Exploring the sources and fate of the Cold Atlantic Water (AW) from Ariane experiments

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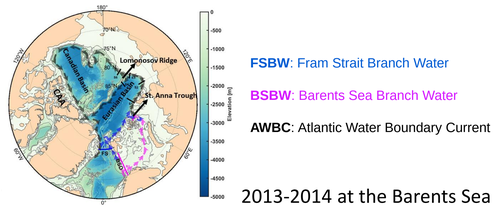
Introduction

- The warm and saline AW enters the Arctic Ocean through two gateways: Fram Strait (FS) and the Barents Sea Opening (BSO)



FSBW: Fram Strait Branch Water

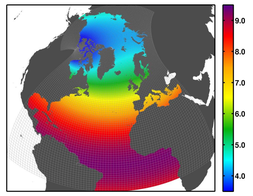
BSBW: Barents Sea Branch Water

AWBC: Atlantic Water Boundary Current

- 2013-2014 at the Barents Sea provides critical preconditioning for the transformation from the AW to the Cold AW.
- The pulses of the Cold AW replace the AW and thus cause the reductions in the AW transport following its poleward pathway.

Numerical Simulations

① **ANHA** *(Arctic and Northern Hemispheric Atlantic)*: a regional configuration based on the coupled ocean-sea ice modelling framework **NEMO**



ANHA12 horizontal mesh (every 20 grids, colour shows the resolution in km)

Mesh grid: 1632×2400×50 (resolution: 1/12°)

Time period: 2002-2019

Set up:

NEMO v3.4 [ocean] + **LIM2** [sea ice]

Initial & Open Boundary Conditions: GLORYS2v3 (3D: T, S, V 2D: SSH, Sea ice)

Atmospheric forcing: CGRF (33km & hourly) (10-m wind, 2-m air temperature and humidity, precipitation, radiation)

No temperature & salinity restoring

Calculations:

The heat content (kJ):

$$H = \int_0^V \rho_o C_p (\theta_i - \theta_{ref})\, dV = \iint_{-D}^{0} \rho_o C_p (\theta_i - \theta_{ref}) dA dz$$

Where θ_i is the potential temperature, θ_{ref} is the reference temperature (0 ℃), ρ_o is the reference density (1,030 kg/m^3), C_p is the specific heat capacity ($4.0 * 10^3\ J/(kg \cdot ℃)$), dA is the differential area of the horizontal domain (m^2). D is the largest depth of the domain (m).

② **Ariane**: an offline Lagrangian particle-tracking product to examine the oceanic advection of a particular water mass.

Calculations:

The number of particles to be released in each grid cell:

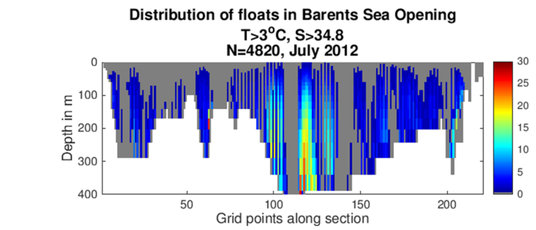
$$n = N * \frac{V}{V_{total}} * \frac{v}{v_{mean}}$$

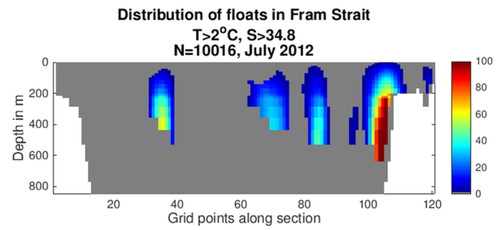
where n is the number of the particles in an identified grid cell along the sections and N is the sum of all the particles at each identified grid cell; V is the volume of each identified grid cell (m^3) and V_{total} is the total volume of identified grid cells (m^3); v is the velocity of each identified grid cell (m/s) and v_{mean} is the mean velocity of all the identified grid cells (m/s).

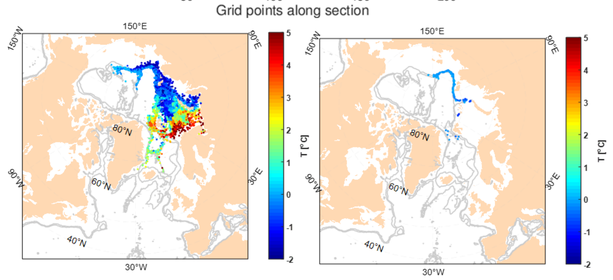
the Sources of the Cold AW

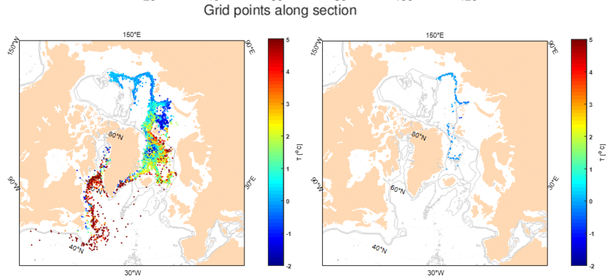
Ariane experiments:

Initial released particle locations:







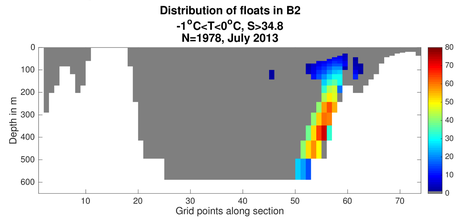


The Barents Sea Branch Water (BSBW) is one of the crucial sources for the Cold AW production.

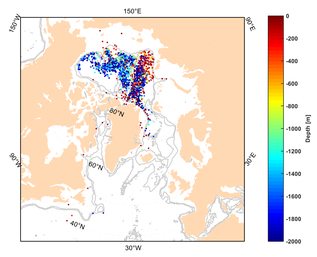
The Fram Strait Branch Water (FSBW) contributes to the Cold AW formation through entering the St. Anna Trough and mixing with the BSBW.

the Fate of the Cold AW

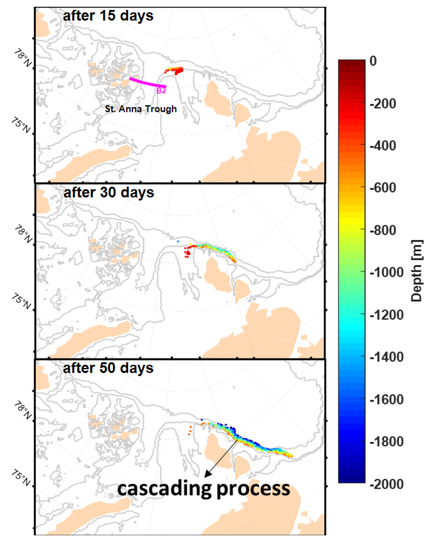
Initial released particle locations:



At the end of the simulation:



The early stages of the evolution:

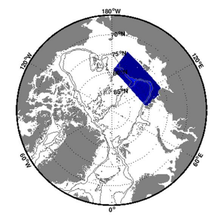


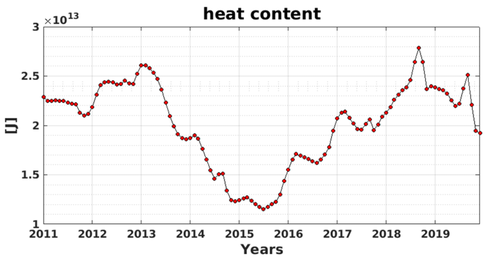
Canadian Basin:	**Eurasian Basin:**
In the deep layer (>1200 m)	Throughout the entire depth profile

Fifty days from the beginning, the particles clearly demonstrate the cascading process of the Cold AW, with some distributed near the basin edge of 500 m and successively extending along the 2000 m isobath.

the Impact of the Cold AW

Heat content:





- The heat content quantifies the heat contained in the AW layer referenced to 0 ℃.
- The heat content has experienced a significant downturn in 2015, which has reduced by over 50% compared to 2013

Conclusions

- **The source of the Cold AW is primarily from the Barents Sea Branch Water (BSBW), with secondary contributions from the Fram Strait Branch Water (FSBW).**
- **The Cold AW exhibits the cascading process as it propagates along the rim of the Eurasian Basin, leading to considerable entrainment with the ambient water.**
- **The heat content decline in the eastern Arctic Basin is dictated by the Cold AW anomaly signals propagating to the region.**

Acknowledgements

NEMO
compute canada | calcul canada
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