Best Practises for Multibeam Data Processing with Qimera

Adapted from AWI 'Polarstern-HSDS3-Survival_Guide_v3_6'

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1.0	Initial version	Mia Schumacher	03/2024

Hi!

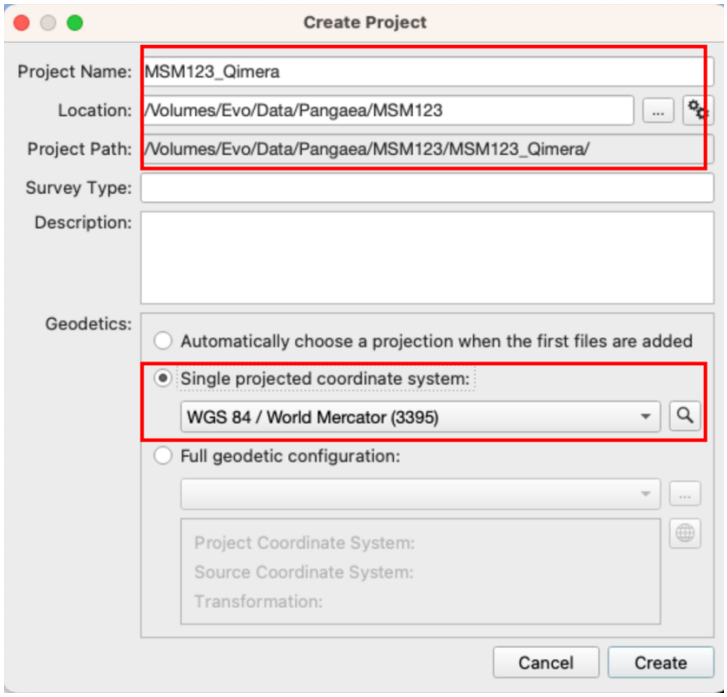
Welcome to the Geomar 'Bathymetry Processing with Qimera' Manual! If you made it to here, you're probably as convinced of bathymetry than we are and you are willing to follow a useful workflow (: This guide is based on the AWI bathy processing guides and workflow and has been adjusted to Geomar needs. It comprises the workflow from processing raw bathymetry data, exporting them to useful formats to provide them to the public. For now (02/2024), this guide only addresses Kongsberg .all data from the EM-family. As we aim towards a seamless data flow within the Geomar data management, we put quite an emphasis on the importance of naming conventions and folder/storage locations. So please consider to use the structure that we propose here. It is also very much recommended to use a processing protocol. Find more in the protocolling section. Note that *click-advices* are printed in *italic* and **processing steps or important stuff** are in **bold**. Also Qimera uses lots of different icons and shortkeys, a list of which you can find at the end of this manual. This doc is part of a bunch of SOPs and best practises for multibeam data work. For help with data acquisition using Kongsberg systems, please refer to the SOP_MultibeamDataAcquisition_KongsbergSIS_Geomar.pdf. For information about the underway data workflow, please go to the SOP_MultibeamDAMWorkflow_Geomar.pdf. Right, let's begin!

Step 1: Create A Qimera Project

As most GIS-like visual software, you need to create a project before anything else. This means that in the background, a folder structure is created that we don't really need but Qimera does. At this point, we hit the first **naming convention**: Please call the new project as follows:

{Cruise}_Qimera where {Cruise} is the cruise name, e.g. MSM123 (Maria S. Merian 123) and save it to the **{Cruise} folder**.

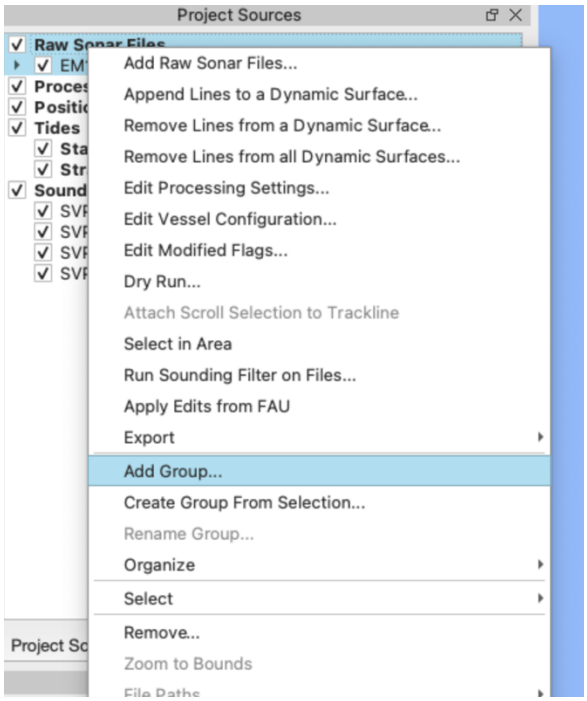
A very important thing when creating a new project is the correct choice of the underlying coordinate systems (CRS). Geographic CRS are a massive topic that can't imaginably be covered here, but **do not use the default settings here**! Qimera per default selects UTM and automatically sets the UTM zone of the first file that comes in. Which is fine for small scale applications, but once there is a change in UTM zones (which is almost always the case on a long cruise) things become very annoying and we encounter significant distortions outside the correct UTM zone. So, under 'Geodetics', activate single projected CRS and select **World Mercator/EPSG3395**. World Behrmann would be the better choice as it preserves areas, but is not supported by Qimera.



1: Qimera create new project

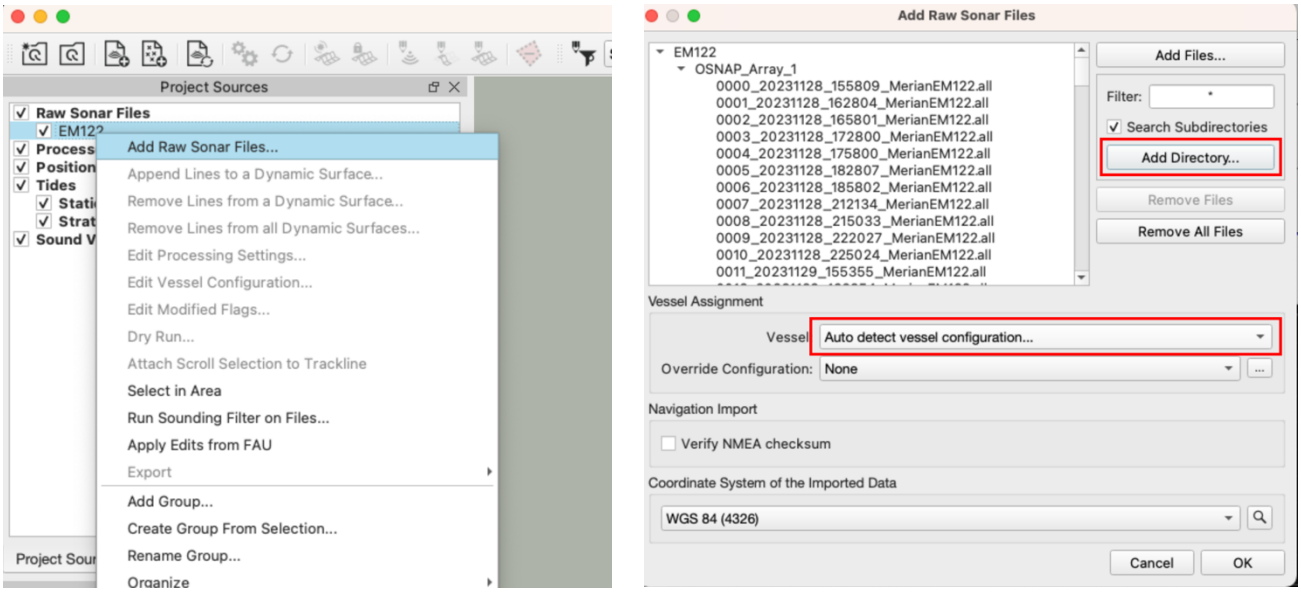
Step 2: Adding Data

Now Qimera asks you to import raw files, but we ignore this for now and first **create a group** under 'Raw Files' for each of the MBES Systems (e.g. EM122, EM710 etc.) (*Right-Click on Raw files -> Add Group*). This later on becomes useful when we create surfaces to separate well between the systems and their files.



2: Qimera Add Group

Now you can *right-click on the group and add Raw Sonar Files*. For the first import of each MBES system, let Qimera automatically detect the **correct vessel configuration**. Behind the term 'vessel configuration' is a file that contains information about the offsets of the transducer to each other, the GPS antenna and the motion unit etc, plus date and time and some **parameters as set during acquisition** in the SIS software templates. Hence, if different templates have been used for the same MBES system during data acquisition (i.e. if someone messed around with templates), there will be **multiple vessel files**. To avoid this and to learn how to correctly set up SIS templates, please refer to the acquisition manual: SOP_MultibeamDataAcquisition_KongsbergSIS_Geomar.pdf. Qimera reads and applies the vessel config automatically. If you encounter issues with different vessels, it can be handy to **organise files by vessel** to see which files belong to which configuration (*select all raw files -> right click -> 'Organize by Vessel'*).
Once the files are loaded, they are **inspected and pre-processed automatically**. (In case you ever have to use the official Qimera manual, this is meant when they refer to the 'dynamic engine'.) In the background, Qimera **creates editable .qpd files** for each raw file. That means everything you do, like removing outliers etc., happens on the .qpd files, not on the raw data themselves. This is great, because if you mess around, the originals won't be affected (:.



3: Qimera add raw data

Step 3: Create A Dynamic Surface

Once Qimera finished preprocessing, you can select all the raw files and create a dynamic surface (*Dynamic Surface -> Create Dynamic Surface*). This basically means that an algorithm in the background **estimates a 2D surface** (like a Digital Terrain Model, DEM) from the sounding point cloud that you've loaded in as raw files. It's called dynamic because of the interpolation between the points. If you see an error message popping up that 'some files need processing', *click yes*. In most cases, this won't help as the respective files contain no data or have no motion data etc. You will see a wheel next to the corrupt file. (If you close and open Qimera, this wheel

will become a little skull (:). This a good way to **identify corrupt data**. Remove them (*right-click on the file -> Remove*) – don't worry, again, this is just the .qpd file you're working on. If all broken files are removed from the project, it should be possible to create a dynamic surface. And here comes the second **naming convention**:

{Cruise}_{MBES}_{Resolution}_{Soundings}_{CRS}

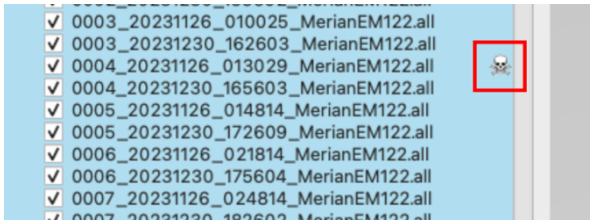
where
{Cruise} = Cruise name
{MBES} = MBES System
{Resolution} = Grid cell resolution
{Soundings} = see below
{CRS} = Project Coordinate System

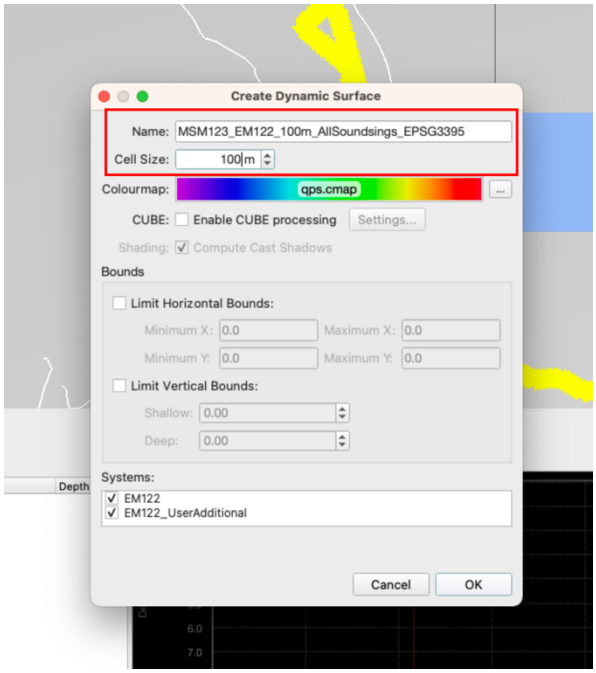
e.g.: MSM123_EM122_100m_AllSoundings_EPSG3395

Where {Soundings} is one of:

- AllSoundings = Completely uncleaned
- Spline = Spline filtered
- AcceptedSoundings = Completely(!) edited manually; This is for the final export and publication
- TEMP = Temporary grid that can be deleted and is just for your purposes; can e.g. be partially cleaned etc.

For the correct grid resolution, you can either refer to Mayer et al. 2018 (more general, table below) or to the system specs (very complex). Don's use CUBE unless you know what you do. It's an automatic cleaning tool that runs in the background when creating a dynamic surface. But if you plan to clean the data manually, CUBE is not needed.





4: Qimera skull and dynamic surface dialogue

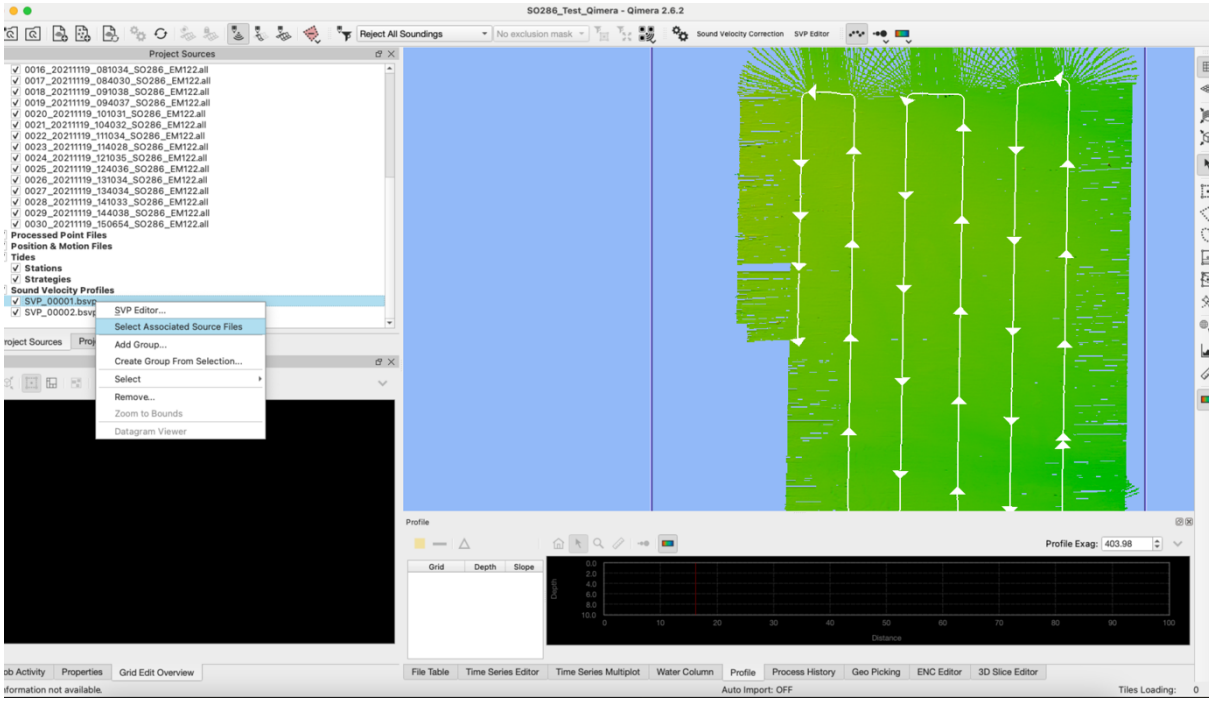
Step 4: Sound Velocity

Sound velocity profiles (SVP) are an important feature that is well underestimated. But they are absolutely crucial to perform correct beam raytracing and hence to locate the exact position of each sounding on the seafloor. Usually, SVP are applied on-the-fly during data acquisition. Technically this means that sound velocity corrections are made to the raw data in real time within the data acquisition software (for Kongsberg this is SIS). These corrections are implemented in the .all files already however, they only affect the files that are recorded after the SVPs has been applied – i.e., if the SVP has been applied too late for example, bathymetry that has been recorded before that will **not be affected by the correct SVP** (but by the one before that might not be the most optimal one). Also, often these applied SVPs **do not possess position information**. The good thing is, if you have SVP profiles from e.g. a CTD, you can always still apply them in the post-processing. It is **even recommended to re-process everything using correct SVP parameters**, to correct for the above-mentioned information lacks. To learn how, please move to the next section. To learn how to process SVPs from CTD or generate SVPs from the World Ocean Atlas (WOA), please refer to the SVP section in the Geomar data acquisition SOP (SOP_MultibeamDataAcquisition_KongsbergSIS_Geomar.pdf).

Import SVP to Qimera

In Qimera, all applied SVPs are listed in the *'Project Sources' tab under 'Sound Velocity Profiles'*. Note there is usually more than one SVP. The .all metadata store information about which SVP has been applied on which .all file. If needed, Qimera lets you **select raw files based on their respective SVP**: Under *‚Sound Velocity Profiles'* (upper left panel) *-> right-click a .bsvp file -> hit 'Select Associated Source Files'*. An important thing to know is that **SVP files are applied per**

vessel configuration. So in case there are multiple vessels (see earlier section), the following adjustments have to be done for each vessel configuration.



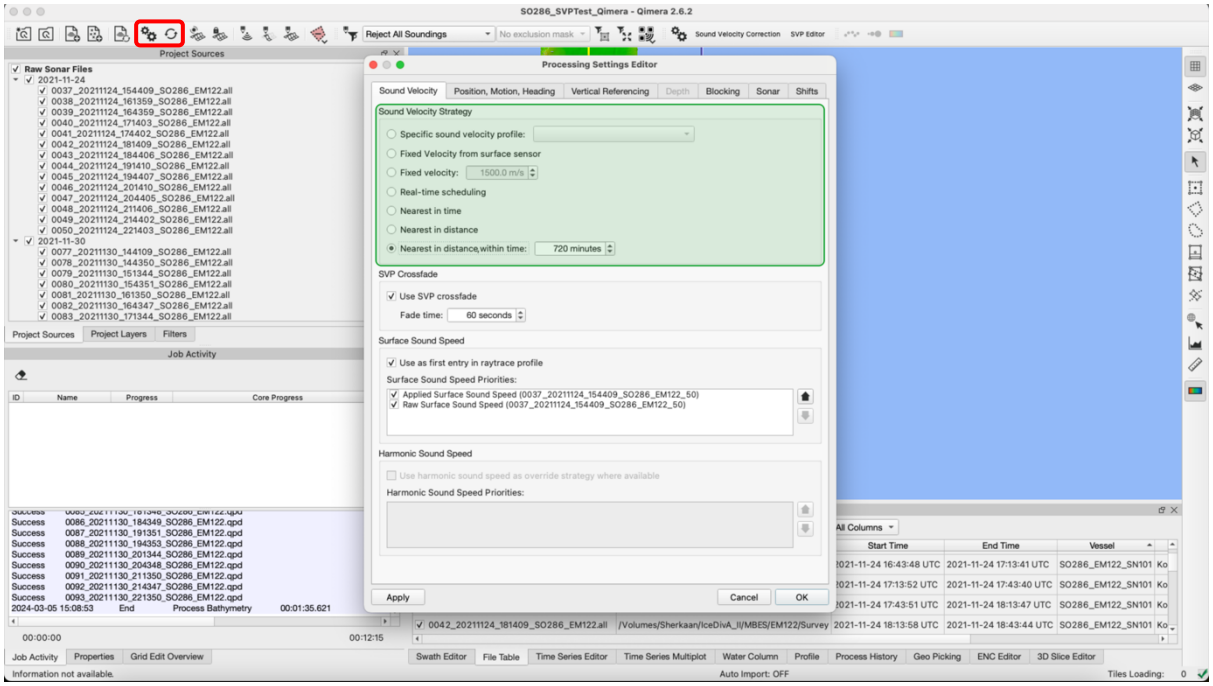
5: Select files based on SVP

Per default, Qimera retrieves SVP as applied during acquisition from the raw multibeam data at the import. But, as mentioned before, we would like to **optimise on-the-fly SVP to it to 'Nearest in position and time'** or, if this is not possible, at least to **'Nearest in Time'**.

If SVPs from CTD are available

If you have processed CTD SVPs available (see here) in the correct Kongsberg format (.asvp), follow these steps to (re-)apply them using '**Nearest in distance and time**' to the raw multibeam data:

- Import **processed .asvp to Qimera**: *click 'Source' -> 'Import' -> 'Import Kongsberg asvp'*
- *Select the* **correct vessel file** (Note: There should be one vessel per MBES (one for each EM122/EM710 etc.)
- If there is more than one vessel: import the same SVPs multiple times and assign them to all vessels; if there is more than one vessel file per MBES, then multiple SIS templates during acquisition were used.
- To make things easier, you can organise .all files e.g. by vessel: *select all .all files -> right click and select 'Organise per Vessel'*
- Delete **automatically imported SVPs**
- *Select* ***all raw files*** *-> open Processing Parameters (gearwheel in the top left panel) -> under 'Sound Velocity', select '****Nearest in distance, within time*** *[720m]'*
- *Also tick 'Use SVP cross-fade'* and leave it to 60s (this helps to reduce jumps in the data).
- Now Qimera needs to **do the raytracing again**, to do so, *click the circle arrows* (top left panel, next to gearwheel)

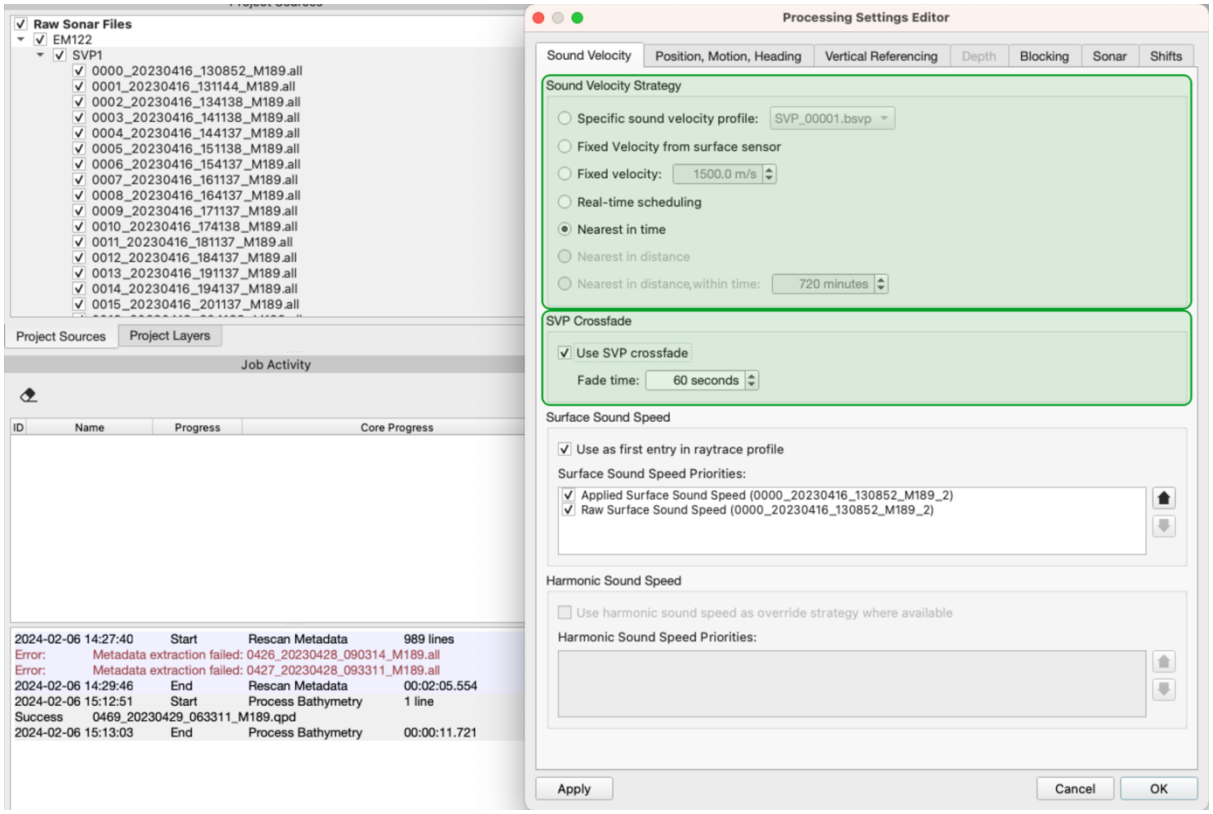


6: Editing Sound Velocity Parameters – with CTD SVP

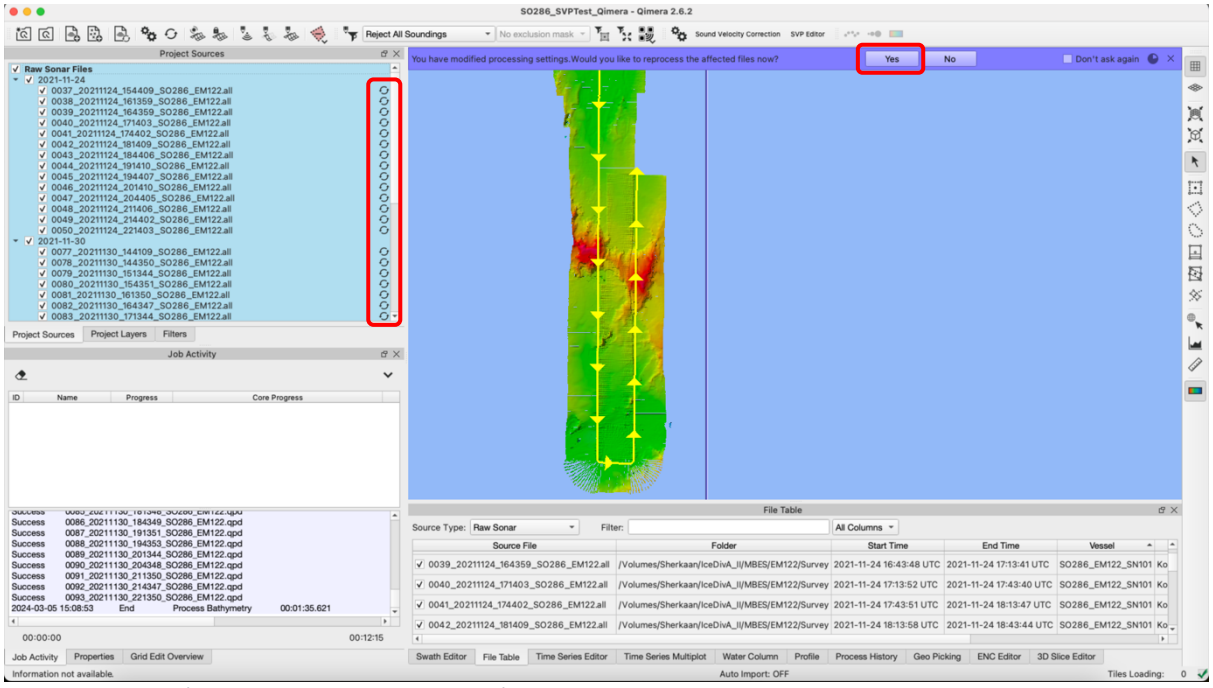
If CTD SVPs are not available

If you ain't have proper SVPs from CTDs, you can still use and adjust those that come with the raw files. This is not optimal but in this case it's the best way to go. (If you're really into it, check out which SVPs are associated with which SVP by default – you'd be surprised! Sometimes it doesn't make sense at all.) Unfortunately, often the auto-imported SVP contain no position information, hence we pick the second best option and apply them again using '**Nearest in time**'. This process is very similar to the one above:

- *Select* ***all raw files*** *-> open Processing Parameters (gearwheel in the top left panel) -> under 'Sound Velocity', select '****Nearest in distance, within time*** *[720m]'*
- *Also tick 'Use SVP cross-fade'* and leave it to 60s (this helps to reduce jumps in the data).
- If there is **more than one vessel**, there will be an error message. In this case: organise .all files e.g. by vessel: *select all .all files -> right click and select '****Organise per Vessel****'*
- *Repeat the first two steps for each vessel*
- Now Qimera needs to **do the raytracing again**, to do so, *click the circle arrows* (top left panel, next to gearwheel)



7: Editing Sound Velocity Parameters – without CTD SVP



8: Raytrace raw data again using new SVP application

If no SVP is available

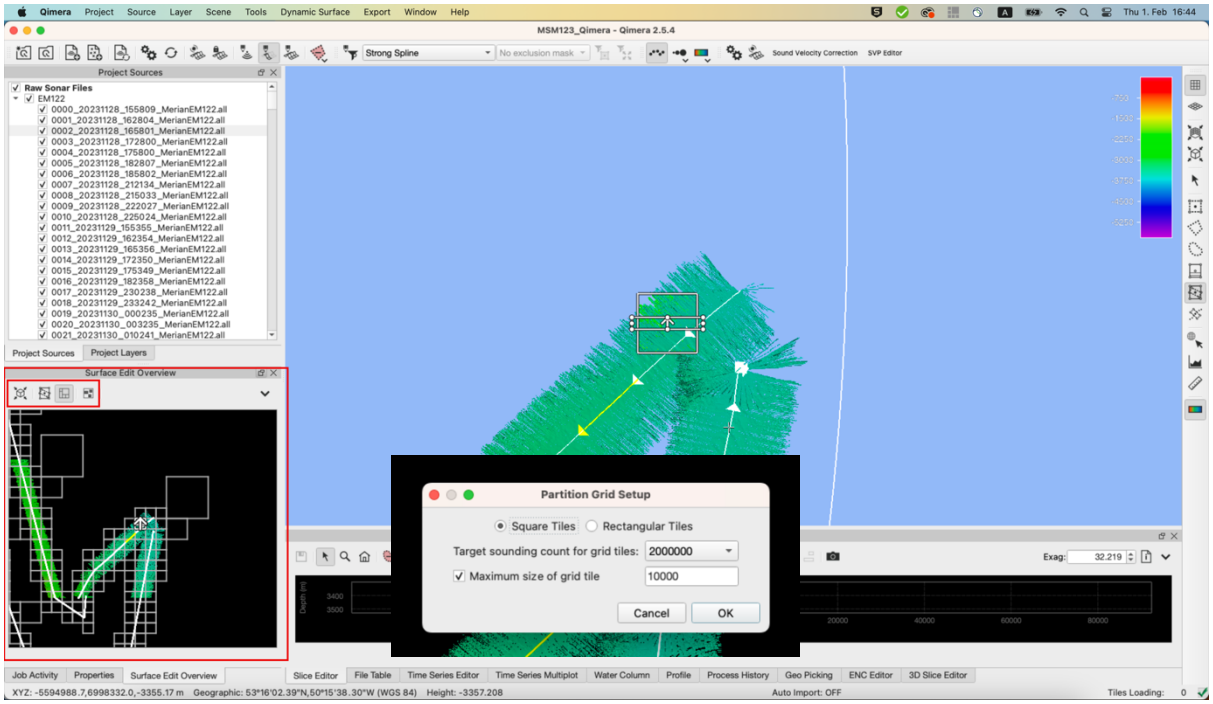
If you ain't have any usable SVP, you need to use **synthetic SVP generated from WOA**. To learn how to do this, please refer to the SVP section in the Geomar data acquisition SOP (SOP_MultibeamDataAcquisition_KongsbergSIS_Geomar.pdf). Once you have enough WOA

profiles exported to Kongsberg format, you can follow the **same logic as you did before for CTD derived SVP**:

- Import **processed .asvp to Qimera**: *click 'Source' -> 'Import' -> 'Import Kongsberg asvp'*
- *Select the* **correct vessel file** (Note: There should be one vessel per MBES (one for each EM122/EM710 etc.) - if there is more than one vessel: import the same SVPs multiple times and assign them to all vessels; if there is more than one vessel file per MBES, something went wrong.)
- Delete **automatically imported SVPs**
- *Select* ***all raw files*** *-> open Processing Parameters (gearwheel in the top left panel) -> under 'Sound Velocity', select '****Nearest in distance, within time*** *[720m]'*
- *Also tick 'Use SVP cross-fade'* and leave it to 60s (this helps to reduce jumps in the data).
- Now Qimera needs to **do the raytracing again**, to do so, *click the circle arrows* (top left panel, next to gearwheel)
- (Optional, for better overview) you can organise .all files e.g. according to Date: *select all .all files -> right click and select 'Organise per Date'*

Step 5: Cleaning the Seafloor

Now into the fun part – data cleaning or editing! Since the latest version, Qimera offers a **surface editing overview**, which is very handy to use to keep track of your work. In the bottom left corner, you find the tool. If you *press the third icon* **'Partition mode'**, a window pops up that proposes some values – they are usually fine. If you press 'OK', then your entire cruise should be split into areas of equal size. The **fourth icon 'Show Visited/Edited'** shows the work progress.



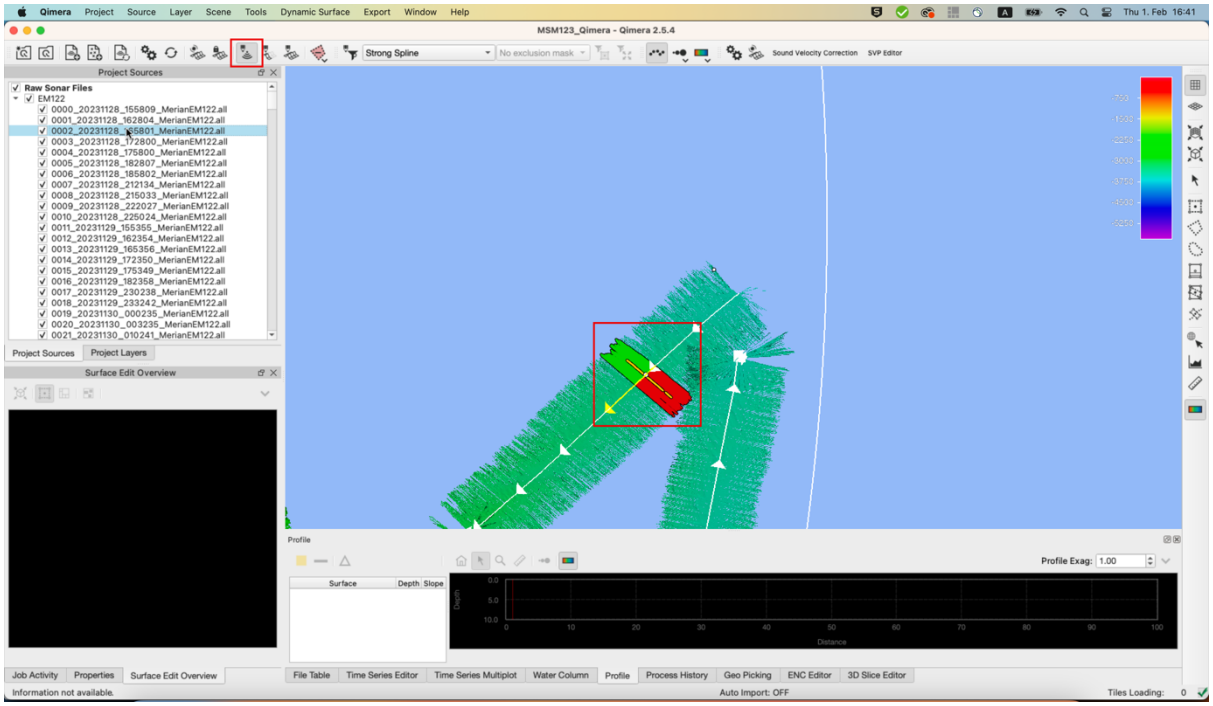
9: Qimera Surface Edit Overview

10: Qimera Surface Edit Overiew Partitions

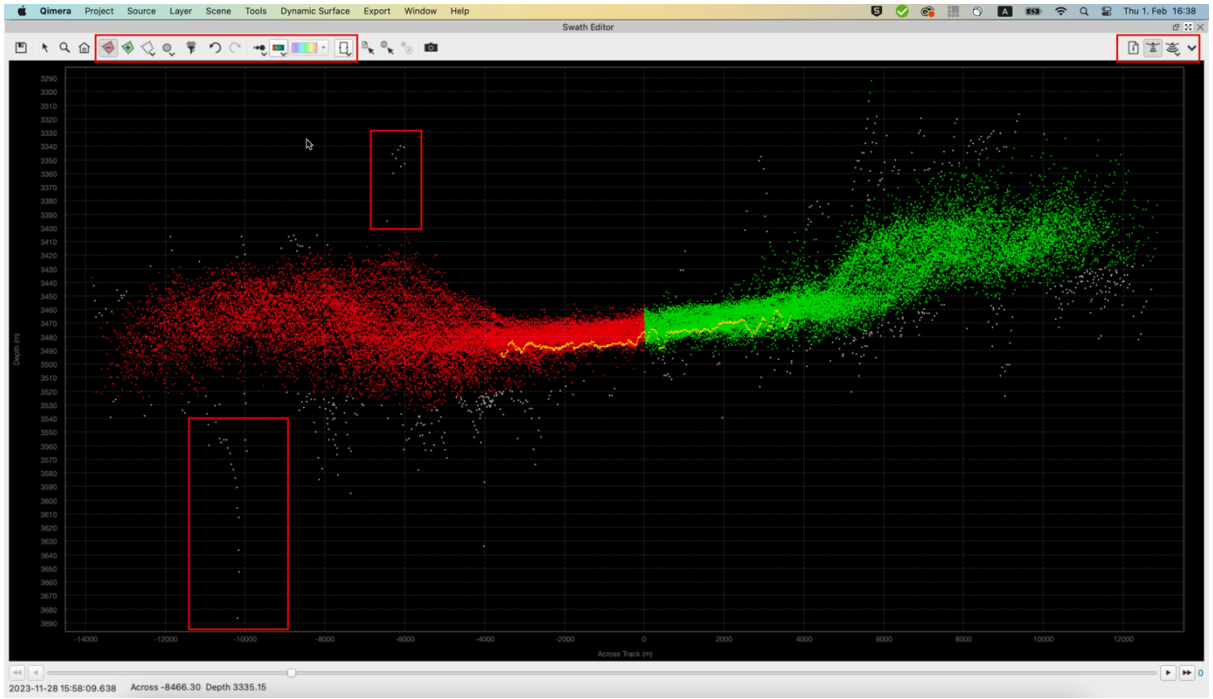
Qimera has three types of editors to manually clean data and reject outliers. By the way: 'Cleaning' usually means **reject outliers** from the data point cloud. And rejecting means they are not deleted but **flagged as bad soundings**. All right, let's go:

The **swath editor is a quick and dirty tool** that let's you easily pick the worst outliers. Open it by *selecting a raw data file and press the swath editor icon*. There are several modes to **adjust the appearance of the data**, e.g. you can connect all the points with lines if you like or colour-code

according to depth, file etc.. **It is recommended (because it's fast) to go over the entire cruise surface first with the swath editor!** At least do so before you go into detailed cleaning. There are several ways how to reject soundings, the most common way though is to select the **polygon tool to encircle the outliers**. Try what suits you best!



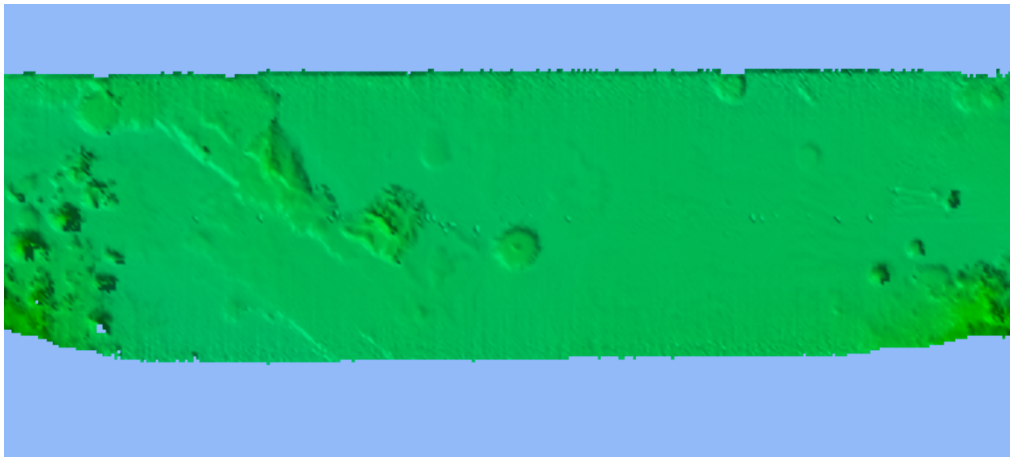
11: Qimera swath editor selection



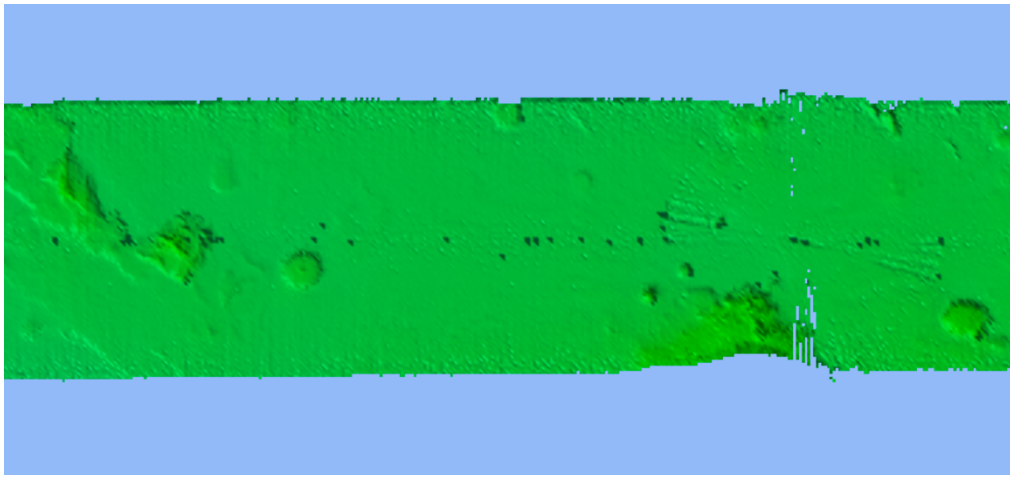
12: Qimera swath editor

Now if you are finished with the swath editor, you can start what I call '**surface browsing**'. You basically fly along the entire surface and check it for **suspect outliers**. What really helps here are

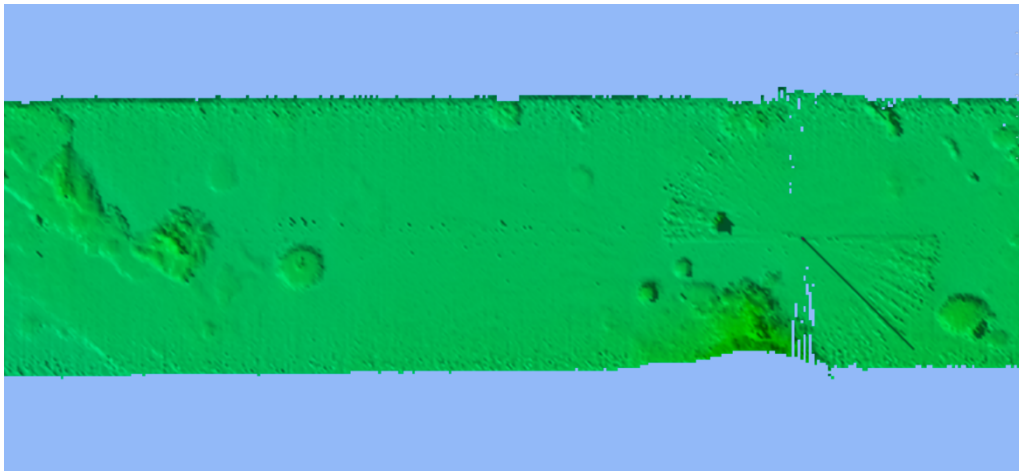
the different depth layers how Qimera can display the surface: **average** (default), **deep** and **shallow**. *You find them in the Projects Layers tab under Depth Layer*. In most cases, outliers can be detected best when using the deep layer option. Hence for surface browsing, you should **select deep** to search for outliers. It is recommended though to also **quickly browse the surface in shallow mode**, but usually, if you cleaned thoroughly in deep mode, there shouldn't be much left.



13: Qimera average mode (default)

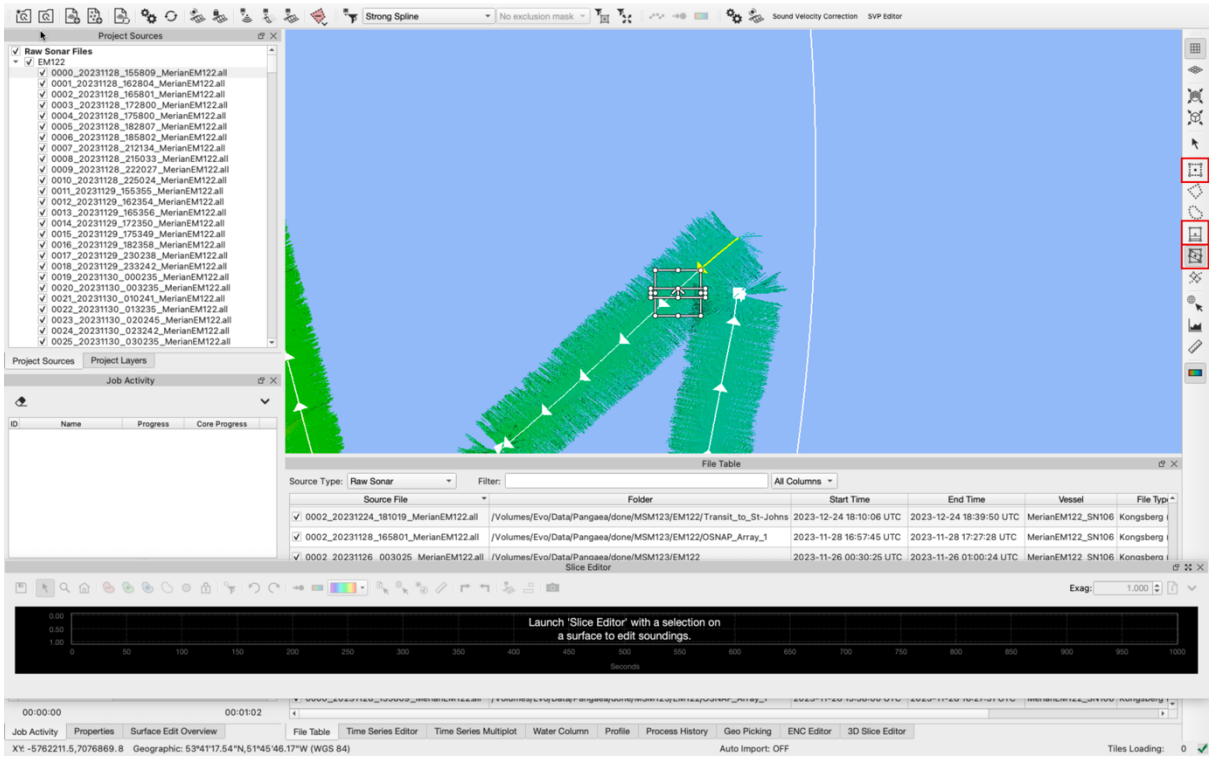


14: Qimera deep mode



15: Qimera shallow mode

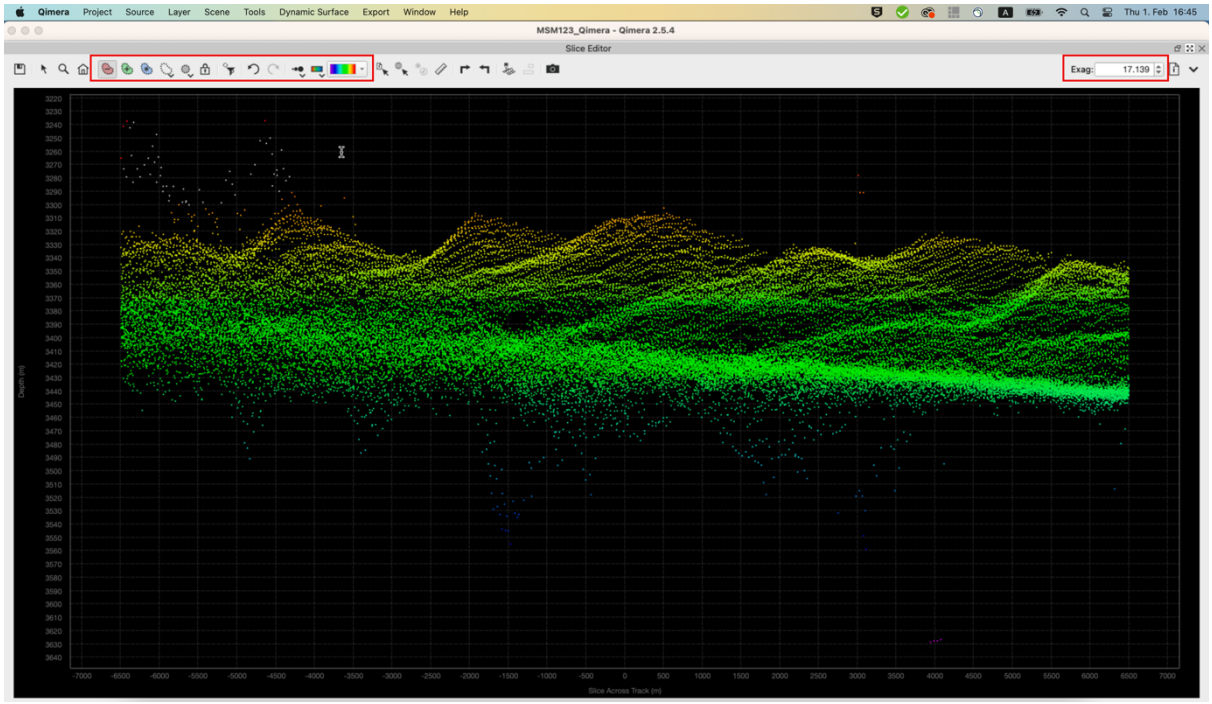
Once you find such regions, there are two options and it's really a matter of taste here: There is a **2D and a 3D editor**. For both you need to pick an area either with the **Rectangular Select** (more points in view at once, **better overview**) or the **Free Slice Select** (slicing within selection BBox, less points in view, **better to remove difficult outliers**) (*on the right panel -> click Rectangular/Fixed Slice/Free Slice Select Icon*). The area mustn't be too large (but Qimera will complain if so) and be selected according to the suspect outlier abundance.



16: Qimera Free Slice Select

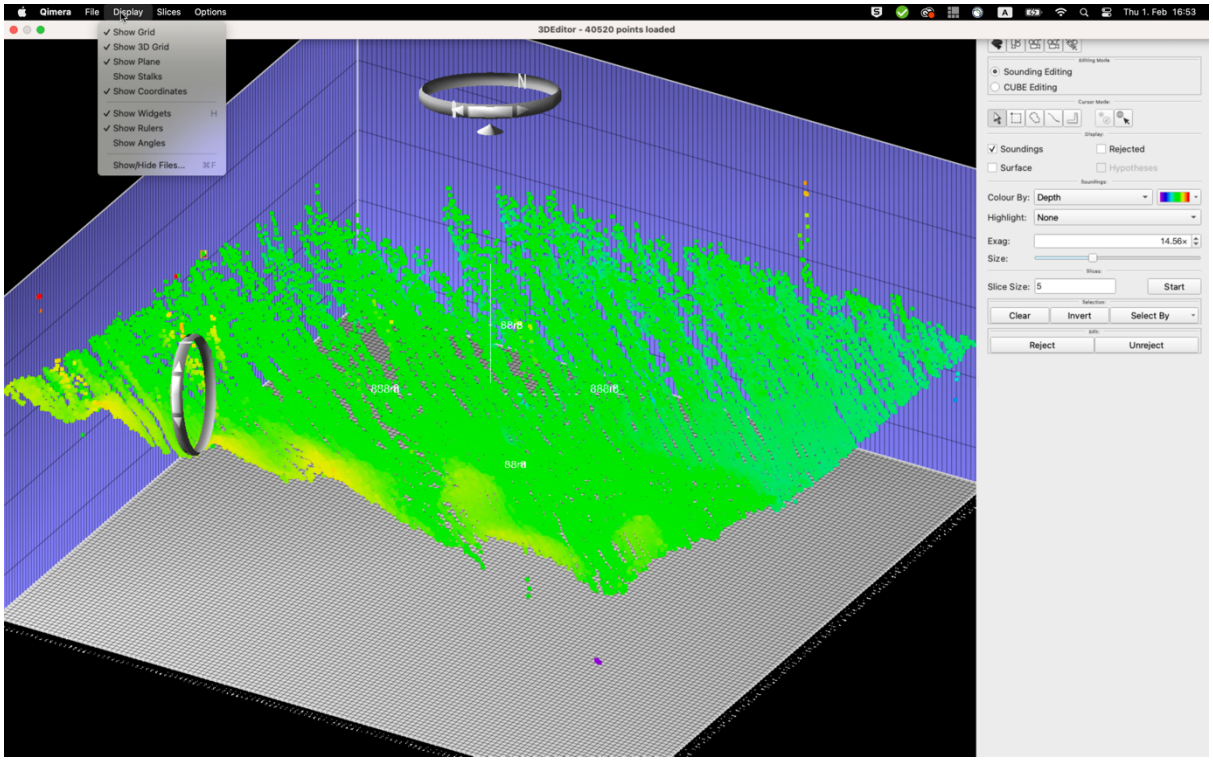
The **slice editor is a 2D tool** that lets you inspect the selected area. You *find its icon on the upper panel*. As for the swath editor, you can **reject soundings by drawing a polygon** (or rectangle or circle) around it and you can adjust colours etc. according to your taste. Also watch the **vertical exaggeration** which can help make outliers visible. But keep it at a reasonable level,

if you feel you see nothing but points, you exaggerated too much (:. If you chose Rectangular Select before, you see the **entire selected region** in the editor, which is great to get an overview but sometimes you can't reach all the outliers with the rejecting tool, especially if they are in a sink. In this case it's better to go for the Free Slice Select, which **slices the area in reasonably sized chunks**. The latter takes more time but is more precise, so it is recommended to use slicing for editing. You can move back and forth between the slices using the **Qimera shortcuts**.

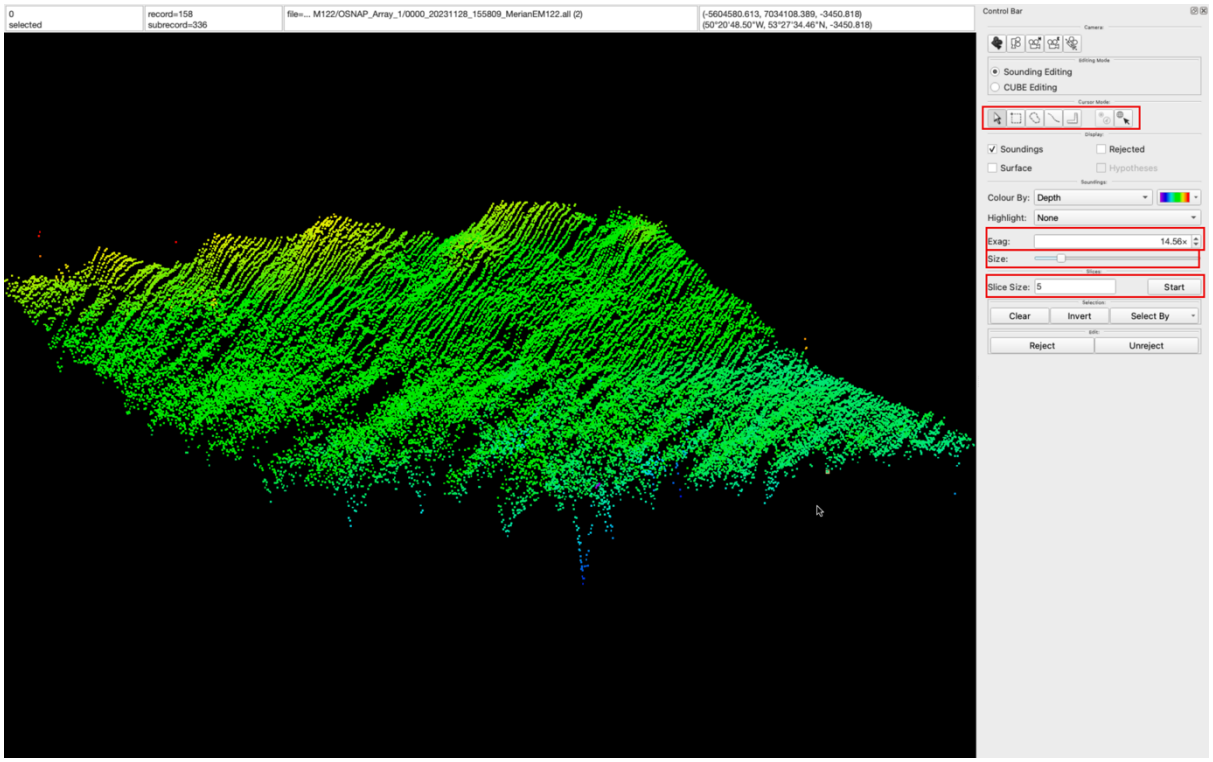


17: Qimera 2D Slice Editor

The 3D editor is very similar to the 2D version, only in 3D (: Which means you can **rotate the entire selected area**. This can help getting an idea about the surface but can also be confusing, so again, it's a matter of taste. *You can find the icon on the upper panel.* Apart from the Free Slice Select, the 3D editor itself also has a **slicing option** that cuts the visible point cloud into chunks. Use it if you feel that there are inaccessible outliers, but make sure that you **don't make the slices too small**, otherwise you might **kill parts of seamounts** or else. Depending on the size and mode for the area selection (rectangular or free slice), it makes more or less sense to use slicing. Per default, the 3D editor is full of unnecessary stuff which you can get *rid of under Display -> Widgets*. See images below. Like in the other two editors, you can adjust everything to your needs on the right panel.



18: Qimera unnecessary widgets and stuff in 3D editor



19: Qimera 3D editor without annoying widgets

After finishing with cleaning, a second person should do a quality check to make sure the data are publishable. This is done visually on the dynamic surface in deep and shallow mode.
A general remark: MBES data cleaning is a process that varies a lot according to the person who does it and needs experience. With this guide we're trying to make it more uniform to have better overall results. **Check out the cleaning-in-pictures guide**: SOP_MultibeamDataProcessing_Qimera_Cleaning-in-pictures_Geomar.pdf!

Step 6: Exporting Data

Excellent, you have done the major work of removing false soundings from bathymetry data and you also re-raytraced the data with more accurately located sound speed. Now to make the data usable for others, there are a number of ways how to generate different **data products** and export them. We mainly focus on three data types here: .xyz (**ungridded cleaned point cloud**), .tif (**gridded raster**) and .gsf (**edited raw data**). If you'd like to know more about data publication, please move to the SOP_MultibeamDAMWorkflow_Geomar.pdf

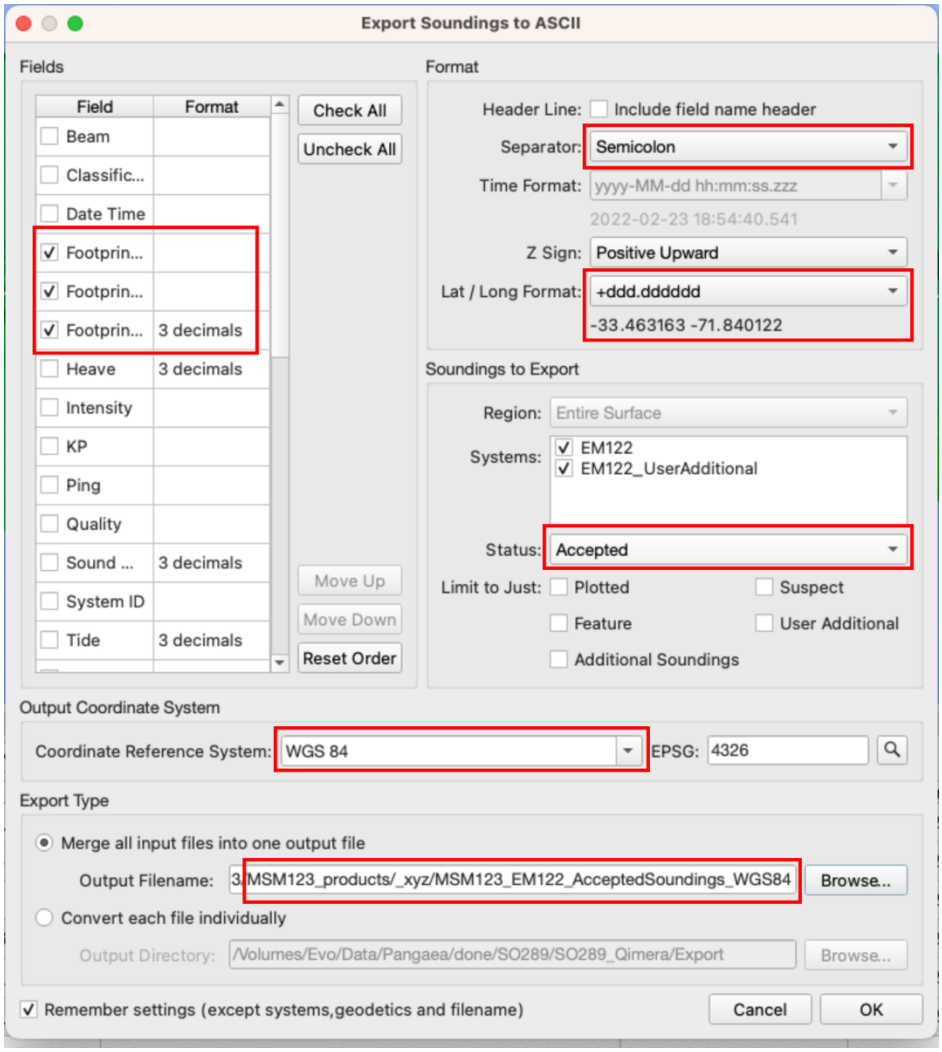
.gsf

.gsf is short for **g**eneric **s**ensor **f**ormat and the files contain everything that the raw data have **plus further information about the edits** that have been applied during processing. This is very handy in case the data need further processing like e.g. sound speed corrections etc.. .gsf can also be read by other software like e.g. MB-System. To export .gsf, *select all raw files -> Export -> Raw Sonar File -> Export to GSF.* Leave everything as is, it will automatically export the .gsf files to the 'Export' folder in the Qimera folder structure (one original file = one .gsf file. The naming is done automatically, Qimera takes the original file name and adds '.gsf' instead of '.all'). **Please move them over to the _gsf folder**.

.xyz

.xyz are basically human readable text files that contain longitude; latitude; depth. When cleaned properly they are the most useful data products as we can still grid them in different resolutions. Due to the fact that they are human-readable, this can be done with any tool you want, like python, R, gmt etc. However, all **information about sound velocity, motion, navigation and tides are lost** and should have been applied before. To export .xyz data, *select all raw files -> Export -> Raw Sonar File -> Export to ASCII*. A window will open and there are some important things to do:

- In the left panel under Fields, only tick '**Footprint X, Y, Z**' (default)
- Under Format, select '**Semicolon**' as separator and '**Positive Upward**' (default)
- Under Soundings to Export and Status, select '**Accepted**' (default)
- *Under Output Coordinate System, select '**WGS 84**' (**change from default project CRS!**).* This is especially important as we need **longitude/latitude** values for xyz, not coordinates from a projected CRS.
- Note that now under Format, a new option popped up: **Lat/Lon format**; *Select +ddd.dddddd (**decimal degrees**).* You will see an example in the line below – if the formatting looks similar to e.g. -33.463163 -71.840122 you're good. If you see any letters in the example, you're wrong.
- Under Export type, leave 'Merge into one file' ticked (default)
- And export to the _xyz folder (**change default file path**)
- **Naming Convention**: {Cruise}_{MBES}_{Soundings}_{CRS}.xyz
  e.g.: MSM123_EM122_AcceptedSoundings_WGS84.xyz (Watch the CRS!)
- The entire file path should be similar to:
  _xyz/ MSM123_EM122_AcceptedSoundings_WGS84.xyz



20: Export data to .xyz

.tif

For immediate use, rastered data products are always handy which is why we export the data or the surface, to be more precise, as a raster. To do so, *select the dynamic surface -> Export -> Dynamic Surface -> Export to Surface*. Again, a window will pop up:

- *Select the geotiff as output format* and leave the rest as is.
  Note: You see there is also an XYZ option. This would export the gridded(!) soundings as a (2D) point cloud into human – readable format. **Do not use it!** It can become really messy and confusing when working with .xyz and it's not straightforward to check, if the .xyz are gridded or not. **.xyz should always be ungridded**.
- *Hit Save*, you're asked to enter a file path:
- **Naming Convention**: {Cruise}_{MBES}_{Resolution}_{Soundings}_{CRS}.tif
  e.g.: MSM123_EM122_100m_AcceptedSoundings_EPSG3395.tif (Again, watch the CRS!) **Note**: Qimera exports rastered data in the project CRS per default, you can't change that. But **make sure you put the correct CRS in the name**!

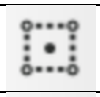
Important Notes

Below are some useful information concerning the entire multibeam processing workflow.

Protocolling

This is the most boring and tedious, but, trust us, one of the most important things when processing bathymetry: having a **decent protocol**. Especially if more than one person works on the data, this can help to avoid painful 'what did person x/y do here?'- quests. We have **protocol templates** that should be located in the _protocol folder of each cruise. They should be self-explanatory. Please **fill them in as thoroughly as possible**, this is also crucial for the person who does the QC at the end!

Qimera Shortkeys & Iconlist

Icon	Name
	Rectangular Select
	Fixed Slice Select
	Free Slice Select
	Swath Editor
	Slice Editor
	3D Editor
	Reject by polygon
	Accept by polygon

Shortkey	Function
F	Jump forward (in Swath/Slice/3D Editor)
B	Jump backward (in Swath/Slice/3D Editor)
Space	Explore mode (3D Editor)
R	Reject sounding (in Swath/Slice/3D Editor)
C	Clear selection (in Swath/Slice/3D Editor)

References

Mayer, L.; Jakobsson, M.; Allen, G.; Dorschel, B.; Falconer, R.; Ferrini, V.; Lamarche, G.; Snaith, H.; Weatherall, P. The Nippon Foundation - GEBCO Seabed 2030 Project: The Quest to See the

World's Oceans Completely Mapped by 2030. *Geosciences* **2018**, *8*, 63. https://doi.org/10.3390/geosciences8020063