



THOR Deliverable D06

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|-----------------------------|---|---|------------|----------------|------------|
| Deliverable description: | | Reference data set for pre-existing data on properties and fluxes through key sections: Greenland-Scotland Ridge, Deep Western Boundary Current and across 26.5° N. | | | |
| WP No. | 3.1 | Lead Beneficiary: | UiB | | |
| WP Title | Sustained observations of ocean properties and fluxes through key sections and model validation | | | | |
| Work duration ¹⁾ | 1-12 | Delivery deadline ²⁾ : | 2009-11-30 | Delivery date: | 2009-11-30 |

¹⁾ Work duration = project month

²⁾ Delivery deadline: as contracted in Description of Work (Annex 1 to Grant Contract)

| | | |
|-------------------------------|-------------------------|-----------------------------|
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| Contributing partners: | Sherwin / Berx | SAMS |
| | Hansen / Hatun / Larsen | HAV (former FFL) |
| | Jonsson / Valdimarsson | MRI |
| | Fischer / Nunes | IFM-GEOMAR |
| | Cunningham | NERC-NOCS |
| | Quadfasel | UHAM |

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1. Executive Summary

A THOR-CT3 workshop was held in Tórshavn 25-26 June 2009 to compile and discuss the reference data set for pre-existing hydrographic data (T, S and O₂). We agree to start with the WOCE hydrographic data (from 1990). For the fluxes through key sections we will use the time series already held by the THOR CT3 group.

All data are compiled by partner IFM-GEOMAR and user software is under development.

The D6 data set of fluxes and hydrographic properties are highly relevant for the THOR objectives and essential for the future work in CT 3 and 4.

2. Main objectives, description of work and role of participants (Annex I: DoW)

Objectives

- To provide a data base of pre-existing data on properties and fluxes through the key sections studied in THOR: across the sill of the Greenland-Scotland Ridge (GSR), across the Deep Western Boundary Current at the exit of the Labrador Sea (DWBC), and across the Atlantic at 26.5°N (RAPID)
- To provide time series of properties and fluxes through the key sections during the field phase of the project
- To estimate monthly to decadal variability on key sections
- To provide an overview of the consistency between flux estimates through the different sections and other observations
- To assess the ability of models to reproduce observed properties and fluxes of the THC at 26.5°N and its sources

Description of work and role of participants

At the project start, work will begin to generate a reference data base (hydrographic data, float data, and mooring data) from pre-existing data from all the key sections. This work, which will be led by UiB with contributions from all other partners in this WP, will form the basis to which additional observations acquired during the project will be added continually. In addition to this, the Work Package is divided into four different tasks:

Task 3.1.1 Monitoring the inflow of Atlantic water to the Nordic Seas

- Existing mooring arrays for monitoring Atlantic inflow over the sill will be updated with necessary additional instrumentation on the three sections crossing the inflow [UiB, FFL, MRI, SAMS]
- Using data acquired by the moored instrumentation and associated regular CTD cruises, time series of hydrographic properties and fluxes for the three Atlantic inflow branches will be generated annually during the field phase of the project [UiB, FFL, MRI, SAMS]

Task 3.1.2 Monitoring the dense water overflow across the Greenland-Scotland Ridge

- Existing mooring arrays for monitoring overflow over the sill will be updated with necessary additional instrumentation in the key overflow areas [UHAM, UiB, FFL, MRI, SAMS]
- Using data acquired by the moored instrumentation and associated regular CTD cruises, timeseries of hydrographic properties and fluxes for the two main overflow branches (Denmark Strait and Faroe Bank Channel) will be generated annually during the field phase of the project [UHAM, UiB, FFL, MRI]
- In the two weaker overflow areas (Iceland-Faroe Ridge and Wyville-Thomson Ridge), observations will be carried out to clarify the key features of these overflows [UHAM, UiB, FFL, MRI, SAMS]

Task 3.1.3 Monitoring the export of deep waters at the exit of the Labrador Sea

- Based on data from instrumentation and hydrographic surveys, timeseries of hydrographic properties and currents in the DWBC will be updated to allow estimates of inter-annual to decadal DWBC variability [IFM-GEOMAR]
- An index of deep water export in the DWBC (THC-index) will be developed and continued [IFM-GEOMAR]
- The penetration of newly formed water masses into the DWBC will be evaluated using the observations in this task together with other observations and models [IFM-GEOMAR]

Task 3.1.4 Validating variability of climate models against THC observations

- The variability of the THC at 26.5°N and hydrographic properties in models will be compared to observations [MPG-M, NERC]

- The variability of overflow fluxes and hydrographic properties in models will be compared to observations [MPG-M, NERC, FFL, UiB, UHAM, MRI, IFM-GEOMAR]

3. Report on Deliverable D06

A reference data set for pre-existing data on properties and fluxes through key sections: Greenland-Scotland Ridge, Deep Western Boundary Current and across 26.5° N has been made available to the THOR community. Figure 1 gives some examples of time series now available for the THOR community. These data together with data provided in D7 and D8 form the data base of pre-existing data

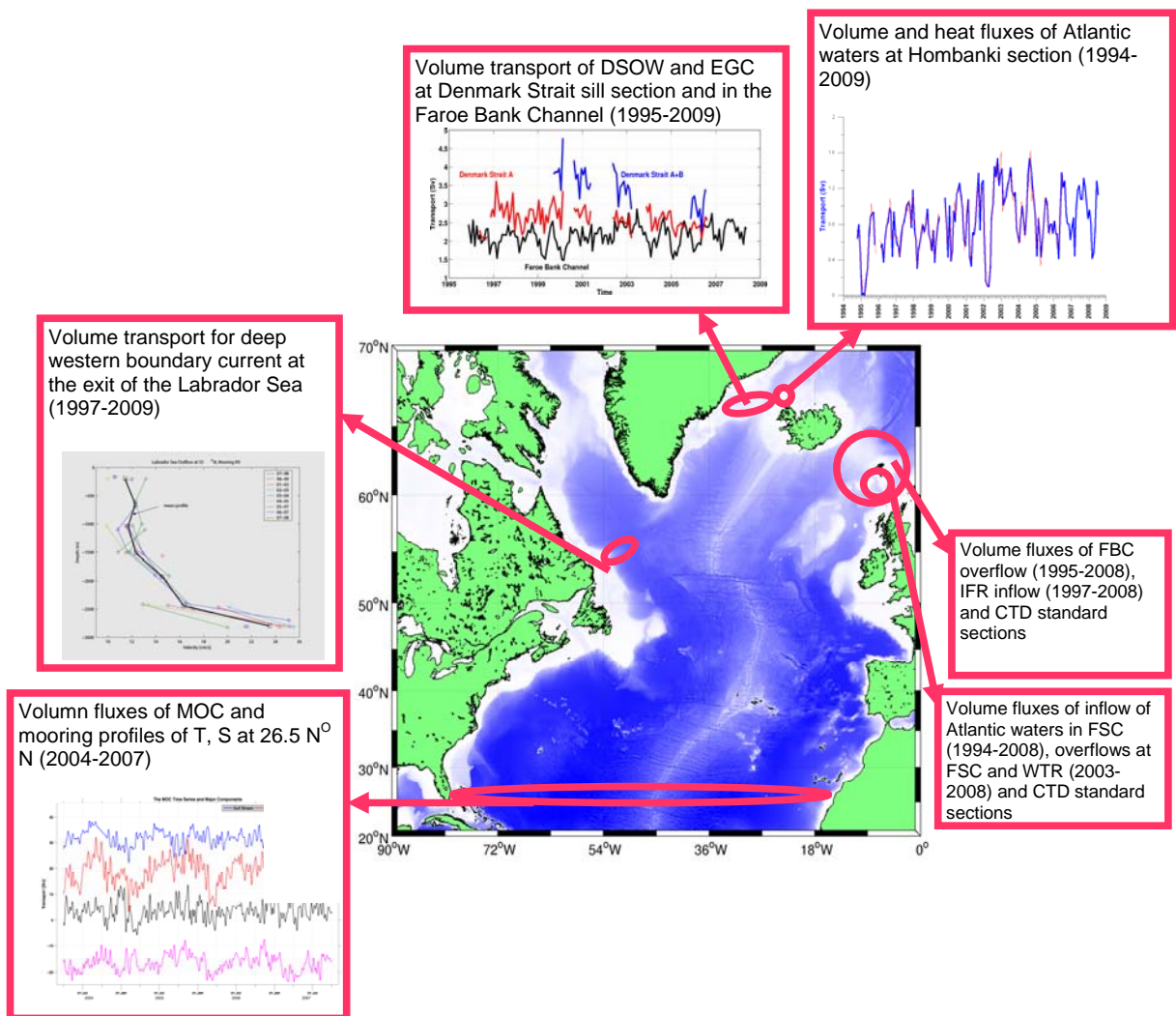


Figure 1: THOR reference data set of pre-existing data.

Table 1 lists the different contributions to Deliverable D06, as agreed in the CT3 meeting in Torshavn, July 2009.

Table 1: Components of the THOR reference data set (Deliverable D06 only).

| Location | Available data | Period | Status |
|------------------------|---|---------------|--|
| Faroe Bank Channel | overflow transport | 1995-2008 | completed |
| Hornbanki section | volume and heat fluxes | 1994-2009 | completed |
| RAPID array at 26.5 N | volume fluxes of MOC components and T,S time series | 2004-2007 | completed |
| Wyville Thomson Ridge | overflow transport | 2003-2008 | completed |
| Lab Sea exit at 53 N | deep WBC transport | 1997-2009 | partly included, expected completed Jan 2010 |
| Angmagssalik array | DSOW transport and T,S time series | 1994-2009 | processing, expected completed Jan 2010 |
| Denmark Strait | DSOW and EGC transports | 1995-2009 | processing, expected completed Jan 2010 |
| Iceland Faroe Ridge | Atlantic water inflow and CTD sections | 1997-2008 | processing, expected completed Jan 2010 |
| Faroe Shetland Channel | Atlantic water inflow and CTD sections | 1995-2008 | processing, expected completed Jan 2010 |
| Faroe Shetland Channel | overflow transport | 2003-2008 | processing, expected completed Jan 2010 |

4. List of Publications

Peer reviewed articles:

- Hughes, Holliday, Colbourne, Ozhigin, Valdimarsson, Østerhus, and Wiltshire, K. 2009. Comparison of in situ time-series of temperature with gridded sea surface temperature datasets in the North Atlantic. *ICES J. of Marine Science*, 66: doi: 10.1093/icesjms/fsp041, <http://icesjms.oxfordjournals.org/cgi/content/abstract/fsp041?ijkey=cPH1tzEu30GbY0s&keytype=ref>
- Baehr, J., A. Stroup, and J. Marotzke, 2009: Testing concepts for continuous monitoring of the meridional overturning circulation in the South Atlantic. *Ocean Modelling*, in press.
- Baehr, J., S. A. Cunningham, H. Haak, P. Heimbach, T. Kanzow, and J. Marotzke, 2009: Observed and simulated estimates of the meridional overturning circulation at 26.5°N in the Atlantic. *Ocean Science*, 5, www.ocean-sci.net/5/575/2009
- Bryden, H. L., A. Mujahid, S. A. Cunningham, and T. Kanzow, 2009: Adjustment of the basin-scale circulation at 26°N to variations in Gulf Stream, deep western boundary current and Ekman transports as observed by the Rapid array. *Ocean Science*, 6, 871-908.
- Cunningham, S. A. and R. Marsh, 2009: Observing and modelling changes in the Atlantic MOC. *Wiley Interdisciplinary reviews*, in press.
- Cunningham, S. A., M. O. Baringer, J. Toole, S. Østerhaus, J. Fischer, A. Piola, E. McDonagh, S. Lozier, U. Send, T. Kanzow, J. Marotzke, M. Rhein, S. L. Garzoli, S. Rintoul, S. Speich, S. Wijffels, L. Talley, J. Baehr, C. Meinen, A.-M. Treguier, and P. Lherminier, 2009: The present and future system for measuring the Atlantic Meridional overturning circulation and heat transport. *OceanObs09*, in press.
- Hirschi, J. J.-M., P. D. Killworth, J. R. Blundell, and D. Cromwell, 2009: Sea surface height signals as indicators for oceanic meridional mass transports. *J. Phys. Oceanog.*, 39, 581-601.
- Kanzow, T., H. Johnson, D. Marshall, S. A. Cunningham, J. J.-M. Hirschi, A. Mujahid, H. L. Bryden, and W. E. Johns, 2009: Basin-wide integrated volume transports in an eddy-filled ocean. *J. Phys. Oceanog.*, 39, 3091–3110.

Plan for future publication:

- Hansen, Hátún, Kristiansen, Olsen and Østerhus (2010). Thermohaline forcing controls the Iceland-Faroe inflow of heat and salt to the Arctic. Submitted to *Nature GEO Science*.
- Cunningham, S. & Co-Authors (2010). "The Present and Future System for Measuring the Atlantic Meridional Overturning Circulation and Heat Transport" in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2)*, Venice, Italy, 21-25 September 2009, Hall, J., Harrison D.E. & Stammer, D., Eds., ESA Publication WPP-306.

Rayner, Bryden, Wright, Collins, Kanzow, Johns, Barringer, Meinen, Cunningham (2010) "The RAPID-MOC/MOCHA Mooring Array at 26°N in the Atlantic" in Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21-25 September 2009, Hall, J., Harrison D.E. & Stammer, D., Eds., ESA Publication WPP-306.

Baehr, J., 2009: Influence of the 26°N RAPID/MOCHA array and Florida Current cable observations on the ECCO-GODAE state estimate. J. Phys. Oceanog., submitted.

Baehr, J., 2010: An observation-based detection variable for the meridional overturning circulation at 26°N in the Atlantic. Deep Sea Research, submitted.

Kanzow, T., S. A. Cunningham, W. E. Johns, J. J.-M. Hirschi, J. Marotzke, M. O. Baringer, C. S. Meinen, M. P. Chidichimo, C. Atkinson, L. M. Beal, H. L. Bryden, and J. Collins, 2009: Seasonal variability of the Atlantic meridional overturning circulation at 26.5°N. J. Clim., submitted.

Rayner, D., J. J.-M. Hirschi, T. Kanzow, W. E. Johns, P. G. Wright, E. Frajka-Williams, H. L. Bryden, C. S. Meinen, M. O. Baringer, J. Marotzke, L. M. Beal, and S. A. Cunningham, 2010: Monitoring the Atlantic Meridional Overturning Circulation. Deep Sea Research, submitted.

Smith, G. C., K. Haines, T. Kanzow, and S. A. Cunningham, 2009: Impact of hydrographic data assimilation on the Atlantic meridional overturning circulation. Ocean Science, submitted.

5. The project / deliverable is delayed: Yes No

6. Changes made and difficulties encountered, if any

No changes or difficulties, development and procedure according to the original plan.

7. Efforts for the deliverable D06

| Institute | Person-Months | Period |
|------------------|---------------|-----------------|
| UHAM | 4 | 02.2009-07.2009 |
| UIB | 1 | 02.2009-11.2009 |
| IFM-GEOMAR | 2 | 12.2008-11.2009 |
| HAV (former FFL) | 4 | 02.2009-11.2009 |
| MRI | 2.5 | 01.2009-11.2009 |
| SAMS | 1.5 | 02.2009-11.2009 |
| NERC-NOCS | 9 | 02.2009-11.2009 |

8. Sustainability

The D6 deliverables will be extensively used by CT3 and this data set will constitute the observational "standard" against which results from the modelling activities in THOR CT4 will be assessed.