

# Warming of the Barents and GIN Seas

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## Abstract

MAJOR POINTS: 1) The Barents and GIN basins are warming rapidly and exhibiting strong interannual variability. 2) While interannual variability of heat content in the GIN Seas is controlled by Atlantic water transport, we show interannual variability of heat content in the Barents is controlled by surface flux (see also Schlichtholtz et al 2011). 3) Interannual variations in surface flux are the result of variations in wintertime latent heat loss resulting from intrusions of warm moist air from the south. 4) (not shown) these variations also control winter sea ice cover.



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- 1) The Barents and GIN basins are warming rapidly and exhibiting strong interannual variability.
- 2) While interannual variability of heat content in the GIN Seas is controlled by Atlantic water transport, we show interannual variability of heat content in the Barents is controlled by surface flux (see also *Schlichtholtz et al 2011*).
- 3) Interannual variations in surface flux are the result of variations in wintertime latent heat loss resulting from intrusions of warm moist air from the south.
- 4) (*not shown*) these variations also control winter sea ice cover.

## SODA3 REANALYSIS

### Model

- MOM5/SIS1 1/4°x1/4°x50Lev, 10m nearsurface, Arakawa-B grid, polar cap north of 60N
- 5-ice type active (dynamics and thermodynamics) SIS1 sea ice
- Freshwater: Pseudo-freshwater flux, Dai et al. (2009) river discharge, Bamber (2012) Greenland discharge.

### Data

- Hydrography: WOD2018 {includes ITP}
- SST: ICOADS2.5/3, Pathfinder, ACSP0
- Sea ice: Walsh et al, CRYOSAT, ICEBRIDGE, ICESAT, Submarine,

### DA

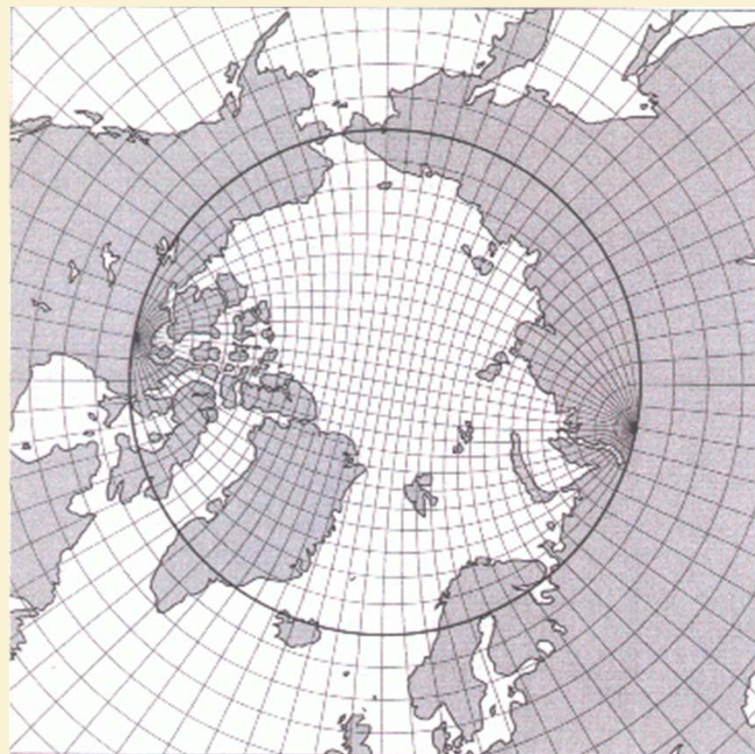
- Ocean: 'Enhanced' OI, flux bias correction, 10-dy assimilation cycle
- Sea ice: enthalpy-based

### Forcing

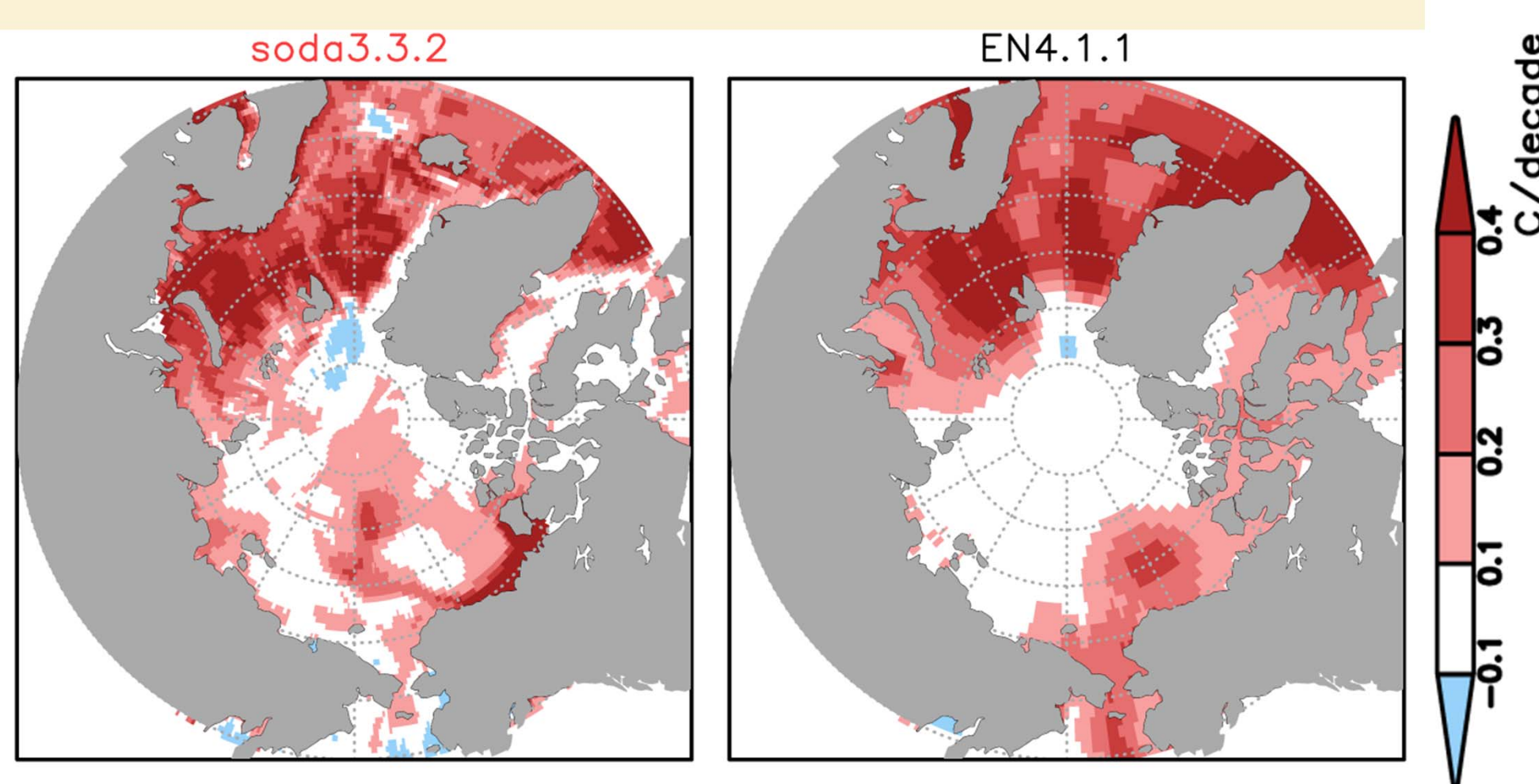
- MERRA2, ERA-I, JRA55, JRA55-DO, DFS5.2, CORE1, CERA20C, ERA5

## MODEL GRID AT HIGH LATITUDE

Every 10<sup>th</sup> grid line shown

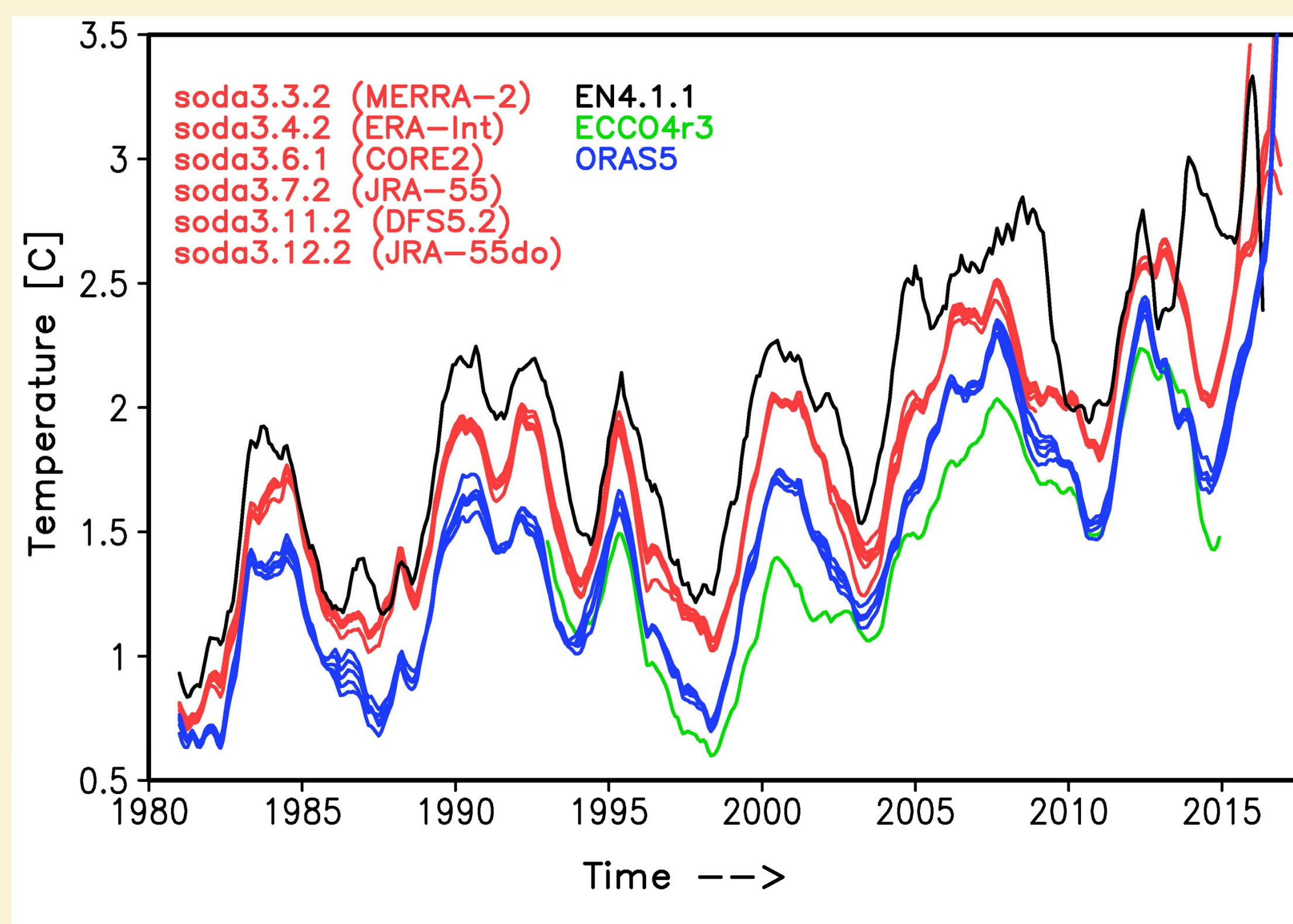


## BIG TRENDS IN 0-100M TEMPERATURE 1980-2017



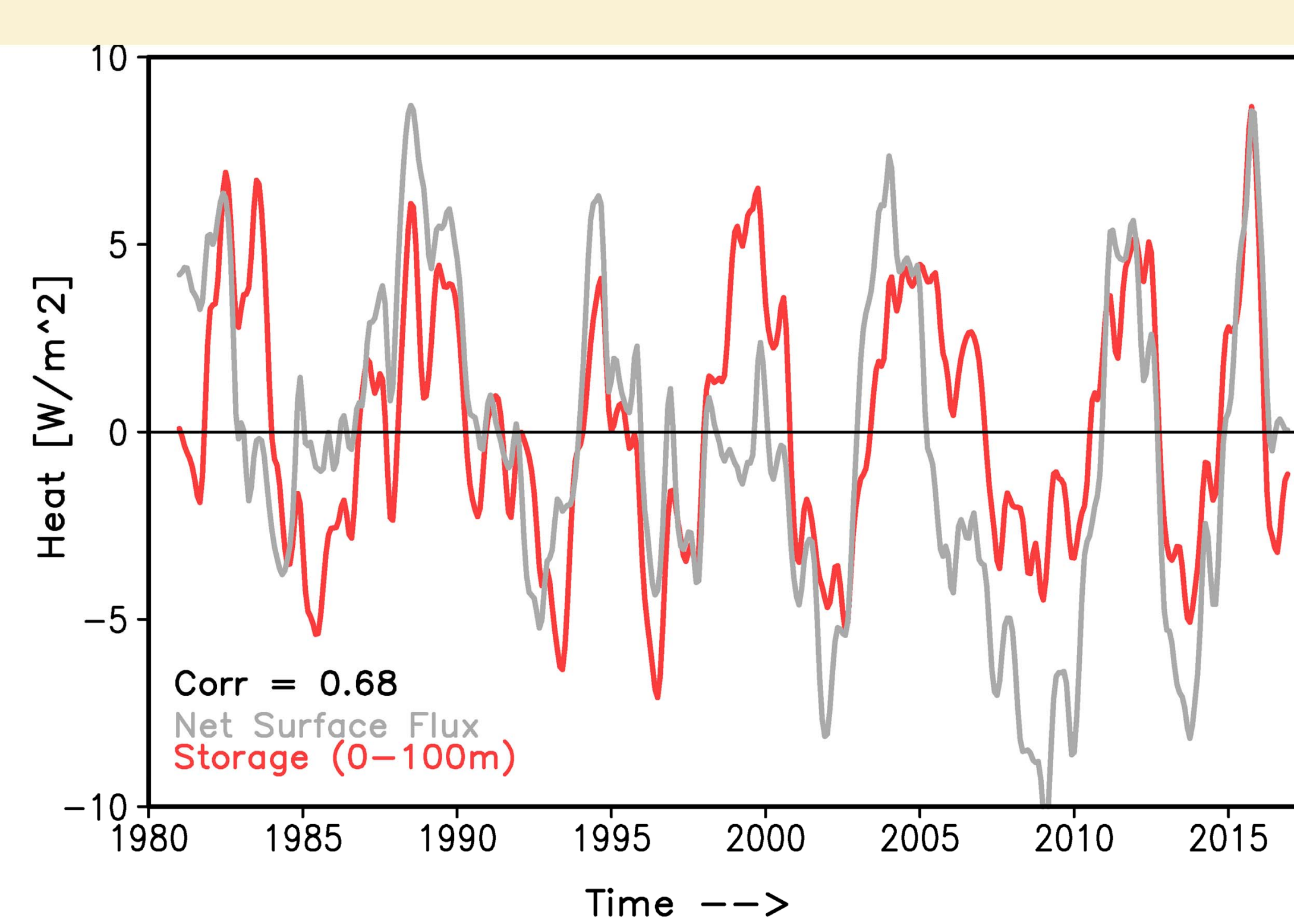
SODA3 and EN4.1.1 (included for comparison) show 0-100m temperatures in the Nordic (and Barents) Seas rising at a rate in excess of 0.3K/decade since 1980!

## BARENTS SEA HEAT CONTENT



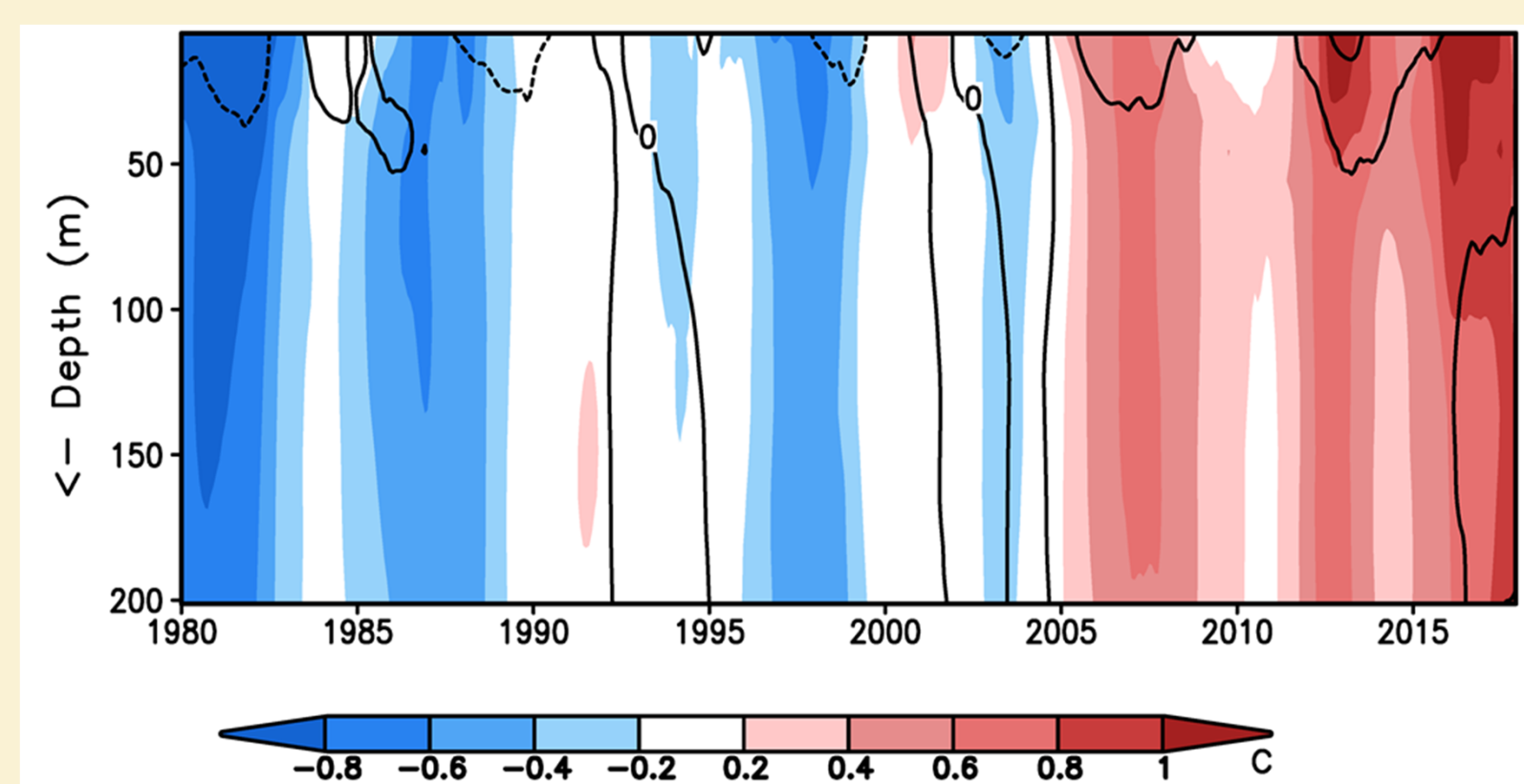
Temperature change in the upper 100m of the Barents Sea shows up in SODA3 ensemble members as well as EN4.1.1, ORAS5 and ECCO4. Trend: 0.38K /decade and seven warm events over 39 years.

## DETRENDED BARENTS SEA HEAT BUDGET



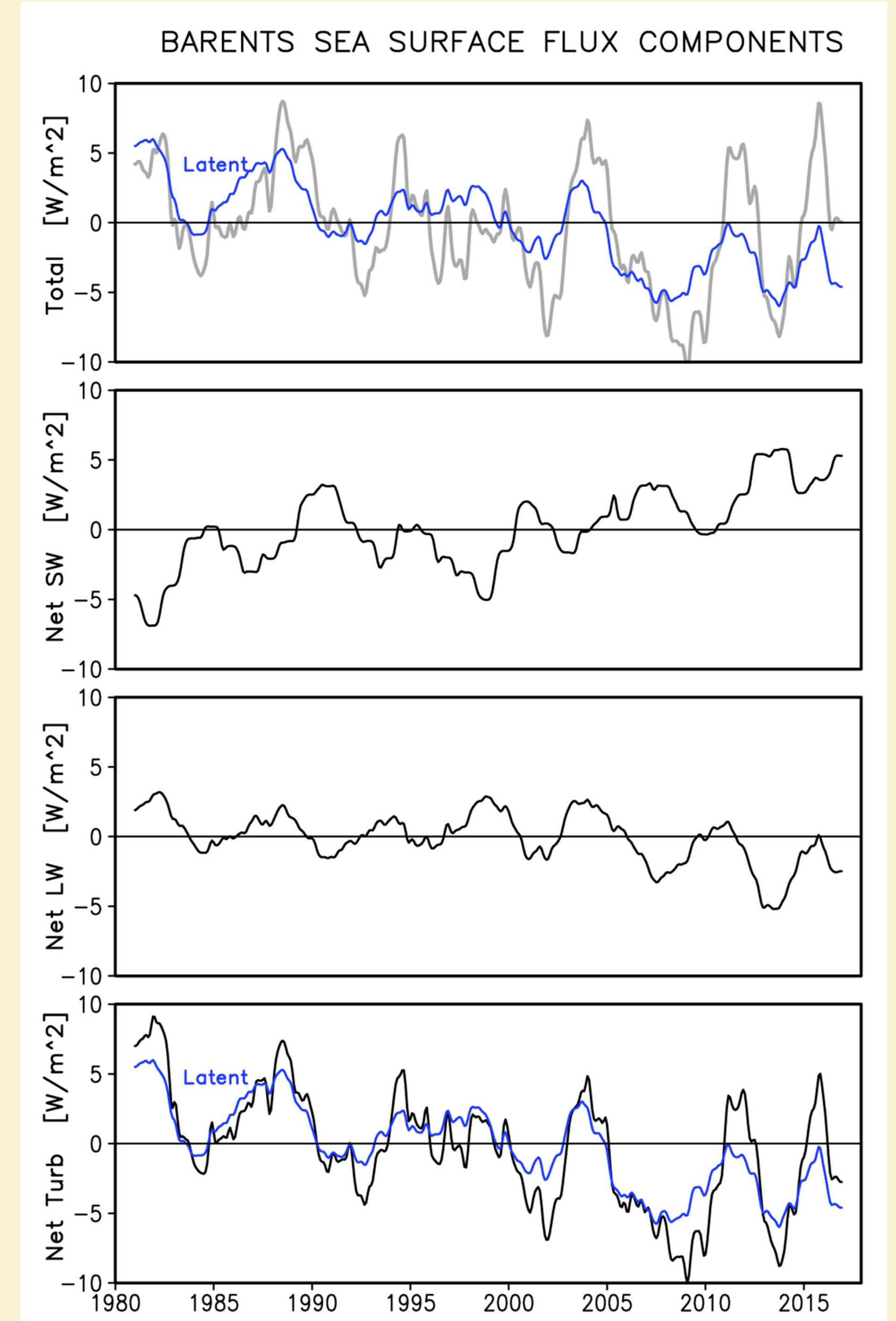
However, a basin-average heat budget shows that much of the interannual variability can be explained by surface fluxes alone without invoking changes in ocean heat transport convergence. Surface flux is provided by the new ERA5 reanalysis.

## Annual average temperature and salinity anomalies with depth and time



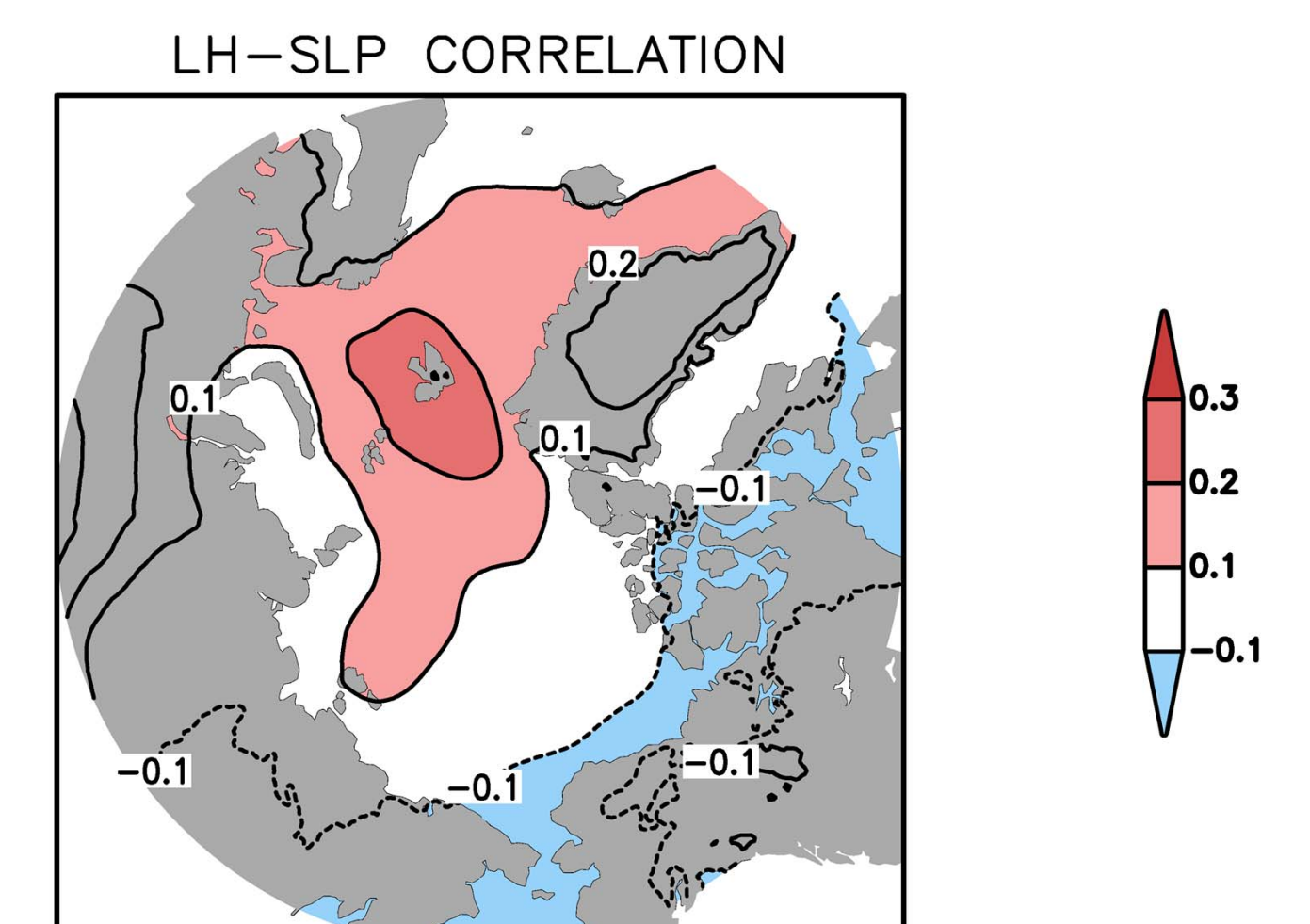
At interannual timescales the temperature anomalies are coherent vertically leaving open the question of the importance of changes in net heating over the Barents region.

## ANALYSIS OF SURFACE FLUX COMPONENTS



By decomposing the net surface heat flux into radiative and turbulent components it is evident that the source of interannual fluctuations in Barents Sea heat is: episodic reductions in latent heat loss in winter.

## ANTICYCLONIC SLP PATTERN ASSOCIATED WITH INCREASES IN LATENT HEAT LOSS

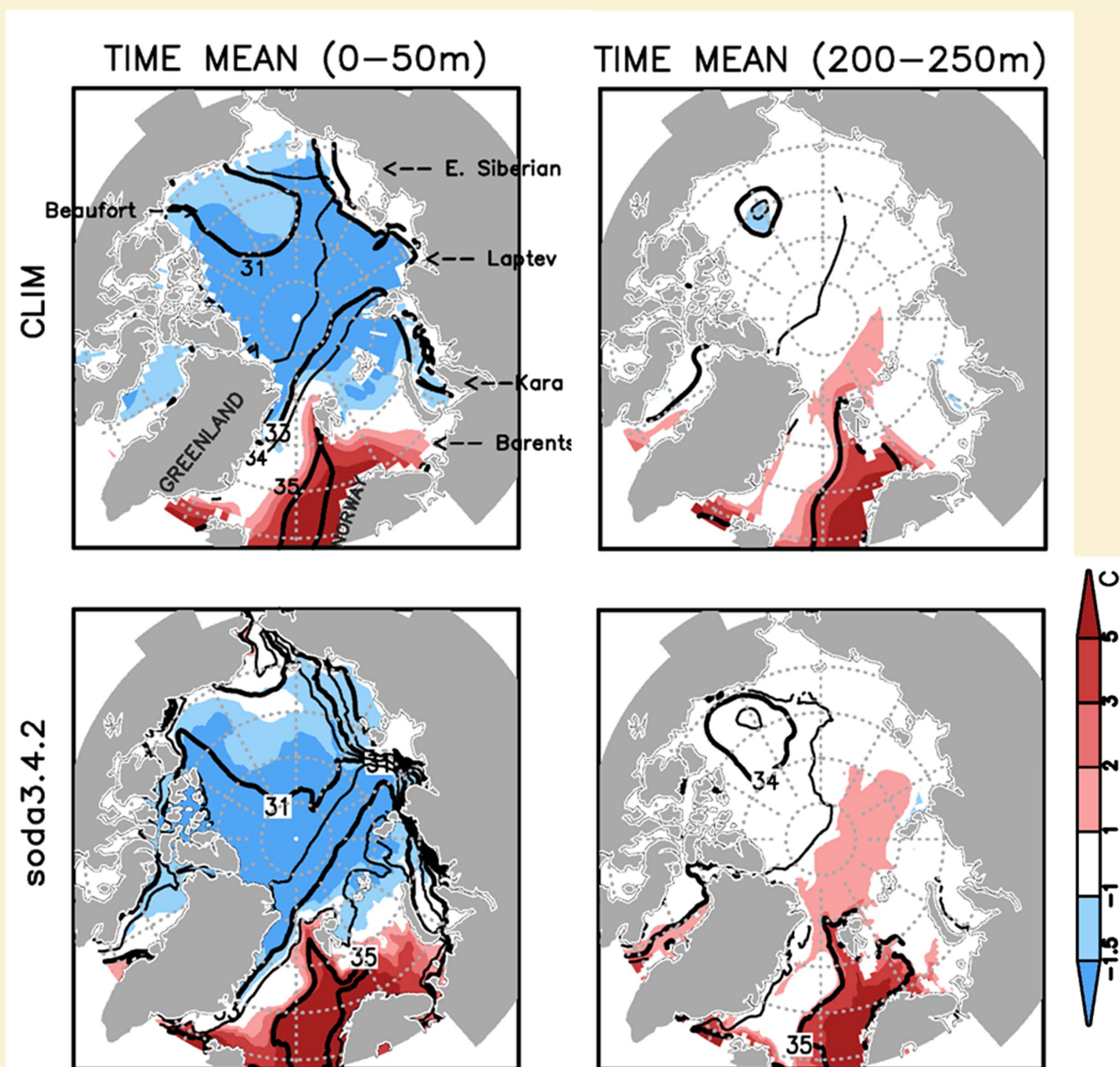


Latent heat loss is associated with warm, moist air flows into the Barents. Sea region from the south.

## BASIN DECOMPOSITION

Focus on changes in Greenland, Iceland, Norwegian and Barents basins beginning with the Barents.

## SODA3 CLIMATOLOGY



PHC3.0 climatology temperature and salinity (left) 0-50m conditions, and (right) 200-250m resemble SODA3. One difference is that SODA3 shows more influence of Atlantic water (lower right) in the interior basin.

## Final Questions

- 1) GIN Seas have their own interannual variability. Under what circumstances can transport across the BSO import that variability into the Barents?
- 2) What is the impact of the Barents Sea temperature variability on the central Arctic Ocean?

## Reference

Schlichtholtz, P., and M. N. Houssais, 2011: Forcing of oceanic heat anomalies by air-sea interactions in the Nordic Seas area. J. Geophys. Res., 116, C01006, doi:10.1029/2009JC005944.