# Impact of the North Atlantic Atmospheric Variability on the Northern European Mean Sea Level

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## Aim and motivations

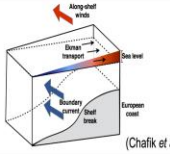
We study how the large-scale atmospheric circulation in the North Atlantic affects the northern European mean sea level on a few days timescale.

This could help understand the ability of climate models to reproduce the internal component of the sea level variability. At the same time, it might be useful when studies sea level extremes as the mean sea level is believed to affect phenomena such as storm surges.

## Winds along the slope and on the continental shelf

Winds blowing parallel to the continental slope drive a water mass exchange between the open ocean and the continental shelf, therefore affecting the sea level on the shelf (Ekman theory).

Due to the shallowness of the continental shelf, the impact of the winds on the shelf water differs from the one in the open ocean. Bottom friction is felt even near the surface and, as a result, on-shelf currents driven by the winds tend be along the same direction of the winds.

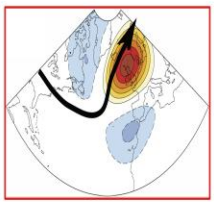


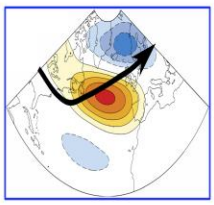

(Chafik *et al.*, 2017)

## Atmospheric variability

The wintertime atmospheric variability is described in terms of the jet clusters (Madonna *et al.*, 2017). Each jet cluster refers to a particular configuration of the eddy-driven jet stream (4 in total) and have the ability to summarize the surface weather patterns on time scales from a few days up to a few weeks.

Here, we focus on the "Mixed jet cluster" (red frame) and the "Northern jet cluster" (blue frame) for which the jet stream is circa located at the same latitude of the Northern European continental shelf and slope.



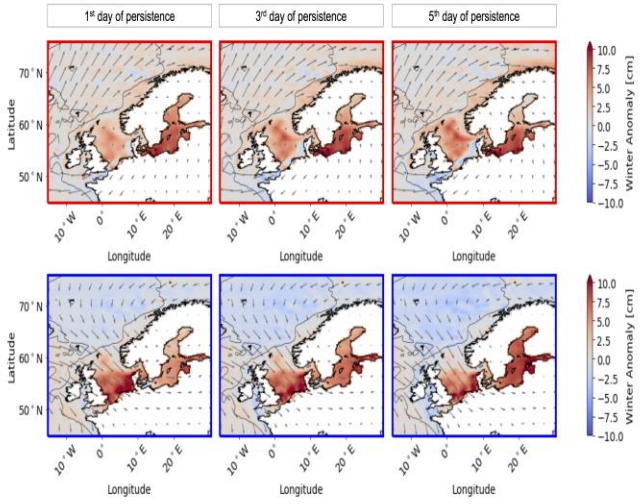


## Sea Level anomaly evolution

- We focused on one jet cluster at the time
- In an attempt to isolate the impact of the jet cluster, we considered only those cases when it persists for 5 days or longer
- For each day of persistence, we produced a composite map of the sea level anomaly (downloaded from the Copernicus website) and of the zonal and meridional components of the winds (ERA-Interim)

N.B.:

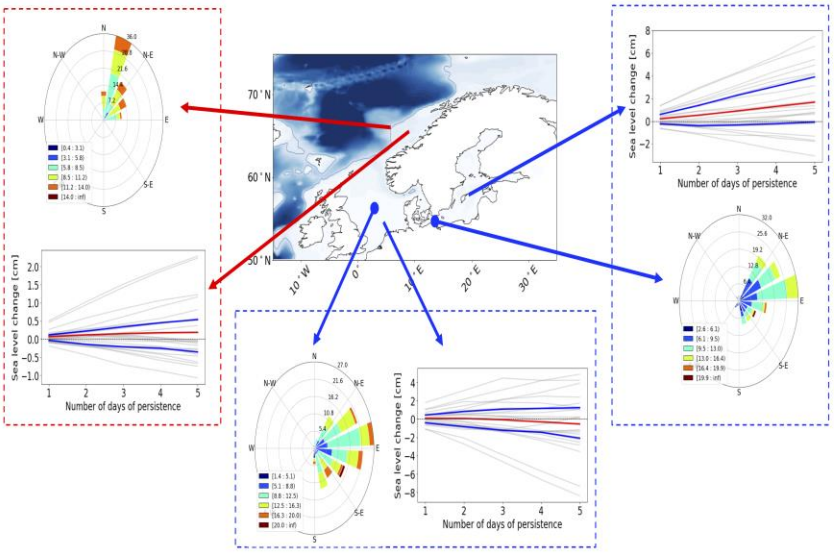
1. data are the winter period (DJF) between 01/12/1993 and 28/02/2014
2. before performing the analysis, we removed the inter-annual variability from the sea level anomaly (referred to as "Winter Anomaly") and from the zonal and meridional components of the wind field




## Sea level variation with respect to the first day of occurrence of a jet cluster

- We averaged the sea level anomaly over the Norwegian shelf, the Southern North Sea and the Baltic Sea
- We focused on one jet cluster at the time
- For each time the jet cluster persists for 5 days or longer, we computed the sea level variation with respect to the first day of occurrence of the jet cluster
- Then, for each of the three sub-regions, we plotted the sea level variation as a function of the jet cluster persistence
- The red lines show the average of the sea level variation for each day of persistence
- The blue lines show the 25th and the 75th percentiles of the sea level variation for each day of persistence
- The windroses show the intensity (colours) and the direction of the wind field along the Norwegian sector of the continental slope, in the middle of the North Sea and in the Danish Straits

NB: the blue arrows refer to Northern cluster, whereas the red ones to the Mixed cluster




## Preliminary results

- The Mixed cluster seems to drive a positive mean sea level change over the entire shelf (with the only exception of the German Bight)
- The Northern cluster seems to mainly affect the southern side of the North Sea and the Baltic Sea
- Sea level variations in the North Sea and in the Baltic Sea are more pronounced than over the Norwegian Shelf
- Water redistribution within the shelf might play a major role in determining the on-shelf sea level anomaly (e.g. the water mass exchange between North Sea and the Baltic Sea)
- It seems that there is a wide spread in the sea level variability induced by the Northern and the Mixed clusters
- It is not always easy to relate local winds and the sea level variations on the shelf (e.g. during Mixed clusters events, the wind along the Norwegian sector of the slope mainly blow with the coast on their right, however these are not always associated with a positive sea level variation on the Norwegian shelf)

## Future work

- Repeat analysis using tide gauges
- Analyse the data provided by the current meter located at the Svinøy section
- In depth analysis of a case study (e.g. a long period dominated by one of the jet clusters)
- Volume budget on the shelf

### References

1. Chafik L, J. Nilsson, Ø. Skagseth, P. Lundberg, (2015). On the flow of Atlantic water and temperature anomalies in the Nordic Seas toward the Arctic Ocean. *J. Geophys. Res. Oceans*, 120, 7897-7918, DOI: 10.1002/2015JC011012.
2. Madonna E, L Camille, CM Grams, T Woollings. (2017). The link between eddy-driven jet variability and weather regimes in the North Atlantic-European sector. *Q. J. R. Meteorol. Soc.*, 143: 2960–2972, DOI:10.1002/qj.3155.

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