Spreading dynamics of central Labrador and Irminger Sea Waters

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[Credit C. Rohleder]

Motivation

- Subpolar North Atlantic important in our climate system connecting the upper and lower AMOC limb
- Every year deep convection in the Labrador Sea with different intensity [Yashayaev and Clarke, 2008; Kieke and Yashayaev, 2015]
- Recent years (2015- 2018) deep convection largely increased in the Irminger Sea [Väge et al. 2009; de Jong et al. 2012, 2018; Piron et al. 2016, 2017; de Jong and de Steur, 2016; Fröb et al. 2016; Zunino et al. 2020]
  - After 2015 average air-sea buoyancy flux
  - Preconditioning through:
    - local cooling of the intermediate water (200–800 m)
    - advection of a negative S anomaly in the LSW layer between 1200–1400 m
- LSW spreading is well documented beyond the Labrador basin
- Limited number of observations within the Labrador Sea provide little information about the mechanisms by which it leaves the Seas interior

Hypothesis

- Previously formed LSW spreading from the Labrador towards Irminger Sea important for convective activity south of Greenland and in the Irminger Sea

What are the timescales and pathways connecting the central Labrador and Irminger Sea?

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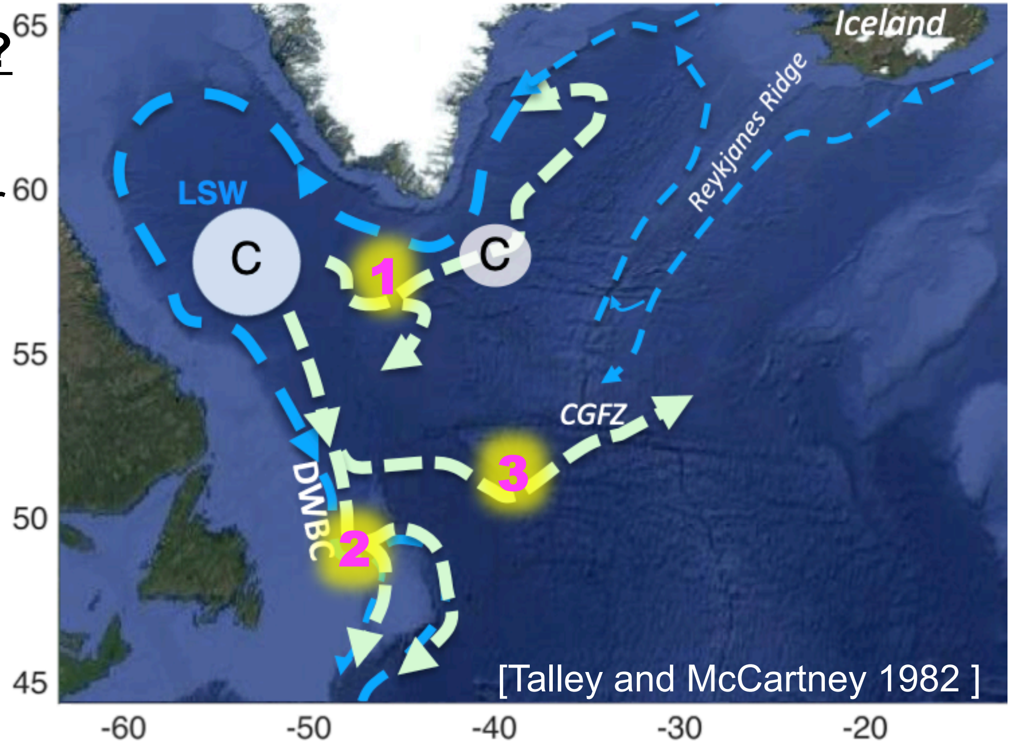
How does LSW spread after formation?

- One major export pathway of LSW connecting Labrador Sea and Irminger Sea along anticyclonic recirculation [Talley and McCartney 1982 …]
- 1 – 3 years transit time from Labrador to Irminger Sea [Lavender et al. 2000; Rhein et al 2002 …]
  - 0.5 years [Sy et al. 1997]
- 20 – 40 % of particles connect the two regions [Lavender et al. 2000; Rhein et al. 2002…]



Methods

- Isobaric Lagrangian particle experiments
  - high resolved mean velocity fields (advective / advective-diffusive (Makov 0 - 200m²/s))
    - Resolution ~25 km (¼ of previous experiments [Straneo et al. 2003; Kvarleberg et al. 2008])
      - Argo based [Fischer et al. 2018]
      - VIKING20X based [Rieck et al. 2019]
  - temporally and spatially high resolved VIKING20X output of year 2005 (advective)
    - Resolution 1/20°, daily velocity fields

- Seeding in Labrador Sea(forward) /Irminger Sea(backward)
- 12000 particles seeded
- 4 years trajectory integration

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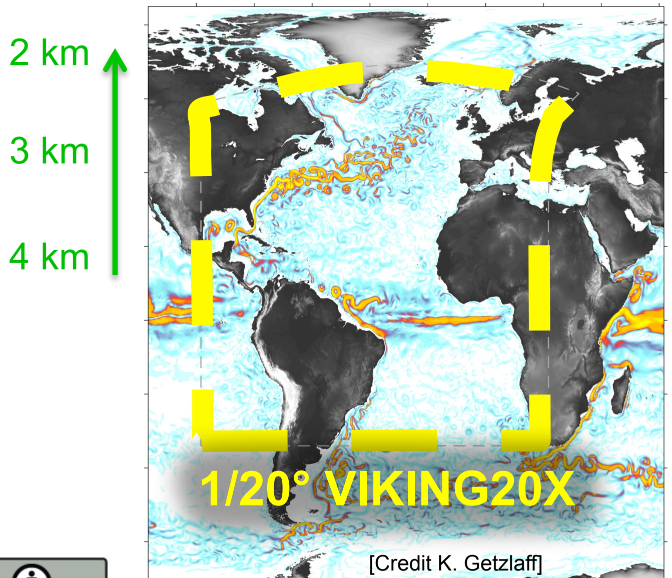
VIKING20X

- ORCA025 (1/4° resolution) global resolution
- 1/20° two-way nest (34°S – 70°N)
- 46 vertical z-levels
- CORE v2.0 atmospheric forcing
- Hind cast 1958-2009

- Mean field of 2005 computed with same PV-constraints as with the Argo data[Davis et al. 1998]

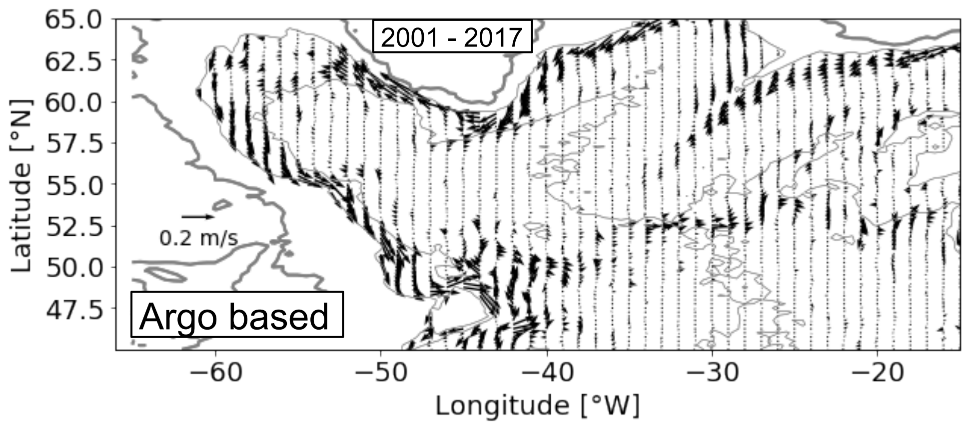
- Daily fields of 2005 used in full 1/20° resolution

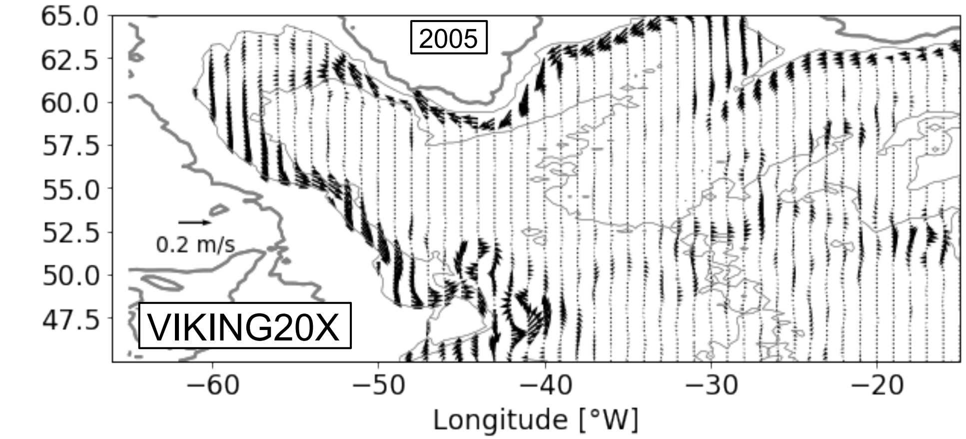


ARGO based mean velocity field

- 2001 – 2017 mean field
- 1000 -1500 m [Fischer et al. 2018]
- ~25 km grid

- Interpolation of Argo data with PV constraints [Davis et al. 1998]





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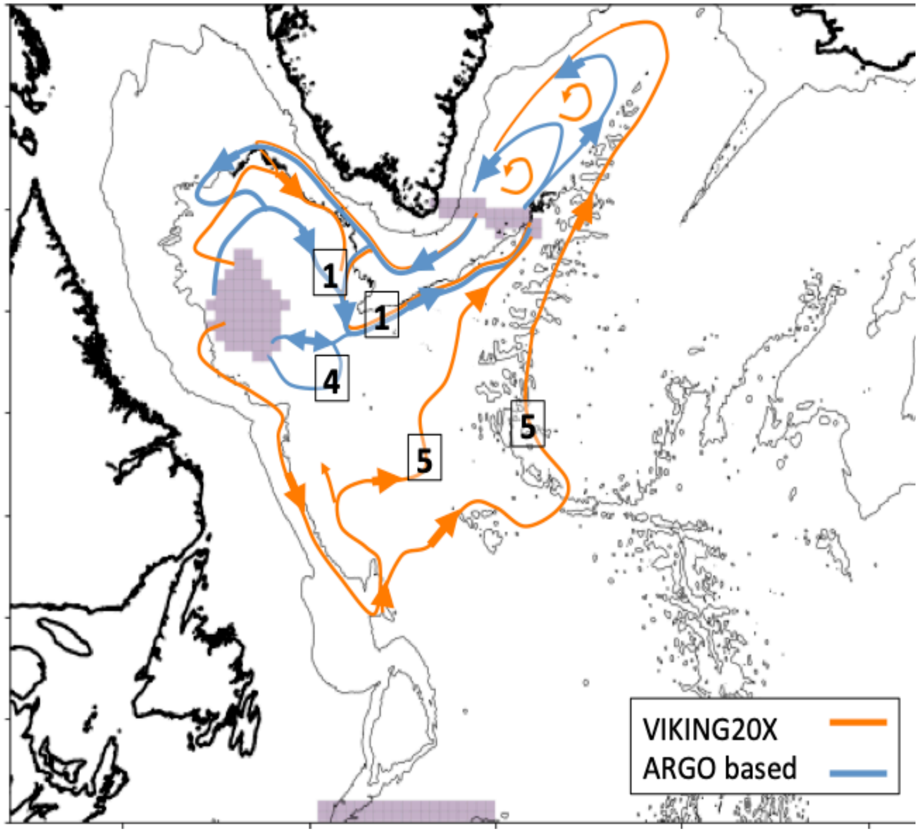
Results

1) New pathways (map 4,5) depend on the mesoscale eddy diffusivity
(ba Path table)
   - Path 5 could be related to stronger DWBC in VIKING20X and hence related shedding of eddies at Orphan Knoll and Northwest Corner
   - Path 4 is a slow short cut from central Labrador Sea to the anticyclonic recirculation (Argo based experiments)

2) Transit times governed by advective time scale (TTD table- compare advective and advective-diffusive)
   - The introduction of a spatially non varying diffusivity of 200 m^2s^{-1} did not alter TTD significantly



n.c. – no connection *TTD –Transit time distribution* ***fo** - forward* ***ba** - backward*	**fo 50% TTD [years]**	**ba 50% TTD [years]**	**Connectivity**		**fo Path**	**ba Path**
			fo [%]	ba [%]		
Argo based ***advective***	2.7	2.4	36.5	2.1	1	1
Argo based **advective-diffusive**	2.5	2.3	22.7	18.8	1	1,4
VIKING20X mean ***advective(*)***	3.2	3.6	3.1	20	1,5	1
VIKING20X mean **advective-diffusive**	3.4	3.1	2.5	3.3	1,5	1,5
VIKING20X daily **advective (**)**	1.6	n.c.	21.1	n.c.	1,5	n.c.

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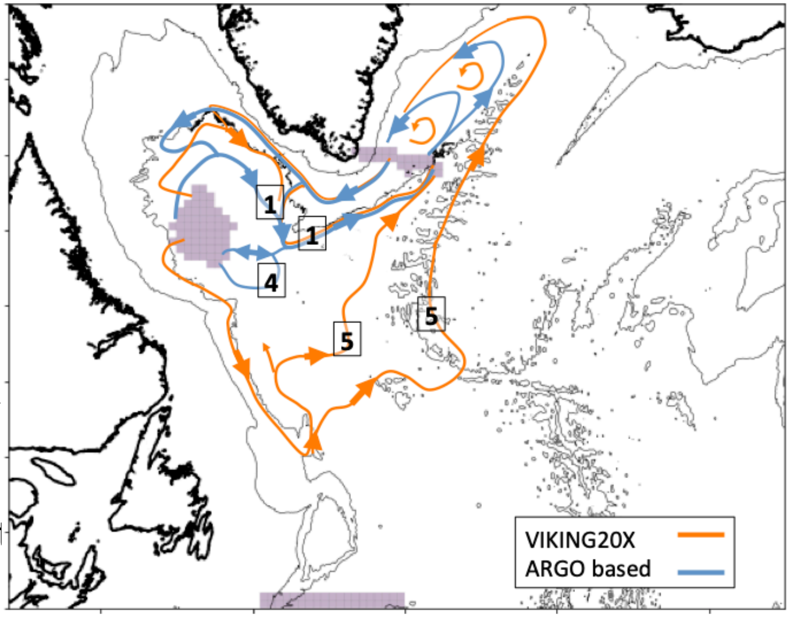
Results

3) Real mesoscale eddy transport can shorten transit times by 50% (TTD table - compare ** and *)

- Comparing VINKING20X mean field and daily field experiments – the travel time between regions is halved – eddies originating at Orphan Knoll/ Northwest Corner region represent fast track

4) Amount of particles connecting the Labrador Sea and Irminger Sea (20-40%) and the time scales (1-3 yr) are reproduced (TTD,Connectivity table)

- The previously proposed TTDs between regions represent advective timescales



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To achieve transit times of 0.5 years [Sy et al. 1997]:

1. High velocities along the anticyclonic recirculation in Labrador Sea
2. Convection closer to the Irminger Sea e.g southeast of Greenland

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