



Arctic Freshwater Budget

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ArcFresh Team



Norwegian
Meteorological
Institute



Environment and
Climate Change Canada



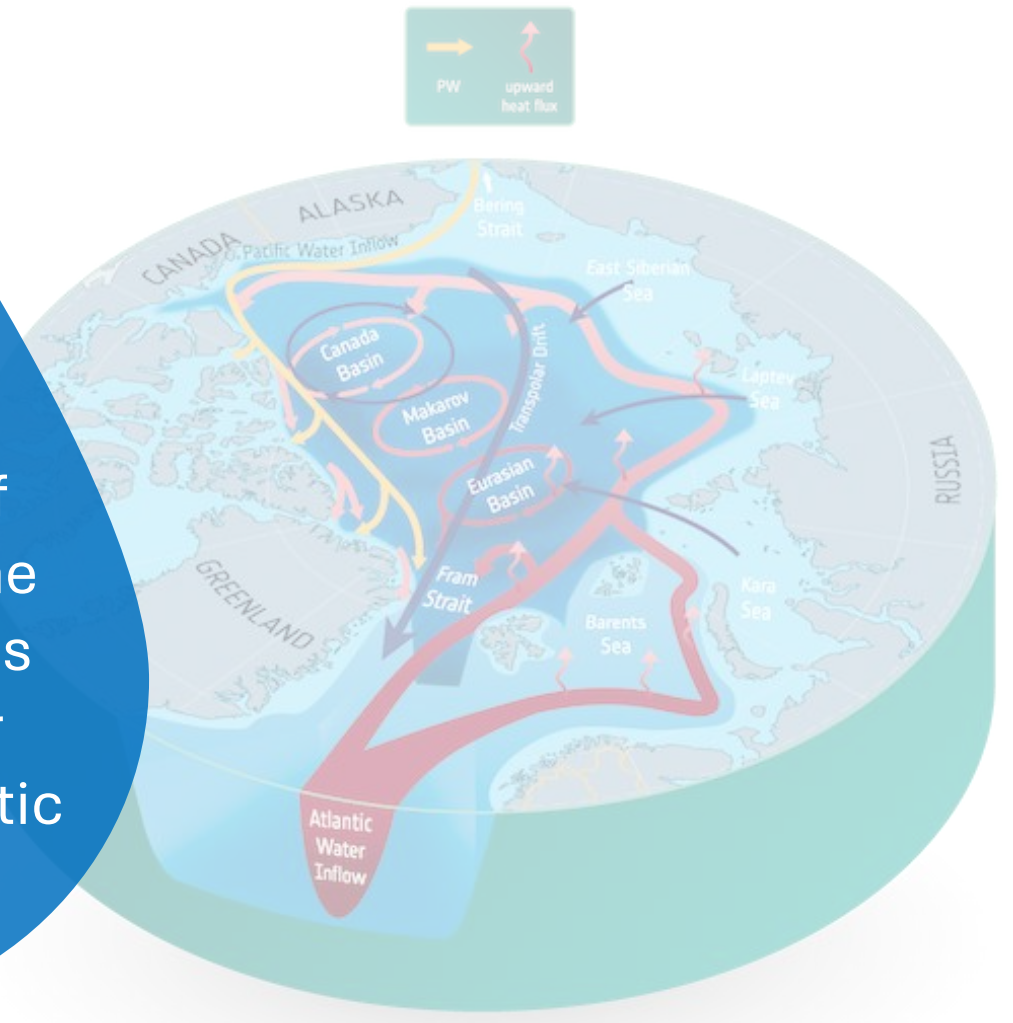
Ole B. Andersen (Project lead), Louise S. Sørensen, Sara N. Jensen, H. Skourup	DTU Space, Denmark
Stephen Howell, Alex Cabaj	ECCC, Canada
Thomas Nagler, Jan Wuite, Gabriele Schwaizer	ENVEO, Austria
Andreas Dobler, T. Lavergne	MET-NO, Norway
Laurent Bertino, R. P. Raj, H. Regan, A. Bonaduce	NERSC, Norway
Robert Ricker, Marion Bouquet	NORCE, Norway
Emma Woolliams, B. Modi, T. Erny, T. Reynolds	NPL, UK
David Gustafsson, Christophe Sturm	SMHI, Sweden
Daniele Fantin	S&T, Norway
Nicolas Kolodziejczyk	Uni Bretagne, France
Anna Maria Trofaier/Sophie Hebden	ESA ECSAT



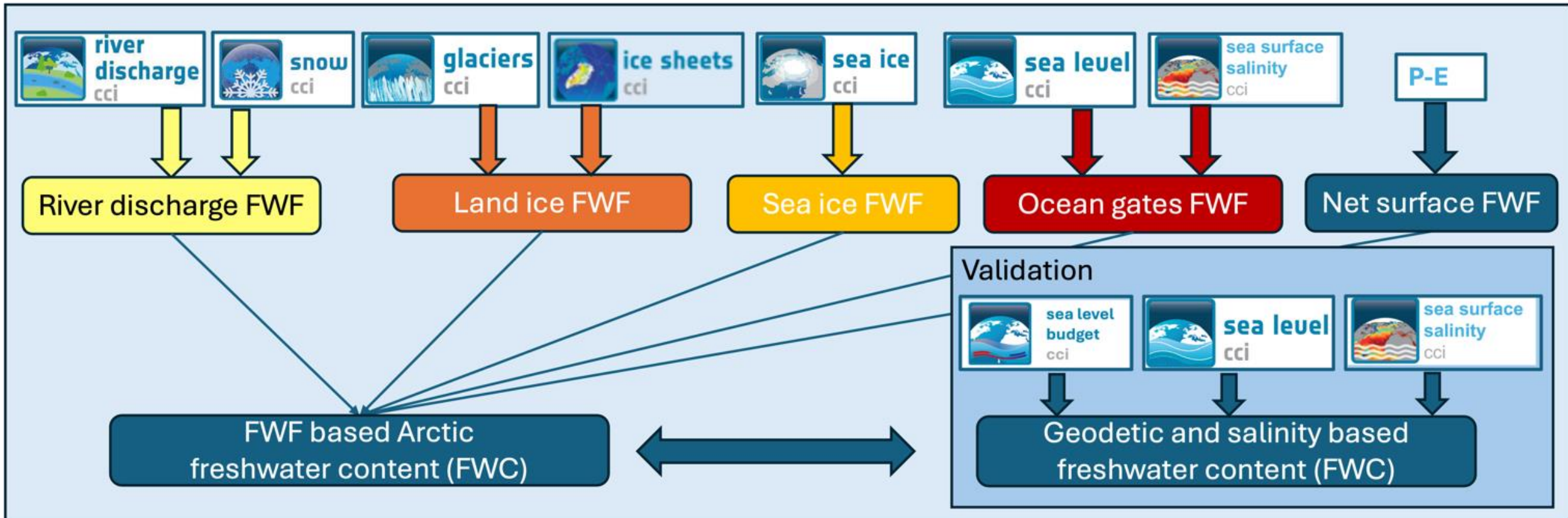
Pan-Arctic Freshwater system is changing

- Arctic upper layer is freshening (*Haine et al., 2015*) up to 2010, then less clear (*Solomon et al., 2021*)
- FW redistribution (gain in Canadian Basin)
- Impacts of sea ice reduction on the Arctic Ocean and atmosphere are still being debated
- Mass loss from the Greenland Ice Sheet, other Arctic glaciers and permafrost thaw
- Missing terms : groundwater, incomplete discharges (~40%), ...
- Increased Vertical mixing/ halocline weakening
- Large uncertainties among model reanalysis and observations

ArcFresh will advance the current state of knowledge on the freshwater fluxes and freshwater budget in the Arctic Ocean,



Maximizing the use of CCI ECV datasets



Scientific Topics addressed by ArcFresh

- 1. Improve current estimates of lateral freshwater fluxes** between land, sea ice, and ocean in the Arctic. This topic focuses on refining our understanding and quantification of freshwater movements, critical for accurate modeling and predictions.
- 2. Determine the pan-Arctic and Sub-regional Freshwater Budget** in the Arctic Ocean and its evolution in the context of a changing climate. This involves a detailed analysis of the inputs, storage, and outputs of freshwater within the Arctic system, vital for assessing global climate impacts.
- 3. Investigate Extreme Freshwater Change Events**, such as an extreme Greenland or sea ice melt season, and their impact on the Arctic Ocean. This topic aims to understand the ramifications of such events on Arctic freshwater balance and broader climate implications.

Five Steps to creating an uncertainty budget following the QA4EO system



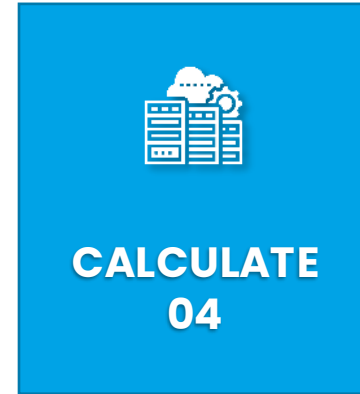
Define the measurand and measurement function



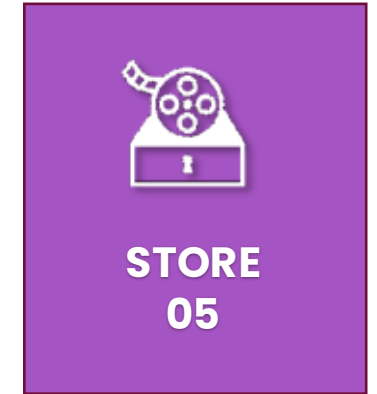
Establish the traceability with a diagram



Evaluate each source of uncertainty and fill out an effects table



Calculate the product and its uncertainty



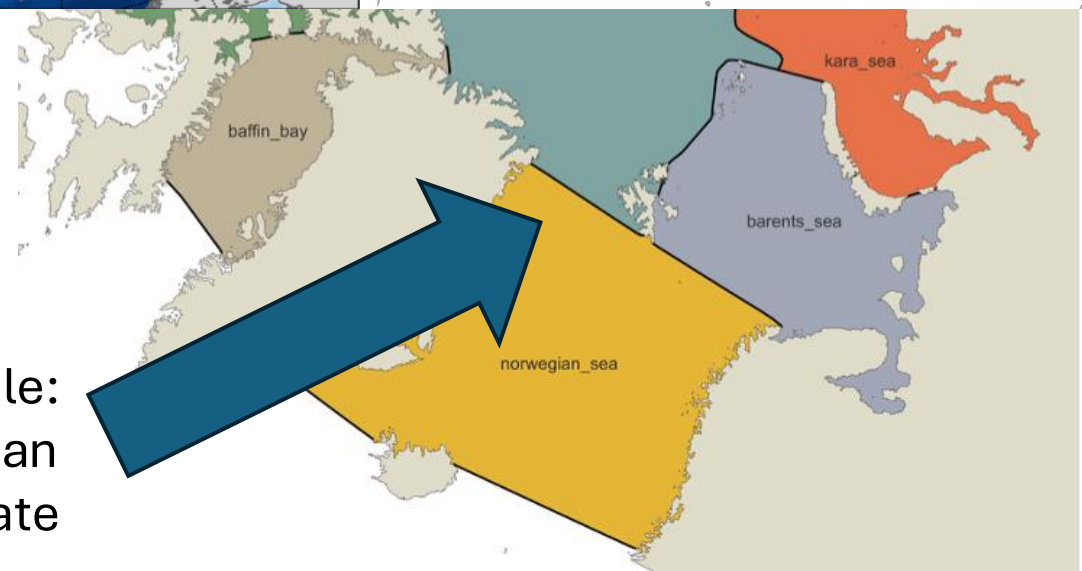
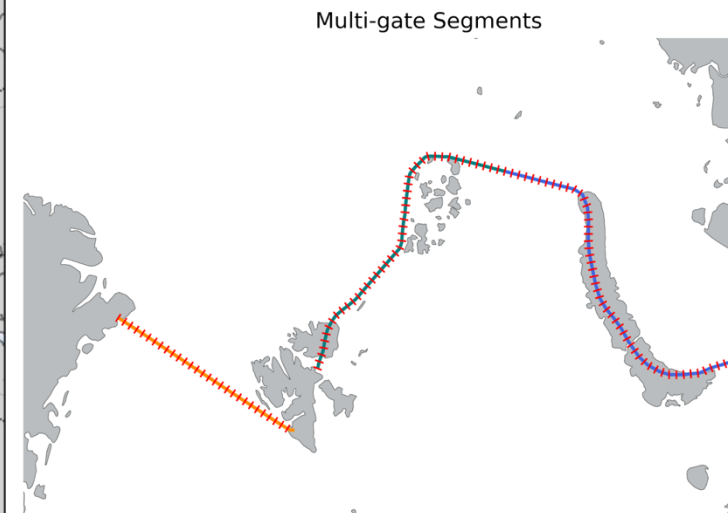
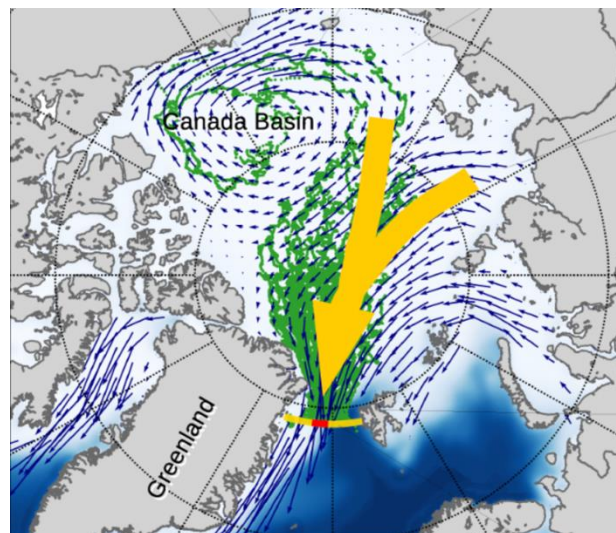
Store relevant information for future users

Improving current estimates of lateral freshwater fluxes

- Measurand: Fluxes (water-equivalent volume transport of ice and liquid water at the internal and external gates defined in the project)
- → Assess the uncertainties associated with each flux estimate

Uncertainty assessment requires knowledge of the spatial and temporal error correlation of the observations

- how do we integrate along the gateways or across the Arctic?
- What is the uncertainty associated with the integrated quantity?



FRAM Strait example:
Major Sea ice and ocean
transport gate



Sea-ice volume flux Q_{gate} across Fram gate is derived from gridded fields of sea-ice concentration, sea-ice thickness, and sea-ice drift (NORCE).



Salt, Volumen and estimated Freshwater (DTU) using CMEMS geostrophic currents (u)

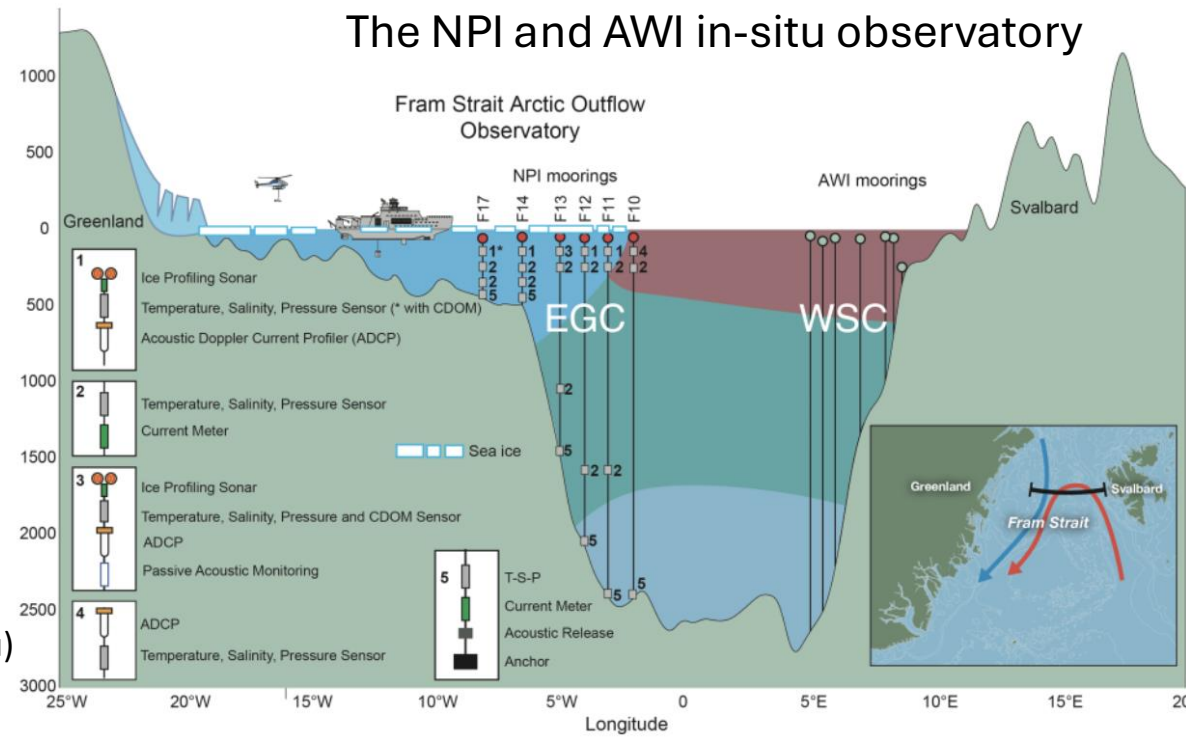
Salt mass transport [kg/s]:

$$\dot{m}_{S,j} = \iint_{A_{XSC}} \rho \frac{S_A}{1000} \mathbf{u} \cdot \mathbf{n}_j dA_{XSC}$$

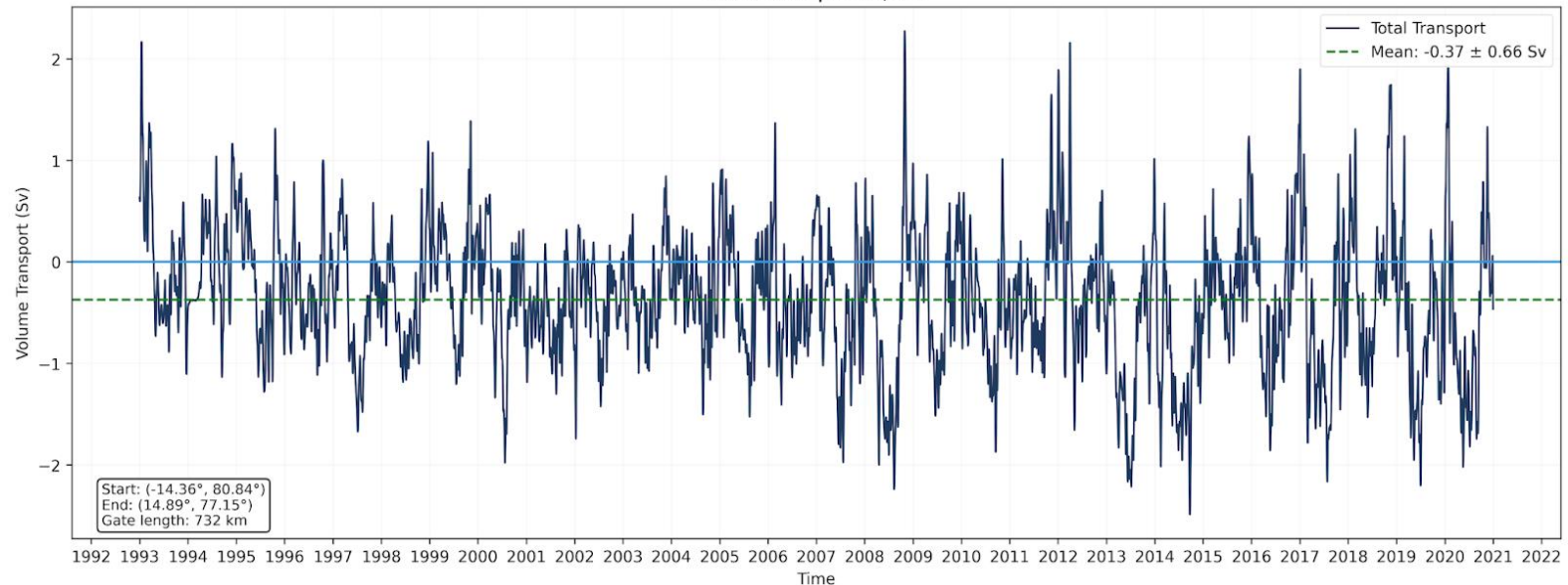
Freshwater transport [m³/s]:

$$F_{fw,j} = \iint_{A_{XSC}} f_{fw} \mathbf{u} \cdot \mathbf{n}_j dA_{XSC} \quad f_{fw} = 1 - \frac{S_A}{S_{A,ref}}$$

The NPI and AWI in-situ observatory



fram_strait - Total Volume Transport
CMEMS Global Ocean Gridded L4 Sea Surface Heights (SEALEVEL_GLO_PHY_L4_NRT_008_046)
1993-2020 | N=10,227



Take home message

- ArcFresh is active during 2025-2027
- Huge collaboration between 10 institutions Funded by ESA Climate Office
- ArcFresh utilizes data from several CCI ECV projects to estimate the freshwater fluxes (FWF) and budget of the Arctic Ocean
- Uncertainty follow QA4EO principles
- We computed first estimates of lateral and horizontal fluxes through all ARCTIC gates for various component
- Visit the ArcFresh webpage:
https://climate.esa.int/en/Cross_ECV_Projects/arcfresh/

