EMODnet Bathymetry

2022 DTM integration

Technical Report

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1. Introduction to the 2022 release

The 2022 release of the EMODnet DTM is a major product of the 2 year EMODnet Bathymetry project with reference EASME/EMFF/2019/1.3.1.9/Lot1/SI2.836043 which started in December 2019. The main differences with the 2020 release are the addition of the Caribbean Sea to the EMODnet coverage and rendering of webservices in both epsg 4326 and Web Mercator (epsg 3857). In addition, many new datasets have been included in this release.

Figure 1 shows which areas of the DTM have been updated or re-processed. Figure 2 shows new data for areas where previously only GEBCO data was available.

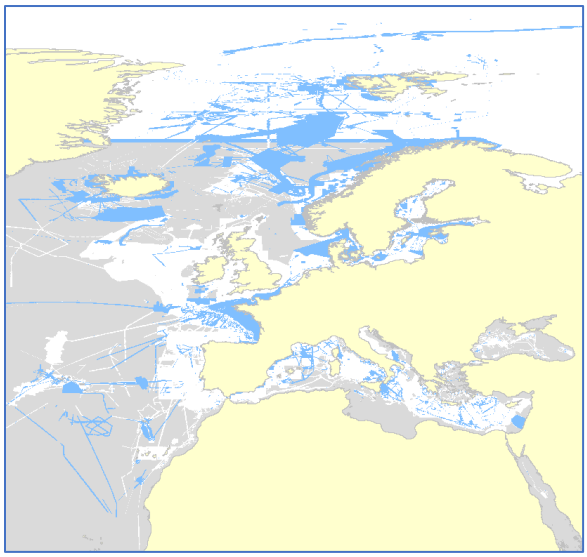


Figure 1

Areas in blue have been updated. Updates also include changes in cdi references.
GEBCO data (grey area) is updated from version 2020 to version 2022. All data for the Caribbean Sea is new. See figure 2.

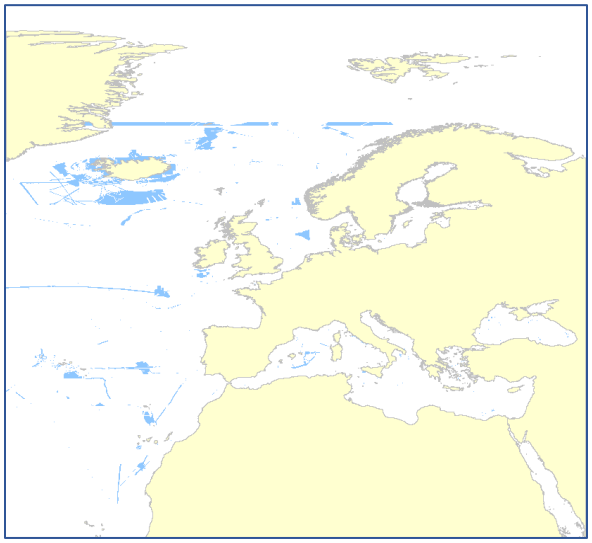
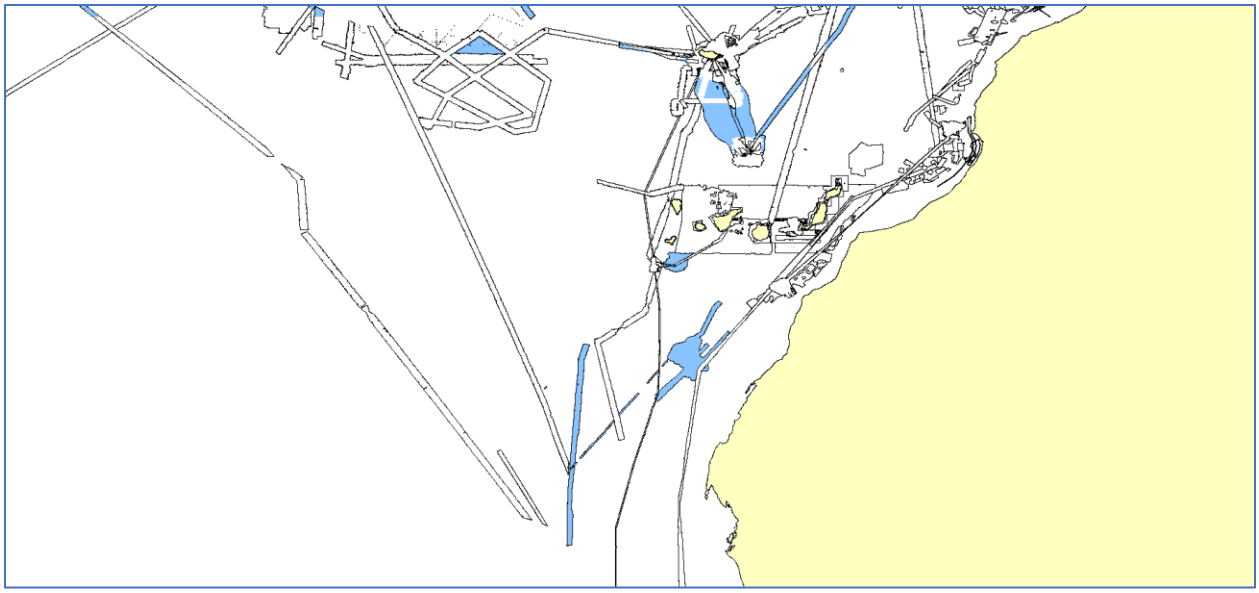


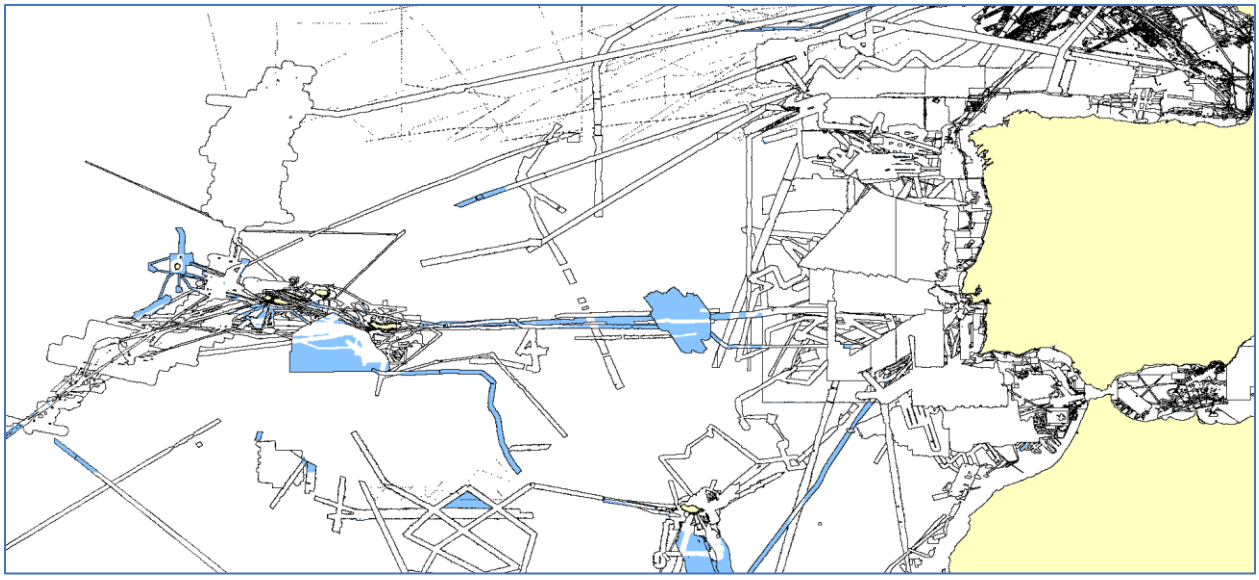
Figure 2 – Europe and Caribbean

New data shown in blue



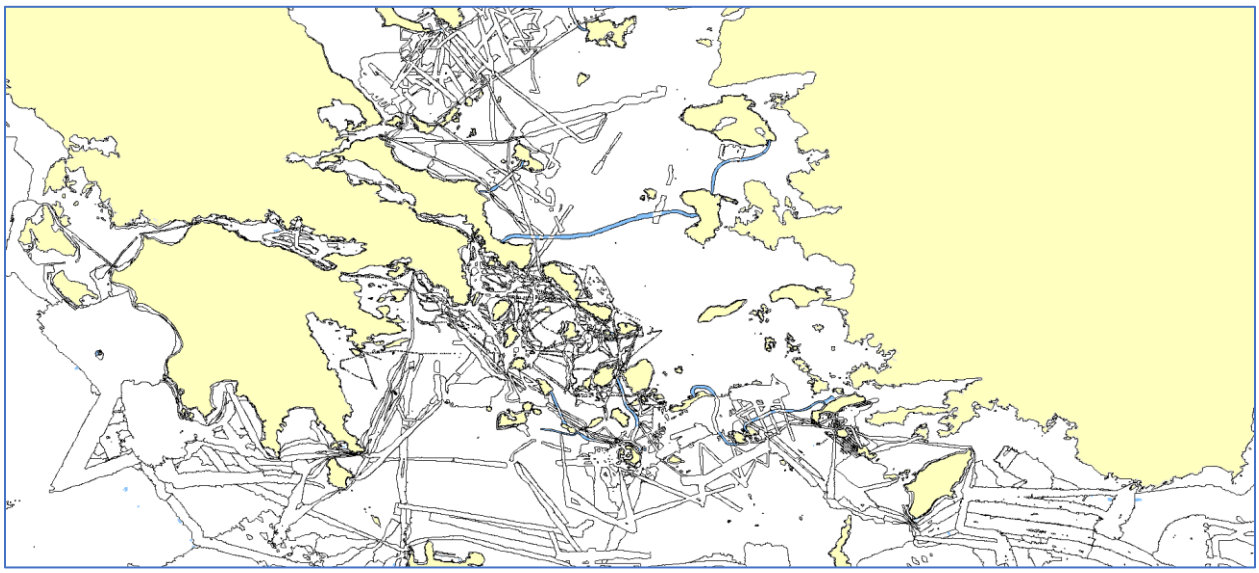
New data in Southern Atlantic. Existing data shown as black outline

Figure 3



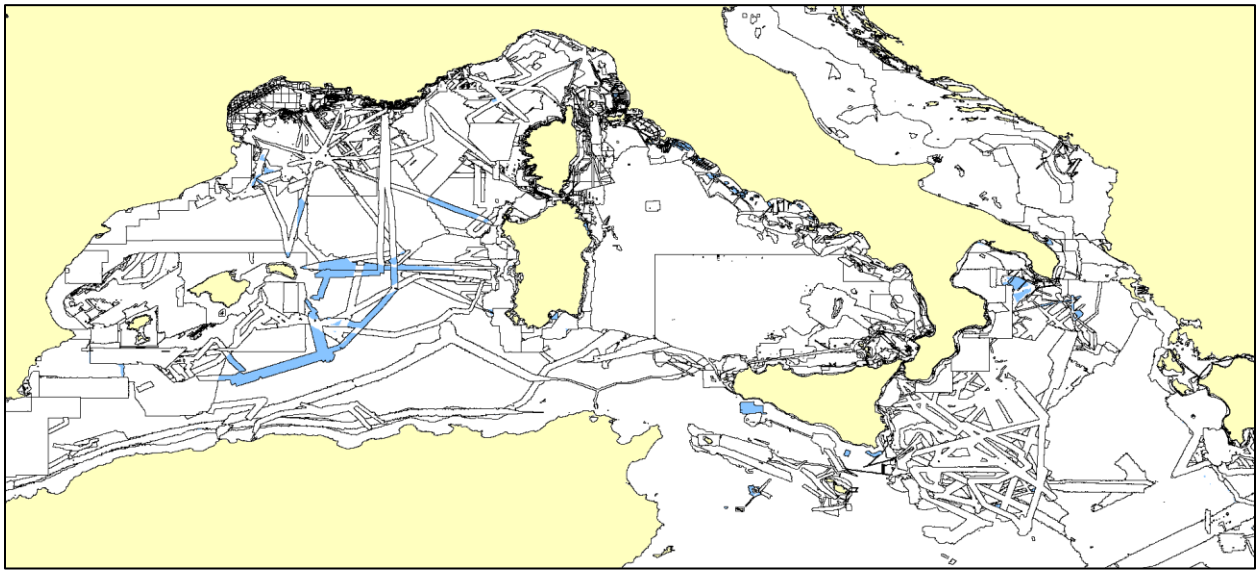
New data in Central Atlantic.

Figure 4



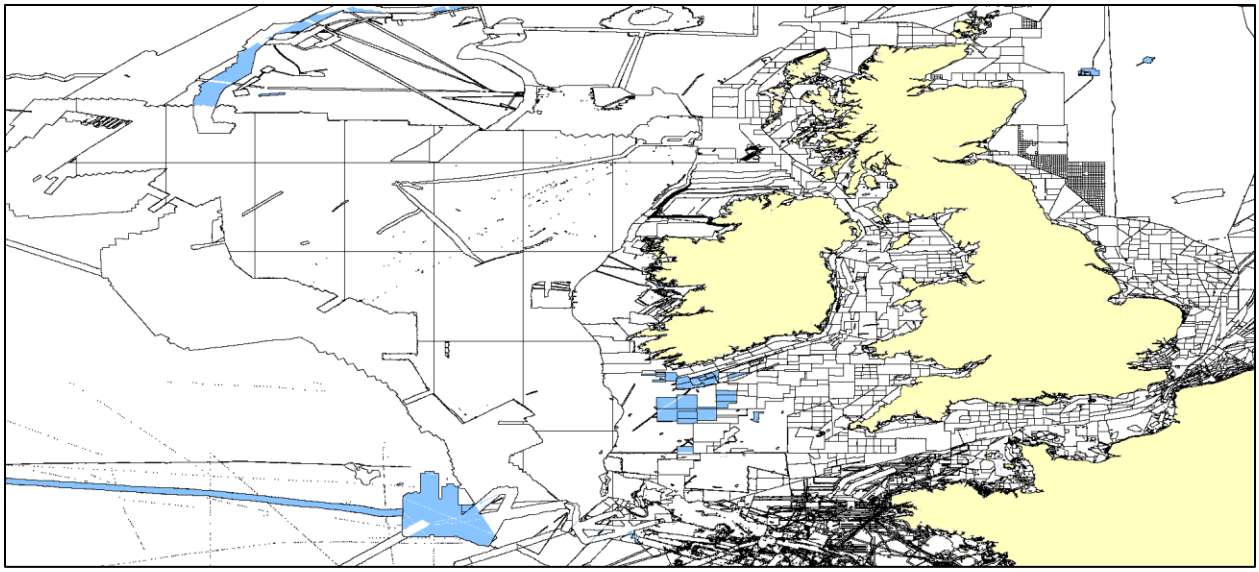
New data in Eastern Mediterranean

Figure 5

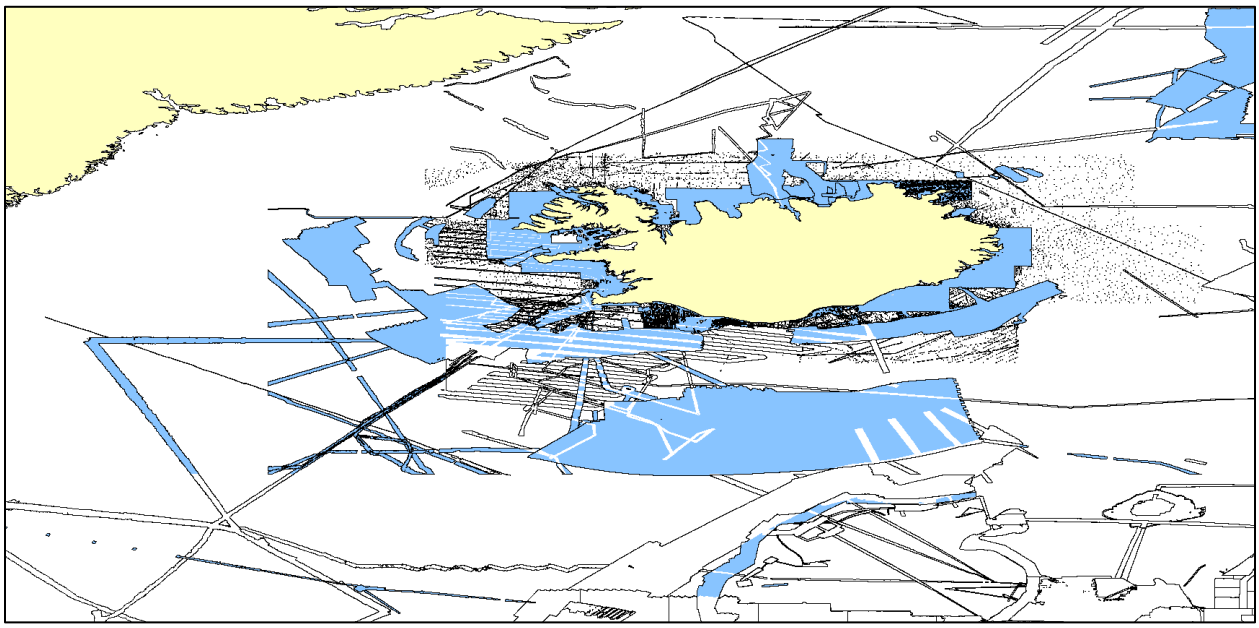


New data in Western and Central Mediterranean

Figure 6



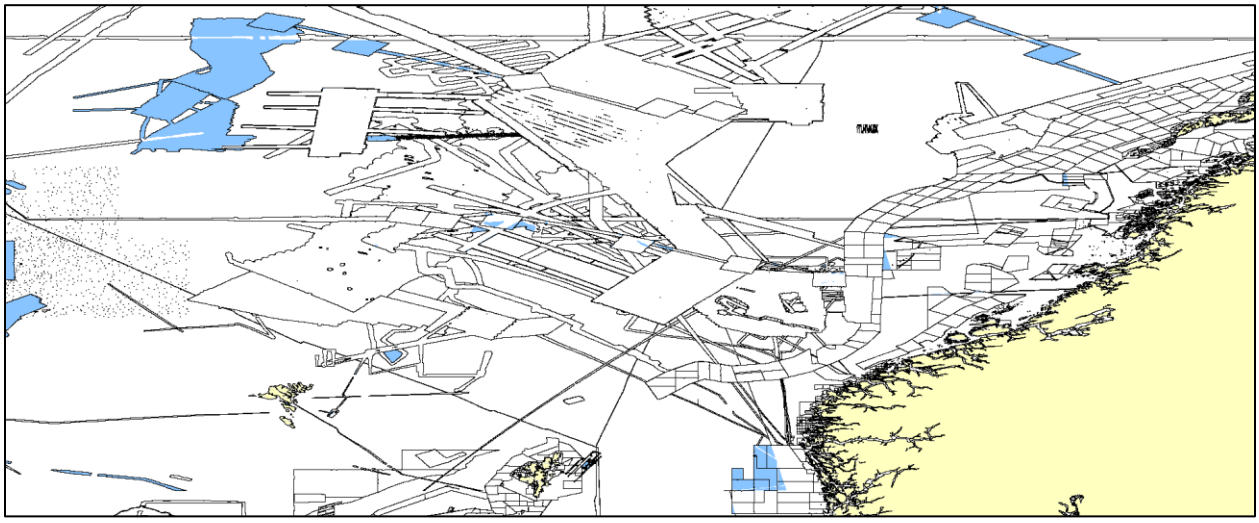
New data in Celtic Sea and North Sea *Figure 6*



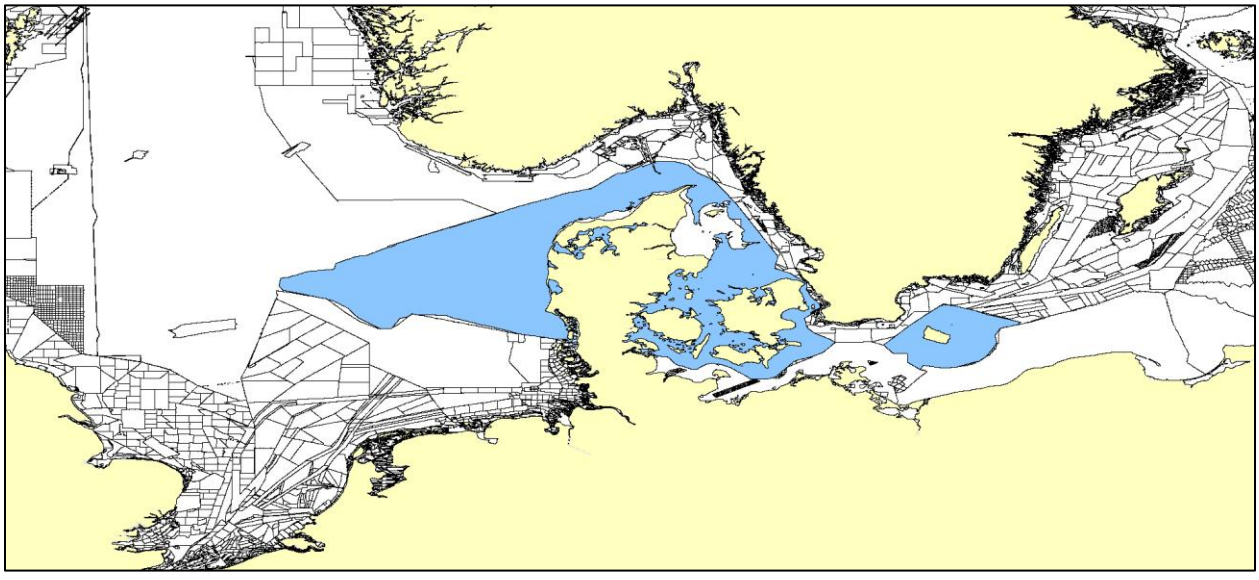
New data around Iceland *Figure 7*

Added to the 2022 release is a very large data contributions from the Icelandic Coast Guard Hydrographic Department (ICGHD) and the

Marine and Freshwater Research Institute (MFRI). Their initial commitment was made 4 years ago but because of lack of resources it took until 2022 for them to contribute. The ICGHD and MFRI together are the largest new data contributor for this release (see figure 7).



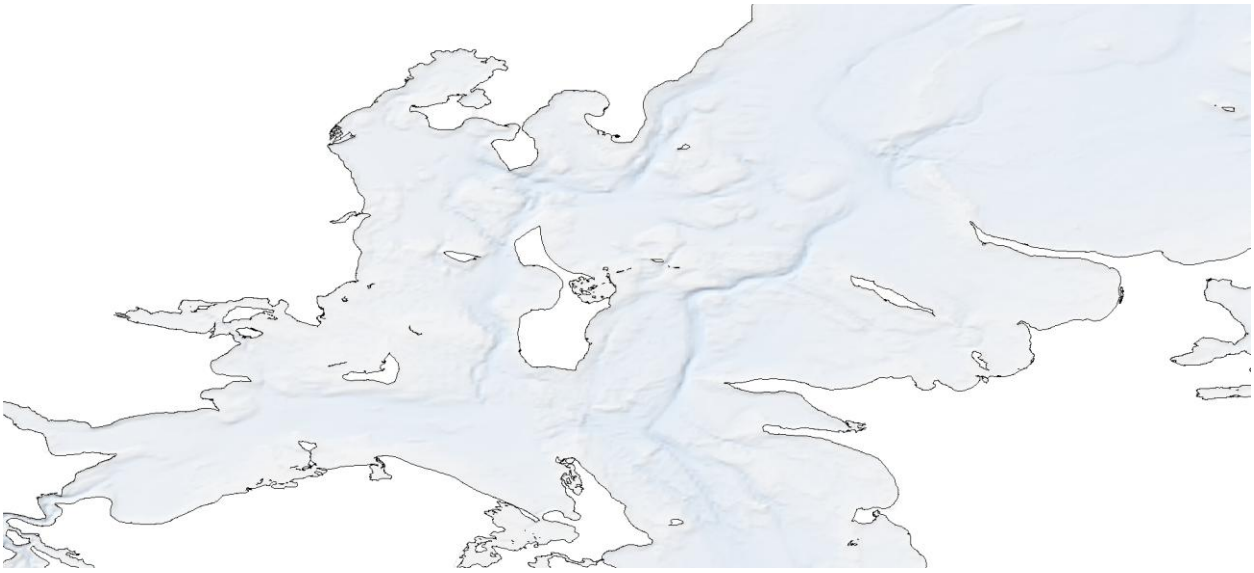
New data in the Norwegian Sea *Figure 8*



Update of the Danish 50 m grid *Figure 9*

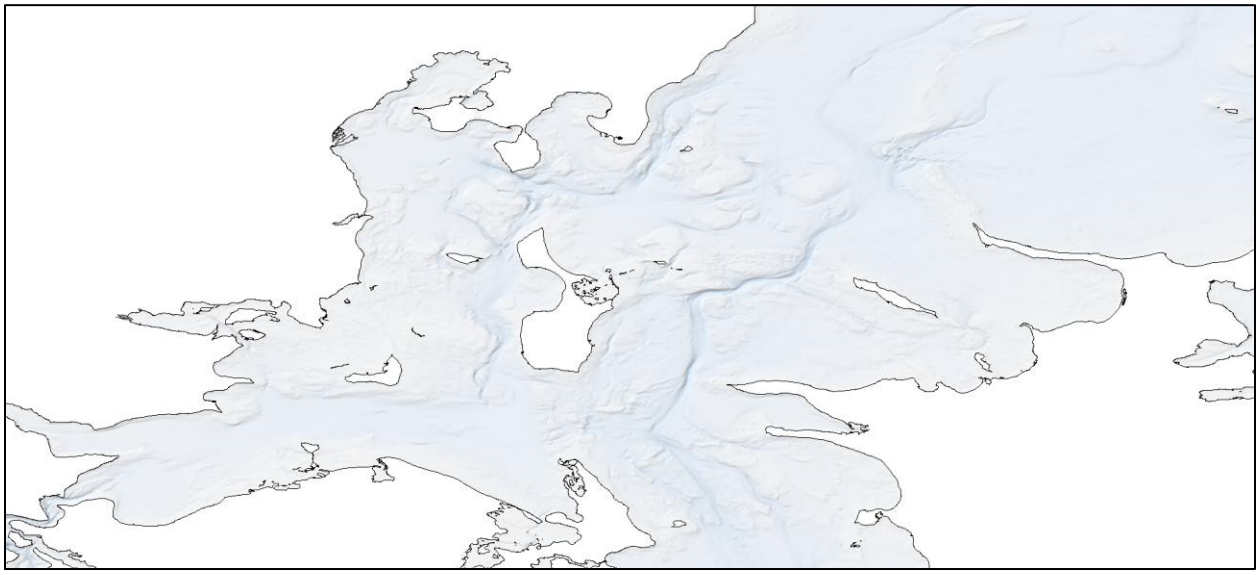
Only a few days before the closing of the data contribution deadline, the Danish Geodata Agency, Danish Hydrographic Office (GST) released a new version of their 50 meter resolution bathymetric grid. This grid has been built from scratch and now act as the official public release of the Danish 50m bathymetric grid. The publication was announced by Masetti et al. in

Geomatics in September 2023[1]. For more than 10 years the use of old Danish 50m grid was embargoed by GST for public use. The late release of the new version of the grid did cause some issues with the integration but overall, the data quality in Danish waters has been greatly enhanced as shown by the following figures:



2020 Great Belt Denmark

Figure 10



2022 Great Belt Denmark clearly showing the increase of data quality compared to the 2020 release shown in figure 10

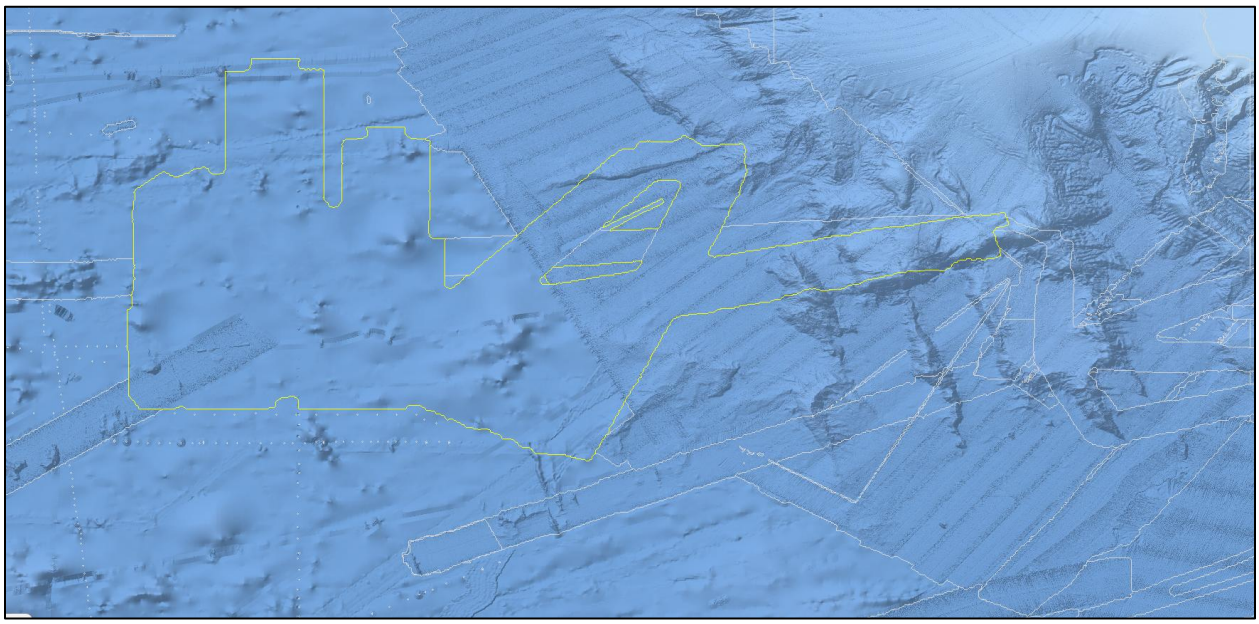
Figure 11

[1] Giuseppe Masetti, Ove Andersen, Nicki R. Andreasen, Philip S. Christiansen, Marcus A. Cole, James P. Harris, Kasper Langdahl, Lasse M. Schwenger and Ian B. Sonne, "Denmark's Depth Model: Compilation of Bathymetric Data within the Danish Waters", geomatics, 2023

Pangaea source data

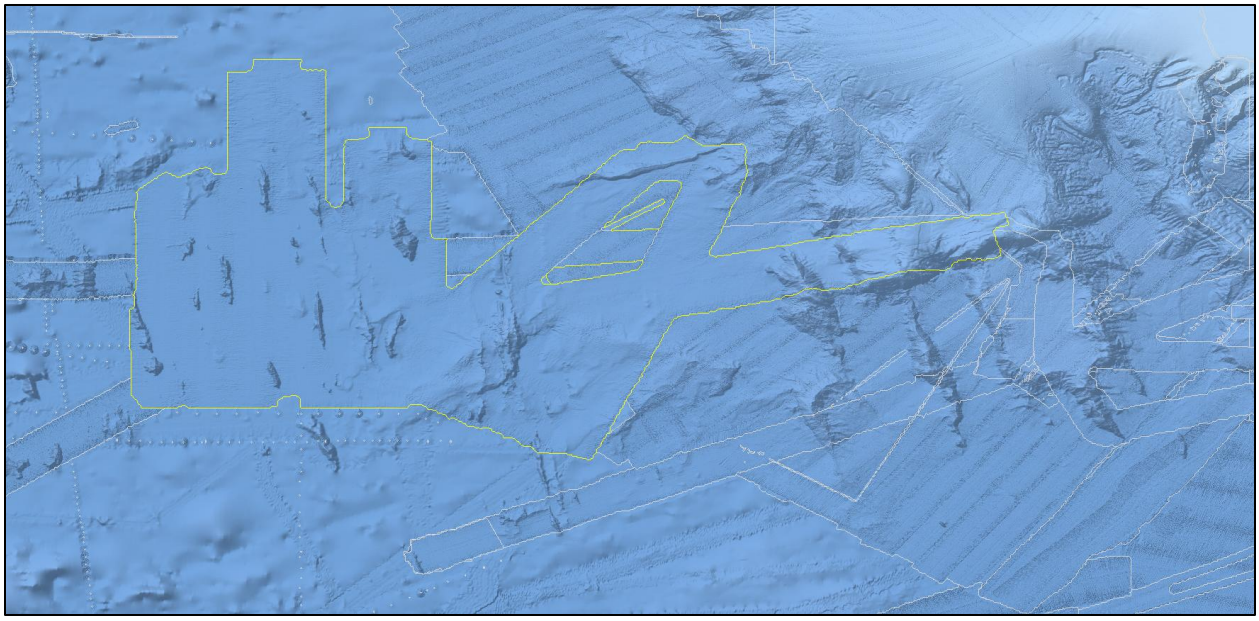
Many new survey data sets were harvested from Pangaea (the German data center for Ocean Sciences). In the past EMODnet Bathymetry received German (scientific) Bathymetric surveys via EMODnet partner MARUM. Due to staff changes this has proven more difficult in the 2020-2022 period. Nevertheless, most systematic surveys available through the Pangaea services have now been included in the 2022 release of EMODnet. More investigation is necessary for the next contract period to see if more data are available.

The following images show "before and after" of the two largest new Pangaea surveys:



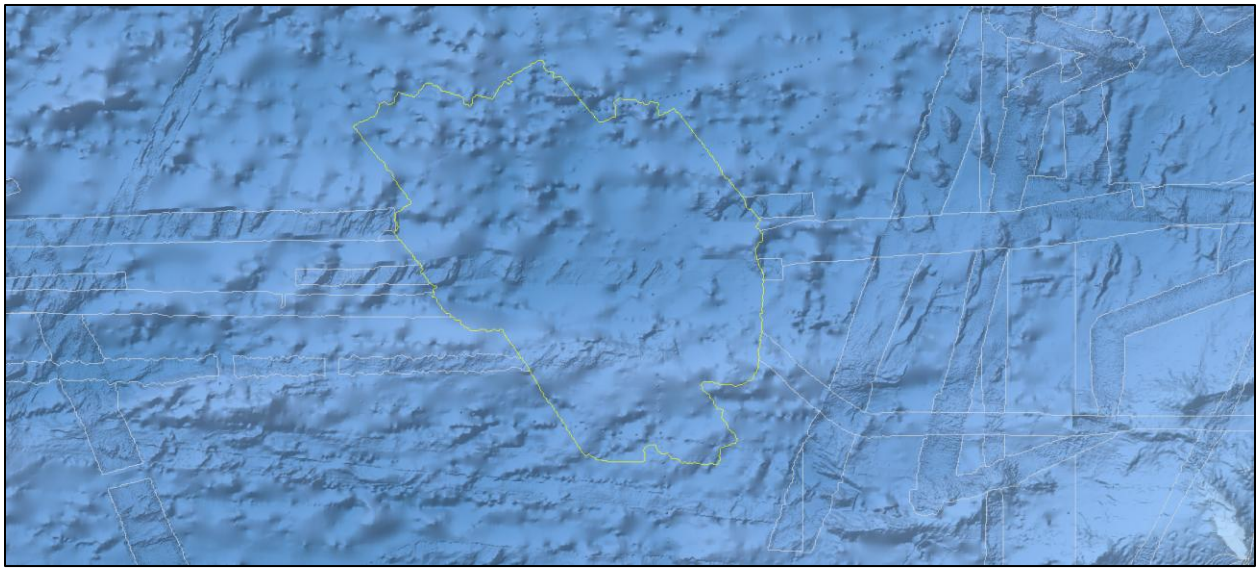
2020 DTM Atlantic Ocean (South West of Ireland, 48N, 15W) without Pangaea survey1568_MSM96_WA1_PAP_100m. The yellow polygon is the outline of this survey.

Figure 12



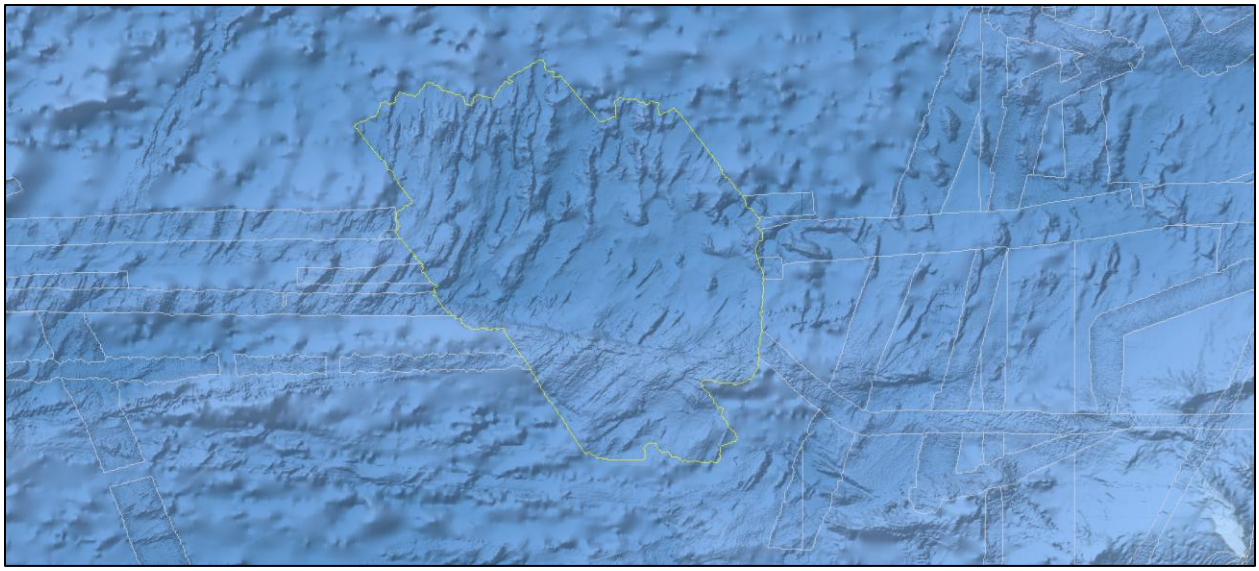
Same area as in figure 12 but with Pangaea survey 1568_MSM96_WA1_PAP_100m

Figure 13



2020 DTM Atlantic Ocean (West of Portugal, 38N, 17W) without Pangaea survey 1568_MSM96_WA2_IAP_100m. The yellow polygon is the outline of this survey.

Figure 14



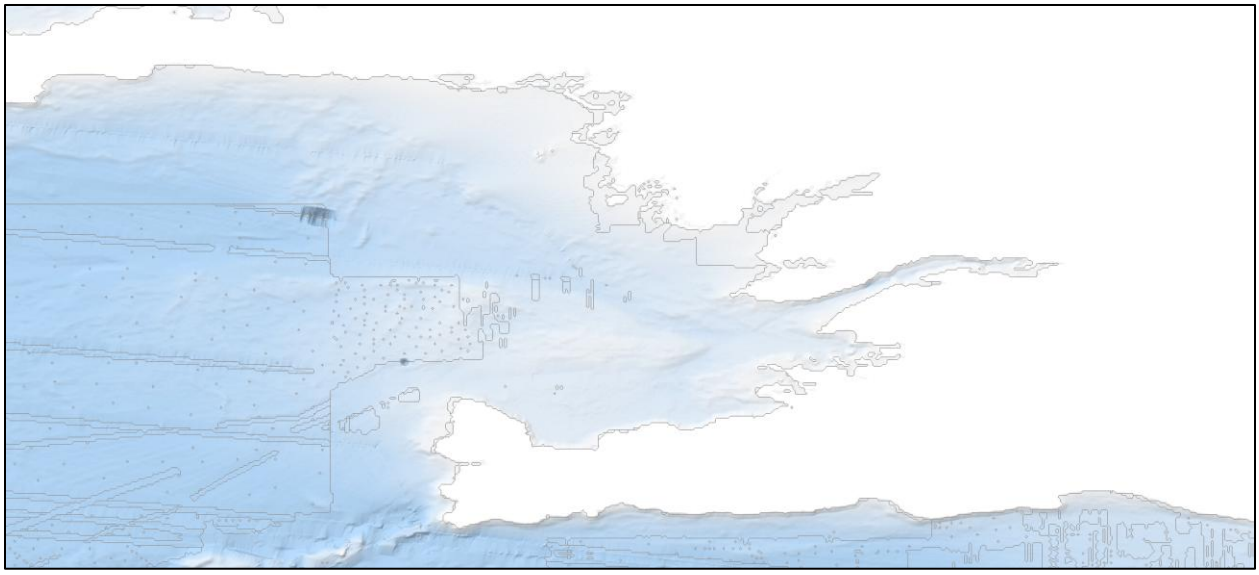
Same area as in figure 14 but with Pangaea survey 1568_MSM96_WA2_IAP_100m

Figure 15

Icelandic Coast Guard Hydrographic Department (ICGHD) and Marine and Freshwater Research Institute (MFRI) data contribution

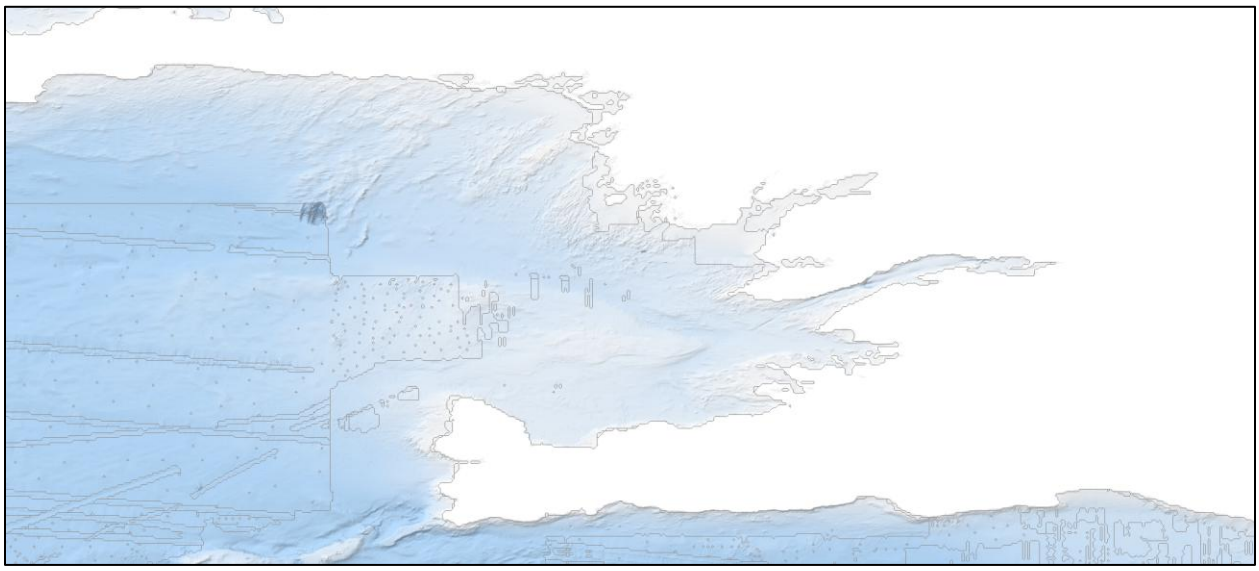
The Icelandic Coast Guard Hydrographic Department (ICGHD) was first approached in 2019 in preparation for the 2020 release of EMODnet. Although they expressed their willingness to support and contribute to EMODnet, they were unable to deliver due to lack of resources. Now in 2022 they made their first delivery to EMODnet. Although they delivered data as a CPRD (composite DTM) the contribution is very substantial and covers more than 15000 sq nautical miles of water. For the 2024 release, ICGHD intends to deliver their data with CDI references.

As a spin-off of the ICGHD contribution, also the Icelandic Marine and Freshwater Research Institute (MFRI) made a huge contribution to EMODnet. The area covered by their data is over 50000 sq nautical miles.



Waters west of Reykjavik in the 2020 DTM

Figure 16



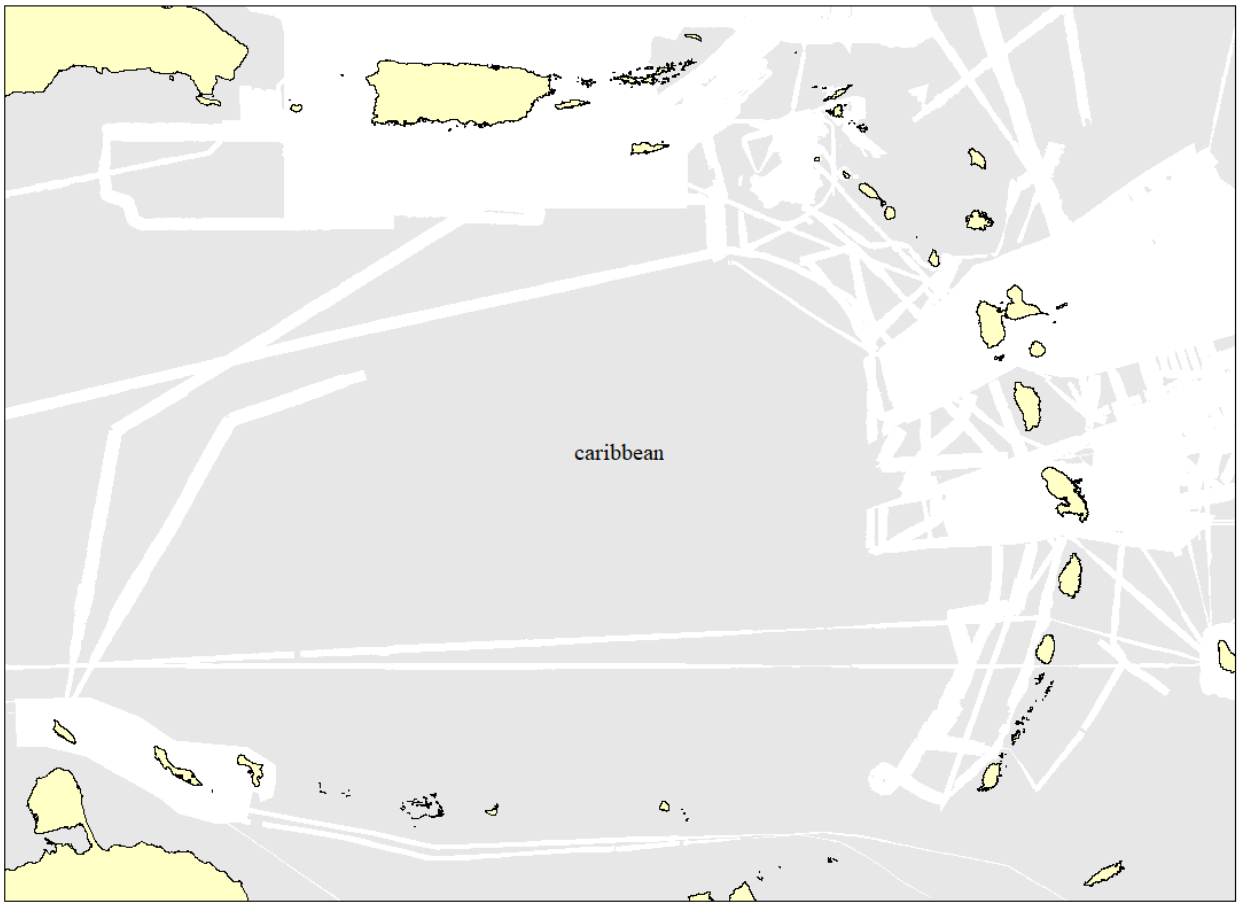
Much better quality in the 2022 DTM (same area as shown in figure 16)

Note the artifact (present in the GEBCO data) in the upper left corner. Although smaller compared to the 2020 DTM is was not fully covered by the new and better Icelandic data. The smaller artifact more to the east has disappeared.

Figure 17

Caribbean

The 2022 release of EMODnet Bathymetry is the first release to include the Caribbean Sea.



Caribbean Sea coverage with GEBCO shown in gray

Figure 18

The extent of the area for the first release of the Caribbean has been chosen based on the existence of European overseas territories in the area. The extent will be evaluated during the 2022-2024 period and may be changed based on the outcome.
Ifremer acts as the regional coordinator of the Caribbean Sea. Difficulty here is the existence of scientific data in national waters. Ifremer holds a large repository of scientific data that has not been used for this first release. Governments need to be contacted individually for approval and this has proven to be difficult. The effort will continue in the next project phase with hopefully better results.

GEBCO 2022 data has been used as gap filler in the EMODnet Caribbean DTM. In addition, GRMT data was used in areas where it exceeded the GEBCO resolution.

Base data

For the 2022 release all regional coordinators were asked to download the latest GEBCO (2022) release for quality control purposes. With the Globe software, GEBCO data was resampled and used as base data or backdrop in order to check the fit between the CDI/CPRD and GEBCO data. Some regional coordinators delivered their rDTM with the resampled GEBCO data, while others decided to remove it before sending their rDTM to GGSgc for integration.

The GEBCO grid is rapidly improving due to the ongoing and successful Seabed 2030 project. This is positive for EMODnet as it makes to GEBCO data as "gap filler" much more valuable.

The co-operation between GEBCO and EMODnet Bathymetry also continues to improve. The is communication between the two groups is very effective and in 2021 George Spoelstra (GGSgc) took over the chair of GEBCO's technical subcommittee TSCOM from Thierry Schmitt (SHOM) which safeguards easy communication for at least another 3 year.

Software used for the integration

The major overhaul of the GGSgc workbench software in 2020 made processing much faster in 2022. This allowed GGSgc to include last minute data contribution that would otherwise have been left out. New software was developed for the production of a single NetCDF file for the complete EMODnet DTM. The Central Portal is using ERDDAP as data management tools and its configuration requires a single NetCDF file for the complete EMODnet DTM. Total size of the file is 133 GB in size. Production takes about 1 hour and requires less than 4 GB of internal memory.

Coast line

No update was made to the 2022 coastline. Instead, the 2020 version was used. A small correction was made to the coastline of the main island of Ireland. In 2020 due to an editing mistake the Irish coastline was shifted by a 100m (note, this was not related to the Irish shift described in the 2020 integration report).

Originally it was the intension to use the satellite derived coastline created by Deltares. However, the quality of this coastline in the artic region is still not good enough (ice coverage makes it almost impossible to generate a coastline from satellite imagery in those regions).

Research by Deltares and GGSgc on how best to apply tidal heights to the coastline is ongoing. It is expected that the 2024 release will make use of this technique where the coastline will be given a height value based on the local high water levels. This prevents a sudden drop in elevation at the coastline in areas with a large tidal range. In the 2022 release this is still visible in areas like the Dutch Waddenzee and around French Mont Saint Michel.

2. Characteristics of the Regional DTM data sources relevant to the overall EMODnet 2022 DTM

rDTMs contributing to the overall EMODnet 2022 DTM have been prepared and contributed by the following EMODnet Bathymetry partners:

Data contributor	Country	Format	Full coverage	Parts	Area
SHOM	France	Globe NC	Yes	1*	- Bay of Biscay / Channel
Ifremer	France	Globe NC	Yes	2	- Western Mediterranean - Black Sea
NODC	GB	Globe NC	No	1	- Celtic Sea
IPMA	Portugal	Globe NC	Yes	6*	- Atlantic and Iberian Coast
Portuguese Hydrographic Institute	Portugal	Globe NC	Both	2	- Azores - Madeira / Canaries
GRID Arendal	Norway	Globe NC	No	1	- Norwegian Sea / Icelandic Sea
BSH	Germany	Globe NC	No	1	- Greater North Sea
SMA	Sweden	Globe NC	Yes	2*	- Baltic and new Danish grid
HCMR	Greece	Globe NC	Yes	1	- Eastern Mediterranean
ISMAR	Italy	Globe NC	Yes	1	- Central Mediterranean
SU	Sweden	Globe NC	Yes	20	- Artic Sea
GEBCO/IHO	International	NetCDF	n/a	1	- GEBCO Europe 1/4 arc minute xyz grid 2022 version

*) multiple updates received

The dataset distribution of each contributor is illustrated below.

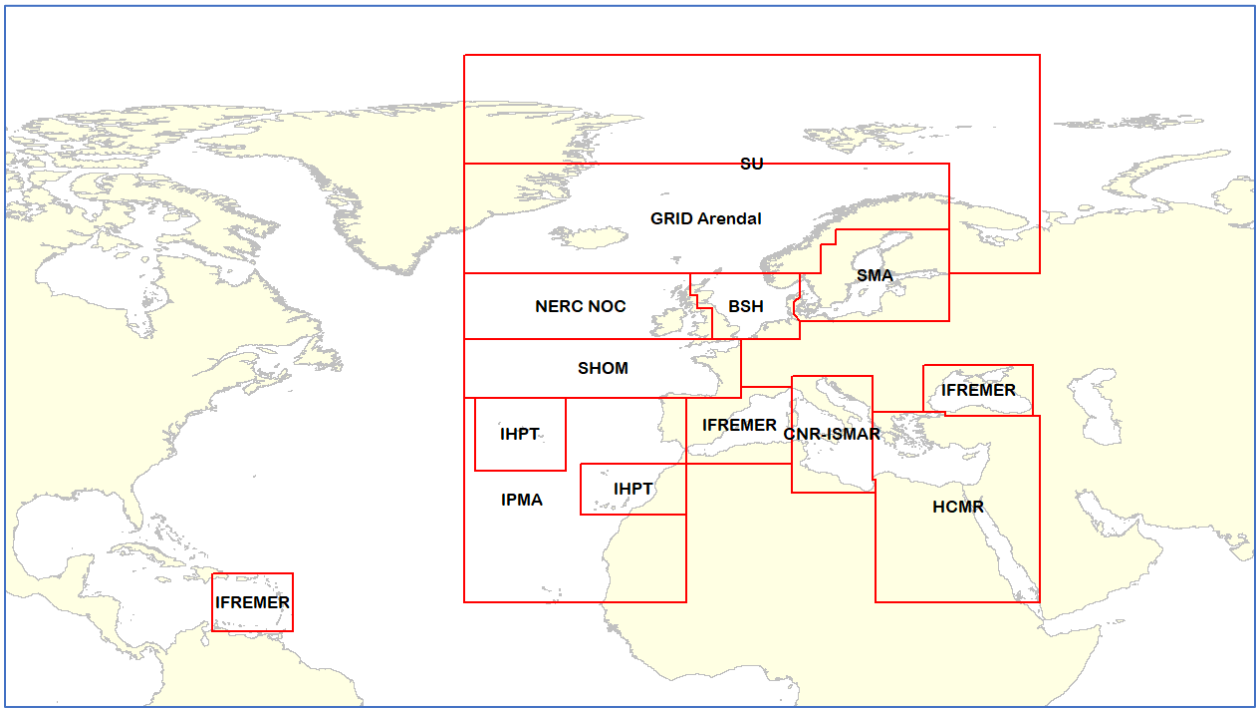


Figure 19

The following general comments can be made about the rDTMs received:

- Gridding artefacts are still present in the data although less compared to the 2020 release. The effects of reprojecting gridding data are still not well understood by the data providers. For the 2024 release more needs to be done (preferably in Globe) to guide data providers to avoid this problem.

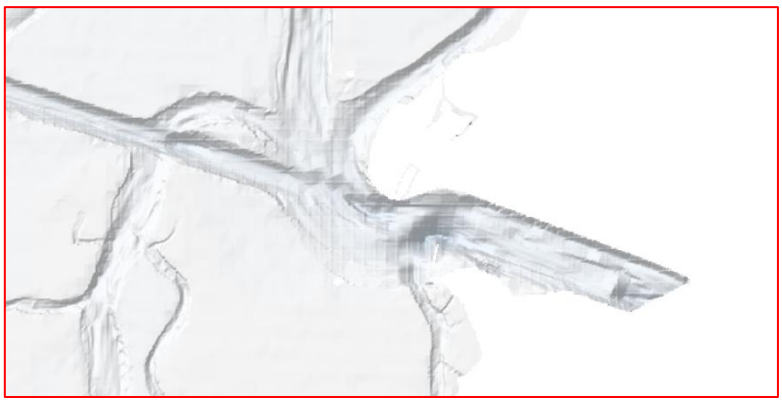


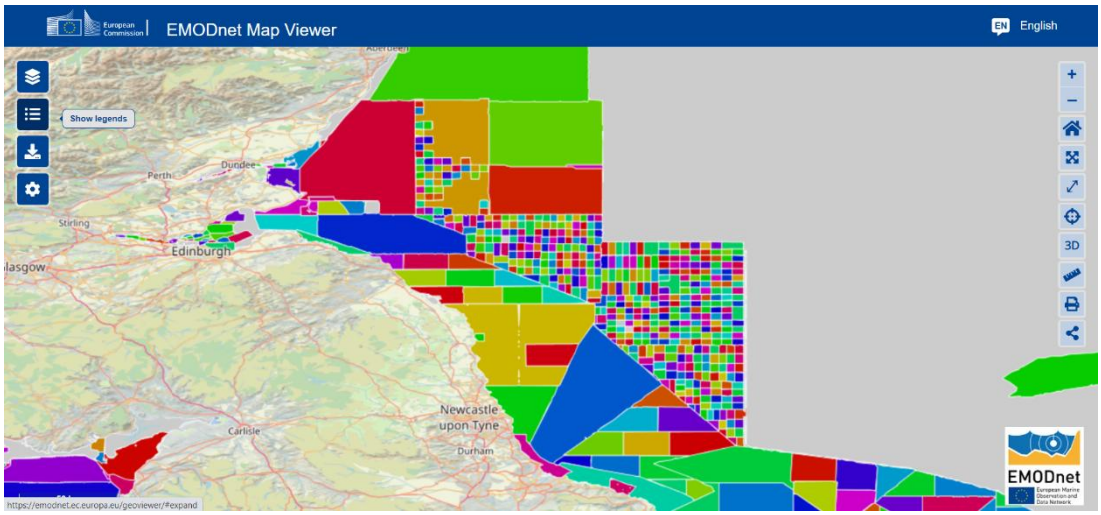
Figure 20

Example of strong gridding artifacts in the Venice Lagoon HR contribution

- A total of 21647 unique CDI references are now used in the overall DTM (16138 in the 2020 version)

- A total of 143 unique DTM references are used in the overall DTM (122 in the 2020 version)
- Of the initial 2022 data delivery, only 627 CDI/CPRD references were either incorrect or unknown in SeaDataNet or Sextant. These have been corrected by GGSgc and MARIS interacting with data providers and/or the Regional Coordinators or in case of minor typo's corrected in the integrated products (and subsequently reported to the Regional Coordinators).
- Partner Oceanwise did not deliver any data this round. UKHO introduced a new bathymetric system and all links with the old data were lost or incorrect. Oceanwise decided to manually correcting the links and this took more time than expected. As a result, all regional coordinators that would normally use Oceanwise data did not include any Oceanwise data in their 2022 rDTM. To solve the issue GGSgc used the 2020 Oceanwise data for the integration.

  The 2020 Oceanwise data had issues with the cdi references (also caused by incorrect deliveries from UKHO). As a consequence, these issues are now also present in the 2022 release. This is most prominent in the area south-west of Edinburgh where many very small surveys have been included (see figure 21).



2020 Oceanwise data in the 2022 DTM re-introduced older problems with UKHO cdi data. The small chessboard like surveys should have been grouped in larger parts.

Figure 20

- The quality of the data received from the regional coordinators was much better in quality compared to the 2020 project. It is clear that the Globe software has improved a lot. Only minor issues were detected mainly dealing with missing data. As mentioned, some of the regional coordinators do not include older datasets already present in the previous releases. There is no agreed rule for this. Although is reduced the data set considerably and hence makes it easier to process, it creates a risk of data inconsistency between new and old data. In case the regional coordinators use the older data to validate the new rDTM this is not a problem but for the integration process it is not always clear if this has

happened.

3. Processing steps

No major changes were made to the overall integration process shown in figure 21. The one before last processing step deals with the generation of the WMS/WMTS image stacks. This step consumes the most computer resources of all steps. It is the intention for the 2024 release to further optimize this by using parallel and multi core computing. The challenge will be the rendering of the hill shade. In a geographic system, this is not as straightforward as in in a projected system. Running it in parallel requires all processes to be aware of the larger context otherwise the outcome of each of the processes will not match colour wise.

The development and optimization of the rendering process is scheduled for 2023.

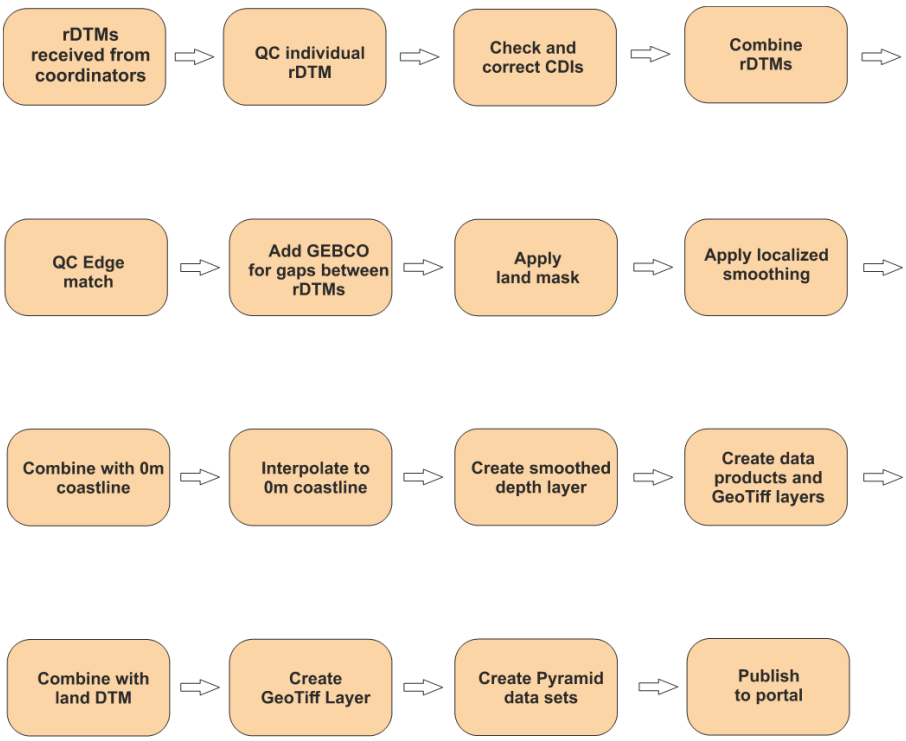


Figure 21

4. World base layer

The current release of the World Baselayer is almost 4 years old and is comprised of GEBCO and EMODnet data released in 2018. If the EMODnet Bathymetry budget in 2023 allows, a new and updated version will be released end of 2023.

5. 2022 Deliverables

The 2022 deliverables of the data integration work comprise the following products and services:

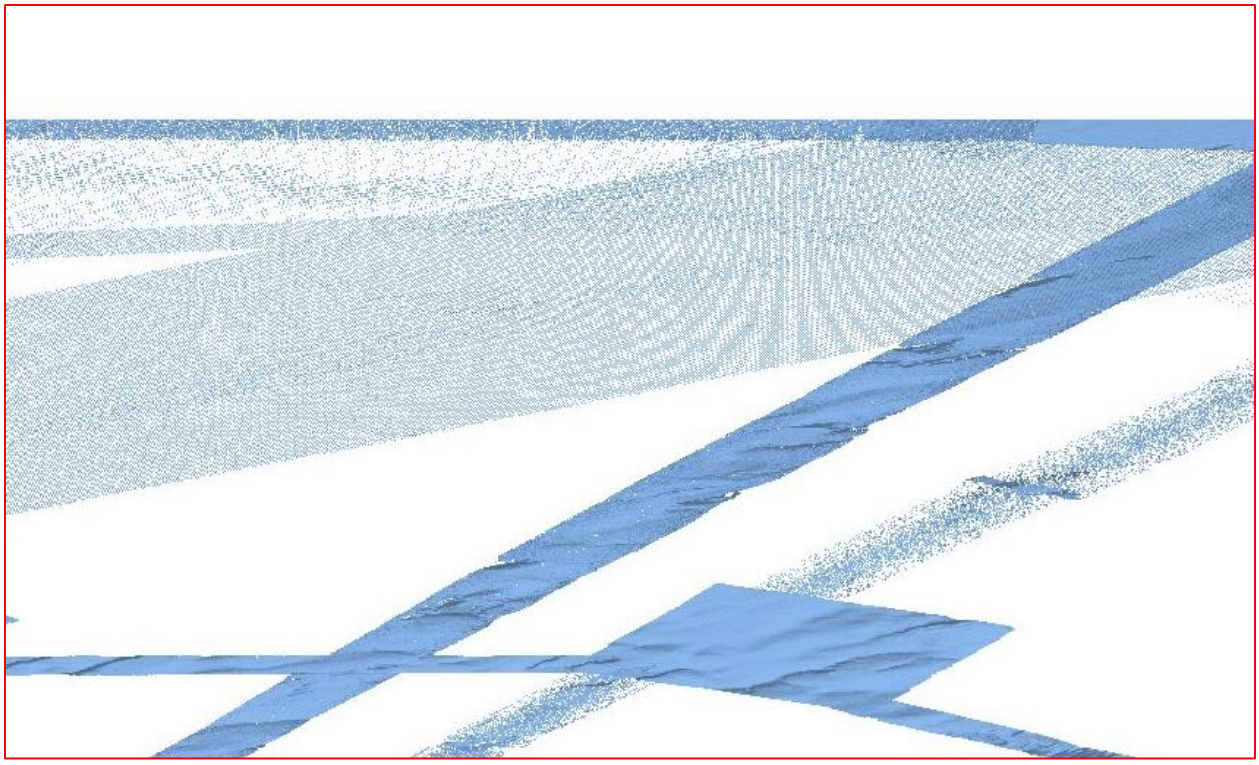
- 65 EMODnet DTM tiles (9 data fields) as 32 bit multi band GeoTiff
- 1 EMODnet DTM NetCDF file (complete DTM, size > 130 GB)
- 65 Product tiles in the following formats:
    - 32 bit GeoTiff xyz
    - esri ASCII grid LAT
    - esri ASCII grid MSL
    - ASCII xyz
    - SD
    - NetCDF
    - EMO
    - EMO no gebco
    - rgb Tiff (rainbow colours)
- Source Reference data layer
- Data Quality Index layer
- Contour layer
- Image tile pyramid for WMS/WMTS in ATLAS colours (epsg 4326)
- Image tile pyramid for WMS/WMTS in Rainbow colours (epsg 4326)
- Image tile pyramid for WMS/WMTS in Multi colours (epsg 4326)
- Image tile pyramid for WMS/WMTS in ATLAS colours (WebMercator)
- Image tile pyramid for WMS/WMTS in Rainbow colours (WebMercator)
- Image tile pyramid for WMS/WMTS in Multi colours (WebMercator)
- 19 HR DTM data files in EMO format
- HR DTM coverage layer
- Image tile pyramid for WMTS 2022 HR DTM layer (epsg 4326)
- Image tile pyramid for WMTS 2018 - 2022 HR DTM layer (WebMercator)
- 2022 version of the PostGIS database (used for the REST services)

Total volume of the data is more than 2 TB.

6. Detailed issues and actions

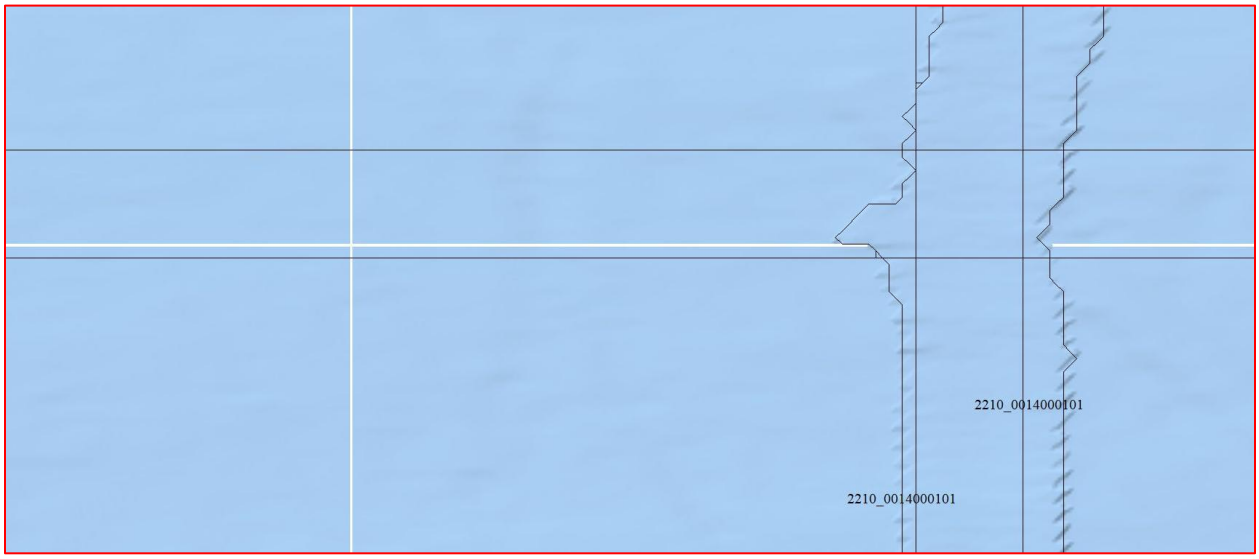
The following table presents an overview of issues and actions per rDTM. These actions are performed as part of the QC step of the rDTMs.

Region	Issue	Action	Remark
Eastern Mediterranean	Low resolution DTMs missing from 2022 rDTM	Solved by using the 2020 release as a backdrop before adding GEBCO	
Madeira Canarias	None		
Bay of Biscay	Older SHOM surveys outside French waters missing	Used 2018 data for SHOM surveys outside French waters	
	Patchiness in source reference	Solved by applying rule base noise filter	Rule based on survey data
	Erroneous surveys from BGS in 2020 gap fill data	Surveys removed and gaps interpolated	
North sea	No Oceanwise data causing BODC data to become too prominent	Separated BODC allowing a correct deconfliction (stacking order) with 2020 Oceanwise data	
	Data slivers without CDI	Slivers removed	Globe is now updated to better check for data without cdi reference
Western Mediterranean	Moiré in min and max layers	Not repaired	This seems to be an issue in Globe as the patterns do not appear in the mean layer. Needs more investigation for the 2024 release
Central Mediterranean	None		
Norwegian Sea	Moiré in min and max layers.	Not repaired	This seems to be an issue in Globe as the patterns do not appear in the mean layer. Needs more investigation for the 2024 release. See figure 22
	Parts of Norwegian 50m grid missing	Replaced with 2020 data	
Artic Sea	Empty grid lines in a regular pattern	Interpolated the empty cells	See figure 23
Celtic Sea	None		
Baltic Sea	None		



Moiré in min and max layer data (example from Norwegian Sea rDTM

Figure 22



Empty grid lines in IBCAO-4 data

Figure 23

7. HR DTM data

A total of 19 new HR DTM data sets have been made available for the 2022 release. This includes a contribution for the Caribbean sea at a 1 meter resolution (see figure 24). All 19 data sets have been added to the HR DTM data sets already available from the 2018 and 2020 releases.

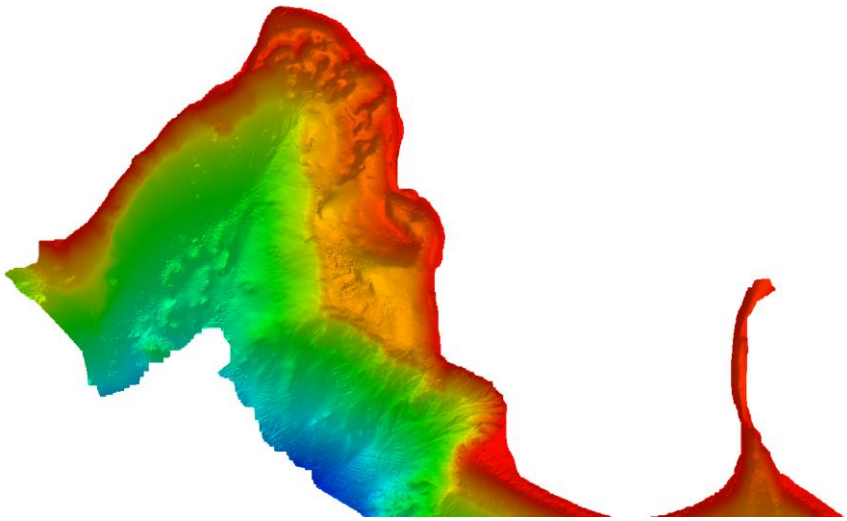


Figure 26

1 meter resolution data for the Caribbean Sea (south of Curaçao). Data received from Map the Gaps.

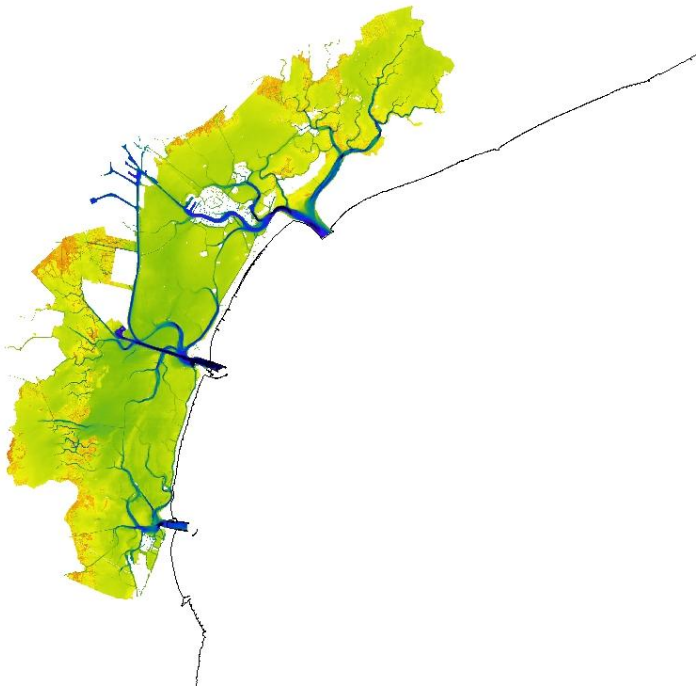


Figure 27

10 meter resolution data is now available for the complete Venice Lagoon. The HR dataset is a combination of in-situ data for the canals and intertidal SDB for the shallow flats.

8. Creation of the WMS/WMTS image pyramids

From March 2023 on, the default map projection used in the Central Portal will be Web Mercator (epsg 3857). Therefore, all data of the 2022 release of EMODnet needed to be rendered in 2 projections as the 4326 rendering cannot be dropped because of legacy. This caused a huge increase in computer time for this release. Especially the data volume and processing of the HR DTM layers are considerable. Also, for the HR DTM layer not only the 2022 release had to be rendered in WebMercator but also older data from the 2018 and 2020 releases.

This year GGSgc will investigate if the rendering process can be optimized for the next release.

9. 3D data

Coronis created a new data set for use in the 3D Cesium viewer available in the Portal. The 3D data set is based on the EMODnet 2022 release. The dataset is integrated in the World Base layer data in order to have global 3D coverage.

10. Conclusions for the 2022 integration work package

Compared to the 2020 release the overall quality of the regional DTMs has improved considerably. Many of the issues found in the 2020 release were solved in the 2022 deliveries. Gridding artifacts remain an issue, something that really needs to be addressed in Globe and by further training of the data providers.
The lack of Oceanwise data caused an issue with the overall schedule but fortunately this was compensated by the GGSgc software improvements done in 2020.
The increase in CDI entries is very positive, especially because more and more data providers previously only delivering cprd data have now started to include cdi references in their data.

Many new data sets have been added to the 2022 release. Especially the Icelandic contributions have increased the cdi/cprd coverage substantially. Although not new coverage, the new Danish 50 meter grid is much welcomed as it improves the data quality in the Kattegat region.

Overall GGSgc believes that the 2022 DTM is a considerable improvement compared to the 2020 release. In the 2020 integration report many of the issues reported caused last minutes and sometimes sub-optimal data corrections. This was much less the case with the 2022 release.

References: EMODnet Bathymetry 2022 intermediate data integration report, GGSgc BV, October 2022