# The 2002-2010 mean circulation across the Greenland to Portugal A25-OVIDE Section

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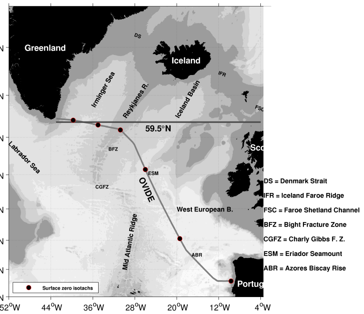
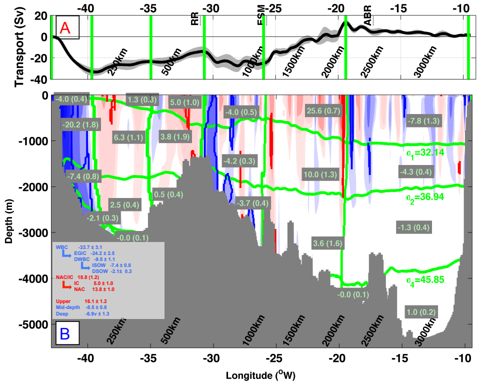
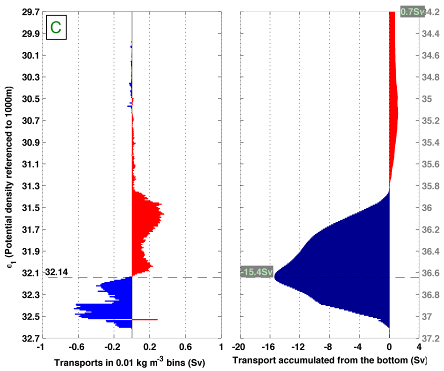
## 1 - Introduction

The OVIDE project aims at documenting and understanding the variability of the oceanic circulation and water mass properties in the northern North Atlantic on climate-relevant time scales. Based on summer (June – July) hydrographic measurements made every other year since 2002, we assessed a mean state of the full-depth circulation across the A25-OVIDE section between Cape Farewell (Greenland) and Portugal. The absolute transports across the sections were estimated, for each of the five realizations, using a geostrophic box inverse model constrained by ship-mounted Acoustic Doppler Current Profiler velocity measurements and by an overall mass balance (Lherminier et al., JGR, 2007 ; DSR I, 2010). Then, the mean circulation across the section was obtained by averaging the five synoptic estimates.




## 2 - 2002-2010 mean summer transports (Sv) across OVIDE




A: Vertically integrated transport accumulated along the OVIDE Section from Greenland (left) to Portugal (right). Green vertical lines delimit the regions for transport computation. B: The 2002-2010 mean summer velocity (m/s) and selected transports (Sv) across the OVIDE line; The thick green lines define the regions of transport integration. Isopycnal limits are $\sigma_1$= 32.14, $\sigma_2$= 36.94, $\sigma_4$= 45.85 and vertical limits are zero isotachs. Thick red lines = persistent northward currents (ie the flow has the same direction in the 5 sections) ; Thick blue lines = persistent southward currents. C: The 2002– 2010 mean summer Greenland to Portugal integrated transports (Sv) as a function of potential density $\sigma_1$ (left panel) and accumulated from the bottom (right panel); positive transports are northward.

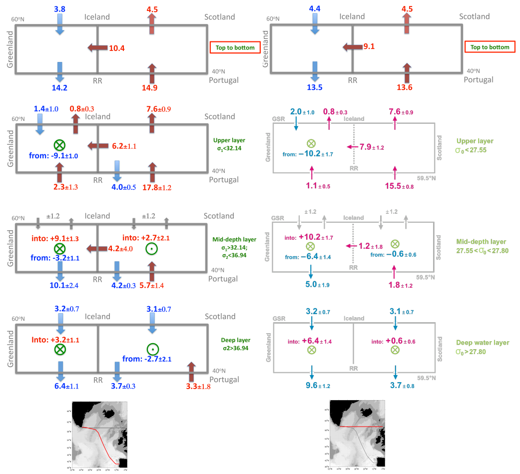
The East Greenland Irminger Current (EGIC), the Deep Western Boundary Current (DWBC), the barotropic current on the eastern flank of the Reykjanes Ridge, and the current veins transporting Iceland-Scotland Overflow water are persistent southward circulations. The North Atlantic Current (NAC) system is composed of several branches with embedded mesoscale features or meanders. A permanent branch of the NAC is locked at the Eriador seamount and a permanent dipole is observed west of the Azores-Biscay Rise. Generally, the northward currents are more baroclinic and less permanent than the southward. This is especially illustrated on both sides of the Reykjanes Ridge.

The top-to-bottom integrated transports of the main currents were quantified: 33.7 Sv southward for the Western Boundary Current (WBC), 19.5 Sv for the northward circulation in the Irminger Basin, 11.8 Sv for the southward circulation along the eastern flank of the Reykjanes Ridge, 39.2 Sv northward for the NAC region from Eriador Seamount to the maximum of the barotropic stream function, and 12.4 Sv for the southward recirculation in the west European Basin. With our limits, the permanent dipole at 19.5°W adds about 6 Sv to the northward NAC and southward recirculation transports. The net transport is northward (0.7 Sv).

The maximum of the overturning stream function at $\sigma_1$= 32.14 ($\sigma_2$≈ 36.58) defines the amplitude of the MOC (15.4 ± 1.5 Sv). This value corroborates the 16.5 ± 2.2 Sv 2002-2008 mean MOC amplitude reported by Sarafanov et al. (JGR, 2012) at 59.5°N.

## 3 – Comparison of OVIDE and 59.5°N 2000's mean circulations

We built a three layer box model describing the volume balance between the Ovide section and the Greenland-Scotland Ridge (left panel) for comparison with Sarafanov et al. (JGR, 2012; right panel) who studied a similar balance but using the 59.5°N section as southern boundary condition. The upper layer is the upper limb of the MOC, the mid-depth and deep layers belongs to the lower limb of the MOC. The transports across the Greenland-Island-Scotland Ridge (GISR) are prescribed from literature. The net transport across Ovide and 59.5°N are slightly different (0.7 vs 0.1 Sv). Accordingly, the prescribed upper layer transports at the GISR are adjusted to match these values. The transport over the Reykjanes Ridge (RR) and the vertical transports were computed as residuals of the volume balance.



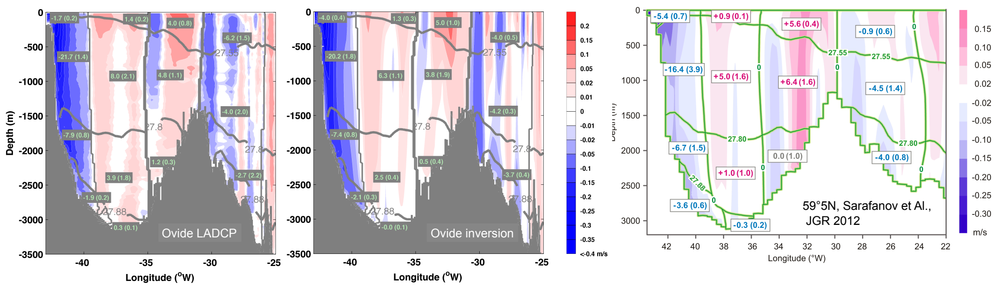

The top-to-bottom integrated transports in the two models are fully compatible, including the ~10 Sv over the RR.

Upper layer: The two models gives similar results. About half of the net northward flow east of the RR crosses the RR and enters the Irminger Sea were about ~10 Sv of warm water belonging to the upper branch of the MOC is transformed in denser water.

Mid-depth layer: East of the RR, the net northward transport across Ovide and 59.5°N are the same, whereas, west of the RR, the net southward transport across Ovide is larger than across 59.5°N (10.1 vs 5.0 Sv).

Deep layer: In the eastern basin, the volume balance in the Ovide model results in an upwelling of 2.7 Sv fed by the northward flow of deep and bottom water (3.3 Sv) and likely located along the continental slopes. Accordingly, the ISOW transports in the Ovide and 59.5°N models are basically the same in the eastern basin. The volume balances differ significantly in the Irminger Sea, where the net Overflow transport is 6.4 Sv for Ovide and 9.6 Sv for 59.5°N.

## 4 - Iceland Scotland Overflow Waters




Our mean geostrophic velocities from the Ovide inversion are compatible in the Irminger Sea and around Reykjanes Ridge with the velocities derived from LADCP measurements (middle and left panels). The two velocity fields are independent. Transports derived from mean LADCP velocities corroborate inverse model transports. For comparison, we also present the mean velocity field across 59.5°N from Sarafanov et al. (2012, right panel). In Ovide, east of the western boundary current, the deep layer velocity field presents several northward branches separated by weak flows resulting in 3 Sv northward. This flow pattern is associated with the Island-Scotland Overflow Water (ISOW). It differs from Sarafanov et al. (JGR, 2012) who have found a 1.0 Sv transport in this area since most of the ISOW flowing northward along the western flank of the Reykjanes Ridge recirculates southward in the centre of the Irminger Basin. The origin of this circulation difference has to be investigated, but we note that it is at the origin of the differences in the doubling of the entrainment from the intermediate to the deep layer reported above in the volume budgets derived from Ovide and 59.5°N.