Operational processing of Argo data in Germany

B. Klein and M. Stawarz

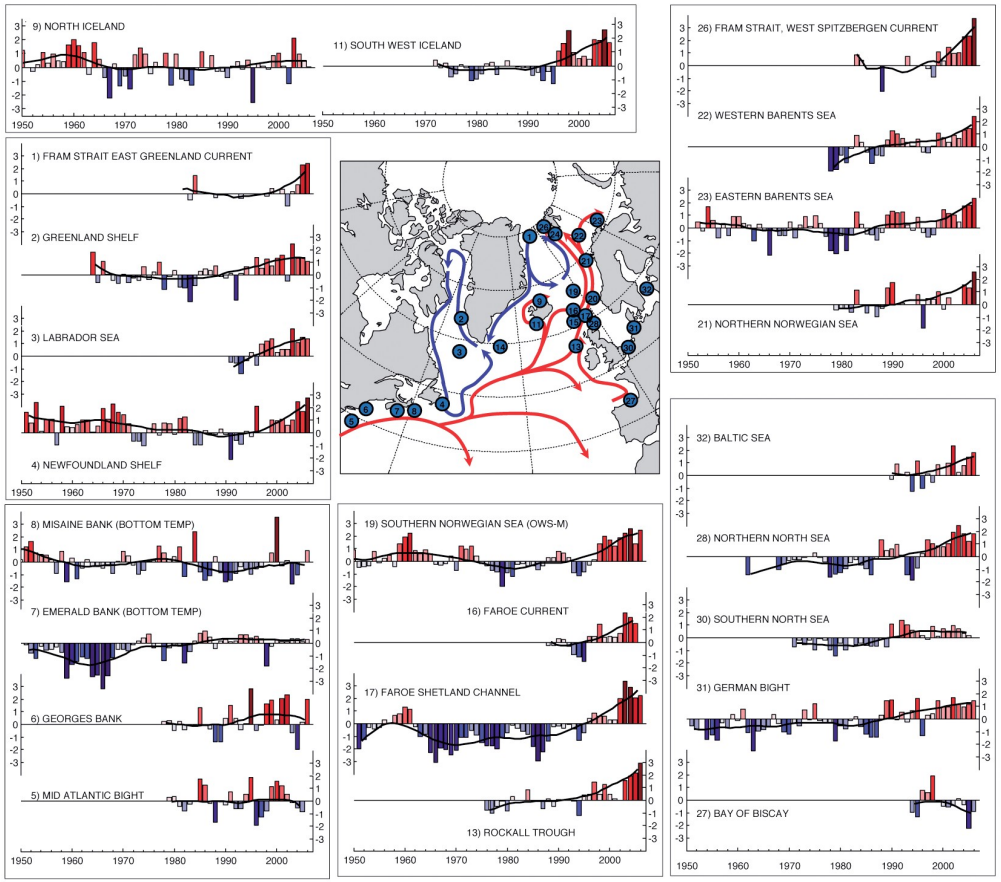
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Bundesamt für Seeschifffahrt und Hydrographie
Federal Maritime and Hydrographic Agency

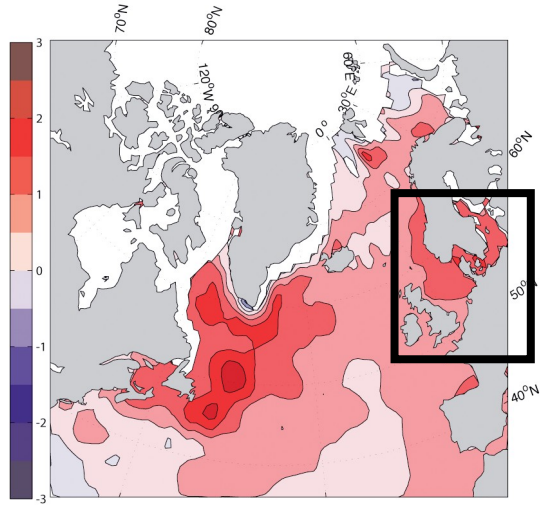
The BSH is a maritime governmental agency aiding the maritime industry, science, and environmental organisations. Our responsibilities are:

- Services to the German commercial fleet (International Shipping Register, law of the flag)
- Issue and registration of mariners' certificates
- Type-testing and approval of radiocommunications and navigation equipment
- Publication of nautical charts
- Approval of offshore activities, e.g. wind farms, pipelines, submarine cables
- Prosecution of environmental offences
- Prediction of tides, water levels, and storm surges
- Surveys in the North and Baltic Seas
- Monitoring the marine environment
- Improving the knowledge of the oceans to be able to mitigate climate change

Changes in water mass properties in the Atlantic sector: temperature

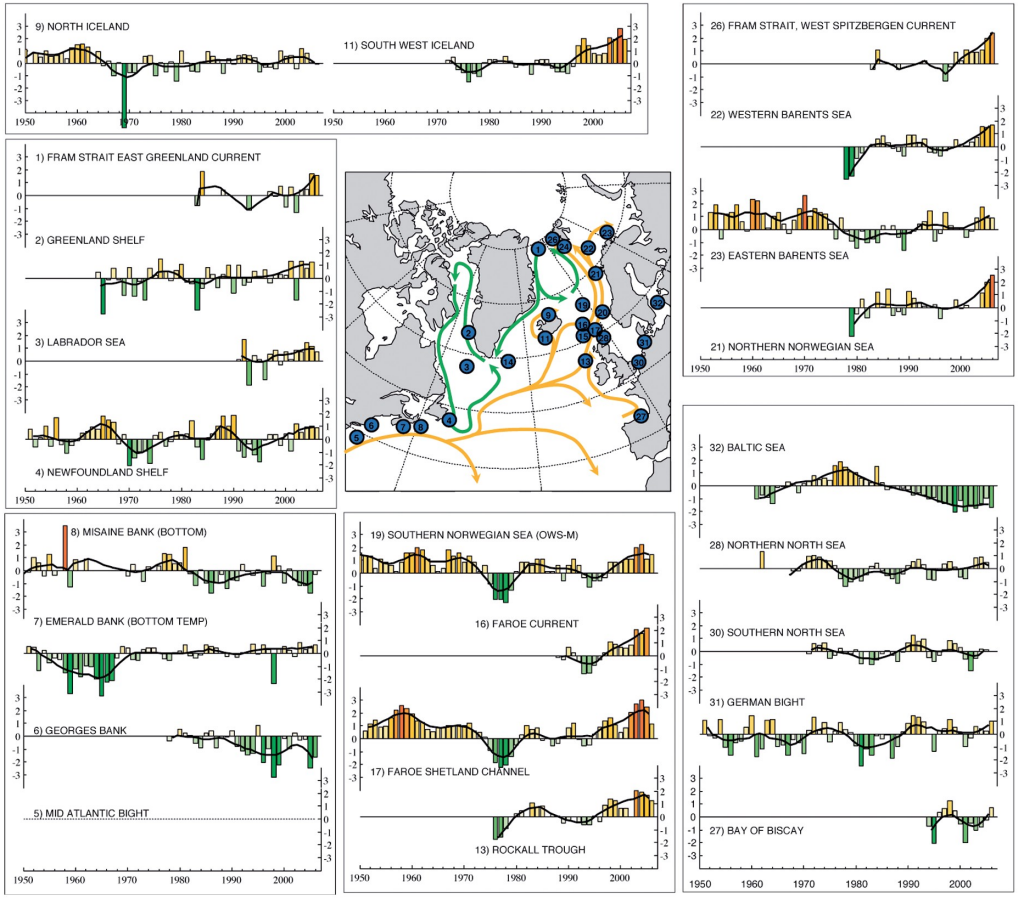


Source: ICES report on Ocean Climate, 2007



Normalized temperature anomalies for 2006

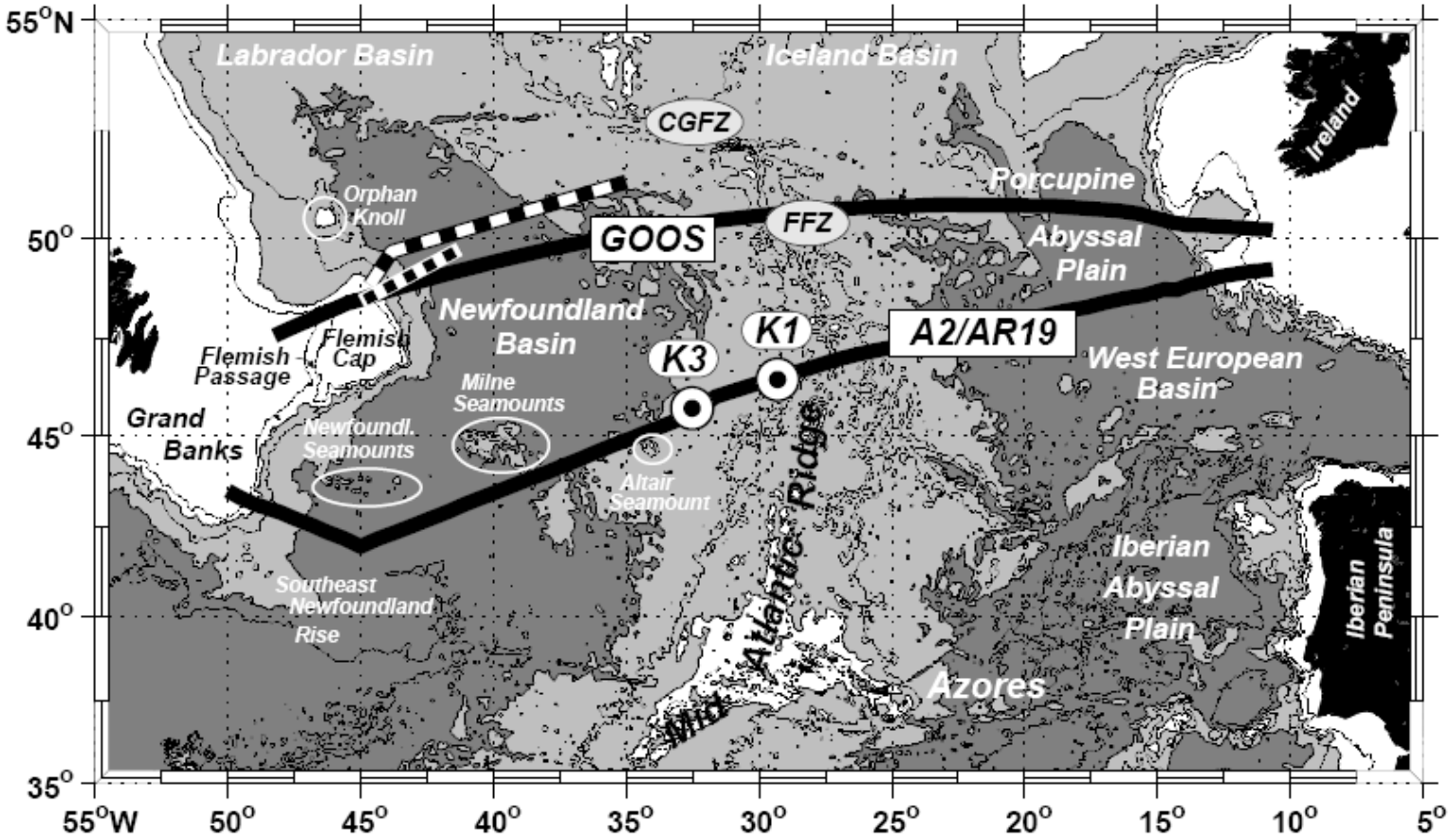
Changes in water mass properties in the Atlantic sector: salinity



Normalized salinity anomalies for 2006

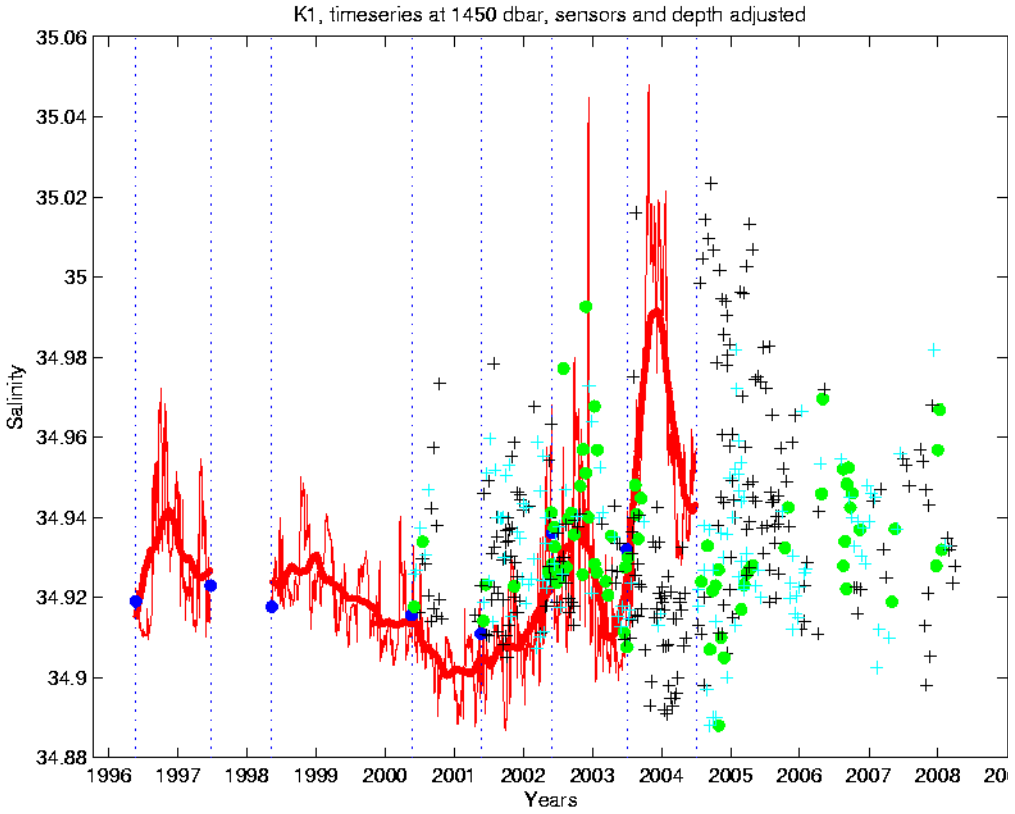
Source: ICES report on Ocean Climate, 2007

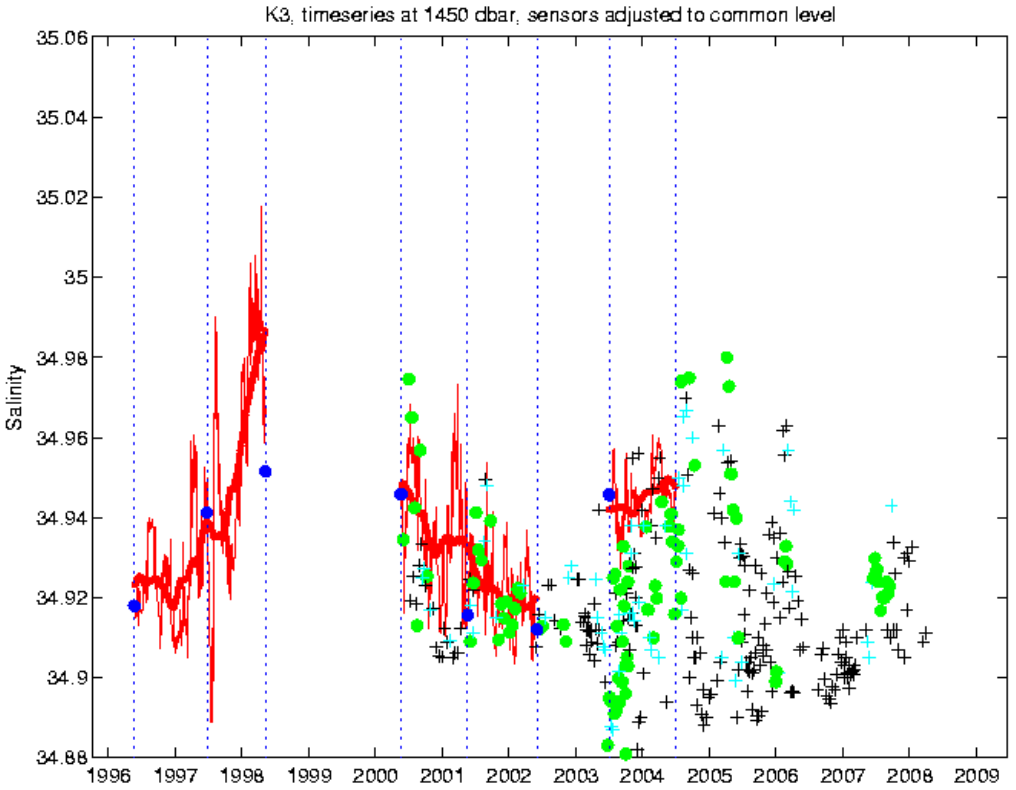
Combining mooring time series with Argo data



Combining mooring time series with Argo data

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE





Mooring data — mooring data smoothed ● argo float <80 km ● argo floats <100 km + argo floats <220 km

Combing repeated CTD sections with Argo data

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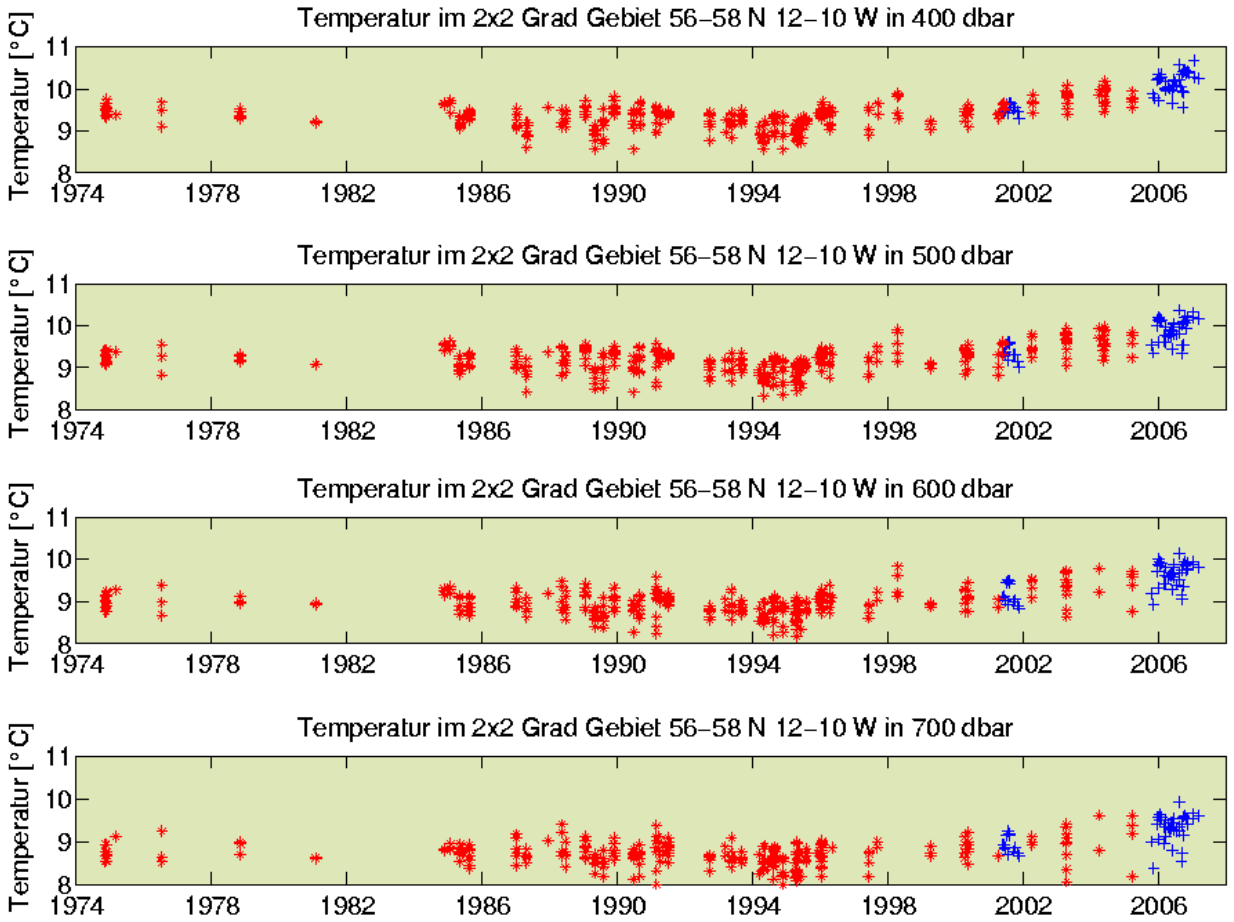
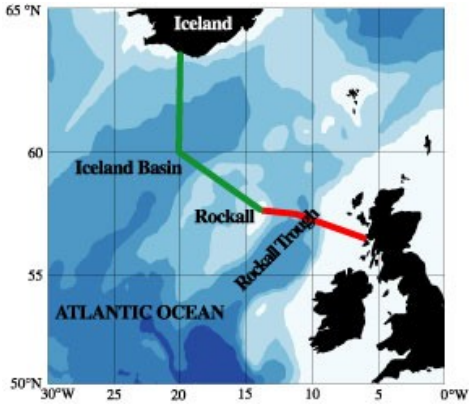
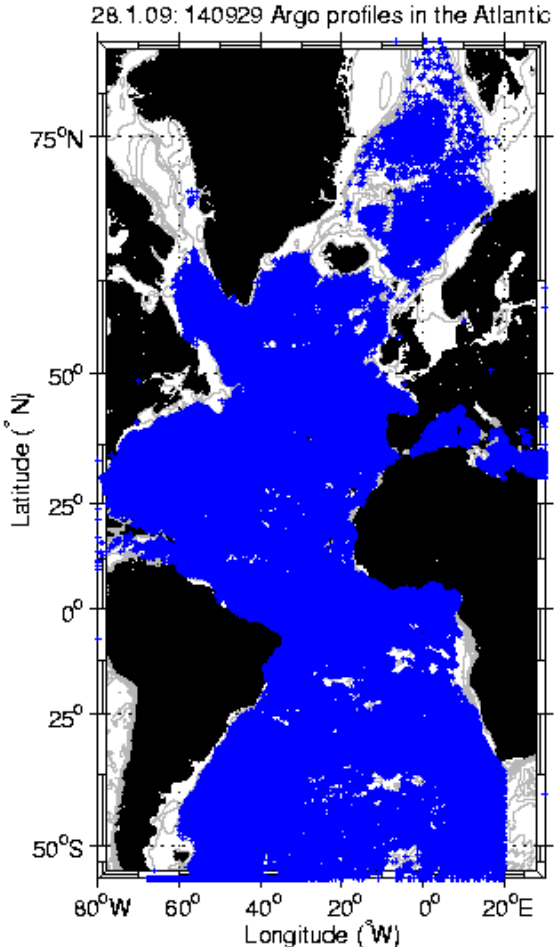




Extended Ellot Line

+ CTD data + Argo data

Analyzing trends from Argo data



All available Argo data in the North Atlantic are collected on a regular basis (6 month)

Quality control for each float is performed

Sorting of profiles into 2x2 ° boxes

Regional quality control for 2x2 ° boxes is performed

Gridding to 10 dbar intervals and construction of annual profiles

Data set in MATLAB format is provided to other user (argo@bsh.de)

Analyzing trends from Argo data:

Nordic Seas (74-76 N, 2-4 W)

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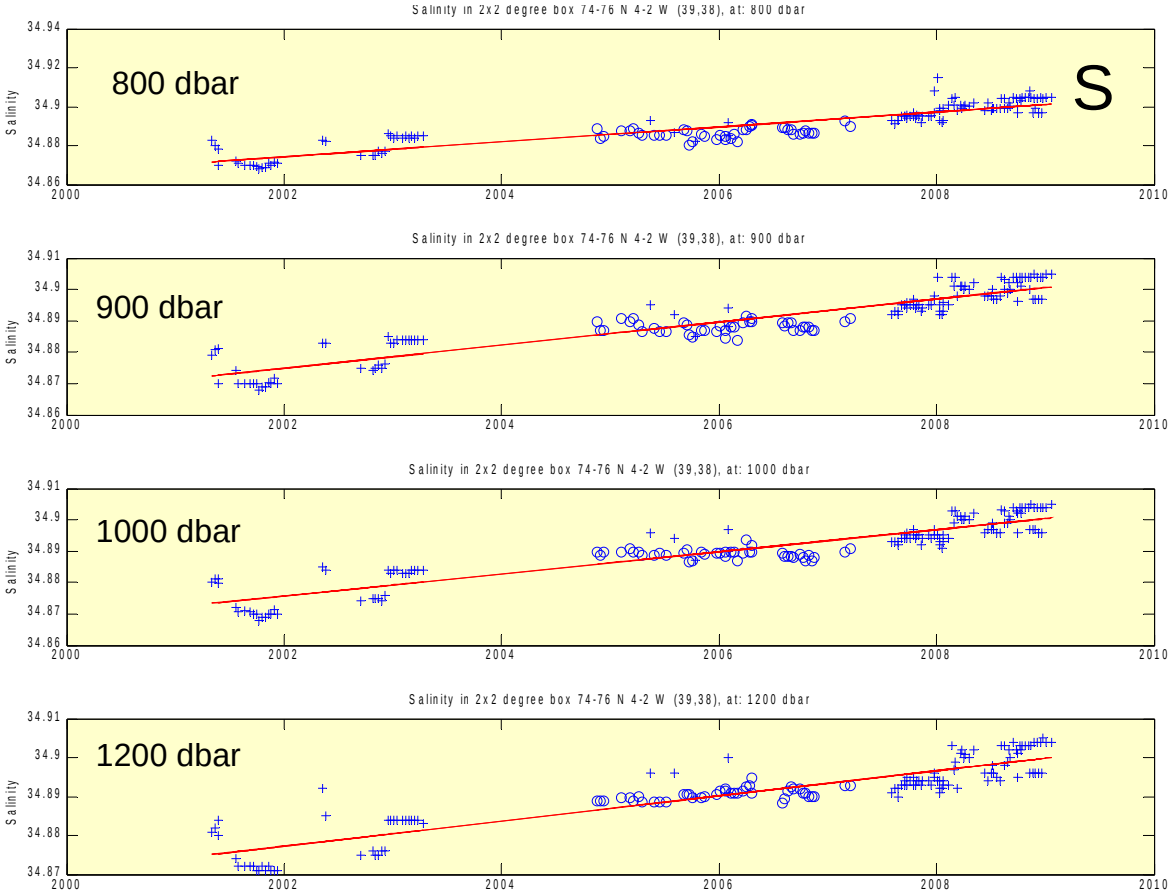
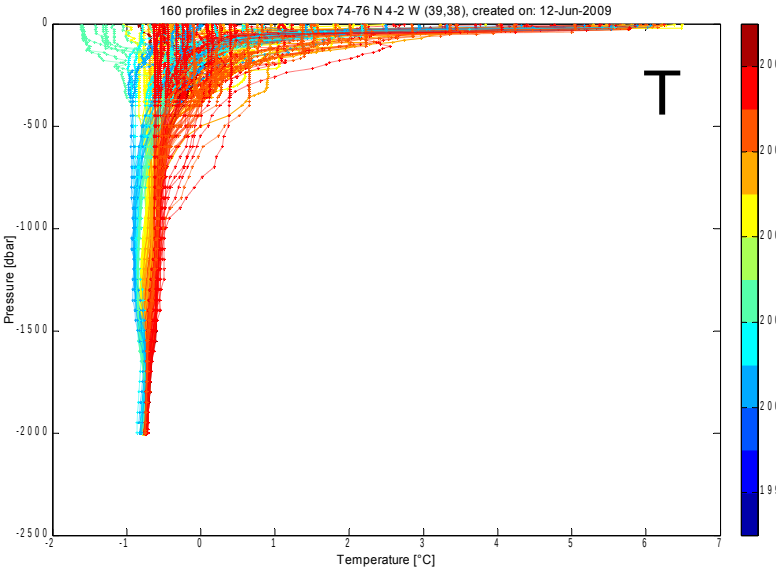
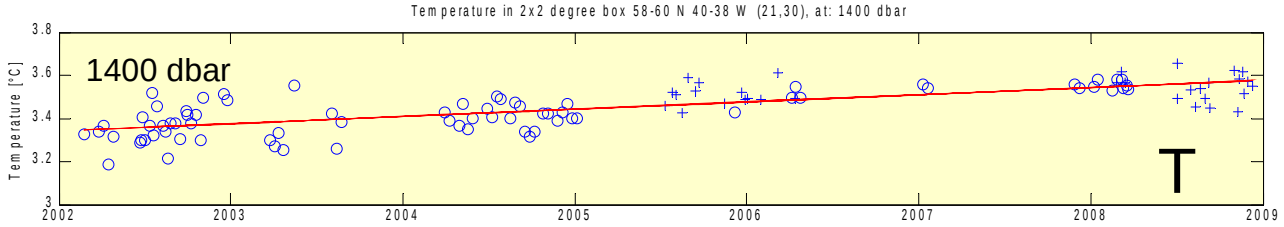


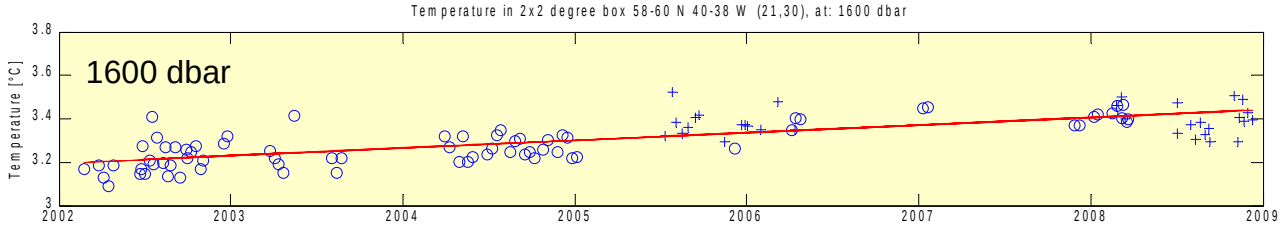


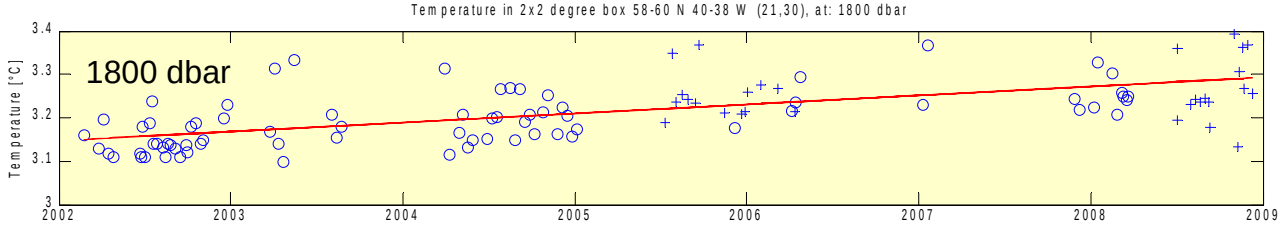
Analyzing trends from Argo data:

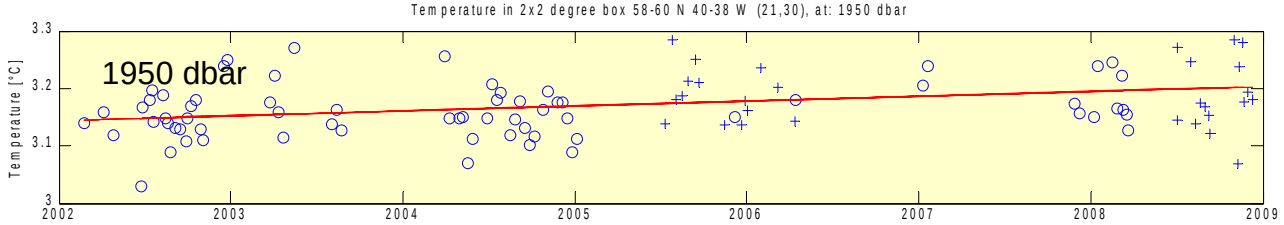
Irminger Sea (58-60 N, 38-40 W)

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE





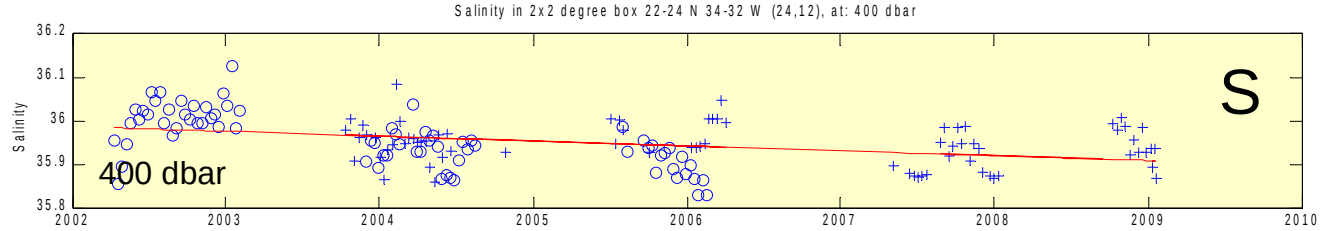


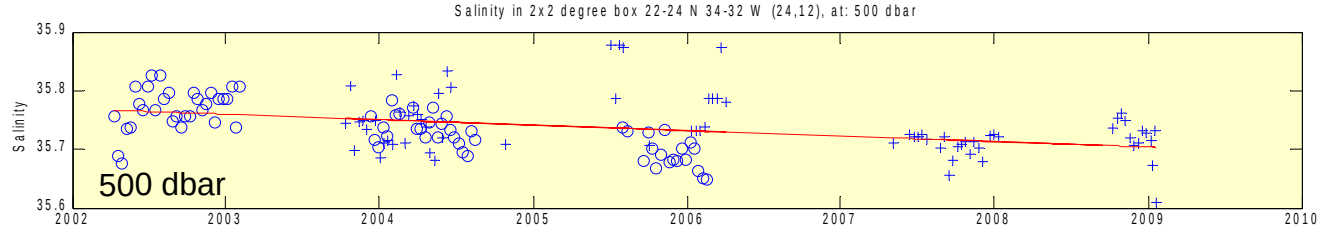


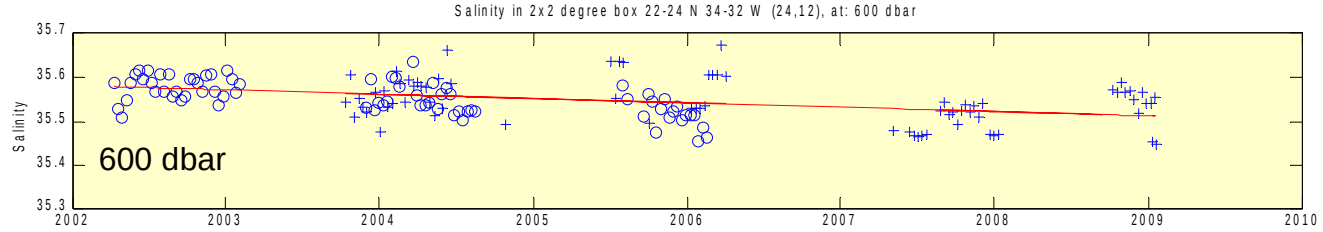
Analyzing trends from Argo data:

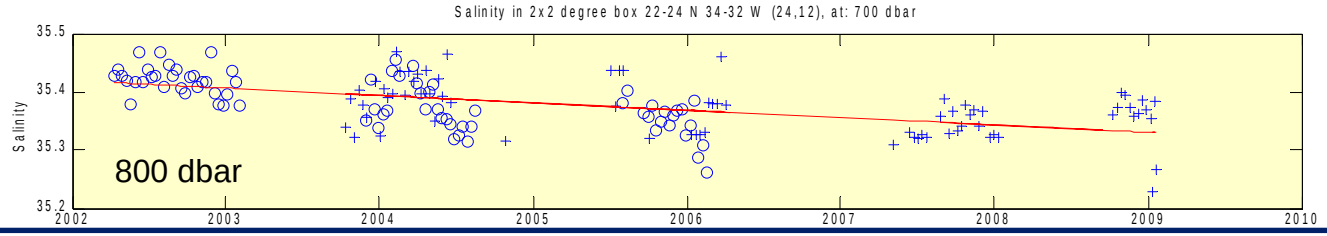
Subtropical Atlantic (22-24 N, 32-34 W)

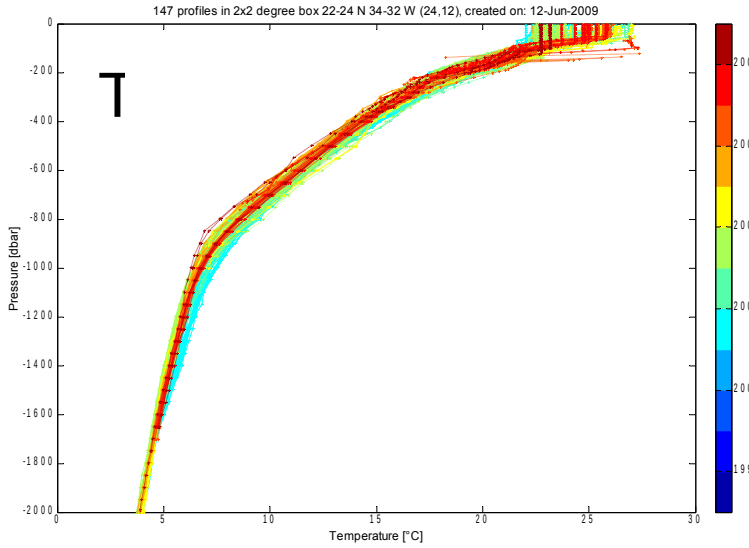
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE











Additional delayed mode processing of Argo data at BSH

2nd Euro-Argo Users' Workshop

B. Klein, M. Stawarz

Trieste, 15-17 June 2009

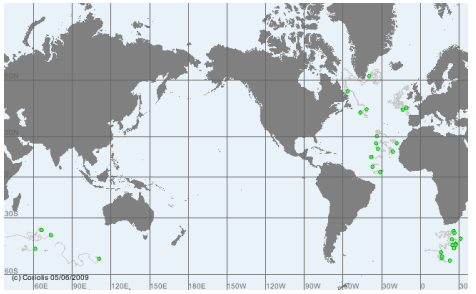
Delayed mode processing of Argo data at BSH

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

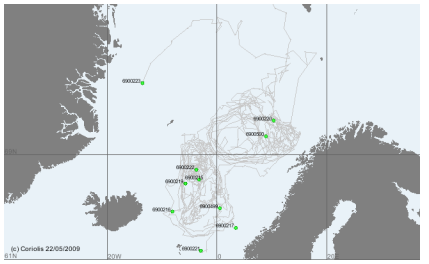
Floats have been deployed also by European countries without a national centre or a delayed mode operator.

BSH endorsed the delayed mode processing of following national Argo programs and projects (in total: 115 floats):

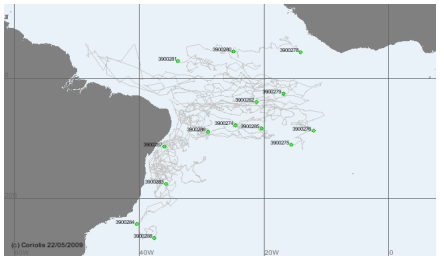
- Danish Argo
- Argo Norway
- Dutch Argo Program
- IfM-GEOMAR Projects:
  - Tropat
  - sfb460
  - IFM 2
  - IFM Geomar



Dutch Argo



Argo Norway



Tropat

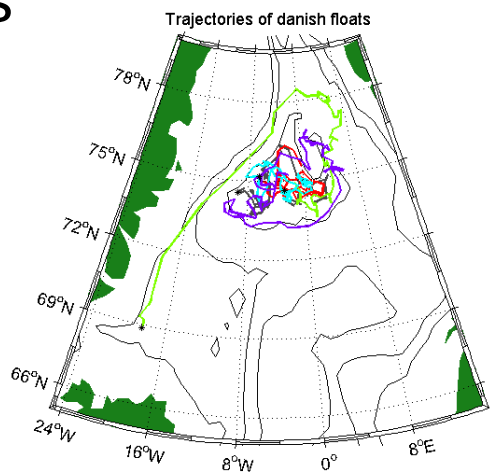
Delayed mode processing of Argo data at BSH

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Floats in the Nordic Seas

Danish Argo Floats:

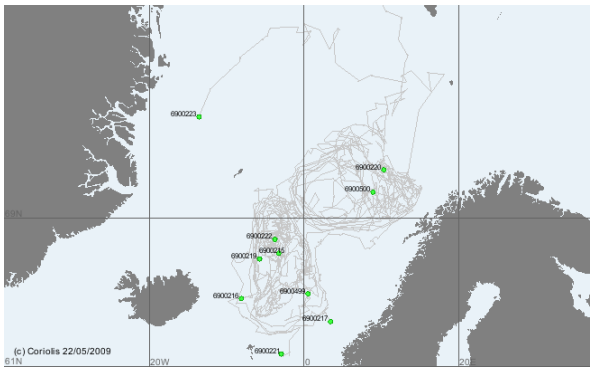
- 5 floats deployed in the Greenland Sea between March and June 2001and operated up to 2003 (between 1½ and 2½ years)
- most of the floats stayed inside the Greenland Sea Gyre all the time and followed its cyclonic movements

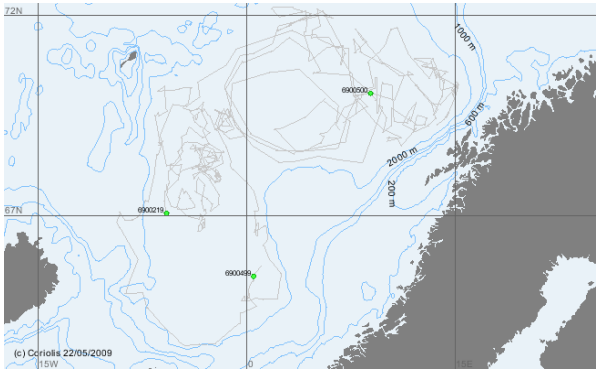


Norway Argo floats:

- all floats: 11
- active: 3 floats are still transmitting data

Deployments:
9 floats: Jun 2002 - Aug 2003
2 floats: Apr 2006





Trajectories of Norway-Argo profilers; left: all, right: active

Delayed mode processing of Argo data at BSH

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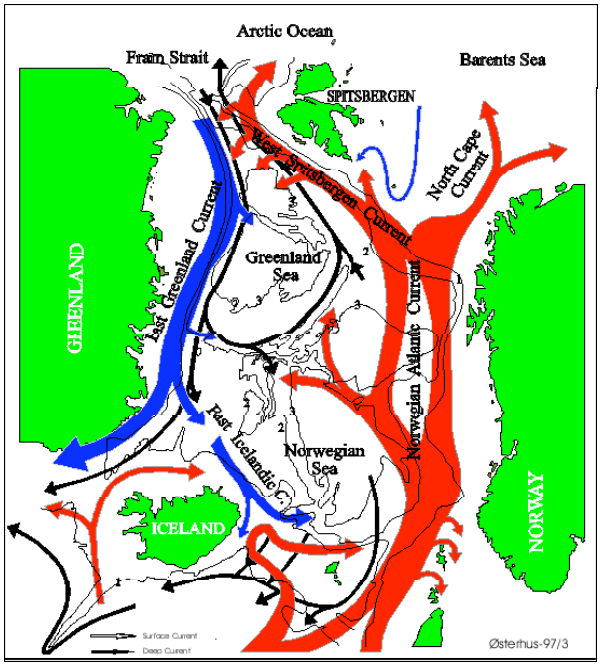
The importance of the Nordic Seas in the climate system.



Surface circulation of the Nordic Seas. Warm and saline Atlantic water is marked in red. Cold and fresh water transported from the Arctic by the East Greenland Current is marked in blue. Black: intermediate and deep water circulation.

The Nordic Seas contribute significantly to the production and export of the North Atlantic Deep Water and therefore help to drive the Atlantic Meridional Overturning Circulation and hence the global thermohaline circulation.

It is manifested in the North Atlantic Ocean as northward-flowing surface waters which sink in the Nordic (Greenland, Iceland and Norwegian) seas and return southwards - after overflowing the Greenland-Scotland ridge - as deep water.

The overflow from the Nordic seas is an important part of the global climate system.

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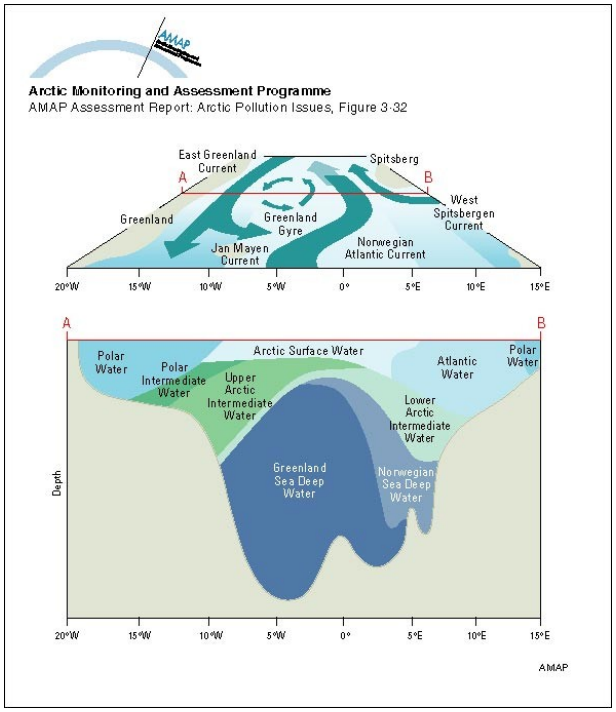
The water masses of the Greenland Sea.



Schematic diagrams of the Greenland Sea showing the surface circulation (above) and water mass structure at a section across the central gyre (below).

Greenland Sea Deep Water (GSDW) is a mixture of deep water formed locally by convection during cold winters, and deep waters deriving from the Arctic Ocean.

NSDW:	**S = 34.91**
GSDW:	**S = 34.88-34.91**
AIW:	**S = 34.7-34.9**
PIW:	**S < 34.7**

Delayed mode processing of Argo data at BSH

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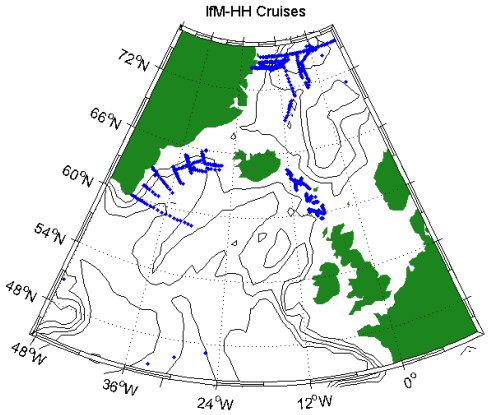
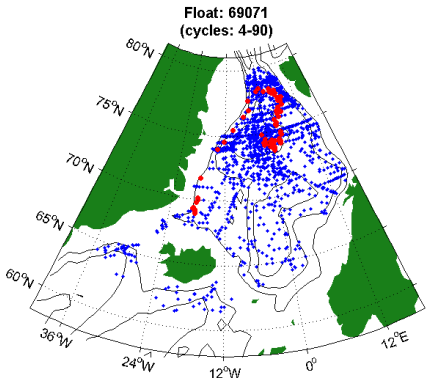
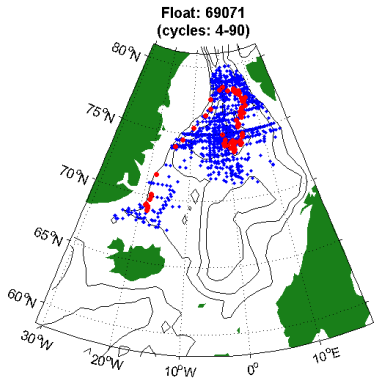
The BS software package used for the DMQC was adapted to the regional conditions of the Nordic Seas:

The reference dataset using for estimation of the salinity sensor drift was updated with recent in situ-based CTD data from IfM Hamburg and AWI.





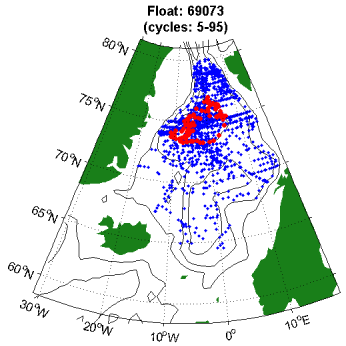


Scales used in DMQC were changed.

Delayed mode processing of Argo data at BSH

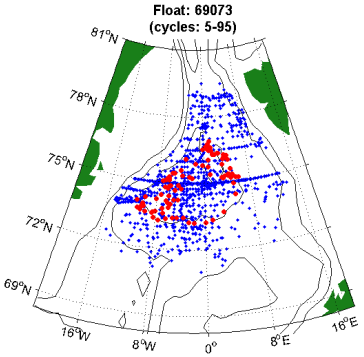
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

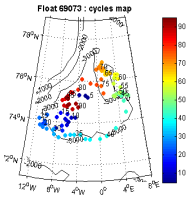
The scaling parameters used in DMQC for Nordic Seas drawing on example of Danish Float 69073.

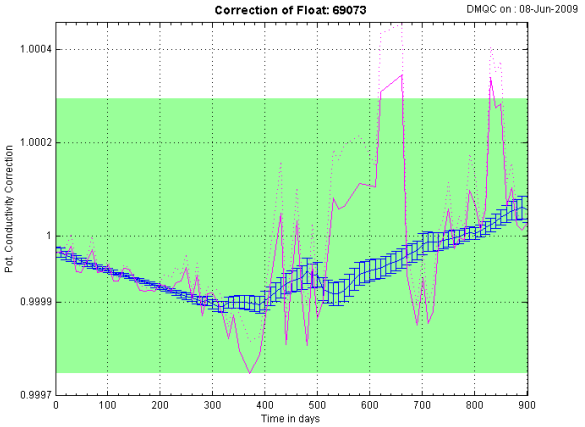


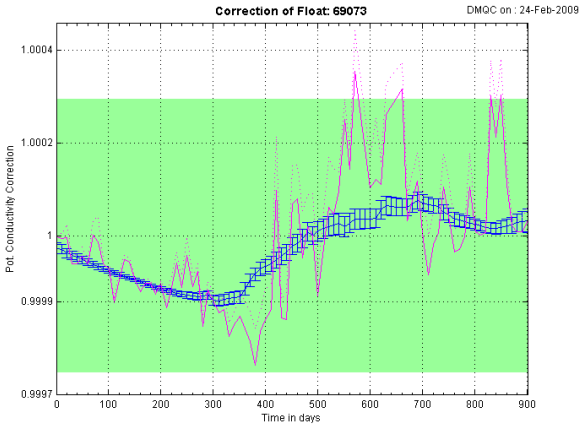
Large scale radius:

900-1200 km → **250-350 km**









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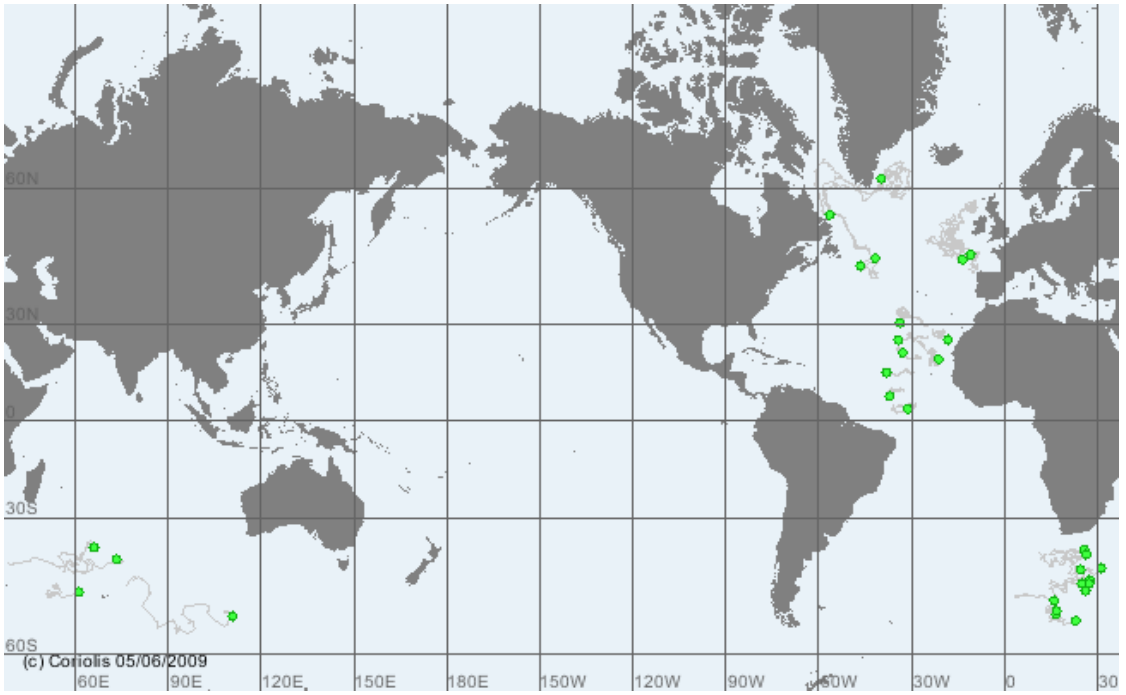
Dutch Argo Program:

- all floats: 31
- active: 24

First float deployed in 2000, last deployments in January 2006.



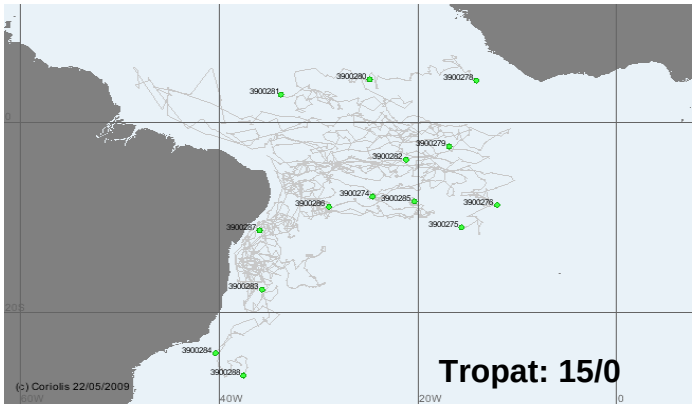
Trajectories of all Dutch Argo Program profilers

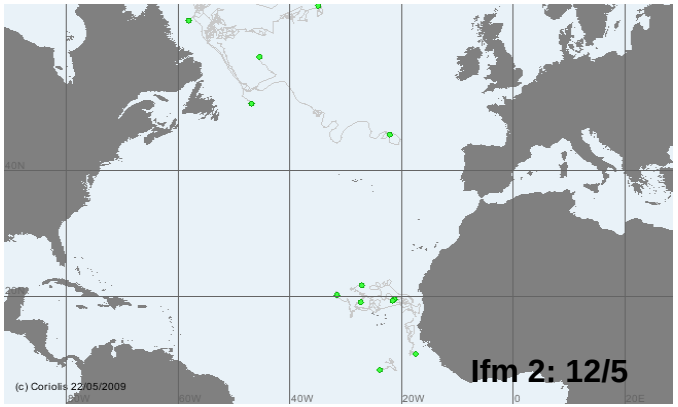
Delayed mode processing of Argo data at BSH

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

IfM GEOMAR Projects: all/active floats: 68/37.

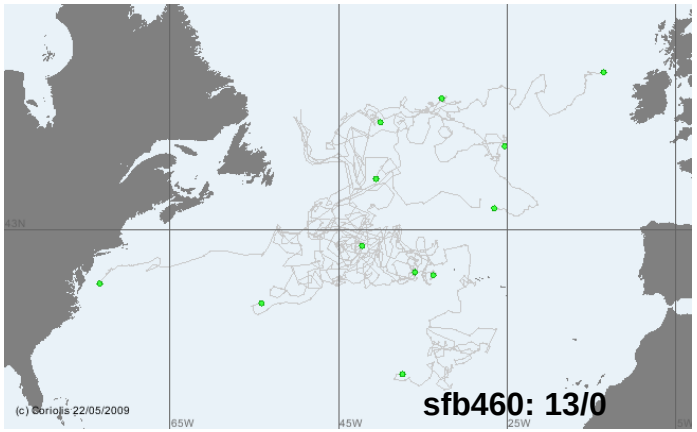
Aug 2004 - Sep 2004

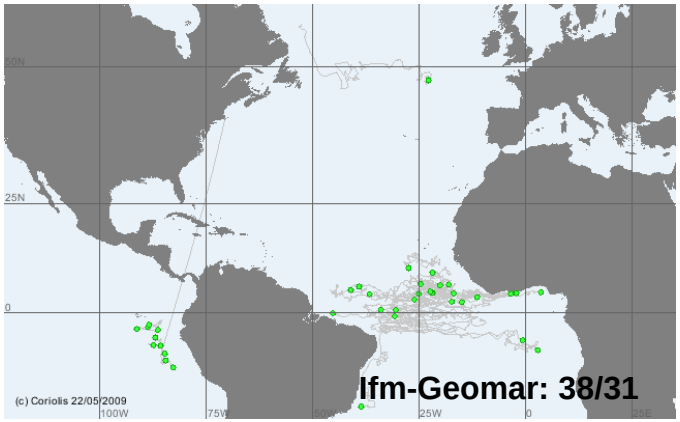




Sep 2003 - Apr 2008

May 2001 - Oct 2003





Jun 2005 - Jun 2006

Delayed mode processing of Argo data at BSH

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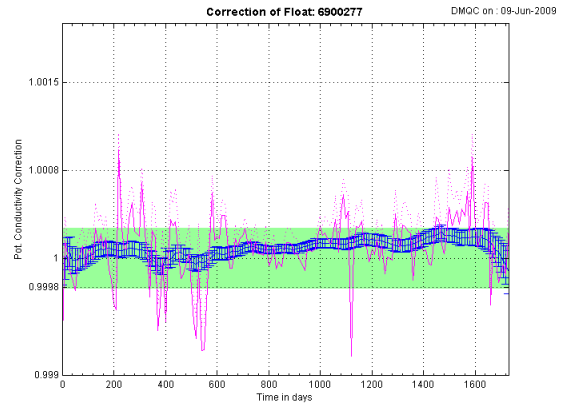
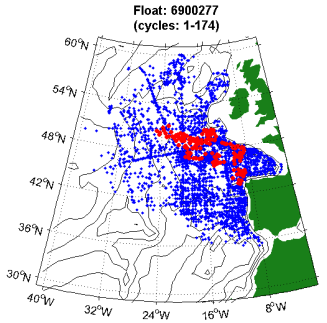
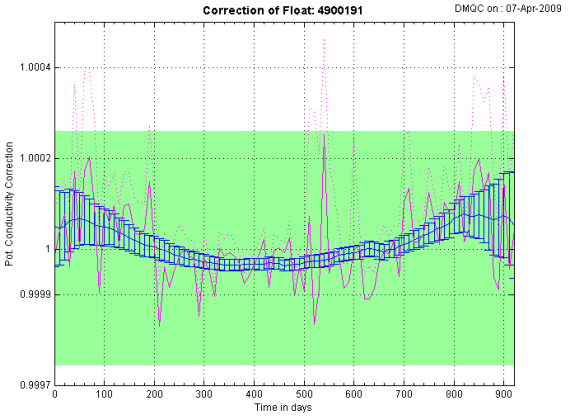
Examples of final proposed conductivity corrections:

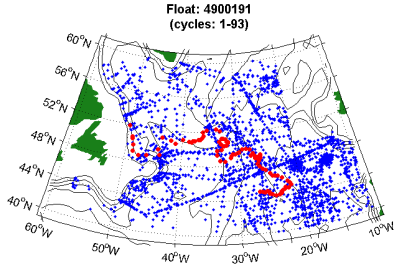
Stable measurements (no sensor drift) without constant offset





Dutch Argo





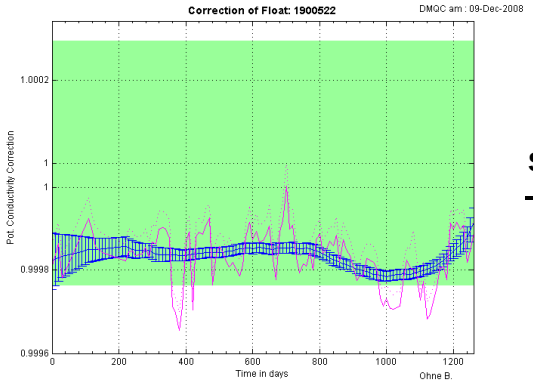
sfb460

Delayed mode processing of Argo data at BSH

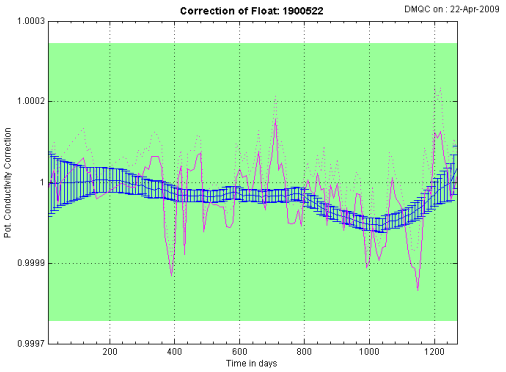
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

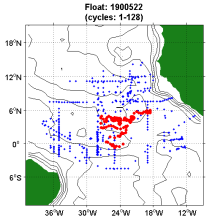
Examples of final proposed conductivity corrections:

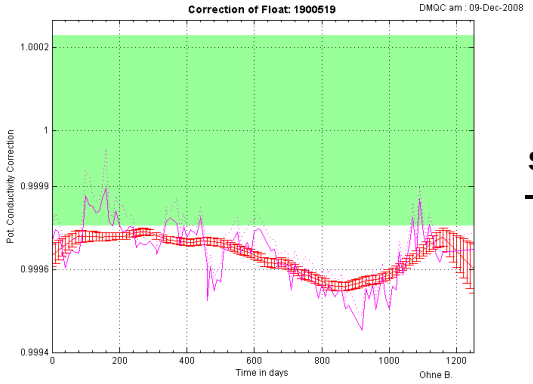
Stable measurements (no sensor drift) including constant offset



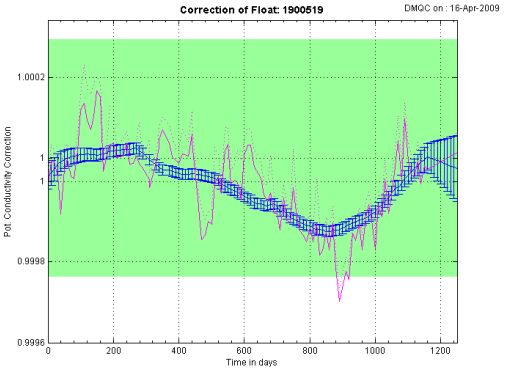
S offset = -0.005

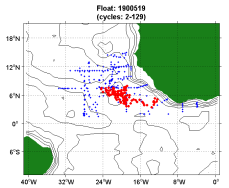






S offset = -0.011





Project: ifm-Geomar

The offset of the sensor is clearly seen in the estimated corrections.

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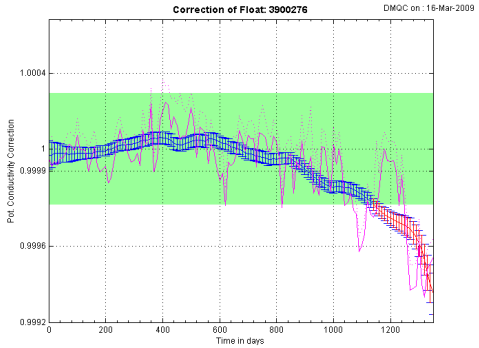
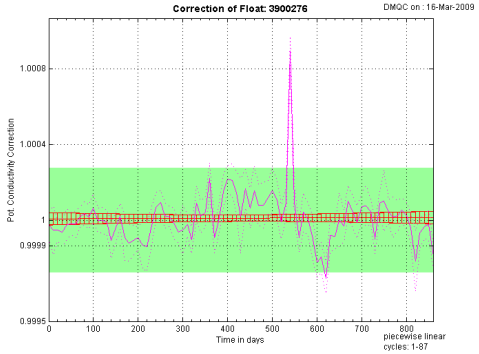
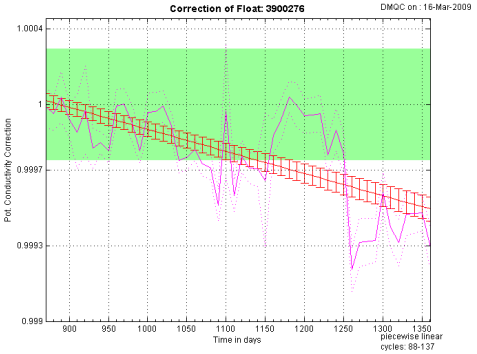
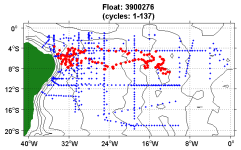
Examples of final proposed conductivity corrections:

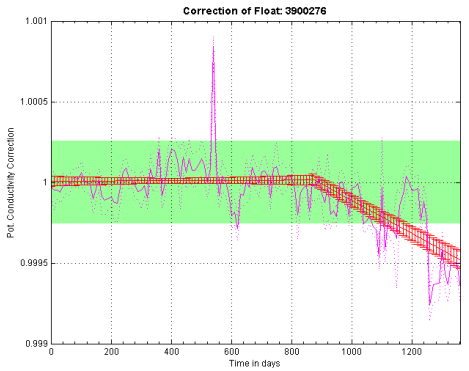
sensor drift after a stable period

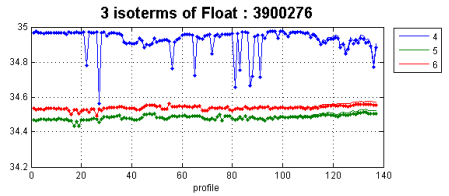


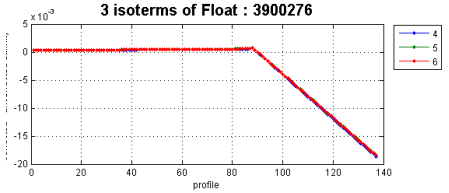












The float 3900276 was in good agreement with the climatological estimates for more than 2 years and then measurements started to drift toward higher values.

Float: 3900276, Project: tropat

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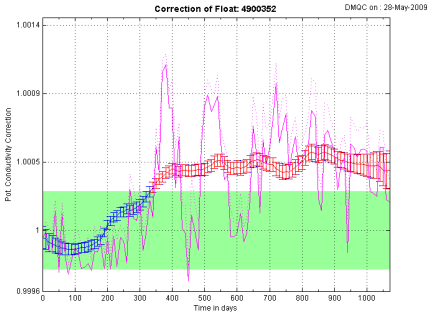
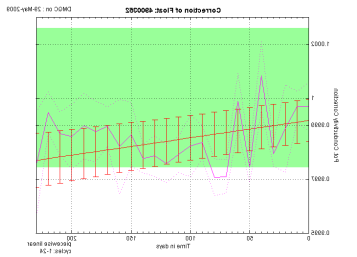
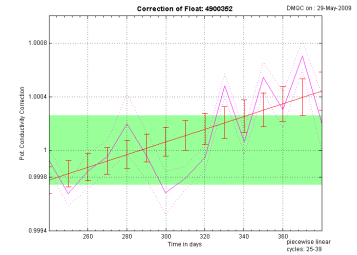
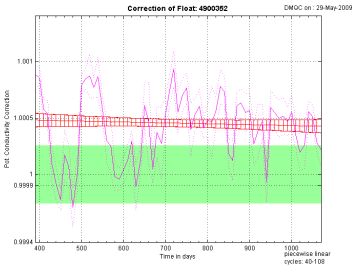
Examples of final proposed conductivity corrections:

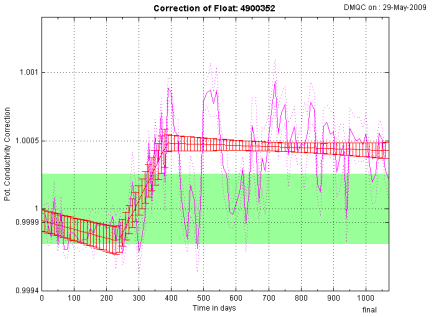
splitting the float series for calibration

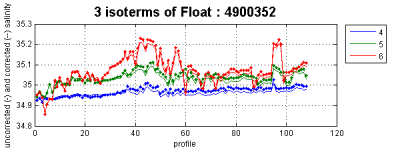


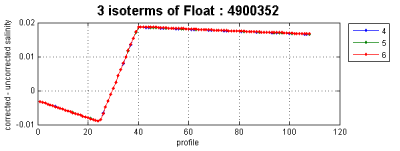


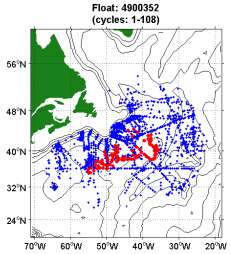












Source of error:
manual manipulation and subjective decision during processing of float salinity data, e.g. by splitting time series into separate segments over which the fits are made

More objective solution:
the OW method (developed by Owens and Wong) with a new piece-wise linear fit introduces breakpoints by statistical techniques which minimizes subjective judgment and inconsistency during data processing

Float: 4900352, Project: sfb460

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Thanks for your attention!