Winter Atlantic Water intrusions in Kongsfjorden: atmospheric triggering and oceanic preconditioning

Francesco De Rovere[1,2], Davide Zanchettin[1], Angelo Rubino[1], Leonardo Langone[2], Francesco Calogiuri[3], Paolo Ruggieri[3], Angelo Lupi[2], Jacopo Chiggiato[4]
1 Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Venice, Italy
2 CNR-ISP, Consiglio Nazionale delle Ricerche, Istituto di Scienze Polari, Bologna, Italy
3 Department of Physics and Astronomy, University of Bologna, Bologna, Italy
4 CNR-ISMAR, Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine, Venice, Italy

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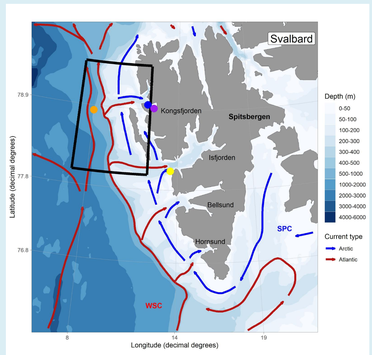
THIS POSTER IN A NUTSHELL
1. Kongsfjorden (Svalbard) is characterised by occasional winter intrusions of Atlantic Water, leading to a fast increase of temperature and salinity in the fjord.
2. These intrusions are triggered by abrupt ***reversals*** of local meridional winds, which lead to the development the Spitsbergen Trough Current (Nilsen et al., 2016), but intrusions do not follow every *reversal* event.
3. Freshwater advected in Kongsfjorden during the whole winter lowers its density, disrupt the **geostrophic control** (Cottier et al., 2005) and opens the fjord to AW intrusions only in specific winters. We hypothesise the Arctic sea-ice melting during the previous summer to be the critical source of these low density waters.



Kongsfjorden is an Arctic fjord in Svalbard and its hydrography is influenced by the Atlantic (**WSC**) and the Arctic (**SPC**) currents.
The fjord is characterised by occasional Atlantic Water (AW) intrusions in winter, regulated by two main mechanisms:
- Strong southerly wind events develop the **Spitsbergen Trough Current (STC)**, transporting AW toward the fjord (Nilsen et al., 2016).
- The shelf-fjord density gradient influence the coastal SPC and determines the degree of blocking of waters advected from the WSC. This process is termed **geostrophic control mechanism** (Cottier et al., 2005).

Cottier et al., (2005). *Journal of Geophysical Research: Oceans*
Nilsen, et al. (2016). *Journal of Physical Oceanography*

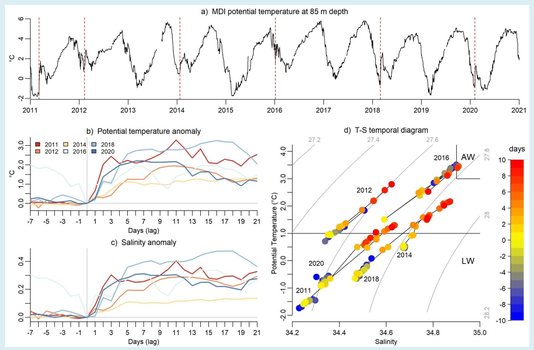
Data
Marine observations from moorings:
MDI (ISP-CNR) – **KF** (UiT/SAMS) - **F3** (AWI) – **I1** (UNIS).
ERA5 reanalyses: 10 m winds (over the shelf and Fram Strait); 850 hPa geopotential over the Arctic.
CMEMS Arctic Ocean reanalyses: salinity at 50 m depth.

MOTIVATION and TARGETS

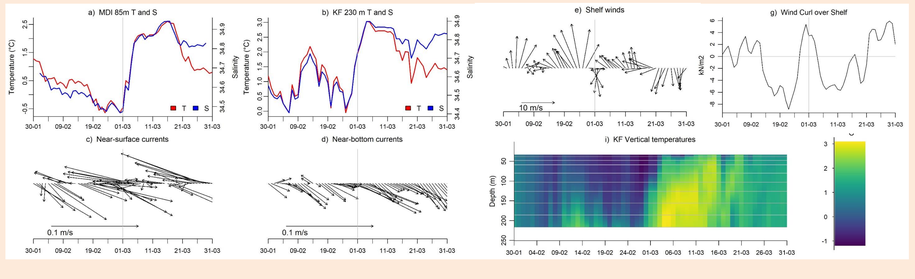
- Thoroughly examine AW winter intrusions over the 2011-2020 decade.
- Robustly define common traits of AW winter intrusions, especially the large-scale atmospheric and oceanic settings.
- Study the relation and interplay between the two most important mechanisms (STC and geostrophic control).
- Understand the influence of the SPC on winter water masses variability in Kongsfjorden.

ATLANTIC WATER INTRUSIONS

Atlantic Water winter intrusions in the 2011-2020 decade, as evidenced by MDI observations.
Intrusions lead to a fast increase of temperature and salinity in a few days. These conditions persist for several weeks, influencing the structure of the water column and spring blooms.

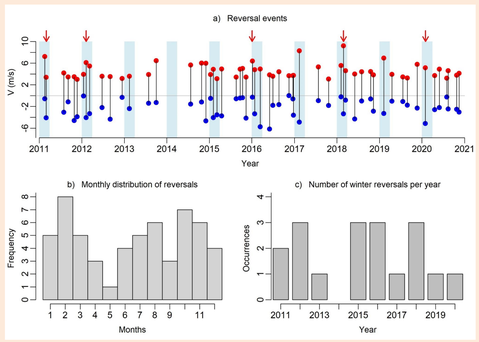


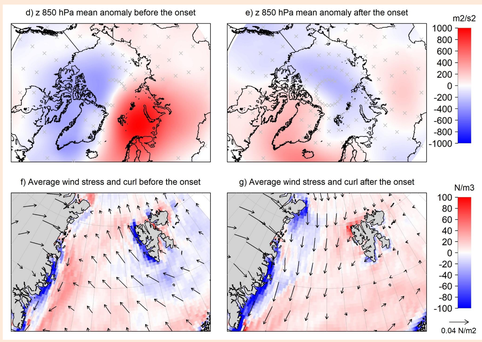
ATMOSPHERIC TRIGGERING



AW intrusions occurred in 2011, 2012, 2016, 2018 and 2020 shared common dynamics: the AW intrusion is forced by ***reversal*** events (southerly winds followed by northerly winds) through the development of the **STC** and subsequent upwelling.

Southerly winds and a negative wind curl force surface waters to stack up along the coast. The resulting increase in the cross-shelf sea surface tilt forces the WSC on lower isobaths on the shelf, developing the STC. Once southerly winds cease, the sea-surface tilt relaxes and surface waters tend to flow offshore, compensated by an inflow of AW from the shelf break near the bottom. Northerly winds further drive the upwelling of AW from the STC to the surface of Kongsfjorden.

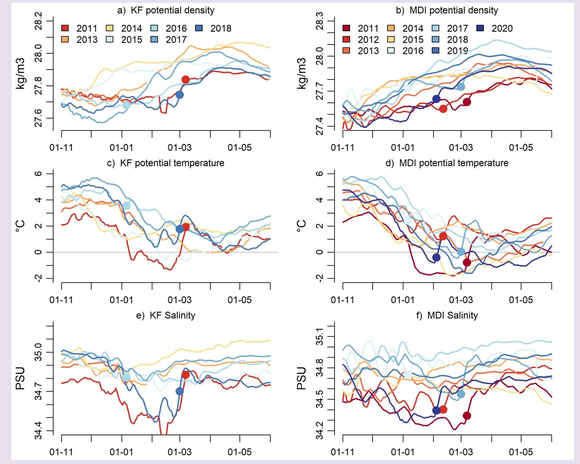




Reversals are strong southerly wind events generated by the setup of a high pressure anomaly over the Barents Sea and a low pressure anomaly over northeastern Canada and Greenland. This geopotential dipole generates strong geostrophic winds blowing from the south over the Fram Strait, instaurating downwelling on the shelf. The restoration of a low pressure anomaly over Svalbard triggers northerly winds initiating upwelling.

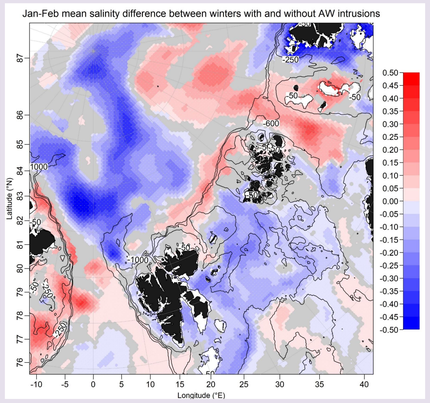
Reversals are common phenomena occurring throughout the decade. So, why do AW intrusions occur only in some winters and do not follow every *reversal* event?

OCEANIC PRECONDITIONING



Atmospheric *reversals* triggering an AW intrusion occur only when **low density waters** are found within the fjord at depth. Low density fjord waters disrupt the **geostrophic control mechanism** and allow AW uplifted through the STC by *reversal* events to enter the fjord.
These low density/low salinity waters characterize the whole winter season and are found both in Kongsfjorden (MDI and KF) and Isfjorden (I1), suggesting a common freshwater source for these two locations, which could only be the **SPC**.

Significantly lower salinities are seen in those years featuring an AW intrusion by upwelling (2011, 2012, 2018, 2020), compared to the other winters (2013, 2015, 2017, 2019).
We hypothesize this winter large scale salinity structure to be consistent with a strong sea-ice melting during the previous summer season.



For additional info: francesco.derovere@unive.it