iAOOS Workshop on the NwAC, Tromsø, August 31-September 2, 2009

Propagation of anomalies, AW transport and heat flux in a coherent flow in the NwAC and WSC

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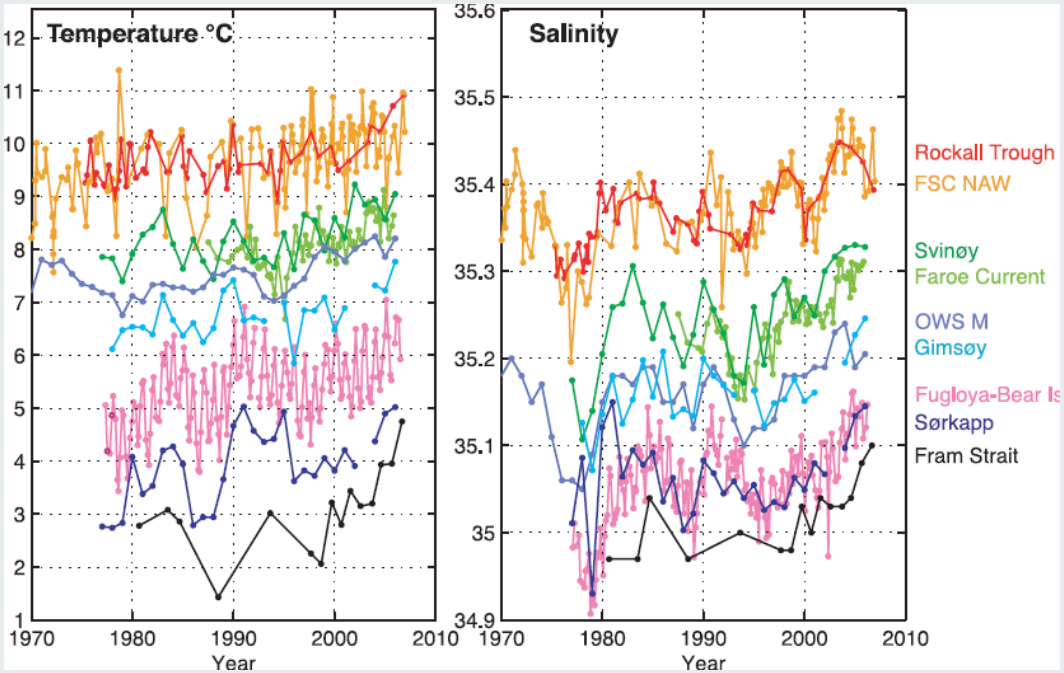
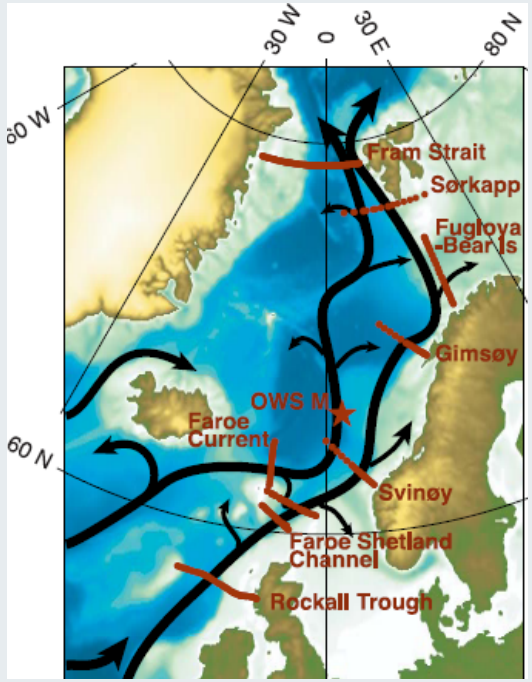
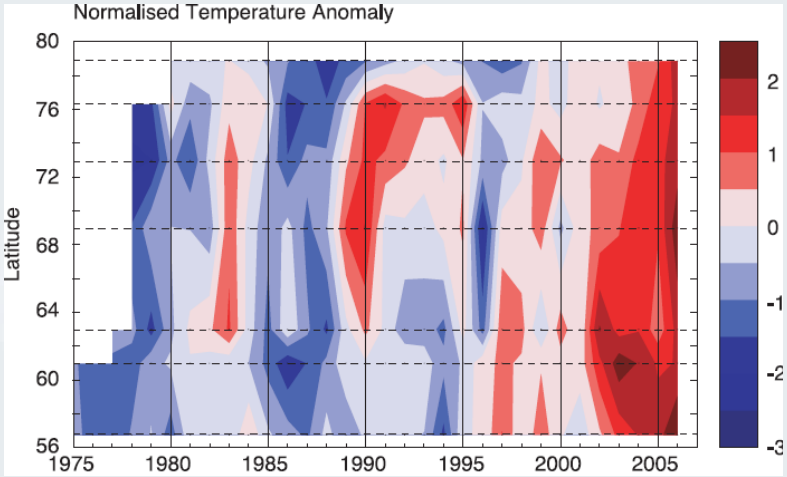
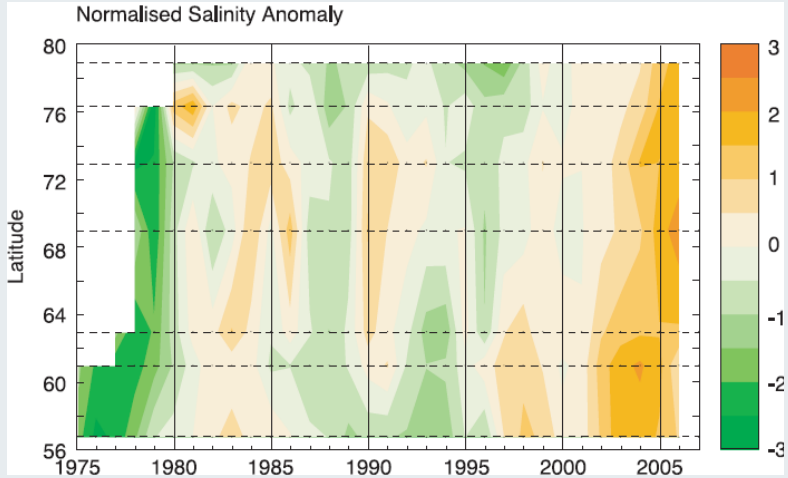
Propagation of warm anomalies from the North Atlantic



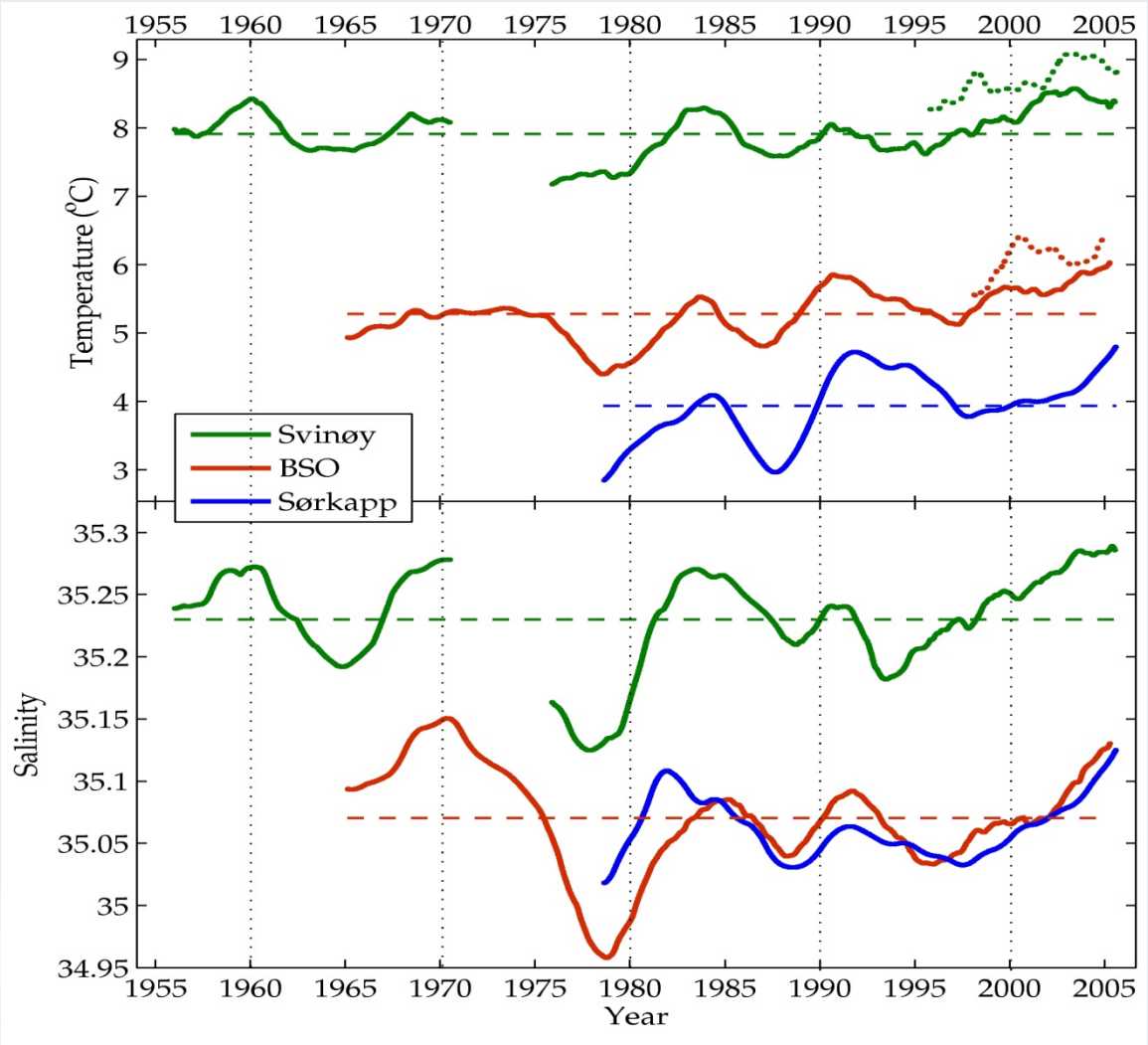


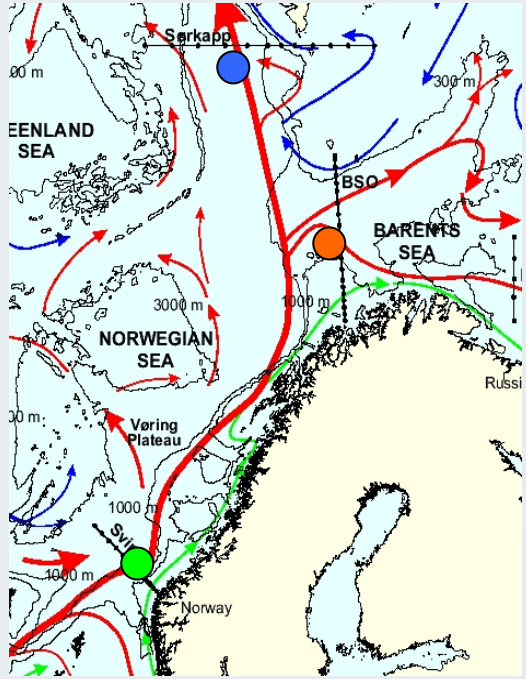
Holliday et al., GRL, 2008





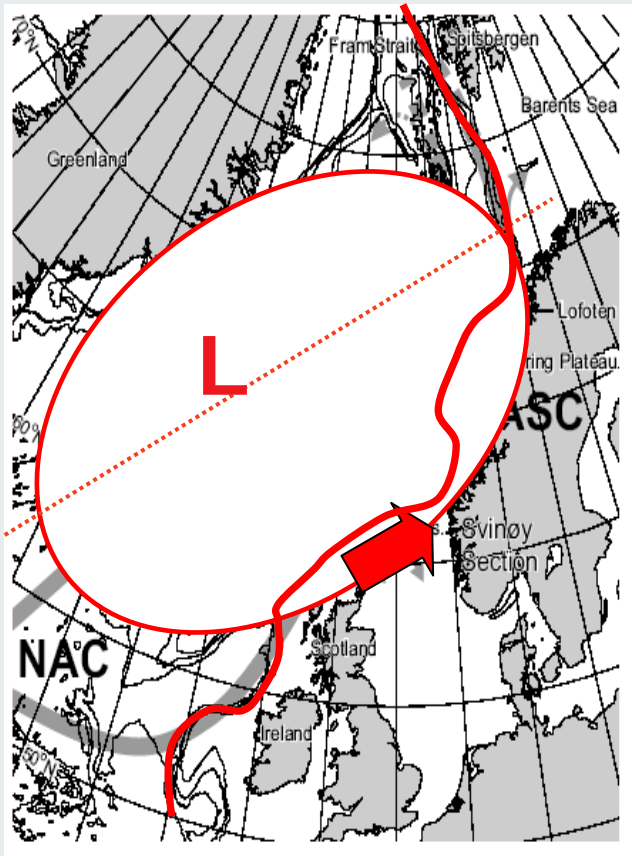
Propagation of warm anomalies in the Nordic Seas

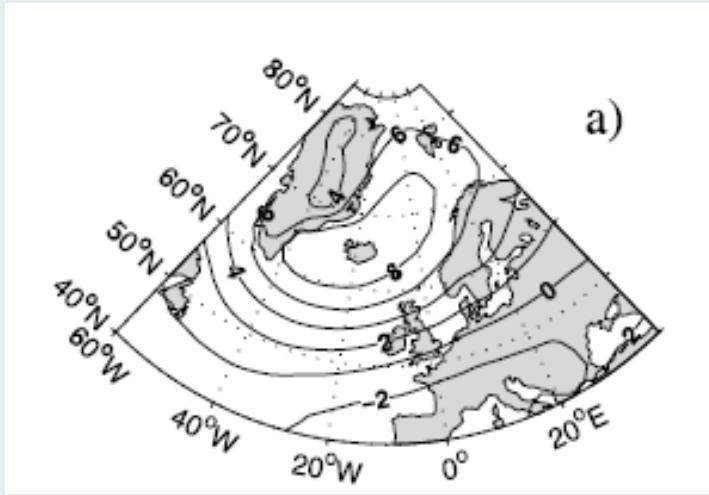




Skagseth et al. 2008

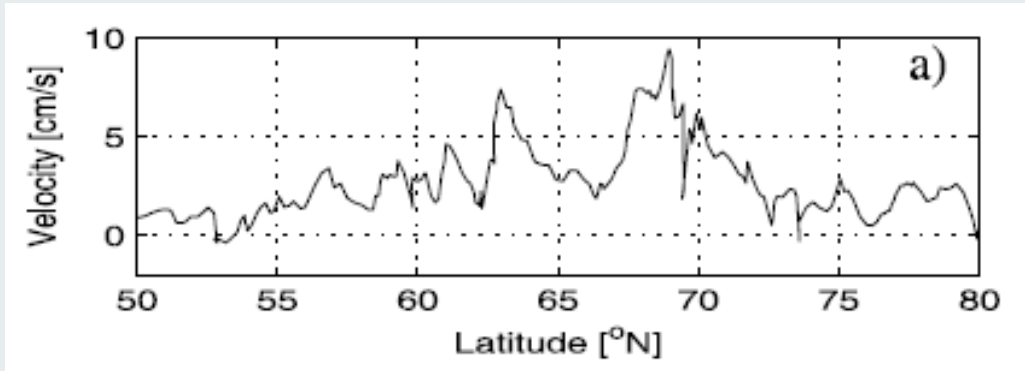
Coherent changes in the NwASC from west of Ireland to Fram Strait



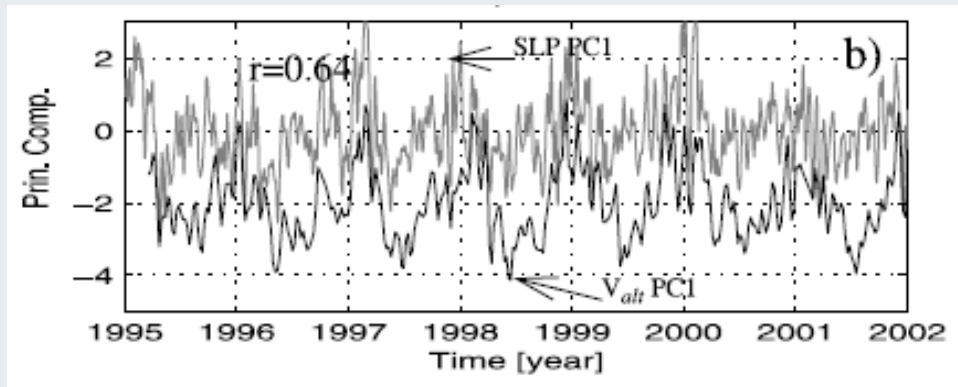


Leading EOF of SLP

Leading EOF of surface current from altimetry

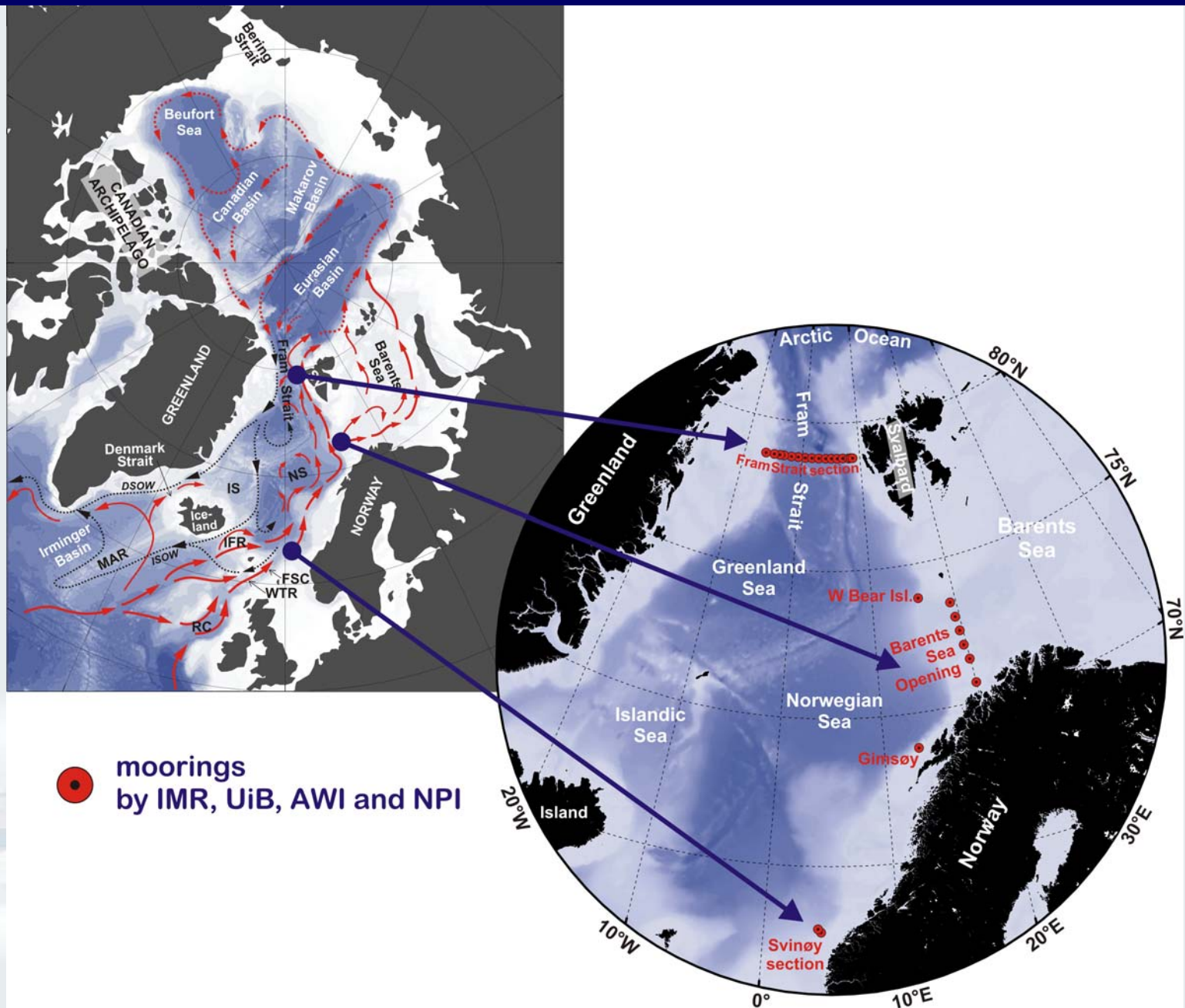


Time series of leading EOFs of SLP and surface current V_{alt}

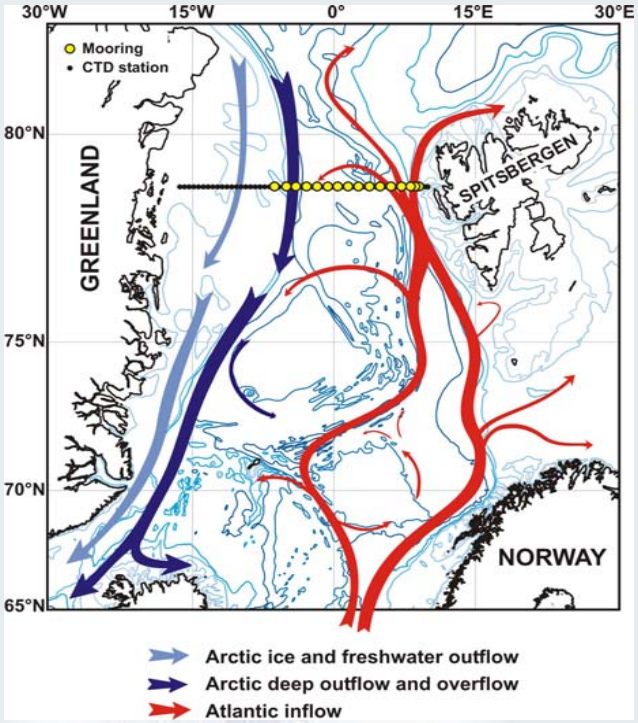


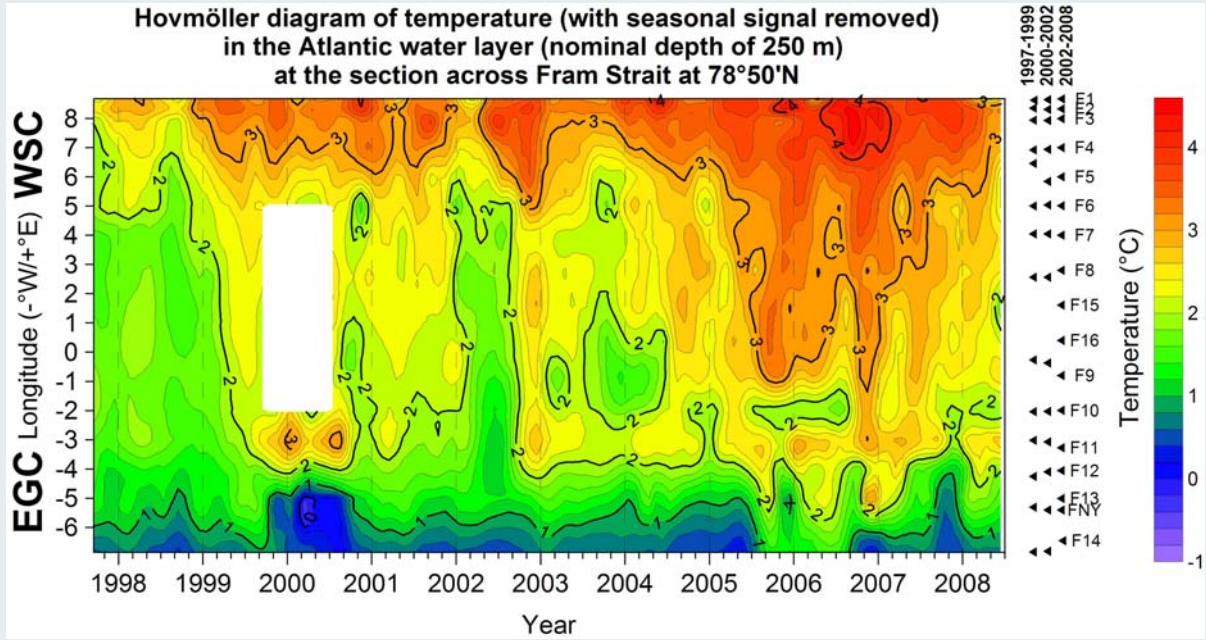
Skagseth, Orvik, Furevik, GRL 2004

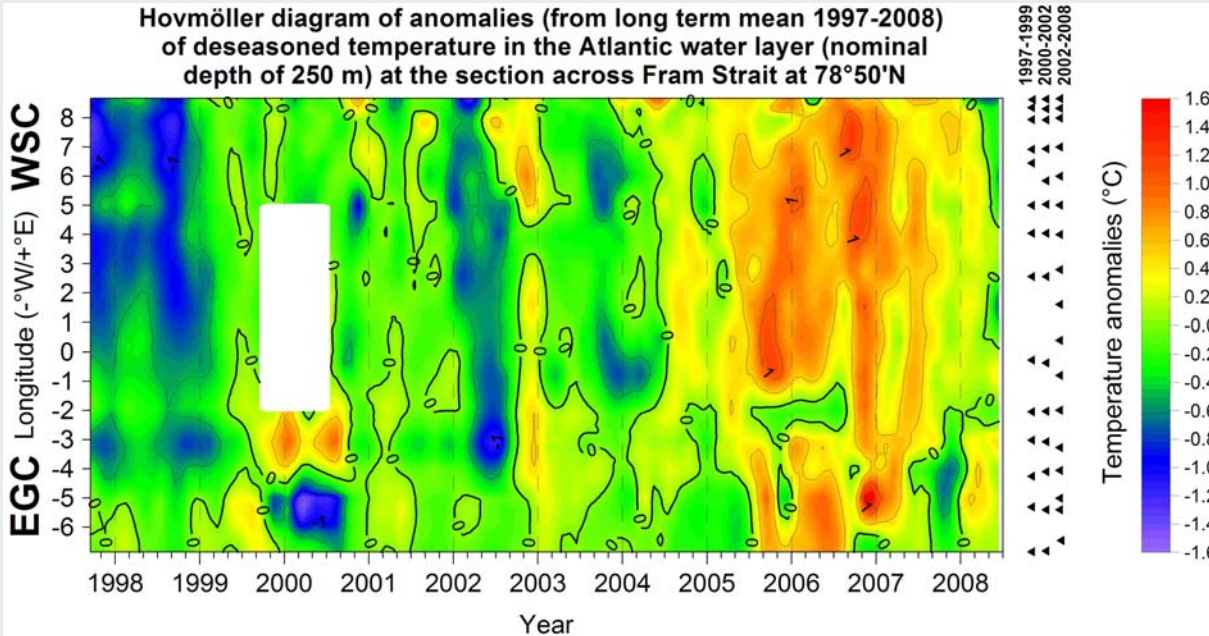
Moored arrays measuring AW inflow to the Arctic Ocean: Svinøy section, BSO and Fram Strait



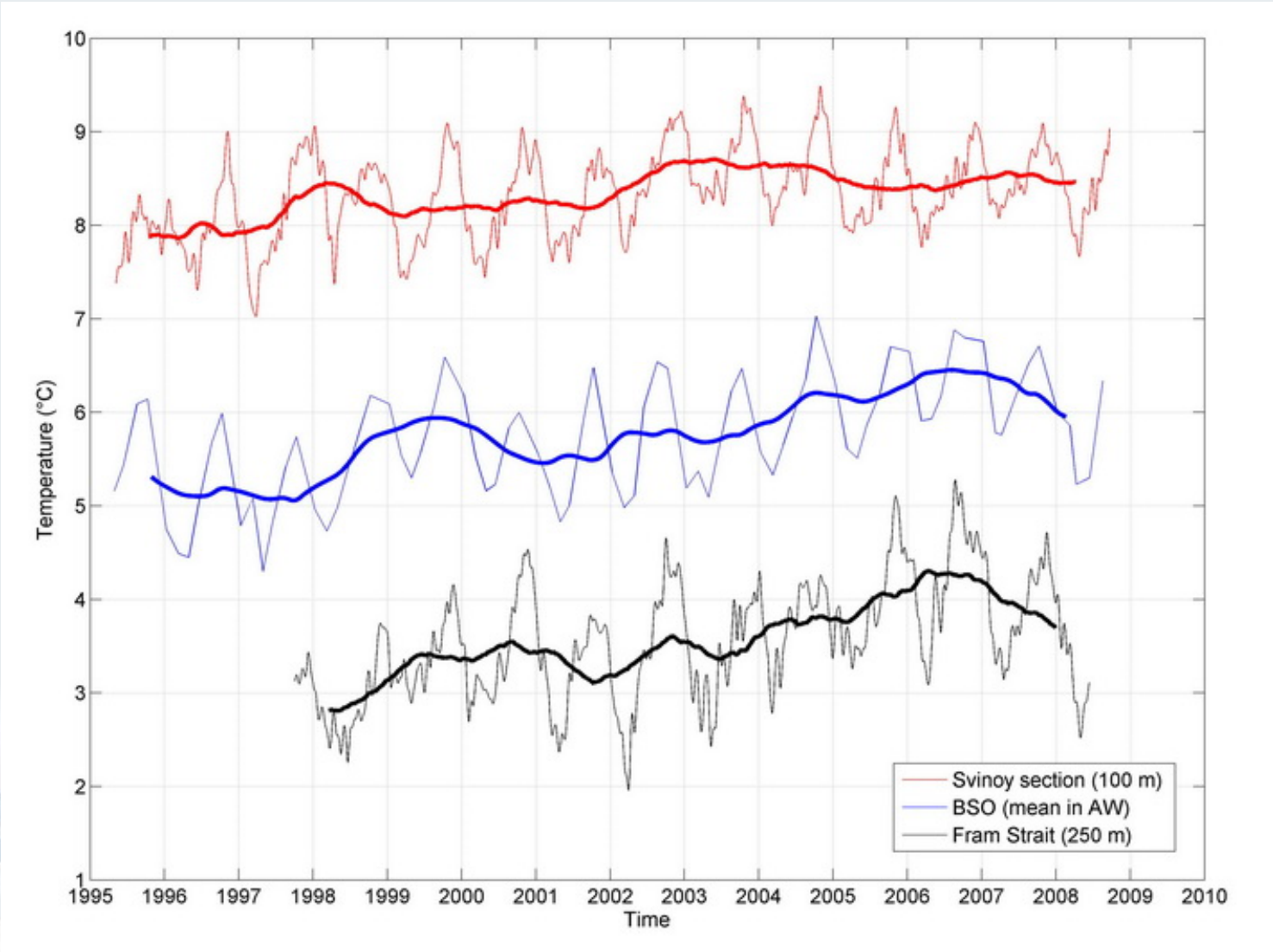
AW temperature and temperature anomalies observed in Fram Strait



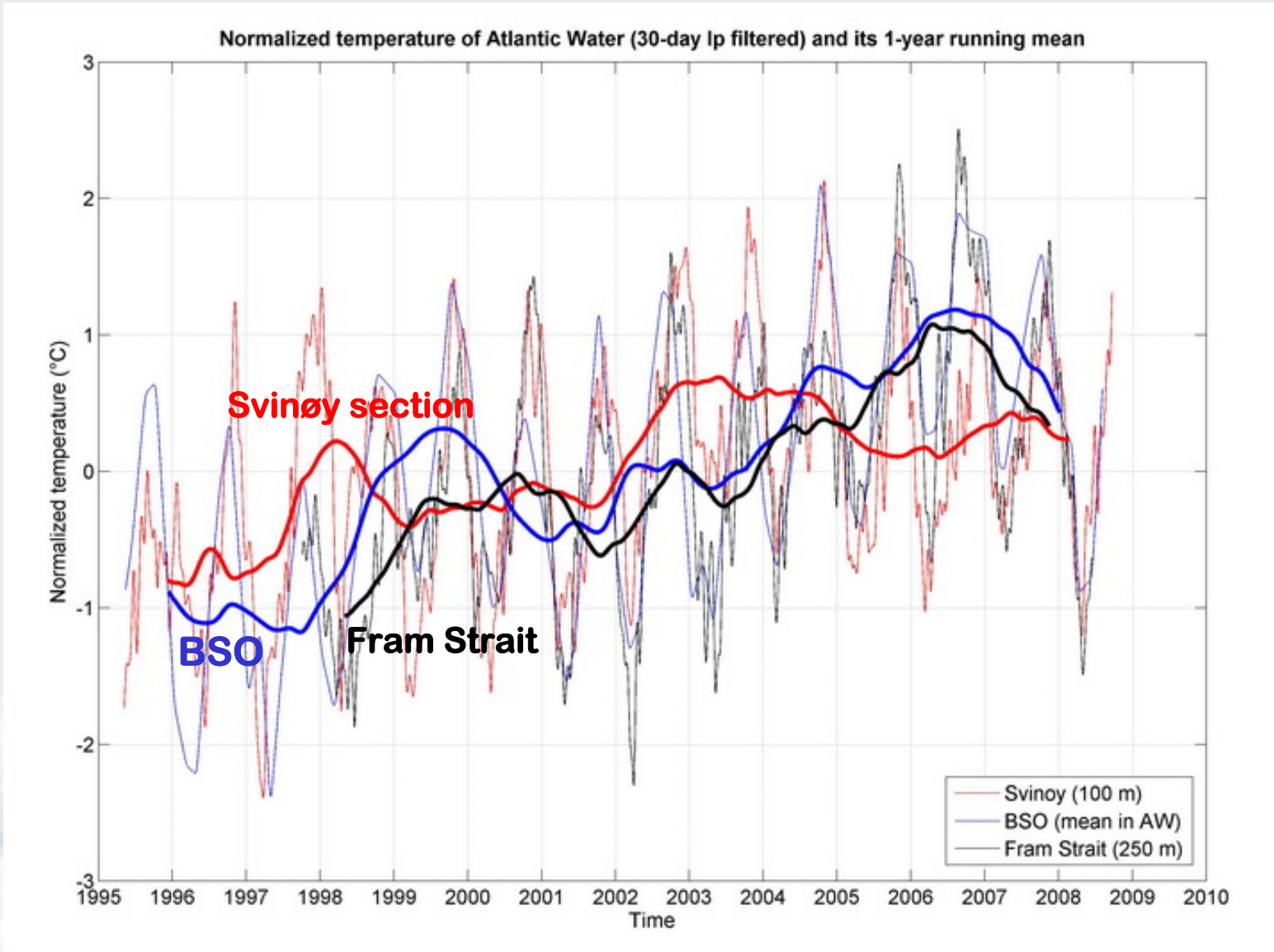




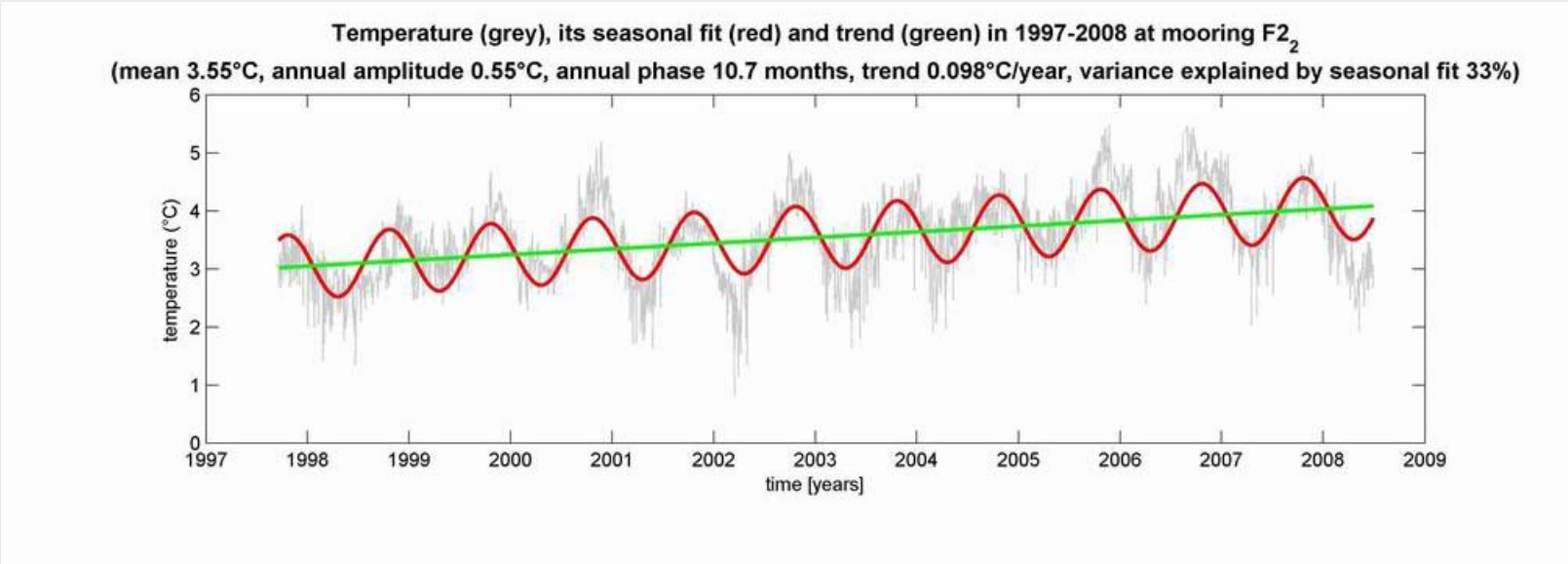
AW temperature observed at moored arrays: Svinøy section, BSO and Fram Strait

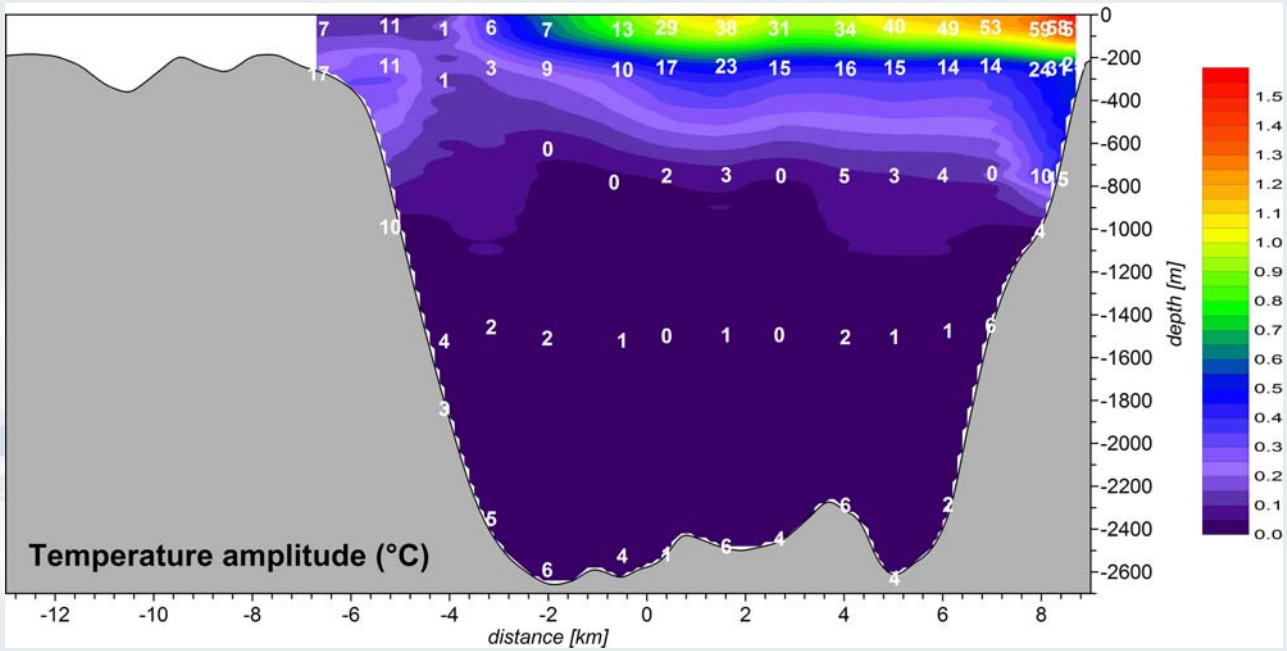


Standarized temperature of AW observed at moored arrays: Svinøy section, BSO and Fram Strait

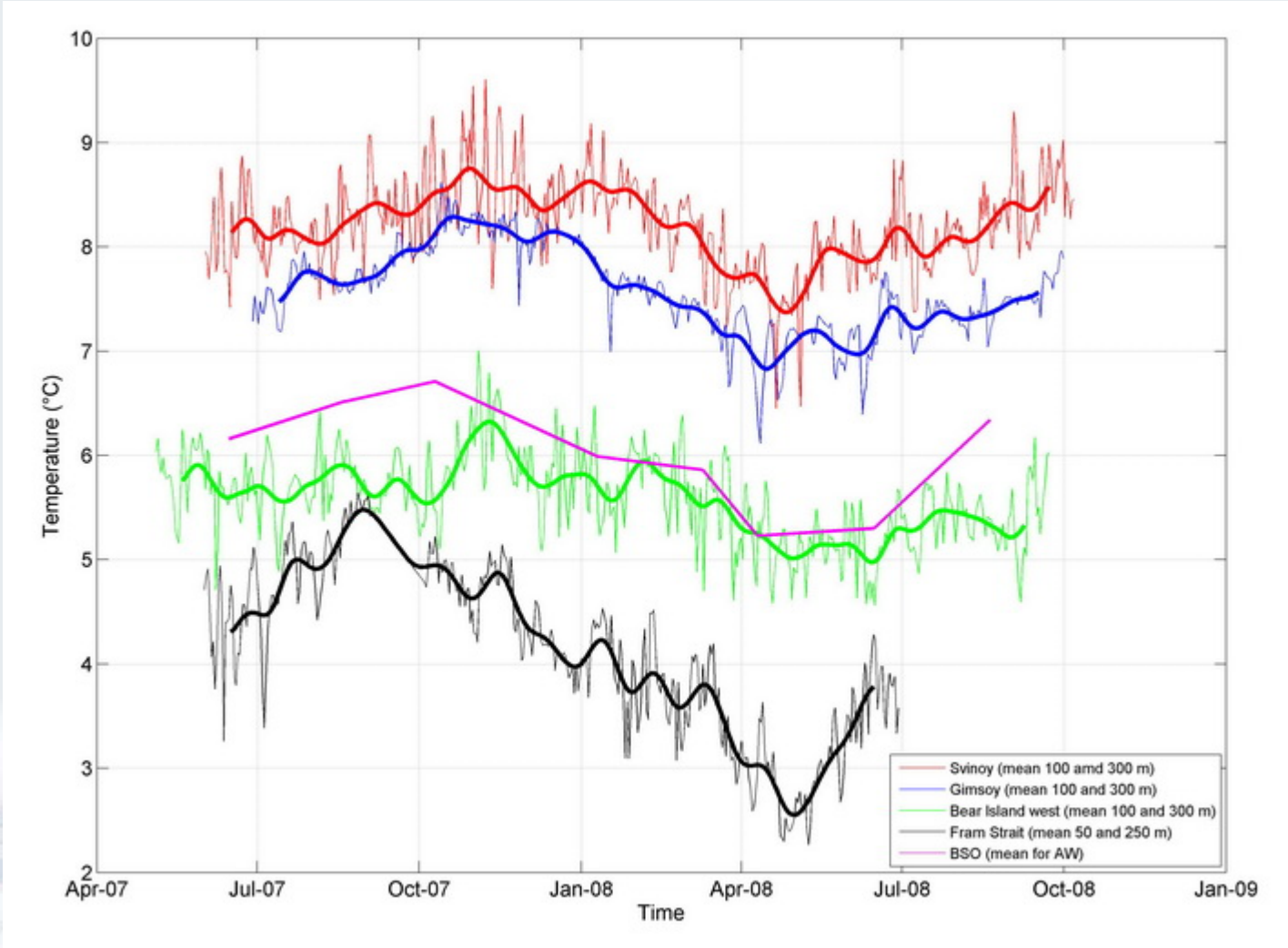


Seasonal signal in AW temperature observed in Fram Strait

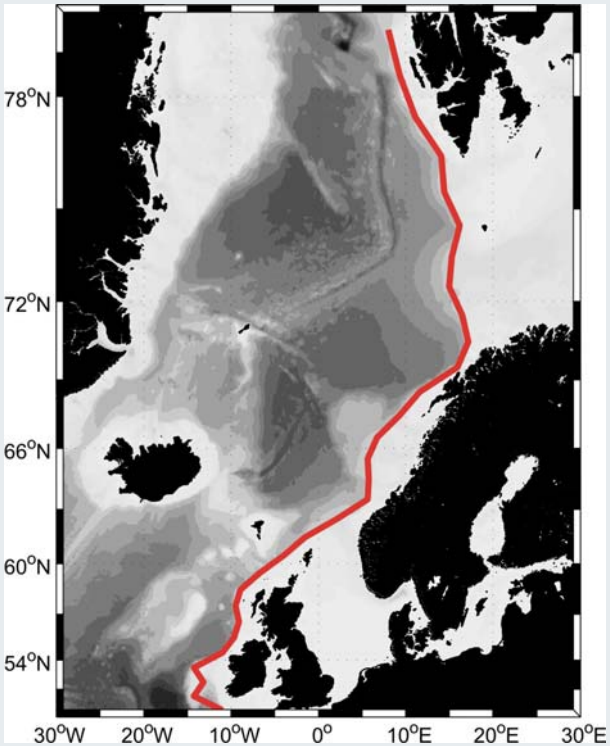


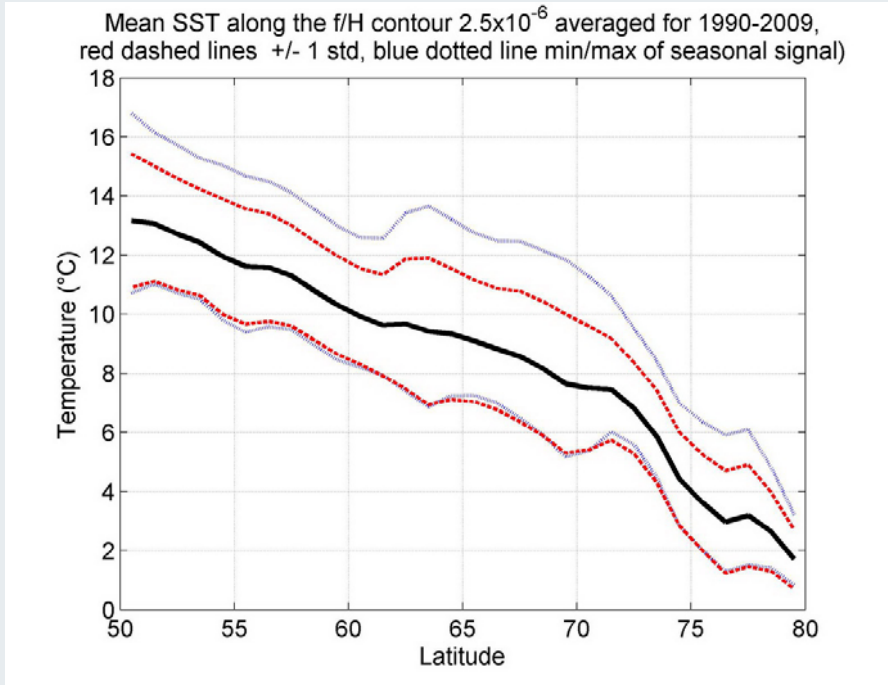


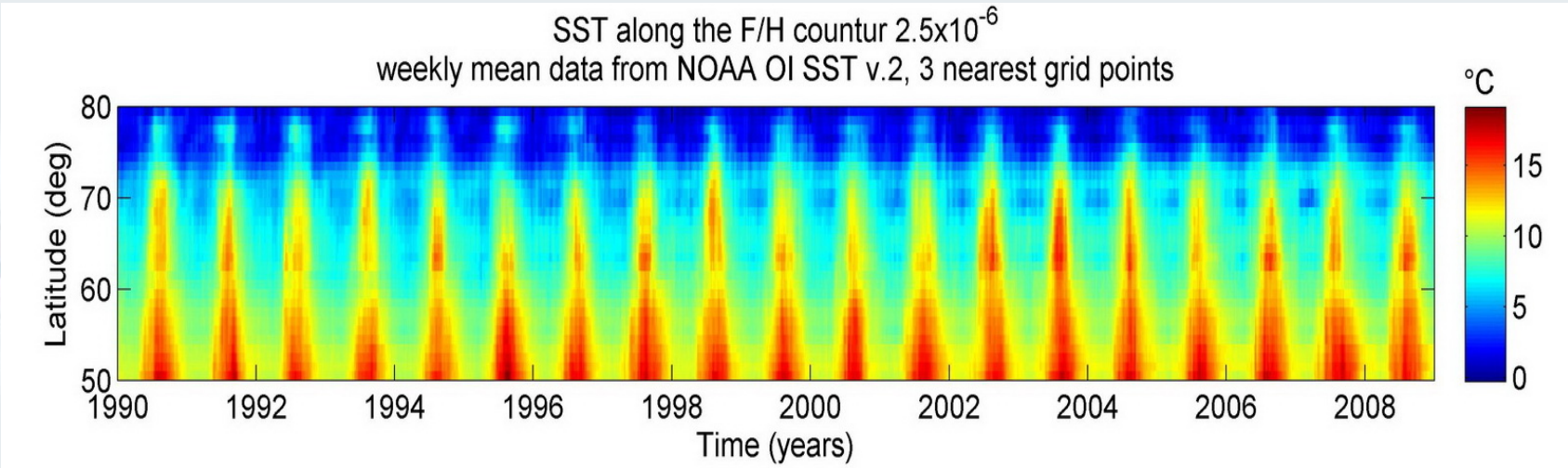
1-year long time series of AW temperature at 5 moorings: Svinøy, Gimsøy, BSO, west of Bear Island, Fram Strait



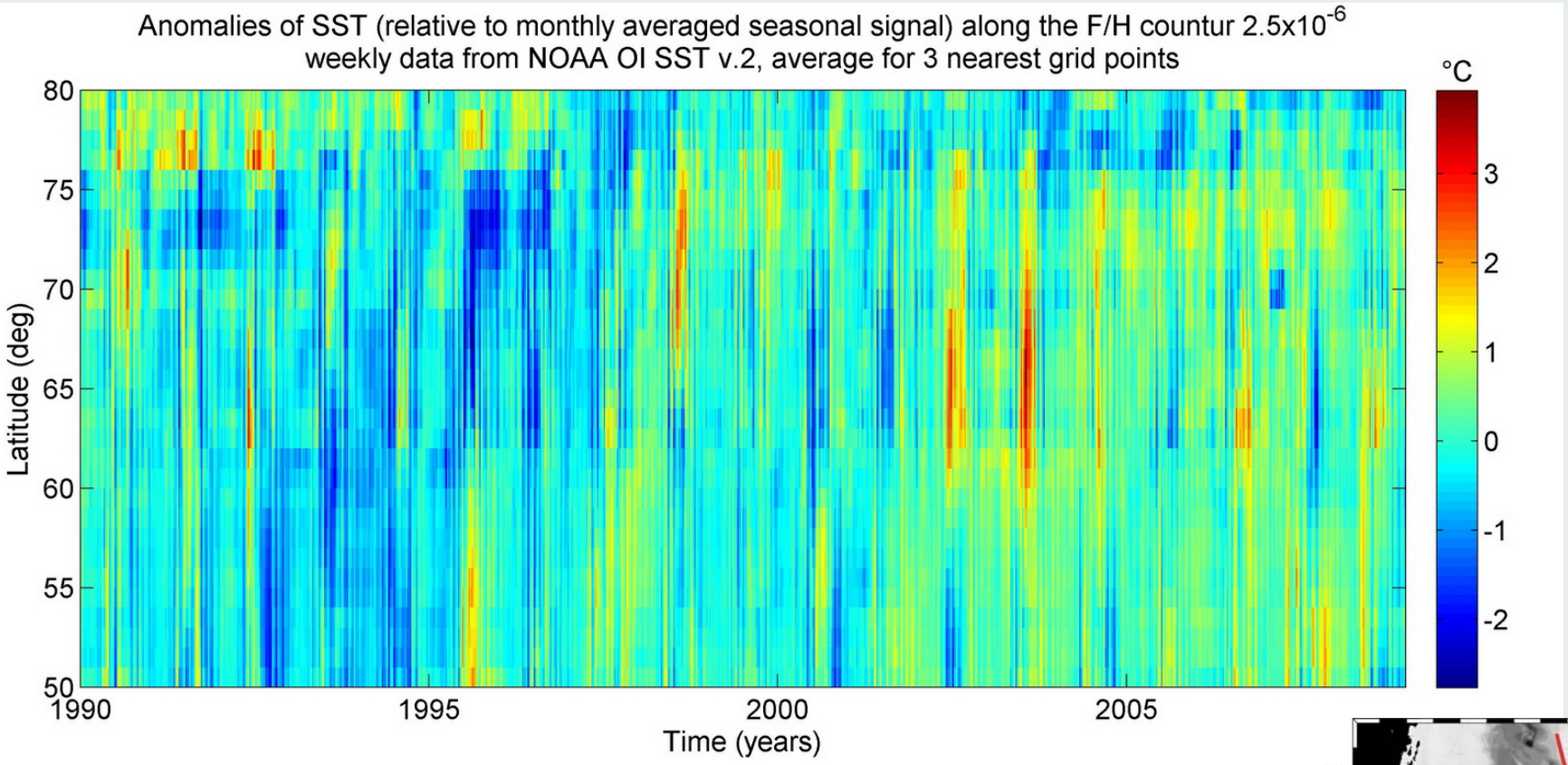
Sea surface temperature along f/H contour respresenting the shelf break



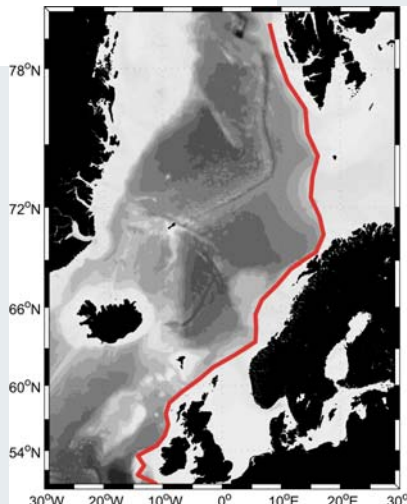




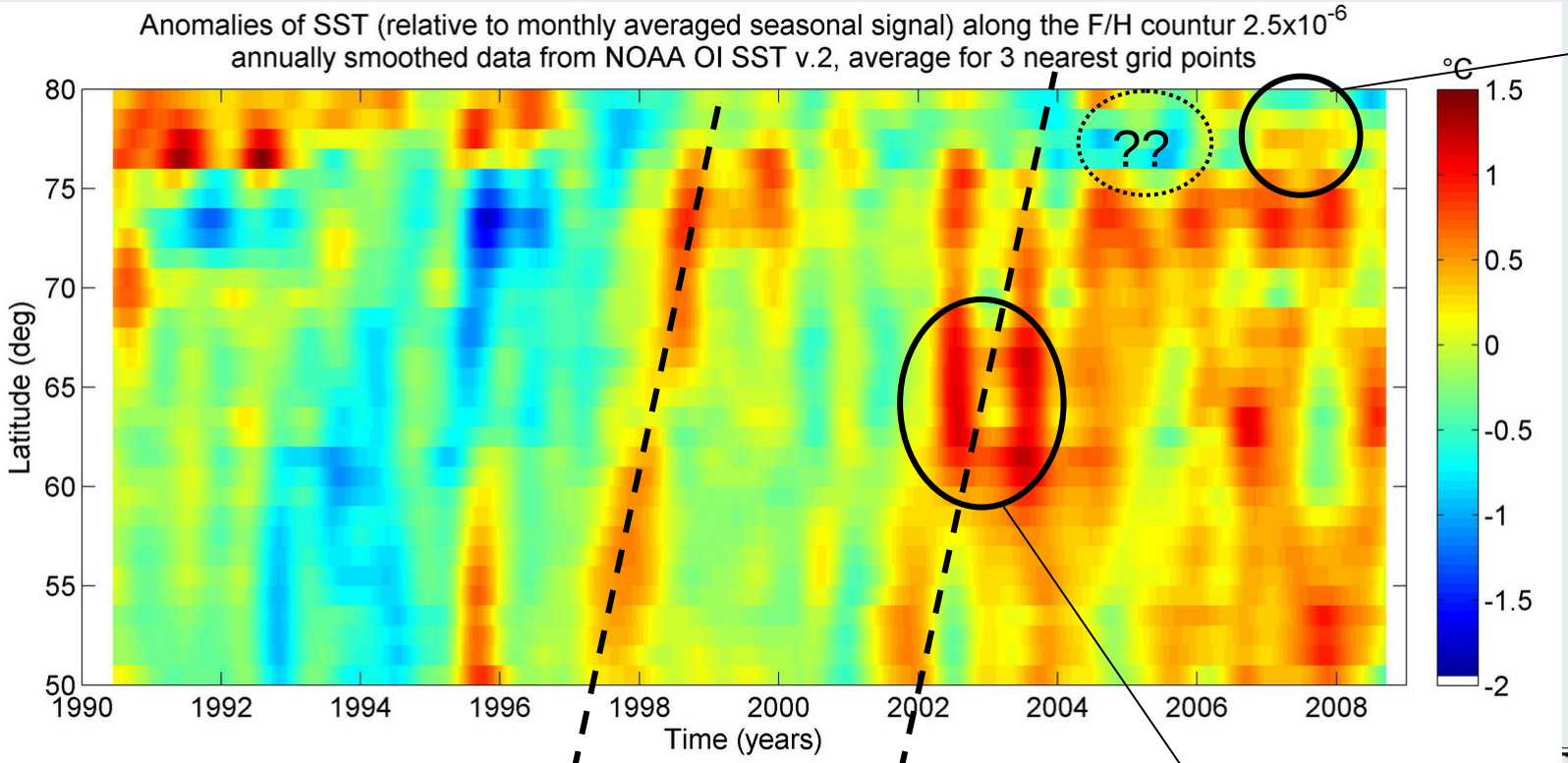
Anomalies of SST along f/H contour respresenting the shelf break



Mean seasonal signal (monthly mean seasonal values) and mean removed.
Strong anomalies exceeding 3°C are visible, propagating toward higher latitudes.
Weekly values are noisy, but they give an impression about magnitude of anomalies.



Anomalies of SST on interannual scale along f/H contour respresenting the shelf break

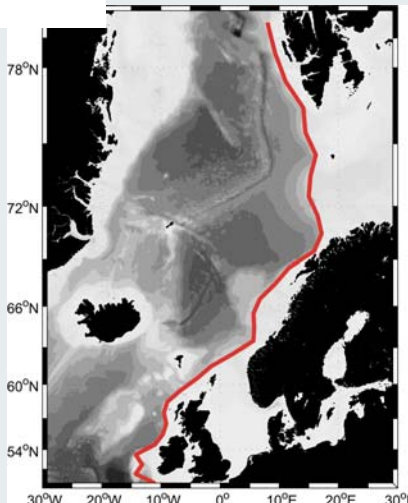


peak of AW temperature observed at FS moorings

1st warm event

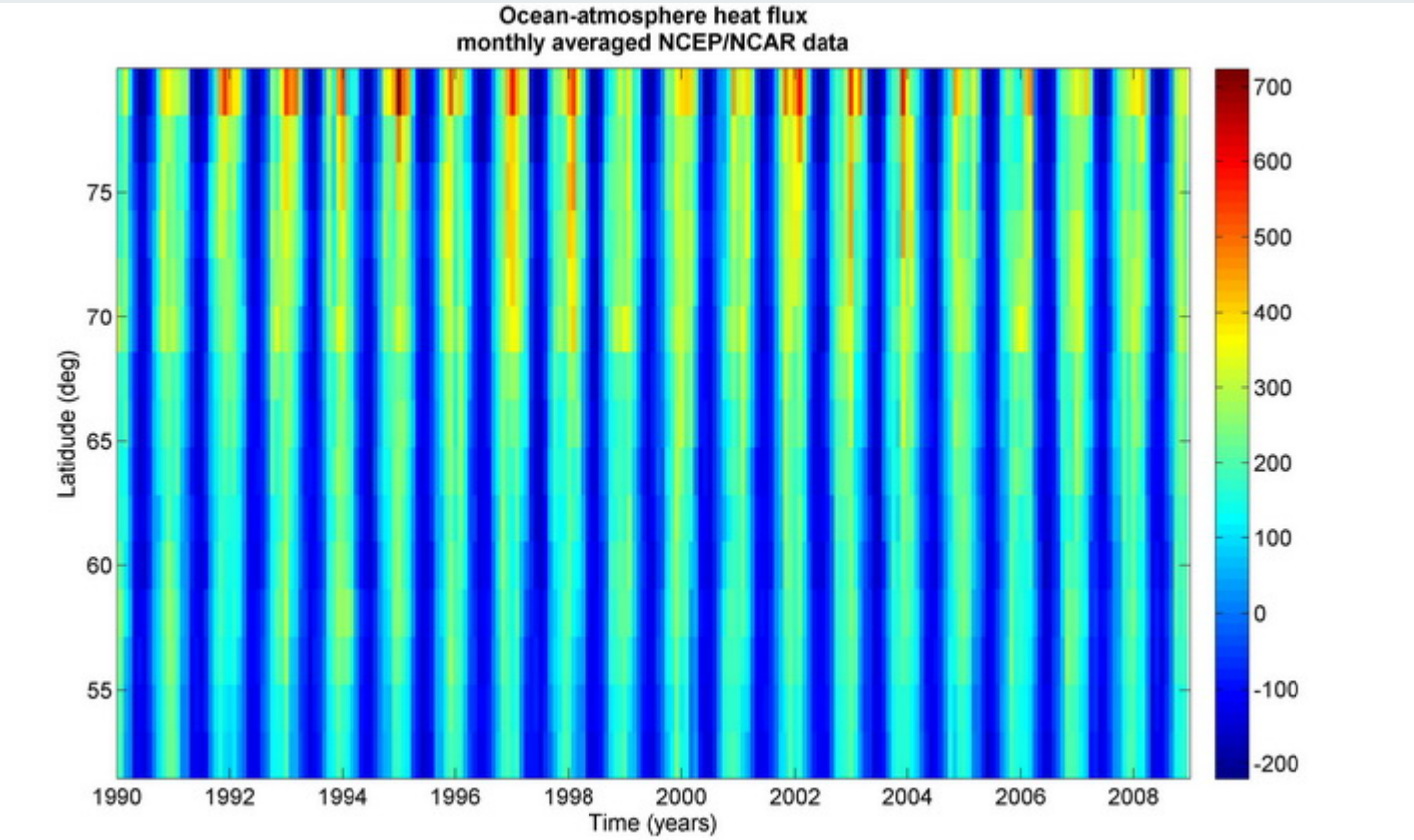
2nd warm event

anomaly observed at Svinoy in AW temperature

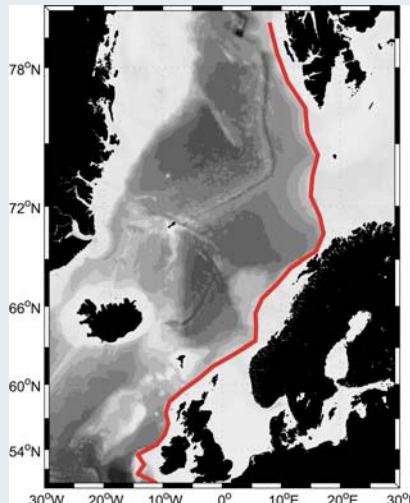


Early 90s warming outstanding but present only far north.
Strongest anomaly at the latidude of Svinoy section and around 2002-2004.
In annually smoothed data anomalies are damped but propagation and time shifts between different latitudes are better visible.

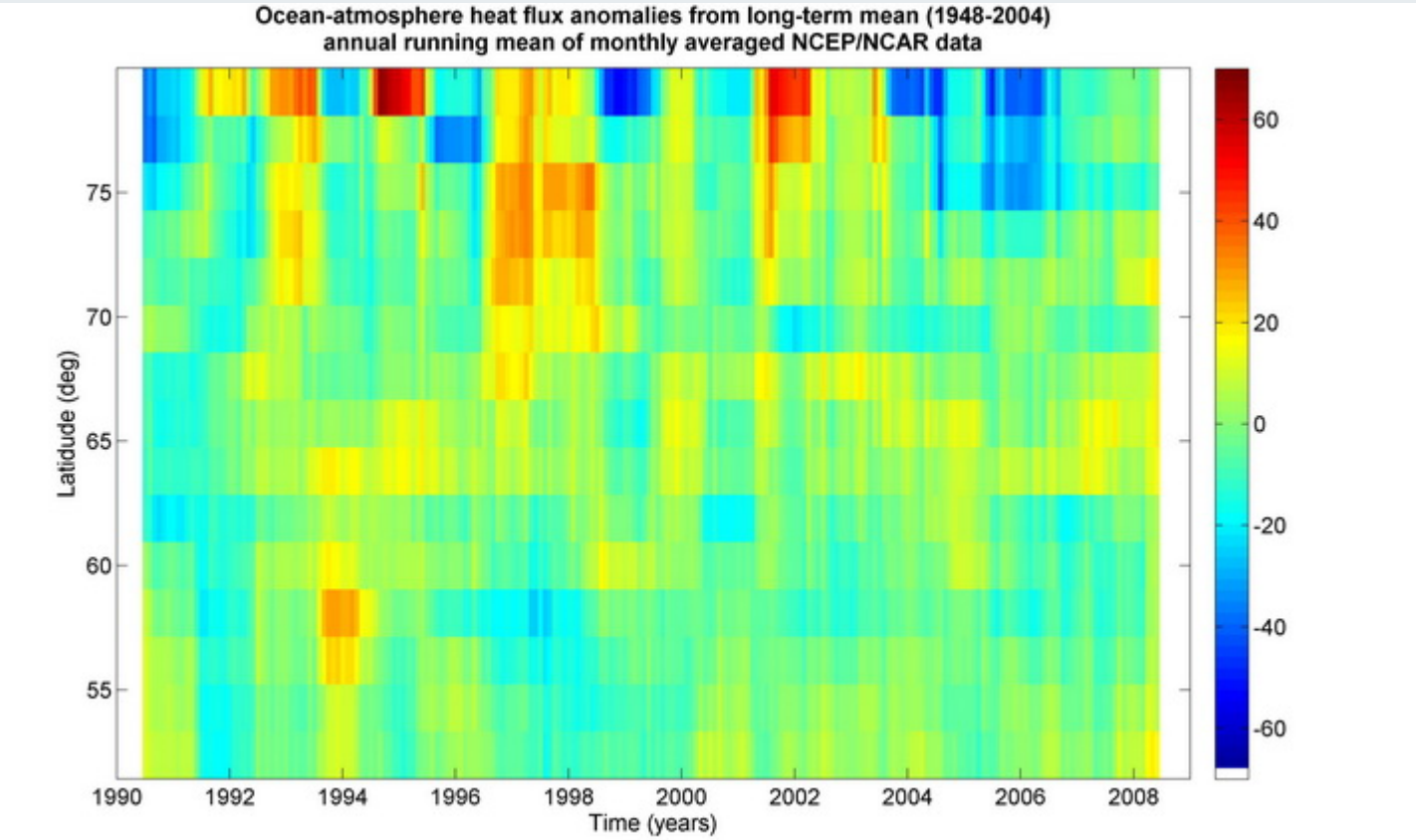
Ocean-atmosphere net heat flux from NCEP/NCAR data along f/H contour respresenting the shelf break



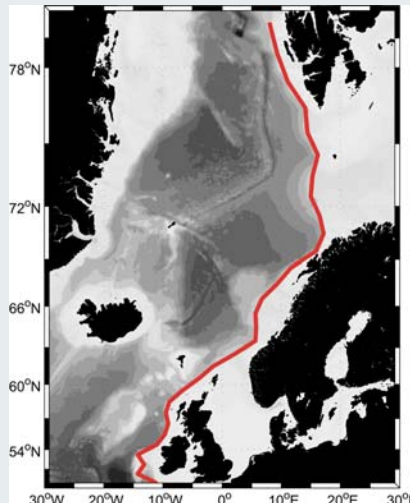
Seasonal signal dominates, stronger towards higher latitudes.
Larger meridional differences with positive fluxes in winter



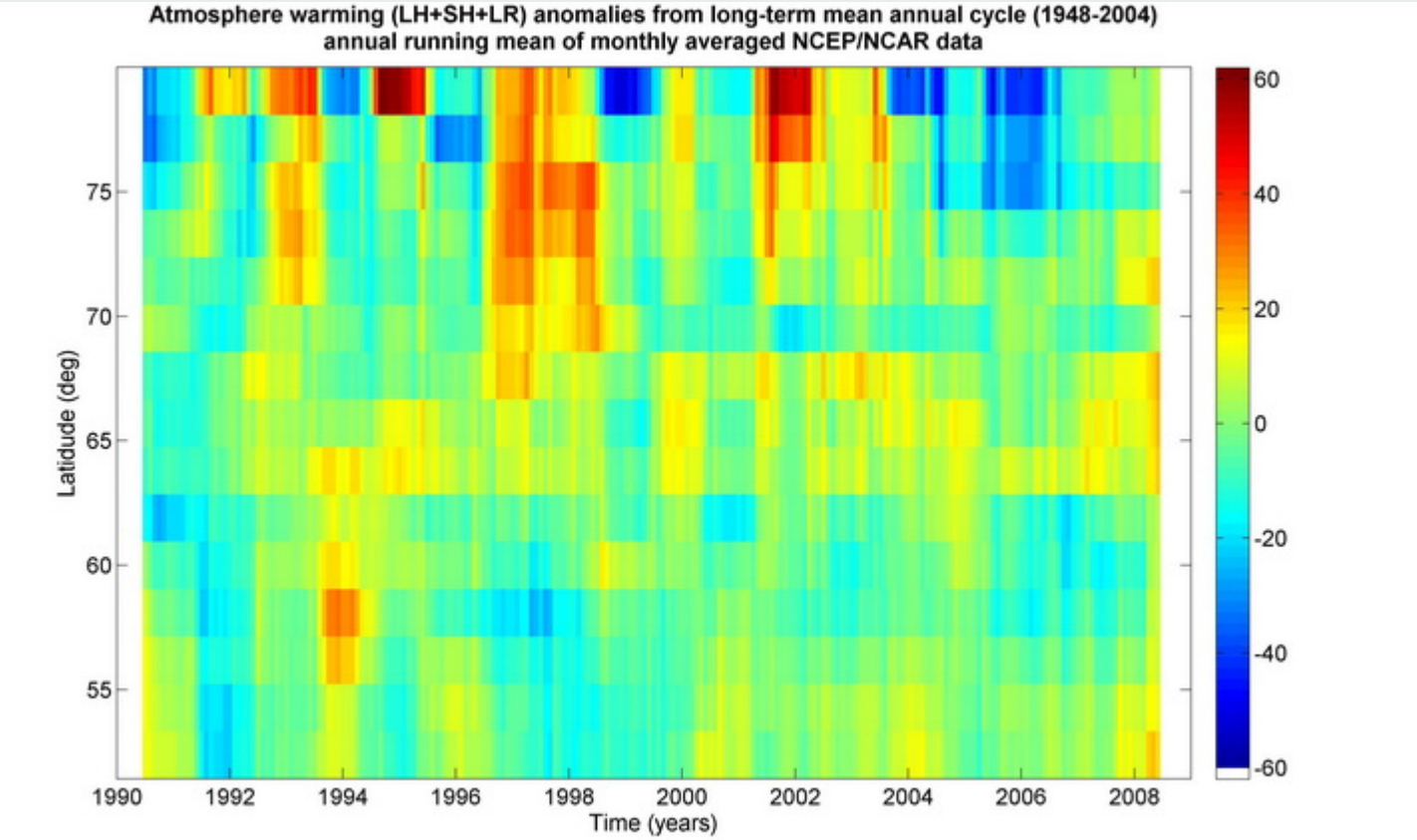
Anomalies of ocean-atmosphere net heat flux from NCEP/NCAR data along f/H contour respresenting the shelf break

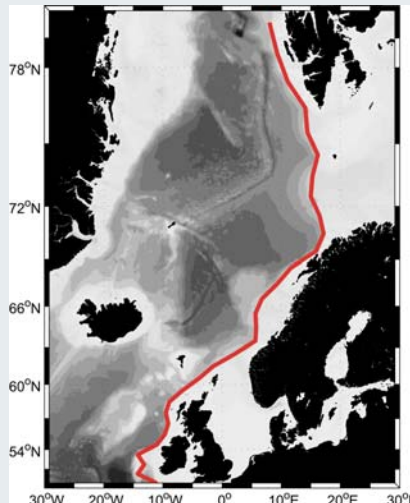


Warm periods (in particular the recent one) in higher latitudes coíncide with negative anomalies in ocean-atmosphere net heat flux

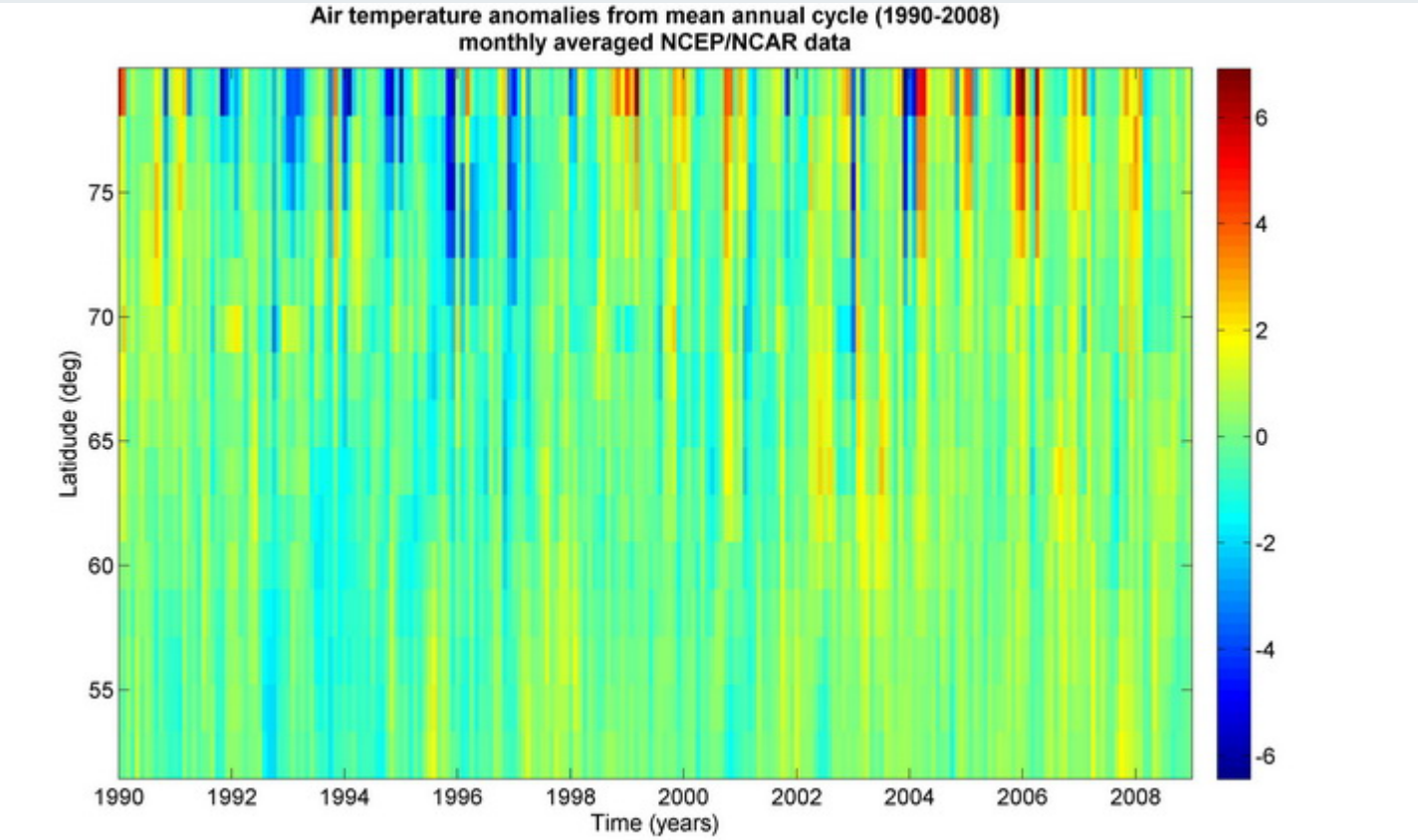


Anomalies of atmosphere warming components of heat flux (LH+SH+LR) from NCEP/NCAR data along f/H contour respresenting the shelf break

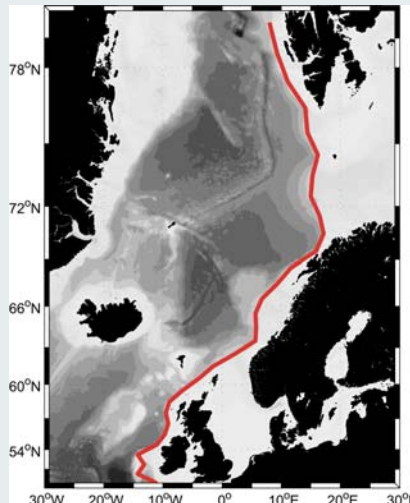




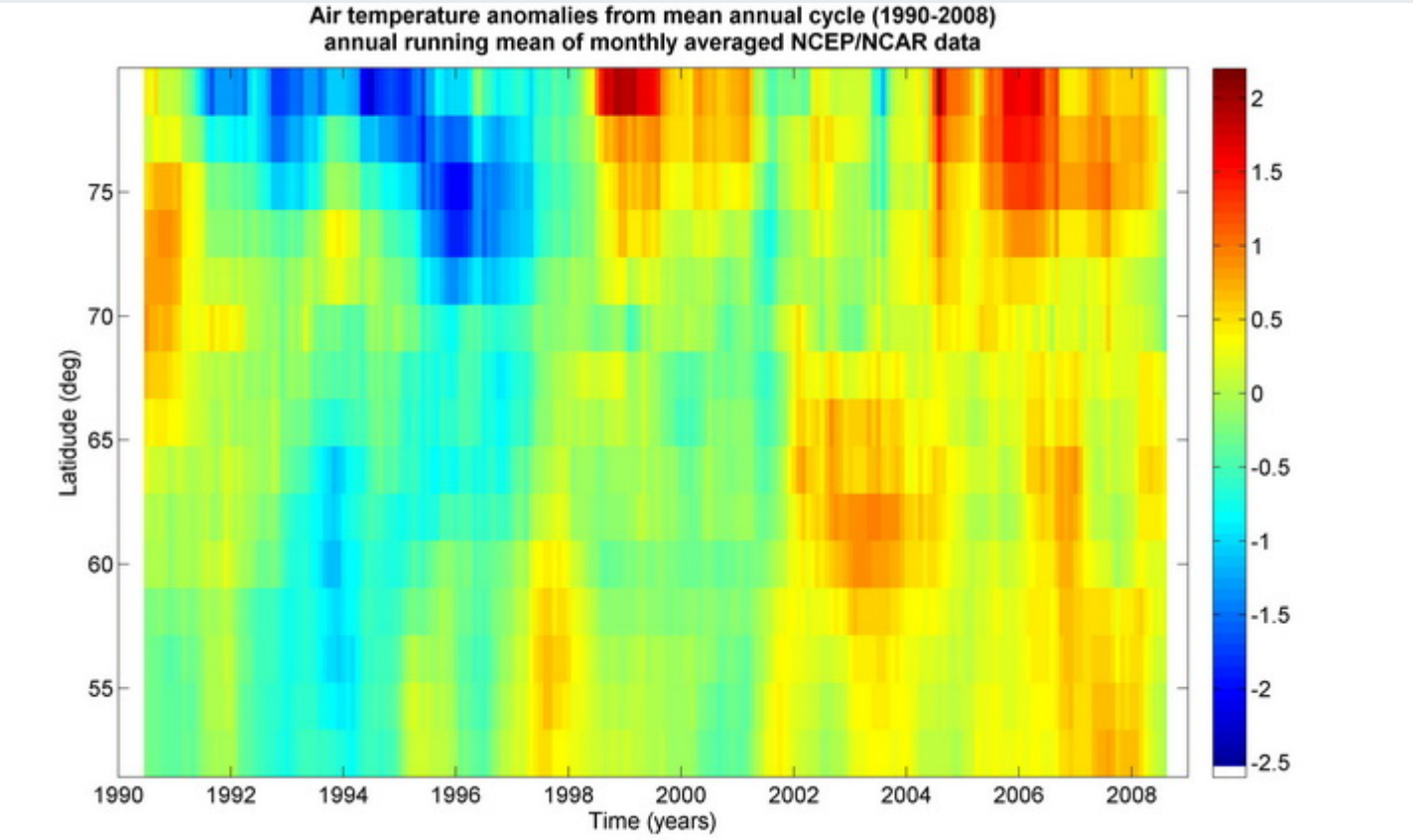
Air temperature anomalies from NCEP/NCAR data along f/H contour respresenting the shelf break



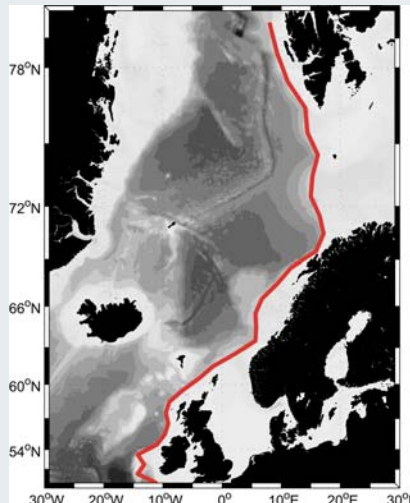
On monthly time scale anomalies over 6° found in higher latitudes



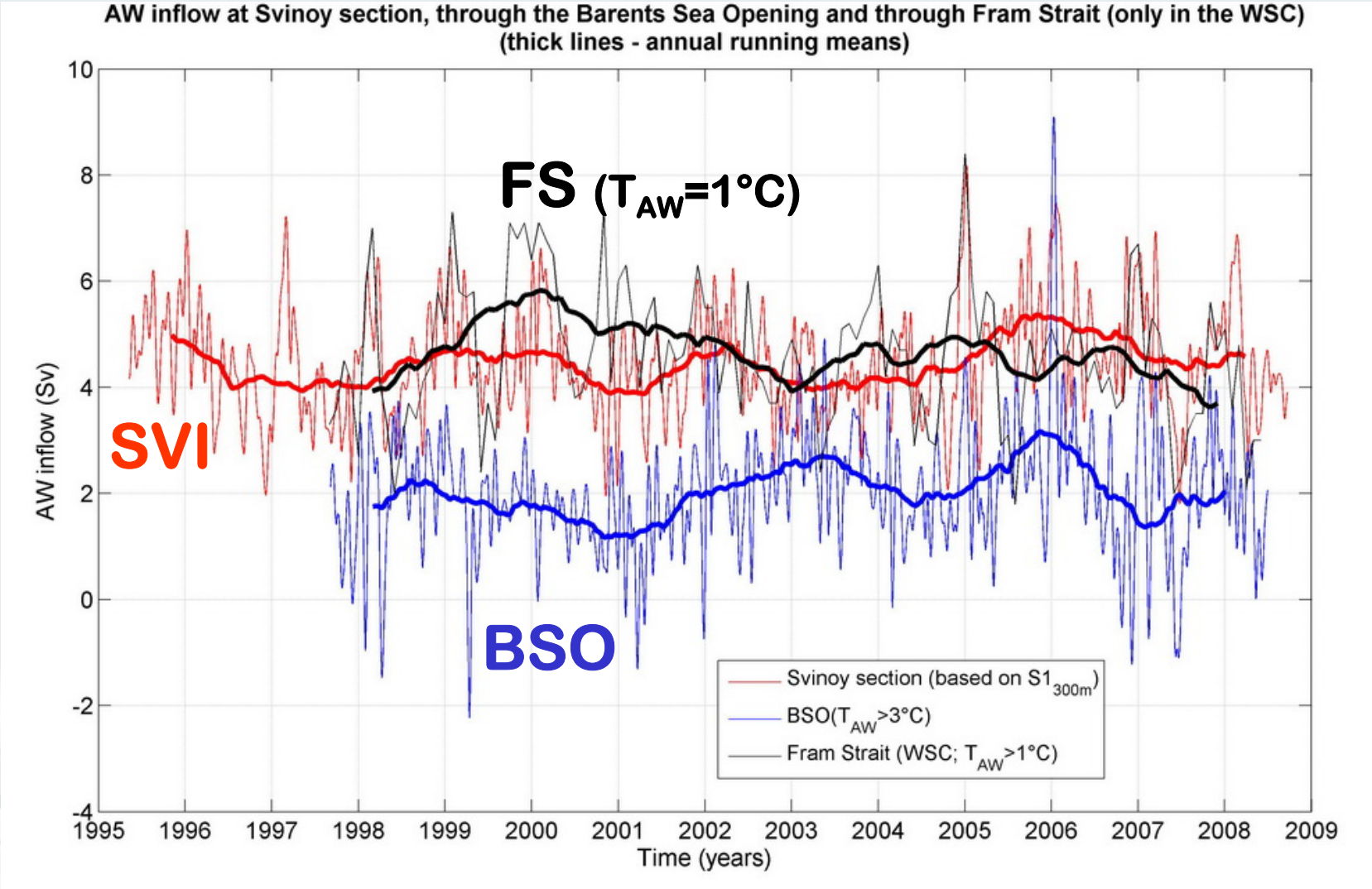
Anomalies of air temperature on interannual scale from NCEP/NCAR data along f/H contour respresenting the shelf break



On interannual time scale warm anomalies in the first 'warm period' stronger in higher latitudes, since 2002 warm anomalies found all along the f/H contour from 50°N to 80°N



Time series of AW inflow at three moored arrays: SVI, BSO, FS



Heat fluxes for the 'stream tube' concept linking SVI, BSO and FS

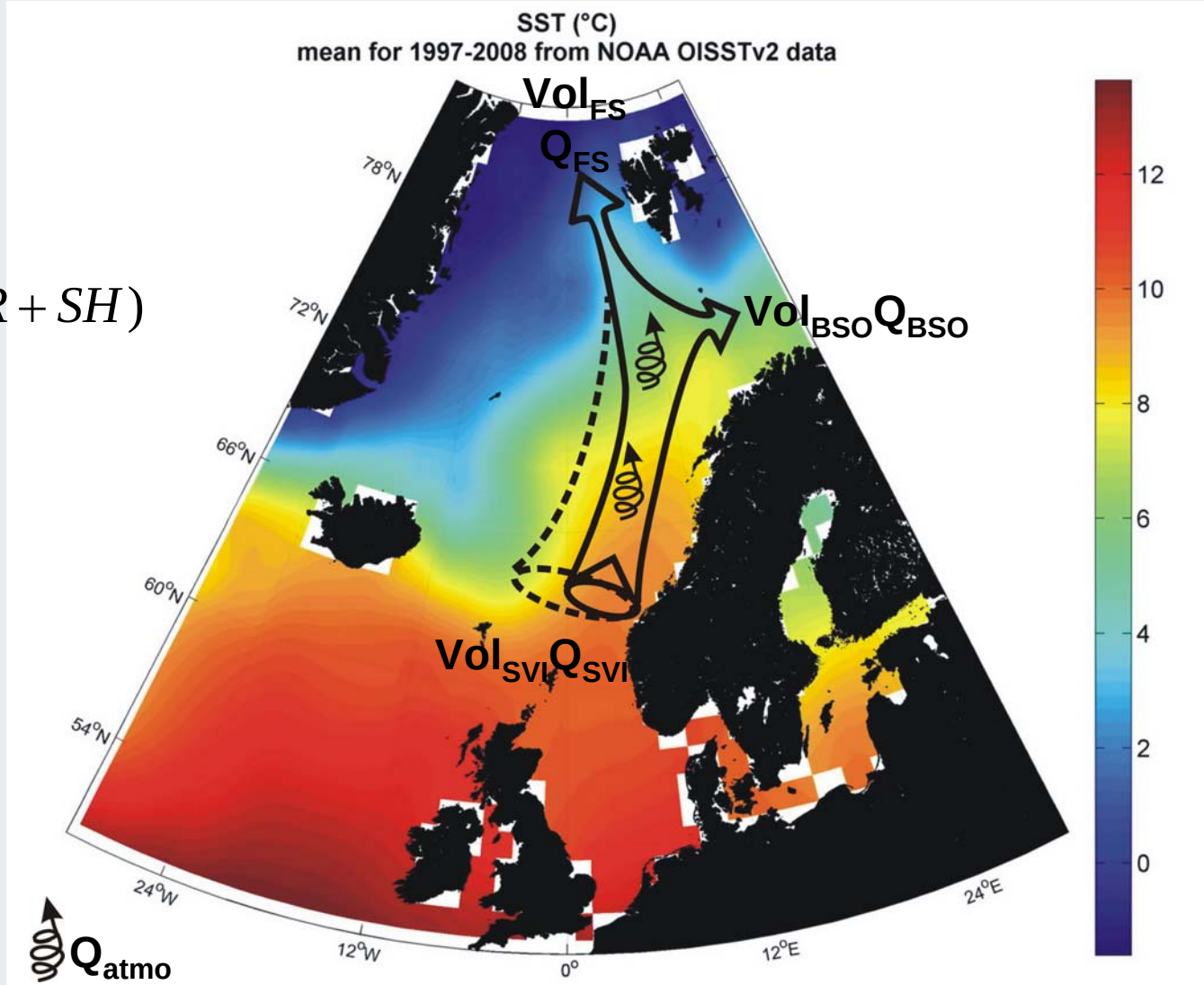
$$c_p \rho V \frac{dT}{dt} = Qin + Qout + Q_{atmo}$$

$$Vol_{SVI} = Vol_{BSO} + Vol_{FS}$$

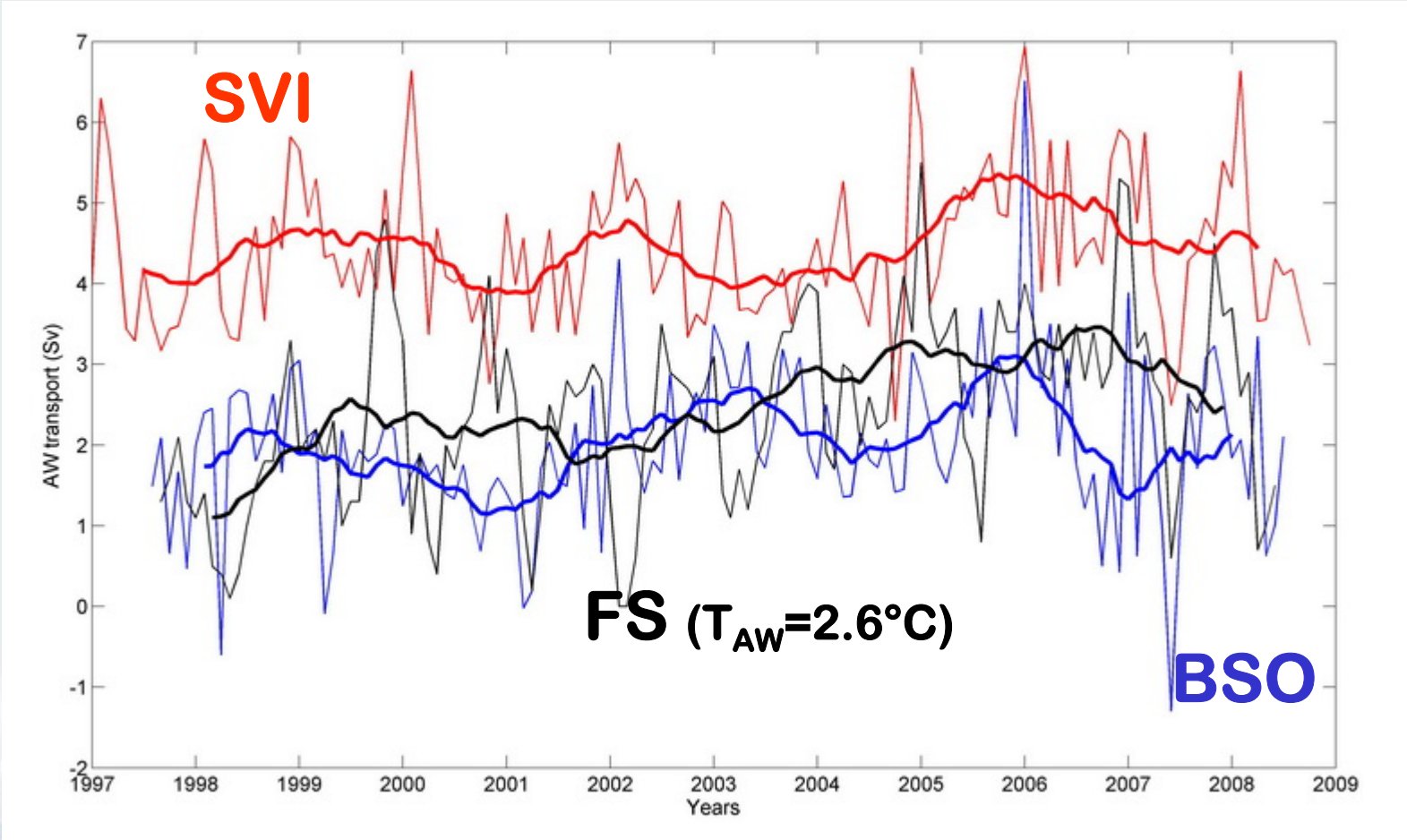
$$Qin = Q_{SVI}$$

$$Qout = Q_{BSO} + Q_{FS}$$

$$Q_{atmo} = A(LH + SH + LR + SH)$$



Time series of AW inflow at three moored arrays balanced between Svinoy section and BSO plus FS



Mean heat fluxes based on the 'stream tube' concept

Mean volume transport:
SVI 4.4 Sv (5 Sv)
BSO 2 Sv
FS 2.4 Sv (3 Sv)

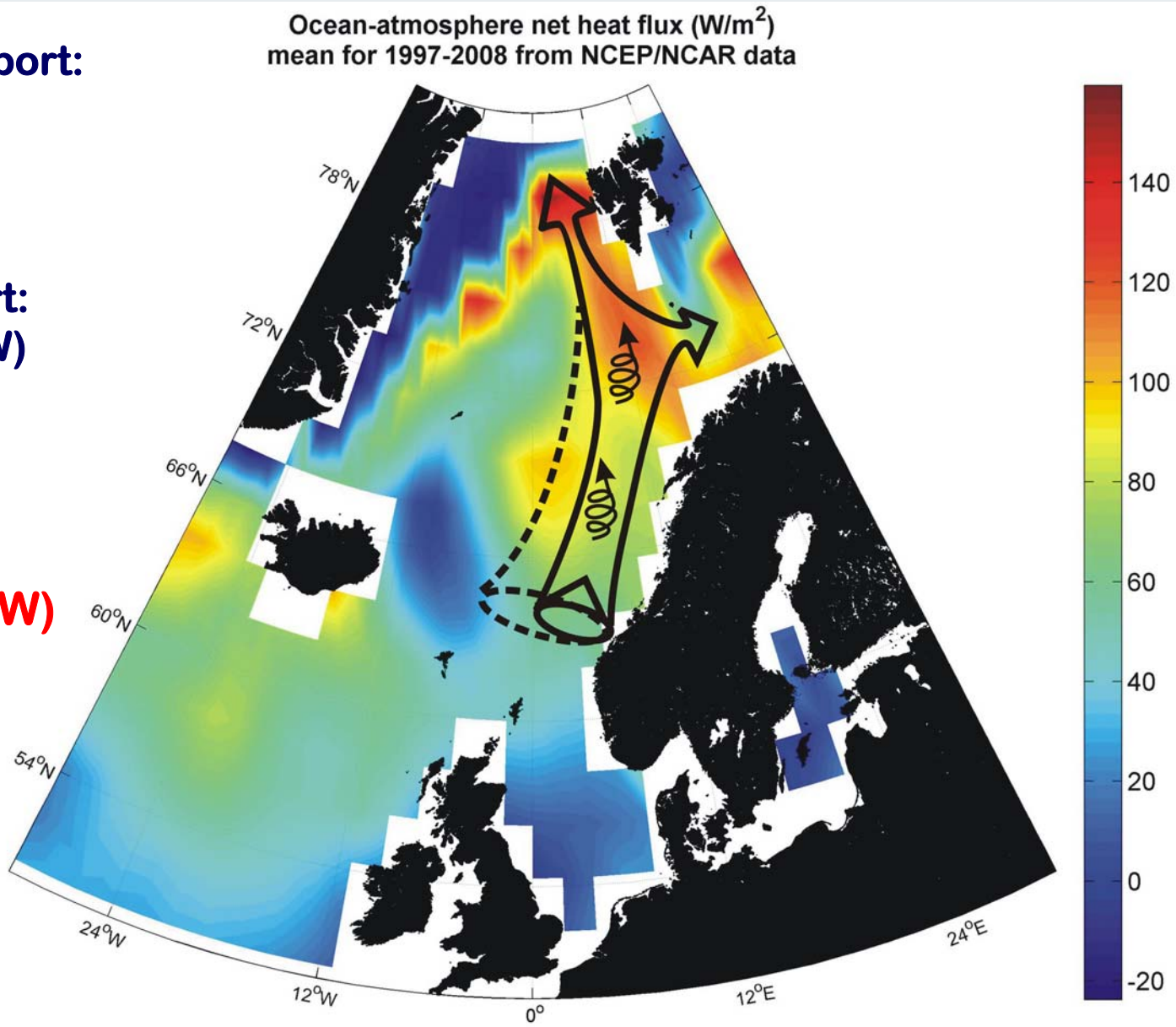
Mean heat transport:
SVI 146 TW (157 TW)
BSO 46 TW
FS 34 TW (40 TW)

⇓ ⇓ ⇓

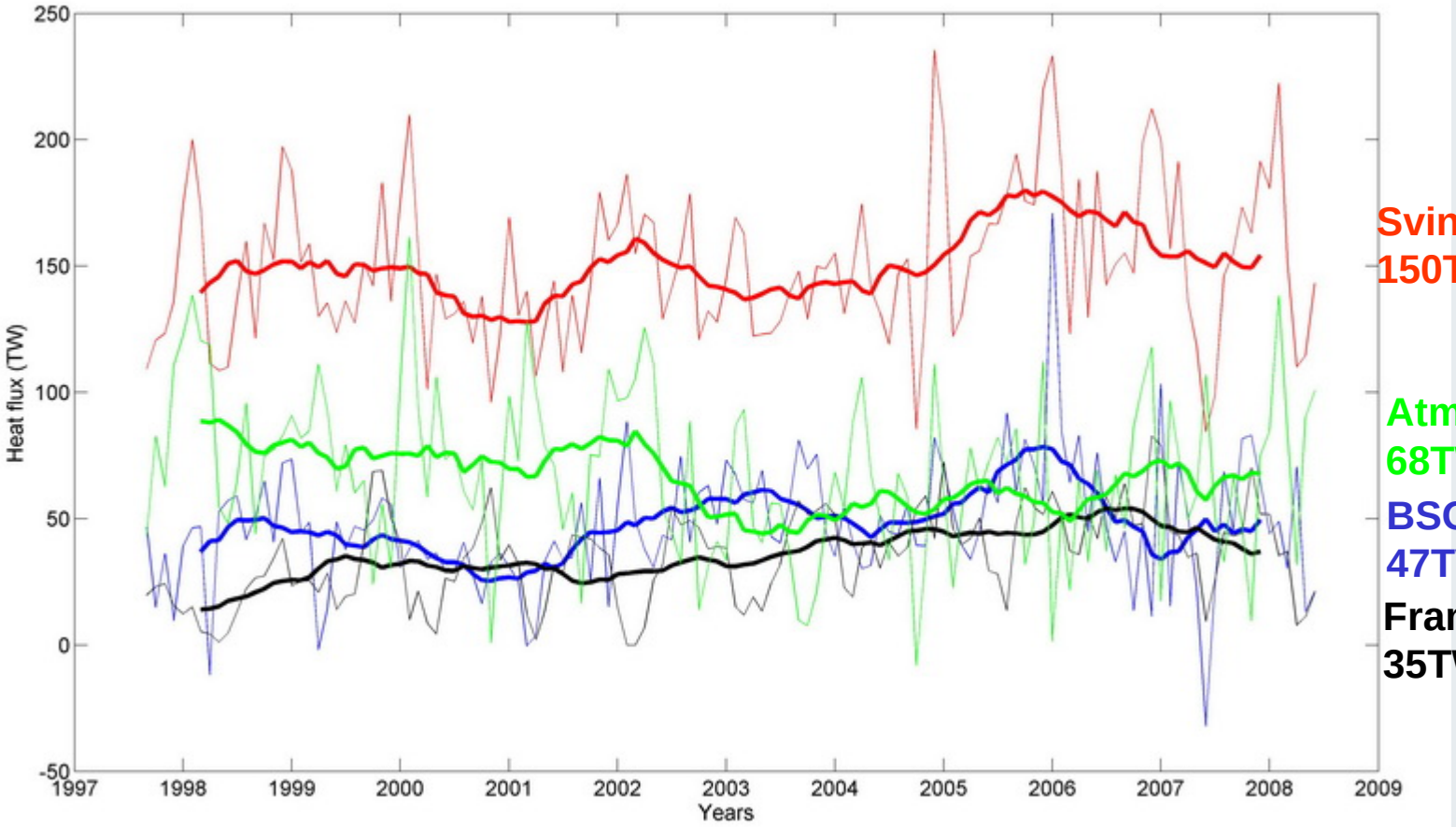
Q_{atmo} 66 TW (71 TW)

NCEP/NCAR:
63°N÷79°N
0°÷18°E
Q_{atmo} = 85 TW

63°N÷79°N
4°÷18°E
Q_{atmo} = 58 TW



Time series of heat fluxes based on the 'stream tube' concept



Mean heat fluxes based on the 'stream tube' concept – recirculation ??

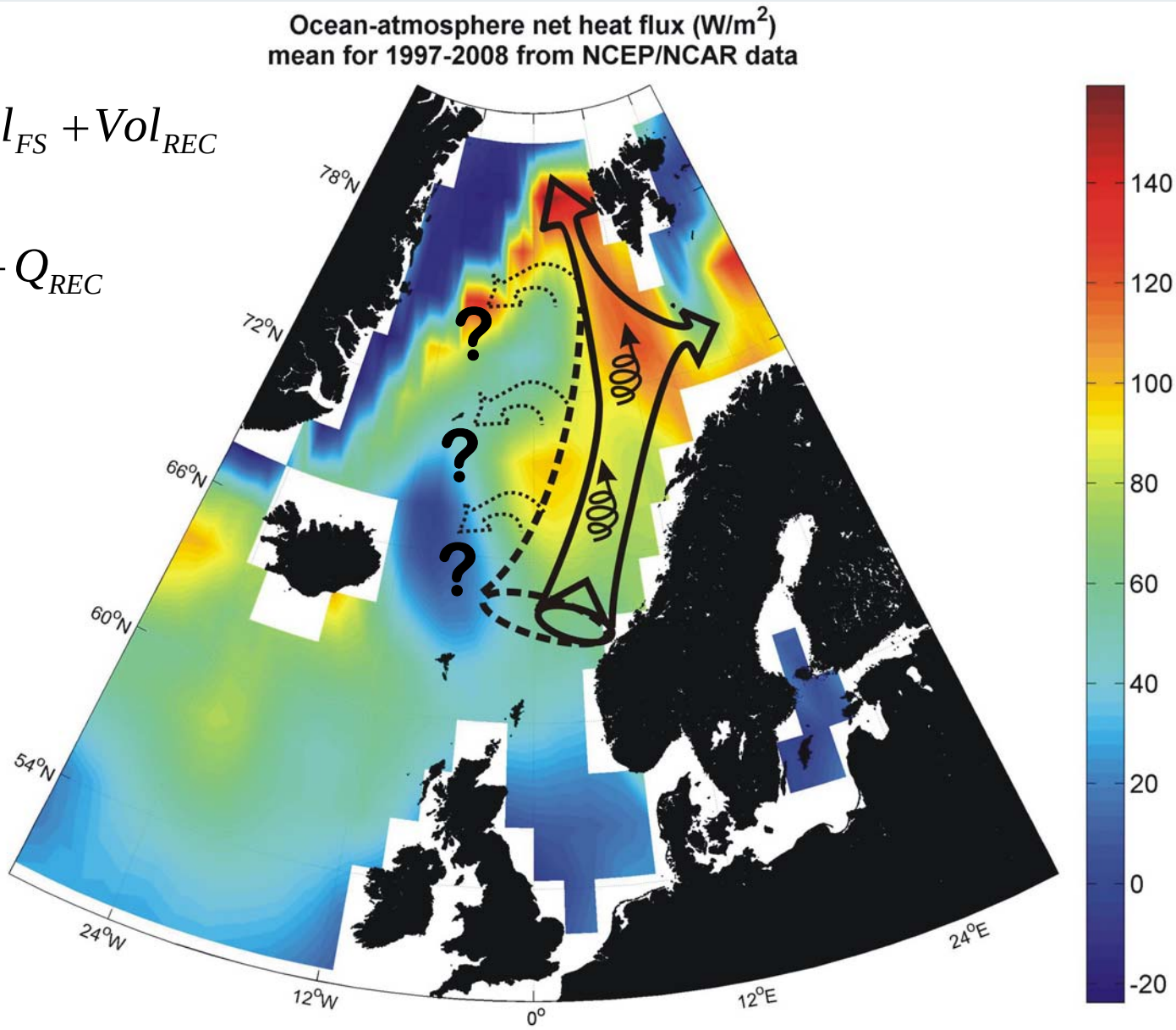
$$Vol_{SVI} = Vol_{BSO} + Vol_{FS} + Vol_{REC}$$

$$Qin = Q_{SVI}$$

$$Qout = Q_{BSO} + Q_{FS} + Q_{REC}$$

Vol_{REC} = ??

Q_{REC} = ??



Summary, questions, ideas for future work…

- Temperature anomalies found propagating through three moroed arrays with ca. 1.5-2 years time lag from Svinoy section to BSO and Fram Strait
- Seasonal signal retained and amplified along the way from Svinoy to Fram Strait
- Anomalies can be continuously traced along the shelf break in SST, however less clearly visible farther north.
- Recent warm anomaly strenghtened by high air temperature and less heat lost to the atmosphere in higher latitudes
- With balanced volume flux between Svinoy section, BSO and Fram Strait the heat budget based on the 'stream tube' can be obtained with reasonable ocean-atmosphere heat fluxes over the area of AW inflow in the Nordic Seas

However….

- How to incorporate recirculation in the budget ?
- Can difference between ocean-atmosphere fluxes obtained from stream tube budget and from NCEP/NCAR be used for a rough estimate of recirculation ?
- AW inflow balancing Svinoy and BSO inflows has to be refined on monthly scale with variable T_{AW} (also problem with underresolved AW flow in early years)
- How damping/amplifying of warm anomalies relates to wind forcing (mixed layer depth ?)
- More in-depth analysis of how seasonal signal is modified between Svinoy section and Fram Strait
- ….