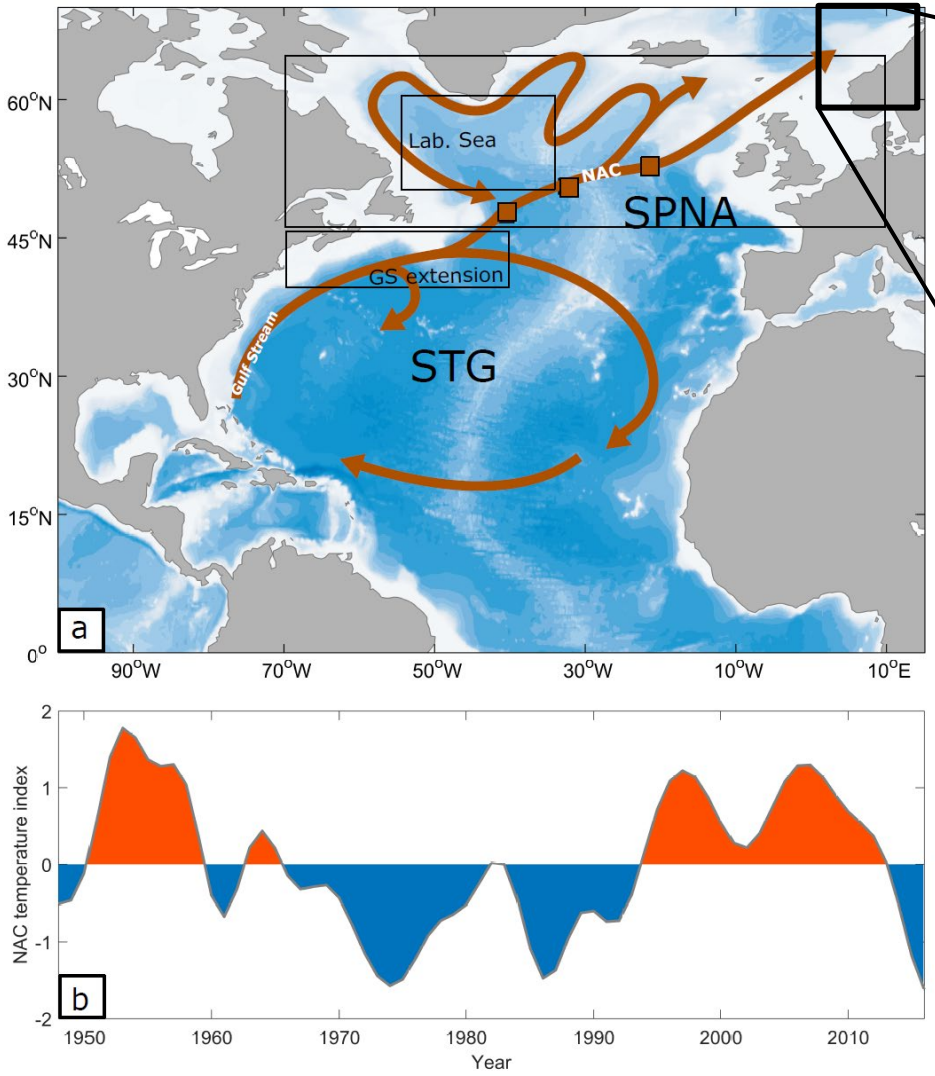
BJERKNES CENTRE
for Climate Research

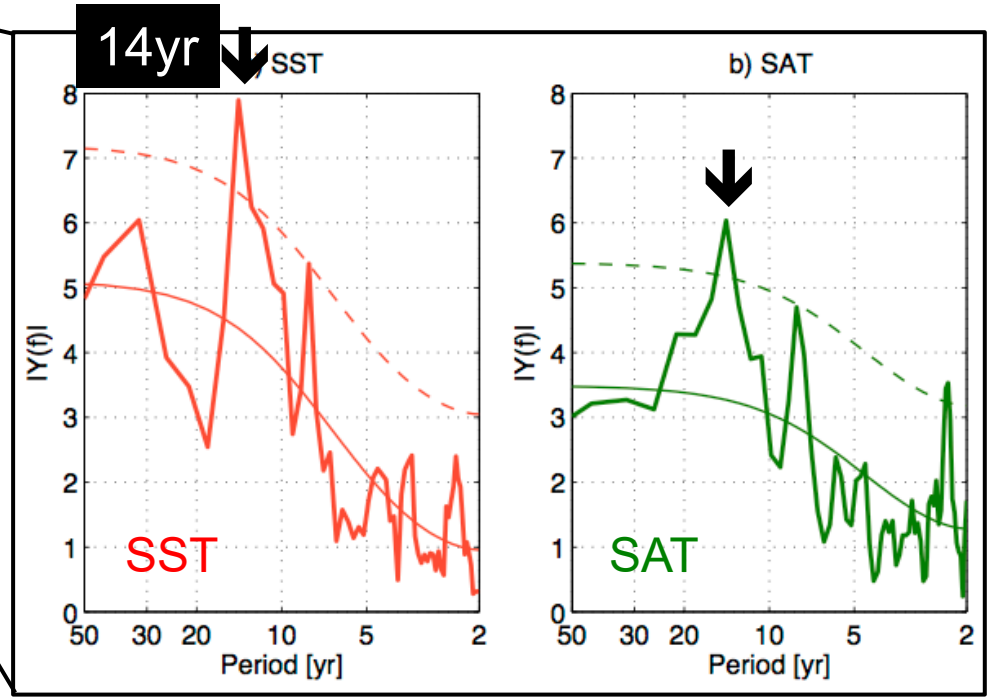
Mechanisms of decadal North Atlantic climate variability and implications for the recent cold anomaly

MARIUS ÅRTHUN
ROBERT C. J. WILLS, HELEN L. JOHNSON, LEON CHAFIK, HELENE R. LANGEHAUG

SEE FULL STORY IN *JOURNAL OF CLIMATE*

North Atlantic-Nordic Seas climate characterized by substantial decadal variability





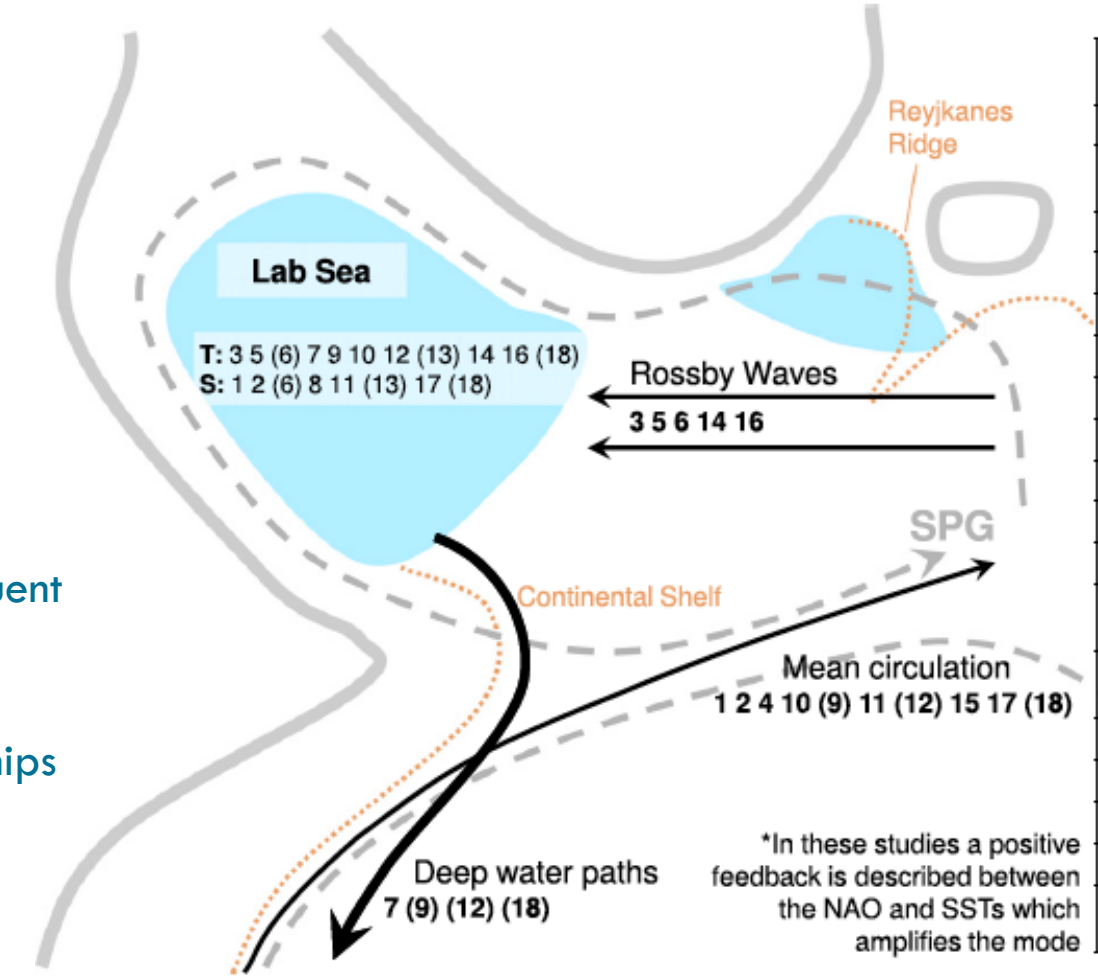
Årthun et al. (2017; 2018)

Wide range of mechanisms

- Ocean circulation vs atmospheric forcing
- Gyre vs overturning circulation
- Time scales (10 – 50 years)

One potential source of discrepancy is the frequent use of low-/band-pass filters

Complicates the detection of lead-lag relationships



	Study	Period (years)	Mech-anism
1	Delworth '93	50	Ocean
2	Timmermann '98	35	Coupled
3	Grotzner '98	17	Coupled
4	Visbeck '98	12-16	Ocean*
5	Watanabe '99	~10	Ocean*
6	Dong '01	-	-
7	Eden '01	12-18	Coupled
8	Holland '01	20	Ocean
9	Eden '03	16	Ocean*
10	Dai '05	24	Ocean
11	**Dong '05**	**25**	**Ocean**
12	Àlvarez-Garcia '08	24	Ocean*
13	Danabasoglu '08	21	-
14	Frankcombe '10	20-30	Ocean
15	Born '12	15-20	Ocean
16	Sevellec '13	24	Ocean
17	Escudier '13	20	Ocean
18	Kwon '14	20 "regime 1"	Ocean*

Menary et al. (2015)

Objective

Use **low-frequency component analysis** to identify the time scale, spatial pattern, and mechanisms underlying decadal variability in the North Atlantic

Data

Winter (Nov-Apr) SST

Observations 1948-2017 (HadISST, NOAA-20C)

CESM-LE (30 members, historical: 1920-2005)

CMIP5 piCTRL (6 models*500 years)

Method (see e.g., Wills et al., 2019)

Low-frequency defined as >10 years

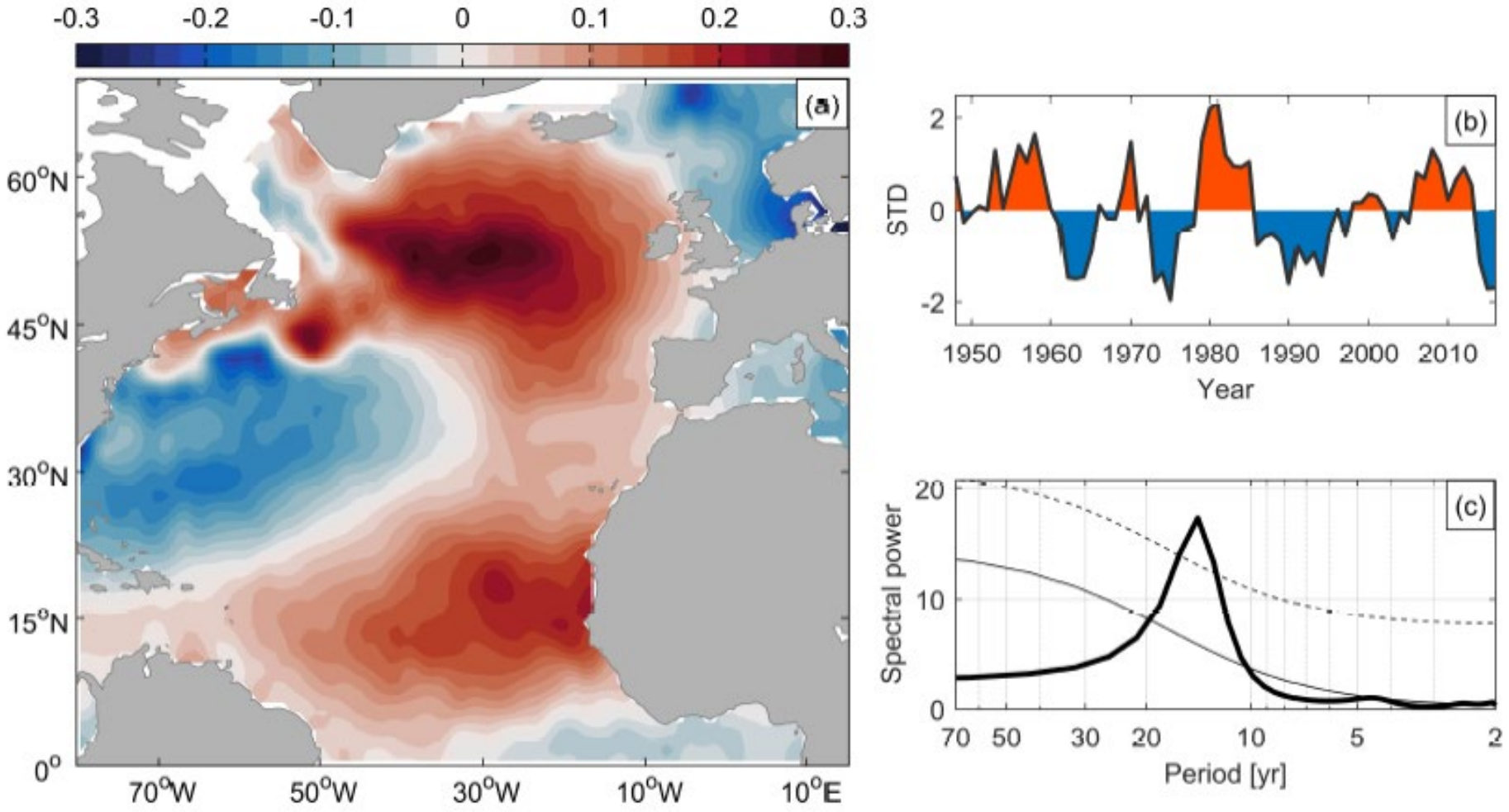
Low-frequency components sorted by the ratio of low-frequency to total variance

Low-frequency components are unfiltered

Low-frequency components are orthogonal

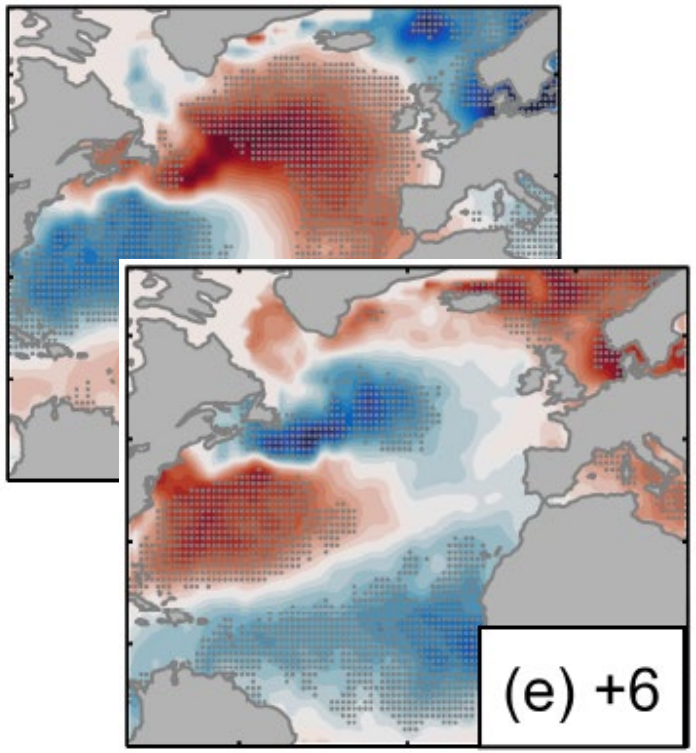
Low-frequency component analysis – observations

Atlantic Decadal Variability (ADV)

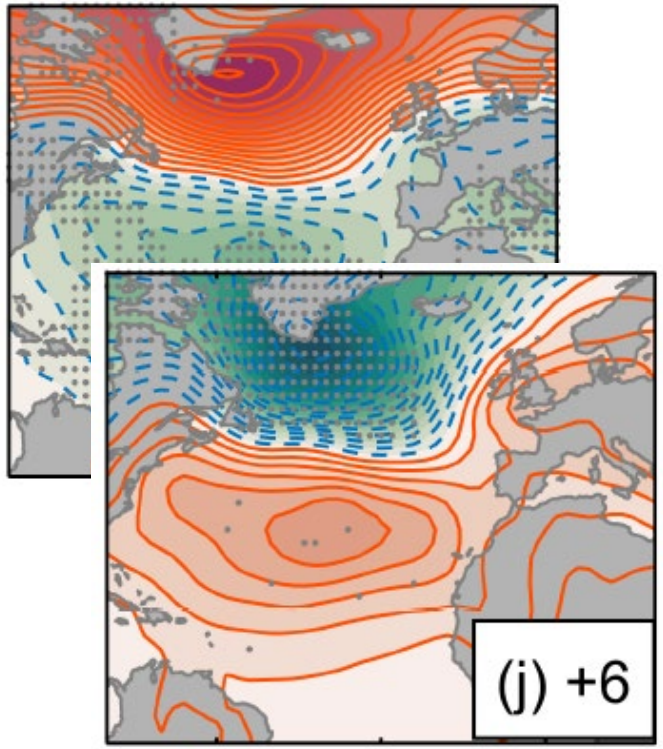


Lagged regressions of SST, SLP, SHF onto observed ADV

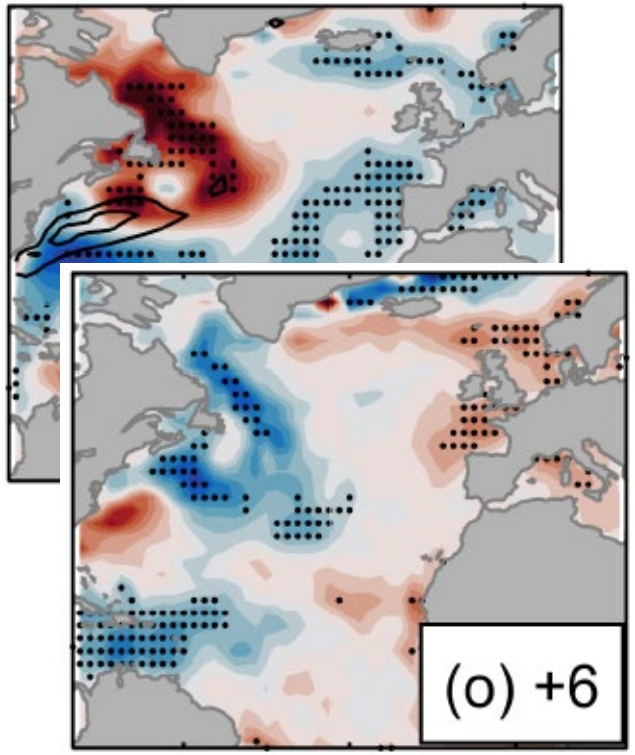
SST



SLP



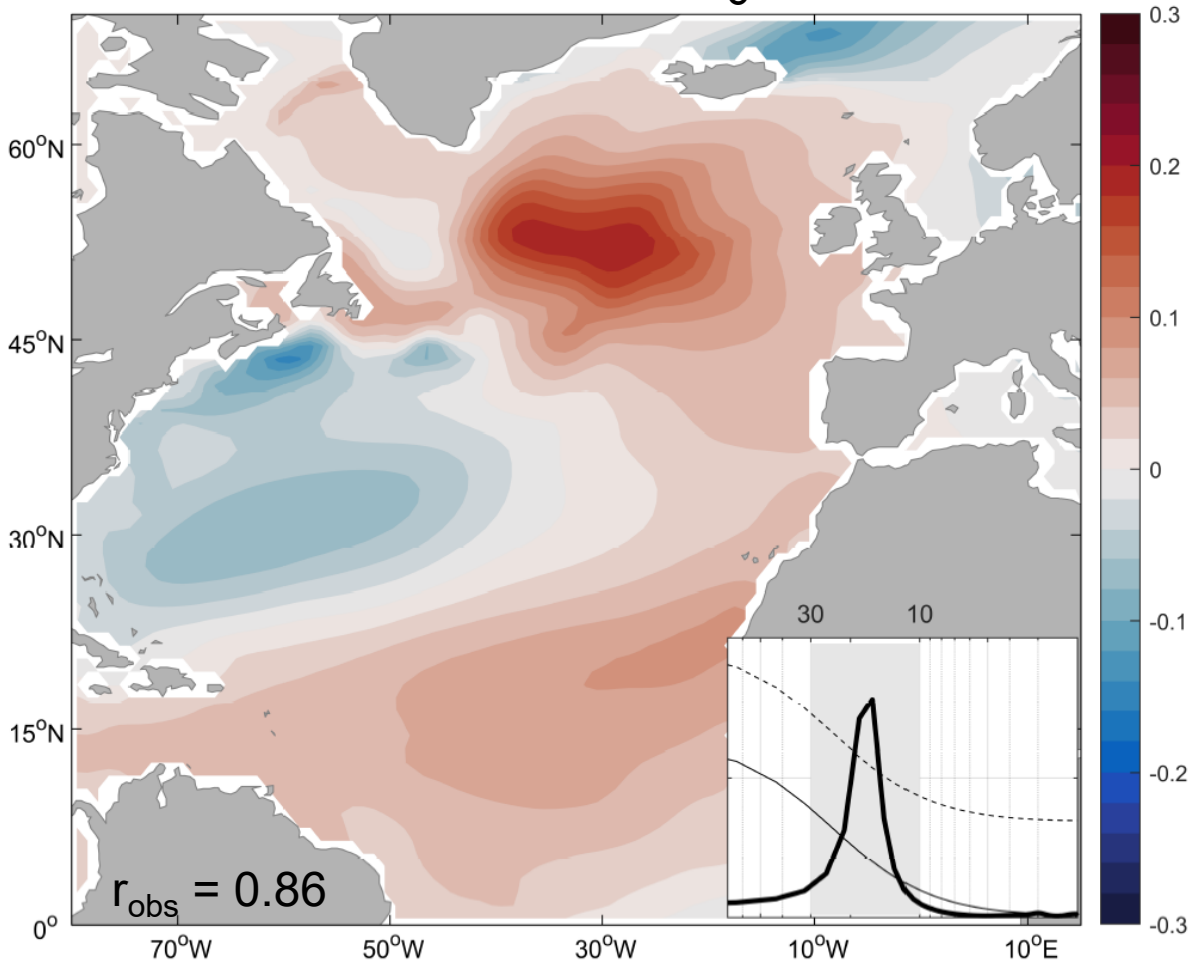
SHF



Ocean heat loss

Simulated Atlantic Decadal Variability – CESM-LE

Ensemble average

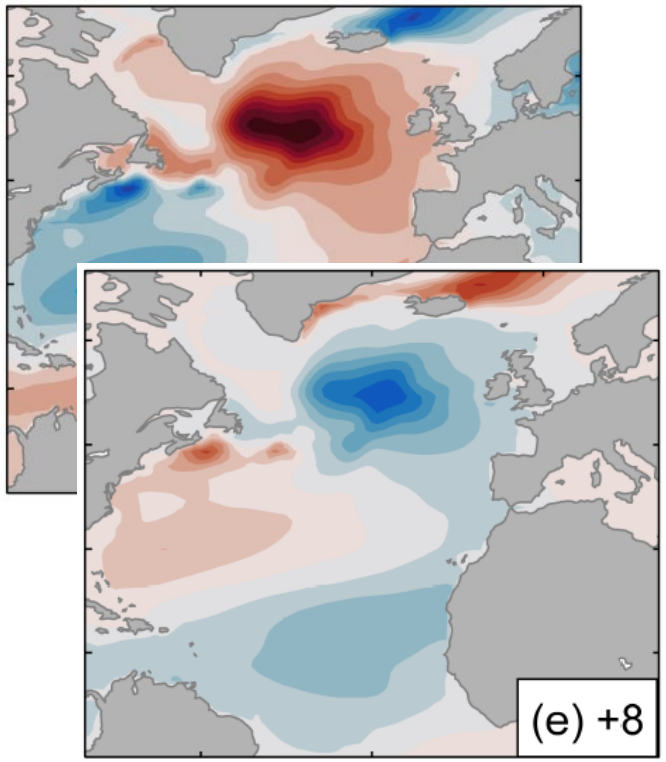


NOTE ON ADV IN CESM:

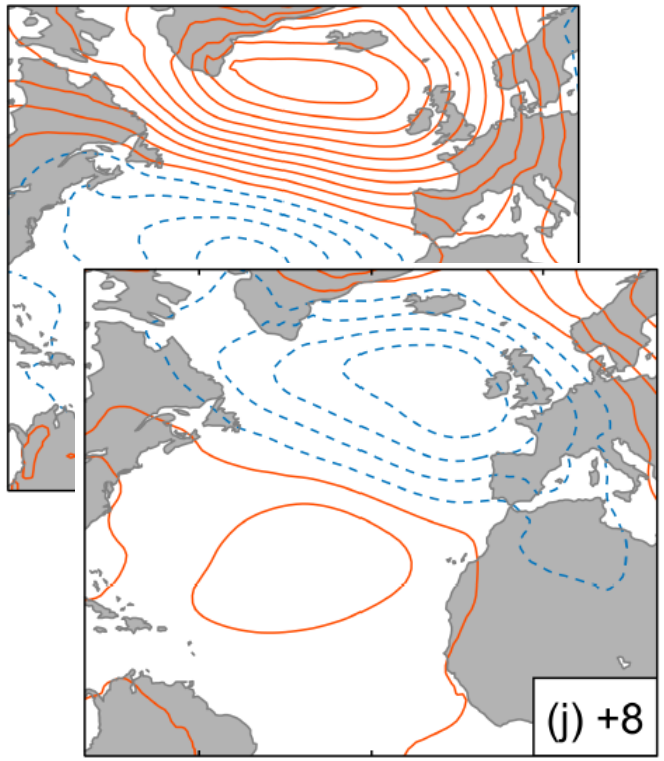
For each ensemble member we calculate the linear combination of the leading five LFPs that maximizes the pattern correlation with the observational LFP.

Lagged regressions of SST, SLP, SHF onto observed ADV

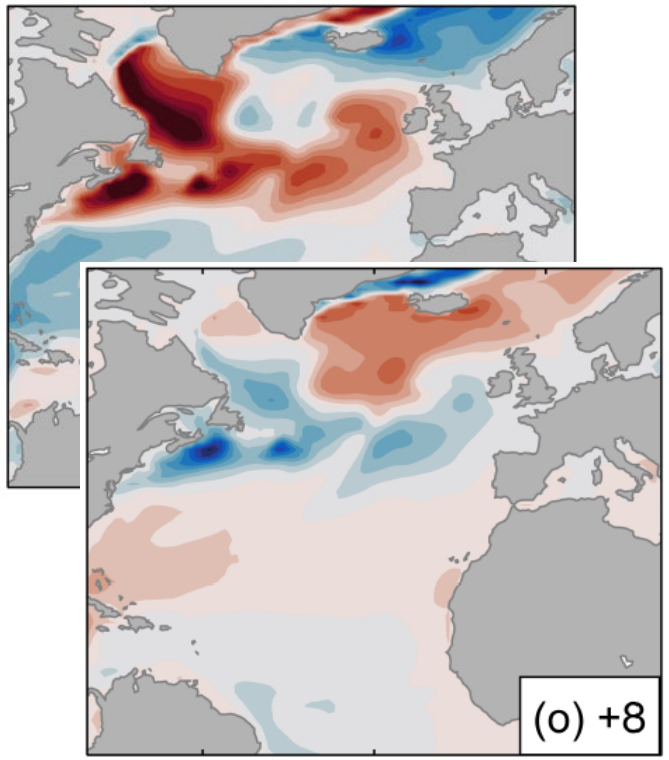
SST



SLP



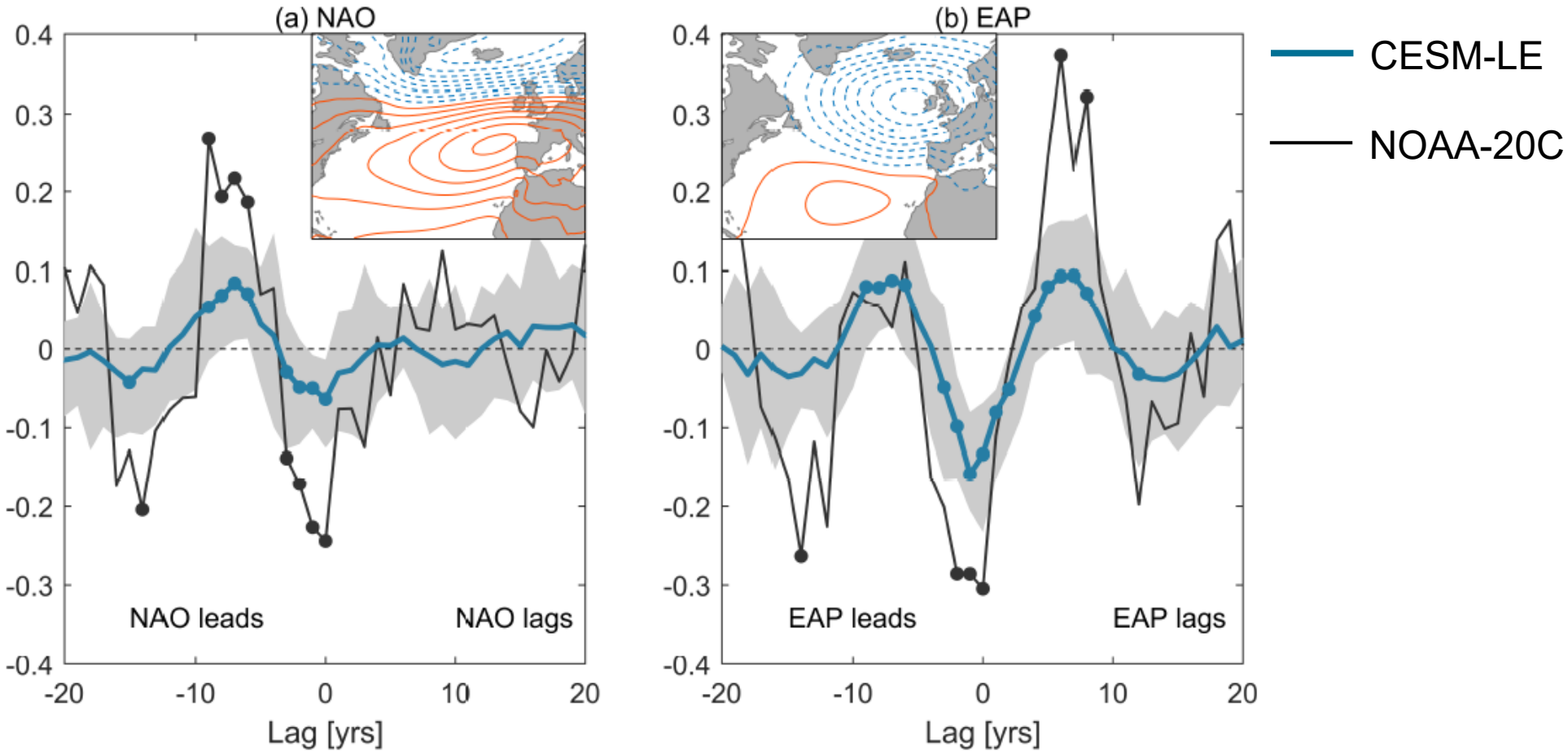
SHF



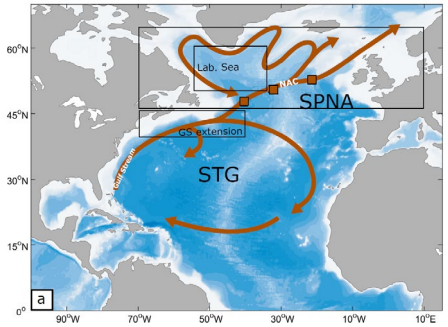
Ocean heat loss

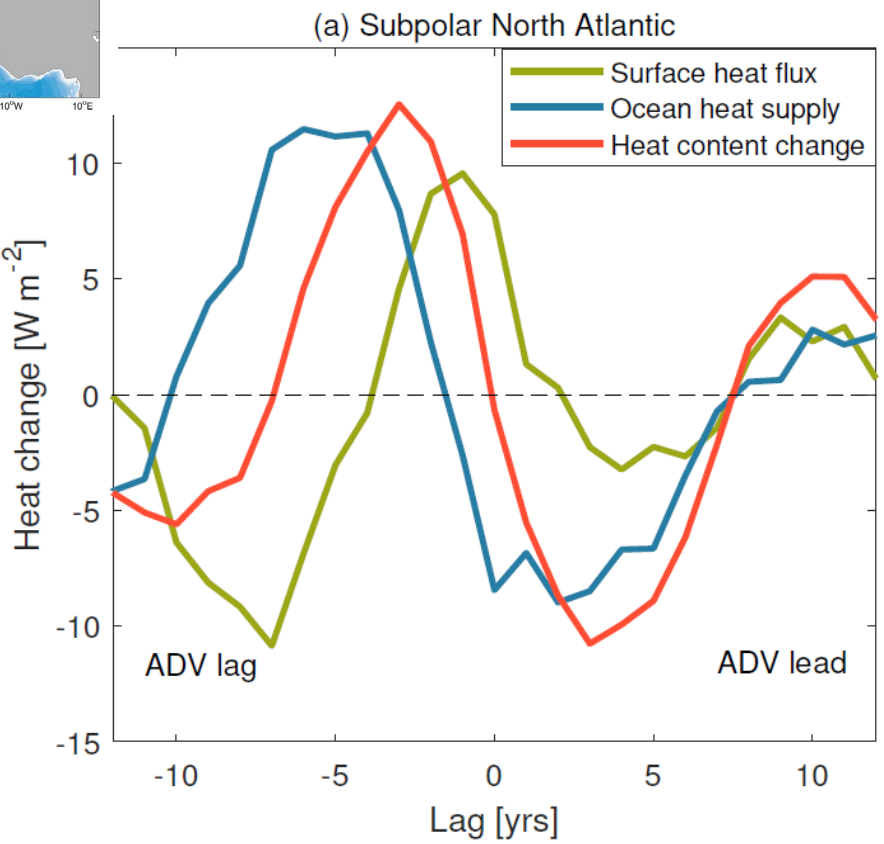
Forcing projects onto a combination of the NAO and EAP

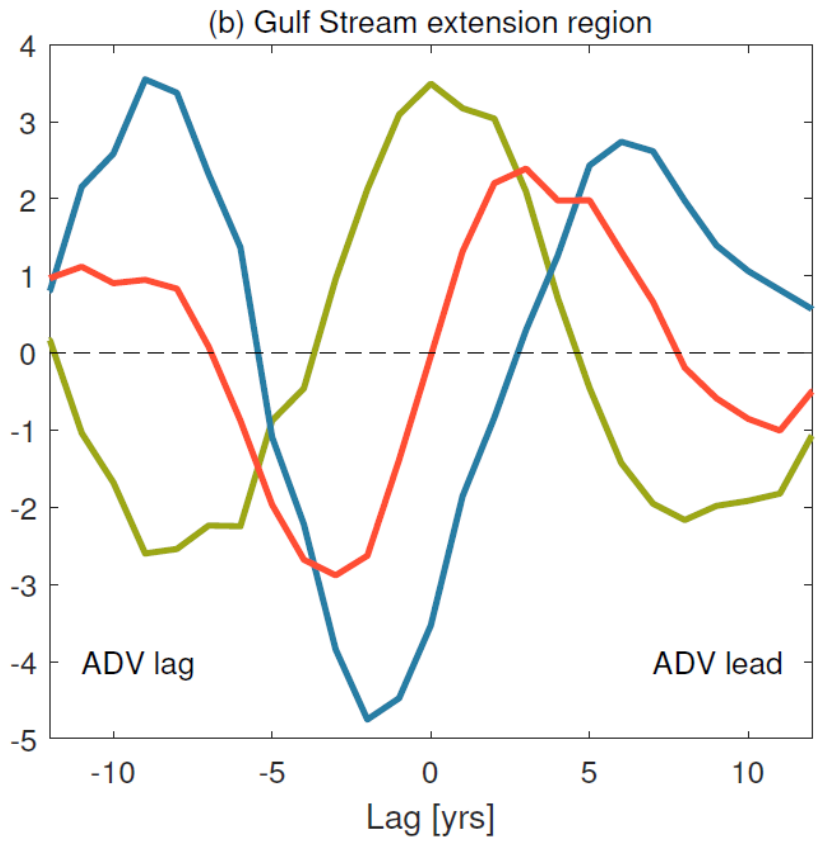
Response mainly captured by the EAP



Upper-ocean (0-744m) heat budget

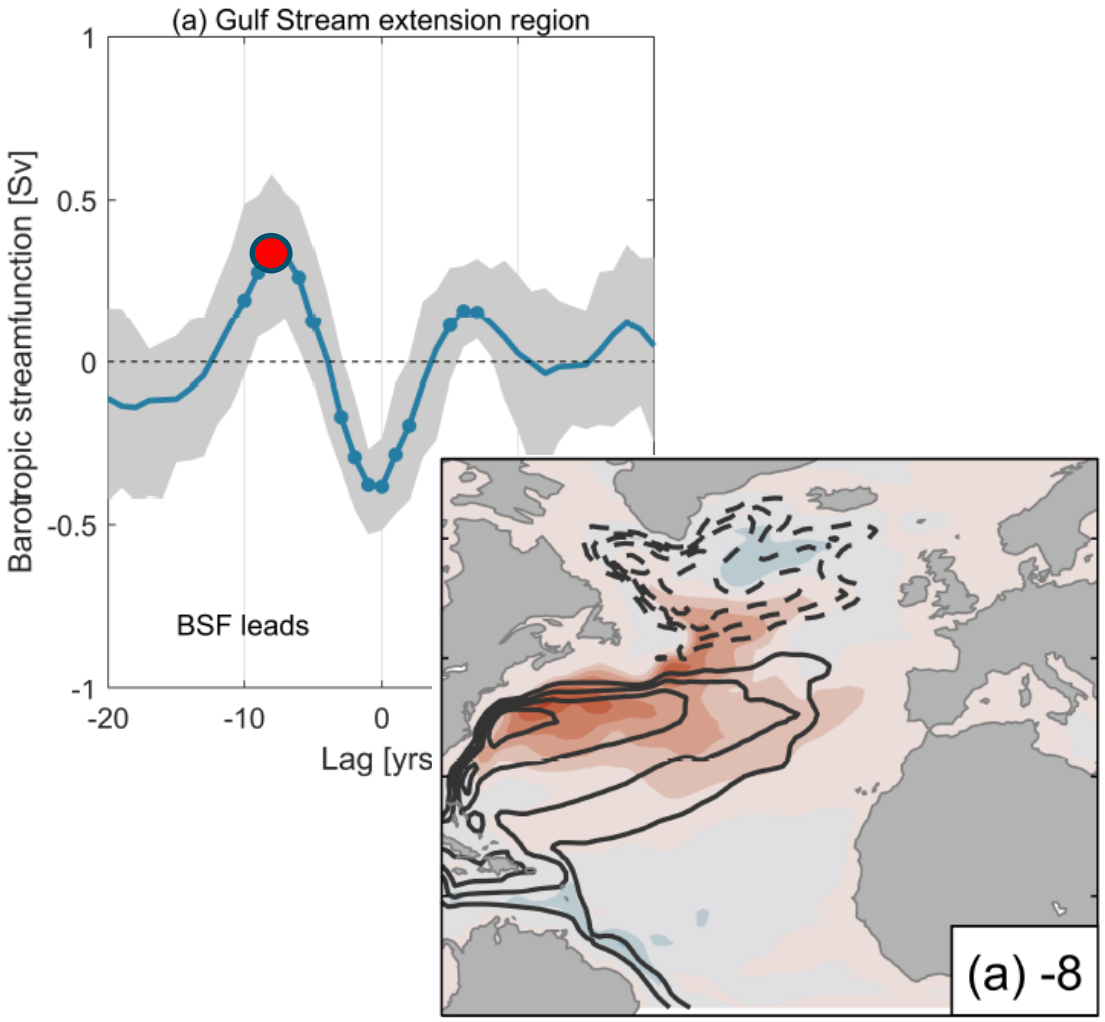




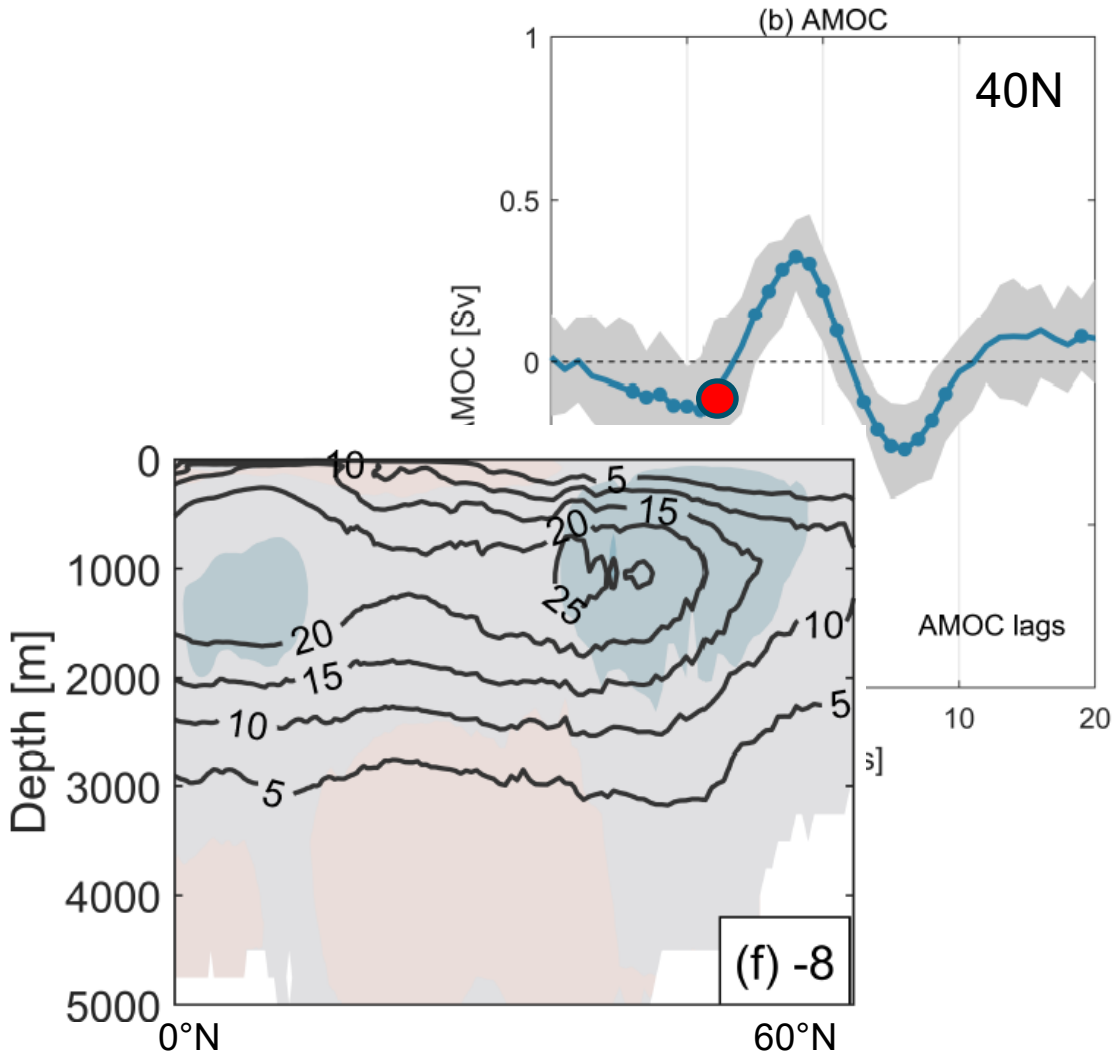


Ocean heat transport convergence is the dominant term in the upper-ocean heat budgets
More detailed CESM heat budgets: Gervais et al. (2018), Yeager et al. (2020)

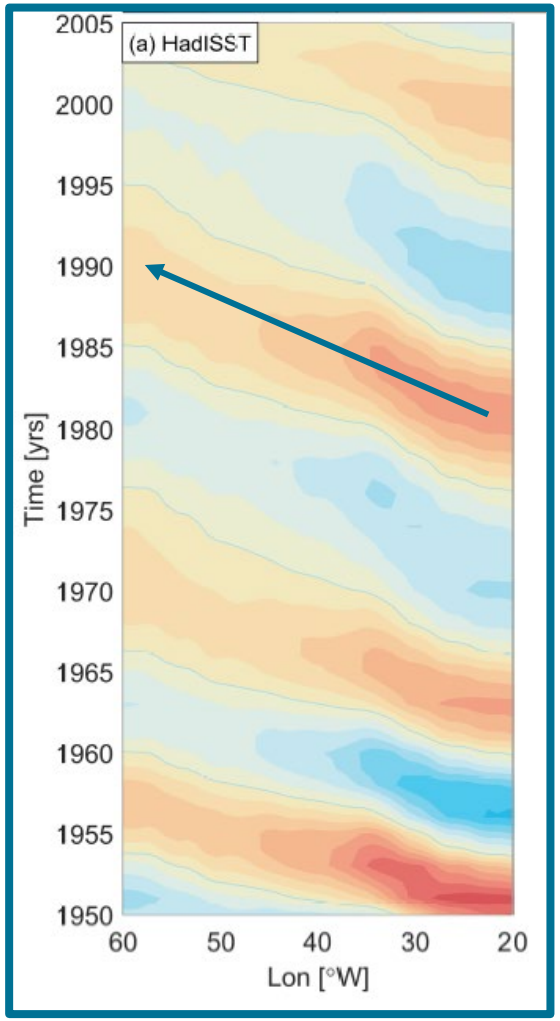
Barotropic streamfunction



Meridional overturning circulation

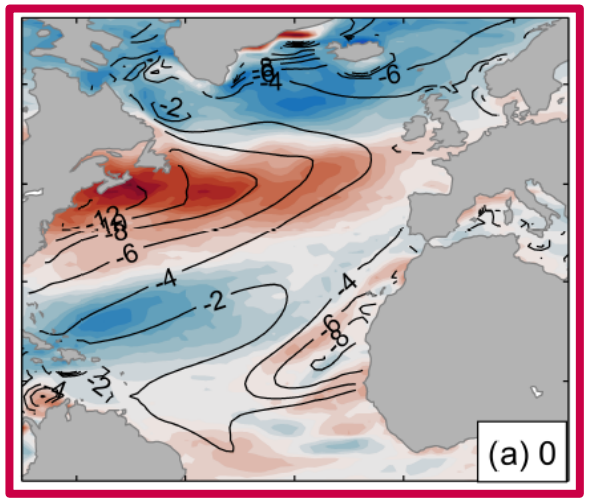


The paper also includes analysis showing that:

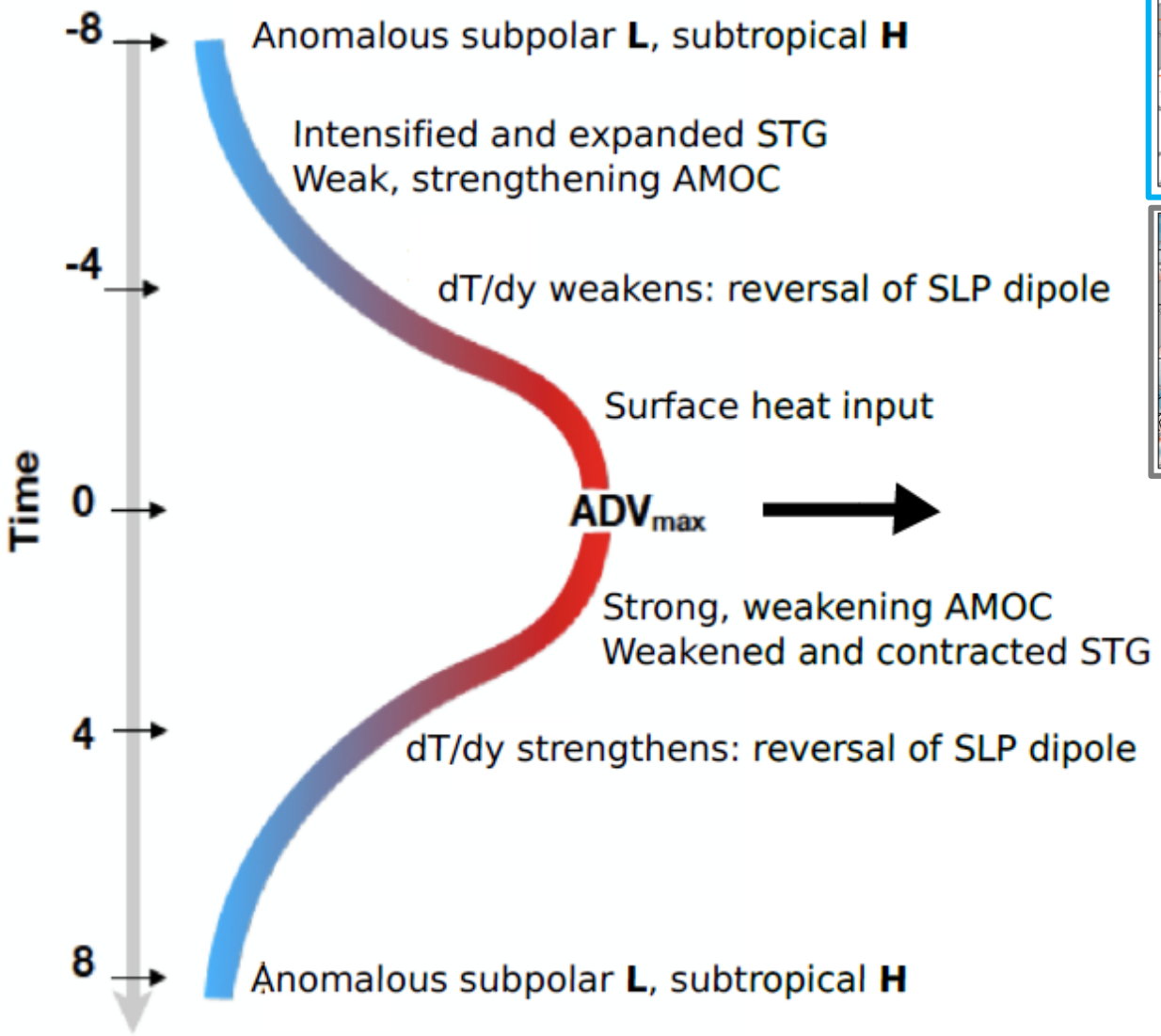


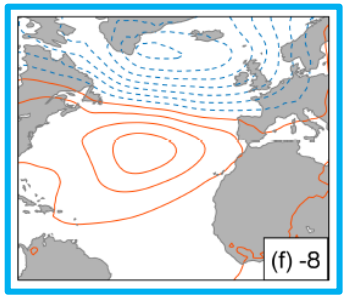
- The time scale of variability is consistent with wind-driven westward traveling Rossby waves in the North Atlantic.

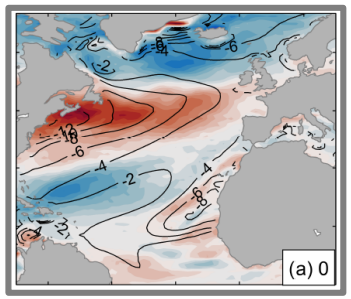
- Decadal SSTs impact atmospheric temperature gradient and zonal winds over the Gulf Stream region.

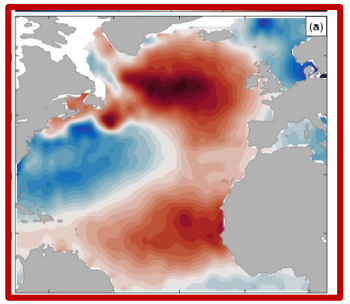


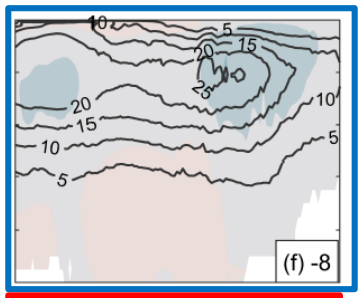
Atlantic Decadal Variability (ADV)

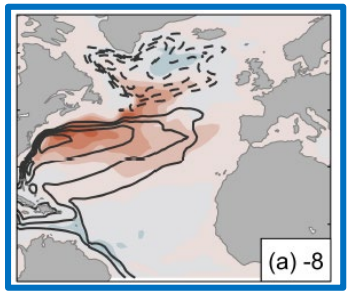


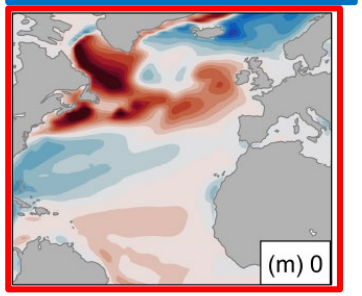




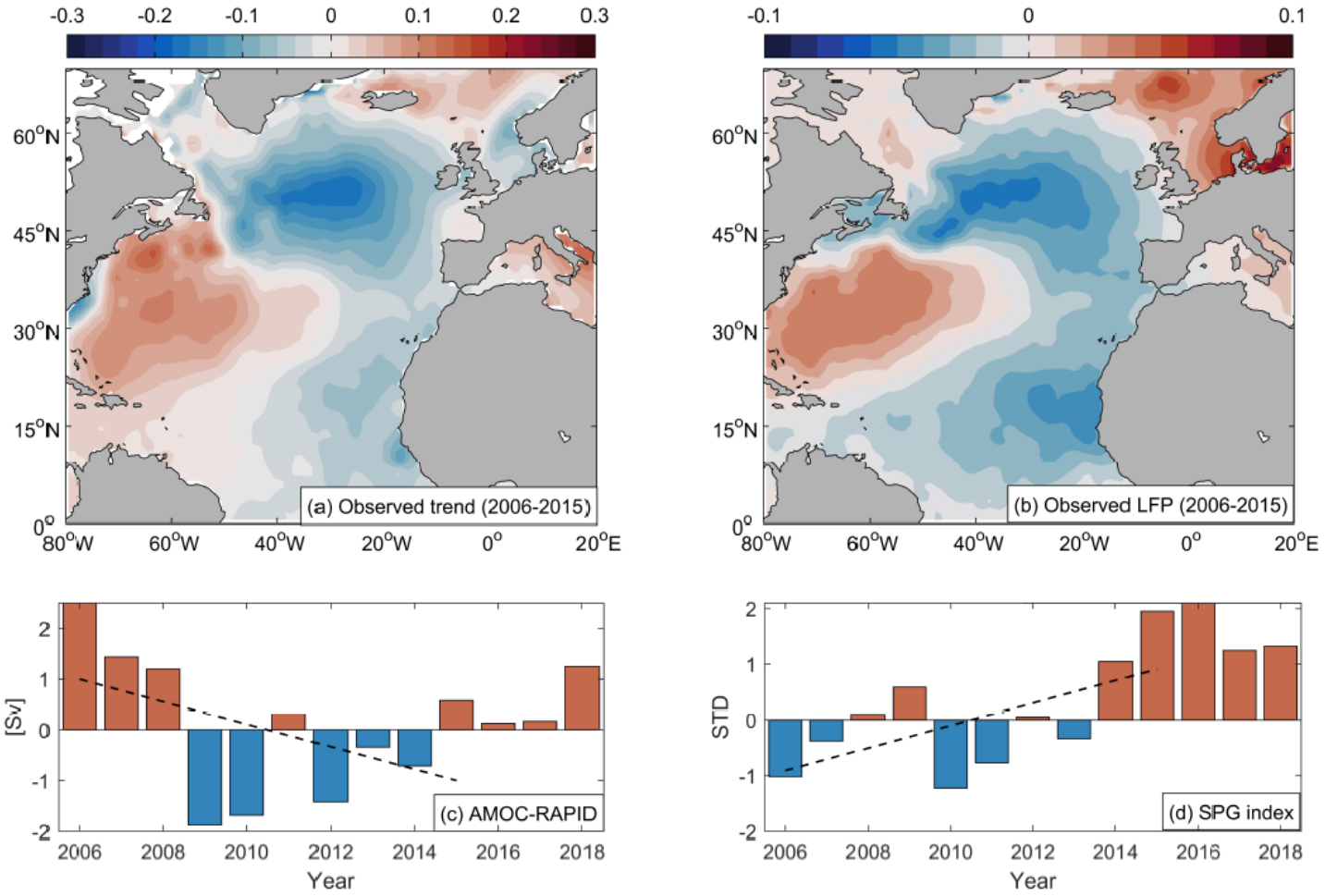








Implications for the recent North Atlantic cold anomaly



The recent cooling in the SPNA is consistent with the temporal development and spatial pattern of the ADV, suggesting that the recent observed cooling is, in part, related to decadal-scale SST variability.

THANK YOU!

Årthun et al. (2021). Mechanisms of decadal North Atlantic climate variability and implications for the recent cold anomaly. Journal of Climate.