In addition to this coverage, the ARF routinely acquires data during transits to research

Improving the Discovery and Bathymetric Data

- | | |
|---|--|
| <p>Christiane Reiser
 <i>National Centers for Env. Info.</i>
 NOAA
 Boulder, CO, USA
 christiane.reiser@noaa.gov</p> | <p>Erin Heffron
 <i>Ocean Mapping Svcs. LLC</i>
 Portsmouth, NY, USA
 ejheffron@gmail.com</p> |
| <p>Sheila Caceres
 <i>Lamont-Doherty Earth Observ.</i>
 Columbia University
 Palisades, NY, USA
 ccaceres@ldeo.columbia.edu</p> | <p>Tinah Martin
 <i>Lamont-Doherty Earth Observ.</i>
 Columbia University
 Palisades, NY, USA
 vmartin@ldeo.columbia.edu</p> |
| <p>George Spoelstra
 <i>GGS Geo Consultancy BV</i>
 Breda, Netherlands
 george@ggsqc.eu</p> | |

webinar series, organized as listening sessions, highlighted complementary themes of the bathymetric data life cycle: (1) data stewardship, (2) data discovery and identifying data gaps, (3) data access and community needs, and (4) data processing, transformation and integration. Each session was led by a community member experienced with aspects of the session topic and included 4 - 5 guest panelists who provided perspectives on current barriers, opportunities, and future vision.

These conversations highlighted both existing and emerging efforts to improve accessibility of bathymetric data and yielded commentary and suggestions from the global community. The outcomes of the listening sessions were used to develop a framework for an in-person working meeting that sought community consensus on priorities for addressing current and future needs with respect to data discovery, access, and re-use. Participants in the webinars and working meeting included representatives from academia, government and industry, and individuals with perspectives as survey planners, data managers, applications developers, geospatial data experts, managers, sonar manufacturers, data processors, and data consumers.

The community engagement series was co-designed and hosted by the General Bathymetric Chart of the Ocean (GEBCO) Technical Sub-Committee for Ocean Mapping (TSCOM), the International Hydrographic Organization's Data Center for Digital Bathymetry (IHO DCDB), and the Regional Center for the Atlantic and Indian Oceans of the Nippon Foundation - GEBCO Seabed 2030 Project. TSCOM provides technical advice towards the maintenance and improvements of GEBCO products and supporting data. The DCDB, hosted by

• Inertia

Ferrini et al., 2023

DOI: [10.23919/OCEANS52994.2023.10337031](https://doi.org/10.23919/OCEANS52994.2023.10337031)

Multibeam Data in the US Academic Research Fleet

- Complementary data stewardship projects that address technical, resource and cultural limitations
- Promote routine acquisition and preservation of high-quality bathymetry data
- Deliver openly available tools, data and best practices
- Increases return on investment in MBES capabilities



Ship Info	Sonar System Info	MAC Resources
Atlantic (WROO)	Kongsberg EM104 (12 kHz, 130°, 1+1° beams)	MAC Technical Data
Blue Heron (UMNO)	Rona Seabat 302 (240 kHz, 130°)	Coming Soon!
Steady (USOC)	Kongsberg EM122 (12 kHz, 130°)	MAC Technical Data
High R. Sharp (UDELL)	Rona Seabat 7125 (200 kHz, 400kHz, 130°)	MAC Technical Data
Elsa Stearns (SH)	Kongsberg EM122 (12 kHz, 130°) Kongsberg EM700	MAC Technical Data
Koor (retired)	Seabeam 2112	

Providing access to and ensuring the preservation of national oceanographic research data.

The Rolling Deck to Repository (R2R) program provides fleet-wide management of underway data to ensure preservation of, and access to, our national oceanographic research assets.

With their global capability and diverse array of sensors, research vessels are essential mobile observing platforms for ocean science. Data collected on every expedition are of high value, given the high cost and increasingly limited resources for ocean exploration.

R2R catalogs and submits the underway environmental sensor data routinely acquired on research expeditions to long-term public archives, including the NOAA National Centers for Environmental Information (NCEI). Data from each cruise are submitted directly to R2R by the vessel operator, rather than by the science party.

Global Multi-Resolution Topography Data Synthesis

Create Custom Maps and Grids with GMRT Map Tools
 Now available in South Polar and North Polar Projections!

The Global Multi-Resolution Topography (GMRT) synthesis is a multi-resolution compilation of edited multibeam sonar data collected by scientists and institutions worldwide. It is received, processed and gridded by the GMRT Team and merged into a single continuously updated compilation of global elevation data. The synthesis began in 1982 as the Ridge Multibeam Synthesis (RIMS), was expanded to include multibeam bathymetry data from the Southern Ocean, and now includes bathymetry from throughout the global and coastal oceans. GMRT is included in the ocean basemap in Google Earth (since June 2011) and the GEBCO 30x1 completion. [Learn more](#)

GMRT v4.0 was released in January 2022 and includes 37,245,849 square kilometers of curated multibeam data from 1,388 cruises.

MGDS MARINE GEOSCIENCE DATA SYSTEM

Search Data | Contribute Data | Web Services

Related Resources

- GMRT Global Bathymetry
- SeaRiseApp
- Antarctic Data (USAP-DC)
- EDA

Recent Data Contributions

- NAO20 Data: ROV Hercules Dive Reports from E/V Nautilus expedition NA201 (2020)
- 2017 AUV Sentry vehicle-connected navigation and raw magnetic sensor data, Azal Beaufort
- 2017 Data: 2017 AUV Sentry vehicle-connected navigation and raw magnetic sensor data, Azal Beaufort
- NAO19 Data: Processed Gridded Acoustic Backscatter Data

Recent Citations

- Allen et al., 2020. Physiographic inference of Sumatran vents bearing geothermophilous isolates with regard to the Palaeocene storage systems of Sundaflat. *Sci Rep.* 10, 2001. DOI: 10.1038/s41598-020-14728-6
- Parsons, 2019. Geochemistry of trawler Shelves: Santa Maria Island, Azores, Portugal. Thesis
- Smith et al., 2020. Hydrothermal Alteration Within the Southern Submarine Arc, Hikurangi, Kermadec, New Zealand. *Geochimica et Cosmochimica Acta*

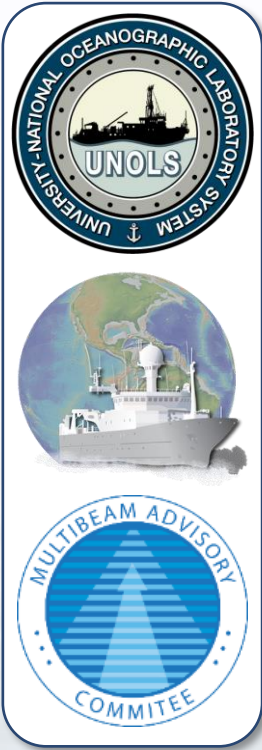
Acquisition

Preservation

Synthesis & Integration

Preservation, Provenance & Access

Growth of raw MB source data in NOAA Archive



Bathymetric Data Viewer

<https://www.ncei.noaa.gov/maps/bathymetry/>

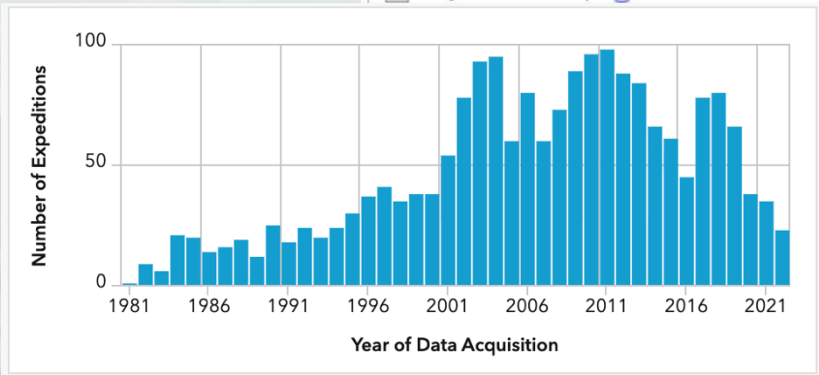
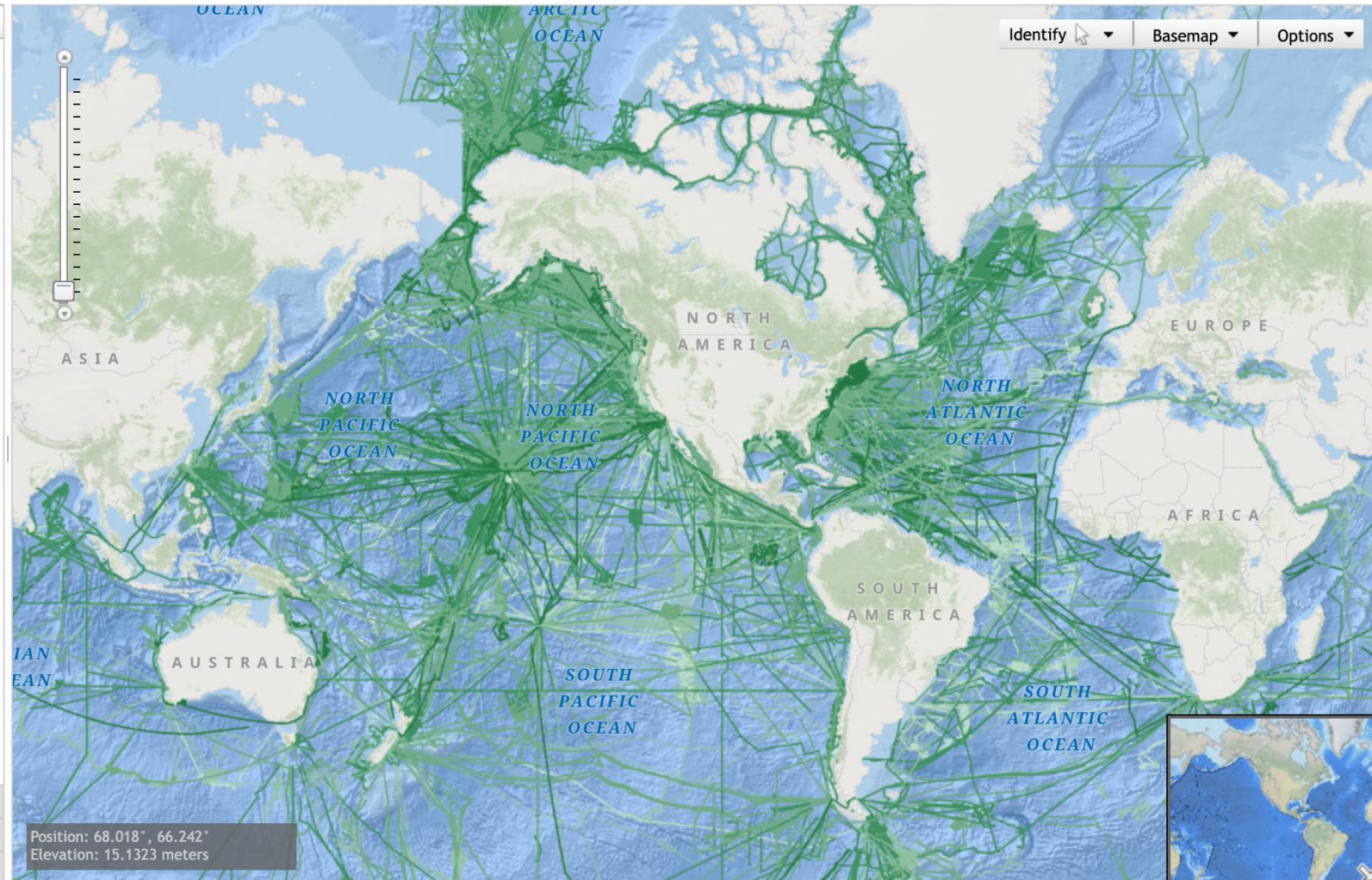
Layers

Bathymetric Surveys and Products

- Multibeam Dataset Tracklines ?
- All Multibeam Datasets
- Multibeam Raw
- Multibeam Processed
- Multibeam Products
- Multibeam Survey Footprints ?
- Multibeam Bathymetry Mosaic ?

NOAA NOS Hydrographic Data and Products

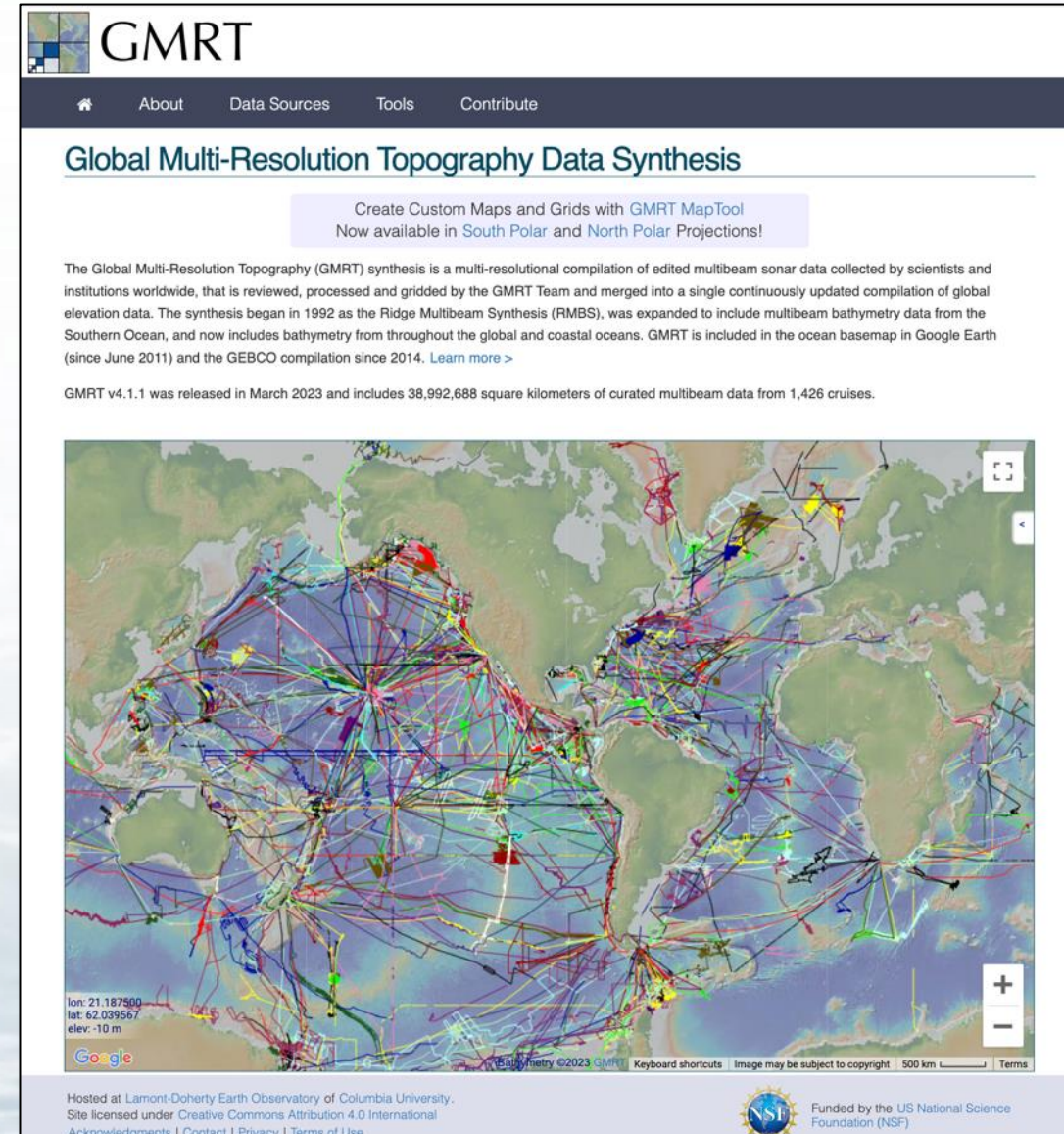
- Hydrographic Survey Outlines: ?
 - All Surveys with Digital Data
 - Surveys with Bathymetric Attributed Grids (BAGs)
 - Surveys without Digital Data
- BAG Color Shaded Relief ?
- U.S. Bathymetry Coverage and Gap Analysis ?
- BlueTopo ?
- Single-Beam Surveys ?



Multibeam Bathymetry Database (MBBDB) at NCEI

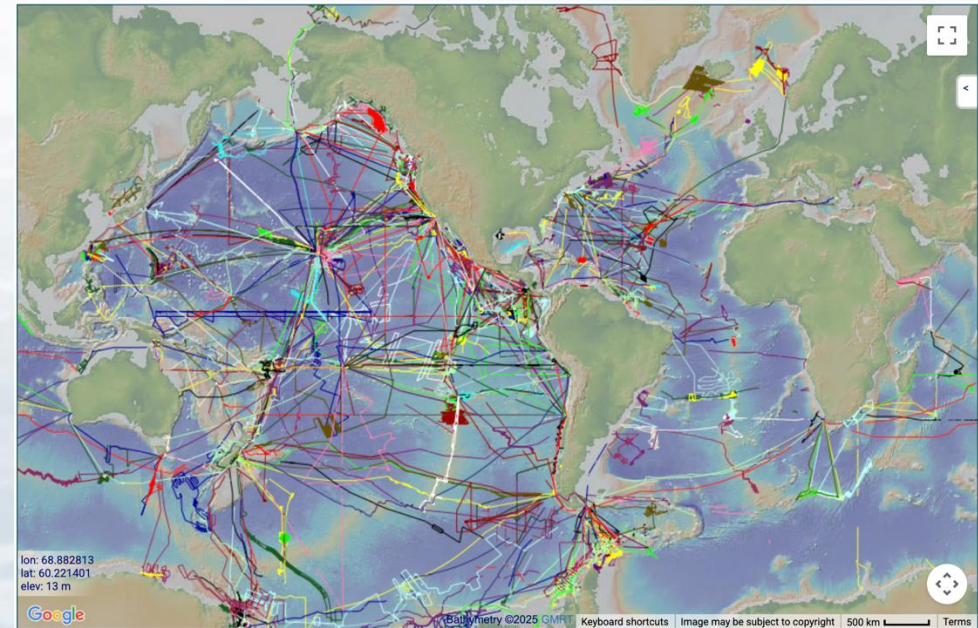
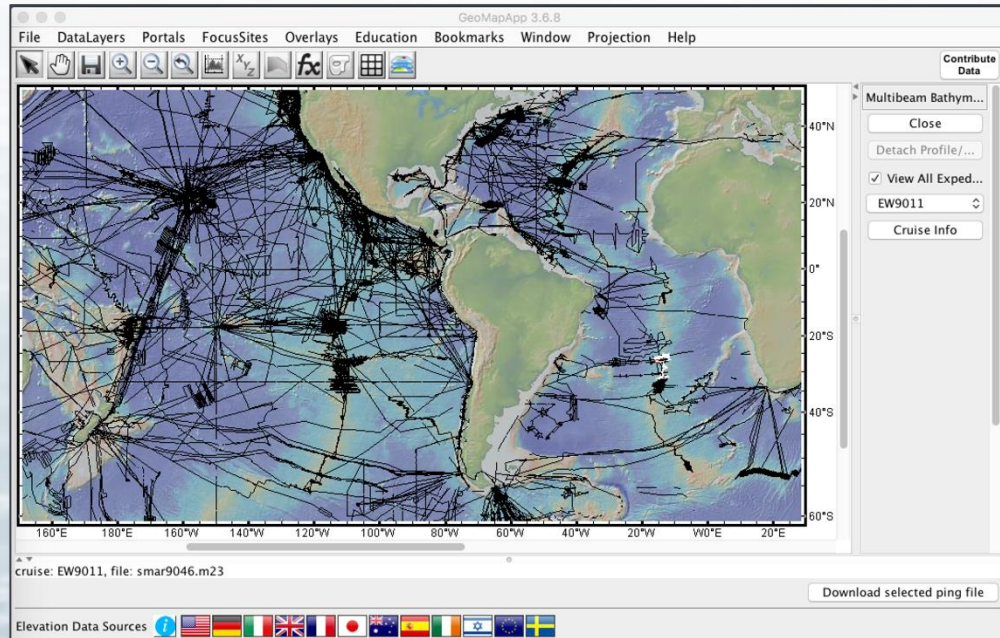
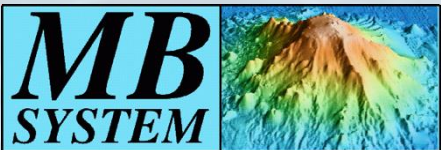
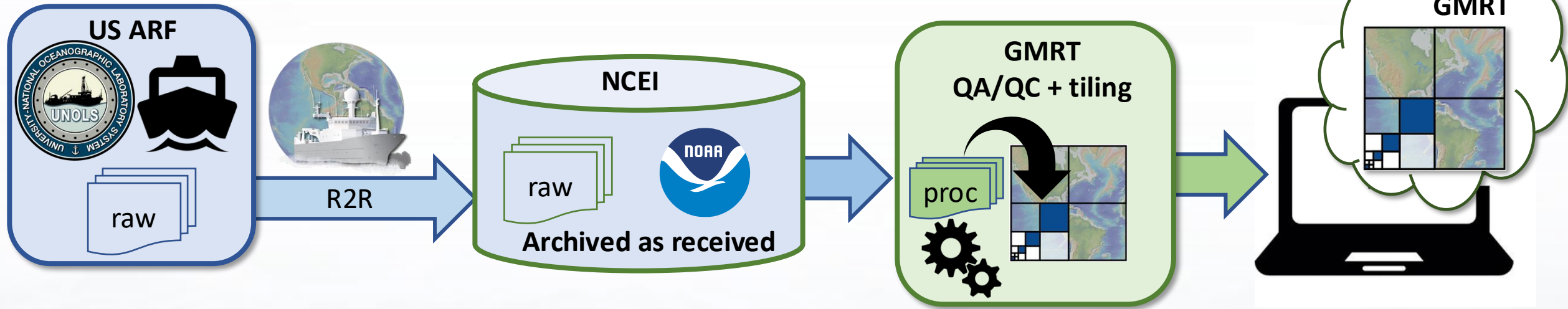
GMRT: Global Multi-Resolution Topography

- Provide users with access to **seamlessly integrated bathymetry** and land elevation data at the best resolution available for a particular area of interest
- Support broad **accessibility** by **specialists and non-specialists** alike through multiple user interfaces, services, and output formats
 - Web services, web app, desktop app
- Continuously **expand bathymetry coverage** by integrating new data and highlighting data gaps
- Strive for scalability and efficiency in all aspects of data stewardship continuum



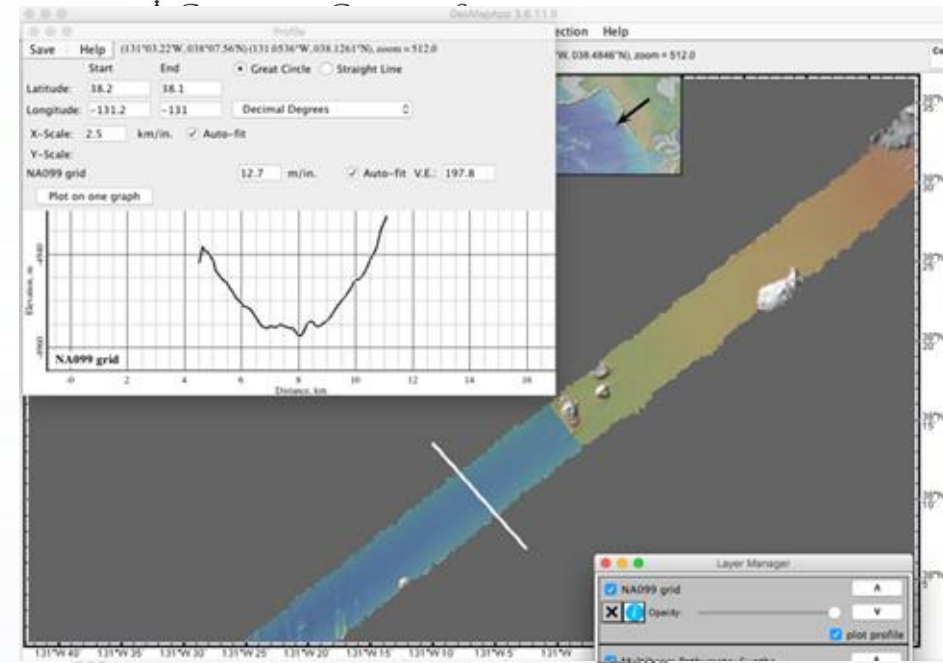
The screenshot displays the GMRT website's main interface. At the top, there is a navigation bar with links for 'About', 'Data Sources', 'Tools', and 'Contribute'. Below this is a header section titled 'Global Multi-Resolution Topography Data Synthesis'. A prominent call-to-action button reads 'Create Custom Maps and Grids with GMRT MapTool', with a sub-note 'Now available in South Polar and North Polar Projections!'. The main content area contains a paragraph describing the GMRT synthesis as a multi-resolutional compilation of edited multibeam sonar data. Below the text, it states 'GMRT v4.1.1 was released in March 2023 and includes 38,992,688 square kilometers of curated multibeam data from 1,426 cruises.' The central feature is a large map of the world with a dense network of colorful lines representing bathymetry data. The map includes standard Google Maps controls like zoom in (+) and zoom out (-) buttons, and a coordinate display at the bottom left showing 'lon: 21.187500', 'lat: 62.039567', and 'elev: -10 m'. The footer contains the Lamont-Doherty Earth Observatory logo, the NSF logo, and text indicating the site is hosted at Lamont-Doherty Earth Observatory of Columbia University and licensed under Creative Commons Attribution 4.0 International.

GMRT MBS Data Curation

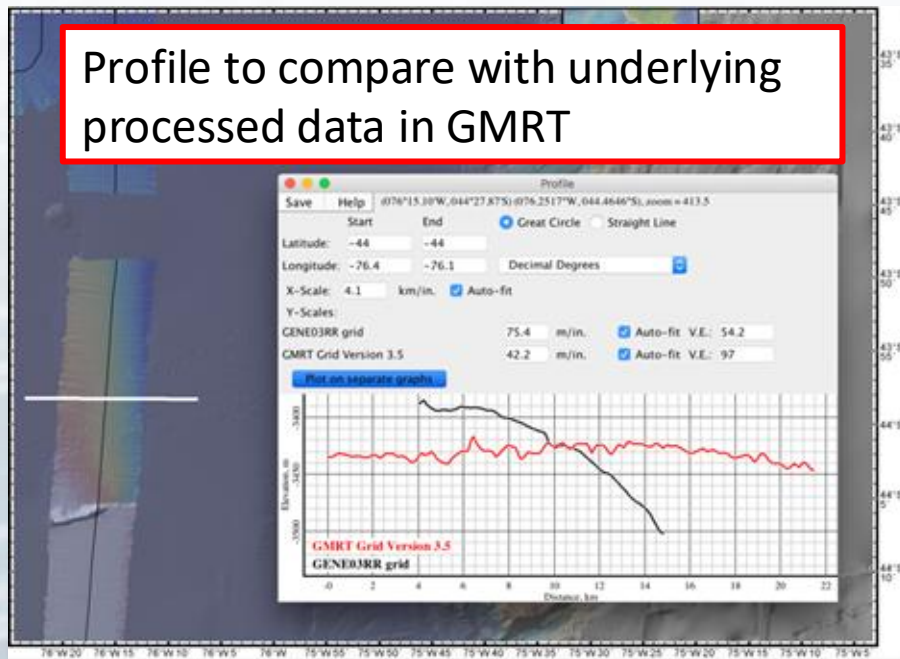


GMRT: MBES Data Curation

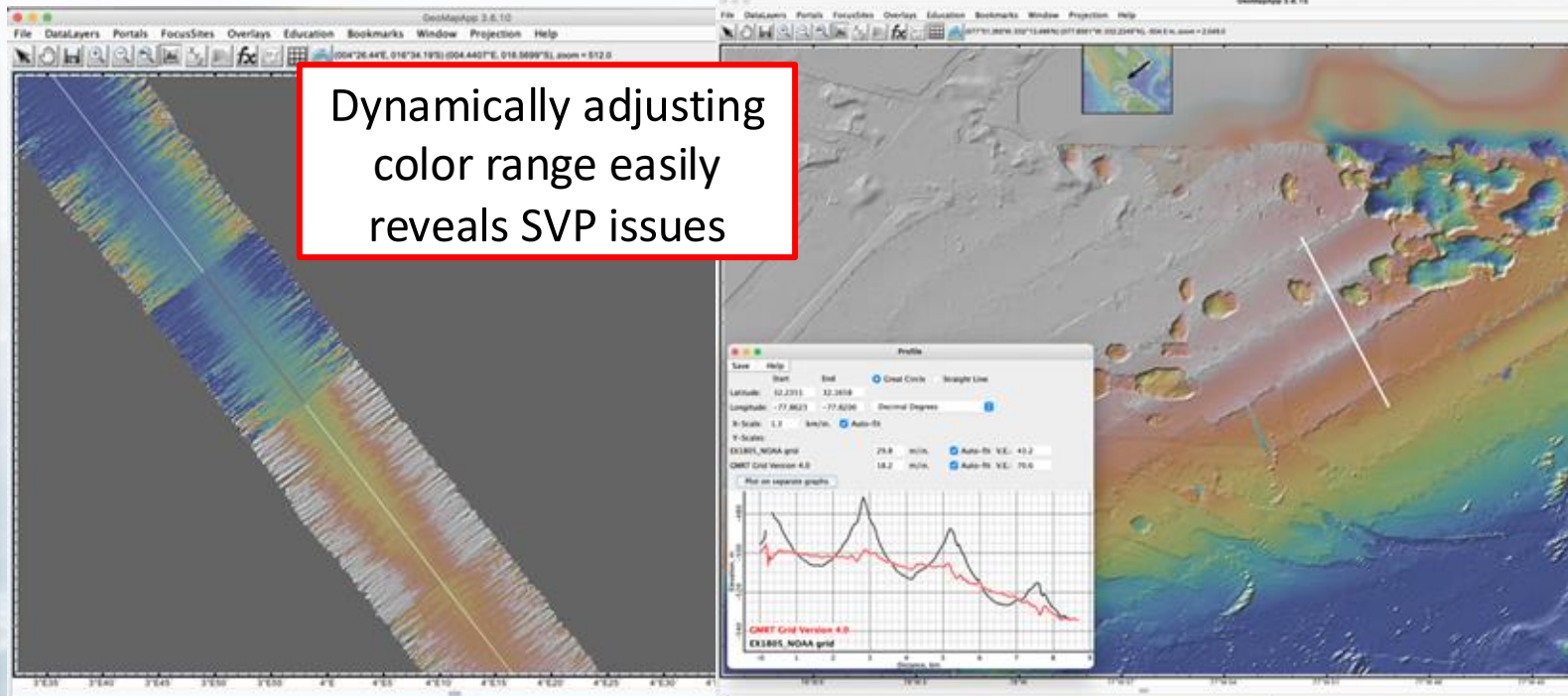
- Create tiled rasters from swath files
 - Review rasters & compare with underlying GMRT data
- Identify and address data quality issues
 - Ping edits, SSP issues
- Ensure that processed data are fit-for-purpose and can be seamlessly integrated with other data



Profile to compare with underlying processed data in GMRT



Dynamically adjusting color range easily reveals SVP issues



GMRT MBS Data Stewardship

- Processed data accessible through integrated synthesis (grids + images)
- Processed swath files preserved, available & citable with full attribution to data collectors and data processors

GMRT

GMRT Multibeam Data Report

MGL1002 Transit (2010)

R/V Marcus G. Langseth
 Kongsberg EM122
 Chief Scientist: Dr. John Diebold

Data Summary

515 Data Files Processed
 Data Processed By: the GMRT Team
 Total Ship-Track Coverage: 4730 km
 Total Area Mapped: 7261 km²

Sonar Extinction Plots (swath width vs depth):
 Extinction plots show the swath width of the MB echosounder as a function of depth. This information can be important for planning survey line spacing and can be a diagnostic tool when reviewing sonar system health.

Marine Geoscience Data System (MGDS)
 Related Information at MGDS

Multibeam Advisory Committee (MAC)
 The Multibeam Advisory Committee (MAC) works with vessel operators to promote consistent operation and calibration of multibeam sonars across the US Academic Fleet. In addition to ship visits, the MAC develops best practice guidelines, software tools, and cookbooks to assist vessel operators and scientists with multibeam sonar operations. Related Information for Marcus G. Langseth

Rolling Deck to Repository (R2R)
 The R2R Program performs programmatic quality assessment (QA) on unprocessed data in order to seek signals that may indicate problems that may affect data quality. The results of those tests can be accessed through the R2R QA Certificate (XML). R2R also ensures underway data from the US Academic Fleet are delivered to the NOAA National Centers for Environmental Information (NCEI), which in turn makes multibeam data available for integration into GMRT. Download Raw Swath Files

MGDS
 MARINE GEOSCIENCE DATA SYSTEM

MGL1002 Backscatter:Acoustic, Bathymetry:Swath, Sidescan

Processed ship-based Multibeam Sonar Data (version 2) acquired in the eastern Pacific Ocean during the Marcus G. Langseth expedition MGL1002 (2010)

This data set was acquired with a ship-based Kongsberg EM122 Multibeam Sonar system during Marcus G. Langseth expedition MGL1002 conducted in 2010 (Chief Scientist: Dr. John Diebold). These data files are of MBSystem format and include Swath Bathymetry, Sidescan, and Acoustic Backscatter data and were processed by the GMRT Team using the open source MB-System multibeam sonar processing software as part of the GMRT Synthesis effort. These data are included in the GMRT Synthesis, version 2.0. Data were acquired while the Marcus G. Langseth was in transit.

GMRT, Investigator
Device Info Sonar:Multibeam
 Kongsberg EM122
Platform Marcus G. Langseth
 LDEO
Data DOI 10.26022/NEDA/316812

Quality 2
 The data have been processed/modified to a level beyond that of basic quality control (e.g. final processed sonar data, photo-mosaic).

515 Total Files. Select files to download and choose Download Selected File(s) above.

Data Files	Documents	Data Citation Information	ISO/XML Metadata
0004_20100508_014957_Langseth.allp.mb71	Start 124.4318° W 45.9673° N 2010-05-08T01:49:56 Depth: 158.934	Stop 124.6302° W 45.9061° N 2010-05-08T02:19:55 Depth: 155.676	Size 17.8MB Format MBSystem MB Format: 71
0005_20100508_021957_Langseth.allp.mb71	Start 124.6303° W 45.9061° N 2010-05-08T02:19:56 Depth: 154.218	Stop 124.7285° W 45.846° N 2010-05-08T02:49:53 Depth: 339.924	Size 12.3MB Format MBSystem MB Format: 71
0006_20100508_024957_Langseth.allp.mb71			

IHO International Hydrographic Organization

Data Centre for Digital Bathymetry Viewer

Layers

- IHO DCDB/NOAA NCEI
 - Multibeam Surveys
 - Multibeam Survey Footprints
 - Multibeam Bathymetry Mosaic
 - Single-Beam Surveys
 - Single-Beam Sounding Density
 - NOAA Hydrographic Surveys
 - All Surveys with Digital Data
 - Surveys with BAGs
 - BAG Shaded Relief Imagery
- Search NCEI/DCDB Surveys
- Search CSB Files
- U.S. Bathymetry Coverage and Gap Analysis

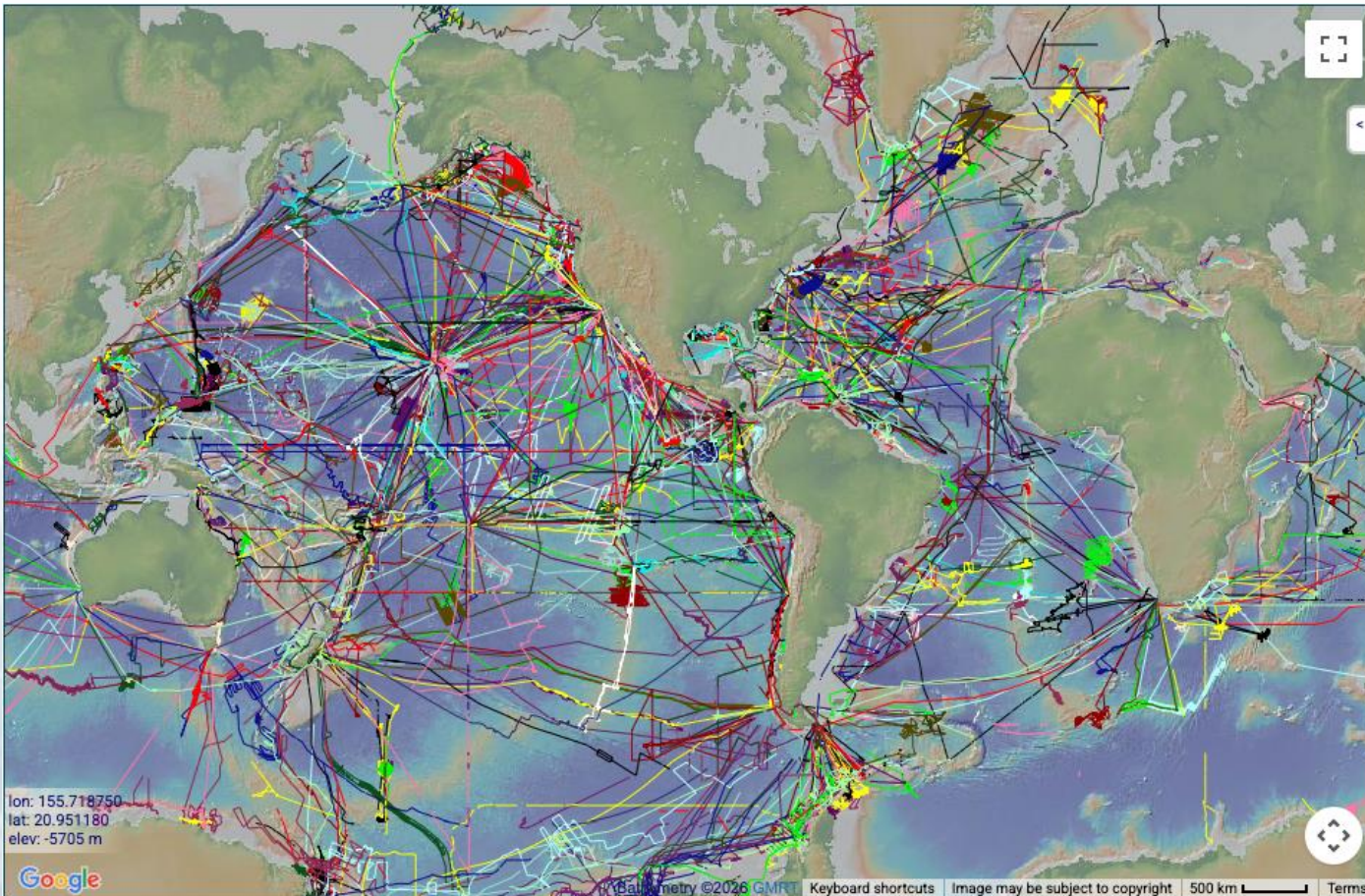
EMODnet
 Australia
 Canada
 France
 Germany
 Japan
 Netherlands
 New Zealand
 Norway
 Portugal

Grid Extract
 More Information
 Help

Position: -52.822°, -10.460°
 Elevation: 310.261 meters

GMRT: MBES Data Sources

- Data Processing Priority: US Academic Research Fleet
- Data acquired during surveys and transits



GMRT V 4.4.1 Curated Multibeam Stats

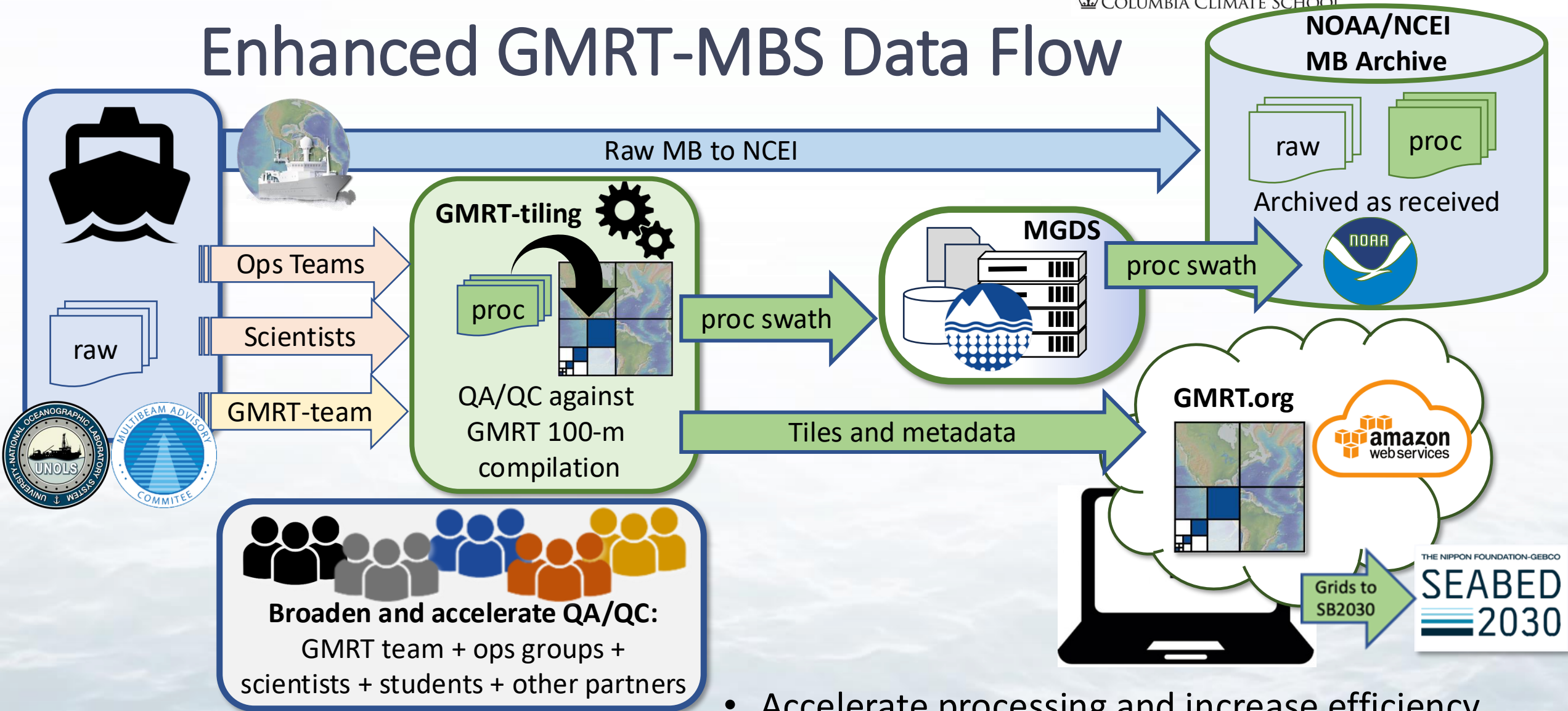
Expeditions	1,621*
Multibeam Devices	24
Ships	54
Ship Operators	40
Chief Scientists	636
Total Swath Files	311,244
Total Area Mapped (km ²)	44,116,654
Total Area Mapped (%)	12.19%
“Transit” Cruises (%)	13%

*70% USARF expeditions,
75% processed from raw by GMRT Team

<https://www.gmrt.org/>

<https://www.geomapapp.org/>

Enhanced GMRT-MBS Data Flow



- Accelerate processing and increase efficiency
- Common lens to ensure fit-for-purpose standard
- Optimize data quality in processed data archives

GMRT: Distributable Data Processing and Curation

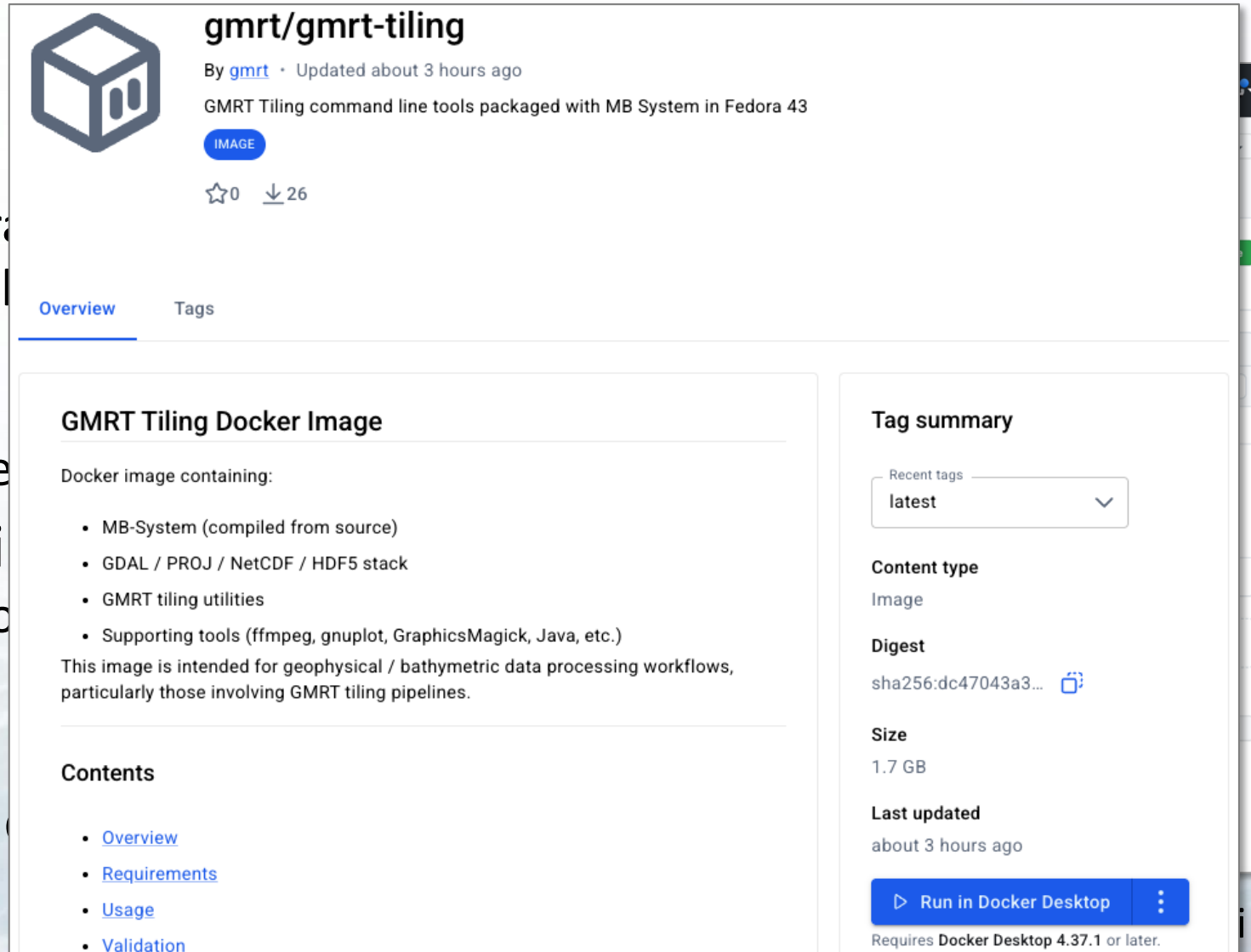
- Goals

- Establish common fit-for-integration
- Improve quality of publicly available swath files
- Minimize need reprocessing
- Accelerate the pace of data integration

- Successfully deployed in multiple environments

- Physical and virtual machines (cloud)
- Personal computers
- At-sea

- Code and instructions available



The screenshot shows the Docker Hub page for the repository `gmrt/gmrt-tiling`. The repository is owned by `gmrt` and was updated about 3 hours ago. It is described as "GMRT Tiling command line tools packaged with MB System in Fedora 43". The page includes a Docker image icon, a star count of 0, and a download count of 26. The "Overview" tab is selected, showing the "GMRT Tiling Docker Image" section. This section lists the contents of the Docker image: MB-System (compiled from source), GDAL / PROJ / NetCDF / HDF5 stack, GMRT tiling utilities, and supporting tools (ffmpeg, gnuplot, GraphicsMagick, Java, etc.). A note states that the image is intended for geophysical / bathymetric data processing workflows, particularly those involving GMRT tiling pipelines. The "Contents" section provides links to Overview, Requirements, Usage, and Validation. The "Tag summary" section shows the "latest" tag, content type "Image", a digest of `sha256:dc47043a3...`, a size of 1.7 GB, and a last updated time of about 3 hours ago. A "Run in Docker Desktop" button is visible at the bottom right, with a note that it requires Docker Desktop 4.37.1 or later.

gmrt/gmrt-tiling
By [gmrt](#) · Updated about 3 hours ago
GMRT Tiling command line tools packaged with MB System in Fedora 43

IMAGE
☆0 ↓ 26

Overview Tags

GMRT Tiling Docker Image

Docker image containing:

- MB-System (compiled from source)
- GDAL / PROJ / NetCDF / HDF5 stack
- GMRT tiling utilities
- Supporting tools (ffmpeg, gnuplot, GraphicsMagick, Java, etc.)

This image is intended for geophysical / bathymetric data processing workflows, particularly those involving GMRT tiling pipelines.

Contents

- [Overview](#)
- [Requirements](#)
- [Usage](#)
- [Validation](#)

Tag summary

Recent tags
latest

Content type
Image

Digest
sha256:dc47043a3...

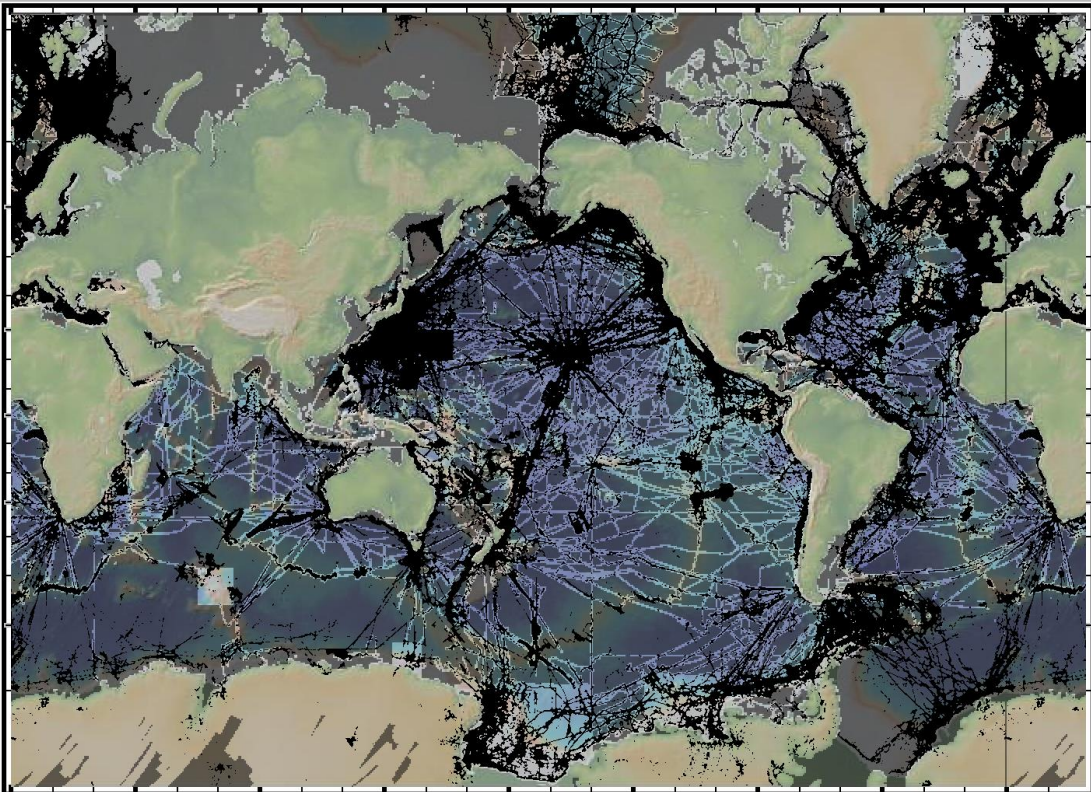
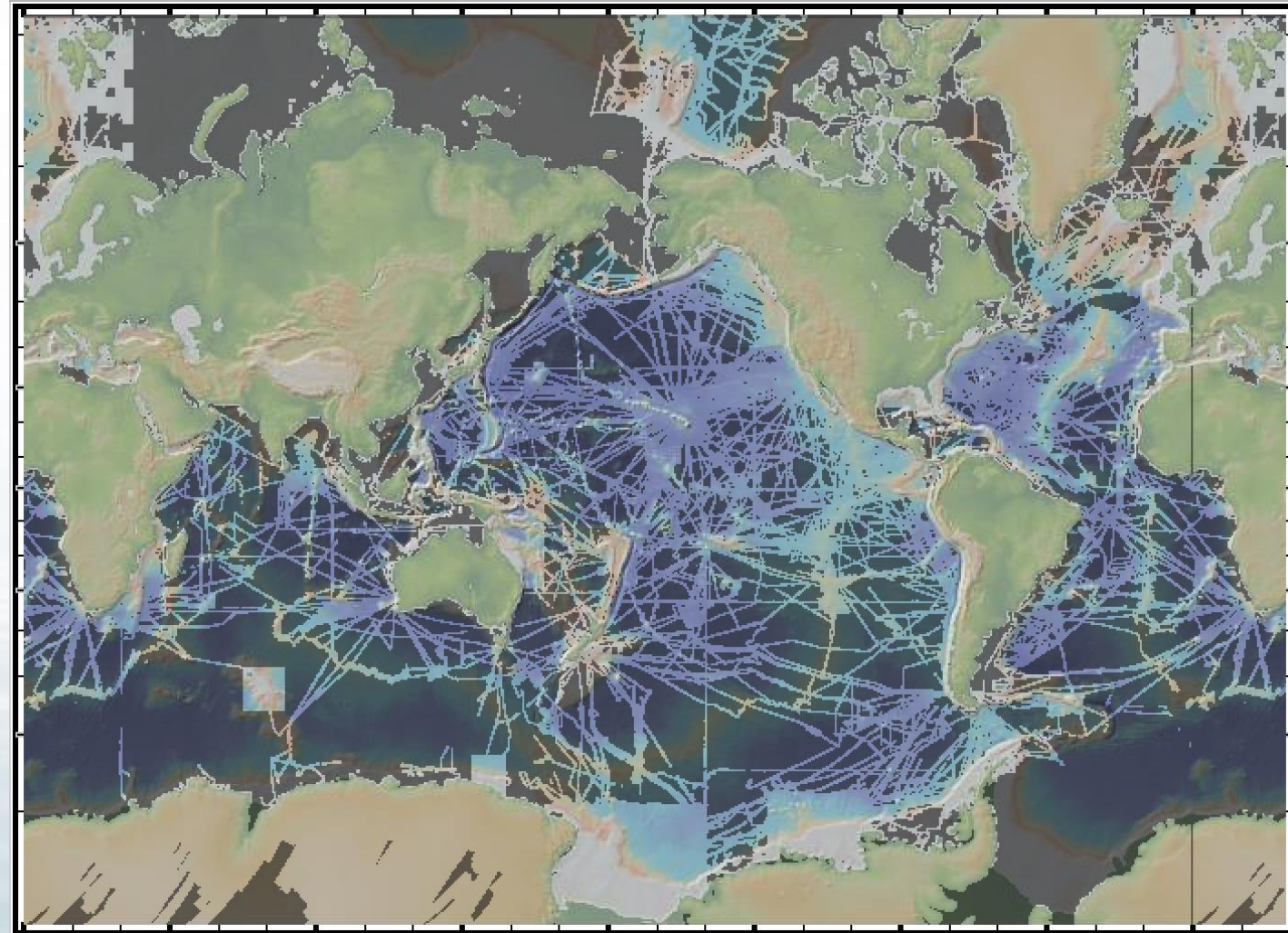
Size
1.7 GB

Last updated
about 3 hours ago

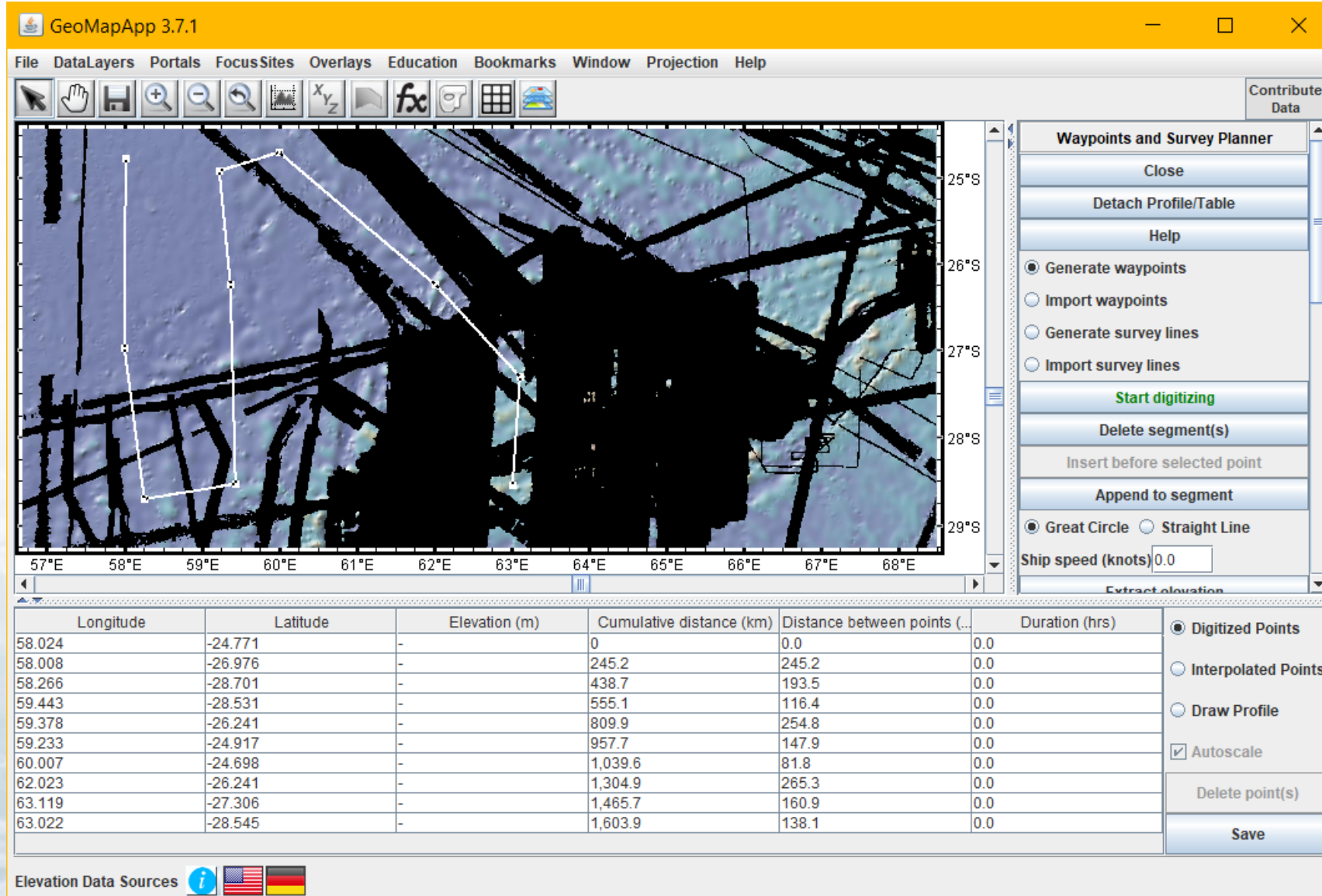
Run in Docker Desktop
Requires Docker Desktop 4.37.1 or later.

Identifying Data Gaps with GMRT

- GMRT Mask
- GEBCO Type Identifier
- NCEI MB Data Holdings



Identifying Data Gaps with GMRT & GeoMapApp



The screenshot shows the GeoMapApp 3.7.1 interface. The main map displays a satellite-style view of a region with a white survey path overlaid. The path starts at approximately 58.024°E, 24.771°S and ends at 63.022°E, 28.545°S. The map includes a coordinate grid and a toolbar with various navigation and editing tools.

On the right side, the 'Waypoints and Survey Planner' panel is open, showing options to generate waypoints and survey lines. The 'Generate waypoints' option is selected. Below this panel, a table displays the survey data points.

Longitude	Latitude	Elevation (m)	Cumulative distance (km)	Distance between points (...)	Duration (hrs)
58.024	-24.771	-	0	0.0	0.0
58.008	-26.976	-	245.2	245.2	0.0
58.266	-28.701	-	438.7	193.5	0.0
59.443	-28.531	-	555.1	116.4	0.0
59.378	-26.241	-	809.9	254.8	0.0
59.233	-24.917	-	957.7	147.9	0.0
60.007	-24.698	-	1,039.6	81.8	0.0
62.023	-26.241	-	1,304.9	265.3	0.0
63.119	-27.306	-	1,465.7	160.9	0.0
63.022	-28.545	-	1,603.9	138.1	0.0

At the bottom of the interface, there are icons for 'Elevation Data Sources' and flags for the United States and Germany.

GMRT in Third-Party Tools

The screenshot displays a web-based interface for a Geospatial Mapping and Routing Tool (GMRT). The interface is divided into several sections:

- Header:** Includes a user profile for "Vicki Ferrini" and a project name "Untitled Project".
- Navigation:** Three tabs are visible: "LOCATION" (selected), "STATION DETAILS", and "TIME TABLE".
- Summary Table:**

Total Time	Station Time	Distance	CO2
0d 0h	0d 0h	0 nm	0t
- Configuration:** Includes a "Select Port of Departure" dropdown (set to "Medium vessel") and a "Select Port of Arrival" dropdown.
- Instructions:** A text box states: "You can add research locations by manually drawing them on the map or by importing a file with coordinates".
- Map:** A satellite-style map of the North Atlantic Ocean showing a dense network of blue lines representing shipping routes. Several red circular markers are placed on the map, indicating specific research locations. A coordinate box at the bottom left shows "Position: 41.9349, -42.9497" and "Elevation: -4665m". A scale bar indicates "2,000 km".
- Mapbox:** The Mapbox logo is visible in the bottom left corner of the map area.

GMRT in Third-Party Tools

The image displays two overlapping web interfaces. The background interface is R2R (Rolling Deck to Repository), featuring a search bar with 'Atlantis' entered, a navigation menu with 'The Observatory', 'Science', 'Participate in OOI', 'Community Engagement', 'OOI Data', and 'Resources', and a sidebar with 'Download Parameters', 'Grid Parameters', and 'Map Preview'. The foreground interface is the Bathymetric Data Viewer, showing a map of the North Pacific and North Atlantic Oceans with a dense network of blue bathymetric survey tracks. The viewer includes a 'Layers' panel with options for 'Bathymetric Surveys and Products' and 'NOAA NOS Hydrographic Data and Products', and a search bar for 'Search Bathymetric Surveys'.

R2R (Rolling Deck to Repository)

- Search:
- Navigation: The Observatory, Science, Participate in OOI, Community Engagement, OOI Data, Resources
- Visit the OOI Data Portal
- Sidebar: Download Parameters, Grid Parameters, Map Preview, Activity Log

Bathymetric Data Viewer

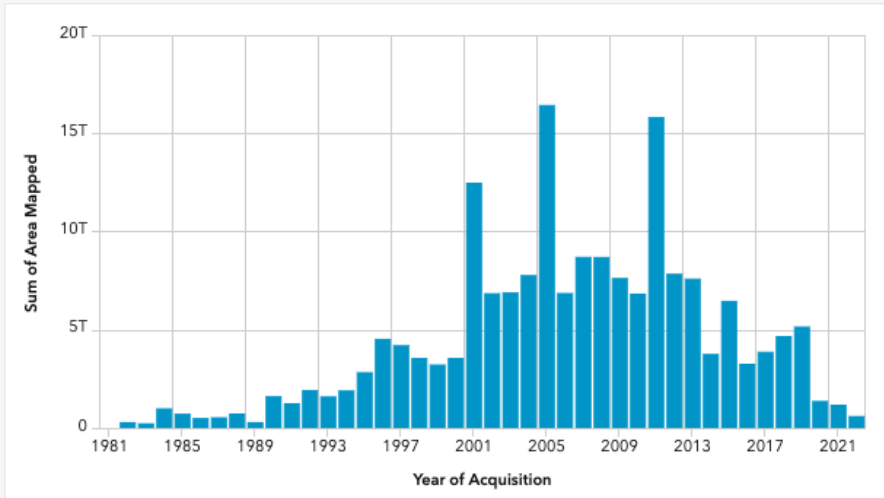
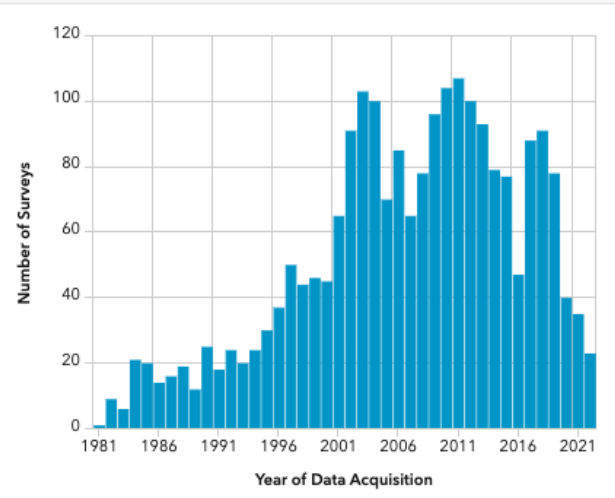
- Layers:
 - Bathymetric Surveys and Products
 - Multibeam Dataset Tracklines
 - All Multibeam Datasets
 - Multibeam Raw
 - Multibeam Processed
 - Multibeam Products
 - Multibeam Survey Footprints
 - Multibeam Bathymetry Mosaic
 - NOAA NOS Hydrographic Data and Products
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 - All Surveys with Digital Data
 - Surveys with Bathymetric Attributed Grids (BAGs)
 - Surveys without Digital Data
 - BAG Color Shaded Relief
 - U.S. Bathymetry Coverage and Gap Analysis
 - BlueTopo
 - Single-Beam Surveys
 - Single-Beam Sounding Density

- Search: Search Bathymetric Surveys, Search CSB Files
- Grid Extract, More Information, Help

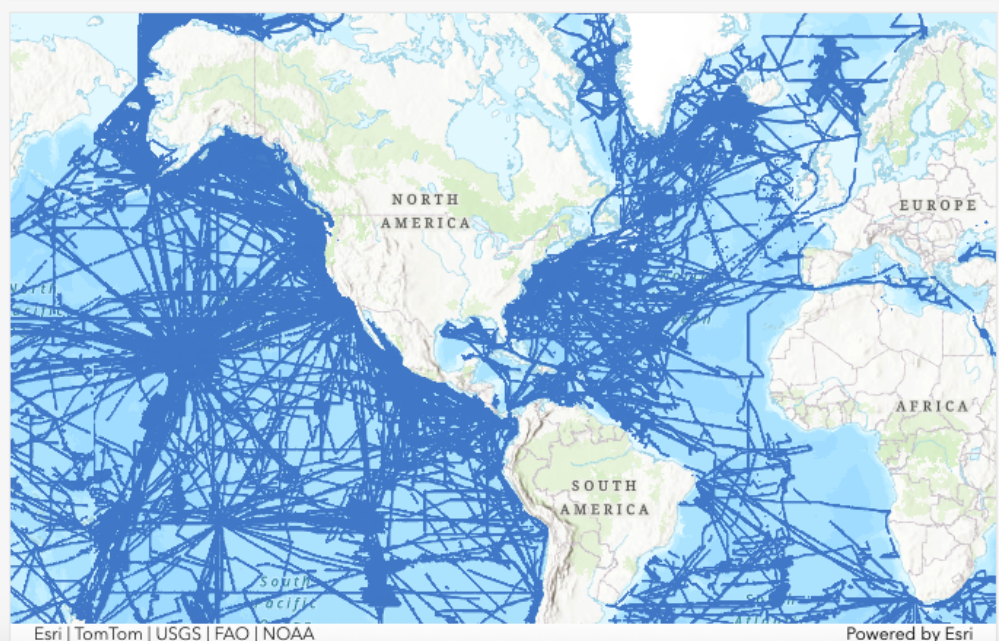
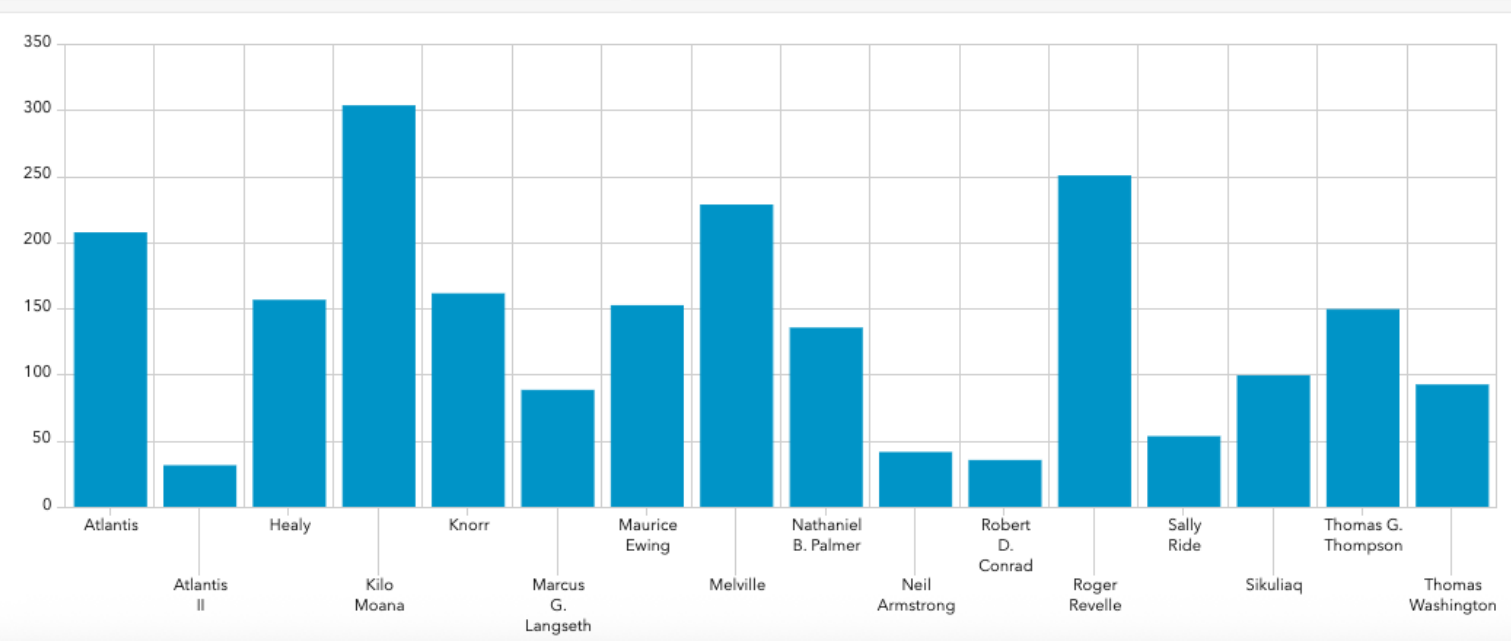
ARF MB Coverage Dashboard (Under Development)

ARF-MBCoverage Dashboard

Vicki Ferrini
 vlf2102_columbia



PLATFORM	NUMBER OF SURVEYS (INCL TRANSITS)
Kilo Moana	304
Roger Revelle	251
Melville	229
Atlantis	208
NOAA Ship OKEANOS EXPLORER (R337)	188
Knorr	162
Healy	157
Maurice Ewing	153



Main Take-Aways

- USARF delivers significant amounts of data to national and global mapping efforts through surveys & transit mapping
- Multiple tools to identify data gaps (GMRT, GeoMapApp + more)
- Community of experts ready to process data (GMRT + Seabed 2030)
- Distributable tools available to help ensure data are fit for integration (GMRT)
- New tools on the horizon to enhance opportunistic and continuous data acquisition (MAC + GMRT)
- Dashboard highlighting ARF impact under development
- Contact us – we're here to help!