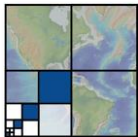


# Global Multi-Resolution Topography (GMRT)

Vicki Ferrini and the GMRT Team



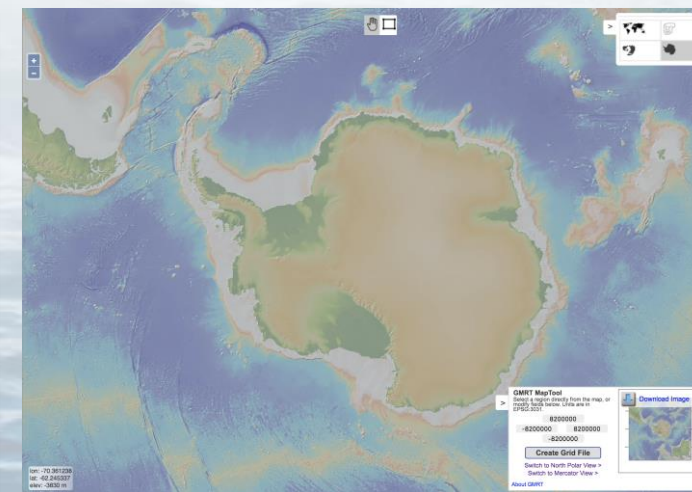
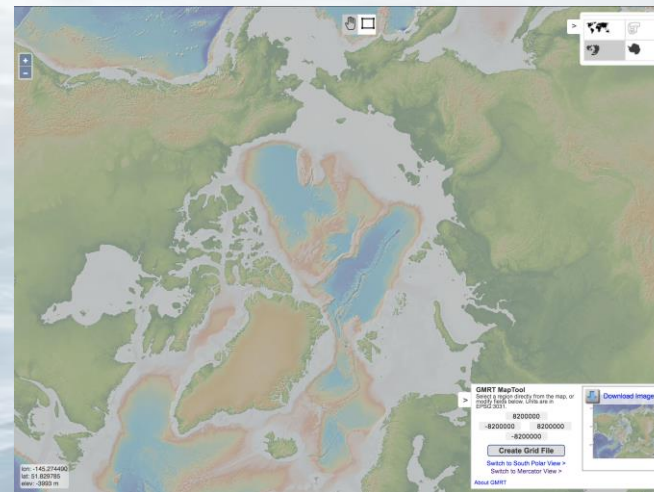
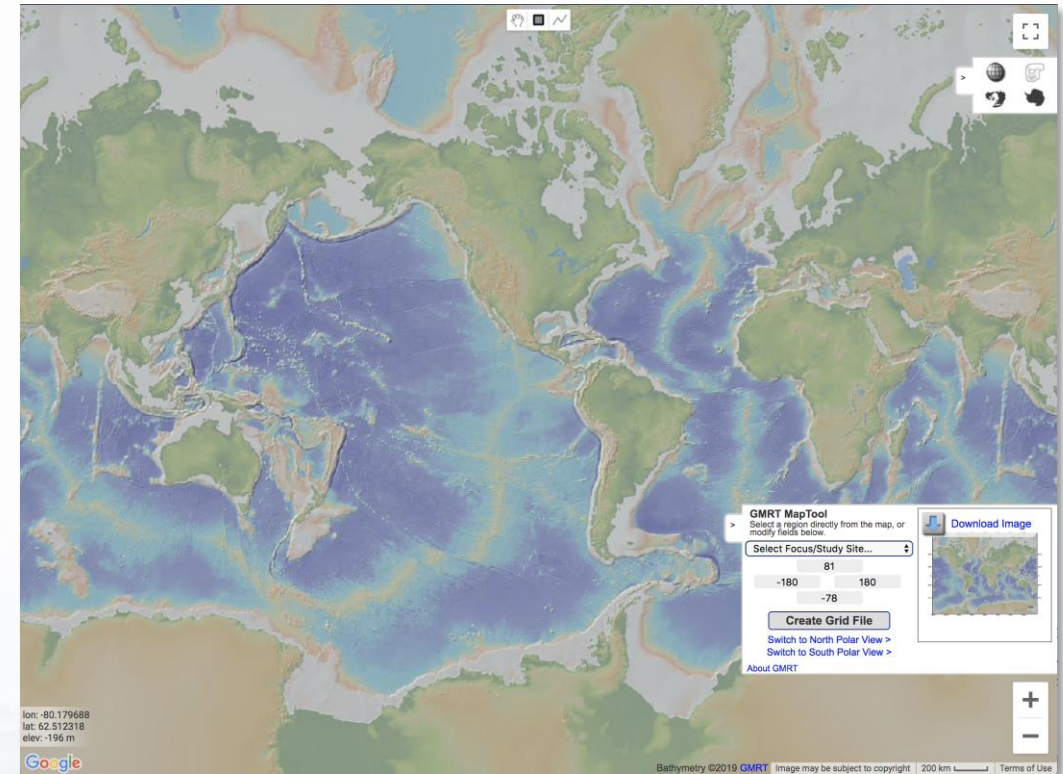
Lamont-Doherty Earth Observatory  
COLUMBIA UNIVERSITY | EARTH INSTITUTE

GMRT is supported by the US National Science Foundation.

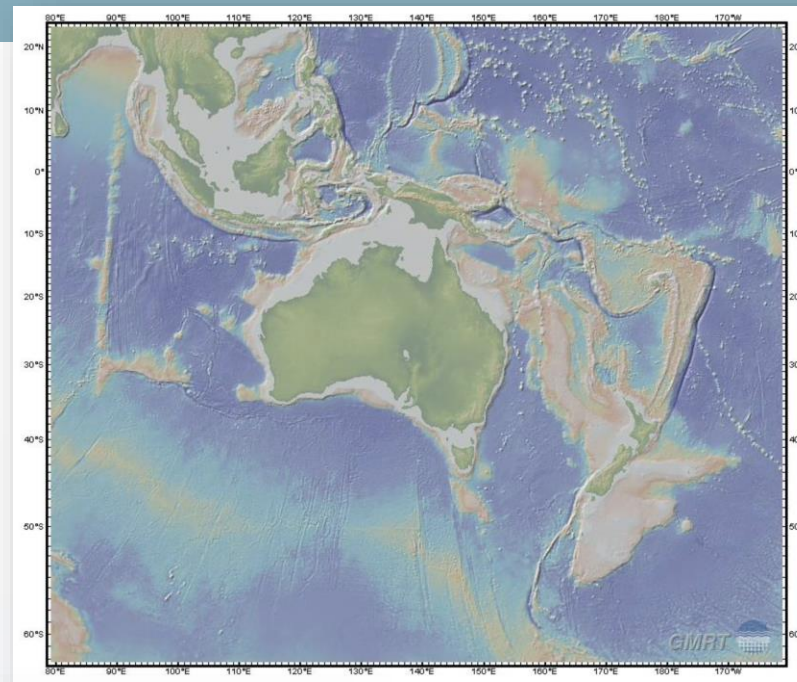


# GMRT: Overview

- Multi-resolution tiled synthesis
  - Topography and **bathymetry**
- Comprehensive metadata
  - Full attribution to sources & access to source data
- Simultaneously maintained in 3 projections
- Elevation data available in many formats
  - Grids, Images, Points, Profiles
- Accessible via:
  - GMRT MapTool Web App
  - GeoMapApp Desktop App
  - GMRT Web Services



# GMRT: Image Access



## NAMSS map

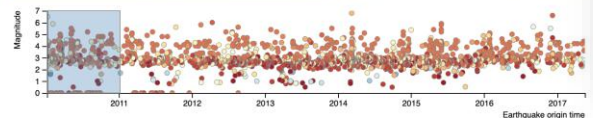
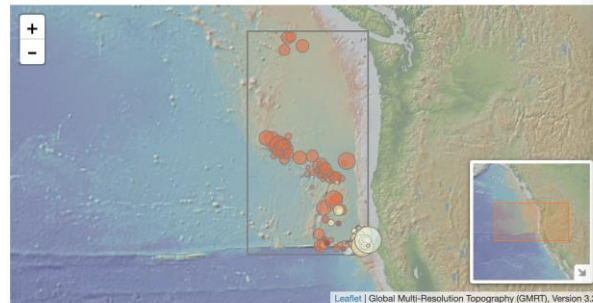


## Plate Boundary Features Exploration

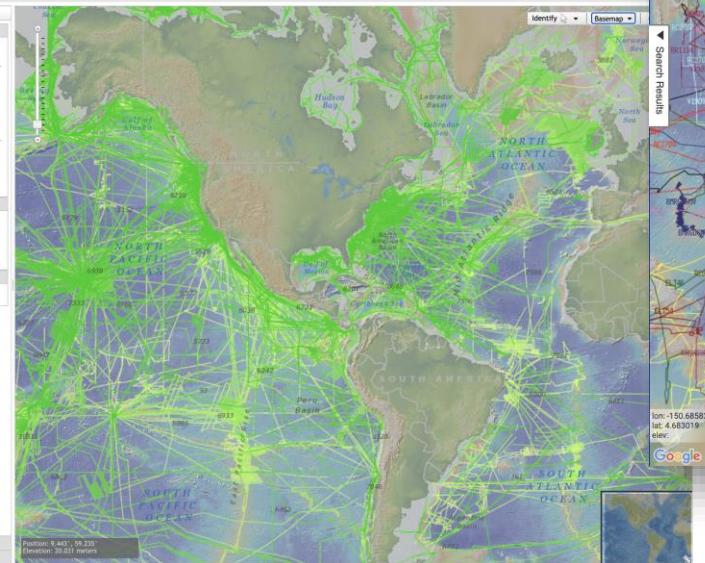
### Your Objective

Use earthquake data from plate boundaries in ocean regions off of the Pacific Northwest to look if the patterns between 2010-17.

- Make a prediction about what kind of patterns in earthquake magnitude and location you may observe over time.
- Explore the data below to see what you can observe.

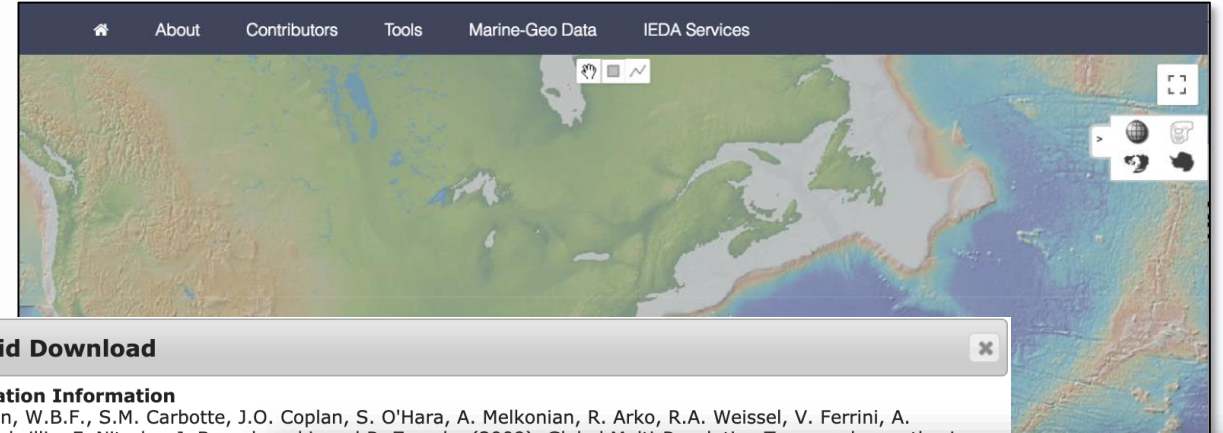
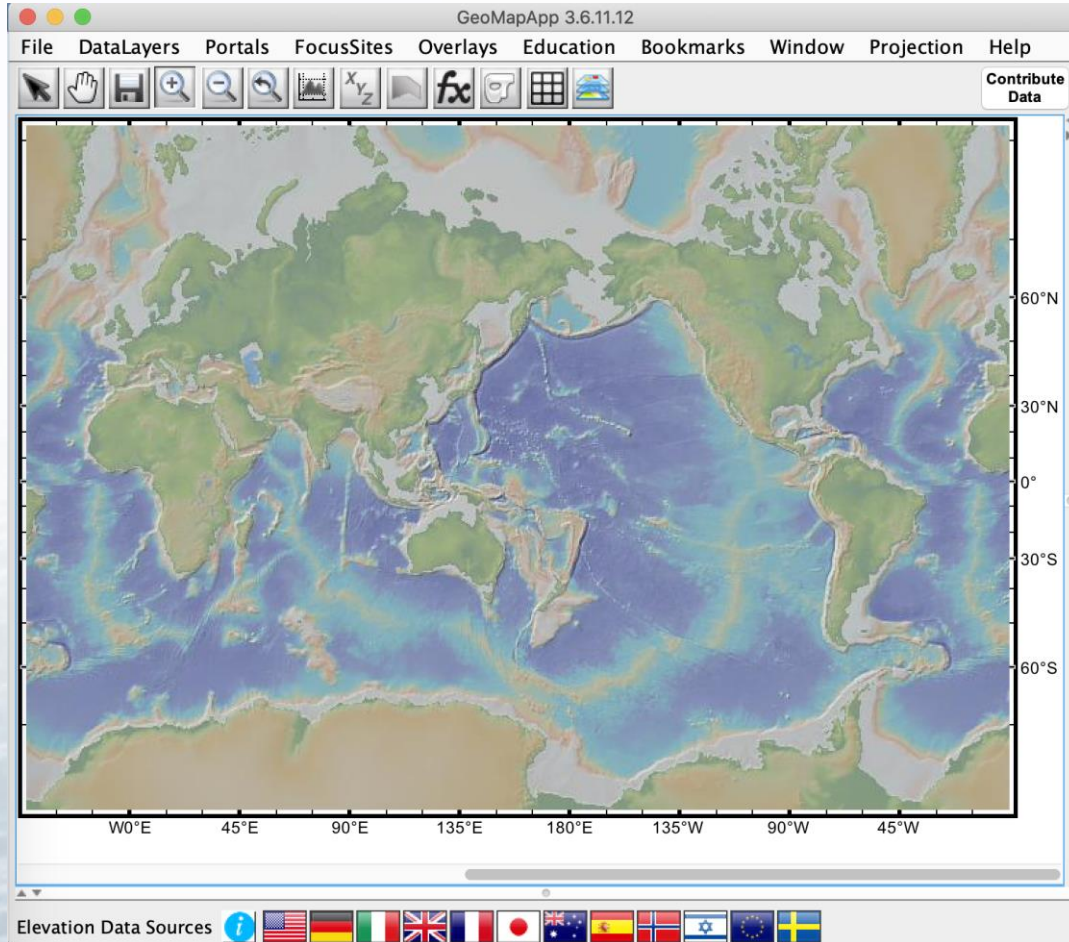


VOAA > NESDIS > NCEI > Maps > Bathymetry



CRUISE ID	SUMMARY	START DATE	START PORT	END DATE	END PORT
KM2009	Project: HOT-321 Chief: White, Angelique	2020-08-06	Honolulu	2020-08-11	Honolulu
KM2008	Project: Abyssal Food Web Chief: Deane, Jeffrey				

# GMRT: *Grid Access*



## Grid Download

### Citation Information

Ryan, W.B.F., S.M. Carbotte, J.O. Coplan, S. O'Hara, A. Melkonian, R. Arko, R.A. Weissel, V. Ferrini, A. Goodwillie, F. Nitsche, J. Boncz, Geochem. Geophys. Geosyst.,

### File Format

- GMT v3 Compatible NetCDF
- Coards/CF Compliant NetCDF
- GeoTIFF (lower max resolution)
- ArcASCII (lower max resolution)

### Mask

- Unmasked
- Masked

*Unmasked grids are filled with values where high-resolution data is missing in the ocean.*

### Grid Resolution

*dependent on size of selected area*

- Low** 15654 m/node  
File size: ~1MB
- Medium** 7827 m/node  
File size: ~5MB
- High** 3913 m/node  
File size: ~20MB

### GMRT REST-type Services

- **GMRT GridServer** is a REST-type service for direct access to gridded data from the GMRT Synthesis. A variety of output formats are supported. Requested data may be up to 1GB in NetCDF, or approximately 14 by 14 degrees at 100 meters per node (maximum available resolution). GeoTIFF and ESRI ASCII grids have smaller node size limits (25% and 12.5% of NetCDF node size respectively). To request larger areas at higher resolution, use our [URL Builder Service](#). More information about the service is available from its documentation page. *(Output formats: GMT3 NetCDF, COARDS compliant NetCDF, ESRI ASCII (see note above), and GeoTIFF (see note above))*
  - [GMRT GridServer Documentation and Url Builder](#)
  - [GMRT Attribution Service Documentation and Url Builder](#)
  - [GMRT URL Builder Service Documentation and Url Builder](#)
  - [GridServer WADL description](#)
- **GMRT ImageServer** provides access to images from the GMRT Synthesis. Requested images may be up to 8000 pixels in either dimension. *(Output format: jpeg)*
  - [GMRT ImageServer Documentation and Uri Builder](#)
  - [ImageServer WADL description](#)
- **GMRT Profile Server** provides access to bathymetry profiles from the GMRT Synthesis. Profiles are currently 100 points and can be specified as a single line or a multiline segment. *(Output formats: json, geojson, plain text)*
  - [GMRT ProfileServer Documentation and Uri Builder](#)
  - [ProfileServer WADL description](#)
- **GMRT Point Server** provides access to point data from the GMRT Synthesis. Point data is retrieved from the highest resolution data available. *(Output formats: json, geojson, plain text, xml)*
  - [GMRT PointServer Documentation and Uri Builder](#)
  - [PointServer WADL description](#)
- **GMRT Cruise Info** provides access to cruise metadata from the GMRT Synthesis. *(Output formats: json)*
  - [Merged Cruises](#)
  - [Rejected Cruises](#)
  - [Under Review Cruises](#)

Save Grid as NetCDF, Coords/CF, ArcASCII, GeoTiff

# GMRT: Source Data Access

Applying geoscience to Australia's most important challenges

**Australian Government**  
Geoscience Australia

Home | About | Our Projects | Managing Australia's Marine Jurisdictions | MH370 - Phase One Data Release

## MH370 - Phase One Data Release

Explore the data [CLICK HERE](#)

The search for MH370 involved the collection and analysis of large volumes of marine data from a remote area. The data obtained during the first phase of sea floor mapping is now available to the public.

On 8 March 2014, Malaysia Airlines flight MH370 disappeared from air traffic control radar during a flight from Kuala Lumpur, Malaysia to Beijing, China with 239 passengers and crew on board.

Overview of the MH370 sea...

GeoMapApp 3.6.11.12

File DataLayers Portals FocusSites Overlays Education Bookmarks Window Projection Help

**MGDS - Data Download**

Programs: SOJN05MV  
Data Types: Bathymetry:Swath  
Contributing Scientists: MGDS,  
References: Ryan et al., 2009

You may browse freely, but you may not circulate or publish materials you obtained from this site if you do not accept the terms of providing adequate citation to the contributing scientists and MGDS ([www.marine-geo.org](http://www.marine-geo.org)).

Users are strongly encouraged to contact the original investigators responsible for data made available on this site. Where appropriate, researchers are also encouraged to consider collaboration and/or co-authorship with original investigators. Click the button below to agree to our [terms of use](#).

A Business Use License may be available for marine seismic data. For queries, contact [techventures@columbia.edu](mailto:techventures@columbia.edu).

[Accept Terms](#)

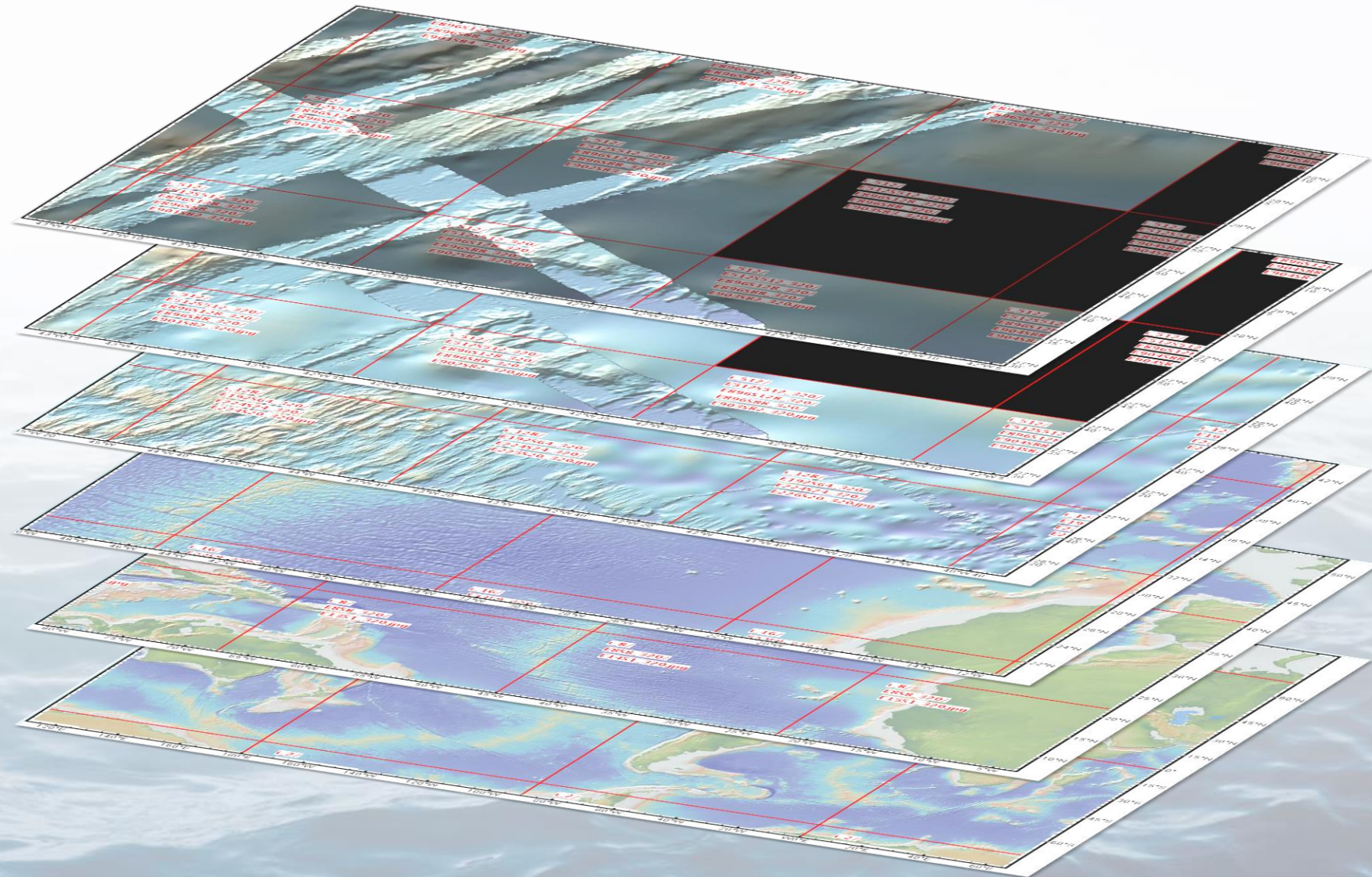
cruise: SOJN05MV, file: SBfixavg.97feb21p.mb32

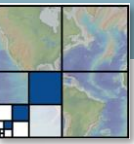
[Download selected ping file](#)

Elevation Data Sources

# GMRT: Tiled Multi-Resolution Architecture

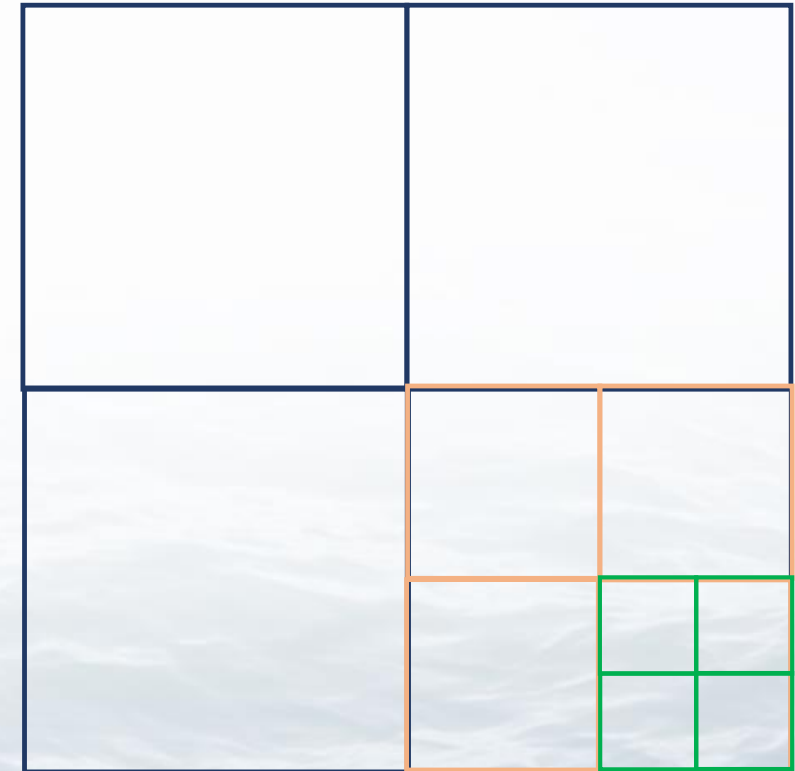
- Manage and integrate sparse high-resolution data
- Provide access to variable resolution data from 1km to sub-meter scale
- Assemble and deliver gridded products on-demand at user-declared resolution for user-defined region
- Multiple resolutions of tiled rasters

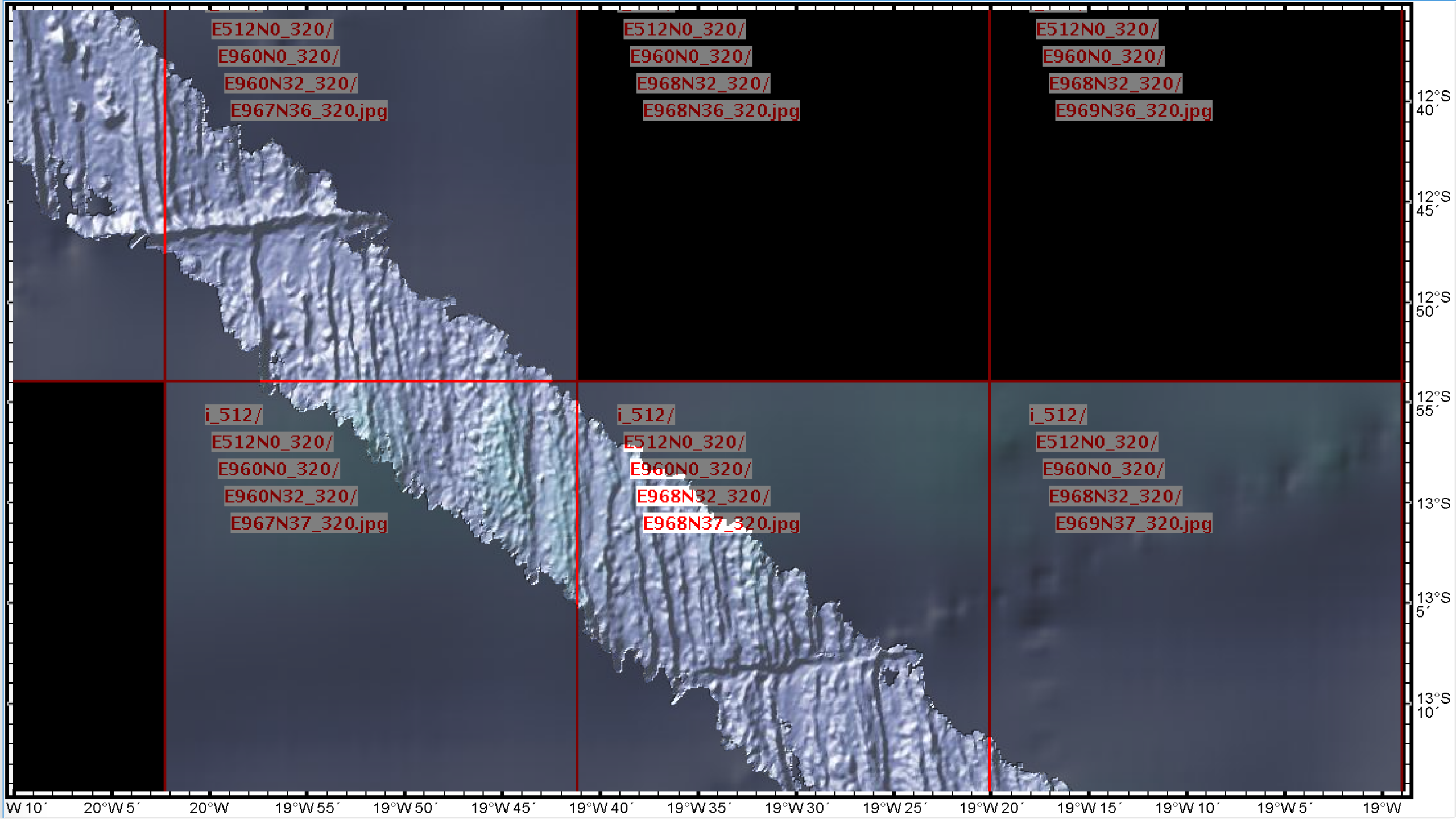




# GMRT: Tiling Scheme

- Quadtree subdivision
- Tiles are sparse at high resolution
- Directory structure & tile name carries geospatial information





E512N0\_320/  
E960N0\_320/  
E960N32\_320/  
E967N36\_320.jpg

E512N0\_320/  
E960N0\_320/  
E968N32\_320/  
E968N36\_320.jpg

E512N0\_320/  
E960N0\_320/  
E968N32\_320/  
E969N36\_320.jpg

i\_512/  
E512N0\_320/  
E960N0\_320/  
E960N32\_320/  
E967N37\_320.jpg

i\_512/  
E512N0\_320/  
E960N0\_320/  
E968N32\_320/  
E968N37\_320.jpg

i\_512/  
E512N0\_320/  
E960N0\_320/  
E968N32\_320/  
E969N37\_320.jpg

12°S  
40'

12°S  
45'

12°S  
50'

12°S  
55'

13°S

13°S  
5'

13°S  
10'

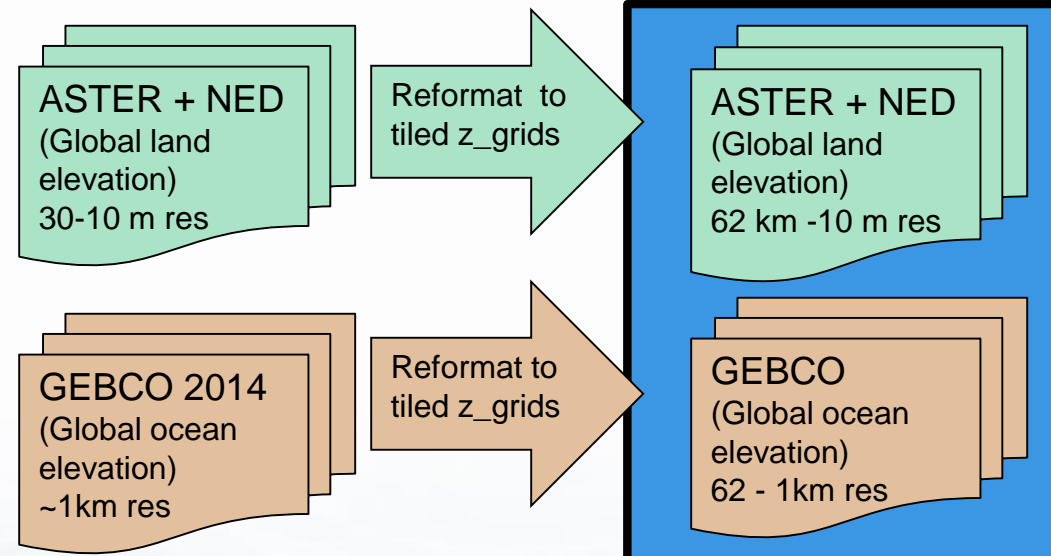
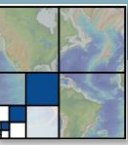
W 10' 20°W 5' 20°W 19°W 55' 19°W 50' 19°W 45' 19°W 40' 19°W 35' 19°W 30' 19°W 25' 19°W 20' 19°W 15' 19°W 10' 19°W 5' 19°W



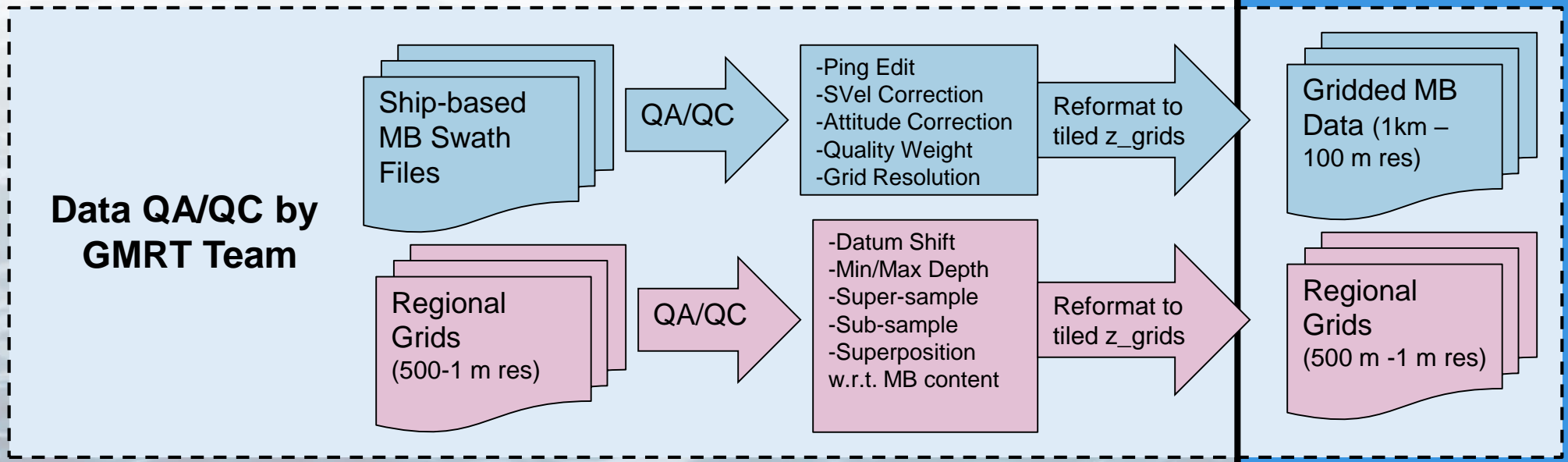
# GMRT: Data Curation Approach

- Offer best resolution data to user that is seamlessly integrated with lower resolution data
- Manage elevation components as raster data converted to a tiled multi-resolution architecture
  - Integrate and blend raster components based on data quality and rule set
- Global solution maintained simultaneously in three projections
- For GMRT-Multibeam Synthesis (GMRT-MBS) clean/integrate/manage multibeam data for entire cruise - from port to port
- Extensive Metadata Catalog
  - Cruise, dataset, file metadata
  - Coverage statistics (for GMRT-MBS on a per-swath-file-basis)
  - Links to source files (raster & swath for advanced users)
- Visually identify “mapped” portions of the ocean with mask tiles

# GMRT: Data Synthesis



*Leverage singlebeam & SRTM via GEBCO, IBCAO & IBCSO*



# GMRT: Grid Composer

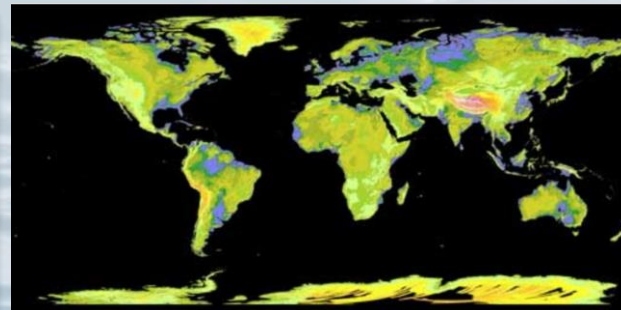
- Maintain input raster data at native resolution
- Curate four discrete tiled elevation components
  - update components independently and on different schedules
- Raster data merged on-the-fly to create custom products for users

Custom grids delivered to users (netCDF, GeoTiff, ArcAscii)

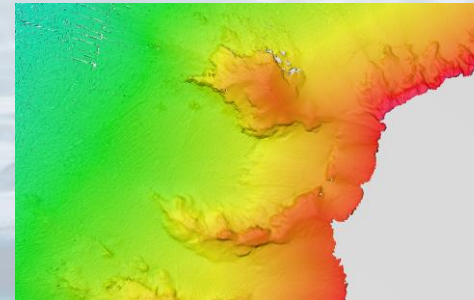
GEBCO 2014 (~1 km)



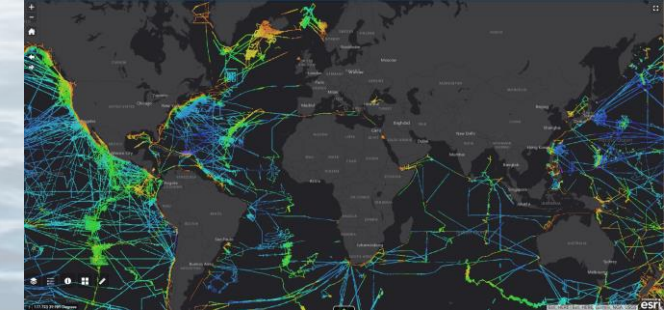
Topography (10-30 m)



Contributed Grids  
(1 to 100s of m)



GMRT-MBS  
Multibeam Synthesis (100m)



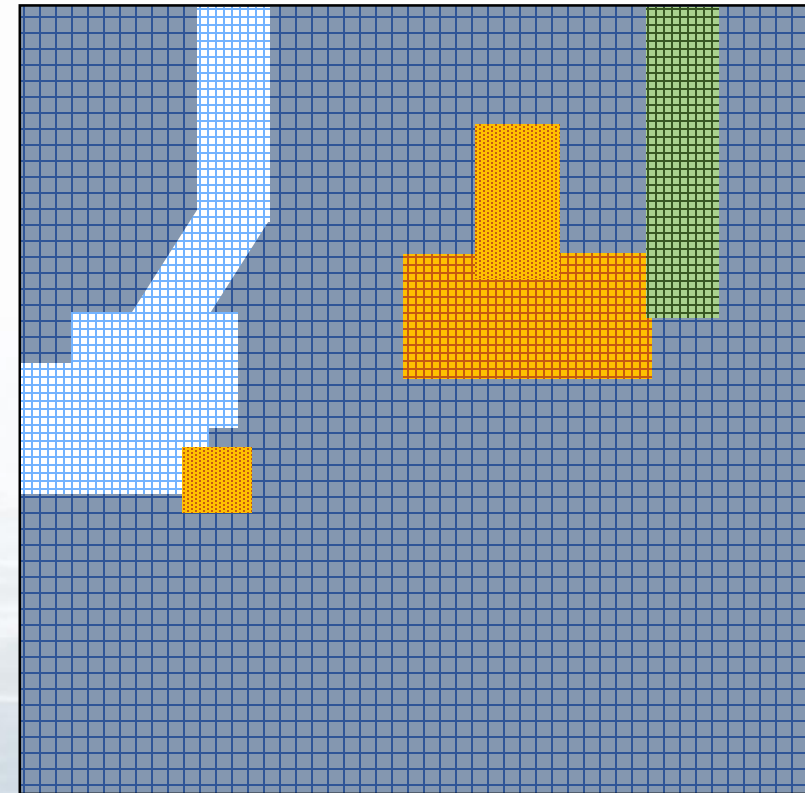
# GMRT: Grid Composer

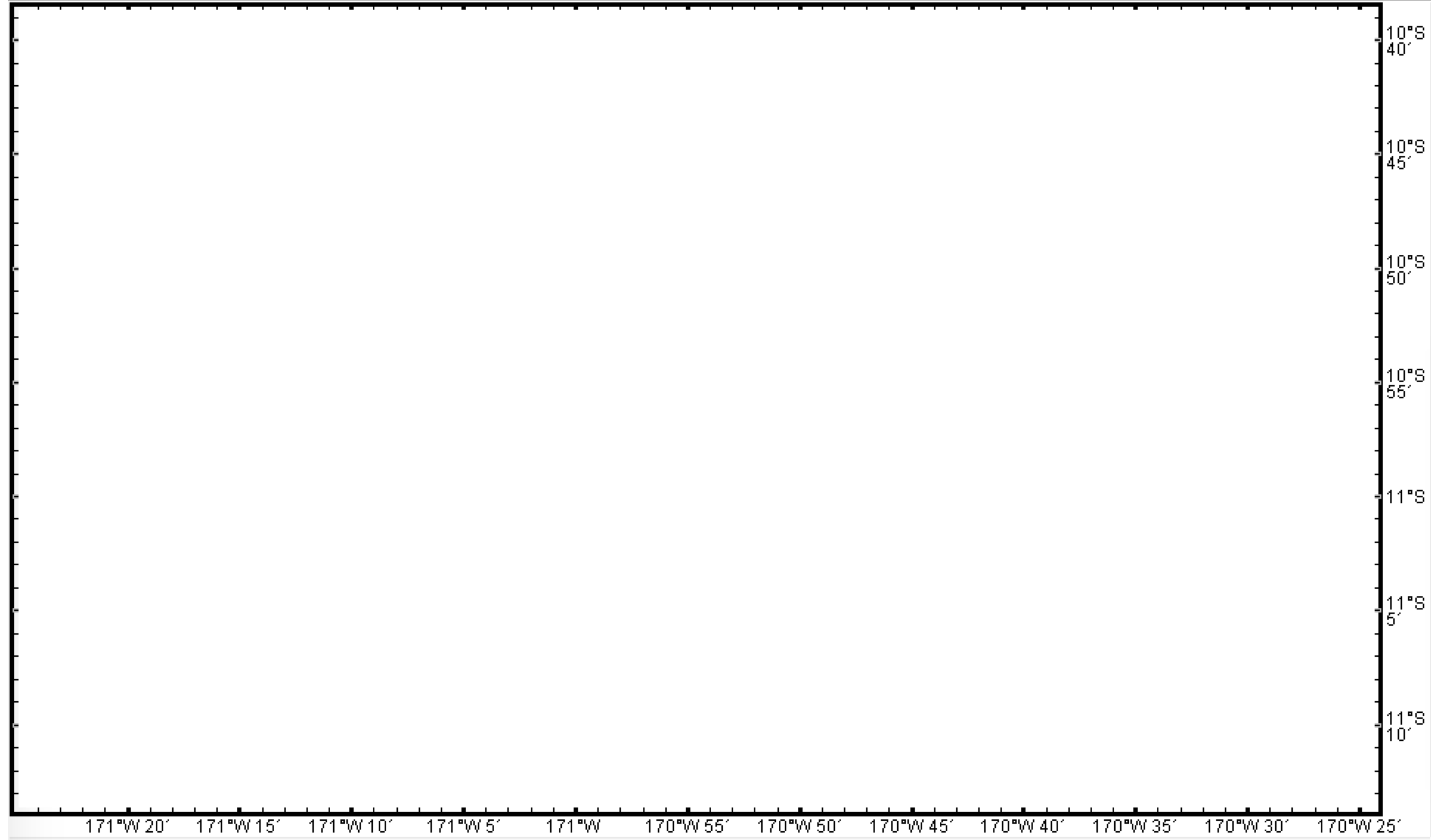
 GMRT Multibeam (100m)

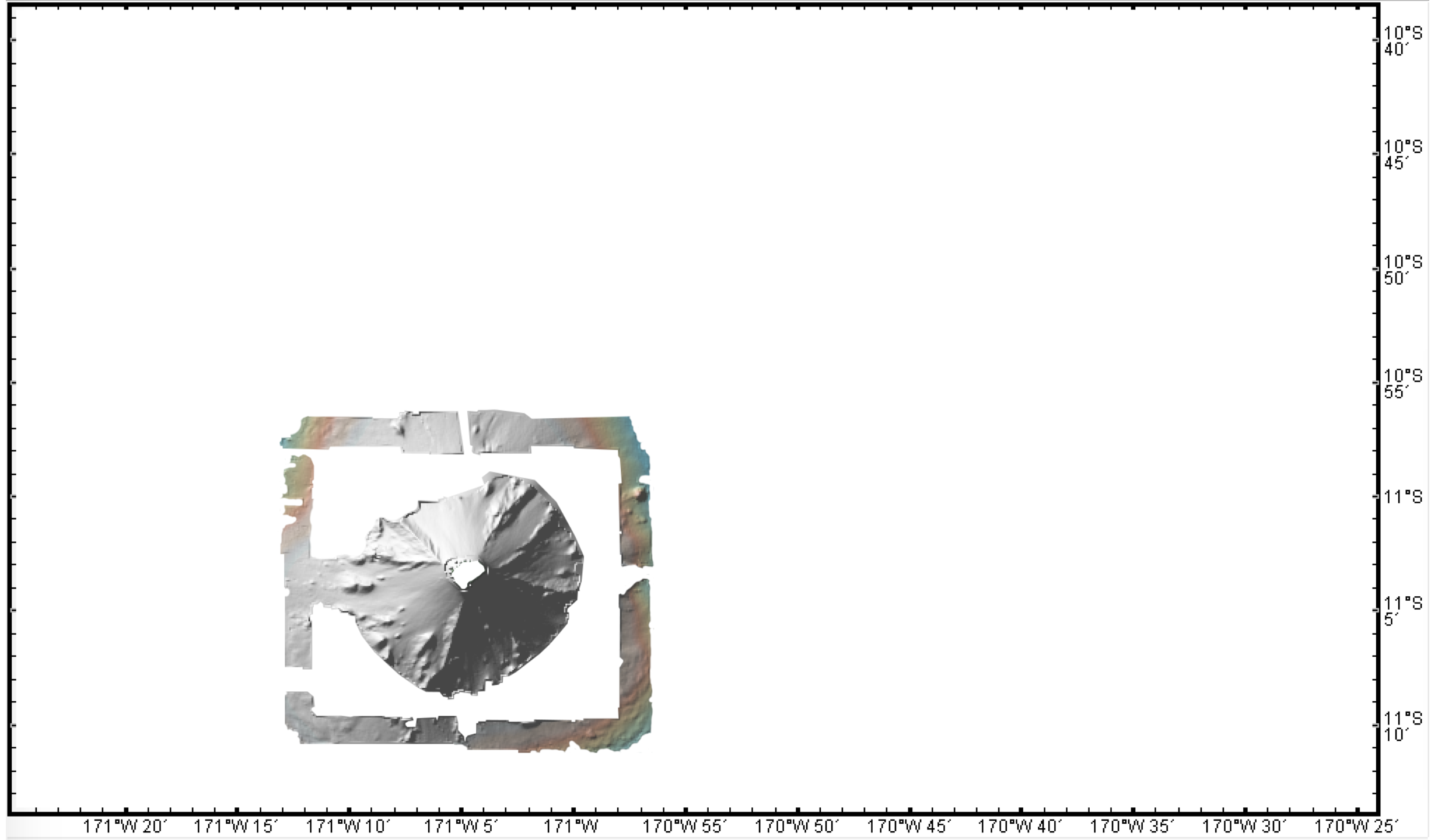
 Contributed Grids  
(1 to 100s of m)

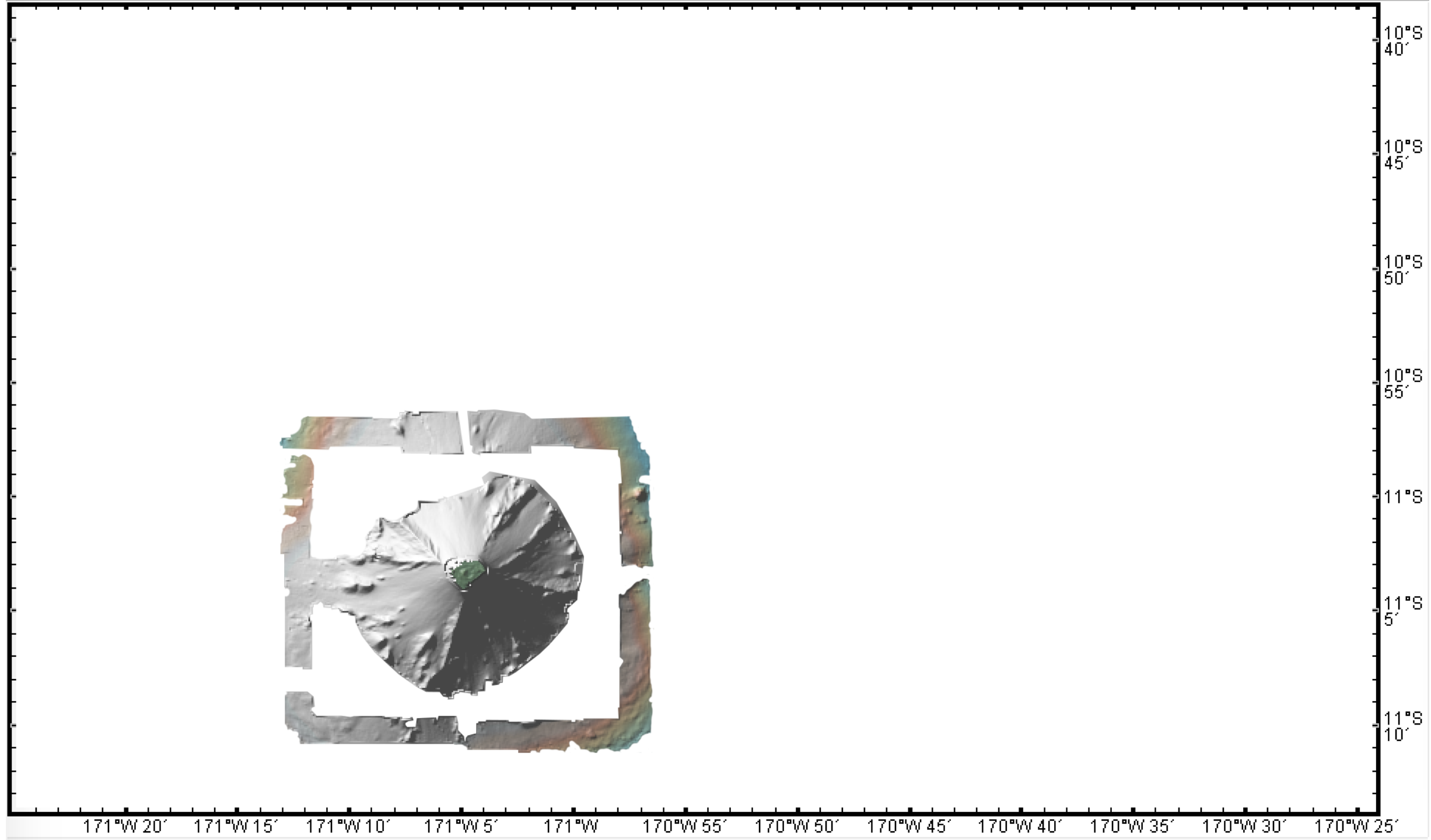
 Topography (10-30 m)

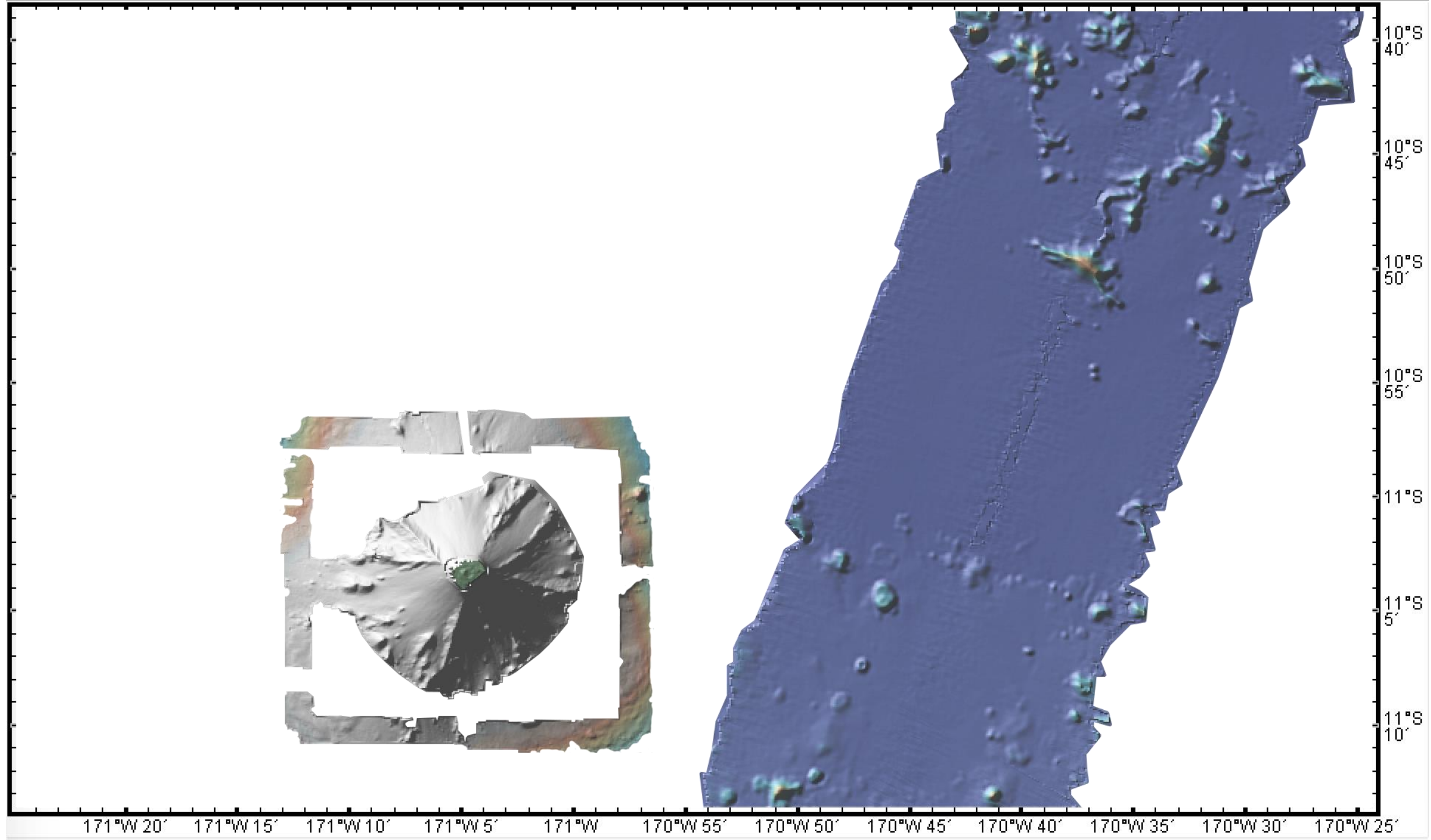
 GEBCO 2014 (~1 km)



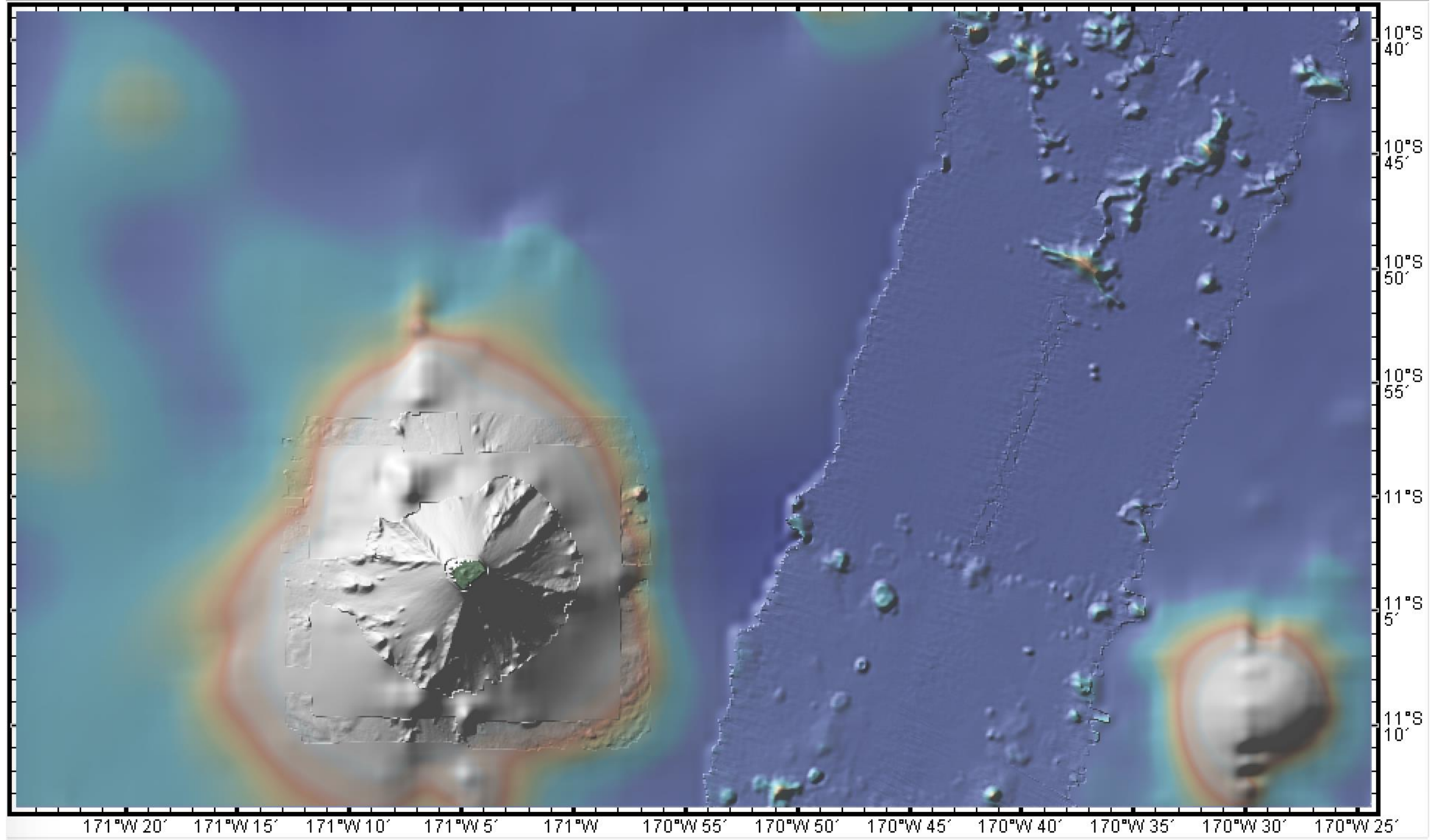


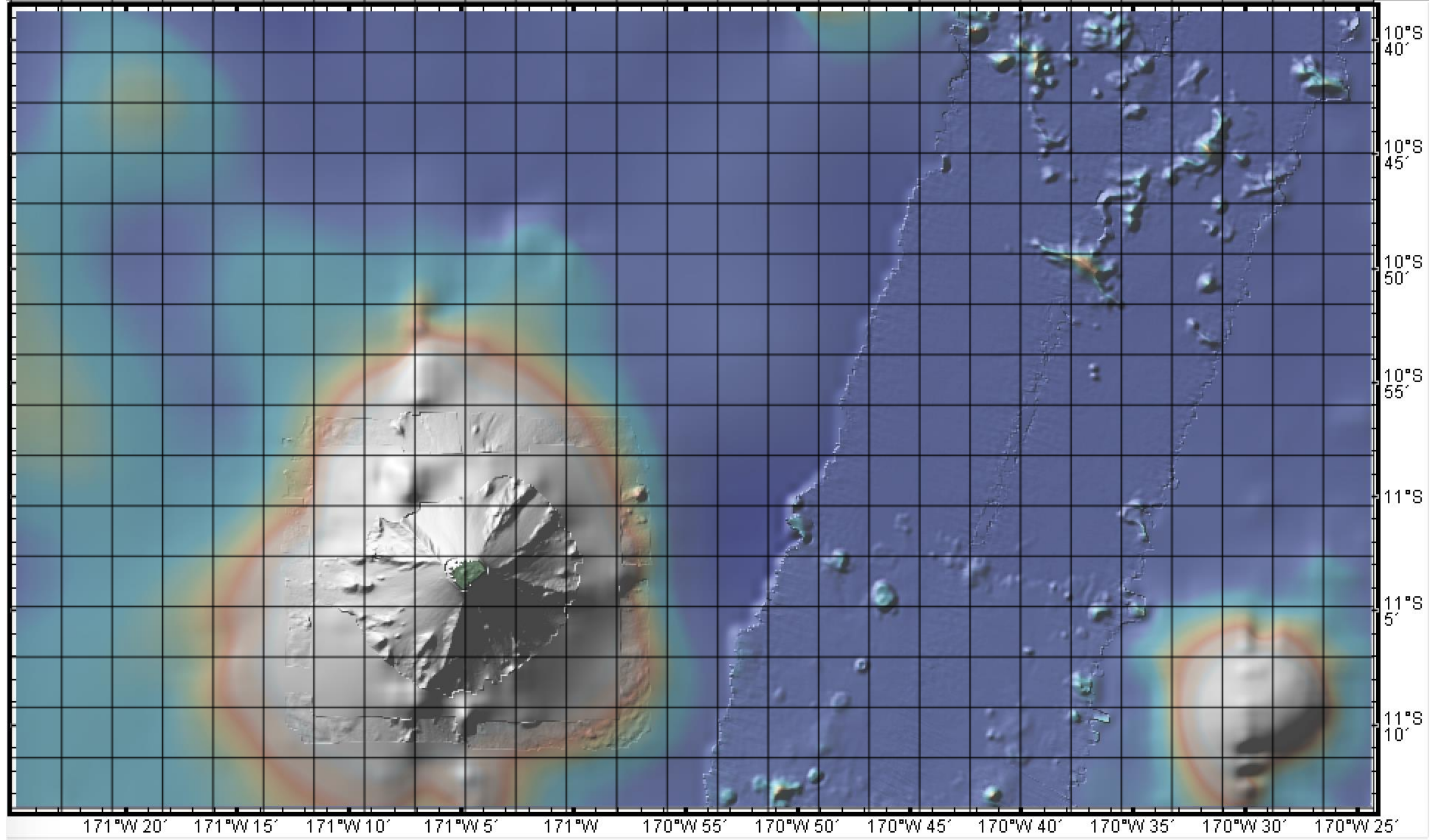


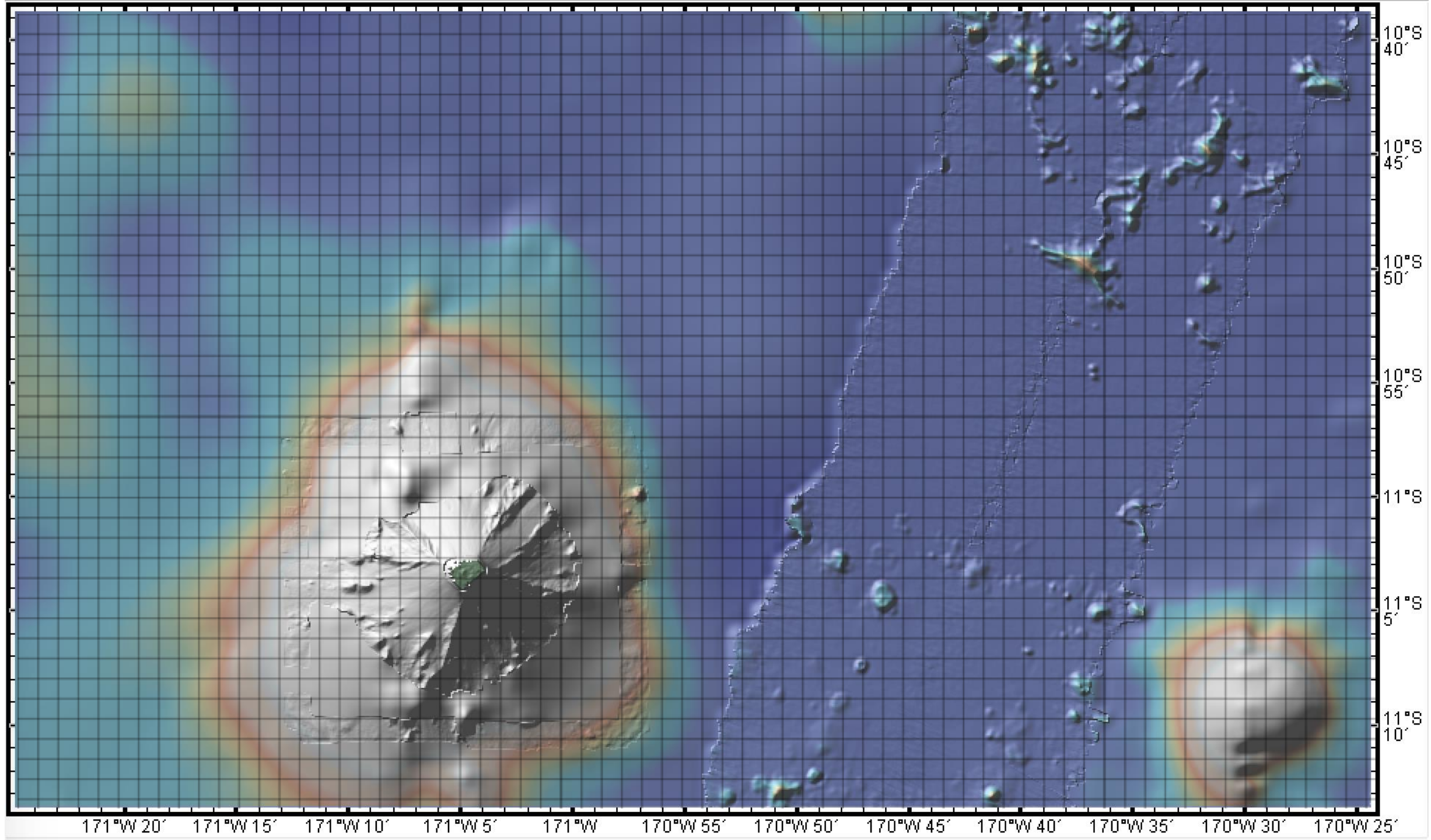












# GMRT Grid Composer

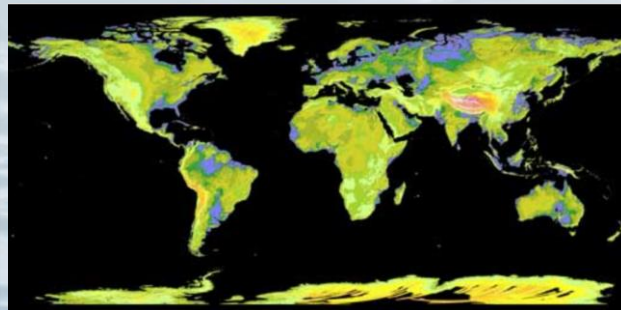
- Maintain input raster data at native resolution
- Curate four discrete tiled elevation components
  - update components independently and on different schedules
- Raster data merged on-the-fly to create custom products for users

Custom grids delivered to users (netCDF, GeoTiff, ArcAscii)

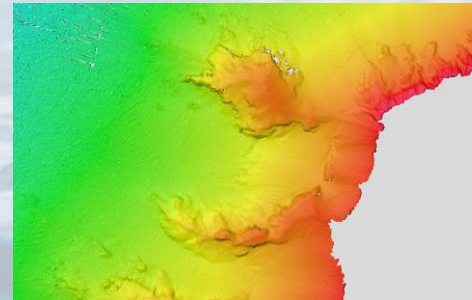
GEBCO 2014 (~1 km)



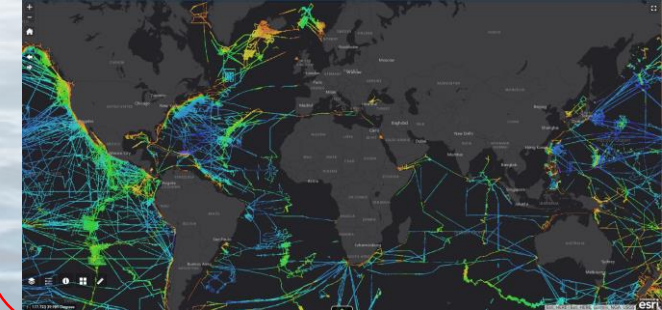
Topography (10-30 m)



Contributed Grids  
(1 to 100s of m)

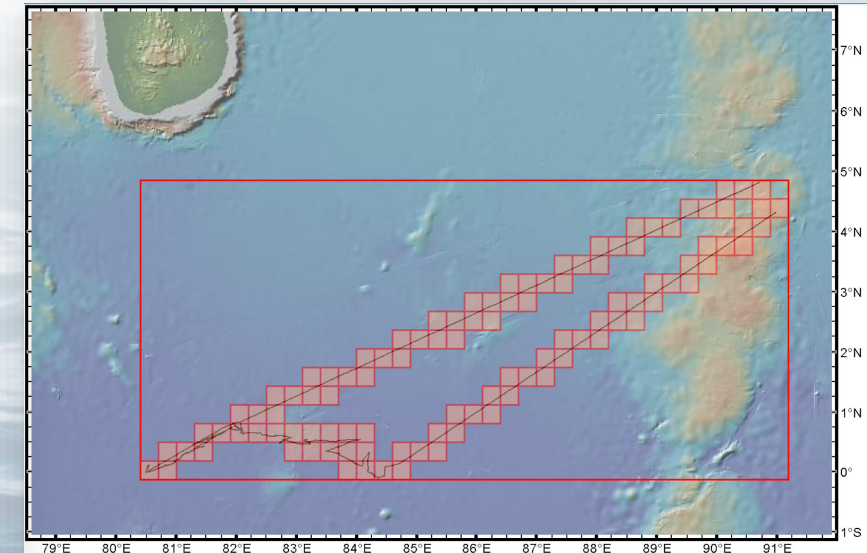


GMRT-MBS  
Multibeam Synthesis (100m)



# GMRT MBS Data Curation – Strategy & Rationale

- Create clean swath files and review them as rasterized tiles in the context of existing GMRT MB Synthesis
- Grid at best resolution data can support = *at least* 100m resolution
- Tiled rasters optimize disk space
- Maintain source data as compressed swath files that can be re-accessed and re-processing if necessary but computation from points is not required routinely
- Rasters for each cruise blended with tiled rasters from other cruises and then consumed by GMRT grid composer
- Rasters for each cruise are maintained on back-end to facilitate removal/updating and/or custom grid composition

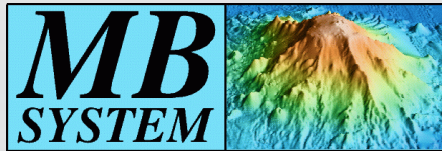


# GMRT: MBS Data Workflow

## GMRT-Tiling

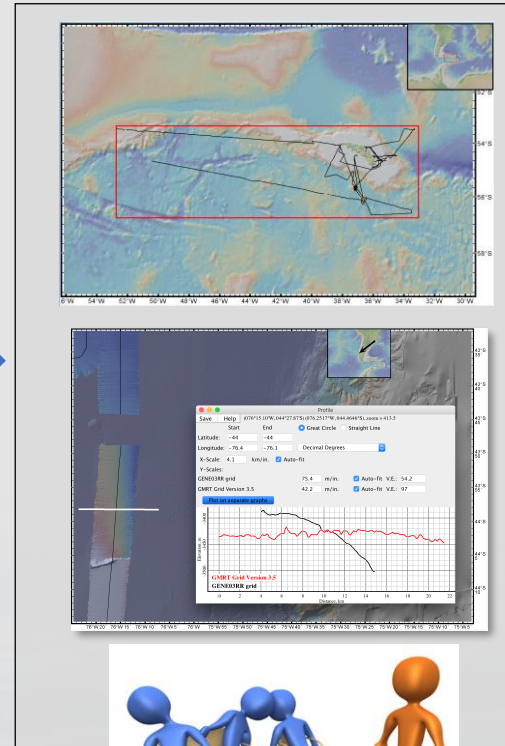
Proc MB Files\*

Raw MB Files\*



Generate tiled rasters from swath files. Tiles produced for projections based on latitude (merc, NP, SP).

*\*source data in public domain*



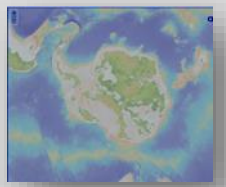
### QA/QC

- Ping edit, SVP corrections, roll corrections etc.
- Define resolution
- Define weight – affects blending

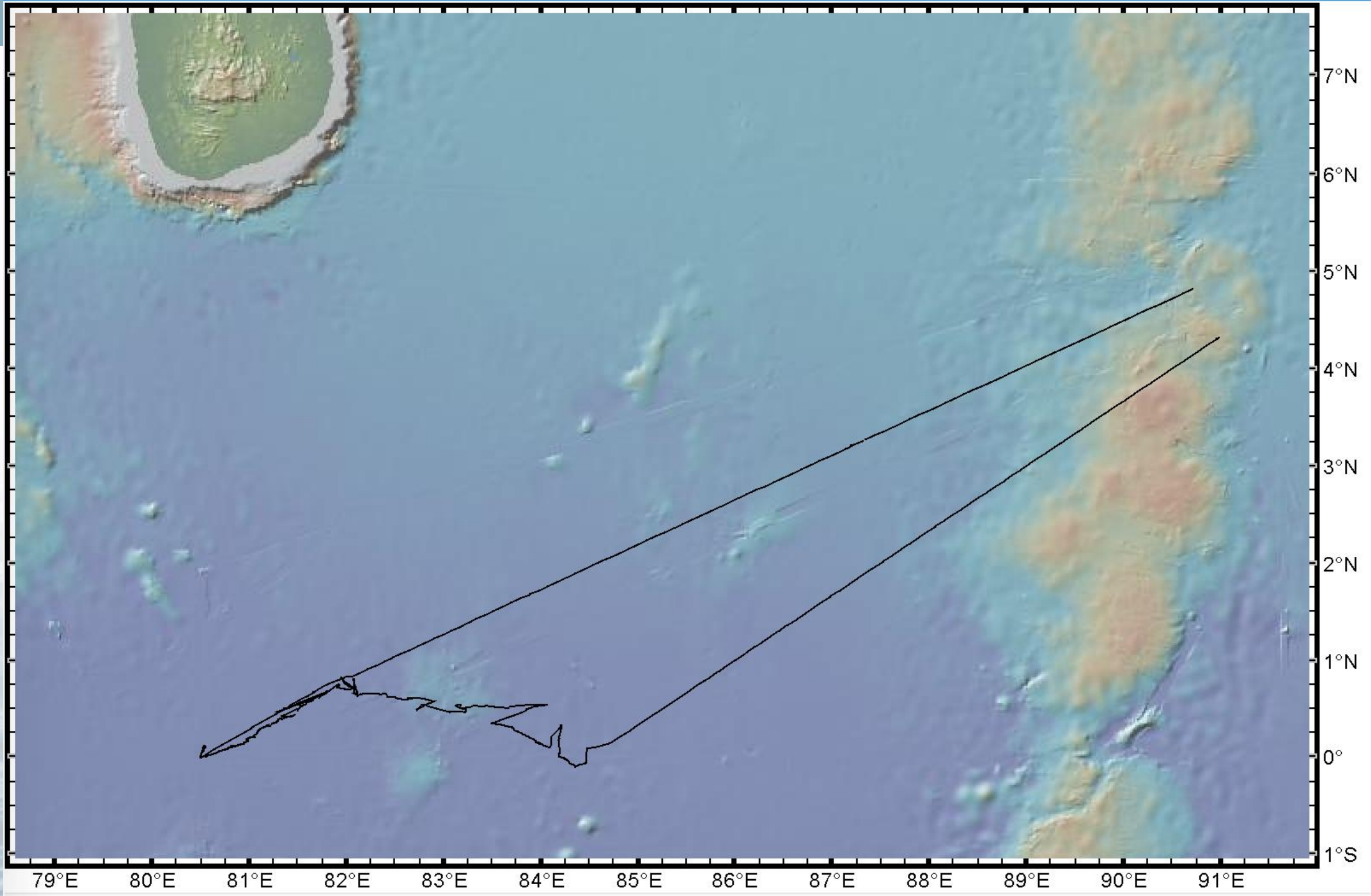
## GMRT Services

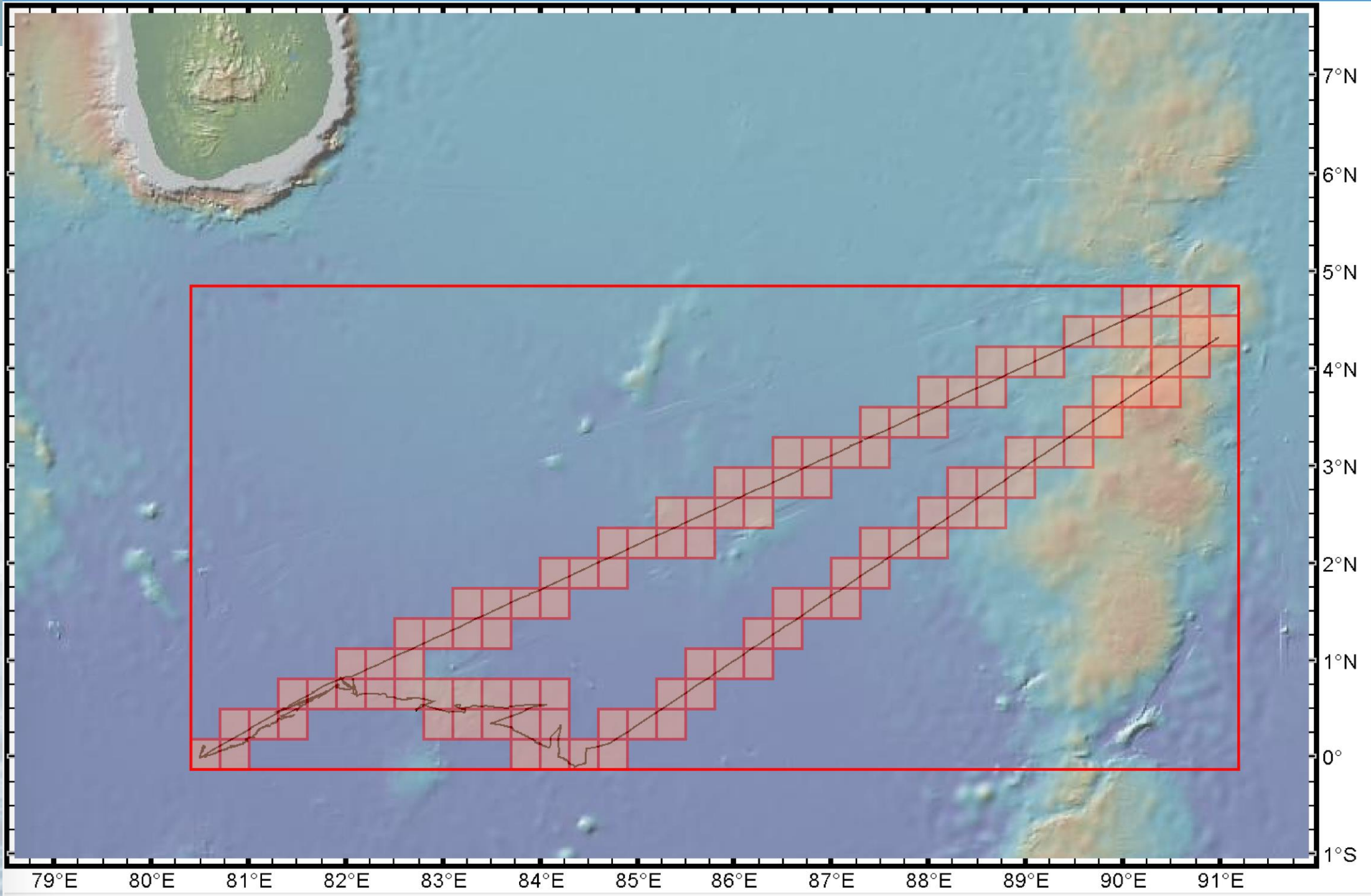
Processed MB files

metadata

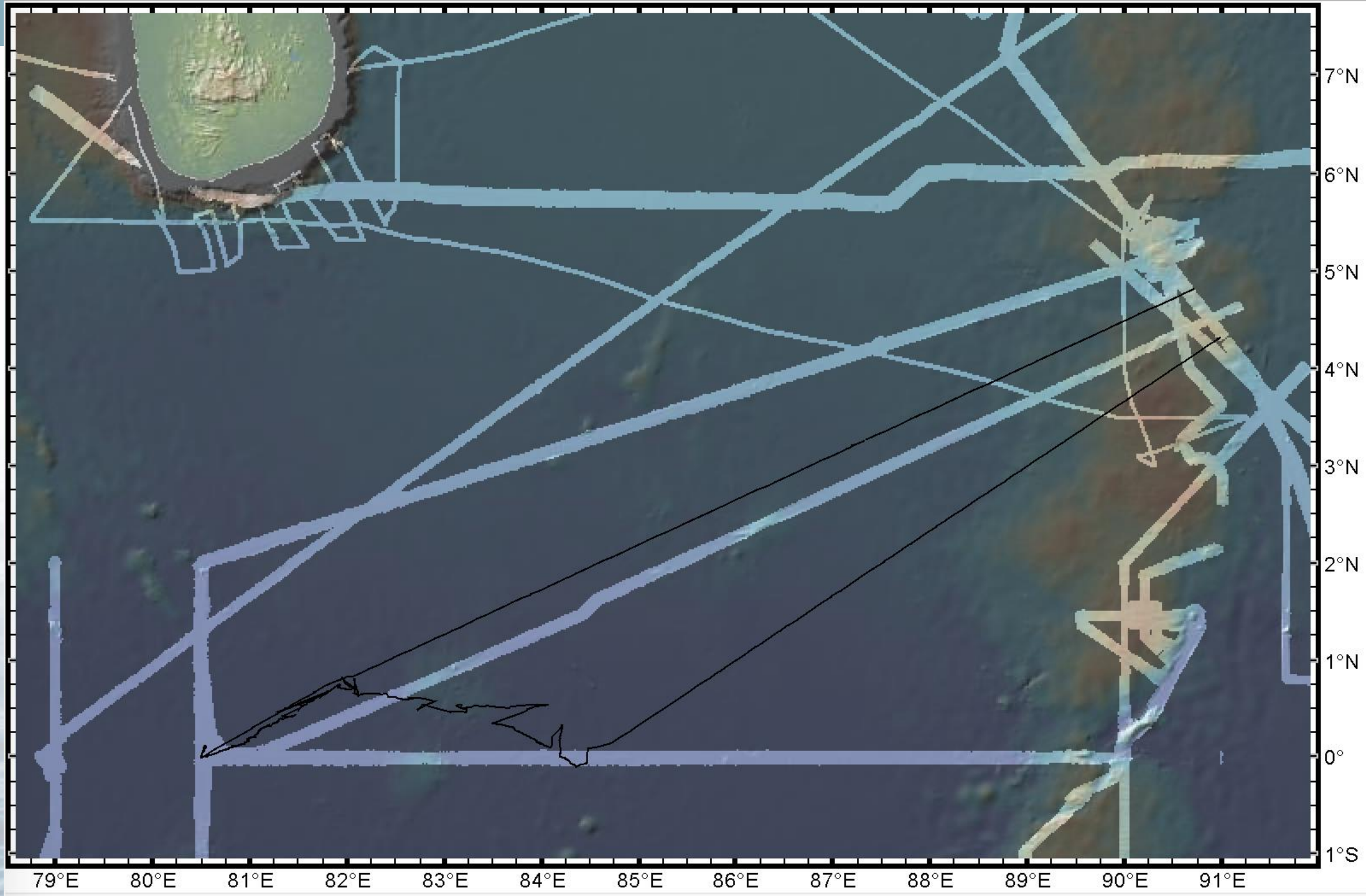


Tiled images, grids, mask



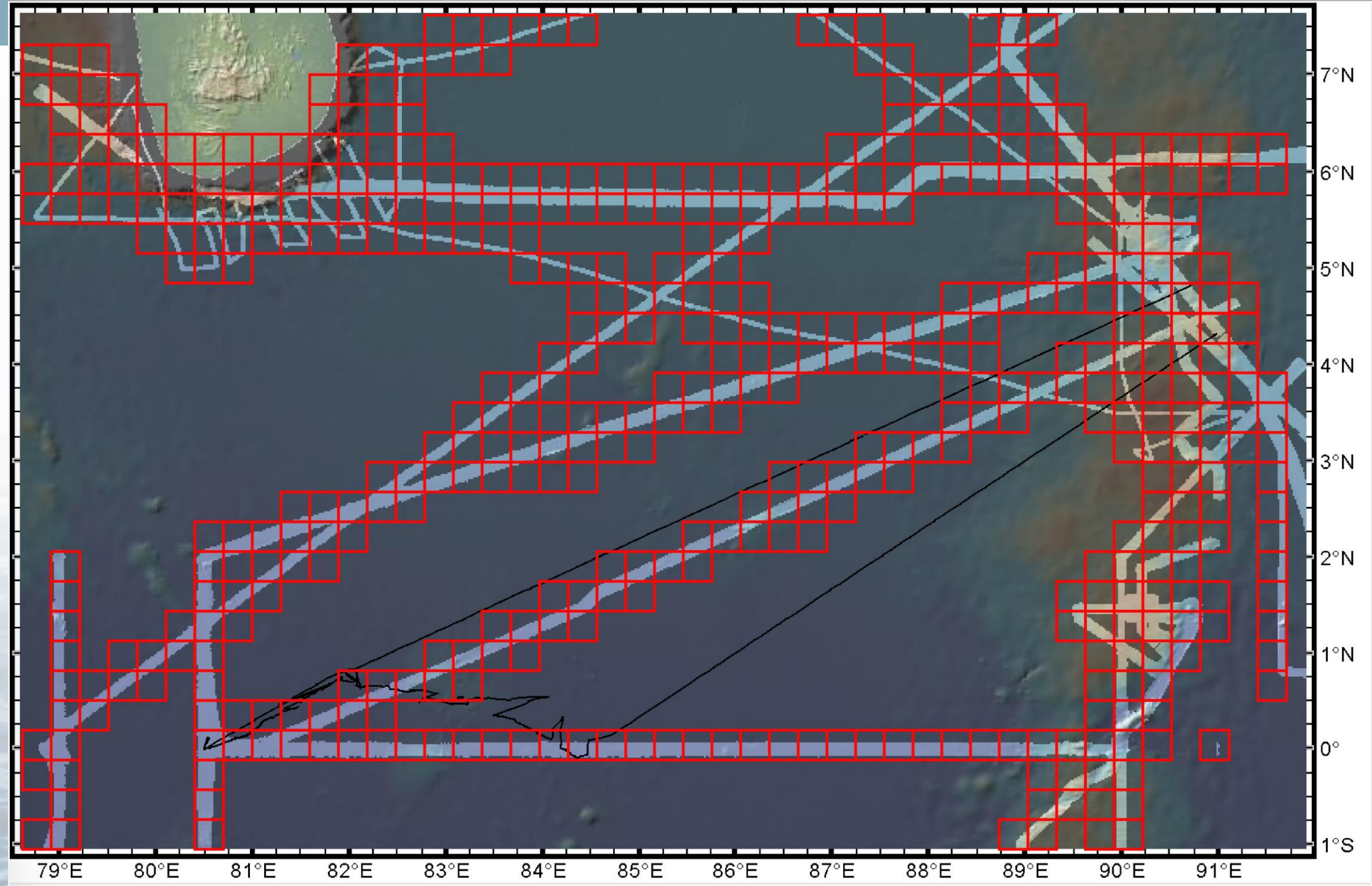






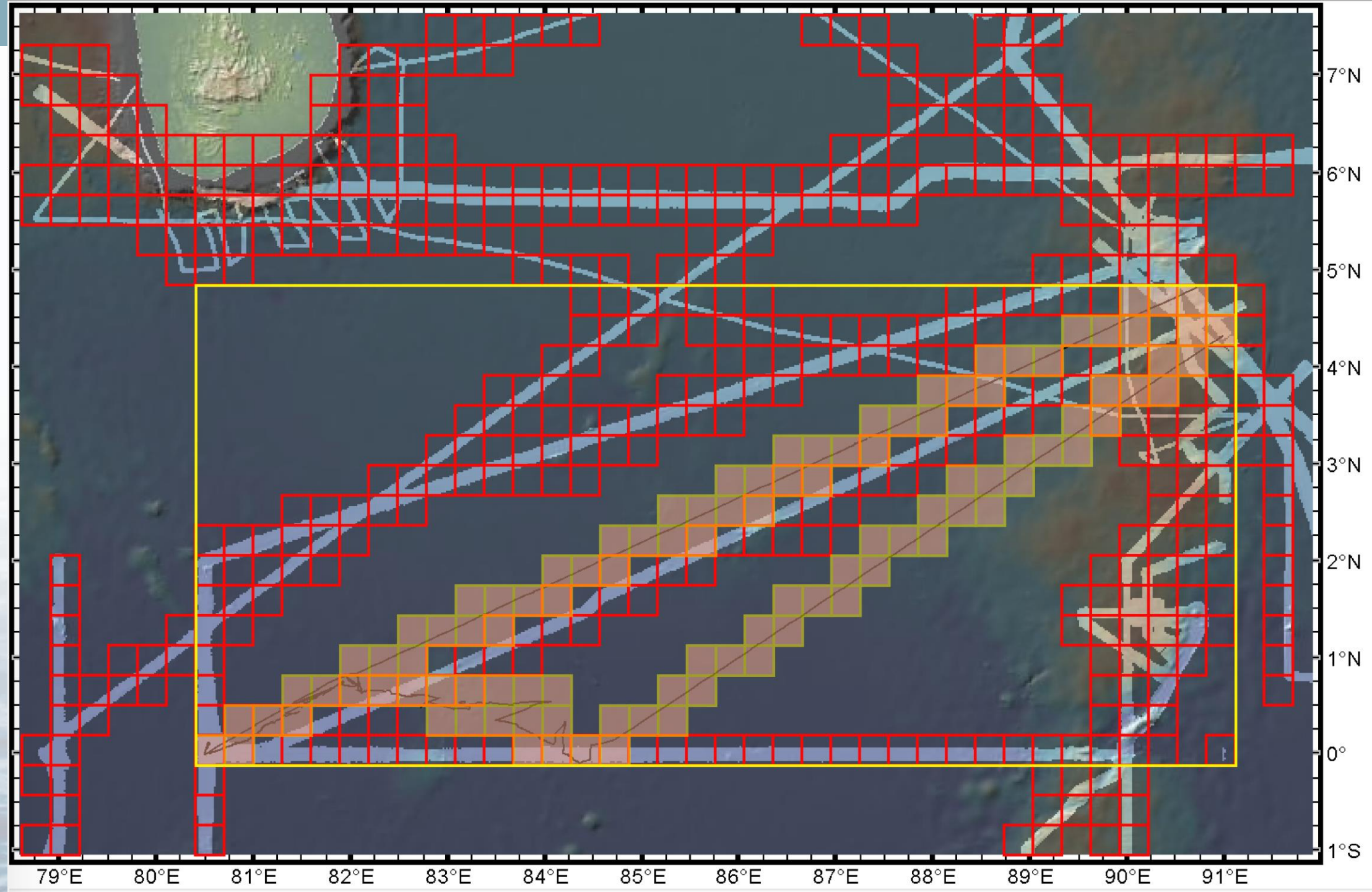
7°N  
6°N  
5°N  
4°N  
3°N  
2°N  
1°N  
0°  
1°S

79°E 80°E 81°E 82°E 83°E 84°E 85°E 86°E 87°E 88°E 89°E 90°E 91°E



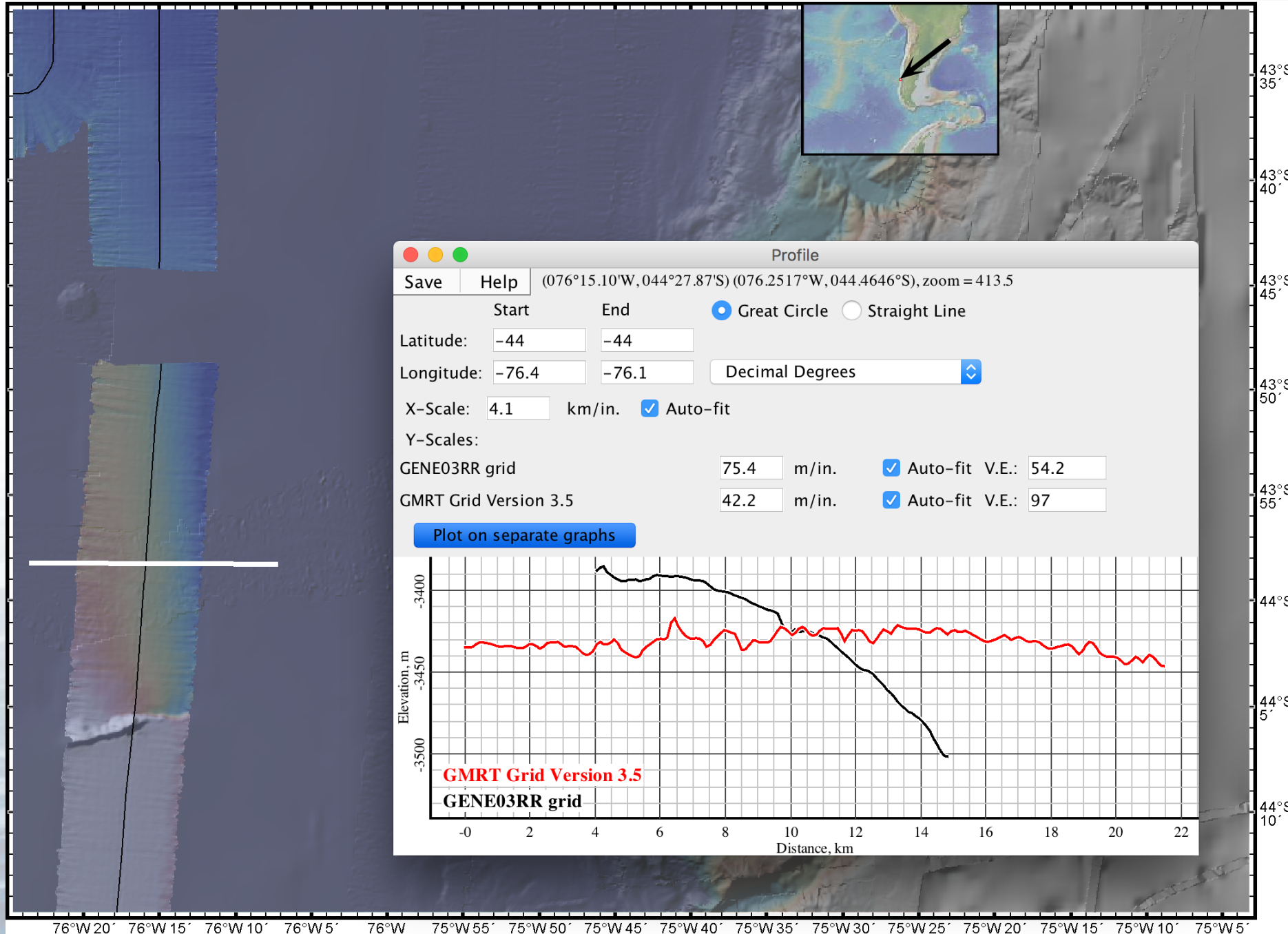
7°N  
6°N  
5°N  
4°N  
3°N  
2°N  
1°N  
0°  
1°S

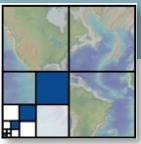
79°E 80°E 81°E 82°E 83°E 84°E 85°E 86°E 87°E 88°E 89°E 90°E 91°E



7°N  
6°N  
5°N  
4°N  
3°N  
2°N  
1°N  
0°  
1°S

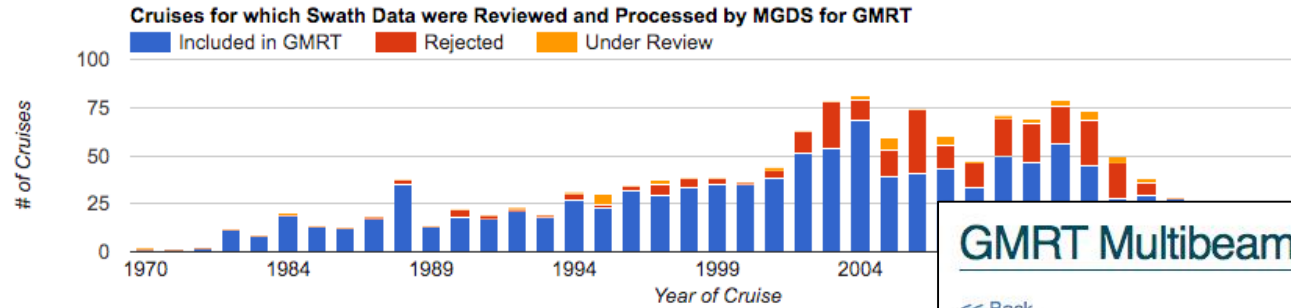
79°E 80°E 81°E 82°E 83°E 84°E 85°E 86°E 87°E 88°E 89°E 90°E 91°E





# GMRT-MBS Metadata

## GMRT Multibeam Data Sources



Current GMRT Version: 3.7

- 981107RR** *Dr. David Checkley (1998)*  
 Roger Revelle (*SeaBeam 2112*) GMRT v1

---

- A112-24** *Dr. Richard Hey (1985)*  
 Atlantis II (*SeaBeam Classic*) GMRT v1

---

- A114-02** *Dr. Robert Pockalny (1986)*  
 Atlantis II (*SeaBeam Classic*) GMRT v1

---

- A118-21** *Dr. Stephen Hammond (1987)*  
 Atlantis II (*SeaBeam Classic*) GMRT v1

---

- A118-22** *Dr. Jody Deming (1987)*  
 Atlantis II (*SeaBeam Classic*) GMRT v1

---

- A118-41** *Dr. H. Paul Johnson (1988)*  
 Atlantis II (*SeaBeam Classic*) GMRT v1

---

- AMAT01RR** (*Transit*) (2006)

## GMRT Multibeam Data Report

[<< Back](#)

### NBP1701 (2017)

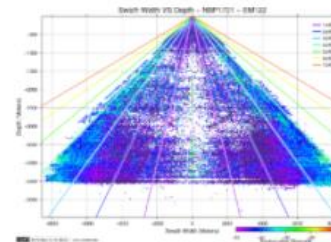
RV *Nathaniel B. Palmer*   
 Kongsberg EM122  
 Chief Scientist: Dr. Tatiana Rynearson  
[Related Information at MGDS](#)

#### Data Summary

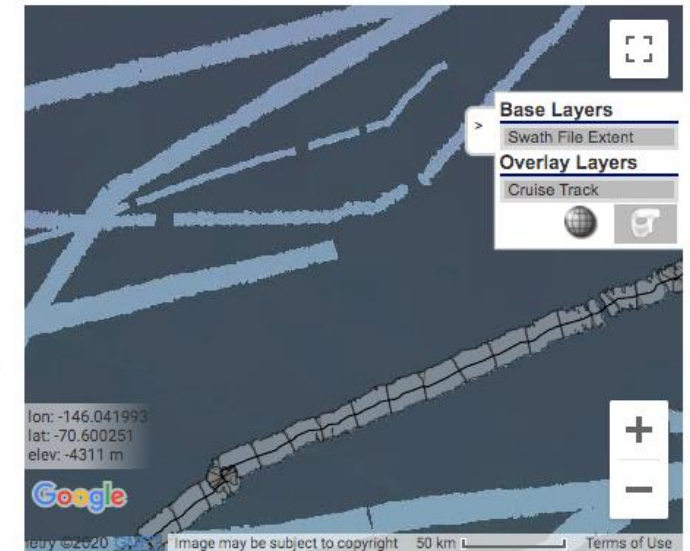
484 Data Files Processed  
 Total Ship-Track Coverage: 7960 km  
 Total Area Mapped: 71219 km<sup>2</sup>

#### 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.



Coming soon!




# GMRT-MBS Metadata

## Cruises Not Included


In addition to the cruises that have been added to the GMRT Synthesis, several cruises that have been reviewed have not been included. This lists those cruises and some information about why the data have not been processed and included.


A125-04 *Not needed - no new coverage*


 [A125-25 \(1991\)](#) *Not needed - no new coverage*

A125-39 *Not needed - no new coverage*

A129-03 *Not needed - no new coverage*


 [A131-09 \(1994\)](#) *Not needed - no new coverage*


 [A131-11 \(1994\)](#) *Not needed - no new coverage*


 [ACLV01RR \(1999\)](#) *Not needed - no new coverage*


AMAT05RR *Not needed - no new coverage*


AMAT08RR *Not needed - no new coverage*


 [AT03-24 \(1998\)](#) *Not needed - no new coverage*

 [AT07-04 \(2001\)](#) *Not needed - no new coverage*

 [AT07-06 \(2002\)](#) *Not needed - no new coverage*

 [AT11-09 \(2004\)](#) *Not needed - no new coverage*

 [AT11-26 \(2005\)](#) *Not needed - no new coverage*

 [AT15-03 \(2006\)](#) *Not needed - no new coverage.*

## Cruises Under Review

In addition to the cruises that have been added to the GMRT Synthesis or rejected, several that are currently being reviewed. This lists those cruises.

 [EW0403 \(1970\)](#)

 [EW9205 \(1992\)](#)

 [EW9417 \(1994\)](#)

 [EW9510 \(1995\)](#)


 [EW9706 \(1997\)](#)


EW9706\_trouble


EX1402

 [FK005C \(2012\)](#)

FK0301

 [FK160320 \(2016\)](#) *Processed files supplied by UNH/CCOM*

 [FK161010 \(2016\)](#) *Processed files supplied by UNH/CCOM*

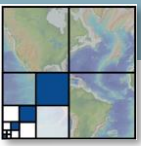
 [FK181210 \(2018\)](#) *Processed files supplied by UNH/CCOM*

 [FK181210 \(2018\)](#) *Processed files supplied by UNH/CCOM*

◦ **GMRT Cruise Info** provides access to cruise metadata from the [GMRT Synthesis](#). *(Output formats: json)*

- [Merged Cruises](#)
- [Rejected Cruises](#)
- [Under Review Cruises](#)

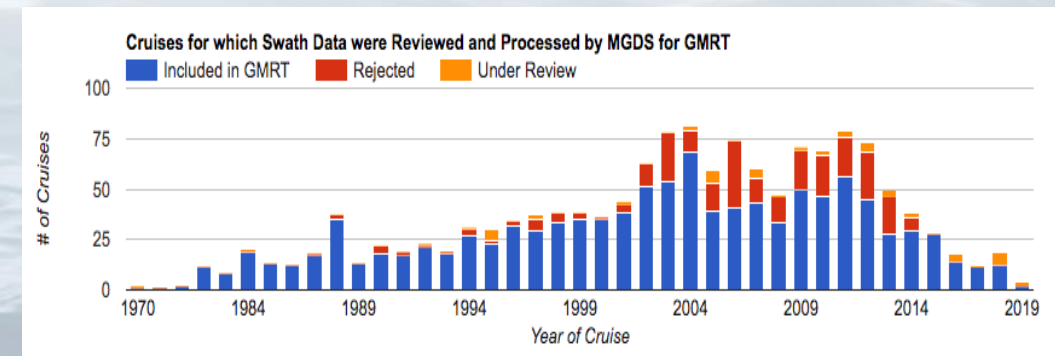
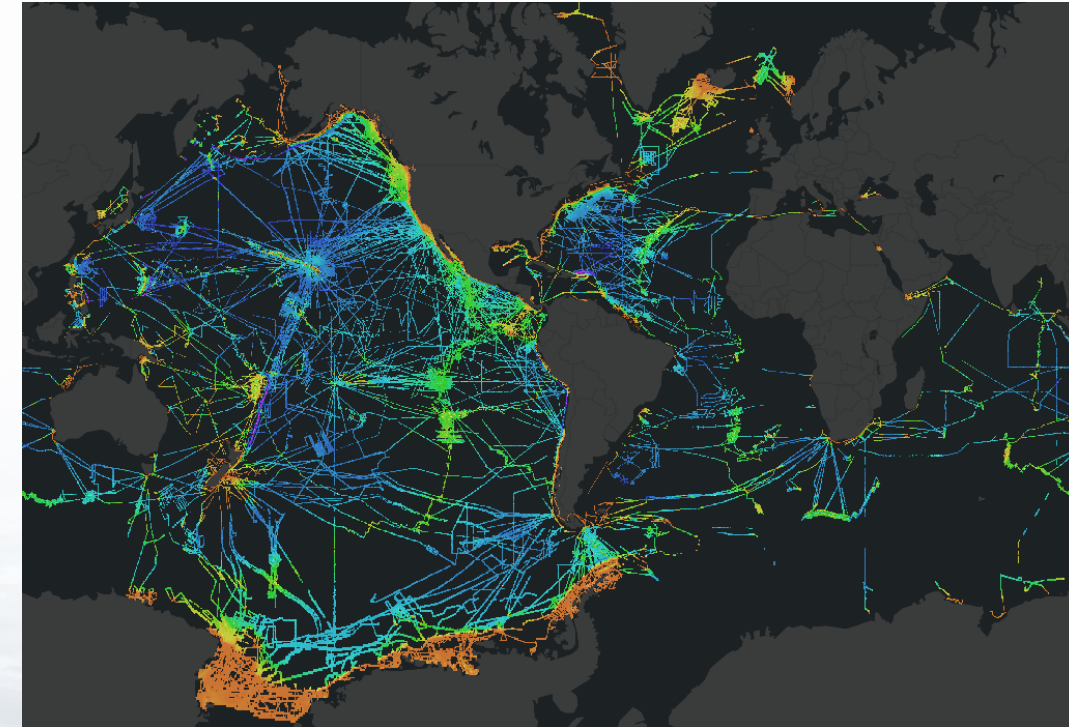
<https://www.gmrt.org/services/index.php>



# GMRT-MBS: Multibeam Synthesis Data Curation

## GMRT v. 3.7 Metrics

% Ocean mapped	9.1%
Total Curated Swath Data Files	253,730
Total Pings	> 200 Million
Total Input Data Points	> 31 Billion
Total Swath File Volume	5.4 TB
Total Volume 100m Tiles	2.6 GB
Total Cruises	1,109
Total Tracklength (km)	> 5 Million
Total km <sup>2</sup>	> 32.7 Million
Years of data acquisition	1980 - 2018





# GMRT: Recent Achievements

- GMRT v3.8 to be released imminently
  - > 2.6 million square kilometers of new curated multibeam data from 84 expeditions.
  - Data processed by GMRT Team *and* NOAA OER, Ocean Exploration Trust, Seabed 2030 Atlantic/Indian Regional Center
- Revised AWS Architecture to improve performance and minimize costs
- Assembled and tested distributable tiling code for MB data
  - Initial deployments tested on Linux, Mac, Windows



# GMRT: On the Horizon

- Programmatic quantitative comparison of MB data with GMRT-MBS for better and faster QA/QC
- New paper describing advances in GMRT over the last decade (Ferrini et al., in prep)
- Further optimization of AWS deployment
- Extend grid composer functionality
  - Enable user-customizable grid composition
  - Parallel cloud-based data stores to enable integration of partner data synthesis efforts



# GMRT is...

- a Global Multi-Resolution Topography **data synthesis**
- an **infrastructure for delivering elevation data** as grids, images, profiles and points at user-defined locations/elevations & full access to source data
- a **tiling scheme** for efficiently storing and delivering multi-resolution data, maintained simultaneously in 3 projections
- a **scalable methodology** for QA/QC'ing multibeam sonar data that is very well-suited for integrating multibeam data acquired during transits