

Interpolation and Contouring of Sparse Sounding Data

Hans Werner Schenke
Alfred Wegener Institute
for
Polar- and Marine Research
Bremerhaven
Germany



H.W. Schenke
Monaco, GEBCO
Centenary 2003



Content

1. Introduction
2. Mapping in Sparse Data Regions
3. Pratical Procedure
4. Examples
5. Future Development



H.W. Schenke
Monaco, GEBCO
Centenary 2003



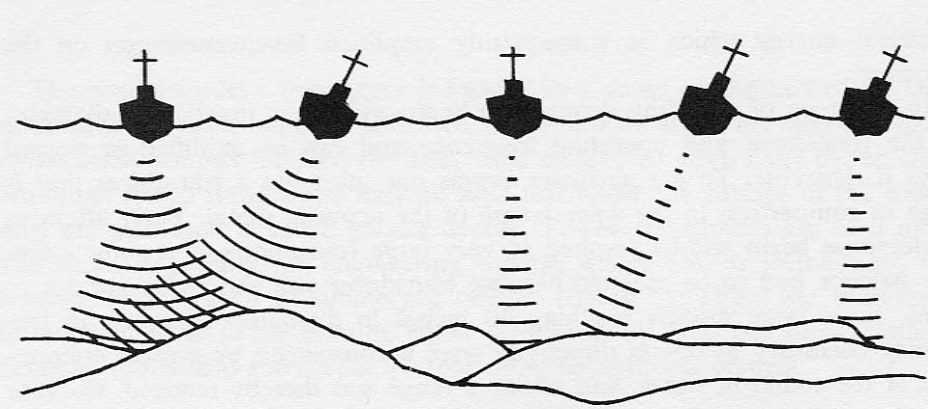
Problems:

1. Medium water is not transparent
2. Optimal survey planning not possible
3. Random distribution of tracks
4. Only few systematic surveys
5. Navigation and positioning different
6. „White spots“ in polar regions



H.W. Schenke
Monaco, GEBCO
Centenary 2003



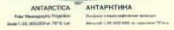


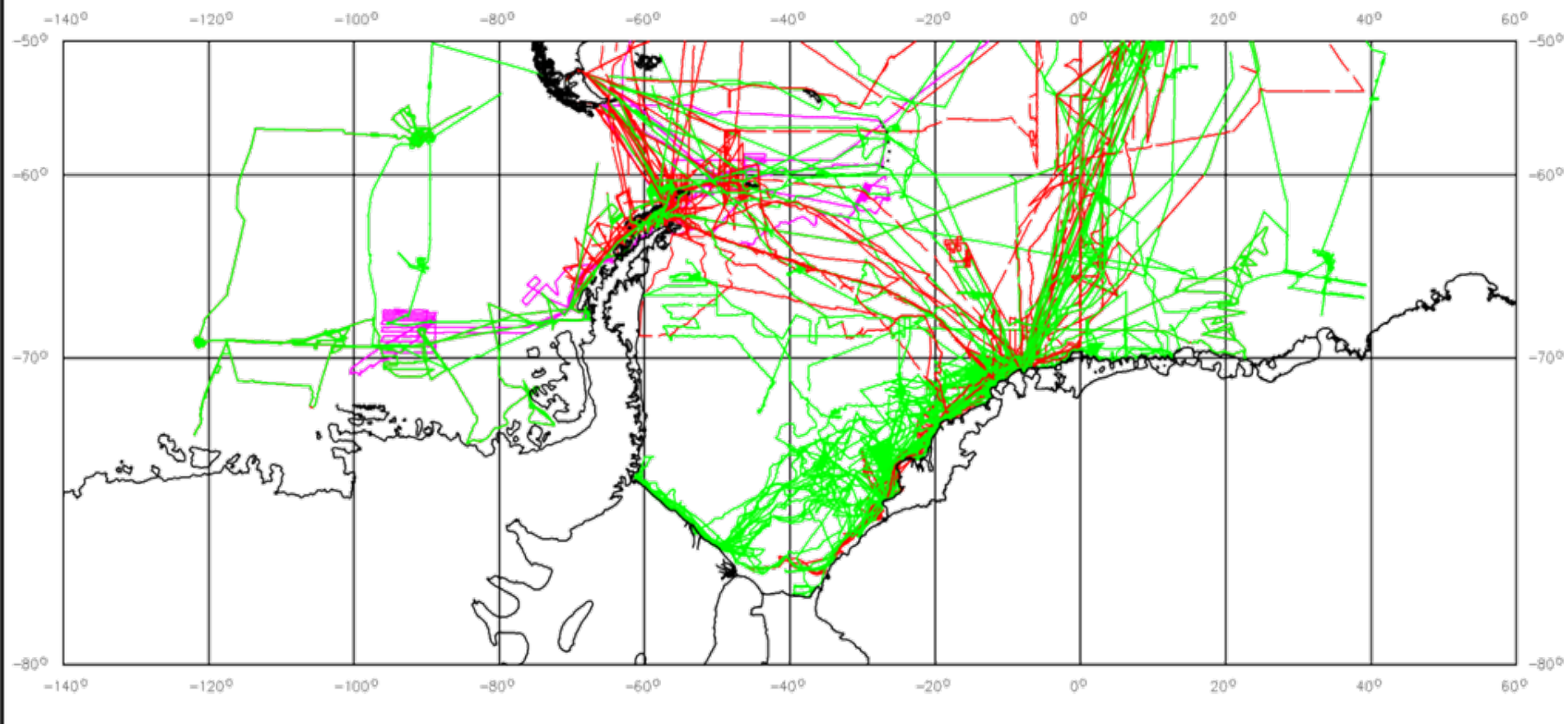
From lead lines to echo sounders From celestial navigation to GPS



H.W. Schenke
Monaco, GEBCO
Centenary 2003







red = Polarstern NBS data
green = Polarstern multibeam data
magenta = GAP 95 and 98 multibeam data

„Polarstern“ and
„Petrov“

MB and NBS data

Mercator Projection
Scale: 1 : 45000000
Standard Parallel: 65°S
World Geodetic System 1984 (WGS 84)



Bathymetric Group
Alfred Wegener Institute for
Polar and Marine Research
D-27515 Bremerhaven



H.W. Schenke
Monaco, GEBCO
Centenary 2003



Digital Terrain Models

3 kinds of
DTM's:

Raster

TIN

Contour Lines

Software:

Kriging

Bicubic Splines, min.curv.
Least Squares Interpol.

Akima

TASH, mov. surfaces

HIFI, fin. elements



H.W. Schenke
Monaco, GEBCO
Centenary 2003



Methodology

Historic Data

QC
weighting

Contour lines

bathymetric charts
track control

Original Data

New Data

Multibeam
Sonar

Single beam
Sonar

Edit

Edit

Auxiliary Data

pred. bathy

Sat. RM

Mar. Gr

Magn.

Source Data

Processing

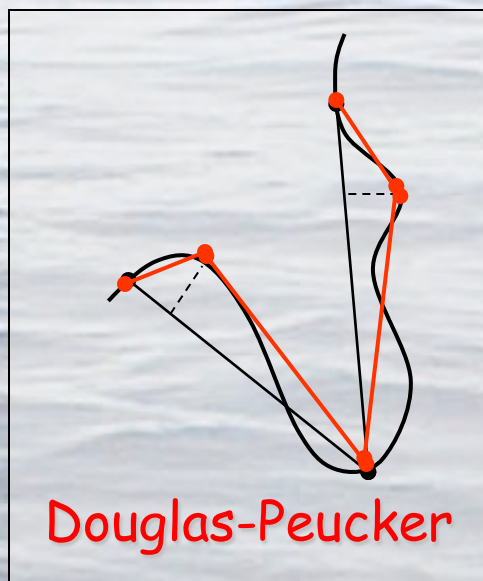
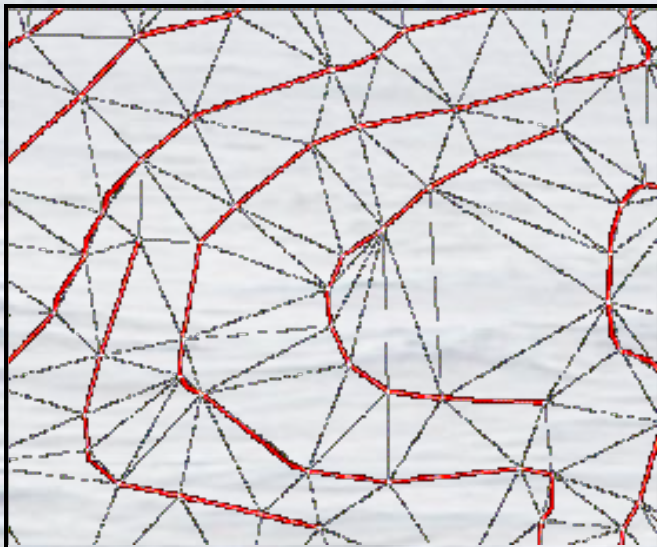
Douglas/Peucker
generalisation - > **TIN**
Gridding:
coarse grid



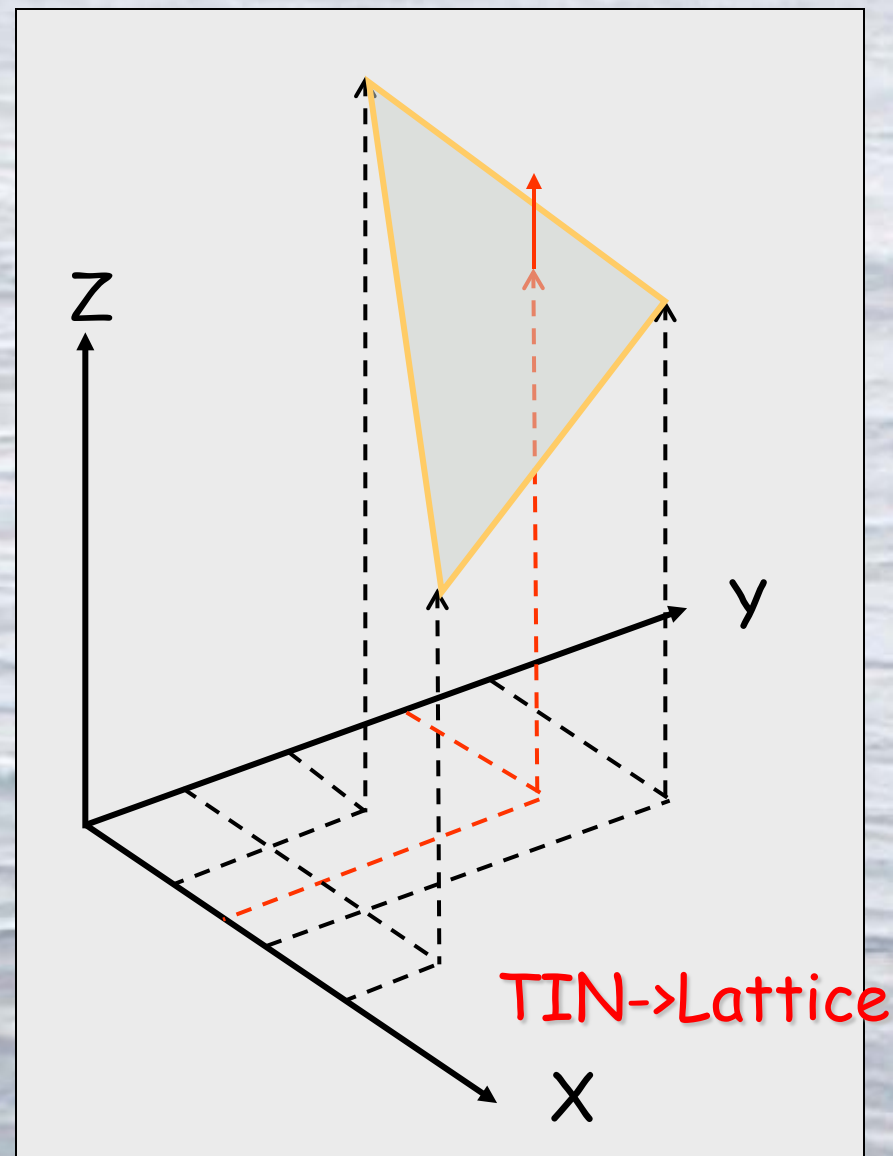
H.W. Schenke
Monaco, GEBCO
Centenary 2003



TIN



Douglas-Peucker

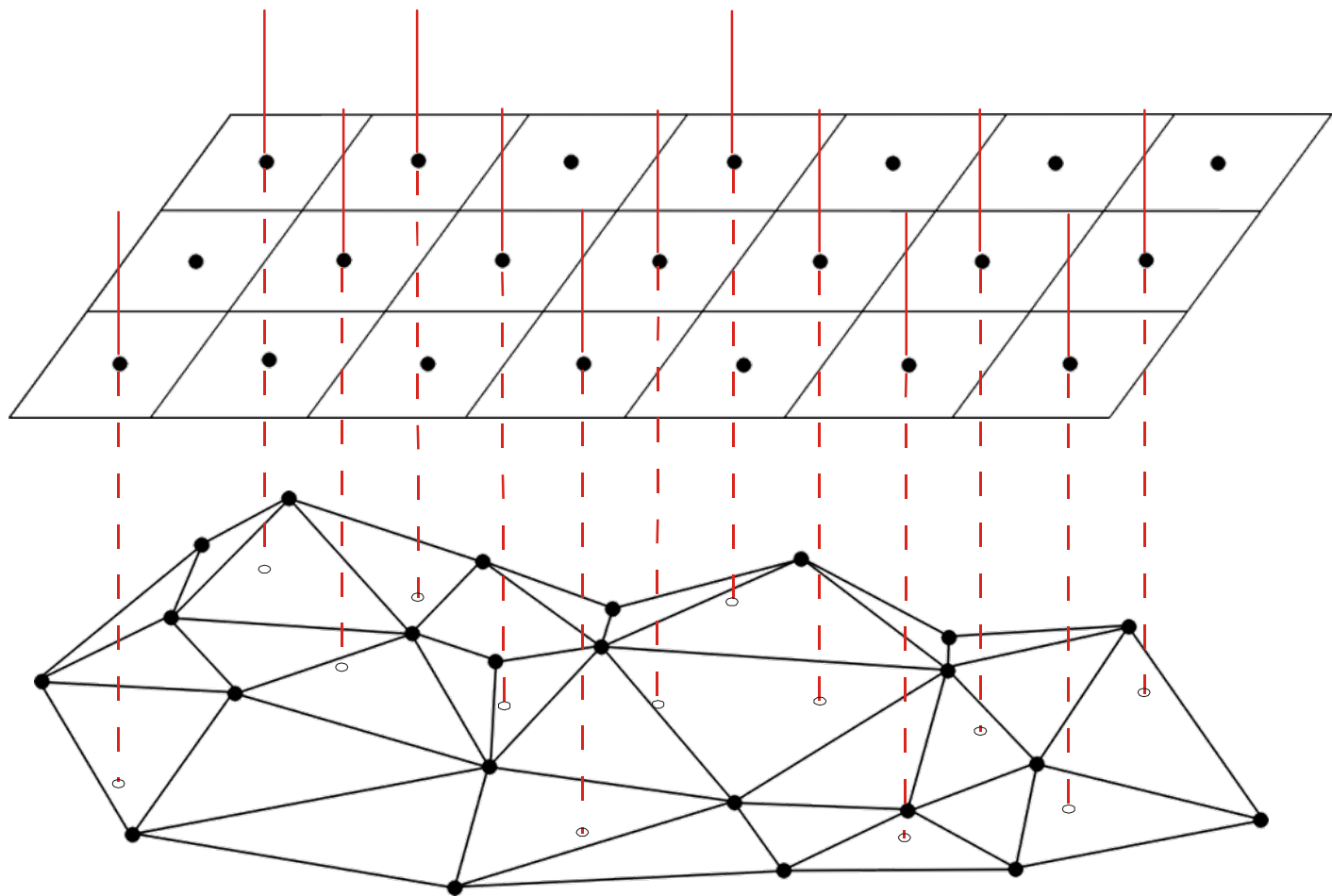


TIN->Lattice



H.W. Schenke
Monaco, GEBCO
Centenary 2003





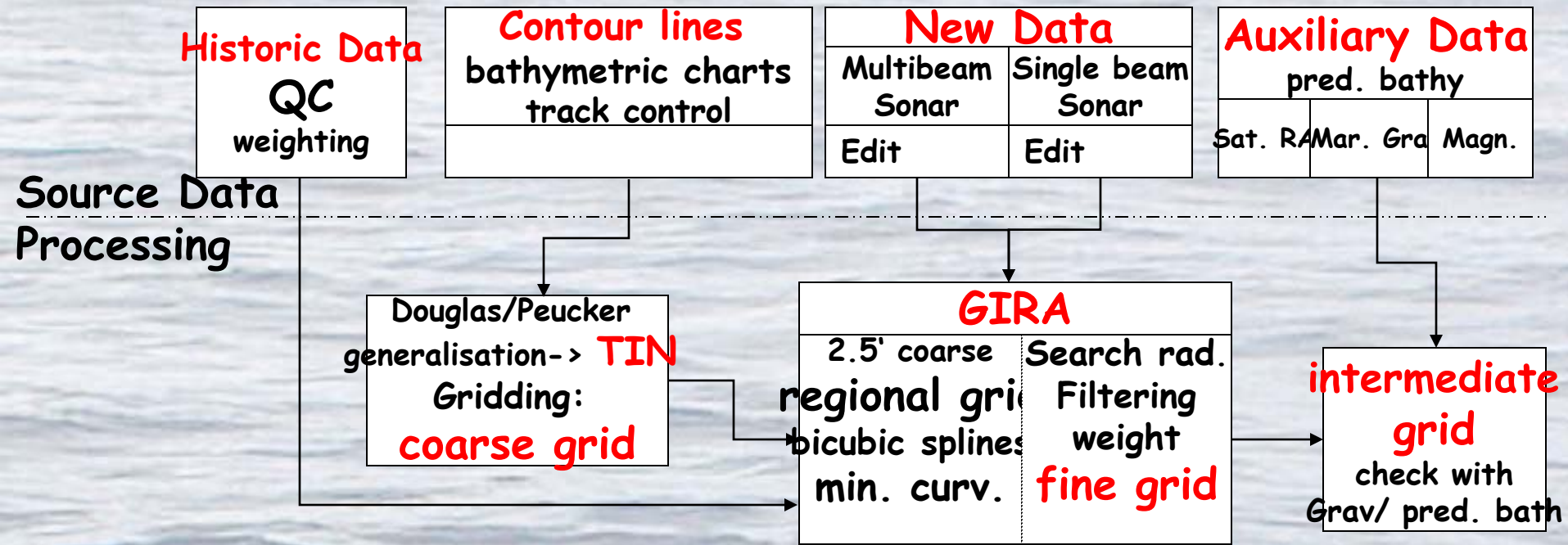
TIN- Lattice



H.W. Schenke
Monaco, GEBCO
Centenary 2003

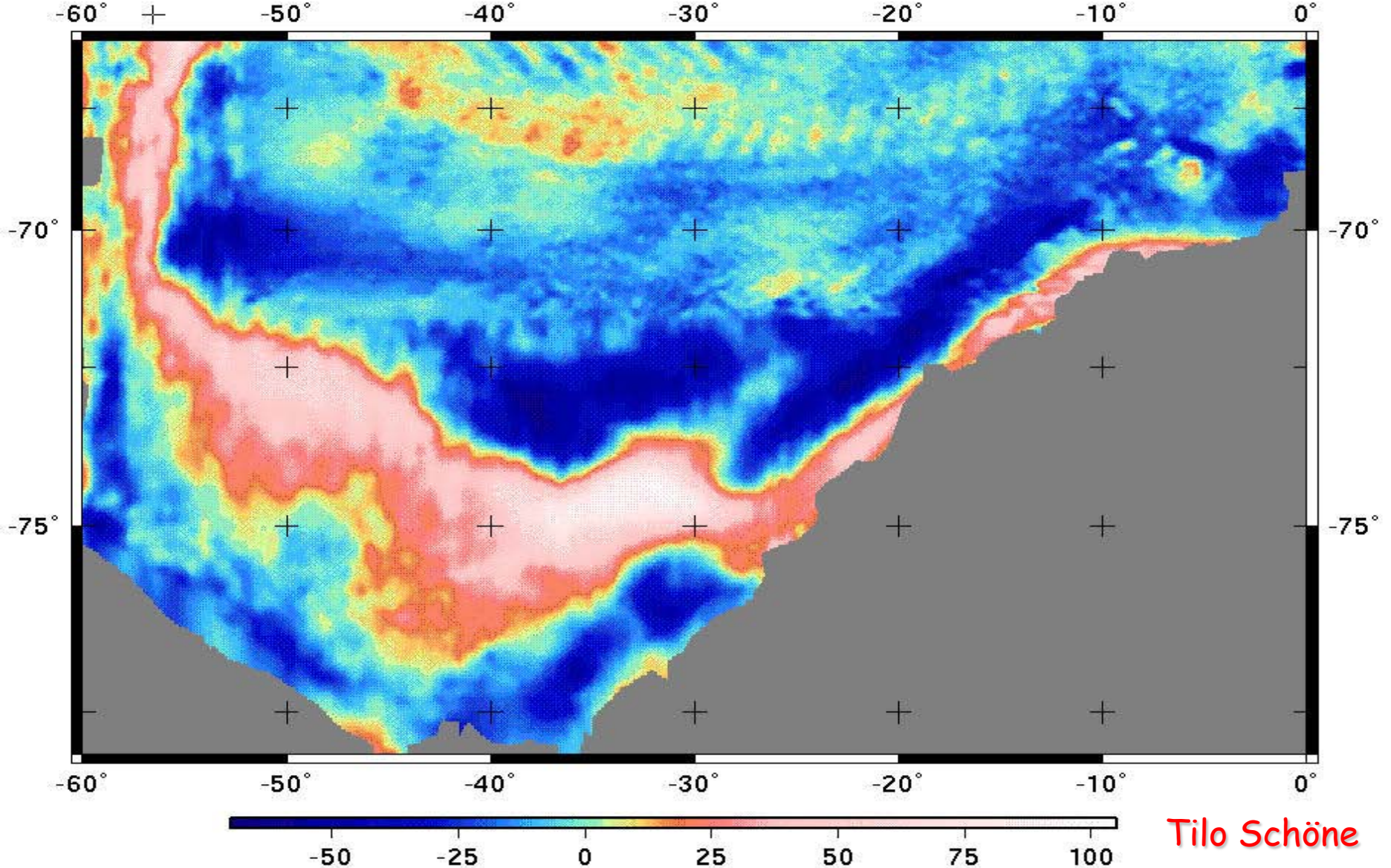


Methodology



H.W. Schenke
Monaco, GEBCO
Centenary 2003





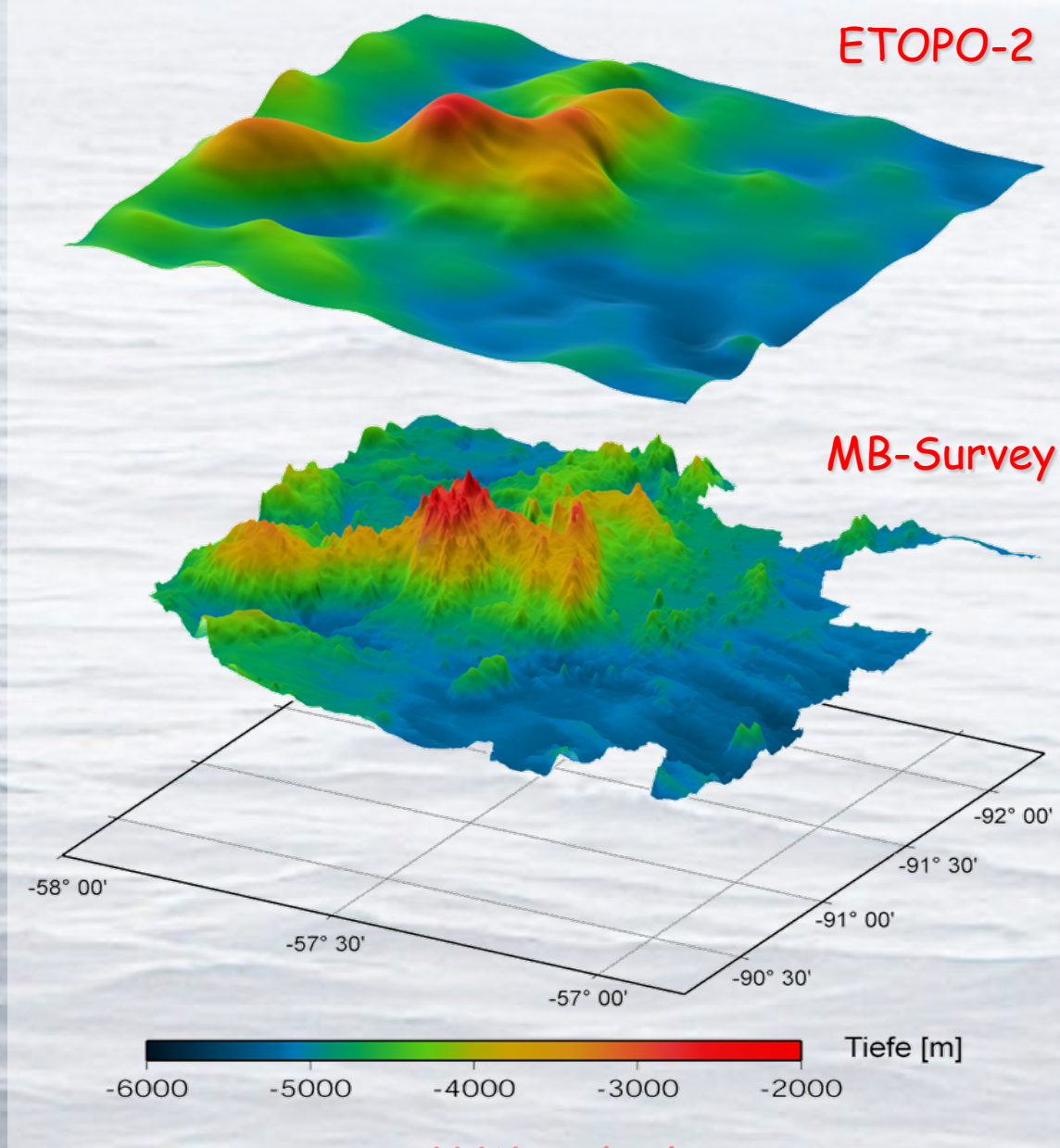
Tilo Schöne

ERS-1/2 Free Air Grav
Anomalies



Monaco, GEBCO
Centenary 2003

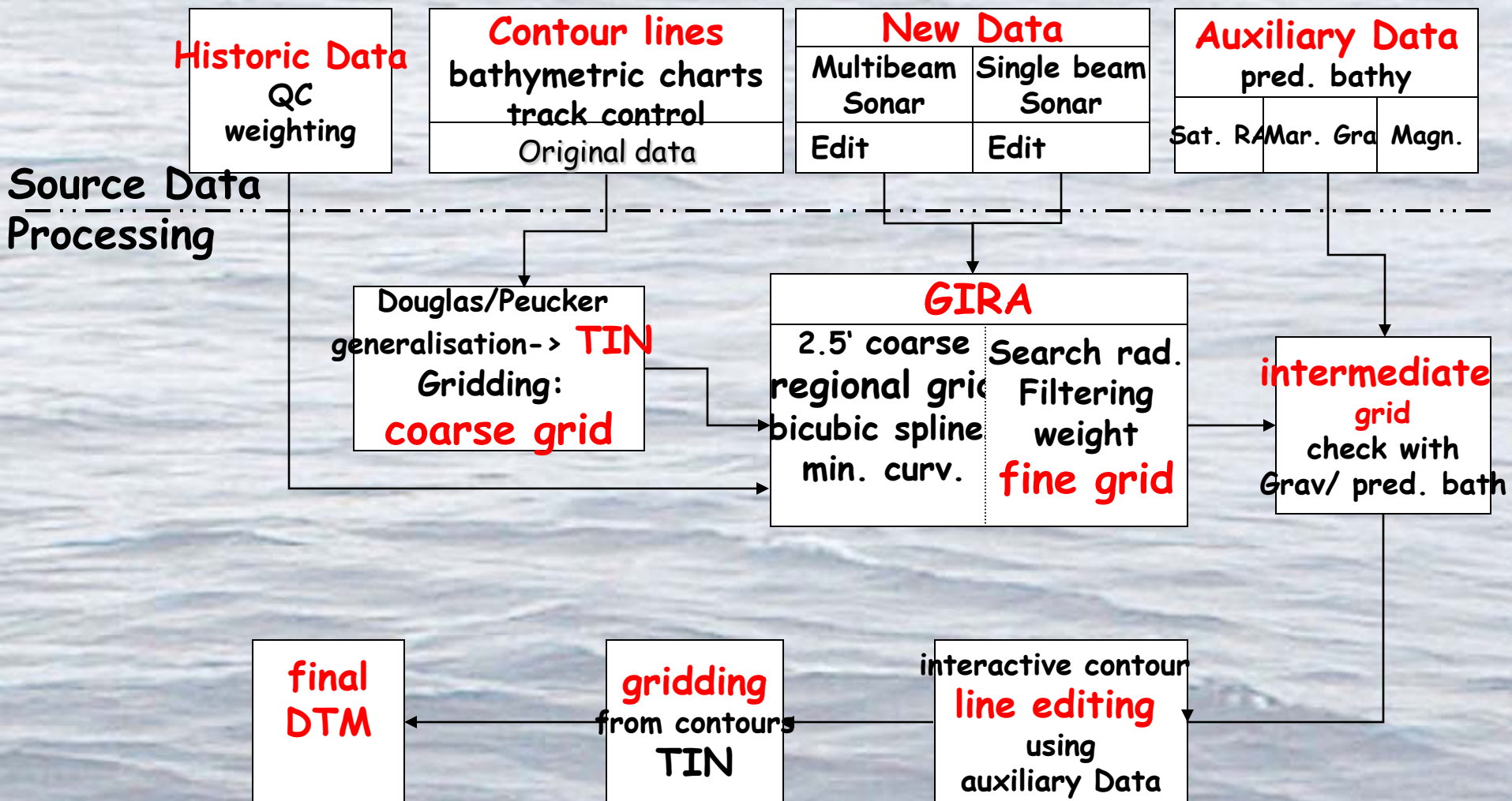




H.W. Schenke
Monaco, GEBCO
Centenary 2003



Methodology



H.W. Schenke
Monaco, GEBCO
Centenary 2003



AWI

AWI-BCFS
IBCAO

Mapping
Programs



Arctic

„Polarstern“



AWI-BCWS
IBCSO*

*planned



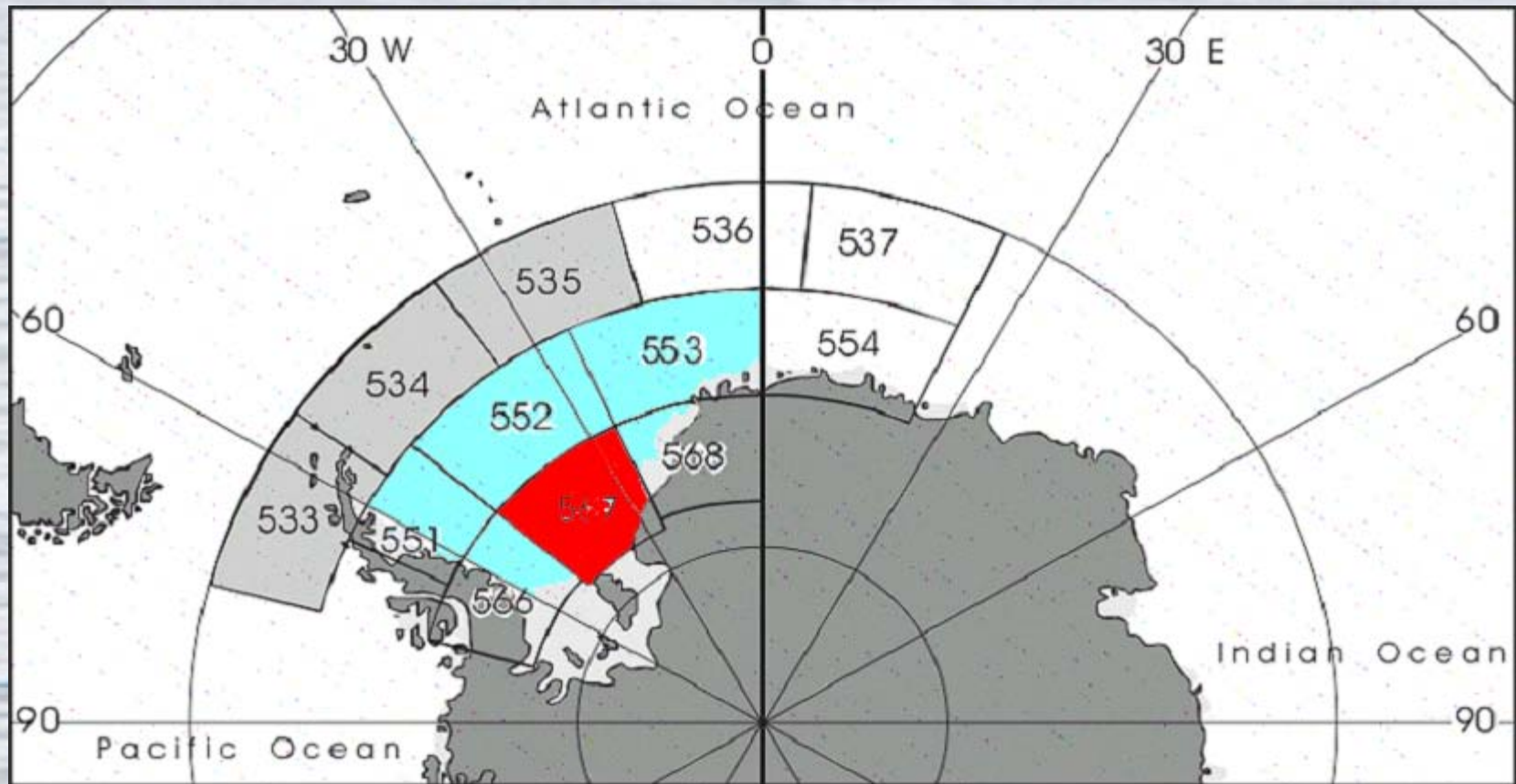
H.W. Schenke
Monaco, GEBCO
Centenary 2003



Antarctica



Index of the Bathymetric Chart of the Weddell Sea



AWI-BCWS 1:1 Mio

50/100 m contour interval
9 sheets

AWI-BCWS 1:3 Mio

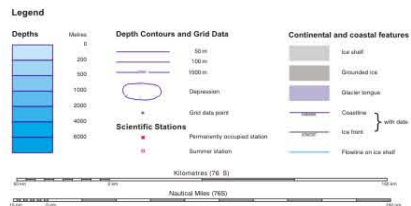
200 m contours



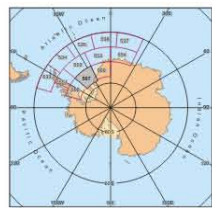
H.W. Schenke
Monaco, GEBCO
Centenary 2003



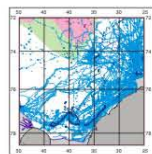
17



Sheet Index of the AWI BCWS

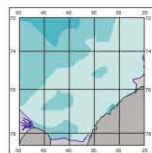


Source Data Diagram



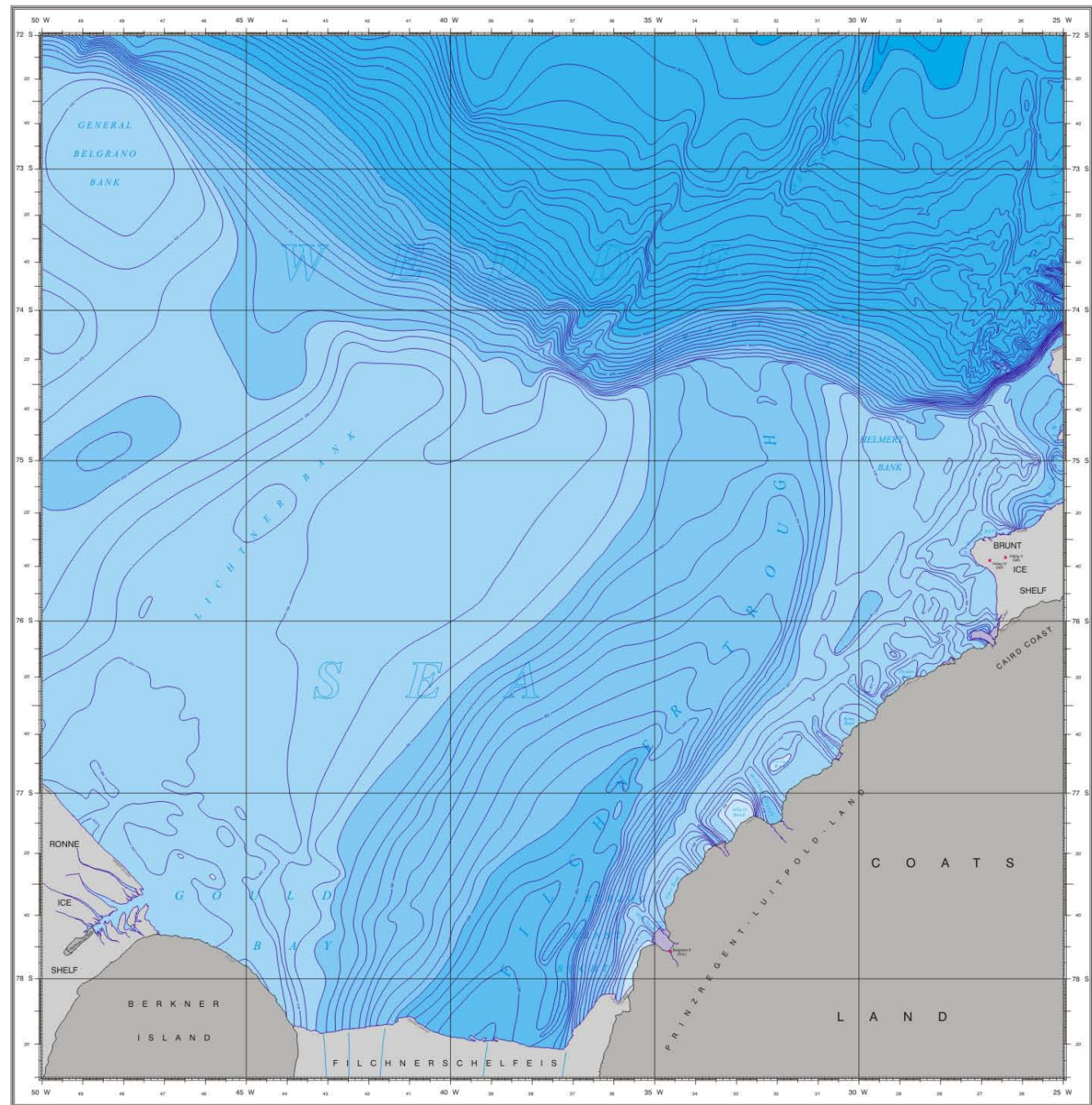
Date from	Area	Track Line	Spot Data
General			
Hydrographic Institutions			
Scientific Institutions			
Submarine Altimetry			

Accuracy of Bathymetric Depths

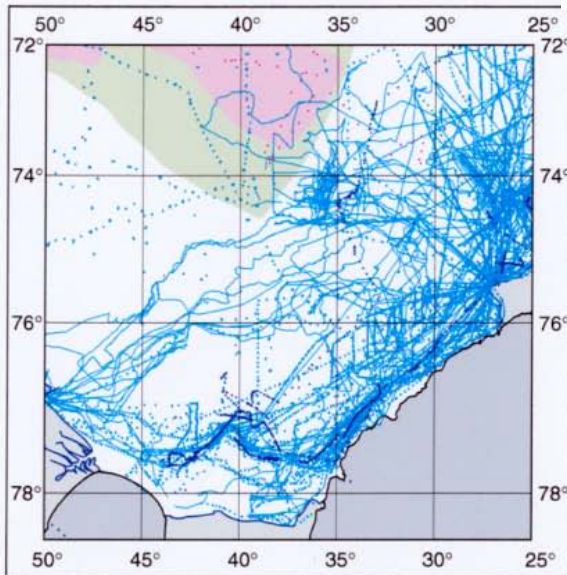


Accuracy

	50 m
	100 m
	200 m
	Worse than 200 m



Source Data Diagram



Scale 1 : 10 000 000

Data from	Area	Track Line	Spot Data
GEBCO			
Hydrographic Institutions			
Scientific Institutions			
Satellite Altimetry			

Contours/soundings from GDA

Hydrographic Organisations

Scientific Institutions

Satellite Altimetry Topographic Data

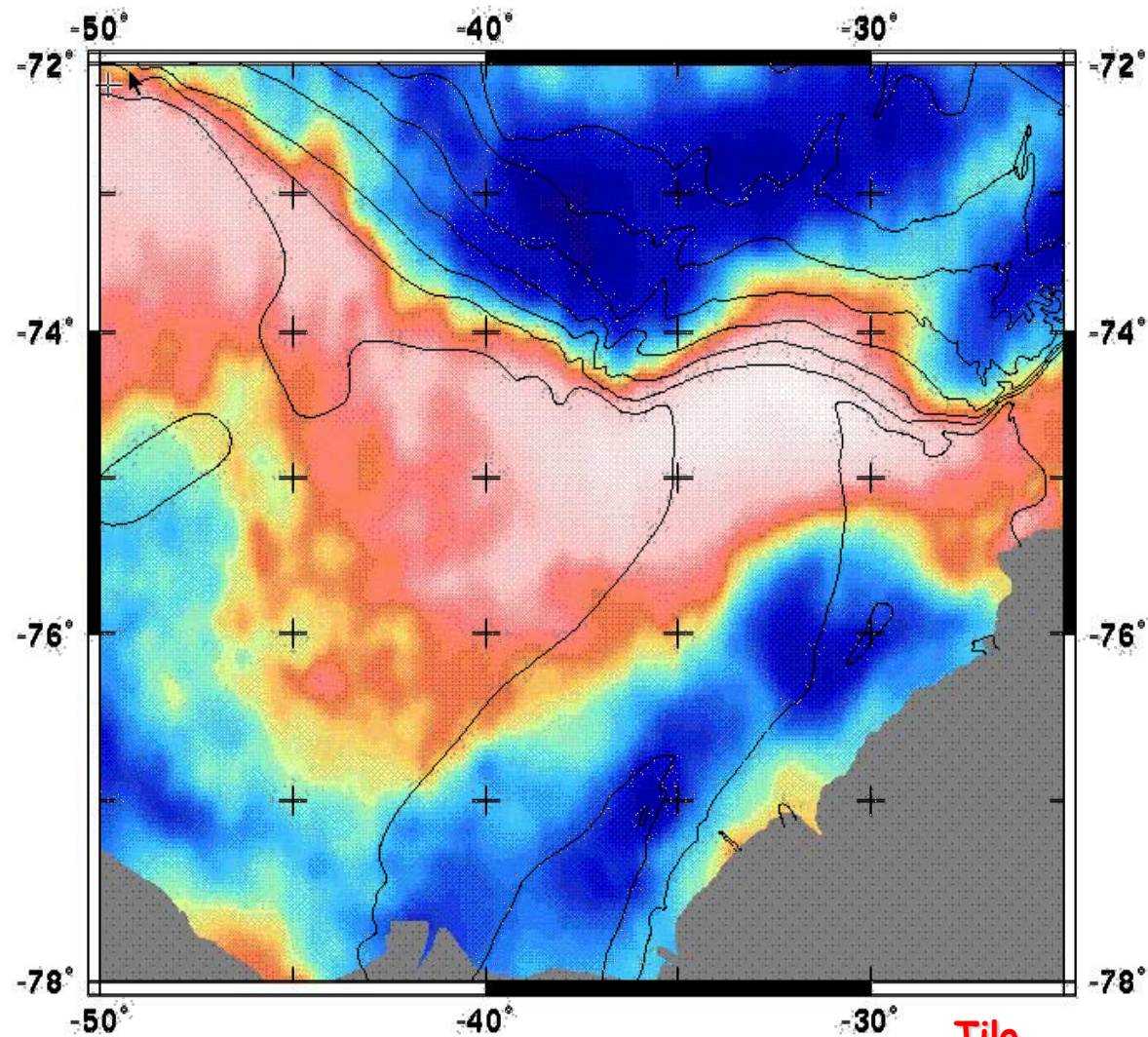
- 2.2 National Hydrographic Offices: Nautical Charts (various scales):
- Argentina
 - Republic of South Africa
 - United Kingdom
- 2.3 National Hydrographic Offices: Plotting Sheets (various scales)
- GEBCO Ocean Plotting Sheets (OPS) 1:1 000 000 by:
 - Argentina
 - Republic of South Africa
 - United Kingdom
 - Plotting Sheets 1:500 000 by:
 - Soviet Union / Russia
- 2.4 National Hydrographic Offices: Digital Data

- Multibeam data from SeaBeam and Hydrosweep system, single beam data from navigation echo sounder, narrow beam echo sounder, and Parasound sediment echo sounder.
- V. Krukov and V.S. Pozdeev, digital data, pers. comm.
 - V. Krukov and V.S. Pozdeev, digital data, pers. comm.
- 3.2 Scientific Publications
- Hoppe, H., F. Thyssen 1988: Ice thickness and bedrock elevation in Western Neuschwabenland and Berkner Island, Antarctica. *Annals of Glaciology*, vol.11, 42-45, 1988.
 - Huybrechts, P. 1992: The Antarctic ice sheet and environmental change: a three-dimensional modelling study. *Berichte zur Polarforschung* 99, 1992.
 - Pozdeev, V.S., R.G. Kurin 1987: Nowye dannyye o morfologii ledovoy tolschtschi i reliefe podlednogo losha i morskogo dna v jushnoj tschasti bassejna Morja Ueddella (Sapadnaja Antarktika). *Antarktika, Doklady Komissii*, 26, 66-71, 1987.
- 3.3 Other Sources
- Doake, C.S.M., BAS, UK: Filchner-Ronne Ice Shelf oversnow traverse gravity data, calculation by B. Harrods, pers. comm.
 - Hinze, H., AWI, Germany: Southern Ocean and Antarctica collected depth and bathymetry data. Internal report.



H.W. Schenke
Monaco, GEBCO
Centenary 2003





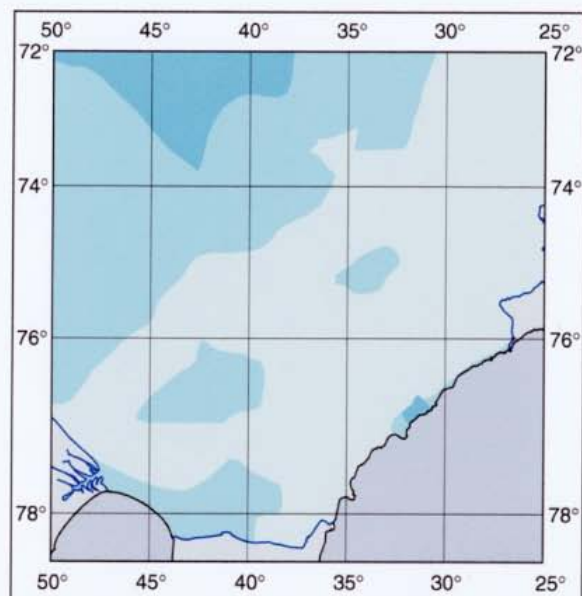
500 m contours BCWS mgal RA Free-air grav anomalies



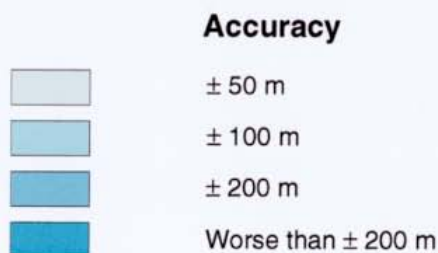
Monaco, GEBCO
Centenary 2003



Accuracy of Bathymetric Depths



Scale 1 : 10 000 000



The bathymetry contained in this chart is evaluated from various data sets of different quality, and is therefore of varying accuracy. Compilation and contouring are in accordance with the IHO standards (IHB S-44), applied to Antarctic waters.

Reported but unconfirmed or suspect depths were omitted if they conflicted with morphologic evidence from other sources.

Reference: Hinze, H., 1994: Charting the Bathymetry of Weddell Sea, Antarctica. Marine Geodesy, vol.17, 139-145.

The positional accuracy of bathymetric data, contour lines and features in relation to the graticule is approximately 1 mm (or 1 kilometre on the Earth).

Mean positional error: horizontal accuracy e_h for contour lines of the given scale may be estimated by Koppe's empirical formula, which depends on the terrain slope α ($a=50$ m, $b=2000$ m):

$$e_h = b + a \cdot \cot \alpha;$$

A vertical accuracy of better than 2% of depth was achieved with the compilation from heterogeneous depth data. However, some suspect data still may be present within the map.

Mean depth error: accuracy e_d of a contour or interpolated depth value from the map may be estimated by

$$e_d = a + b \cdot \tan \alpha;$$

$a=50$ m and $b=500$ m.

In areas with slopes greater than 20° the error may exceed 200 m due to generalisation effects.

Despite an automatic accuracy estimation, a classification may reflect how closely the ideal has been approached under the existing constraints, e.g. inhomogeneous data and seabed roughness. Thus, categories for the accuracy of bathymetric depths were chosen. The 1 : 10 000 000 inset map of bathymetric accuracy gives an overview of accuracies, but it does not reflect special features, e.g. canyons or seamounts. Areas with depths estimated worse accurate than 200 m, better than 200 m, better than 100 m, and better than 50 m are given.

Caution.

Due to incomplete survey coverage dangers may exist, particularly within the 200 metre depth contour. Vessels should therefore navigate with due caution.

For further information on navigation, magnetic variation, ocean currents, and ice in the area of this map see Sailing Directions and Routing Charts and contact the Hydrographic Offices or IHB. For further information on research stations and glaciology contact the SCAR. For further informations on bathymetry contact the IHB-IOC GEBCO Committee or AWI.

Koppe's Formula:

$$e_h = b + a \cdot \cot \alpha$$

$$e_d = a + b \cdot \tan \alpha$$

$$a=50\text{m}$$

$$b=2000\text{m}$$

$$a=50\text{m}$$

$$b=500\text{m}$$



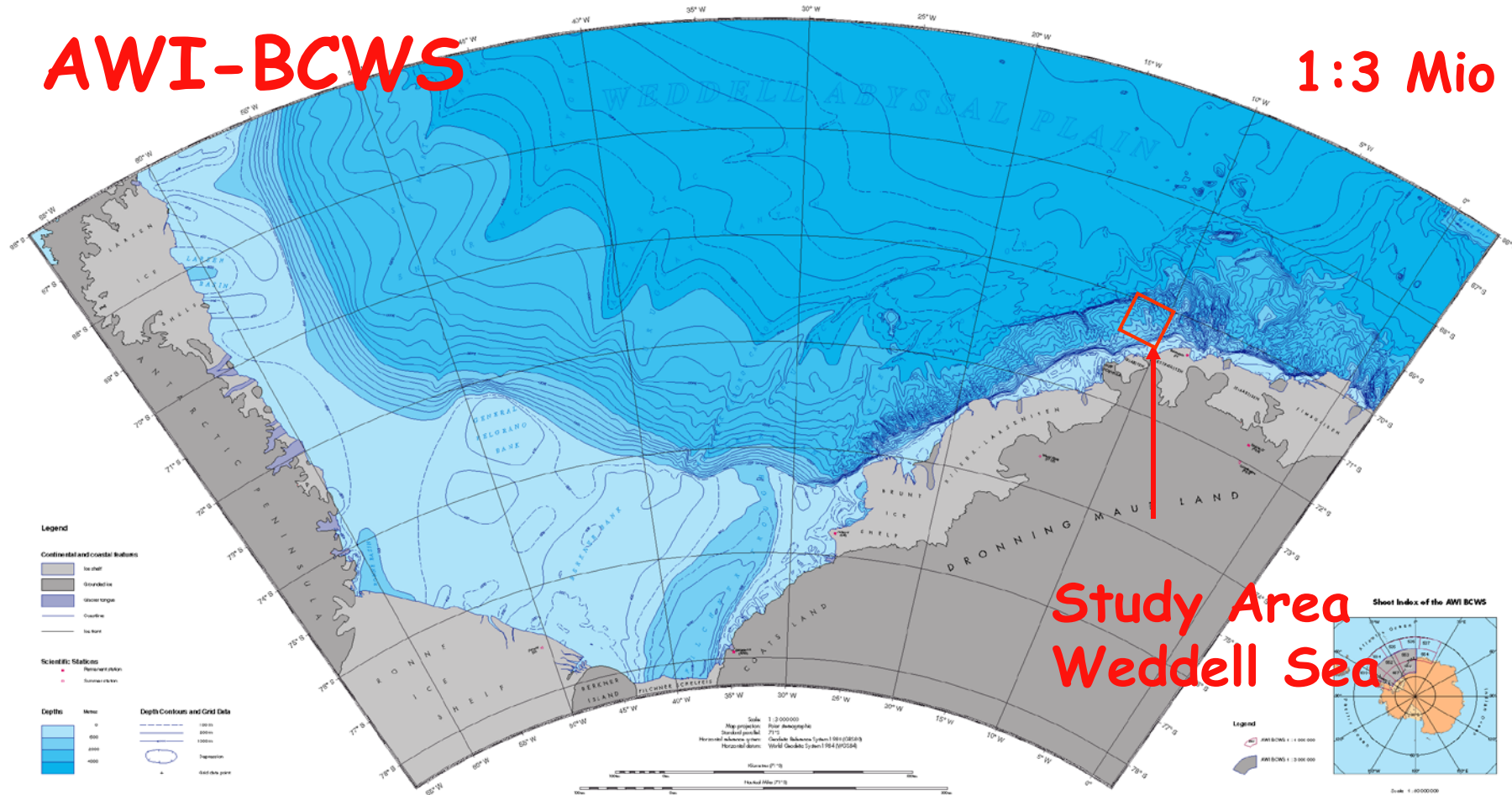
H.W. Schenke
Monaco, GEBCO
Centenary 2003





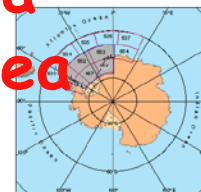
AWI-BCWS

1:3 Mio



Study Area Weddell Sea

Sheet index of the AWI BCWS



General Information

This chart is a bathymetric chart of the Weddell Sea, Antarctica, at a scale of 1 : 3 000 000. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is based on data from the German Research Expedition (GRS) to the Weddell Sea in 1992/93, and other sources. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is a bathymetric chart of the Weddell Sea, Antarctica, at a scale of 1 : 3 000 000. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is a bathymetric chart of the Weddell Sea, Antarctica, at a scale of 1 : 3 000 000. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is based on data from the German Research Expedition (GRS) to the Weddell Sea in 1992/93, and other sources. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is a bathymetric chart of the Weddell Sea, Antarctica, at a scale of 1 : 3 000 000. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is a bathymetric chart of the Weddell Sea, Antarctica, at a scale of 1 : 3 000 000. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is based on data from the German Research Expedition (GRS) to the Weddell Sea in 1992/93, and other sources. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

The chart is a bathymetric chart of the Weddell Sea, Antarctica, at a scale of 1 : 3 000 000. It is a product of the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.

Source Data

1. General Bathymetric Chart of the Ocean (GBCO) Digital Atlas, 1993, published by the International Hydrographic Association (IHO), Monaco.

2. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

3. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

4. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

5. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

6. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

7. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

8. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

9. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

10. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

11. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

12. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

13. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

14. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

15. National Hydrographic Office (NHO) charts, including the NHO chart of the Weddell Sea, 1993, published by the NHO, Washington, D.C., USA.

AWI BCWS 1:3 000 000 South of Weddell Sea

AWI BCWS 1:3 000 000 Southern Weddell Sea

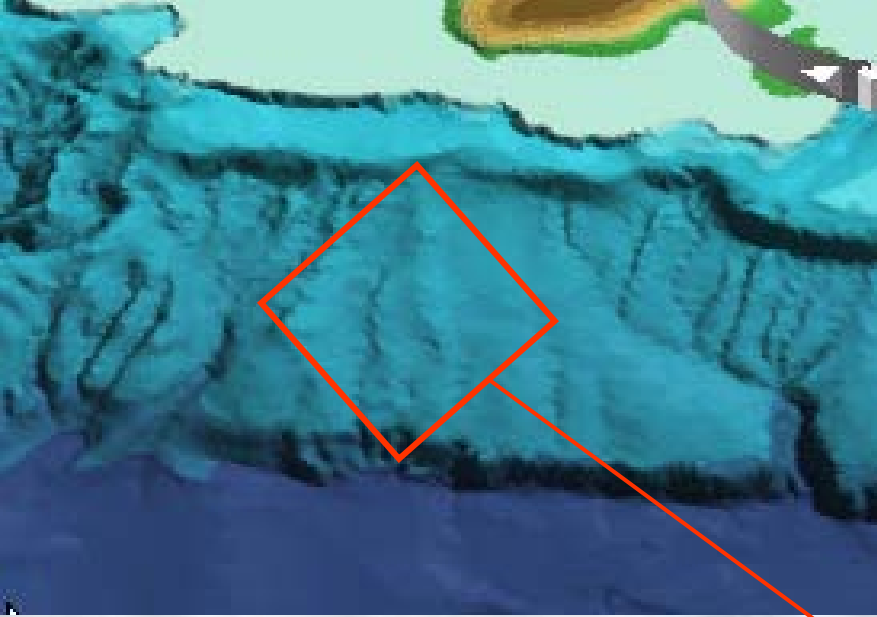
NOT TO BE USED FOR NAVIGATION



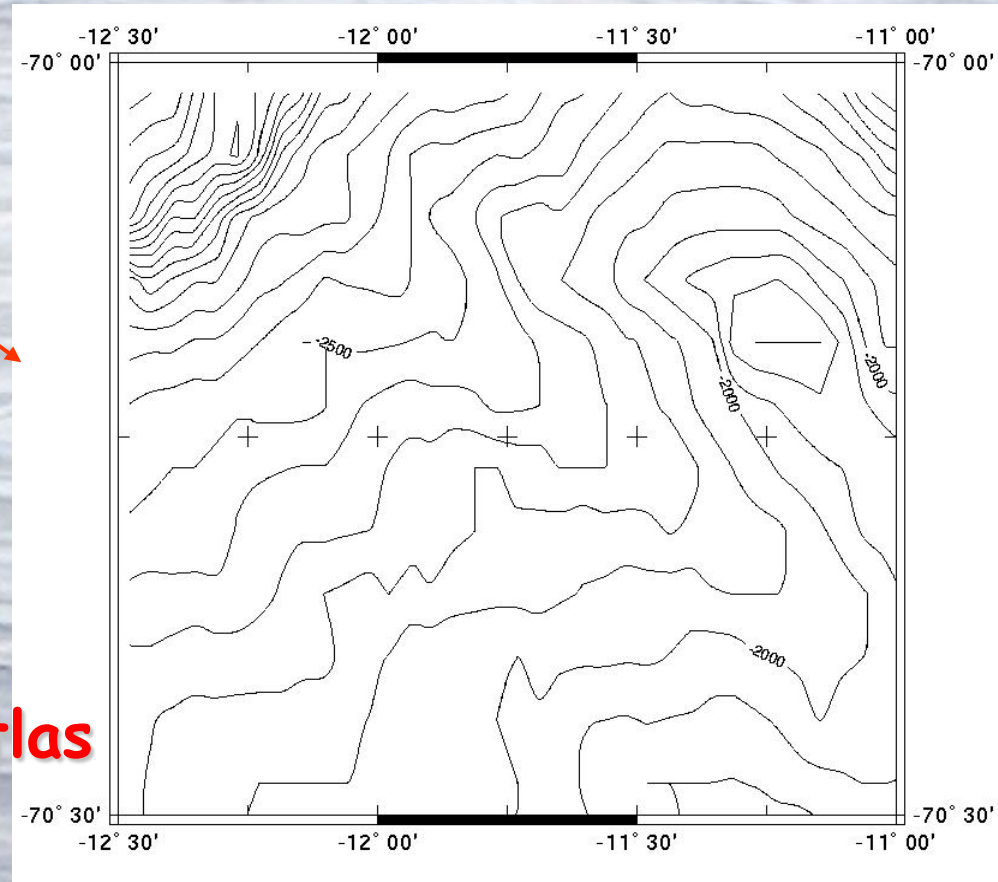
H.W. Schenke
Monaco, GEBCO
Centenary 2003



Antarctic Continental Shelf



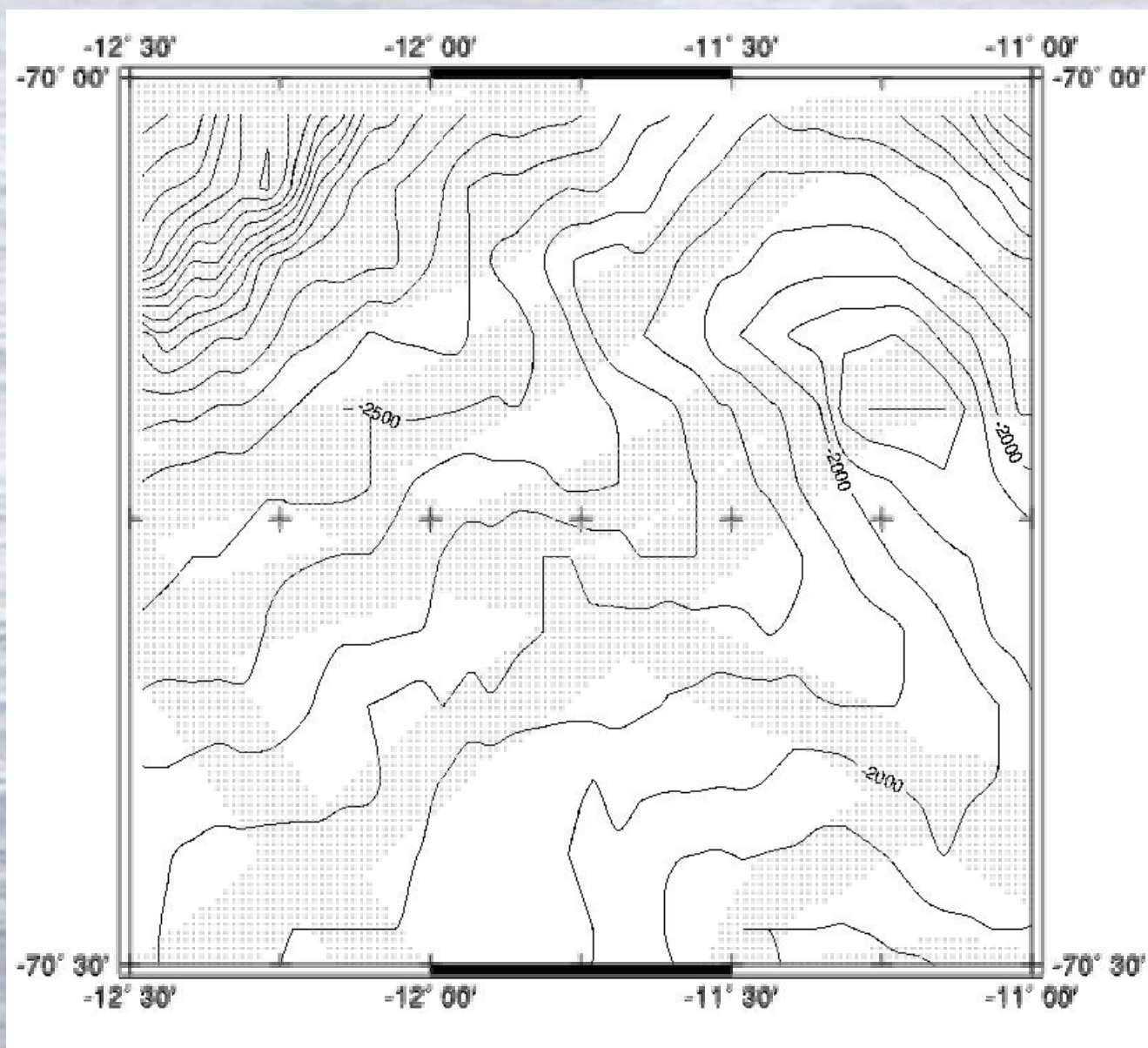
Contours from
GEBCO Dig. Atlas



H.W. Schenke
Monaco, GEBCO
Centenary 2003



GDA-
Contours
plus
MB-
cover.



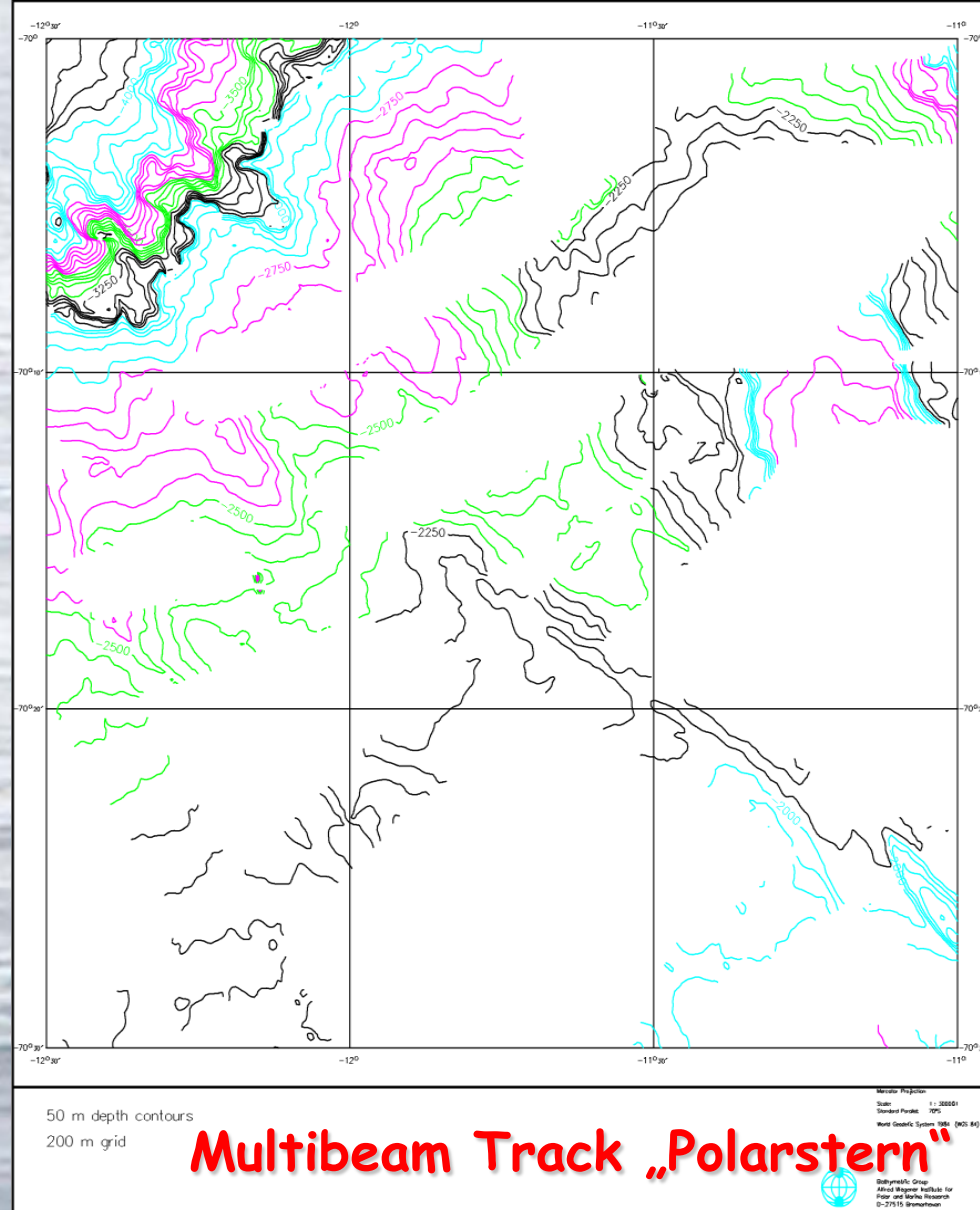
15.02.2012



Centenary 2003

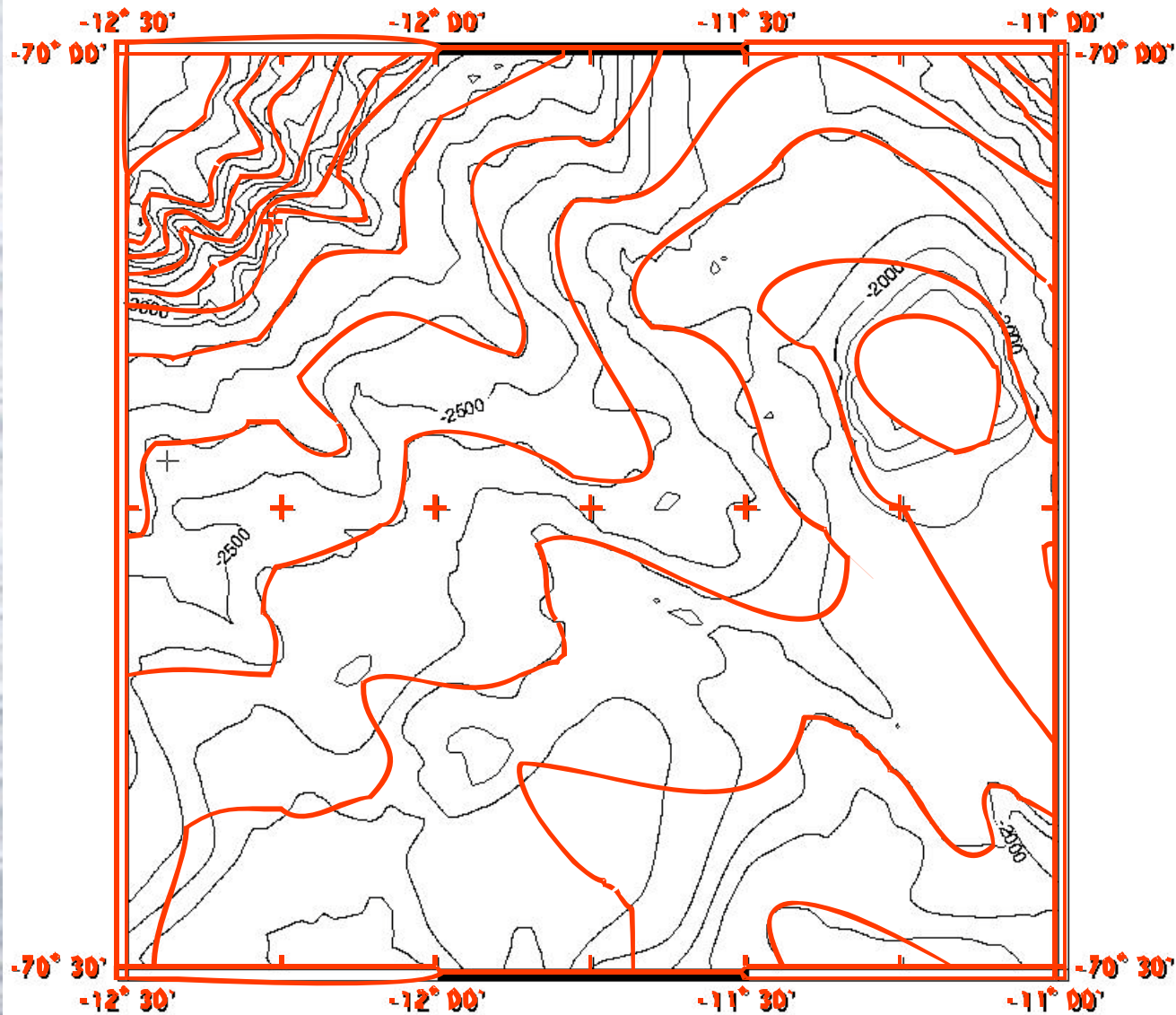


24



H.W. Schenke
Monaco, GEBCO
Centenary 2003





Combined GEBCO-contours with Multibeam data



H.W. Schenke
Monaco, GEBCO
Centenary 2003



Future Development

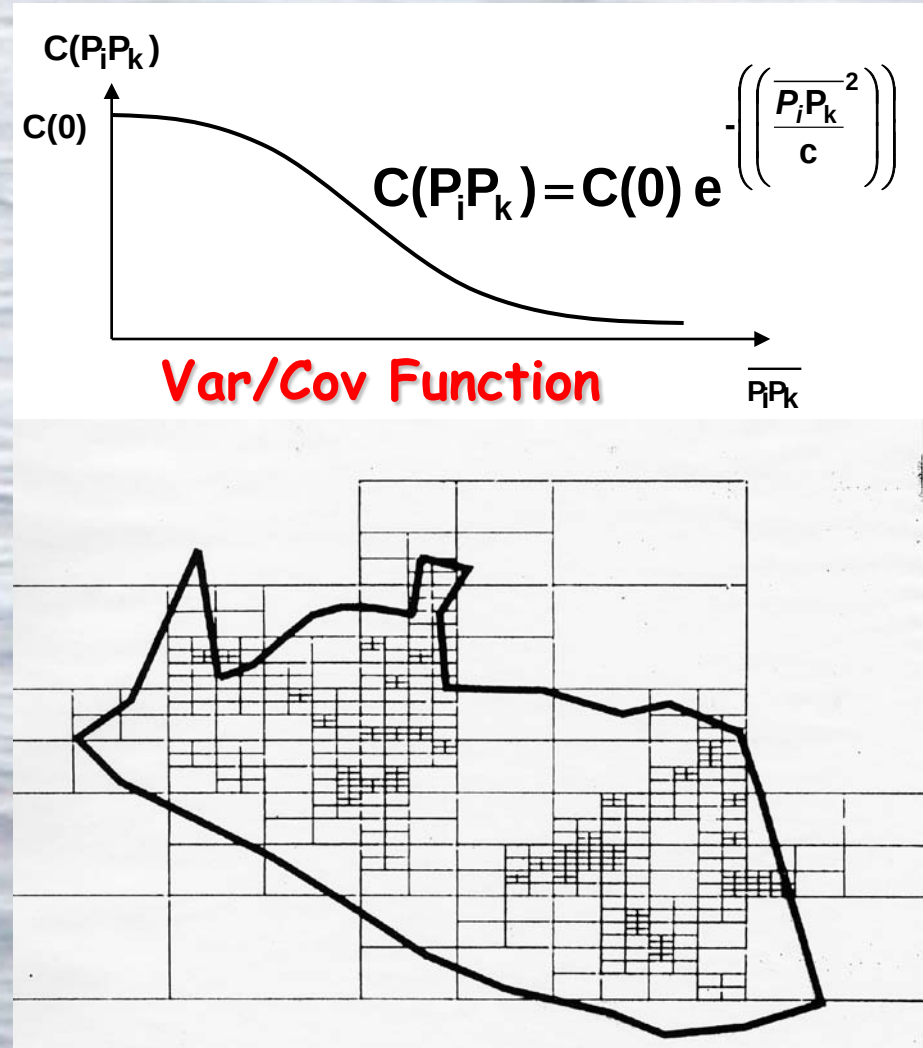
DTM-
Interpolation
Kriging
Collocation

DTM-hierarchy:

Quadtree



H.W. Schenke
Monaco, GEBCO
Centenary 2003





Thank you!

Little boy: „Good Lord, isn't the ocean large!”

Friend: „Yeah, and what you see is only the cover!”



H.W. Schenke
Monaco, GEBCO
Centenary 2003

