Circulation in the vicinity of the Reykjanes Ridge in June-July 2015

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Abstract

The Reykjanes Ridge is a major topographic feature that lies south of Iceland in the North- Atlantic Ocean and strongly influences the Subpolar Gyre (SPG) circulation. Based on velocity and hydrographic measurements carried out along the crest of the Ridge from the Icelandic continental shelf to 50°N during the RREX cruise in June-July 2015, we derived the first direct estimates of volume and water masses transports over the Ridge. The circulation was mainly westward north of 53.35°N and eastward south of it. The westward transport was estimated at 21.9 ± 2.5 Sv (Sv = 10 6 m 3 s -1) and represents the SPG intensity. The westward flows followed two main pathways at 57°N near Bight Fracture Zone and at 59 – 62°N. We argue that those pathways were respectively connected to the northern branch of the North Atlantic Current and to the Sub-Arctic Front that were intersected by the southern part of the section. In addition to this horizontal circulation, mixing and bathymetry shaped the water mass distribution. Water mass transformations in the Iceland Basin lead to the formation of weakly stratified SubPolar Mode Water (SPMW). We explain why SPMW, which was the main contributor in terms of water mass to the westward flow, was denser at 57°N than at 59–62°N along the Ridge. At higher densities, both Intermediate Water, defined by a dissolved oxygen minimum, and Icelandic Slope Water contributed as much to the westward transport across the Ridge as the sum of Labrador Sea Water and Iceland-Scotland Overflow Water.

First direct estimates of volume and water mass transports across the Reykjanes Ridge

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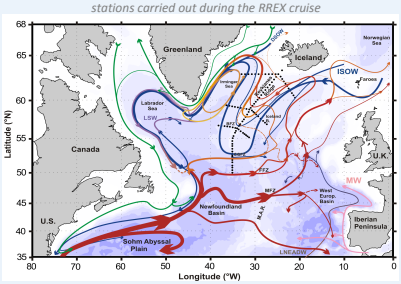
Outline

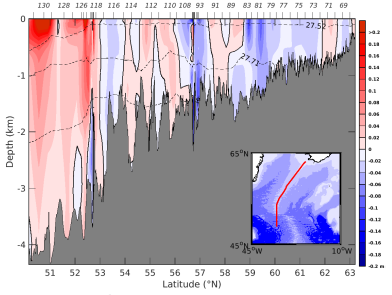
The Reykjanes Ridge is a major topographic feature of the North-Atlantic Ocean, lying south of Iceland, which strongly influences the pathways of the meridional overturning circulation. Until now, the cross-Ridge flow was only indirectly estimated such as results where subject to controversy. Combining ADCP and hydrographic data carried out from the RREX cruise during summer 2015, we computed the first direct geostrophic transports along the top of the Reykjanes Ridge from Iceland to 50°N in order to: Quantify the top to bottom and the north to the south cross-Ridge flow; Estimate the distribution and transport of the water masses over the Ridge section.

Schematic large scale circulation in the northern North Atlantic adapted from Daniault et al. [2016] with the locations of hydrographic stations carried out during the RREX cruise

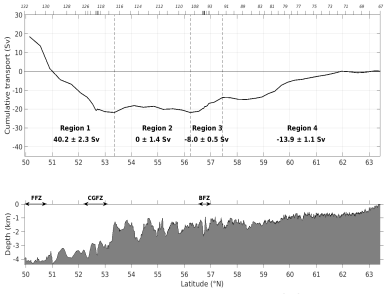


- **North of 53.35°N, the Subpolar Gyre intensity was 21.9 ± 2.5 Sv westward**
- **The westward flows were intensified at the Bight Fracture Zone (57°N) and at 59 – 61°N**
- **The water mass distribution over the Ridge was shaped by horizontal circulation and bathymetry**

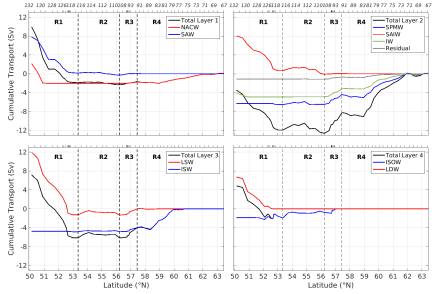
Volume and water mass transports above the Reykjanes Ridge



Velocity profile along the Ridge section. Positive values correspond to eastward velocities.



Top-to-bottom vertically integrated transport (Sv) along the Ridge section cumulated from Iceland to 50°N.



Transports integrated in each water mass layer along the Ridge section and cumulated from Iceland to 50°N.

- Region 1 delimits the eastward flow of the NAC with **22.8 ± 1.1 Sv** in the SAF and **17.4 ± 1.7 Sv** in the northern branch.
- Region 2 is characterized by no net flow (**0 ± 1.4 Sv**).
- The westward flow is high in region 3 and 4 with an intensification at BFZ (57.3 – 56.4°N) of **-8 ± 0.5 Sv** and at 59 – 61°N of **-13.6 ± 0.8 Sv**.

- The **SAIW** was mainly transported eastward by the NAC with 7.3 ± 0.6 Sv
- The **SPMW** followed the pathways at BFZ (-2.1 ± 0.1 Sv) and at 59 – 61°N (-5 ± 0.4 Sv) as well as the **IW** whose the total transport was -4.9 ± 0.4 Sv
- The **ISW** was **only** transported between 58.5 and 60°N with -4.3 ± 0.3 Sv
- The **ISOW** crossed the Ridge through the CGFZ (-0.8 ± 0.8 Sv) and BFZ (-1.1 ± 0.7 Sv)

Water mass characterization

North Atlantic Central Water (**NACW**)

Sub-Arctic Water (**SAW**)

Sub-Arctic Intermediate Water (**SAIW**)

Intermediate Water (**IW**)

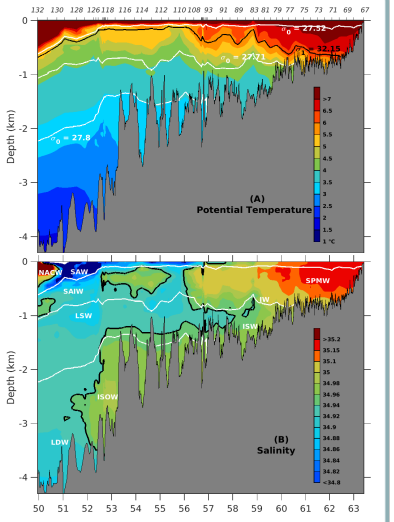
SubPolar Mode Water (**SPMW**)

Labrador Sea Water (**LSW**)

Icelandic Slope Water (**ISW**)

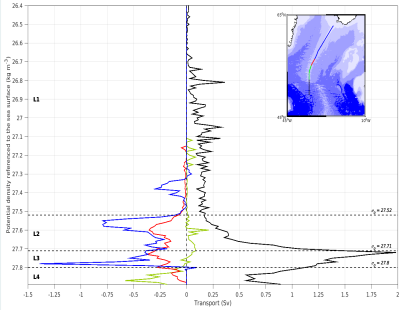
Lower Deep Water (**LDW**)

Iceland-Scotland Overflow Water (**ISOW**)

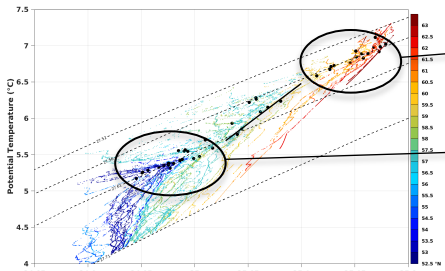


(upper) Potential temperature (°C) and (lower) Salinity sections along the Reykjanes Ridge. The potential density anomalies 27.52, 27.71 and 27.8 are in white and are used to delimit the identified water masses . The potential density anomaly 32.15 and the isohaline 34.94 are in black. Bathymetry in grey is from the ship survey.

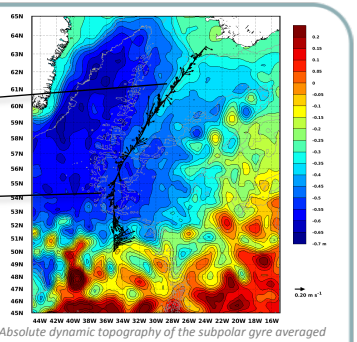
Evolution of water masses along the Ridge



Transport integrated in 0.01bin of density for the 4 regions



Θ/S diagram of hydrographic profiles in the SPMW layer. Black dots mark the properties at the minimum of potential vorticity



Absolute dynamic topography of the subpolar gyre averaged between 24 June and 5 July 2015. Black vectors show the surface velocities along the Ridge section during the cruise

- The northern branch of the NAC contains a larger proportion of subpolar waters (83.6%) than the SAF (61.4%)
- The comparison between outflow (region 2-3-4) and inflow (region 1) reflects the integral measurement of the mixing in the Iceland Basin and shows a densification of the water masses

- Two pools of SPMW are density compensated at 59 – 63°N (27.56) and at 53 – 55.5°N (27.61)
- The southward increase in density between 59°N and 55.5°N is related to the circulation and composition of the NAC branches in the Iceland Basin
- The southern pool of SPMW at 53 – 55.5°N is locally formed in the center of the Subpolar Gyre where the net flow is weak

- The SAF and the northern branch of the NAC are connected to the 59 – 61°N and BFZ pathways respectively
- The northern branch of the NAC was north and strong enough to disturb the ISOW flow in the CGFZ
- A weak dynamic height gradient is located along the Ridge section between 53.35 and 56.4°N