What are the Dominant Atmospheric Patterns Responsible for Surface-forced Decadal Variability in the Atlantic Meridional Overturning Circulation?

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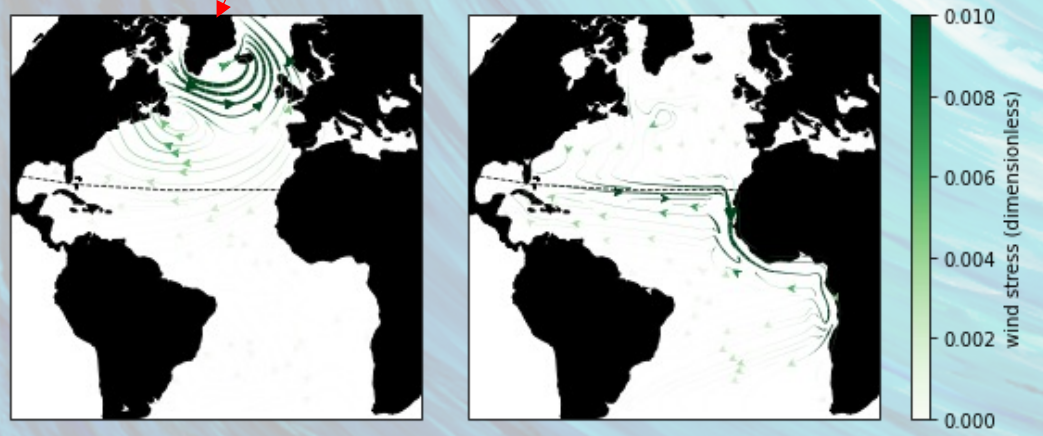
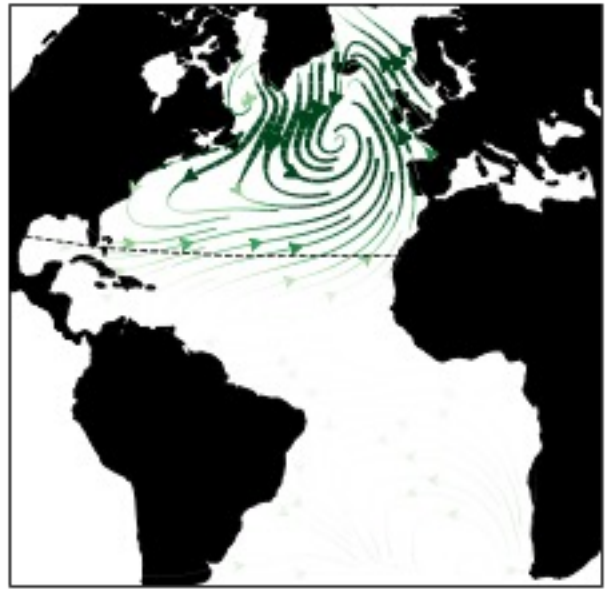
Motivation: origins and influence of decadal AMOC variability

- DV in AMOC influences climate variability; can mask anthropogenic warming signal
- Junction between high-frequency (e.g. wind) and low-frequency (e.g. buoyancy) influences
- Untangling influences using a causes-first (EOF) or effects-first (SO) approach produces different results

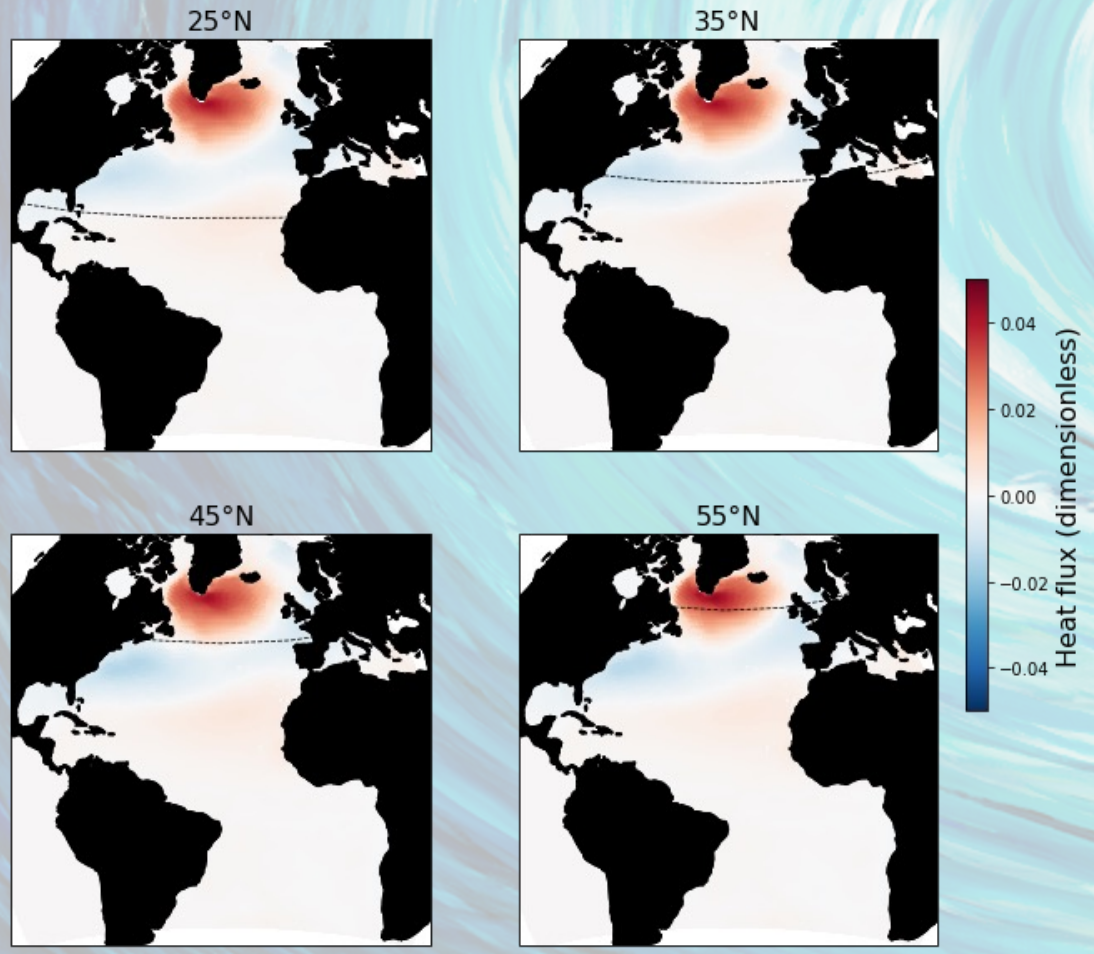


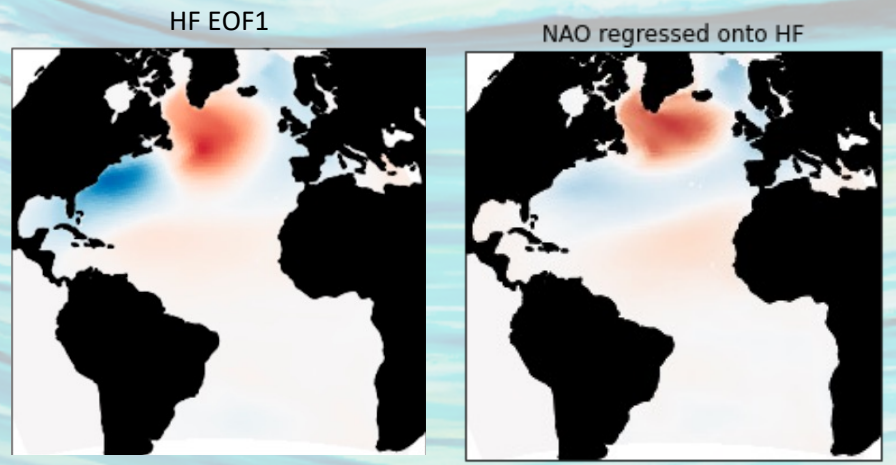
New framework:
dynamics-weighted PCA
(Amrhein and Stephenson, *in prep.*)
Forcing modes that maximize variability



What are the dominant atmospheric patterns responsible for surface-forced decadal AMOC variability?

Heat flux patterns (four latitudes):

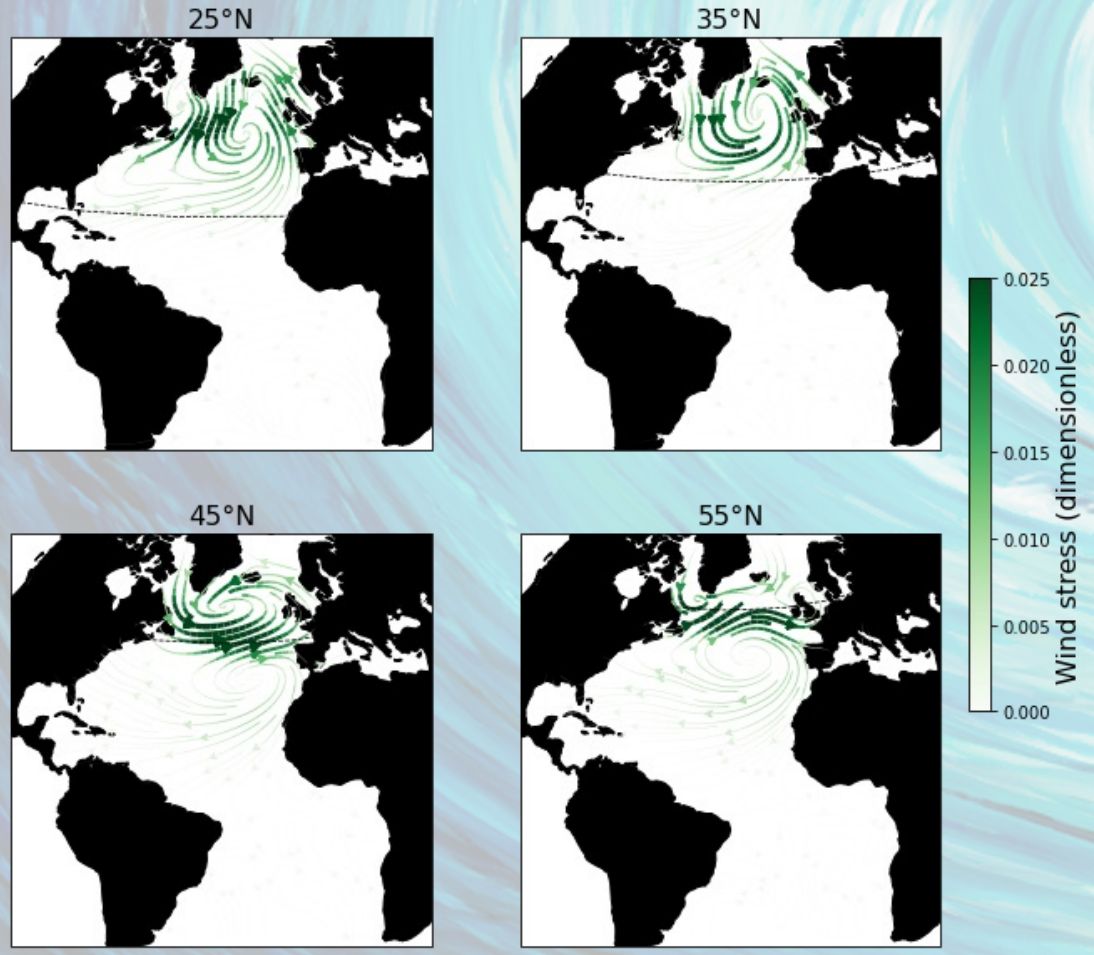




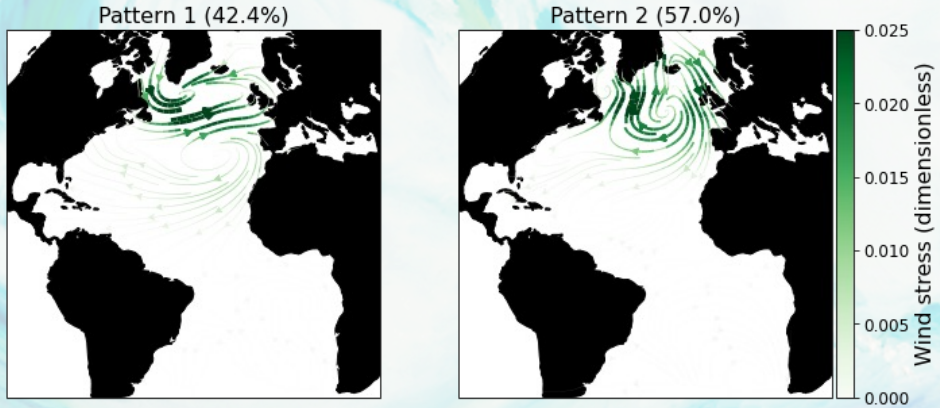
- Leading pattern is almost identical at all four latitudes (>99% agreement)
- Again, structurally different from leading EOF pattern
- … but highly similar to the heat flux signature of NAO (>90% agreement)

What are the dominant atmospheric patterns responsible for surface-forced decadal AMOC variability?

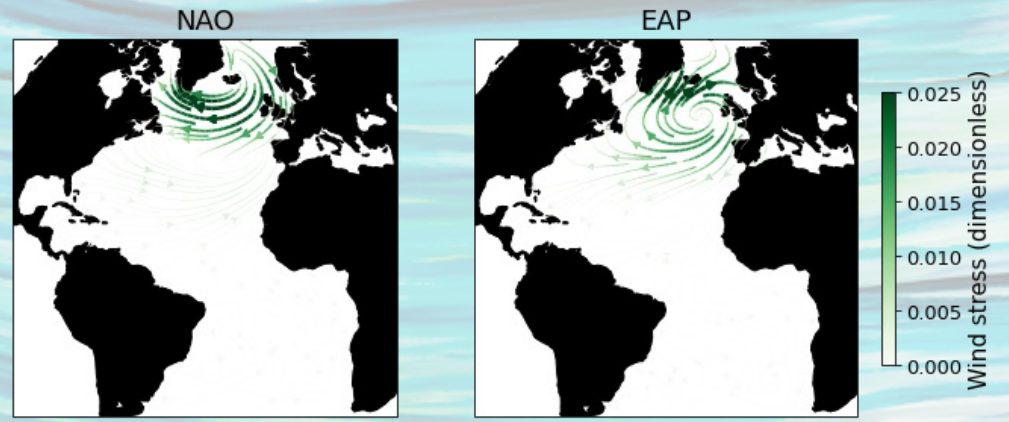
Wind stress patterns (four latitudes):



- Substantially different between AMOC latitudes
- But can be >99% explained by a subpolar pattern (1) and a subtropical pattern (2)

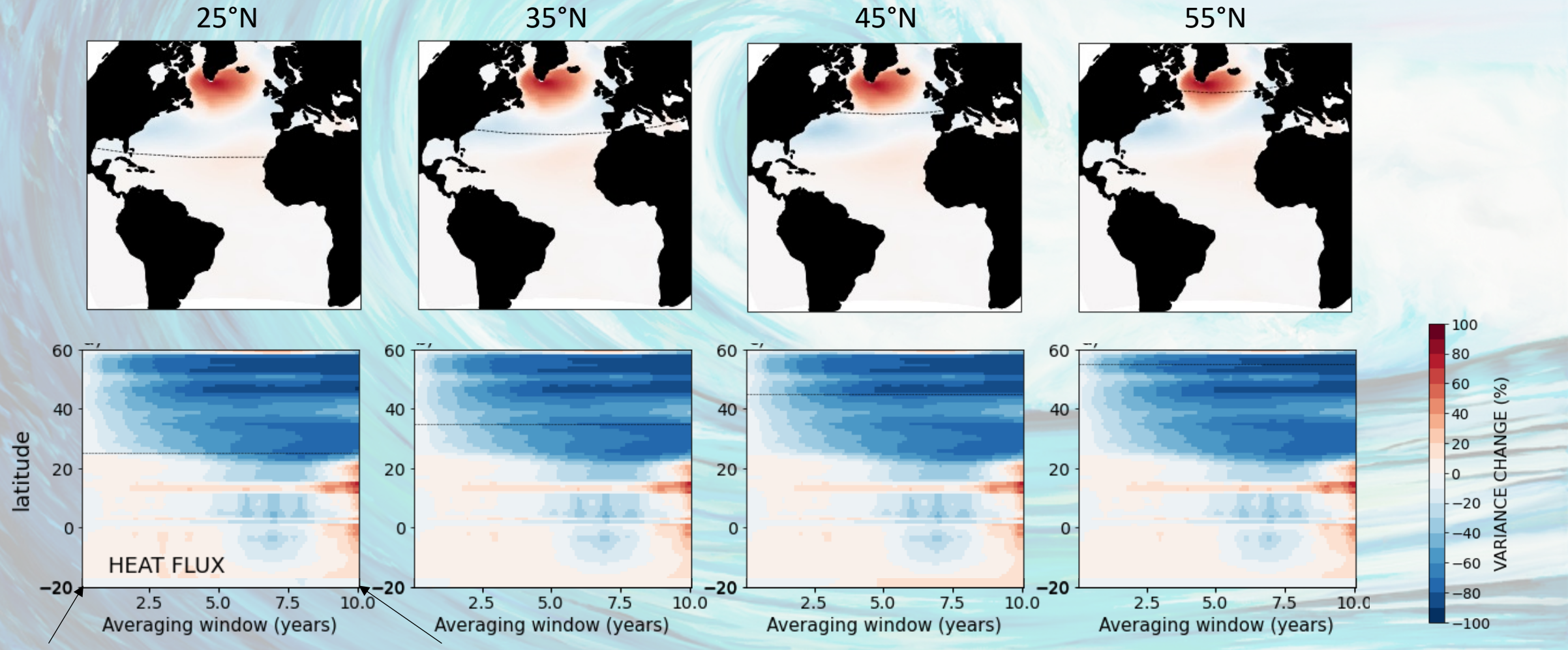


Qualitative similarities to the NAO and EAP:



How much AMOC variability do these patterns explain?

- We compare AMOC variability on different time-scales in ECCOv4r4 with and without these forcing patterns
- Up to 90% change in variance at the decadal time scale (vs. <30% with the first EOF)



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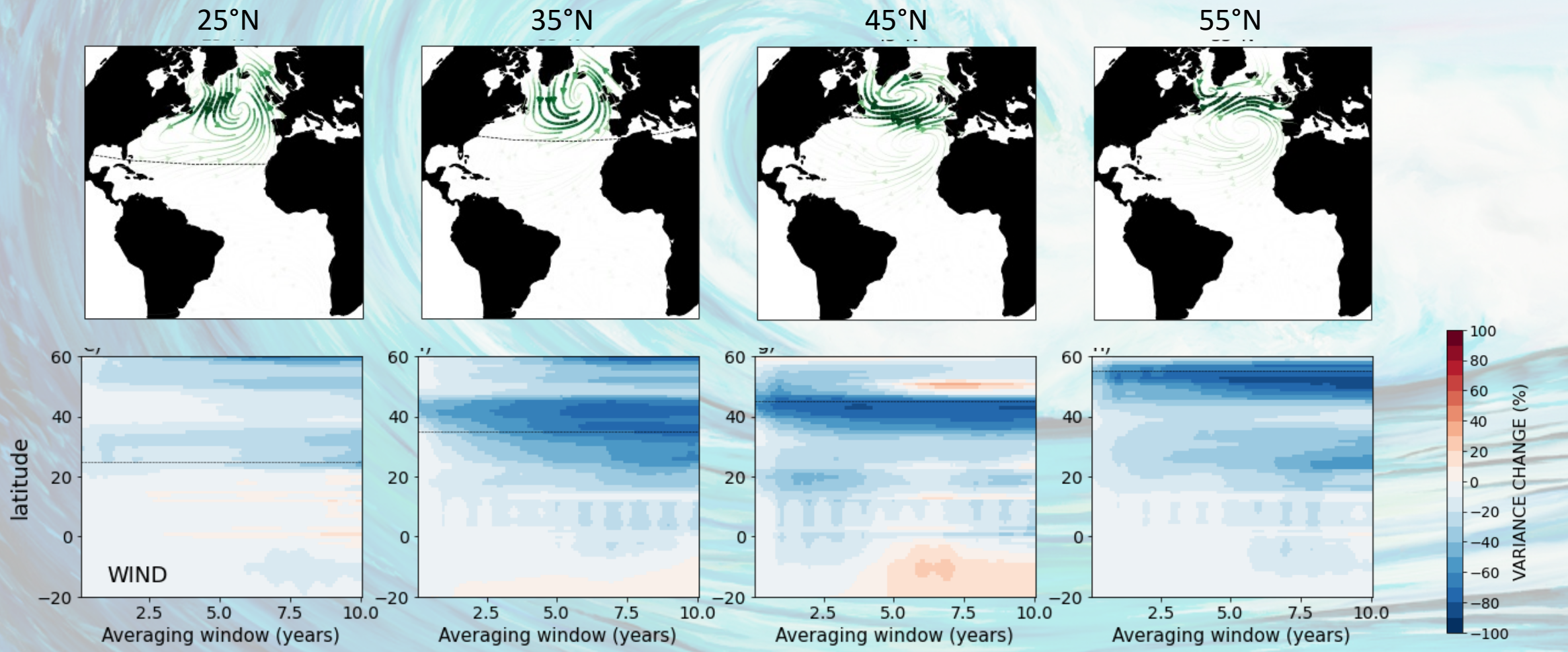
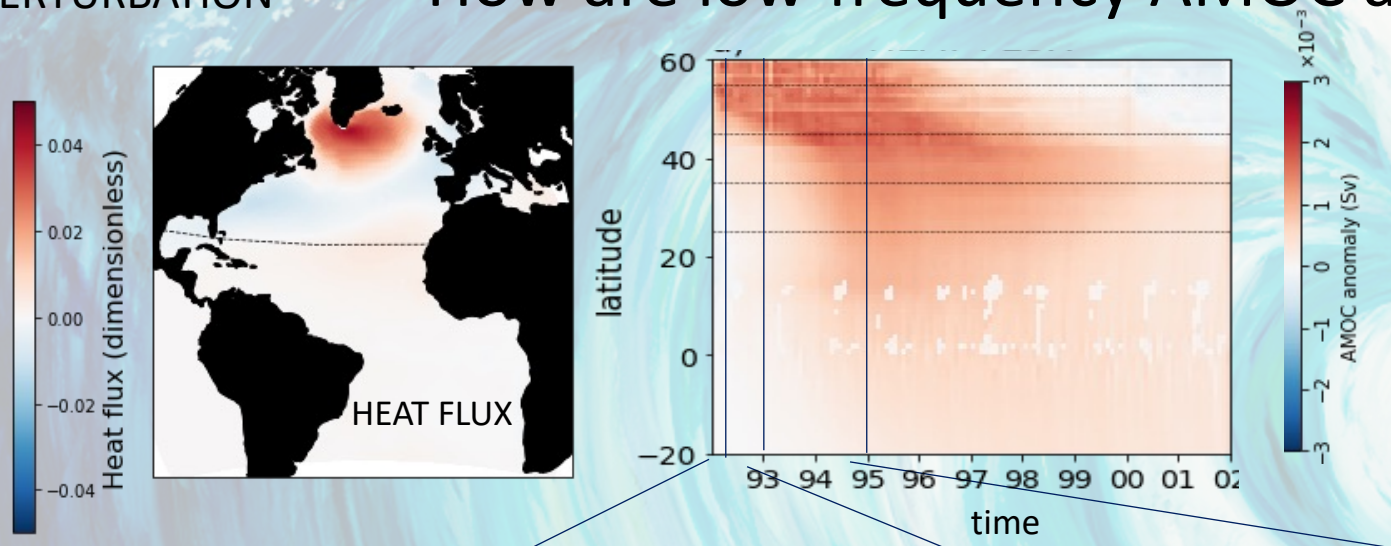
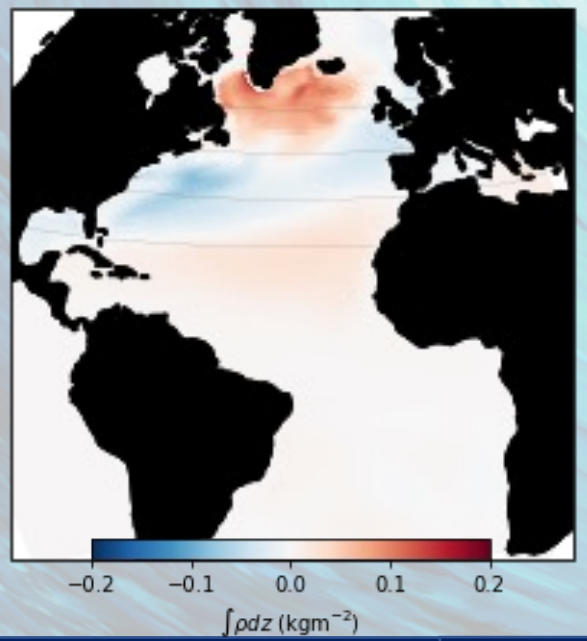


PERTURBATION

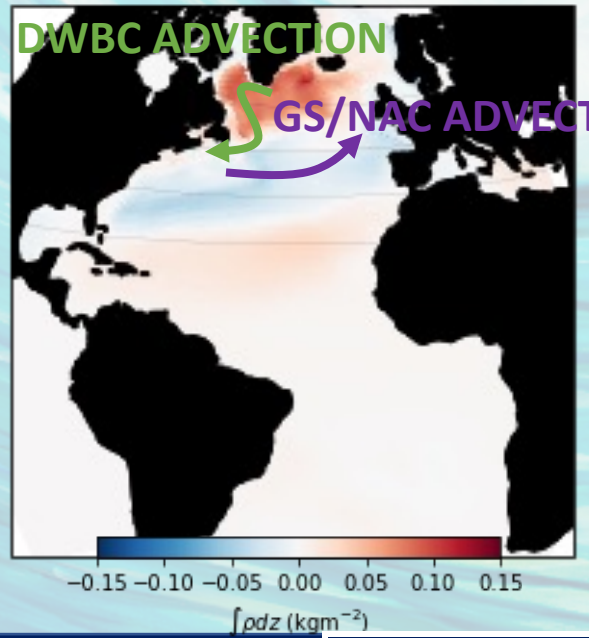
How are low-frequency AMOC anomalies established?



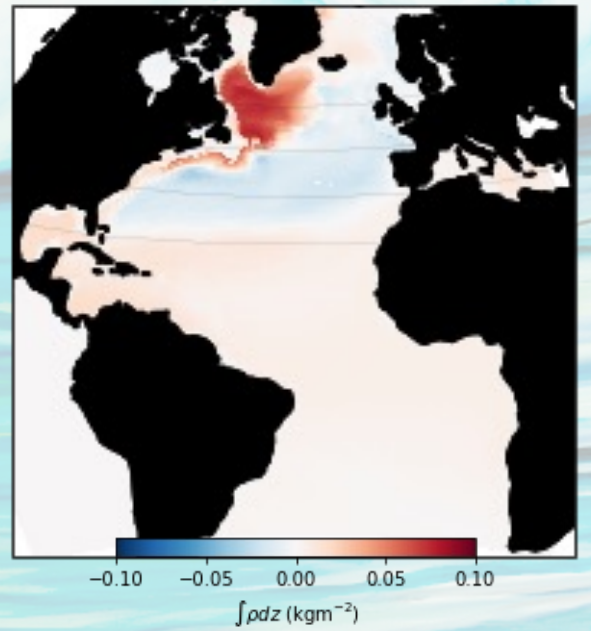
3 MONTHS



1 YEAR



3 YEARS



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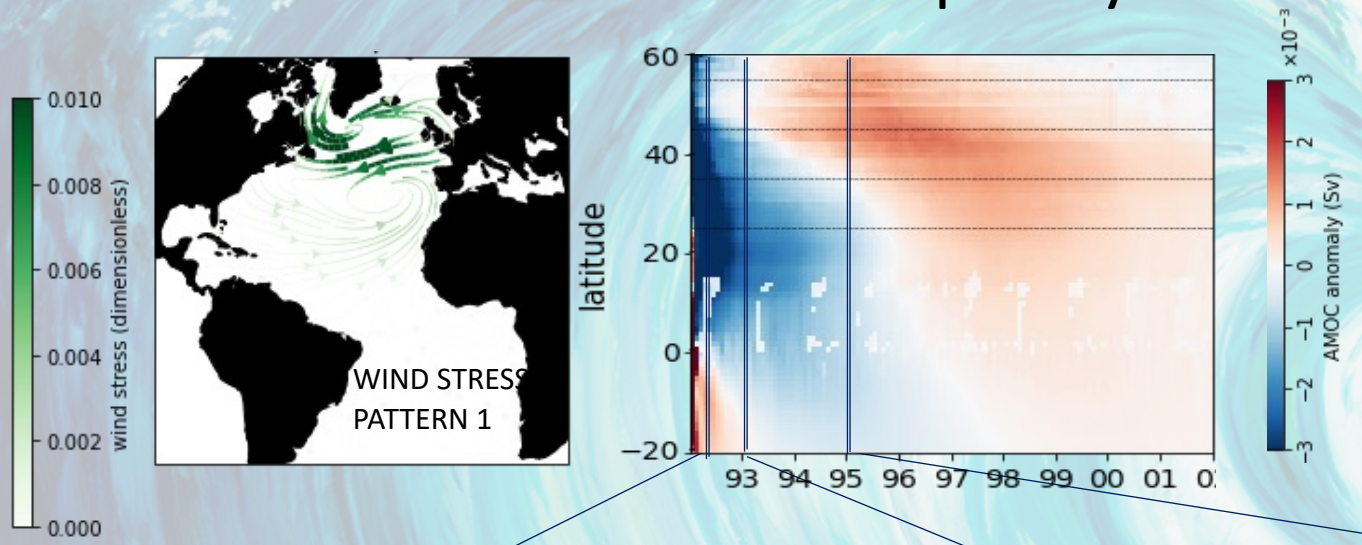

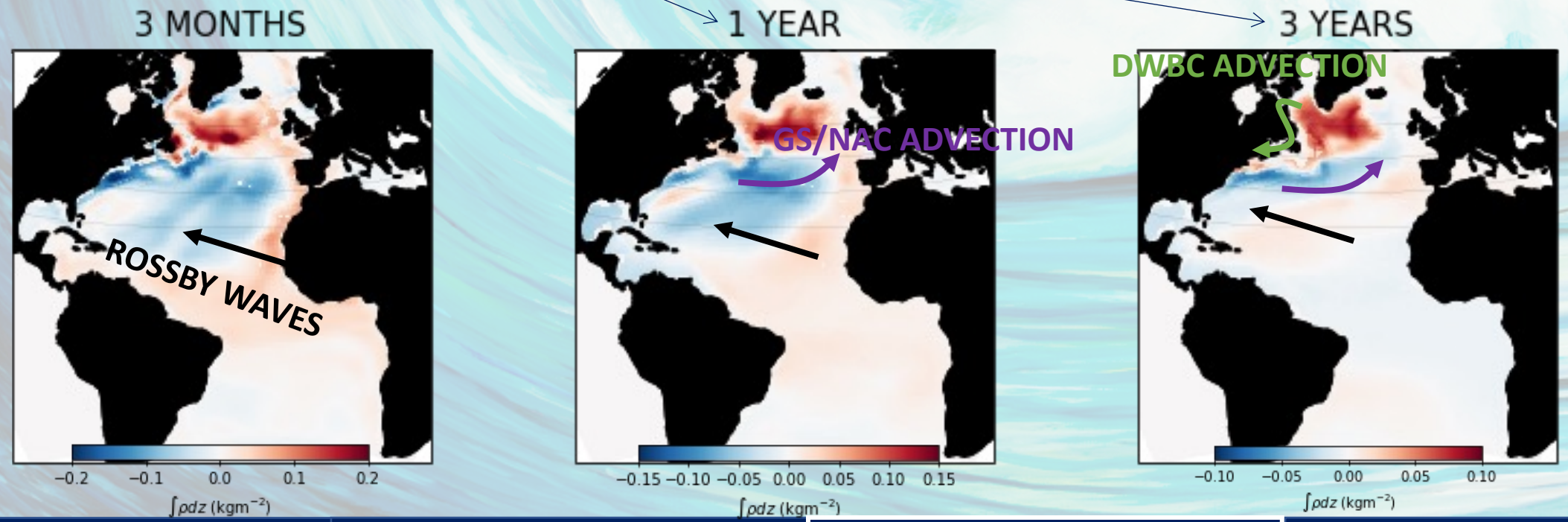

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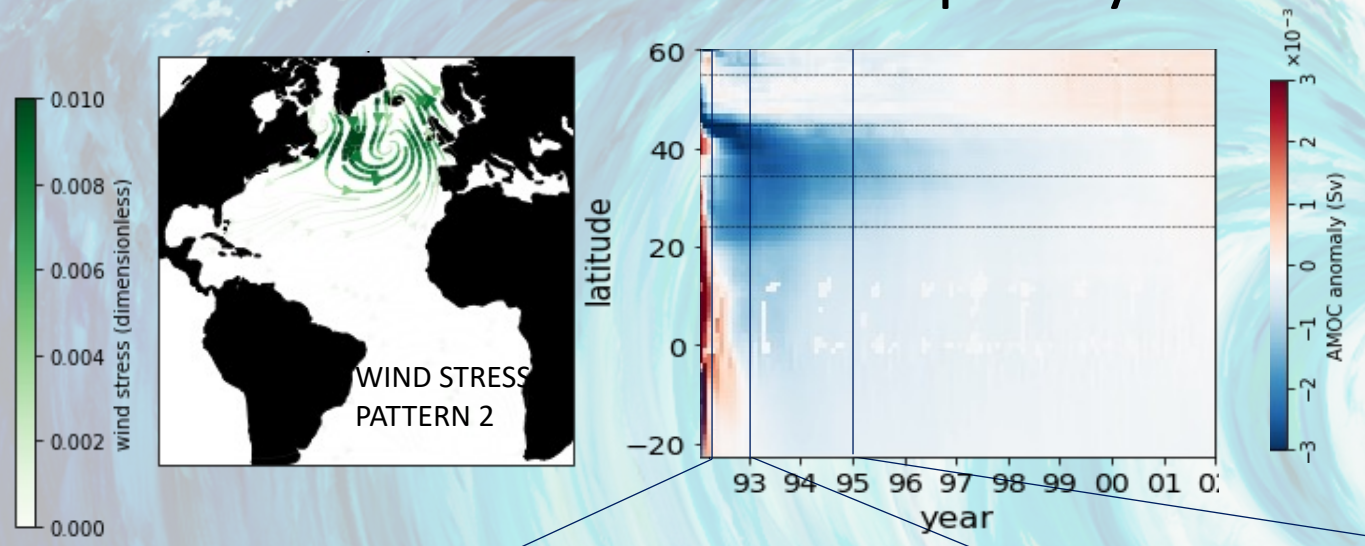
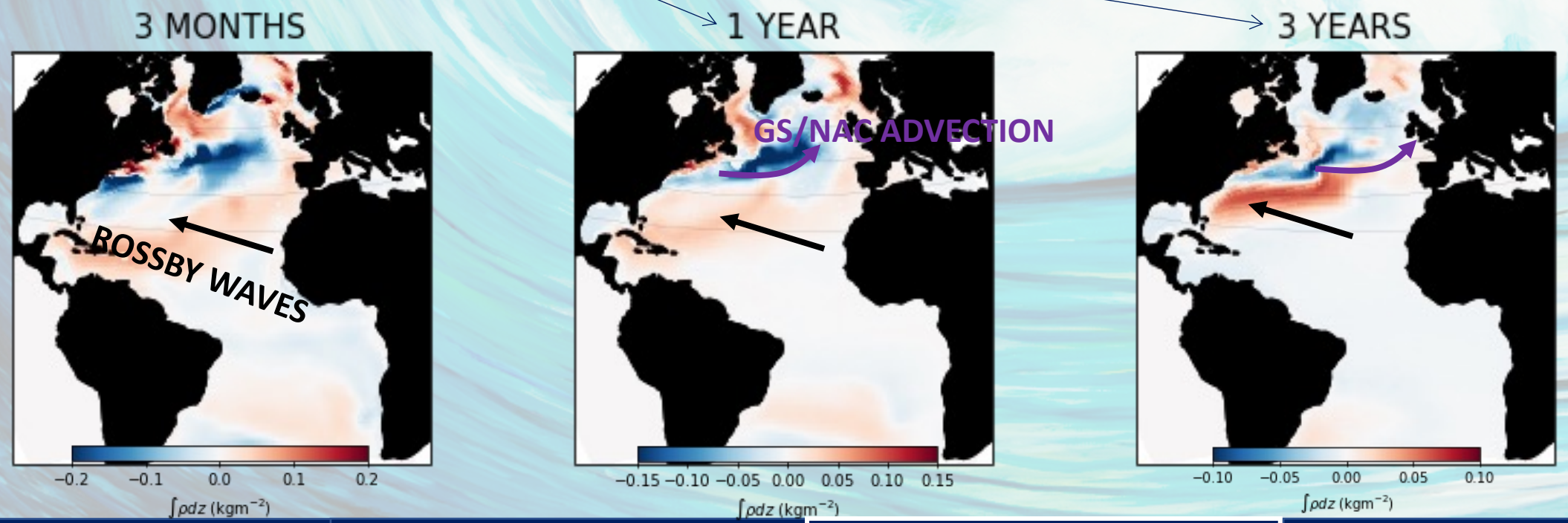
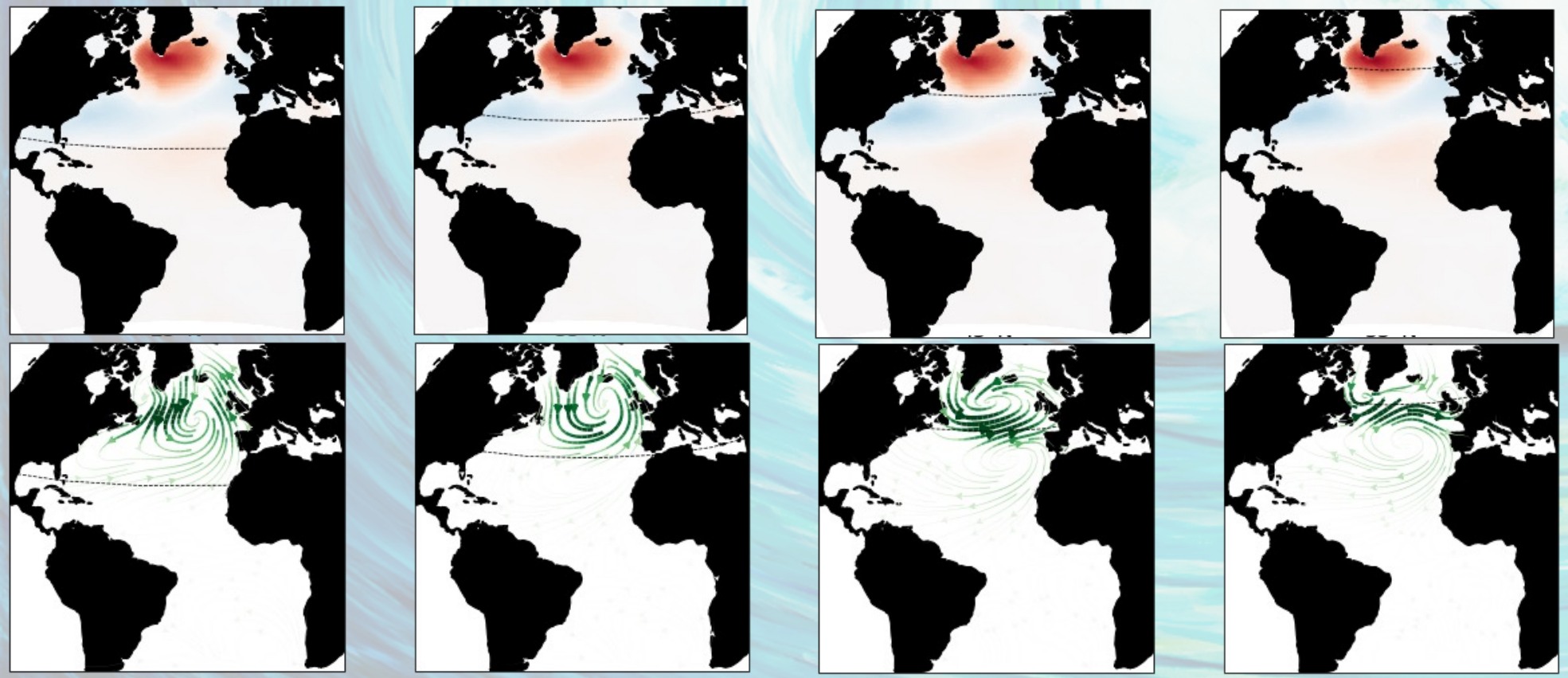




Conclusions

- New framework for finding dominant atmospheric forcing contributions to ocean variability
- For decadal AMOC, dominant heat flux patterns are consistent between latitudes, resemble NAO
- Corresponding wind patterns vary between latitudes, but have an EAP-like (subtropics) and NAO-like (subpolar) component
- Removing these patterns reduces AMOC variability at decadal time-scales by up to 90% through a combination of slow responses

25°N 35°N 45°N 55°N



Papers in prep:
- Amrhein & Stephenson (Methods)
- Stephenson et al. (AMOC results)