EMODnet Thematic Lot n° 0 – High Resolution Seabed Mapping (HRSM)

EMODnet Phase III

Final Report

Reporting Period: 20/12/2016 – 19/12/2018

CONTRACT NUMBER – EASME/EMFF/2015/1.3.1.7/SI2.742125

Call No. EASME/EMFF/2016/005

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Contents

1. Executive summary

This report describes the activities and results of the EMODnet **High Resolution Seabed Mapping** contract (HRSM) which ran for 2 years from 20th December 2016. It is a follow-up of the earlier developments in EMODnet Hydrography, Seabed Mapping, and Bathymetry projects which took place since June 2009 and that resulted in the portal: http://www.emodnet-bathymetry.eu.

The portal and servcices have been outfitted with an upgraded design and layout, responsive design, and conforms to the new overall EMODnet style.

The first part of the project was dedicated to training and supporting data providers in populating the CDI data discovery and access catalogue with bathymetric survey entries and the Sextant catalogue with composite DTM entries. The total number of CDIs has increased from **14791 to 27168** records and Composite DTM entries from **78 to 147.** The latter also includes **18** satellite derived Composite DTMs for the Mediterranean coastal zones of Spain, Greece and Libya. The number of data providers has increased from **28 to 51.**

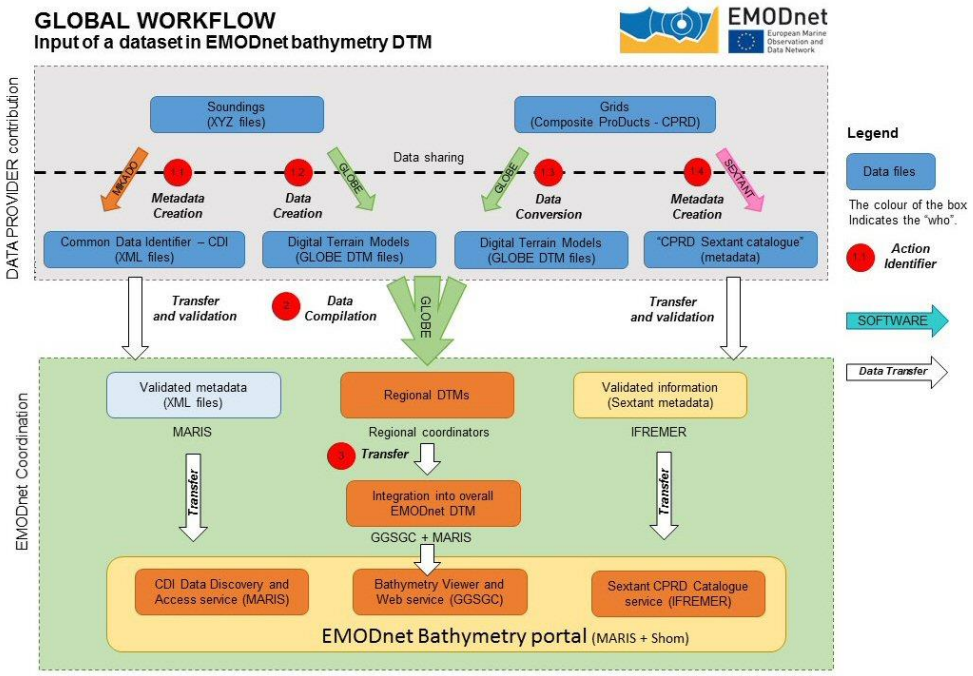

Image: Workflow for EMODnet HRSM

The methodology, software tools, and guidelines for gathering and processing bathymetric survey and composite DTM data sets from data providers into Regional DTMs were improved. The GLOBE software for pre-processing and pre-gridding of input data sets and generation of the Regional DTMs was

upgraded. Not only regional coordinators but also data providers were encouraged to use it preparing their data input. This way there was a harmonized process in all steps from data input to Regional DTMs.

24th September 2018 a new and upgraded version of the EMODnet DTM (Digital Terrain Model) was officially released. Compared to the 2016 release, grid resolution has improved from 1/8 * 1/8 to 1/16 * 1/16 arc minutes (circa 115 * 115 m^2). It contains approx. 12.3 billion grid nodes, organized in 113892 columns and 108132 rows (seabed and terrestrial coverage included) while e.g. GEBCO has 933 million grid nodes for worldwide coverage. From all the data sources gathered, a total of 9369 unique CDI references and 87 DTM references are used in the overall DTM (6924 in 2016 version). It is available free of charge for viewing and downloading, and sharing by OGC web services from the EMODnet Bathymetry portal.

Other new features of the new release are:

- A powerful 3D bathymetry visualisation functionality in the viewer without plugins;
- All European seas including part of the Arctic Ocean and Barents Sea;
- Inclusion of Satellite Derived Bathymetry data products, in particular for coastal stretches of Spain and Greece;
- Improved source reference layer with quality indication: the source reference layer gives a map with polygons which correspond to contributing surveys and composite DTMs for which related metadata can be retrieved. Metadata has been expanded with characterization of the dataset by vertical, horizontal and temporal indicators, purpose of the survey, and information about commonly adopted standards. Analysis resulted in extra maps with Quality Indicators for each source reference, which have been integrated in the Bathymetry viewer as extra layer;
- Downloading of DTM tiles is integrated into a shopping mechanism which facilitates registration of users and their reasons for use.

In addition several other new products were generated and published:

- An inventory and report presenting baseline and coastline data as collected from 21 national authorities. This can be downloaded from the portal together with shapefiles of the baselines and coastlines;
- Best-estimate coastlines were determined from satellite data (typically Sentinel-2 and Landsat-8) and in combination with the Global Tide Surge Model (GTSM) processed into digital coastlines for the European seas at LAT (Lowest Astronomical Tide), MSL (Mean-Sea-Level), and MHW (Mean-High-Water). Coastlines can be viewed as extra layer in the Bathymetry Viewer and downloaded with documentation from the EMODnet Bathymetry portal;
- Using the GTSM DTM tiles of the 2018 Version can be downloaded both relative to LAT and MSL reference levels;

- A multi-resolution layer has been added consisting of a collection of even higher resolution composite DTMs for selected areas which have been gathered and processed by data providers into High Resolution DTM (HR-DTM) files. The resolution of HR-DTMs varies between 1/32 and 1/512 arc minutes, depending on local data policy of data providers. All HR-DTMs are described with metadata in a special section of the Sextant Catalogue. In total 196 HR-DTM files have been provided can be viewed, interrogated for metadata and downloaded by an extra HR-DTM layer in the Bathymetry viewer.

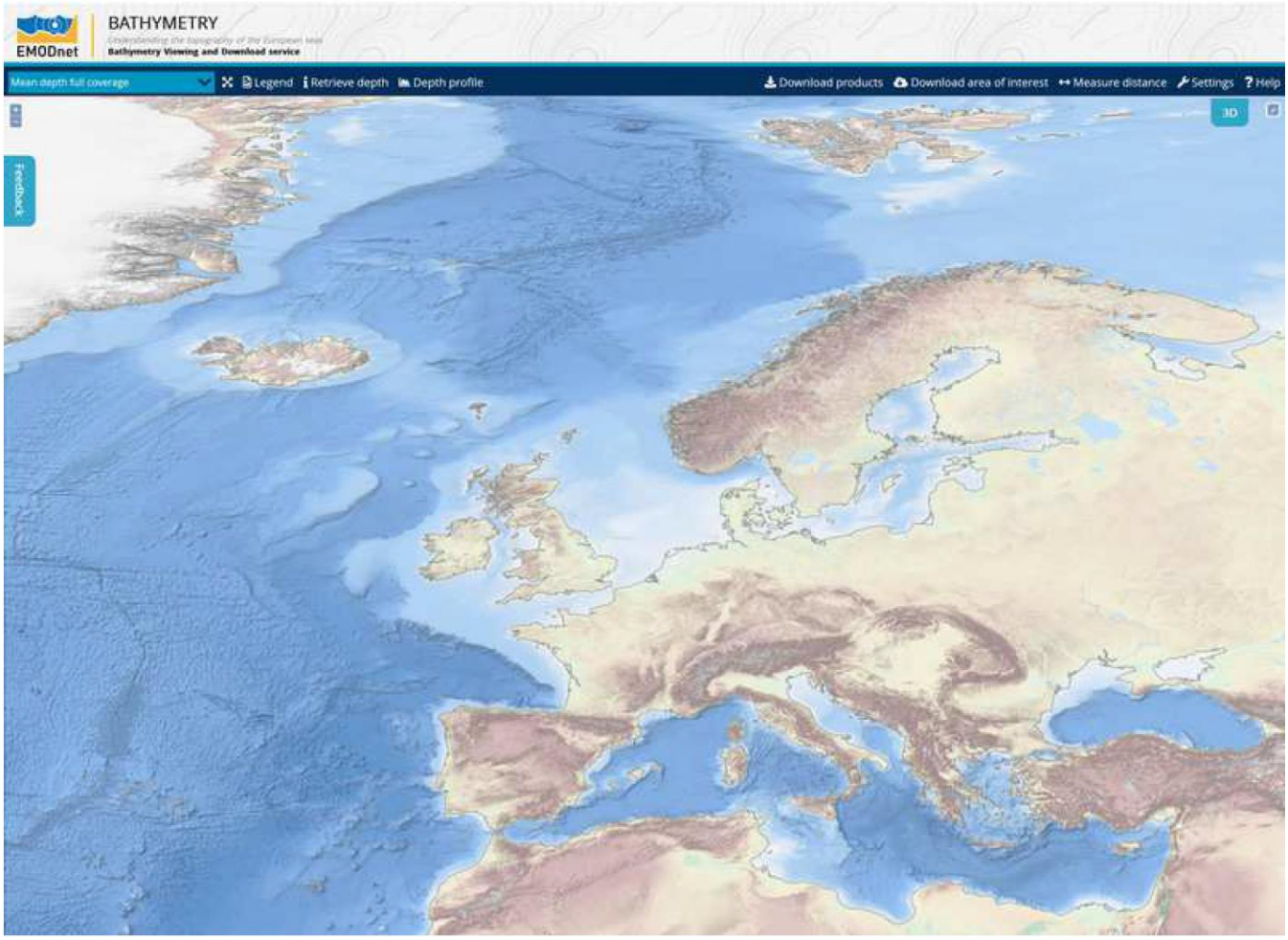

Figure: New EMODnet DTM with higher resolution and including arctic waters

2. Highlights of the reporting period

The highlights are reported against the tasks as included in the tender specifications.

Task 1 - Gather and give access to bathymetric survey data:

- Data providers have gathered and made bathymetric data sets ready for transfer and use by the basin coordinators, whereby Globe software was used for processing and pre-gridding. The total number of CDIs as populated for bathymetry surveys into the CDI Data Discovery and Access service has largely increased from **14791 to 27168** records, while the number of Composite DTM entries into the Sextant Catalogue has expanded from **78 to 147.** The number of data providers has increased from **28 to 51.** In comparison to the start situation data has become available also for the Arctic and Baltic regions, while increasing the coverage for all other European sea areas;
- 18 composite DTMs have been generated from Landsat satellite data for coastal and near shore zones in the Mediterranean of Spain, Greece and Libya, while related metadata has been populated in the Sextant Products Catalogue;
- Data providers have gathered and made **196** higher resolution surveys and composite DTMs datasets ready, using Globe software, for inclusion in a multi-resolution layer with High Resolution DTMs (HR-DTMS). Related metadata has been populated in a special section of the the Sextant Products Catalogue.

Task 2 - Compile a multi-resolution digital terrain model of European seas:

- The regional basin coordinators have selected and merged the pre-gridded and pre-processed datasets as received from data providers and have build the regional DTMs for the 11 specified regions. In addition they drafted QA-QC reports. RDTMs and reports were forwarded to the integrator for building the new overall EMODnet DTM;
- The integration started in March 2018 and was finalised end of August 2018. The whole area is divided in 64 sub-tiles in order to be easily managed. Some considerable local quality issues were identified in some regional DTMs which required solving in cooperation with regional coordinators: e.g. selecting other data sets and applying local interpolation and smoothing techniques. Actions were also undertaken for checking the presence of all CDI/CPRD references, quality assessment (visual checks of remaining artefacts), and uptake of the new EMODnet DTM into the Bathymetry portal;
- 24th September 2018 the new version of the EMODnet DTM has been officially released as the result of a great collaborative effort. Compared to the 2016 release, the grid resolution has improved from 1/8 * 1/8 to 1/16 * 1/16 arc minutes (circa 115 * 115 m2). A total of 9369 unique CDI references and 87 DTM references are used in the overall DTM versus 6924 in the 2016 version;

- Next to the new DTM with a common resolution another layer was compiled and made available in the Bathymetry viewer, consisting of 198 High Resolution DTMs as prepared by data providers. The resolution of HR-DTMs varies between 1/32 and 1/512 arc minutes, depending on local data policy of data providers. The HR-DTMs allow to zoom deeper than the common DTM layer and can be interrogated for metadata and downloaded;
- The methodology for determining a Quality Index has been refined which included adding extra metadata to CDI and Sextant entries, such as vertical and horizontal indicators. Further analysis has resulted in an improved source reference layer in the Bathymetry viewer with quality indication by means of maps for 'age', 'vertical precision', 'horizontal precision', 'purpose', and 'combined' whereby the last one is resulting from an algorithm combining the earlier four indicators.

Task 3 - Establish best-estimate European digital coastlines and compile overview of legal baselines:

- Best-estimate coastlines were determined from satellite data (typically Sentinel-2 and Landsat-8) and in combination with the Global Tide Surge Model (GTSM) processed into digital coastlines for the European seas at LAT (Lowest Astronomical Tide), MSL (Mean-Sea-Level), and MHW (Mean-High-Water). The level of detail is bound to the resolution of the satellite sensor (e.g. 10m for Sentinel-2). These satellite derived coastlines can be viewed as extra layer in the Bathymetry Viewer and downloaded with documentation from the EMODnet Bathymetry portal;
- An inventory and report was compiled with baseline and coastline data as collected from 21 national authorities in Europe. It describes the information available per country, the resolution, the source of the data and the institute providing/ hosting the data. This can be downloaded from the portal together with shapefiles of the baselines and coastlines. A disclaimer has been included to underpin the prerogatives that national states have on this type of information, including legal implications. It also states that the main objective of this report is to provide the contracting authority with an inventory of these available datasets at a fixed date in time;
- The Global Tide Surge Model (GTSM) has been improved. It now includes e.g. the effects of thermal expansion and radiational tides that are important in the Mediterranean and Baltic. The coastal resolution has been increased to 1.25 km to better represent straits and estuaries. The model was used to provide the new downloadable EMODnet DTM tiles also at MSL reference level next to the prevailing LAT reference level.

Task 4 - Establish machine-to-machine connections to data and data products:

- The new EMODnet DTM and additional layers have been integrated in the Bathymetry Viewing and Download service. The new common DTM (2018 version) has replaced the existing common DTM (2016 version). The layer menu provides the mean depth layers with 3 colour palettes. Also

the source references layer has been replaced, giving options foir retrieving metadata from the CDI and Sextant Catalogue services;

- The OGC web services (WMS, WFS, WCS, and WMTS) from the Bathymetry viewer have been updated by including the new 2018 version of the EMODnet DTM, while publishing of the older 2016 version is continued;
- Extra functionality was added to the Bathymetry viewer for 3D visualisation of the new EMODnet DTM. For this purpose a method and software was developed for generating a TIN model from the EMODnet DTM which is instrumental for supporting stable 3D viewing. The 3D software has been documented and made available at GitHub: https://github.com/coronis-computing/emodnet_qmgc.
- The pilot for the **Collaborative Virtual Environment (CVE)** was successfully finalized. It had a focus on generating 2 neighbouring RDTMs (West Med and Central Med) and 1 additional RDTM (Bay of Biscay) using Globe online on a cloud computing platform and involving a few basin coordinators. A storage space of 3TB was reserved on the DATARMOR cloud infrastructure as managed by IFREMER and loaded with copies of pre-processed and pre-gridded data sets as have been used for the new regional DTMs. Links were set-up from the DATARMOR data pool to the CDI and Sextant web services to facilitate the Globe Workflow. The pilot concerned building selected regional DTMs having all data and the Globe software online together in the cloud. Two ways for working with the GLOBE software on the cloud were set-up: 1) as a full package and installed as a Docker container instance; and 2) as a set of OGC WPS services for selected GLOBE functions. Examples of both have been made available to pilot regional coordinators for try-out and feedback in order to improve the services. As part of the pilot, an OGC WPS has been developed, facilitating to select DTMs stored on the cloud and merge them. The pilot has provided insights into the practical feasibility of adopting the cloud for the EMODnet Bathymetry workflow and where it should be improved. Also it demonstrated how two basin coordinators for neighbouring regions can collaborate, in particular for establishing seamless boundaries between their two regional DTMs. This experience will be used in the new EMODnet phase for upgrading the pilot set-up to an operational configuration which will be used by a few Regional Coordinators for generating new Regional DTMs;

Task 5 - Maintain a web portal:

- The EMODnet Bathymetry portal has been upgraded with a modern and responsive design and the contents has been updated to reflect the scope of the new HRSM project. The upgraded portal has been launched at 27 March 2017 at the existing domain to ensure continuity: www.emodnet-bathymetry.eu. In October 2017 the Bathymetry portal and associated services have been restyled following the latest EMODnet style guide;
- In the following period the web portal was operated and maintained with adding news, promotion items and information about new products and services as they became available;

- The Bathymetry Viewing and Download service of the Bathymetry portal was upgraded to include the new EMODnet DTM, the Satellite Derived Coastlines, the HR-DTM files and layer, and the Quality Index layer. The downloading of 2016 DTM tiles was expanded with tiles from the new 2018 DTM version in various formats, including DTM files with MSL reference next to LAT reference, HR-DTMs, and Satellite Derived Coastlines. The downloading facility was upgraded to register identity of users and reasons for use. The number of DTM tiles for the new 2018 version has increased from 16 to 64 due to the higher resolution and associated increase in volume.

Task 6 - Operate a help-desk:

- The help desk is integrated in the portal and frequently used. In the reporting period questions from more than 80 users were received and answered by the helpdesk.

Task 7 - Achieve international interoperability:

- A 'Report on Interoperability and International Collaboration' was drafted, submitted to the EU and accepted together with the 1st Annual Progress report early 2018;
- Follow-up was given to the cooperation as mentioned in the given report with GEBCO, NOAA (as part of AORA), IHO, BSHC, NSHC, IBCAO, and the Seabed 2030 initiative.

Task 8 - Achieve INSPIRE compliance:

- The 'Report on Interoperability and International Collaboration' from early 2018 also describes how EMODnet Bathymetry is seeking INSPIRE compliance for its range of services;
- A further dialogue took place between the INSPIRE team at JRC and the EMODnet Bathymetry team together with SeaDataCloud and EMODnet Chemistry colleagues. In May 2018 five INSPIRE change requests were prepared and submitted to the INSPIRE team concerning the metadata validator and the data implementation rules. Feedback was received and reviewed by the SeaDataCloud Technical Task Group. The next step took place at the TG-DATA meeting in December 2018. At the meeting JRC indicated to undertake measures for making the INSPIRE implementation more flexible and forthcoming to change requests as heard from several communities in order to achieve more success.

Task 9 - Monitoring of performance:

- The overall performance of the portal and its services is continuously measured and reported at a quarterly basis. The web portal and its services are well visited with > 10.000 unique visitors per month. Also the OGC web services (machine-to-machine) are very popular with more than 250.000 visitors per year;
- Downloading of DTM tiles is also continuously measured and reported at a quarterly basis. The number of downloaded tiles amounts to circa 10.000 per quarter. With the launch of the new

DTM end September 2018 registration was added of the identity of downloaders and reasons for use. In the last quarter of 2018 the new service registered > 12.000 downloaded tiles from circa 1700 unique users from > 800 organisations from industry (22 %), government (6%), research institutes (18%), universities (43%), public (8%), international organisations (1%) and NGO's (2%). Thereby each user indicated trustworthy reasons for use;

- At the begin of 2018 the set of key indicators was amended upon request of the EU and 'MATOMO' software was installed to register visitors to the portal and services in a common way at all EMODnet portals;
- Using Google Scholar nearly 160 references to EMODnet Bathymetry can be found for accepted papers and edited books during the project duration.

Task 10 – Project management:

- The contract was awarded by EASME to the EMODnet High Resolution Seabed Mapping (HRSM) Consortium and signed by both parties on 20/12/2016. A Consortium Agreement was agreed and signed between Shom and all full partners, while bilateral Subcontracts were agreed and signed between Shom and subcontractors;
- The first annual report and the associated report on interoperability and international collaboration have been drafted and submitted by the coordinator and technical coordinator which were officially accepted by EU (EASME and DG MARE);
- Each three months a quarterly progress report including key indicators was prepared by the coordinator and technical coordinator which were accepted by EU (EASME and DG MARE);
- Three plenary project meetings took place, including a training workshop at the project start; in addition four core group meetings took place for preparing and monitoring project activities.

3. Summary of the work done

Organisation wise, the first year of the EMODnet High Resolution Seabed Mapping (HRSM) project was dedicated to managing the expansion of the consortium from 24 members in the predecessor EMODnet Bathymetry project to now 41 active members. This included establishing an agreed Consortium Agreement with all partners and individual subcontracts with each subcontractor. It also included working on shaping again a team with good understanding of the project targets and approach as well as with the joined will to undertake the planned activities. This was achieved by organizing in the first year 2 plenary meetings with all consortium members, including training sessions to make all aware and to give all hands-on instructions and training with the EMODnet HRSM methodology, tools and services. Moreover several mailings were undertaken by the coordinating team of Shom and MARIS to inform and to encourage data providers in the consortium to get into action and make progress.

The first part of the project was also dedicated to improving, adapting and validating the methodology, procedures and software tools for processing bathymetric survey data sets and Composite DTM data sets from data providers into Regional DTMs. This was required because the common resolution of the overall EMODnet DTM will increase from a grid size of 1/8 minute * 1/8 minute to a grid size of 1/16 minute * 1/16 minute. Moreover an improved formulation was required for the later determination of the Quality Index on the EMODnet DTM. This implicated adding extra metadata to the existing CDI respectively Sextant metadata formats for bathymetric survey data respectively Composite DTMs. Therefore a lot of effort has been spent in particular by Shom, IFREMER, MARIS, and GGSGC with help of others for upgrading the DTM production methodology and the Quality Index determination. This has resulted in updated Guidelines [1] [2] which have been circulated and transferred to the consortium members. Moreover the GLOBE software for pre-processing and pre-gridding of input data sets by data providers and later generation of the Regional DTMs by regional coordinators has been upgraded by IFREMER. In the previous project the GLOBE software was used only by the regional coordinators while it was optional for data providers. In the HRSM project it has been strongly advised to all data providers as the best tool for pre-processing and pre-gridding their data contributions (both survey data and Composite DTMs) to the EMODnet grid and minimum required resolution of 1/16 minute * 1/16 minute. This way there has been a harmonized process in all steps from data input to Regional DTMs. The GLOBE software is made available by IFREMER to all consortium members under a free user license.

A new EMODnet Bathymetry portal has been launched at the existing domain www.emodnet-bathymetry.eu on 27 March 2017. The contents was updated to reflect the scope and challenges of new High resolution Seabed Mapping (HRSM) phase and its extended consortium compared to the previous EMODnet Bathymetry phase.

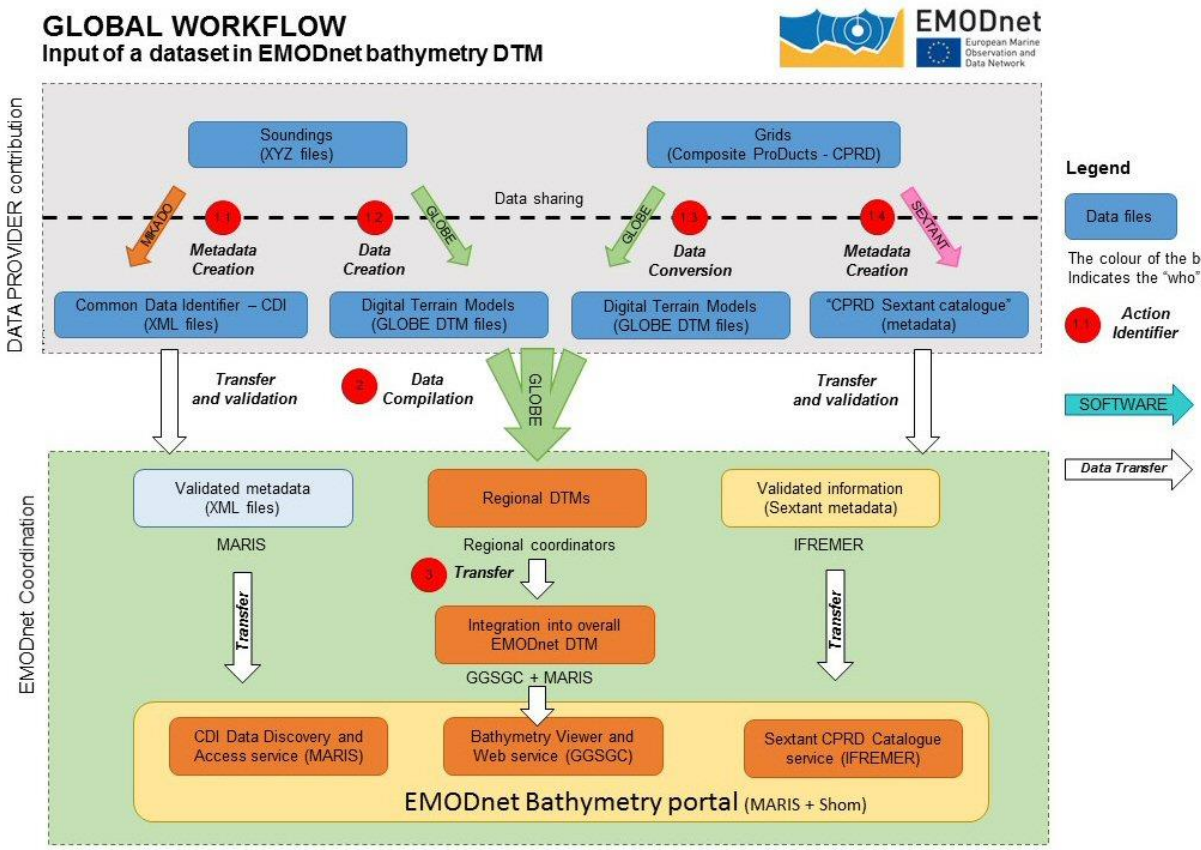

Image: Workflow for EMODnet HRSM

The design and layout of the portal have been upgraded to provide a modern look and include responsive design for dynamic support of the portal on multiple platforms. In the 3rd and 4th project quarters the look & feel of the portal and associated services have been upgraded, adopting the new EMODnet styling, and adopting responsive design. The Sextant catalogue service for composite DTMs has been upgraded by IFREMER and is now operational, embedded by API. For the CDI Data Discovery and Access service new screens have been designed and implemented by MARIS. For the Bathymetry Viewing and Download service new screens have been designed and implemented by GGSGC.

All the preparatory, training and coaching activities have resulted in the situation that in the 4th quarter of 2017 and consecutive months a major acceleration was achieved in gathering and making bathymetric data sets ready for transfer and use by the Regional Coordinators. The total number of CDIs has increased considerably in the project from **14791 to 27168** records, while the number of Composite DTM entries into the Sextant Catalogue has expanded from **78 to 147.** The latter also includes 18 satellite derived Composite DTMs generated by partner EOMAP for the Mediterranean coastal zones of Spain, Greece and Libya. The number of data providers has increased from **28 to 51.** In comparison to the start situation data has become available also for the Arctic and Baltic regions, while increasing the coverage for all

other European sea areas. Also arrangements have been put into place for new partners connecting to the CDI infrastructure for handling user requests for data sets.

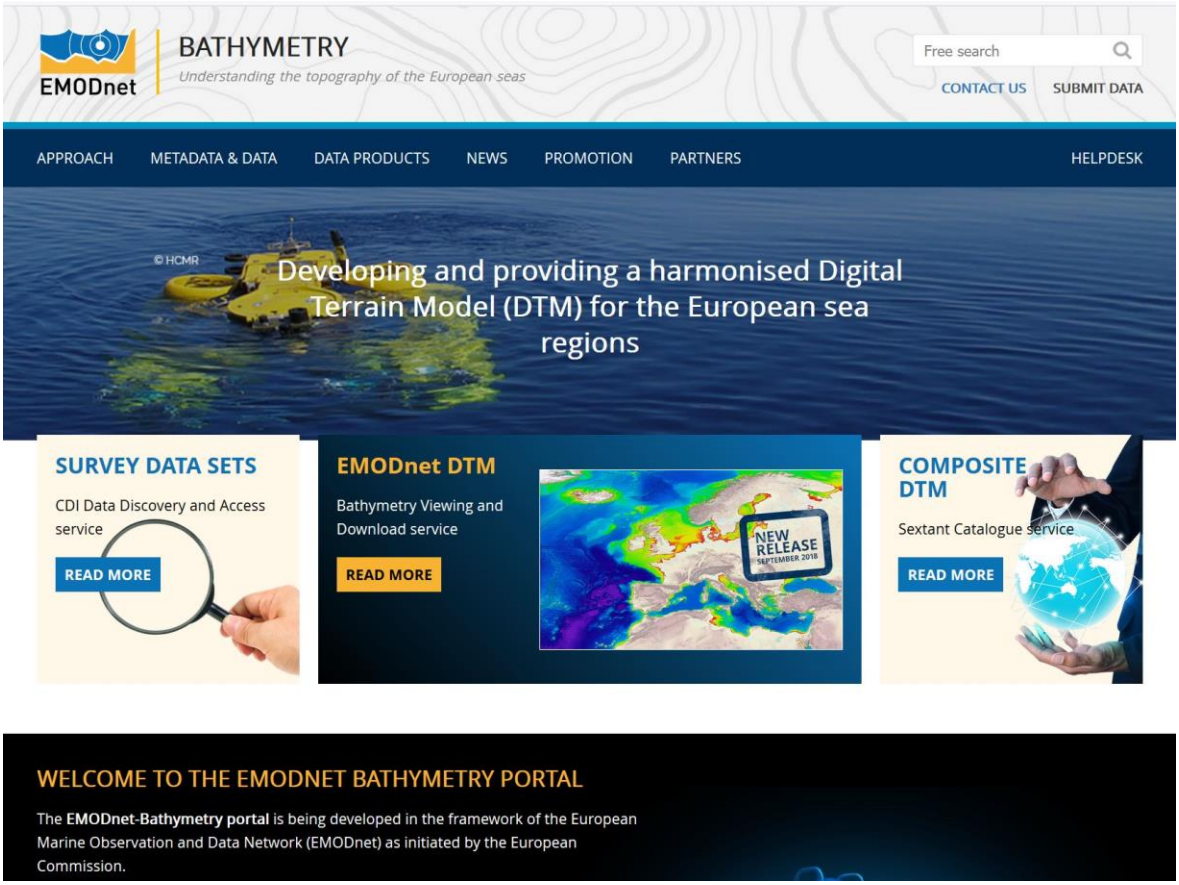

Image: Homepage of upgraded EMODnet Bathymetry portal

After population of the CDI data discovery and access service and the Sextant catalogue data providers undertook actions for pre-gridding and pre-processing their data sets with the Globe software for later hand-over of the files to the regional basin coordinators.

Remark: In a later stage of the project data providers were requested in addition to bring together and pre-grid and pre-process survey and composite DTM data sets with a higher resolution than needed for the common EMODnet DTM and to make these available for publishing and downloading as a collection of circa 200 High Resolution DTMs (HR-DTMs). The resolution of the provided HR-DTMs varies between 1/32 and 1/512 arc minutes, depending on local data policy of data providers. All HR-DTMs are described with metadata in a special section of the Sextant Catalogue.

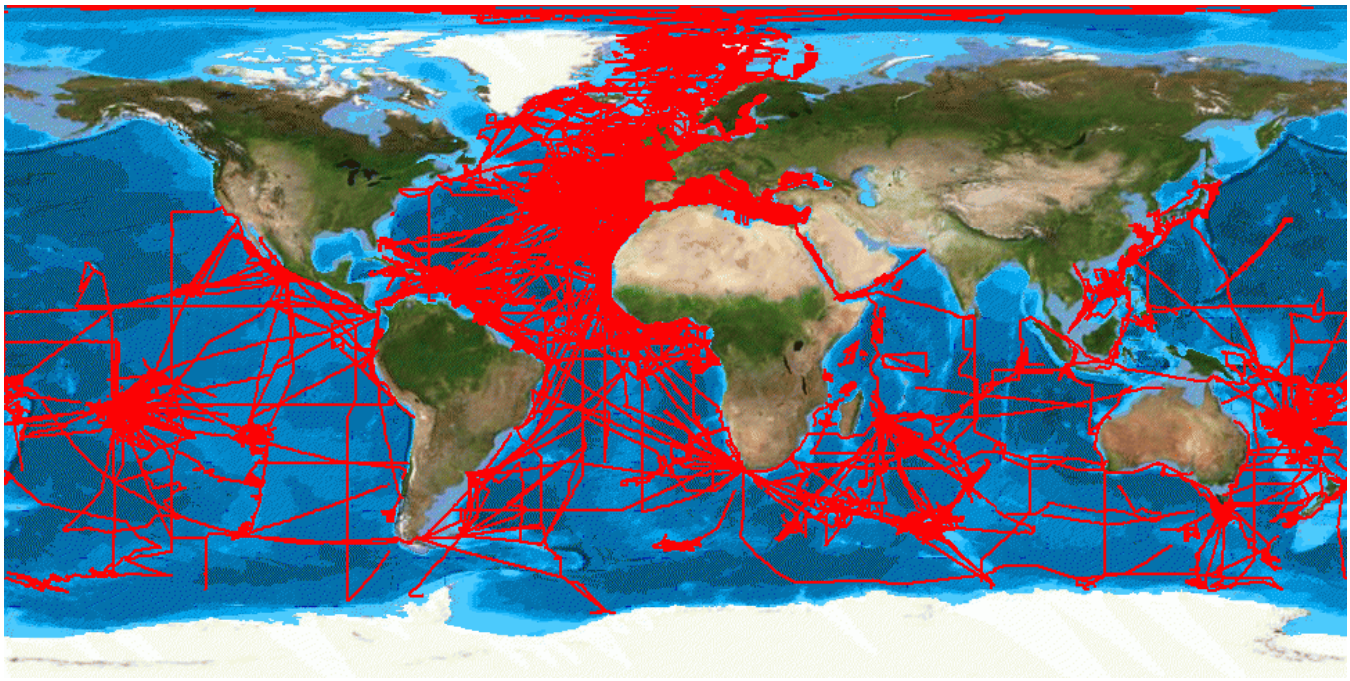

Image: Map of all entries in the CDI catalogue service

The generation of Regional DTMs was divided over regional sea basin subgroups, each with a Regional Coordinator and a number of contributing data providers. Each Regional Coordinator was responsible for a quality assessment and selection of the data contributions and the compilation of the Regional DTM using the GLOBE software. Also each Regional Coordinator drafted a QA-QC report for its regional DTM.

RDTMs and QA-QC reports were forwarded to the integrator (GGSGC) for building the new overall EMODnet DTM. The integration started in March 2018 and was finalised end of August 2018. The whole area is divided in 64 sub-tiles in order to be easily managed. Some considerable local quality issues were identified in some regional DTMs which required solving in cooperation with regional coordinators: e.g. selecting other data sets and applying local interpolation and smoothing techniques. Actions were also undertaken for checking the presence of all CDI/CPRD references, quality assessment (visual checks of remaining artefacts), and uptake of the new EMODnet DTM into the Bathymetry portal. The overall integration of the Regional DTMs into the EMODnet DTM was the responsibility of GGSGC with support of MARIS and it was not only an integration but also a final QA – QC to achieve a high quality bathymetry product that can be made public by the Bathymetry Viewing service at the portal for viewing and for downloading.

Figure: Division of EMODnet DTM coverage over Regional DTMs

24th September 2018 a new and upgraded version of the EMODnet DTM (Digital Terrain Model) was officially released. Compared to the 2016 release, grid resolution has improved from 1/8 * 1/8 to 1/16 * 1/16 arc minutes (circa 115 * 115 m2). It contains approx. 12.3 billion grid nodes, organized in 113892 columns and 108132 rows (seabed and terrestrial coverage included) while e.g. GEBCO has 933 million grid nodes for worldwide coverage. From all the data sources gathered, a total of 9369 unique CDI references and 87 DTM references are used in the overall DTM (6924 in 2016 version). It is available free of charge for viewing and downloading, and sharing by OGC web services from the EMODnet Bathymetry portal.

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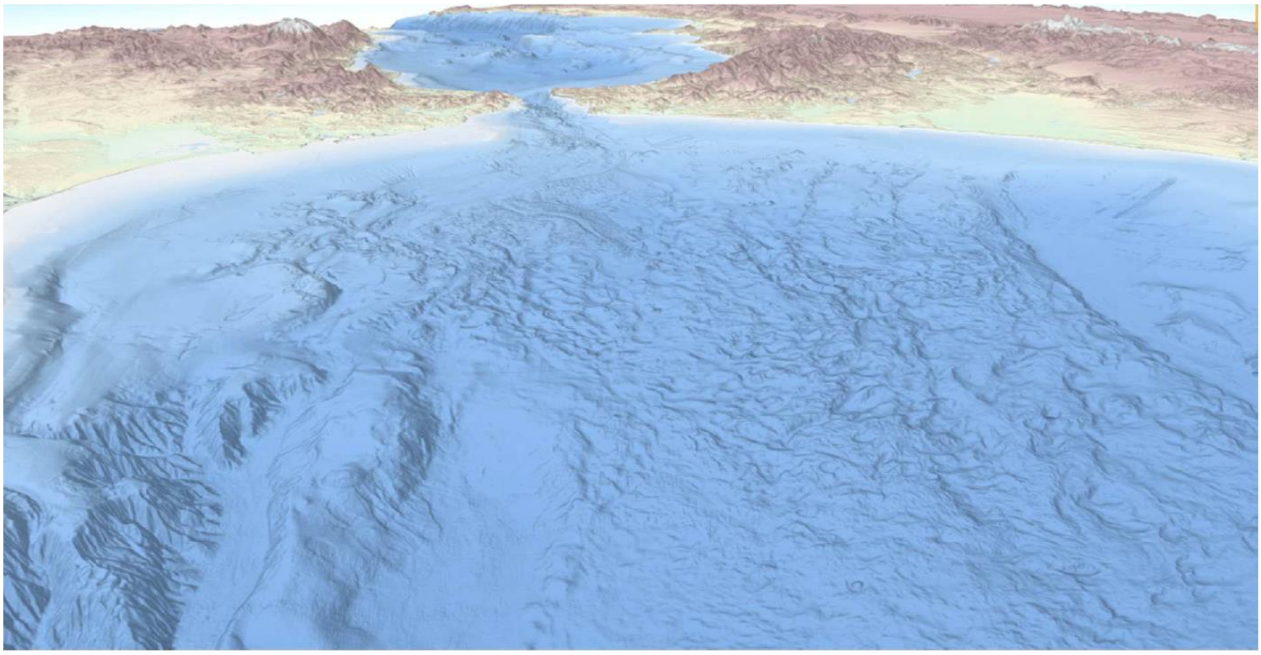

Figure: 3D view of the entrance of the Mediterranean Sea from the Gibraltar Strait.

- Inclusion of Satellite Derived Bathymetry data products, in particular for coastal stretches of Spain and Greece;

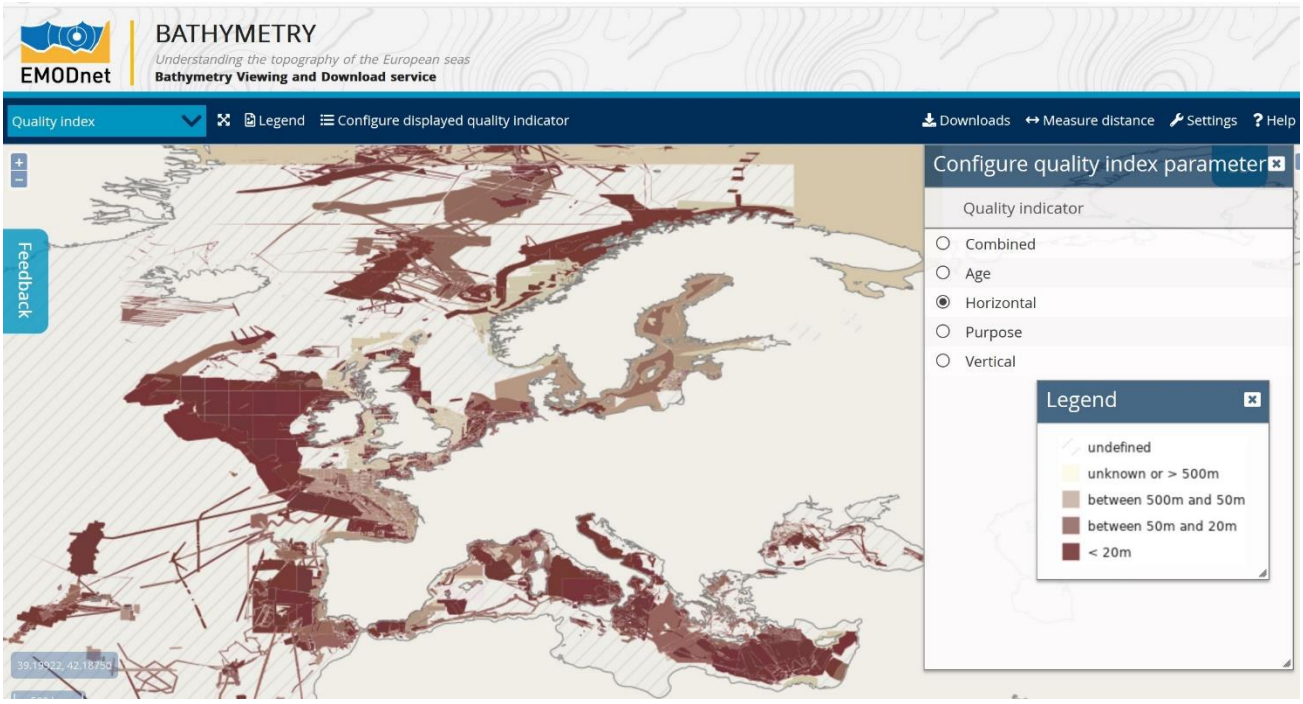

Figure: Quality Index layer with map for horizontal precision

- Improved source reference layer with quality indication: the source reference layer gives a map with polygons which correspond to contributing surveys and composite DTMs for which related metadata can be retrieved. Metadata has been expanded with characterization of the dataset by vertical, horizontal and temporal indicators, purpose of the survey, and information about commonly adopted standards. Analysis resulted in extra maps with Quality Indicators for each source reference, which have been integrated in the Bathymetry viewer as extra layer;
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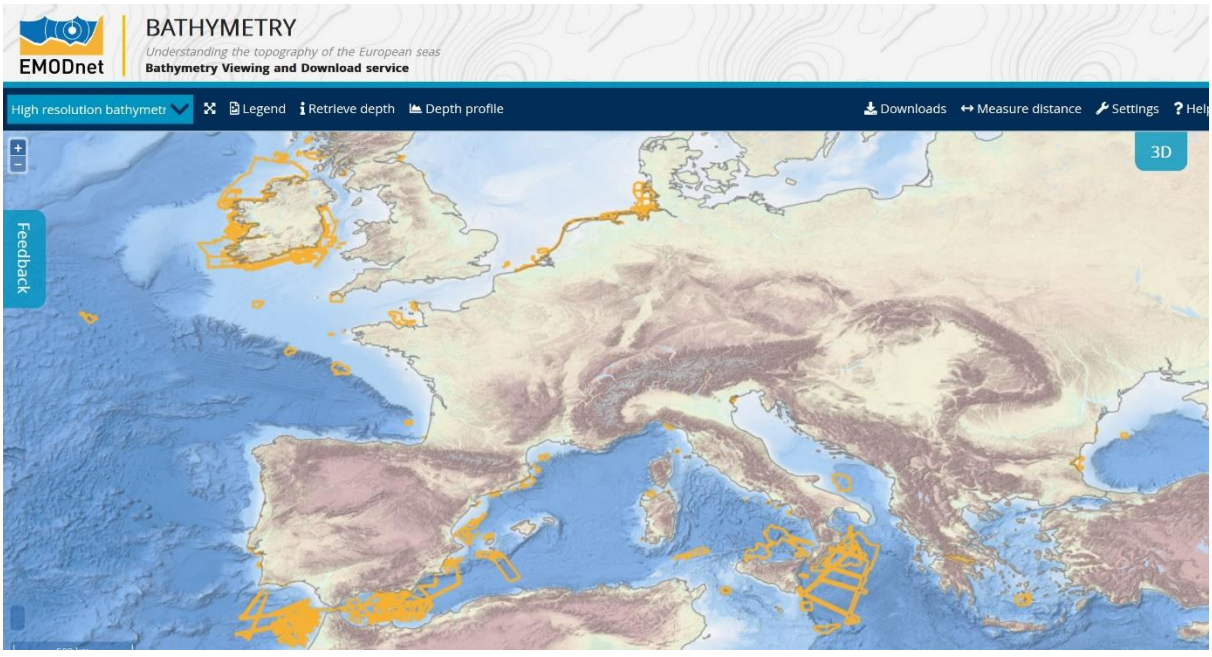


Figure: Multi-resolution HR-DTM layer with areas of HR-DTMs demarcated

- A multi-resolution layer has been added consisting of a collection of even higher resolution composite DTMs for selected areas which have been gathered and processed by data providers into High Resolution DTM (HR-DTM) files. The resolution of HR-DTMs varies between 1/32 and 1/512 arc minutes, depending on local data policy of data providers. All HR-DTMs are described with metadata in a special section of the Sextant Catalogue. In total 196 HR-DTM files have been provided can be viewed, interrogated for metadata and downloaded by an extra HR-DTM layer in the Bathymetry viewer.

The EMODnet Bathymetry portal is very popular among users from all sectors (government – research – industry). The web portal and its services are well visited with > 10.000 unique visitors per month. Also the OGC web services (machine-to-machine) are very popular with more than 250.000 visitors per year. The number of downloaded tiles amounts to circa 10.000 per quarter.

4. Challenges encountered

Main challenge	Measures taken
Gathering and providing bathymetry data sets in a common way	All data providers are instructed and coached for the population of the CDI Data Discovery and Access service for bathymetry surveys and the Sextant Catalogue for composite DTMs and how to use the related tools. In addition, the coordinating team has sent out multiple group emails to encourage / urge data providers to start their activities. This was followed by bilateral direct mails encouraging data providers to start and make progress within the agreed planning. Momentum has come after the summer in the 3rd and 4th project quarters and all data providers have met their targets. Also the second plenary meeting in October 2017 has motivated data providers to accelerate their actions for gathering and pre-processing data sets.
Establishing a high quality integrated EMODnet DTM	A common methodology is used by all basin coordinators, including all using GLOBE software. That software is also used beforehand by all data providers to process and pregrid their data contributions according to the EMODnet standards. The integration is done by the integrator who has an additional workflow and software tools for visualisations, checking inconsistencies, identifying artefacts which can be overcome, also in dialogue with basin coordinators, by local smoothing, replacing used data sets and other ways.
Establishing a High Resolution DTM collection and layer for viewing and downloading	The data providers have all used Globe software and the common EMODnet methodology to prepare High Resolution DTM files which have been described with metadata in a separate Sextant catalogue section. The resulting HR-DTM files of different resolutions have been integrated by GGSGC into an additional layer for viewing and downloading. The latter has been integrated in the existing download mechanism for DTM tiles.
Establishing the European coastlines	As major input use is made of satellite images from Sentinel and Landsat, next to in-situ data. A European tidal model is used to cope with tidal elevations and to determine the coastlines at different references. Issues are still areas with ice coverage and complex intertidal areas whereby it is difficult to determine the coastlines.

5. Allocation of project resources

The following tables gives an indication of the efforts in % of the total project efforts for the various work packages over the 2 years:

- WP0: Project Management
- WP1: Bathymetric data collection and metadata compilation for all maritime basins
- WP2: QC/QA, data processing and producing Digital Terrain Models for the basins
- WP3: Integration and inclusion of the DTM's into the portal
- WP4: Technical Development & Operation of portal, tools and services
- WP5: Coastlines, legal baselines and vertical reference levels
- WP6: Helpdesk, cooperation and outreach

Partner	WP0	WP1	WP2	WP3	WP4	WP5	WP6	TOTAL %
SHOM	2.50	1.27	1.50	0.21	0.43	1.28	1.12	8.31
MARIS	1.40	1.12	0.35	0.28	1.71	0.56	0.61	6.03
IFREMER	0.22	0.99	1.96	0.16	3.96	0.33	0.32	7.93
NERC-NOC	0.10	0.51	1.38	0.26	0.00	0.75	0.05	3.04
NERC-BODC	0.10	0.37	0.25	0.26	0.00	0.13	0.12	1.23
NERC-BGS	0.10	0.49	0.24	0.00	0.00	0.34	0.04	1.21
CNR-ISMAR	0.10	0.97	0.98	0.13	0.00	0.64	0.25	3.05
CNR-IAMC	0.10	0.76	0.12	0.00	0.00	0.22	0.02	1.22
CNR-IGAG	0.10	0.56	0.12	0.00	0.00	0.22	0.02	1.02
OGS	0.10	0.79	0.09	0.00	0.00	0.20	0.04	1.22
IEO	0.10	0.75	0.05	0.00	0.00	0.32	0.02	1.23
GSI	0.10	0.72	0.17	0.00	0.00	0.54	0.10	1.63
IHPT	0.10	0.56	0.28	0.00	0.00	0.26	0.02	1.22
IPMA	0.10	0.85	0.61	0.06	0.00	0.37	0.05	2.03
HCMR	0.10	0.64	0.64	0.07	0.00	0.55	0.03	2.04
IO-BAS	0.10	0.41	0.65	0.06	0.00	0.36	0.05	1.63
BSH	0.10	0.87	1.00	0.14	0.00	0.86	0.08	3.06
GRID	0.10	0.76	0.86	0.10	0.00	0.57	0.05	2.44
MDK	0.10	0.58	0.12	0.00	0.00	0.40	0.02	1.22
GGSGC	0.22	0.00	0.40	1.39	2.80	0.24	0.04	5.08
OceanWise	0.10	0.93	0.31	0.00	0.00	0.62	0.08	2.04
CSIC	0.10	1.55	0.11	0.00	0.00	0.26	0.02	2.04
NHS	0.10	0.61	0.11	0.00	0.00	0.40	0.02	1.23

Partner	WP0	WP1	WP2	WP3	WP4	WP5	WP6	TOTAL %
NIOZ	0.10	0.40	0.21	0.00	0.00	0.04	0.06	0.81
SMA	0.10	0.67	1.32	0.22	0.00	0.66	0.09	3.05
IIM	0.10	0.73	0.15	0.00	0.00	0.62	0.02	1.63
MAL	0.10	0.27	0.09	0.00	0.00	0.34	0.02	0.81
MARUM	0.10	2.05	0.12	0.00	0.00	0.22	0.06	2.54
DDNI	0.10	0.28	0.07	0.00	0.00	0.34	0.02	0.81
GIS	0.10	0.34	0.05	0.00	0.00	0.32	0.02	0.82
EOMAP	0.10	0.53	0.27	0.00	0.00	1.48	0.06	2.44
SU	0.10	0.82	1.34	0.27	0.00	0.28	0.24	3.04
Deltares	0.22	0.00	0.44	0.00	1.32	5.28	0.36	7.61
RNLN	0.10	0.23	0.23	0.00	0.00	0.64	0.05	1.23
Jardfeingi	0.10	0.24	0.12	0.00	0.00	0.14	0.02	0.61
GeoEcoMar	0.10	0.19	0.07	0.00	0.00	0.24	0.02	0.61
CORONIS	0.18	0.00	0.00	0.00	1.52	0.00	0.02	1.72
MR	0.10	0.19	0.05	0.00	0.00	0.26	0.02	0.61
UoM	0.10	0.17	0.09	0.00	0.00	0.02	0.04	0.41
CONISMA	0.10	0.40	0.13	0.00	0.00	0.36	0.02	1.01
NIMRD	0.10	0.20	0.07	0.00	0.00	0.20	0.02	0.60
HHI	0.10	0.50	0.05	0.00	0.00	0.36	0.02	1.02
IGME	0.10	0.61	0.12	0.00	0.00	0.36	0.02	1.22
IOLR	0.10	0.44	0.16	0.00	0.00	0.28	0.04	1.02
GST	0.10	0.33	0.17	0.00	0.00	0.38	0.04	1.01
TOTALS PER WP (%)	**8.46**	**26.65**	**17.64**	**3.59**	**11.74**	**23.23**	**4.44**	**95.76**

Remark: Next to this external costs have been made for workshops at conferences, customised OSM hosting, and logistics for meetings which have been funded from the contigency budget.

6. Meetings held

Date	Location	Topic	Short Description
2017-01-13	Brussels, Belgium	Kick-off meeting EC - HRSM consortium	Mutual presentations from DG-MARE, EASME and Coordinators of the HRSM consortium of the objectives and contractual terms of the contract. (Minutes of the meeting are available at the extranet)
2017-01-26 to 2017-01-27	Paris, France	HRSM Technical Core Group meeting	Session with work package leaders and coordinators intended to initiate actions and to prepare the plenary meeting (Project Kick-off and Training session, see below). (Minutes of the meeting are available at the extranet)
2017-02-14 To 2017-02-15	Brussels, Belgium	EMODnet Steering Committee	Meeting held by the EMODnet secretariat. Objectives and status of the HRSM contract were presented. (Minutes of the meeting are available at the EMODnet Secretariate).
2017-03-19	Venice, Italy	HRSM Steering Committee	Session with Work Packages leaders and Coordinators discussing internal organization and procedure, International relations and closely related projects. (Minutes of the meeting are being drafted).
2017-03-19 To 2017-03-22	Venice, Italy	Project Kick off	Plenary session with representatives of all the members of the HRSM consortium. (Minutes of the meeting are being drafted).
2017-03-21 To 2017-03-22	Venice, Italy	Training Session	Software training held by IFREMER for all the members involved in the metadata, data and DTM production.
2017-03-01 To 2017-06-30	Brest, France	Tuning between Shom and IFREMER	Drafting of guidelines for data pre-processing and DTM Quality Index formulation.
2017-07-04 to 2017-07-07	Genua, Italy	EMODnet Technical Group meeting	Shom and MARIS have participated to discuss plans for new key indicators, central statistics and revamping of EMODnet portal styling.
2017-07-01 to 2017-09-30	Brest, France	Bilateral phone meetings	Discussion with respect to Quality Index use in the production of the DTM.

Date	Location	Topic	Short Description
2017-09-13 to 2017-09-15	Rome, Italy	EMODnet Steering Committee meeting	Shom and MARIS have participated to give a project progress update and to contribute to various discussions
2017-09-21 to 2017-09-22	Brest, France	Technical Core Meeting	Shom, MARIS, Ifremer, GGSGc, Deltares met to discuss project progress, individual Work package progress and to prepare next plenary meeting (October 2017)
2017-10-25 to 2017-10-26	Heraklion, Greece	EMODnet HRSM Plenary Meeting	Full project group meeting to monitor and discuss progress of project activities.
2017-11-15 to 2017-11-17	Antwerp, Belgium	EMODnet 'Open Sea Lab' hackaton	Participation of GGSGC and Shom to provide support and information about the various EMODnet HRSM products and services as well as to learn from users about their experiences.
2018-01-29 To 2018-01-30	Haarlem, The Netherlands	EMODnet HRSM Basin coordinators meeting	Project group meeting to monitor and discuss fine tuning elements on the aggregation of the pregridded datasets.
2018-03-21 to 2018-03-23	Mallorca, Spain	9th EMODnet Steering Committee meeting	Reporting on project progress and discussing overall EMODnet developments
2018-03-20 to 2018-03-21	Mallorca, Spain	EMODnet TWG meeting	Discussing technical tuning with EMODnet Central portal and European Marine Atlas, and how to apply new indicators
2018-05-28	N.A.	Web conference	Meeting between MARIS and GGSGC to discuss the technical integration of the new DTM and the inclusion of download user registration in the Bathymetry Viewing and Download service
2018-06-06 to 2018-06-07	Herrsching, Germany	SDB Day	Participation of MARIS and Shom, both with presentations, at the Satellite Derived Bathymetry workshop, organised by EOMAP. Also used by Shom and MARIS to discuss project progress and actions
2018-06-19	Brest, France	CVE development	Meeting between Shom and IFREMER on progress of CVE development

Date	Location	Topic	Short Description
2018-09-07	N.A.	EMODnet Communication webmeeting	Meeting of Shom and MARIS with EMODnet Secretariat and TRUST-IT to discuss promotional activities
2018-09-27	Brest, France	Technical meeting	Meeting between Shom, MARIS, GGSgc, CNR-ISMAR, and IFREMER on progress of CVE development
2018-10-30 to 2018-10-31	Split, Croatia	Final EMODnet HRSM (Phase 1) meeting	Progress meeting with the full consortium. Results were discussed along with final actions needed to finalise the contract.
2018-11-20 to 2018-11-21	Brussels, Belgium	10th EMODnet Steering Committee	Progress meeting with presentation of EMODnet HRSM
2018-11-21	Brussels, Belgium	9th IHO-EU Network Working Group	Presentation to the European hydrographic offices on the results of the EMODnet Bathymetry project. Discussions on limitation and need for disclaimers on the products.
2018-11-13 To 2018-11-15	Brest, France	EMODnet Seabed Habitat progress meeting	Presentation on the DTM update and the generation of Quality indicators. Discussion on the use or the later for Seabed Habitat confidence assessment.
2018-12-05	Copenhagen, Denmark	7th meeting of the Technical Group on Marine Data	Presentation of EMODnet as support for MSFD process. Discussions on INSPIRE implementation.

7. Work package reports

WP0 – Project Management

The EMODnet HRSM project, successor to the EMODnet Bathymetry project, has been awarded by EASME on 24 November 2016 to the consortium, led by Shom. The contract was signed by both parties on the 20 December 2016 after arranging requested evidences. The kick-off meeting between coordinators (Shom and MARIS) of the consortium, EASME and DG-MARE took place in Brussels on 13 January 2017, where scope of the technical tender, deliverables, administrative and financial matters have been acknowledged by all the parties. A consortium agreement (for full partners) and subcontractor agreements (for subcontractors) were drafted, introduced and following feedback amended. The Consortium Agreement has been finalized and signed by all partners in the Consortium in the 2nd project quarter; this also concerns the subcontracts which have been agreed and signed by all subcontractors. The Technical Core Group, composed of Coordinators and Work package leaders, have met 26 – 27 January 2017 in Paris – France, hosted by Shom, to prepare the project kick-off meeting and to discuss updating of the methodology, technology and production processes as used in the previous EMODnet Bathymetry project considering the new scope of the HRSM contract. Minutes and action list of the meeting have been prepared and included in the extranet for sharing with all project members.
The HRSM kick-off meeting including all consortium members took place 19 – 22 March 2017 in Venice – Italy, hosted by CNR-ISMAR, with presentations of Coordinators, WP leaders, Regional DTM leaders and specific experts to introduce and discuss the workplan and expected actions. All presentations have been included in the extranet together with minutes and list of actions. The minutes give a detailed action plan for the first year of the project. At the kick-off meeting also all have been trained with the software (Mikado, Sextant, Globe) used in the project for the production of metadata, pre-processing of bathymetric data sets, and production of regional DTMs. The training was undertaken to refresh capabilities of existing members and to introduce the methodology and software tools to new members.
The Technical Core Group met again 21 – 22 September 2017 in Brest – France, hosted by Shom, to prepare the next plenary meeting, to monitor the evolution of metadata and data provision, and to plan next steps. The 2nd EMODnet HRSM plenary meeting took place 25 – 26 October 2017 in Heraklion – Greece, hosted by HCMR. The meeting was dedicated to refreshing the understanding of all data providers about the methodology and tools to be applied for preparing the metadata entries for the CDI and Sextant catalogue services and preprocessing the associated data sets. The progress of gathering and preparing data sets was discussed per region, coordinated by its Regional Coordinator, and with input by all data providers. This also included instructions about updating and enriching existing metadata in order to facilitate the later calculation of the EMODnet DTM Quality Indicator per gridcell. Other topics at the meeting included progress with the technical developments for the portal and services, the methodology for determining coastlines using both in-situ and satellite data as well as tidal

model results, and international cooperation. Following the meeting an action list was prepared and circulated to all consortium members urging to meet the deadlines. A meeting of the coordinating team with the regional coordinators, integrator, leaders of tasks for coastlines, baselines and Satellite Derived Bathymetry, and technical developers was held in January 2018 to monitor progress, to identify and solve any possible issues, and to fine tune the planning and approach. Following the meeting an action list was prepared and circulated to all consortium members urging to meeting the deadlines. The Technical Core Group met again 27 September 2018 in Brest – France, hosted by IFREMER, to prepare the next plenary meeting, and to review the progress with the CVE developments, and to plan next steps. The 3rd EMODnet HRSM plenary meeting took place 25 – 26 October 2017 in Split – Croatia, hosted by HHI. The meeting was dedicated to presenting the new EMODnet DTM and discussing the remaining activities and method for preparing the HR-DTM files and layer, finalizing the inventory of national baselines and coastlines, finalizing the Satellite Derived Coastlines, and discussing the definition and progress of the Quality Index approach. Following the meeting an action list was prepared and circulated to all consortium members urging to meet the deadlines. The coordinator (Shom) and technical coordinator (MARIS) prepared 8 quarterly progress reports which have been accepted by the EU (EASME and DG MARE). Shom and MARIS have also drafted this 1st Annual Report and the separate report on Interoperability and International Cooperation [3] which was accepted by the EU (EASME and DG MARE). Shom invoiced EASME for the first payment (50% total budget) which was paid. Consortium members have been requested to submit to Shom their requests for payments which all have been processed.
Shom and MARIS have also participated in EMODnet Steering Committee meetings, presenting the project progress and contributing to discussions, and EMODnet Technical Working Group meetings, discussing technical interaction between the thematic and central portals.

WP0 contributes to the following task as shared with WP4 and WP6:

- Task 9: Monitoring of performance

This task has been completed as described in the progress of WP0, WP4 and WP6.

WP1 – Bathymetric data collection and metadata compilation for all maritime basins

During the project kick-off meeting, all the partners holding bathymetric data have presented their planned contribution along with potential new datasets that will be added. They have been instructed and trained in the software tools and services made available by the project and to be used for the production of metadata (Mikado), pre-processing of their data sets (GLOBE) and production of regional DTMs (GLOBE) [1]. Prior to the kick-off meeting the GLOBE software has been updated to suit the updated methodology for pre-processing bathymetric survey data sets. See also WP2. All data providers were encouraged to familiarize themselves with the software tools and services and to start the process of preparing their datasets and related metadata entries for the CDI and Sextant catalogue services. In

the 2nd project quarter a team of Shom, IFREMER, GGSGC, MARIS and RNLN have upgraded the formulation of the Quality Index for the EMODnet DTM. This resulted in requirements for extra metadata attributes to be supplied by data providers. Therefore a guideline [2] has been drafted and circulated concerning the Quality Index including the specifications of new metadata elements to provide for metadata files associated with new entries, but also for already existing ones. Furthermore a guideline [3] has been drafted and circulated to data providers describing how to pre-process the data submissions to regional DTM coordinators using the GLOBE software. This way it is strived that all survey data and composite DTMs are pre-gridded and pre-processed in the standard EMODnet DTM methodology. After further encouragement from Shom and MARIS before and after the summer period, all data providers have started in the 3rd project quarter preparing their expected contributions in terms of metadata and data for the project. This concerns updating existing metadata entries, preparing and submitting new metadata entries for the CDI and Sextant catalogues, and pre-processing related data sets. They follow the methodology for data gathering, metadata generation and population as agreed and instructed at the kick-off meeting and make use of the provided software (Mikado and Sextant). Many new data providers required extra guidance and substantial support by MARIS and Ifremer. In the 4th project quarter a major acceleration was achieved in gathering and making bathymetric data sets ready for transfer and use by the Regional Coordinators. The actual process gained great momentum following the 2nd Plenary Meeting where all data providers were again informed and instructed about the methodology to apply for preparing and updating metadata entries and pre-gridding associated data sets. Moreover almost daily support has been given by MARIS for guiding the CDI catalogue population process, including regular updates and encouragements to data providers about the status of progress compared to expectations. Also support and guidance was given by IFREMER for the Sextant catalogue population. This has resulted in the 5th project quarter in a major increase of the total number of CDIs from **14791 to 27168** records, while the number of Composite DTM entries into the Sextant Catalogue has expanded from **78 to 147.** The latter also includes 18 satellite derived Composite DTMs generated by partner EOMAP for the Mediterranean coastal zones of Spain, Greece and Libya. The number of data providers has increased from **28 to 51.** In comparison to the start situation data has become available also for the Arctic and Baltic regions, while increasing the coverage for all other European sea areas. During the 5th project quarter the last steps were undertaken and pre-processed and pre-gridded data sets were transferred by data providers to the Regional Coordinators. For example quite some additional data has been gathered for the Black Sea region which now has a coverage of 30% of its area as illustrated below.

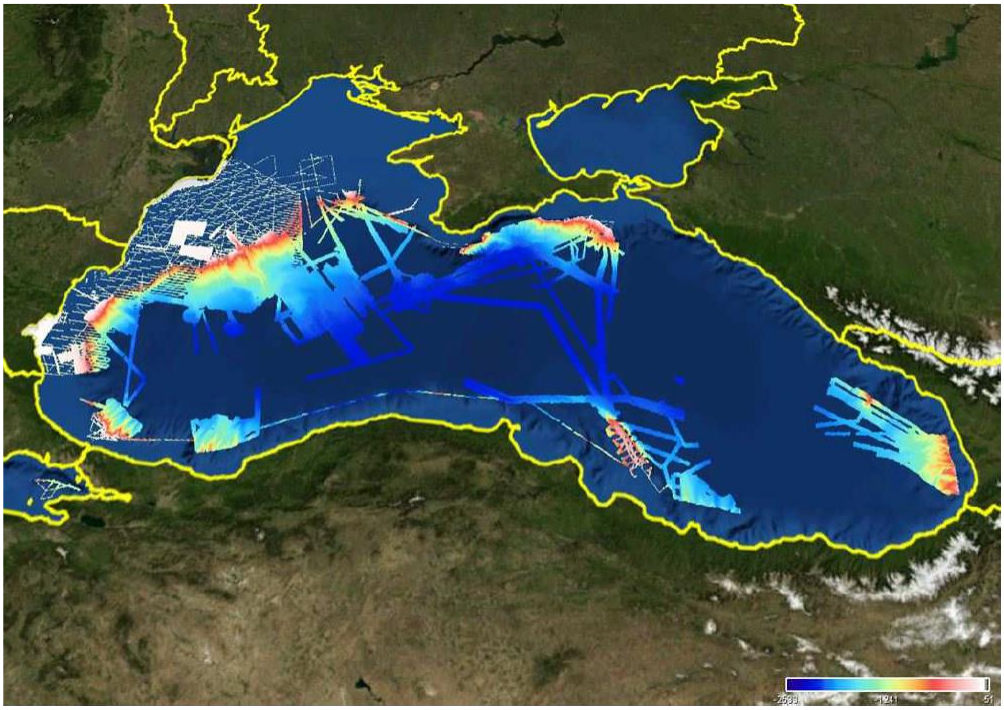


Figure: Area covered by all data contributions available for the new EMODnet DTM

A snapshot of the overall CDI coverage shows that also many data sets are now included for the Baltic Sea and the Arctic region.

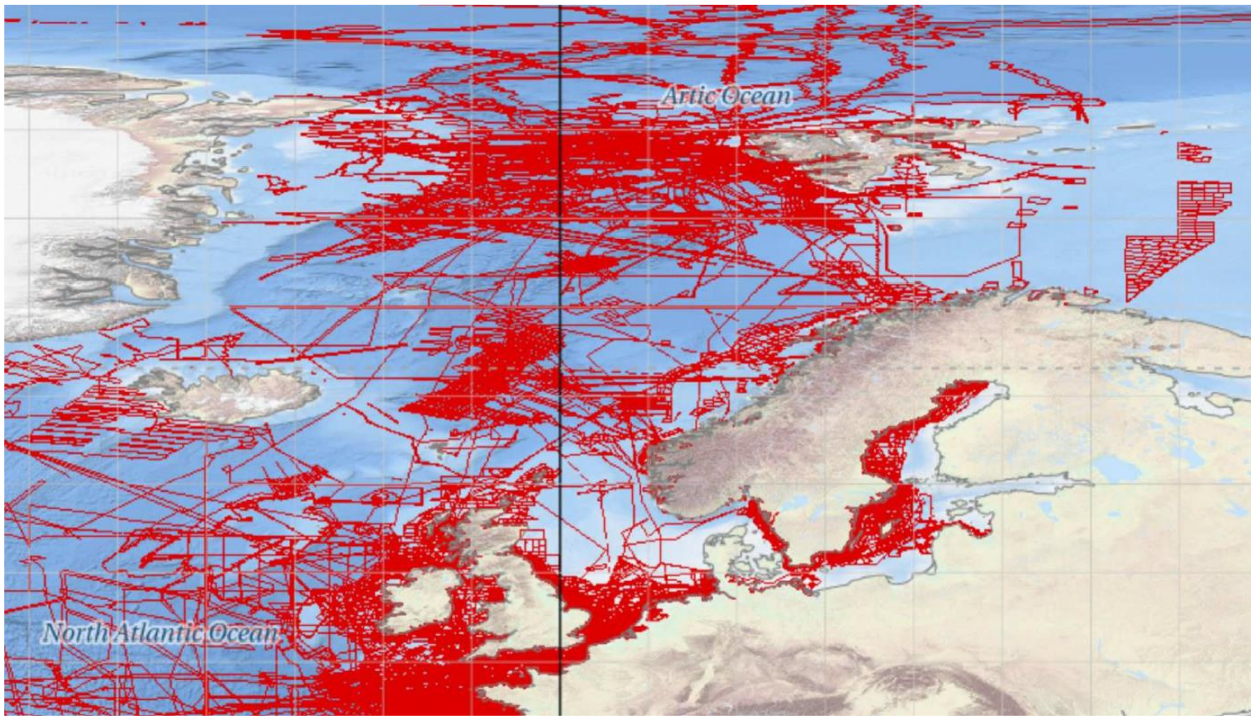


Figure: Snapshot of CDI coverage in Northern Europe

At the 3rd Plenary Project Meeting data providers were requested and instructed how to gather and build an additional collection of pre-gridded and pre-processed High Resolution DTMs (HR-DTMs) for selected surveys and composite DTMs. Immediately after the meeting the data providers have worked on identifying, processing and putting making HR-DTMs into practice. The processing of these files has been done using the Globe software and applying the EMODnet methodology which comprises including references to survey data by CDIs and composite DTMs by CPRDs. The resolution of the HR-DTMs files conforms to the EMODnet grid range and lies between 1/32 and 1/512 arc minutes, depending on the local data policy of the data provider. All HR-DTMs have also been described by their data providers with metadata with support of IFREMER in a special HR-DTM section of the Sextant Catalogue, while internally in the files references are made to CDI and CPRD. The consistency of all these references has been checked by GGSGC, MARIS and IFREMER. In total **196** HR-DTM files have been provided to IFREMER for validation and from them to GGSGC for building the HR-DTM layer in the Bathymetry Viewing and Download service.

WP1 contributes to the following tasks as shared with WP2:

- Task 1: Bathymetric surveys

WP1 also contributes to the following tasks as shared with WP2 and WP5:

- Task 3: Coastline data

WP1 also contributes to the following tasks as shared with WP6:

- Task 7: International interoperability

WP1 also contributes to the following tasks as shared with WP3 and WP4:

- Task 8: INSPIRE compliance

Task 1 and 3 have been completed as described in the progress section of WP1, WP2 and WP5. Task 7 and 8 has also progressed according to plan and will continue. This is documented in detail in the separate report on interoperability and international collaboration [4].

WP2 – QA-QC, data processing and producing Digital Terrain Models for the basins

The global methodology for the generation of the EMODnet grid has remained similar to the one applied in the previous EMODnet Bathymetry phase. However at the project kick-off meeting improvements of the methodology were introduced, needed to incorporate elements related to the higher resolution, refining the quality indicator and the extension towards higher latitudes (Arctic waters). Following this brainstorming session a team of Shom and IFREMER have upgraded the EMODnet methodology [1] for generating the regional DTMs considering the new target resolution of 1/16 arc minute for the overall EMODnet DTM and insets with higher resolution, where possible. Moreover IFREMER has upgraded the GLOBE software to make it ready for data providers (see WP1) and regional coordinators (WP2). Sources of data might have different quality (various sounders, various positioning system, age of the survey …).

Therefore new fields have been added to the metadata (see also WP1) in order to qualify these differences. These metadata will support regional Coordinators to select better which datasets to prefer in case of multiple choices. Moreover this is instrumental for producing the Quality Indicator for each DTM gridcell. Data providers have transferred their pre-processed and pre-gridded data sets to the relevant regional coordinators. The basin coordinators have undertaken the activities for selecting and merging datasets for building the Regional DTMs. In this process they came back occasionally to contributors with requirements of further data processing. Using this loopback strategy of communication between the basin coordinator and the data provider strongly improves the quality of source information. Also minor enhancements were needed of the merging tools as implemented in the GLOBE software. At the meeting held in Haarlem, The Netherlands, with regional coordinators, the deadline for production of each of the RDTMs was set to the end of the fifth project quarter and with some exceptions this deadline was achieved. In addition each basin coordinator has prepared a QA-QC report for their RDTM following the agreed EMODnet HRSM template. This contributes to the assessment of the quality of the overall EMODnet DTM. All basin coordinators have finalised their task and new regional DTMs have been forwarded to GGSGC as overall integrator. The figure below give an example from the new regional DTM for the Iberian coast – Atlantic ocean region.

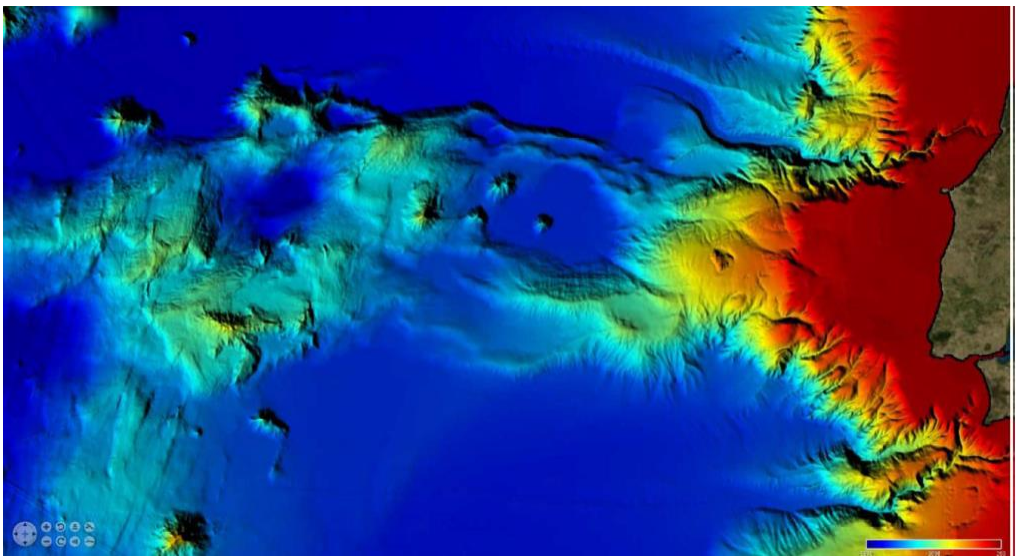


Figure: Example of high quality data around Iberia- Tore Sea Mountain, Nazaré, Lisbon and Setúbal canyons in front of Portugal

The following regional coordinators were tasked with generating and providing regional DTMs.

Data contributor	Country	Format	Full coverage	Parts	Area
SHOM	France	Globe	No	4	- Bay of Biscay / Channel
Ifremer	France	Globe	Yes	4	- Western Mediterranean - Black Sea
NOC	United Kingdom	Globe	Yes	5	- Celtic Sea
IPMA	Portugal	EMODnet	Yes	7	- Atlantic and Iberian Coast
IHPT	Portugal	Globe/ EMODnet	Yes	6	- Azores - Madeira / Canaries
GRID Arendal	Norway	EMODnet	No	8	- Norwegian Sea / Icelandic Sea
BSH	Germany	EMODnet	No	4	- Greater North Sea
SMA	Sweden	Globe	Yes	5	- Baltic Sea
HCMR	Greece	Globe	Yes	7	- Eastern Mediterranean
CNR-ISMAR	Italy	EMODnet	Yes	2	- Central Mediterranean
SU	Sweden	Globe	Yes	19	- Artic Sea
GEBCO/IHO	International	NetCDF	n/a	1	- GEBCO Europe ½ arc minute xyz grid

Figure: Division of EMODnet DTM coverage over Regional DTMs

The GLOBE software has been maintained and upgraded all along the project duration in order to satisfy both data providers and regional coordinators taking into consideration that sources of data might have different quality (various sounders, various positioning system, age of the survey …). Workshops have been organised to train the software users and gather their comments and recommendations. Amongst major improvements, the inclusion of tools to help the coordinators in their selection of the most relevant bathymetric source using quality indicators (see below) is worth mentioning. Using the Globe software allows all the survey data and composite DTMs to be interoperable when they are handed over to the regional coordinator and aggregated. Benefits of all the methodology, the tools developed and the training of all the members of the EMODnet HRSM consortium have concretised in September 2018 when the full new DTM was released. This will be further detailed as part of WP2 progress.

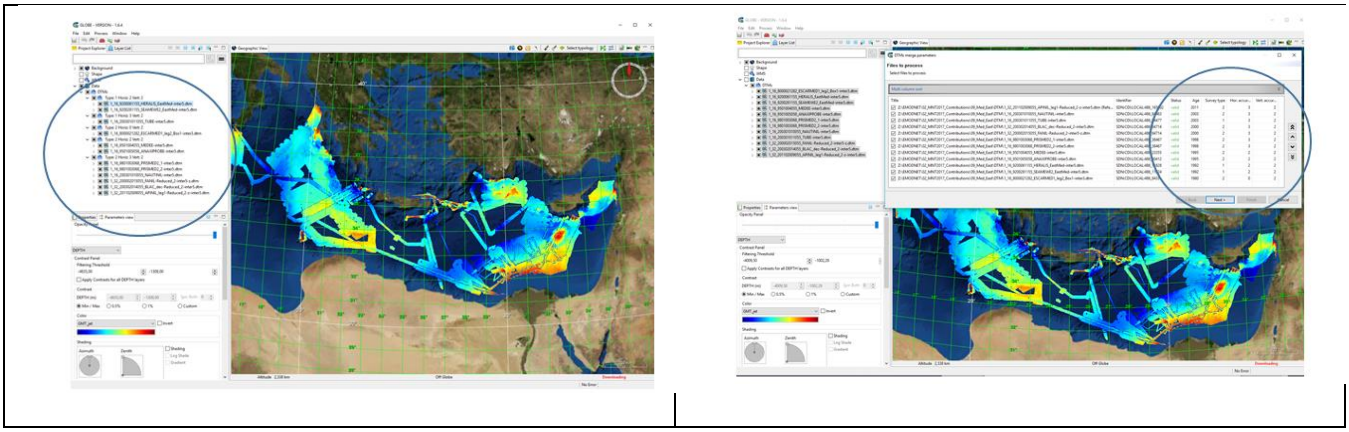


Figure: Examples of use (and associated implementation in the GLOBE software) of the QI information as part of the selection/level of priority of superposed surveys as part of the DTM compilation by the basin coordinators.

Generating an updated EMODnet Bathymetric grid and hotspots of higher resolution

As indicated in the progress report of WP1 it was also an objective to make available higher resolution bathymetry data sets by means of HR-DTMs files. Therefore data providers have processed their files using the GLOBE software and applying the EMODnet methodology which comprises including references to survey data by CDIs and composite DTMs by CPRDs. The resolution of the HR-DTMs files conforms to the EMODnet grid range and lies between 1/32 and 1/512 arc minutes, depending on the local data policy of the data provider. All HR-DTMs have also been described by their data providers with metadata with support of IFREMER in a special section of the Sextant Catalogue, while internally in the files references are made to CDI and CPRD. In total 196 HR-DTM files have been provided which are made available to users through an additional HR-DTM layer in the Bathymetry Viewing and Download service.

Figure: HR-DTM layer with demarcated polygons

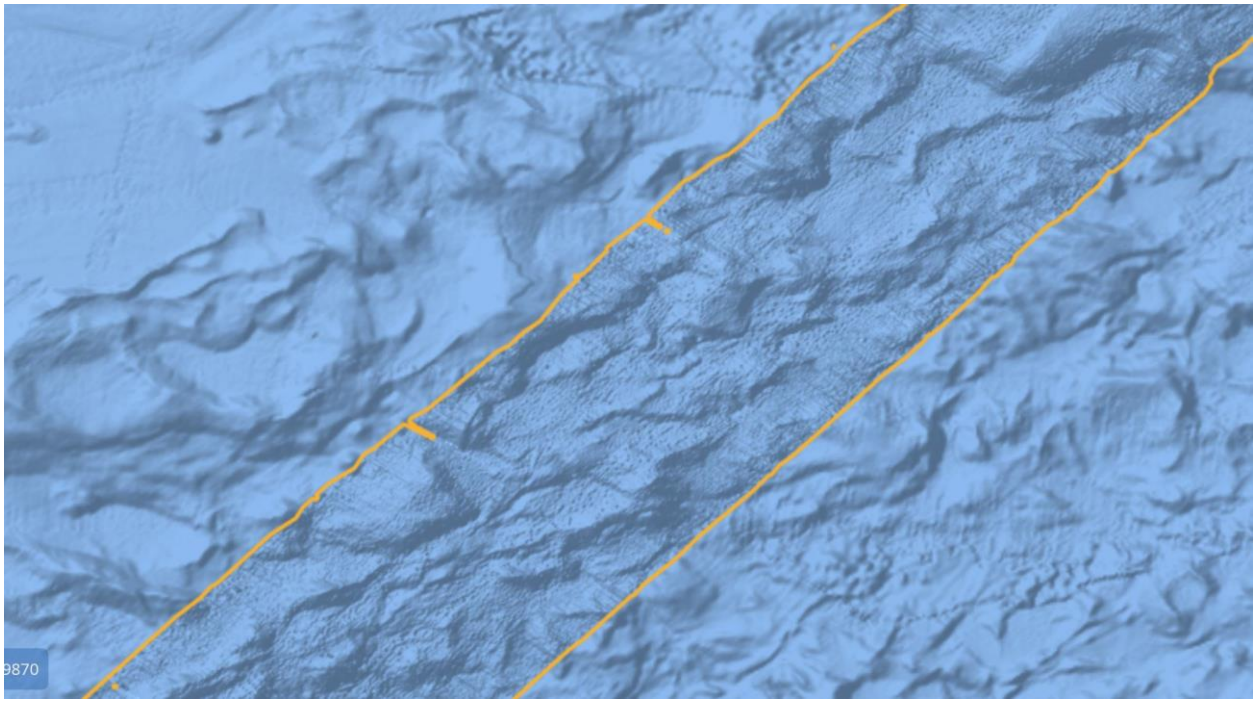


Figure: HR-DTM layer with higher resolution area in the Ionian Sea

Providing a quality index layer

Inspired from earlier work from the IHO on bathymetric data quality assessment (known under the name of CATZOC, CATegory of Zone Of Confidence), EMODnet HRSM has been working on a process to generate a map of confidence associated with the DTM. Bearing in mind though that not all the providing

organisations follow hydrographic standards, a conceptual evaluation of the quality of a bathymetric dataset has been defined on the following 3 main parameters:

- The accuracy of the survey, which is a function of both the vertical and horizontal precision of the sounding measurement.
- The temporal representativity or in other terms the consistency between the measurement (at the time when the measurement was acquired) and the actual morphology of the seabed (e.g. bathymetric measurements cannot be considered accurate if they were surveyed, for example, ten years ago in a highly dynamic area, such as for sand dunes)
- The completeness or the sampling of the seabed, which provides some forms of confidence in the sounding measurement (as of a number of soundings by unit of space). This is often related to the survey conditions such as speed of the boat or the strategy followed to get an overlapping between adjacent lines.

In more details these parameters have been subdivided into 4 indices for which classes have been defined based on expert knowledge. Data providers have been asked to describe the quality of their surveys against this classification as part of the production of their metadata. Catalogues (CDI and Sextant) and tools (GLOBE, sea above) were modified accordingly. Using the elements provided by the data providers and the source layer which is generated as part of the DTM allows displaying a geographical distribution of the quality indicator. This spatial distribution of the different indicators taken one by one or mixed in a combined qualitative indicator has been implemented on the EMODnet portal as an extra layer (See Figure below). This information can be used by the users to assess the confidence they can get from the local sources of the DTM with respect to their own needs. A full report [5] has been written on this topic, describing the rationale, the methodology, results and limitation. This report is included in the EMODNet Bathymetry portal. With this improvement, at the present stage, to the knowledge of the writers of this report, the EMODnet Bathymetry product is the only publicly available bathymetric product which provides a detailed description of its quality at the geographical level. Most of the other bathymetric products either provide a statistical value of the adequacy between reference data samples and the product (typically Root Mean Square Error); or simply indicates the origin of the soundings (Source Identifier concept of GEBCO) with no relations with associated qualitative descriptors. For the EMODnet HRSM consortium this topic of confidence assessment of bathymetric compilation products is of high importance and will be pursued in the future.

QI_horizontal	QI_vertical	QI_age	Purpose of the survey Respect of a standard
-1 : Multisources – unable to assess	- 1 : Multisources – unable to assess		
0: Unknown or > 500m (That is grossly equivalent to TACAN, OMEGA systems or similar)	0: Unknown, plummet, leadline	0 : > 30 y	0 : Purpose of the survey unknown (historical survey with no associated information).
1: between 500m and 50m (That is grossly equivalent to LORAN, DECCA systems or similar)	1: SBES Low Frequency, SDB (similar than 2+5%d)	1 : 10-30 y	1: Transit and/or opportunity
2: between 50m and 20m (That is grossly equivalent to natural GPS systems)	2: MBES low frequency (lower than 100kHz) (similar than 1+2%d)	2 : 5y -10 y	2: Bathymetric/morphologic survey
3: < 20m (GPS with correction) (That is grossly equivalent to aided GPS system DGPS, RTK ...)	3: Lidar, SBES High Frequency	3 : 0y – 5y	3: Hydrographic survey or compatible with hydrographic standards
	4: MBES High frequency (higher that 100kHz) (1+0.5%d)		

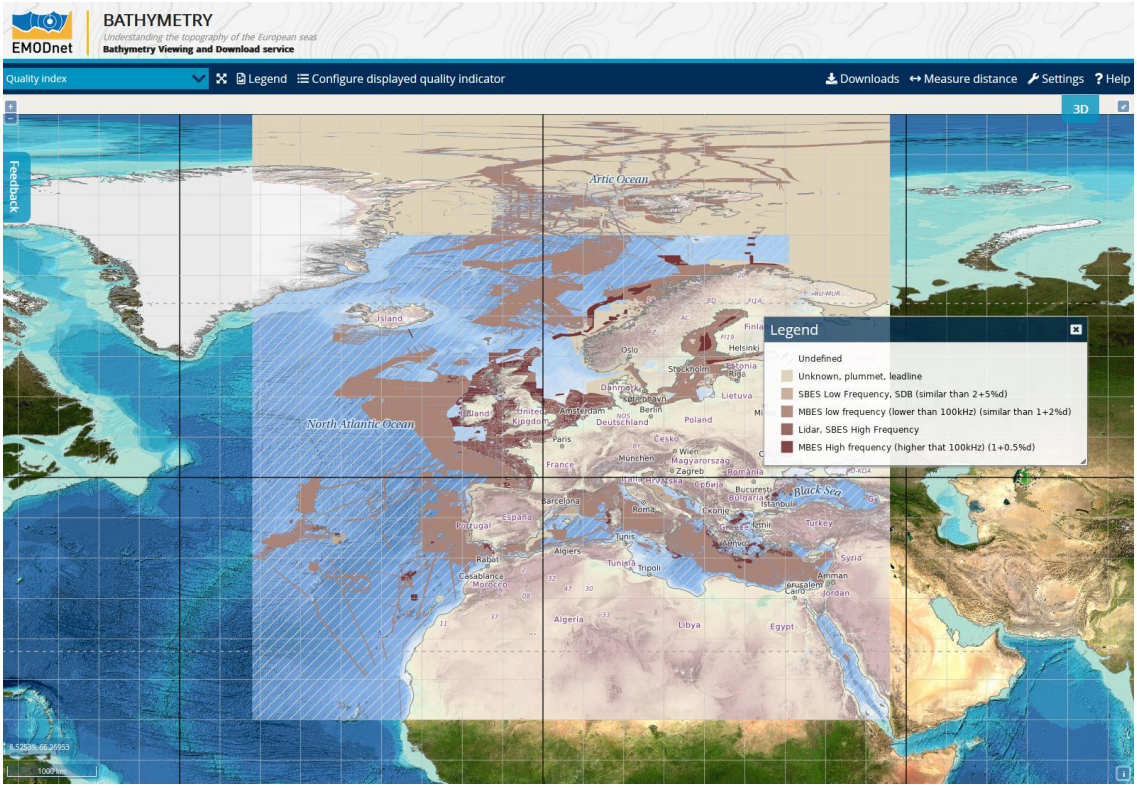


Figure: Quality Index layer with map for vertical precision indicator

WP2 concerns the following task as formulated in the tender and as shared with WP1:

- Task 1: Bathymetric surveys

WP2 also concerns the following tasks as shared with WP1 and WP5:

- Task 2: Digital Terrain Model
- Task 3: Coastline data

All tasks have been completed as can be derived from the WP1, WP2 and WP5 progress reporting.

WP3 – Integration and inclusion of the DTMs into the portal

The integration of the Regional DTMs into the overall EMODnet DTM has taken place in the 6th and 7th project quarters. Partner GGSGC has led the work with support from regional coordinators and MARIS. A number of actions, illustrated in the Figure below, describe the actions being done for each RDTM (subdivided in 64 sub-tiles, in order to be easily managed). Most of the processing steps have been automated, while a few of them still need human interventions.

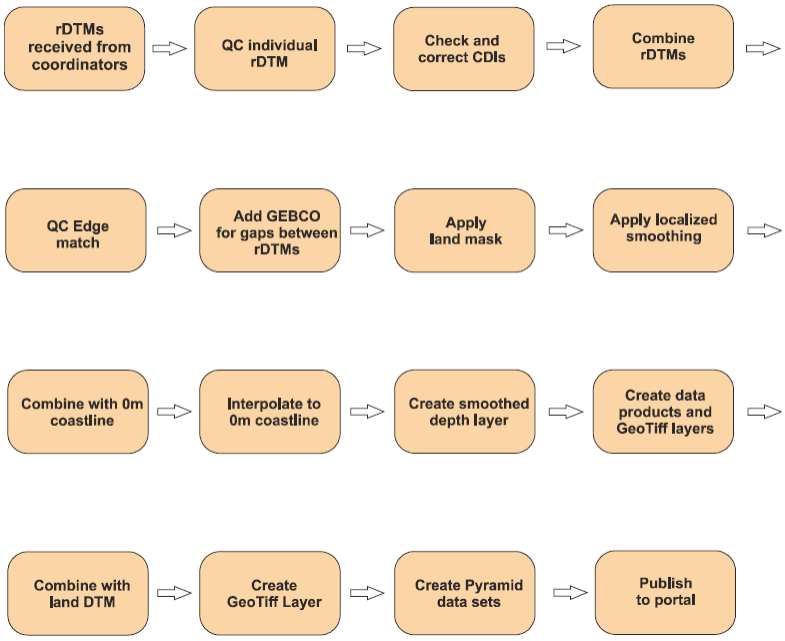


Figure: Actions undertaken for individual RDTM before integration in the final EMODnet HRSM DTM product.

Within the integration process, actions have been undertaken to evaluate the quality of each RDTM. This is done through quality checks (presence of all the requested statistics and CDI/CPRD reference, coherence with previous release of EMODnet (250m) …) and quality assessment (visual checks of remaining artefacts). Issues have been solved between the basin coordinators and GGSGC. Sometimes data providers needed to be involved. Some considerable local quality issues were identified in some regional DTMs which required solving: e.g. selecting other data sets and applying local interpolation and

smoothing techniques. This has caused extra efforts and delays. A preparatory activity by GGSGC has been up-sampling the existing EMODnet DTM and GEBCO to the new target resolution of 1/16 arc minute. At the kick-off meeting it was agreed to use the existing EMODnet DTM as basis to be enriched with the existing and new bathymetric data sets (surveys and Composite DTMs) with their higher pre-gridded resolution. The up-sampling also concerned the areas of the existing EMODnet DTM that have been completed with GEBCO derived data. This was done because there is a greater confidence in the coherence and quality of the existing integrated DTM product than returning to using EMODnet and existing GEBCO next to each other. The increase in resolution required the existing DTM to be up-sampled from 1/8 to 1/16 of an arc minute without losing existing CDI and DTM references in the data. Furthermore, the interpolated (or resampled) data cells should inherit the CDI or DTM reference from the cell that contributed to the resample process. The up-sampling itself was performed using an Overhauser spline algorithm that uses a moving 4x4 grid in the 1/8 arc minute source to calculate each cell in the 1/16 up-sampled result. Overhauser is used because it is known to respect the controlling data points better than any other spline algorithm (see image below).

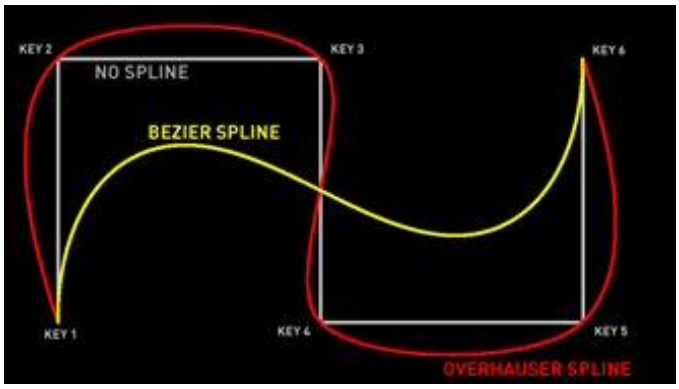


Image: Overhauser spline versus Bezier spline alternative.

The new area of interest covers a larger area than the existing EMODnet DTM. The basis for the new coverage has to be GEBCO. For this the GEBCO data is up-sampled from a 1/2 arc minute resolution to a 1/16 arc minute. As the new area extends all the way to the North Pole, special attention was required for the pole area as GEBCO data is non-projected. Up-sampling the area around the North Pole requires a re-projection of the GEBCO data to a polar projection (EPSG 3996). Later in the process this area was covered with the Arctic Regional DTM which is a refined version of IBCAO prepared following EMODnet methodology and including CDI and CDTM referencing. The integration of the regional DTMs into the new EMODnet DTM was finalized end of August 2018 and thereafter actions were undertaken for integrating the new DTM into the portal. This included also checking that all data references (>9500) were covered by entries in the CDI and Sextant Catalogues. **24th September 2018** a new and upgraded version of the EMODnet DTM (Digital Terrain Model) has been officially released which is the result of a great collaborative effort. Compared to the 2016 release, the grid resolution has improved from 1/8 * 1/8 arc minutes to 1/16 * 1/16 arc minutes (circa 115 * 115 m2). It now contains approx. 12.3 billion grid

nodes, organised in 113892 columns and 108132 rows (seabed and terrestrial coverage included) while GEBCO has 933 million grid nodes for worldwide coverage. From all the data sources gathered a total of 9369 unique CDI references and 87 DTM references are used in the overall DTM (6924 in 2016 version). It is available free of charge for viewing and downloading, and sharing by OGC web services from the EMODnet Bathymetry portal.

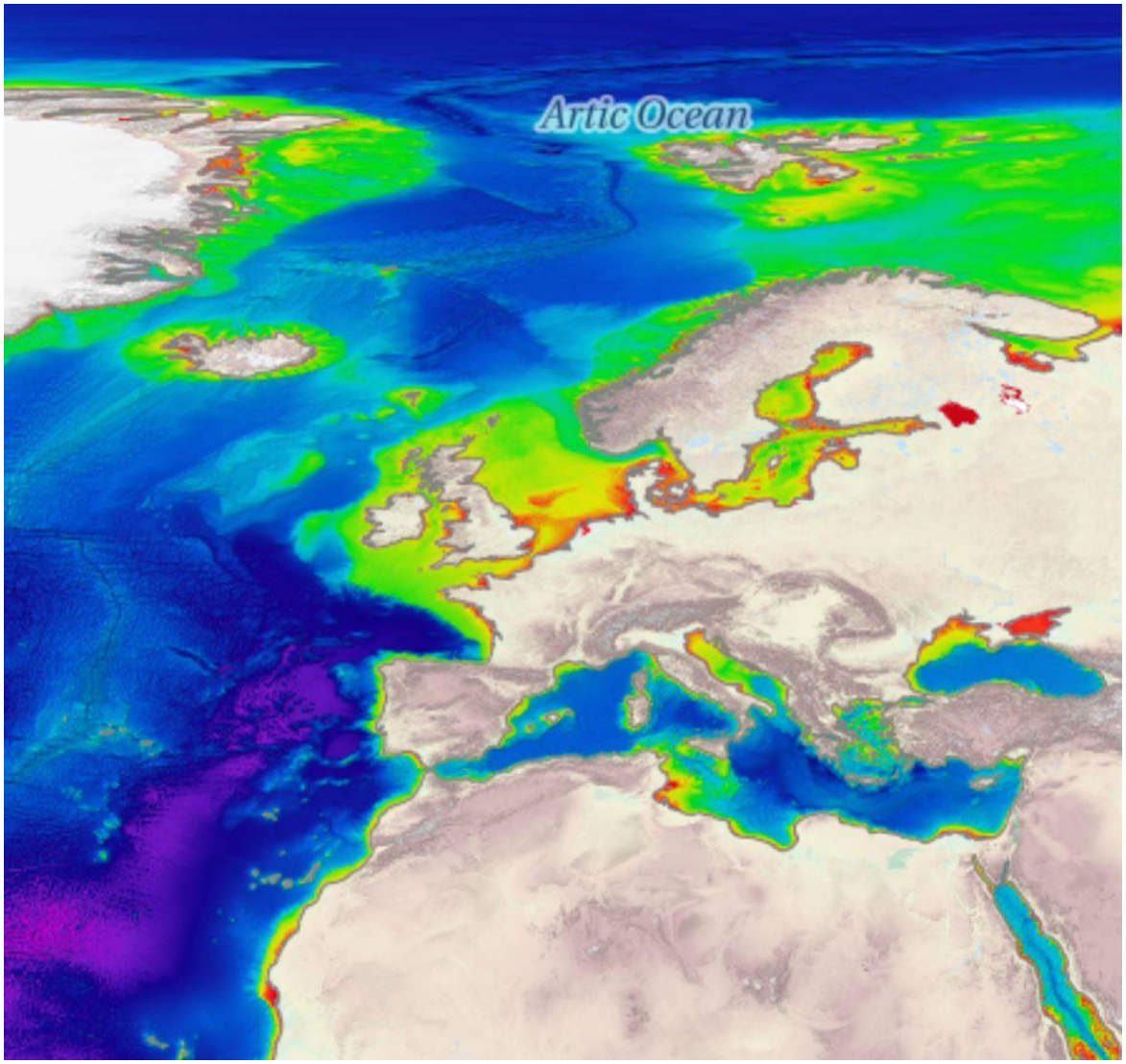


Figure: New EMODnet DTM with higher resolution and including arctic waters

Major challenges were:

- **Computer resources and processing time:** with the increase of datasets and DTM grid size, computer resources have been challenged. This was principally solved by tiling the EMODnet coverage in 64 tiles and automating the integration processes. This experience and associated

processing steps are taken into account for the development of a pilot Collaborative Virtual Environment (CVE) which aims at further improving the overall EMODnet data processing chain;

- **Integration of land and coastal data:** although land terrain is not an official deliverable for the project, the EMODnet viewing portal is enriched with land terrain to enhance the viewing experience. The source for the land data is a downloadable data set available in the open domain with a grid resolution of 3 arc seconds globally. The use of the land terrain is also of prime importance for ensuring the continuity of the bathymetric DEM in coastal areas where no measured (either from conventional sounding measurements or from Satellite Derived Bathymetry) data are available. The result is shown below. Note that the partner EOMAP has provided satellite derived bathymetry for some areas, which inherently improves the surface continuity between land and sea.

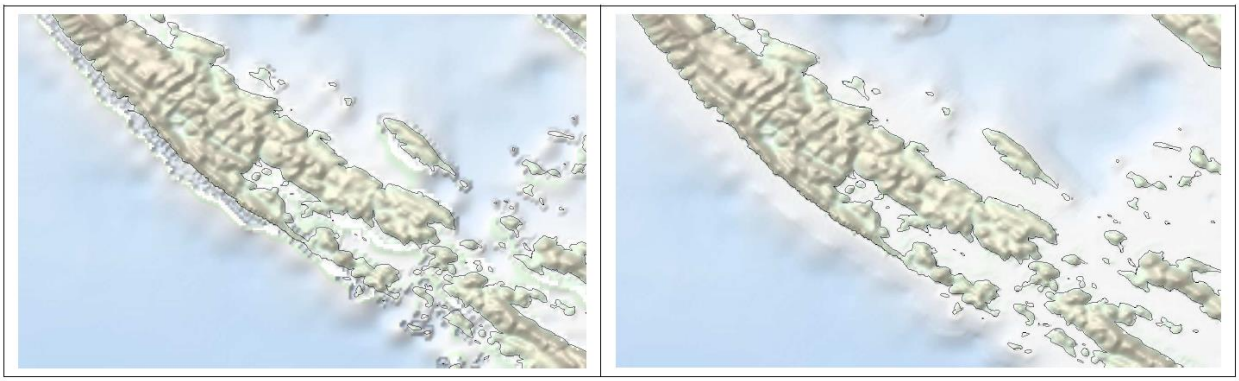


Figure: Poor coastal interpolation without land dataset and use of GEBCO without filtering (left). Same area, as included in the new EMODnet Bathymetry grid, with the integration of land data and filtering of the GEBCO data above 18m (below LAT) (right).

- **Generating an updated and improved source reference layer:** along with the DTM comes a layer indicating the local contribution of each of the data sources. By doubling the resolution of the new DTM, the source reference graph has also become more detailed compared to the 2016 release. Regional coordinators apply different methods when it comes to de-conflicting datasets. In areas where a newer data set simply replaces an older, the source reference graph looks rather discrete and the individual datasets are clearly recognizable (see Figure below). However, in some areas where concurrent datasets do not allow for the priorisation of one data over the other patchy areas were generated. This effect is more prominent in the 2018 release than the 2016 release; therefore a generalisation of some of these features was applied using a noise reduction algorithm.

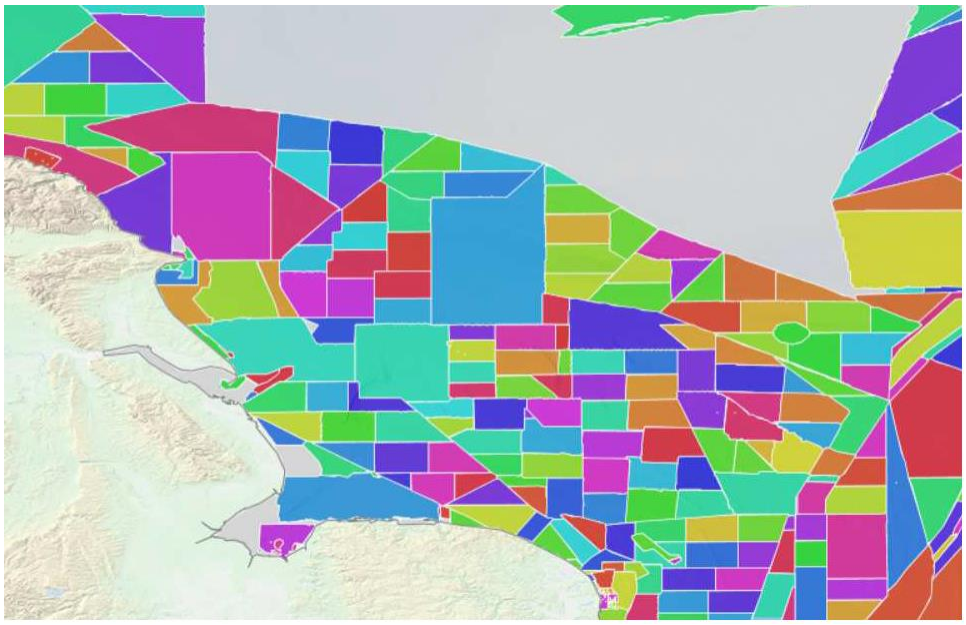


Figure: example of source reference layer in the North Sea. Each colour represents an individual data source.

- **Imperfections, remaining artefacts:** improvement of the resolution of the DTM also introduces further imperfections especially in case data sources are of lower resolution than the target resolution. A preliminary overview of these issues indicates that most of them are originating from the GEBCO gap filling, especially in deep sea areas. Although GEBCO is considered to be valuable, the altimetry derived component (used where no data are available) has not been updated since 2008, which is one of the main reasons of such vertical discrepancies.

GGSGC and MARIS have integrated the new DTM in the Bathymetry Viewing and Download service. The new common DTM (2018) has replaced the existing common DTM (2016) in the layer menu of the Bathymetry Viewing and Download service for the mean depth layers with 3 colour palettes. Also the source references layer has been replaced to fit the new DTM release. However in the OGC web services (WMS, WFS, WCS, and WMTS) and the DTM download service the new DTM has been added next to the old DTM. Also a new DOI (http://doi.org/10.12770/18ff0d48-b203-4a65-94a9-5fd8b0ec35f6) has been minted and a new landing page has been completed and launched for the new DTM so that users can cite this DOI as a persistent reference, while the DOI and landing page of the 2016 DTM version have been sustained.

All in all, the new EMODnet release provides a much better quality DTM than the 2016 version, while certain imperfections maintain due to lack of better source data. The release of the native, web embedded 3D viewing facility developed by partner Coronis (see figure and WP4 report) allows a fluid and immersive flythrough over the seabed of the European seas.

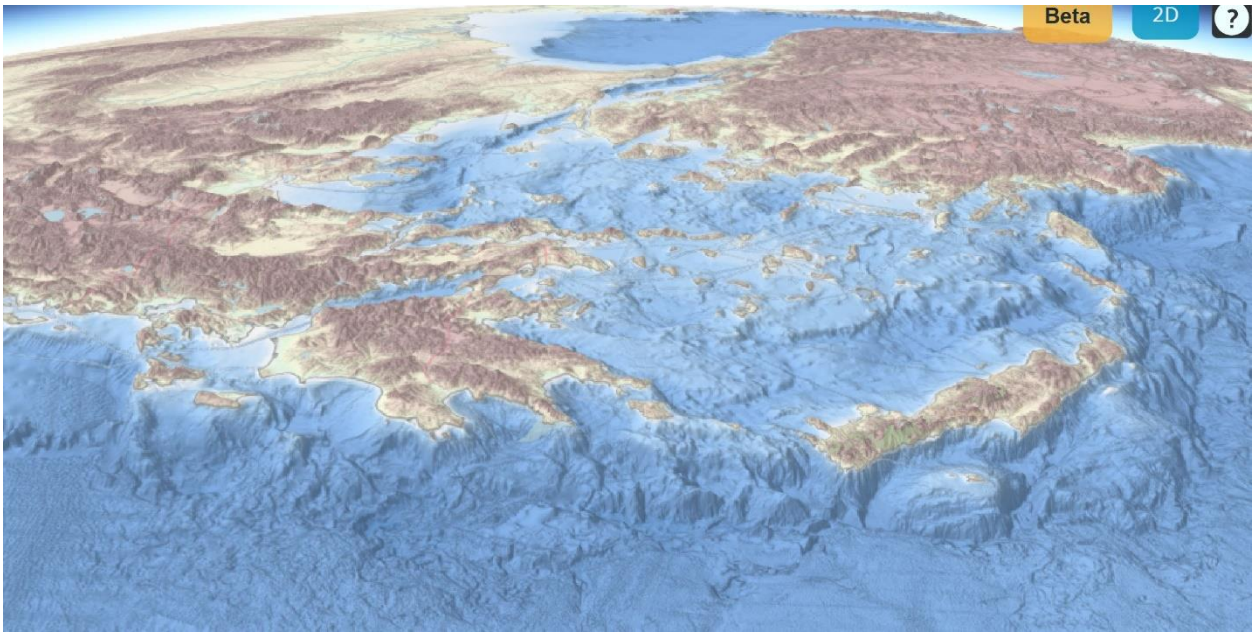


Figure: 3D view of Aegean Sea near Greece and Turkey.

WP3 contributes to the following task as formulated in the tender and as shared with WP2 and WP5:

- Task 2: Digital Terrain Model

WP3 also contributes to the following task as shared with WP4:

- Task 4: Machine-to-machine connections to data and data products

WP3 also contributes to the following task as shared with WP1 and WP4:

- Task 8: INSPIRE compliance (see

All tasks have been completed as can be derived from the WP1, WP2, WP3, and WP4 progress reporting and the separate report on international interoperability [4].

WP4 – Technical Development & Operation of portal, tools and services:

A new EMODnet Bathymetry portal has been launched at the existing domain www.emodnet-bathymetry.eu on 27 March 2017. The contents has been updated to reflect the scope and challenges of new High resolution Seabed Mapping (HRSM) phase and its extended consortium compared to the previous EMODnet Bathymetry phase. The design and layout of the portal have been upgraded to provide a modern look and include responsive design for dynamic support of the portal on multiple platforms. In the 3rd and 4th project quarters the look & feel of the portal and associated services have been upgraded, adopting the new EMODnet styling, and adopting responsive design. The Sextant catalogue service for composite DTMs has been upgraded by IFREMER and is now embedded by API. For the CDI Data Discovery and Access service new screens have been designed and implemented by MARIS. For the Bathymetry Viewing and Download service new screens have been designed and implemented

by GGSGC. Moreover, in support of the EMODnet Open Sea Lab hackathon, improved instructions for the existing machine-to-machine services have been included in the portal.

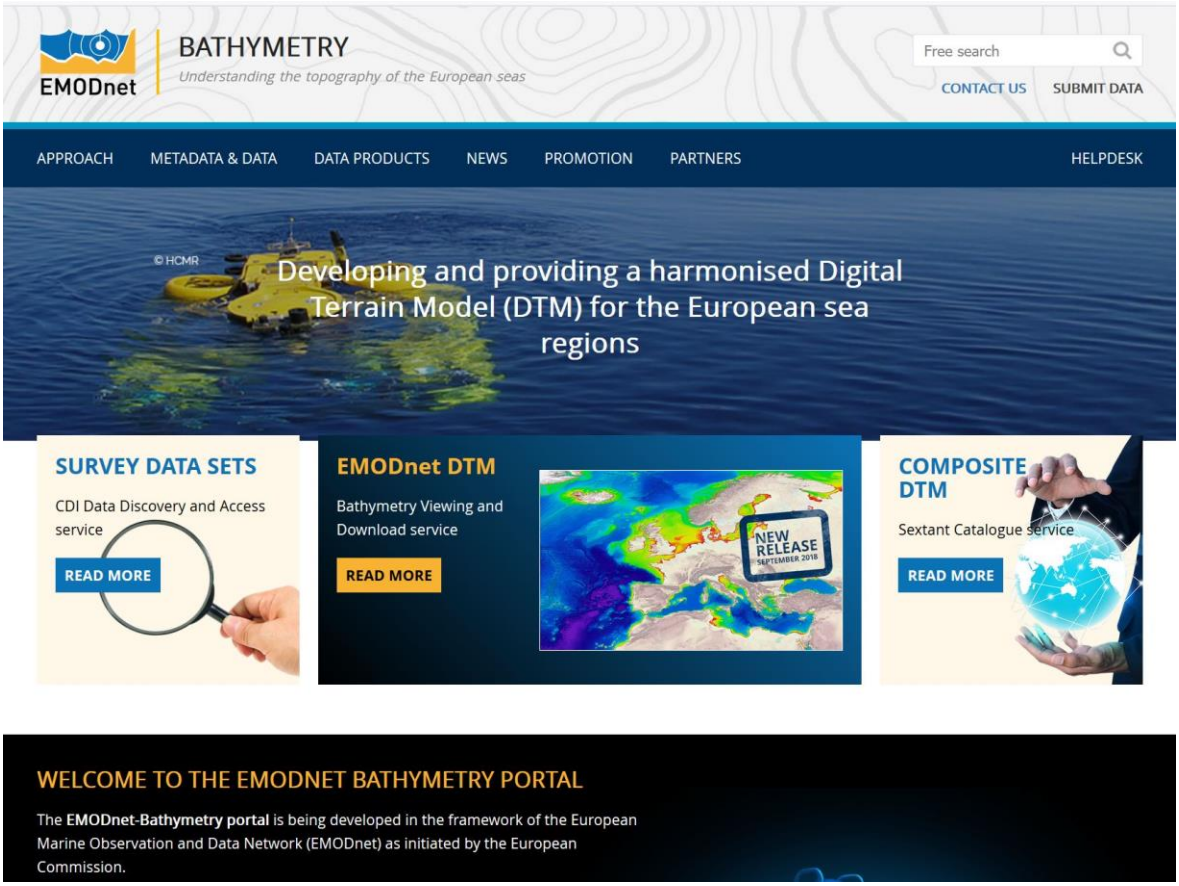


Figure: Homepage of upgraded EMODnet Bathymetry portal

Upgrading of the Bathymetry Viewing and Download service:

Multiple new features and enhancements have been incorporated in the latest release of the Bathymetry Viewing and Download service. This is reflected in the new layer menu which features several new layers.

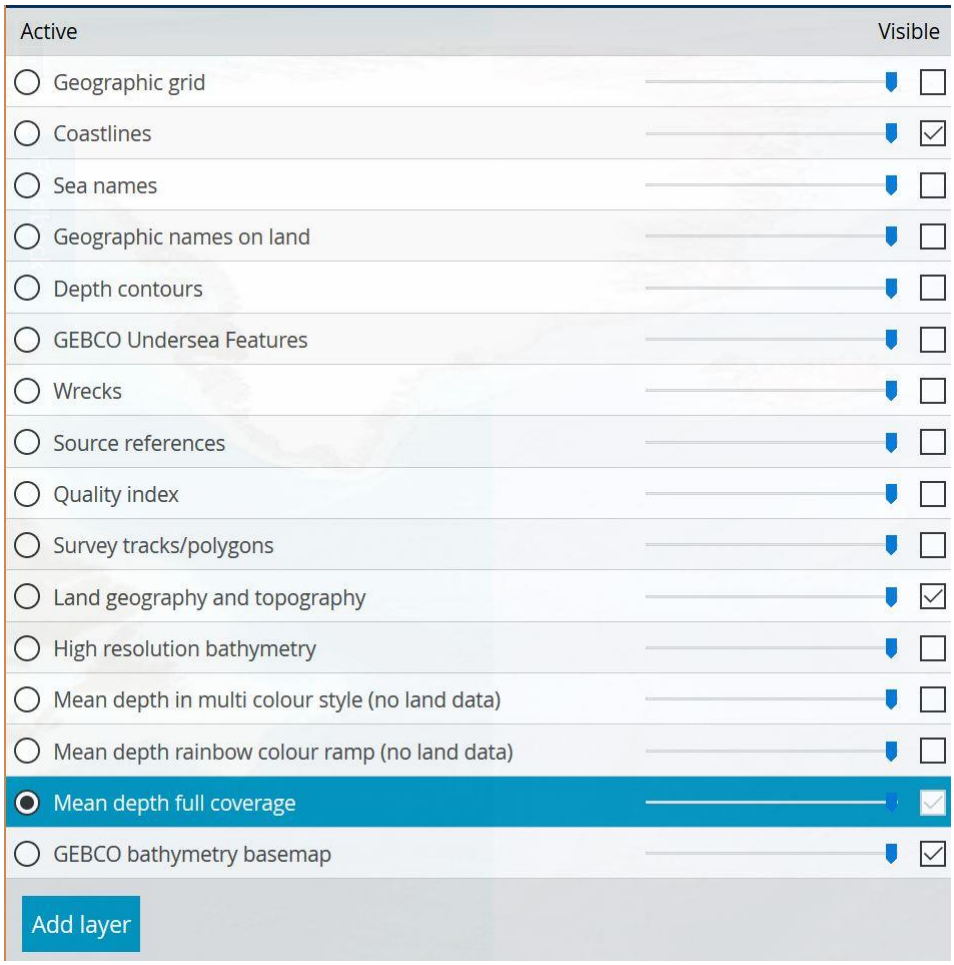


Figure: new layer menu of the Bathymetry Viewer and Download service

Integration of new DTM in the viewer:

In September 2018 the new EMODnet DTM has been integrated into the Bathymetry Viewing and Download service. The new common DTM (2018) has replaced the 2016 version in the layer menu for the mean depth layers with 3 color palettes and source references layer. While in the OGC web services (WMS, WFS, WCS, and WMTS) and the DTM download service the new DTM has been added next to the old DTM. As background map again use is made of OpenStreetMap (OSM). In previous releases EMODnet did not show geographical names as there has been an issue with naming in specific disputed areas. EMODnet Bathymetry uses the services of Geofabrik who provide a cached version of OSM for performance reasons. This OSM version has also been customized to offer a specific appearance and moreover now a separate geographical names layer has been added. This can be switched on/off independent of the background layer to avoid clutter of the display and it has been 'filtered' for specific areas. Further improvements in the OpenStreetMap layer include the removal of geographic features on sea that can obscure viewing of the bathymetry layers. Although it is not easy to maintain as OSM is

a crowd-sourced project whereby some contributors add and publish objects to the sea area without tuning.

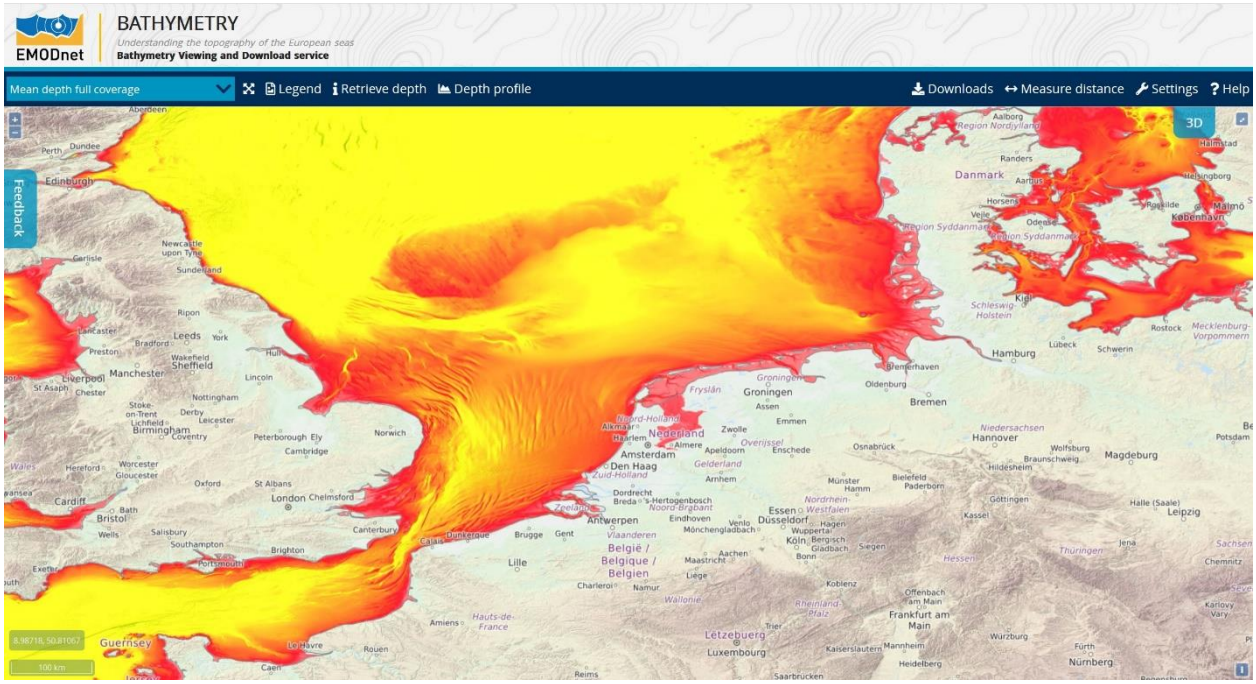


Figure: new DTM with new background map with geographic features layer switched on

3D visualization functionality:

One objective of EMODnet HRSM was to include 3D visualization of the global DTM and this should be using web-based visualization applications (no plug-ins). In these applications, huge amounts of data needs to be passed through the net and the rendering happens on the user side. Thus, it is important to keep a balance between the amount of data to transfer and the amount of effort required for rendering it. Consequently, Level of Detail (LOD) techniques, able to change the complexity of the displayed data based on the point of view required by the end user, are desirable in the EMODnet context. The complexity of the data should adapt to the perception of the user given a point of view. This objective was worked out by partner CORONIS. They proposed to render the terrain using a multiresolution pyramidal tiled data structure. After studying the state of the art in web-based 3D visualization libraries, the best option was to use the Cesium library (https://cesiumjs.org/). Cesium implements a format called quantized-mesh-1.0 [QMSpec], allowing to represent terrains as Triangulated Irregular Networks (TIN), where the coordinates of its vertices are quantized within the bounding box of the mesh. Having a TIN instead of a regular grid is a better representation of the data as the complexity of the map (i.e. the number and size of triangles) adapts to the variations of elevations in the scene. However, there is no free or open-source tool available nowadays that is able to create tiles in quantized mesh format out of a raster format such as the ones generated so far in the EMODnet project. Thus, CORONIS has implemented this software themselves in the following way: given a regularly gridded digital elevation

model (DEM), CORONIS creates a pyramid of different LODs, where each LOD is a Triangulated Irregular Network (TIN) further subdivided into small regular tiles, following a structure similar to that of a quadtree subdivision (see Figure).

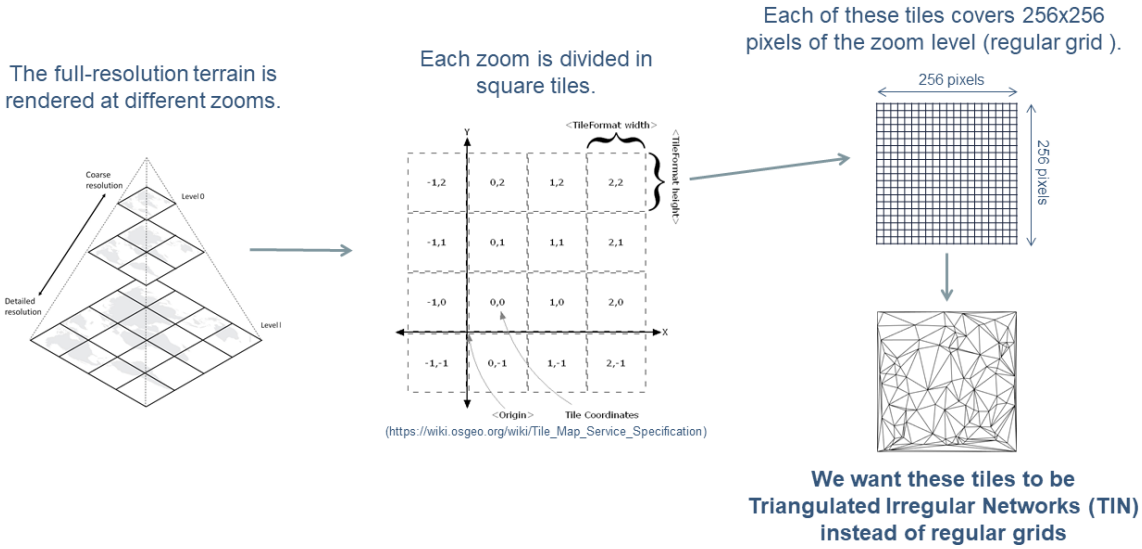


Figure: Overview of the proposed methodology. It aims at creating a multi-resolution tiled representation of a terrain as the one shown on the left hand side. Each of the LOD (also called zooms) is tiled following a regular grid. As shown on the right hand side, each of these tiles covers a 256x256 footprint of a raster file, which regular representation needs to be converted into a TIN.

CORONIS focused on the insights of creating a multiresolution pyramidal tile-based data structure for large terrains, where all the processing is performed at tile level, while making sure the borders of the tile are coincident within a LOD. The key idea is to restrict the new tiles to be computed to stick to the borders of already triangulated ones. Since there is no comparison in the literature regarding the performance of simplification methods when applied to terrain models, CORONIS decided to test several of the methods in the state of the art in order to decide which one would produce the results that best fit our needs. The main objective was to adapt different TIN creation methods of the state of the art to the problem of creating a hierarchical pyramid of tiles out of a large scale high resolution regular gridded terrain. In this context, three popular types of simplification algorithms were adapted to the EMODnet needs:

- Greedy insertion: it performs coarse-to-fine simplification. This algorithm starts from a very basic triangulation (for instance, the two triangles resulting from triangulating the vertices on the bounding box of the terrain in the XY plane). By keeping track of the points falling within each triangle in the XY plane, the point inducing the largest error is added to the surface at each iteration, until all the points are within a user-defined error.

- Edge-collapse simplification: given a gridded terrain or a TIN, it creates an approximation of it by iteratively applying an edge collapse operation. As its name suggests, an edge collapse consists in merging the two endpoints of an edge in a single point. At each iteration, it selects to collapse the edge that would induce least error.
- Point set simplification: in this case, the input is seen as a point set, without connectivity. Without the restriction of not having to stick to a mesh, these methods are easier to implement and more versatile. After simplifying the point sets, the mesh/connectivity needs to be reconstructed somehow (by means of triangulating the points in the XY projection plane, for instance).

To provide a qualitative comparison of the behaviour of the methods, the following figure presents the results of applying the different TIN creation strategies applied to the data.

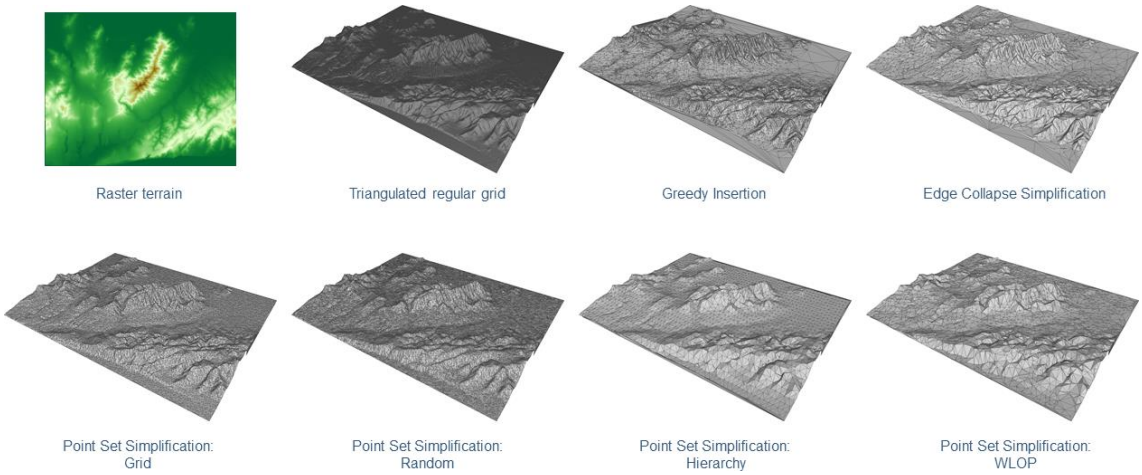
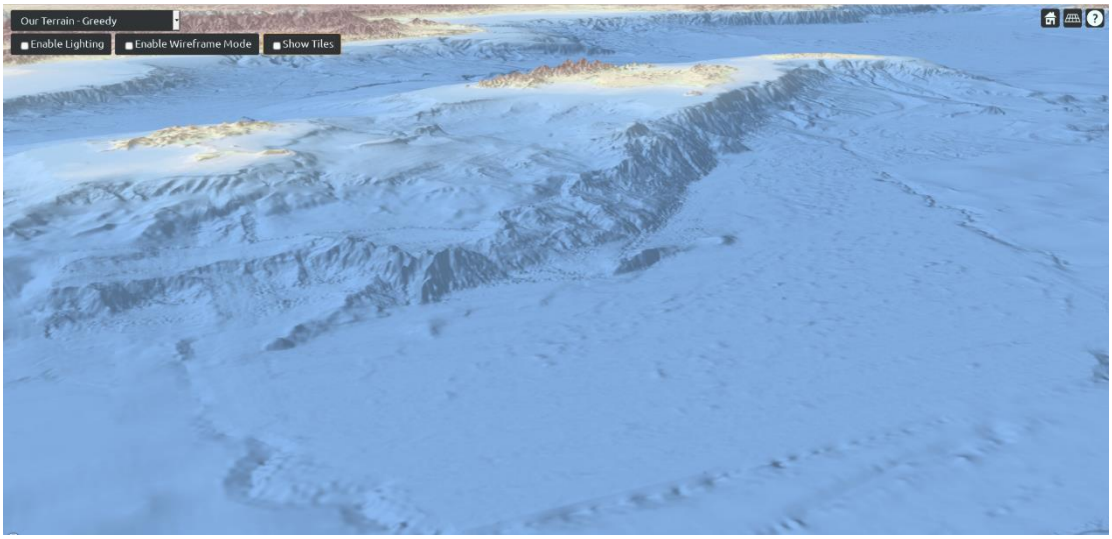
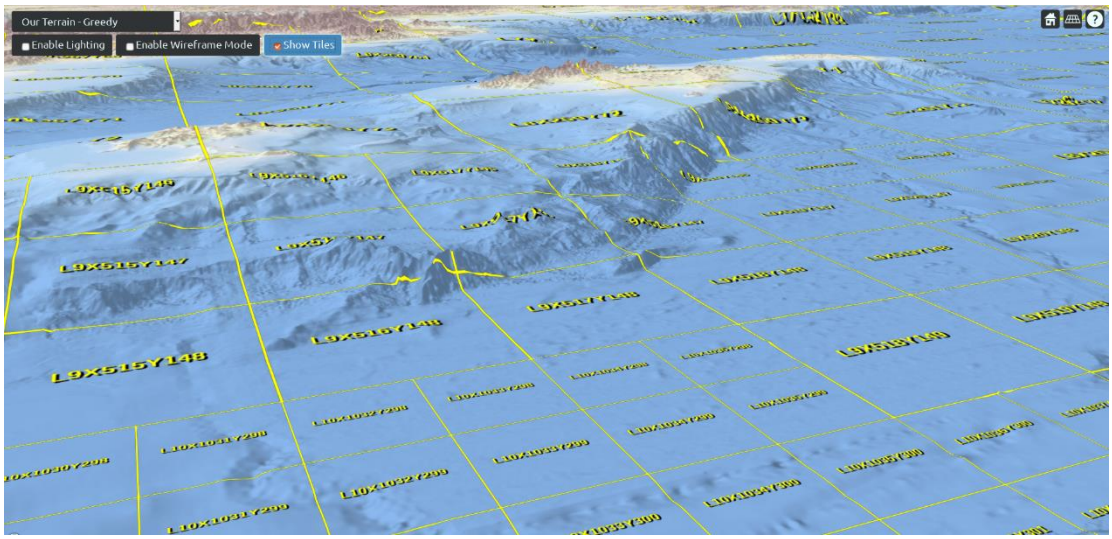


Figure: From left to right, top to bottom, it shows the original raster as an image, the result of triangulating all the samples in the terrain (and the huge number of triangles that this produces), and then the result of applying the different simplification methods studied in this project (the name of each appears below its corresponding subfigure).

It can be observed how the different methods provide different results in terms of the number of triangles, their shape and their adaptability to the terrain variance. Given the analyses, CORONIS decided to render the EMODnet DTM released in 2018 using the greedy insertion method. The figure below shows some screenshots of the viewer using Cesium running in the web portal.


Our Terrain - Greedy
Enable Lighting
Enable Wireframe Mode
Show Tiles


Our Terrain - Greedy
Enable Lighting
Enable Wireframe Mode
Show Tiles

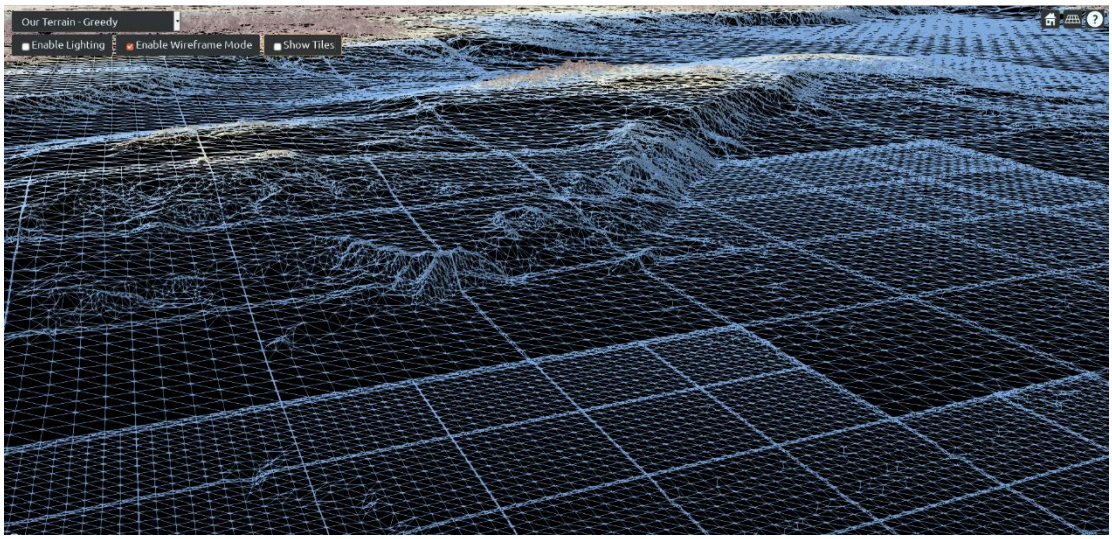

Our Terrain - Greedy
Enable Lighting
Enable Wireframe Mode
Show Tiles

Figure: The top image shows an arbitrary slanted view of the EMODnet DTM. The middle one highlights the tiles that are actually rendering (L indicates zoom level, and X Y are the coordinates of the tile within the zoom). The bottom image shows the triangles forming each tile.

To serve the community CORONIS has published its code in github: https://github.com/coronis-computing/emodnet_qmgc, along with documentation and wiki pages providing all the information required to run the software. Moreover, CORONIS is preparing a journal article in the ISPRS Journal of Photogrammetry and Remote Sensing. The analysis and method is documented in a publication [6] which can be downloaded from the EMODnet Bathymetry portal.

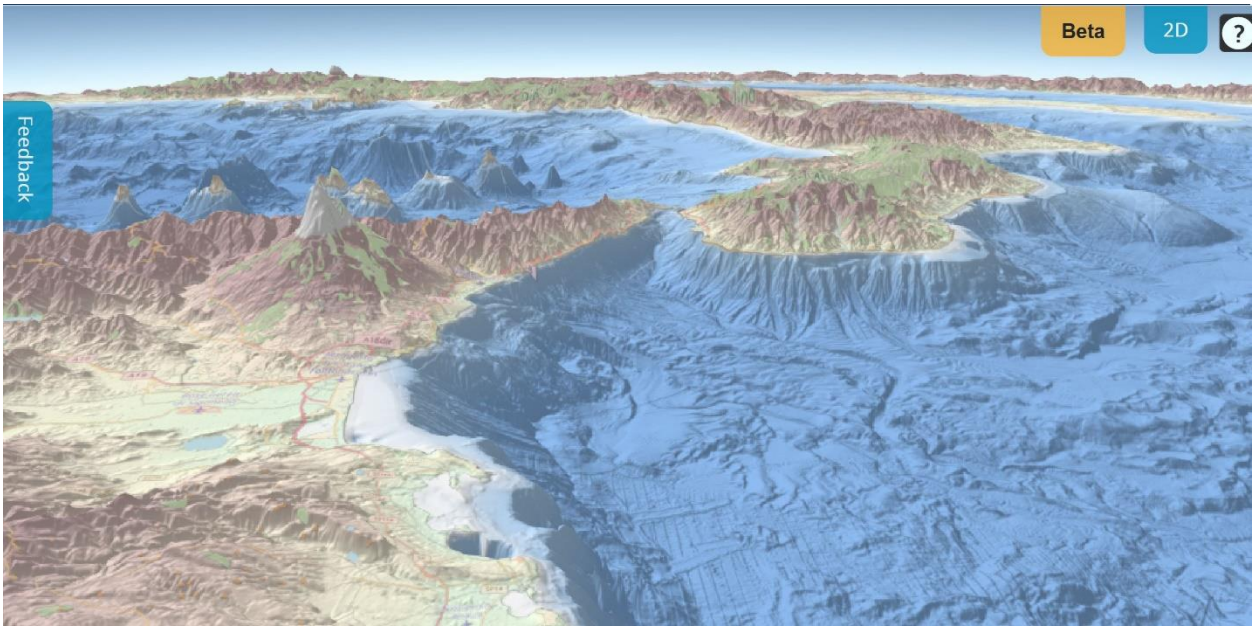


Figure: View from the South along Sicily and the Southern part of mainland Italy

GGSGC has added the 3D visualization as extra functionality to the EMODnet Bathymetry Viewing and Download service. It works by switching on the 3D button in the top right of the map screen.

New downloading functionality:

The download functionality of the EMODnet Bathymetry Viewing and Download service has been upgraded together with the new DTM release by introducing registration of user details and reasons for downloading. The downloading service allows to specify the usual file formats, to choose between downloading 16 tiles of the old DTM and 64 tiles of the new DTM, to download user specified areas (using WCS), and to include user details and reasons, before submitting the download requests. Users can choose between logon with Marine-ID (after one-time registration) or entry of free text for their personal details. After submissions users receive an email with confirmation and URLs for downloading

their requested DTM files. Use is made of 64 tiles for the new DTM because the volume of the DTM has largely increased due to the resolution improvement. The new download functionality has been launched at 24th September 2018 and since then till end 2018 > 4000 transactions have been recorded from > 2000 individual users whereby everybody provided the requested information. Also no complaints were received about the new registration which requires more personal information. The downloading service will be illustrated in the next sections on new layers.

High-Resolution layer:

The Bathymetry Viewing and Download service has been expanded with a layer with the high resolution hot spots made of the 196 HR-DTMs as generated by the data providers (see WP1 and WP2). The HR-DTM layer indicates the contours of the hot spots, while users can zoom in from the common DTM layer as deep as the hotspot resolution allows. The HR-DTMs are linked to metadata records in the Sextant catalogue and included in the Download service.

Resolution in arc minutes	Number of datasets	Remarks
1/32	19	
1/64	59	
1/128	82	
1/256	25	
1/512	9	*Some have been split into smaller section in order to keep the data sets manageable*
1/1024	1	

Table: overview of HR-DTMs

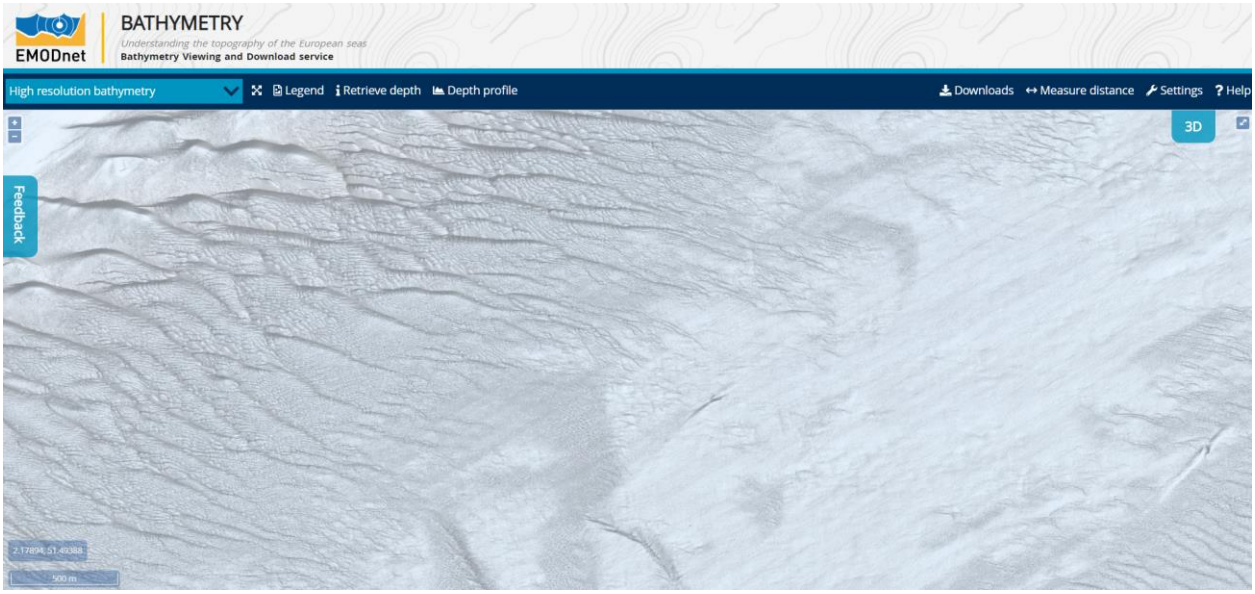


Figure: Spectacular sand wave formations in the southern Northsea at 1/1024 arc minute resolution

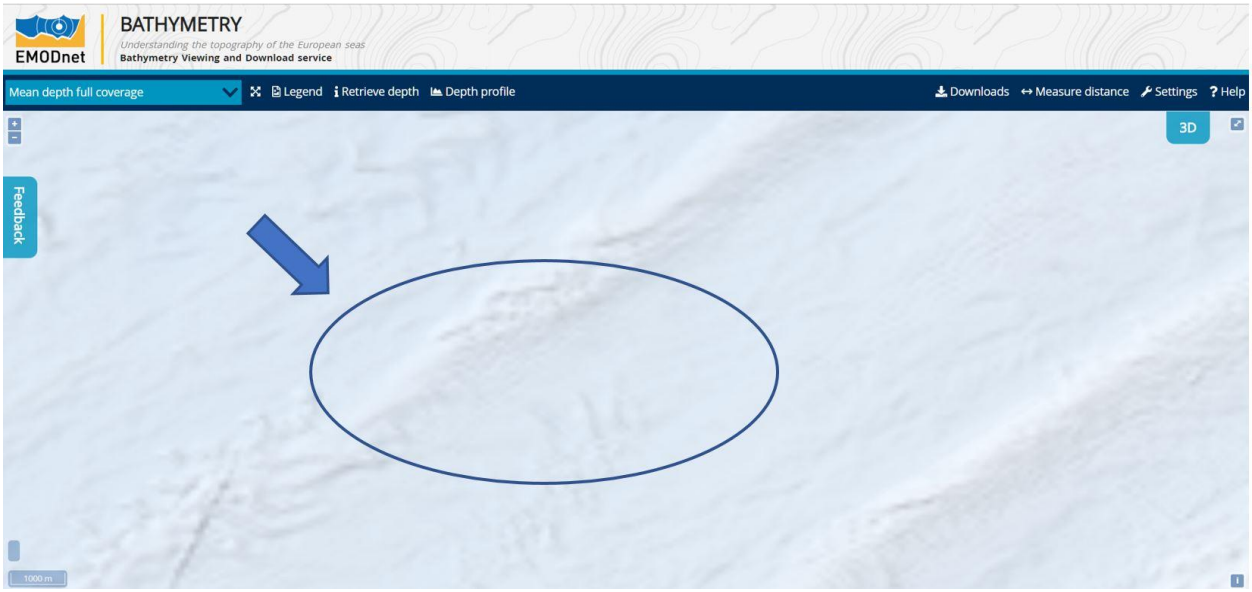


Figure: The same area as above but now at the standard 1/16 arc minute resolution at maximum zoom level

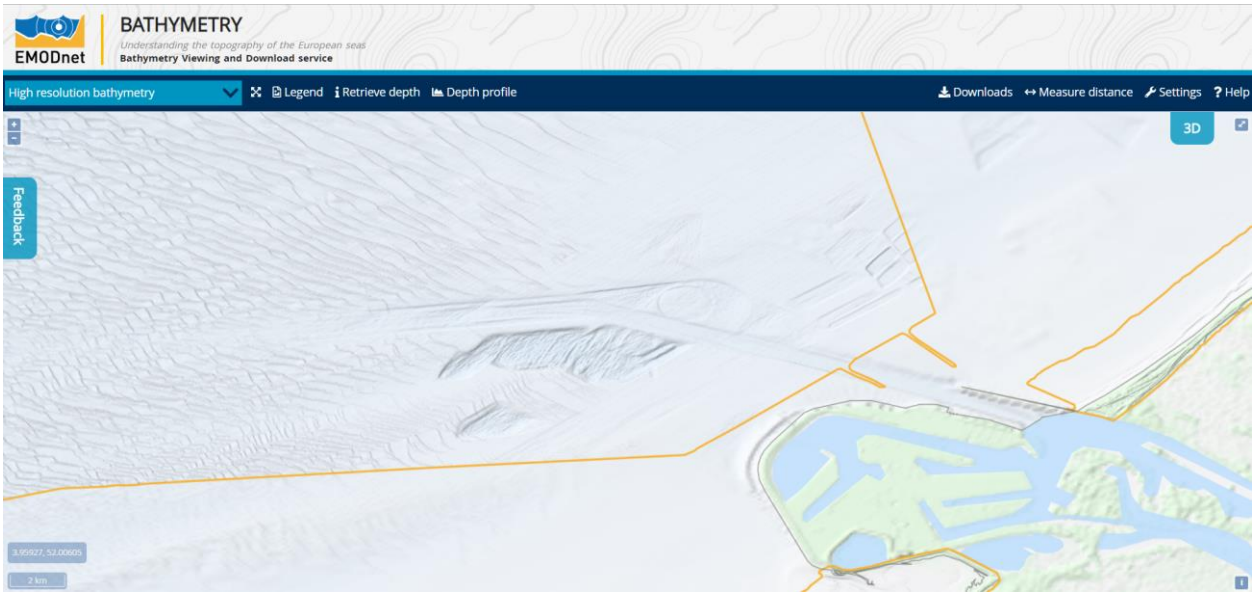


Figure: Sand excavation pit created for the construction of Maasvlakte 2 in the Netherlands

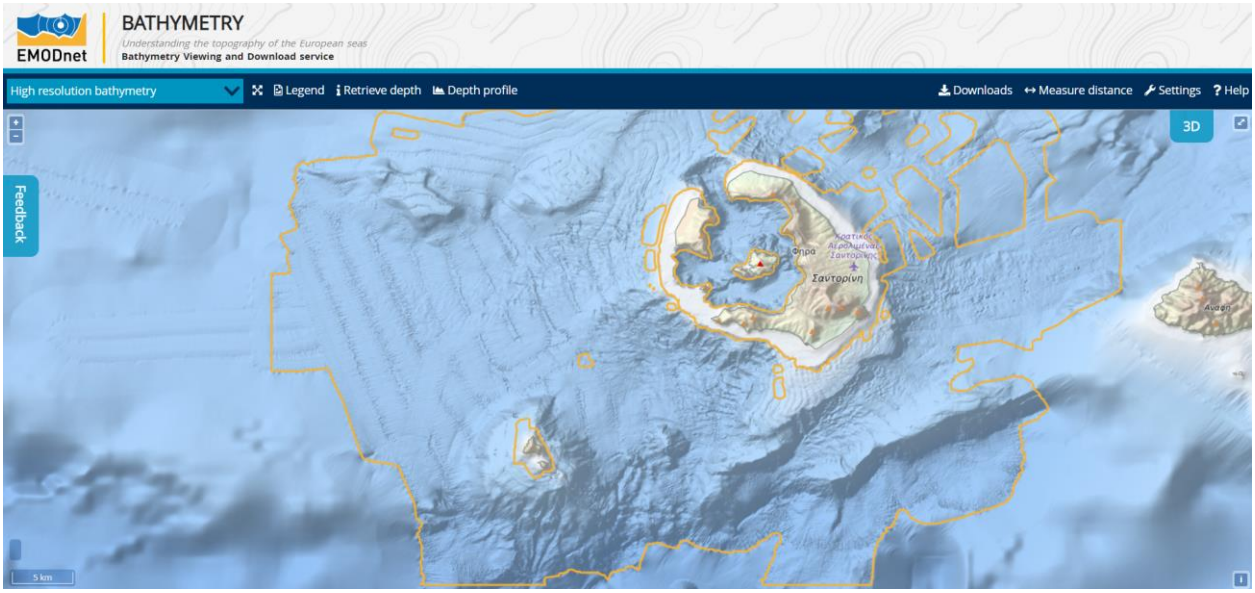


Figure: Vulcanic seabed surrounding the Greek island of Santorini

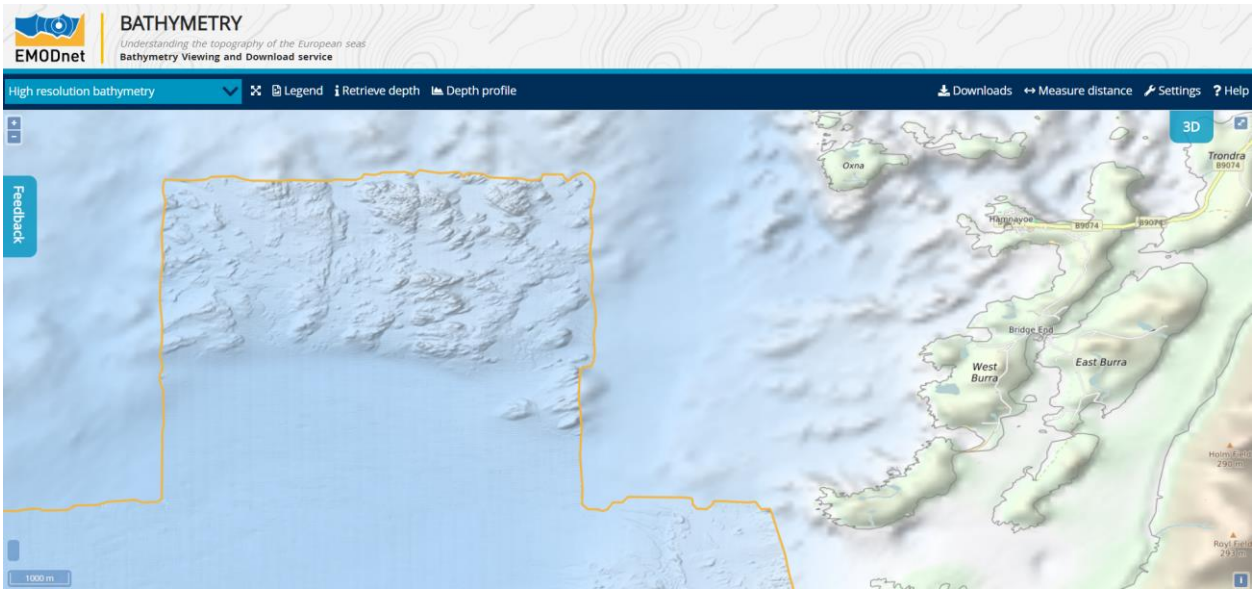


Figure: Rock formations south west of the Shetland Islands

Users can interact with the high resolution data sets in various ways. Just as with the main bathymetry layers it is possible to retrieve individual depths at cursor position, to generate depth profiles and query the underlaying metadata. The layer is activated by selecting the high resolution bathymetry layer from the layer menu. All high resolution datasets are based on source data sets from the EMODnet Bathymetry data providers. For reasons of consistency and accessibility of otherwise restricted datasets, all data sets are compiled into high resolution products based on the EMODnet Bathymetry resolution scheme (1/32, 1/64 etc). For each of these derived products a separate metadata set is created and stored in the Sextant Catalogue service. By using the "retrieve depth" function, users can access both the HR-DTM product metadata stored in a special section of the Sextant Catalogue OR the metadata

associated with the source data (either stored as composite DTM in the regular Sextant Catalogue or in the CDI Data Discovery and Access service.

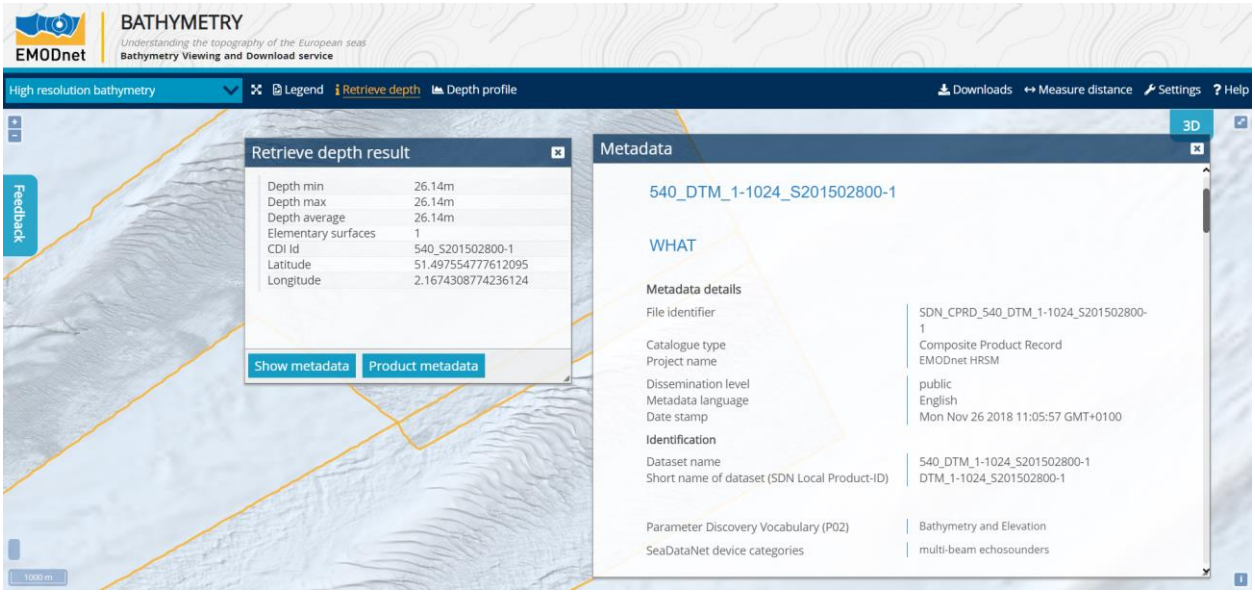


Figure: Retrieve depth and metadata query function for high resolution data products

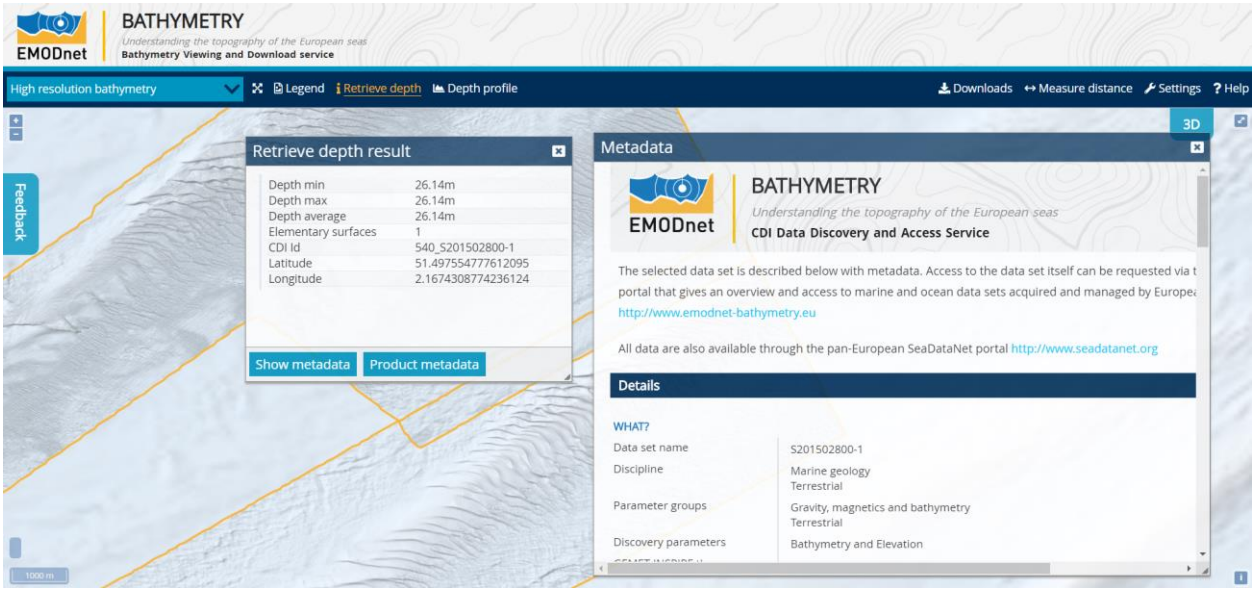


Figure: Retrieve metadata for underlaying source data of the high resolution data products

The download service for the high resolution datasets is integrated in the new shopping basket system. By clicking on the “high resolution areas” button, the areas can be selected one by one and will be added to the basket.

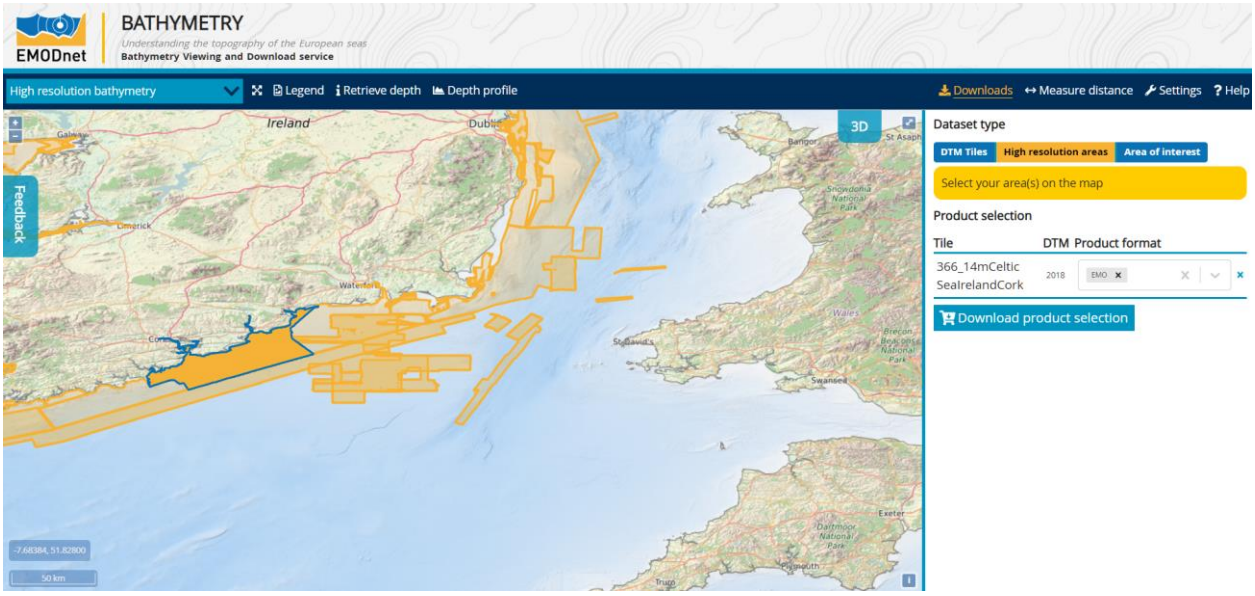


Figure: Shopping basket for high resolution datasets

Quality Index layer:

The Bathymetry Viewing and Download service has been expanded with the Quality Index layer which has been developed by Shom and IFREMER (see WP2). It is linked to the new source references layer which refers to circa 9.600 data sets (surveys and composite DTMs). All data providers have updated the metadata entries in both the CDI discovery service and the Sextant Catalogue service following the instructions of the Quality Index approach. As a result, 4 parameters have been added to the metadata:

- QI_Age – provides an indication of how old the survey or dtm is (4 options)
- QI_Purpose – provides an indication of the purpose of the survey (4 options)
- QI_Vertical – an indication of the vertical accuracy (5 options)
- QI_Horizontal – idem for the horizontal accuracy (4 options)

In order to derive at a single indication for quality a 5th parameter (QI_Combined) has been added which is calculated using a well-defined algorithm. The algorithm and underlaying logic for the QI_Combined parameter is described in the EMODnet Quality Index report [5]. More detail is given in the progress report on WP2. The various parameters of the Quality index are rendered in the portal as choropleth maps. The layer is activated in the layer drop down menu. The layer is also available as a Web Feature Service (WFS).

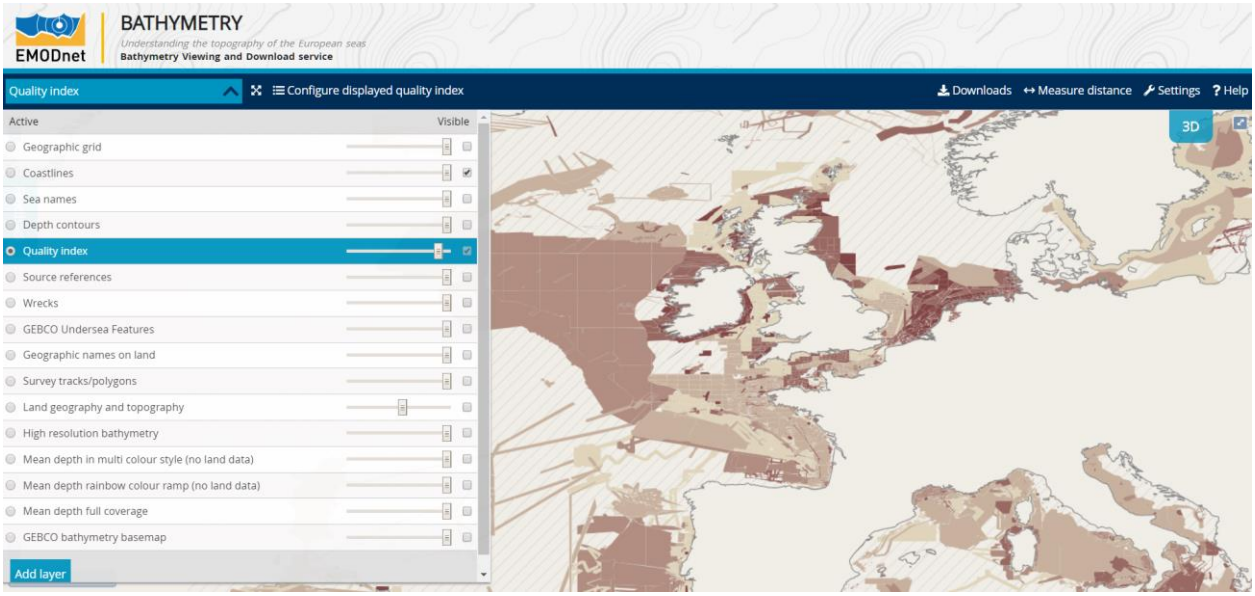


Figure: EMODnet bathymetry quality index layer

Satellite Derived Coastlines layer:

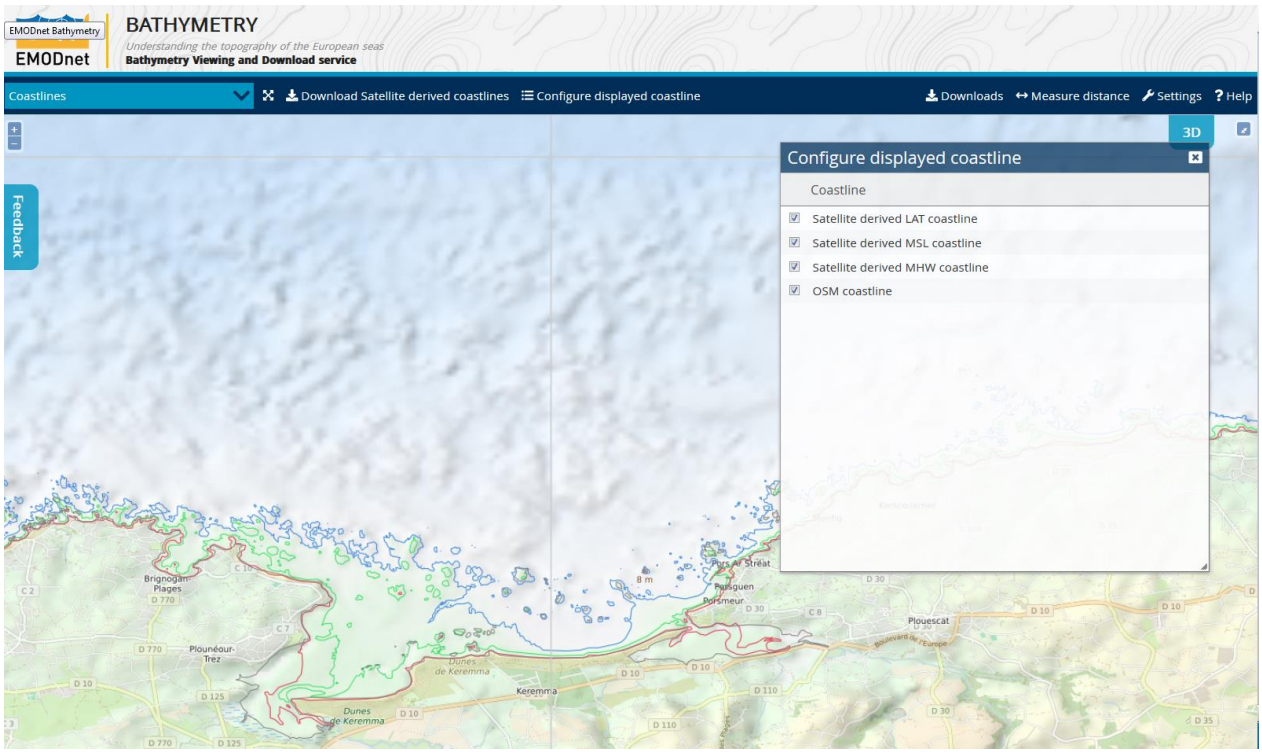


Figure: Representation of the three new coastlines near Brest (F) and the coastline configuration menu

Users can download a zip archive that contains three shape files, one for each coastline representation. After selecting the download option, the zip archive is added to the shopping basket.

Monitoring:
Activities were undertaken by MARIS together with IFREMER and GGSGC to install the PIWIK / MATOMO script for monitoring web traffic on the portal and related services as agreed in the EMODnet Technical Working Group. The results of the monitoring are followed by TRUST-IT. In the meantime MARIS and GGSGC also continue their own monitoring as back-up.

Help section:
Also the HELP section of the Bathymetry Viewing and Download service has been updated to reflect all the changes and new features, and the section on Web Services has been updated too.

Proposal for base layer:
A proposal was prepared by GGSGC and presented by MARIS at the EMODnet TWG meeting for developing and providing a common EMODnet background layer adopting the EMODnet HRSM approach. This should have a global coverage and based upon the EMODnet DTM, upsampled GEBCO, a global satellite derived DEM for land coverage, a customised Open Street Map layer, and all rendered to the EMODnet HRSM look & feel. The common background layer should be used by all thematic portals and possibly wider. In principle the EMODnet TWG has accepted the proposal and it will be elaborated by EMODnet Bathymetery in its successor project.

Pilot Collaborative Virtual Environment (CVE) development:
The bathymetric survey data sets are really massive, and processing them to produce a Digital Terrain Model, in particular on regional and pan-European scales, is very challenging. The grid resolution of the new EMODnet DTM is 1/16 * 1/16 arc minutes (circa 115 * 115 m2) and it contains approximately 12.3 billion grid nodes, organized in 113892 columns and 108132 rows (seabed and terrestrial coverage included). To handle the integration the overall DTM was split over 64 tiles. Also the regional coordinators (11) had to split their regional DTMs in tiles during production, because their desktop PC's could not handle the number of data points, while production runs took considerable time in practice. Not only is this time consuming, but it also increases chances for anomalies at the edges of tiles, which need to be corrected. Furthermore, regional coordinators work independently of each other, albeit with agreed overlap zones between the regional DTM areas in order to minimise possible edge effects. For sure one can speak of big data and a high challenge for the regional coordinators and integrator to handle and process their DTM components. This understanding has laid the basis for exploring the development of an integrated Collaborative Virtual Environment (CVE), to be hosted in the cloud and with strong computing power. The CVE should facilitate the data provision from data providers and the collaborative processing of regional DTMs between regional coordinators and their interaction with the integrator. This way the CVE should make it more efficient for regional coordinators and integrator to perform their workflows for generating the DTM, also in closer interaction and with additional functions to optimize results. Following this idea activities were undertaken for developing a pilot Collaborative

Virtual Environment (CVE) and to make the GLOBE software fit for running in the cloud. The pilot was developed based on 3 components:

1. A data and computing infrastructure for DTMs storage and processing tasks
2. An online version of Globe software for sharing data and work sessions
3. Migration of processing tools into Web Processing Services

1) Data and computing infrastructure:

The data and computing infrastructure is provided by Pôle de Calcul Intensif pour la Mer (PCIM www.ifremer.fr/pcim) located in Brest-France and funded by French Government, Brittany Region, and several research organizations such as IFREMER and Shom. This **Datarmor** computing facility is dedicated to marine studies, which include for example hosting software and libraries used by the marine community, marine databases, reference data such as climatologies, global or regional DTM's, marine species taxonomies and marine related ontologies. PCIM high performance computing (HPC) facility has a history of more than 15 years, and its infrastructure is operated by partner IFREMER with engineers to maintain and monitor the system, to give support to users both for running applications and for optimizing their softwares for marine scientists (e.g. adaptation to parallel computing, optimization of storage access…).

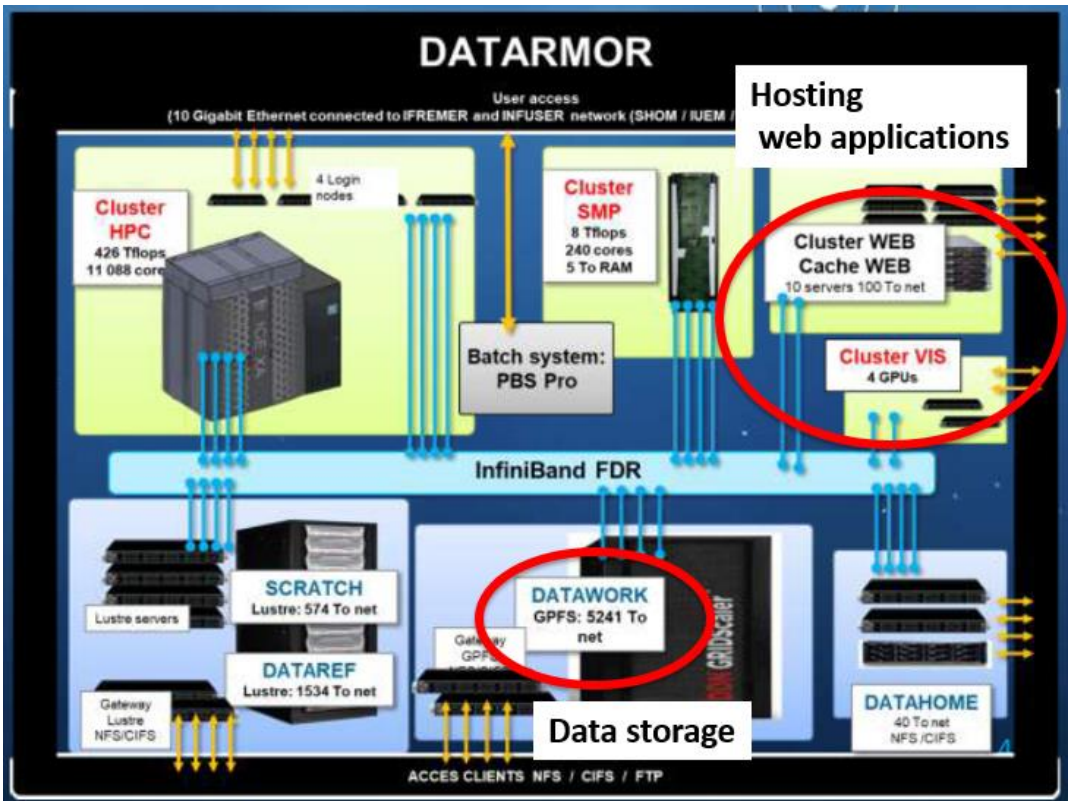


Figure: Datarmor infrastructure: data storage capabilities and access to the cluster Web for hosting applications are open to the EMODnet HRSM project

The DATARMOR infrastructure provides facilities for storing and managing the EMODnet Bathymetry pilot data sets. 3Tb disk has been dedicated to the pilot project and defined as a working space for the regional coordinators. The pilot has been formulated to focus on 3 regions, of which 2 are neighbouring (West Mediterranean and Central Mediterranean sea) and one separate (Bay of Biscay), and involving 3 regional coordinators, including IFREMER, CNR-ISMAR, and Shom. The relevant input data resources, consisting of the pre-gridded and pre-processed bathymetric survey and composite DTM data sets as provided by the data contributors, have been stored in this space. These data resources have all been previously processed in accordance with the guidelines defined by the consortium and they are ready for merging by the basin coordinators. The data infrastructure can also host the working space and the merged products processed by the regional coordinators.

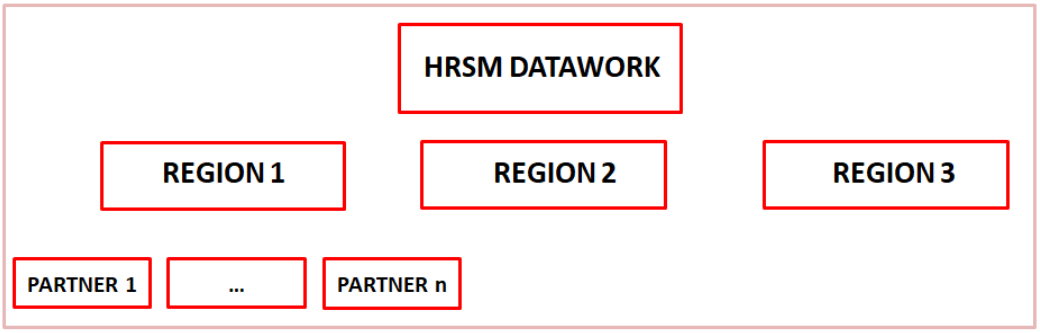


Figure: Configuration of the Datarmor storage space for pilot CVE

This working space is called « DATAWORK » and it opens many facilities for archiving, exploring and using the pre-gridded DTMs of all contributors.

2) Virtual Machine and Globe software:

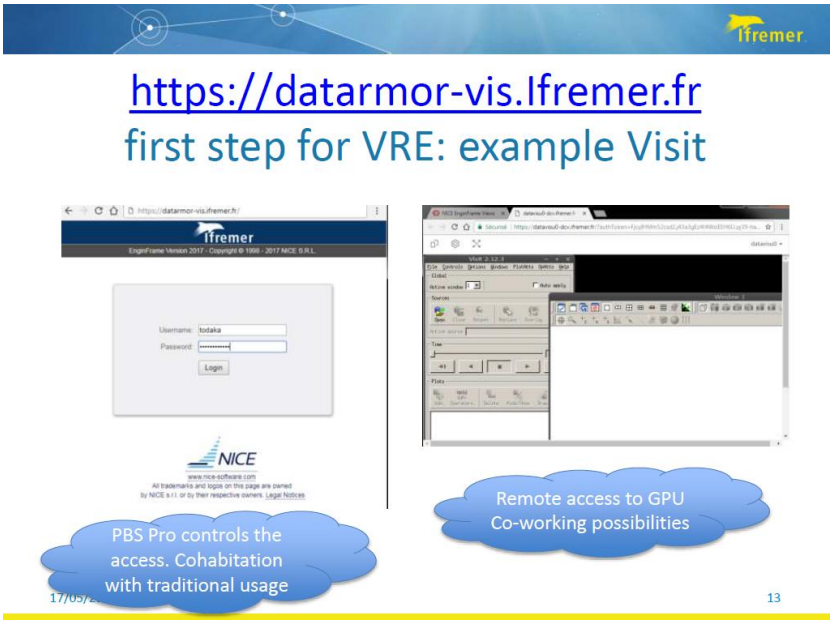
The starting position for regional coordinators is as follows:

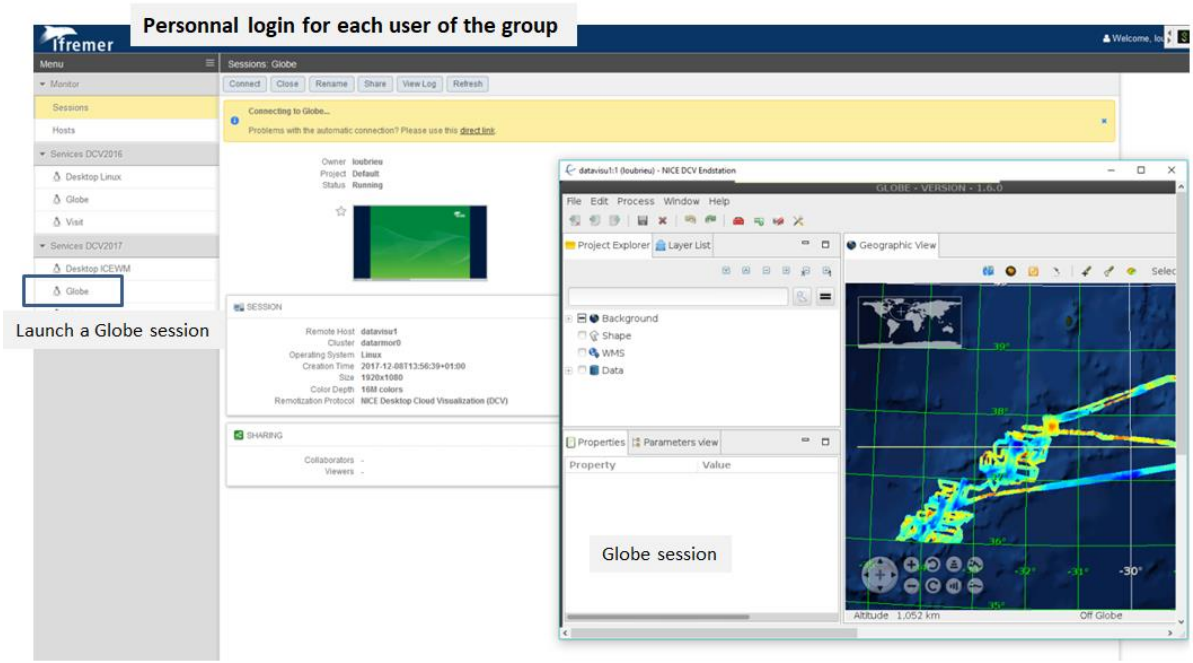
- All partner data contributions are transferred to the regional coordinator by a file server, e-mail or other tools,
- The regional coordinators have their own workspace and configuration for the DTM processing, the processing is undertaken using the Globe software
- The regional DTMs are uploaded by the coordinators to the global integrator by a file server.

The common objective has been to provide regional coordinators tools for producing the merged DTMs. Therefore two types of Collaborative Environment have been explored, consisting of a) an online Globe configuration, and b) a Work Processing Service (WPS) configuration.

For the online Globe configuration, the DATARMOR infrastructure offers the opportunity to implement a collaborative space for the regional coordinators, combining a working space, “DATAWORK” presented above, and the access to a shared version of the Globe software. Using the cluster VIS of DATARMOR,

the users can connect a virtual machine which allows the access to the DATAWORK disk space and which hosts a GLOBE online version. They access the virtual machine through a remote desktop protocol, via a web gateway. This configuration has been available to the restricted group of 3 basin coordinators and IFREMER technicians. The group connects to the virtual machine with an Extranet login to DATARMOR. The basin coordinators have individually validated the tools and their efficiency in comparison with their local configuration.





Figures: Collaborative environment for a shared access to Globe software and data

The main functions tested were:

- Connection to the server and the virtual machine
- Launching GLOBE and performing basic and advanced routines on the data, such as operation on DTMs (fill in gaps, reset cells), merging DTMs
- A data viewer.

The GLOBE tools, which were tested, are those which are the main components of the EMODnet HRSM workflow of the basin coordinators. A useful option is the opportunity to share a GLOBE project between two or more users at the same time. It provides many opportunities in terms of collaborative work, support and training. This option was tested by basin coordinators of Central and West Med. They worked simultaneously on the same Globe project. This function is supporting the processing of DTMs along the boundaries between both regions.

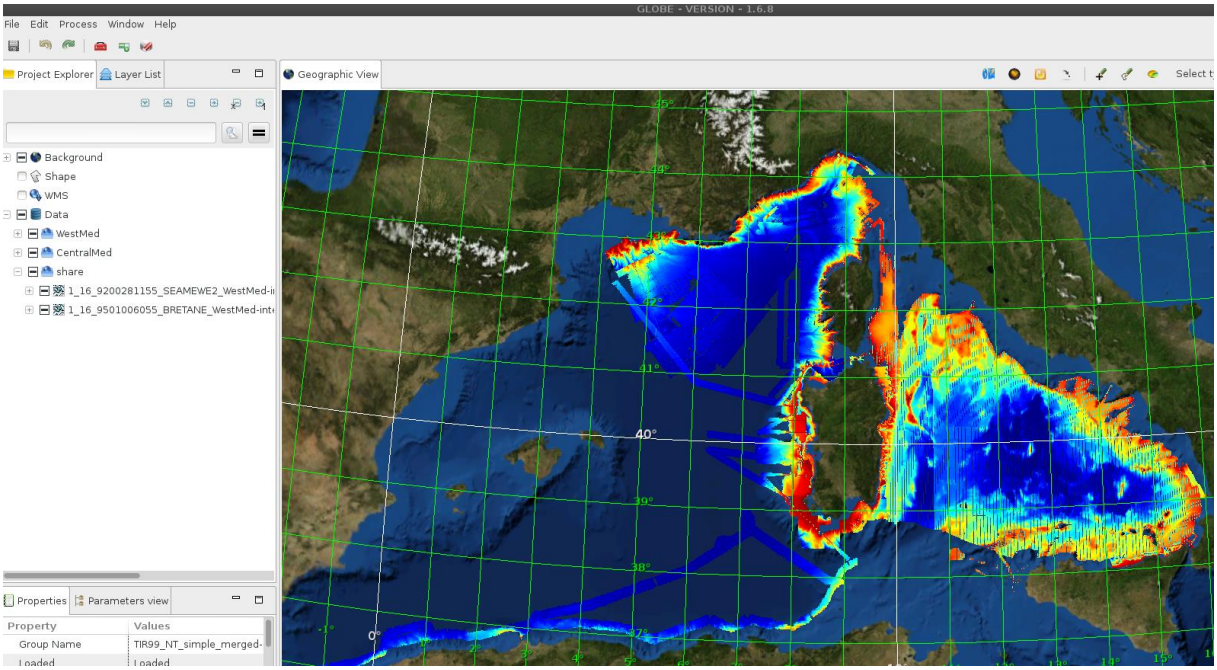


Figure: Illustration of share session

This configuration provides a collaborative environment as proposed for a restricted group of users.

3) Migration of processing tools into Web Processing Services

The second Collaborative Environment configuration aimed at providing a full online WorkBench with Globe as OGC Work Processing Service (WPS). The goal of this configuration is to unify and simplify the workflow of regional coordinators, giving them access to the full set of tools for performing DTM analysis, comparison and merge:

- by building a simplified software we can ease and speed up the work of regional coordinators by putting the tools they need on a less-cluttered interface;

- by building a specialized tool we can push forward a workflow that will ensure consistency between the work of various regions and coordinators : we can integrate checks for grid resolution, automatic file naming, merge hierarchy history etc.;
- by using a web-based user interface running on the client computer we can reduce computing power requirements compared with Globe online in a multi-user context.

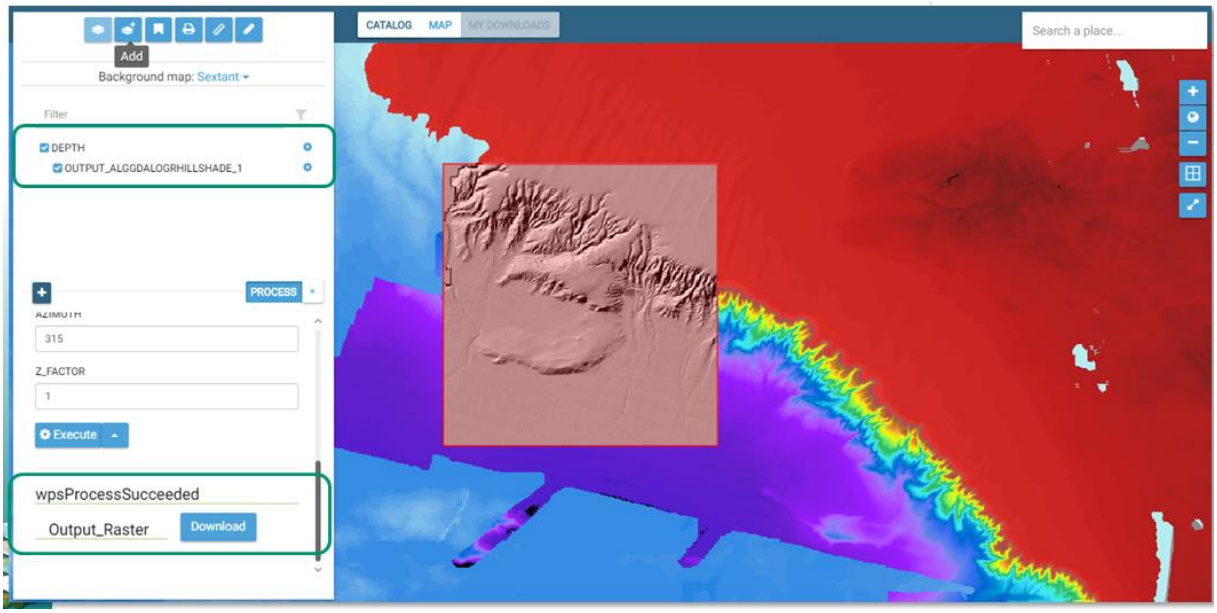


Figure: data visualisation

The main user requirements were gathered and the technical prerequisites arising from those needs were explored:

- the user needs to be able to see contributing DTMs. The needs are: data storage read access, netCDF-aware backend, adequate mapping data transfer protocol and frontend display;
- the user needs to be able to perform selected processes on these DTMs. It requires writable workspace, process description and launch protocol implemented on a server;
- the data must be partitioned according to their regions. Needs for parametrized generation of DTM lists, user access control.

These needs led to choose the following technical solutions: QGIS server providing OGC Web Map Services and Web Processing Services, and a user interface built on top of the Sextant Web Viewer.

OGC services on Sextant: display with Web Map Service (WMS): WMS defines supply of image rasters with extents and a resolution specified by the client. This OGC standard is suitable to build a map display Web user interface. Our implementation is provided by QGIS Server. It is able to provide a WMS Context based on the contents of a .qgs project file referencing netCDF files and individual WMS raster service for each of the referenced netCDF DTMs. The Sextant Web User Interface already uses the Open Layers library which is able to query WMS servers and display their map data. So by using QGIS server and

Sextant viewer, users can be provided with the DTM viewing interface they need. There is one layer per DTM file with a fixed palette.

OGC services on Sextant: processing with Web Processing Service (WPS): The user needs to be able to launch processes on the selected DTMs. There are various ways to do this, but one was needed which would enable to leverage synergies with other software workflow solutions. The OGC WPS protocol specifies ways for a server to provide a list of available services, their required and optional inputs, their outputs, and the means to launch them and retrieve results. A WPS-aware library can query a WPS server to get information about available processes and their respective inputs and outputs, and given a particular process can ask the user for input with proper data entry fields and execute that process. WPS, like WMS, is widely supported in GIS tools (ArcGIS, QGIS...), allowing advanced users to build their own workflows using these tools if needed. There is now also provision to call WPS processes from Sextant Viewer, which made it a perfect fit for the application. On the server side, the WPS programming interface and service provider are implemented by QGIS Server and a customized version of PyWPS. One can write R or Python scripts with a few additional headers and QGIS Server/PyWPS handle the dispatch of input and output data in WPS format. That allowed to build a DTM merge WPS with Python, calling a command-line derivate of Globe for core data processing. On the client side, the Sextant Web UI is able to build ad-hoc data entry fields from WPS embedded inputs/outputs description and send the appropriate WPS Execute requests. Although from a theorical point of view WMS and WPS available on a same server are completely separate, for this application, both services use the same data. Therefore the Sextant Web user interface was enhanced so it is able to use the state of checkboxes on the map layer list (coming from WMS) to build a layer list as an input for a WPS, thus giving a more streamlined experience to the user who can now directly call the merge WPS after selecting the displayed DTMs, without having to select them a second time from the drop-down lists.

Regional partition: As a regional coordinator, the user wants only to view or process the data of the region he works on. Therefore, a set of predefined DTM lists was implemented, one for each region. Upon an update of the set of contributed DTMs, a process can be launched that will automatically refresh qgs projects and configuration files to have an up-to-date environment for each region. A simple access control was added using the existing Ifremer extranet connection API based on CAS (Central Authentication Service).

Prototype: The prototype was developed using the previously described tools which is able to access the regional data on the DATAWORK disk space for input. The WPS allows one to select DTMs stored on the “DATAWORK” space and merge them. Behind the scenes, a Python script managed by QGIS server+PyWPS calls the “EmodnetProcesses” command-line tool derived from Globe to perform the merge operation and stores the generated file in-place. Furthermore, provision has been taken to allow the web application to query Sextant, CDI and Sextant Catalogues in order to display metadata and to query Quality Indicators, based on the CDI or CPRD identifier of the file. The main functionalities developed for the prototype are:

Data selection tools

- Exploring and retrieving of available data sets from the "DATAWORK" DTMs pool,
- 2D mapping and visualization services,
- Interaction with the SeaDatanet CDI and Sextant services.

Data processing tools

- Sorting the DTMs with their quality indicators
- Merging of pre-gridded datasets in final DTMs: the algorithms developed in Globe are implemented in the prototype.

An instance of the working prototype is open for testing by selected basin coordinators, using a subset of the Centre Med data set centered on Sardinia island. One can select and merge DTMS of this area and visualize the results.

Pilot CVE conclusions: The pilot for the **Collaborative Virtual Environment (CVE)** was successfully finalized. It had a focus on generating 2 neighbouring RDTMs (West Med and Central Med) and 1 additional RDTM (Bay of Biscay) using Globe online on a cloud computing platform and involving a few basin coordinators. The pilot concerned building selected regional DTMs having all data and the Globe software online together in the cloud. Two ways for working with the GLOBE software on the cloud were set-up: 1) as a full package and installed as a Docker container instance; and 2) as a set of OGC WPS services for selected GLOBE functions. Examples of both have been made available to pilot regional coordinators for try-out and feedback in order to improve the services. As part of the pilot, an OGC WPS has been developed, facilitating to select DTMs stored on the cloud and merge them. The pilot has provided insights into the practical feasibility of adopting the cloud for the EMODnet Bathymetry workflow and where it should be improved. Also it demonstrated how two basin coordinators for neighbouring regions can collaborate, in particular for establishing seamless boundaries between their two regional DTMs. This experience will be used in the new EMODnet phase for upgrading the pilot set-up to an operational configuration which will be used by a few Regional Coordinators for generating new Regional DTMs.

INSPIRE compliance and international interoperability:

The European Union and national states have considered for long time the economic benefit of the use of spatial data to support policy making such as in the context of the Marine Strategic Framework Directive (2008). With the INSPIRE directive, policies have been defined in order to enable the creation of National Spatial Data Infrastructures (SDI), within the context of harmonization across Europe through interoperable datasets and service towards the goal of the European Spatial Data Infrastructure (ESDI). Within this context, since 2009, the European Marine Observation and Data Network, EMODnet, has been focused to design, populate and maintain the mutli-thematic marine infrastructure and the associated organization needed to facilitate the sharing of marine and coastal fragmented data. In the domain of bathymetry, all the efforts put together since the infancy of EMODnet Bathymetry (2009)

have demonstrated to be very successful when generating the compilation of bathymetric data into a European wide bathymetric digital elevation model alongside a detailed description of the filiation of the data sources composing it. This success is largely achieved by implementing key concepts that are, amongst others, common practices, semantic interoperability, standardization of formats and processing, cross-domain and cross-country interoperability. Since the early stages of EMODnet Bathymetry, strong relations with SeaDataNet have been established. SeaDataNet's primary goal is the development of a standardized, distributed system for managing the large and diverse data sets collected by oceanographic fleets and automatic observation systems across various scientific themes. The key element in the realization of such a distributed system includes common standards for the expression of data ownership, data acquisition and processing, communication and quality assurance. This includes the use of XML and international standards, such as ISO 19115-19139, OGC, W3C, and shared and commonly defined vocabularies. These shared, or governed vocabularies, facilitate interoperability between all the stakeholders following the lifecycle of the data (data provider, regional coordinator, final, integration and products users). SeaDataNet has relations with, follows and contributes to international standards committees such as the Open Geospatial Consortium (OGC), International Organisation for Standardisation (ISO) and the World Wide Web Consortium (W3C). It has an active cooperation and tuning with the INSPIRE community, in particular the INSPIRE team of JRC, which has been essential to the definition of the INSPIRE Directive 2007/2/EC aiming at establishing an Infrastructure for Spatial Information in the European Community which is supported through legislation and technical guidelines, such as concerning data models (schemas), metadata and network services.

End of the 1st year a separate 'Report on Interoperability and International Collaboration' [4] was drafted, which was accepted by the EU. It gives further details on the INSPIRE compliance and also on the international interoperability of the EMODnet Bathymetry standards and approach. Moreover it gives information on the cooperation of EMODnet Bathymetry with GEBCO, NOAA (as part of AORA), IHO, BSHC, NSHC, IBCAO, and the Seabed 2030 initiative. In the 2nd year a further dialogue took place between the INSPIRE team at JRC and the EMODnet Bathymetry team together with SeaDataCloud and EMODnet Chemistry colleagues. In May 2018 five INSPIRE change requests were prepared and submitted to the INSPIRE team concerning the metadata validator and the data implementation rules. Feedback was received and reviewed by the SeaDataCloud Technical Task Group. The next step took place at the TG-DATA meeting in December 2018. At the meeting JRC indicated to undertake measures for making the INSPIRE implementation more flexible and forthcoming to change requests as heard from several communities in order to achieve more success. The dialogue with the INSPIRE team will continue in order to achieve mutually acceptable results as it will further INSPIRE uptake.

WP4 contributes to the following task as formulated in the tender and as shared with WP3:

- Task 4: Machine-to-machine connections to data and data products

WP4 also contributes to the following task as shared with WP6:

- Task 5: Web portal

WP4 also contributes to the following task as shared with WP1 and WP3:

- Task 8: INSPIRE compliance

WP4 also contributes to the following task as shared with WP0 and WP6:

- Task 9: Monitoring of performance

All tasks have been completed as can be derived from the WP0, WP1, WP3, WP4, and WP6 progress reporting and the separate report on international interoperability [4].

WP5 – Coastlines, legal baselines and vertical reference levels:

With the increase of the resolution of the EMODnet DTM, the EMODnet Bathymetry team has strongly focused on the land-sea interface. Two main tasks have been pursued along the duration of the contract. The first one concerns the location of the coastline, while the second concerns the conversion between vertical references. These have been essentially managed by consortium member Deltares.

Official coastline and legal baselines:

Official coastline and legal baselines were requested as part of the tender of the present contract. These information have been collected from all the EMODnet Bathymetry data providers, and when possible from other EU member states. Deltares has been collating these information from the officially recognised national sources. The result of this inventory [8] provides a snapshot of the inventory of existing coastlines and baselines without any attempt to resolve existing legal disputes as this is out of scope and capability of EMODnet.

Nr	Country	Baseline	Coastline
1	Albania	N/A	N/A
2	Belgium	Available	Available
3	Bulgaria	N/A	Available
4	Croatia	N/A	Available
5	Cyprus	N/A	N/A
6	Denmark	Available	Available
7	Estonia	N/A	N/A
8	Finland	N/A	N/A
9	France	Available	Available
10	Georgia	N/A	N/A
11	Germany	Available	Available
12	Greece	Available	Available
13	Iceland	N/A	N/A
14	Ireland	Available	Available
15	Israel	N/A	Available
16	Italy	Available	Available
17	Latvia	Available	Available

Nr	Country	Baseline	Coastline
18	Lithuania	N/A	N/A
19	Malta	Available	Available
20	Monaco	N/A	N/A
21	Montenegro	N/A	N/A
22	Netherlands	Available	Available
23	Norway	Available	Available
24	Poland	N/A	N/A
25	Portugal	Available	Available
26	Romania	Available	Available
27	Russia	N/A	N/A
28	Slovenia	Available	Available
29	Spain	Available	Available
30	Sweden	N/A	Available
31	Turkey	N/A	N/A
32	Ukraine	N/A	N/A
33	United Kingdom	Available	Available

Table: Status of collected national legal baseline data-sets and coastline data-sets (12/2018)

The information provided as part of the coastline and baseline inventory were collected with the utmost care from authorities responsible for the definition and maintenance of official coastline and baseline in their national jurisdiction in Europe. Information made available in this inventory has been verified in December 2018, but might have been subject to changes since then. When available, a national disclaimer specific to each coastal state specifies its use and its legal scope. This national disclaimer must be used complementary to the present document. Therefore EMODnet Bathymetry is by no means responsible for the production, the maintenance, the completeness, the accuracy, the reliability, the suitability and/or the availability of this information (all or parts). The inventory report [8] and the digital files of the coastlines and baselines can be downloaded from the EMODnet Bathymetry portal.

Satellite Derived Coastlines at different reference levels:

At international level, the coastline definition is suffering from lack of consensus. Pragmatically, a usefull coastline can be determined primarly by the intersection of the bathymetry/topography surface with a selected tidal level (most likely Mean High Water). As a continuous surface from sea to land is not always available, it was decided to develop a method based on satellite imagery. This method is based on a 5 steps procedure (see figure below) based on multispectral satellite imagery, filtered for cloud and sand dust, followed by classification of wet and dry area by image processing techniques. Then it is extrapolated based on the vertical adjustment between the instantaneous tide level (tide level at the time when the satellite image was collected) to specifically defined tidal levels

(Lowest Astronomical Tide, Mean High Water). As a result the generated intersection is then digitised as a linear feature.

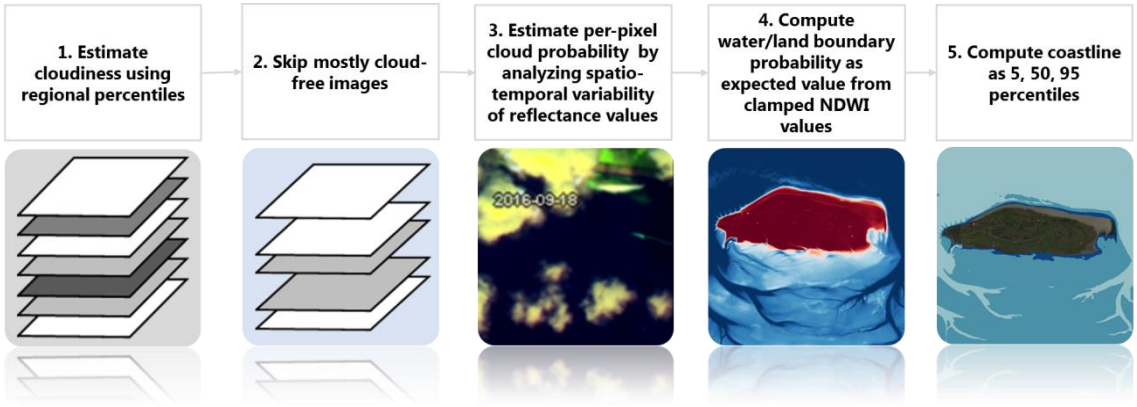


Figure: Processing pipeline for coastline detection from optical satellite images, capturing intertidal water level changes

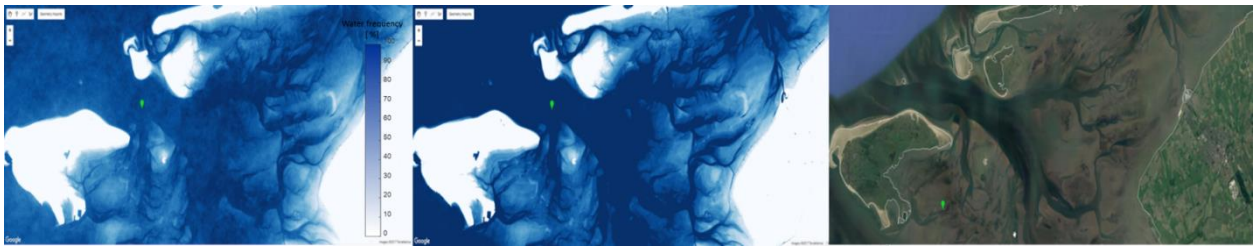


Figure: Water occurrence estimated from Landsat 8 and Sentinel-2 images around Nordseeinsel Memmert (Germany): the first image shows the water occurrence computed as a simple mean NDWI value from all images, the second image shows water occurrence estimate using statistical cloud removal method, and the third image the MHW coastline retrieved from water occurrence.

Figure: Water occurrence estimated for Wadden Sea from multiple satellite images

The methodology has been implemented and optimised, taking benefit from innovative geospatial data management and image filtering tools using Google Earth Engine. Improvements from the tide modeling of Global Tide Surge Model (GTSM) (see below) developed by Deltares also contributed. Most of the satellite data used in this work are those collected from the ESA supported Sentinel-2 satellites and NASA supported Landsat-8. A major time-consuming task consisted of filtering rivers or lakes, which were badly detected as wet areas. Coastline contours have been computed for various levels, such as LAT (Lowest Astronomical Tide), MSL (Mean-Sea-Level), and MHW (Mean-High-Water). Intertidal areas are defined as the area between the lines delimiting the LAT and the MHW.

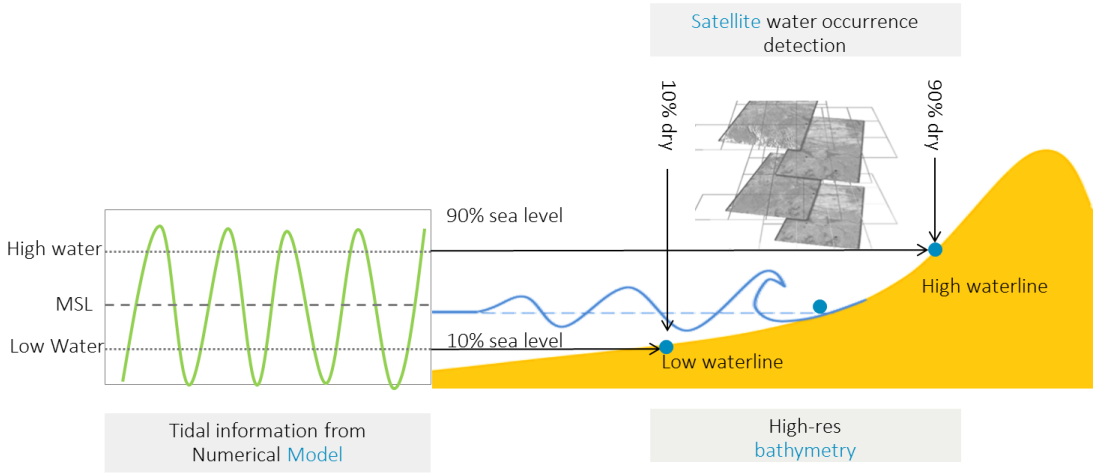


Figure: schematization of the vertical datum referencing of satellite derived coastline

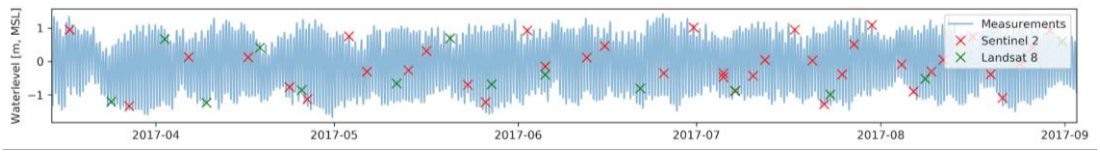


Figure: Water level values and times of images acquired by Landsat 8 and Sentinel-2 satellites.

Coastline contours have been computed for various levels, such as LAT (Lowest Astronomical Tide), MSL (Mean-Sea-Level), and MHW (Mean-High-Water). Intertidal areas are defined as the area between the lines delimiting the LAT and the MHW.

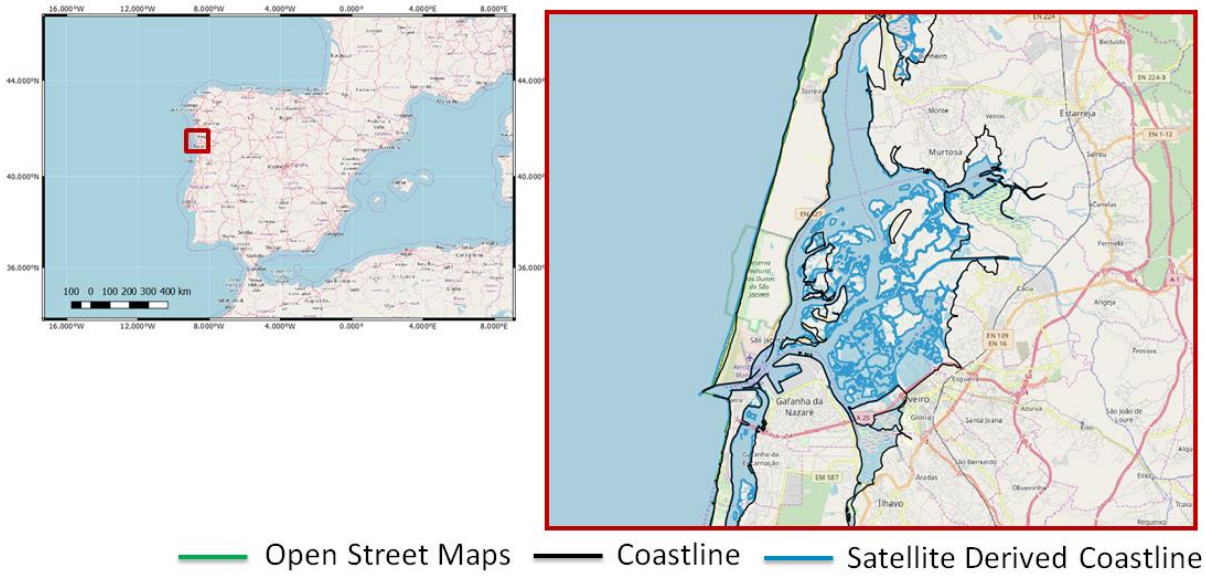


Figure: Portugal (Aveiro): comparison between SDC, OSM and coastline from official sources

The methodology and the associated production are reported in a publication [7] which can be downloaded from the EMODnet Bathymetry portal. The generated coastline products can be visualised in the EMODnet Bathymetry portal viewer under the coastline menu (see also WP3 and WP4 progress) and are also included in the OGC WMS and WFS services.

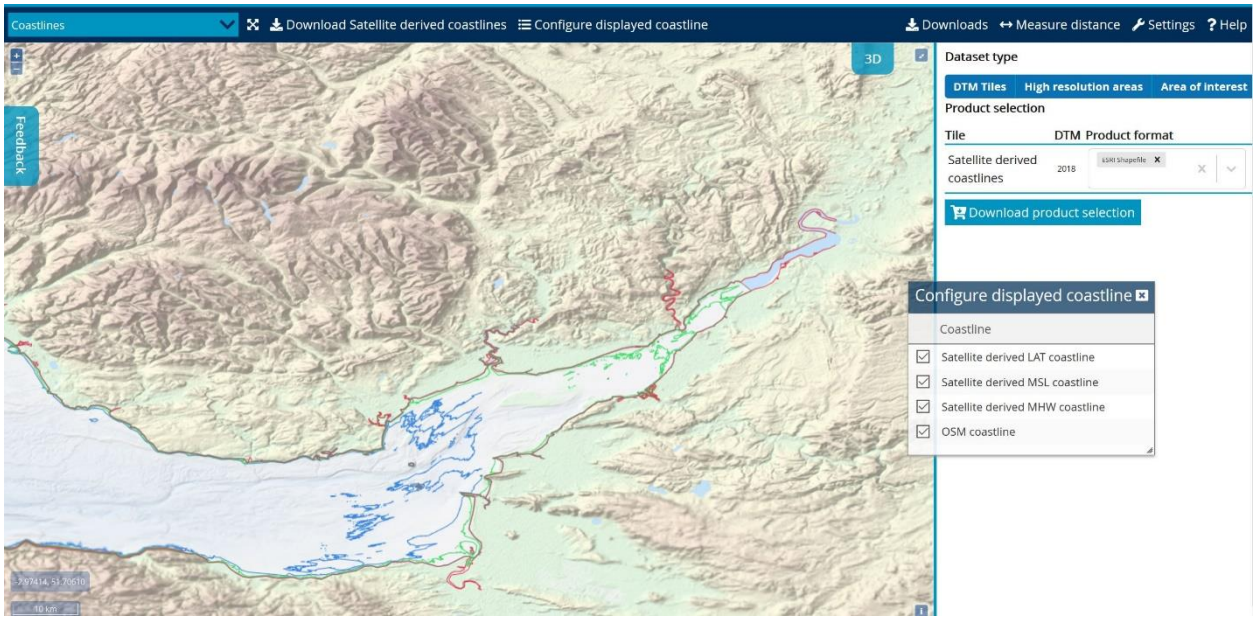


Figure: Illustration of Satellite Derived Coastlines in Bathymetry Viewing and Download service

Also provided in the report are comparisons made between the official national coastline (as gathered from the inventory), the Open Street Maps product and the MHW vector. Despite minor technical issues,

essentially related to high latitudes, the benefits from the method developed during the course of the EMODnet HRSM project, shows a number of technical benefits such as:

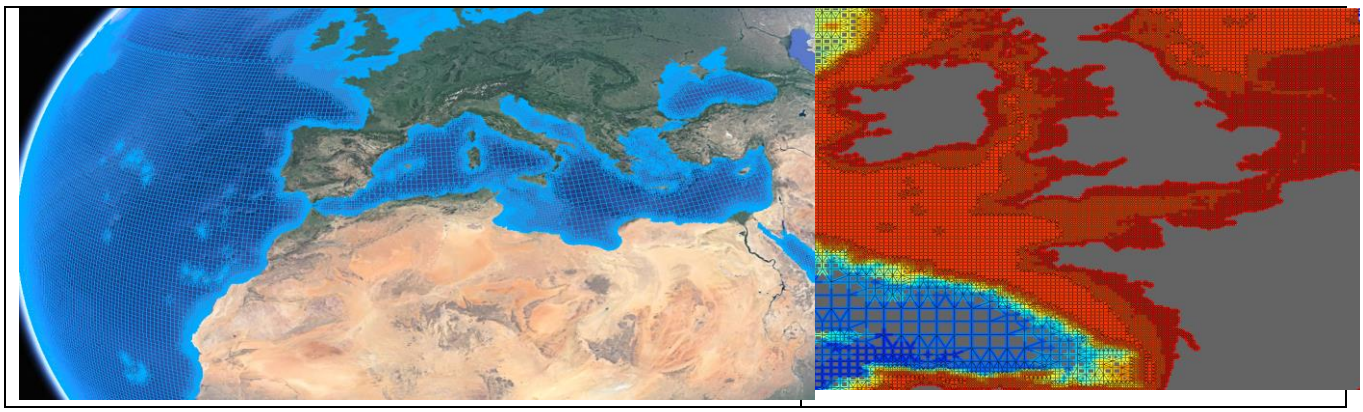
- Strongly automated process, minimizing some level of interpretation or subjectivity;
- The homogeneity in production: the generation of the coastline objects is based on the same methodology anywhere along the European coasts;
- The flexibility of the selection by the user of the coastline object that best satisfies his/her definition and usage of the coastline delineation, being the intersection either of the Lowest Astronomical tide level, the Mean Sea Level tide level or the Mean High Water tide level with the topography;
- The level of detail bound to the resolution of the satellite sensor (e.g. 10m for Sentinel 2);
- Temporal component: the coastline products are based on the processing of recent satellite images. Update can be as frequent as the satellite revisit frequency allows it (e.g. for Sentinel 2, the revisit frequency is 5 days, excluding cloud coverage).

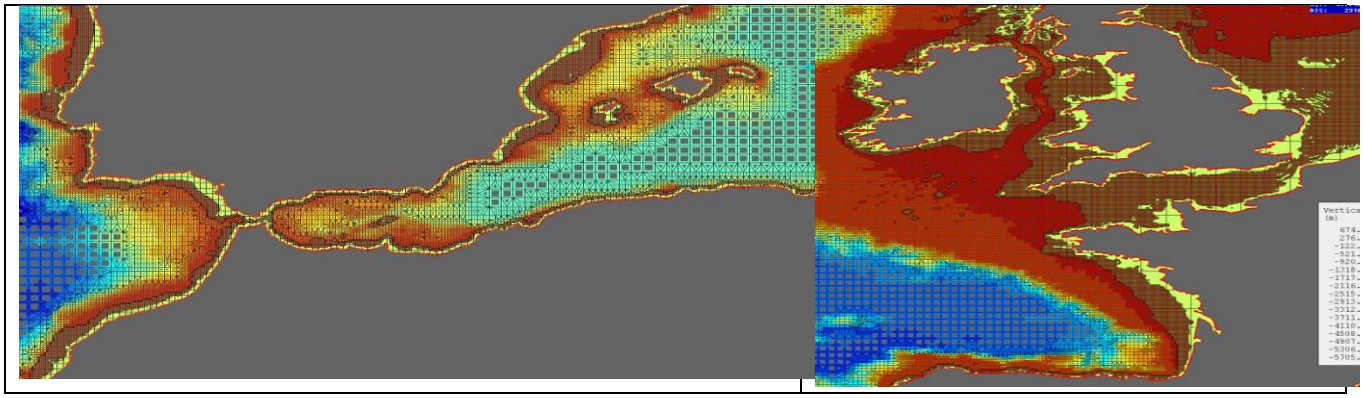
Vertical references

Bathymetric data collected from the data provider, are supposed to be referenced at the Lowest astronomical tide (IHO resolution 3/1919) which is relevant for the vertical reference for nautical charts. Most Hydrographic Offices in Europe have adopted this IHO guideline. Although IHO recommends LAT as the vertical reference for nautical charts, it is not a good vertical reference for several other applications such as hydronamical modelling near the coasts (tide, storm surge or waves). Another limitation of the LAT as vertical reference concerns the aggregation of topographic and bathymetric information in a continuous DTM, knowing that topographic data are often referenced to a MSL based system. For this reason, efforts have been brought during the course of the EMODnet HRSM project to get the ability to convert the bathymetric model from the LAT to the MSL. In order to do so, the main steps of the method are:

1. Modelling of LAT with respect to MSL with a numerical tide model for Europe
2. Extending this, relatively coarse data, in very shallow and inter-tidal waters
3. Adding the LAT-MSL difference to the LAT-referenced gridded bathymetry

The numerical tide model ‘Global Tide Surge Model (GTSM)’ is used as a robust model.





Figures: GTSM Version 3 grids: Deep water 50km→25km; Coast: 5km→2.5km globally, 1.25km Europe

Without entering in heavy physical explanations the following lines illustrate improvements gained during the EMODnet HRSM project. This model is a worldwide model which is based on an unstructured mesh (mesh decreasing to 25km in the middle of the oceans to 1.25km along the coasts of Europe. This model is forced by the most recent and publically regognised bathymetric and topographic information (EMODnet 2016 at 250m in Europe and GEBCO 2014 for the rest of the world), along with tide generating forces including amongst other winds and surface pressure. Also the model has been extensively validated against tide measurements. Despite a tendency to slightly over-predict the tide amplitudes, overall the spatial distribution of errors and correlation shows good performances with a standard deviation of the error of 0.141 m, on an extension considered comparable to the EMODnet HRSM DTM.

area	stations	STDE [m]	rel.range	R
Arctic Ocean	1	0.099	110.4%	0.97
Baltic Sea	134	0.043	188.4%	0.76
Barentz Sea	4	0.217	93.2%	0.95
Black Sea	4	0.061	71.2%	0.18
Canary Current	7	0.121	118.2%	0.99
Celtic-Biscay Shelf	56	0.253	106.3%	0.98
Iberian Coast	16	0.121	111.3%	0.99
North Sea	59	0.282	113.7%	0.94
Norwegian Shelf	12	0.136	105.0%	0.98
Mediterranean Sea	31	0.117	116.6%	0.85
total	324	0.141	142.5%	0.86

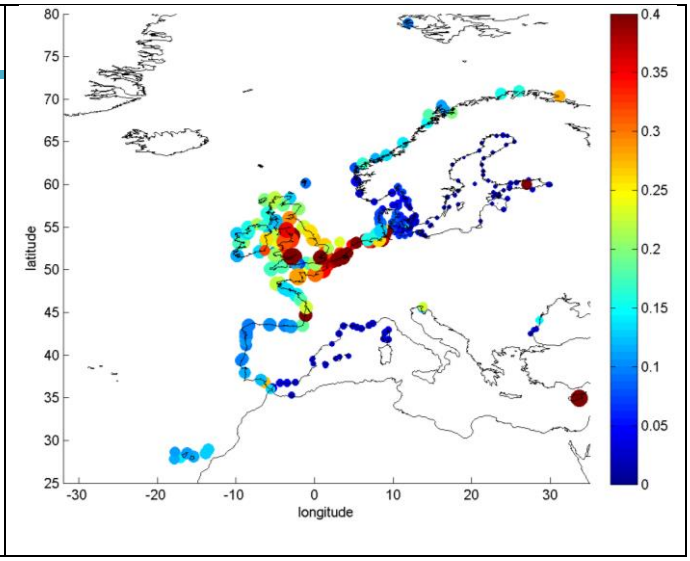


Figure: Comparing GTSM model with monitoring station data series

Although the unstructured grid of the GTSM model is much refined near the coast, its resolution is still considerably lower than that of the EMODnet-bathymetry (release 2018). This is especially

important near the coast where differences in the position of the coastline can lead to interpolation issues when correcting the bathymetry from LAT to MSL. In addition the LAT in shallow water becomes very sensitive to the bathymetry. Although somewhat arbitrarily, the following method was applied to extend the results from the GTSM modeling to inter-tidal areas all over the extension of the EMODnet DTM coverage:

1. The GTSM model values were limited to depths larger than 11 meters. This threshold was determined with a number of experiments;
2. Next the cell's that have no value were filled with a 'flood fill' procedure that assigns iteratively the average value of neighbouring cells. This filled much of the area correctly, but created sharp transitions behind islands;
3. Then the results were smoothed with a diffusion equation that only affected the values that were deleted in the first step;
4. Finally, the remaining waters were assumed to be non-tidal. The correction value was set to 0.0 here.

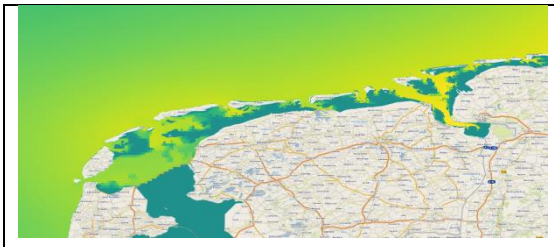


Figure: LAT-MSL separation directly from GTSM

Figure: LAT-MSL separation after removing shallow and inter-tidal waters

Figure: LAT-MSL separation after filling empty cells

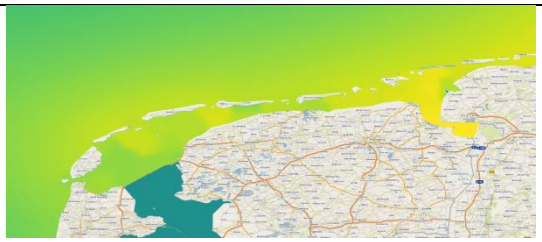


Figure: LAT-MSL separation after smoothing

Figures: LAT-MSL process illustrations

With a similar grid sampling as the bathymetric DTM, this surface has been used to convert the LAT generated DTM to a MSL vertically referenced product. As a result DTM tiles of the new EMODnet DTM can be downloaded both to LAT and MSL.

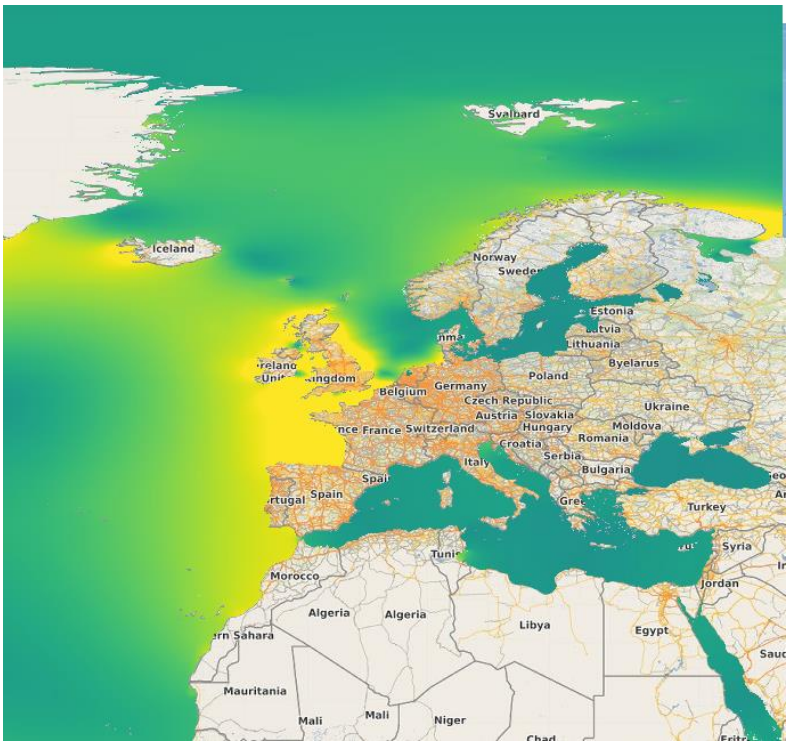


Figure: Resulting LAT-MSL separation as used for DTM tiles

WP5 contributes to the following task as formulated in the tender and as shared with WP2 and WP3:

- Task 2: Digital terrain model

WP5 also contributes to the following task as formulated in the tender and as shared with WP1 and WP2:

- Task 3: Coastline data

All tasks have been completed as can be derived from the WP1, WP2, WP3 and WP5 progress reporting.

WP6 – Outreach, helpdesk and evaluation

Thanks to the success of the previous EMODnet Bathymetry phase there are lot of interest and lots of users for the portal. The new HRSM project has benefitted from this for its outreaching activities which promote both the EMODnet Bathymetry DTM results alongside with the new challenges and results of the High Resolution Seabed Mapping (HRSM) Consortium. Chapter 9 gives a list of participations of consortium members in conferences, papers and other outreaching activities. For example, the International Hydrographic Organization (IHO) held its Assembly in Monaco, April 2017. EMODnet HRSM was cited on multiple occasions as a successful regional project involving both hydrographic offices and research institutes with complementing approaches in terms of data coverage and methodologies (acquisition, processing and validation). The Seabed 2030 initiative (https://seabed2030.gebco.net/), led by the IHO-IOC GEBCO, under the financial sponsorships of the Nippon Foundation and launched on the 6/6/2017, recognised EMODnet Bathymetry as a worldwide key actor of bathymetric data production

(https://seabed2030.gebco.net/documents/seabed_2030_roadmap_v10_low.pdf). EMODnet HRSM joined the EMODnet Open Sea Lab Hackathon in September 2017 which was very valuable for the EMODnet HRSM Consortium members, as they were able to experience and evaluate how the EMODnet Bathymetry data are used. The progress of EMODnet HRSM was presented to an international audience of bathymetry experts in December 2017 at AGU in New Orleans, USA. In March 2018 EMODnet HRSM was presented and promoted at Oceanology International 2018 in London – United Kingdom by a poster at the MARIS stand, by a presentation at the Ocean ICT Expo, and by a dedicated half-day EMODnet HRSM Workshop. At the Workshop the EMODnet context, methodology, use of present data portal, new satellite derived bathymetry, coastline generation, and planned new DTM release have been presented followed by group discussion. Also the EMODnet Ingestion portal was presented as a way for third parties to make their survey data available. EMODnet Bathymetry has also been presented to a French audience of specialists in marine geographical sciences in May 2018 at the MERIGEO conference (http://www.merigeo.fr/). This was followed by presentations of MARIS and Shom in June 2018 at the Satellite Derived Bathymetry (SDB) Day workshop, organised by EOMAP. This offered a unique opportunity for hydrographic institutions, government and industry to discuss capabilities, data integration,requirements and quality standards.In September 2018 Shom gave a presentation at the First International Hydrographic Remote sensing Workshop, in Ottawa, Canada, organised jointly by the Canadian Hydrographic Service (Canada), Shom (France) and the National Oceanographic and Atmospheric Administration (USA. September 2018 also marked the release of the new DTM which was launched with a lot of promotion such as a press release distributed in cooperation with EMODnet Secretariat, EU DG-MARE and international collaborators (IHO/GEBCO) to circa 4000 – 5000 contacts. The press release was also relayed to Hydro International,Dredging News Online, Offshore Services Online OSO to reach the hydrographic community,offshore and maritime industry and research sector. This press release and the new DTM launch generated a lot of portal traffic as can be seen from the key indicators in Chapter 10. Then in November 2018 EMODnet HRSM and its new DTM were presented at the International conference on Marine Data and Information System (IMDIS), Barcelona, Spain, which was organized by SeaDataNet. Also in November 2018, it was presented at the GEBCO – Map the Gaps conference in Canberra, Australia. Finally in December 2018 a poster of the new DTM was presented at the AGU Fall Meeting, Washington, USA.

The web portal was maintained, and statistics about use of portal and services were collected. Specific work has been done in order to comply with the new definition of progress indicators. Also many questions were received and answered by the helpdesk. In the project period questions from more than 80 users were received and answered by the helpdesk. The user questions are summarized in chapter 8. As indicated in WP3 and WP4 a lot of efforts have been undertaken for expanding the offer of products and services of the EMODnet Bathymetry portal. Also functionality has been expanded such as adding registration of downloading users, their downloaded DTM tiles and related formats by means of an order form. The web statistics are detailed in chapter 10 and are very good. The web portal and its services are well visited with > 10.000 unique visitors per month. Also the OGC web services (machine-to-

machine) are very popular with more than 250.000 visitors per year. The number of downloaded DTM tiles amounts to circa 10.000 per 3 months. With the launch of the new DTM end September 2018 registration was added of the identity of downloaders and reasons for use. In the last quarter of 2018 the new service registered > 12.000 downloaded tiles from circa 1700 unique users from > 800 organisations from industry (22 %), government (6%), research institutes (18%), universities (43%), public (8%), international organisations (1%) and NGO's (2%). Thereby each user indicated trustworthy reasons for use. Close interaction and cooperation took place with the international community in order to ensure interoperability. Further details about international cooperation are detailed as part of the separate "EMODnet HRSM report on interoperability and international collaboration" [4].

WP6 combines the following task as formulated in the tender:

- Task 6: Helpdesk

WP6 contributes to the following task as formulated in the tender and as shared with WP4:

- Task 5: Web portal

WP6 also contributes to the following task as formulated in the tender and as shared with WP1:

- Task 7: International interoperability

WP6 also contributes to the following task as formulated in the tender and as shared with WP4:

- Task 9: Monitoring of performance

All tasks have been completed as can be derived from the WP1, WP4, and WP6 progress reporting and the separate report on interoperability and international collaboration [4].

8. User Feedback

Quite a number of feedback forms were received through the Helpdesk. These were support messages for the project, and questions about technical issues and citation. Messages were answered where needed. Sometimes answering took a few days as it had to be analysed. The table below gives a summarised overview of feedback events. Due to privacy law no personal names or email addresses are mentioned. In some cases use of general email providers like Yahoo, Hotmail and Gmail also makes it difficult to identify the organization of users.

Date	Country	Organization	Type of user feedback	Response time to address user request
2017-01-10	Greece	HCMR	How to download small area as XYZ	One day later
2017-02-08	France	Aix-Marseille Université	Problem with downloading DTM tiles	Same day
2017-02-14	??	??	Problem with downloading DTM tiles	Next day
2017-03-08	Iceland	ISOR	Question about wrecks	Two days later
2017-03-23	Ireland	UCC	Question about WCS service	One day later
2017-03-27	Ireland	UCC	Question about MSL – LAT conversions	Same day
2017-04-03	Netherlands	UNESCO-IHE	Question about historic data sets	Three days later
2017-04-07	United Kingdom	FUGRO	Question about using EMODnet DTM in publication.	Three days later
2017-04-12	Denmark	GEUS	Question about shaded WMS	Three days later
2017-04-13	??	??	Question about vertical reference.	Two days later
2017-04-14	Spain	??	Downloading DTM for Mediterranean.	One day later
2017-05-08	United Kingdom	FUGRO	Continuation of earlier communication about using EMODnet DTM in publication and sharing FUGRO data.	Not applicable
2017-05-15	??	??	Reference level for bathymetry	Two days later
2017-06-14	Spain	IGME	How to download the DTM	Two days later

Date	Country	Organization	Type of user feedback	Response time to address user request
2017-06-30	Romania	DDNI	Change of website URL and email for DDNI in EDMO	Two days later
2017-8-31	??	??	Question about using LAT	Immediately
2017-8-31	Belgium	RBINS	Question about how to download the DTM	A few days later
2017-9-5	United Kingdom	GeoCento	Question about OpenSearch / API's for EOBroker project	Next day
2017-9-15	United Kingdom	UK MetOffice	Question about anomalies near coasts	10 days later in order to have a good answer
2017-10-6	United Kingdom	Fugro	Question about Israel EEZ data	Same day
2017-10-9	United Kingdom	Coventry University	Question about format	Same day
2017-10-10	United Kingdom	BP	Question about portal issue	Same day
2017-10-19	??	??	Question about area of interest	Two days later
2017-10-30	Belgium	IMDC	Question about vertical reference	Three days later
2017-10-24	United Kingdom	ERILAW	Question about REST service for site for diving in Greece	A week later. Had to check first.
2017-11-07	Germany	Student	Question about waterdepth profiles	Same day
2017-12-06	Netherlands	Periplus	Question about OGC web services	Same day
2017-12-07	Cyprus	CUT	Wants to use DTM in EU project for Augmented Reality	Same day
2017-12-12	Oman	Mirath Petrogas	Search for survey companies	One week later
2017-12-19	United Kingdom	Cardiff University	In search of current data.	Next day
2018-01-17	United Kingdom	University of Nottingham	Question about units in DTM	Next day
2018-01-25	Spain	?	Compliment	N.A.

Date	Country	Organization	Type of user feedback	Response time to address user request
2018-01-31	Denmark	MAKE	Request for 30-70 m meter map becausde of wind data fields	A few days later
2018-02-12	Italy	EDPR	How to acknowledge EMODnet Bathymetry DTM	Same day
2018-03-01	Belgium	Universite de Liege	How to use the WCS service	Same day
2018-03-02	Netherlands	?	What is the source of the DEM	Same day
2018-03-03	United Kingdom	University	Question about coastal data for UK waters	A few days later
2018-03-29	Germany	Niedersachsen	Question about LAT – MSL vertical references	A few days later
2018-04-04	USA	ExxonMobil	Terms and conditions for downloading and use of EMODnet DTM	A few days later
2018-04-09	France	?	Problem with WCS	Same day
2018-04-10	?	?	Question about ODV format	Same day
2018-04-24	Turkey	Karadeniz Technical University	Question about a position at EMODnet Bathymetry because of study	A few days later
2018-04-30	Netherlands	Ecopath International Initiative	Question about brush strokes to the EMODnet secretariat	A week later
2018-04-25	USA	Massachusetts Institute of Technology	Question about downloading	A few days later
2018-04-30	Netherlands	IRM-Smart Pipeline Data BV	Interest in survey data of North Sea for a pipeline provider.	A few days later
2018-04-30	?	?	Question about acknowledgement because of publishing.	A few days later
2018-05-07	Netherlands	Aquavision	Question about reference levels.	A week later
2018-05-11	Greeece	?	Question about circles on Google Maps	A few days later
2018-05-16	?	?	Question about wrecks data	A week later
2018-05-18	Spain	ULPGC	Compliment and explaining how they use EMODnet Bathymetry.	A few days later

Date	Country	Organization	Type of user feedback	Response time to address user request
2018-05-23	United Kingdom	MSPTV	Looking for bathy data in Danish sector	Same day
2018-05-29	Spain	ICM-CSIC	Question about datums	Same day
2018-06-13	Spain	AZTI	Has local problem with viewing the bathy service	Same day
2018-06-14	Turkey	TR-ARGE	Question about bathy data for Turkish waters	Same day
2018-07-10	United Kingdom	ONEBV	Question about data access for the NL Waddensea. Delivery arranged together with Royal Netherlands Navy, Hydrographic Service	A few days because of interaction
2018-07-19	Curacao	?	Question about the depth of Playa Canoa, Curacao Willemstad (location Caribbean sea).	4 days later due to asking info from partner
2018-08-12	?	?	Question about higher resolution DTM release	A few days later
2018-08-20	Israel	?	Question about selection by area of interest	Same day
2018-08-22	United Kingdom	Caravan-Media	Question about using DTM for a documentary as open source.	1 day later
2018-08-20	United Kingdom	NOC	Question about NetCDF format.	2 days later
2018-08-29	United Kingdom	Intertek	Question about age of data sets used.	Same day
2018-09-17	Netherlands	TNO	Question about vertical reference level of DTM	Same day
2018-09-19	Germany	University of Kiel	Question about European coastlines.	Same day
2018-09-25	Netherlands	BosKalis	Question: Isue with ArcGrid format.	Same day
2018-09-26	United Kingdom	?	Question: Issue with opening EMO files.	Same day
2018-09-16	United Kingdom	Atkins Global	Question about European coastlines.	Same day

Date	Country	Organization	Type of user feedback	Response time to address user request
2018-09-23	France	?	Question about WCS service use	3 days later
2018-09-26	?	?	Question about ARCGIS format	Same day
2018-09-27	United Kingdom	Atkins Global	Question about possibly corrupted tile data	Same day
2018-09-27	USA	3UTECH	Question about download time out	Next day
2018-10-01	?	?	Question about tile overlap	Same day
2018-10-04	United Kingdom	Atkins Global	Question about handy tool for splitting large files	Same day
2018-10-15	?	?	Problem with 3D viewer	Same day
2018-10-10	Italy	ARPAE	Identified issue with NetCDF tiles	Few days later
2018-10-22	Denmark	FCOO	Identified issue with NetCDF tiles	Same day
2018-10-24	Netherlands	NIOZ	Question about LAT – MSL conversion	Week later
2018-11-01	Netherlands	UN-IHE	Question about coastlines	Same day
2018-11-01	United Kingdom	UKHO	Identified issue with NetCDF tiles	Same day
2018-11-05	United Kingdom	Spirit Energy	Question about UTM versus Lat-Lon	Week later
2018-11-18	Norway	NGI	Question about use of Mapper software	Few days later
2018-12-04	Tunesia	ESAT University	Looking for a job	Few days later
2018-12-11	United Kingdom	STFC	Issues with ordering	Same day

9. Outreach and communication activities

See also WP6 report in Chapter 7.

Date	Media	Title	Short description and/or link to the activity
2017-03-01	Press release at Hydro International website	UK Input into EMODnet Phase 3 High Resolution Seabed Mapping Project	Web link : Press release by OceanWise
2017-03-08	Presentation at 7th ODIP II Workshop, Hobart - Australia	EMODnet – Bathymetry	Web link : Presentation by MARIS
2017-03-08	Article in EOS magazine	Airline Flight Paths over the Unmapped Ocean	Web link : Article by Shom together with NOAA
2017-04-24	Presentation at EGU 2017 Conference, Vienna, Austria	EMODnet High Resolution Seabed Mapping – further developing a high resolution digital bathymetry for European seas	Web link: Presentation by MARIS
2017-04-24 to 2017-04-28	Presence of 13 members of the consortium at the IHO Assembly	IHO Assembly	Refer to https://www.iho.int/mtg_docs/conf/19IHC2017/letters/A1_WP1_01_EN.pdf
2017-05-30 To 2017-05-31	EMODnet Geology Kick Off meeting	EMODNet High Resolution Seabed Mapping (HRSM) presentation	Technical presentation done in order to introduce potential collaboration between both thematic portals
2017-05	Short insert in the French review Geomètre	Portal.emodnet-bathymetry.eu	Géomètre – Revue des géomètres-experts n°2147 – Mai 2017
2017-06-21	Oral presentation at the 16th International User Conference, CARIS 2017	Data Dissemination and Interpretation at the British Geological Survey	Technical presentation done by BGS in front of the community of users of the bathymetric softwares CARIS
2017-06-21	Oral presentation at the 16th International	Coastal and Marine Spatial Data Infrastructure in Flanders, Belgium	Technical presentation done by MDK in front of the community of users of the bathymetric softwares CARIS

Date	Media	Title	Short description and/or link to the activity
	User Conference, CARIS 2017		
2017-06-01	Popular journal "le Marin"	L'hydrographie vers un partage de données	http://www.lemarin.fr/archives/search/shom/Le%20Marin/2017-06-01/2017-06-01
2017-09-29	General public presentation	"Nuit européenne des chercheur(e)s"	Demonstration of Shom's activities to the general public including the bathymetry of european waters as part of EMODnet Bathymetry – Horizon 2020 Marie Curie Sklodowska – Grant Agreement N°722266.
2017-09-27	Oral presentation	IHO EU Network Working Group	Oral presentation of the general objectives and recent progresses of the EMODnet High Resolution Seabed Mapping to
2017-09-13 To 2017-09-15	Oral presentation	8th EMODnet Steering Committee	Oral presentation giving recent updates to the other thematic lots, Check Point lots and the EMODnet Secretariat.
2017-07-11 To 2017-07-12	Oral presentation, discussion and portal demonstration	Workshop on "Global Reference Grid Systems for Big Geospatial Data"	Invited to provide input in terms of technical descriptions and need in terms of representation of marine environmental data and more especially bathymetric data.
2017-10-19	Oral presentation	SeaDataCloud Plenary Meeting, Athens - Greece	Presentation by MARIS giving overview and latest progress of the EMODnet HRSM project and portal
2017-11-13	Oral presentation	GEBCO Guiding Committees – Busan – South Korea	Presentation by Shom at the technical committees of the GEBCO annual meeting.
2017-11-15	Participation	EMODnet 'Open Sea Lab' hackaton, Antwerp - Belgium	Participation of GGSGc and Shom on behalf of EMODnet HRSM to give support and information about EMODnet HRSM products and services.
2017-11-15	Oral presentation	IODE – ODIP Best Practices workshop, Paris, France	Presentation by MARIS about SeaDataNet, EMODnet and AtlantOS, also highlighting EMODnet HRSM.
2017-11-16	Oral presentation	Hydro'17 – Rotterdam – The Netherlands	Presentation by RNLN and Shom at the international hydrographic conference HYDRO'17. Two presentations given during this conference referenced the EMODnet Bathymetry portal and product.
2017-12-05	Oral presentation	5th Crowd Source Bathymetry Working Group - Monaco	Presentation by Shom to the members of the IHO - CSBWG, with highlights on the

Date	Media	Title	Short description and/or link to the activity
			evaluation of the quality of source data and metadata management.
2017-12-06	Demonstration	International Hydrographic Organization - Monaco	Demonstration of the EMODnet Bathymetry portal and EMODnet HRSM current project to the new board of Directors of the International Hydrographic Organisation
2017-12-13	Oral presentation	AGU Fall meeting, New Orleans - USA	Presentation by MARIS and Shom at the American Geophysical Union annual conference giving overview and latest progress of the EMODnet HRSM project and portal
2018-03-13	Oral presentations Discussion forum	EMODnet HRSM workshop at Oceanology International, UK	Presentation by MARIS, Shom, GGSGC, Deltares, Ifremer of the EMODnet HRSM project and portal.
2018-03-13 To 2018-03-15	Poster	Promotion by stand and presentation, UK	Poster at MARIS stand and presentation by MARIS at Ocean ICT Expo.
2018-03-20 to 2018-03-22	Oral Presentation	MERIGEO conference France	Presentation by Shom at a national conference on marine geographic information technology. Refer to http://www.merigeo.fr/content/download/116244/1585768/file/30_Oral_Monpert_merIGeo2018.pdf?version=1
2018-06-06 To 2018-06-07	Oral presentation	Satellite derive bathymetry (SDB) Day 2018 Workshop Germany	Workshop organised by partner EOMAP, with attendance from Ca 60 participants from for hydrographic institutions, government and industry, including IHO Secretary General. EMODnet HRSM was presented and promoted with emphasis on the use of SDB information to provide information where bathymetric coverage with more accurate techniques is missing. Refer to : https://sdbday.org/
2018-09-20	Oral Presentation	First International Hydrographic Remote sensing Workshop Canada	Workshop organised by major Hydrographic Offices with strong interest in the use of remote sensing techniques for the mapping of coastal areas. Like for the previous presentation EMODnet HRSM was presented and promoted with emphasis on the use of SDB information to provide information where bathymetric coverage with more accurate techniques is missing.

Date	Media	Title	Short description and/or link to the activity
2018-09-24	Press campaign	Promotions of the new bathymetric grid	Wide communication jointly organised by EMODnet Bathymetry Consortium coordinators, Partners, EMODnet Secretariat and DG-MARE and international collaborators (IHO/GEBCO) using social networks and professional networks (specialized magasines)
2018-09-24	Youtube Movie	3D Animated fly-through over in the Atlantic and Mediterrannean areas	Refer to: https://www.youtube.com/watch?v=xR6Qx6UxSbw&feature=youtu.be
2018-10-05	Oral presentation	Institute of Marine Science, ICM - CSIC, Barcelona,	Internal presentation detailing What the UTM does and what can do with the data of your oceanographic cruises, at national and international level (SeaDataCloud, EMODnet)
2018-10-06 To 2018-10-07	Hackathon	Ocean Hackathon, France	Promotion by the Secretariat and EMODnet bathymetry members of all the EMODnet thematic layers in order to foster innovation through the usage of the information for GIS/IT projects.
2018-10-17 To 2018-10-19	Oral presentation	JONSMOD conference, The Netherlands	On the computation of LAT grids
2018-11-07	Oral presentation	International conference on Marine Data and Information System (IMDIS), Barcelona, Spain	Promotion of the EMODnet bathymetry products and collaboration to marine geospatial practitioners from research organisations and governmental bodies.
2018-11-21 To 2018-11-23	Poster and contributions in oral presentation	EOOS Conference 2018 - The European Ocean Observing System, Brussels, Belgium	Poster and numerous contributions in presentations to a public of ocean observing stakeholders from the scientific community, public authorities, industry and civil society.
2018-11-14	Oral presentations	GEBCO map the gaps – Canberra, Australia	Oral presentation dedicated to international experts in bathymetry.
2018-11-14	Oral presentation	Nippon Foundation-GEBCO Seabed 2030 Project regional mapping meeting for Atlantic and Indian Oceans - Palisades, New York, USA	Presentation of the EMODnet Bathymetry coverage and metadata content to the SEABED2030/GEBCO
2018-12-11	Video	Video, describing the benefit of EMODnet Bathymetry	Generated by the EMODnet secretariat with contributions from EMODnet Bathymetry coordinators. Refer to: https://www.youtube.com/watch?v=ICOoEsxDaSY

Date	Media	Title	Short description and/or link to the activity
2018-12-10 To 2018-12-14	Poster	AGU Fall Meeting, Washington, USA	Poster dedicated to the international community of R&D in earth, oceanographic and spatial sciences.

10. Updates on Progress Indicators

The following indicators 1 - 8 are derived from the 'old' key indicators system in order to have a complete and consistent set of key indicators over the full project duration as the 'new' key indicator system just was introduced in 2018. However there are a few new indicators with additional type of information. Therefore these indicators have been included in the paragraph 'Additional Indicators'.

Indicator 1 - Volume of data made available through the portal

The total number of CDIs for bathymetric survey data sets has increased from **14791 to 27168.**

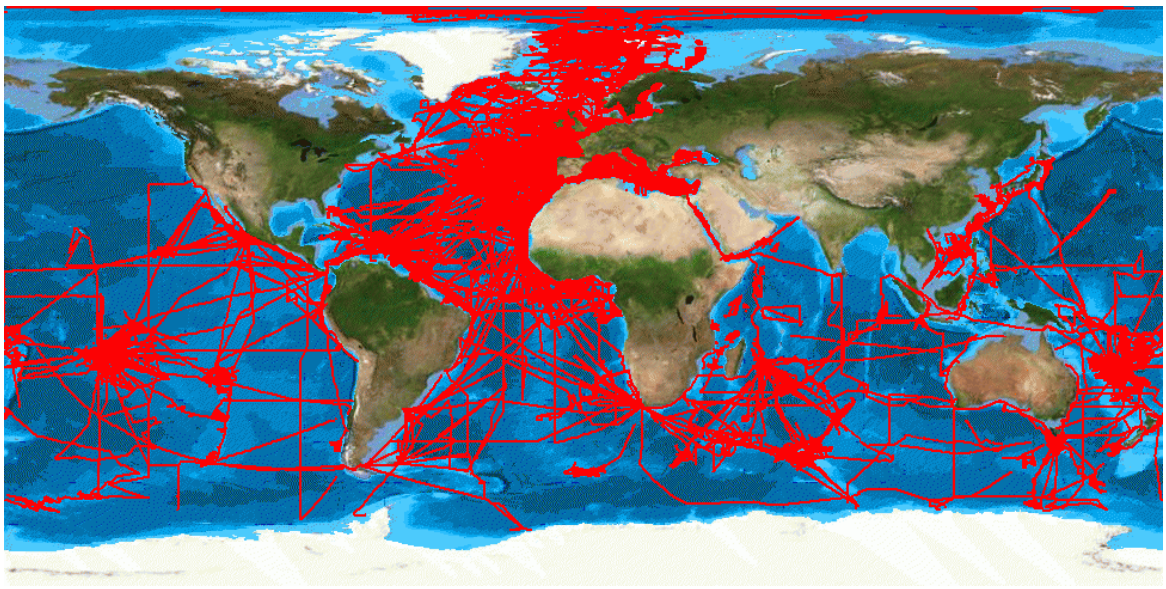


Image: Map of all entries in the CDI catalogue service

The total in production covers the whole globe. Specifically relevant for European waters (Lat Long box**: N80, W-30 ; N20, E45)** has increased from **11505 to 22486.**

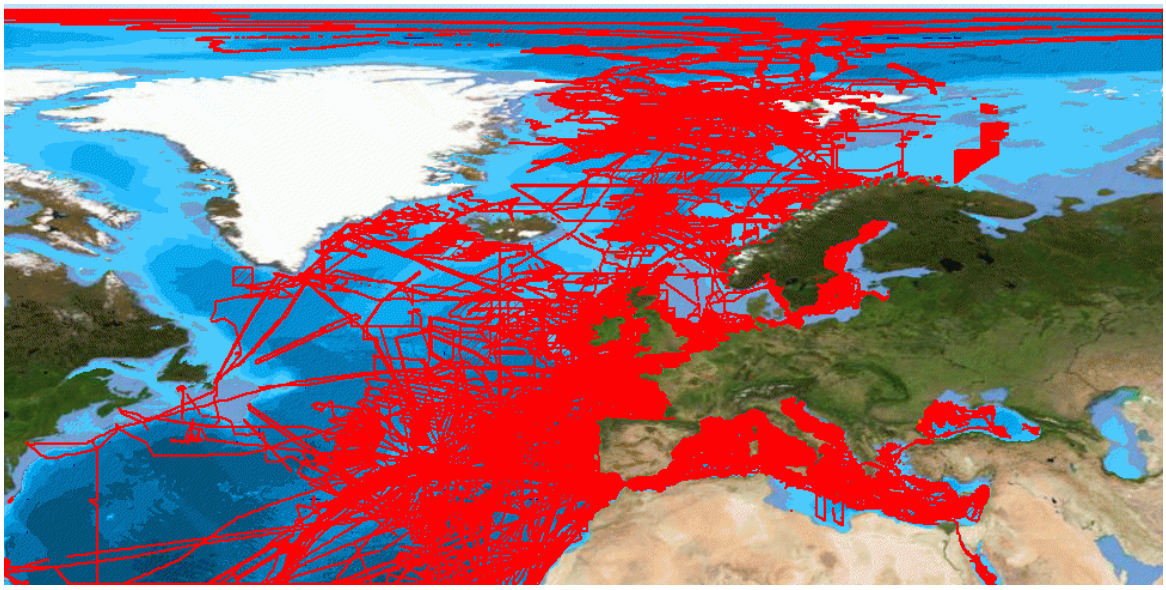


Image: Map of entries in the CDI catalogue service for European marine waters

Of these **1774** are unrestricted, while all other require negotiation. Bathymetric survey data are costly to acquire and by most data providers treated with access restrictions which are indicated as part of the CDI metadata. Users can submit requests for access by means of the shopping mechanism in the CDI Data Discovery and Access service. This way data providers are informed about the requests and will contact the users by email or telephone for further discussing their requests. Most of the time this leads to positive decisions and delivery of data sets through the CDI Data Discovery and Access service or directly by e-mail by-passing the CDI service. It can also be that no agreement can be reached and then users will not get access to the requested data sets. Anyway the negotiation is an issue between the users and the data providers whereby the CDI service and in particular its Request Status Manager (RSM) service can serve as an instrument, but it can be by-passed. So as EMODnet Bathymetry there is no absolute complete insight in all transactions. Remark: as part of the EU SeaDataCloud project developments are underway to overcome this issue by introducing a third status option in the RSM which allows data providers to by-pass the RSM for delivery, but still indicate to the RSM that the delivery has been granted to the user. This way the RSM stats will be more complete in the near future.

Next to survey data as described in the CDI Data Discovery and Access service, there are also **Composite DTM's** used as source data. These are described with metadata in the Sextant catalogue service. The table below gives a list of the present Composite DTM entries.

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Regional DTM for Norway area	Norwegian Hydrographic service	Norway	Electronic charts NHS	unclear	Arctic
NHS 50m grid from multi-beam surveys	Norwegian Hydrographic service	Norway	multi-beam	50 m	Arctic
Norway coastal 50 m composite DTM	Norwegian Hydrographic service	Norway	single beam and multi-beam	50 m	Arctic
Svalbard_data_2016	Norwegian Hydrographic service	Norway	multi-beam echosounders	10 m	Arctic
International Bathymetric Chart of the Arctic Ocean	Stockholm University	Sweden	single beam and multi-beam	100 m	Arctic
Bathymetry_Bay of Biscay	IFREMER	France	Single beam and multi-beam	1000 m	Atlantic
Satellite derived bathymetry Channel Islands	EOMAP	Germany	Sentinel 2 satellite data	10 m	Atlantic
NHS 50m grid	Norwegian Hydrographic service	Norway	multi-beam	50 m	Atlantic
Norwegian Hydrographic Service 1/16 EMODnet grid 2018-04	Norwegian Hydrographic service	Norway	multi-beam echosounders	125 m	Atlantic
West Continental Shelf of Portugal	EMEPC	Portugal	Multi-beam	500 m	Atlantic
West Central Continental Shelf Portugal	IPMA	Portugal	(EMEPC sources)	250m	Atlantic
EMEPC Central_Continental_Shelf_Portugal	IPMA (EMEPC sources)	Portugal	Multi-beam	500 m	Atlantic

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
ZEE_GALICIA	IEO	Spain	multi-beam	460 m	Atlantic
Gulf of Cádiz (353_291106)	IEO	Spain	Single beam and multi-beam	200 m	Atlantic
Gulf of Cádiz (353_291219)	IEO	Spain	multi-beam	200 m	Atlantic
Gulf of Cádiz (353_291218)	IEO	Spain	multi-beam	200 m	Atlantic
PAIS_VASCO	IEO	Spain	multi-beam	250 m	Atlantic
353_291721 - Lanzarote Island Margin Eco-cartography	IEO	Spain	multibeam echosounders	100 m	Atlantic
353_291704 - Cabrera Island Natural Park Spain	IEO	Spain	multibeam echosounders	100 m	Atlantic
353_291716 - El Hierro Island Margin Eco-cartography	IEO	Spain	multibeam echosounders	100 m	Atlantic
353_291718 - La Gomera Island Margin Eco-cartography	IEO	Spain	multibeam echosounders	100 m	Atlantic
353_291720 - Fuerteventura Island Margin Eco-cartography	IEO	Spain	multibeam echosounders	100 m	Atlantic
2607_Saint Mounts Bay, Cornwall, U.K. composite DTM comprising multiple surveys	OceanWise	United Kingdom	multi-beam echosounders	15 m	Atlantic
Regional bathymetric Atlantic – Channel – North-Sea DTM (100 m, HOMONIM project)	Shom	France	single beam and multi-beam	100 m	Atlantic / North Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Estonian waters 50m resolution	Estonian Maritime Administration	Estonia	Single beam	50 m	Baltic
3085_Estonia_DTM	Estonian Maritime Administration	Estonia	single beam and multi-beam	50 m	Baltic
Finnish EEZ waters 200 m resolution	Finnish Transport Agency (FTA)	Finland	multibeam echosounders	200 m	Baltic
Finnish waters, charted soundings	Finnish Transport Agency (FTA)	Finland	single beam and multi-beam	300 m	Baltic
Baltic Sea – German zone	BSH	Germany	Single beam and multi-beam	.375 arc minutes	Baltic
Polish waters in 500 m resolution	Hydrographic Office of the Polish Navy, HOPN	Poland	single beam and multi-beam	500 m	Baltic
Baltic Sea Bathymetry Database	Baltic sea Hydrographic Commission	Sweden	Multiple sources	500 m	Baltic
Swedish EEZ waters 20m resolution	Swedish Maritime Agency	Sweden	single beam and multi-beam	20 m	Baltic
Swedish territorial waters 300 m resolution	Swedish Maritime Agency	Sweden	single beam and multi-beam	300 m	Baltic
Regional DTM of German continental shelf	BSH	Germany	from German Hydrographic Office	50 m	Baltic / North Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Danish waters in a 500 m grid	Danish Maritime Agency	Denmark	single and multibeam echosounders	500 m	Baltic / North Sea
Latvian waters, charted soundings	Latvian Hydrographic Office	Latvia	Single beam and multi-beam	300 m	Baltic Sea
Bulgarian Black Sea South Shore	IO-BAS	Bulgaria	single-beam echosounders	58 m	Black Sea
Bulgarian Black Sea Central Slope	IO-BAS	Bulgaria	multibeam echosounders	54 m	Black Sea
Gridded bathymetry from multibeam echosounder HS-DS2 data of the cruise M51/4 (2001)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder HS-DS2 data of the cruise M52/1 (2002)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM120 data of the cruise M72/1 (2007)	MARUM	Germany	single-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM710 data of the cruise M72/1 (2007)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry south of Crimea from multibeam echosounder EM120	MARUM	Germany	multi-beam echosounders	125 m	Black Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
data of the cruise M72/2 (2007)					
Gridded bathymetry from multibeam echosounder EM120 data of the cruise M72/3a and M72/3b (2007)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM120 data of the cruise M72/4 (2007)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM120 data of the cruise M72/5 (2007)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise M84/2, off Eregli (2011)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise M84/2, off Georgia (2011)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise M84/2, off Kerch and the eastern Crimea (2011)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Gridded bathymetry from multibeam echosounder EM122 data of the cruise M84/2, off Samsun (2011)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM120 data of the cruise MSM15/1 (2011)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM120 data of the cruise MSM15/2 (2011)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise MSM33 (2013)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise MSM34/1 (2013)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise MSM34/2 (2013)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM122 data of the cruise MSM35 (2015)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder ELAC BottomChart MkII data	MARUM	Germany	multi-beam echosounders	125 m	Black Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
of the cruise POS317/3 (2004)					
Gridded bathymetry from multibeam echosounder ELAC BottomChart MkII data of the cruise POS317/4 (2004)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Gridded bathymetry from multibeam echosounder EM12S data of the cruise TTR6/2 (1996)	MARUM	Germany	multi-beam echosounders	125 m	Black Sea
Mediterranean sea South of France and Corsica	IFREMER - Shom	France	multibeam echosounders	100 m	Med Sea
MULTIBEAM GRIDDED DATA FROM CIRCEE CRUISE	Universite de Bretagne Occidentale	France	multi-beam echosounders	50 m	Med Sea
Satellite Derived Bathymetry Crete - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry South Aegean- Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Tobruk - Libya	EOMAP	Germany	LandSat 8 satellite	30 m	Med Sea
Satellite Derived Bathymetry Andalusia, Murcia, Com. Valencia- Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Peloponnese, South Aegean, Attica, West Greece - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Satellite Derived Bathymetry Andalusia II- Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Attica, Central Greece, Thessaly - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Central Macedonia, Mount Athos, East Macedonia and Thrace - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry South Aegean, Karpathos, Rhodos & Cos, - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Balearic Islands - Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Melilla - Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Attica & Peloponnese - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Ceuta - Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Catalonia - Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry North Aegean & East Macedonia and Thrace - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Andalusia- Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Satellite Derived Bathymetry Com. Valencia- Spain	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry North Aegean, Chios, Lesvos, Psara, Antipsara - Greece	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Satellite Derived Bathymetry Crete Spinalonga - High Resolution	EOMAP	Germany	LandSat 8 satellite	15 m	Med Sea
Composite high resolution DTM of a subset form the Calabrian Arc	MARUM	Germany	multi-beam echosounders	25 m	Med Sea
Cyprus-Compilation	Geological Survey of Israel	Israel	Composite 25 m grids from single beam	0.25 minutes	Med Sea
Joint Israel National Bathymetric Survey Data	Geological Survey of Israel	Israel	Multi-beam	0,25 minutes	Med Sea
Nile-Delta-UKHO-UKHD-Soundings	Geological Survey of Israel	Israel	Soundings from UKHO – single beam	0.1 minutes	Med Sea
Libya-Italian-HDNO-0.25min	Geological Survey of Israel	Israel	Italian surveys – single beam	0.25 minutes	Med Sea
Central-southern Tyrrhenian Sea	CNR-IGAG	Italy	multibeam echosounders	25 m	Med Sea
Adriatic_singlebeam	CNR-ISMAR	Italy	Single beam	200 m	Med Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Adriatic_Emilia-Romagna	CNR-ISMAR	Italy	Single beam and multi-beam	10 m	Med Sea
Venice lagoon	CNR-ISMAR	Italy	multibeam echosounders	5 m	Med Sea
South Adriatic sea	CNR-ISMAR	Italy	multibeam echosounders	20 m	Med Sea
Mid Adriatic sea	CNR-ISMAR	Italy	multibeam echosounders	20 m	Med Sea
Tyrrhenian Sea - Sardinian Channel	CoNISMa	Italy	multibeam echosounders	50 m	Med Sea
Continental margins of Calabria	CoNISMa	Italy	multibeam echosounders	50 m	Med Sea
South Tyrrhenian Sea	CoNISMa	Italy	multibeam echosounders	50 m	Med Sea
Tyrrhenian-Ionian seas	CoNISMa	Italy	multibeam echosounders	50 m	Med Sea
Continental margins of Puglia	CoNISMa	Italy	multibeam echosounders	50 m	Med Sea
Valona Bay, Albania	CoNISMa	Italy	multibeam echosounders	50 m	Med Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Ionian sea	CoNISMa	Italy	multibeam echosounders	25 m	Med Sea
Adriatic Sea - joint SI bathymetry database	Geodetic Institute of Slovenia	Slovenia	multibeam echosounders	20 m	Med Sea
Balear Islands Margin	IEO	Spain	Single beam and multi-beam	250 m	Med Sea
Catalan Margin	IEO	Spain	Multi-beam	100 m	Med Sea
Strait of Gibraltar	IEO	Spain	Single beam and multi-beam	100 m	Med Sea
Alboran Sea	IEO	Spain	Multi-beam	250 m	Med Sea
Cantabric Sea	IEO	Spain	Single beam and multi-beam	200 m	Med Sea
Golfo de Vera (Spain) Margin	IEO	Spain	Multi-beam	200 m	Med Sea
Levante margin	IEO	Spain	Single beam and multi-beam	100 m	Med Sea
South Alboran Sea	IEO	Spain	From IBCM: single beam and multi-beam	unclear	Med Sea
Murcia Margin	IEO	Spain	multi-beam	100 m	Med Sea
Formentera Island South Margin	IEO	Spain	multi-beam	200 m	Med Sea
ECOMARG	IEO	Spain	multi-beam	200 m	Med Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
Balear Islands South Margin	IEO	Spain	multi-beam	200 m	Med Sea
Canal Menorca Margin	IEO	Spain	multi-beam	250 m	Med Sea
MARCONI	IEO	Spain	multi-beam	100 m	Med Sea
Catalan margin Coast Brava	IEO	Spain	multi-beam	100 m	Med Sea
Ecocartografia IBIZA - FORMENTERA	IEO	Spain	multi-beam	225 m	Med Sea
Ecocartografia MENORCA	IEO	Spain	multi-beam	225 m	Med Sea
Espace-Medit-Continental-Shelf	IEO	Spain	multi-beam	225 m	Med Sea
353_291717 - La Palma Island Margin Eco-cartography	IEO	Spain	multi-beam	225 m	Med Sea
353_291715 - Formentera Island Margin Spain	IEO	Spain	multi-beam	100 m	Med Sea
353_291702 - MARCONI CANTABRIAN SEA SPAIN	IEO	Spain	single-beam echosounders	100 m	Med Sea
353_291701 - Cantabrian Sea Spain	IEO	Spain	single and multibeam echosounders	100 m	Med Sea
353_291711-Strait of Gibraltar	IEO	Spain	single and multibeam echosounders	100 m	Med Sea
353_291709 - Valencian Community Margin Eco-cartography	IEO	Spain	multibeam echosounders	100 m	Med Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
353_291708 - Mediterranean South Margin Spain	IEO	Spain	single and multibeam echosounders	100 m	Med Sea
353_291705 - Canal Menorca Margin	IEO	Spain	multibeam echosounders	100 m	Med Sea
353_291707 - Murcia Margin Spain	IEO	Spain	multibeam echosounders	100 m	Med Sea
Mediterráneo zona MED93S	IHM	Spain	single-beam echosounders	231.5 m	Med Sea
Balearic Islands bathymetry	IsardSAT	Spain	CryoSat-2 and Jason-1 altimeter sensors	1000 m	Med Sea
EMODnet Regional DTM of the Belgium Continental Shelf Version 4	Flemish Hydrographic Office	Belgium	single beam and multi-beam	125 m	North Sea
EMODnet Regional DTM of the Belgium Continental Shelf Version 5	Flemish Hydrographic Office	Belgium	single beam and multi-beam	60 m	North Sea
EMODnet Regional DTM of the Belgium Continental Shelf Version 6	Flemish Hydrographic Office	Belgium	single beam and multi-beam	60 m	North Sea
EMODnet Regional DTM of the Belgium Continental Shelf Version 7	Flemish Hydrographic Office	Belgium	single beam and multi-beam	60 m	North Sea
DGMW Jade Model A	BSH	Germany	multi-beam echosounders	1 m	North Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
North Sea - German approaches	BSH	Germany	Single beam	115 m	North Sea
DGMW Baltrum/Langeoog	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGMW Elbe Model A	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGMW Elbe Model A	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGMW Ems Model A	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGMW Juist/Norderney	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGMW Langeoog/Spiekeroog Model A	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGMW Weser Model A	BSH	Germany	multi-beam echosounders	1 m	North Sea
DGM-W Unter-/Außenems-2015	BSH	Germany	single beam and multi-beam	50 m	North Sea
DGMW Norderney DTM (1m)	BSH	Germany	multibeam echosounders	1 m	North Sea
Regional DTM of NL continental shelf	Hydrographic office of NL	Netherlands	Single beam and multi-beam	125 m	North Sea

Composite DTM	DTM provider	Country	Type of data	Resolution	Sea region
REGIONAL DTM OF NETHERLANDS CONTINENTAL SHELF version 2017	Hydrographic office of NL	Netherlands	multi-beam echosounders	12 - 20 m	North Sea
HRDTM 1/512 Schleswig-Holstein	BSH	Germany	multi-beam echosounders	1.5 m	North Sea
1850 HRDTM Weser approach - Version 2	BSH	Germany	multi-beam echosounders	1.5 m	North Sea

Table: Overview of data providers and Composite DTM entries in Sextant Catalogue

Indicator 2 - Organisations supplying each type of data based on (formal) sharing agreements and broken down into country and organisation type (e.g. government, industry, science).

Data Centre	Country	No of CDIs	No restrictions	Restrictions
Shom	France	8801	0	8801
Swedish Maritime Administration	Sweden	5774	0	5774
Rijkswaterstaat Central Information Services	Netherlands	2703	0	2703
OceanWise Limited	United Kingdom	2130	0	2130
IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	France	1390	463	927
Norwegian Hydrographic Service (NHS)	Norway	1233	0	1233
Italian Navy Hydrographic Office	Italy	1073	0	1073
German Oceanographic Datacentre	Germany	1004	1004	0
Maritime Administration of Latvia	Latvia	580	0	580
Flemish Ministry of Mobility and Public Works; Agency for Maritime and Coastal Services; Coastal Division	Belgium	342	0	342
Royal Netherlands Navy, Hydrographic Service	Netherlands	332	0	332
IHPT, Hydrographic Institute	Portugal	301	0	301

Data Centre	Country	No of CDIs	No restrictions	Restrictions
Geological Survey Ireland	Ireland	266	266	0
British Oceanographic Data Centre	United Kingdom	160	158	2
CNR, Institute of Marine Science (ISMAR) - Bologna	Italy	119	0	119
IEO/ Spanish Oceanographic Institute	Spain	112	46	66
Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)	Greece	94	0	94
Management Unit of North Sea and Scheldt Estuary Mathematical Models, Belgian Marine Data Centre	Belgium	93	93	0
Portuguese Institute of Ocean and Atmosphere	Portugal	86	0	86
Stockholm University, Department of Geological Sciences	Sweden	67	0	67
British Geological Survey, Edinburgh	United Kingdom	62	0	62
IHM/ Hydrographic Institute of the Navy	Spain	58	0	58
Croatian Hydrographic Institute	Croatia	54	0	54
CONISMA, National Interuniversity Consortium for Marine Science	Italy	37	0	37
NIOZ Royal Netherlands Institute for Sea Research	Netherlands	37	0	37
Marum - Center for Marine Environmental Sciences, University of Bremen	Germany	35	0	35
CSIC-UTM/ Marine Technology Unit	Spain	34	0	34
CNR, Institute for the Marine and Coastal Environment (IAMC) - Napoli	Italy	30	0	30
Bulgarian National Oceanographic Data Centre(BGODC), Institute of Oceanology	Bulgaria	25	1	24
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Infrastructures Division	Italy	22	0	22
CNR, Institute of Environmental Geology and Geoengineering (IGAG)	Italy	20	0	20
GRID-Arendal	Norway	14	0	14

Data Centre	Country	No of CDIs	No restrictions	Restrictions
National Institute of Marine Geology and Geoecology	Romania	14	0	14
Jardfeingi, the Faroe Islands Earth and Energy Directorate	Faroe Islands	13	0	13
SC Marine Research SRL	Romania	12	0	12
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography	Italy	10	0	10
National Institute for Marine Research and Development Grigore Antipa""	Romania	9	2	7
IGME, Geological Survey of Spain	Spain	8	0	8
International Ocean Institute - Malta Operational Centre (University Of Malta) / Physical Oceanography Unit	Malta	6	0	6
Iv.Javakhishvili Tbilisi State University, Centre of Relations with UNESCO Oceanological Research Centre and GeoDNA (UNESCO)	Georgia	3	3	0
Geodetic Institute of Slovenia	Slovenia	3	0	3
TOTALS		**27168**	**2036**	**25132**

Table: Overview of data centres and number of CDI entries for global waters

Most centres are government and research institutes. Industry parties are: OceanWise and SC Marine Research SRL. The increase over the project duration for the European waters is given in the next table.

Data Centre	Country	No of CDIs end 2018	No of CDIs end 2016	Difference
Shom	France	4853	4650	203
Swedish Maritime Administration	Sweden	5774	0	5774
Rijkswaterstaat Central Information Services	Netherlands	2703	2165	538
OceanWise Limited	United Kingdom	2108	2066	42
Norwegian Hydrographic Service (NHS)	Norway	1222	0	1222
Italian Navy Hydrographic Office	Italy	1073	0	1073
German Oceanographic Datacentre (NODC)	Germany	1004	256	748

Data Centre	Country	No of CDIs end 2018	No of CDIs end 2016	Difference
IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	France	780	716	64
Maritime Administration of Latvia	Latvia	580	0	580
Royal Netherlands Navy, Hydrographic Service	Netherlands	332	313	19
Flemish Ministry of Mobility and Public Works; Agency for Maritime and Coastal Services; Coastal Division	Belgium	342	197	145
IHPT, Hydrographic Institute	Portugal	296	275	21
Geological Survey Ireland	Ireland	268	223	45
CNR, Institute of Marine Science (ISMAR) - Bologna	Italy	110	73	37
British Oceanographic Data Centre	United Kingdom	116	100	16
Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre (HCMR/HNODC)	Greece	94	76	18
Management Unit of North Sea and Scheldt Estuary Mathematical Models, Belgian Marine Data Centre	Belgium	93	93	0
IEO/Spanish Oceanographic Institute	Spain	112	66	46
Portuguese Institute of Ocean and Atmosphere	Portugal	76	53	23
British Geological Survey, Edinburgh	United Kingdom	62	0	62
Hydrographic Institute of the Navy	Spain	58	58	0
Marum - Center for Marine Environmental Sciences, University of Bremen	Germany	35	0	35
CONISMA, National Interuniversity Consortium for Marine Science	Italy	37	0	37
CNR, Institute for the Marine and Coastal Environment (IAMC) - Napoli	Italy	30	0	30
NIOZ Royal Netherlands Institute for Sea Research	Netherlands	30	30	0
CSIC-UTM/ Marine Technology Unit (CSIC-UTM)	Spain	34	11	23
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Infrastructures Division	Italy	22	23	-1

Data Centre	Country	No of CDIs end 2018	No of CDIs end 2016	Difference
Bulgarian National Oceanographic Data Centre(BGODC), Institute of Oceanology	Bulgaria	25	20	5
CNR, Institute of Environmental Geology and Geoengineering (IGAG)	Italy	20	0	20
GRID-Arendal	Norway	14	10	4
National Institute of Marine Geology and Geoecology	Romania	14	9	5
Jardfeingi, the Faroe Islands Earth and Energy Directorate	Faroe Islands	13	5	8
SC Marine Research SRL	Romania	12	3	9
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography	Italy	10	10	0
IGME, Geological Survey of Spain	Spain	8	0	8
National Institute for Marine Research and Development "Grigore Antipa"	Romania	9	0	9
International Ocean Institute - Malta Operational Centre (University Of Malta) / Physical Oceanography Unit	Malta	6	4	2
Israel Oceanographic and Limnological Research (IOLR)	Israel	2	0	2
Iv.Javakhishvili Tbilisi State University, Centre of Relations with UNESCO Oceanological Research Centre and GeoDNA (UNESCO)	Georgia	3	0	3
Geodetic Institute of Slovenia	Slovenia	3	0	3
Croatian Hydrographic Institute	Croatia	54	0	54
Stockholm University, Department of Geological Sciences	Sweden	49	0	49
TOTALS		**22486**	**11505**	**10981**

Table: Overview of data centres and increase in number of CDI entries for European marine waters in the first project year

Indicator 3 - Organisations that have been approached to supply with no result, including type of data sought and reason why it has not been supplied.

During the project there has been some delays with certain partners providing their agreed data sets. However over time all data providers have contributed.

Indicator 4 - Volume of each type of data and of each data product downloaded from the portal

The numbers are given for the full project duration:

Number of CDI requests:

Period	No of CDI basket transactions	No of CDIs requested	Different users	Different data centres
20 December 2016 – 31 March 2017	13	3325	13	21
1 April 2017 – 30 June 2017	22	2846	14	16
1 July 2017 – 30 September 2017	12	327	10	11
1 October 2017 – 31 December 2017	30	497	24	19
1 January 2018 - 31 March 2018	21	1170	12	19
1 April 2018 – 30 June 2018	28	3485	15	25
1 July 2018 – 30 September 2018	24	347	17	18
1 October 2018 – 31 December 2018	23	9235	21	23
Totals	**173**	**21232**	**126**	**152**

Table: Overview of CDI requests over the project period

Data products – DTM downloads:
The EMODnet DTM covers all European seas and can be downloaded in a number of formats: EMODnet csv, EMODnet excl GEBCO csv, ESRI ASCII, GeoTiff, NetCDF, SD, and XYZ file. The 2016 version of the DTM can be downloaded in 16 tiles while the new 2018 version can be downloaded in 64 tiles (since 24th September 2018).

Figure: Tile download options for 2016 DTM version; the tile naming starts from top-left to top-right with A1 to D1 and from top-left to bottom-left with A1 to A4 etc.

Figure: Tile download options for 2018 DTM version; the tile naming starts from top-left to top-right with A1 to A8 and from top-left to bottom-left with A1 to H1 etc. More tiles than 2016 version because of higher resolution giving much larger files.

DTM version 2016								
Tile	**20 Dec 2016 – 31 Mar 2017**	**1 Apr 2017 – 30 Jun 2017**	**1 Jul 2017 – 30 Sep 2017**	**1 Oct 2017 – 31 Dec 2017**	**1 Jan 2018 – 31 Mar 2018**	**1 Apr 2018 – 30 Jun 2018**	**1 Jul 2018 – 30 Sep 2018**	**1 Oct 2018 – 31 Dec 2018**
A1	87	52	64	88	210	92	41	12
A2	127	106	85	85	119	109	37	10
A3	221	111	77	85	149	100	53	11
A4	316	147	96	138	221	154	104	8
Area of interest	8482	5789	5062	5905	6541	6255	4651	0
B1	101	63	47	63	88	69	42	8
B2	495	320	330	378	520	386	313	24
B3	939	749	714	756	1024	856	627	26
B4	526	394	262	282	578	491	351	10
C1	156	71	53	86	123	83	76	9
C2	479	289	289	265	435	318	262	30
C3	846	494	476	549	816	735	537	21
C4	488	349	336	347	532	514	280	9
D1	101	54	46	76	97	62	35	10
D2	124	96	111	79	133	74	45	9
D3	387	266	219	462	387	356	258	15
D4	452	341	302	276	500	545	351	14
	-	-	-	-				
Totals	**14327**	**9691**	**8569**	**9920**	**12473**	**11199**	**8063**	**226**

Table: Overview of number of downloaded DTM version 2016 tiles

DTM version 2018	
Tile	**1 Oct 2018 – 31 Dec 2018**
A1	59
A2	45
A3	47
A4	42
A5	47
A6	45
A7	44
A8	47

DTM version 2018	
Tile	**1 Oct 2018 – 31 Dec 2018**
Area of interest	3062
B1	55
B2	56
B3	61
B4	67
B5	75
B6	68
B7	57
B8	54
C1	68
C2	88
C3	133
C4	148
C5	148
C6	115
C7	99
C8	59
D1	65
D2	92
D3	214
D4	377
D5	312
D6	175
D7	108
D8	53
E1	57
E2	88
E3	241
E4	443
E5	327
E6	201
E7	447
E8	420
F1	85
F2	106
F3	185
F4	332

DTM version 2018	
Tile	**1 Oct 2018 – 31 Dec 2018**
F5	301
F6	355
F7	749
F8	546
G1	66
G2	115
G3	166
G5	129
G6	136
G7	173
G8	162
H1	61
H2	62
H3	70
H8	54
Totals	**12262**

Table: Overview of number of downloaded DTM version 2018 tiles

This also includes the Web Coverage Service (WCS) by which users can draw and download their own 'area of interest'.

	DTM version 2016								DTM version 2018
TYPE	**20 Dec 2016 – 31 Mar 2017**	**1 Apr 2017 – 30 Jun 2017**	**1 Jul 2017 – 30 Sep 2017**	**1 Oct 2017 – 31 Dec 2017**	**1 Jan 2018 – 31 Mar 2018**	**1 Apr 2018 – 30 Jun 2018**	**1 Jul 2018 – 30 Sep 2018**	**1 Oct 2018 – 31 Dec 2018**	**1 Oct 2018 – 31 Dec 2018**
32 bit float GeoTiff	2555	1284	1173	1364	1344	1552	1013	0	931
EMO	295	207	181	245	330	246	206	3	347

	DTM version 2016								DTM version 2018
TYPE	**20 Dec 2016 – 31 Mar 2017**	**1 Apr 2017 – 30 Jun 2017**	**1 Jul 2017 – 30 Sep 2017**	**1 Oct 2017 – 31 Dec 2017**	**1 Jan 2018 – 31 Mar 2018**	**1 Apr 2018 – 30 Jun 2018**	**1 Jul 2018 – 30 Sep 2018**	**1 Oct 2018 – 31 Dec 2018**	**1 Oct 2018 – 31 Dec 2018**
EMO (without GEBCO data)	137	108	81	100	163	111	83	48	270
ESRI ASCII	6355	4469	3888	4548	5823	5209	3833	70	5896
NetCDF	600	580	374	518	640	575	362	49	1386
RGB GeoTiff	3181	2188	2073	2176	3008	2335	1948	35	2231
SD	225	164	129	212	193	200	96	3	151
XYZ	979	691	670	757	972	971	522	18	1050

Table: Overview of formats of downloaded DTM tiles

Indicator 5 - Organisations that have downloaded each data type

organisation	**country**
TIDETECH	Australia
?	Bangladesh
?	Belgium
DEME Group	Belgium
FUGRO	Belgium
Ghent University	Belgium
?	Canada
University of Ottawa	Canada
?	China
East China Normal University	China
?	Croatia
Cyprus University of Technology	Cyprus
COWI	Denmark
?	France
ACRI-HE	France

organisation	country
CHORUS acoustics	France
CNRS	France
Geoazur	France
IUEM	France
LEGOS	France
Lucia Holding	France
Noveltis	France
?	Germany
Christian-Albrechts Universität zu Kiel	Germany
Friedrich-Schiller-Universität Jena - IGW	Germany
Geomar	Germany
GeoZentrum Nordbayern	Germany
GMX	Germany
Kiel University	Germany
NEMOS GmbH	Germany
University of Heidelberg	Germany
?	Greece
National Observatory of Athens	Greece
Private	Greece
Iceland GeoSurvey	Iceland
Geospatial Information Agency	Indonesia
Geological Survey of Ireland	Ireland
Marine Institute	Ireland
Technion	Israel
?	Italy
Arpacal	Italy
C-Map Italy Srl	Italy
EASY MAP	Italy
European Space Agency	Italy
HPC AG	Italy
Istituto Idrografico della Marina	Italy
UniBo	Italy
unipa	Italy
Arcadis	Netherlands
Bakser	Netherlands
Boskalis	Netherlands
CGI	Netherlands

organisation	country
Deltares	Netherlands
NARWAL	Netherlands
NIOZ	Netherlands
Oceans of Energy	Netherlands
Periplus Archeomare	Netherlands
TNO	Netherlands
UNESCO-IHE	Netherlands
Wageningen UR	Netherlands
NIWA	New Zealand
??	Norway
BK Marine	Norway
OSD	Norway
SailorsMate	Norway
PNA	Poland
?	Portugal
Faculdade de Ciências da Universidade de Lisboa	Portugal
Universidade do ALgarve	Portugal
University of the Azores	Portugal
?	Spain
ARGONGRA	Spain
IDEN	Spain
Movistar	Spain
private	Spain
Spanish Meteorological Agency	Spain
TURSIOPS	Spain
Universidad Pablo de Olavide	Spain
Universitat Politècnica de Catalunya	Spain
UPCT	Spain
architectural association school of architecture	United Kingdom
Coastal Science Ltd	United Kingdom
DeepOcean	United Kingdom
Durham University	United Kingdom
Environment Agency	United Kingdom
Marine Biological Association	United Kingdom
NERC	United Kingdom
private	United Kingdom

organisation	country
QUB	United Kingdom
RPS	United Kingdom
Sasol	United Kingdom
Scottish Salmon	United Kingdom
St Andrews University	United Kingdom
UK National Oceanography Centre	United Kingdom
UKHO	United Kingdom
University of Southampton	United Kingdom
University of St-Andrews	United Kingdom
Clarkson University	United States
JO	United States
L-3 Communications	United States
NAVO	United States
NGA	United States
NOAA NCEI	United States
Scripps Institution Of Oceanography	United States
StrikeLines	United States
University of New Hampshire	United States
University of Southern Mississippi	United States
?	United States

Table: Overview of organisations that have requested data from the CDI service

Since the launch of the new 2018 EMODnet DTM end September 2018 there is now also registration of organisations who have downloaded DTM tiles. In this quarter there were > 3500 download transaction events involving 1774 users from 887 organisations. The following table gives an overview for the last quarter of 2018 by types of organisations following the new key indicators reporting format.

Organisation type	% of users
company	22.27
government	5.58
international organisation	0.58
NGO	1.82
public	8.56
research institute	17.66
university	43.17
unknown	0.36
TOTAL	100

Table: Types of organisations that have downloaded DTM tiles in last quarter of 2018

Indicator 6 – Portal visit statistics

Bathymetry main portal:

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Dec-16	7,642	9,872	45,334	112,210	3.81 GB
Jan-17	9,040	11,446	43,137	117,990	5.12 GB
Feb-17	5,991	7,692	48,989	127,782	4.78 GB
Mar-17	7,395	9,451	44,866	138,578	5.22 GB
Apr-17	7,013	8,395	29,746	77,222	3.09 GB
May-17	7,058	8,729	47,399	153,443	3.98 GB
Jun-17	7,122	8,682	78,472	191,738	4.72 GB
Jul-17	7,669	9,105	76,228	159,438	6.09 GB
Aug-17	9,560	10,976	72,012	108,401	2.29 GB
Sep-17	10,945	12,399	73,670	132,839	4.22 GB
Oct-17	12,609	14,754	96,437	205,244	5.42 GB
Nov-17	15,067	17,695	95,944	171,951	4.44 GB
Dec-17	13,697	15,896	86,935	164,026	3.97 GB
Jan-18	13,390	15,754	92,805	152,383	3.99 GB
Feb-18	10,622	12,574	85,410	145,283	3.78 GB
Mar-18	12,785	15,421	90,111	156,916	4.97 GB
Apr-18	12,170	14,609	82,927	141,706	4.02 GB
May-18	12,074	14,161	81,770	140,455	4.04 GB
Jun-18	12,055	14,133	81,982	136,241	3.75 GB
Jul-18	10,583	12,612	81,084	133,927	3.44 GB
Aug-18	7,033	8,729	76,182	122,997	3.33 GB
Sep-18	8,565	10,758	95,761	206,524	13.71 GB
Oct-18	7,663	10,248	98,219	207,934	9.56 GB
Nov-18	5,393	7,489	97,562	184,473	9.27 GB
Dec-18	3,646	5,056	73,713	132,356	4.54 GB

Table: Web statistics of EMODnet Bathymetry portal

Bathymetry Viewing and Download service:

Month	Unique visitors	Pages	Hits	Bandwidth Gb
Dec-16	3800	17719	23131	94,05
Jan-17	3631	16263	21612	131,62
Feb-17	4391	10079	16298	161,01
Mar-17	4666	11181	17537	149,75
Apr-17	3654	8921	14172	109,66

Month	Unique visitors	Pages	Hits	Bandwidth Gb
May-17	4137	14626	21406	108,79
Jun-17	3809	9450	1436	168,54
Jul-17	3189	6801	10820	89,71
Aug-17	3884	7614	11768	119,78
Sep-17	3808	7342	11476	103,45
Oct-17	3,918	7,470	12,157	136,29
Nov-17	4,072	7,447	11,789	134,6
Dec-17	3,093	6,340	9,912	62,73
Jan-18	3,518	8,899	11,917	81,879
Feb-18	3,310	15,180	17,423	64,967
Mar-18	3,673	17,235	19,678	53,970
Apr-18	3,189	19,184	21,576	56,372
May-18	3,340	9,098	11,615	41,051
Jun-18	2,908	7,255	9,104	3,306
Jul-18	3,307	13,424	15,359	44,704
Aug-18	3,235	6,536	8,453	31,222
Sep-18	8,386	11,817	42,433	647,160
Oct-18	7,441	11,111	35,375	479,827
Nov-18	5,288	6,742	23,418	314,275
Dec-18	3,425	4,589	16,996	215,803

Table: Web statistics of Bathymetry Viewing and Download service

Indicator 7 - List of what the downloaded data has been used for (divided into categories e.g. Government planning, pollution assessment and (commercial) environmental assessment, etc.)

Since the launch of the new 2018 EMODnet DTM end September 2018 there is now also registration of organisations who have downloaded DTM tiles. In this quarter there were > 3500 download transaction events involving 1774 users from 887 organisations. The following table gives an overview for the last quarter of 2018 by types of organisations and the reasons given for requesting DTM tiles, following the new key indicators reporting format.

Organisation type	% of users	Main use cases and application areas
company	22.27	hydrodynamic modelling, map creation, Hydromorfology study, vessel monitoring, tsunami model simulation, wave modelling, Seagrass Mapping, seabird diving depths research, Fishery information, cable routing plans, route assessment, GIS seabed analysis, Dredging, Possible E&P project, Prospection for future offshore wind project, environmental impact assessment, survey planning, bathymetry studies, wave propagation studies, coastal engineering, modelling underwater noise, Aquaculture project,
government	5.58	Naval Mine Warfare, Protected area management, research, seabed mapping, Planning and manegement of fisheries, hydrodynamic modelling, Marine spatial planning, Offshore tectonic mapping, base map, Storm surge modeling, planification
international organisation	0.58	Base map, Whales monitoring, Mapping ocean litter, IOI ocean governance training
NGO	1.82	Marine Conservation Research, study fisheries, Habitat mapping, Base map, underwater acoutics propagation, Planning marine expedition, Seabird research
public	8.56	private mapping, fishing, research, recreation, education, GIS course, environmental study, school, journalism, gaming
research institute	17.66	paleogeographic study, Geomorphology, base map, hydrographic course, habitat modelling, spatial planning, PhD, publications, wave modelling, morphology modelling, offshore wind assessement, cartography, X-Prize, mission preparation, hazard studies, coastal dynamics, topography, background map, storm surge impact assessment, Tsunami calculations, Creating model bathymetry, Reconstruct sea level change, prospection, anchoring analysis, glider deployment, Marine life monitoring on wrecks, For educational purposes,
university	43.17	academic research, Archaeology, Master thesis, Geological research, habitat analysis, Education and research, Deep sea species distribution modelling, PhD and master studies, numerical modelling, Active tectonics research, Coursework, delphins study, Tectonic Geomorphology, wave modelling, studies, homework, tutorials,
unknown	0.36	Research, education, mapping

Table: Reasons given by downloading organisations in last quarter of 2018

Indicator 8 – List of web-services made available and user organisations connected through these web-services

The GIS layers in the Bathymetry Viewing and Download service can be shared as OGC services with other EMODnet portals and beyond. Also WMS layers from other EMODnet portals and external services can be added to the Bathymetry Viewer and Download service. The OGC services can be found at the following URLs:

WMS: http://ows.emodnet-bathymetry.eu/wms
WFS: http://ows.emodnet-bathymetry.eu/wfs
WMTS: http://tiles.emodnet-bathymetry.eu/wmts
WCS: http://ows.emodnet-bathymetry.eu/wcs

More detailed info about the web services is given at: http://portal.emodnet-bathymetry.eu/services/

These URLs are advertised in the HELP section of the Viewing Service and also at the main portal. The web services concern WMS, WFS, WMTS and WCS and are applied by various users. These services are very popular as can be seen from its statistics in the table below.

Page Views	**2017**	**2018**
Total Page Views	34,800,350	19,446,254
Average Page Views per Day	71,458	53,277
Average Page Views per Visitor	136.65	160.86
Visitors	**2017**	**2018**
Total Visitors	254,665	120,886
Average Visitors per Day	522	331
Total Unique Ips	36,942	39,688

Table: Web statistics of Bathymetry Viewing web services in project period

The total number of pageviews is somewhat misleading as a full page can be composed of multiple views.

Additional indicators – taken from the new reporting

Since early 2018 a new set of key indicators is included in the Quarterly Reports. Most of these are overlapping with the older key indicators as reported above which have been continued for ensuring a consistent reporting over the whole project period. However there are a few new indicators which are selected and added below to make the picture complete.

Indicator 1.1: Volume and coverage of available acquired data								
1.1. Volume of available acquired data*	*Date*	*Portal*	*Unit*					*Total Volume*
	1/1/2019	*Bathymetry*	*Data sets*					*27168*
Sub-theme [6]	Atlantic [7]	Arctic	Baltic	Black Sea	Med Sea	North Sea	Other Seas	Total Volume per theme
Bathymetry	4350	1143	5483	103	3761	8566	3995	27168

Table: CDI records divided over sea regions

Indicator 1.2: Number and coverage of acquired external data products								
1.2. Number and coverage of available acquired data products*	*Date*	*Portal*						*Total Number of external data products*
	1/1/2019	*Bathymetry*						*147*
Sub-theme	Atlantic [6]	Arctic	Baltic	Black Sea	Med Sea	North Sea	Other seas	All sea basins
Bathymetry	19	5	12	23	69	22	0	147

Table: Sextant records divided over sea regions

Indicator 4: Quality Control and Quality Assurance steps				
4. Quality Control & Quality Assurance	*Date*	*Portal*		
	1/1/2019	*Bathymetry*		
QA / QC steps	✓	Short Description	By whom?	Automatic / Semi-automatic / Manual
Metadata curation	✓	ISO XML 19115 metadata templates associated to each sources of bathymetry (corresponding to individual surveys – CDI – or composite DTM – CPRD) are filled using appropriate vocabularies (see below)	Data providers, MARIS for CDI import, IFREMER for Sextant import	Semi-automatic (use of Mikado editor tool, coupled to local database for generation of CDIs and Sextant CMS for generation of Sextant entries by data providers). Automatic verifications done for CDI and Sextant cataloguing databases during import with reporting to data providers
Data standards compliance checks	✓	Data sets in CDI service must follow a standard list of possible data formats (L24 vocabulary). This is checked during import.	By MARIS	Automatic as part of Syntax and semantics checks during import
Geographic Location Control	✓	Well-formed CDIs are included in Import CDI interface for visual checking including geo-coverage (staging process)	By data providers and MARIS	Manual. If data provider is ok, then CDIs are moved to production CDI service and made public

Indicator 4: Quality Control and Quality Assurance steps				
4. Quality Control & Quality Assurance	*Date*	*Portal*		
	1/1/2019	*Bathymetry*		
QA / QC steps	✓	Short Description	By whom?	Automatic / Semi-automatic / Manual
Error Detection thanks to thematic expertise	✓	Bathymetric data are processed to the better of the knowledge of the data providers (to account for tide, variable sound speed, bias in positioning or vertical measurement) or up to internationally agreed standards (IHO S-44 standard for Hydrographic Offices). All the data providers follow the same data delivery methodology	Data providers, Basin Coordinators, GGSGC (final integration)	Manual. Aided through use of 3D visualization using DTM production software (Globe).
Quality Index / Accuracy assessment	✓	Data providers give details on their dataset with respect to positional accuracy, vertical accuracy, and age of the dataset and purpose of the survey. These elements will be used for data grouping and merging and also to provide a global quality indicator for the EMODnet bathymetry DTM product	Data providers	filled manually or semi-automatically entered (depending on fields mapping from provider's database)

Indicator 4: Quality Control and Quality Assurance steps				
4. Quality Control & Quality Assurance	*Date*	*Portal*		
	1/1/2019	*Bathymetry*		
QA / QC steps	✓	Short Description	By whom?	Automatic / Semi-automatic / Manual
Data aggregation	✓	Each of the elements composing the EMODnet DTM are aggregated at a sea basin level and then at the global level. Insurance that the link between the DTM product and the source data through the metadata description is verified at each levels.	Basin coordinators, GGSGC (final aggregation), MARIS	Manual (selection of appropriate sources and associated order of priority).
Other				
Harmonisation		Unified methodology applied by all data providers and regional coordinators and implemented by using the Globe software as made available for the project members by IFREMER	all	Semi-Automatic
Language	✓	English	all	Manual + Automatic
Units	✓	Bathymetry in meters and to LAT reference level, integrated in the Globe software	all	Automatic
Terminology	✓	Metadata are marked up, where possible, with SeaDataNet controlled vocabularies and with terminology as defined with hydrography experts.	SeaDataNet	Automatic; vocabularies are integrated as web services in editing tools for metadata.

Indicator 4: Quality Control and Quality Assurance steps				
4. Quality Control & Quality Assurance	*Date*	*Portal*		
	1/1/2019	*Bathymetry*		
QA / QC steps	✓	Short Description	By whom?	Automatic / Semi-automatic / Manual
Coordinate Systems	✓	Unified methodology integrated in the Globe software. Also adoption of agreed grid definitions by all data providers.	All	Automatic
Data format	✓	EMO data format defined and documented for all DTM production. Integrated in the Globe software.	all	Automatic
Metadata	✓	CDI and Sextant metadata are based upon the ISO19115 – 19139 standards. During DTM production references to CDI and Sextant are integrated into the resulting grid cells, so that users can query which data set is related to each specific grid cell. This is part of the EMO format as applied for the EMODnet DTM.	all	Automatic

Table: Quality Control and Quality Assurance steps

Indicator 5.2: List of data product releases by the portal

5.2.1 Latest Data Product Releases	*Date*	*Portal*	*# of EMODnet data products*
	1/1/2019	*Bathymetry*	*2*
EMODnet data product name	Last release date (< 3 months only)	Creation or Update	Description
EMODnet DTM		Oct-16	DTM for all European seas - http://doi.org/10.12770/c7b53704-999d-4721-b1a3-04ec60c87238
EMODnet DTM	Sep-18	Sep-18	DTM for all European seas - http://doi.org/10.12770/18ff0d48-b203-4a65-94a9-5fd8b0ec35f6

Table: List of data products released by the portal

11. List of publications referencing to EMODnet Bathymetry

The following references to EMODnet Bathymetry can be found using Google Scholar on the 18/01/2019. References are given for accepted papers and edited books for the full project duration. This list is not exhaustive, hower it indicates nearly 160 references with a link to the EMODnet bathymetry products.

Date	Publication	Title	Reference
January 2017	Continental Shelf Research (Peer reviewed article)	Authigenic carbonate mounds from active methane seeps on the southern Aquitaine Shelf (Bay of Biscay, France): Evidence for anaerobic oxidation of biogenic methane and submarine groundwater discharge during formation	http://www.sciencedirect.com/science/article/pii/S0278434316301273
February 2017	Quaternary Science Reviews (Peer reviewed article)	Sea-level rise and potential drowning of the Italian coastal plains: Flooding risk scenarios for 2100	http://www.sciencedirect.com/science/article/pii/S0277379116307430
February 2017	Marine Ornitology (Peer reviewed article)	Status and diet of the European Shag (Mediterranean subspecies) Phalacrocorax Aristitelis desmarestii in the Libyan sea (South Crete) during the breeding season	http://www.marineornithology.org/PDF/45_1/45_1_1-9.pdf
February 2017	Biogeochemistry (Peer reviewed article)	Predicting the standing stock of organic carbon in surface sediments of the North–West European continental shelf	http://link.springer.com/article/10.1007/s10533-017-0310-4
February 2017	Thesis report	Estudio sobre la viabilidad económica de un parque eólico Offshore en España	http://oa.upm.es/45981/1/TFG_JOSE_IGNACIO_DIAZ_VILLAMOR.pdf

Date	Publication	Title	Reference
March 2017	Earth Science Reviews (Peer reviewed article)	The configuration, sensitivity and rapid retreat of the Late Weichselian Icelandic ice sheet	http://www.sciencedirect.com/science/article/pii/S001282521630246X
March 2017	Book	Morphodynamics of Mediterranean Mixed Sand and Gravel Coasts	
March 2017	Earth and Planetary Science Letters (Peer reviewed article)	Active tectonics of the Calabrian subduction revealed by new multi-beam bathymetric data and high-resolution seismic profiles in the Ionian Sea (Central Mediterranean)	http://www.sciencedirect.com/science/article/pii/S0012821X16307336
March 2017	EOS Earth & Space Science News (Peer reviewed opinion article)	Airline Flight Paths over the Unmapped Ocean	https://eos.org/opinions/airline-flight-paths-over-the-unmapped-ocean
April 2017	Information Systems (peer reviewed article)	A survey of official online sources of high-quality free-of-charge geospatial data for maritime geographic information systems applications	http://www.sciencedirect.com/science/article/pii/S0306437916304185
April 2017	Palaeogeography, Palaeoclimatology, Palaeoecology (Peer reviewed article)	Fish otoliths in superficial sediments of the Mediterranean Sea	http://www.sciencedirect.com/science/article/pii/S0031018216305156
April 2017	Ocean Dynamics (Peer reviewed article)	Numerical modeling of space-time wave extremes using WAVEWATCH III	http://link.springer.com/article/10.1007/s10236-016-1025-0

Date	Publication	Title	Reference
2017	Book	Atlas of Bedforms in the Western Mediterranean	DOI 10.1007/978-3-319-33940-5
April 2017	Journal of Applied Ecology. (Peer review journal)	Seals and shipping: quantifying population risk and individual exposure to vessel noise.	http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12911/full
April 2017	Proceeding of the Royal Society (Peer review journal)	Statistical simulation of landslide-induced tsunamis at the Rockall Bank, NE Atlantic.	http://rspa.royalsocietypublishing.org/content/473/2200/20170026
April 2017	AIMS ENERGY (Peer review journal)	Assessment of offshore wind power potential in the Aegean and Ionian Seas based on high-resolution hindcast model results	https://www.researchgate.net/profile/Takvor_Soukissian/publication/315464558_Assessment_of_offshore_wind_power_potential_in_the_Aegean_and_Ionian_Seas_based_on_high-resolution_hindcast_model_results/links/58d8eb9f92851c44d4ae3363/Assessment-of-offshore-wind-power-potential-in-the-Aegean-and-Ionian-Seas-based-on-high-resolution-hindcast-model-results.pdf
May 2017	Natural Hazards (Peer review journal)	Tsunami hazards in the Catalan Coast, a low-intensity seismic activity area	doi:10.1007/s11069-017-2918-z
May 2017	Wind Engineering (Peer review journal)	Assessment of levelized cost of electricity of offshore wind energy in Egypt	http://journals.sagepub.com/doi/abs/10.1177/0309524X17706846
May 2017	Uder the Sea: Archaeology and Palaeolandscapes of the	Palaeotopography and Transgression Velocity on the Continental Shelf	https://link.springer.com/chapter/10.1007/978-3-319-53160-1_3

Date	Publication	Title	Reference
	Continental Shelf (Book Chapter)		
May 2017	Stochastic Environmetal Research and Risk Assessment (Peer review journal)	Source characterisation by mixing long-running tsunami wave numerical simulations and historical observations within a metamodel-aided ABC setting	https://link.springer.com/article/10.1007/s00477-017-1423-y
May 2017	Submerged Landscapes of the European Continental Shelf: Quaternary Paleoenvironments (Book Chapter)	Standard Core Variables for Continental Shelf Prehistoric Research and Their Availability	https://books.google.fr/books?hl=fr&lr=&id=x5jCDgAAQBAJ&oi=fnd&pg=PA83&dq=%22emodnet+bathymetry%22+-habitat&ots=Xfquy7b5qv&sig=tl28lW1-MoeCiKXii0mIceHBjEc#v=onepage&q=%22emodnet%20bathymetry%22%20-habitat&f=false
May 2017	Coastal Engineering (Peer review journal)	Implementation and validation of a multi-domain coastal hazard forecasting system in an open bay.	https://doi.org/10.1016/j.coastaleng.2017.08.008
June 2017	Renewable and Sustainable Energy Reviews. (Peer review journal)	Feasibility study of an offshore wind farm in the Aegean Sea, Turkey	http://www.sciencedirect.com/science/article/pii/S1364032117310055
June 2017	Geo-Marine Letters (Peer review journal)	Morphology of the last subaerial unconformity on a shelf: insights into transgressive ravinement and incised valley occurrence in the Gulf of Cádiz.	https://link.springer.com/article/10.1007/s00367-017-0511-9

Date	Publication	Title	Reference
July 2017	Environmental Science & Technology (Peer review journal)	Shallow gas migration along hydrocarbon wells–An unconsidered, anthropogenic source of biogenic methane in the North Sea.	10.1021/acs.est.7b02732
July 2017	Bulletin of the Geological Society of Greece (Peer review journal)	Deformation pattern in the western North Aegean trough: Preliminary results.	http://dx.doi.org/10.12681/bgsg.11708
July 2017	Geomorphology (Peer review journal)	Seabed geodiversity in a glaciated shelf area, the Baltic Sea.	https://doi.org/10.1016/j.geomorph.2017.07.014
July 2017	Submarine geomorphology (Book section)	Submarine Canyons and Gullies.	Amblas, D., Ceramicola, S., Gerber, T. P., Canals, M., Chiocci, F. L., Dowdeswell, J. A., ... & Iacono, C. L. (2018). In Submarine Geomorphology (pp. 251-272). Springer, Cham.
July 2017	Frontiers in Marine Science (Peer review journal)	Habitat Suitability Modeling to Identify the Potential Nursery Grounds of the Atlantic Mackerel and Its Relation to Oceanographic Conditions in the Mediterranean Sea.	Giannoulaki, M., Pyrounaki, M. M., Bourdeix, J. H., Ben Abdallah, L., Bonanno, A., Basilone, G., ... & Valavanis, V. D. (2017).
July 2017	Coastal Engineering (Peer review paper)	Tsunami taxonomy and detection from recent Mediterranean tide gauge data.	https://doi.org/10.1016/j.coastaleng.2017.06.007
July 2017	Frontiers in Marine Science	Habitat Suitability Modeling to Identify the Potential Nursery Grounds of the Atlantic Mackerel	

Date	Publication	Title	Reference
	(Peer review paper)	and Its Relation to Oceanographic Conditions in the Mediterranean Sea.	
July 2017	Coastal Engeeniring (Peer review paper)	Tsunami taxonomy and detection from recent Mediterranean tide gauge data.	
July 2017	Geoscientific Model Development Discussion (peer reviewed paper	AMM15: A new High resolution NEMO configuration for operational simulation of the European North West Shelf	https://www.geosci-model-dev-discuss.net/gmd-2017-127/gmd-2017-127.pdf
August 2017	Biogeography	The importance of temporal resolution for niche modelling in dynamic marine environments.	https://doi.org/10.1111/jbi.13080
August 2017	Marine Micropaleontology. (Peer review journal)	Comparison of qualitative and quantitative dinoflagellate cyst approaches in reconstructing glacial-interglacial climate variability at West Iberian Margin IODP 'Shackleton'Site U1385.	https://doi.org/10.1016/j.marmicro.2017.08.003
August2017	Marine and Petroleum Geology (peer review paper)	Intra-salt deformation: Implications for the evolution of the Messinian evaporites in the Levant Basin, eastern Mediterranean.	https://doi.org/10.1016/j.marpetgeo.2017.08.027
August 2017	Earth System Science Data Discussion (Peer review journal)	A synthetic map of the northwest European Shelf sedimentary environment for applications in marine science.	https://doi.org/10.5194/essd-2017-88

Date	Publication	Title	Reference
August 2017	Science of the total environment (Peer review journal)	Multi-objective spatial tools to inform maritime spatial planning in the Adriatic Sea.	https://doi.org/10.1016/j.scitotenv.2017.07.264
September 2017	Tectonophysics (Peer review journal)	Long-term in situ observations at the Athina mud volcano, Eastern Mediterranean: Taking the pulse of mud volcanism	https://doi.org/10.1016/j.tecto.2017.09.010
September 2017	Nature Scientific report (Peer review journal)	Fine-scale harbour seal usage for informed marine spatial planning.	10.1038/s41598-017-11174-4
September 2017	Natural Scientific Data (Peer review journal)	Fish and fishery historical data since the 19th century in the Adriatic Sea, Mediterranean.	10.1038/sdata.2017.104
October 2017	Advances in Space Research (peer review journal)	Validation of CryoSat-2 SIRAL sea level data in the eastern continental shelf of the Gulf of Cadiz (Spain)	https://doi.org/10.1016/j.asr.2017.10.042
October 2017	Ecology and evolution (peer review journal)	Taking movement data to new depths: Inferring prey availability and patch profitability from seabird foraging behavior	DOI: 10.1002/ece3.3551
October 2017	(Doctoral Thesis)	Seabed landscapes of the Baltic Sea: Geological characterization of the seabed environment with spatial analysis techniques	http://urn.fi/URN:ISBN:978-952-217-386-7
October 2017	(Bachelor Thesis)	Wave propagation patterns along the northern catalan coast	http://hdl.handle.net/2117/108165

Date	Publication	Title	Reference
October 2017	12th International Conference on Parallel Processing and Applied Mathematics (Oral presentation)	Using GPGPU accelerated interpolation algorithms for marine bathymetry processing with on-premises and cloud based computational resources	http://www.dma.unina.it/mamhyp/mamhip17/montella.pdf (oral presentation given as part of H2020 RAPID (H2020-ICT-644312) project)
November 2017	Tectonophysics (peer review journal)	Long-term in situ observations at the Athina mud volcano, Eastern Mediterranean: Taking the pulse of mud volcanism	https://doi.org/10.1016/j.tecto.2017.09.010
November 2017	(Proceeding International conference)	Strike - slip deformation behind the Hellenic subduction: The Amorgos Shear Zone, South Aegean Sea	8th International INQUA Meeting on Paleoseismology, Active Tectonics and Archeoseismology (PATA), 13 – 16 November, 2017, New Zealand
November 2017	Climate of the past (peer review journal)	Atlantic Water advection vs. glacier dynamics in northern Spitsbergen since early deglaciation	https://doi.org/10.5194/cp-13-1717-2017
November 2017	Geoscientific Model (peer review journal)	The UKC2 regional coupled environmental prediction system	https://doi.org/10.5194/gmd-11-1-2018
November 2017	The Black Sea (Book Chapter)	Geophysics of the Black Sea Basin.	In: The Black Sea. Springer Geography. Springer, Cham (https://doi.org/10.1007/978-3-319-70855-3_4)
November 2017	Frontiers in Ecology and Evolution (peer review journal)	Early Engagement of Stakeholders with Individual-Based Modeling Can Inform Research for Improving Invasive	https://doi.org/10.3389/fevo.2017.00149

Date	Publication	Title	Reference
		Species Management: The Round Goby as a Case Study	
November 2017	Science Advances (peer review journal)	The Mediterranean Overflow in the Gulf of Cadiz: A rugged journey	DOI: 10.1126/sciadv.aao0609
November 2017	Nature communications (peer review journal)	Volcanism in slab tear faults is larger than in island-arcs and back-arcs	doi:10.1038/s41467-017-01626-w
November 2017	Scientific Reports (peer review journal)	Intrinsic and extrinsic factors drive ontogeny of early-life at-sea behaviour in a marine top predator	doi:10.1038/s41598-017-15859-8
November 2017	Marine Geology (peer review journal)	Massive Mn carbonate formation in the Landsort Deep (Baltic Sea): Hydrographic conditions, temporal succession, and Mn budget calculations	https://doi.org/10.1016/j.margeo.2017.10.010
November 2017	(Report)	AQUASPACE - Ecosystem Approach to making Space for Aquaculture - Deliverable 3.3 AquaSpace tool to support MSP.	http://www.aquaspace-h2020.eu/wp-content/uploads/2017/10/D3.3-AquaSpace-tool-to-support-MSP-tool-manual-2nd-version.pdf (EU Horizon 2020 project grant no. 633476)
November 2017	Geochemistry, Geophysics, Geosystems (peer review journal)	Gravity-Driven Deposits in an Active Margin (Ionian Sea) Over the Last 330,000 Years	DOI: 10.1002/2017GC006950
December 2017	Geomorphology (peer review journal)	Long-term variability of supratidal coasltal boulder activation in Brittany (France).	https://doi.org/10.1016/j.geomorph.2017.12.028

Date	Publication	Title	Reference
December 2017	Natural Hazards and Earth System Sciences (peer review journal)	Tsunami run-up estimation based on a hybrid numerical flume and a parametrization of real topobathymetric profiles	https://doi.org/10.5194/nhess-2017-445
December 2017	Global and Planetary Change (peer review journal)	The dyke swarms of the Old Volcanic Edifice of La Gomera (Canary Islands): Implications for the origin and evolution of volcanic rifts in oceanic island volcanoes	https://doi.org/10.1016/j.gloplacha.2017.12.004
December 2017	Comptes rendus Geosciences (peer review journal)	Pockmarks on the South Aquitaine Margin continental slope: The seabed expression of past fluid circulation and former bottom currents	https://doi.org/10.1016/j.crte.2017.10.003
December 2017	Quaternary International (peer review journal)	Reconstruction of LGM faunal patterns using Species Distribution Modelling. The archaeological record of the Solutrean in Iberia	https://doi.org/10.1016/j.quaint.2017.10.042
January 18	Journal	AMM15: a new high-resolution NEMO configuration for operational simulation of the European north-west shelf	https://www.geosci-model-dev.net/11/681/2018/gmd-11-681-2018.pdf
January 18	Journal	Rheological considerations for the modelling of submarine sliding at Rockall Bank, NE Atlantic Ocean	https://aip.scitation.org/doi/10.1063/1.5009552
January 18	Journal	The Nippon Foundation—GEBCO Seabed 2030 Project: The Quest to See the World's Oceans Completely Mapped by 2030	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwjmlN67wbPgAhWHDewKHRnuB-MQFjABegQICRAC&url=https%3A%2F%2Fwww.mdpi.com%2F2076-3263%2F8%2F2%2F63%2Fpdf&usg=AOvVaw3wMZGvSLa3Yhn3joYlNZHS

Date	Publication	Title	Reference
January 18	Conference	Scientific Seabed Mapping: Challenges of a Sustainable Data & Metadata Management on a National Level	https://epic.awi.de/id/eprint/45954/
January 18	Journal	Evidence of the Zanclean megaflood in the eastern Mediterranean Basin	https://www.nature.com/articles/s41598-018-19446-3
January 18	Journal	Absolute marine gravimetry with matter-wave interferometry	https://www.nature.com/articles/s41467-018-03040-2
January 18	Journal	Tidal dynamics in the inter-connected Mediterranean, Marmara, Black and Azov seas	https://www.sciencedirect.com/science/article/pii/S0079661117303567
January 18	Journal	A synthetic map of the north-west European Shelf sedimentary environment for applications in marine science	https://www.earth-syst-sci-data.net/10/109/2018/
January 18	Journal	The UKC2 regional coupled environmental prediction system	https://www.geosci-model-dev.net/11/1/2018/gmd-11-1-2018.pdf
February 18	Journal	Massive Mn carbonate formation in the Landsort Deep (Baltic Sea): Hydrographic conditions, temporal succession, and Mn budget calculations	https://www.sciencedirect.com/science/article/abs/pii/S0025322717300427
February 18	Section of a book	Submarine canyons and gullies	https://link.springer.com/chapter/10.1007/978-3-319-57852-1_14
February 18	Journal	The complexities and challenges of conserving common whelk (Buccinum undatum L.) fishery resources: Spatio-temporal study of variable population demographics with an environmental context	https://www.sciencedirect.com/science/article/abs/pii/S0165783618300511?via%3Dihub
February 18	Journal	A critical review of potential tsunamigenic sources as first step towards the tsunami hazard assessment for the Napoli Gulf (Southern Italy) highly populated area	https://link.springer.com/article/10.1007/s11069-018-3191-5

Date	Publication	Title	Reference
March 18	Journal	Using the FACE-IT portal and workflow engine for operational food quality prediction and assessment: An application to mussel farms monitoring in the Bay of Napoli, Italy	https://www.sciencedirect.com/science/article/pii/S0167739X16308305
March 18	Journal	Three-dimensional modeling of Mount Etna volcano: volume assessment, trend of eruption rates and geodynamic significance	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017TC004851
April 18	Book section	Geophysics of the Black Sea Basin	https://link.springer.com/chapter/10.1007/978-3-319-70855-3_4
April 18	Journal	Geomorphometric characterization of pockmarks by using a GIS-based semi-automated toolbox.	https://www.mdpi.com/2076-3263/8/5/154
April 18	Journal	Large landslide stress states calculated during extreme climatic and tectonic events on El Hierro, Canary Islands.	https://link.springer.com/article/10.1007/s10346-018-0993-1
April 18	Section of a book	Gas Hydrates 2: Geoscience Issues and Potential Industrial Applications.	https://archimer.ifremer.fr/doc/00453/56507/
April 18	Journal	Consistency between Sea Surface Reconstructions from Nautical X-Band Radar Doppler and Amplitude	https://journals.ametsoc.org/doi/abs/10.1175/JTECH-D-17-0145.1
April 18	Thesis	Toward a coastal processing resolving ocean model- nesting LES-COAST and MITgcm	https://arts.units.it/handle/11368/2922532
Mai 18	Journal	Constraints on the structure of the crust and lithosphere beneath the Azores Islands from teleseismic receiver functions	https://academic.oup.com/gji/article-abstract/213/2/824/4819286?redirectedFrom=fulltext
Mai 18	Journal	Sediment failures within the Peach Slide (Barra Fan, NE Atlantic Ocean) and relation to	https://www.sciencedirect.com/science/article/abs/pii/S0277379117309629

Date	Publication	Title	Reference
		the history of the British-Irish Ice Sheet	
Mai 18	Journal	Wahlenbergfjord, eastern Svalbard: a glacier-surrounded fjord reflecting regional hydrographic variability during the Holocene?	https://onlinelibrary.wiley.com/doi/abs/10.1111/bor.12325
Mai 18	Conference	Modeling the velocity of marine currents resources on a Moroccan coastal (Tarfaya) using SWAN model.	https://ieeexplore.ieee.org/document/8362571
Mai 18	Journal	Quaternary build-ups and rhodalgal carbonates along the Adriatic and Ionian coasts of the Italian peninsula: A review.	https://riviste.unimi.it/index.php/RIPS/article/view/10269
Mai 18	Journal	Co-location opportunities for renewable energies and aquaculture facilities in the Canary Archipelago.	https://www.sciencedirect.com/science/article/pii/S0964569117309122
Mai 18	Thesis	"Modelling the ecological niche of cetaceans: new perspectives and applications".	https://repositorio.uac.pt/bitstream/10400.3/4670/1/TeseDoutoramentoResumoIndIntrodMFM2018.pdf
Mai 18	Journal	Variability of Shelf Growth Patterns along the Iberian Mediterranean Margin: Sediment Supply and Tectonic Influences.	https://digital.csic.es/handle/10261/165060
Mai 18	Journal	Predicting shifting sustainability trade-offs in marine finfish aquaculture under climate change.	https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14296
June 18	Journal	Comparative effects of climate change and tidal stream energy extraction in a shelf sea	https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JC013832
June 18	Journal	Bottom-trawling fisheries influence on standing stocks, composition, diversity and trophic redundancy of macrofaunal assemblages from the West Iberian Margin.	https://www.sciencedirect.com/science/article/pii/S0967063718300013

Date	Publication	Title	Reference
June 18	Conference	Bathymetry derived from Sentinel-1 Synthetic Aperture Radar data.	https://www.vde-verlag.de/proceedings-en/454636154.html
July 18	Journal	Ice margin oscillations during deglaciation of the northern Irish Sea Basin.	https://onlinelibrary.wiley.com/doi/10.1002/jqs.3057
July 18	Journal	The role of subsidence in shelf widening around ocean island volcanoes: Insights from observed morphology and modeling.	https://www.sciencedirect.com/science/article/pii/S0012821X18304138
July 18	MSc Thesis	Linking physical oceanography, metapopulation dynamics and human pressures. Toward sustainable hake fisheries in the NW Mediterranean Sea.	https://www.politesi.polimi.it/handle/10589/141223
July 18	Journal	Drivers of the summer-distribution of Northeast Atlantic mackerel (Scomber scombrus) in the Nordic Seas from 2011 to 2017; a Bayesian hierarchical modelling approach.	https://academic.oup.com/icesjms/advance-article/doi/10.1093/icesjms/fsy085/5051297
July 18	Book Chapter	Submarine landslide catalogue onshore/offshore harmonization: Spain as a case study.	http://sp.lyellcollection.org/content/early/2018/07/31/SP477.38
July 18	Journal	From regional to local SPTHA: efficient computation of probabilistic inundation maps addressing near-field sources.	https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2018-202/nhess-2018-202-supplement.pdf
August 18	Journal	Ecosystem damage from anthropogenic seabed disturbance: A life cycle impact assessment characterisation model.	https://www.sciencedirect.com/science/article/pii/S0048969718332753
August 18	Journal	Risk screening assessment for ranking historic coastal landfills by pollution risk.	http://www.nrcresearchpress.com/doi/full/10.1139/anc-2018-0001

Date	Publication	Title	Reference
August 18	Journal	An analytical cost model for co-located floating wind-wave energy arrays.	https://www.sciencedirect.com/science/article/pii/S0960148118309935
August 18	Journal	Narrow shelf canyons vs. wide shelf canyons: Two distinct types of Black Sea submarine canyons.	https://www.sciencedirect.com/science/article/pii/S1040618218305226
August 18	Journal	Wave boundary layer model in SWAN revisited.	https://www.ocean-sci-discuss.net/os-2018-90/
August 18	Journal	Beached bachelors: An extensive study on the largest recorded sperm whale Physeter macrocephalus mortality event in the North Sea	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0201221
August 18	Journal	Source characterisation by mixing long-running tsunami wave numerical simulations and historical observations within a metamodel-aided ABC setting	https://link.springer.com/article/10.1007/s00477-017-1423-y
September 18	Journal	Numerical Landslide-Tsunami Hazard Assessment Technique Applied on Hypothetical Scenarios at Es Vedrà, Offshore Ibiza.	https://www.mdpi.com/2077-1312/6/4/111
September 18	Book Chapter	Chapter 14 - Plio-Quaternary Extension and Strike-Slip Tectonics in the Aegean	https://www.sciencedirect.com/science/article/pii/B9780128120644000141
September 18	report	Within the network of fluvial ports	https://www.db-thueringen.de/servlets/MCRFileNodeServlet/dbt_derivate_00041418/HarbourDataRepository_001_Kroeger_2018.pdf
September 18	report	Images and imaginations of roman ports	https://www.db-thueringen.de/servlets/MCRFileNodeServlet/dbt_derivate_00041422/HarbourDataRepository_002_Bendschus_Feuser_2018.pdf
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September 18	Journal	Modelling Offshore Wave farms for Coastal Process Impact Assessment: Waves, Beach Morphology, and Water Users.	https://www.mdpi.com/1996-1073/11/10/2517
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October 18	Journal	Post-spreading deformation and associated magmatism along the Iberia-Morocco Atlantic margins: Insight from submarine volcanoes of the Tore-Madeira Rise.	https://www.sciencedirect.com/science/article/pii/S002532271830224X
October 18	BSc. thesis.	Cost estimation for the Helsinki-Tallin fixed link connection.	https://upcommons.upc.edu/bitstream/handle/2117/123089/TFG_FINAL_MARC_ARRANZ.pdf?sequence=1&isAllowed=y
October 18	Journal	Structure in a sea of sand: fish abundance in relation to man-made structures in the North Sea.	https://academic.oup.com/icesjms/advance-article/doi/10.1093/icesjms/fsy142/5145713
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October 18	Journal	Active tectonics and seismic hazard in Skyros Basin, North Aegean Sea, Greece.	https://www.sciencedirect.com/journal/marine-geology/vol/407/suppl/C
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November 18	Journal	A GIS case study from the Atlantic: Where do we map next?	https://www.hydro-international.com/content/article/where-do-we-map-next
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November 18	Journal	A 20-yr database (1997-2017) of co-seismic displacements from GPS recordings in the Aegean area and their scaling with Mw and hypocentral distance.	https://ejournals.epublishing.ekt.gr/index.php/geosociety/article/view/18070
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November 18	Journal	FESOM-C: coastal dynamics on hybrid unstructured meshes.	https://www.geosci-model-dev-discuss.net/gmd-2018-112/

Date	Publication	Title	Reference
December 18	Conference	Computing complex for modeling the Black Sea.	https://iopscience.iop.org/article/10.1088/1755-1315/211/1/012082/meta
December 18	Conference	Fatigue Load Reductions in Offshore Wind Turbine Monopile Foundations in Co-Located Wind-Wave Arrays.	http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=2718903
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December 18	Journal	Impact of dense bottom water on a continental shelf: An example from the SW Adriatic margin.	https://www.sciencedirect.com/science/article/abs/pii/S0025322718302925
December 18	Thesis	Estratigrafia sísmica da plataforma continental ao largo da cadeia da Arrábida: contributo para o conhecimento da evolução pós-miocénica.	http://repositorio.ul.pt/handle/10451/35675?mode=full
December 18	Journal	North Sea demersal fisheries prefer specific benthic habitats	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0208338
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December 18	Conference	Fatigue Load Reductions in Offshore Wind Turbine Monopile Foundations in Co-Located Wind-Wave Arrays.	http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=2718903

12. Recommendations for follow-up actions by EU

- Promote the EMODnet Bathymetry infrastructure as a repository for all european bathymetric data and more especially those financed by european funds. This could take the form of citing EMODnet Bathymetry in contractual documents (tenders or calls for proposal) which concern bathymetry data acquisition and/or management.
- Discuss strategies to motivate non EU data providers, especially for north Africa, but also Russian Federation.

13. List of acronyms

Acronyms as used in this report are defined in the following list:

BSBD, Baltic Sea Bathymetry Database.

BSHC, Baltic Sea Hydrographic Commission.

CDI, Common Data Index, provides a highly detailed description of the survey data, answering to the questions: where, when, how and who collected the data, and how to get them. One CDI describes a survey by means of a polygon or survey track. The CDI service also includes a shopping service for requesting access to selected data sets and for downloading as data files, if access has been granted by the data owners.

CPRD, Composite DTM data sets, giving a gridded bathymetry. In practice it was found that Hydrographic Offices (HO's) do not want or can not deliver primary surveys but composite data sets from the Digital Terrain Models that they maintain themselves for producing and maintaining their nautical charts following international IHO procedures. Composite DTM's are DTM's that have been generated by the data provider itself at a specific resolution and making use of survey data sets as managed by that data provider. These Composite DTM's might contain grid cells for which no survey data were available and which are then possibly completed by interpolation or other manipulation. Overall the EMODnet project prefers to get access to survey data sets, where possible, and not the derived Composite DTM's. However in practice this is not (yet) always possible and using the Composite DTM's can then be considered as the next best option. In addition, Composite DTM providers are encouraged to describe anyway their survey data sets in the CDI Data Discovery and Access service in order to give better insight in the real survey coverage. This is followed up by an increasing number of providers, but not always possible for historic reasons.

CVE, Collaborative Virtual Environment, also known as Virtual Research Environment

DEM, Digital Elevation Model. It is a digital model or 3D representation of a terrain's surface. In the context of EMODnet HRSM it is used to describe the land elevation, while the bathymetry is described with a Digital Terrain Model (see next).

DTM, Digital Terrain Model, is a resulting grid data set with attributes for lat, lon, minimum depth, maximum depth, average water depth, standard deviation, number of values, number of elementary surfaces, smoothed average water depth, depth smoothed offset, CDI reference, and Composite DTM reference / GEBCO_2014 reference.

GEBCO, the General Bathymetric Chart of the Oceans (GEBCO) consists of an international group of experts who work on the development of a range of bathymetric data sets and data products, including

gridded bathymetric data sets, the GEBCO Digital Atlas, the GEBCO world map and the GEBCO Gazetteer of Undersea Feature Names. GEBCO operates under the joint auspices of the the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) (of UNESCO). GEBCO 30" gridded data is used by the EMODnet project to complete area coverage in case there are no survey data or Composite DTM data sets available to the partners. GEBCO is represented in the EMODnet HRSM consortium by its editor, NERC-BODC.

GTSM, Global Tide Surge Model developed and operated by Deltares.

IBCAO, the International Bathymetric Chart of the Arctic Ocean is an initiative to develop a Digital Terrain Model (DTM) based upon all available bathymetric data north of 64° North, for use by mapmakers, researchers, institutions, and others whose work requires a detailed and accurate knowledge of the depth and the shape of the Arctic seabed. Initiated in 1997, this undertaking has been endorsed by the Intergovernmental Oceanographic Commission (IOC), the International Arctic Science Committee (IASC), the International Hydrographic Organization (IHO), the General Bathymetric Chart of the Oceans (GEBCO), and the US National Centers for Environmental Information (NCEI). IBCAO is represented in the EMODnet HRSM consortium by its coordinator, the University of Stockholm.

Sextant, catalogue service used to provide details about Composite DTM data sets. It allows to discover any Composite DTM's as available and used for the EMODnet DTM instead of bathymetry survey data sets. The location is given by a Lat-Lon box in a map and descriptions are given of each Composite DTM with information for what, when, how, and who. The Sextant entries are linked as references in the EMODnet DTM grid cells, where appropriate, to indicate the source data. The Sextant service for EMODnet HRSM does not give a shopping service, but includes contact links for requesting access to the Composite DTM's.

SeaDataNet, is the pan-European infrastructure for ocean & marine data management sponsored within FP7 (grant agreement 283607, 1/10/2011-30/9/2015) connecting at present more than 100 national oceanographic data centres and marine data centres from 35 countries riparian to all European seas.

SeaDataCloud, is the successor project to SeaDataNet II for further developing the technical basis of the SeaDataNet infrastructure, funded by HORIZON 2020 (grant agreement 730960, 1/11/2016-31/10/2020).

TIN, triangulated irregular network, a way to model the EMODnet DTM using triangles in different sizes to support 3D viewing.

VRE, Virtual Research Environment, also known as Collaborative Virtual Environment

WCS, Web Coverage Service is an OGC standard defining Web-based retrieval of coverages i.e. digital geospatial information representing space/time-varying phenomena.

WFS, Web Feature Service is an OGC standard allowing requests for geographical features across the web using platform-independent calls.

WMS, Web Map Service is a standard OGC protocol for serving geo- referenced map images over the Internet.

WMST, Web Map Tile Service is a standard OGC protocol for serving pre-rendered georeferenced map tiles over the Internet.

14. References

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