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1 Introduction

The Denmark Strait Overflow (DSO) is the densest source of North Atlantic Deep Water, that forms the deep return flow of the Atlantic Meridional Overturning Circulation.

Direct observations by ADCPs deployed at the 650 m deep sill exist for the period 1996-2006.

Here, the ADCP measurements are compared with upstream hydrographic profiles and NCEP wind stress data to obtain DSO transport estimates for the past decades.

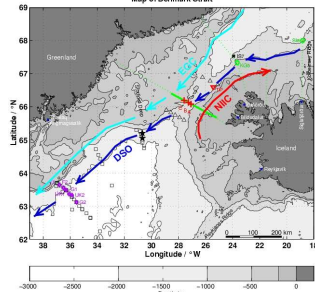


Fig. 1: Denmark Strait. EGC: East Greenland Current. NIIC: North Icelandic Irminger Current. DSO: Denmark Strait Overflow. Mooring sites ADCP A,B,C at the sill; TP temperature sensor mooring and Kögur section (dotted green line with KG5) further upstream. Angmagssalik array 600 km downstream.

3 Kögur section

Icelandic hydrographic standard section
200 km upstream of DS sill
- bottle data since 1950
- 4 times per year since ~1975
- full CTD profiles since ~1990

Dense water height normally largest at KG5 → used as hydraulic reservoir height estimate here.

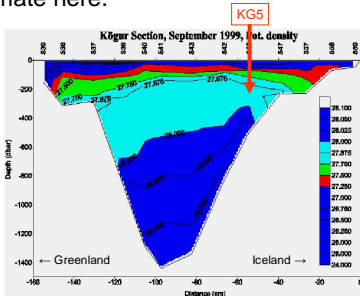


Fig. 3: Kögur section - σ_θ Sep 1999. Typically, the rise of the 28.0 and 27.8 isopycnals is located at station KG5. For geographical location, see Fig. 1.

5 Forcing of DSO: Hydraulics

The density-driven overflow plume is hydraulically controlled (downstream descent, $F=1$, geostrophic balance; Macrander et al., 2005,7). Since $PV \neq const.$, maximum transport is calculated according to Stern (2000):

$$\Psi_{Stern} = 9/16 \cdot 1/2 \cdot g' / f \cdot h_{eff}^2$$

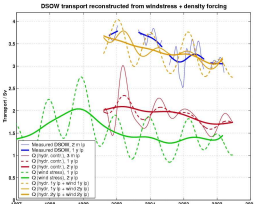
with h_{eff} = height of 27.8 isopycnal above sill

Average values 1999-2004:

DSO transport (ADCP measured): 3.4 Sv
Hydraulic transport (KG5 Ψ_{Stern}): 1.9 Sv
=> residual transport 1.5 Sv

Fig. 5: DSO transport time series 1999 – 2004.

brown: Kögur5- Ψ_{Stern}
green: residual transport, here empirically determined from Iceland Sea wind stress
yellow: Reconstructed transport $\Psi_{Stern} + \text{wind stress}$. Compare with direct ADCP measurements (blue).



Acknowledgements

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2 Upstream Pathways

A large part of the DSO approaches the sill in a current confined to the Iceland shelf edge: A lagged temperature correlation between TP mooring site and ADCP B reveals advection speed of 10 cm/s, consistent with direct current measurements (Jónsson and Valdimarsson, 2004)

In contrast to the East Greenland Current, the „Iceland shelf edge current“ persistently flows towards the sill; it represents the coldest waters of the later DSO.

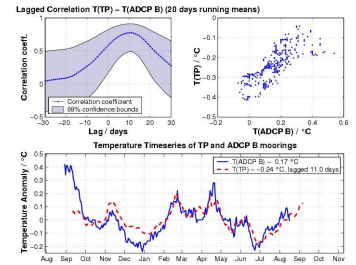
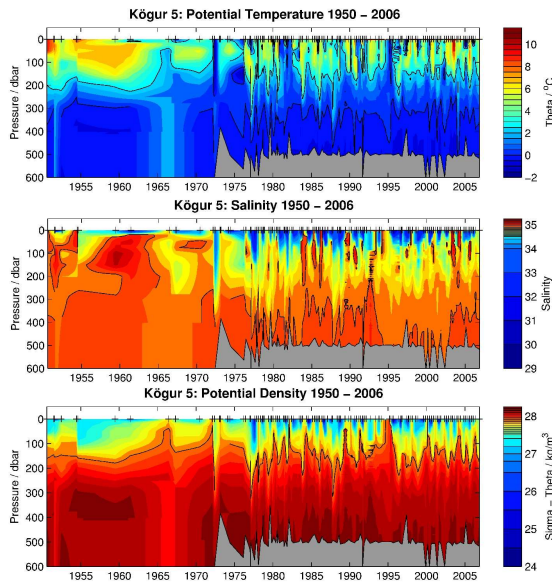


Fig. 2: Temperature correlation between TP mooring 93 km upstream of the sill, and ADCP B at the sill. Time lag of 11 days corresponds to advection velocity of 10 cm/s.

4 Timeseries at Kögur 5: Θ / S / σ_θ from 1950 to 2006



Despite of aliased short-term variability, long-term trends are evident:

- warm surface water maxima mid-80s and 2001-2005
 - cold bottom water mid-80s & end-90s
 - overall freshening of subsurface waters
 - overflow waters: S minima ~1984 and 1994-2000.
 - 27.8 isopycnal (upper DSO boundary): maximum height ~1965-1972 and mid-90s
- DS overflow variability...

Fig. 4: Time series at Kögur 5 1950-2006. + signs denote actual sampling dates. Top: Θ . Black contours mark 0°C and 2°C isotherms. Middle: Salinity. Black contour marks 34.9 isohaline. Bottom: σ_θ . Black contour marks 27.8 kg/m³.

6 Forcing of DSO: Wind stress

The residual transport of 1.5 Sv corresponds to the observed 20 cm/s mean barotropic velocity due to the cross-strait surface height gradient and is likely wind-driven.

NCEP wind stress is largest over Denmark Strait and Iceland Sea. 1999 – 2004, local wind stress decreased by 20%, as did the residual transport. Correlation analysis suggests a time lag of 10 – 80 days depending on the distance to the DS sill.

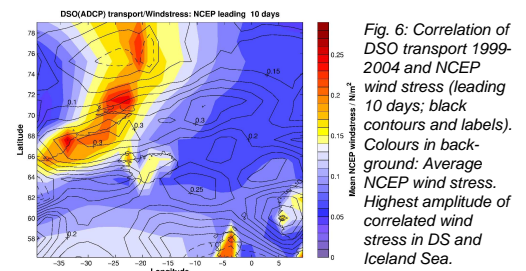


Fig. 6: Correlation of DSO transport 1999-2004 and NCEP wind stress (leading 10 days; black contours and labels). Colours in background: Average NCEP wind stress. Highest amplitude of correlated wind stress in DS and Iceland Sea.

7 Decadal estimates

- Hydraulically controlled transport 1975-2006 varies between 1 Sv and 3 Sv
- Positive correlation (but no direct causal link) with wind driven transport (1 – 2 Sv)
- Reconstructed DSO transport consistent with observations 1996 – 2006.
- Indication of positive correlation with NAO and/or Iceland Sea Wind Stress.
- Time series to be validated against numerical models

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