Seasonal and interannual variability of heat and freshwater content in the Norwegian Sea

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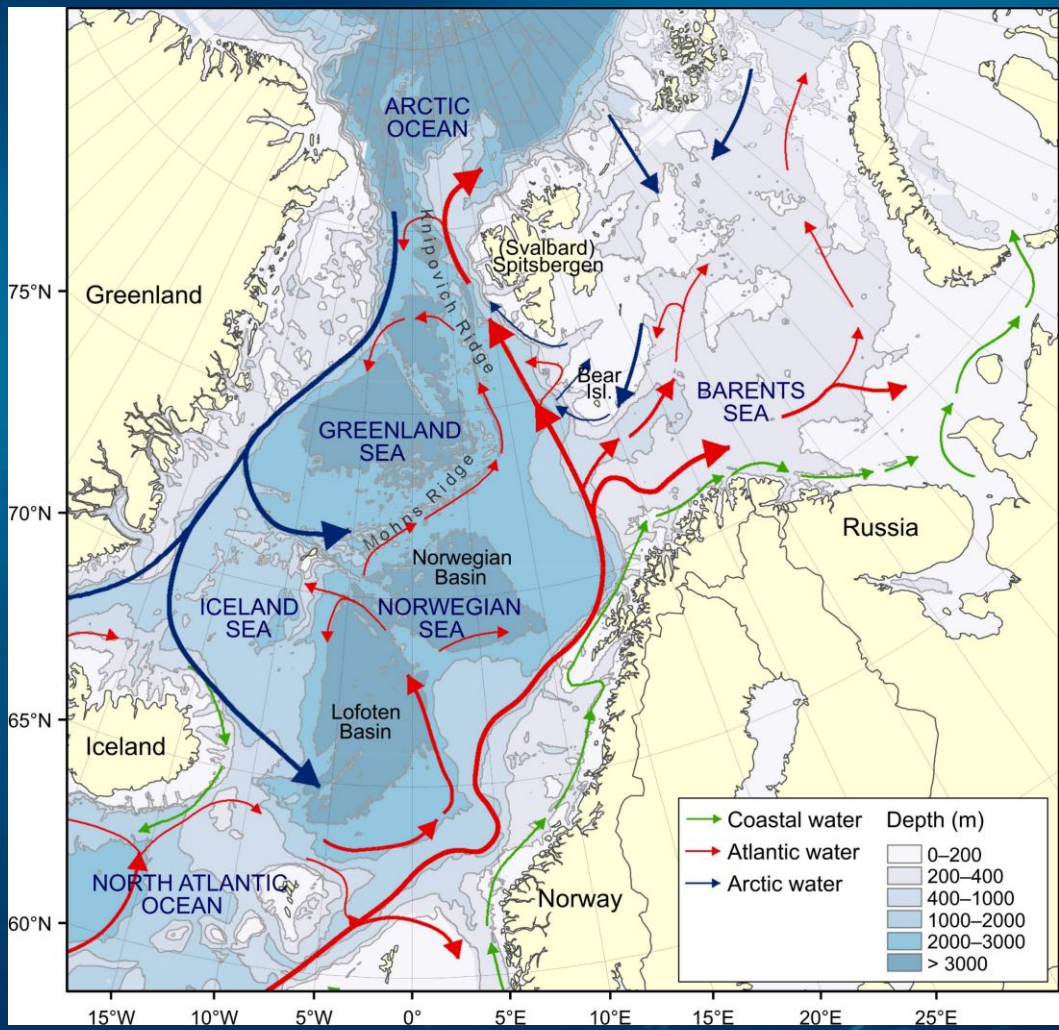
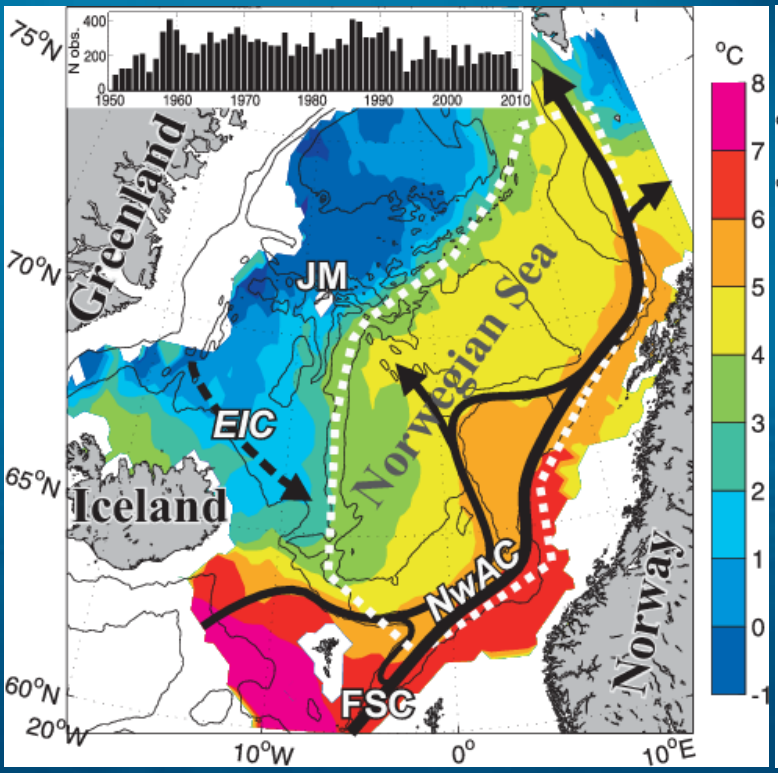
The Nordis Seas

- Atlantic Water (AW) from the south and Arctic water from the north
- Major region of water mass transformation, where AW is transformed into a dense water mass
- Intense atmospheric cooling of AW, occurs largely in the Norwegian Sea (e.g., Isachsen et al., 2007)

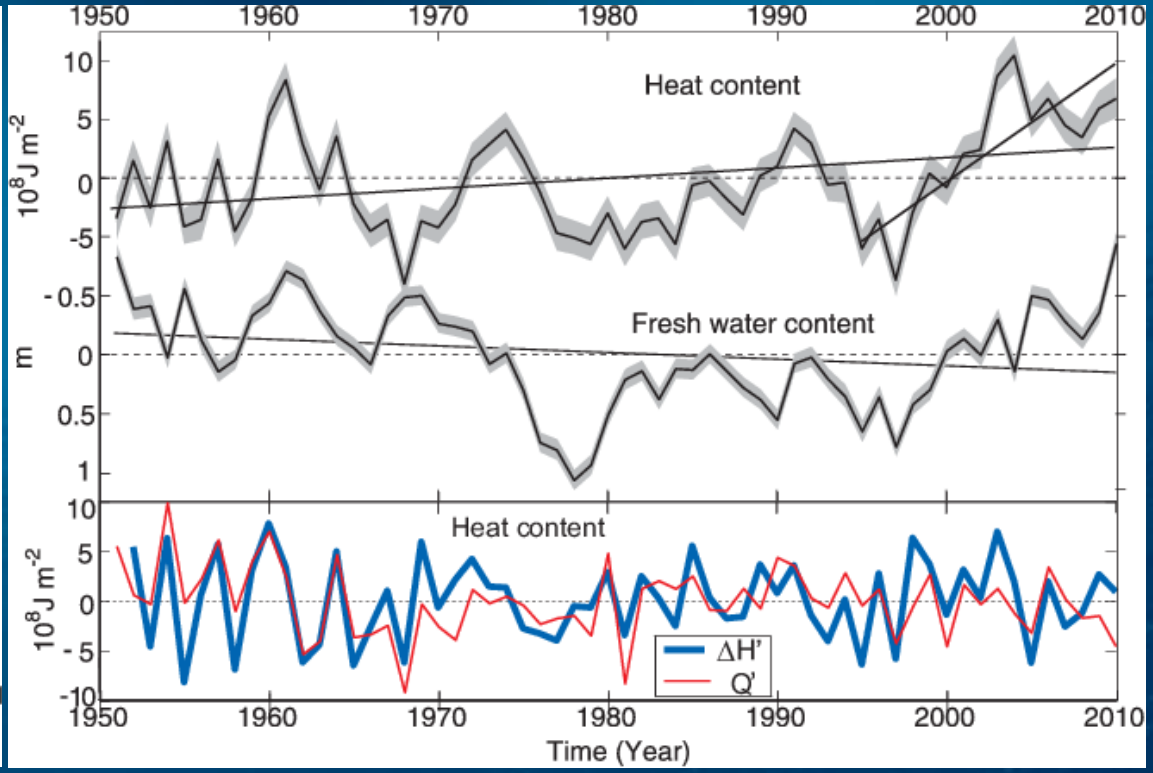


Surface circulation in the Nordic Seas

Heat and freshwater content in the Norwegian Sea (covering Atlantic layer) using gridded historical hydrographic observations (1951-2010)



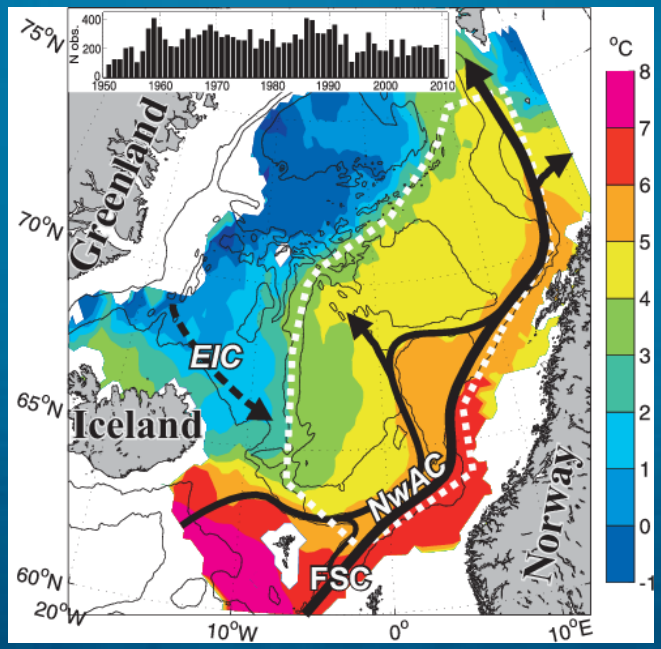
Upper layer temperature



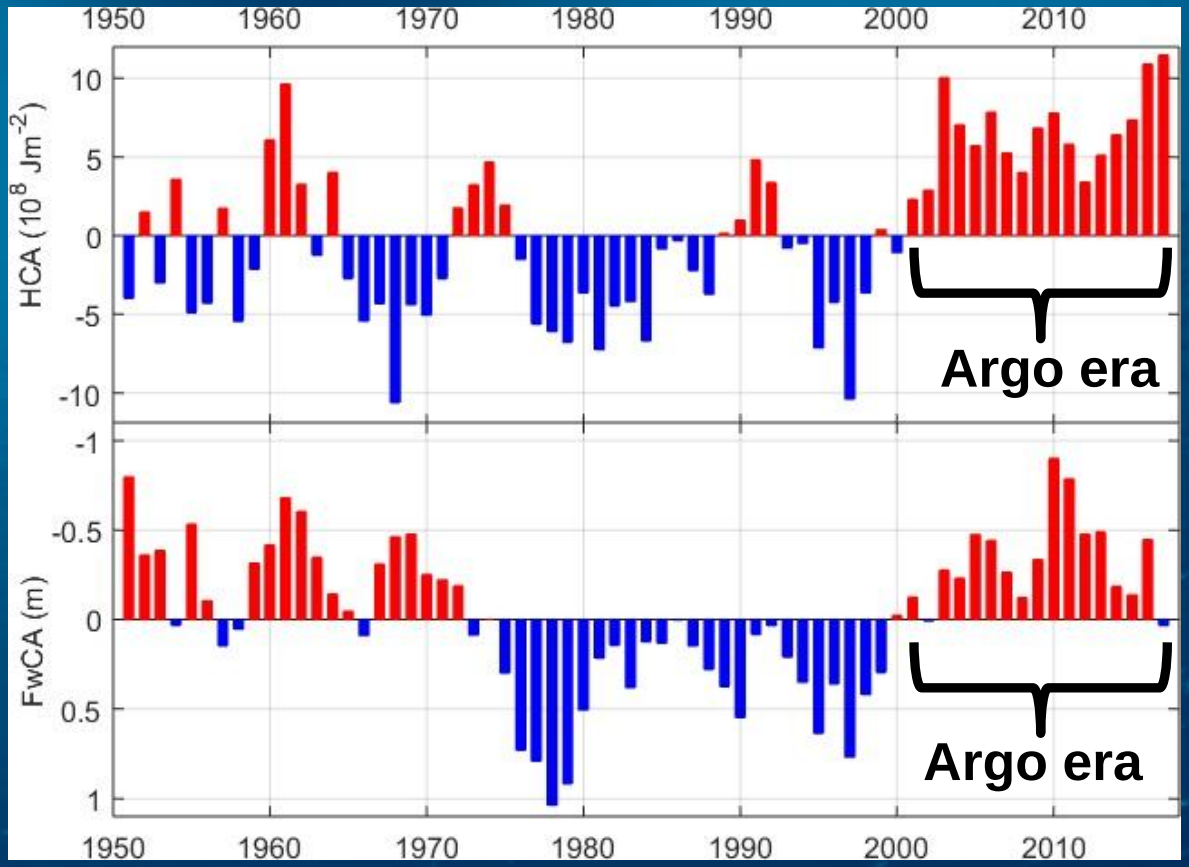
Heat content change (ΔH')
Q'=air-sea heat flux (NCEP/NCAR)

The air-sea heat fluxes explain about half of the interannual changes in heat content. **Mork et al., 2014**

The heat and freshwater content in the Norwegian Sea (covering Atlantic water)

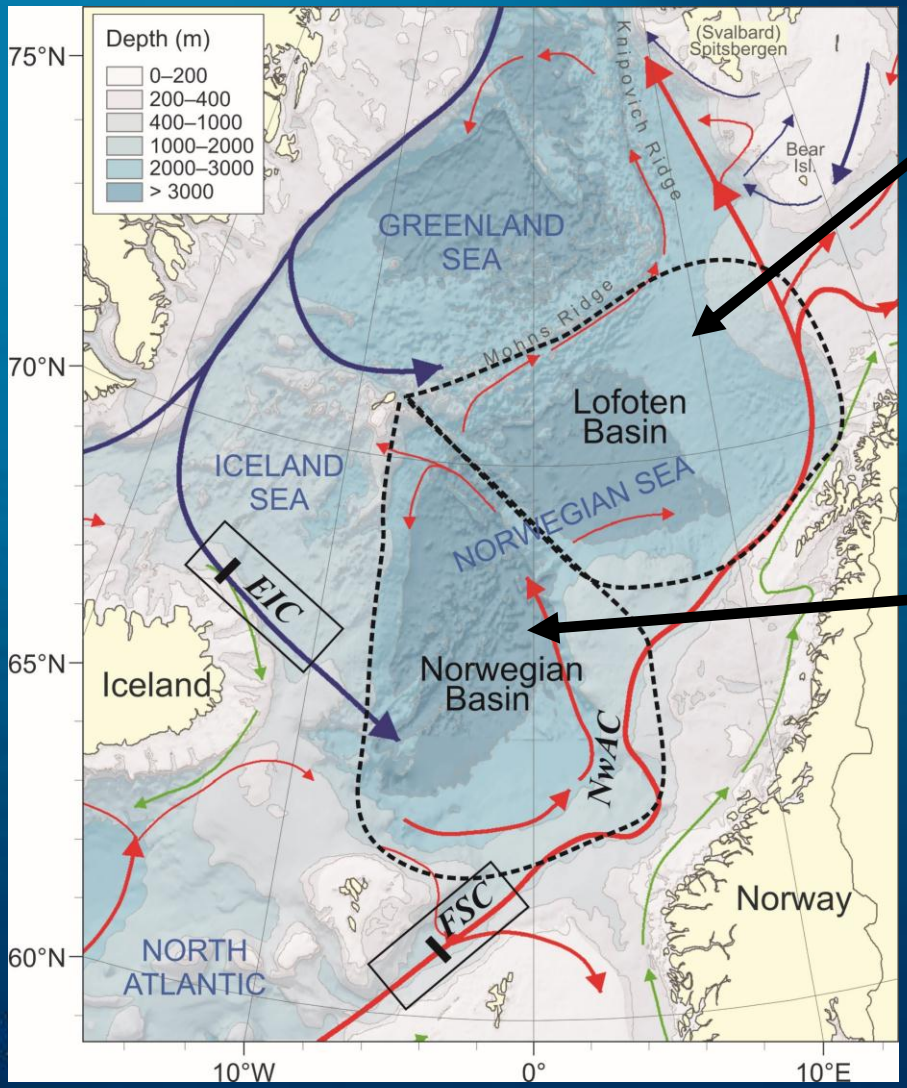


The dash line defines the averaging area



Updated from Mork et al., 2014

Norwegian Sea = two basins



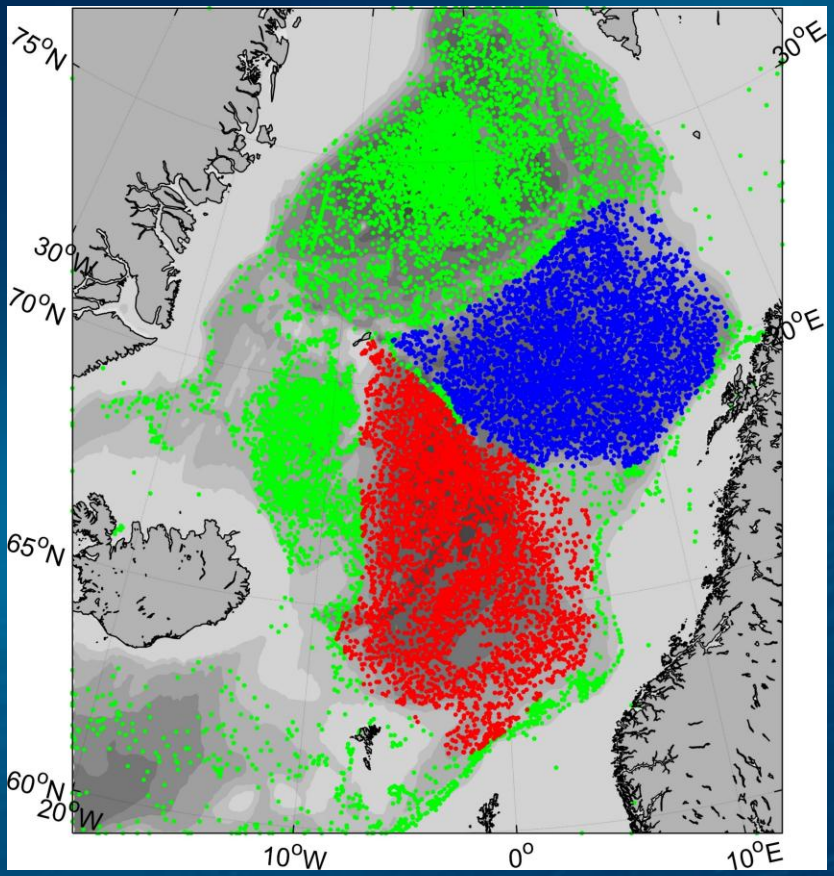
Lofoten Basin (LB):

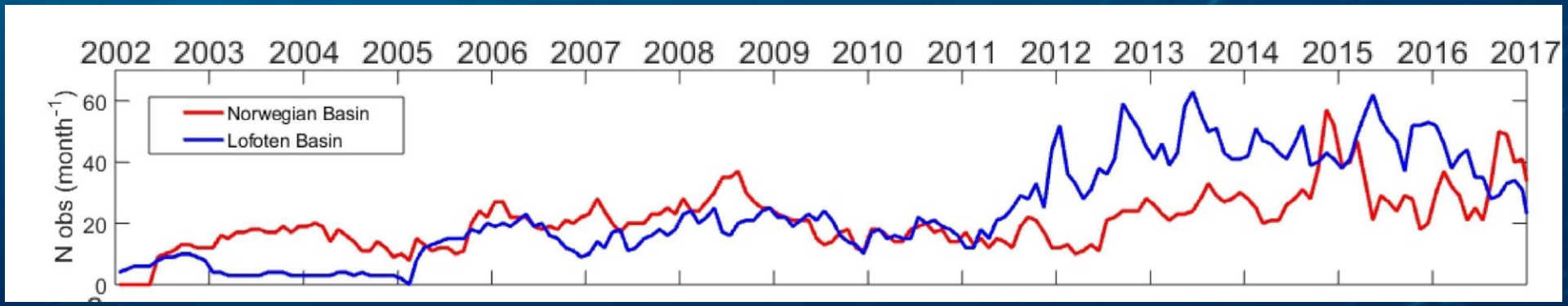
- Advection of Atlantic water
- high eddy activity
- large/deep heat reservoir (thicker Atlantic layer)

Norwegian Basin (NB):

- Advection of Atlantic water
- Advection of Arctic water (EIC)

Number of Argo profiles per month in the Norwegian and Lofoten Basin





Monthly averages of heat and fresh water content anomalies

Heat and fresh water content anomalies (HCA/FwCA) at each Argo location

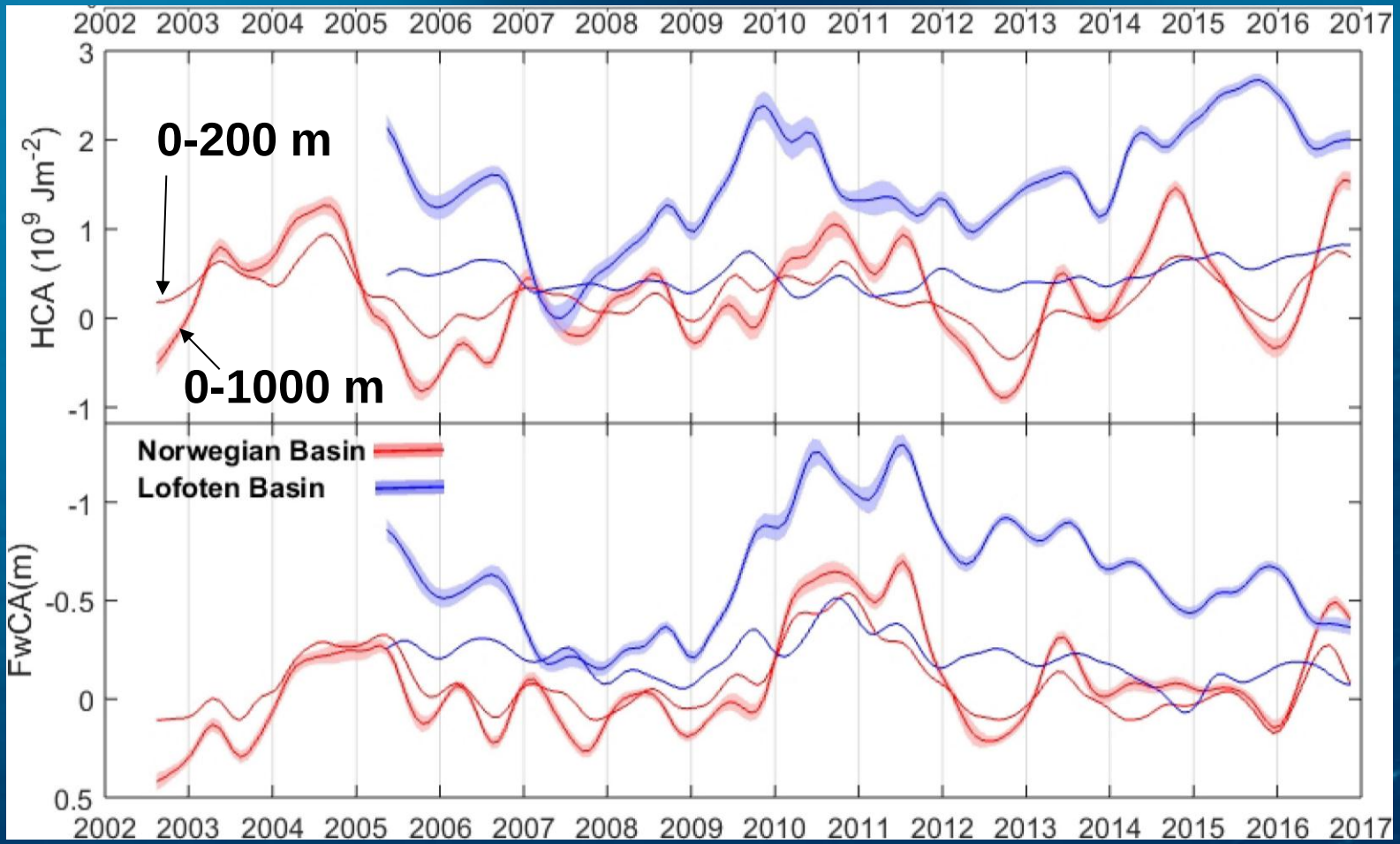
$$H' = H - H_{c\mathrm{lim}} = c_p \rho_0 \int_{-h}^{0} \left(T - T_{\mathrm{clim}}\right) \mathrm{d}z$$

$$F' = F - F_{c\mathrm{lim}} = -S_{ref}^{-1} \int_{-h}^{0} \left(S - S_{\mathrm{clim}}\right) \mathrm{d}z$$

Averaged all HCAs and FwCAs per month within each basin

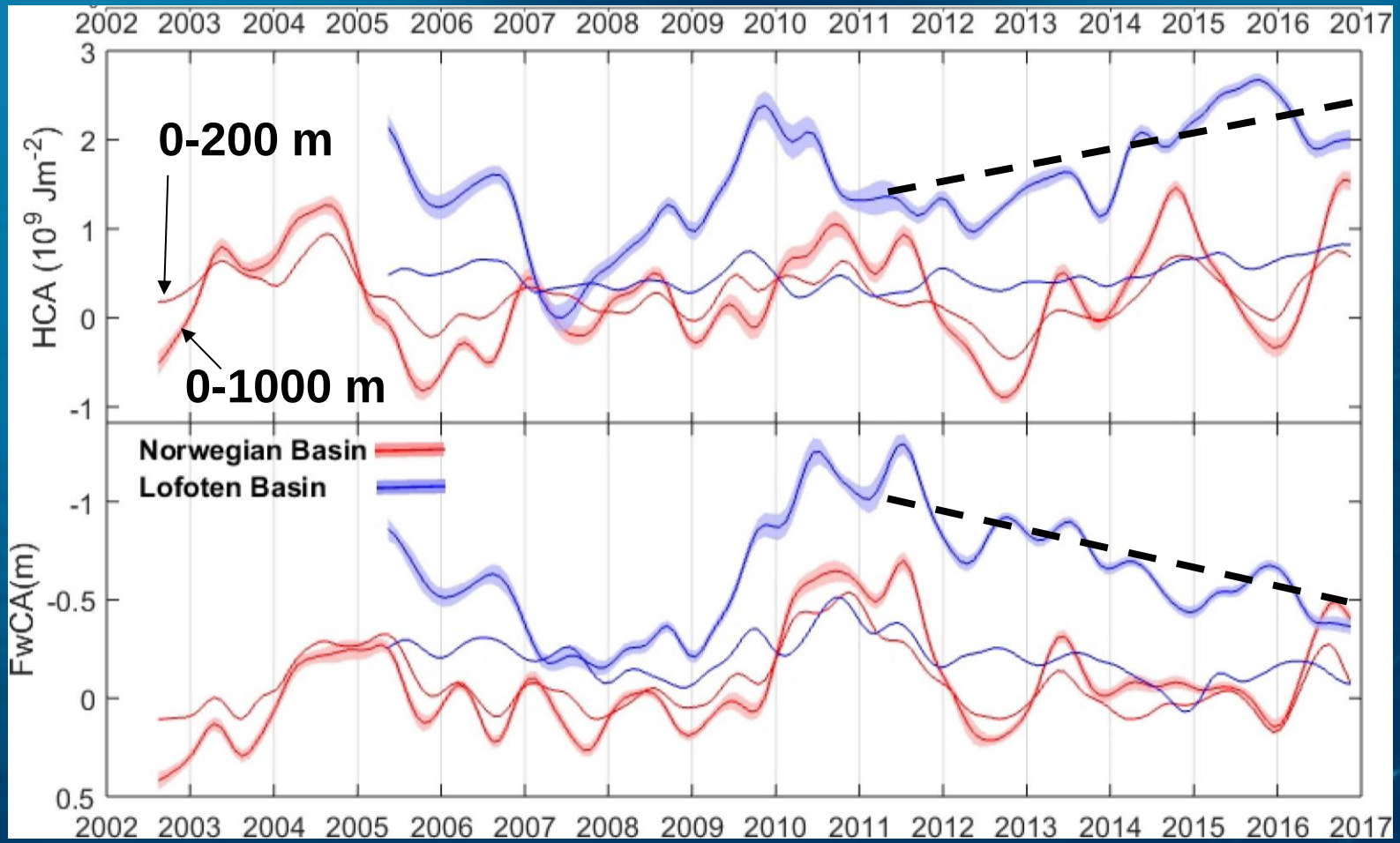
HCA and FwCA for h=200 m and h=1000m

Monthly heat and fresh water content anomalies



Data are smoothed (5 months Hanning window)

Warming and freshening 2011-2016 in the Lofoten Basin



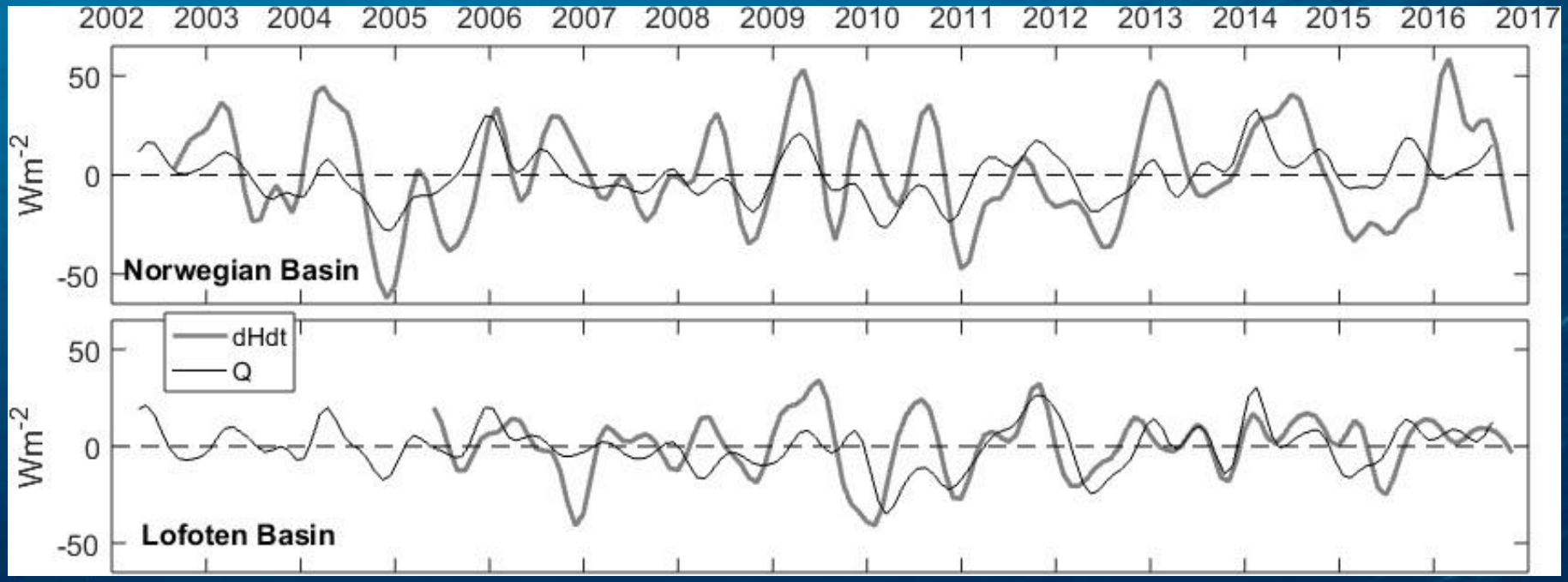
Data are smoothed (5 months Hanning window)

Heat content change and air-sea heat flux

$$\frac{\partial H}{\partial t} = Q_{net} + ADV + \ldots$$

— dHdt (0-200m)

— Q_{net} (air-sea heat flux)

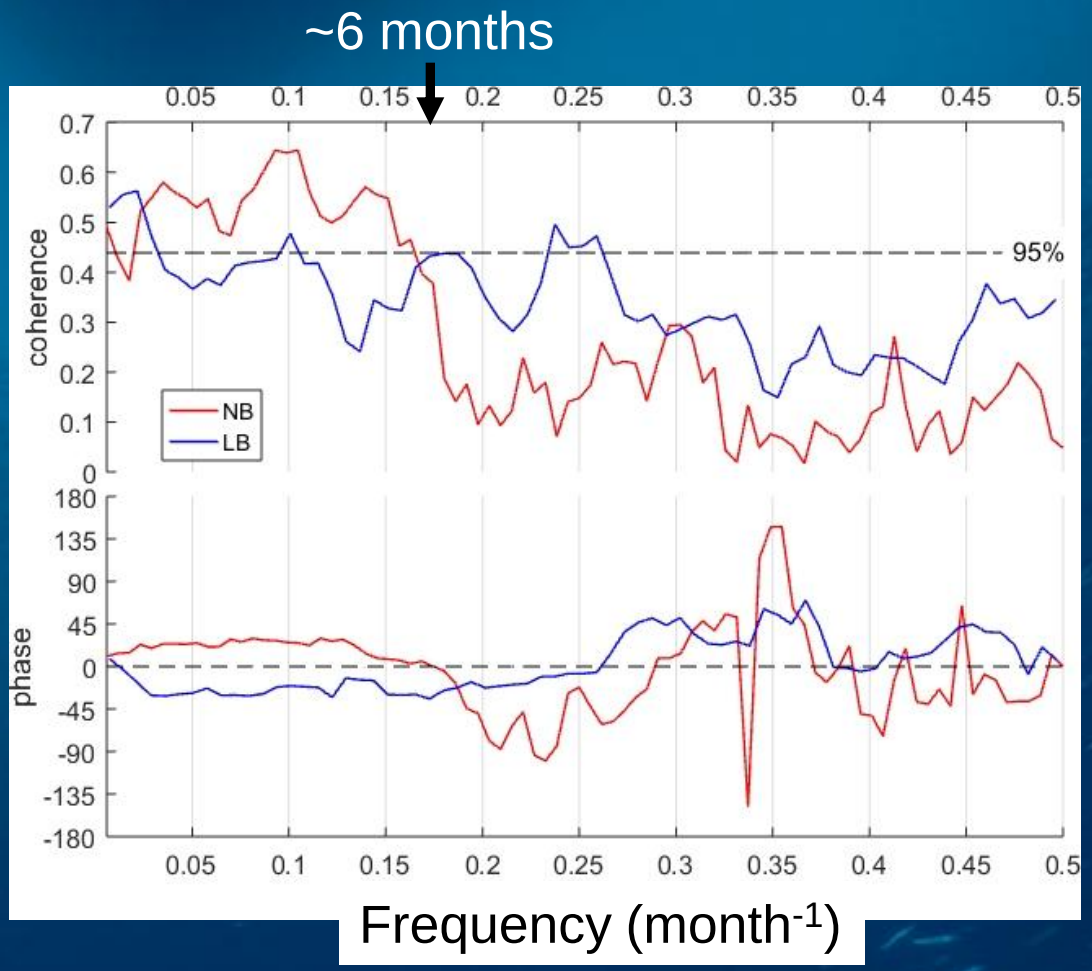


Heat content change and air-sea heat flux

Coherence analysis

between the heat content change (dHdt) in the upper 200 m and the air-sea heat flux in the Norwegian (NB) and Lofoten (LB) Basin.

Largest coherence in the NB (>0.5) for time scales of 6 months and higher (95% significant).



Residual - advective mechanisms

Argo ERA-I.

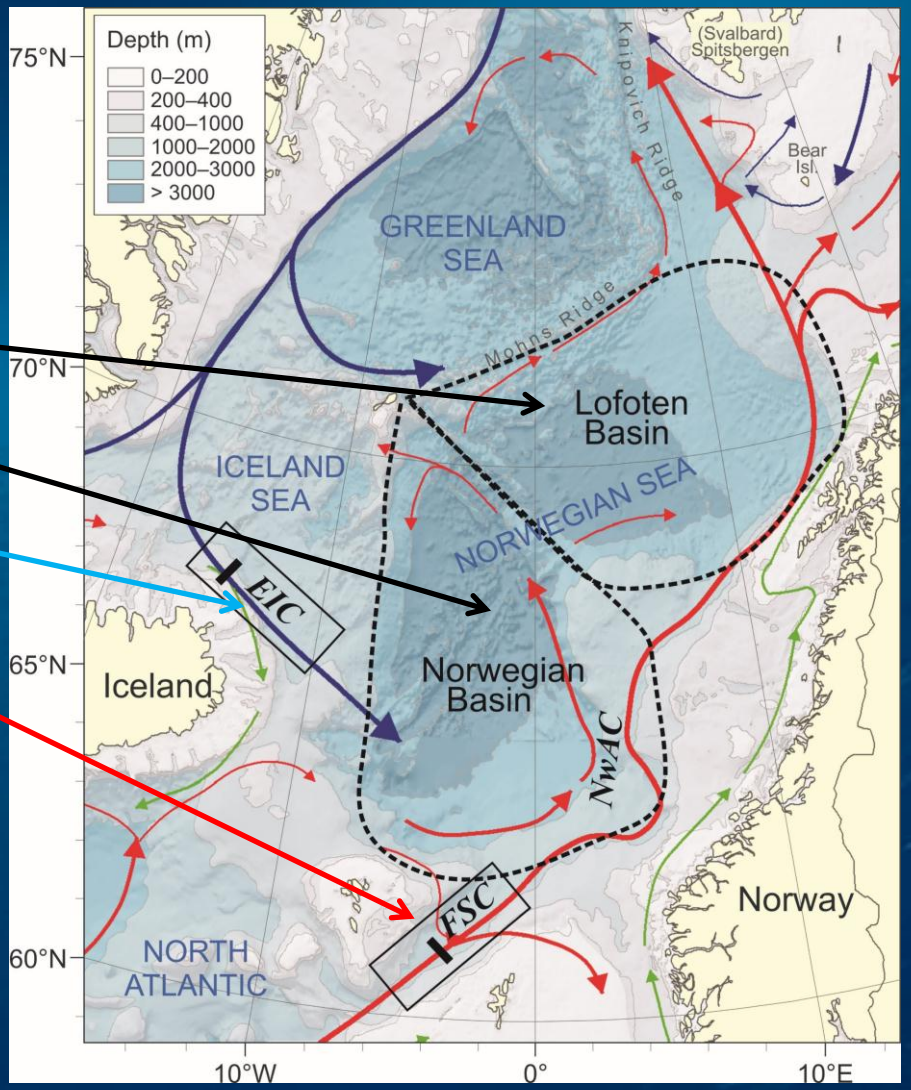
$$\frac{\partial H}{\partial t} - Q_{net} = X + \varepsilon$$

Advection

H:0-1000 m

Upstream sources:
EIC: Arctic water
FSC: Atlantic water

$$X = c_0 + c_1 W'_{EIC} + c_2 W'_{FSC} + c_3 T'_{EIC} + c_4 T'_{FS}$$



- Wind (ERA-Interim): proxy for the strength of the current (anomalies)
- Temperature time series (ICES-IROC, Hughes et al., 2011)

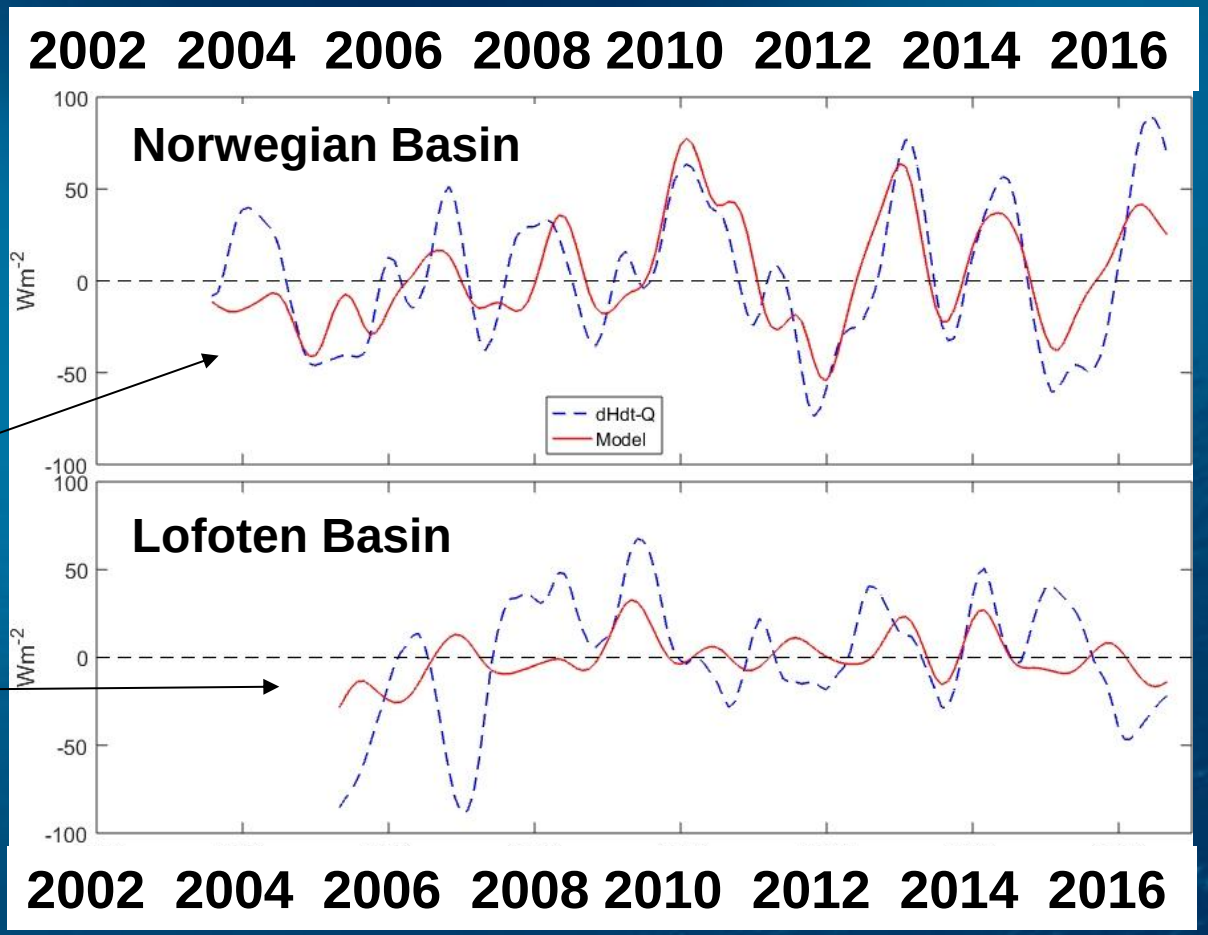
Performance of the «model»

The model (X):

$$\frac{\partial H}{\partial t} - Q_{net} = X$$

Norwegian Basin:
Good (R^2=0.58)

Lofoten Basin:
Bad (R^2=0.13)



The coeficients for wind in X are largest and most significant

	c_1 (W_{EIC})	c_2 (W_{FSC})	c_3 (T_{EIC})	c_4 (T_{FSC})
Norwegian Basin	**-0.48 ± 0.21**	**-0.52 ± 0.20**	-0.03 ± 0.19	-0.15 ± 0.21
Lofoten Basin	**-0.37 ± 0.32**	0.14 ± 0.31	-0.03 ± 0.30	0.27 ± 0.32

Conclusions

- The air-sea heat fluxes explain half of the heat content change in the Norwegian Sea for time scales >= 6 months
- Freshening and warming in the Lofoten Basin 2011-2016): less ocean heat loss to the atosphere, sea-ice melting?
- The wind forcing contributes most to the residual in the Norwegian Basin, while other processes may be more important in the Lofoten Basin (eddies, thicker Atlantic layer, etc.)

The end