GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

DAM

SOP: Acquisition and Processing of Multibeam Data for Kongsberg EMXXX Systems

Name: Standard Operation Procedures (SOP) for multibeam data acquisition, processing and publication in the DAM Project Underway Research Data Project; valid for systems on RV MARIA S. MERIAN, RV METEOR, RV SONNE.
Version: 1.0
Valid from: 05/2024
Status: This is a public version. Sensitive information, such as server names, addresses, and exact paths and storage locations have been removed.
Changelog:

05/2024: Initial Publication

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Background

Approx. 230 million km^2 of ocean floor still need to be mapped in the deep sea (Wölfl et al. 2019). Research vessels that operate internationally usually have long transit routes when going from one study area to the other. Often these routes lead through international waters, where data recording is unrestricted. Since 2015, German research vessels RV MARIA S. MERIAN, RV METEOR, RV SONNE and RV POLARSTERN started to collect multibeam data on their transits through international waters on a regular basis. Data acquisition is complemented by the DAM Project Underway Research Data coordinated by the German Marine Research Alliance (DAM) (Wölfl et al. 2020) and aims at a systematic publication of hydroacoustic raw and processed data.

Purpose and Scope

Description: This SOP describes the workflow for the three German research vessels RV MARIA S. MERIAN, RV METEOR and RV SONNE of multibeam data acquisition, onboard-storage, quality assessment of data and metadata and their publication in the frame of the DAM Project Underway Research Data. **Note**: If not stated otherwise, the term 'data' will refer to both data and their metadata. Specific manuals and further SOPs regarding multibeam data acquisition, data processing etc., are listed in the respective 'Auxiliary Documents' sections.
Intended user groups: Device operators (trained scientists, ship-board technicians) and data managers
Comment: This document is managed and edited by the team research data management of GEOMAR and project employees.

Device Description

EM series Kongsberg echosounders are mounted under the hull of the ship and controlled from the acquisition computer in the hydroacoustic labs via the operating software SIS.

Name: Kongsberg EM122/EM710/EM712 multibeam echo sounder
Description: Deep water echo sounder for bathymetry, backscatter and water column data
Technical Details:

Operating Frequency: 12kHz
Depth Range: 20 – 11 000m
Max. Swath Angle: 150°

Name: Kongsberg EM710/EM712 multibeam echo sounder
Description: Shallow water echo sounder for bathymetry, backscatter and water column data
Technical Details:

Operating Frequency: 40 – 100kHz
Depth Range: 3600m
Max. Swath Angle: 140°

Auxiliary Documents

Name: EM 122 Multibeam echo sounder Product Description (pdf)
Type: Manual
Description: Technical documentation of the EM 122 multibeam echo sounder.
Version: 4.0 (10/2006)

Name: Multibeam echo sounder EM712 (pdf)
Type: Datasheet
Description: Technical overview of the EM 712 multibeam echo sounder.
Version: 03/2022

Data Workflow

Acquisition

The multibeam is usually supervised by either a trained scientist or by the vessel's technical staff (WTD). For underway data, the echo sounder is operated in international waters and switched off when reaching Exclusive Economic Zones (EEZs). Mainly the EM122/EM120 system is used for transit data to ensure full coverage at all depths, however the following guidelines can also be applied for the EM712/EM710 systems. In the following section, the workflow for EM122 is described, however that for EM712/710 is exactly the same.

For easier later-on processing and data curation, the data follows a **naming convention** to avoid confusion with file names and storage. This can be **set up using automised file naming** for data acquisition within the **Kongsberg Seafloor Information System (SIS)**. The raw data file names should then have the following format:

{LineNumber}_{Date}_{Time}_{Cruise}_{MBES}.all

Where:
{LineNumber} = continuous number per line
{Date} = YYYMMDD
{Time} = HHMMSS
{Cruise} = Cruise name
{MBES} = MBES System

Example: 0001_20180212_051724_M133_EM122.all

Important Note: Never change file names after data have been collected and files have been written, since this may cause problems during data reuse. Changing file names may also change the date of modification of the file (depending on the operating system).

It is very recommended to make use of a protocol to **keep track of information** about parameters changes, Sound Velocity Profile (SVP) application etc. More information on how to

operate and create SIS templates to automise naming and data storage and hints for protocol templates can be found in the manual list below.

During acquisition, data are constantly stored on the local ship server and synced to the Mass Data Management system (MDM) on-board component which is integrated in the D-Ship information system. All data are then transferred to a land-based MDM as well as to an archive hosted by Bundesamt für Seeschifffahrt und Hydrographie (BSH). From the MDM, the data can be retrieved for processing and publication. Only employees related to the DAM Project Underway Research Data have access to those files. At GEOMAR Helmholtz Centre for Ocean Research, Kiel, all raw data files are examined and quality assessed before they are submitted to the PANGAEA - Data Publisher for Earth & Environmental Science (Felden et al. 2023).

File Description

The list below shows metadata as retrieved from Qimera from the multibeam raw files of MARIA S. MERIAN. METEOR and SONNE use the same multibeam system, hence this is information similar for all vessels.

Example: 0001_20180212_051724_MSM133_EM122.all

File Type: Kongsberg (.ALL)
Sensor Type: Kongsberg EM122
Number of Heads: 1
Coordinate System: WGS84
Time Reference: UTC+0.0
Range & Angle: Yes/No
Intensity: Yes/No
Beam Time Series: Yes/No
Water Column: Yes/No
Runtime Setting: Yes/No
Points: Yes/No
Vessel Config: Yes/No
Position: Yes/No
Motion: Yes/No
SVP: Yes/No
Tide: Yes/No

Auxiliary Documents

Name: SOP_MultibeamDataAcquisition_KongsbergSIS_Geomar.pdf
Type: Manual
Description: Detailed documentation and SOPs of how to acquire multibeam data
URL: in preparation
Version: 1.0 (03/2024)

Name: SIS Reference Manual EM122
Type: Manual

Description: Full description of the procedures and parameters required to allow an efficient use of SIS, as well as a thorough understanding of the system parameters and adjustments.
URL:
Version: 4.0 (SIS Version 4; 10/2013)

Name: Acquisition Protocol (adapted from AWI Bathymetry Group)
Type: Protocol
Description: Detailed acquisition protocol, containing information about parameters, sea conditions operator(s)
Access: Contact to request template

Name: BSH Metadata
Type: Metadata Sheet
Description: Contains all metadata as required from BSH
Access: Contact to request template

Processing

Multibeam data processing is done on request using Qimera (QPS Software) for datasets related to the DAM Project Underway Research Data. Processing or editing includes rejection of outliers, i.e. significantly overhanging and underlying data points. In most cases, this has to be done manually. It further includes implementing corrections for sound velocity, tide and navigation, if necessary. If no sound velocity profiles (SVP) are available, general SVPs can be pulled directly from online databases such like World Ocean Atlas (WOA) via the Sound Speed Manager software (Masetti et al. 2017, SSM).

For a full manual on processing bathymetry with Qimera and how to use SSM to process SVP, please refer to the list below:

Auxiliary Documents

Name: Processing Protocol (adapted from AWI Bathymetry Group)
Type: Protocol
Description: Detailed processing protocol, containing information about processing progress and user
Access: Contact to request template

Name: SOP_MultibeamDataProcessing_Qimera_Geomar.pdf
Type: Manual
Description: Detailed documentation and SOPs of how to process bathymetry with Qimera.
URL: not yet published
Version: 1.0 (03/2024)

Products

Data products are created on the base of edited soundings. Data edits are not stored in the raw data files but can be exported to Generic Sensor Format (.gsf) as edited raw data (see section below). Fully edited and ungridded soundings are stored in .xyz format and are always based on **WGS84: x = Longitude, y = Latitude and z = Water Depth (m)**. Bathymetric grids are usually created in .tif or netCDF format. The resolution of grids depends on the water depth and can be defined according to Mayer et al. 2018 and the quality/point density of the data. Gridded data are automatically projected onto the plane chosen in the Qimera settings (should be EPSG:3395). A file **naming convention** has proven helpful and should be given out like so:

Grids:
{Cruise}_{MBES}_{Resolution}_{Soundings}_{CRS}.tif
Example: MSM123_EM122_100m_AllSoundings_EPSG3395.tif

.xyz:
{Cruise}_{MBES}_{Soundings}_{CRS}.xyz
Example: MSM123_EM122_AcceptedSoundings_WGS84.xyz

Where:
{Cruise} = Cruise name
{MBES} = MBES System
{Resolution} = Grid cell resolution
{Soundings}:
- {AllSoundings} = Completely uncleaned
- {Spline} = Spline filtered
- {AcceptedSoundings} = Completely(!) edited manually; This is for the final export and publication

{CRS} = Project Coordinate System

It is recommended to export the edited raw data into a **cross – platform readable format**. For Qimera, this is .gsf, for MB System, they are .esf files. Those data contain all the information of the raw (.all) files (Depth, Backscatter, applied SVP, tide model, motion/GPS information) plus information about the edits that have been made during post-processing (flagging bad soundings, SVP/navigation/tide adjustment etc.). They can for example be used to **extract backscatter from cleaned raw data**, create new grids or make further adjustments. The files have the same name as the respective original raw file. Only .gsf files and .esf files should be made available via PANGAEA like described above, since only these files can be processed with open source software like MB System.

Publication

All published multibeam data products (raw, processed raw, grid, xyz) will have **standardised metadata,** (e.g. standardised titles) **to ensure the FAIR data principles**. Standardised data publication of bathymetric data at PANAGEA is described here https://wiki.pangaea.de/wiki/Bathymetry. All datasets are published under a CC-BY: Creative

Commons Attribution 4.0 International license. Further, it is common practise to list all persons that have been involved in the bathymetry data acquisition as co-authors for all submissions, as they are stated in the **(short) cruise reports**. Additional information about the cruise purpose can also be found in the (short) cruise reports which are added to the abstract. The short cruise reports are found here for Maria S. Merian, Meteor and Sonne. The entire cruise report lists are available here. The final raw data publication is carried out in consultation and in agreement with the cruise leader/s. For processed data publications, only people involved in the data processing are listed as co-authors. An example of a full submission of raw data is given below:

	Format	Example
Author(s)	Principal investigator; Cruise leader; others involved; data manager	Achterberg, Eric, GEOMAR Helmholtz Centre for Ocean Research; Galley, Chris, Uni Ottawa; Schumacher, Mia, GEOMAR Helmholtz Centre for Ocean Research;
Title	Multibeam bathymetry raw data *[multibeam system, dataset]* of *[vessel name]* during cruise *[cruise abbreviation]*	Multibeam bathymetry raw data (Kongsberg EM 122 echosounder entire dataset) of RV SONNE during cruise SO289
Abstract	Abstract containing information about the data	Raw multibeam bathymetry data were collected aboard RV SONNE during cruise SO289 using a Kongsberg EM 122 multibeam echosounder. The expedition took place during 18.2.2022 - 8.4.2022 from Valparaíso (Chile) – Nouméa (New Caledonia) across the central Pacific Ocean. The main objective of SO289 was to determine the distributions of trace elements and their isotopes (TEIs), quantify their sources from the four major ocean boundaries (rivers, atmosphere, exchange with sediments, ocean crust), and determine their biogeochemical cycling and relationships to large scale ocean circulation along a cruise track in the South Pacific Ocean (SPO). Data were recorded within the Chilean EEZ and outside EEZs. Sound velocity profiles (SVP) were applied on the data for calibration. Please see environmental data and the cruise report for details. The data are unprocessed and can therefore contain incorrect depth measurements (artifacts) if not further processed. Note that refraction errors may occur when no proper SVP is applied. Acquisition and provision of the data are part of the DAM Project „Underway" Research Dataand published according to the FAIR principles.
License	*CC-BY: Creative Commons*	

	Attribution 4.0 International	
References	Cruise report	Achterberg, E. P., Steiner, Z., & Galley, C. G. (2022). South Pacific GEOTRACES, Cruise No. SO289, 18 February 2022 - 08 April 2022, Valparaiso (Chile) - Noumea (New Caledonia). In SONNE-Berichte (SO289, pp. 1-141). Begutachtungspanel Forschungsschiffe. https://doi.org/10.48433/cr_so289
Projects	DAM	DAM_Underway: DAM Underway Research Data

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