Comparison of publicly available global bathymetry grids

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Introduction

Applications of bathymetry data are uncountable nowadays: starting with fundamental questions in geology, geophysics or oceanography and ending with navigation purposes, natural resources investigations and delimitation of the continental shelf limits for the coastal States. Nowadays there is a number of global bathymetry grids available to choose from, for any given application, and usually this choice is not easy to make. This goal of this study is to provide several methods to facilitate the choice of bathymetry grid for given purposes.

In this study several recently released publicly available global bathymetry datasets are compared in terms of their data sources, internal consistency, coherency with each other and their accuracy. The analyzed grids include GEBCO 1 minute grid [1], GEBCO 30 arc second grid [2], Predicted Topography v. 12 [3], ETOPO 1 [4], SRTM30 PLUS [5] and regional grid IBCAO ver. 2.23 [6].

Since the evaluation of global bathymetry grids performed by Marks and Smith [2006] [7], bathymetry grids have undergone serious updates (e.g. new global bathymetry products have been released, most of the grids evolved to finer resolution, included more control data, corrected errors pointed out by Marks and Smith, changed extent of coverage, etc.). This research is directed towards pointing out main problems of the grids and assessment of the grids quality using several methods. For validation purposes, the gridded datasets will be compared with more accurate multibeam data.

This poster presents the work in progress.

Materials

Materials used in this study include 6 bathymetry grids and gridded multibeam data available from several research cruises of RV "*Akademic Nikolai Strakhov*". The **main differences** between analyzed grids are borne by resolution, data format, projections, interpolation methods used and the sources of data included in compilation. Table summarizes main differences between the grids. Figure 2 illustrates visual differences between datasets.

GRID	Date released	Spacing	Projection	Node	Based on
GEBCO 1 min, version 2.00	2003, updated 2008	1 min	Geographic WGS 1984	grid	soundings derived from hydrographic, contour and sounding charts and recent single and multibeam surveys, interpolated on digitized hand drawn contours [9]
GEBCO_08 30 arc seconds ver. 20090202	Feb. 2009	30 arc sec	Geographic WGS 1984	pixel	soundings interpolated with satellite-derived gravity data from SRTM30_Plus, includes IBCAO database for latitudes 64°-90° N [10]
SRTM30_Plus v.6.0	Nov. 2009	30 arc sec	Geographic WGS 1984	pixel	soundings interpolated on gravity model from Smith and Sandwell v.18.1, includes IBCAO database for latitudes north 80° N [5]
Global Topography v.12.1	Aug. 2009	1 min	Spherical Mercator	pixel	high resolution marine gravity model derived from Geosat and ERS-1 missions and calibrated with available depth soundings [3]
ETOPO 1	2009	1 min	Geographic WGS 1984	grid / pixel	soundings interpolated with satellite-derived gravity data from Global Topography, includes IBCAO database for latitudes 64°-90° N [4]
IBCAO ver 2.23	2001, updated 2008	2 km/ 1 min	Polarstereographic, true scale at 75 N, WGS 1984 / Geographic WGS 1984	grid/pixel	soundings derived from hydrographic, contour, sounding charts, ice camp expeditions, recent single and multibeam surveys and recently declassified sumbarine measurements interpolated on digitized hand drawn contours [6]

Study Area

The region of the Norwegian-Greenland and Barents Seas have been chosen for the study:

- region has non-uniform exploratory density: the Norwegian - Greenland Sea with abundant ship sounding control and the Barents Sea with sparse coverage mainly from old ship surveys (Figure 1a).
- different trackline coverage used for datasets compilation (Figure 3)
- there is available multibeam data which is not incorporated into any of the analyzed grids (Figure 1b)
- region is represented by all main topographic provinces (continental shelve, continental slope, abyssal plain and mid-oceanic ridge) with multibeam coverage.
- the comparison will be performed on the main topographic provinces, which is dictated by the overall uncertainty of measurements dependent on the oceanic depth and slope as well as by the different coverage density.

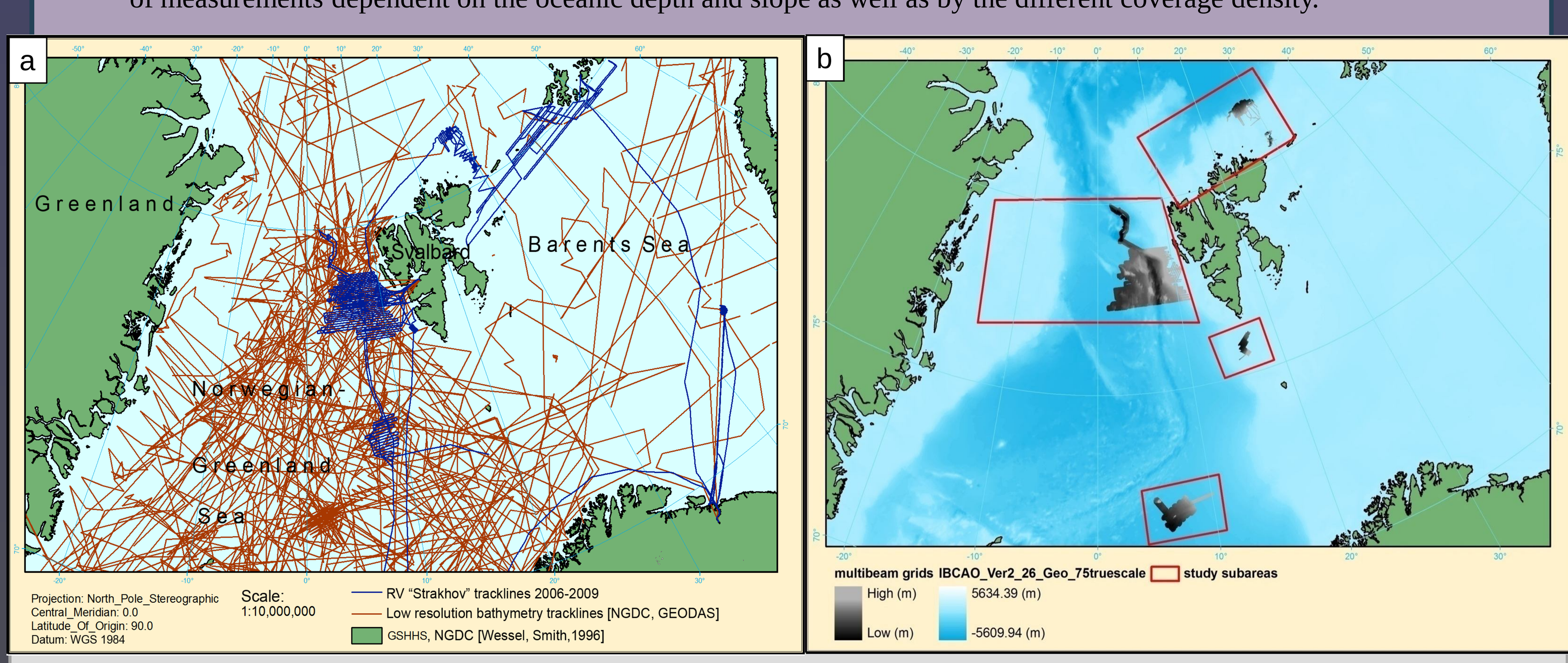

Figure 1.(a) Study area; the NGDC tracklines are supplied solely for the purpose of displaying the extent to which the area is explored; coverage of multibeam data acquired during cruises of RV "Akademik N. Strakhov" is shown.

(b) Study subareas chosen based on available multibeam grids.

Methods used

Several indicators of the grids quality:

- source information (trackline coverage)
- presence of artifacts in the dataset
- internal consistency of the dataset
- dataset distribution
- how well grid resolves shoreline
- how resultant product is close to the "the truth"

Main methods used to evaluate grid quality:

❑ **visual assessment** of grid quality includes check for the artifacts in the data, check for internal consistency of the datasets, check how well grids agree with the shoreline on which they are based

❑ **quantitative comparison** includes analyses of datasets distribution and spectral density, surface subtraction between the datasets and comparison with quality controlled multibeam data

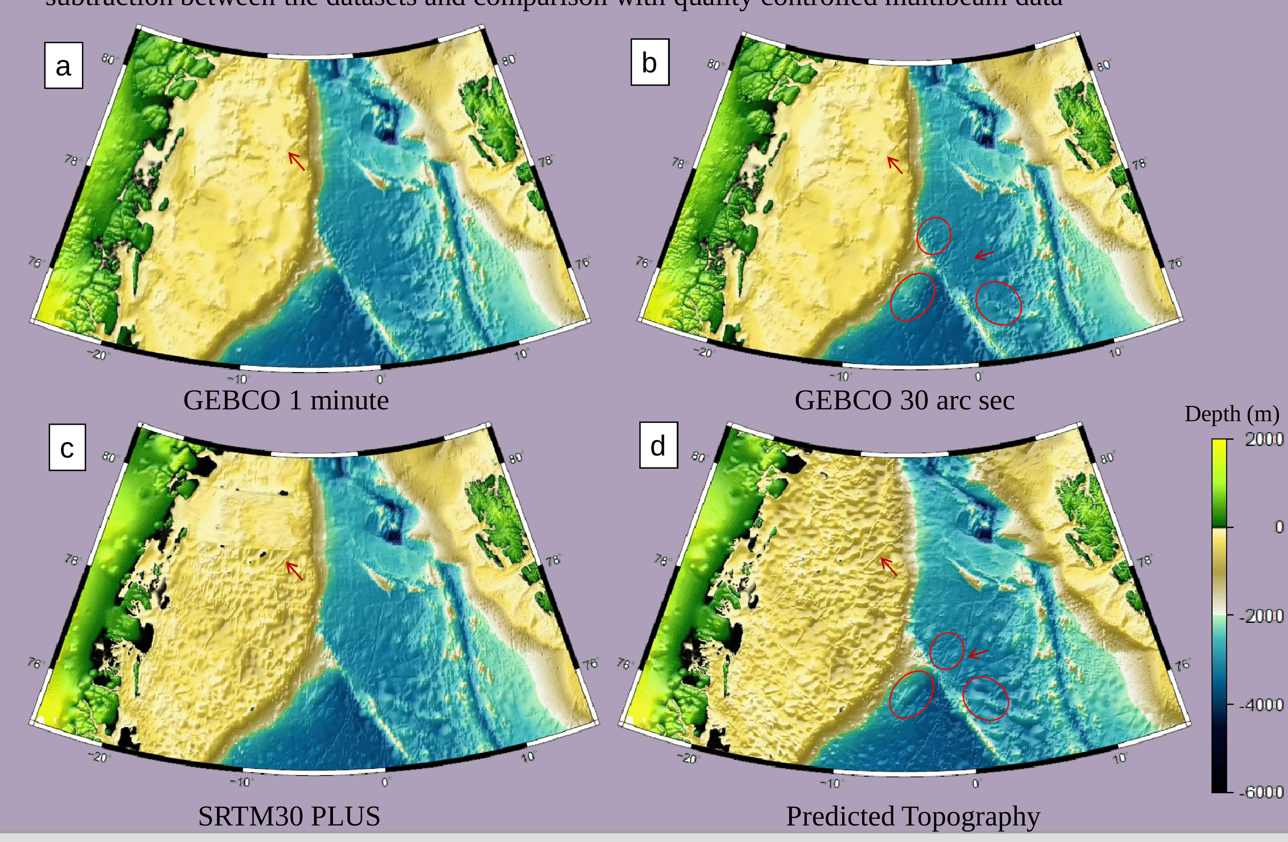

Figure 2. Visual differences between the datasets in one of the study sub areas. Note difference between two GEBCO datasets (a), (b) interpolated on contours and SRTM30 PLUS (c) together with Predicted Topography (d) interpolated on satellite altimetry. First two datasets have more smooth appearance rather than last two with more rugged appearance and with presence of artifacts represented by "traces" of tracklines in the bathymetry (shown by ↖). At the same time, seamounts which are resolved by satellite altimetry grids are absent on the grids based on contours(shown by ◯).

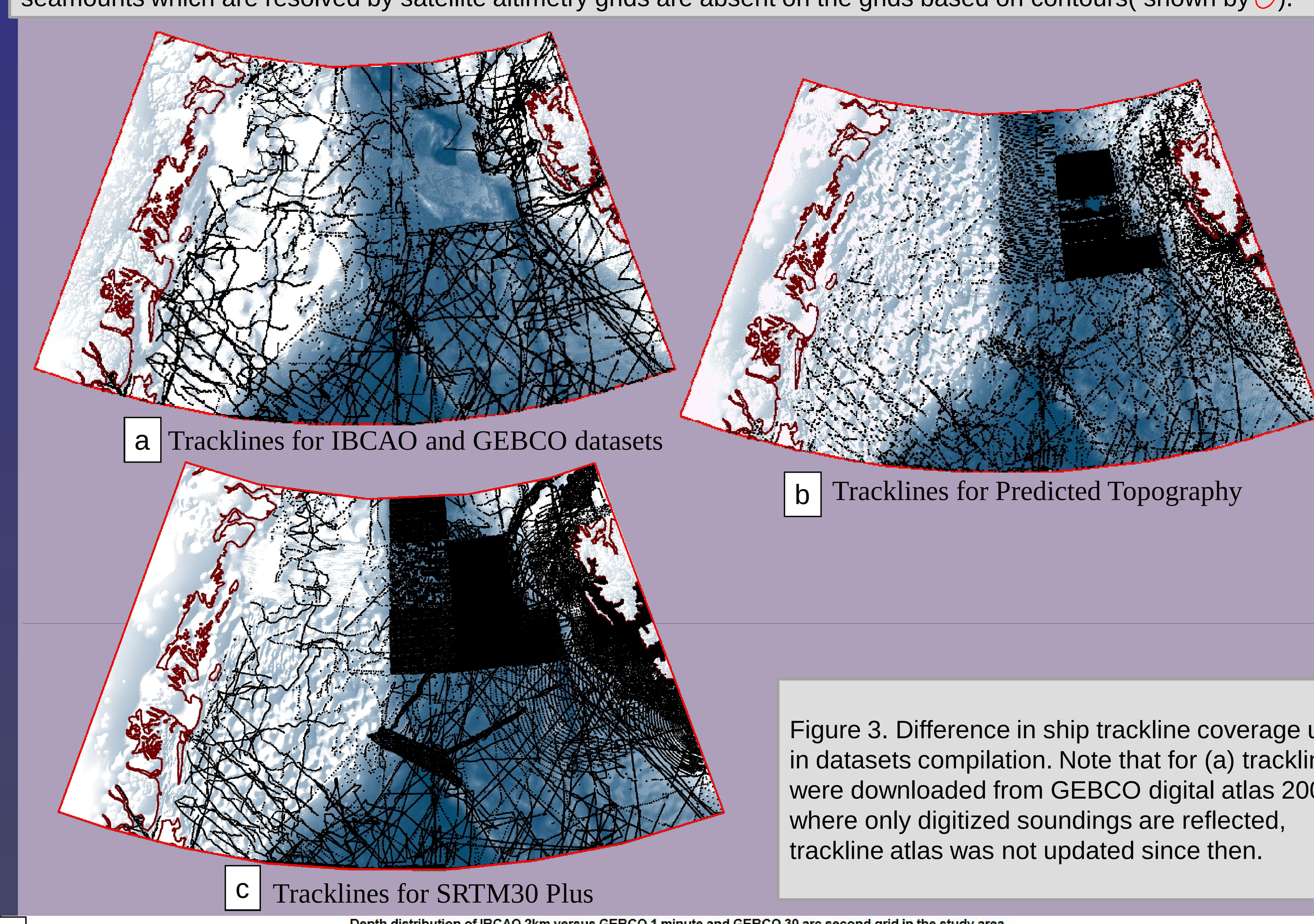

Figure 3. Difference in ship trackline coverage used in datasets compilation. Note that for (a) tracklines were downloaded from GEBCO digital atlas 2003, where only digitized soundings are reflected, trackline atlas was not updated since then.

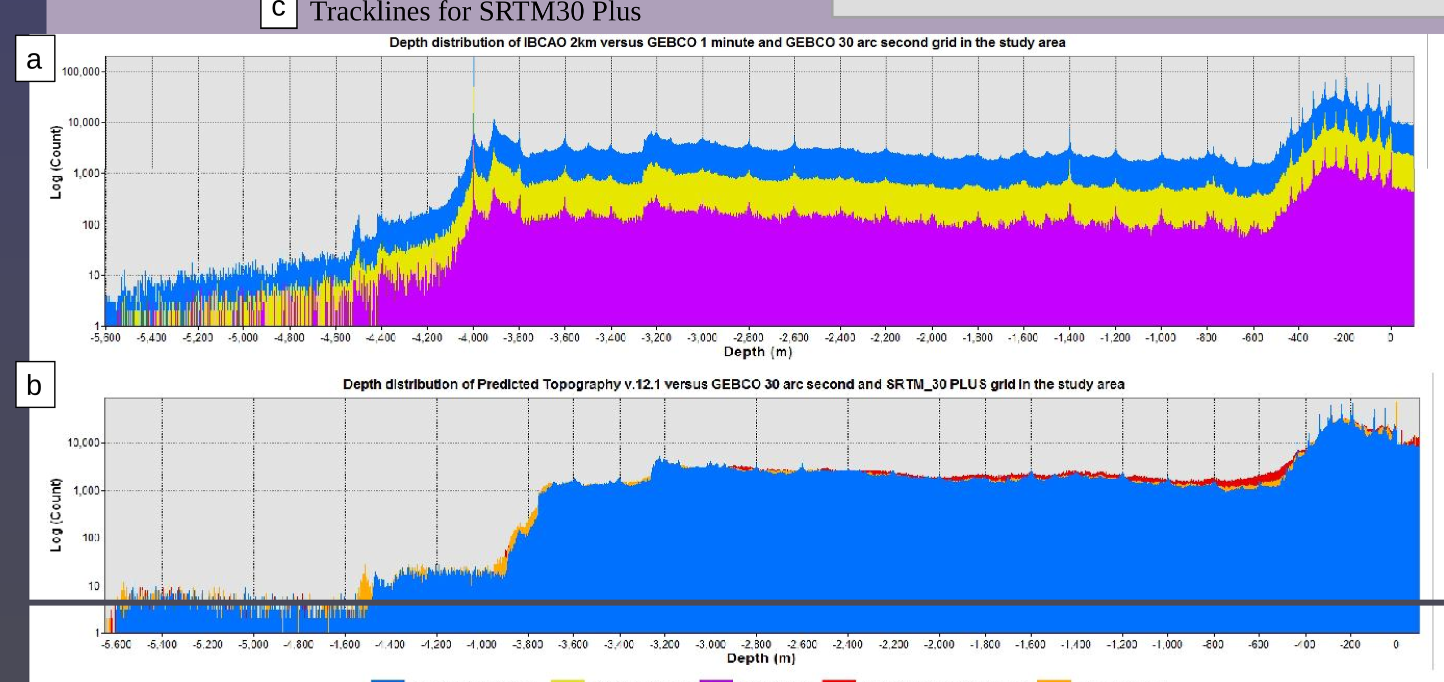

Figure 4. Comparison of depth distribution between analyzed datasets: (a) between IBCAO 2 km grid, GEBCO 1 minute and GEBCO 30 arc second for the region 30 E - 52 W 64 N - 85 N, (b) between Predicted Topography v 12.1, GEBCO 30 arc second and SRTM_30 PLUS for the region 30 E - 52 W 64 N - 80 N. Similarity of distribution between datasets in (a) implies that GEBCO datasets were based on IBCAO by regridding it to finer resolution without adding new information to the datasets. Grids based on satellite altimetry reveal smoother distribution compared to datasets based on contours with spikes at contour values (b). At the same time GEBCO 30 sec grid has very similar distribution to SRTM30 Plus and Predicted Topography, that raises the question: is the area so well studied that in the end interpolation on contours performs as good on contours as on satellite altimetry?

Datasets consistency

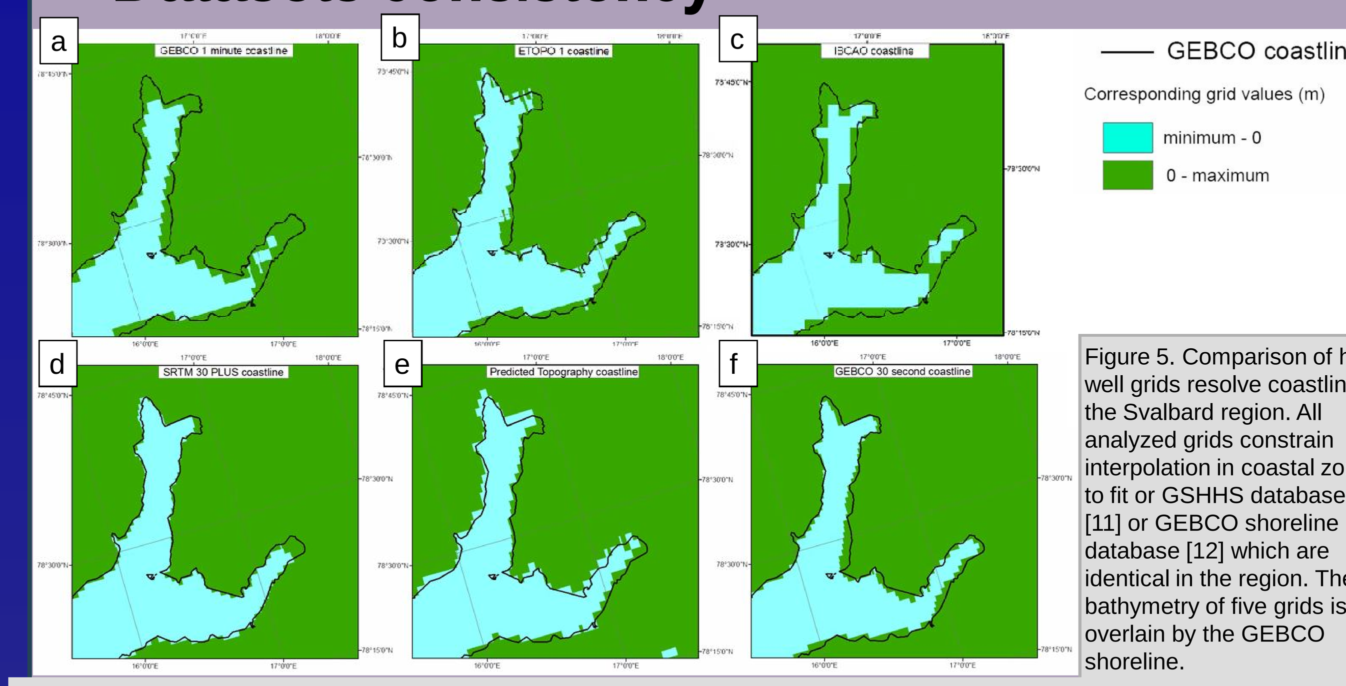

Figure 5. Comparison of how well grids resolve coastline in the Svalbard region. All analyzed grids constrain interpolation in coastal zone to fit or GSHHS database [11] or GEBCO shoreline database [12] which are identical in the region. The bathymetry of five grids is overlain by the GEBCO shoreline.

Figure 5 (continue). At large scales GEBCO 1 minute (a) and IBCAO (c) do not resolve shoreline mainly due to the resolution of the grid, while the rest of the grids reveal shift between shoreline and gridded values: in Predicted Topography grid (northern shift) (e), in ETOPO 1 grid (northern shift)(b), in GEBCO 30 arc second (north-western shift)(f) as well as in SRTM 30 Plus grid (southern shift)(d).

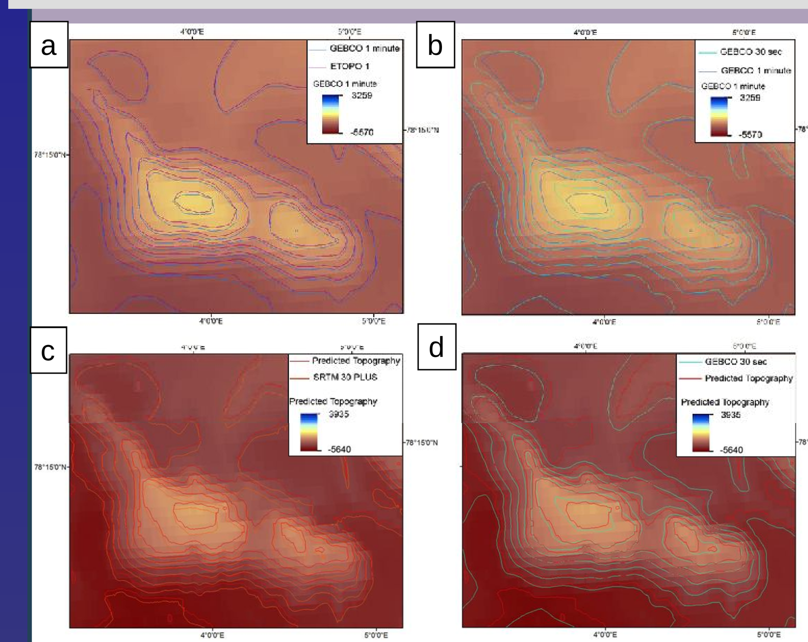

Figure 6. Bathymetry overlain by contours (200 m interval) in a well studied region: GEBCO 1 minute bathymetry overlain by a) ETOPO 1 contours and b) GEBCO 30 arc second contours; Predicted Topography overlain by c) SRTM 30 PLUS contours and d) GEBCO 30 arc second contours.

Comparison between contours reveal consistency between IBCAO, GEBCO 1 minute contours, GEBCO 30 sec grid and Predicted Topography contours. Consistent offset between ETOPO 1 and GEBCO 1 minute grid is observed (a). Same problem is observed in registration of SRTM 30 PLUS data (c), where systematic south offset of contours with respect to Predicted topography contours occur.

Comparison

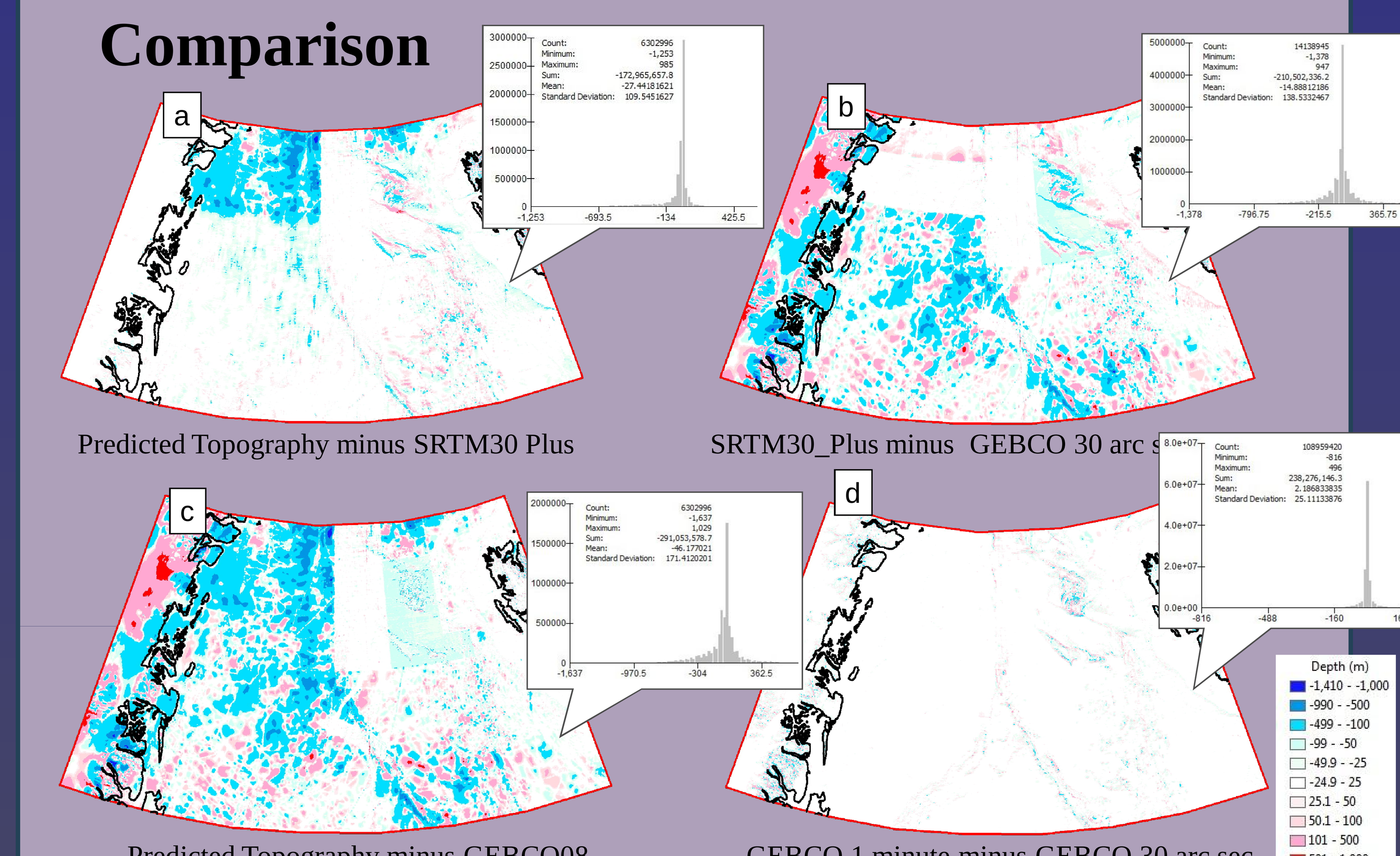

Figure 9. Preliminary results of surface difference between grids which are expected to be similar such as SRTM30 Plus based on Predicted Topography (a), GEBCO 30 sec based on SRTM30 Plus (b), and grids which are expected to be different such as Predicted Topography and GEBCO 08 (c) and GEBCO 1 minute and GEBCO 30 sec grids (d). Subtraction between different bathymetric surfaces also can be used as a method to notice artifacts in the data, such as observed "steps" in bathymetry. Subtraction was performed in ArcGIS, which performs subtraction by giving resultant surface with the resolution of the coarser grid. These results might be biased and erroneous.

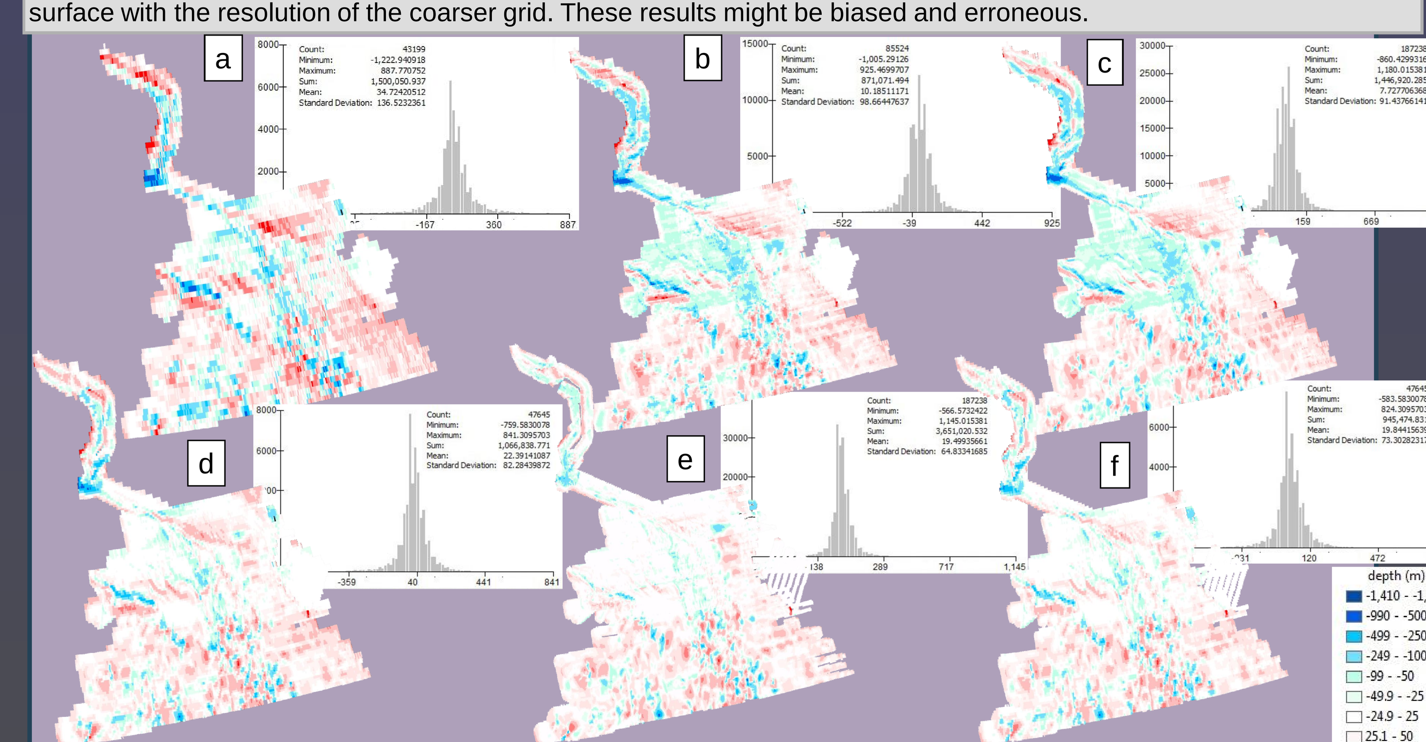

Figure 9. Preliminary results of surface subtraction between (a) IBCAO, (b) Predicted Topography, (c) SRTM30 Plus, (d) GEBCO 1 minute, (e) GEBCO 30 sec, (f) ETOPO 1 and multibeam grid in the study sub area.

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Conclusions

1. Grids interpolated on contours such as GEBCO 1 minute, GEBCO 30 arc second, IBCAO and ETOPO 1 reveal more smooth appearance compared to grids interpolated on satellite altimetry with large number of artifacts in the bathymetry. At the same time Grids based on satellite altimetry resolve seamounts unresolved by grids based on contours.
2. At large scales comparison between grids and shoreline reveals slight shift in all datasets except IBCAO and GEBCO 1 minute, where it can not be noticed due to the resolution of the grid.
3. Consistent offset of contours produced on SRTM30 Plus and ETOPO 1 relative to contours produced on other datasets was revealed.
4. Within the study sub area comparison between grids reveals considerable similarity between GEBCO 1 minute and GEBCO 30 arc second grid which implies that no new information was added to the latter in the study subarea.
5. Expected similarity was identified between Predicted Topography and SRTM30 Plus, with regional differences directly correlated with differences in trackline coverage.
6. Preliminary comparison between analyzed grids and multibeam data reveals nearly same results: difference between grids and multibeam is skewed towards positive values due to finer resolution of multibeam grid (100 m). GEBCO datasets and ETOPO 1 perform slightly better than other 3 grids.
7. **Ongoing work** includes improvement of comparison method; cross-over comparison of multibeam data acquired by RV "*Akademic Nikolai Strakhov*" with other multibeam surveys; estimation of multibeam grid uncertainty; spectral density analyses of datasets; final comparison between multibeam data and analysed grids.

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