EMODnet Thematic Lot n°1 – Bathymetry

EASME/EMFF/2019/1.3.1.9/Lot1/SI2.836043

Start date of the project: 20/12/2020 - (24 months)

Centralisation Phase

Interim Progress Report

Reporting Period: 20/12/2020 – 19/12/2021

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Contents

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1. Introduction

This report gives the progress in the 1st year of the new **EMODnet Bathymetry contract (HRSM3)** which runs for 2 years from 20th December 2020. It is a follow-up of the earlier developments in EMODnet Hydrography, Seabed Mapping, Bathymetry and High-Resolution Seabed Mapping projects which took place since June 2009 and that resulted in the portal: https://www.emodnet-bathymetry.eu.

EMODnet HRSM3 aims at a continuation of services, at an expansion of the collection gathered of bathymetry survey data sets, composite DTMs and high resolution DTMs, and at a refinement of the quality and precision of the overall EMODnet DTM of 1/16 minute * 1/16 minute, inter alia by optimizing the production methodology and associated tools next to filling gaps and replacing less accurate data with new data, where possible.

The overall methodology is a continuation from the earlier approach in HRSM2, although refinements are to be made, for instance in the GLOBE tool, and interpolation techniques. Moreover, it is planned that as part of the process for producing regional DTMs, use will be made by Regional Coordinators of the online Collaborative Virtual Environment (CVE) for which IFREMER will upgrade the earlier developed and tested prototype. The CVE includes an online and improved version of the GLOBE software and it runs on a High-Performance computer network, managed at IFREMER.

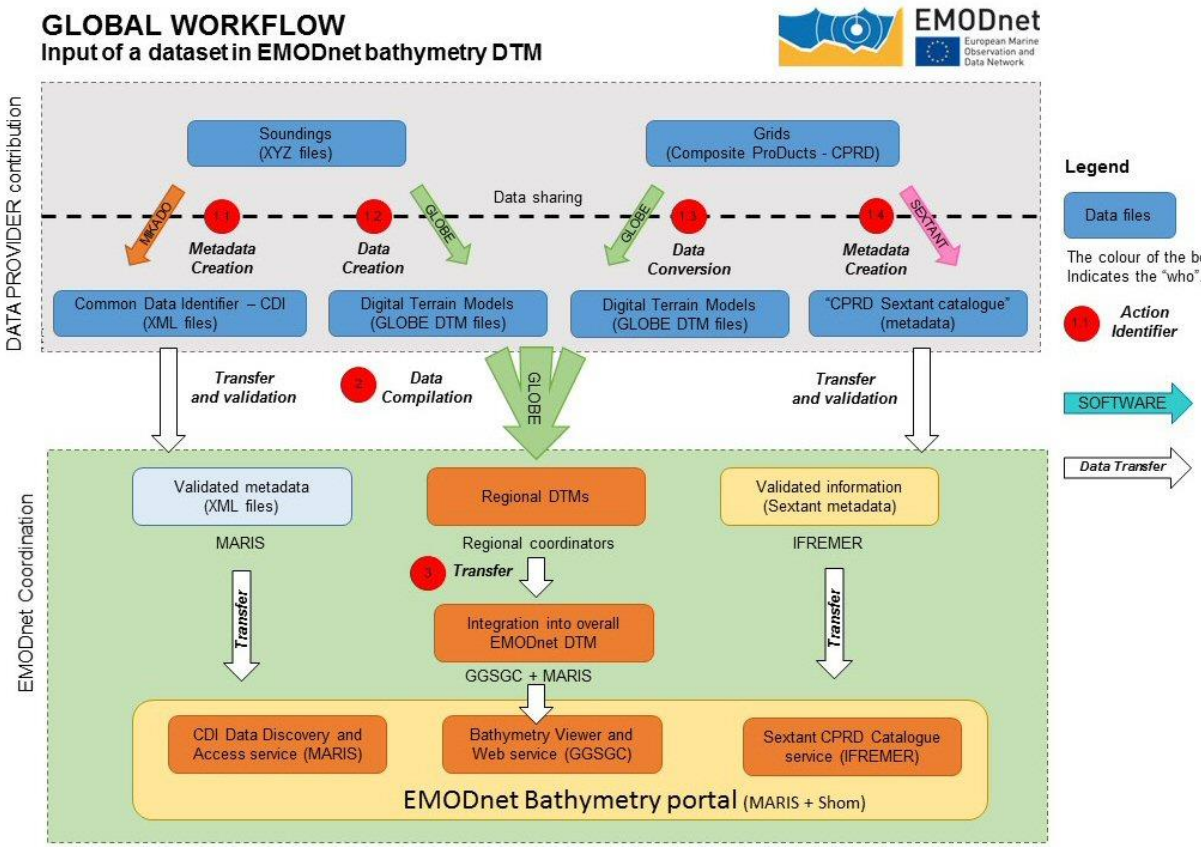


Image: Workflow for EMODnet HRSM2

As illustrated in the flow chart above, the generation of Regional DTMs is again divided over regional sea basin subgroups, each with a Regional Coordinator and a number of contributing data providers. The coverage of

the Regional DTMs will be expanded with (part of) the Caribbean Sea region. Each Regional Coordinator will be responsible for a quality assessment and selection of the data contributions and the compilation of the Regional DTM using the GLOBE software. This process will start end February 2022 when all data providers have finalized their data gathering and population activities for the CDI and CPRD catalogues and will have undertaken pre-processing and gridding of their data sets for delivery as DTMs to the regional coordinators. The regional DTMs are planned to be ready by end July 2022, after which the central integrator (GGSgc) will start it's work of validating and merging all regional DTMs into the new release of the EMODnet DTM. The step from Regional DTM to overall EMODnet DTM is not only an integration but also a final QA – QC to achieve a high-quality bathymetry product that can be made public for viewing and for downloading.

The new EMODnet DTM will continue to have a common resolution of 1/16 minute * 1/16 minute overall. This will be published by OGC services and as a number of OGC layers, while users will be able to download DTM tiles in a range of formats. In addition, additional higher resolution DTMs will be produced as hotspots and for the near coastal areas and coastal zones, where possible. These HR-DTMs with different resolutions will be published as another OGC layer and users will be able to download each individual HR-DTM file at its highest resolution.

Furthermore, the existing inventory of national coastlines and legal baselines will be updated, trying to get also entries from currently missing countries around the European seas. And new versions of the best-estimate digital European coastlines and a new set for selected islands in the Caribbean Sea region will be produced at three vertical reference levels (LAT, MSL, and MHW).

A major new challenge is working on a successfull migration of the various products and services of EMODnet Bathymetry from its existing own portal to a new EMODnet Central Portal, that is hosted at the Europa domain. EMODnet Bathymetry will remain responsible for generating its various products and for hosting machine-to-machine services which can be used by the Central Portal for publishing and downloading as part of a Central Products catalogue and related Central Map Viewer, while EMODnet Bathymetry also maintain a section at the Central Portal for publishing its information pages. The migration requires a close cooperation with the Central Portal (CP) team, which also has to interact with all other thematic EMODnet lots.

The new EMODnet Bathymetry contract is undertaken by almost the same consortium as the previous contract and this consists of altogether 43 legal entities from 20 countries (18 EU member states) along European seas, comprising major marine research institutes (20), national hydrographic services (15), and companies (8), with major expertise and experience in the field of bathymetry, such as surveys, generating bathymetric data products, Satellite Derived Bathymetry, tidal modelling, developing services, data management, system architecture analysis, standards such as INSPIRE, ISO, and OGC, product visualisation, and project management. The new project is again coordinated by Shom, while MARIS acts as Deputy-Coordinator.

2. Update on the Tasks

Task 1 - Gather and give access to bathymetric survey data:
Gathering and population of new survey data sets and new Composite DTMs provide contributions for updating and generating the new versions of the Regional DTMs. This task has been completely fulfilled by 38 of the 43 contractual data providers and together they have increased the number of survey data sets considerably from 30560 to 31432 CDI entries and the number of Composite DTM entries from 207 to 258 Sextant entries. The remaining 5 data providers are underway and expect to deliver in the first months of 2022. The received data sets also include survey data sets, composite DTMs and Satellite Derived Bathymetry (SDB) files for the Caribbean Sea region as a new region for EMODnet Bathymetry. Deliverable D2.1 with updated guidelines for catalogue population has been delivered in April 2021.

Task 2 - Compile a multi-resolution digital terrain model of European seas:
As follow-up to task 1, data providers have been busy with pre-processing and gridding their new data sets to EMODnet standards, making use of the latest version of the GLOBE software. This was upgraded by IFREMER, following a list of requirements from consortium members and derived from earlier experiences. Data providers participated to the GLOBE Training Workshop, held online in September 2021. New formatted datasets are transferred in NetCDF V4 format by data providers to respective Regional Coordinators, who are reviewing new received datasets, using dedicated functionalities of the GLOBE software. A plenary project meeting is planned for January 2022 to check the status of this transfer.Also, a Training Workshop is planned at the same date for Regional Coordinators to be informed and trained in the use of the Collaborative Virtual Environment (CVE) with online GLOBE and dedicated functionalities. Ultimately, Regional Coordinators are expected to provide the results of their compilation of regional DTMs before the summer 2022 to the Integrator who will integrate all regional components into the full EMODnet DTM product.
Deltares progressed with updating and refining the best-estimate European digital coastlines for 3 vertical levels (LAT, MSL, and MHW) and expanding this with the Caribbean Sea region. These are to be determined from satellite data (typically Sentinel-2 and Landsat-8) and combined with sea level reference data from the Global Tide Surge Model (GTSM). So far, Deltares has further optimised the methodology and the precision of the GTSM tidal model. Moreover, it is introducing use of new data sources, such as the ICESat-2 satellite in support of better results.

Task 3 - Develop procedures for machine-to-machine connections to data and data products:
The present EMODnet Bathymetry portal has many features for providing a gateway to data, metadata and data products. These are combined with web services, such as OGC services for sharing map layers of the EMODnet DTM and sharing locations and metadata of survey data sets (CDI service) and composite DTMs (Sextant catalogue service). A migration is planned to go from thematic portals to one central EMODnet portal, which should become the one-stop-shop for EMODnet products and services. To find and implement a suitable migration path, there has been regular contact between the EMODnet Central Portal team (CP team) and EMODnet Bathymetry since early January 2021. In total already 8 meetings have taken place. Overall, a good understanding has been reached about the way forward, while there are still some items which need further discussion and specification.
IFREMER advanced with the Collaborative Virtual Environment (CVE) with online Globe software. Successfully, the current EMODnet 2018 and 2020 DTM grids and a Difference Map have been loaded so that Regional Coordinators can oversee easily which updates have been made and to what effect. They will also be able to investigate and annotate residual artefacts, with the aim of improving the quality. The status of the CVE development has been discussed with the core team at a technical meeting at 16 December 2021 and a

Training Workshop for Regional Coordinators is planned at 24 January 2022. Deliverable D3.1 with updated specifications and guidelines for using the latest prototype has been delivered in December 2021.

Task 4 - Contribute data, data products and content to a central portal that allows users to find, view and download data and data products:

This is part of the CP migration activities. The CP team has made a start by including some of the map layers and their advanced functions of EMODnet Bathymetry in a test Central Portal map viewer. For the advanced services, EMODnet Bathymetry had made available their software scripts to a GIS expert of the CP team. Next action is to test these map layers and functions. CP team made an index of the information pages of the EMODnet Bathymetry website which will need to be edited for inclusion in a dedicated Bathymetry section at the new Central Portal. EMODnet has reviewed the index and is awaiting the new compilation for review. Also, some examples of metadata XML files of DTM products have been provided to CP team, but further discussion is needed for detailing how the CP downloading for DTM tiles and HR-DTMs might be implemented in the new CP.

Task 5 - Contributing content to dedicated spaces in Central Portal:

As indicated under task 3, EMODnet Bathymetry is awaiting progress by the CP team with an draft compilation of the provided site content according to the new sitemap, so that a review can take place, followed by online maintenance by EMODnet Bathymetry itself.

Task 6 - Ensure the involvement of regional sea conventions:

EMODnet data products and metadata records are extending well beyond European waters. Regional Sea Conventions are well served by the bathymetric information through the easy delivery of the EMODnet Bathymetry products and services. Also, several members of the consortium are involved in HELCOM (eg: Sweden, Danmark), OSPAR (eg: France), Bucharest convention (eg: Bulgaria and Romania), and Barcelona convention (e.g. France, Italy, Croatia, Greece, …) and promoting EMODnet.

Task 7: Contribute to the implementation of EU legislation and broader initiatives for open data:

The consortium consists of organisations that have relevant international networks and are well acquainted with international cooperation, also aiming at international interoperability. This includes relationships concerning standards such as: ISO, OGC, INSPIRE, SeaDataNet, IHO, IOC, and ODIP. It also includes relationships concerning collection and sharing of metadata, data and DTMs such as: GEBCO, IBCAO, BSBD, NSBD, NOAA-NCEI as part of Galway declaration. Leading partners of the consortium are involved in SeaDataCloud, Blue-Cloud, EOSC, and other European digital initiatives and projects, and are interacting with these developments, to the benefits of EMODnet Bathymetry.

EMODnet Bathymetry benefits greatly from tight relations with the IHO, through participation in the IHO Europe Network working group (IENWG) and regional hydrographic commissions, such as North Sea HC, Baltic HC, Eastern Atlantic HC. This is expanded with the Meso American and Caribbean Sea HC, where EMODnet Bathymetry representatives recently have introduced the new activities undertaken for the Caribbean seas. Finally, there is close cooperation with the GEBCO program and Seabed 2030 project, joint initiatives of IHO and IOC, in which colleagues from EMODnet Bathymetry hold important positions such as Vice-chair of GEBCO, Chair and Vice-chair of the Technical Sub-Committee on Ocean Mapping (TSCOM), and GEBCO Digital Atlas Manager.

INSPIRE compliance is promoted, which has been configured for all EMODnet Bathymetry OGC web services. The latest validation by the EMODnet Secretariat indicates a full score. This will be maintained in support of the migration to a Central Portal.

Finally, it is worth mentioning that the metadata and data gridding methodology developed as part of EMODnet Bathymetry has been successfully adopted by Chinese colleagues of NMDIS as part of the EMOD-PACE project.

Task 8 - Monitor quality / performance and deal with user feedback:

The overall performance of the portal and its services are continuously measured and its results are reported in the separate indicators spreadsheet. These demonstrate that the Bathymetry portal and its services and products continue to be highly popular and in great demand for a wide range of user applications. Also, many user feedback questions (52) were received and answered by the helpdesk. These are listed in chapter 6.
The coordinator and technical coordinator prepared four quarterly progress reports. And they organised a number of project meetings and training workshops for EMODnet Bathymetry members which are listed in chapter 7.

Task 9 - Maintain the existing thematic web portal for a maximum of six months from the start of the project:

The current EMODnet Bathymetry portal will be maintained (and used as focal point for Bathymetry users) until agreement is reached between EMODnet Bathymetry team, CP team, CINEA and DG-MARE that the level of service of the new Central Portal has reached a similar standard as the EMODnet Bathymetry portal.

Status of the Milestones and Deliverables listed in the workplan				
Milestone/Deliverable	WP	Date due	Status (Delivered/Delayed)	If Delayed: reason for delay and expected delivery date
D1.1: Quarterly concise progress reports	WP1	M4, M7, M10, M13, M16, M19, M24,	M4, M7 and M10 delivered	
D1.2: Annual Interim report	WP1	M12	Delivered at M14	Delayed with agreement of CINEA with the main reason being to be able to integrate actions which have to be reported in Q4.
D1.3: Final report	WP1	M24		
D1.4: Plan for service continuity, incl. docs and sources	WP1	M24		
D2.1: Upgraded guidelines for data pre-processing and population of metadata	WP2	M3	M4 delivered	Is included as Annex to this Annual Report
D2.2i: Training Workshop for data pre-processing and metadata population	WP2	M3	M4 delivered	
D2.3: Pre-processed survey data sets and included in CDI Service	WP2	M12	Mostly done	A few partners are still underway

D2.4: Pre-processed composite DTMs and included in Sextant service	WP2	M12	Done	
D2.5: Satellite Derived Bathymetry data sets and included in Sextant Service	WP2	M12	Done	
D3.1: Upgraded guideline of EMODnet methodology for DTM production, including using prototype CVE	WP3	M8	M12 Delivered	Is included as Annex to this Annual Report
D3.2i: Upgraded Globe software	WP3	M8	Delivered in M9	
D3.3i: Training and intercalibration Workshop	WP3	M11	Delivered in M9	
D3.4i: Processed and pre-gridded data sets as input for RDTMs	WP3	M14	Well underway	
D3.5i: Regional DTMs with common resolution of 1/16 arc minutes grid	WP3	M17		
D3.6i: Best version HR DTMs for coastal waters and hotspots	WP3	M20		
D3.7: New EMODnet DTM incl Quality Index and loaded in EMODnet web services for viewing and downloading	WP3	M23		
D3.8: HR-DTMs loaded as separate layer in EMODnet web services for viewing and downloading	WP3	M23		
D3.9: Source reference layer to link to CDI and Sextant Catalogue services	WP3	M23		
D3.10: Refined best-estimate European digital coastlines for a range of	WP3	M22		

vertical levels at the portal				
D3.11: Updated Inventory of existing and ratified baselines and registered claims / disputes under UNCLOS, for European countries at the portal	WP3	M20		
D3.12: Tidal bathymetry for Venice Lagoon	WP3	M23		
D4.1: Standard machine-to-machine services delivered for common functionalities	WP4	M3	M1 delivered	
D4.2: Dedicated machine- to-machine services adapted / delivered for special functionalities	WP4	M6	As part of the migration process, scripts have been shared with Central Portal team. Integration in Central Portal is making progress but is delayed compared to initial planning with EU in agreement.	
D4.3i: CVE adapted for handling review of RDTMs	WP4	M14	Done	A demonstration has been done to the technical group. Training workshop for Regional Coordinators is planned 24 January 2022
D4.4i: Globe software + GGSGC workbench upgraded with extra functionality	WP4	When required	An updated version of GLOBE has been delivered (1.18.15)	
D5.1: Operational Help-desk	WP5	continuously		
D5.2: Monitoring data about visits and usage	WP5	continuously		
D5.3: Promotional material and up-to-date thematic space at central portal	WP5	continuously		

D5.4: Presentations at relevant conferences	WP5	regularly		

3. Work Package updates

WP1 – Project management

Covering Tasks 5 + 9

The new EMODnet Bathymetry project, internally known as HRSM3, is successor to the EMODnet Bathymetry - High Resolution Seabed Mapping project (HRSM2), and has been awarded by EASME (nowadays CINEA) to the consortium, led by Shom. The contract was signed by both parties on 20 December 2020. A consortium agreement (for full partners) and subcontractor agreements (for subcontractors) were drafted, amended following feedback, and ultimately signed by all. The Core Group, composed of Coordinators and Work package leaders, have met 8 March 2021 to prepare the project kick-off meeting and to discuss updating, where needed, of the methodology, technology and production processes as used in the predecessor EMODnet HRSM2 project. The work plan has the same composition as the previous contract as it is a continuation. However, a new challenge is he migration to a Central Portal for EMODnet.

The HRSM3 kick-off meeting including all consortium members took place 7 – 9 April 2021, and included also a Training Workshop on how to populate the Catalogues for bathymetric data sets. All partners joined in order to discuss further the implementation of the future update of data sources, the generation of the new EMODnet Digital Terrain Model (DTM) and other targeted products and services. Presentations were given by Coordinators, WP leaders, and specific experts to introduce and discuss the workplan and expected actions. Also, instructions were given relevant for implementation of the project methodology for generating a new release of the DTM took place, highlighting and giving guidance concerning use of the preferred software tools (Mikado, Sextant, Globe). All presentations have been included in the extranet. A second training workshop was organised 6 September 2021, dedicated to the upgraded GLOBE software. The Core Group met again 19 November 2021 to discuss overall progress, reviewing the overall planning, and discussing organisation of a next plenary meeting and training workshop in January 2022. Moreover, a technical meeting took place at 16 December 2021 to review the upgraded Collaborative Virtual Environment (CVE) and to discuss how to arrange uptake by Regional Coordinators. The coordinator (Shom) and technical coordinator (MARIS) have participated in the EMODnet Steering Committee meetings on 19 – 21 April 2021 and 8 – 10 September 2021, presenting the project progress and contributing to discussions. They also participated and contributed to the EMODnet Jamboree and its side meetings in the week from 14 – 18 June 2021. Shom and MARIS together prepared 4 quarterly progress reports of which the first 3 have been accepted by the EU (CINEA and DG MARE), while the last one is under review as it concerns the 4th quarter of 2021. Shom and MARIS have also together drafted this 1st Annual Report.

WP1 concerns overall Project management. It contributes also to Task 5 - Contributing content to dedicated spaces in Central Portal – which is not yet started, and Task 9 - Maintain the existing thematic web portal for a maximum of six months from the start of the projects -, which is being done and will be continued till the migration process has been successfully completed.

WP2 – Bathymetric data collection and metadata compilation for all maritime basins and coastal waters and arranging common access

Covering Task 1

At the project kick-off meeting 19-21 April 2021, all data providers have been informed about the proven approach and software tools and services that are used in EMODnet HRSM3 for gathering source data sets such as bathymetric survey data sets and composite DTMs and populating these into the two major catalogues: the CDI Data Discovery and Access service for describing survey data sets and the Sextant data products catalogue service for describing composite DTMs. During the training session, IFREMER explained in detail the use of the software tools (MIKADO and NEMO for CDI population; online Sextant CMS and GLOBE for CPRD population) and related services. Upon request, the distinction between composite DTMs entries and HR-DTMs was explained. Composite DTM entries are made as input for the generation of the Regional DTMs, next to survey data sets as included in the CDI service, and should be populated into the Sextant CPRD Catalogue. The Composite DTMs should be prepared using GLOBE following the EMODnet Bathymetry methodology and should be provided to Regional Coordinators at a minimum resolution of 1/16 arc minutes but rather 1/32 arc minutes AND having CDI references included of used survey data sets. While, HR-DTMs can be made of single survey data sets, but also as a composite of multiple survey data sets. The HR-DTMs should be populated separately into the Sextant HR-DTM Catalogue. The HR-DTMs are made for public downloading and for these again GLOBE and EMODnet Bathymetry methodology should be followed for delivering a minimum resolution which is higher than the EMODnet DTM, so at least 1/32 arc minutes up to 1/512 arc minutes, as long as the resolution within the HR-DTM is consistent. The HR-DTMs should include CDI reference(s) of used survey data sets. The finalised and indexed composite DTM files must be sent to each concerned Regional Coordinator whereas the HR-DTMs files have to be sent to IFREMER and GGSGC for management and later inclusion in the High-Resolution Bathymetry map layer for viewing and downloading.

A review and update took place of the guidelines for giving guidance on the methodologies for populating the catalogues and pre-processing the data sources. This has resulted in Deliverable D2.1 which has been distributed following the training workshop at the kick-off meeting and also included at the website in the section 'Technical Documentation'. It is included in this Annual Report as Annex 1.

As part of the proposal submission an inventory was prepared with indication of new data sets that would be populated by the data providers in the consortium. In practice, this inventory is used to monitor progress. Where needed, support was given to individual data providers by MARIS for the CDI population and by IFREMER for the Sextant population. Overtime several messages were sent to data providers to remind them of the need for data population and about making use of the latest versions of the software packages. One recent change in the CDI approach has been to use nowadays only two data access conditions, namely 'CC-BY-4.0' for open and unrestricted access, whereby copies of the data sets are replicated to the SeaDataNet central data cloud for direct delivery, and as other option 'Restricted' whereby data providers are alerted about data requests and have to take a decision on deliveries.

The data gathering and population in the first year has been very good and 38 out of the 43 contractual data providers have completed their assignment while the remaining 5 are underway. The total number of CDIs has substantially increased from **30560 to 31432** CDI entries and the number of Composite DTM entries from **207 to 258** Sextant entries. The received data sets also include survey data sets, composite DTMs and Satellite Derived Bathymetry (SDB) files for the Caribbean Sea region as a new region for EMODnet Bathymetry.

As part of the expansion to the Caribbean Sea region, EOMAP has been working on producing Satellite-Derived Bathymetry data for the overseas territories of European countries in the Caribbean. The work was structured into: (1) identification on those oversea territories where survey data exist by other entities which contribute or might be able to contribute those to the project and (2) the analysis of Satellite-Derived Bathymetry for

those sites, where shallow water bathymetric data do not exist or are not shared to the EMODnet project. Resulting SDB data sets are indexed in the Sextant Catalogue service as composite DTMs and also will be pre-processed with GLOBE for hand-over to the Regional Coordinator of the Caribbean area.

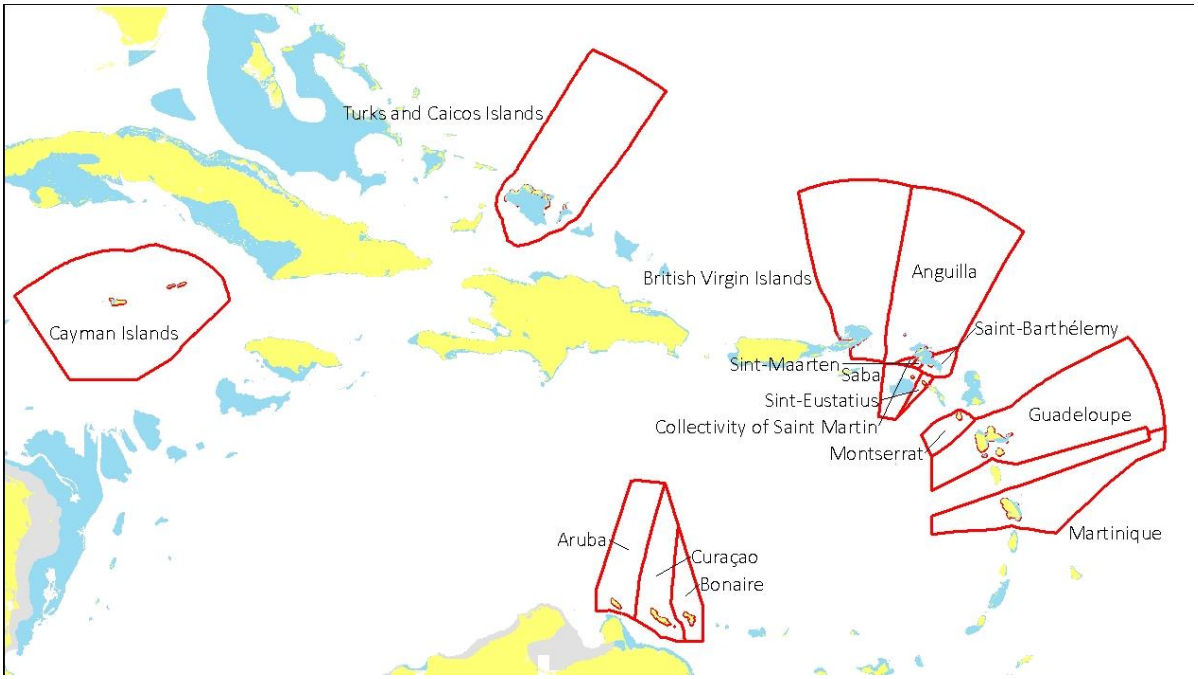


Image: Map of UK, NL and FR Caribbean oversea territories (red) and identification of potential shallow waters (light blue).

More details about this process and production of EOMAP can be found in Annex 4 to this Annual Report.

WP3 – QA-QC, data processing and producing Digital Terrain Models for the basins, the integrated EMODnet DTM, best-estimate Coastlines, overview of legal baselines, and vertical reference levels Bathymetric data collection and metadata compilation for all maritime basins and coastal waters and arranging common access

Covering Task 2

This Work Package includes activities for a range of EMODnet Bathymetry products, such as the production of the EMODnet DTM, updating the inventory of national coastlines and baselines, and producing new versions of the best-estimate digital coastlines at three vertical reference levels (LAT, MSL, and MHW).

Activities for production of EMODnet DTM:

The latest version of the EMODnet DTM (Digital Terrain Model) was released 13 January 2021 with a resolution of 1/16 * 1/16 arc minutes (circa 115 * 115 m2). The overall methodology for the generation of the new EMODnet DTM remains the same as the one applied in the previous EMODnet HRSM2 phase, except that there is now also focus on the Caribbean Sea region. Following the usual approach, the new DTM will be compiled by an integration of new versions of regional DTMs that will be generated by regional coordinators. At a GLOBE training workshop on 6 September 2021 data providers have been instructed on pre-processing and gridding their data input using the latest GLOBE software and following the EMODnet Bathymetry method and grid. This way their new data input is made fit for the Regional Coordinators. Furthermore, IFREMER has made an upgrade of the Collaborative Virtual Environment (CVE) with online GLOBE which Regional Coordinators can use as extra instrument for reviewing the existing DTM and identifying artefacts and anomalies that might be corrected, replacing existing data sets with new received data sets, filling gaps with new data sets, and/or re-running interpolations with new algorithms as becoming available in GLOBE. At 16 December 2021 a technical meeting was held to discuss the upgraded CVE prototype and it was decided to organise a Plenary meeting for all partners and back-to-back a CVE training session for Regional Coordinators in January 2022, in time for the Regional Coordinators to start with their production of Regional DTMs. Moreover, a Deliverable D3.1 was released with guidelines for use of the CVE. This guideline has been distributed and included at the website in the section 'Technical Documentation'. It is included in this Annual Report as Annex 2.

Next steps will be that Regional Coordinators will work on the production of new Regional DTM releases for 12 regions from February to July 2022, while progress meetings will be organized to monitor and coordinate the process. The new regional DTMs will then be transferred to the DTM integrator (GGSGC) around summer 2022 and then analysed and merged from August to October 2022 in order to produce a new version of the EMODnet bathymetry grid. After validation, checking all data references, and additional activities such as preparing a new 3D model and new set of downloadable DTM tiles in multiple formats, the new release should be made available around December 2022.

Activities for LAT-MSL correction of current DTM:

In the summer of 2021, a question was received from a user, who noted some artefacts when subtracting gridded bathymetry relative to LAT compared to bathymetry relative to MSL. A shift of half a grid-cell between different formats was found, which immediately was corrected and related DTM tiles were replaced. The background of this was that several GIS formats allow the data to be defined in points or as a cell average, which results in a shift of half a cell in the coordinates of file. Using this experience, the processing chain has been updated and all steps now consistently handle both options. This makes the bathymetry relative to MSL and relative to LAT fully consistent at the pixel level with the LAT-MSL correction fields.

Activities for refining the Global Tide and Surge Model – GTSM:

Tide and surge modelling is done by Deltares with their GTSM model and their outputs are used in several ways. LAT-MSL differences are computed with the model and applied to the gridded bathymetry, that is collected and compiled with LAT as a vertical reference. This way, the EMODnet DTM can also be delivered as DTM tiles relative to MSL which is preferred by part of the users, e.g. for modelling the coastal ocean because it better fits their assumptions and it facilitates a connection to land-oriented data. In addition, GTSM model outputs are used for processing satellite derived inter-tidal bathymetry and for computation of the satellite derived coastlines. Bathymetry itself is an important factor in the computation of tides and total sea-levels. In 2021, the bathymetry of the GTSM model was updated using newly available data from EMODnet-bathymetry, from GEBCO and several other sources. More specifically, for Europe EMODnet 2016 was replaced by EMODnet 2018 and GEBCO 2014 to GEBCO 2019. The figure and table below show the positive impact this has on model performance. This is consistent with our experience, that updates/improvements of bathymetry lead to a more accurate model performance, which indicates that the uncertainty in the bathymetry in an important factor for the accuracy of coastal ocean models in Europe and elsewhere.

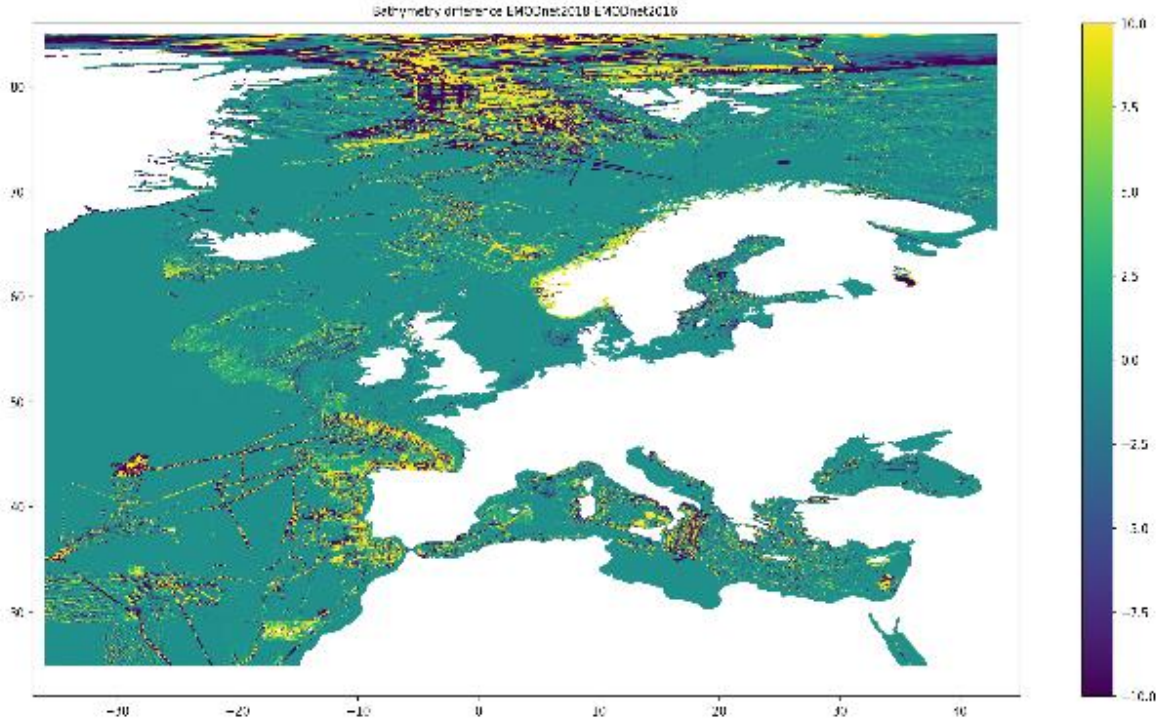


Image: Difference between EMODnet gridded bathymetry releases 2016 and 2018 in meters.

Region	**GTSM with EMODnet 2016/ GEBCO2014**	**GTSM with EMODnet 2018/GEBCO 2019**
Arctic Ocean	5.71 cm	5.22 cm
Indian Ocean	6.93	5.43
North Atlantic	8.03	5.58
North Pacific	6.36	4.98

South Atlantic	5.13	3.93
South Pacific	6.44	4.91
Southern Ocean	5.00	3.95
Total	6.32	4.85

Table: Accuracy of GTSM tides compared to satellite (FES2014) in deep water before and after update of the bathymetry.

Starting from GTSM with updated bathymetry, Wang et al performed a calibration of GTSM version 4.1, which resulted in a much improved accuracy in Europe (see also preprint at https://os.copernicus.org/preprints/os-2021-112/)

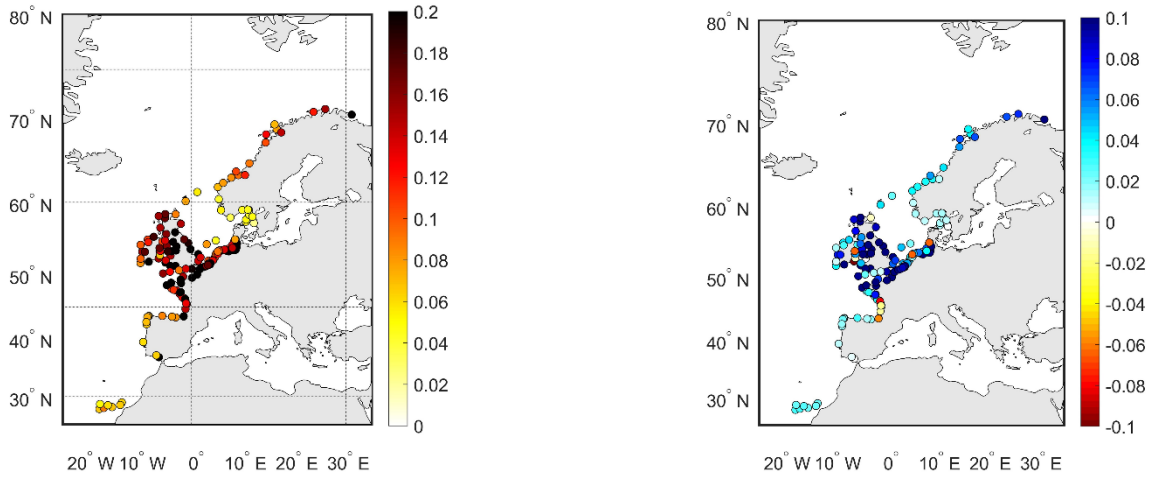
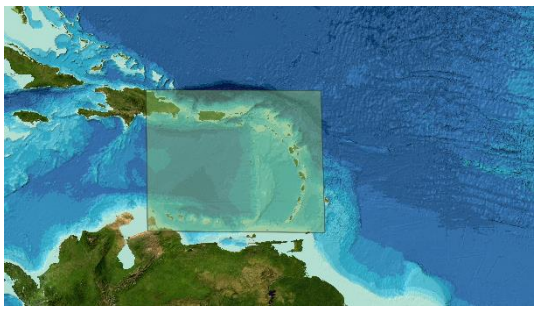


Image: RMSE accuracy [m] of GTSM tides compared to tide-gauges before calibration (left) and difference due to calibration (right).

In the next months, Deltares will aim to compute updated LAT-MSL corrections making use of this version (GTSM 4.1), and when the new EMODnet gridded bathymetry w.r.t LAT becomes available, the LAT-MSL correction will be applied to provide bathymetry relative to MSL.

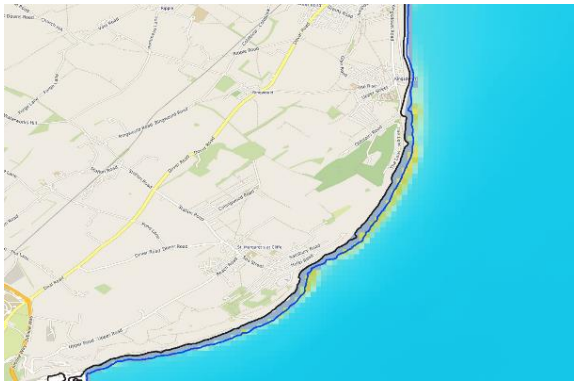
Activities for updating and refining best-estimate European digital coastlines:

Deltares is undertaking several activities to extend, update and improve the satellite derived coastlines at three vertical reference levels (LAT, MSL, and MHW), that are available now on the EMODnet portal. One aspect is including also coastlines of selected islands in the Caribbean for the same area as will be used for the extension of the gridded bathymetry. Data will be processed in 1°x1° tiles for the area shown in the figure below. Since the area for the most part has quite clear water and fewer clouds than the main continent, the NDWI index for optical Sentinel-2 images is expected to perform well. Tests confirm this. The image below shows such an example with a clear separation of land and water. The processing chain for processing the images has been set-up by Deltares on Google Earth Engine. Water Index grids will be computed in the first quarter of 2022. Coastlines for low-water, mean sealevel, and high-water will be computed and linked to percentile sealevels computed with GTSM as described above.



Images: Area for computation of satellite derived coastline for Caribbean, and a sample of NDWI for a Sentinel-2 image on July 13 2020 for an island part of the British Virgin Islands

In the process of building a release for the EMODnet gridded bathymetry a land-sea mask is applied. This is important for the interpolation and extrapolation of the available bathymetry data, since surveys often do no fully extend until the high-water coastline and because in many places there is a steep increase of the height just landward of the high-water coastline (due to levees, dunes, seawalls, cliffs etc.) The mask for the 2020 release is based on the Open Street Map coastline, which is very good in many places, but can result in artefacts in some places. This can for example result in a small gap of beach without values, as in the example below. Extending the data onto the beach is not trivial, since the inclusion of height values at the top of the cliff, would result in much too high values. Here, Deltares and GGSGC want to develop a new approach where the satellite derived coastline is used to build the land-sea mask. At the same time the high-water height is assigned to the grid-cells that fall on the gridded high-water coastline. This avoids including top-of-cliff values in the interpolation. Modelled HAT-LAT values from GTSM are used for the heights. In the first half of 2022, the method proposed above will be worked out in detail and tested for a number of different cases. In the summer, it will then be discussed if it is realistic to include the new approach in the oncoming 2022 release of the EMODnet gridded bathymetry.



Images: Satellite derived coastline near Dover (left, high-water in black and low-water in blue) and a photograph of the same location (right, source google-streetview)

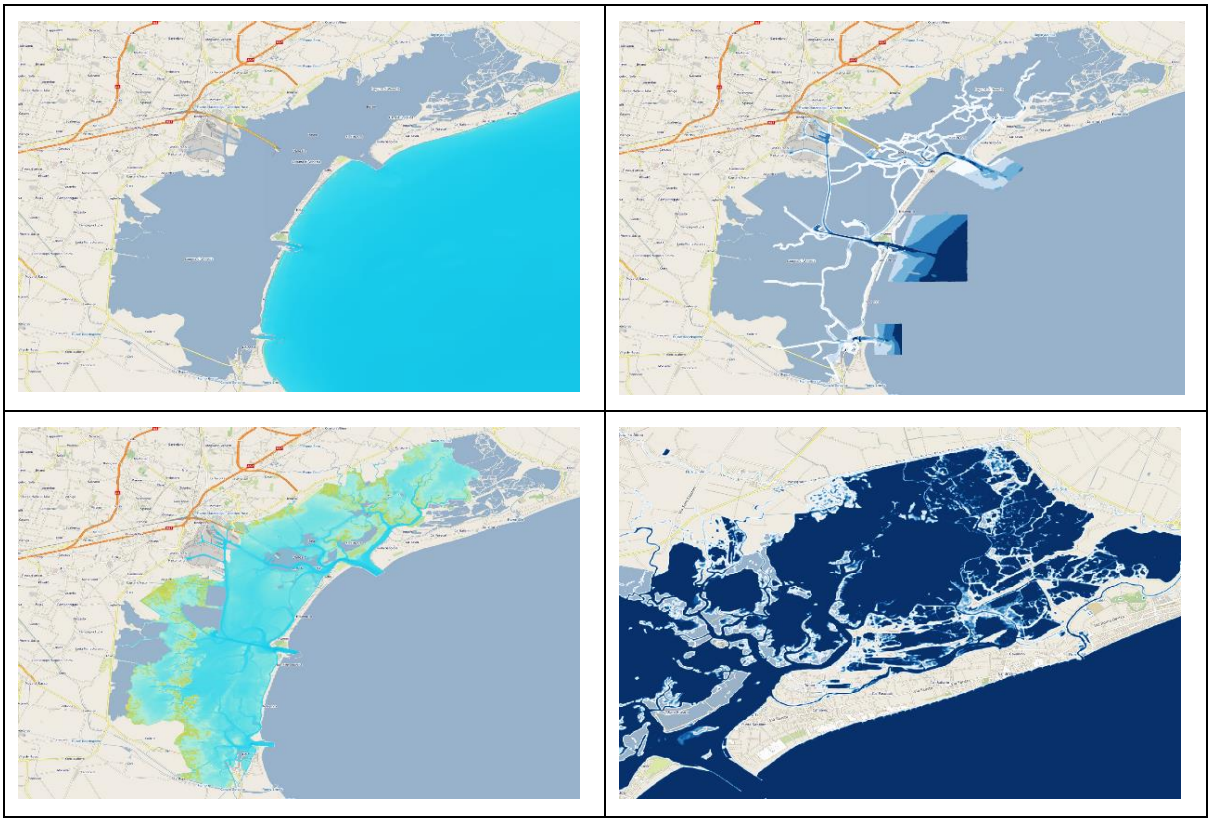
Activities for updating and further completing the overview of legal baselines:

The aim is to update and add entries to the existing inventory of official coastlines and baselines for all countries around Europe. This concerns existing and ratified baselines, registered claims / disputes under UNCLOS, for European countries, and official national coastlines. These activities are pllanned for the first half of 2022 and include reviewing and updating country information where necessary, reaching out to national

contact points to retrieve additional and/or updated data for legal baseline and coastline, collect and unify the GIS data per country, and plot and report updated coastlines and provide a uniform collected dataset.

Activities for establishing tidal bathymetry for the Venice Lagoon:

At the moment, the EMODnet gridded bathymetry does not include Venice lagoon. One of the reasons for this is that the coastline excludes the lagoon, which is related to the inconsistencies between coastline and bathymetry mask discussed above. As a consequence, there are also no LAT values available. The aim of this activity by Deltares and CNR-ISMAR is to include available bathymetry, extend the LAT computation to include the lagoon and add satellite derived bathymetry. A second goal is to show the impact of bathymetry on hydrodynamic modeling for the very relevant storm surges in Venice. In the past year, existing bathymetry was collected. Outside Venice lagoon, there is good coverage in the EMODnet DTM. In the lagoon, there is a high-resolution bathymetry available for the channels. This dataset is also available on the EMODnet portal. In addition, CNR-ISMAR has kindly made available a gridded high-resolution bathymetry for the Venice lagoon. And Deltares has computed the Water Index, as a first step towards computing the intertidal bathymetry for the lagoon.



Images: EMODnet gridded bathymetry (2020, top left), EMODnet high-res bathymetry of channels (top right) ,collected bathymetry from ISMAR (bottom left) and Sentinel-2 Water Index (bottom right)

Next, Deltares created a regional tide and storm surge model for the Adriatic that will be used to compute sea levels for the processing of satellite derived bathymetry in the region and also for the impact study on the value of high-resolution coastal bathymetry. Tide-gauge measurements for the region have been collected and checked. In the next months the regional model will be further refined and compared to measured sea levels. Next, frequency distributions for the sea levels in the lagoon will be computed. These sea level data are necessary to link drying and flooding frequencies from Sentinel-2 to heights.

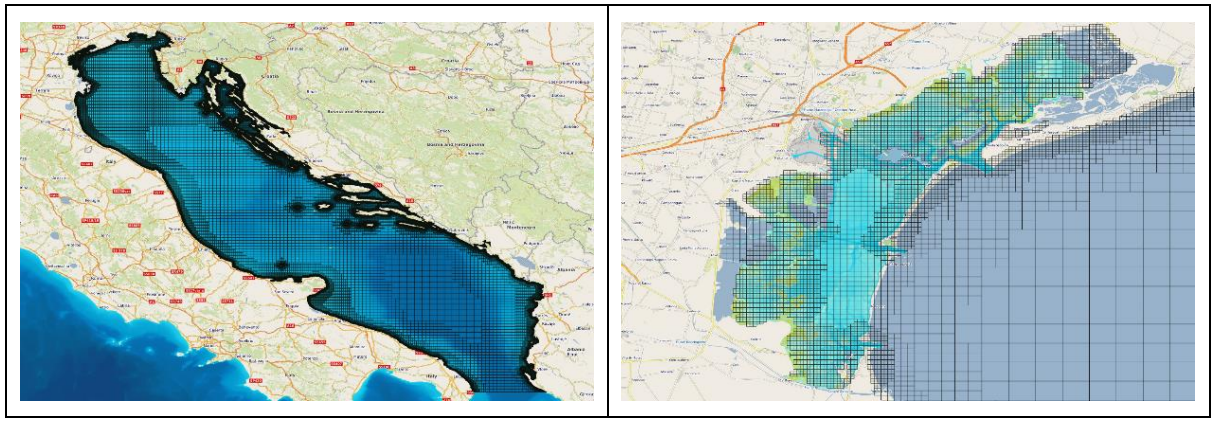


Image: Computational grid for regional model for Adriatic and Venice lagoon.

The first attempt for the local model already results in quite accurate tidal water levels for Venice. See next image. The impact of improving the bathymetry will be assessed in a next step, as well as an assessment of the impact of including the lagoon in this regional model.

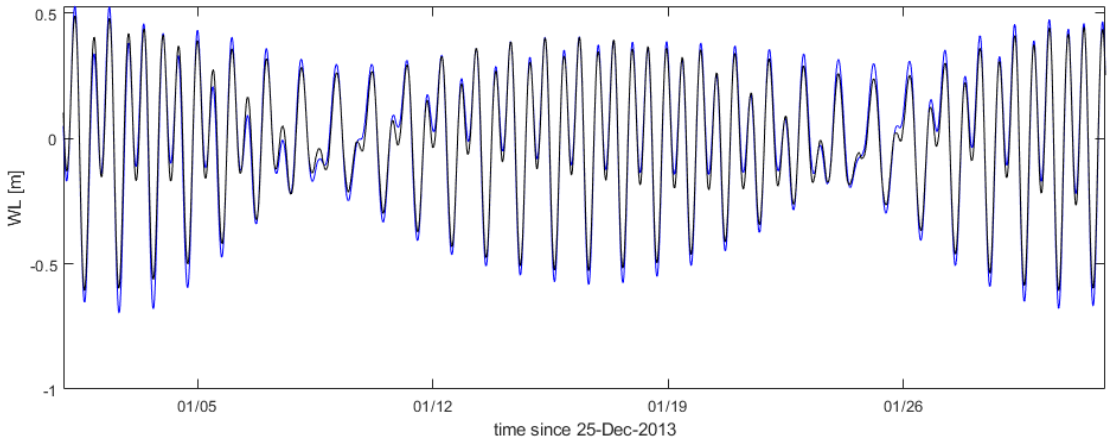


Image: Tidal water levels for Venice (measured in black and modelled in blue)

WP4 – Technical Development & Operation of services and tools

Covering Tasks 3 and 4

This Work Package includes technical activities for a range of EMODnet Bathymetry services, such as the migration from the existing thematic portal to the EMODnet Central Portal, the upgrading of the GLOBE software, the further development and optimization of interpolation techniques, and the further development and adoption of the Collaborative Virtual Environment (CVE) with online GLOBE for the regional DTM production workflow.

Activities for migration to Central Portal:

The present EMODnet Bathymetry portal and its services have many features for providing a gateway to data, metadata and data products. These are combined with web services, such as OGC services for sharing map layers of the EMODnet DTM and sharing locations and metadata of survey data sets (CDI service) and composite DTMs (Sextant catalogue service). As part of the new contract, there is a migration planned from thematic portals to one central EMODnet portal, which will become the one-stop-shop for EMODnet products and services. While, thematic groups will continue to be responsible for the gathering of data sets, generation of their products and the provision of web services and API's which will feed the EMODnet central portal. To find a suitable solution for this migration challenge, there is regular contact between the EMODnet Central Portal team (CP team) and a technical team from EMODnet Bathymetry since early January 2021. In the first year, 8 technical meetings have taken place to discuss and further the migration path. Overall, to seems that there is agreement between the teams, also shared by CINEA and DG-MARE, on the vision for the migration, which could be summarised as follows:

- In principle, all maps and related advanced functions of EMODnet Bathymetry in its map viewer should come back in the central portal map viewer service as these are very instrumental for users and their applications. For this purpose, EMODnet Bathymetry has handed over its software solutions to the CP team, which was expanded with Bilbomatica as GIS expert, extra funded by EU, to adapt the centra portal viewer. Bilbomatica made good progress and gave a preview of the new viewer with a few bathymetry layers and with dedicated functions. Recently, a link was provided to EMODnet Bathymetry for testing these layers and functionality and to provide feedback, while CP team will expand the viewer with the other Bathymetry layers and functionality. The viewer functionality interacts with OGC and REST web services that will continue to be published and maintained by EMODnet Bathymetry. EMODnet Bathymetry is progrsssing with reviewing and testing and findings are reported through JIRA. Moreover, EMODnet Bathymetry has decided to formulate a detailed specification document for the map viewer layers and functions which gives CP team more detailed insight and can be used by both parties for testing;
- The new viewer should also take over the functionality of the Bathymetry viewing and download service to facilitate selection and downloading of EMODnet DTM tiles (different formats and versions) and HR-DTMs. For that purpose, EMODnet Bathymetry has provided CP team with copies of the DTM tiles and HR-DTM files, who are planning to include these in the new central EMODnet Data Products catalogue that will run as an ERDDAP instance. A link will have to be made between the new CP viewer for selecting the requested files and facilitating the downloading. Moreover, metadata should be included for documenting the various DTM products. How the CP team wants to implement this dual functionality, that DTM products can be found and downloaded in the Central Products Catalogue AND the Central Viewer is not clear yet for the EMODnet Bathymetry team and requires further discussion, also because there is no test service of the Central Catalogue made available yet for review. Anyway, the delivery of different formats, MSL and LAT versions, and different DTM releases since 2016 should be continued, also in the new CP situation;
- For the info pages CP team has made an inventory of the EMODnet Bathymetry website contents, whicxh has been reviewed and annotated by EMODnet Bathymetry. Next action is that CP team makes a

compilation of the content, adopting the new CP site map and incorporates that content in the online CMS of the CP site as part of the EMODnet Bathymetry section. In a next stage, EMODnet Bathymetry site manager will get access to the CMS for checking, possibly amending, and finally, approving the draft before going public, and later on for maintenance suggestions in a staging set-up.

- Other important services of EMODnet Bathymetry are the CDI Data Discovery and Access service for survey data sets and Sextant CPRD catalogue service for Composite DTMs. The EMODnet DTM is built from both inputs and both catalogues facilitate to include input references in the DTM gridcells about the data that were used to determine the bathymetry indicators. Moreover, the CDI service allows to submit requests for data access, and if ok, to download those data sets. For both services use is made of SeaDataNet, while currently an EMODnet Bathymetry look & feel is being applied. In the new CP portal, these catalogue services will be continued. The continuation is needed as 1) instrumental for encourage data providers to populate more bathymetric data sets, which are input for refining and expanding the EMODnet DTM; 2) to give users overview and option for access to those underlying data sets; 3) to support the FAIRness that data products (DTM tiles and HR-DTMs) acknowledge in detail which data sets were used, together with INSPIRE compliant metadata. In the new situation both services will be reachable and published as external services from info pages at the CP. SeaDataNet is considered as an external infrastructure and one of the modules on which EMODnet is built. This way, the CDI service also can continue to have its own AAA service, Marine-ID, as part of the CDI shopping module as it is not integrated and presented as an EMODnet service, but a supporting infrastructure. To keep the focus on bathymetry, EMODnet Bathymetry will work with a SeaDataNet CDI version, which cover only relevant bathymetry records and whereby the user interfaces are fitted for bathymetry queries. In practice, it will implicate continuing current services but adapting their URLs (no longer part of EMODnet-Bathymetry domain, but SeaDataNet domain) and adapting their styling somewhat.
- The CDI and Sextant services should also come back in the layers of the new CP viewer: the source reference layer displays which areas of the DTM are originating from specific CDI or CPRD inputs and allows to query to pull up the metadata details of such references. Moreover, there is a Survey tracks / polygons layer in the viewer, which is driven by the WMS – WFS services of the CDI service. This layer is again important for bathymetry to see which surveys have been done and are available in specific sea areas. This way, also a good insight can be gained about gaps in coverage. These CDI WMS – WFS layers are also shared internationally as part of Seabed 2030 with IHO by means of inclusion in the NOAA DCDB viewer, which displays NGDC and EMODnet Bathymetry resources worldwide.
- Furthermore, a solution has to be found for the other products that EMODnet Bathymetry is providing, such as the best-estimated digital coastlines which are included and can be configured in one of the map layers and which can be downloaded.

This way, in practice, EMODnet Bathymetry will continue its back-office system with geographical database, its OGC services, and the external CDI and Sextant catalogue services, while the CP will take over the user interfacing functions, interacting with and building upon the EMODnet Bathymetry infrastructure. Progress is being made with the CP, however still a lot of layers, services and content have to be configured and implemented at the CP, combined with thorough testing before the migration can be completed.

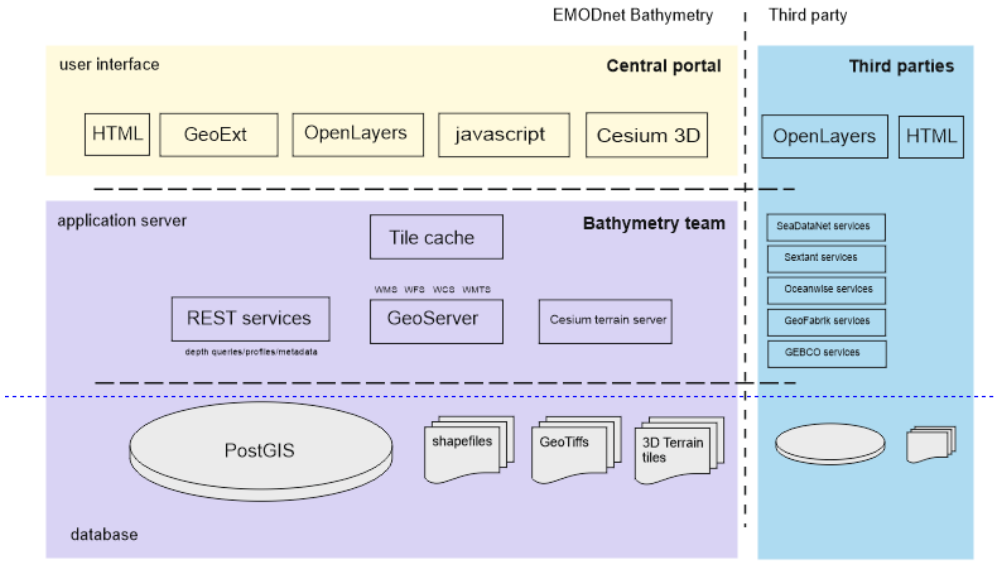


Image: architecture as proposed by EMODnet Bathymetry for interaction between EMODnet Bathymetry services, external services, and the map viewer user interface at the Central portal.

Activities for making the CVE ready for Regional Coordinators:

IFREMER advanced with the Collaborative Virtual Environment (CVE) with online Globe software. Successfully, the current EMODnet 2018 and 2020 DTM grids and a Difference Map have been loaded so that Regional Coordinators can oversee easily which updates have been made and to what effect. They will also be able to investigate and annotate residual artefacts, with the aim of improving the quality. The status of the CVE development has been discussed with the core team at a technical meeting at 16 December 2021 and a Training Workshop for Regional Coordinators is planned at 24 January 2022. The Deliverable D3.1 (see earlier WP3) gives more details about the updated specifications and guidelines for using the latest prototype. This Deliverable is also included as Annex 2 to this Annual Report.

Activities for upgrading GLOBE software:

IFREMER is continually making progresses with upgrading the GLOBE software for pre-processing and pre-gridding of input data sets and generation of the Regional DTMs. Already in 2019 adaptations were made in GLOBE for defining and supporting a NetCDF V4 CF 1.7 data format convention as an international standard, which improves precision in datasets and also facilitates data providers and regional coordinators to import and process much larger data files efficiently instead of having to split these in smaller parts. Even if the relevant functions (import, reduce, merge, export) have been migrated to support this format, a full EMODnet production has not yet been fully conducted with that version. Therefore, the GLOBE team has offered in 2021 to provide again support for EMODnet to find and correct bugs, and to help data migration or fresh data import. Apart from this support, a new set of functionalities or improvements were added to GLOBE in support of increasing the quality of data produced. For data providers, GLOBE now allows to import data directly from geotiff instead of importing data only from text files. GLOBE also supports projected data more efficiently and combined with geotiff import this allows to improve import of datasets originally in UTM coordinates and

prevents 'moire' effects artefacts noticed in previous releases. A huge refactoring has been done in the management of xyz and csv file types: the software allows now to import them as gridded dataset or as point cloud, and is more flexible about column order, field separators and so on. A bunch of improvements have also been made to help data providers working with datasets with a lot of CDIs.

For regional coordinators, a new data smoothing tool allows to apply a local smoothing when merging dtm which help to reduce "stair step" pattern, an effect occurring sometimes at the border of datasets when differences exist between the depth measured along the border. A tool has been added to generate difference maps between DTMs which also helps regional coordinators to check for improvement between EMODnet releases.

Incoming features: IFREMER will soon work on integrating the results of the work done on interpolation methods by CORONIS. An integration of all the new functionalities is planned by end of February 2022 and an upgraded version of GLOBE software will be delivered to the regional coordinators to allow to test, validate and use new interpolation methods. IFREMER also plans to improve the reproducibility of the operations done on datasets by adding a tool that will be able to save and reload the provenance set of operations and parameters applied to the files processed. IFREMER is confident that with a bit of methodology this could ease the build of the new EMODnet release or help to reproduce previous build with updated datasets.

Activities on optimization of interpolation techniques:

CORONIS focused on improving the Python interpolation package, which is the core for the interpolation methods to be implemented in GLOBE. After analyzing the datasets requiring interpolation provided by several data providers and regional coordinators, it was clear that a single interpolation method could not fit the needs of all users. Consequently, CORONIS increased the number of interpolation algorithms in the *heightmap_interpolation* python package implemented. On the one hand, five of the most popular scattered data interpolation algorithms in the literatura were implemented. On the other hand, with the aim of taking advantage of the fact that the problem takes place on a regular grid, six inpainting methods were adapted (usually devised for image processing) to tackle the interpolation problem on elevation grids. Moreover, with the aim of easing its usage not just in GLOBE, but also as a standalone package, the source code is provided at GitHub, a complete documentation, as well as a pre-compiled Docker image at DockerHub. The documentation of the package includes the installation and usage information, a detailed explanation of each method listing their advantages, disadvantages and preferred use cases, and a guide on what method to choose depending on the type of input data and desired interpolation quality. More details on the analys activities of CORONIS can be found in Annex 3 of this Annual Report.

Activities for maintaining the EMODnet Bathymetry website:

One task is about maintaining the operation of the EMODnet Bathymetry portal and user interfaces in the first 6 months. This has been done and is continued for as long as needed, till the migration has been completed. From that point onwards, EMODnet Bathymetry will still continue to manage the well-functioning of all machine-to-machine services and the external services.

WP5 – Uptake, cooperation, helpdesk and outreach

Covering Tasks 6, 7 and 8

This Work Package includes activities for achieving interoperability, ensuring involvement of regional sea conventions, contributing to the implementation of EU legislation and broader initiatives for open data, and to monitor quality / performance and deal with user feedback.

Activities for achieving interoperability:

EMODnet Bathymetry has benefited through the years of increasing mutual interactions with main institutional key leaders in the field of bathymetry and ocean sciences. Namely those main institutions are the IHO, the GEBCO program, Seabed 2030 project, the UNESCO-IOC, individual international organisations like NOAA and obviously European actors both belonging or not to the consortium.

During the first year of the current EMODnet Bathymetry contract, a number of actions have been undertaken to maintain these relationships through active participation in relevant projects/working groups associated with these different organisations. Amongst these activities, one can cite:

- Updating/maintaining the link from the IHO DCDB to the EMODnet Bathymetry inventory/metadata holdings (CDI database) with surveys extending beyond the EMODnet Bathymetry DTM coverage;
- Integration of the EMODnet 2020 DTM as part of the European waters contribution to the GEBCO 2021 grid product;
- Monthly participation to Seabed 2030 project technical meetings (with a strong focus on methodologies and technologies);
- Strong participation of the EMODnet community in the GEBCO sub-committees (see below) with a focus from the TSCOM (Technical Sub-committee on Ocean Mapping) on the metadata interoperability topic;
- Participation through frequent updates in the IHO European Network working group (IENWG);
- Promotion of EMODnet Bathymetry in various forums provided by these cooperations (e.g. GEBCO map the gaps symposium, IMDIS conference, …);
- Participation and presentations in the Meso-American Hydrographic Commission, with the aim to describe the current work undertaken by the EMODnet Bathymetry in the Caribbean area;
- Participation of EMODnet members in the EMOD-PACE project with Chinese colleagues where both metadata format/content and grid format are being shared, based on the EMODnet bathymetry experience.

Beyond this list of activities, it is also part of the EMODnet Bathymetry strategy to get representatives at leading positions in international committees. As illustrated above, members of the EMODnet bathymetry community are strongly involved in the GEBCO program. Recently (2020/2021) both the chair and vice-chair of the guiding committee, along with both the chair and the vice-chair of the TSCOM sub-committee, all members of the EMODnet Bathymetry consortium, have been elected. Their nomination is a proof of the strengthening of the relationship and a support from Europe to the GEBCO global initiative. On a purely technical objective, it might favourably serve the global adoption of principles developed by the EMODnet community (e.g. metadata format and content).

Activities for ensuring the involvement of regional sea conventions:

EMODnet data products and metadata records are extending well beyond European waters. Regional Sea Conventions are well served by the bathymetric information through the easy access of the product from the EMODnet Bathymetry portal and central portal. Also, members of the EMODnet Bathymetry consortium are

also serving as members of HELCOM (eg: Sweden, Danish partners), OSPAR (eg: France), Bucharest convention (eg: Bulgaria and Romania) and Barcelona convention (France, Italy, Croatia, Greece, …). Moreover, EMODnet Bathymetry also benefits from tight relations with the IHO, through the IENWG and also through their regional hydrographic commissions. Amongst these with the highest level of activities, such as the North Sea HC, the Baltic HC, Eastern Atlantic HC, EMODnet Bathymetry is always represented at their meetings. Note must be taken that last year EMODnet Bathymetry representatives have introduced the current work undertaken in the Caribbean seas, as part of meetings of the Meso American and Caribbean Sea HC. Finally, with its tights relation with the GEBCO program and Seabed 2030 project, EMODnet Bathymetry also has access to the IOC and associated bodies such as IODE which in turns promote our work effectively.

Activities for monitoring and dealing with user feedback:

The overall performance of the portal and its services are continuously measured and its results are reported in the separate indicators spreadsheet. These demonstrate that the Bathymetry portal and its services and products continue to be highly popular and in great demand for a wide range of user applications. Also, many user feedback questions (52) were received and answered by the helpdesk. These are listed in chapter 6.

4. Identified issues: status and actions taken

A. Priority issue(s) identified and communicated by CINEA/ DG MARE/ SECRETARIAT				
Priority issue	Status (Pending/ Resolved)	Action(s) taken/ remaining actions planned	Date due	Date resolved
EM-126 Bathymetry to report on number and volume of downloaded data and data products by 6th of January	Resolved	Report as requested	6/1/2021	5/1/2021
EM-136 Inverted Atlas Style on bathymetry DTM WMS request	Resolved	Inverted style	15/01/2021	30/03/2021
EM-147 Bathymetry Source Reference Layer Problem	Resolved	Precision given	28/01/2021	29/01/2021
EM-148 Request to increase level of detail in EMODnet Bathymetry	Resolved	11 zoom levels conform with OGC WMTS service.	28/01/2021	01/02/2021
EM-140 and EM-169 Bathymetry Quality of Service Monitoring	Continuous	EMODnet Bathy conforms to Service Requirements	20/01/2021	-
EM-180 Inconsistent WMS layer name for EMODnet DTM	Resolved	Intermittent issue, Geoserver service restarted. Problem seems to be resolved	29/03/2021	30/03/2021
EM-188 Adding the URL to the metadata as an attribute field in the Bathymetry source Reference layer	Resolved	Consider using the present logic which is already embedded in the current URL	12/04/2021	28/04/2021
EM-231 Bathymetry - Update of Data Protection Notices (see EM-299)	Resolved	Implemented changes as prescribed	14/06/2021	3/06/2021
EM247 Bathymetry – Banner UPDATE - deadline extension	Resolved		02/07/2021	06/07/2021
EM-389 and EM-390 Review of the new Central Portal Map Viewer	Pending	Test and provide feedback		
EM-357 Bathymetry to report on number and volume downloaded and data products	Resolved	Provided number of data products and associated volume downloaded	29/10/2021	27/10/2021
EM-341 Collect fields/forms used on Bathymetry Thematic Portal	Resolved	Involves check if CP team has listed all sections of the current website as part of planned migration	22/10/2021	1/11/2021, but somehow not updated in JIRA. Now ok
EM-333 Collect names of portal editors	Resolved	Name of editors given		14/10/2021

EM-294 Dashboard issue with Helpdesk page-views	Resolved	Checked that Grafana no longer gives unrealistic web stats for helpdesk visits		17/10/2021
EM-162 Issue in information display for the mean depth in multi-colour layer	Pending	Reaching full OGC compliancy. Also refer to EM180. As it is intermittent, both tickets are in review	22/02/2021	03/05/2021 (last action)

B. Issues / challenges identified by the thematic assembly group itself				
Priority issue / challenge	Status (Pending/ Resolved)	Action(s) taken / remaining actions planned	Date due	Date resolved
After release of the new 2020 EMODnet DTM it appeared that some coastal stretches along Sardinia, Liguria, and Sicily had wrong coastal bathymetry.	Resolved	Communication between GGSGC, MARIS, CNR, and IIM revealed that some IIM data sets had been delivered and processing with wrong depth convention (+/-), giving the wrong bathymetry. This was corrected by GGSGC, using the right convention, reproducing part of the DTM and releasing an updated DTM tile for the area in 8 formats.	asap	25/01/2021

5. Allocation of project resources

Information on the allocation of project resources	
Categories	Resource usage[1] (%)
Making data and metadata interoperable and available	22%
Preparing data products	16%
Preparing web-pages, viewing or search facilities	4%
Managing user feedback	1%
Project management	2.5%
Outreach and communication activities	1%
Others	2%
TOTALS	**48.5%**

[1] Provide the workings of your calculations, *i.e.* percentage allocation of the total amount awarded.

6. User feedback

Overview of user feedback and/or requests received in this quarter							
Date	Organisation	Type of user feedback (e.g. technical, case study, etc.) and short description of the feedback received	Means of contact	Response time	Status of user query (Resolved/ Pending)	Measures taken to resolve the query	Status: if not (yet) resolved/ pending, explain reason why and expected timeline
6 Jan 2021	Company, Quiet Oceans, France	Question about possible map shift. There was issue with land mask which was solved.	Email feedback form	Five days later, because of checks with colleagues	Resolved	Explanation given and problem solved	
6 Jan 2021	Company, Quiet Oceans, France	Question about download options.	Email feedback form	Same day	Resolved	Checked and explanation given	
11 Jan 2021	?, France	Question about quality index.	Email feedback form	Same day	Resolved	Explanation given	
7 Jan 2021	?, Portugal	Remarks about quality of bathymetry for Azores.	Email feedback form	One week later because of checks with colleagues	Resolved	Explanation given	
12 jan 2021	University of Catalunya, Spain	Problem with downloaded DTM tile.	Email feedback form	Same day	Resolved	Explanation given	
13 jan 2021	Research Institute, NOC, United Kingdom	Problem with downloading	Email feedback form	Same day	Resolved	Explanation given	

14 Jan 2021	University,Instituto Politécnico de Setúbal, Portugal	Question about negative/positive depths and issue with depth profile function, which was solved.	Email feedback form	Five days later, because of checks with colleagues	Resolved	Explanation given and problem solved in software	
15 Jan 2021	National Metrology Institute, United Kingdom	Question about downloading and WCS function	Email feedback form	Same day	Resolved	Explanation given	
16 Jan 2021	?,?	Alert about issues with new DTM for part of Sardinia and Sicily coast. Was an error in processing, which was repaired and gave a new release of the 2020 DTM.	Email feedback form	Same day	Resolved	Problem analysed and solved and colleague thanked for this alert	
28 Jan 2021	Research Institute, Observatoire Océanologique de Villefranche sur Mer, France	Question about availability of HR data for Arctic fjords.	Email feedback form	Five days later, because of checks with colleagues	Resolved	Checked and info provided from IBCAO	
4 March 2021	Research Institute, TNO, The Netherlands	Question about downloading for specific area.	Email feedback form	Same day	Resolved	Explanation given	
3 March 2021	?,?	Question about availability of wrecks data	Email feedback form	Same day	Resolved		
4 March 2021	National Research Institute of Astronomy and Geophysics (NRIAG), Egypt	Question about downloading bathymetry for Eastern Mediterranean	Email feedback form	Same day	Resolved	Explanation given	

8 March 2021	Research Institute, LNEG, Portugal	Issue with WMS service. Solved for the user.	Email feedback form	Same day	Resolved	Checked and solved	
8 March 2021	University, WUR, The Netherlands	Issue with WCS service. Solved for the user.	Email feedback form	Same day	Resolved	Explanation given	
9 March 2021	Company, OceanExplorer / Norway	Questions about how to download bathymetry and the EMO format.	Email feedback form	Same day	Resolved	Explanation given	
17 March 2021	Company, IBM, ?	Question about the legend of RGB colours.	Email feedback form	Five days later, because of checks with colleagues		Explanation given	
23 March 2021	Research Institute, RBINS, Belgium	Question about MSL version of DTM.	Email feedback form	Next day	Resolved	Explanation given	
12 April 2021	Research Institute, UTM CSIC, Spain	Question about availability of Baselayer as WMS	Email feedback form	Same day	Resolved	Explanation given that baselayer is only given as WMTS	
16 April 2021	Universidade Tecnica do Atlantico, Cabo Verde	Question about formats for DTM tiles	Email feedback form	Same day	Resolved	Explained which formats are available	
16 April 2021	UCC, Ireland	Question about referencing specific data sets	Email feedback form	Same day	Resolved	Explained how to reference using Sextant URLs	
16 April 2021	?, Tunesia	Questionm about legend	Email feedback form	Next day	Resolved	Explained how to use the legend	

19 April 2021	?, Netherlands	Questionm about DTM with MSL	Email feedback form	Same day	Resolved	Explained which format has MSL	
4 May 2021	Company, Svasek, Netherlands	Remark about issues with MSL – LAT in Channel	Email feedback form	Same day	Ongoing	Indicated that this will be resolved	
12 May 2021	?, Spain	Question about coordinate systems	Email feedback form	Same day	Resolved	Explained how to convert using specific software	
12 May 2021	UALG, Portugal	Question about Vertical Reference in DTM	Email feedback form	Two days later	Resolved	Explained that there is LAT and MSL	
20 May 2021	Company, TechnicFMC, ?	Question about ESRI format	Email feedback form	Next day	Resolved	Explained how grid is defined	
23 May 2021	Company, ?, United KIngdom	Question about DTM exports	Email feedback form	Two days later	Resolved	Explained how OGC WFS works	
25 June 2021	Company, Intertidalstrategies, Netherlands	Question about data originators from industry	Email feedback form	Two days later	Resolved	Explained how CDI metadata can be used	
16 July 2021	Irish Wildlife Trust, Ireland	Question if isolines can be provided as separate file	Email feedback form	Same day	Resolved	Explained how to use WMS as alternative	
26 July 2021	??, ??	Question about opening TDM NetCDF in QGIS	Email feedback form	Same day	Resolved	Explained how to do it in QGIS	
26 July 2021	Company, Analytics-Pika, Finland	Question about use of DTM in commercial software	Email feedback form	Same day	Resolved	Explained that DTM is public product	

6 August 2021	Malta government	Question if bathymetric depth contours are available in shapefile	Email feedback form	Same day	Resolved	Explained that there is a WFS for isobaths	
19 August 2021	??, ??	Found a weird structure in the bottom of the Atlantic Ocean north of Funchal.	Email feedback form	Next day	Resolved	Asked to provide some images. No further follow-up	
2 September 2021	Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC), USA	Question about possible API for HR-DTMs	Email feedback form	Next day	Resolved	Explained that there is only GUI	
2 September 2021	JNCC, UK	Question about copyright information to use	Email feedback form	One week later	Resolved	Referred to section about acknowledgement and DOIs	
17 September 2021	Marine Institute, Ireland	Question about how to operate the HR-DTM layer	Email feedback form	Three days later	Resolved	Explained how the layer with HR-DTMs functions	
21 September 2021	Company, C2Wind ApS, Denmark	Noted issue with the WMS service	Email feedback form	Same day	Resolved	Thanked for his alert. Was small glitch	
20 September 2021	Company, Teledetection, FRance	Had a problem with registration	Email feedback form	Next day	Resolved	Asked for more details as message was unclear. No further follow-up	
28 September 2021	Company, TechnipFMC, UK	Issue with downloading areas of nterest	Email feedback form	Same day	Resolved	Checked and asked to look again as files were quite large but no errors. User confirmed all ok.	

4 October 2021	Company, Lighthouse, Italy	Noticed issue with wrecks layer	Email feedback form	Same day	Resolved	Explained that there was issue with external WMS. Now on again.	
10 October 2021	EU, Belgium	Question if functionality of viewing services could be expanded	Email feedback form	Two days later	Resolved	Explained that honoring request will require programming which is not opportune considering the ongoing migration	
17 October 2021	?,?	Wants to use the DTM data for CNC project but experience difficulties	Email feedback form	One week later	Resolved	Explained how the DTM data might be used to overcome the difficulties.	
25 October 2021	University of Rouen, France	Data difficulties with DTM close to Bretagne coast	Email feedback form	Two days later	Resolved	Explained that EMODnet uses LAT which can give large differences in tidal areas. As alternative suggested to consider the MSL DTM.	
26 October 2021	JASCO, UK?	Found an issue with selecting area of interest function along Italian coastal area	Email feedback form	Two days late	Resolved	It appeared that the function used a wrong data set in the area. Has been corrected.	
27 October 2021	Meteo France, France	Question about merging DTM tiles, overlap and scientific analyses	Email feedback form	Multiple Questions and Answers over a week	Resolved	Explained which tools might be used, why overlap and a number of references to publications	
17 November 2021	Deltares, Netherlands	Questions about differences between DTM versions	Email feedback form	Multiple Questions	Resolved	Explained that there is also a resolution difference.	

				and Answers over a week			
18 November 2021	Subacoustech Environmental Limited, United Kingdom	Found an issue with missing DTM tile file	Email feedback form	Next day	Resolved	DTM tile was added and user informe	
19 November 2021	Golden Software, USA	Indicated an issue with WFS and WCS services	Email feedback form	Two days later	Resolved	Checked but no issue, so advised to try again. Which was confirmed by user.	
23 November 2021	Marine Scotland, United Kingdom	Requested a copy of the quality index data for fish habitat map analysis	Resolved	Two weeks later because of arranging file transfer	Resolved	Arranged access the quality index data sets together with Shom	
29 November 2021	Tragsatec, Spain	Interested in receiving the SDB files for Spanish coast	Email feedback form	Two days later	Resolved	Given contact at EOMAP for further arrangements	
16 December 2021	Twozansurveys, Saudi Arabia	Asked if EMODnet can process surveys on commercial basis	Email feedback form	Same day	Resolved	Explained that EMODnet is an EU project	

7. Meetings/events held/attended & planned

A. Meetings/events organised and attended in the quarter					
Date	Location	Type event (internal or external meeting; training/ workshop)	Was a presentation given? (yes/no + short description)	Meeting attended (A) / organised (O)	Short description and main results (# participants, agreements made, etc.)
16 January 2021	WebConf	External, GEBCO committees and symposium	Yes, presenting EMODnet Bathymetry and release of new DTM	A	Mapping the Gaps conference with IHO, GEBCO, and Seabed 2030
21 January 2021	WebConf	External meeting with Central Portal team about migration	Yes, to present present services and products and ideas for migration	A	Technical members + CP team
10 February 2021	WebConf	External meeting with DG MARE and EASME about migration and our vision	Yes, to present present services and products and ideas for migration	A	Technical members + DG MARE + EASME
4 March 2021	WebConf	External meeting with Central Porta team about migration	Yes, to present present services and products and ideas for migration	A	Technical members + CP team
8 March 2021	WebConf	Internal meeting with project core group	Yes, about Work Plan and WPs where needed for discussion	O	Core members present to prepare for plenary kick-off meeting and overall planning
7-9 April 2021	Remote	EMODnet Bathymetry Kick off meeting	Yes, mutiples PPT describing the project and each of the working packages	O	Inform the approx. 50 participants on the objective and activities of the new phases/agenda of the project.
9 April 2021	Remote	EMODnet Central portal and Bathymetry meeting	No	A	Discussing progress of migration and how suggestions/requirements from EMODnet Bathymetry are taken over

12-14 April 2021	Remote	International Conference on Marine Data and Information Systems (IMDIS)	Yes, pre-recorded presentation	A	General presentation to the audience of the conference
19-21 April 2021	Remote	EMODnet Steering Committee and Technical Working Group	Yes, PPT (project status)	A	Giving information on project status and progress.
27 April 2021	Remote	North Sea Hydrographic Commission	Yes	A	General presentation to the members of the commission
21 May 2021	Remote	EMODnet Central portal and Bathymetry meeting	No	A	Discussing progress of migration and how suggestions/requirements from EMODnet Bathymetry are taken over
14 June 2021	Remote	EMODnet Jamboree and various side meetings	Yes, pre-recorded presentation	A	General presentation to the audience of the conference
24 June 2021	Remote	EMODnet Central portal and Bathymetry meeting	No	A	Discussing progress of migration and how suggestions/requirements from EMODnet Bathymetry are taken over
2 September 2021	VTC	IHO Baltic Sea Hydrographic Commission meeting	Yes	A	EMODnet presentation given. 15 participants
6 September 2021	VTC	Internal GLOBE Training workshop	Yes	O	Project workshop with approx. 40 participants of consortium
8-10 September 2021	VTC	EMODnet Steering Committee and Technical Working Group meetings	Yes	A	Presented progress and tuning with other lots and overall developments. Participation by Shom and MARIS.
14-16 September 2021	VTC	IHO Crowd Source Bathymetry	Yes	O	Joined by several members of the EMODnet Bathymetry Consortium. Approx. 30 participants.
22 September 2021	VTC	Marine Strategic Data Infrastructure – Meso-American and Caribbean Working Group meeting	Yes	A	Joined by Shom.

1 Oct 2021	VTC	Technical discussion MARIS – NHS (Norway)	No	O	Discussed best options for NHS for CDI population
14 Oct 2021	VTC	EMODnet Central portal meeting	No	A	Following main developments of the cental portal migration effort
19 Nov 2021	VTC	HRSM3 Progress meeting with core group	No	O	Monitoring project progress with core partners
30 Nov-3 Dec 2021	VTC	GEBCO – Seabed 2030 Map the Gaps Symposium	No	A	Joined by several members of the EMODnet Bathymetry Consortium. Approx. 150 participants.
8-9 Dec 2021	VTC	IHO Europe Network Working Group	Yes	A	Joined by Shom.
16 Dec 2021	VTC	HRSM3 Technical Meeting	Yes	O	Discussing progress of CVE and planning training workshop
17 Dec 2021	VTC	EMODnet Central portal meeting	No	A	Following main developments of the cental portal migration effort
SUM				**O**	**Total # of meetings organised = 7**
SUM				**A**	**Total # of meetings attended = 18**

B. Meetings/events planned in the future				
Date	Location	Type event (meeting, training (workshop), etc.)	Meeting to be attended (A) / organised (O)	Short description and main expected outcomes
13 Jan 2022	VTC	Meeting with Central Portal team about migration. to discuss progress and actions	A	To discuss progress and formulate mutual actions

24 Jan 2022	VTC	HRSM3 Plenary meeting and Training Workshop	O	To monitor overall progress and to train Regional Coordinators in using CVE Workbench with online GLOBE

8. Communication assets

[List all the relevant communication and dissemination products and assets you have developed since the start of the project phase (e.g. brochures, videos, press releases, newsletters, blogs) and are planning to do. At the bottom of the table, provide a summary from the actions on Twitter from (e.g. Twitter Analytics: number of Tweets and followers of Twitter account).]

A. Communication products developed				
Date	Communication material	Short description (of the material, title, …) of the asset	Main results	Name of event at which material was disseminated (if applicable)
13 January 2021	Public release of the new EMODnet DTM	https://www.emodnet-bathymetry.eu/media/emodnet_bathymetry/org/documents/press-release-emodnet-bathymetry_jan2021_final.pdf	Informing our data users and potential new users of the existence of this new DTM.	Map the Gaps conference and EMODnet promotion channels
January 2021	Paper in Hydrographische Nachrichten 117	Thierry Schmitt, Dick Schaap, George Spoelstra, Patricia Slabon, Paul Wintersteller, Knut Hartmann (2021) The European harmonised bathymetry grid EMODnet Bathymetry. Introduction, outlook and contribution from German partners. HN 117:20–26. DOI: 10.23784/HN117-03	Informing bathymetry readers about EMODnet Bathymetry	Magazine

List of known publications using EMODnet data or data products				
Date	Type and name of journal, conference, …	Publication title including DOI (if known)	Author(s)	Organisation(s)
01/2021	*Frontiers in Earth Science*	Marine Sedimentary Carbon Stocks of the United Kingdom's Exclusive Economic Zone https://doi.org/10.3389/feart.2021.593324	Smeaton, C., Hunt, C. A., Turrell, W. R., & Austin, W. E.	University of St Andrews, United Kingdom
01/2021	*Journal of Marine Science and Engineering, 9(2), 208.*	Dynamical Downscaling of ERA5 Data on the North-Western Mediterranean Sea: From Atmosphere to High-Resolution Coastal Wave Climate. https://doi.org/10.3390/jmse9020208	Vannucchi, V., Taddei, S., Capecchi, V., Bendoni, M., & Brandini, C.	LaMMA Consortium, Italy
01/2021	*Deep Sea Research Part I: Oceanographic Research Papers, 103475.*	Megabenthic assemblages on bathyal escarpments off the west Corsican margin (Western Mediterranean). https://doi.org/10.1016/j.dsr.2021.103475	Grinyó, J., Chevaldonné, P., Schohn, T., & Le Bris, N.	Sorbonne Université, CNRS, France
01/2021	*Earth System Science Data Discussions*	An Integrated Marine Data Collection for the German Bight–Part II: Tides, Salinity and Waves (1996–2015 CE). https://doi.org/10.5194/essd-2021-45	Hagen, R., Plüß, A., Ihde, R., Freund, J., Dreier, N., Nehlsen, E., ... & Kösters, F.	Federal Waterways Engineering and Research Institute,, Germany
01/2021	*Master's thesis,*	*Use of Machine Learning techniques for the study of the distribution of the fin whale (Balaenoptera physalus) on the Catalan Coast*	Tort Castro, B.	Universitat Politècnica de Catalunya
01/2021	*Frontiers in marine science*	CMEMS-based coastal analyses: conditioning, coupling and limits for applications. 10.3389/fmars.2021.604741	Sánchez-Arcilla Conejo, A., Staneva, J., Cavaleri, L., Espino Infantes, M., & Mestres Ridge, M.	Universitat Politecnica de Catalunya, BarcelonaTech (UPC), Spain
01/2021	*Journal of Quaternary Science.*	Timing and pace of ice-sheet withdrawal across the marine–terrestrial transition west of Ireland during the last glaciation. https://doi.org/10.1002/jqs.3295	Ó Cofaigh, C., Callard, S. L., Roberts, D. H., Chiverrell, R. C., Ballantyne, C. K., Evans, D. J., ... & Sacchetti, F.	Durham University, UK

01/2021	*In : Guide to Maritime Informatics (Artikis, Zissis (eds))* *https://doi.org/10.1007/978-3-030-61852-0_2*	Navigating the ocean of publicly available maritime data	Tzouramanis, T.	University of Tessaly, Greece
01/2021	*Journal of the Marine Biological Association of the United Kingdom*	Preliminary observations on abundance and distribution of fish fauna in a canyon of the Bay of Biscay (ICES Division 8c). https://doi.org/10.1017/S0025315420001265	Diez, G., Arregi, L., Basterretxea, M., Cuende, E., & Oyarzabal, I.	Azti- Basque Research and Technology Alliance, Spain
01/2021	*Biological Invasions, 1-20.*	Unaided dispersal risk of Magallana gigas into and around the UK: combining particle tracking modelling and environmental suitability scoring. https://doi.org/10.1007/s10530-021-02467-x	Wood, L. E., Silva, T. A., Heal, R., Kennerley, A., Stebbing, P., Fernand, L., & Tidbury, H. J.	Centre for Environment Fisheries and Aquaculture Science, UK
01/2021	*Lithosphere*	Morphostructural Setting and Tectonic Evolution of the Central Part of the Sicilian Channel (Central Mediterranean) https://doi.org/10.2113/2021/7866771	Civile, D., Brancolini, G., Lodolo, E., Forlin, E., Accaino, F., Zecchin, M., & Brancatelli, G.	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Italy
01/2021	*Diversity and Distributions*	Specific niche requirements underpin multidecadal range edge stability, but may introduce barriers for climate change adaptation. https://doi.org/10.1111/ddi.13224	Firth, L. B., Harris, D., Blaze, J. A., Marzloff, M. P., Boyé, A., Miller, P. I., ... & Hawkins, S. J.	University of Plymouth, UK
01/2021	*Frontiers in Earth Science*	Testing Tsunami Inundation Maps for Evacuation Planning in Italy. https://doi.org/10.3389/feart.2021.628061	Tonini, R., Di Manna, P., Lorito, S., Selva, J., Volpe, M., Romano, F., ... & Vittori, E.	Istituto Nazionale di Geofisica e Vulcanologia, Italy
01/2021	*Quaternary Science Reviews*	Late Quaternary coastal uplift of southwestern Sicily, central Mediterranean sea. https://doi.org/10.1016/j.quascirev.2021.106812	Ferranti, L., Burrato, P., Sechi, D., Andreucci, S., Pepe, F., & Pascucci, V.	University Federico II, Italy
01/2021	*Frontiers in Earth Science*	Broadband Q-Factor Imaging for Geofluid Detection in the Gulf of Trieste (Northern Adriatic Sea). https://doi.org/10.3389/feart.2021.640194	Vesnaver, A., Böhm, G., Busetti, M., Dal Cin, M., & Zgur, F	National Institute of Oceanography and Applied Geophysics–OGS, Italy

01/2021	*BÖLÜM XIV*	A Bayesian Network BasedDecisionSupportSystemProposalforThePrevention of ShipAccidents in TheBosphorus	Esra Yağdır Çeliker	İstanbul BilgiÜniversitesi, Turkey
01/2021	*Natural Hazards and Earth System Sciences*	Assessing the impact of explosive eruptions of Fogo volcano (São Miguel, Azores) on the tourism economy.	Medeiros, J., Carmo, R., Pimentel, A., Vieira, J. C., & Queiroz, G.	Centro de Informação e Vigilância Sismovulcânica dos Açores, Portugal
01/2021	*Report of the EU INTERREG JointMonitoring Programme for Ambient Noise North Sea*	Assessment North Sea.	Kinneging, N., & Tougaard, J.	Rijkswaterstaat, The Netherlands
01/2021	*Earth and Planetary Science Letters*	Destructive episodes and morphological rejuvenation during the lifecycles of tectonically active seamounts: Insights from the Gorringe Bank in the NE Atlantic. https://doi.org/10.1016/j.epsl.2021.116772	Gamboa, D., Omira, R., Piedade, A., Terrinha, P., Roque, C., & Zitellini, N.	IPMA, Portugal
01/2021	*Rapport fra havforskningen.*	Havforskningsinsituttets rådgivning for menneskeskapt støy i havet-Kunnskapsgrunnlag, vurderinger og råd for 2021.	Sivle, L. D., Forland, T. N., de Jong, K., Kutti, T., Zhang, G., Wehde, H., & Grimsbø, E.	HAVFORSKNINGSINSITUTTETS, Norway
01/2021	*Rapport*	Occurrences connues des espèces indicatrices d'Ecosystèmes Marins Vulnérables de Méditerranée.	Menot, L., Fabri, M. C., & Vaz, S.	Ifremer, France
01/2021	*ESSOAr*	Predicting dominance of sand transport by waves, tides and their interactions on sandy continental shelves. https://doi.org/10.1002/essoar.10505948.1	King, E. V., Conley, D. C., Masselink, G., & Leonardi, N.	University of Plymouth, UK
01/2021	*Journal of Marine Science and Engineering*	Towards Least-CO2 Ferry Routes in the Adriatic Sea. https://doi.org/10.3390/jmse9020115	Mannarini, G., Carelli, L., Orović, J., Martinkus, C. P., & Coppini, G.	Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy
01/2021	*Geosciences*	An object-based image analysis approach using bathymetry and bathymetric derivatives to classify the seafloor. https://doi.org/10.3390/geosciences11020045	Koop, L., Snellen, M., & Simons, D. G.	Delft University of Technology, The Netehrlands

02/2021	*The Journal of the Acoustical Society of America*	*Noise of underwater explosions in the North Sea. A comparison of experimental data and model predictions.* *https://doi.org/10.1121/10.0003754*	Salomons, E. M., Binnerts, B., Betke, K., & von Benda-Beckmann, A. M.	TNO Acoustics and Sonar, The Netherlands
02/2021	*Earth System Science Data Discussions*	An Integrated Marine Data Collection for the German Bight–Part I: Subaqueous Geomorphology and Surface Sedimentology. Discussion paper in review	Sievers, J., Milbradt, P., Ihde, R., Valerius, J., Hagen, R., & Plüß, A.	Smile Gmbh, Germany
02/2021	*Engineering Geology*	A geotechnical stratigraphy for the shallow subsurface in the Southern Central Graben, North Sea. https://doi.org/10.1016/j.enggeo.2021.106089	Prins, L. T., & Andresen, K. J.	Aarhus University, Denmark
02/2021	*Frontiers in Marine Science*	A Relocatable Ocean Modeling Platform for Downscaling to Shelf-Coastal Areas to Support Disaster Risk Reduction https://doi.org/10.3389/fmars.2021.642815	Trotta, F., Federico, I., Pinardi, N., Coppini, G., Causio, S., Jansen, E., ... & Masina, S.	University of Bologna, Italy
02/2021	*Marine Policy*	Deep-sea trawling off the Portuguese continental coast—Spatial patterns, target species and impact of a prospective EU-level ban. https://doi.org/10.1016/j.marpol.2021.104466	Campos, A., Henriques, V., Erzini, K., & Castro, M.	IPMA, Portugal
02/2021	*Environmental Pollution.*	Preliminary results on the occurrence and anatomical distribution of microplastics in wild populations of Nephrops norvegicus from the Adriatic Sea. https://doi.org/10.1016/j.envpol.2021.116872	Martinelli, M., Gomiero, A., Guicciardi, S., Frapiccini, E., Strafella, P., Angelini, S., ... & Colella, S.	National Research Council – Institute of Marine Biological Resources and Biotechnologies, Italy
02/2021	*Marine and Petroleum Geology, 128, 104999.*	Oblique plate collision and orogenic translation of the Southern Apennines revealed by post-Messinian interregional unconformities in the Bradano Basin (Ionian Sea-Central Mediterranean). https://doi.org/10.1016/j.marpetgeo.2021.104999	Basso, J., Artoni, A., Torelli, L., Polonia, A., Carlini, M., Gasperini, L., & Mussoni, P.	University of Parma, Italy

02/2021	*Renewable and Sustainable Energy Reviews*	Prospects of renewable energy as a non-rivalry energy alternative in Libya https://doi.org/10.1016/j.rser.2021.110852	Almaktar, M., & Shaaban, M.	Karabuk University, Turkey
02/2021	*Geosciences*	Inverted Basins by Africa–Eurasia Convergence at the Southern Back-Arc Tyrrhenian Basin. https://doi.org/10.3390/geosciences11030117	Loreto, M. F., Palmiotto, C., Muccini, F., Ferrante, V., & Zitellini, N.	CNR, Marine Sciences Institute, Italy
02/2021	*Marine and Petroleum Geology*	Siliciclastic and bioclastic contouritic sands: Textural and geochemical characterisation. https://doi.org/10.1016/j.marpetgeo.2021.105002	de Castro, S., Miramontes, E., Dorador, J., Jouet, G., Cattaneo, A., Rodríguez-Tovar, F. J., & Hernández-Molina, F. J.	Royal Holloway Univ. London, UK
02/2021	*Морской гидрофизический журнал*	Сезонная и вертикальная изменчивость энергии течений в субме-зомасштабном диапазоне на шельфе и в центральной части Черного моря. https://doi.org/10.22449/0233-7584-2021-1-41-56	Пузина, О. С., Кубряков, А. А., & Мизюк, А. И.	Marine Hydrophysical Institute, Russian Academy of Sciences Russian Federation, Russia
02/2021	*Science Advances.*	Deep-sea predator niche segregation revealed by combined cetacean biologging and eDNA analysis of cephalopod prey DOI: 10.1126/sciadv.abf5908	Visser, F., Merten, V. J., Bayer, T., Oudejans, M. G., de Jonge, D. S. W., Puebla, O., ... & Hoving, H. J. T.	University of Amsterdam, The Netherlands
02/2021	*Future Science Brief 6 of the European Marine Board* *Report*	Reassessing Eastern Mediterranean tectonics and earthquake hazard from the AD 365 earthquake. https://doi.org/10.31223/X5H036	Ott, R. F., Wegmann, K. W., Gallen, S. F., Pazzaglia, F. J., Brandon, M. T., Ueda, K., & Fassoulas, C.	ETH Zurich, Switzerland
02/2021	*Sedimentary Geology*	Depositional mechanism of the upper Pliocene-Pleistocene shelf-slope system of the western Malta Plateau (Sicily Channel). https://doi.org/10.1016/j.sedgeo.2021.105882	Todaro, S., Sulli, A., Spatola, D., Micallef, A., Di Stefano, P., & Basilone, G.	University of Palermo, Italy
02/2021	*Journal of Maps*	Applying planetary mapping methods to submarine environments: onshore-offshore geomorphology of Christiana-Santorini-Kolumbo Volcanic Group, Greece.	Huff, A. E., Nomikou, P., Thompson, L. A., Hooft, E. E., & Walker, I. J.	Arizona State University, USA

		https://doi.org/10.1080/17445647.2021.1880980		
02/2021	*Aquatic Conservation: Marine and Freshwater Ecosystems.*	Evaluating the distribution of priority benthic habitats through a remotely operated vehicle to support conservation measures off Linosa Island (Sicily Channel, Mediterranean Sea). https://doi.org/10.1002/aqc.3554	Romagnoli, B., Grasselli, F., Costantini, F., Abbiati, M., Romagnoli, C., Innangi, S., ... & Tonielli, R.	Università di Bologna, Italy
02/2021	*EarthArXiv*	A database of submarine landslides offshore West and Southwest Iberia.	Gamboa, D., Omira, R., & Terrinha, P.	IPMA, Portugal
02/2021	*Journal of Geophysical Research: Oceans*	Long–term observations reveal environmental conditions and food supply mechanisms at an Arctic deep-sea sponge ground. https://doi.org/10.1029/2020JC016776	Hanz, U., Roberts, E. M., Duineveld, G., Davies, A., van Haren, H., Rapp, H. T., ... & Mienis, F.	NIOZ Royal Netherlands Institute for Sea Research and Utrecht University, The Netherlands
02/2021	*Deep Sea Research Part I: Oceanographic Research Papers,*	Mediterranean seascape suitability for Lophelia pertusa: Living on the edge. https://doi.org/10.1016/j.dsr.2021.103496	Matos, F. L., Company, J. B., & Cunha, M. R.	University of Aveiro, Portugal
02/2021	*Marine Pollution Bulletin,*	Prediction of marine mammal auditory-impact risk from Acoustic Deterrent Devices used in Scottish aquaculture. https://doi.org/10.1016/j.marpolbul.2021.112171	Todd, V. L., Williamson, L. D., Jiang, J., Cox, S. E., Todd, I. B., & Ruffert, M.	Ocean Science Consulting Limited, UK
02/2021	*Journal of Quaternary Science.*	Pattern, style and timing of British–Irish Ice Sheet advance and retreat over the last 45 000 years: evidence from NW Scotland and the adjacent continental shelf. https://doi.org/10.1002/jqs.3296	Bradwell, T., Fabel, D., Clark, C. D., Chiverrell, R. C., Small, D., Smedley, R. K., ... & Cofaigh, C. Ó.	British Geological Survey, UK
03/2021	*Marine Policy*	The use of a spatial model of economic efficiency to predict the most likely outcomes under different fishing strategy scenarios. https://doi.org/10.1016/j.marpol.2021.104499	Vilela, R., Pennino, M. G., Rodriguez-Rodriguez, G., Ballesteros, H. M., & Bellido, J. M.	Instituto Español de Oceanografía, Spain

03/2021	*Marine Geophysical Research*	Oceanographic control of the submarine landslides of the northern Galicia Area (Bay of Biscay, NE Atlantic). https://doi.org/10.1007/s11001-021-09433-1	León, R., Martínez-Carreño, N., García-Gil, S., Rengel, J. A., Giménez-Moreno, C. J., & Reguera, I.	Instituto Geológico y Minero de España (IGME), Spain
03/2021	*Geosciences*	Dynamics of Stone Habitats in Coastal Waters of the Southwestern Baltic Sea (Hohwacht Bay). https://doi.org/10.3390/geosciences11040171	von Rönn, G. A., Krämer, K., Franz, M., Schwarzer, K., Reimers, H. C., & Winter, C.	Kiel University, Germany
03/2021	*Environmental Research Communications.*	Characterising industrial thermal plumes in coastal regions using 3-D numerical simulations. https://doi.org/10.1088/2515-7620/abf62e	Faulkner, A., Bulgin, C. E., & Merchant, C. J.	University of Reading, United Kingdom
03/2021	*Plos one*	Spatial heterogeneity of Pelagia noctiluca ephyrae linked to water masses in the Western Mediterranean. https://doi.org/10.1371/journal.pone.0249756	Pastor-Prieto, M., Bahamon, N., Sabatés, A., Canepa, A., Gili, J. M., Carreton, M., & Company, J. B	Institut de Ciències del Mar (ICM-CSIC), Spain
03/2021	*Mediterranean Marine Science*	New records of rare species in the Mediterranean Sea	SANTIN, A., AGUILAR, R., AKYOL, O., BEGBURS, C. R., BENOIT, L., CHIMIENTI, G., ... & TIRALONGO, F.	Institut de Ciències del Mar (ICM-CSIC), Spain
03/2021	*NAŠE MORE: znanstveni časopis za more i pomorstvo, 68(2), 110-119.*	Comparison and Analysis of Publicly Available Bathymetry Models in the East Adriatic Sea. https://doi.org/10.17818/NM/2021/2.7	Vrdoljak, L.	Hydrographic Institute of the Republic of Croatia
03/2021	*Marine Geophysical Research*	3D crustal-scale structure of the West Iberia margin: a novel approach to integrated structural characterization of passive margins. https://doi.org/10.1007/s11001-021-09432-2	Granado, C., Muñoz-Martín, A., Olaiz, A. J., Fernández, O., & Druet, M.	Complutense University, Spain
03/2021	*Master Thesis*	Rogue waves in the Dutch North Sea: An experimental study into the occurrence of extreme waves due to abrupt depth transitions at future offshore wind farm locations along the Dutch coast. https://doi.org/10.4121/14301455	Doeleman, M.	TU Delft, The Netherlands

03/2021	*Biogeosciences*	Organic carbon densities and accumulation rates in surface sediments of the North Sea and Skagerrak. https://doi.org/10.5194/bg-18-2139-2021	Diesing, M., Thorsnes, T., & Bjarnadóttir, L. R.	Geological Survey of Norway, Norway
03/2021	*European Journal of Taxonomy*	Two new tanaidaceans (Crustacea: Peracarida) from Portuguese submarine canyons (NE Atlantic, West Iberian Margin). https://doi.org/10.5852/ejt.2021.740.1281	García-Herrero, Á., Esquete, P., & Cunha, M. R.	Universidade de Aveiro, Portugal
03/2021	*Aquatic Conservation: Marine and Freshwater Ecosystems.*	Drivers for spatial modelling of a critically endangered seabird on a dynamic ocean area: Balearic shearwaters are non-vegetarian. https://doi.org/10.1002/aqc.3542	de la Cruz, A., Ramos, F., Navarro, G., Cózar, A., Bécares, J., & Arroyo, G. M.	Cádiz University, Spain
03/2021	*Pure and applied geophysics*	The 30 October 2020 Aegean Sea tsunami: post-event field survey along Turkish coast. https://doi.org/10.1007/s00024-021-02693-3	Dogan, G. G., Yalciner, A. C., Yuksel, Y., Ulutaş, E., Polat, O., Güler, I., ... & Kânoğlu, U.	Middle East Technical University, Ankara, Turkey
03/2021	*Physical Oceanography*	Seasonal and Vertical Variability of Currents Energy in the Sub-Mesoscale Range on the Black Sea Shelf and in Its Central Part. https://doi.org/10.22449/1573-160X-2021-1-37-51	Puzina, O. S., Kubryakov, A. A., & Mizyuk, A. I.	Marine Hydrophysical Institute of RAS, Sevastopol, Russian Federation
03/2021	*Rudarsko-geološko-naftni zbornik*	BATIMETRIJSKA I GEOLOŠKA SVOJSTVA JADRANSKOGA MORA. https://doi.org/10.17794/rgn.2021.2.9	Vrdoljak, L., Režić, M., & Petričević, I.	Hydrographic Institute of the Republic of Croatia, Croatia
03/2021	*Estuarine, Coastal and Shelf Science*	A comprehensive study of the tides around the Welsh coastal waters. https://doi.org/10.1016/j.ecss.2021.107326	Horrillo-Caraballo, J. M., Yin, Y., Fairley, I., Karunarathna, H., Masters, I., & Reeve, D. E.	Swansea University, UK
04/2021	*Chapter in: Second World Ocean Assessment*	Marine invertebrates.	Jørgensen, L. L., Arvanitidis, C., Birchenough, S. N., Clark, M. R., Silva Cruz, I. C., Cunha, M., ... & Vandepitte, L.	United Nations.

04/2021	*Frontiers in Earth Science*	Probabilistic Assessment of Slip Rates and Their Variability Over Time of Offshore Buried Thrusts: A Case Study in the Northern Adriatic Sea. https://doi.org/10.3389/feart.2021.664288	Panara, Y., Maesano, F. E., Amadori, C., Fedorik, J., Toscani, G., & Basili, R.	Università di Pavia,Italy
04/2021	*Marine Policy*	The use of a spatial model of economic efficiency to predict the most likely outcomes under different fishing strategy scenarios. https://doi.org/10.1016/j.marpol.2021.104499	Vilela, R., Pennino, M. G., Rodriguez-Rodriguez, G., Ballesteros, H. M., & Bellido, J. M.	Instituto Español de Oceanografía, Spain
04/2021	*Marine Geophysical Research*	Oceanographic control of the submarine landslides of the northern Galicia Area (Bay of Biscay, NE Atlantic). https://doi.org/10.1007/s11001-021-09433-1	León, R., Martínez-Carreño, N., García-Gil, S., Rengel, J. A., Giménez-Moreno, C. J., & Reguera, I.	Instituto Geológico y Minero de España
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04/2021	*PloS one*	Spatial heterogeneity of Pelagia noctiluca ephyrae linked to water masses in the Western Mediterranean. https://doi.org/10.1371/journal.pone.0249756	Pastor-Prieto, M., Bahamon, N., Sabatés, A., Canepa, A., Gili, J. M., Carreton, M., & Company, J. B.	Institut de Ciències del Mar
04/2021	*Frontiers in Earth Science*	Unraveling past submarine eruptions by dating lapilli tuff-encrusting coralligenous (Actea volcano, NW Sicilian Channel). https://doi.org/10.3389/feart.2021.664591	Lodolo, E., Renzulli, A., Cerrano, C., Calcinai, B., Civile, D., Quarta, G., & Calcagnile, L.	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale
05/2021	*ArWiv Preprint*	Non-deterministic effects in modelling the tidal currents in a high-energy coastal site. https://doi.org/10.31223/X55G7F	Warder, S., Kramer, S. C., & Piggott, M. D.	Imperial College

05/2021	*Tectonophysics*	Subduction related faults and sedimentary basins: The Western Ionian Sea case. https://doi.org/10.1016/j.tecto.2021.228943	Proietti, G., Conti, A., Cuffaro, M., Esestime, P., & Bigi, S.	Sapienza Università di Roma
05/2021	*Acta Geophysica*	Post-event field observations in the İzmir–Sığacık village for the tsunami of the 30 October 2020 Samos (Greece) M w 6.9 earthquake. https://doi.org/10.1007/s11600-021-00582-w	Aksoy, M. E.	Muğla Sıtkı Koçman Üniversitesi, Turkey
05/2021	*Biological Invasions*	Macroalgae niche modelling: a two-step approach using remote sensing and in situ observations of a native and an invasive Asparagopsis. https://doi.org/10.1007/s10530-021-02554-z	Casas, E., Fernandez, M., Gil, A., Yesson, C., Prestes, A., Moreu-Badia, I., ... & Arbelo, M.	Universidad de la Laguna, Spain
05/2021	*Journal of Applied Ecology.*	Auditory impairment from acoustic seal deterrents predicted for harbour porpoises in a marine protected area. https://doi.org/10.1111/1365-2664.13910	Findlay, C. R., Aleynik, D., Farcas, A., Merchant, N. D., Risch, D., & Wilson, B.	Scottish Association for Marine Science
05/2021	*ICES Journal of Marine Science*	Drivers and implications of change in an inshore multi-species fishery https://doi.org/10.1093/icesjms/fsab083	Henly, L., Stewart, J. E., & Simpson, S. D.	University of Exeter
05/2021	*Earth-Science Reviews*	The Strait of Messina: Seismotectonics and the source of the 1908 earthquake. https://doi.org/10.1016/j.earscirev.2021.103685	Barreca, G., Gross, F., Scarfì, L., Aloisi, M., Monaco, C., & Krastel, S. (2021	Università di Catania, Italy
05/2021	*Pure and Applied Geophysics*	Long Tsunami Oscillations Following the 30 October 2020 Mw 7.0 Aegean Sea Earthquake: Observations and Modelling. https://doi.org/10.1007/s00024-021-02761-8	Heidarzadeh, M., Pranantyo, I. R., Okuwaki, R., Dogan, G. G., & Yalciner, A. C.	Brunel University London
05/2021	*Geosciences*	The Santorini-Amorgos Shear Zone: Evidence for Dextral Transtension in the South Aegean Back-Arc Region, Greece.	Tsampouraki-Kraounaki, K., Sakellariou, D., Rousakis, G.,	University of Patras

		https://doi.org/10.3390/geosciences11050216	Morfis, I., Panagiotopoulos, I., Livanos, I., ... & Papatheodorou, G.	
05/2021	*Tectonophysics*	Thermal evolution of onshore West Iberia: A better understanding of the ages of breakup and rift-to-drift in the Iberia-Newfoundland Rift. https://doi.org/10.1016/j.tecto.2021.228926	Barbarand, J., Marques, F. O., Hildenbrand, A., Pinna-Jamme, R., & Nogueira, C. R.	Université Paris-Saclay,
05/2021	*Journal of Archaeological Science*	Satellite-derived bathymetry for maritime archaeology: Testing its effectiveness at two ancient harbours in the Eastern Mediterranean. https://doi.org/10.1016/j.jasrep.2021.103030	Westley, K.	Ulster University
05/2021	*Frontiers in Marine Science*	Mediterranean Coral Provinces as a Sponge Diversity Reservoir: Is There a Mediterranean Cold-Water Coral Sponge Fauna?. https://doi.org/10.3389/fmars.2021.662899	Santín, A., Grinyó, J., Uriz, M. J., Lo Iacono, C., Gili, J. M., & Puig, P.	Institut de Ciències del Mar
05/2021	*International Council for the Exploration of the Sea (ICES). ICES Scientific Report*	Working Group on Nephrops Surveys (WGNEPS ;outputs from 2020). https://doi.org/10.17895/ices.pub.8041	Aristegui-Ezquibela, M., Aguzzi, J., Burgos, C., Doyle, J., Fallon, N., Fifas, S., Jónasson, J., Jonsson, P., Lundy,M., Martinelli, M., Masmitja, I., McAllister, G., Medvešek, D., Naseer, A., Reeve, C., Silva, C., Simon, J.,Vacherot, J-P., Vigo-Fernandez, M., ... Wieland, K.	ICES
06/2021	*TechRxiv. Preprint.*	Going offshore or not: Where to generate hydrogen in future integrated energy systems?. https://doi.org/10.36227/techrxiv.14806647.v2	Gea Bermúdez, J., Koivisto, M. J., Kitzing, L., Ramos, A., & Pedersen, R. B. B.	Technical University of Denmark
06/2021	*Marine Geology*	Late Pleistocene iceberg scouring in the north-eastern Baltic Sea, west of Estonia. https://doi.org/10.1016/j.margeo.2021.106537	Karpin, V., Heinsalu, A., & Virtasalo, J. J.	Estonian Transport Administration

06/2021	*Marine Ecology Progress Series*	A verified distribution model for the lesser sandeel Ammodytes marinus. https://doi.org/10.3354/meps13693	Langton, R., Boulcott, P., & Wright, P. J.	Marine Scotland Science
06/2021	*D-3-3 Metallogeny of hydrothermal deposits in European waters – MINDeSEA project (H2020 project)*	Seabed Mineral Deposits in European Seas: Metallogeny and Geological Potential for Strategic and Critical Raw Materials.	Schiellerup, H.	Geological Survey of Norway
06/2021	*Thesis*	Wave climatology and extreme value analysis in coastal waters of Greek sea areas with application to Sounio nearshore region.	Mosiou, K.	National Technical University of Athens
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06/2021	*Ecological indicators*	Beyond connecting the dots: A multi-scale, multi-resolution approach to marine habitat mapping. https://doi.org/10.1016/j.ecolind.2021.107849	Van Der Reijden, K. J., Govers, L. L., Koop, L., Damveld, J. H., Herman, P. M., Mestdagh, S., ... & Olff, H.	University of Groningen
07/2021	*Preprint Available at SSRN 3885492*	The Influence of Large-Scale Wind Farm Wake Losses and Sector Coupling on the Development of Offshore Grids. https://dx.doi.org/10.2139/ssrn.3885492	Gea-Bermudez, J., Kitzing, L., Matti, K., Kaushik, D., Murcia León, J. P., & Sørensen, P.	Technical University of Denmark Denmark
07/2021	*Synthesis Report.*	Sensitive Ecosystem Assessment and ROV Exploration of Reef (SeaRover),	Picton, B., Morrow, C., Scally, L., & Pfeiffer, N. .	Marine Institute Ireland
07/2021	*Scientific Data, 8(1), 1-9.*	A database of submarine landslides offshore West and Southwest Iberia. https://doi.org/10.1038/s41597-021-00969-w	Gamboa, D., Omira, R., & Terrinha, P.	Instituto Português do Mar e de Atmosfera Portugal

07/2021	*Quaternary Science Reviews, 266, 107071.*	A Holocene relative sea-level database for the Baltic Sea. https://doi.org/10.1016/j.quascirev.2021.107071	Rosentau, A., Klemann, V., Bennike, O., Steffen, H., Wehr, J., Latinović, M., ... & Subetto, D.	University of Tartu Estonia
07/2021	*Deep Sea Research Part I: Oceanographic Research Papers, 176, 103603.*	Potential factors influencing the condition of demersal sharks in the Mediterranean deep sea ecosystems. https://doi.org/10.1016/j.dsr.2021.103603	Ordines, F., Valls, M., Meléndez, M. J., Ramírez-Amaro, S., López, E., Lloret, J., ... & Massutí, E.	Instituto Español de Oceanografía, Palma, Spain
07/2021	*Marine Ecology Progress Series, 670, 121-137.*	Living at the top. Connectivity limitations and summit depth drive fish diversity patterns in an isolated seamount. https://doi.org/10.3354/meps13766	González-Irusta, J. M., De la Torriente, A., Punzón, A., Blanco, M., Arronte, J. C., Bañón, R., ... & Serrano, A.	Instituto Español de Oceanografía Sapin
07/2021	*Marine Ecology Progress Series, 670, 75-91.*	Predicting sea pen (Pennatulacea) distribution on the UK continental shelf: evidence of range modification by benthic trawling. https://doi.org/10.3354/meps13744	Downie, A. L., Noble-James, T., Chaverra, A., & Howell, K. L.	Centre for Environment, Fisheries and Aquaculture Science UK
07/2021	*Journal of Geodesy, 95(8), 1-18.*	The potential impact of hydrodynamic leveling on the quality of the European vertical reference frame. https://doi.org/10.1007/s00190-021-01543-3	Afrasteh, Y., Slobbe, D. C., Verlaan, M., Sacher, M., Klees, R., Guarneri, H., ... & Zijl, F.	Delft University of Technology Netherlands
07/2021	*Marine Pollution Bulletin, 171, 112744.*	Stochastic oil spill modeling for environmental protection at the Port of Taranto (southern Italy). https://doi.org/10.1016/j.marpolbul.2021.112744	Liubartseva, S., Federico, I., Coppini, G., & Lecci, R.	Centro Euro-Mediterraneo sui Cambiamenti Climatici Italy
07/2021	*Report*	Estudio del conocimiento del sector pesquero del Plan Castellón y propuestas de nuevas medidas de gestión.	Pitarch Font, D.	Universidad de Alicante

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07/2021	*Journal of Maps, 1-11.*	Geomorphology of the seafloor north east of the Maltese Islands, Central Mediterranean. https://doi.org/10.1080/17445647.2021.1957034	Prampolini, M., Coratza, P., Rossi, S., Parenti, C., Galea, C., Caruana, A., & Soldati, M.	CNR Bologna Italy
07/2021	*Journal of Geophysical Research: Solid Earth, 126(8), e2021JB021711.*	The Structure of the Continent-Ocean Transition in the Gulf of Lions From Joint Refraction and Reflection Travel-Time Tomography. https://doi.org/10.1029/2021JB021711	Merino, I., Prada, M., Ranero, C. R., Sallarès, V., & Calahorrano, A.	CSIC Spain
07/2021	*arXiv preprint arXiv:2108.00509.*	Current interaction in large-scale wave models with an application to Ireland.	Calvino, C., Dabrowski, T., & Dias, F.	University College Dublin Ireland
07/2021	*Scientific Reports, 11(1), 1-12.*	Habitat suitability mapping of the black coral Leiopathes glaberrima to support conservation of vulnerable marine ecosystems. https://doi.org/10.1038/s41598-021-95256-4	Lauria, V., Massi, D., Fiorentino, F., Milisenda, G., & Cillari, T.	National Research Council CNR (CNR) Italy
07/2021	*Doctoral dissertation,*	Magmatism and Rifting in Oceanic Intraplate Environments: The Evolution of the Azores Plateau	Romer, R.	Friedrich-Alexander-Universität Erlangen-Nürnberg Germany
07/2021	*Environmental Microbiology Reports, 13(5), 744-752.*	The worm affair: fidelity and environmental adaptation in symbiont species that co-occur in vestimentiferan tubeworms. https://doi.org/10.1111/1758-2229.12994	Zvi-Kedem, T., Shemesh, E., Tchernov, D., & Rubin-Blum, M.	University of Haifa Israel
07/2021	*PeerJ, 9, e11898.*	Biogeography, diversity and environmental relationships of shelf and deep-sea benthic Amphipoda around Iceland. 10.7717/peerj.11898	Lörz, A. N., Kaiser, S., Oldeland, J., Stolter, C., Kürzel, K., & Brix, S.	Universität Hamburg Germany
07/2021	*Quaternary Science Reviews, 268, 107131.*	New human remains from the Late Epigravettian necropolis of Arene Candide (Liguria, northwestern Italy): Direct radiocarbon	Sparacello, V. S., Dori, I., Rossi, S., Varalli, A., Riel-Salvatore, J.,	Università Degli Studi di Cagliari Italy

		evidence and inferences on the funerary use of the cave during the Younger Dryas. https://doi.org/10.1016/j.quascirev.2021.107131	Gravel-Miguel, C., ... & Moggi-Cecchi, J.	
08/2021	*Report*	Advanced Energy Storage and Distribution Grid.	Shubov, M. V.	University of MA Lowell USA
08/2021	*Continental Shelf Research, 228, 104535.*	Modelling the water dynamics of a tidal lagoon: The impact of human intervention in the Nador Lagoon (Morocco). https://doi.org/10.1016/j.csr.2021.104535	Maicu, F., Abdellaoui, B., Bajo, M., Chair, A., Hilmi, K., & Umgiesser, G.	CNR-ISMAR Italy
08/2021	*Master's thesis, UiT*	Romlig og tidsmessig analyse av garn-og linefiske. En studie av fiskeriatferd i området Lofoten, Vesterålen og Senja (2011-2018)	Steinsbø, S.	The Arctic University of Norway. Norway
08/2021	*Science of the Total Environment, 801, 149712.*	Offshore benthic habitat mapping based on object-based image analysis and geomorphometric approach. A case study from the Slupsk Bank, Southern Baltic Sea. https://doi.org/10.1016/j.scitotenv.2021.149712	Janowski, L., Wroblewski, R., Dworniczak, J., Kolakowski, M., Rogowska, K., Wojcik, M., & Gajewski, J.	Gdynia Maritime University Poland
08/2021	*Report*	AMAP Litter and Microplastics Monitoring Guidelines	LARSEN, J. R., BOOTH, A. M., ROCHMAN, C. M., LIBOIRON, M., MURPHY, P., PRIMPKE, S., & ALIANI, S.	Arctic Monitoring and Assessment Programme(AMAP) Tromsø, Norway
08/2021	*Marine and Petroleum Geology, 133, 105300.*	Interference between Apennines and Hellenides foreland basins around the Apulian swell (Italy and Greece). https://doi.org/10.1016/j.marpetgeo.2021.105300	Cicala, M., Festa, V., Sabato, L., Tropeano, M., & Doglioni, C.	Università degli Studi di Bari Italy
08/2021	*Earth SystemScience Data (ESSD)*	An integrated marine data collection for the German Bight–Part 1: Subaqueous geomorphology and surface sedimentology (1996–2016).	Sievers, J., Milbradt, P., Ihde, R., Valerius, J., Hagen, R., & Plüß, A.	smile consult GmbH Germany

		https://doi.org/10.5194/essd-13-4053-2021.		
08/2021	*Report*	Análisis del clima marítimo y eventos de inundación en la zona de San Andrés, Tenerife.	López de Subijana Esteban, I.	Universidad de Cantabria Spain
08/2021	*Marine and Petroleum Geology, 133, 105302.*	Seismic imaging of an active fluid conduit below Scanner Pockmark, Central North Sea. https://doi.org/10.1016/j.marpetgeo.2021.105302	Schramm, B., Berndt, C., Dannowski, A., Böttner, C., Karstens, J., & Elger, J.	GEOMAR Helmholtz Centre for Ocean Research Kiel Germany
08/2021	*Geologica Acta, 19.10 1-11*	Critical analysis of Mediterranean sea level limit cycles during the Messinian salinity crisis. DOI: 10.1344/GeologicaActa2021.19.10	Baum, M. .	Harvard University USA
08/2021	*Chapter in Landscapes and Landforms of Scotland (pp. 169-191). Springer, Cham.*	The Outer Hebrides and St Kilda. https://doi.org/10.1007/978-3-030-71246-4_9	Hall, A. M., Ballantyne, C. K., & Hansom, J. D.	Stockholm University Sweden
08/2021	*PhD Thesis*	Wind-Generated Waves in Fjords and Coastal Areas	Christakos, K. .	University of Bergen Norway
08/2021	*Heliyon, 7(9), e07880.*	Living benthic foraminifera from cold-water coral ecosystems in the eastern Alboran Sea, Western Mediterranean. https://doi.org/10.1016/j.heliyon.2021.e07880	Stalder, C., ElKateb, A., Spangenberg, J. E., Terhzaz, L., Vertino, A., & Spezzaferri, S.	University of Fribourg Switzerland
08/2021	*Journal of Marine Science and Engineering, 9(9), 933*	Undercurrents in the Northeastern Black Sea Detected on the Basis of Multi-Model Experiments and Observations. https://doi.org/10.3390/jmse9090933	Demyshev, S. G., Dymova, O. A., Markova, N. V., Korshenko, E. A., Senderov, M. V., Turko, N. A., & Ushakov, K. V. .	Russian Academy of Sciences Russia

08/2021	*Report*	Constructing EUSeaMap-User Guide.	Vasquez, M.	Ifremer France
08/2021	*PHYSICAL OCEANOGRAPHY, 28(4), 393.*	Assessment of the Black Sea Temperature and Salinity Climatic Fields for the Recent Climatological Period (1991–2020).	Markova, N. V., Belokopytov, V. N., Dymova, O. A., & Miklashevskaya, N. A.	Russian Academy of Sciences Russia
08/2021	*Diversity and Distributions. 27(4):668-683*	Specific niche requirements underpin multidecadal range edge stability, but may introduce barriers for climate change adaptation. DOI: 10.1111/ddi.13224	Firth Louise, B., Daniel, H., Blaze Julie, A., Marzloff Martin, P., Aurélien, B., Miller Peter, I., ... & Hawkins Stephen, J.	University of Plymouth, UK
08/2021	*Journal of Marine Science and Engineering, 9(9), 966*	Fin Whale (Balaenoptera physalus) in the Ligurian Sea: Preliminary Study on Acoustics Demonstrates Their Regular Occurrence in Autumn. https://doi.org/10.3390/jmse9090966	Pintore, L., Sciacca, V., Viola, S., Giacoma, C., Papale, E., & Giorli, G.	University of Torino, Italy
08/2021	*Морской гидрофизический журнал, 37(4), 423-435.*	Оценка климатических полей температуры и солености вод Черного моря для современного периода (1991–2020). https://doi.org/10.22449/0233-7584-2021-4-423-435	Маркова, Н. В., Белокопытов, В. Н., Дымова, О. А., & Миклашевская, Н. А.	Russian Academy of Sciences Russia
08/2021	*Progress in Oceanography, 198, 102669.*	First recording of a bathypelagic deep scattering layer in the Bay of Biscay. https://doi.org/10.1016/j.pocean.2021.102669	Peña, M., Munuera–Fernández, I., Nogueira, E., & González-Quirós, R.	Centro Oceanográfico de Baleares Spain
08/2021	*Estuarine, Coastal and Shelf Science, 107573.*	Long-term evolution of an inner bar at the mouth of a microtidal river. https://doi.org/10.1016/j.ecss.2021.107573	Baldoni, A., Perugini, E., Soldini, L., Calantoni, J., & Brocchini, M.	Università Politecnica Delle Marche Italy
08/2021	*MRes Thesis*	Bedrock target analysis for ROV rockdrill sampling and existing sample stratigraphic and mineralogical verification (BeTar_drill).	Strachan, R.	University College Cork. Ireland

08/2021	*. Journal of Maps, 17(2), 533-542.*	Echo-character distribution in the Cantabrian Margin and the Biscay Abyssal Plain https://doi.org/10.1080/17445647.2021.1973917	Maestro, A., Gallastegui, A., Moreta, M., Llave, E., Bohoyo, F., Druet, M., ... & Granja-Bruña, J. L.	Instituto Geológico y Minero de España, Spain
09/2021	*Animal Biodiversity and Conservation, 44.2: 289–301*	Machine learning as a successful approach for predicting complex spatio–temporal patterns in animal species abundance. https://doi.org/10.32800/abc.2021.44.0289	Martín, B., González–Arias, J., & Vicente–Vírseda, J. A.	Departamento de Economía de la Empresa y Contabilida Spain
09/2021	*BÖLÜM XIV*	İstanbul Boğazı'nda gemi kazalarının önlenmesi için bayes ağı tabanlı bir karar destek sistemi önerisi.	Yağdır Çeliker, E., Cenani, Ş., & Çağdaş, G.	İstanbul Bilgi Üniversites Turkey
09/2021	*Cruise report*	Wave induced pockmark formation in the North Sea, Cruise No. MSM 99/2 (GPF 21-1_013), 26.03. 2021-05.04. 2021, Emden (Germany)-Emden (Germany). HELGOLAND POCKMARKS.	Schmidt, C., Böttner, C., Schmidt, M., Müller, T. H., Wünsche, A., Willems, T., ... & Spiegel, T.	GEOMAR Helmholtz Centre for Ocean Research Kiel Germany
09/2021	*Bull. Geophys. Oceanogr.*	Chirp data processing for fluid flow detection at the Gulf of Trieste (northern Adriatic Sea). DOI 10.4430/bgo00361	Vesnaver, A., Busetti, M., & Baradello, L.	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale – Italy
09/2021	*Ecological Indicators, 131, 108219.*	Geomorphological characterization, spatial distribution and environmental status assessment of coralligenous reefs along the Latium continental shelf. https://doi.org/10.1016/j.ecolind.2021.108219	Pierdomenico, M., Bonifazi, A., Argenti, L., Ingrassia, M., Casalbore, D., Aguzzi, L., ... & Chiocci, F. L.	Italian National Research Council Italy
09/2021	*Seismological Research Letters.*	Noise Levels and Signals Observed on Submarine Fibers in the Canary Islands Using DAS. https://doi.org/10.1785/0220210049	Ugalde, A., Becerril, C., Villaseñor, A., Ranero, C. R., Fernández-Ruiz, M. R., Martin-Lopez, S., ... & Martins, H. F.	CSIC Spain

09/2021	*Journal of Marine Science and Engineering, 9(10), 1043.*	First Evidence of Contourite Drifts in the North-Western Sicilian Active Continental Margin (Southern Tyrrhenian Sea). https://doi.org/10.3390/jmse9101043	Spatola, D., Sulli, A., Casalbore, D., & Chiocci, F. L.	Sapienza University, Italy
09/2021	*Mediterranean Marine Science*	New records of rare species in the Mediterranean Sea. https://doi.org/10.12681/mms.25295	Avola, S., & Gerovasileiou, V.	Institute of Marine Sciences (ICM-CSIC), Spain
09/2021	*Marine Geology, 106648.*	A multiproxy reconstruction of the Late Pleistocene-Holocene paleoenvironment: New insights from the NW Black Sea. https://doi.org/10.1016/j.margeo.2021.106648	Ion, G., Briceag, A., Vasiliu, D., Lupaşcu, N., & Melinte-Dobrinescu, M.	Institute of Marine Geology and Geo-ecology, Romania
09/2021	*Technical report*	EUSeaMap 2021. A European broad-scale seabed habitat map. 10.13155/83528	Vasquez, M., Allen, H., Manca, E., Castle, L., Lillis, H., Agnesi, S., ... & Virtanen, E.	Institut Français de Recherche pour l'Exploitation de la Mer ("Ifremer") France
09/2021	*Geological Society, London, Special Publications, 505.*	A First Approach to a Quaternary Geomorphological Map of the German Seas. https://doi.org/10.1144/SP505-2021-24	Breuer, S., & Asch, K.	Bundestanstalt für Geowissenschaft und Rohstoffe Germany
09/2021	*Journal of Marine Science and Engineering, 9(10), 1071.*	Modelling the Past and Future Evolution of Tidal Sand Waves. https://doi.org/10.3390/jmse9101071	Krabbendam, J., Nnafie, A., de Swart, H., Borsje, B., & Perk, L.	Utrecht University The Netherlands
09/2021	*Marine Ecology Progress Series, 675, 35-52.*	A generic approach to develop a trait-based indicator of trawling-induced disturbance. https://doi.org/10.3354/meps13840	Beauchard, O., Amour, A. B., Schratzberger, M., Laffargue, P., Hintzen, N. T., Somerfield, P. J., & Piet, G.	Utrecht University The Netherlands

09/2021	*Report*	EMODnet Geology–WP3 Case Study. Exploring the suitability of historic datasets to produce robust quantitative sediment maps	Mitchell, P.	CEFAS UK
09/2021	*Continental Shelf Research, 104574.*	A new seabed mobility index for the Irish Sea: Modelling seabed shear stress and classifying sediment mobilisation to help predict erosion, deposition, and sediment distribution. https://doi.org/10.1016/j.csr.2021.104574	Coughlan, M., Guerrini, M., Creane, S., O'Shea, M., Ward, S. L., Van Landeghem, K. J., ... & Doherty, P.	University College Dublin, Ireland
09/2021	*Marine Pollution Bulletin, 173, 112982.*	Dropping the microbead: Source and sink related microplastic distribution in the Black Sea and Caspian Sea basins. https://doi.org/10.1016/j.marpolbul.2021.112982	D'Hont, A., Gittenberger, A., Leuven, R. S., & Hendriks, A. J.	Marine Research Inventory & Strategy Solutions, The Netherlands
07/2021	*Preprint Available at SSRN 3885492*	The Influence of Large-Scale Wind Farm Wake Losses and Sector Coupling on the Development of Offshore Grids. https://dx.doi.org/10.2139/ssrn.3885492	Gea-Bermudez, J., Kitzing, L., Matti, K., Kaushik, D., Murcia León, J. P., & Sørensen, P.	Technical University of Denmark Denmark
10/2021	In : *Ocean Science Data*. Elsevier, 2022. p. 131-193.	Chapter 3: Data management infrastructures and their practices in Europe. https://doi.org/10.1016/B978-0-12-823427-3.00007-4	SCHAAP, Dick MA, NOVELLINO, Antonio, FICHAUT, Michele, *et al*	Maris BV, The Netherlands
10/2021	In *Ocean Science Data* (pp. 283-317). Elsevier.	Chapter 5: Connecting marine data to society. https://doi.org/10.1016/B978-0-12-823427-3.00003-7	Larkin, K. E., Marsan, A. A., Tonné, N., Van Isacker, N., Collart, T., Delaney, C., ... & Calewaert, J. B.	European Marine Observation and Data Network (EMODnet) Secretariat, Ostend, Belgium
10/2021	In *Ocean Science Data* (pp. 197-280). Elsevier.	Chapter 4: A collaborative framework among data producers, managers, and users. https://doi.org/10.1016/B978-0-12-823427-3.00001-3	Simoncelli, S., Manzella, G. M., Storto, A., Pisano, A., Lipizer, M., Barth, A., ... & Diggs, S.	Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna, Italy
10/2021	*Basin Research*. In press	Assessing the rate of crustal extension by 2D sequential restoration analysis: A case study from the active portion of the Malta Escarpment.	Gambino, S., Barreca, G., Gross, F., Monaco, C., Gutscher, M. A., & Alsop, G. I.	University of Catania, Catania, Italy,

10/2021	*Ocean Modelling*, *168*, 101894.	The impact of surface currents on the wave climate in narrow fjords. https://doi.org/10.1016/j.ocemod.2021.101894	Christakos, K., Björkqvist, J. V., Breivik, Ø., Tuomi, L., Furevik, B. R., & Albretsen, J.	Norwegian Meteorological Institute, Norway
10/2021	*Atmosphere*, *12*(10), 1360.	Offshore Wind and Wave Energy Complementarity in the Greek Seas Based on ERA5 Data. https://doi.org/10.3390/atmos12101360	Kardakaris, K., Boufidi, I., & Soukissian, T.	National Technical University of Athens, Greece
10/2021	*Tectonics*, *40*(11), e2021TC006870.	Segmentation and Holocene Behavior of the Middle Strand of the North Anatolian Fault (NW Turkey https://doi.org/10.1029/2021TC006870	Benjelloun, Y., de Sigoyer, J., Garambois, S., Carcaillet, J., & Klinger, Y.	Institut de physique du globe de Paris, CNRS, Paris, France
10/2021	Master's thesis,	*Wave environment assessment at a Norwegian harbor for land-based aquaculture facilities using a combined numerical approach*	Reidulff, K.	Norwegian University of Science and Technology, Norway
10/2021	*Doctoral Thesis*	Submarine Landslides in the Central Mediterranean: Causes and Recurrences.	Gauchery, T. T. N. M.	University of Bologna, Italy
10/2021	*Geochemistry, Geophysics, Geosystems*, *22*(11), e2021GC010090.	Slow slip triggers the 2018 Mw 6.9 Zakynthos Earthquake within the weakly locked Hellenic Subduction System, Greece. https://doi.org/10.1029/2021GC010090	Saltogianni, V., Mouslopoulou, V., Dielforder, A., Bocchini, G. M., Bedford, J., & Oncken, O.	GFZ Helmholtz Centre Potsdam, Germany
10/2021	*Marine Geology*, *443*, 106686.	Mobile bedform dynamics approaching a bedload parting site: Pentland Firth, northeast UK. https://doi.org/10.1016/j.margeo.2021.106686	Armstrong, C., Howe, J. A., Allen, C., & Watson, P.	Scottish Association for Marine Science, UK
10/2021	Master's thesis,	*FAIR and Open Energy Data for the wind Energy Sector*	Ziaabadi, M.	Western Norwqy University of Applied Sciences, Norway
10/2021	*Journal of Geophysical Research: Earth Surface*, *126*(11), e2021JF006387.	The role of fluid seepage in the erosion of Mesozoic carbonate escarpments. https://doi.org/10.1029/2021JF006387	Micallef, A., Paull, C. K., Saadatkhah, N., & Bialik, O.	Helmholtz Centre for Ocean Research, Germany
10/2021	*Renewable and Sustainable Energy Reviews*, *154*, 111794.	Global assessment of historical, current and forecast ocean energy infrastructure: Implications for marine space planning, sustainable design and end-of-engineered-life management.	Gourvenec, S., Sturt, F., Reid, E., & Trigos, F.	University of Southampton, UK

10/2021	Fisheries Research, 246, 106156.	Risk assessment of coastal fisheries in the Azores (north-eastern Atlantic). https://doi.org/10.1016/j.fishres.2021.106156	Torres, P., i Figueras, D. M., Diogo, H., & Afonso, P.	Okeanos – Centro I&D da Universidade dos Açores, Portugal
11/2021	*Helgoland Marine Research*, *75*(1), 1-6.	Who lives Where? Macrobenthic species distribution over sediment types and depth classes in the eastern North Sea.	Armonies, W.	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Germany
11/2021	*Journal of Geophysical Research: Solid Earth*, *126*(11), e2021JB022629.	The Rift and Continent-Ocean Transition Structure Under the Tagus Abyssal Plain West of the Iberia. https://doi.org/10.1029/2021JB022629	Merino, I., Ranero, C. R., Prada, M., Sallarès, V., & Grevemeyer, I.	CSIC, Barcelona, Spain
11/2021	*Journal of fish biology*.	Decline in Atlantic wolffish Anarhichas lupus in the North Sea: Impacts of fishing pressure and climate change. https://doi.org/10.1111/jfb.14942	Bluemel, J. K., Fischer, S. H., Kulka, D. W., Lynam, C. P., & Ellis, J. R.	Centre for Environment, Fisheries and Aquaculture Science, UK
	Earth System Science Data Discussions, 1-75.	Last Interglacial sea-level data points from Northwest Europe. https://doi.org/10.5194/essd-2021-390	Cohen, K. M., Cartelle, V., Barnett, R., Busschers, F. S., & Barlow, N. L.	Utrecht University, The Netherlands
11/2021	*Estuarine, Coastal and Shelf Science*, *263*, 107651.	The Irish Sea bed load parting zone: Is it a mid-sea hydrodynamic phenomenon or a geological theoretical concept? https://doi.org/10.1016/j.ecss.2021.107651	Creane, S., O'Shea, M., Coughlan, M., & Murphy, J.	University College Cork, Ireland
11/2021	*Report*	Dynamics and variability of POC burial in depocenters of the North Sea (Skagerrak), Cruise No. AL561, 2.08. 2021–13.08. 2021, Kiel–Kiel, APOC.	Schmidt, M., Sommer, S., Böttner, C., Dale, A. W., Lenz, N., & Spiegel, T.	GEOMAR Helmholtz Centre for Ocean Research Kiel Germany
11/2021	*Paleoceanography and Paleoclimatology*, *36*, e2020PA004171.	Rapid Climate Changes in the Westernmost Mediterranean (Alboran Sea) Over the Last 35 kyr: New Insights From Four Lipid Paleothermometers (U K'37, TEX H 86, RI-OH', and LDI). 10.1029/2020PA004171	Morcillo-Montalbá, L., Rodrigo-Gámiz, M., Martínez-Ruiz, F., Ortega-Huertas, M., Schouten, S., & Sinninghe Damsté, J. S.	CSIC, Spain
11/2021	Environ Sci Ecol: Curr Res 2: 1038	Data Sharing, Public Engagement and Innovation: the Open Science Pillars to Support Knowledge-Based Marine Strategies.	Altobelli, C., Giorgetti, A., Diviacco, P., Salon, S., Saraò, A., & Tirelli, V.	National Institute of Oceanography and Applied Geophysics, OGS, Italy

11/2021	*Marine Ecology Progress Series*, *679*, 181-194.	Foraging distribution of breeding northern fulmars is predicted by commercial fisheries. https://doi.org/10.3354/meps13887	Darby, J. H., de Grissac, S., Arneill, G. E., Pirotta, E., Waggitt, J. J., Börger, L., ... & Jessopp, M.	University College Cork, Ireland
11/2021	*Evolutionary Applications*.	Population and seascape genomics of a critically endangered benthic elasmobranch, the blue skate Dipturus batis. https://doi.org/10.1111/eva.13327	Delaval, A., Frost, M., Bendall, V., Hetherington, S. J., Stirling, D., Hoarau, G., ... & Noble, L. R.	Nord University, Norway
11/2021	*Natural Hazards and Earth System Sciences*, *21*(12), 3713-3730.	Characterization of fault plane and coseismic slip for the 2 May 2020, M w 6.6 Cretan Passage earthquake from tide gauge tsunami data and moment tensor solutions. https://doi.org/10.5194/nhess-21-3713-2021, 2021.	Baglione, E., Lorito, S., Piatanesi, A., Romano, F., Basili, R., Brizuela, B., ... & Amato, A.	OGS, Italy
11/2021	*European Maritime Board Position Paper 26*	Marine geohazards: Safeguarding society and the Blue Economy from a hidden threat.	Kopp, H., Latino Chiocci, F., Berndt, C., Namık Çağatay, M., Ferreira, T., Juana Fortes, C., ... & Yeo, I.	Marine Board Expert Working Group on Marine Geohazard
	Journal of Maps, *17*(2), 891-900.	Gravity data on the Central Pyrenees: a step forward to help a better understanding of the Pyrenean structures. https://doi.org/10.1080/17445647.2021.2001386	Ayala, C., Rey-Moral, C., Rubio, F., Soto, R., Clariana, P., Martín-León, J., ... & Benjumea, B.	IGME-CSIC, Spain
	Geo-Marine Letters, *41*(4), 1-16.	Palaeoenvironmental context and significance of ferruginous tubular bioforms and other authigenic mineral formations in source-to-sink sedimentary systems. https://doi.org/10.1007/s00367-021-00726-3	López-Pérez, A. E., Rubio, B., Rey, D., & Plaza-Morlote, M.	Universidade de Vigo, Spain
12/2021	Doctoral dissertation	*Structure, tectonic processes and deformation of the South Aegean Sea*	Tsampouraki-Kraounaki, K.	University of Patras, Greece
12/2021	Doctoral dissertation,	*Landscape response to glacial-interglacial cycles: insights from a southern North Sea offshore wind farm dataset*	Eaton, S. J.	University of Leeds, UK

12/2021	Master research dissertation	*Climatic and environmental drivers of extinction in Mediterranean island reptiles since the height of the last Ice Age*	Kalb, S.	University of Michigan, USA
12/2021	*Earth and Planetary Science Letters*, *578*, 117333.	How hazardous are tsunamis triggered by small-scale mass-wasting events on volcanic islands? New insights from Madeira–NE Atlantic https://doi.org/10.1016/j.epsl.2021.117333	Omira, R., Baptista, M. A., Quartau, R., Ramalho, R. S., Kim, J., Ramalho, I., & Rodrigues, A.	Universidade de Lisboa, Lisbon, Portugal
12/2021	*Marine Geology*, 106706.	A combined approach to cliff characterization: Cliff Stability index. https://doi.org/10.1016/j.margeo.2021.106706	Bergillos, R. J., Rodriguez-Delgado, C., Medinad, L., Fernández-Ruiz, J., Rodriguez-Ortiz, J. M., & Iglesias, G.	Universitat Politècnica de València, Spain
12/2021	*Renewable and Sustainable Energy Reviews*, *156*, 111943.	Subsea superconductors: The future of offshore renewable energy transmission?. https://doi.org/10.1016/j.rser.2021.111943	Cullinane, M., Judge, F., O'Shea, M., Thandayutham, K., & Murphy, J.	University College Cork, Ireland
12/2021	*Estuarine, Coastal and Shelf Science*, 107737.	Ecological role and phylogenetic position of a new habitat-forming species (Canalipalpata, Sabellidae) from the Mediterranean mesophotic soft bottoms. https://doi.org/10.1016/j.ecss.2021.107737	Enrichetti, F., Baldrighi, E., Bavestrello, G., Betti, F., Canese, S., Costa, A., ... & Bo, M.	University of Genova, Italy

9. Monitoring indicators

Comments on the progress indicators in the indicators spreadsheet		
Progress indicator	Means of collecting figures	Comment
1. Current status and coverage of total available thematic data A) Volume and coverage of available data	CDI catalogue service	There is a substantial increase of CDIs by almost all contractual data providers from 30560 to 31432 entries. This is related to the fact that data providers are tasked in the new contract with populating new data sets in the first year. Some providers should follow in the next months to finish this activity for having sufficient new input for the generation of the new EMODnet DTM release.
B) Usage of data in this quarter	CDI RSM shopping ledger service	Considerable decrease in number of downloaded CDIs compared to previous year from 19514 to 5884 this year. Number of users over whole period was 143 persons, compared to 203 in the previous year. We have no explanation for this.
2. Current status and coverage of total number of data products A) Volume and coverage of available data products	Viewing and Download service and Sextant CPRD catalogue service	There is a substantial increase of Composite DTMs (CDTMs) from 207 to 258 by several data providers as they are tasked in the new contract with populating new data sets in the first year. The cataloguing of new HR-DTMs will start before summer 2022.
B) Usage of data products in this quarter	Shopping module and analytics reporter of the Viewing and Download service	As always a large volume of downloads, both in numbers (ca 50.000) as in volume (> 5.7 TerraByte). However, a decrease of circa 30% compared to the previous year. Also the number of WMS requests is decreased by 27% but still very high (36072859 requests). The decrease cannot be explained, but overall the products stay very popular.
3. Organisations supplying/approached to supply data and data products within this quarter	CDI catalogue service	There is a substantial increase of CDI population from 30560 to 31432 entries by almost all contractual data providers. This is related to the fact that data

		providers are tasked in the new contract with populating new data sets in the first year. Only a few data providers are still underway and will deliver soon.
4. Online 'Web' interfaces to access or view data	N.A.	No changes
5. Statistics on information volunteered through download forms	CDI RSM shopping ledger service and shopping module and analytics reporter of the Viewing and Download service	Bathymetry is used by all sectors and for many applications as it provides basis information. A lot of users do not give details about themselves, unless they use Marine-ID in the download forms.
6. Published use cases	Matomo	EMODnet Bathymetry has a steady number of use cases which all continue to receive attention from users
8.1. Technical monitoring	Matomo – Grafana	The portal has a very good and stable response time and overall a very good up time (100%).
8.2. Portal user-friendliness (Visual harmonization score)	Trust-IT analysis	Nearly 100% score; only minor remarks
9. Visibility & Analytics for web pages	Matomo – Grafana	As expected and targeted, the pages related to the "EMODnet bathymetry viewing and Download Service" have the highest score and this traffic is very stable, like also other sections and services. This means that users spent the most time browsing and interacting with the viewing service which has many functions and overall is the most interesting product and service that EMODnet Bathymetry has to offer. As second interest, users undertake downloading of DTM tiles and visit the CDI service for details and downloading of survey data sets, which both have a comparable user interest level. The section on web services and standards also is well visited.
10. Visibility & Analytics for web sections	Matomo – Grafana	This indicator shows the interest of users for specific sections of the website, excluding the Bathymetry Viewing and Download service. The CDI service receives most attention, followed by the CPRD products catalogue service.

11. Average visit duration for web pages	Matomo – Grafana	Average visit duration is erratic, ranging from few seconds to 2:30 minutes. The interpretation of this diagram is complex as it might be interpreted in terms of user's interest but also as difficulty to understand the concept described on the web page.

The monitoring numbers reported as part of the progress monitoring of EMODnet performance are collected through Matomo and/or Europa Analytics, unless reported otherwise.

10. Recommendations for follow-up actions by the 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.

11. Annex: Other documentation attached

Annex 1: D2.1 - Upgraded guidelines for data pre-processing and population of metadata – Technical Report – April 2021

Annex 2: D3.1 - Upgraded guideline of EMODnet methodology for DTM production, including using prototype CVE – Technical Report – December 2021

Annex 3: Progress report by CORONIS on improving interpolation techniques for production of EMODnet DTMs – December 2021

Annex 4: EOMAP progress with Satellite Derived Bathymetry (SDB) production for EMODnet Bathymetry – December 2021

Annex 1: D2.1 - Upgraded guidelines for data pre-processing and population of metadata – Technical Report – April 2021

EMODnet Thematic Lot n°1 - Bathymetry

EASME/EMFF/2019/1.3.1.9/Lot1/SI2.836043

Start date of the project: 20/12/2020 - (24 months)

Centralisation Phase

D2.1: Upgraded guidelines for data pre-processing and population of metadata

Technical report

Date: 12/4/2021

Prepared by: Cecile Pertuisot (IFREMER)

The European Marine Observation and Data Network (EMODnet) is financed by the European Union under Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7 July 2021 establishing the European Maritime, Fisheries and Aquaculture Fund and its predecessor, Regulation (EU) No. 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.

Contents

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1. Flowchart of overall EMODnet Bathymetry approach

The first phase of the project is dedicated to gathering new bathymetric data sets such as survey data sets, composite DTMs, and Satellite Derived Bathymetry (also considered as composite DTMs) by all data providers. The data providers should populate all new data sets in the Catalogue services, namely survey data sets in the SeaDataNet based CDI Data Discovery & Access service and the composite DTMs in the Sextant CPRD Catalogue service. Once populated in these Catalogues, the data providers are requested to pre-process and grid the new data sets using the GLOBE software and following the EMODnet standards. These data sets, at least at a resolution of 1/32 arc minute grid, should be transferred by data providers to Regional Coordinators.

The generation of Regional DTMs is divided over regional sea basin subgroups, each with a Regional Coordinator and a number of contributing data providers. Each Regional Coordinator will be responsible for a quality assessment and selection of the data contributions and the compilation of the Regional DTM using the GLOBE software. This process will start end February 2022 when all data providers have finalized their data gathering and population activities for the CDI and CPRD catalogues and will have undertaken pre-processing and gridding of their data sets for delivery as DTMs to the regional coordinators. In a later stage, the data providers also have to gather HR-DTMs which they have to enter in the Sextant HR-DTM Catalogue service.

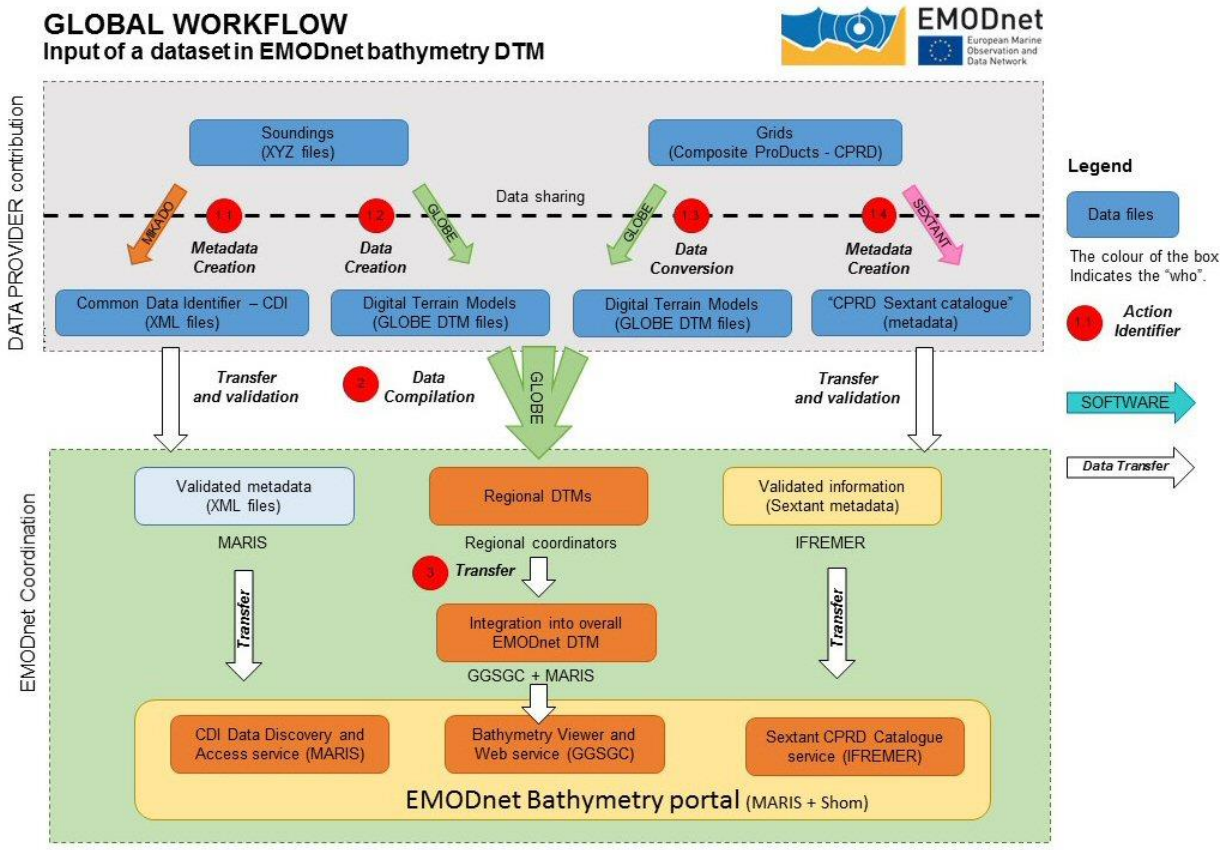


Image: Flow chart of EMODnet Bathymetry approach

2. MIKADO software for population of SeaDataNet directories

MIKADO is used to generate XML descriptions for a number of the SeaDataNet directories. This is done using SDN common vocabularies for metadata exchange of:

- CSR - Cruise Summary Reports
- EDMED - Marine Environmental Data sets
- CDI - Common Data Index
- EDMERP - Marine Environmental Research Projects
- EDIOS – Permanent Ocean-observing System

MIKADO is written in Java Language (Version >= 1.8) and is available under multiple environments: Windows, Unix – Solaris, Linux. Users can use either interactive or batch modes. The SeaDataNet common vocabularies web services are used to update lists of values but Mikado works offline once the lists are up-to-date. MIKADO can be downloaded from the SeaDataNet portal.
EMODnet Bathymetry populates new bathymetric survey data sets as CDI entries. Thereby, data providers are asked to provide additional background when available. This might be done by including references to CSR, EDMERP, and EDMED, which then possibly also have to be populated, if not yet available in the pull-downlists of MIKADO.

2.1 Recent MIKADO developments

Many developments in MIKADO have been undertaken since the last Training Workshop in Brest – France as part of the previous EMODnet HRSM 2 project at the kick-off meeting in 2019.

Version 3.6.1 (May 2020)

- Updates
  - CDI ISO 19139 schema/schematron updated to v12.2.0
  - CSR ISO 19139 schema/schematron updated to v5.2.0
  - New URL for EDMO-EDMERP codelists in CDI and CSR XML files: https://edmo.seadatanet.org/isocodelists/edmo-edmerp-codelists.xml
  - New URL for EDMO SOAP webservice: https://edmo.seadatanet.org/ws/ws_edmo.asmx
  - New URL for EDMERP SOAP webservice: https://edmerp.seadatanet.org/ws_edmerp/edmerp.asmx
  - Protocol change from http to https for BSH webservices
- Bug fixed
  - With protocol changes from http to https for BODC webservices, SeaDataNet schemas, URN resolver in version 3.6 EDMED/EDMERP/EDIOS fails for creation in Mikado.

Version 3.6.2(May 2020)

- Bug fixed
  - Mikado automatic : var03 Horizontal datum - default value fixed to 'UNKCRS' for new CDI from NEMO export

Version 3.6.3 (October 2020)

- Bug fixed
  - Mikado CSR download working again with new BSH web service
  - Mikado automatic continue-when-error=true : WARNING message added in log for validation errors by xsd
  - Some unexpected P06 vocabularies references removed from xml (only L26 used now)
- Updates
  - Coupling table for Download Manager menu renamed to Coupling table for Replication Manager
- Add-ons
  - INFO or WARNING messages added in log for Mikado and xsd versions
- Bug to be fixed in V3.6.4 (April 2021)
  - Download EDMED XML entry (manual mode) due to migration to HTTPS of the URL of EDMED WSDL webservice

Version 3.6.4 (June 2021)

- Updates
  - Manual/Download/EDMED from BODC is now in https
  - for CDI : L08 Access Restrictions are reduced to shorter list
    - CB Creative Commons Attribution 4.0 International
    - RS by negotiation
    - Mikado performs conversion in manual mode when you just open the file and save it again
    - Mikado performs conversion in automatic mode with old configurations for compatibility

    - The CSR reference list is completed with https://csr.seadatanet.org/isoCodelists/csrCodeList.xml for cruises not found in https://seadata.bsh.de/isoCodelists/sdnCodelists/csrCodeList.xml
- Add-ons
  - Automatic/New/CDI from NEMO export : a Relocate Nemo Export button added in Connection tab to change Nemo Export location in automatic configuration file (to use if you moved the Nemo Export)

  - Automatic/CDI/batch mode : nemo-export= added as an alternative to conf-file= to directly generate CDI from Nemo export

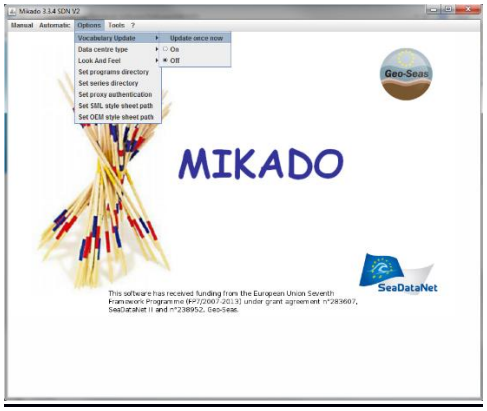
Version 3.7(January 2022)

- Add-ons
  - CDI ISO 19139 format updated to v13.0.0 for ENVRI-FAIR :
    - Addition of L22 sensor model (var49) – optional
    - Mapping L22/L05 when only L22 information is provided
- Updates
  - Coupling table for Replication Manager: selection in L24 vocabulary list for modus 1 and 3

2.2 Recommendations

A few recommendations can be made to partners to optimize the use of MIKADO:

Recommendation 1: Vocabularies updates

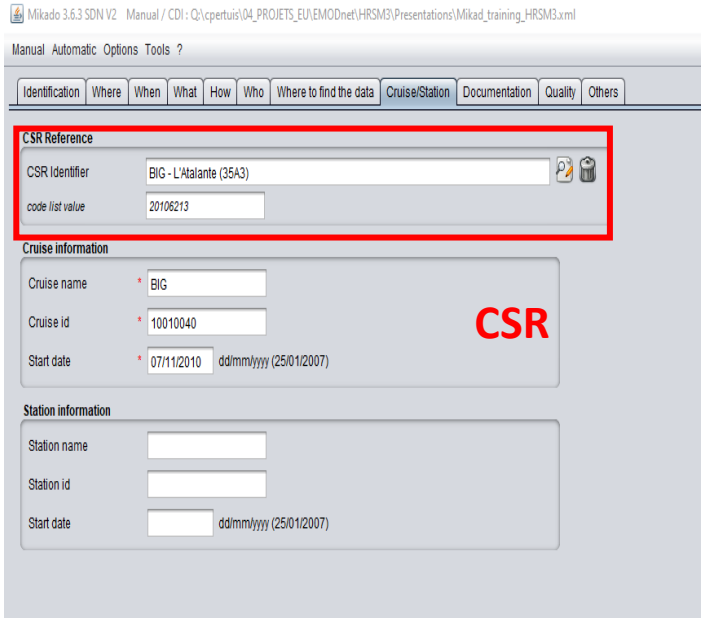


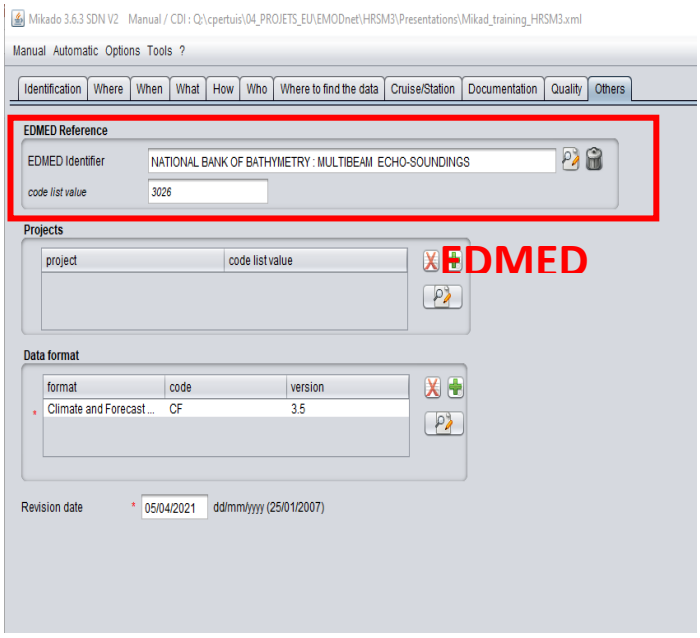
Automatic check of the version of the vocabulary lists is possible when MIKADO starts:
If “On” is clicked in the Vocabulary Update Menu, then MIKADO downloads locally the latest version of each list
It is possible to enable-disable the automatic check if “Off” is clicked
Manual check is also possible using the button “Update once now”

Recommendation 2: include CSR and EDMED links in the CDIs

Including references to CSR, EDMED, and EDMERP can be useful for enriching the CDI metadata, which makes the metadata more FAIR for users.

Each CDI can refer to a CSR Ref + EDMED Ref:





In a comparable way, also EDMERP references can be added to CDI.
- Mikado manual: dropdown lists via webservices
- Mikado automatic: var80 (EDMED), var81 (CSR), var13 (EDMERP)

Recommendation 3: Include EMODNet Bathymetry Quality Indicators in the CDIs

Quality Indicators have been implemented in the CDI format in 2017 and are used to qualify each source datasets used in the final DTM. These values are later used to generate the overall Quality Index for each new EMODnet DTM release. Therefore, it is mandatory that each CDI and CPRD entry contains these Bathymetry Quality Indicators.

Quality indicators are not part of any SDN lists and have to be written between quote marks, using either manual or automatic modes.

The quality indicators have been described in the document '**Completing metadata elements for the generation of the Quality Index for the EMODnet DTM.pdf'** which can be found at the EMODnet Bathymetry portal as technical documentation:

https://www.emodnet-bathymetry.eu › approach › technical-documentation

4 QIs have been defined to assess the quality of the datasets:

- QI_Horizontal: related to the positioning system
- QI_Vertical: related to the MBES instrument
- QI_purpose: related to the survey objective
- QI_Age: related to the survey dates

In Manual mode go in the Quality tab and add 4 entries :

- Name: QI_Horizontal (free text)
- Date: date of publication of the CDI
- Comment: write down the index of the corresponding QI (free text)

- Status: true

QI_Age: fill the start and end date in the When tab

In Automatic mode: from var95 to var98. QI_Age: Under the single subqueries folder, define your SQL queries under var28 and var29 to describe the start and end date of your dataset.

3. Sextant for CDTM population

The resulting EMODnet DTM is compiled from survey data sets as referenced in the CDI service, composite DTMs as referenced in the Sextant CPRD Catalogue service, and GEBCO Digital Bathymetry to fill gaps.

The CDI and CPRD catalogues are based upon SeaDataNet standards, using where possible SeaDataNet controlled vocabularies and SeaDataNet Directories for completing the metadata and for giving many details about the data sets, such as their acquisition details, access restrictions, originators and distributors and other.

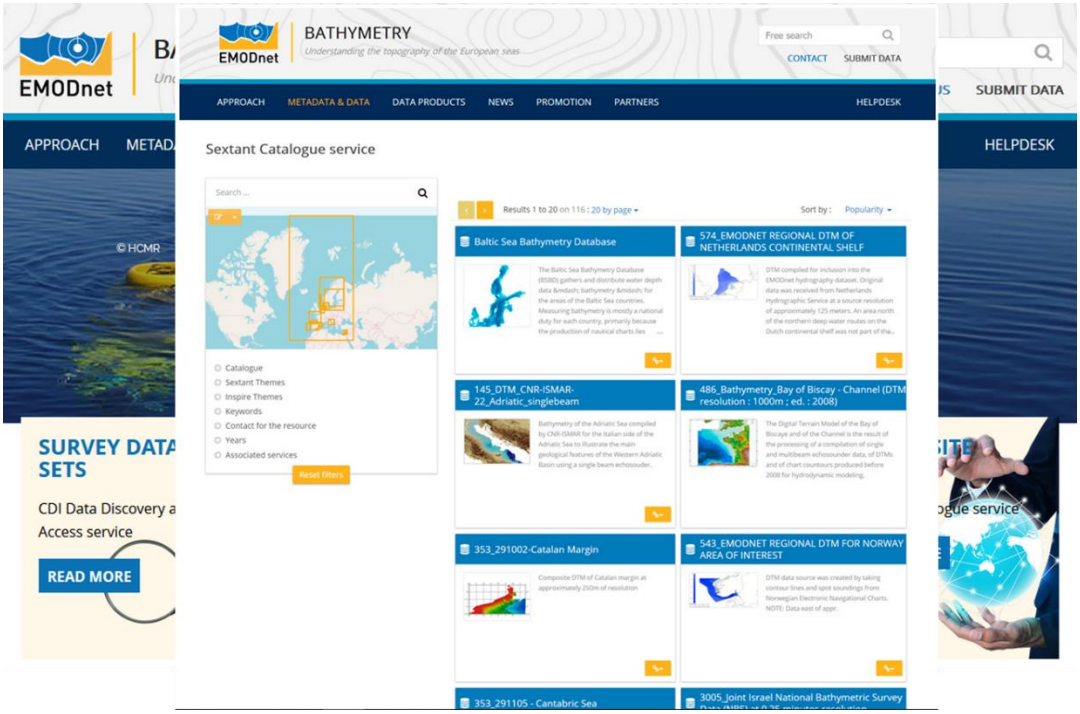
The Sextant Catalogue, portal, and data infrastructure have been developed by Ifremer for the management and the distribution of spatial data, and have been adopted for EMODnet Bathymetry for describing composite DTMs and HR-DTMs from the EMODnet Bathymetry datas providers. Moreover, the resulting EMODnet DTM products are included in Sextant together with DOIs.

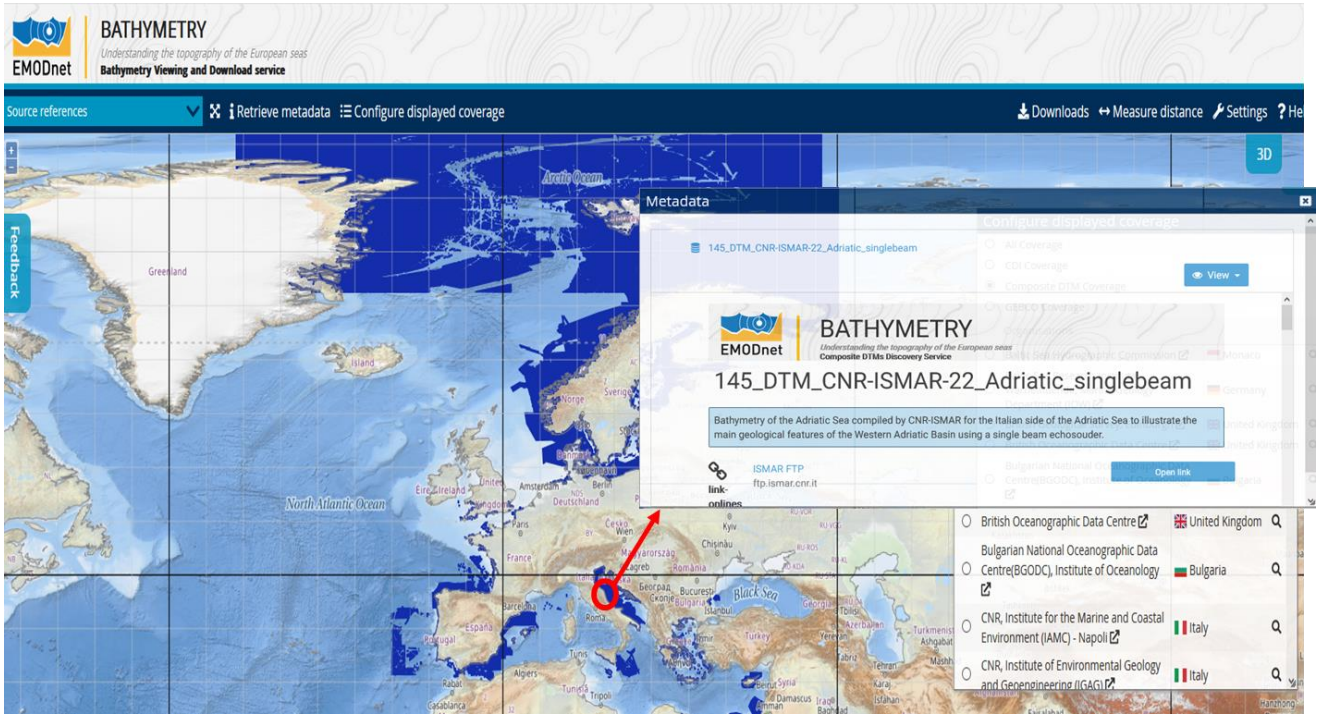
Sextant is implemented using Geonetwork to set-up the Catalogue Service for the Web and the Open Geospatial Consortium (OGC) and ISO TC211 standards.

This way, Sextant provides an index and descriptions of the **composite products (CPRD)** delivered by partners and associated providers of EMODnet Bathymetry who have opted to deliver bathymetric data as products of their own for the construction of the EMODnet DTM.

These products are in most of the cases DTMs constructed with a methodology different of the EMODnet methodology. They derive usually from multiple surveys but use occasionally other source of depth information such as isolines. They are not an observed data files, but a derived product. So they cannot be described in the SeaDataNet CDI catalogue.

The user interface of Sextant is now implemented in the EMODnet Bathymetry portal as an API (Application Programming Interface) that offers a better integration in the website. Log in function is available through Sextant API on EMODnet website:http://www.emodnet-bathymetry.eu/metadata-amp-data/composite-dtms-catalogue-service#/search?from=1&to=20





3.1 Detailed guidelines for Managing spatial data using Sextant

Data providers of composite DTMs are requested to enter the CPRD metadata entries online, using a Content Management System. Before creating new metadata, data providers are advised to read the EMODnet HRSM specifications documents which contain instructions for filling some of the metadata:"

- Methodology and guidelines for processing orginal input data into DTMs
- Completing metadata elements for the generation of the Quality Index for the EMODnet DTM

Both documents can be found at:

https://www.emodnet-bathymetry.eu › approach › technical-documentation

Registration

To register to the Sextant CMS, each partner needs an external account. If you don't have any, then contact the Sextant team: sextant@ifremer.fr.

Vocabulary

Common vocabulary lists and organization identification:

Lists implemented in the EMODnet template use the SeaDataNet Common Vocabularies as can be found at: https://vocab.seadatanet.org/search

Organizations are identified using the European Directory of Marine Organizations (EDMO) maintained by SeaDataNet. Organization name and identifier can be queried on the SDN portal at: https://www.seadatanet.org/Metadata/EDMO-Organisations

File dentifier

The file identifier at the top of the metadata information of the form is generated automatically using a combination of metadata edited by the partner. The syntax (derived from SeaDataNet practices) is:

SDN_CPRD_EDMO-Id_ short-name-of-dataset

Note that the short name of dataset is the product identifier at the holding data centre and must be unique. It is a component of the file identifier of the CPRD catalogue. The unicity of the entry is guaranteed by an automatic combination with the EDMO id of the data provider.

It is requested to rename the DTM file corresponding to your metadata entry as **EDMO-Id_ short-name-of-dataset.dtm as** this will greatly help Regional Coordinators.

The EDMO_Id of the holding data center and the short name of dataset of the product used as source data for the EMODnet DTM are also recorded in the "Identifier" layer of the EMODnet DTM (see EMODnet hydrography specifications). This allows viewing services of the EMODnet bathymetry portal and of the 3D viewer of the Ifremer Globe software to generate the URL to access the metadata set of the CPRD catalogue.

Data set name

This is the title of the data set that will appear in the catalog

Abstract

Partners are strongly encouraged to complete carefully the ABSTRACT / SHORT SUMMARY with a valuable description of the (composite) DTM what).

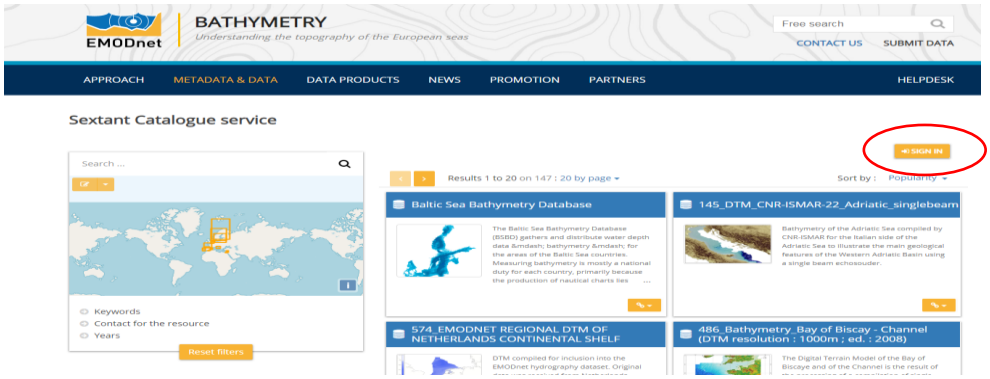
In case, the file is also associated to a CDI entry, please note it in the "description of processed data sources" field.

Other fields

Mandatory fields have been defined not only in function of the ISO and Inspire standards and Directive but also in function of the requirement of the projects. For example, someone may consider it useless to ask data providers to fill Min and Max depth field but it is a requirement to allow an automatic scaling of the colours when viewing the DTM. Other fields are not mandatory because it depends on the dataset but they are all strongly recommended to allow improved data processing by the end users.

3.1.1 Log in instructions

Log in function is available through Sextant API on EMODnet website:http://www.emodnet-bathymetry.eu/metadata-amp-data/composite-dtms-catalogue-service#/search?from=1&to=20
And sign in with your sextant credentials:



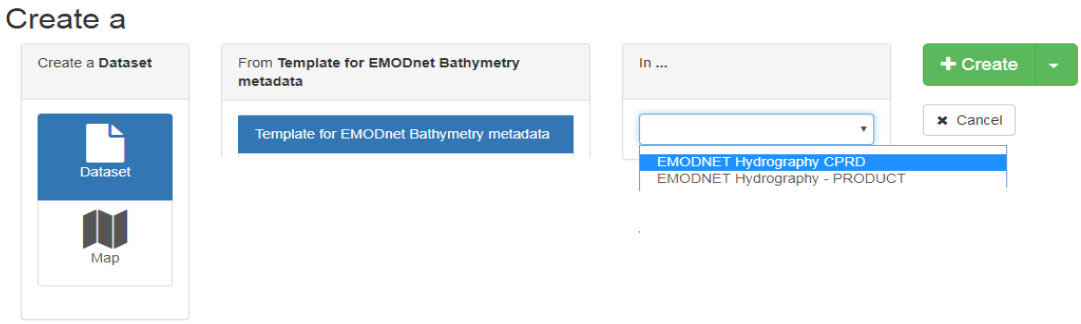
The “Administration” functionality appears.

3.1.2 Detailed instructions

To create a new metadata description, a dedicated metadata template has been designed for the purpose of EMODnet projects.

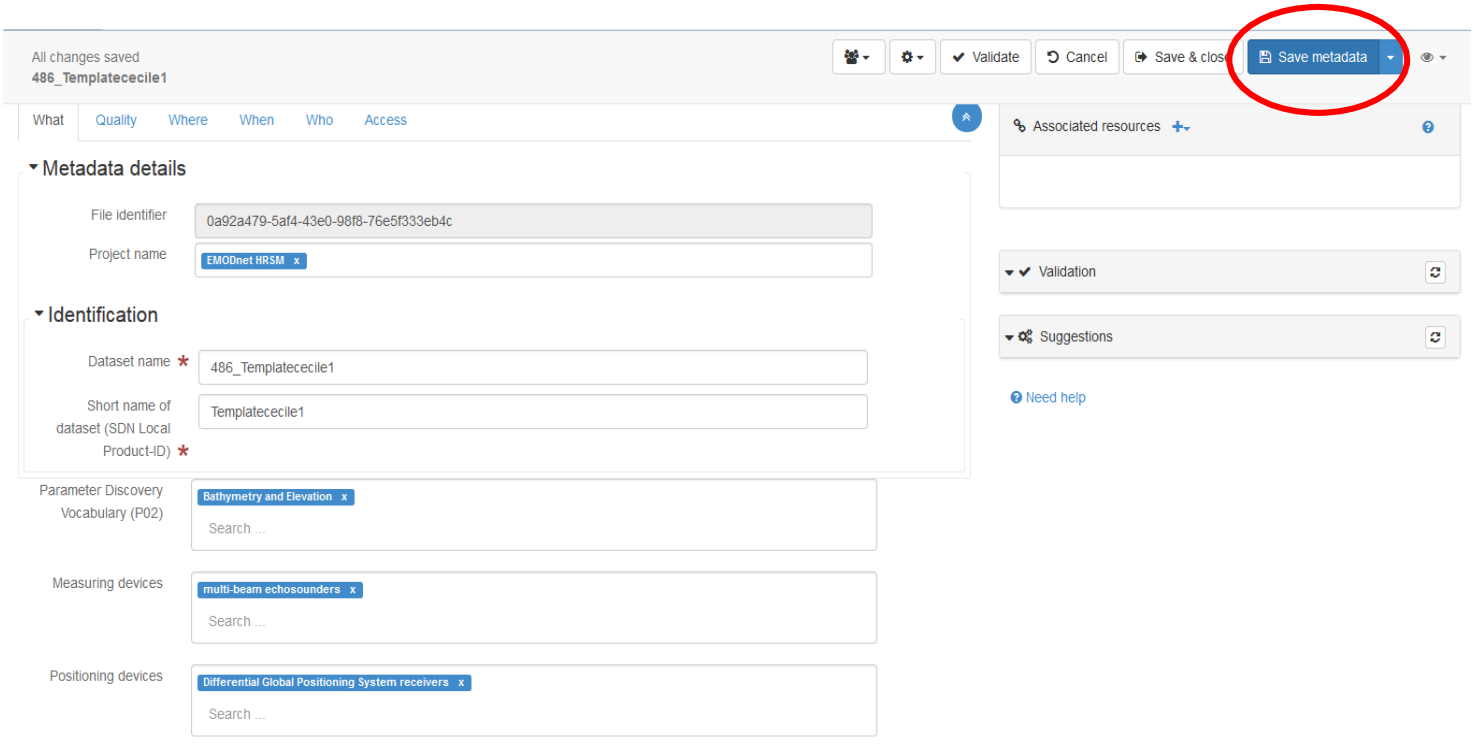
Select "New metadata" in the menu “Administration” (see 4.2.) A window appears:

- As Template, select "Template for EMODnet Bathymetry metadata"
- As "In", select the appropriate catalogue "EMODnet hydrography - **CPRD**" catalogue
- And then "Create".



SEXTANT disconnects you automatically if you are inactive. Save regularly what you have edited (every15 mns). Most of the fields are pre-filled or user friendly and don't need specific explanation. Attention will be paid to specific or text fields. Explanations are given by thematic tabs.

3.1.3 What



It is **strongly recommended** to start filling the "Dataset name" and "Short name of dataset" to avoid Sextant to save your entry under a default name. Use the "Save metadata" button and continue.

File identifier: is generated automatically using a combination of metadata edited by the partner. The syntax is: "SDN_CPRD_EDMO-Id_local-product-Id"

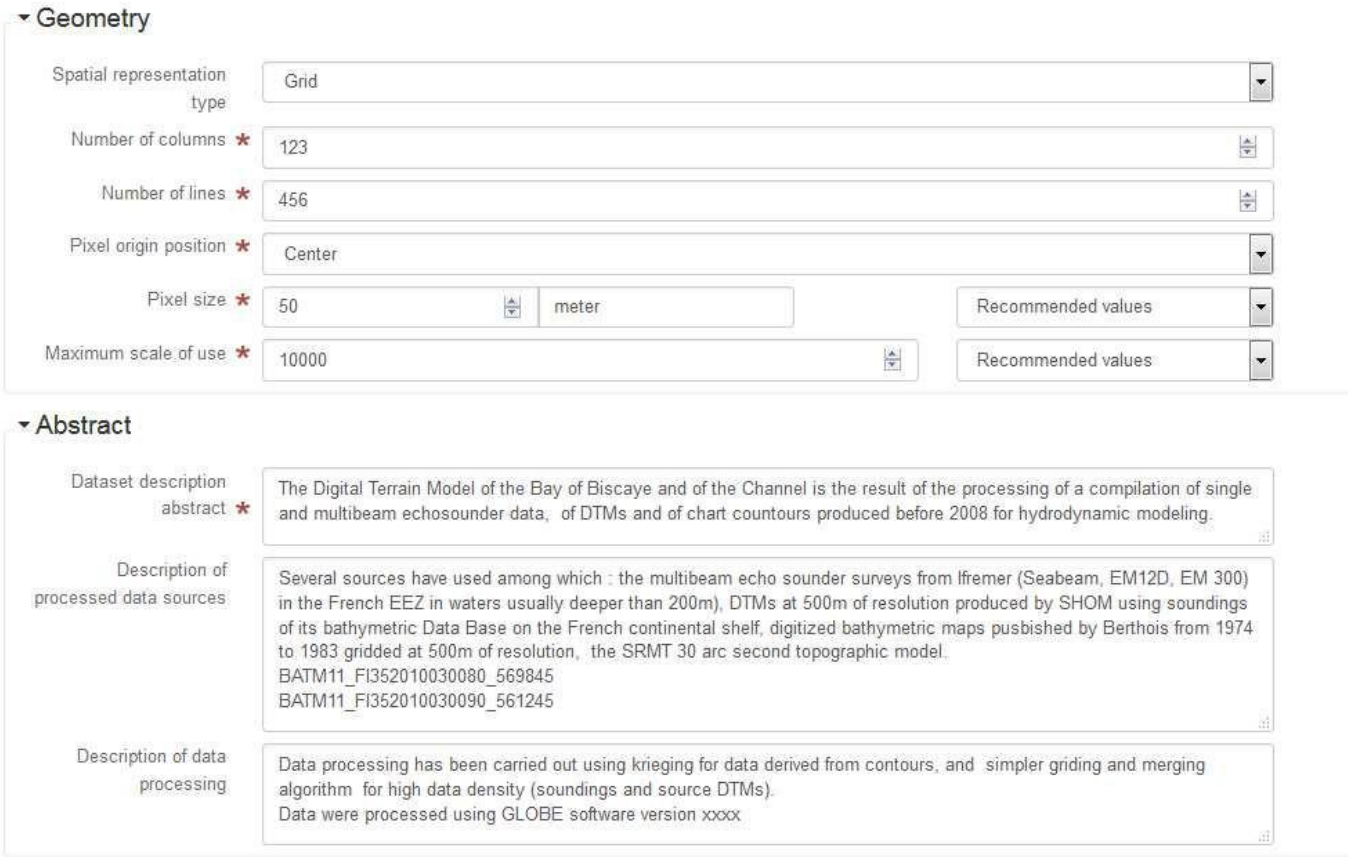
Project name: Choose EMODnet HRSM3. This field corresponds to the EDMERP SDN list.

Dataset name: title of the data set that will appear in the catalog.

Short name of dataset (SDN Local Product-ID): Local identifier of the bathymetric grid

(according to local rules of Data Center). **This is a component of the file identifier.** The local identifier must not be longer than 75 characters (this constraint comes from the length of the string used to keep track of the source of data in the DTM NetCDF format.

Parameter Discovery/Measure devices/Positioning devices: metadata are given by default but you can also delete them and/or add others by clicking on "Search" (auto completion search). Use of L05 and P02 lists.



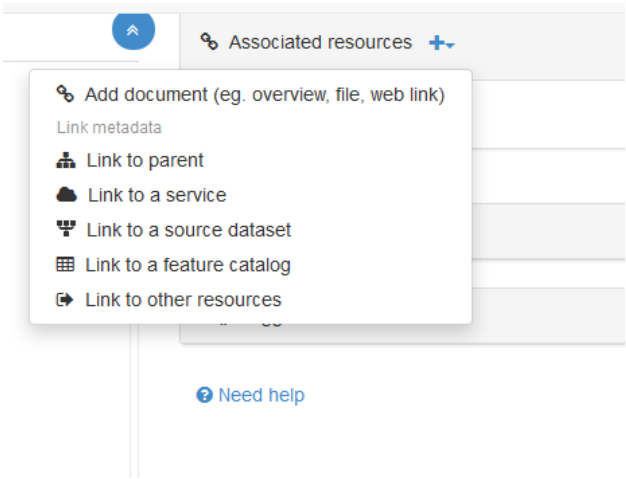
Geometry: fill in the information, and use lists or "Recommended" values when proposed.

Dataset description abstract: write down a summary about the dataset (cruise/purpose/context description, specific characteristics, valuable details…)

Description of processed data sources: indicate the data sources and write down the corresponding CDIs when they exist.

Description of data processing: any valuable detail about the processing software or processing methodology.

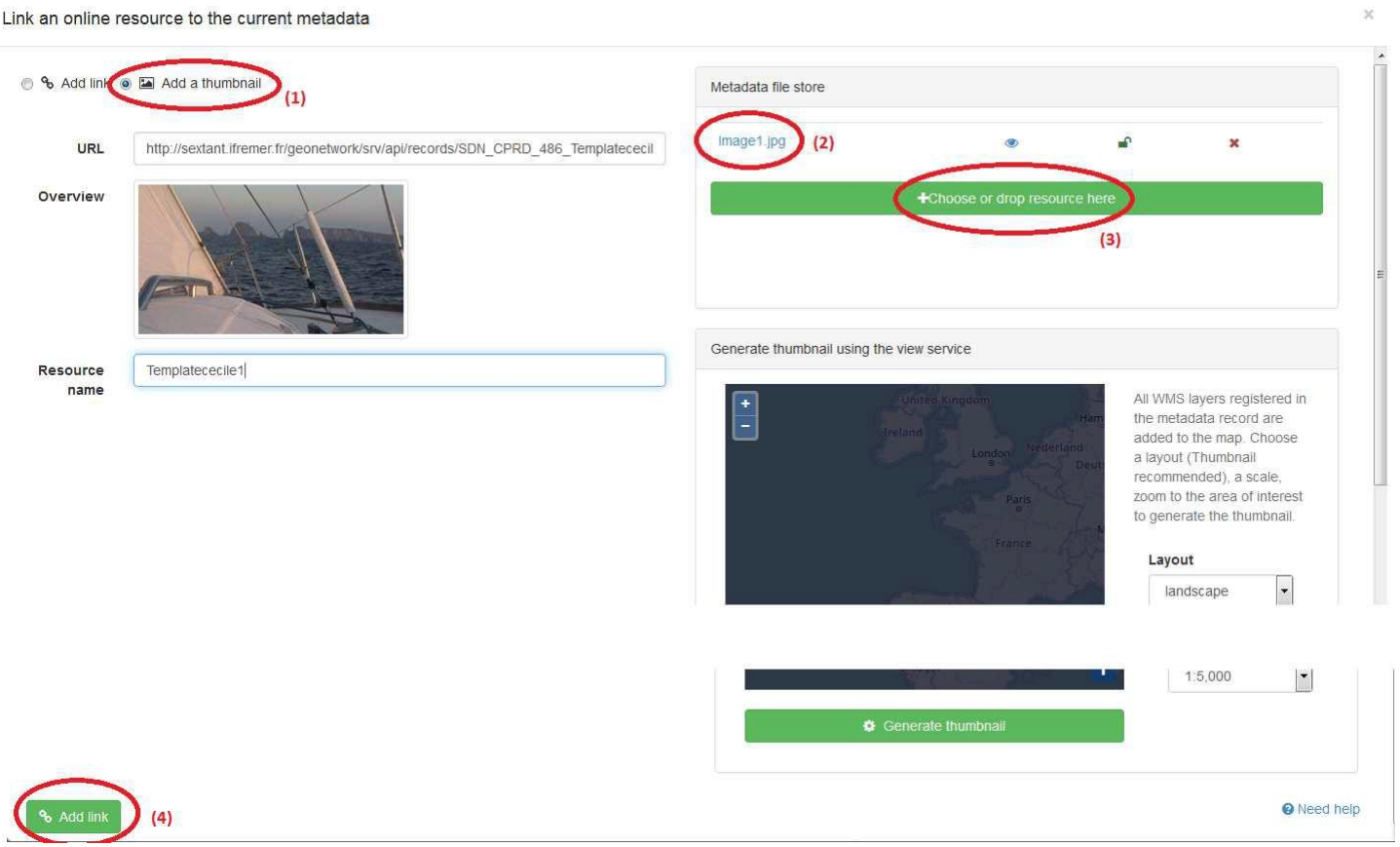
3.1.4 Associated resources (tab "What" upper right corner) – thumbnail and online resources



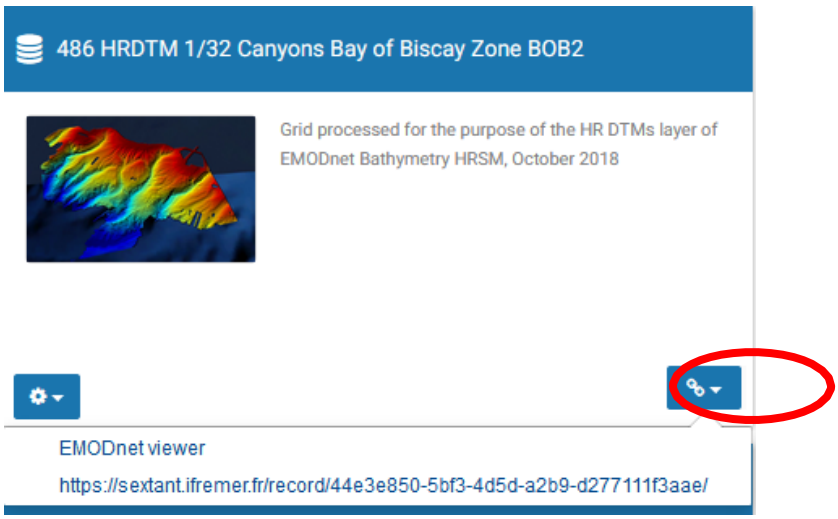
It is recommended to attach a thumbnail to illustrate your composite product in the catalogue. Click on the add button of the "**Associated resources**" field and seclect "**Add document**".

Click on "Add a thumbnail" (1), select the thumbnail with the "Choose or drop reource here" tool (2) and click on your thumbnail in the "metadata file store" to update the

URL. Click at the very bottom of the page to "add the link" (4).

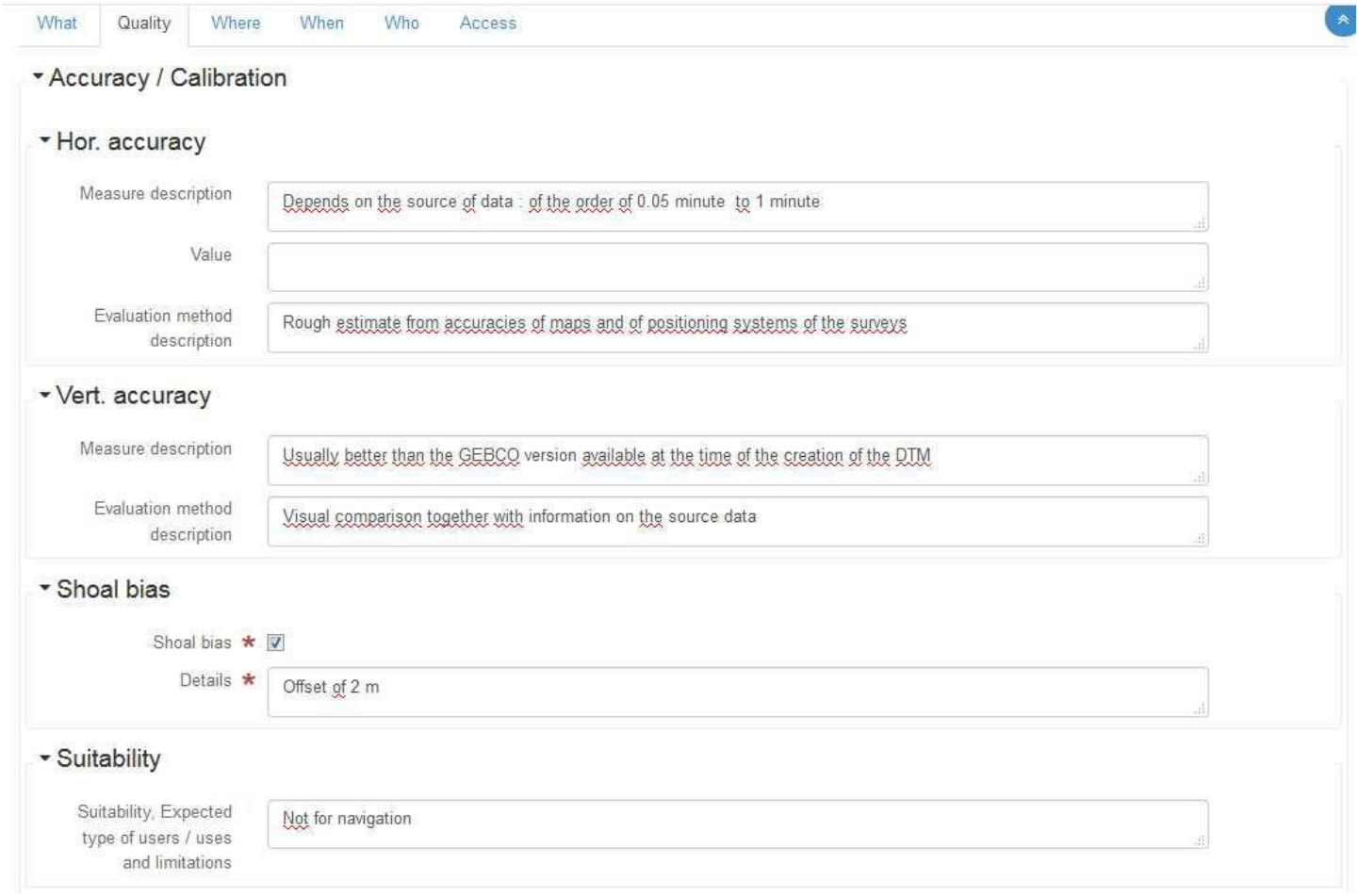


You can also add different kind of links, like a URL to a web site or to web services (WMS, WFS…). Click on the add button of the "**Associated resources**" field and select "**Add link**" and select the appropriate information in the Function and Protocol lists. Fill in others details and click on "Add link".



These links will be attached to your metadata description in the catalogue:

3.1.5 Quality



Horizontal accuracy:

Measure description: give any information about the horizontal accuracy of the acquisition system, the positioning system as well as the sounding method.
Value: In case you wish to give a digital estimator of the horizontal accuracy.

Evaluation method description: Reference to standard which have been used to qualify the horizontal accuracy (hydrographic standards, industrial specification…)

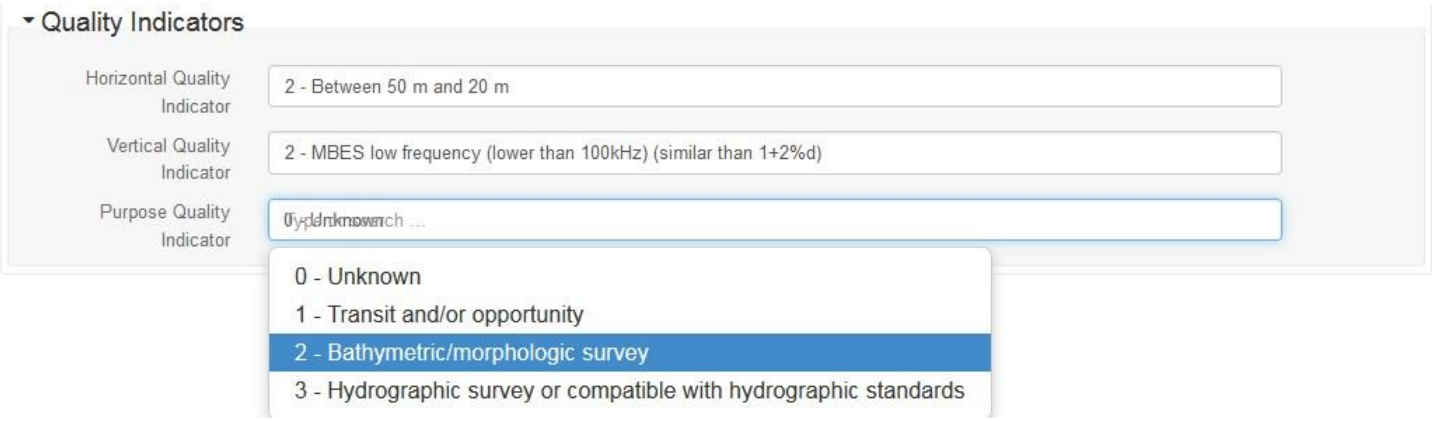
Vertical accuracy:

Meaure description: any information about the vertical accuracy of the depth in the file

Evaluation method description: Reference to standard which have been used to qualify the horizontal accuracy (hydrographic standards, industrial specification…)

Shoal bias: tick this field only in case of existing bias and precise details in text field below.

Suitability: precise the type of use that can be made of the datasets (example: not suitable for navigation)



Quality Indicators have been implemented in the EMODnet HRSM project to use further qualitative information (in CPRD and CDI) related to the data source such as type of sensor. For the CPRD case, the data producer has to consider giving each of the quality indicator based on the contribution with the lowest quality. Click on "search" to make appear the appropriate list.

The following document describes the Quality Index proposed in the framework of the HRSM project:

- Completing metadata elements for the generation of the Quality Index for the EMODnet DTM

Which you can find at:

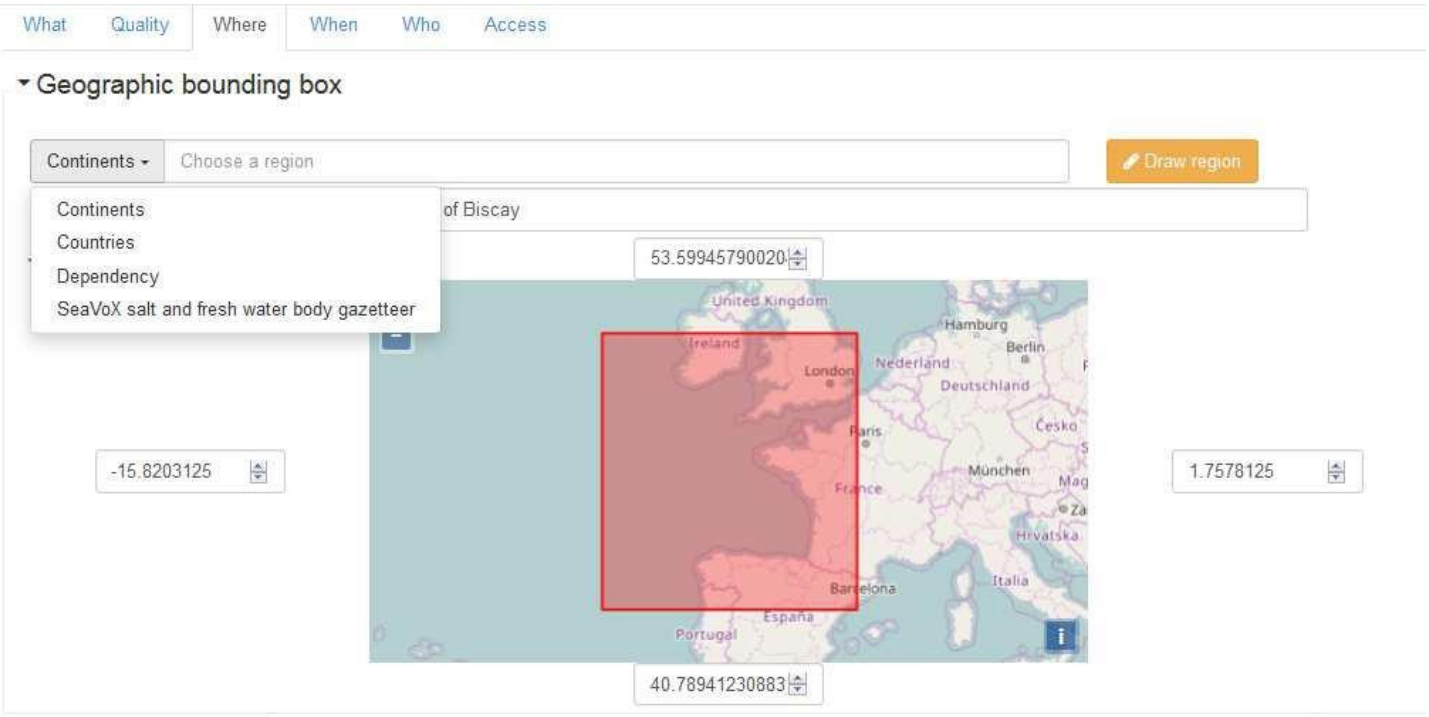
https://www.emodnet-bathymetry.eu › approach › technical-documentation

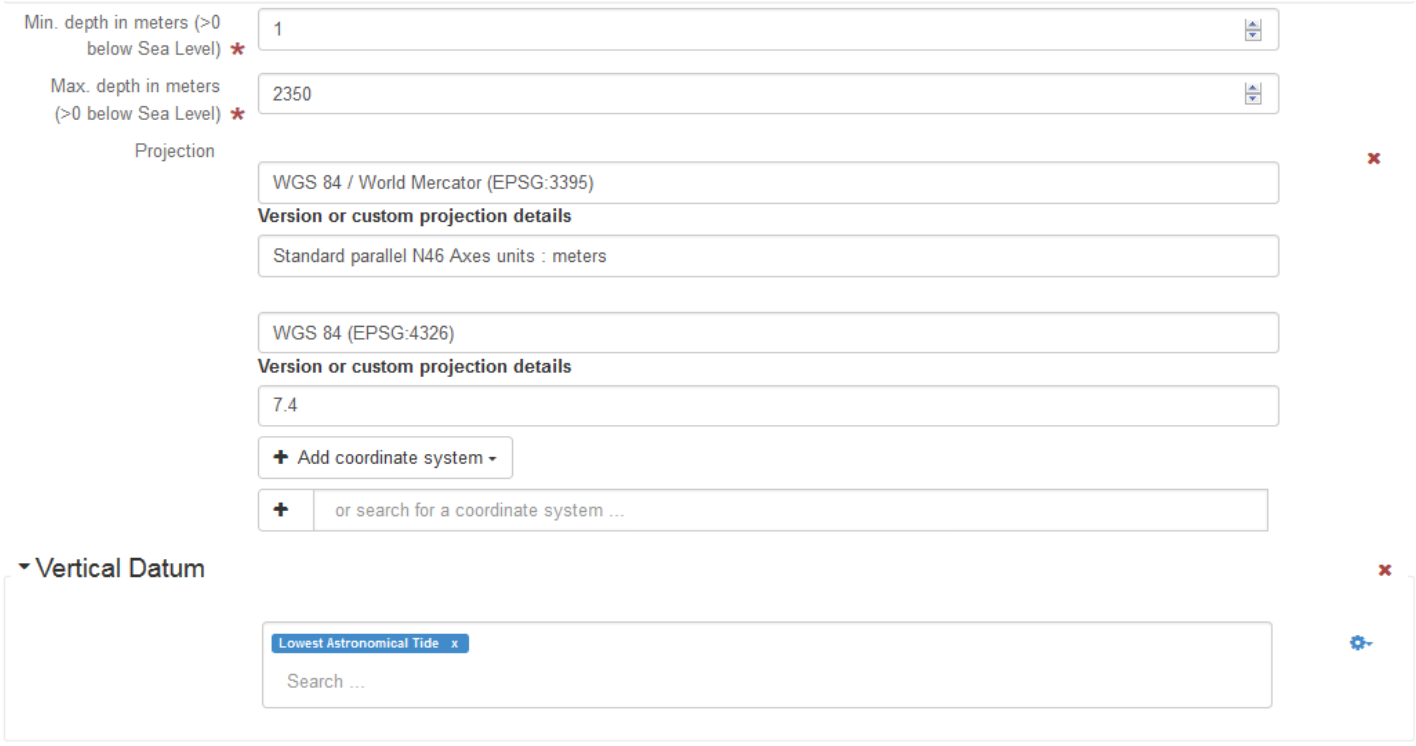
It will help you to verify your entries.

3.1.5 Where

The **Geographic Bounding Box** can be created in 3 different ways:

- By drawing your own area: click on "Draw region", select the area and the coordinates will automatically be updated
- By entering the coordinates (decimal degrees) manually in the appropriate fields
- By selecting an area in the international SeaVox list





Fill in the information, and use lists values when proposed.

Projection: fill in the geodetic system and the projection of the catalogued product. Some of them are listed in the "Add coordinate system" list.

You can input additional details in the "Version or custom projection details.

As example:

for a latitude/longitude file :

Write "WGS84" in the "Projection" field. for a UTM

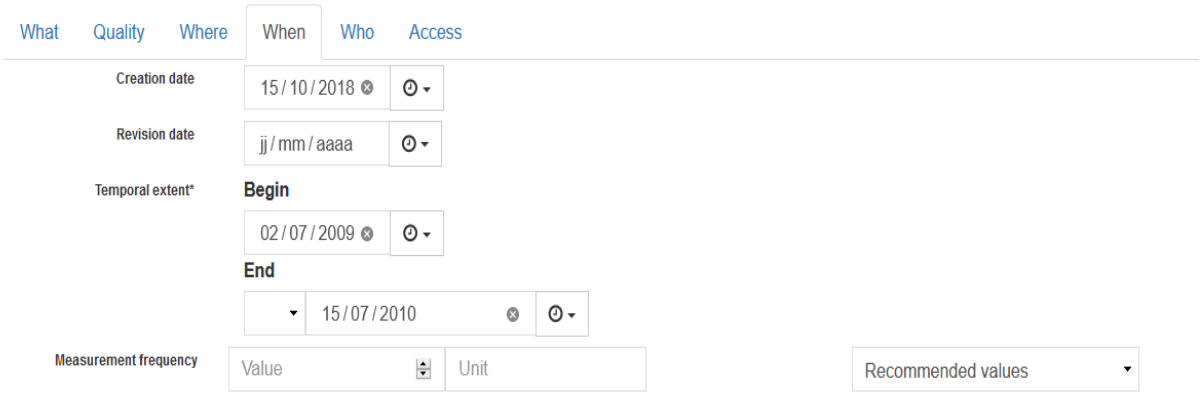
Zone 33 file

Write "WGS84 / UTM" in the "Projection" field

Then write "Zone 33" in the "Custom projection details.

Vertical Datum uses L11 SDN list.

3.1.6 When



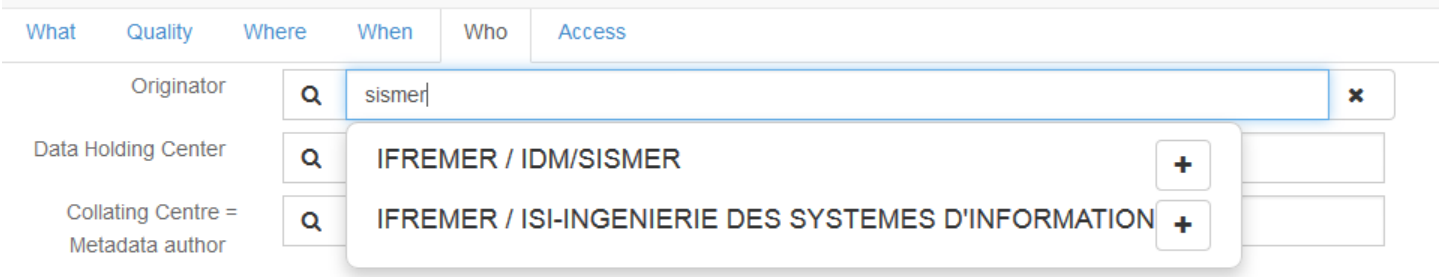
Fill in the date information using the calendar. To go throw years, click first once or twice on 2017.

Creation date is the date of production of the composite product.

Temporal extent covers the period of datasets used in the composite product

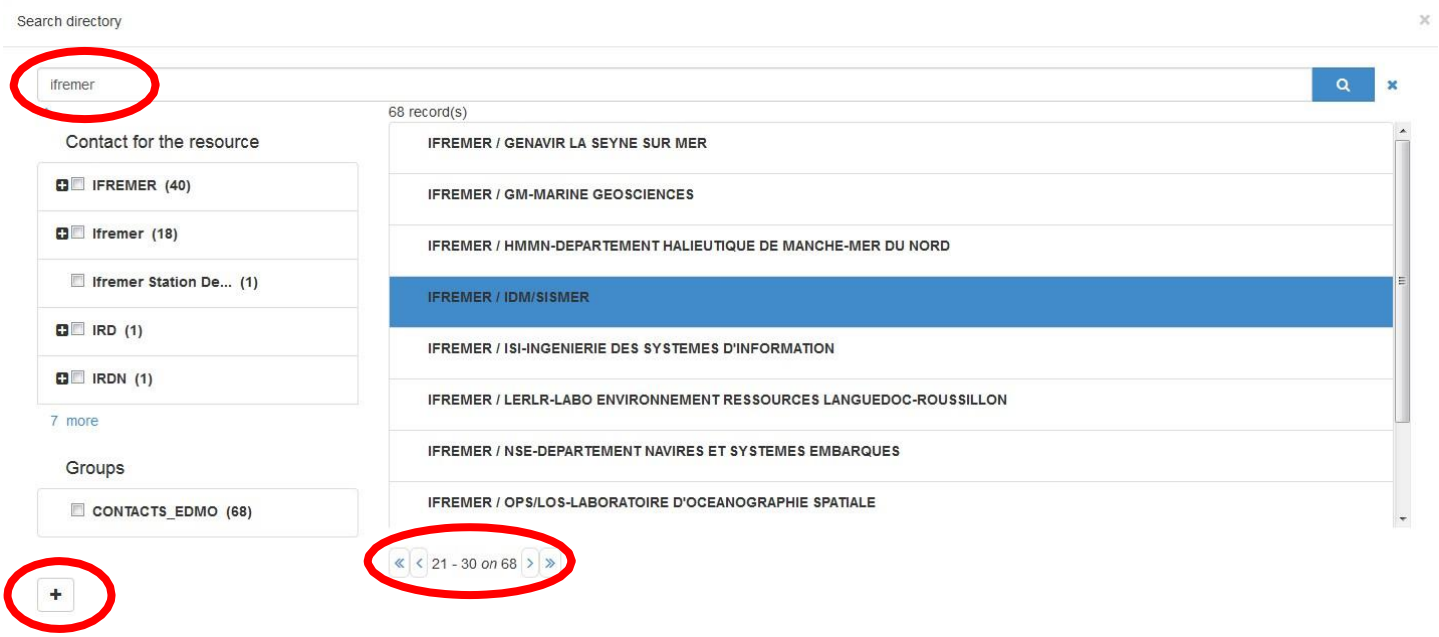
Measurement frequency can be used in case of periodic acquisition of datasets. Optional field.

3.1.7 Who



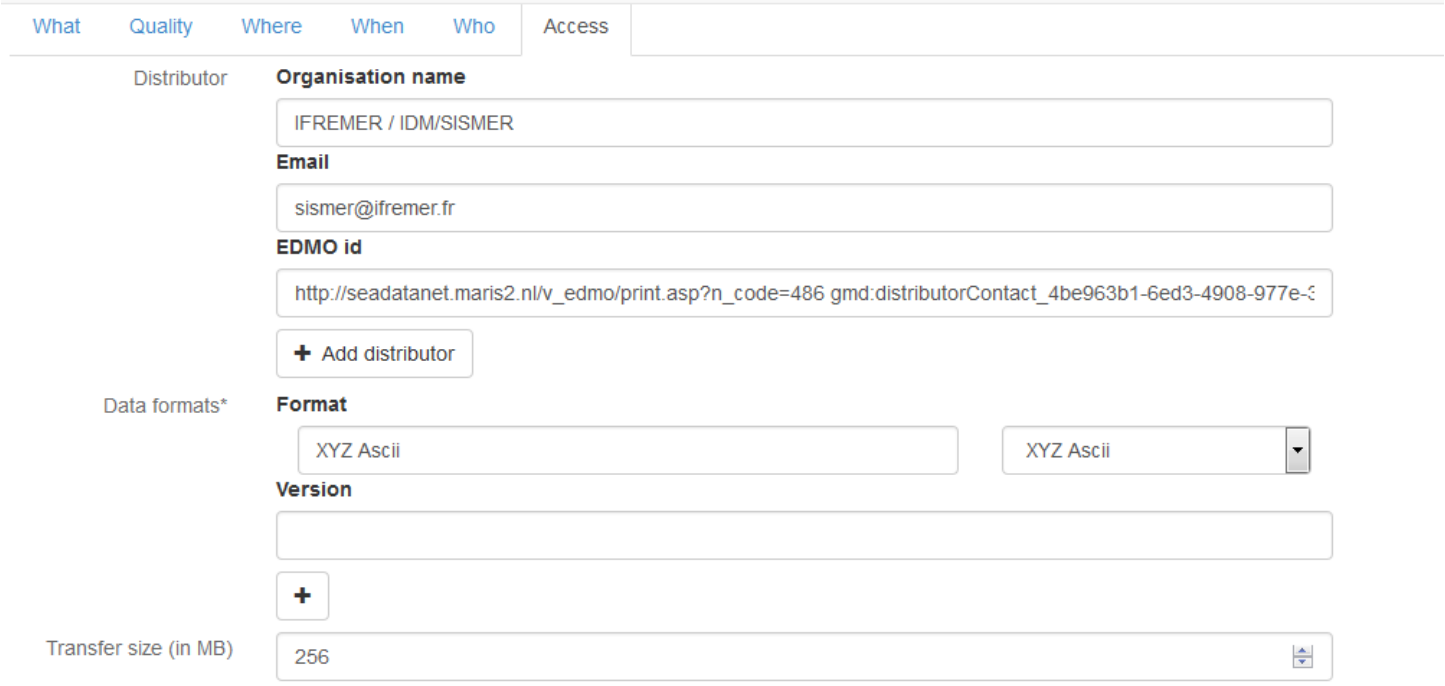
The **Originator**, **Data Holding Center** and **Collating Center** contacts are filtered on the EDMO_id list. **The data holding center contact is a component of the file identifier.**

Enter the name of your institute or department and corresponding entries will appear (then click on the corresponding “+” button). If not, click on the binocular, and write in “search for a contact” field or use the proposed filters on the left of the screen (check number of pages). Once you have found the correct entry, click on the “+” button at the bottom left corner.



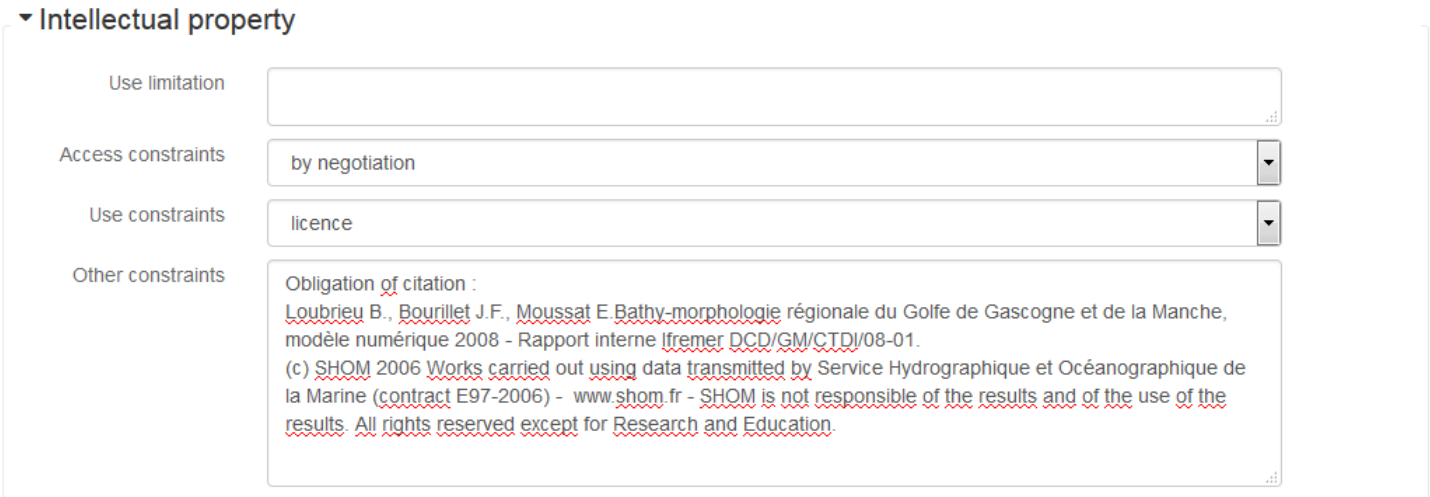
Once you selected the correct contact, Organisation name, Email and EDMO id are automatically filled in.

3.1.8 Access



Click on “Add distributor” to enter the **Distributor** contact details (also filtered on EDMO id). And fill in the other information using “Recommended values” when possible.

Version and **Transfer size** are optional.



Use limitation: free text field that can be used to detail intellectual property rights when no appropriate values are found in the **Use constraints** list – but is optional.

Access constraints: uses list SDN L08. Gives information about how to get access to the DTM.

Use constraints: gives information about the condition of use of the DTM.

Other constraints: complementary information about the use of the data. This is the appropriate field to enter the DOI of your dataset when existing or the obligation of citation

3.2 Save your metadata

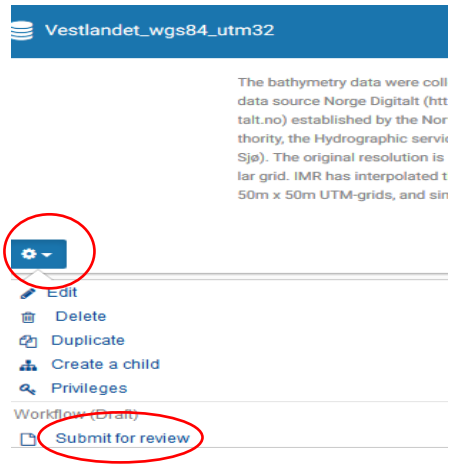
Your sextant template is now complete, you can "**save and close**" the template. You can check your new entry on the sextant API catalogue: http://www.emodnet-bathymetry.eu/metadata-amp-data/composite-dtms-catalogue-service?#/search?from=1&to=20

3.3 Submit your metadata for validation

A workflow status has been implemented to prevent any inconsistency with EMODnet rules when updating or creating a metadata. Each creation or update will has to be validated by a sextant administrator.

To submit your metadata:

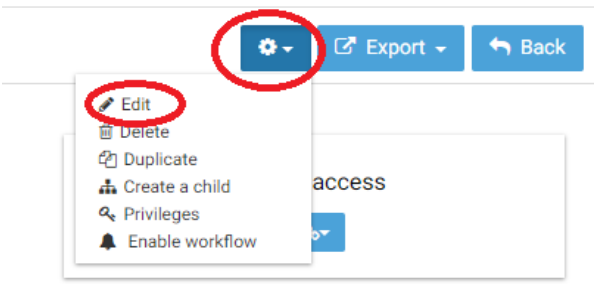
click on the Wheel tool>Submit for review



The sextant catalogue administrator will receive a notification by email and will validate and publish your sextant entry. **These short steps have to be done for each new entry and each updated entry.**

3.4 Guidelines for updating an existing CPRD entry

If you need to update any of your description, select your sextant entry on the sextant API catalogue: http://www.emodnet-bathymetry.eu/metadata-amp-data/composite-dtms-catalogue-service?#/search?from=1&to=20
and click on the wheel tool on the upper right hand corner and select edit.



Once updated, do not forget to submit again your entry through the sextant workflow.

3.5 Sextant helpdesk

If any problem when using Sextant, you can contact the Sextant team sextant@ifremer.fr .

Your question will be routed toward the appropriate person.

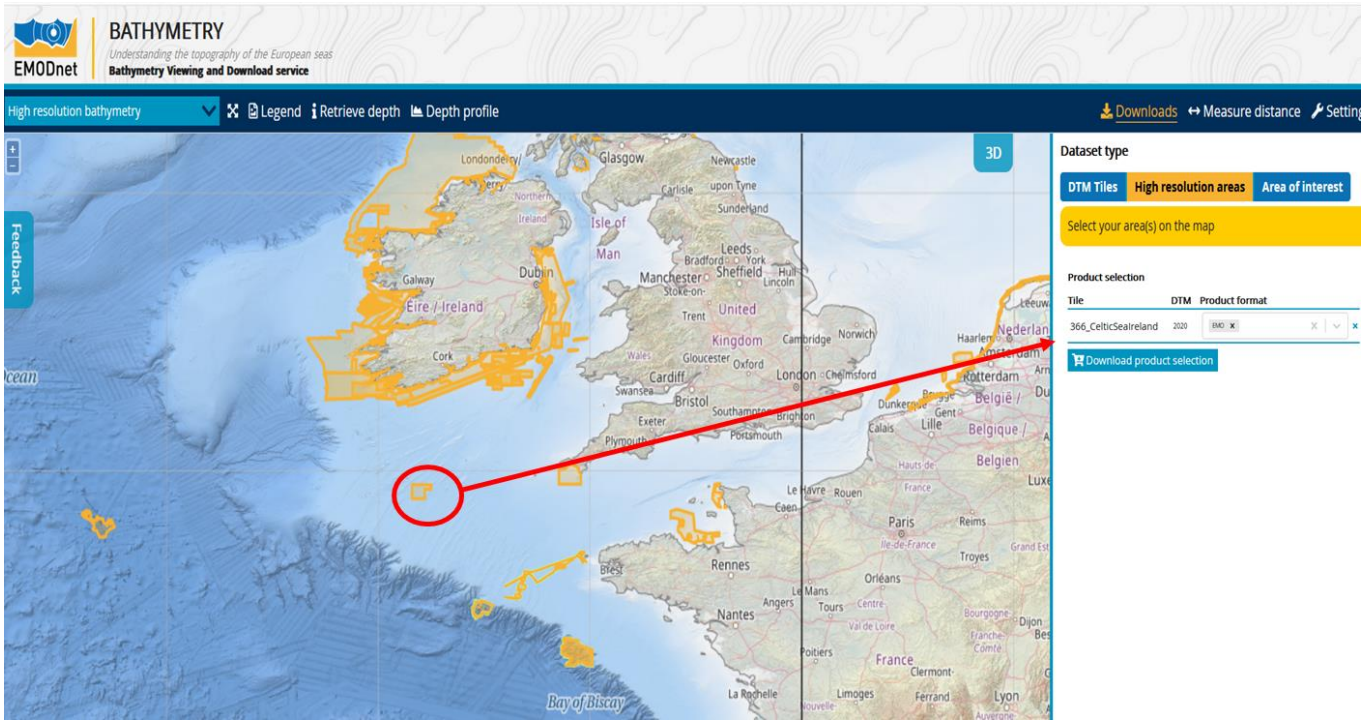
4. Sextant for HR-DTM population

Besides the composites DTMs, partners are asked to produce High Resolution DTMs freely accessible through the bathymetry viewer available on the EMDOnet Bathymetry website. These HR-DTMs are of higher resolution than the composite DTMs, and are produced following the EMODnet processing rules.

The HR-DTMs are described in a dedicated sextant catalogue to facilitate their identification.

	CPRD (Historical EMODnet catalogue)	**PRODUCT (HR-DTMs) created for HRSM project**
Content	- Historical Composite DTMs in your institutions - New composite DTMs at a resolution of 1/16 arc minute	- Higher Resolution DTMs (1/32, 1/64 …) - initially on smaller area or specific area of interest for showcases
Methodology	- Compilation using Globe software - EMODnet bathymetry methodology - Historical DTMs might differ	- Compilation using Globe software - EMODnet bathymetry methodology
Use	- Integration in the regional DTM - To be sent to your regional co-ordinator	- Will be integrated in the HR layer of the bathymetry viewer - To be sent to Benoit Loubrieu,Cecile Pertuisot (Ifremer), George Spoelstra (GGSGC)
Visibility	Connected to Sextant API => visible from EMODnet website	Only visible through Bathymetry Viewer / HR layer
Access	No direct access to the DTMs for the end users DTMs are stored at each partners	Public downloading through the EMODnet viewer DTMs stored on a centralised cloud

Downloading is made direclty from the bathymetry viewer:

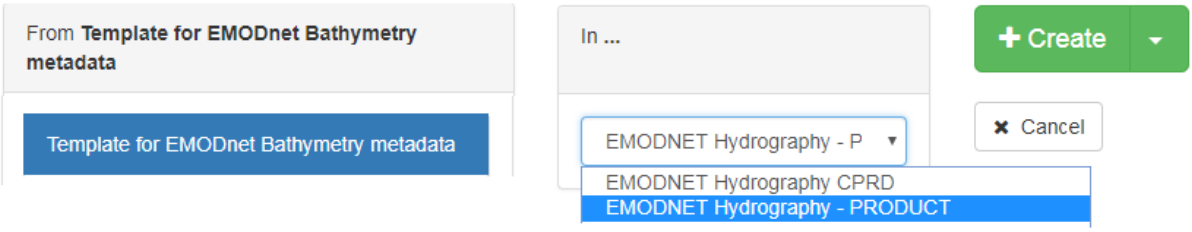


The guidelines to edit the HR-DTMs metadata description in Sextant are identical to the guidelines for the cDTMs metadata, the only difference stands in the selection of the dedicated catalogue when editing the EMODnet Bathymetry template:

To create a new metadata set, a dedicated metadata template has been designed for the purpose of EMODnet projects. To use it, follow the instructions below.

Select "New metadata" in the menu “Administration”. A window appears:

- As Template, select "Template for EMODnet Bathymetry metadata"
- As "In", select the appropriate catalogue "EMODnet hydrography - **PRODUCT**" catalogue



5. Globe for pre-processing and gridding of bathymetry data sets

For the project, Ifremer provides the Globe software for the production (1) of single DTMs by data providers and (2) of merged DTMs by regional coordinators.

During the first year of the project, DTMs processing is focused on the production of single DTMs, one per each dataset, by all data providers.
For supporting this action, a training workshop was given by Ifremer in September 2021: a first half day for a general presentation of the Globe software and the dedicated tools for HRSM project, and a second half day for an online training based on standard datasets and time of exchanges between data providers and Globe team

The training focused on the following main items :
- (1) reminding the methodology adopted by EMODnet Bathymetry for generating DTMs,
- (2) how to process sounding datasets described in the CDI infrastructure ? what are the appropriate Globe tools for that purpose ?
- (3) how to process composite DTMs described in the Sextant CPRD catalogue ? what are the appropriate Globe tools for that purpose ?
- (4) general presentation of helpful Globe tools for the project.

The slides below were the basis of the training workshop and provide to the data providers the guidelines for gridding of single bathymetry data sets.

EMODnet Bathymetry - HRSM, September 2021, Brest Globe training

HRSM, 2 types of data sources :

- **Flow 1 : Sounding data files** : CDI description + gridding in Globe
- **Flow 2 : CPRD files** : Sextant description + import and reproject in Globe

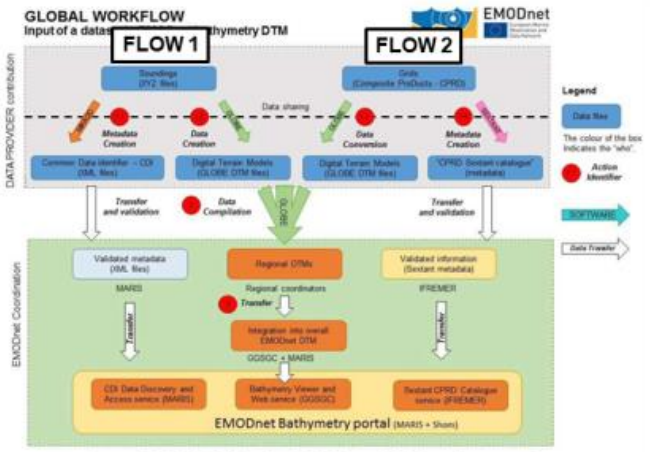


Image: DTM Workflow for EMODnet HRSM and new project

- **Flow 1 : Sounding files / Observed data**
  - Metadata are described in the CDI
  - A Multi layer grid is processed based on the sounding data
    - Latitude /Longitude coordinates, no projection
    - Grid spacing : 1/16, 1/32,… arc minute, according to the data resolution
    - For each pixel, layers :
      - Gridded bathymetry = mean depth of all soundings
      - Min and ax depths are recorderd
      - Satandard deviation
      - Number of soundings in the pixel
      - CDI Id, in order to link to the data sources metadata
    - Grids are reduced to 1/16 arc minute grid for integration on the regional DTMs

- **Flow 2 : Composite product CPRD / Pre-processed grid**
  - Metadata are described in the Sextant catalog « CPRD »
  - Original grids are converted into the EMODnet format :
    - Latitude /Longitude coordinates, no projection. (conversion required when the pre-processed grid is projected).
    - Grid spacing : 1/16, 1/32,… arc minute, according to the pre-processed grid resolution
    - For each pixel, only 2 layers :
      - Gridded bathymetry : interpolated from the original grid
      - CPRD Id, in order to link to the Sextant metadata

1 : Soundings files

file for training : CDI_extract_essnaut2009.csv

Flow 1 : Soundings files / Observed data

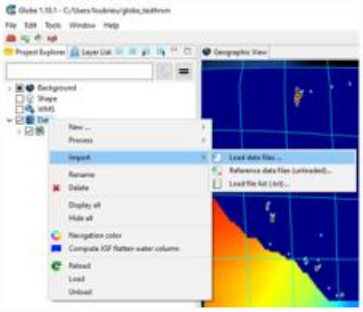
Input files = csv / ascii files of soundings

Latitude Longitude Depth

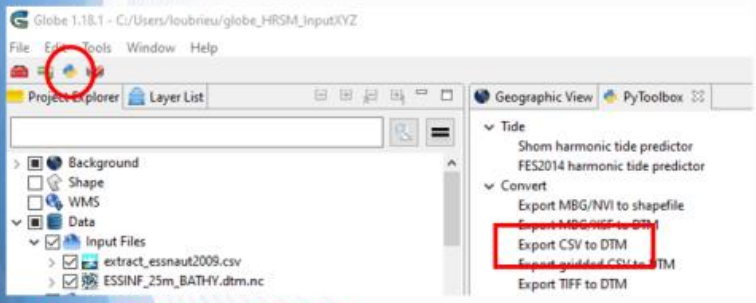
47.57773733706089,-7.569250567854567,-706.4299829006195
47.57764585113019,-7.569313096662855,-704.3799951076508
47.57759111946973,-7.569347055671392,-704.2000024318695

Loading in Globe :

right click Data/Import/load data files

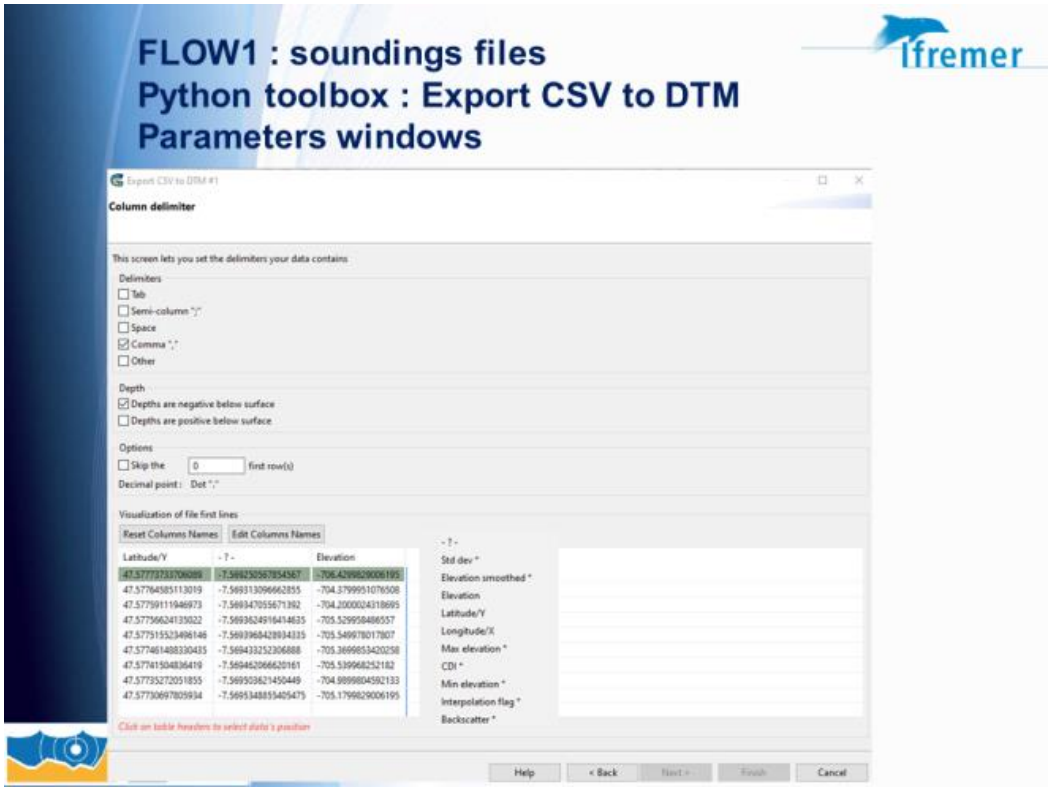


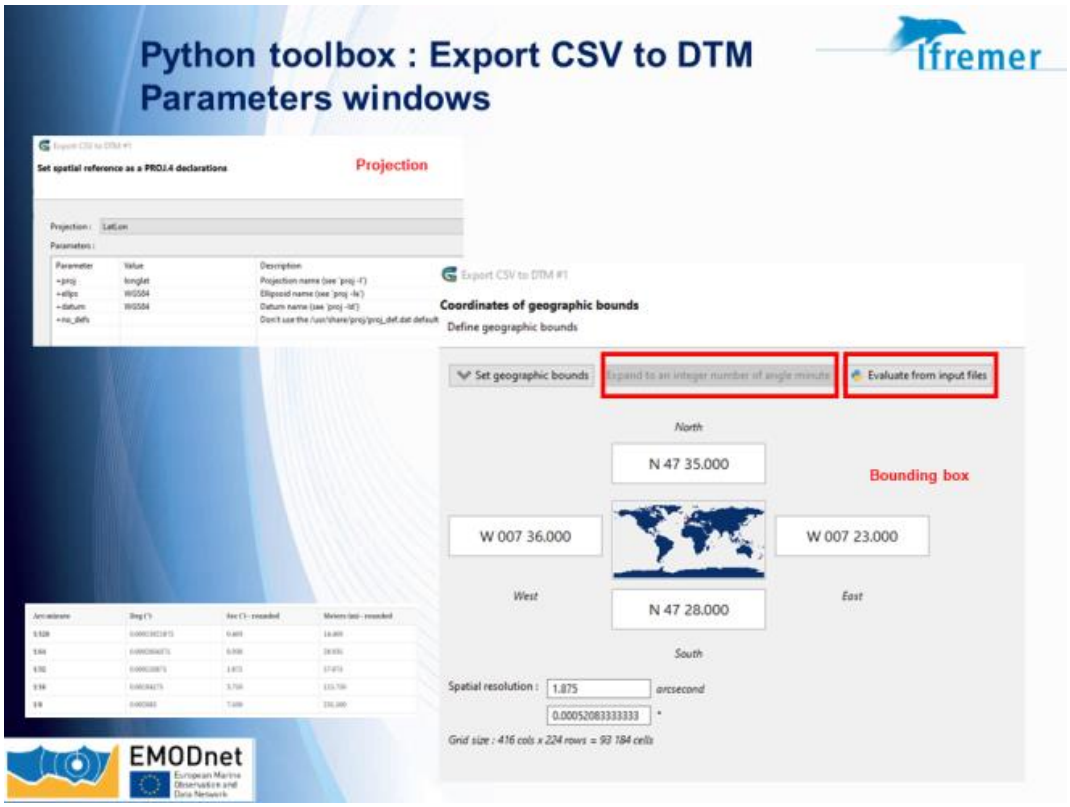
Flow 1 : Soundings files processed into a DTM :
Python toolbox : Export CSV to DTM

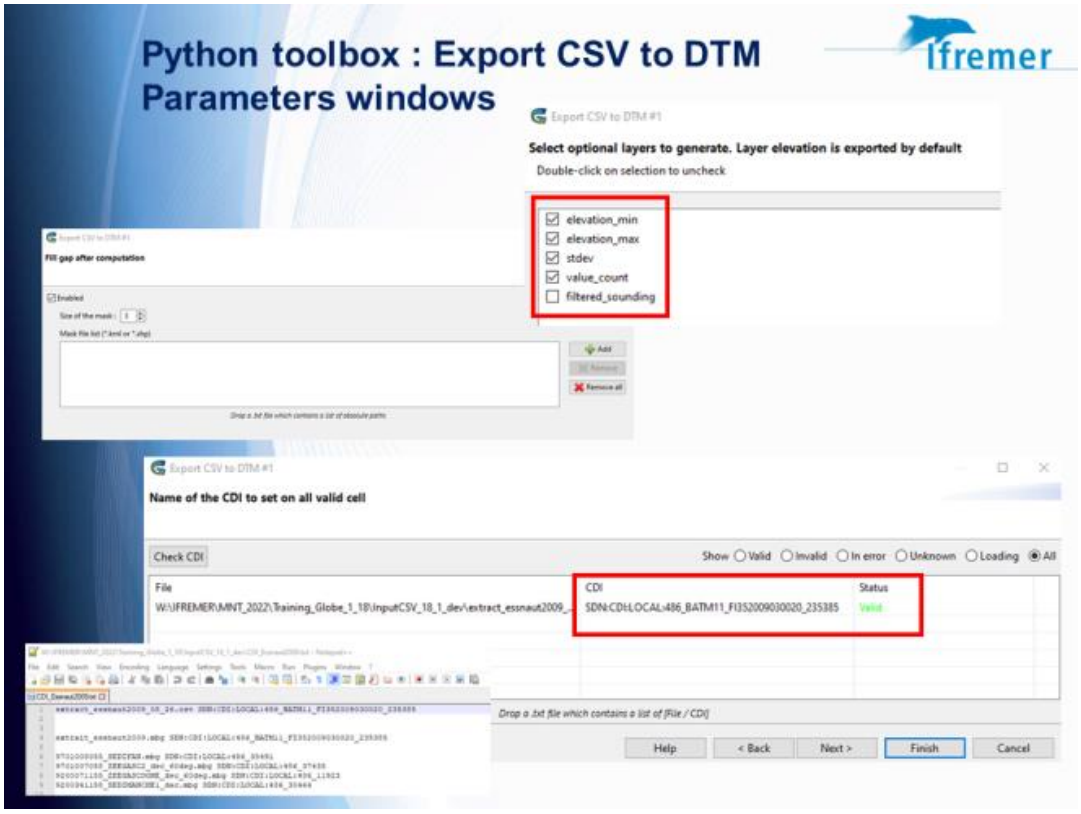


Required : CSV file, CDI Id

Flow 1 : Soundings files processed into a DTM :
Python toolbox : Export CSV to DTM


FLOW1 : soundings files
Python toolbox : Export CSV to DTM
Parameters windows
Ifremer
Column delimiter
This screen lets you set the delimiters your data contains
Delimiters
Tab
Semi-column ";"
Space
Comma ","
Other
Depth
Depths are negative below surface
Depths are positive below surface
Options
Skip the 0 first row(s)
Decimal point : Dot "."
Visualization of file first lines
Reset Columns Names
Edit Columns Names
Latitude/Y
- ? -
Elevation
Std dev *
Elevation smoothed *
Elevation
Latitude/Y
Longitude/X
Max elevation *
CDI *
Min elevation *
Interpolation flag *
Backscatter *
Help
< Back
Next >
Finish
Cancel


Python toolbox : Export CSV to DTM
Parameters windows
Ifremer
Set spatial reference as a PROJ.4 declarations
Projection
Projection :
Parameters :
Parameter
Value
Description
Export CSV to DTM #1
Coordinates of geographic bounds
Define geographic bounds
Set geographic bounds
Expand to an integer number of angle minute
Evaluate from input files
North
N 47 35.000
Bounding box
W 007 36.000
W 007 23.000
West
East
N 47 28.000
South
Spatial resolution : 1.875 arcsecond
0.00052083333333 °
Grid size : 416 cols x 224 rows = 93 184 cells
EMODnet
European Marine Observation and Data Network


Python toolbox : Export CSV to DTM
Parameters windows
Ifremer
Export CSV to DTM #1
Select optional layers to generate. Layer elevation is exported by default
Double-click on selection to uncheck
elevation_min
elevation_max
stdev
value_count
filtered_sounding
Fill gap after computation
Export CSV to DTM #1
Name of the CDI to set on all valid cell
Check CDI
Show Valid Invalid In error Unknown Loading All
File
CDI
Status
Drop a .txt file which contains a list of [file / CDI]
Help
< Back
Next >
Finish
Cancel


Ifremer
2 : Composite product CPRD
(pre-processed grid)
file for training : CPRD_ESSINF_inputgridXYZ.csv
EMODnet

- **Flow 2 : Composite product CPRD (pre-processed grid)**

Input files = gridded csv files

Regular coordinates : grid points are aligned

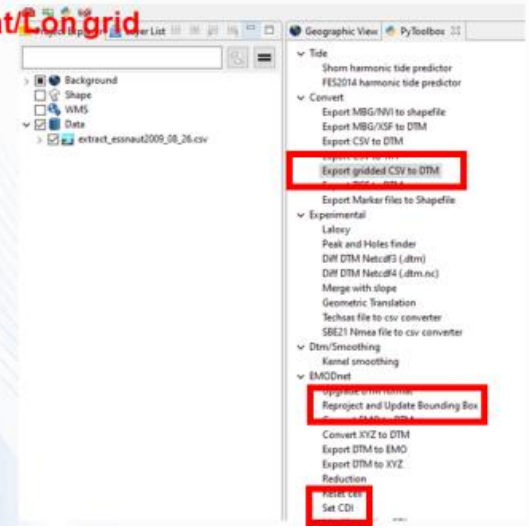
Projected XY coordinates + depth

-384511.98712828 4016812.11739030;-359.15
-384461.98712828 4016812.11739030;-350.55
-384436.98712828 4016812.11739030;-350.95

- **Flow 2 : Composite product CPRD (pre-processed grid)**

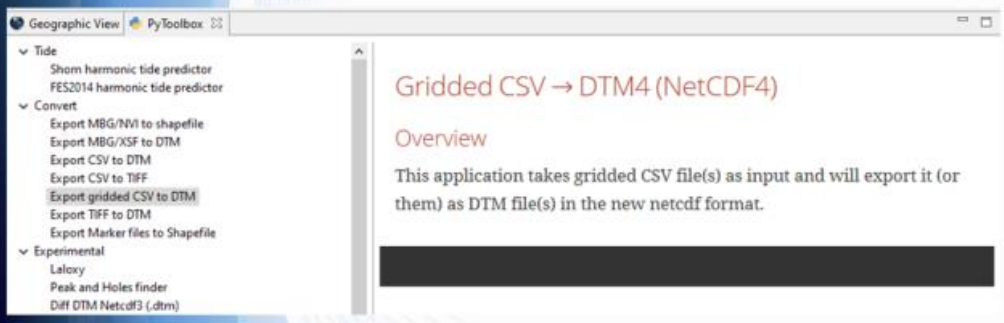
3 steps in the Python toolbox :

- **Export gridded CSV to DTM**
- **Set CDI**
- **Reproject into a Lat/Lon grid**



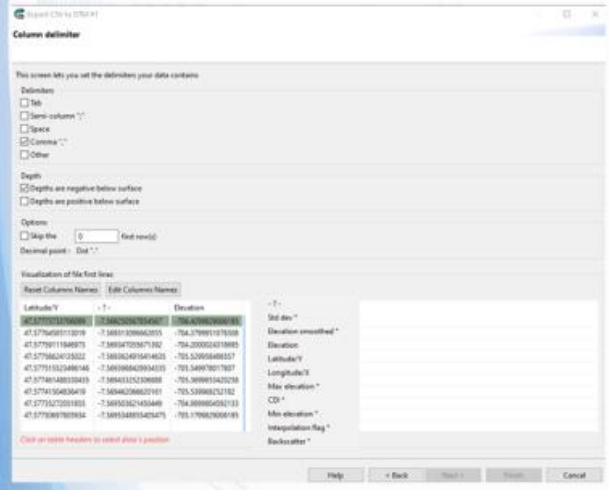
- Flow 2 : Composite product CPRD (pre-processed grid)

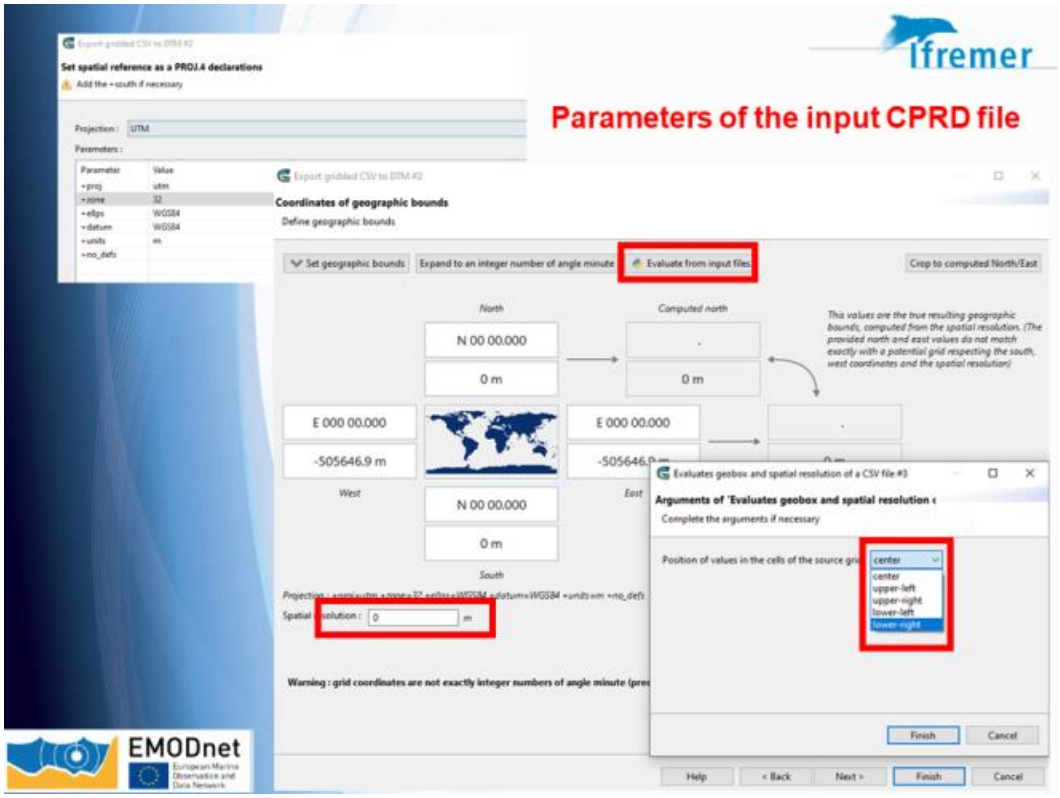
Step 1 : Export gridded CSV to DTM

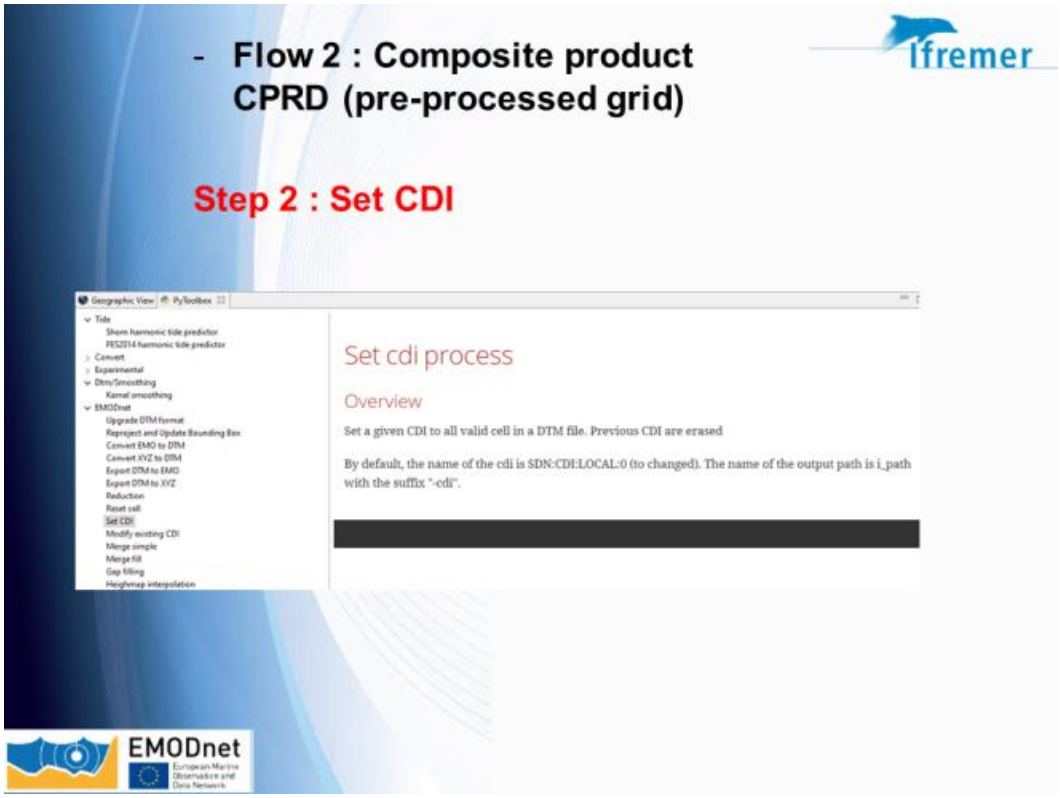


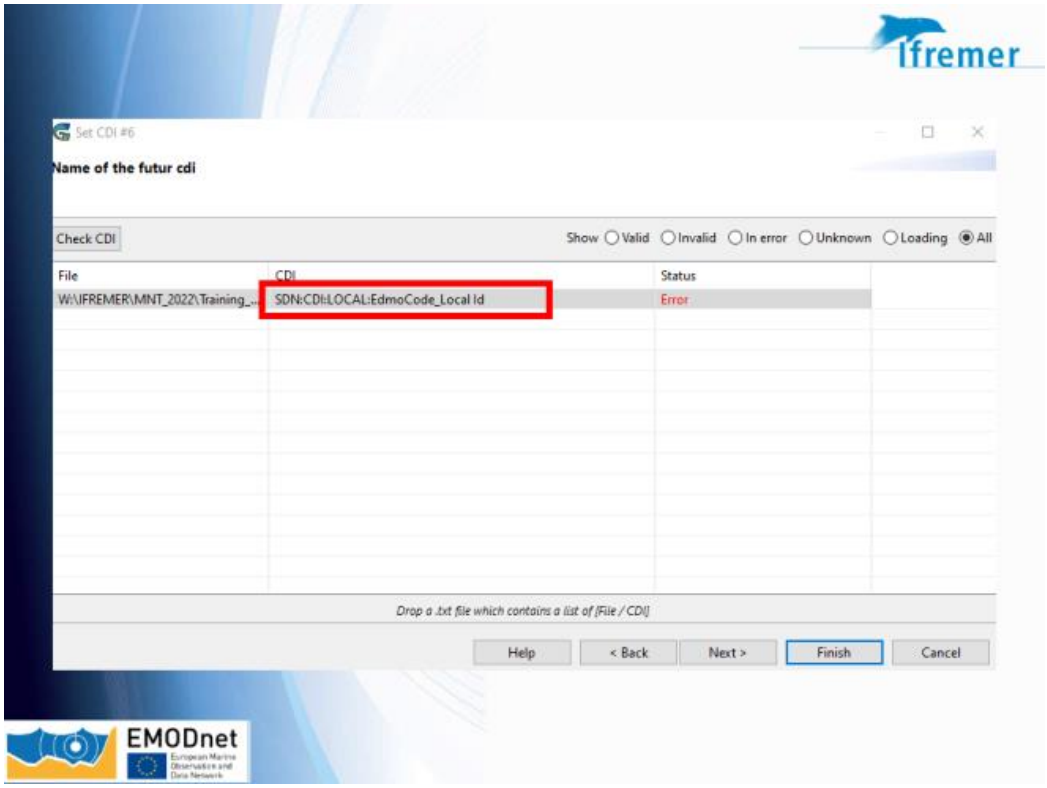
- Flow 2 : Composite product CPRD (pre-processed grid)

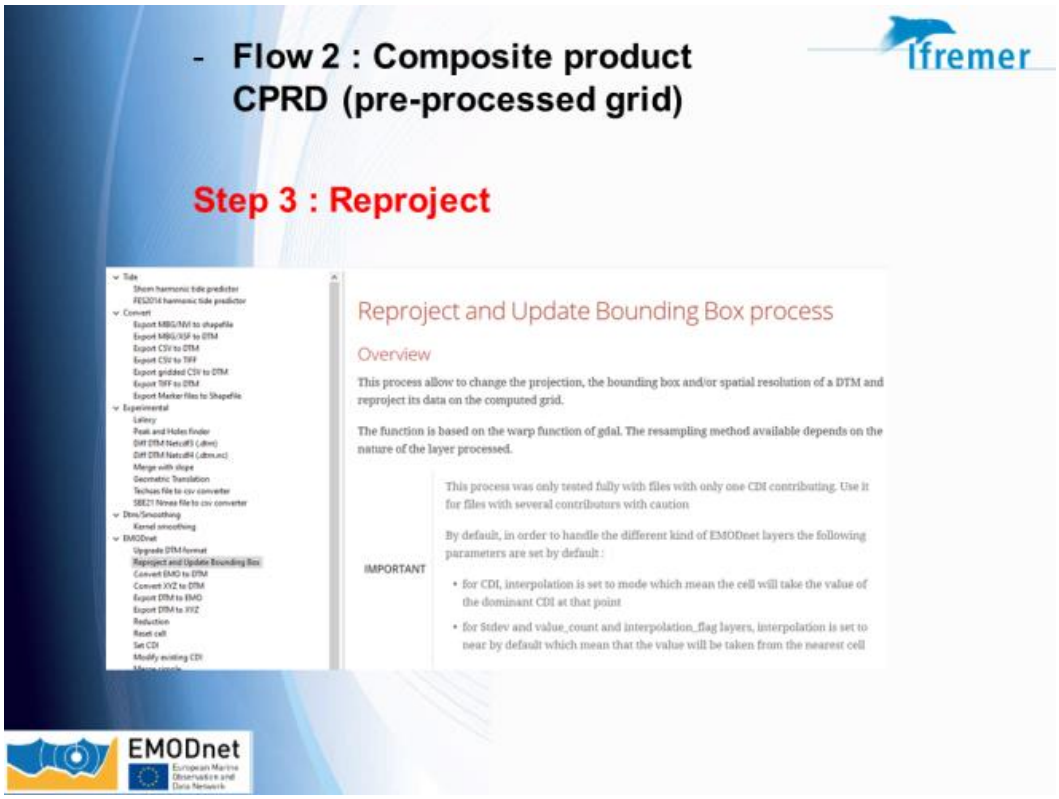
Step 1 : Export gridded CSV to DTM

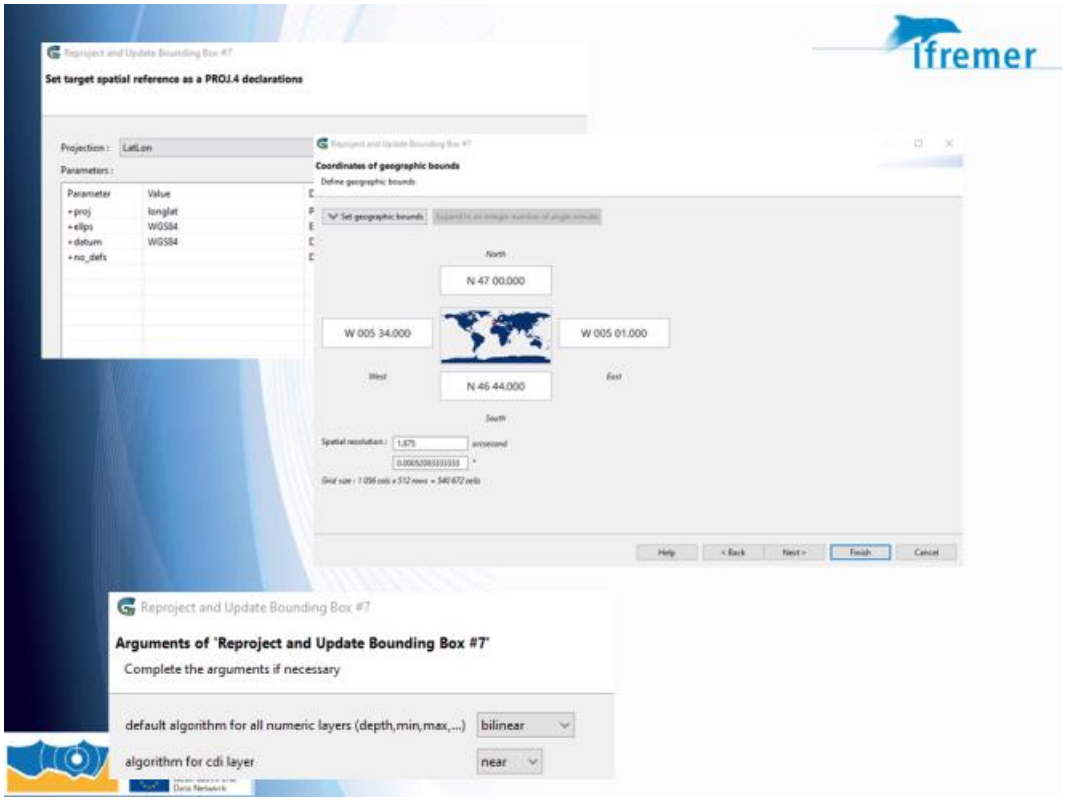


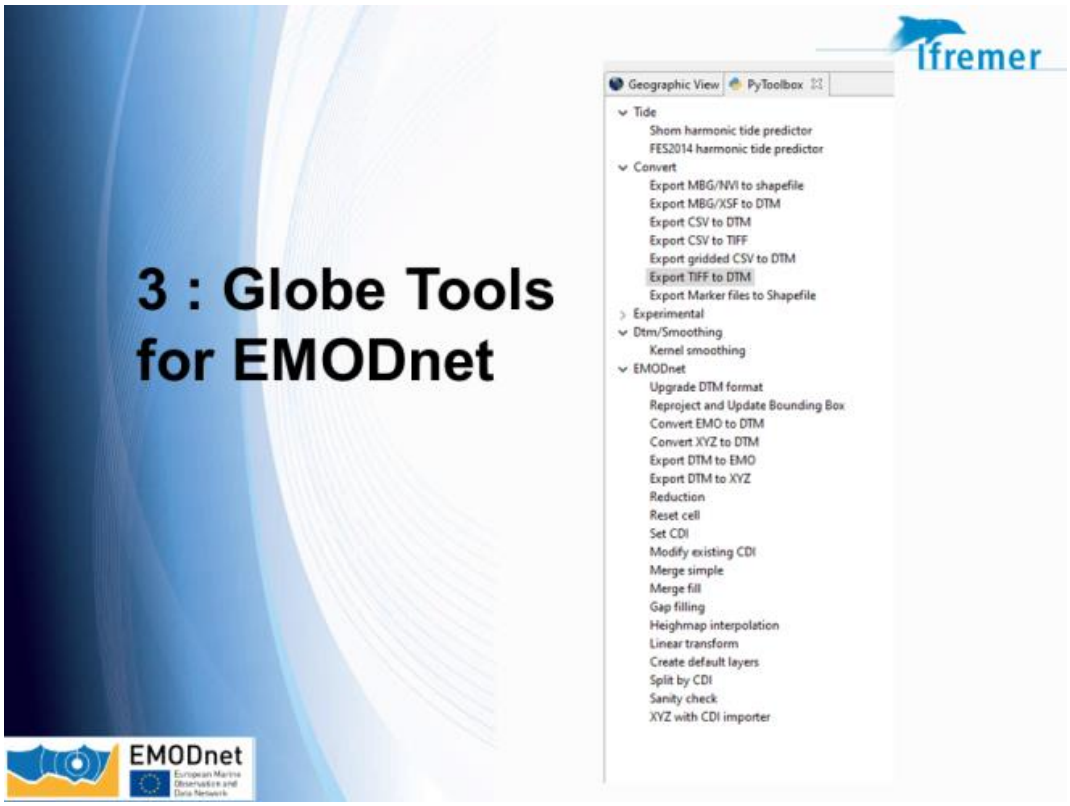

Parameters of the input CPRD file
Set spatial reference as a PROJ.4 declarations
Coordinates of geographic bounds
Define geographic bounds
Set geographic bounds
Expand to an integer number of angle minute
Evaluate from input files
Crop to computed North/East
North
Computed north
N 00 00.000
0 m
E 000 00.000
-505646.9 m
West
East
South
Spatial resolution :
Warning : grid coordinates are not exactly integer numbers of angle minute
Arguments of 'Evaluates geobox and spatial resolution
Complete the arguments if necessary
Position of values in the cells of the source
center
upper-left
upper-right
lower-left
lower-right
Finish
Cancel
Help
< Back
Next >
EMODnet


- Flow 2 : Composite product CPRD (pre-processed grid)
Step 2 : Set CDI
Set cdi process
Overview
Set a given CDI to all valid cell in a DTM file. Previous CDI are erased
By default, the name of the cdi is SDN:CDI:LOCAL:0 (to changed). The name of the output path is i_path with the suffix "-cdi".
EMODnet

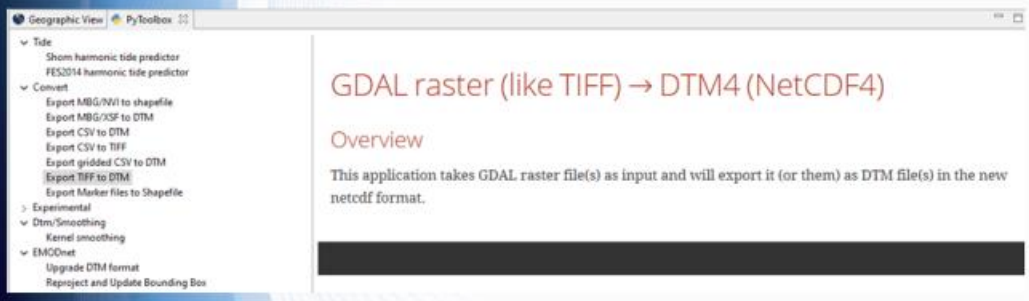

Set CDI #6
Name of the futur cdi
Check CDI
Show Valid Invalid In error Unknown Loading All
File
CDI
Status
W:\IFREMER\MNT_2022\Training_...
SDN:CDI:LOCAL:EdmoCode_Local Id
Error
Drop a .txt file which contains a list of [File / CDI]
Help
< Back
Next >
Finish
Cancel
EMODnet


- Flow 2 : Composite product CPRD (pre-processed grid)
Step 3 : Reproject
Reproject and Update Bounding Box process
Overview
This process allow to change the projection, the bounding box and/or spatial resolution of a DTM and reproject its data on the computed grid.
The function is based on the warp function of gdal. The resampling method available depends on the nature of the layer processed.
IMPORTANT
This process was only tested fully with files with only one CDI contributing. Use it for files with several contributors with caution
By default, in order to handle the different kind of EMODnet layers the following parameters are set by default :
• for CDI, interpolation is set to mode which mean the cell will take the value of the dominant CDI at that point
• for Stdev and value_count and interpolation_flag layers, interpolation is set to near by default which mean that the value will be taken from the nearest cell
EMODnet

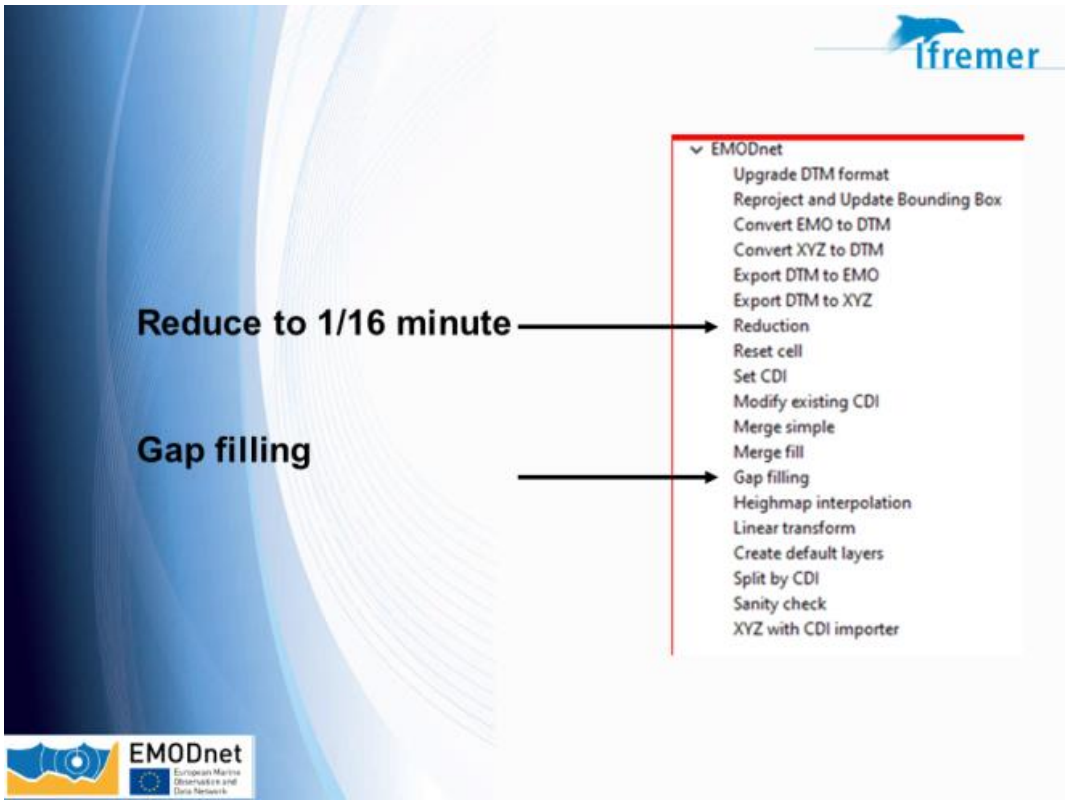

Ifremer
Set target spatial reference as a PROJ.4 declarations
Projection : LatLon
Parameters :
Parameter
Value
+proj
longlat
+ellps
WGS84
+datum
WGS84
+no_defs
Coordinates of geographic bounds
Define geographic bounds
Set geographic bounds
North
N 47 00.000
W 005 34.000
W 005 01.000
West
East
N 46 44.000
South
Spatial resolution :
1.875
arcsecond
Help
< Back
Next >
Finish
Cancel
Reproject and Update Bounding Box #7
Arguments of 'Reproject and Update Bounding Box #7'
Complete the arguments if necessary
default algorithm for all numeric layers (depth,min,max,...)
bilinear
algorithm for cdi layer
near

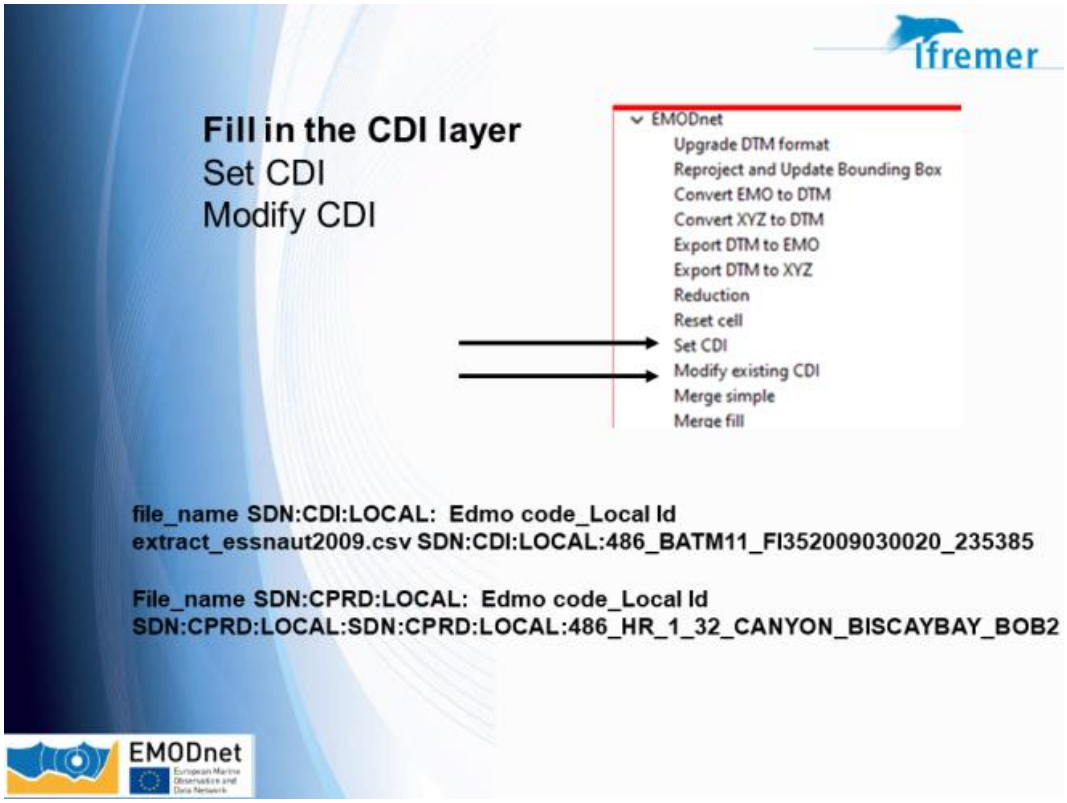

Ifremer
3 : Globe Tools for EMODnet
Geographic View
PyToolbox
Tide
Shom harmonic tide predictor
FES2014 harmonic tide predictor
Convert
Export MBG/NVI to shapefile
Export MBG/XSF to DTM
Export CSV to DTM
Export CSV to TIFF
Export gridded CSV to DTM
Export TIFF to DTM
Export Marker files to Shapefile
Experimental
Dtm/Smoothing
Kernel smoothing
EMODnet
Upgrade DTM format
Reproject and Update Bounding Box
Convert EMO to DTM
Convert XYZ to DTM
Export DTM to EMO
Export DTM to XYZ
Reduction
Reset cell
Set CDI
Modify existing CDI
Merge simple
Merge fill
Gap filling
Heighmap interpolation
Linear transform
Create default layers
Split by CDI
Sanity check
XYZ with CDI importer
EMODnet
European Marine Observation and Data Network

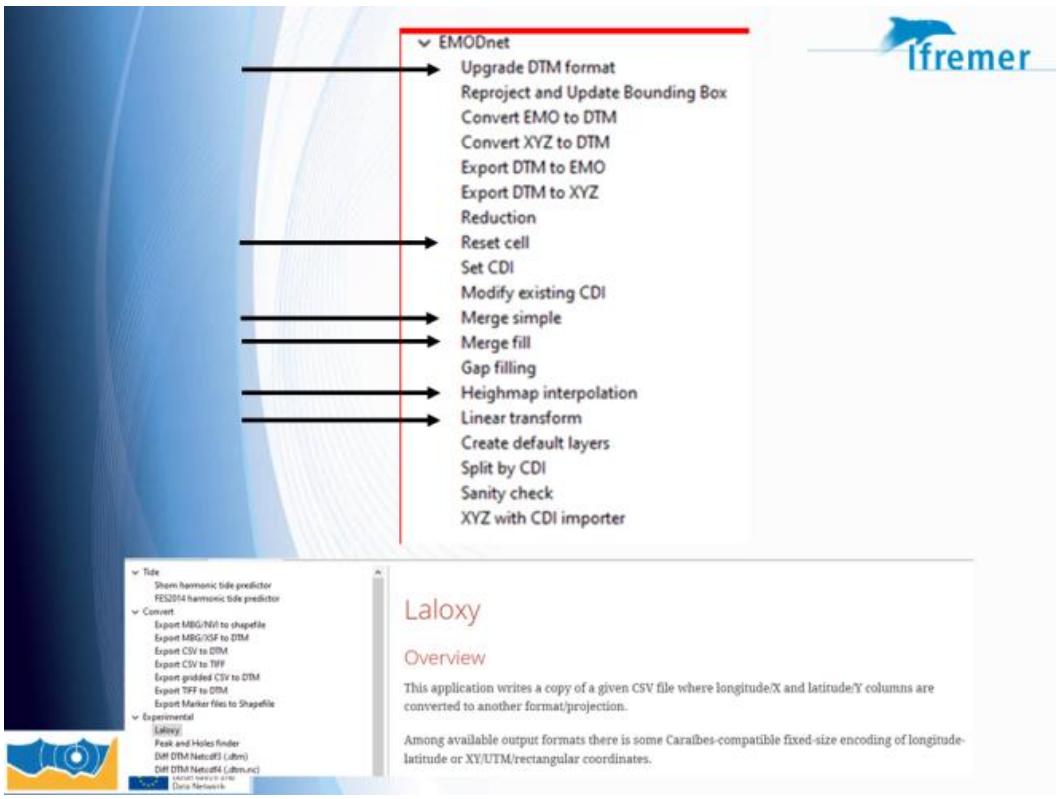
Geotiff to DTM

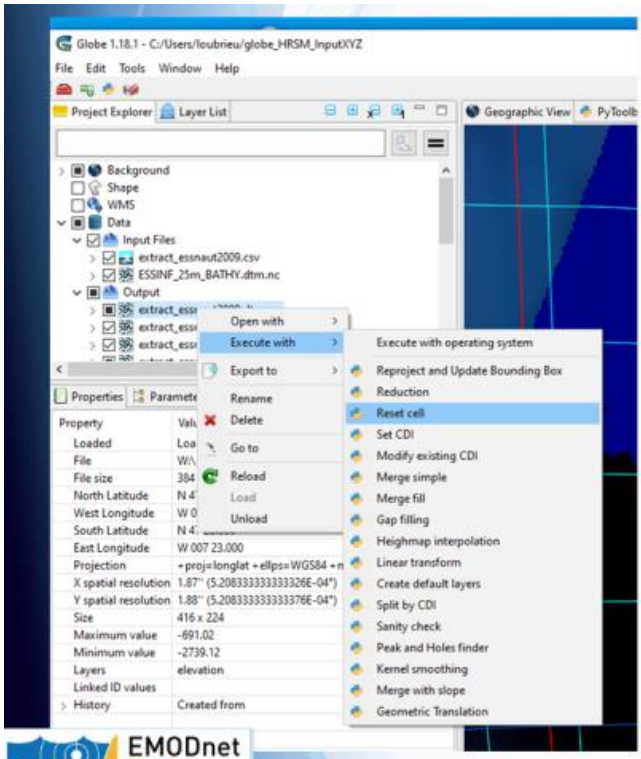


Set CDI is required after converting a GEOTIFF file into Globe DTM




Ifremer
Fill in the CDI layer
Set CDI
Modify CDI
EMODnet
Upgrade DTM format
Reproject and Update Bounding Box
Convert EMO to DTM
Convert XYZ to DTM
Export DTM to EMO
Export DTM to XYZ
Reduction
Reset cell
Set CDI
Modify existing CDI
Merge simple
Merge fill
file_name SDN:CDI:LOCAL: Edmo code_Local Id
extract_essnaut2009.csv SDN:CDI:LOCAL:486_BATM11_FI352009030020_235385
File_name SDN:CPRD:LOCAL: Edmo code_Local Id
SDN:CPRD:LOCAL:SDN:CPRD:LOCAL:486_HR_1_32_CANYON_BISCAYBAY_BOB2
EMODnet


Ifremer
EMODnet
Upgrade DTM format
Reproject and Update Bounding Box
Convert EMO to DTM
Convert XYZ to DTM
Export DTM to EMO
Export DTM to XYZ
Reduction
Reset cell
Set CDI
Modify existing CDI
Merge simple
Merge fill
Gap filling
Heighmap interpolation
Linear transform
Create default layers
Split by CDI
Sanity check
XYZ with CDI importer
Laloxy
Overview
This application writes a copy of a given CSV file where longitude/X and latitude/Y columns are converted to another format/projection.
Among available output formats there is some Caraïbes-compatible fixed-size encoding of longitude-latitude or XY/UTM/rectangular coordinates.



Access with right click

Annex 2: D3.1 - Upgraded guideline of EMODnet methodology for DTM production, including using prototype CVE – Technical Report – December 2021

EMODnet Thematic Lot n°1 - Bathymetry

EASME/EMFF/2019/1.3.1.9/Lot1/SI2.836043

Start date of the project: 20/12/2020 - (24 months)

Centralisation Phase

D3.1 - Upgraded guideline of EMODnet methodology for DTM production, including using prototype CVE

Technical report

Date: 2/12/2021

Prepared by: Benoit Loubrieu and Mickael Treguer (IFREMER)

The European Marine Observation and Data Network (EMODnet) is financed by the European Union under Regulation (EU) 2021/1139 of the European Parliament and of the Council of 7 July 2021 establishing the European Maritime, Fisheries and Aquaculture Fund and its predecessor, Regulation (EU) No. 508/2014 of the European Parliament and of the Council of 15 May 2014 on the European Maritime and Fisheries Fund.

Contents

Disclaimer

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1. Overall approach

The overall approach of EMODnet Bathymetry for generating a new release of the EMODnet DTM is indicated in the following flow chart.

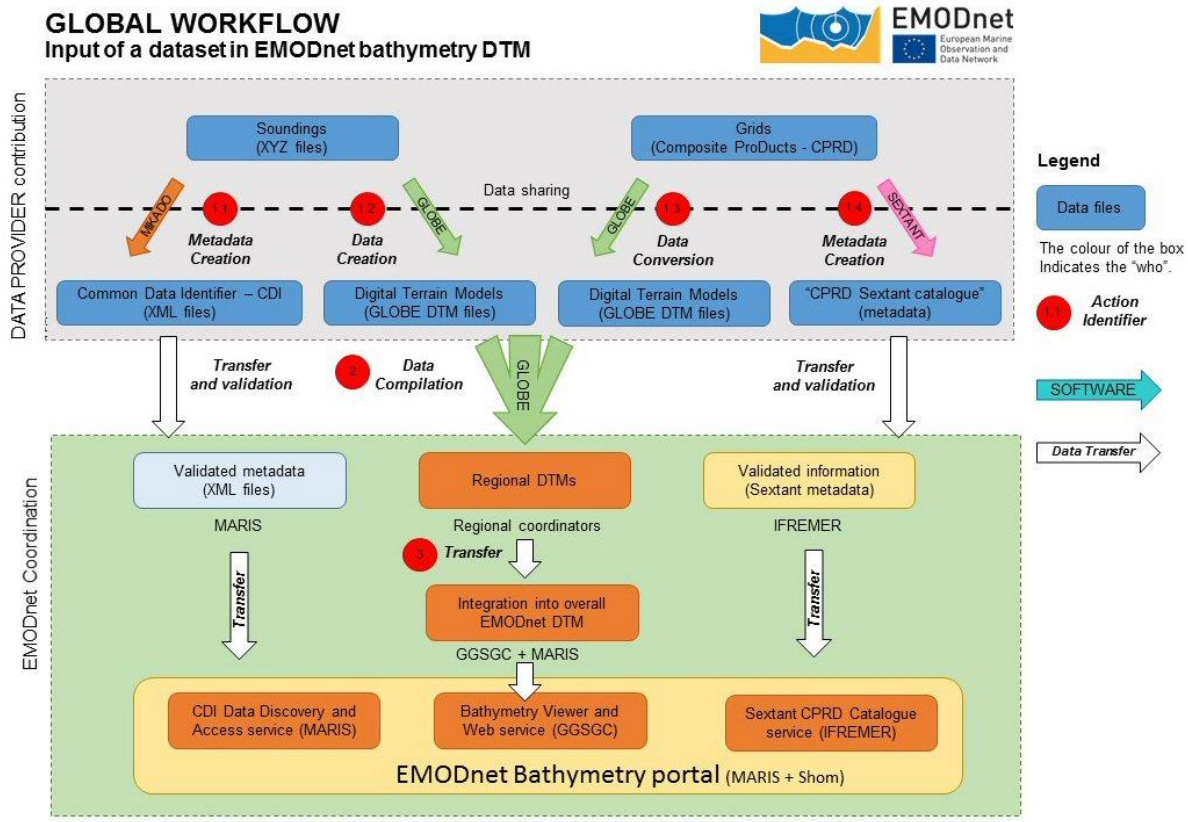


Image: Flow chart of EMODnet Bathymetry approach

The first year of the project is mostly dedicated to data gathering and populating new bathymetric data sets in the EMODnet Bathymetry catalogue services as managed with the SeaDataNet CDI service and the Sextant CPRD service. Moreover, data providers have to pre-process and grid their new data sets using GLOBE and the EMODnet Bathymetry standards and forward these as new inputs to the Regional Coordinators.

The generation of Regional DTMs is divided over regional sea basin subgroups, each with a Regional Coordinator and a number of contributing data providers. Each Regional Coordinator will be responsible for a quality assessment and selection of the data contributions and the compilation of the Regional DTM using the GLOBE software. This process by Regional Coordinators will start end February 2022 using the latest EMODnet DTM tiles, the previously used data sets and the new data sets. Their task is then to update and improve their Regional section, focusing on updating parts of the DTM with new and possibly higher quality data, and on improving already known and new to be identified anomalies in the latest EMODnet DTM release.

2. Principles for set-up of CVE

For the regional DTM production process, the Regional Coordinators should make use of the latest GLOBE software version, which they run on their local machines. However, to overcome local memory and processing challenges when handling the Regional DTMs, this round Regional Coordinators might also make use of the Collaborative Virtual Environment (CVE) on the DATARMOR computing infrastructure of IFREMER with online Globe software.

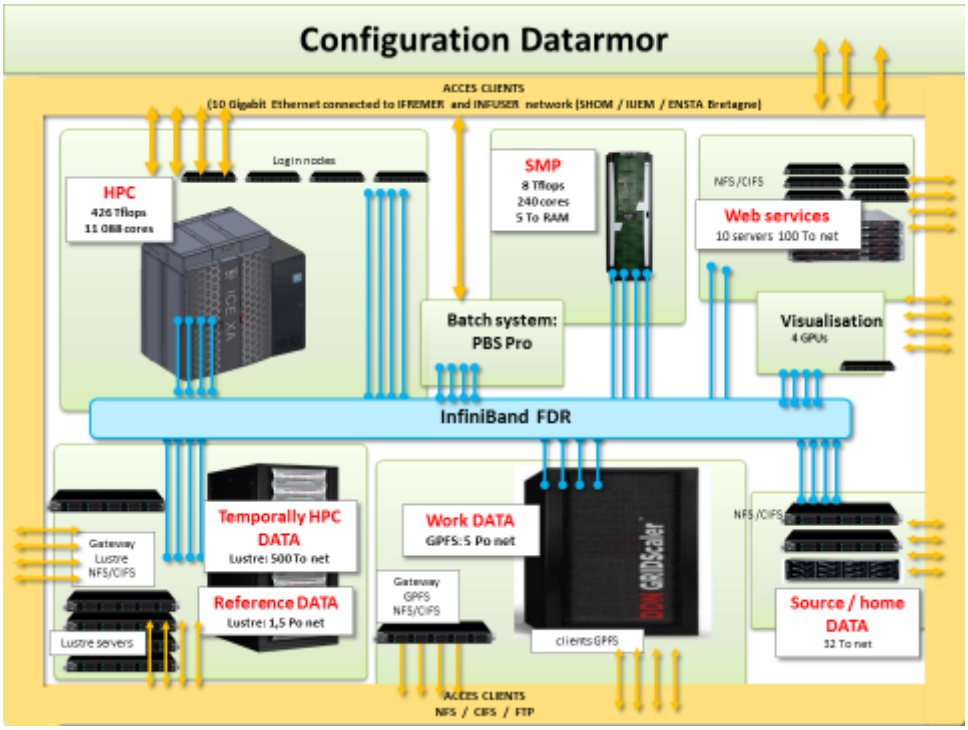


Image: Configuration of DATARMOR

The DATARMOR HPC infrastructure is connected to the French Network for Research and to Geant. The hosting of the EMODnet CVE service in this HPC environment will guarantee a high bandwidth, high performance and high operational availability for consortium members.

As part of WP4, IFREMER has further elaborated the earlier developed prototype for the CVE and made it ready with the latest online GLOBE version for validating regional DTMs by visualisation, checking for anomalies and outliers, which then can be corrected, before files are forwarded to the integrator. Regional Coordinators might inspect the existing EMODnet DTM and their new draft regional DTMs for anomalies. Corrections might include using other data sets, if possible, and using improved interpolation and/or smoothing algorithms as provided in GLOBE. Due to its computing configuration, the CVE should provide the Regional Coordinators more efficient performant handling and visualisation of the full regional DTMs.

The current version of the CVE focuses on 3 main functionalities:

- Display of Regional DTMs

- Implementation of Web processing tools, which are dedicated to the quality analysis of DTMs
- Annotation tools, allowing the regional Coordinators to document and share remaining issues on regional/final DTMs.

3. Current configuration

The CVE as further developed by IFREMER as part of WP4 has the following specifications.

Technical framework

The CVE Website is based on three components which are all based on OGC standards and which all benefit of previous technical choices made by the project (NetCDF grid format, OGC WMS services). The project setting up is based on the free open source QGIS. Display/Delivery of the grid is based on WMS/WMTS functionalities. Dedicated processing tools on the grid are based on the emerging OGC Web Processing Services (WS) technology.

Data input

For the prototype, the four regions of the Mediterranean Sea and Black Sea have been selected. Regional Coordinators of these regions have already been engaged in the tresting and evaluation of the earlier version of the collaborative tools (Globe online in 2020).

Four layers of information are made available:

- both grids of the water depth for 2018 and 2020 DTM grids
- their difference
- the 2020 source reference layer.

Analysis tools

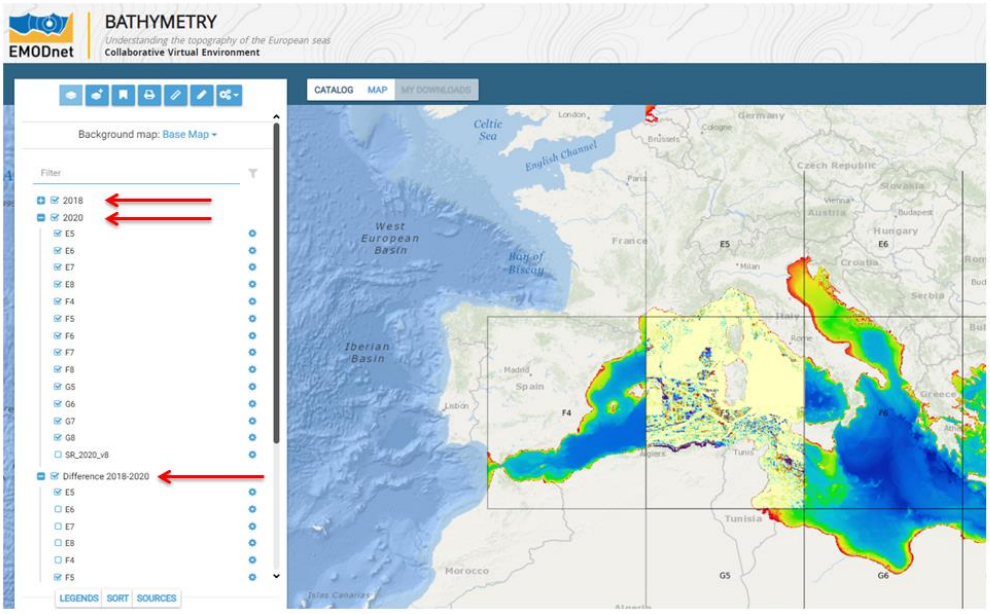
In order to help the Regional Coordinators delineating issues in individual depth grid, tools for the DTMs analysis have been implemented such as the calculation at grid node of the slope, the detection of erratic peaks, artificial hill shading, and iso-value (isobath) contours.

An annotation tool allows observations to be recorded as a geographic object (point/line/polygon) associated with a textual description.

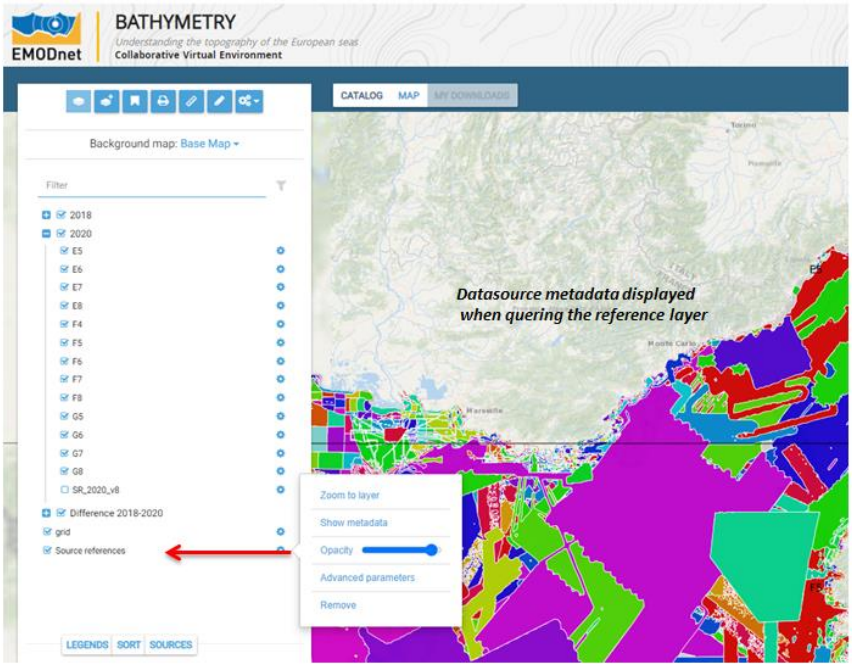
Objective

These annotations are made available to all the partners of the project, so that we all can share a common understanding of remaining issues, which can be then directed to the relevant partner (data provider or regional coordinator, respectively) for actions such as further data processing or modification of the selection of data source used as part of the fusion process. The following screens give illustrations of the current CVE configuration.

Tiles 2020, 2018 and difference are imported in the project



Source reference layer available



Images: Data layers available in the prototype web site

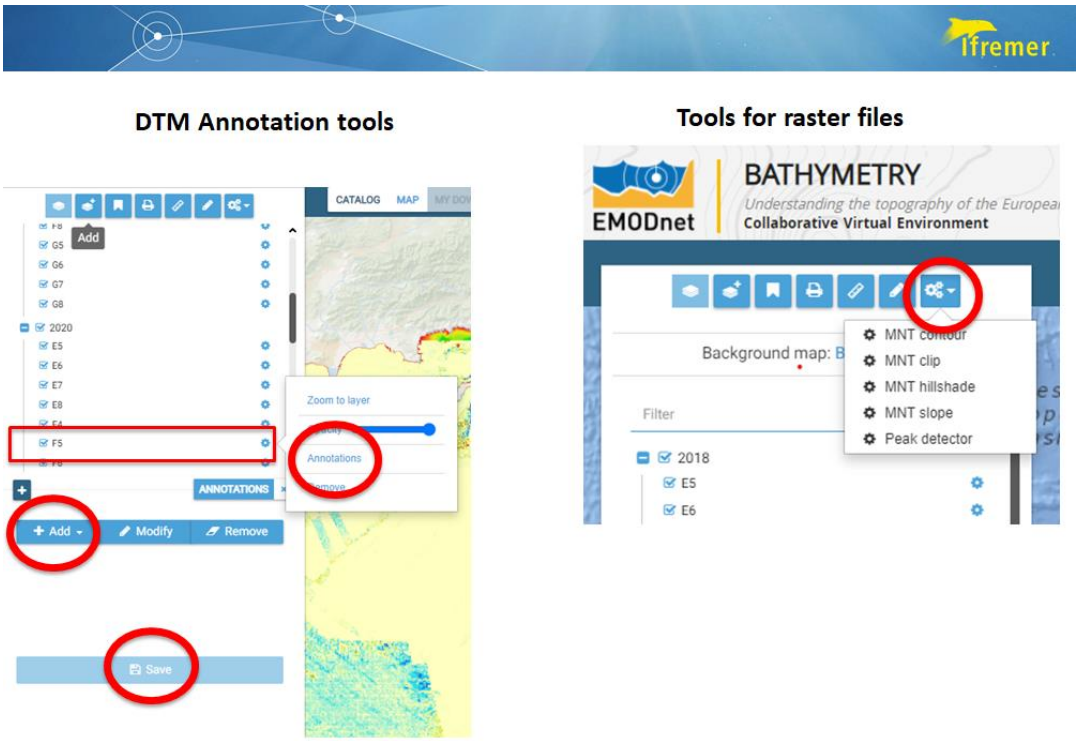


Image: Implemented tools for the DTM analysis

The prototype is available at the following website https://www.ifremer.fr/sextant_doc/emodnet_bathymetry/api/whole_mediterranean_wmts.html#/map

Connection can be provided only to EMODnet Bathymetry partners and works with an IFREMER Extranet login.

4. Proposed use for Regional DTMs production

This CVE prototype has been developed on the basis of 2 successive versions of the global DTM (2018 and 2020). It allows the principle of comparing each version of the global DTM with its previous one. This gives an indication of latest changes made, but also where improvements might be needed.

Another use is also considered: compare new data provided during the process of a new version with the existing.

As part of the EMODnet Bathymetry project, the latest CVE version will be presented to the full consortium at the next plenary meeting planned in January 2022. Moreover, back-to-back with this plenary meeting a dedicated CVE Workshop will be held in particular for the Regional Coordinators.

During these meetings two options can be discussed:

(1) analysis of the difference between the two most recent versions of the global DTM (namely 2018 and 2020 for the current phase). This means the integration of all the regions/title. This option can also be dedicated to a larger group of external users. It can be made available soon after the delivery of a new grid, until the next one is generated.
(2) analysis of the difference between a new draft contribution from one of the Regional Coordinators, during the phase of grid creation and testing, before the full integration into the DTM. Comparison will be made in this case against the latest full version available (2020). For this second option, it is required to produce for each region a preliminary merged DTM of the new single DTMs to be made available for integration into the system.

5. Further development

After the Meeting and CVE Workshop in January 2022, the main further development for the CVE will focus on extending the information layers to the full EMODnet DTM, so covering all regional areas. This will allow all Regional Coordinators to make use of the extra options of the CVE for their Regional DTM activities.

Further functionalities might also be implemented:

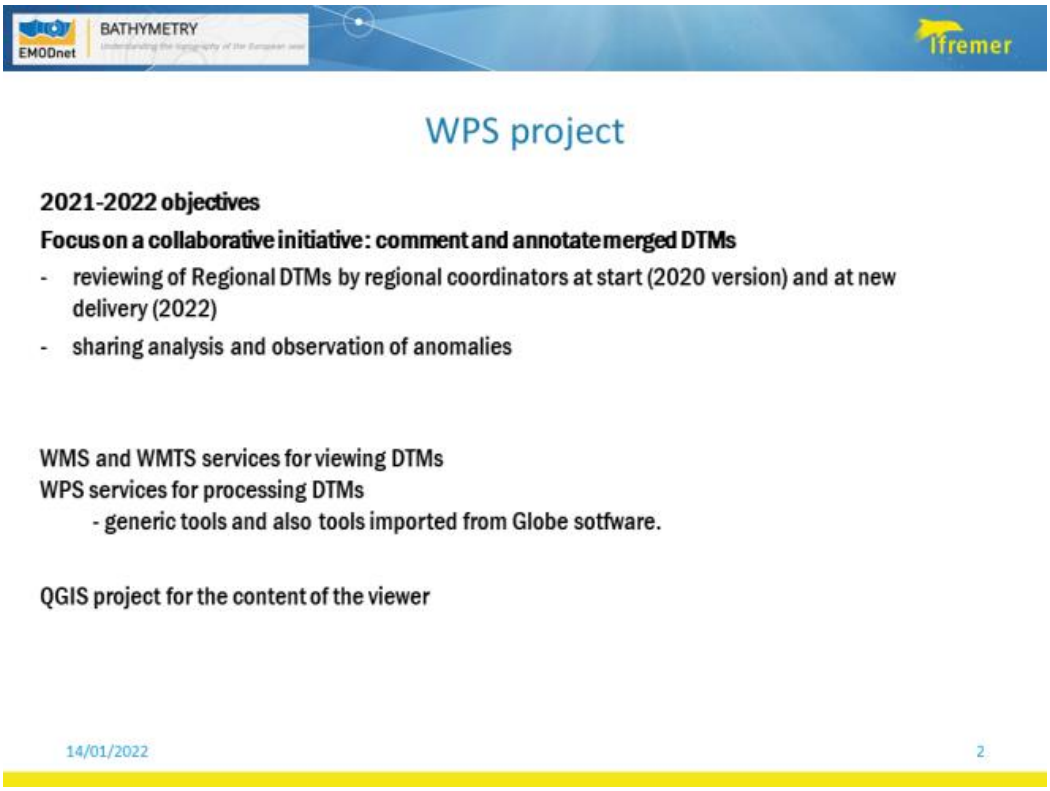
- standardization of the annotation tool : author / date /…
- additional algorithm from Globe for the DTM analysis.

One of both options described above will be selected and implemented. The IFREMER team will configure a new QGIS project and open a new Website to make it available in the period of processing for the next Regional DTMs which is planned from February 2022 until summer 2022.

6. Draft presentation of the CVE prototype for January 2022 Project Meeting and Workshop

As indicated, the latest version of the CVE will be presented in an interactive way at the next Plenary Meeting and CVE Training Workshop in January 2022. This will be directed towards informing all partners and making the Regional Coordinators more acquainted with the CVE and how they might use the CVE for validating and improving their Regional DTMs. A series of slides has already been prepared that will be used for that Workshop.

In preparation of these meetings the following set of slides has been prepared.



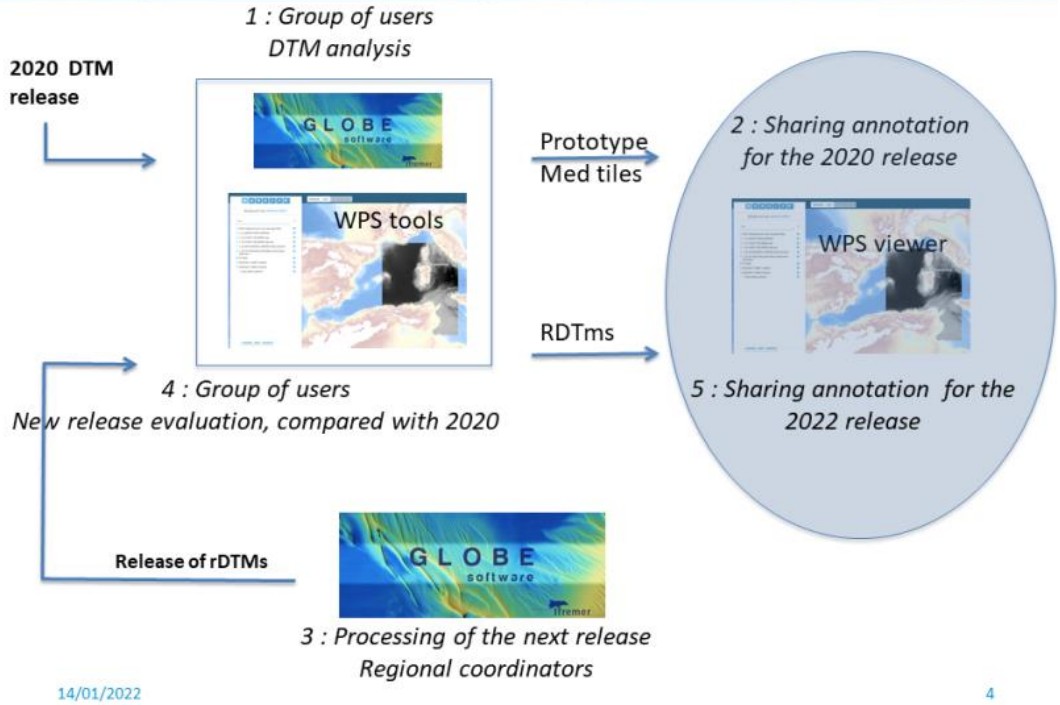
WPS project

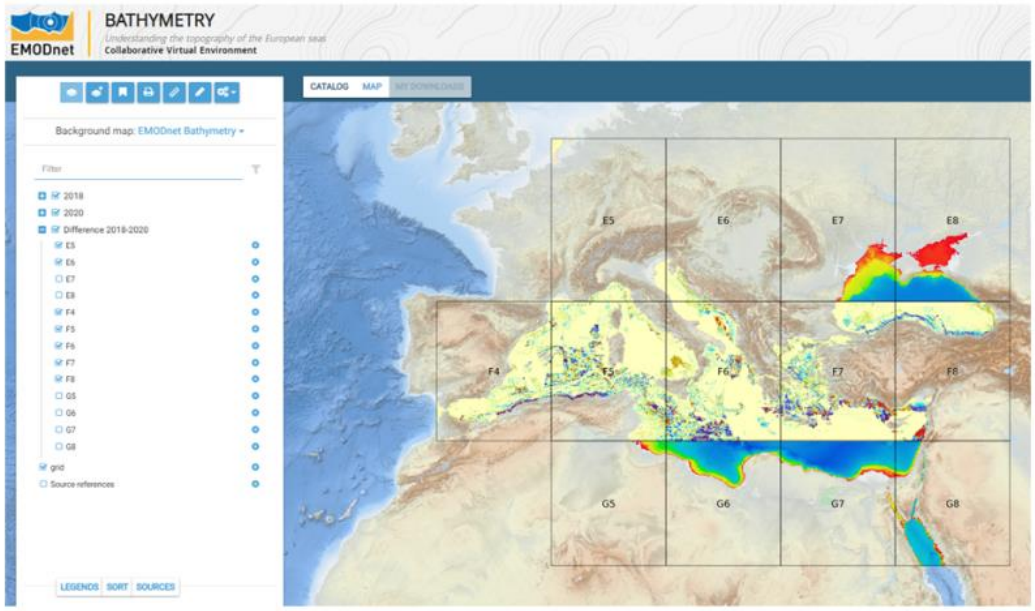
2021

- Upgrade of annotation tools
  - Attributes (authors, date, comments,...), Import / export of annotations (exchange with Globe)
- November 2021 : Prototype of the WPS project for the Mediterranean Sea, based on the current version of the EMODnet DTMs

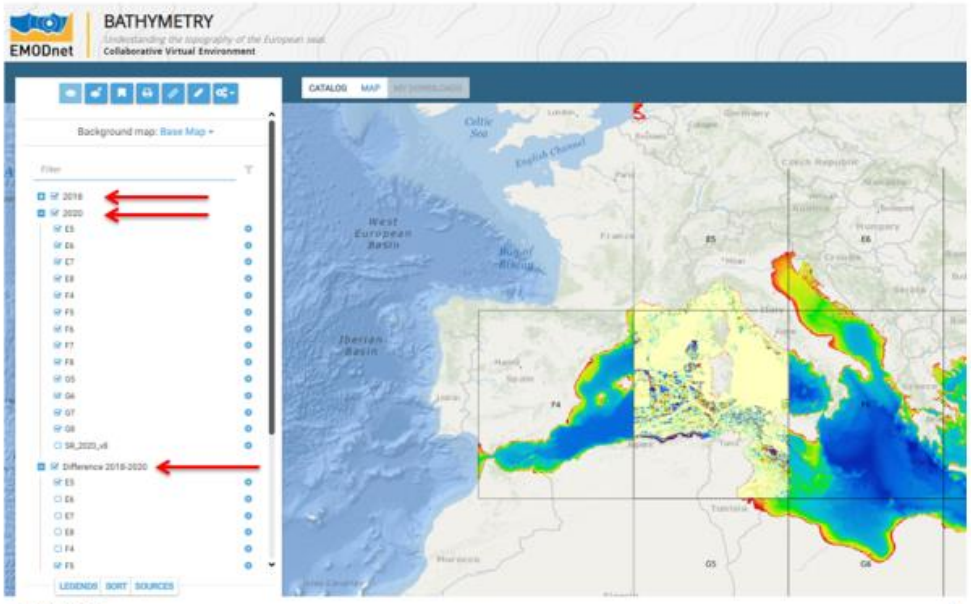
2022

- Update of the WPS project for the global DTM : Integration of new version of the RDTMs when made available by the regional coordinators
  (April / May 2022).

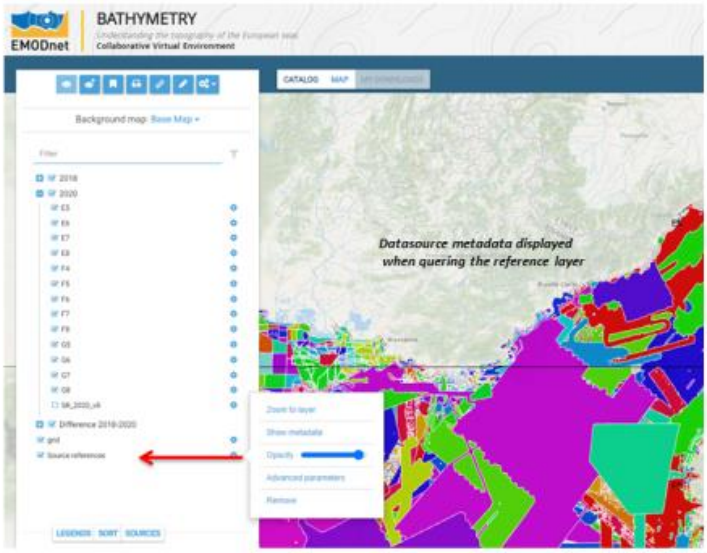




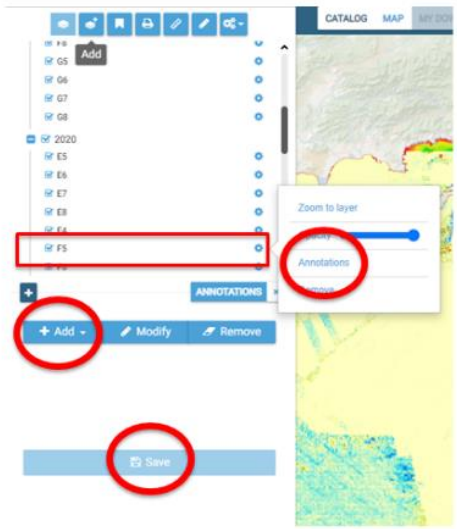
Tiles 2020, 2018 and difference are imported in the project



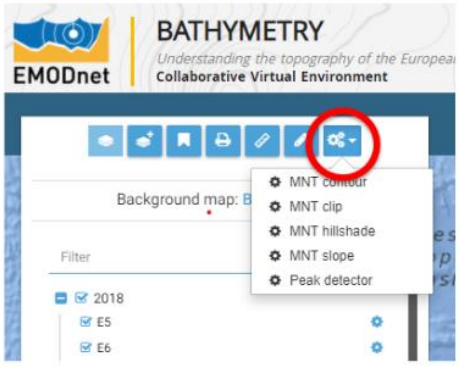
Source reference layer available



DTM Annotation tools



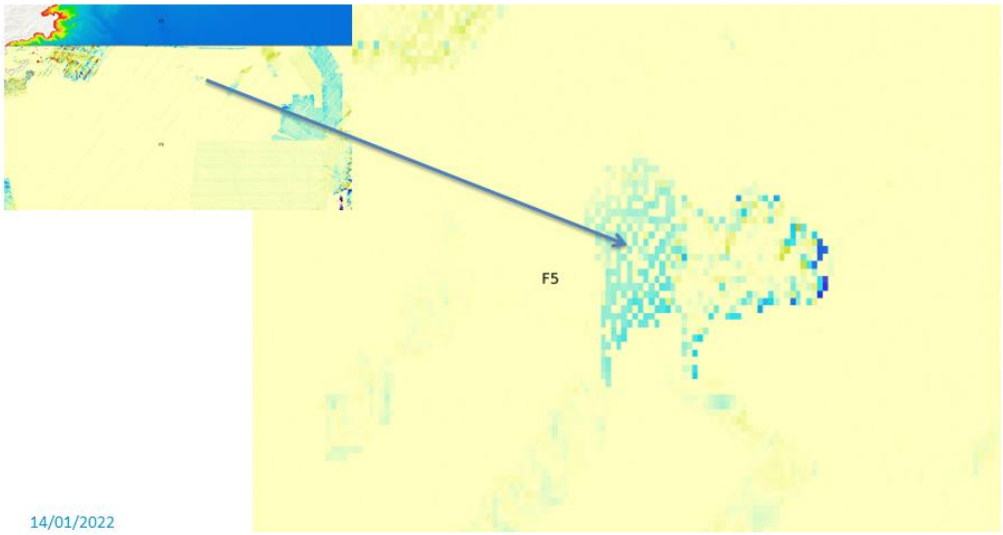
Tools for raster files



Use case

Example of use case
Tile E5 : area of unconsistency between both version 2018 and 2020

Step 1 : observation with the « Difference » tile

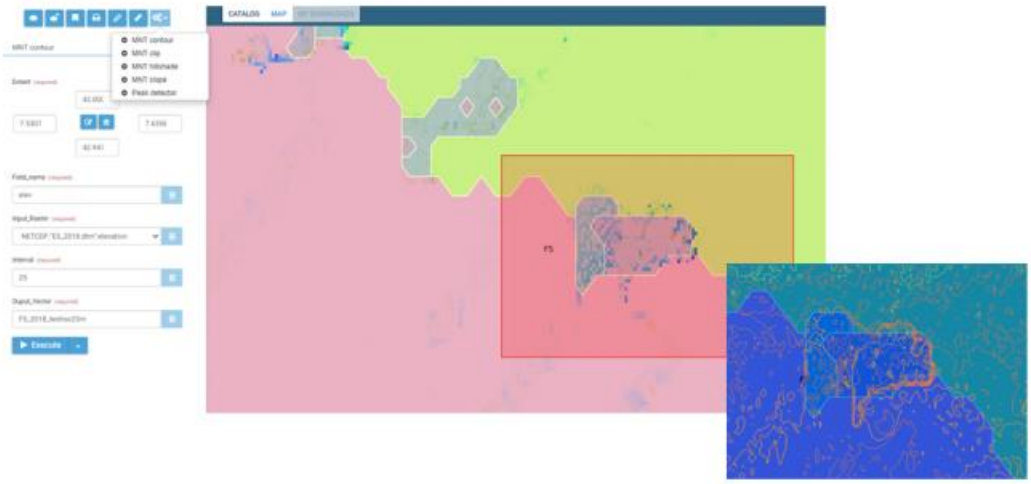


Example of use case
Tile E5 : zone of unconsistency between both version 2018 and 2020

Step 2 : identification of data sources (source reference layer)

Example of use case
Tile E5 : zone of unconsistency between both version 2018 and 2020

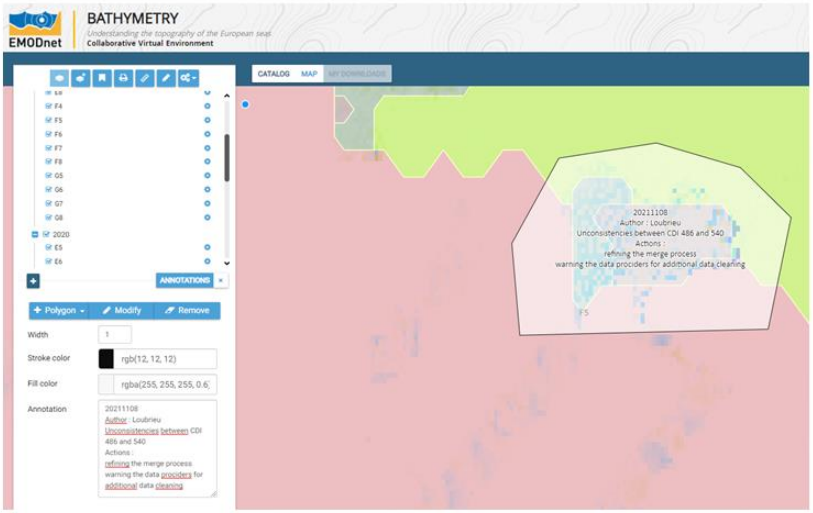
Step 3 : local contours for a better understanding



Noisy data in the merge area

Example of use case
Tile E5 : zone of unconsistency between both version 2018 and 2020

Step 4 : create an annotation, open an action.



Annex 3: Progress report by CORONIS on improving interpolation techniques for production of EMODnet DTMs – December 2021

Annex 3: Progress report by CORONIS on improving interpolation techniques for production of EMODnet DTMs – December 2021

Introduction:

During this first year of the project, Coronis focused on improving the python interpolation package, which is the core library for the interpolation methods to be implemented in Globe.

While the plan is to use it within Globe, the package can be used standalone, as well as a typical python library (to be added in other projects). The source code of the package is publicly available at:
https://github.com/coronis-computing/heightmap_interpolation

Also, a complete documentation, expanding the information in the present report, and including installation and usage information, was made available at:
https://emodnet-heightmap-interpolation.readthedocs.io/en/latest/

Moreover, with the aim of easing the adoption of the library, we also provide an already compiled docker image at DockerHub:
https://hub.docker.com/r/coroniscomputing/heightmap_interpolation

Several data providers and regional coordinators were kindly asked to provide relevant datasets requiring some kind of interpolation. The study on the density and distribution of the samples in those datasets put into relief that a single interpolation method may not fit the needs of all users. Consequently, we increased the number of interpolation algorithms in the Python package initially developed in HRSM2. Moreover, in order to ease usage, we unified all methods within the single command line entry point *interpolate_netcdf4.py*.

In the following sections, we start by introducing the interpolation problem, as well as the motivations for implementing several methods in the package. Then, we list all the interpolation methods implemented, along with their suitability depending on the input data and their pros/cons. Finally, we present the work to be done in the second year of the project.

Interpolation Methods

"Interpolation" is a broad term. In our case, it consists in obtaining elevation values at cells/points given a set of known reference elevation data at known locations. However, depending on the sampling/distribution of the input data, and where we want to interpolate it, there are several ways of dealing with this problem.

The typical literature for interpolation does not consider any specific distribution for the samples. In this sense, we find the **Scattered-data interpolators**. These methods work in two steps:

1. Take the known data points as reference to create an *interpolator*.
2. Apply the interpolator at whatever query point you desire. For interpolations on a grid, as in our case, the interpolation is queried at all the grid cells to be interpolated.

However, there are several cases in which the interpolation problem consists in filling "missing data", in the sense of having continuous and densely-sampled parts of the map that are missing and that we need to fill given the known data surrounding these parts. In these cases, the problem can be seen as "filling the holes in a coherent way". Obviously, the scattered data interpolators can be used for this purpose. However, there is a wide literature of methods trying to take advantage of the "filling" happening on a regular grid. In the computer vision literature, these are called **inpainting** methods. In this package we use inpainting approaches, usually devised for image processing, to tackle the interpolation problem on elevation grids. As mentioned above, these methods only work on the regular grids, but provide the advantage of providing **higher-degree** approximations **faster** than some similar approaches in the scattered area, and require **much less memory** to execute (the solver we implement just applies convolution operations on the input grid).

In the following sections, for each of the methods in the package, we will briefly describe their behaviour, provide the cases for which a given method is more suitable, and list their pros/cons. For a complete reference on how to call each method, and the list of parameters available to tune in each case, please refer to the documentation.

In addition, in order to get a qualitative evaluation of the behaviour of each method, we will run them with default parameters on the following dataset:

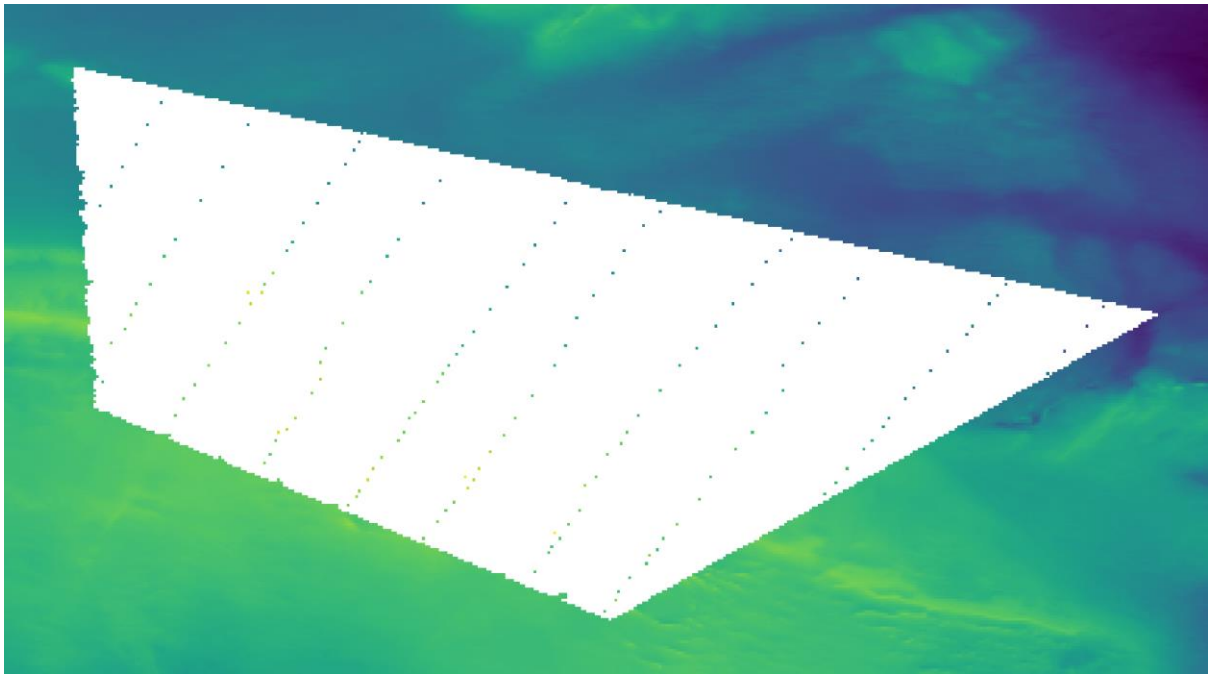


Figure 1. Example dataset. Colored areas and points represent the known reference elevation data, while the area to interpolate is shown in white. Data by courtesy of the Swedish Maritime Administration

Note that this dataset mixes both scattered and densely-sampled reference data.

Scattered data Interpolators

Nearest Neighbors

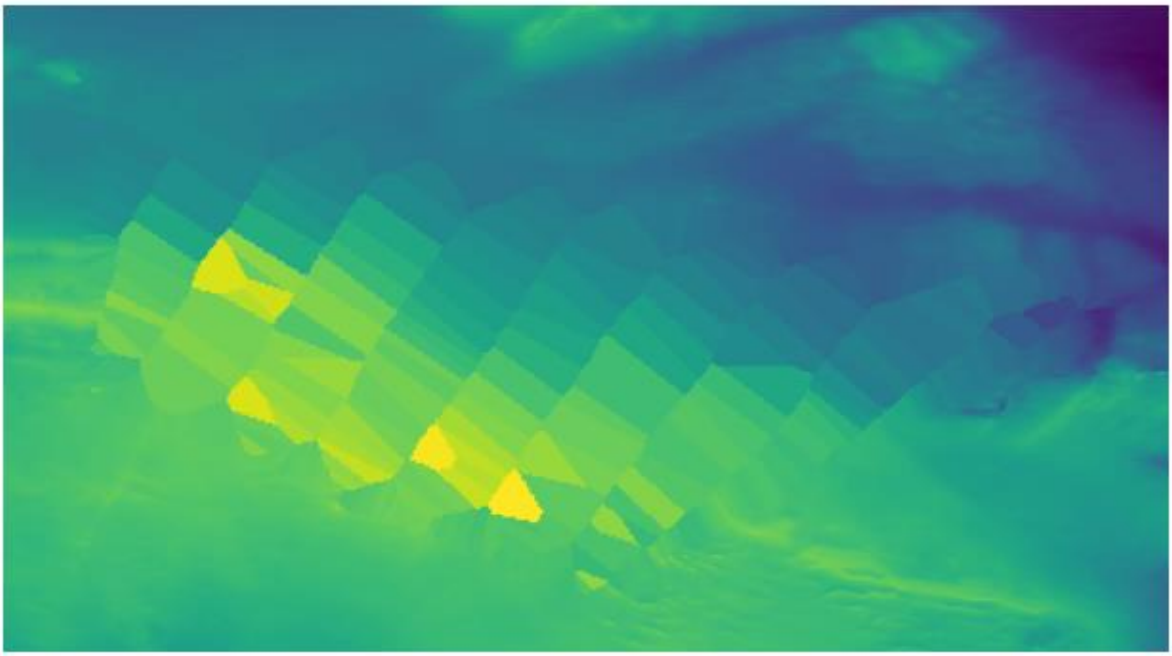


Figure 2. Example dataset interpolated using the Nearest Neighbors interpolant (*nearest* option in interpolate_netcdf4.py).

Each cell to interpolate gets its value from the nearest reference cell.

Suitable for

- Quick initialization of the interpolation using PDE inpainters (see sections below).
- Quick large-area interpolation.

Advantages

- Fastest interpolator.
- As opposed to the other two fast scattered data interpolation methods (*linear* and *cubic*), it can interpolate outside of the convex hull of the reference data.

Disadvantages

- Results look *blocky*, as many points get the same elevation value.

Linear

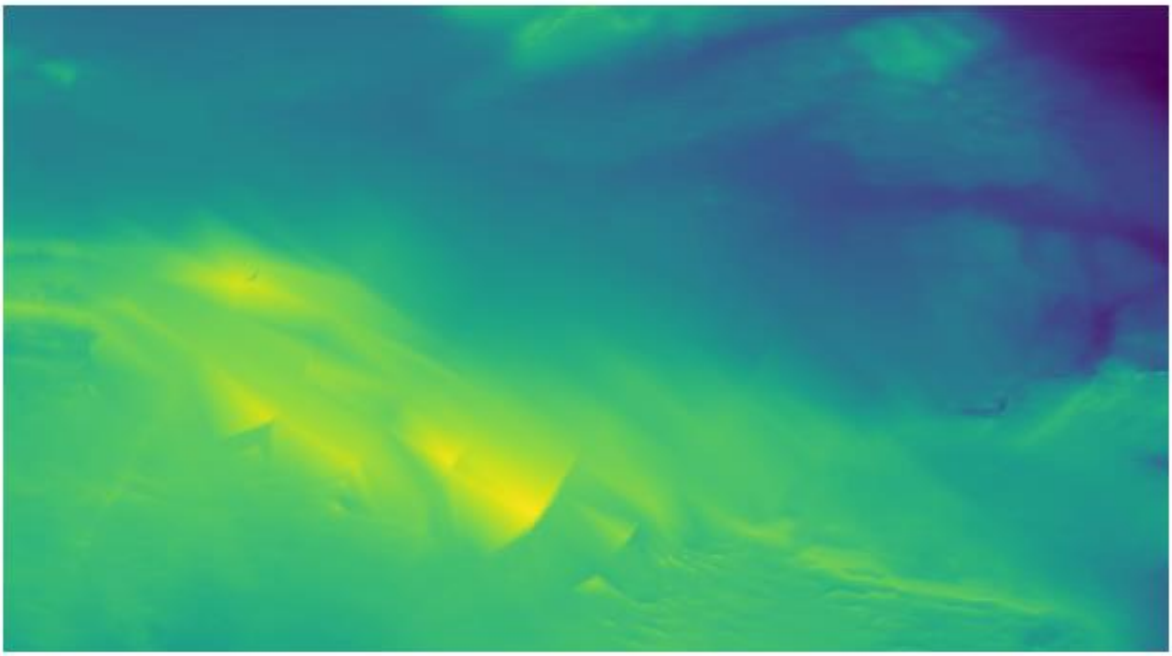


Figure 3. Example dataset interpolated using the Linear interpolant (*linear* option in interpolate_netcdf4.py).

Computes a linear interpolant by creating a 2D Delaunay triangulation using the reference data points. Upon a given query point, it searches in which of the triangle in the XY plane it

falls, and computes a barycentric interpolation of the elevation using the reference values at the vertices of the triangle.

Suitable for

- Quick large-area interpolation.

Advantages

- Fast classical interpolation method applicable to large areas.

Disadvantages

- May produce artifacts if samples' density vary rapidly, or if the scattered samples are not uniformly distributed over the inpainting area (see figure above).
- Does not "extrapolate" in query locations outside of the convex hull of the reference data.

Cubic

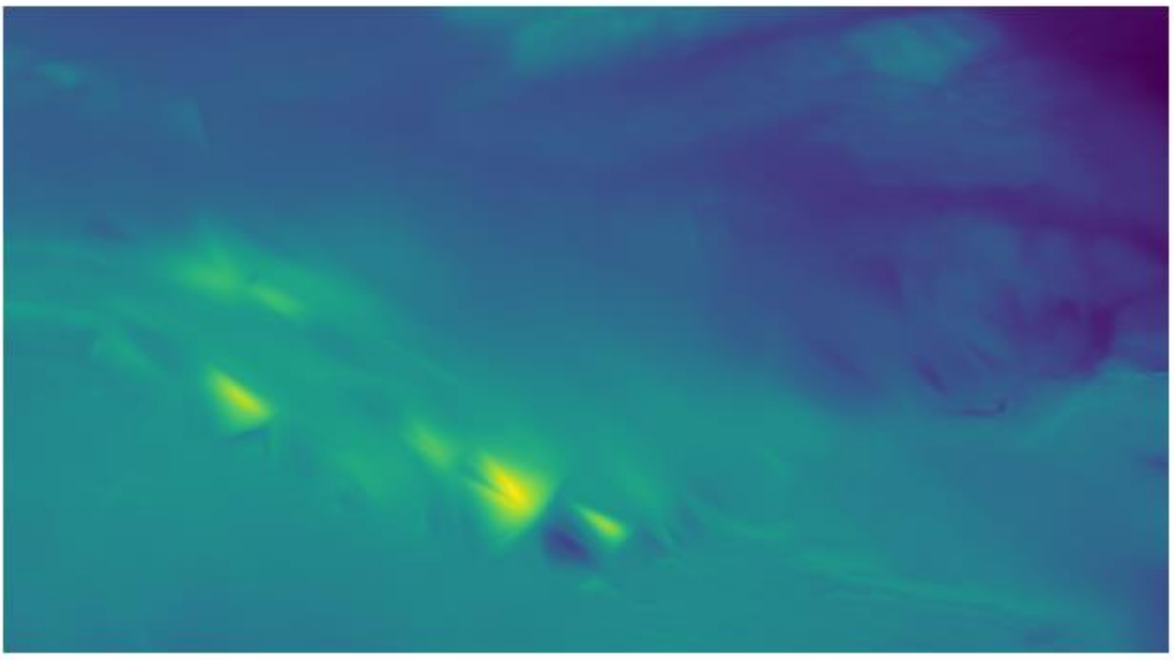


Figure 4. Example dataset interpolated using the Cubic interpolant (*cubic* option in interpolate_netcdf4.py).

As in the *linear* method, it creates a 2D Delaunay triangulation using the reference data points and query points are interpolated within the triangle where they fall in the XY plane. However, as opposed to using a linear barycentric interpolation within the triangle, it uses a piecewise cubic interpolating Bezier polynomial.

Suitable for

- Quick large-area interpolation.

Advantages

- Provides a smoother interpolation than the *linear* method at a similar computational cost.

Disadvantages

- May produce artifacts if samples' density vary rapidly, or if the scattered samples are not uniformly distributed over the inpainting area (see figure above).
- Does not "extrapolate" in query locations outside of the convex hull of the reference data.

Radial Basis Functions

This method was developed in the previous phase of EMODnet Bathymetry (HRSM2), and included in the package as part of the new command-line interface.

A Radial Basis Function (RBF) is a function whose value depends only on the distance between the input and some fixed point. The basic idea of a RBF interpolator is to construct an interpolant of the data using a summation of several RBF centered at the input reference data points. The formal definition is the following:

$$s(x) = p(x) + \sum_{i=1}^{N} \lambda_i \phi(|x - x_i|)$$

Where $\phi(|x - x_i|)$ is a given radial basis function centered at a known/reference data point x_i, $p(x)$ is a polynomial of small degree evaluated at point x, and λ_i is a scalar weight.

Thus, basically, we have a polynomial (1st term) capturing the main trend of the data, and the summation of weighted RBFs (2nd term). Therefore, the unknowns of this interpolant are mainly the few terms of the polynomial $p(x)$ and the λ_i weight of each RBF. These unknowns can be solved using a linear system of equations. In matrix form, this corresponds to:

$$A = \begin{pmatrix} A & P \\ P^T & 0 \end{pmatrix} \begin{pmatrix} \lambda \\ c \end{pmatrix} = \begin{pmatrix} f \\ 0 \end{pmatrix}$$

Where:

- $A_{i,j} = \phi(|x_i - x_j|)$
- $P_{i,j} = p_j(x_i)$ are the coefficients of the polynomial.
- f are known elevation values at x_i.

While solving this system of equations is conceptually simple, it is important to notice that the matrix A is a square matrix with side length equal to the number of input data points. Therefore, this formulation becomes prohibitively complex for large datasets, as the amount of memory and computational resources required for solving and/or evaluating the interpolant is too large. This is the reason why there is no figure showing the result in this section: even for a small dataset as the one we are using, **it is not feasible to compute the interpolant in a reasonable amount of time and resources**.

However, it has the nice feature of allowing some "tuning" of the properties of the interpolating surface via the RBF type that we choose. You can check the complete list of RFB types available in the documentation.

Suitable for

- Best approximation quality for the interpolant.
- Small datasets. They can be small in the number of input reference points, and large in the number of query points (huge scattered data).

Advantages

- Allows tuning the properties of the interpolating surface by changing the RBF type and parameters.

Disadvantages

- Depending on the input data and the selected RBF type, the resulting interpolant surface may **overshoot** the input data (minimum and maximum elevation values may be outside the range of the input data).

Partition of Unity Radial Basis Functions

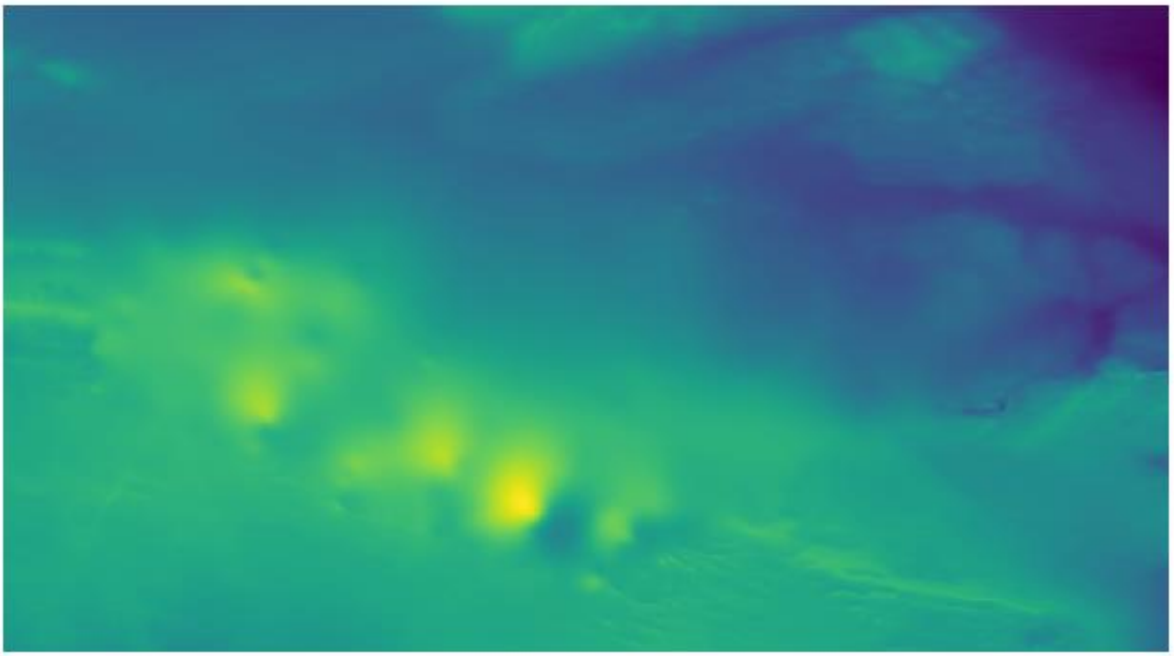


Figure 5. Example dataset interpolated using the Partition of Unity Radial Basis Functions interpolant (*purbf* option in interpolate_netcdf4.py).

This method was also developed in EMODnet Bathymetry HRSM2. Based on the low applicability of the original definition of the RBF interpolant, the Partition of Unity Radial Basis Functions (*purbf*) is an attempt to lower as much as possible the memory and computational requirements of the RBF interpolator.

The Partition of Unity Method (PUM) divides the global domain into smaller overlapping subdomains. In each of these subdomains, a RBF interpolant is computed using the formulation presented in *Radial Basis Functions*. Then, when evaluating a query location, the contributions of several neighboring RBF interpolations are *blended* together in order to get the final value.

More precisely, we enforce a quadtree decomposition. In the following figure we can see an example of this decomposition:

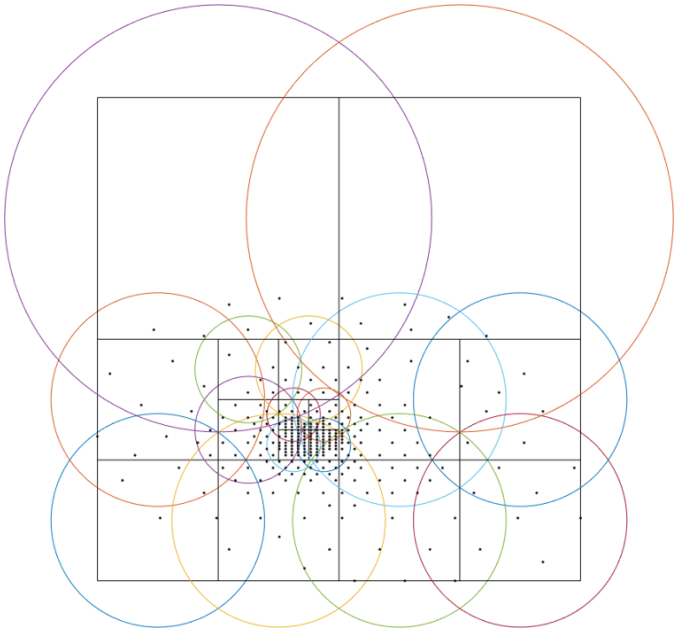


Figure 6. An example of the decomposition in *purbf* method. Reference data points are marked as black dots, the quadtree decomposition is shown using squares, and the domain of each local RBF corresponding to each square is shown with a colored circle.

Each cell in the quadtree defines a local RBF interpolant and its area of influence. Note how the different areas overlap between them (a condition for continuity) and how the area of influence of each local interpolant adapts to the complexity of the data (larger regions in more sparse areas, and smaller regions in denser ones). Finally, since the extent of local RBF is limited, we also ensure that at least one local interpolant covers all the data within the possible query space (i.e., it covers the extent of the input grid).

The PU interpolant preserves the local approximation order for the global fit. Therefore, large RBF interpolants can be computed by solving small interpolation problems and then combining them together with the global PU.

Suitable for

- Datasets for which the basic RBF interpolator required too much memory and computational resources.

Advantages

- Tunnable output: as in the RBF interpolator, changing the base RBF will change the shape/properties of the output interpolated surface.
- Preferrable in cases where the number of reference data points is far smaller than the number of points to interpolate.

Disadvantages

- While compared to the pure RBF, reduction in computational requirements is huge, it may not be sufficient for processing large datasets (i.e., it will still be slower to compute than other options in this package).

PDE-based Inpainting Interpolators

Our heightmaps are bivariate functions of the form $u(x, y) = z$, where x/y are the coordinates in a plane and z the corresponding elevation value.

A simple way of defining the interpolant is to define the properties that the "interpolating surface" $f(u)$ must be satisfied at interpolated areas using Partial Differential Equations (PDEs).

Once defined a given PDE, we can solve it using finite differences in a gradient-descent manner, where:

$$f(u)_{t+1} = u_t - \phi * \nabla(f(u_t))$$

Being the subindex t the iteration index, $\nabla(f(u_t))$ the PDE or the *gradient* that we need to follow,ϕ the size of the update step at each iteration. Given a properly small ϕ, we can iterate the equation above to *steady state* (i.e., no change) in order to solve for the functional.

Using discretized differential stencils, we can work directly on the input cell grid, and evolve the previous equation using just convolutions. We implement all the methods in this section using the same PDE solver. However, we explain in the next section some of the speed-up tricks that we use to accelerate the classical gradient descent optimization.

Speed-Up Tricks

The convergence speed of the gradient descent optimization on the inpainted area is highly dependent on the initial values. It is not the same as trying to evolve the solution using the optimization starting from a very vague solution (e.g. all unknown initial values are zero) rather than starting from initial values closer to the solution. In this direction, we provide two ways to better initialize the problem in Initializer and Multi-Grid Solver below.

Initializer

The initializers available are:

- *zeros*: init unknown values with zeros. This is the worst initializer, just kept here for comparison purposes with the rest.
- *mean*: init unknown values with a constant equal to the mean of the reference elevation values.
- *nearest*: use the nearest interpolant to initialize unknown values.

- *linear*: use the linear interpolant to initialize unknown values. Since this interpolant is just defined over the convex hull of the input data, data outside it will get a constant value equal to the mean of the reference elevation values.
- *cubic*: use the cubic interpolant to initialize unknown values. Same as in *linear*, it will get the mean value of reference value outside the convex hull of the reference data points.
- *harmonic*: uses the harmonic inpainter to fill the missing data. Note that, while being the fastest of the inpainter methods, this involves solving another gradient descent optimization, so depending on the complexity of the data it may be very slow.

Multi-Grid Solver

By setting the proper parameters, the interpolate_netcdf4.py function will use a Multi-Grid Solver (MGS). Basically, instead of solving the optimization problem at the full resolution grid directly, it will do it in a multi-resolution way.

The MGS starts building a pyramid of different levels of resolution from the original grid, where each level of the pyramid contains a halved resolution version of the previous one:

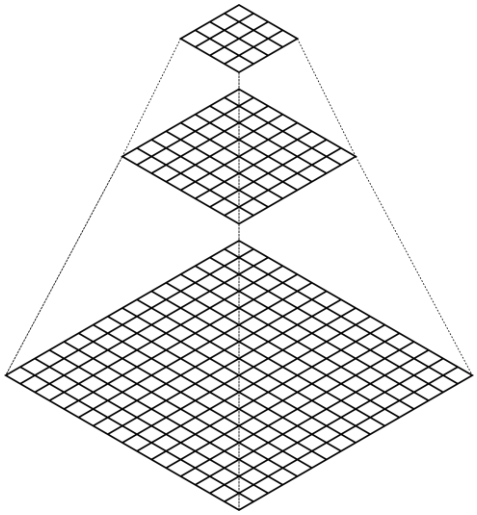


Figure 7. Schematic of the multi-resolution pyramid created by the Multi-Grid Solver. The original grid (bottom of the pyramid) is halved in resolution recursively to get lower resolution versions of the problem. Then, starting from the top of the pyramid, the inpainting problem is solved in a lower resolution version, and upscaled and propagated to the next (higher resolution) level of the pyramid as initial guess.

Then, starting from the coarser level, we solve the inpainting problem there, and use that solution to initialize the solver in the next (higher resolution) level of the pyramid.

Therefore, we use upscaled versions of the problem solved at coarser resolutions to initialize the inpainting problem at higher resolutions. In this way, the initial values of the optimization

at each level of the pyramid are closer to the final solution, decreasing like this the number of iterations required for convergence.

Harmonic Inpainter

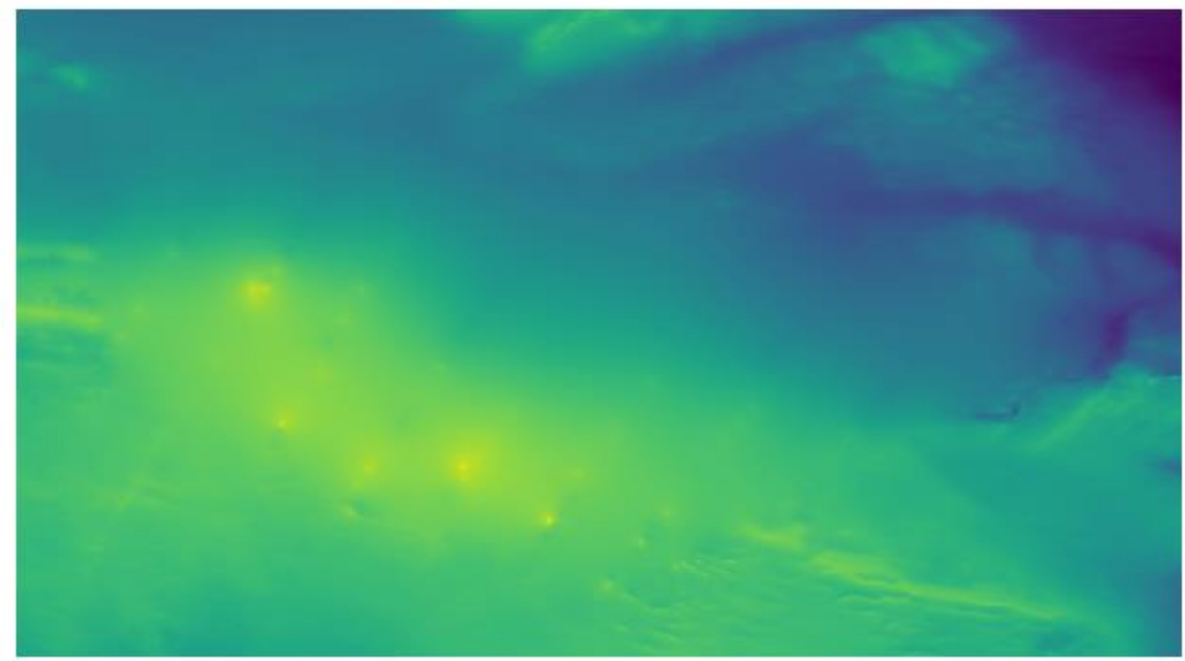


Figure 8. Example dataset interpolated using the Harmonic inpainter (*harmonic* option in interpolate_netcdf4.py).

An harmonic surface is a twice differentiable function satisfying the Laplace equation:

$$\nabla(f(u_t)) = \nabla^2 u_t = 0$$

This method has many analogies:

- It can be seen as an "isotropic diffusion" of the elevation values at the borders surrounding the missing data towards the area to interpolate.
- Its evolution follows the heat diffusion equation.
- It minimizes the Sobolev norm on the grid, constrained to the input reference data.
- The interpolated surface is a "minimum energy surface", and many times it is described as the "shape a film of soap would take if layed over the data points".

Suitable for

- Filling large gaps smoothly without overshooting the input data.

Advantages

- Fastest of the inpainting methods.

- It will never overshoot the data (minimum and maximum elevation values never below/over the reference ones).

Disadvantages

- Does not work well with sparsely sampled data: isolated data points will not contribute much to the interpolation.

Total Variation (TV) Inpainter

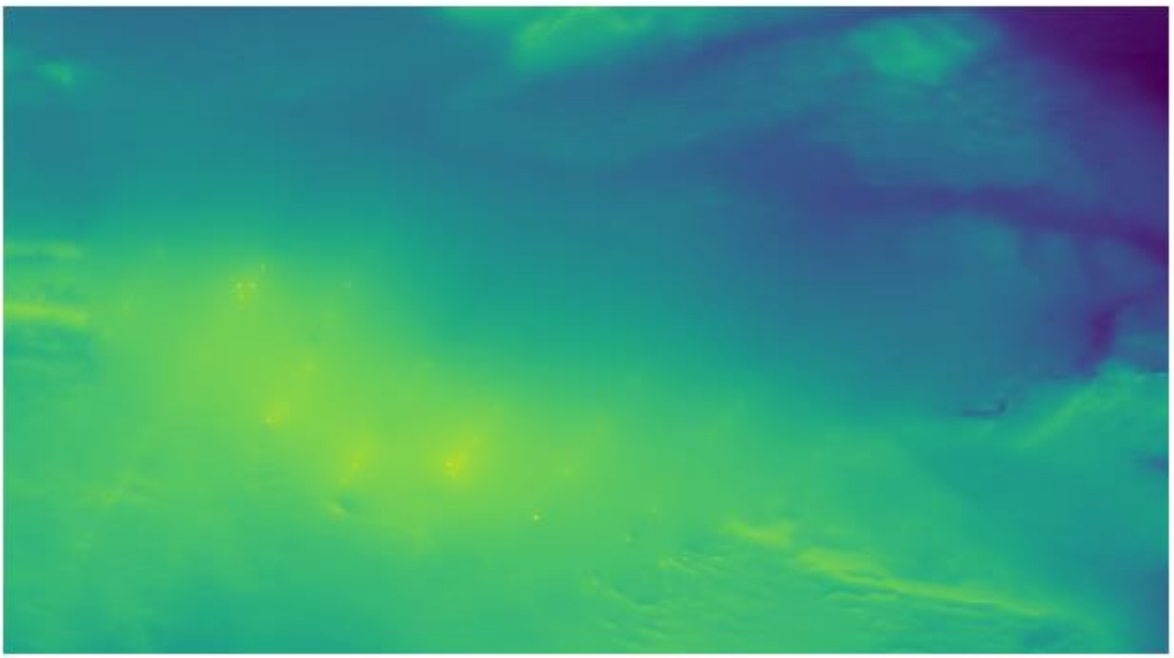


Figure 9. Example dataset interpolated using the Total Variation inpainter (*tv* option in interpolate_netcdf4.py).

Minimizes the Total Variation formula within the area to inpaint:

$$\nabla(f(u_t)) = -divN_\epsilon(\nabla u_t)$$

Where:

$$N_\epsilon(u) = \frac{u}{\sqrt{\|u\|^2 + \epsilon^2}}$$

Intuitively, it tends to preserve/continue high gradients better than *harmonic*, since the evolution of the optimizer can be considered a type of anisotropic diffusion.

However, it will not take into account isolated points, and should only be used for filling gaps with no data fully surrounded with reference data.

Suitable for

- Filling continuous gaps of data (i.e., not suitable for scattered data interpolation).

Advantages

- Provides similar results to the *harmonic* inpainter, but tends to better preserve level lines of the surroundings.

Disadvantages

- Does not work well with sparsely sampled data: isolated data points will not contribute much to the interpolation.

Continous Curvature Splines in Tension (CCST) Inpainter

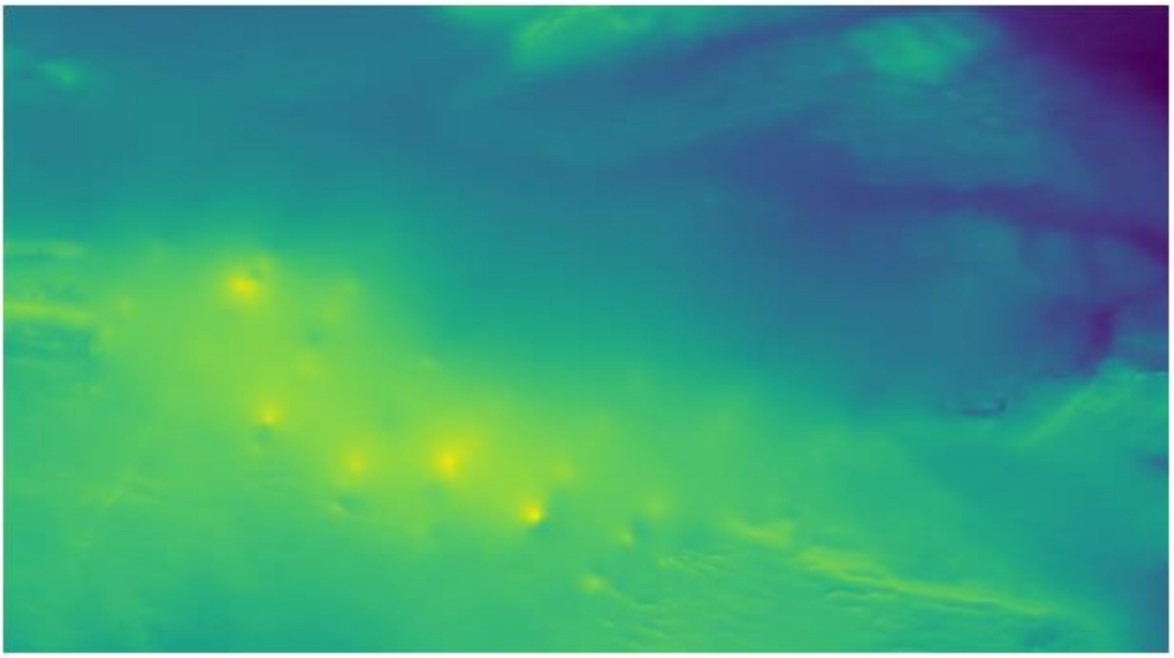


Figure 10. Example dataset interpolated using the Continous Curvature Splines in Tension inpainter (*ccst* option in interpolate_netcdf4.py).

Implements the method in [Smith90]. The PDE guiding this interpolant is the following:

$$\nabla(f(u_t)) = (1-t)\nabla^4 u_t - t\nabla^2 u_t = 0 \quad (1)$$

If we take a look to equation (1), we will identify that $\nabla^2 u_t$ is the harmonic equation (same as in Harmonic Inpainter). Also, in the other term, we find $\nabla^4 u_t = \nabla^2 \nabla^2 u_t$, the "harmonic of the harmonic", that is, the biharmonic surface. And, in both terms, they are affected by a constant t.

The *tension* parameter t allows tuning the influence of an harmonic and a biharmonic surface in the final result. Therefore:

- $t = 0$ equals a biharmonic surface.
- $t = 1$ equals an harmonic surface (same result as in Harmonic Inpainter).
- A value of t between 0 and 1 is a mixture of both harmonic/biharmonic interpolants.

In a nutshell, if we chop off the peak of a mountain at a given altitude, and we try to interpolate it using this method, $t = 0$ would probably reconstruct the peak of the mountain (note that this means that it will **overshoot** the input data), while $t = 1$ would reconstruct a flat area. A t between 0 and 1 would be a mix of both results.

Note that this is a re-implementation/variant of the method in [Smith90], which in turn is the method implemented in GMT surface.

[Smith90] Smith, W. H. F, and P. Wessel, 1990, Gridding with continuous curvature splines in tension, Geophysics, 55, 293-305.

Suitable for

- Getting a higher order interpolating surface, similar to what we achieve with the *purbf* method.
- Achieving **the same** results as using the *purbf* with a thin plate spline RBF (tension == 0) for datasets where the number of reference data points is much larger than the number of points to interpolate with smaller memory requirements and computational cost.

Advantages

- It provides an “easy to tune” mix of a harmonic and a biharmonic interpolant.

Disadvantages

- Slower execution time than other inpainters.
- Depending on the parameters, it may overshoot the data.

Absolutely Minimizing Lipschitz Extension (AMLE) Inpainter

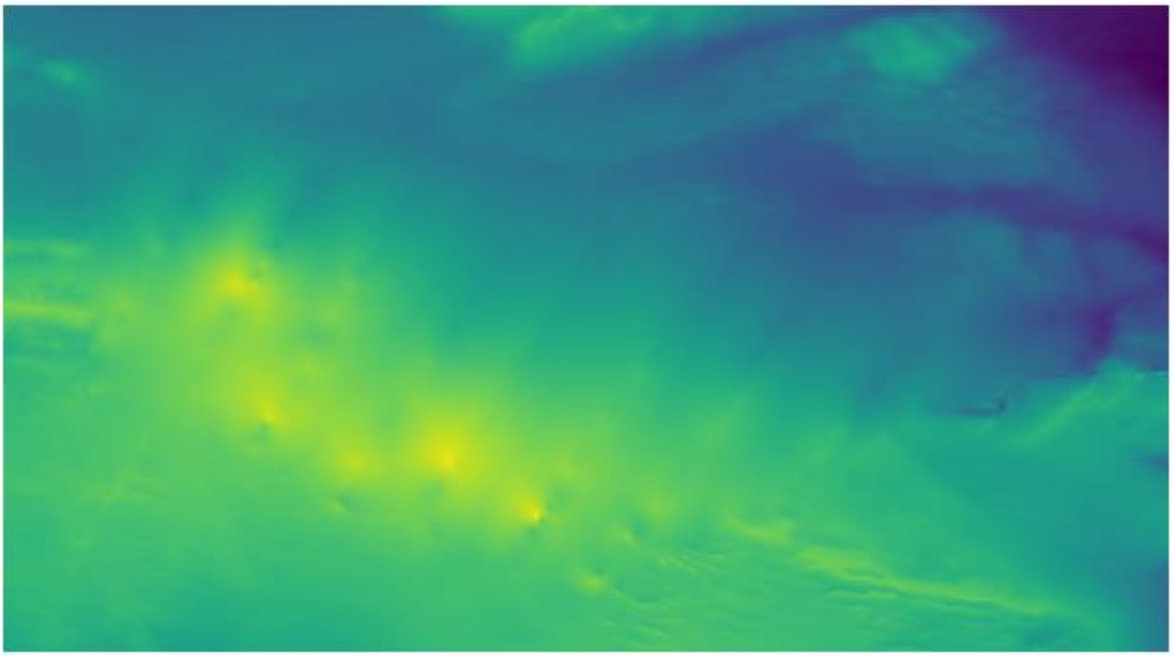


Figure 11. Example dataset interpolated using the Absolutely Minimizing Lipschitz Extension inpainter (*amle* option in interpolate_netcdf4.py).

Implements the method in [Almansa02]. Following the notation of the original reference, The PDE guiding this interpolant is the following:

$$\nabla(f(u_t)) = D^2 u_t \left(\frac{Du_t}{|Du_t|}, \frac{Du_t}{|Du_t|} \right)$$

Where Du denotes the gradient of u.

The main effort of the AMLE model is to “avoid oscillations”, i.e., to avoid the interpolated elevation to overshoot the reference values (min and max elevation value do not change). Also, it handles “isolated points'' in the reference data.

[Almansa02] Andrés Almansa, Frédéric Cao, Yann Gousseau, and Bernard Rougé. Interpolation of Digital Elevation Models Using AMLE and Related Methods. IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 40, NO. 2, FEBRUARY 2002

Suitable for

- Interpolating gaps in terrain data using a better interpolant, but trying not to overshoot the original data.
- Scattered data: this is the only approach that always takes into account scattered data properly (*ccst* with a tension apoaching 1 also does, but not so well if tension approaches 0…).

Advantages

- It is the only inpainter method in this package that was originally devised for interpolating heightmaps without overshooting the data.
- Contribution of isolated points is properly propagated within the area to interpolate.

Disadvantages

- Slower execution time than other inpainters.
- Depending on the dataset, it may require manual tuning of the update step size for the solver to converge.

Other Inpainters

Since one of the dependencies we use is OpenCV, and this library has some inpainting methods already implemented, we created interphases for using them on our heightmap interpolation problem. Note that these methods are typically used for closing small, thin gaps, as the ones you can see in the examples of the OpenCV documentation.

OpenCV's Telea

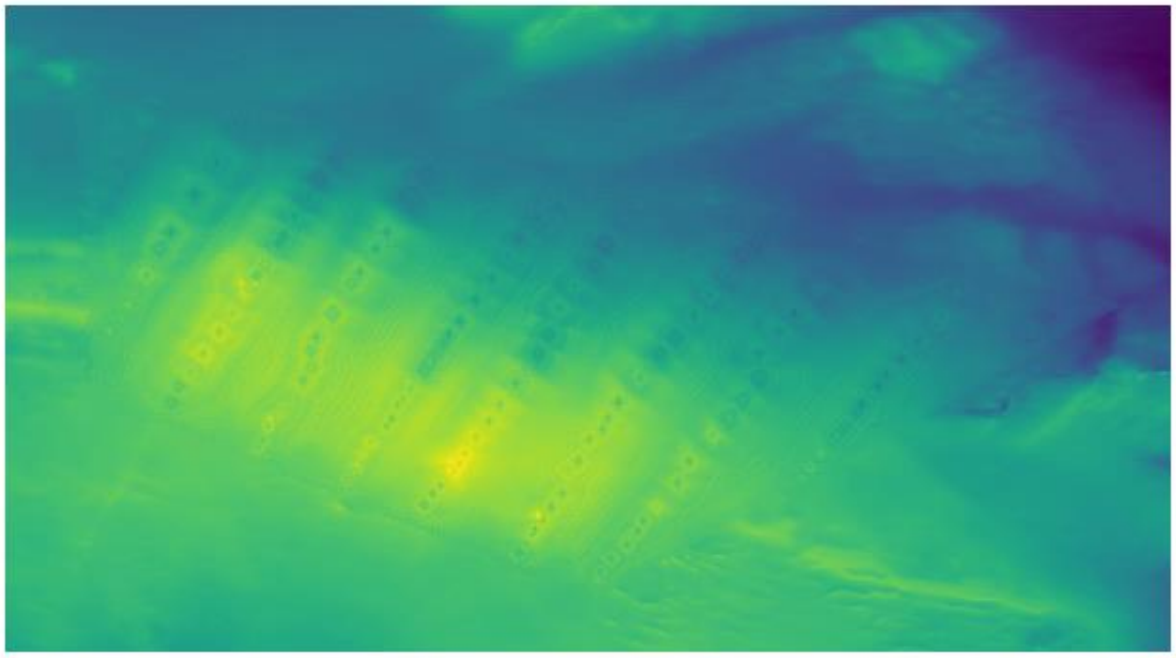


Figure 12. Example dataset interpolated using the OpenCV's Telea inpainter (*telea* option in interpolate_netcdf4.py).

The Telea variant of OpenCV's inpaint function.

Suitable for

- Interpolating “thin” continuous missing data parts fast.

Advantages

- Faster than PDE-based inpainters.

Disadvantages

- Does not consider scattered data at all.

OpenCV’s Navier-Stokes

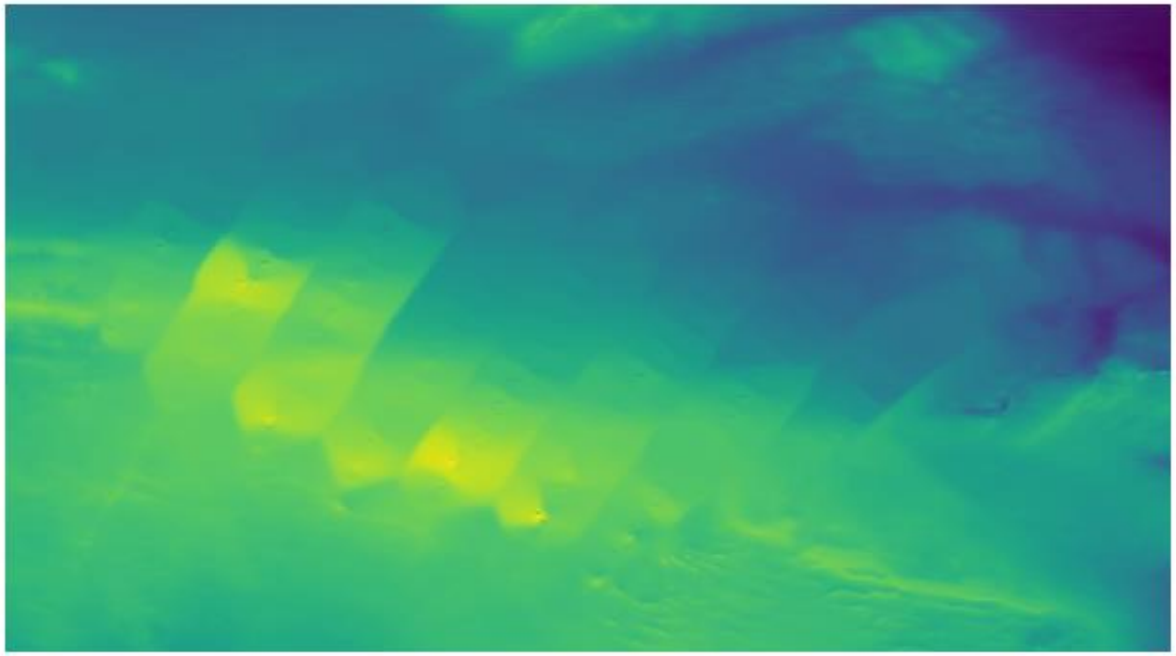


Figure 13. Example dataset interpolated using the OpenCV’s Navier-Stokes inpainter (*navier-stokes* option in interpolate_netcdf4.py).

The Navier-Stokes variant of OpenCV’s inpaint function.

Suitable for

- Interpolating “thin” continuous missing data parts fast.

Advantages

- Faster than PDE-based inpainters.

Disadvantages

- Does not consider scattered data at all.

Work to be done during the 2nd year of the project

In the same line, CORONIS will be trying to update the interpolation package with new methods. One specific problem that was not directly tackled by any of the methods implemented so far is to continue ridges inside missing areas for densely sampled datasets. In other words, if we were to inpaint a “hole” in the elevation map, surrounded by densely-sampled areas, we would like the ridges and elevation lines orthogonal to the hole to continue coherently inside the missing part. CORONIS will review the state of the art in this problem in the image inpainting literature and implement/adapt suitable methods to the elevation inpainting problem.

Annex 4: EOMAP progress with Satellite Derived Bathymetry (SDB) production for EMODnet Bathymetry – December 2021

Annex 4: EOMAP progress with Satellite Derived Bathymetry production for EMODnet Bathymetry – December 2021

1 Objective

EOMAP will provide Satellite-Derived Bathymetry data for all the overseas territories of European countries in the Caribbean where shallow water data gaps exist or are not accessible to the EMODnet Bathymetry project.

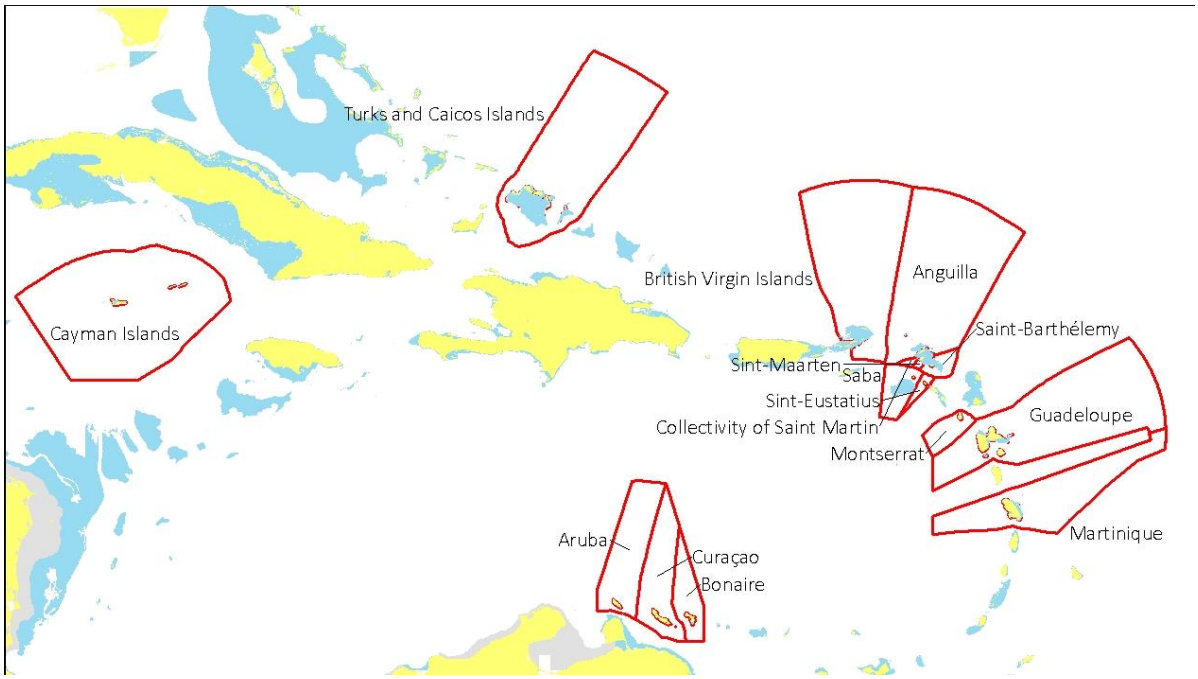


Figure 1: Map of UK, NL and FR Caribbean oversea territories (red) and identification of potential shallow waters (light blue).

The work was structure into a (1) the identification on those oversea territories where survey data exist by other entities which contribute or might be able to contribute those to the project and (2) the analysis of Satellite-Derived Bathymetry for those sites, where shallow water bathymetric data do not exist or are not shared to the EMODnet project.

2 Identification of shallow water bathymetric data for European oversea territories.

The French oversea territories were recorded my recent and high resolution Airborne Lidar Topo-Bathy data. Data will be shared with EMODnet. Thus, no data gaps and therefore no need for SDB activities exist.

UK territories are fully (Anquilla) or partly (Cayman, Turks&Caicos, Montserrat, British VI) covered by recent airborne or acoustic survey data. However, discussion with UKHO is ongoing (jointly with Thierry Schmitt) to see if and what kind of data UKHO might or might not contribute. We have decided to include the UK sites in the SDB analytics, but being aware that some of those might be replaced by existing data of UKHO if they are provided in future.

Shallow waters of the NL oversea territories are partly covered by acoustic (single beam or MBES) surveys but data gaps exist in the very shallow water zones. For Sint Maarten, new bathymetric airborne Lidar data have been collected but are not accessible at time of writing. Thus, SDB data add value in the coastal/very shallow waters. For Sint Maarten, new bathymetric airborne Lidar data have been collected but are not accessible at time of writing.

See section 4 for a summary of the sites.

3 Current status on Satellite-Derived Bathymetry analytics

3.1 Satellite data selection

For each of the sites we have identified 3 to 10 satellite records from the Sentinel-2, multispectral satellites. We have selected datasets based on the following criteria: (1) atmosphere free of clouds, haze or dust, (2) no floating substances or objects (oil films, floating vegetation), (3) as clear water as possible, (4) the most favourable illumination and recording geometries to ensure radiometric stability and avoid water surface effects (sunglint) and (5) minor or no impact of waves and wave-breaking. The image data were recorded between 2017 to 2021.

3.2 Satellite-Derived Bathymetry (SDB) analytics

EOMAP uses the Modular Inversion and Processing System (MIP) to process imagery and apply a number of relevant pre- and post-processing corrections. Since 1998, a team of physicists, mathematicians and IT experts have systematically developed MIP processors for shallow-water and SDB applications[1] within various research programs[2]. This has continued to evolve since 2006 as proprietary EOMAP technology[3]. Within the MIP, radiative transfer modelling of the coupled atmosphere-water systems is based on the Finite Element-Method (FEM) reference model of EOMAP staff Dr. Kiselev. This has a 30 years development history[4, 5], featuring the state-of-the-art algorithms as listed below. To support efficient production workflows and automated processing, MIP modules and EOMAP pre-/post processors are orchestrated within the EOMAP Workflow System (EWS).

As part of EOMAP's relentless R&D program, this system is continuously being improved. Several years ago, saw the full physical implementation of the atmosphere, water column and seafloor system, in order to map bathymetry independently of any ground truth data availability. Water

[1] a) Heege, T. , Häse, C. , Bogner, A., Pinnel, N. (2003): Airborne Multi-spectral Sensing in Shallow and Deep Waters. Backscatter p. 17-19, 1/2003

b) Heege, T., Bogner, A., Pinnel, N. (2004): Mapping of submerged aquatic vegetation with a physically based process chain. Remote Sensing of the Ocean and Sea Ice 2003. Editors: Charles R. Bostater, Jr. &RosaliaSantoleri. Proc. of SPIE Vol. 5233, ISBN: 0-8194-5116-9 pp. 43-50.

[2] 1998 - 2007, Collaborative research project SFB 454 "Lake Constance Littoral" - research project D3 "Remote sensing of shallow water areas", funded by the DFG (German Research Foundation). Interdisciplinary joint project Univ. Konstanz and DLR. DLR project lead: Dr. T. Heege

2002 - 2005: Development of automated remote sensing tools, supporting management of littoral zones in lakes, part B, BWC21011, supported by BWPLUS. Interdisciplinary joint project DLR and Univ. Hohenheim. DLR lead: Dr. T. Heege

2003 - 2005: High-Tech Offensive Zukunft Bayern project No. 290, Pilot project Waging-Tachinger See, Limnological Station of the Technical University Munich

2016 – 2018: Horizon 2020 project BASE-platform.

[3] 2008 - 2010: AUKLASS, Development of operational image classification processors for seafloor mapping applications. AUKLASS IBS-3667a/321/7/-TOU-08080003, supported by the Bavarian Ministry of Economy and Infrastructure

2010 - 2013: EU FP7 FRESHMON Downstream project.

2012 - 2015: Apps4GMES: Development of automated bathymetry processor, supported by the Bavarian Ministry of Economy and Infrastructure.

2015 - 2017: EU H2020 Base-platform: Development of integrated bathymetry services

[4]Kisselev, V.; Bulgarelli, B. (2004). Reflection of light from a rough water surface in numerical methods for solving the radiative transfer equation. Journal of Quantitative Spectroscopy and Radiative Transfer 85, 419-435.

B. Bulgarelli, V. Kisselev, L. Roberti (1999): Radiative Transfer in the Atmosphere Ocean System: The Finite-Element Method. Appl. Opt. 38, pp. 1530-1542

[5]Kisselev, V.B.; Roberti, L.; Perona, G. (1995), Finite-element algorithm for radiative transfer in vertically inhomogeneous media: numerical scheme and applications. Appl. Opt. , 34, 8460-8471.

depth, water constituent's optical properties, as well as sub-surface and seafloor reflectance are derived in a coupled, iterative process, which several correction and algorithms to correct for various recording and environmental specification (details to be provided on request). More recently, multi-image parallel processing (US Patent, 2017) was implemented for MIP, significantly increasing vertical accuracy and the robustness of depth retrievals.

The following figure provides the results for Grand Cayman Island as a showcase of the created bathymetric data.

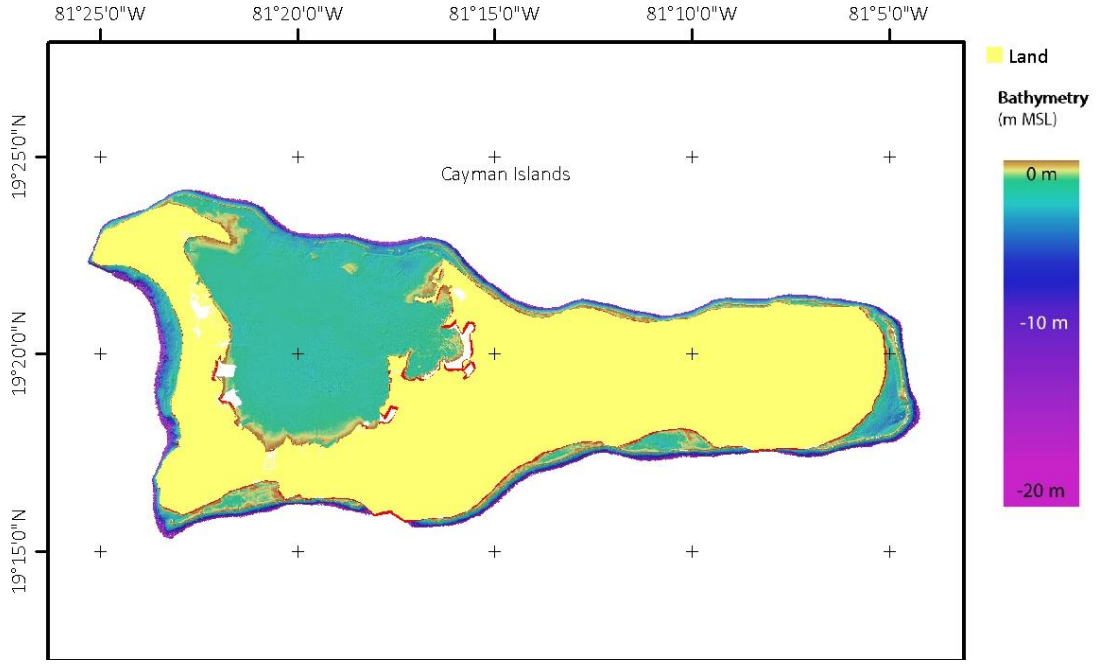


Figure 2: Satellite-Derived Bathymetry (SDB) coverage for Grand Cayman Island.

So far, we have created 6,291 sq km of shallow water bathymetric data – similar to those shown in the previous figure - for the Caribbean oversea territories.

3.3 Satellite-Lidar Bathymetry (SLB) analytics

EOMAP's Satellite-Lidar Bathymetry (SLB) database holds bathymetric depth points which are derived from the ICESat-2 satellite. NASA's ICESat-2 satellite launched in September 2018 and carries ATLAS, a green photon-counting lidar with a 10kHz pulse repetition rate and nominal 17m diameter footprint. Correction routines are applied to account for the water refraction and recording geometry [6]as well as effects on tides and water heights[7]. A proprietary cluster algorithm separates seafloor photon returns from both the water column and water surface returns (see next figure).

[6] Parrish, C.E.; Magruder, L.A.; Neuenschwander, A.L.; Forfinski-Sarkozi, N.; Alonzo, M.; Jasinski, M. Validation of ICESat-2 ATLAS Bathymetry and Analysis of ATLAS's Bathymetric Mapping Performance. Remote Sens. 2019, 11, 1634. https://doi.org/10.3390/rs11141634

[7] Neumann T., Brenner A., Hancock D., Robbins J., Saba J., Harbeck K.,Gibbons A., Lee J., Luthcke S., Rebold T. 2021. CESat-2 Algorithm Theoretical Basis Document for Global Geolocated Photons (ATL03). Release 004. https://icesat2.gsfc.nasa.gov/sites/default/files/page_files/ICESat2_ATL03_ATBD_r004.pdf

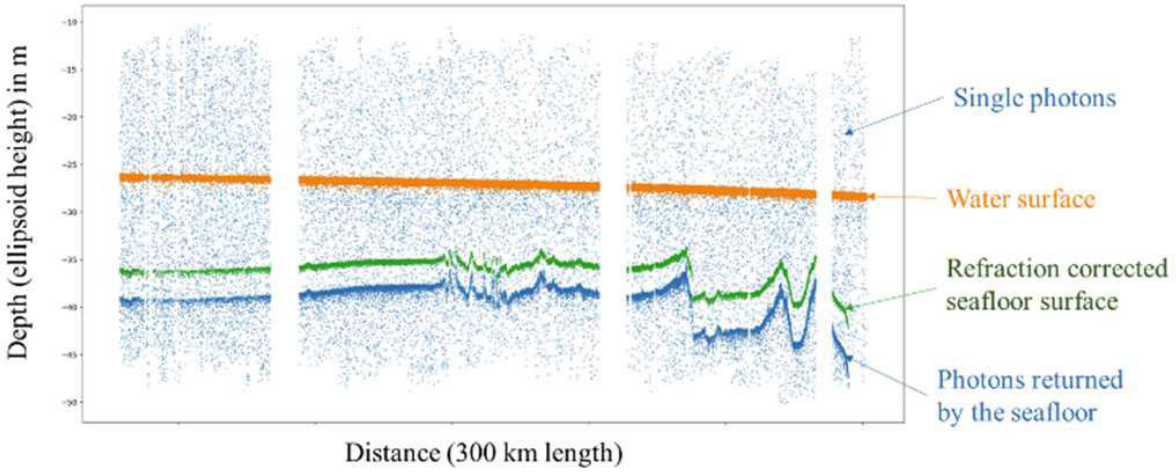


Figure 3: Example of an IceSat-2 Atlas trackline for the Bahamas. The orange line represents single photons which are returned from the water surface, each blue point represents one single photon and the clustered blue dots represent the seafloor returns. Following the correction for the recording geometry and water refraction the blue dots represent the non-tidal corrected depth. Note that the heights are given in ellipsoid and the curvature of the water surface can be seen for this transect of 300 km length.

ATLAS records photon returns in discrete tracklines covering the entire globe, which are capable of measuring bathymetry in a similar procedure to that applied in multispectral imagery. Importantly, ATLAS by itself cannot create a dense spatial grid as each trackline can be up to hundreds of kilometres apart.

We have accessed all ICESat ATLAS tracklines for the study sites and performed the bathymetric data analysis which resulted in 6.7 Million bathymetric depth points in total (see next figure for an example of Grand Cayman Island).

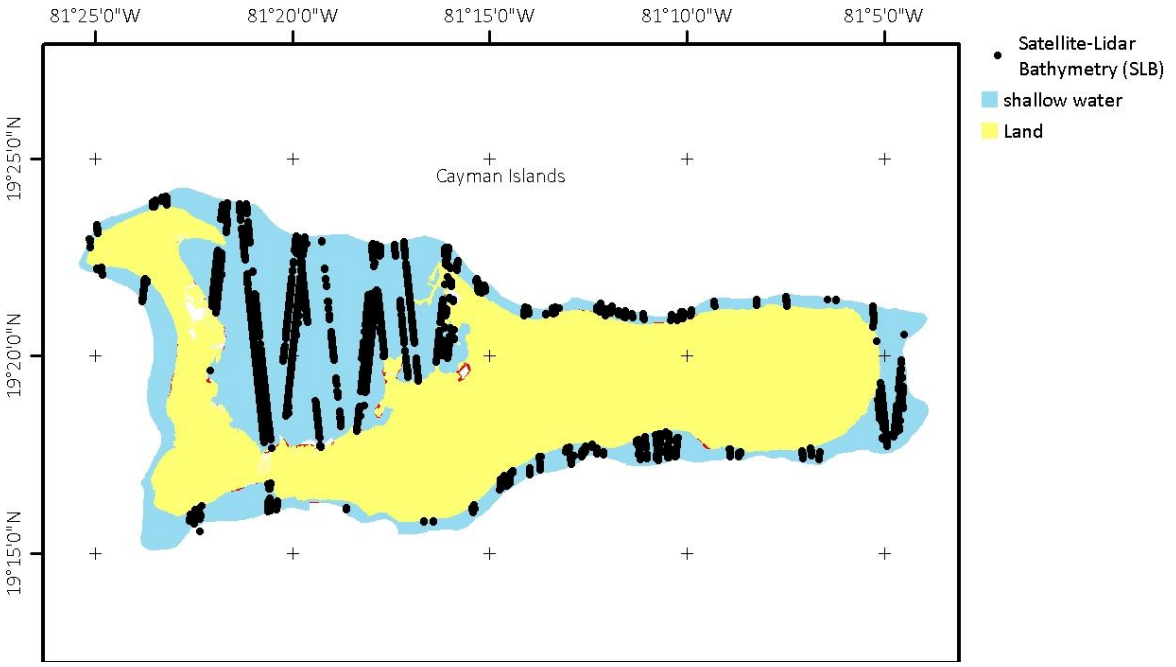
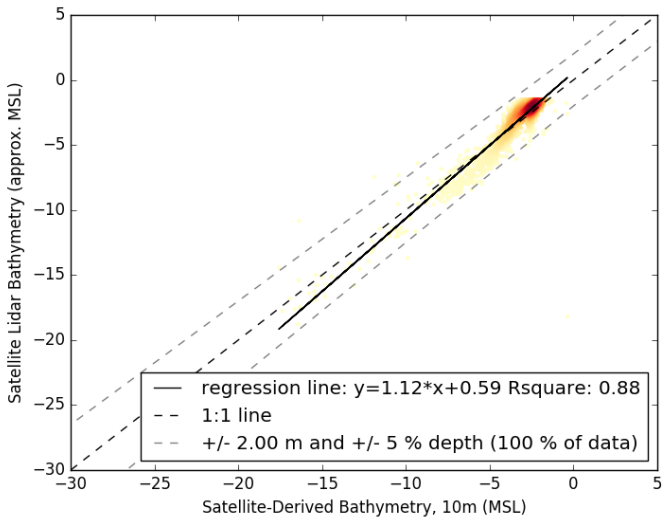


Figure 4: Satellite-Lidar Bathymetry (SLB) coverage for Grand Cayman Island.

3.4 SDB data validation and verification

We have compared the SDB grids against survey data if accessible (mostly accessible for NL territory so far) and against the Satellite-Lidar Bathymetry data (see section 3.3). For each site we created scatterplots, such as shown in the next figure for Grand Cayman Island and statistics on the comparison.



Statistics of the comparison of SDB and SLB*

N	*48220*
Mean Square Error	*0.56cm*
CAT ZOC B (% of data)	*74.7 %*
CAT ZOC C (% of data)	*99.5 %*
R^2	*0.88*

* Note that SLB has it's own vertical uncertainties in the rang of 0.5 to 1m and cannot be compared against modern airborne Lidar surveys.

Figure 5: Comparison of Satellite-Derived Bathymetry grid of 10m spatial resolution (X-axis) and the Satellite-Lidar Bathymetry data (Y-axis) for Grand Cayman Island.

4 Current status in summary

The following table provides a summary of the current status of the SDB data analytics. To summarize, all data have been created and checked, final validation and conversion to the required EMODnet Bathymetry DTM file format need to be done. Sextant metadata have been uploaded.

6.7 Million bathymetric data have been created using the Satellite-Lidar sensor and shallow water bathymetric grids created from Satellite-Derived Bathymetry technique have been create for 6.3 K sq km.

Site name	Status on available bathymetric survey data	SDB action	Satellite-Lidar Bathymetry (SLB) Analytics	Satellite-Derived Bathymetry (SDB), multi-scene analytics	Satellite-Derived Bathymetry (SDB), Validation	Satellite-Derived Bathymetry (SDB), QA/QC	EMODnet Bathymetry delivery package creation	Satellite-Derived Bathymetry (SDB), delivered to project	Total SDB area (sq km)
Sint Maarten (NL)	NL survey data available but data gaps exist	filling data gaps	100%	100%	75%	100%	not yet	not yet	
Saba (NL)	NL survey data available but data gaps exist	filling data gaps	100%	100%	0%	0%	not yet	not yet	
Aruba (NL)	NL survey data available but data gaps exist	filling data gaps	100%	100%	75%	100%	not yet	not yet	
Curacao (NL)	NL survey data available but data gaps exist	filling data gaps	100%	100%	75%	100%	not yet	not yet	
Bonaire (NL)	NL survey data available but data gaps exist	filling data gaps	100%	100%	75%	100%	not yet	not yet	
Caymen, East (UK)	no survey data	SDB data analysis and provision	100%	100%	75%	100%	not yet	not yet	
St. Martin (FR)	SHOM surveyed all shallow waters with high resolution airborne lidar data.	no SDB analysis requried	not relevant	not relevant		not relevant	not relevant	not relevant	
Saint Barthelemy (FR)	SHOM surveyed all shallow waters with high resolution airborne lidar data.	no SDB analysis requried	not relevant	not relevant		not relevant	not relevant	not relevant	
Guadeloupe (FR)	SHOM surveyed all shallow waters with high resolution airborne lidar data.	no SDB analysis requried	not relevant	not relevant		not relevant	not relevant	not relevant	
Martinique (FR)	SHOM surveyed all shallow waters with high resolution airborne lidar data.	no SDB analysis requried	not relevant	not relevant		not relevant	not relevant	not relevant	
Anquilla (UK)	UKHO has full bathymetric coverage but it is not known if data are provided to the project	pending, depending on data contribution of UKHO	100%		75%		not yet	not yet	
Cayman, Grand Cayman (UK)	UKHO has limited survey coverage but it is not known if data are provided to the project	SDB data analysis and provision	100%	100%	75%	100%	100%	not yet	
Caicos Islands (UK)	UKHO has limited survey coverage but it is not known if data are provided to the project	SDB data analysis and provision	100%	100%	75%	100%	not yet	not yet	
Turks Islands (UK)	UKHO has limited survey coverage but it is not known if data are provided to the project	SDB data analysis and provision	100%	100%	75%	100%	not yet	not yet	
Montserrat (UK)	UKHO has limited survey coverage but it is not known if data are provided to the project	SDB data analysis and provision	100%	100%	75%	100%	not yet	not yet	
British Virgin Islands (UK)	UKHO has partly coverage but it is not known if data are provided to the project	SDB data analysis and provision	100%	100%	75%	100%	not yet	not yet	

Table 1: Summary of the current SDB status for EMODnet Bathymetry.