Mechanisms of the North Atlantic internal variability at multidecadal timescale in the CNRM-CM5 model

Yohan Ruprich-Robert and Christophe Cassou

Outline

Study the North Atlantic internal variability with the Pre-industrial control run of CNRM-CM5

1) Characteristics of the CNRM-CM5 AMV

2) Link between AMV and AMOC

3) Mechanism leading to AMV/AMOC variability

4) Importance of the SPG (?)

5) Conclusion

Outline

1) **Characteristics of the CNRM-CM5 AMV**

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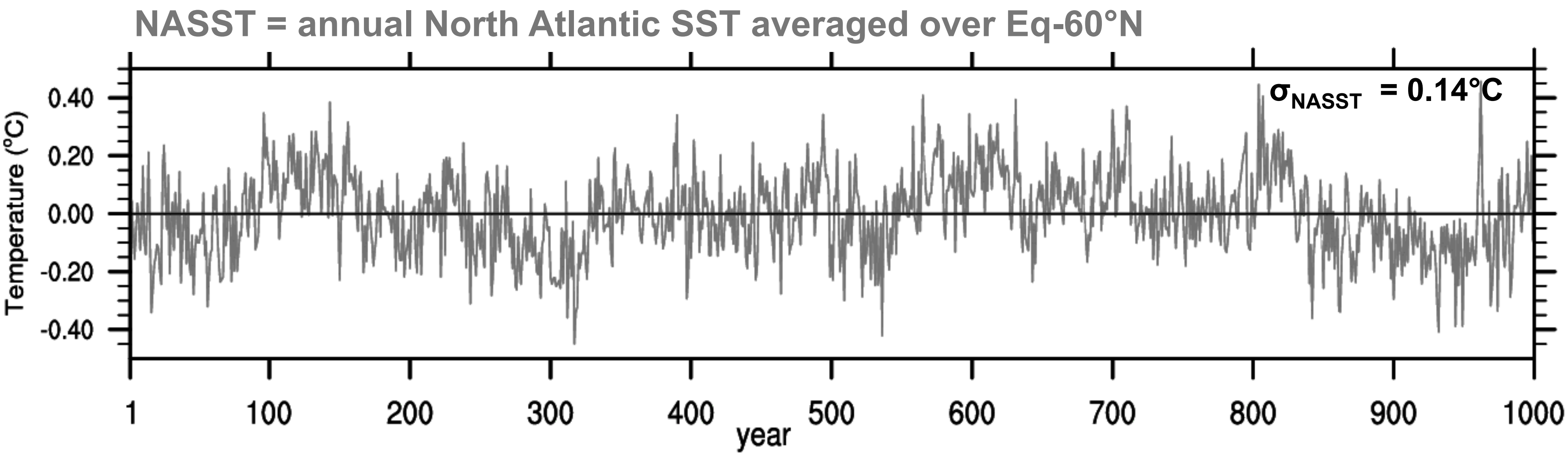
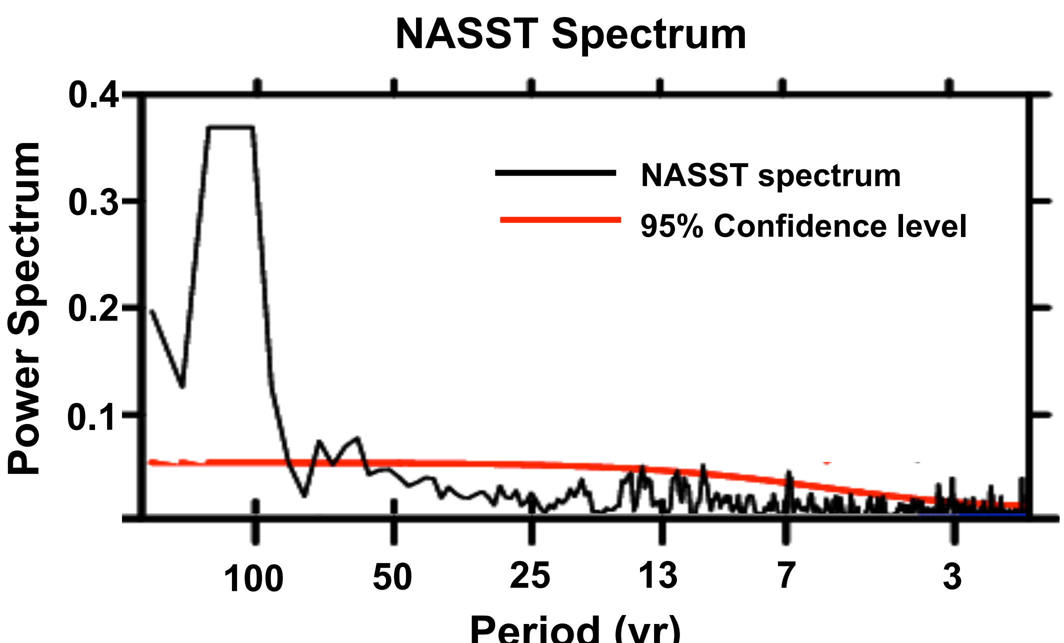
The AMV in CNRM-CM5
(Atlantic Multidecadal Variability)





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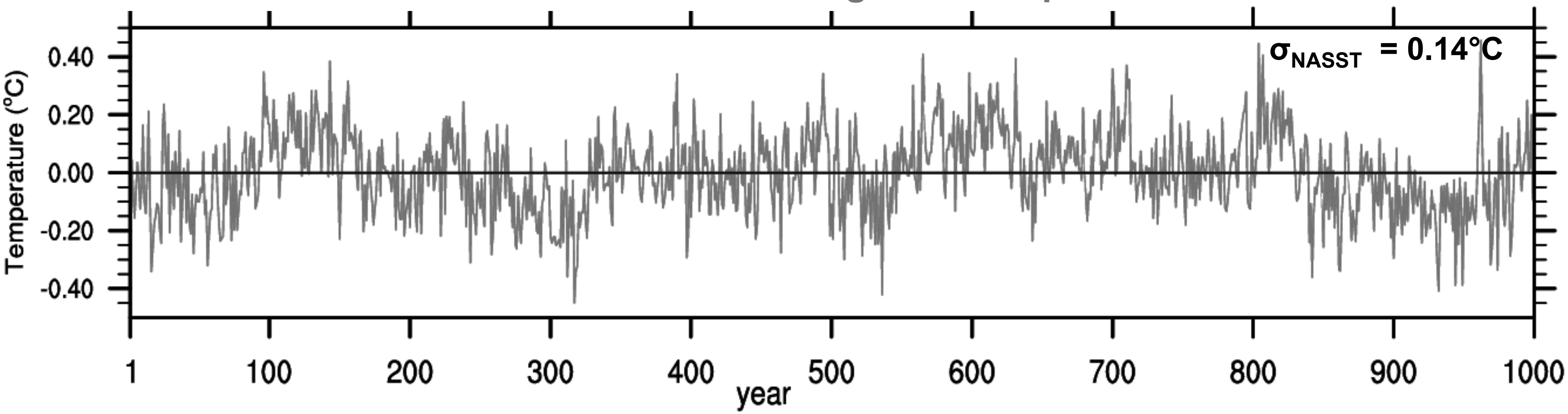
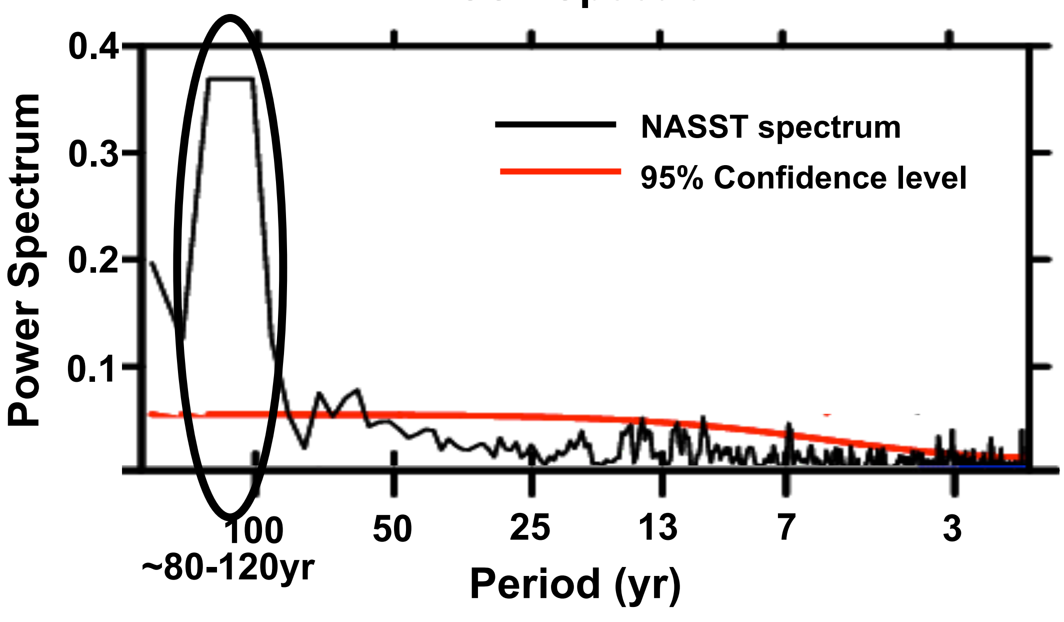
NASST = annual North Atlantic SST averaged over Eq-60°N



NASST Spectrum



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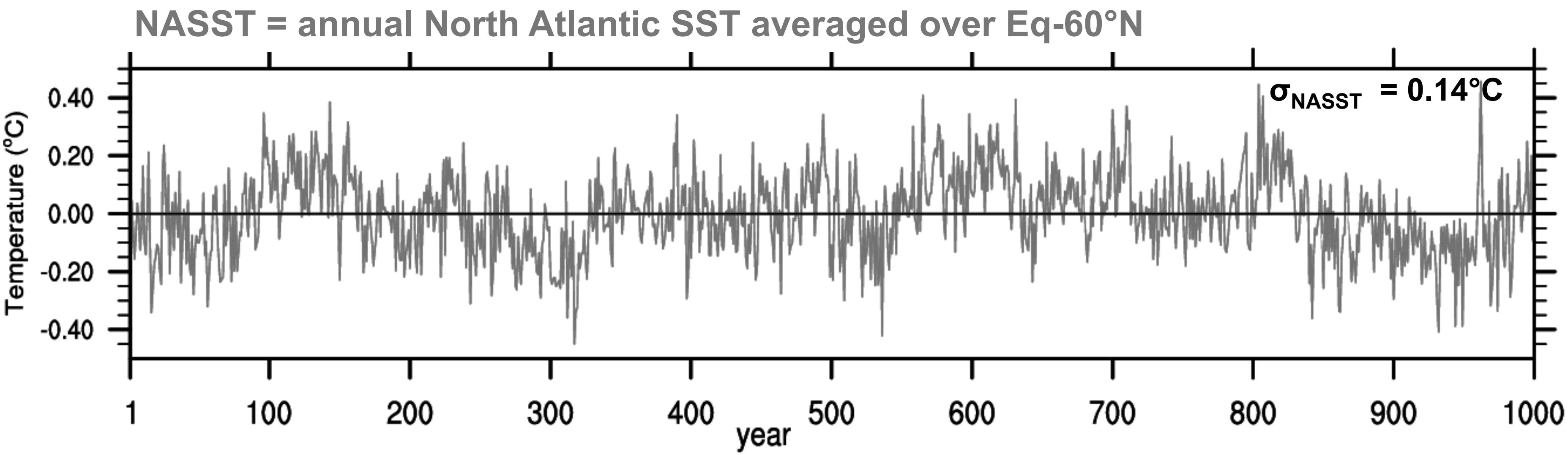

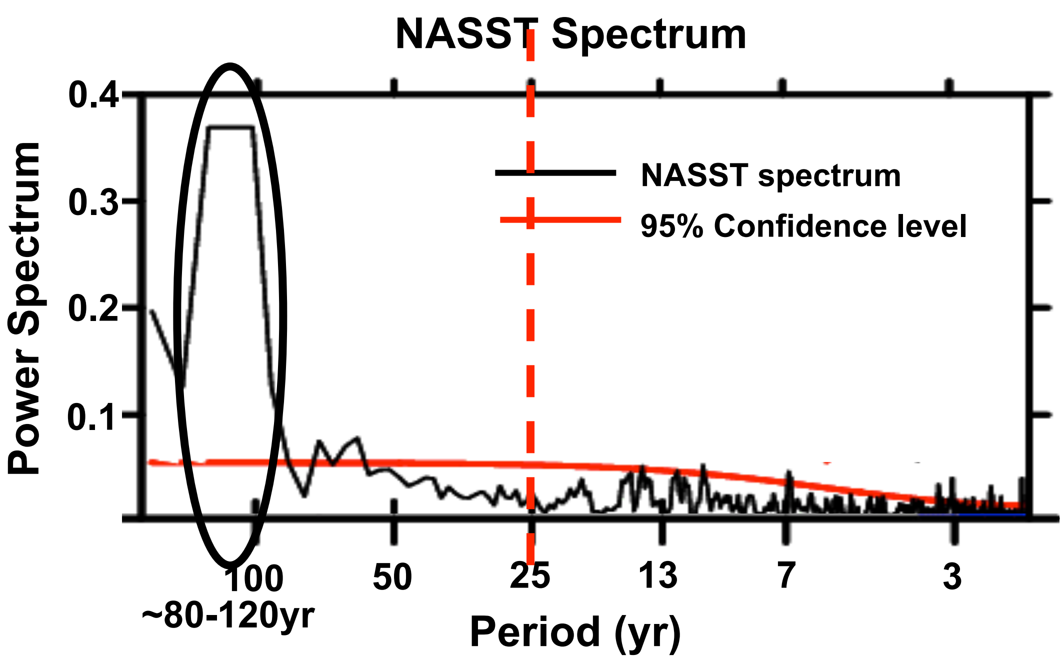

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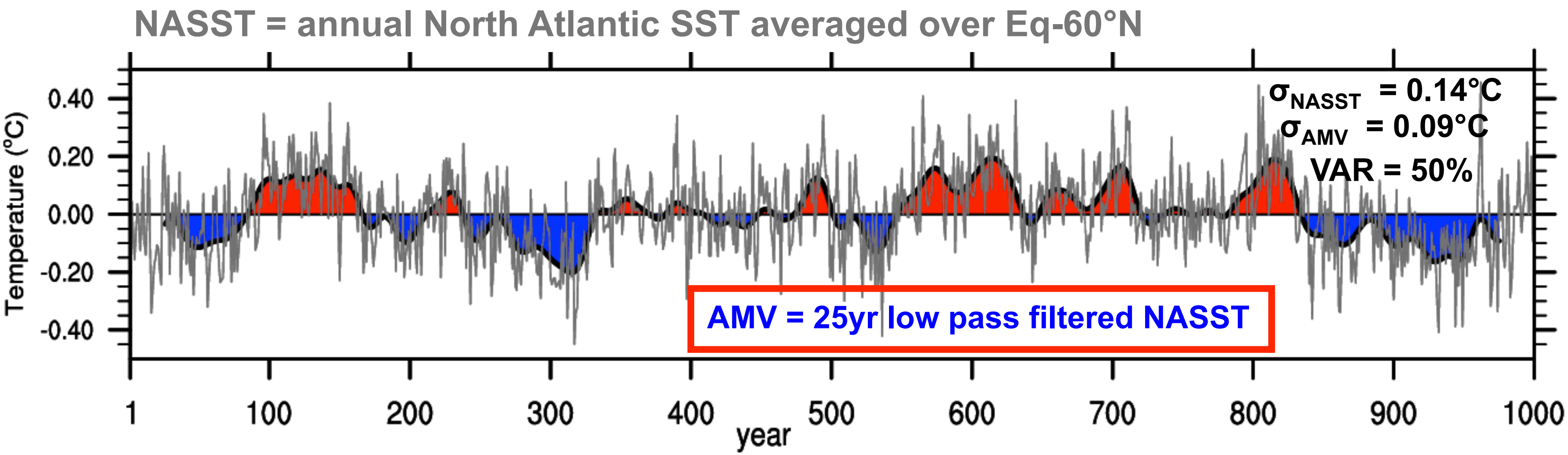

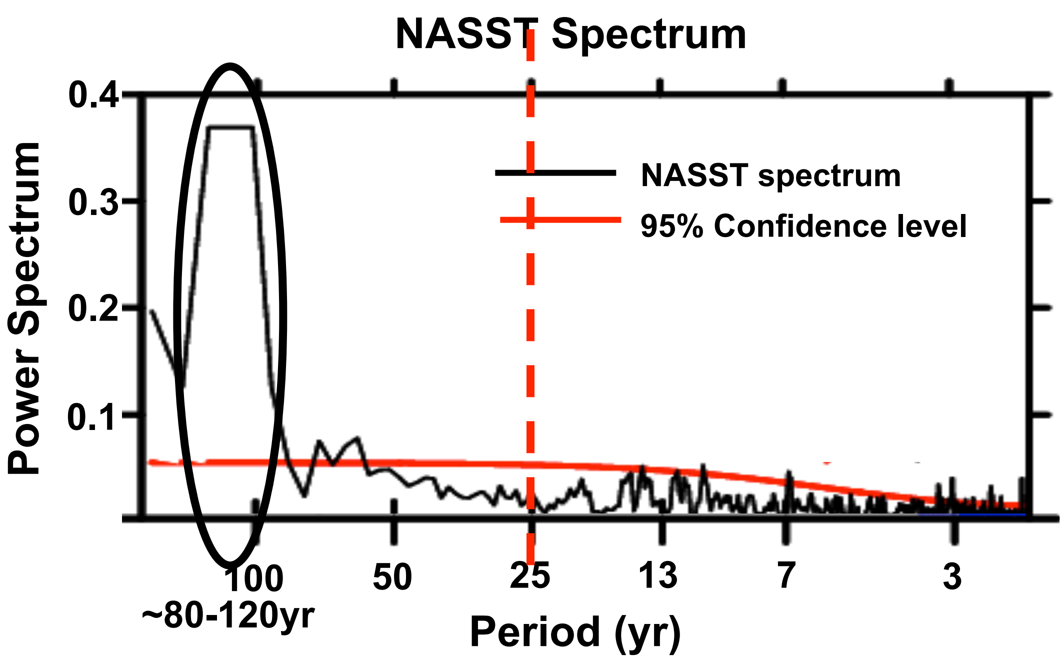

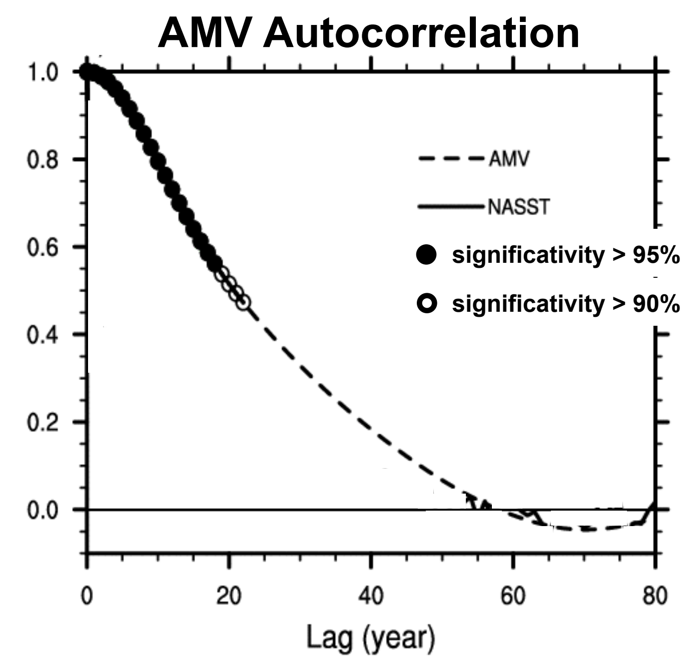

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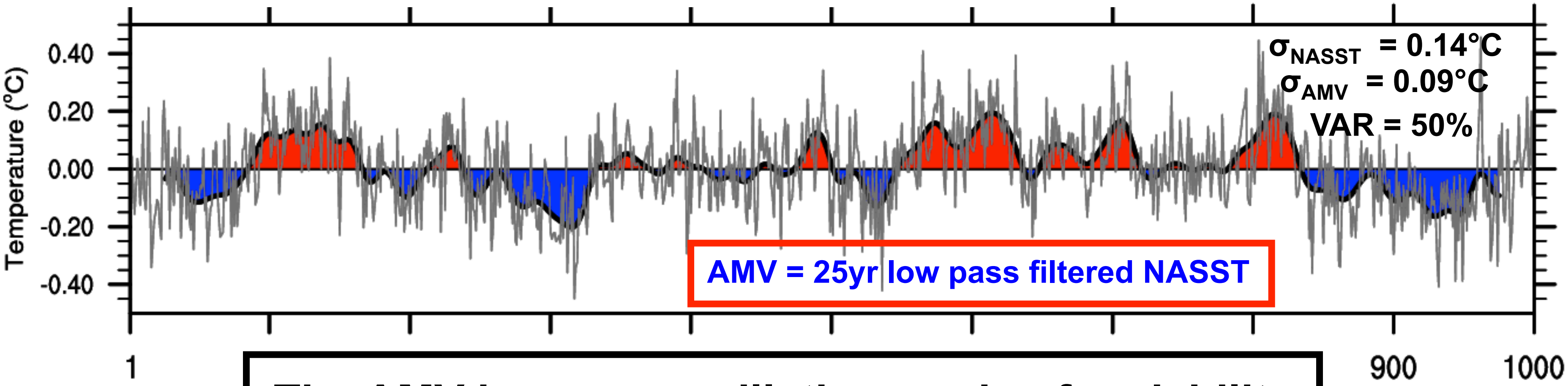
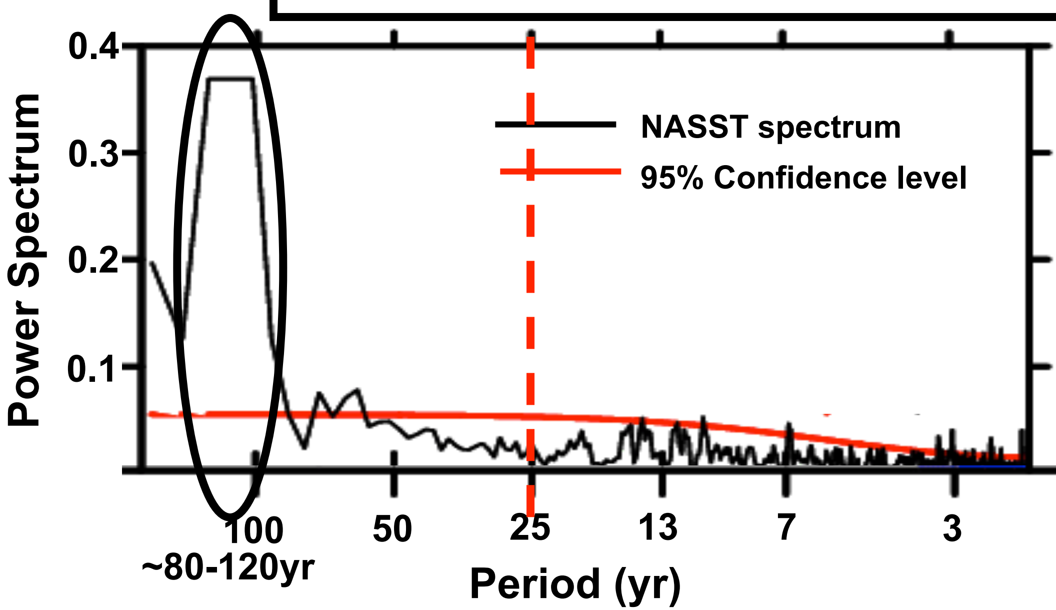
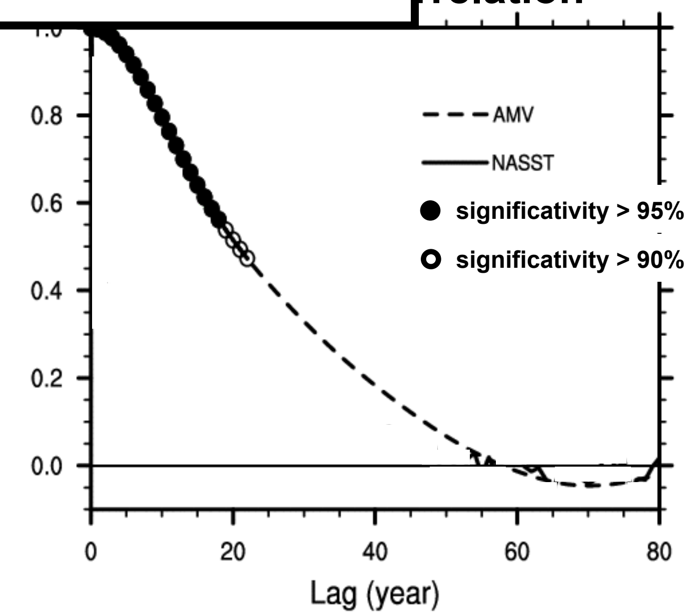


The AMV is a non oscillating mode of variability at multidecadal to centennial timescale





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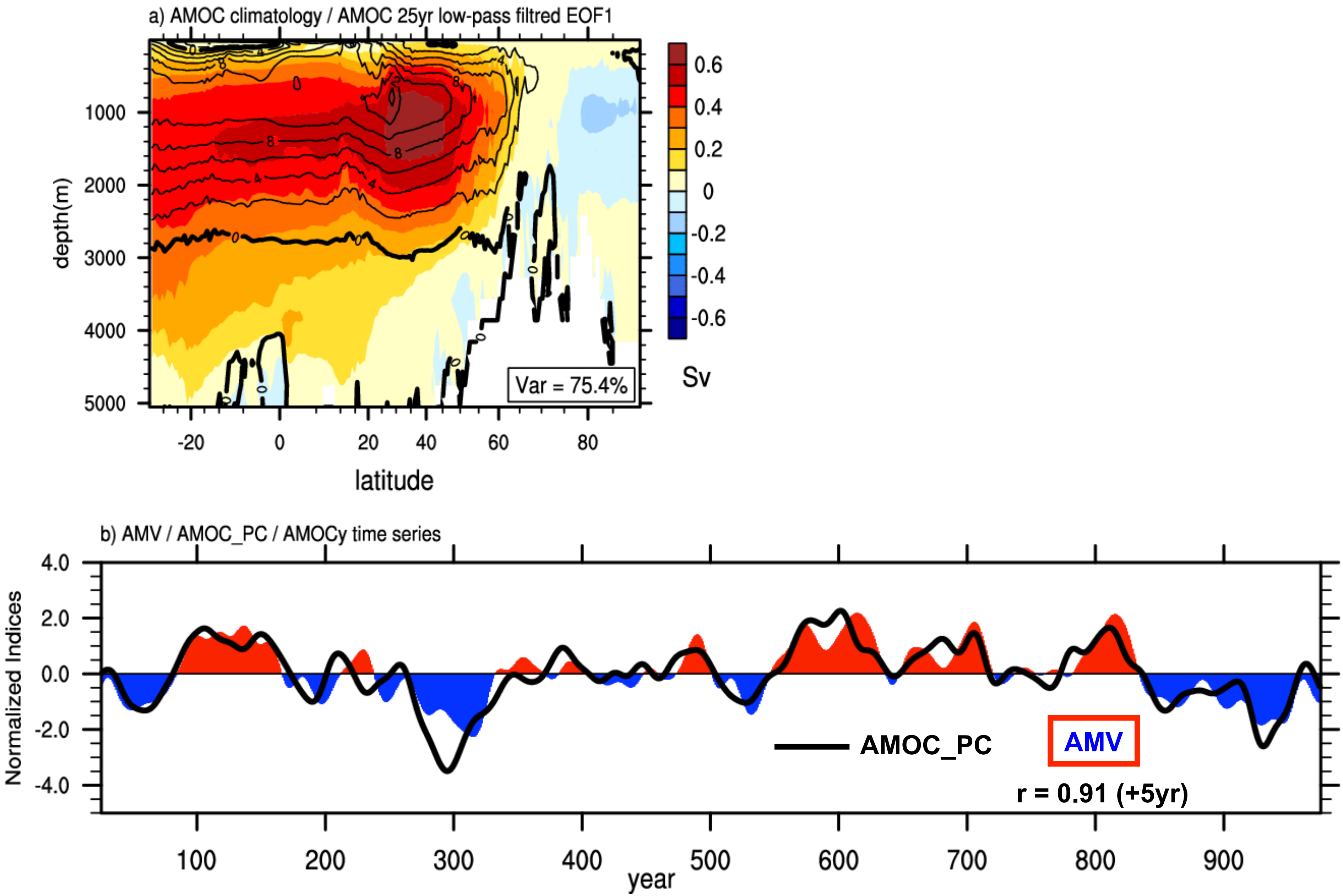
AMV / AMOC links



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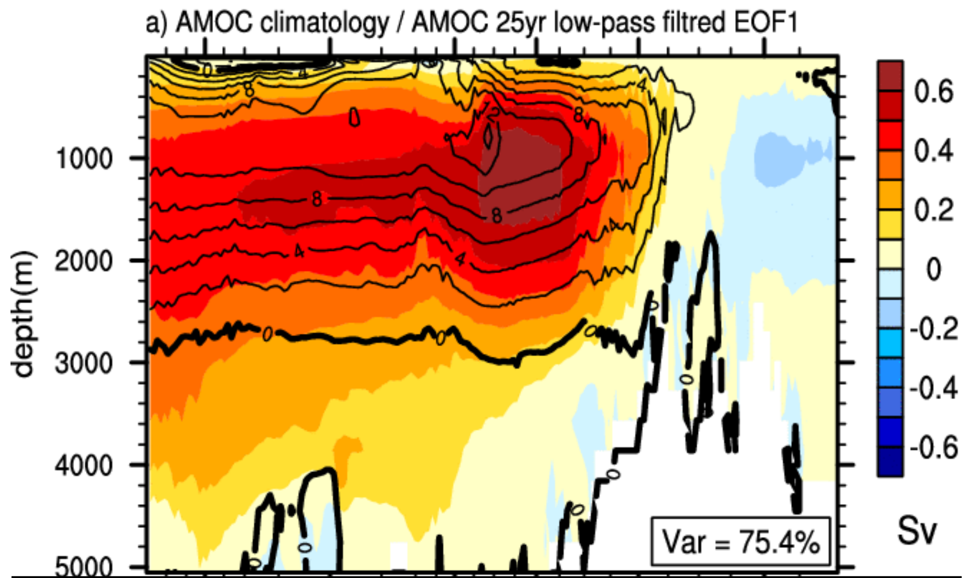
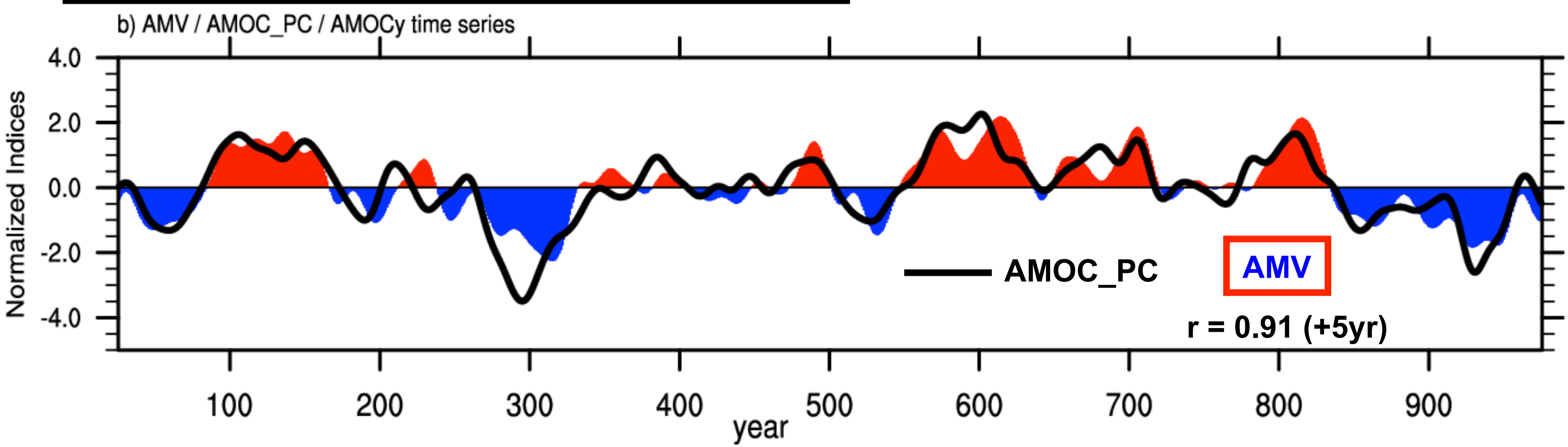


The AMOC variability explains more than 80% of the AMV



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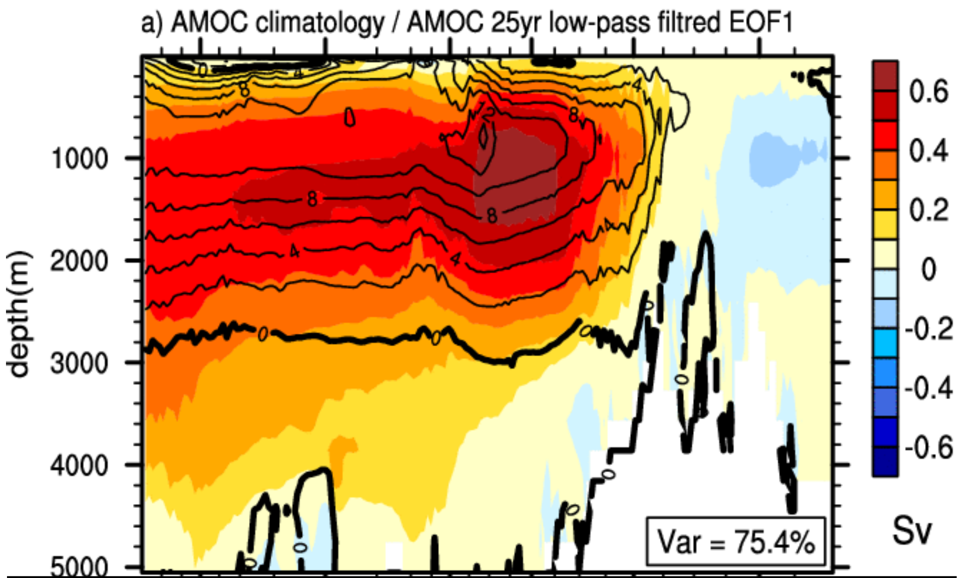


The AMOC variability explains more than 80% of the AMV

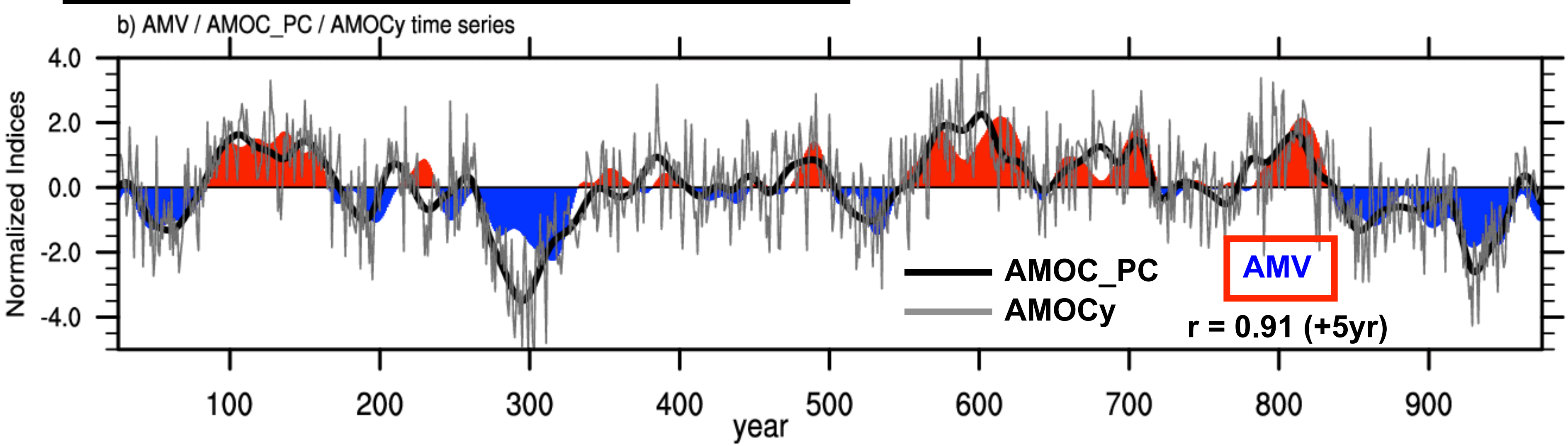
<u>**AMOCy**</u>

Annual time resolution

Same low-frequency than AMOC_PC

Useful for O/A relationships

(Msadek and Frankignoul 2009)



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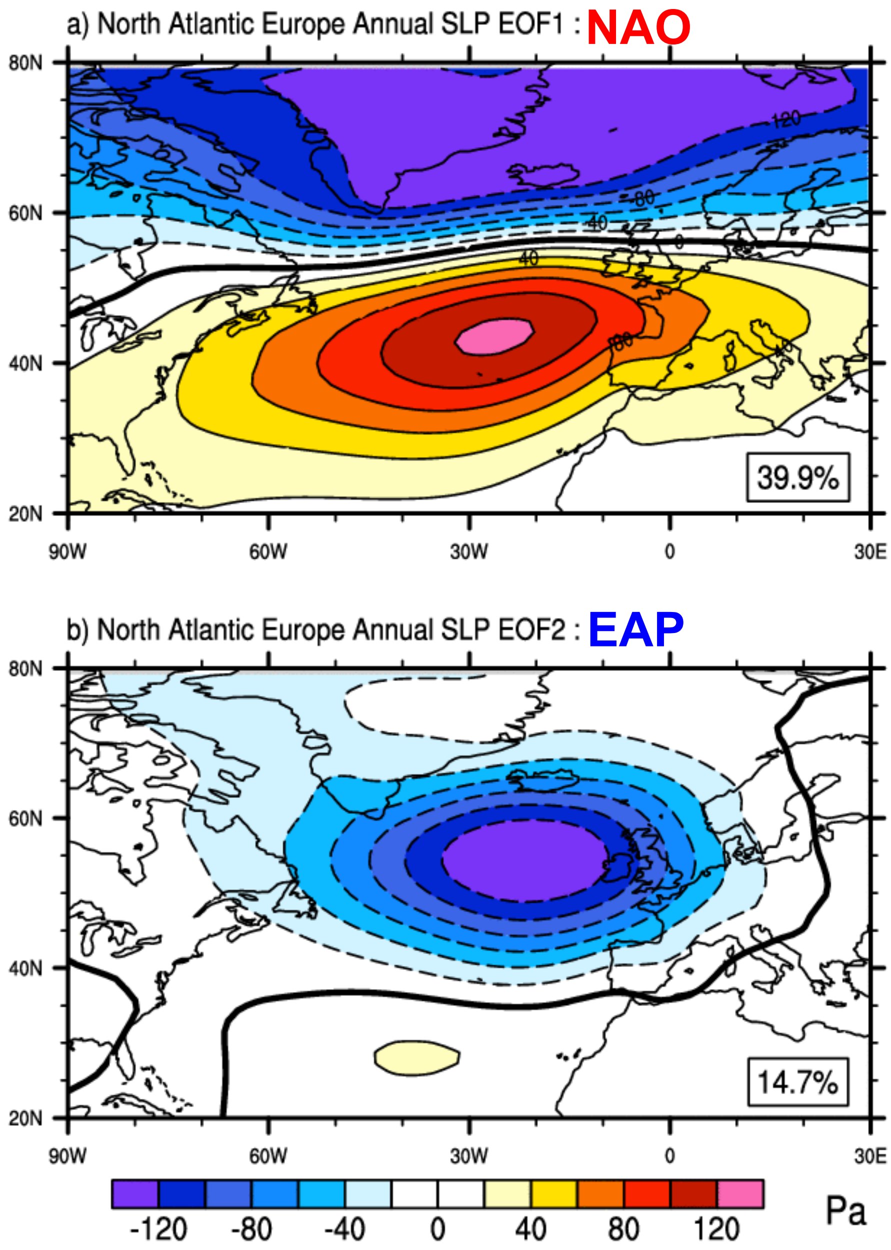
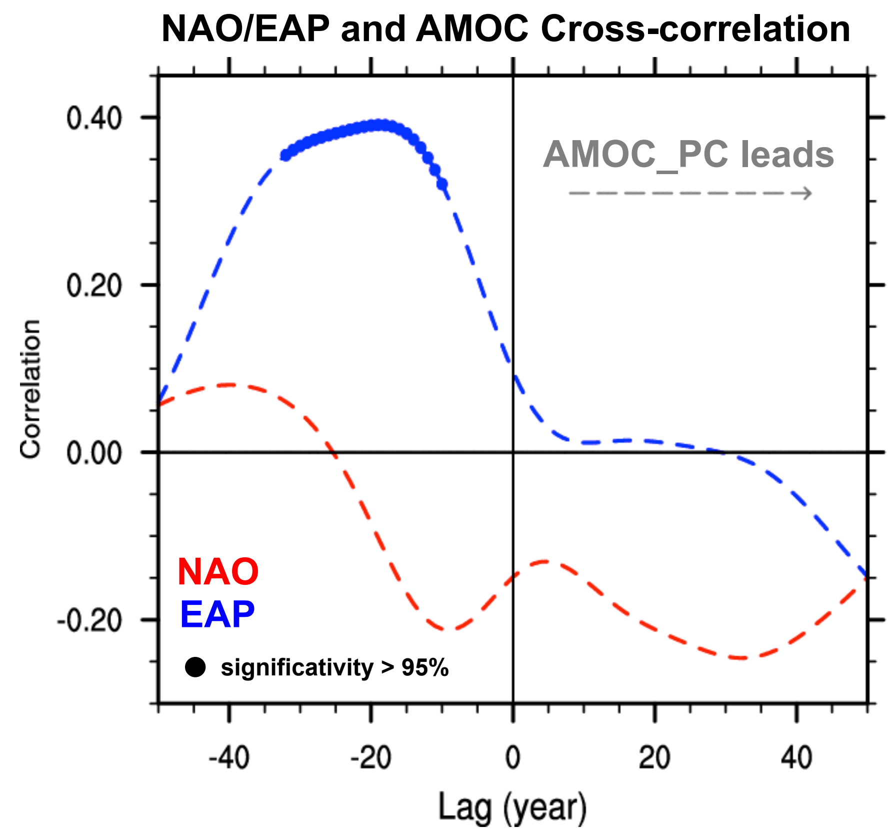
The atmosphere and the AMOC variability





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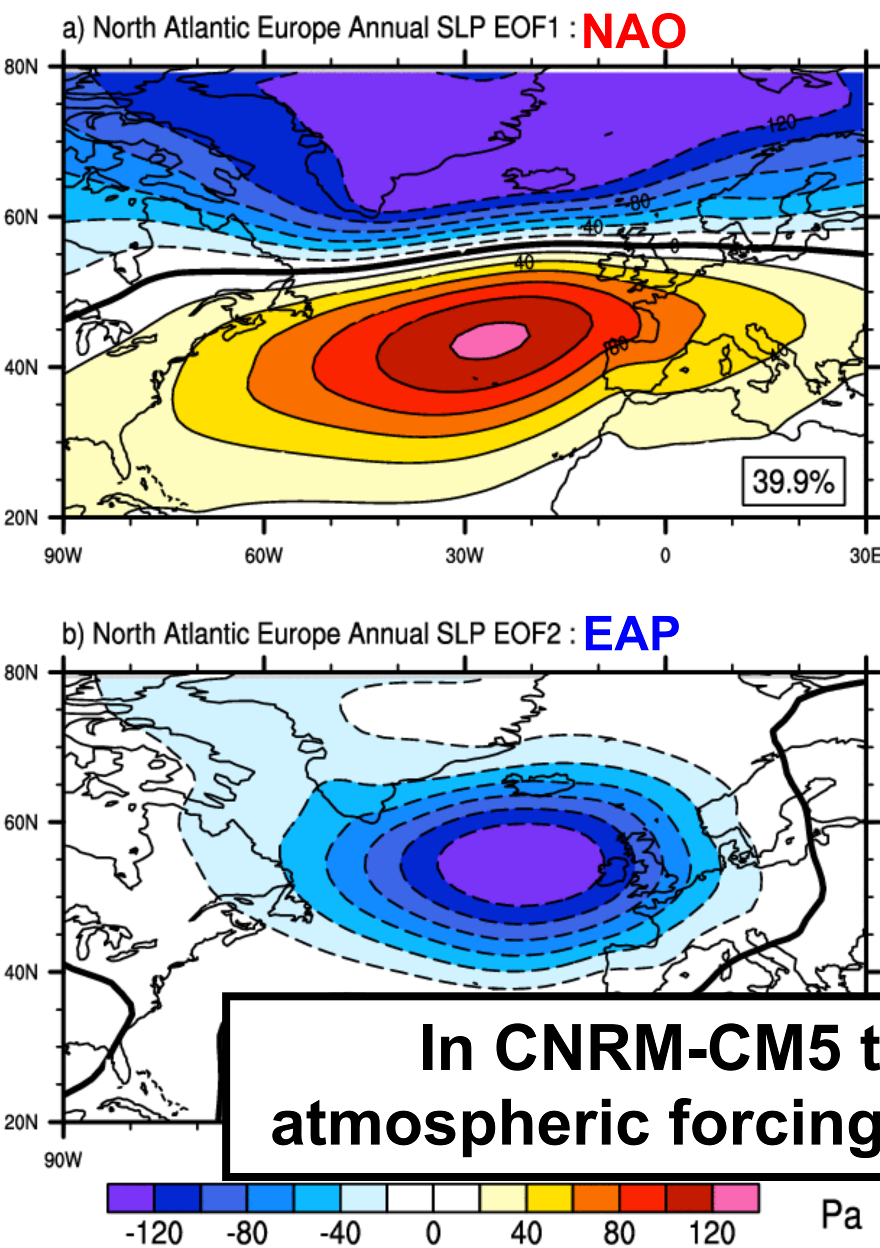
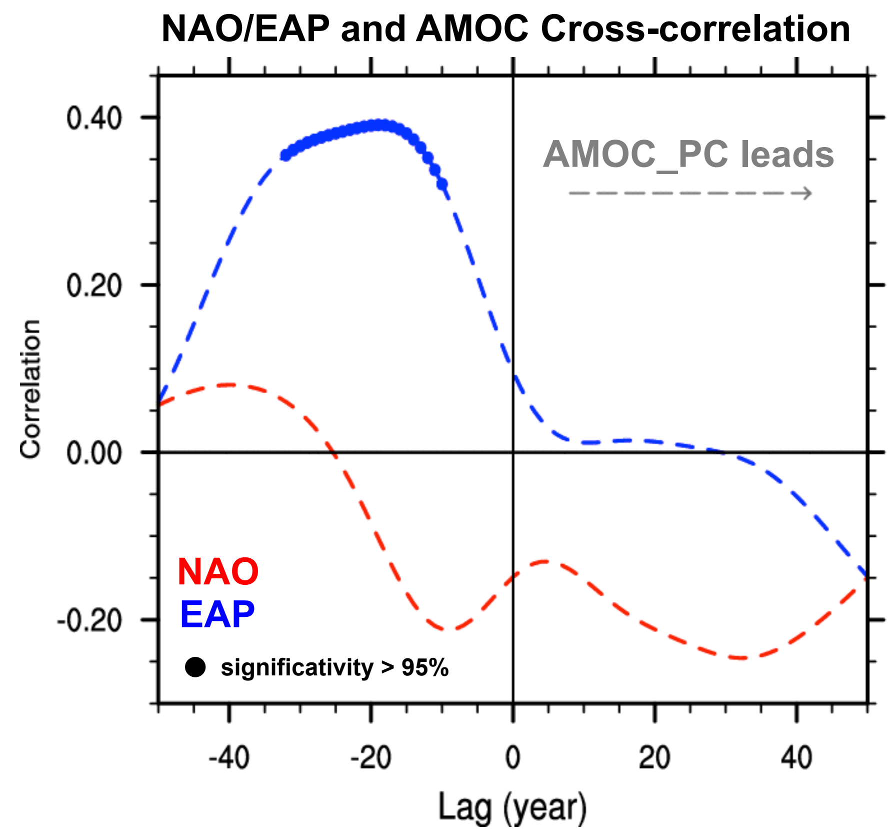
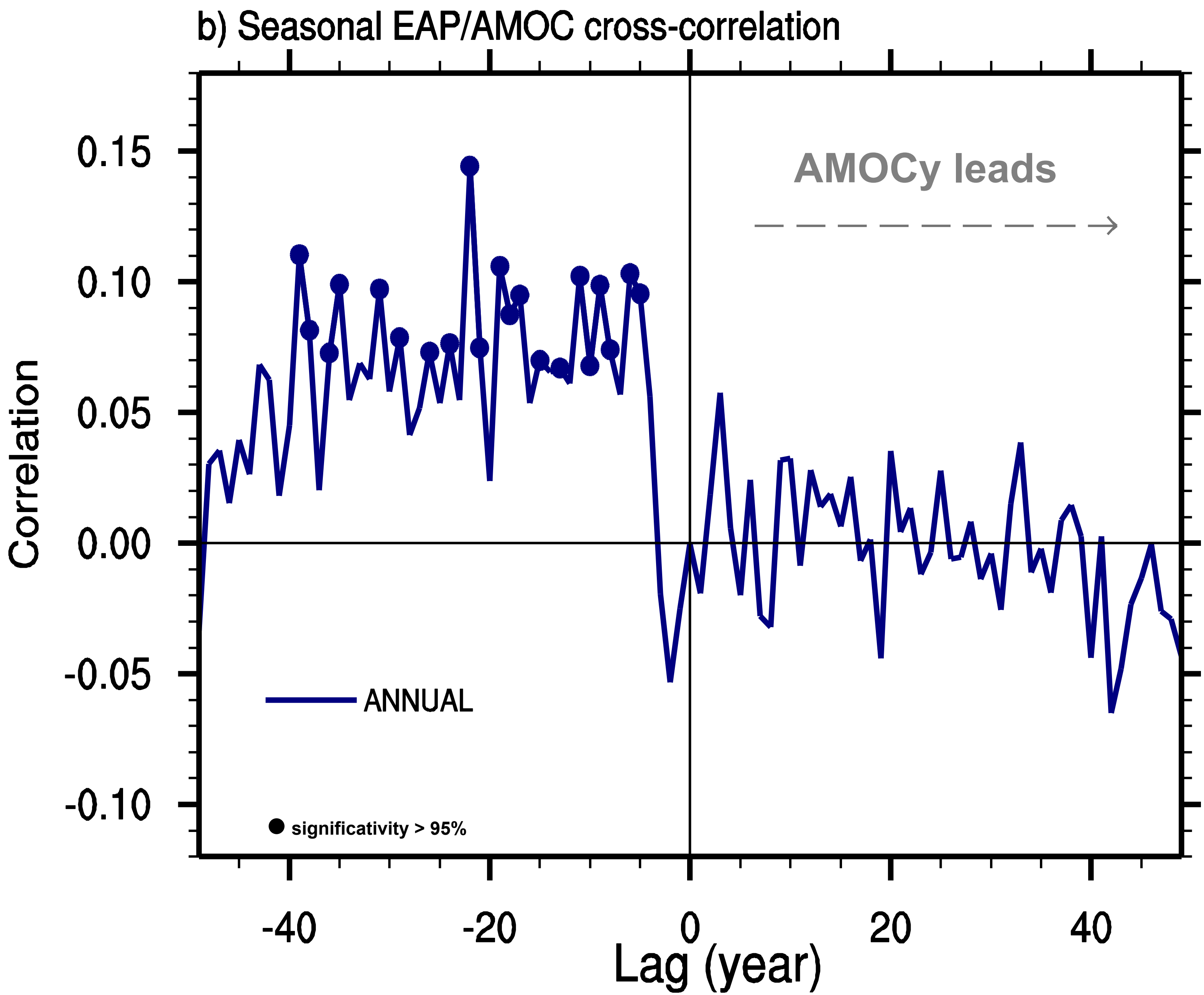




In CNRM-CM5 the EAP is the main atmospheric forcing of the AMOC variability

The EAP seasonality and the AMOC variability



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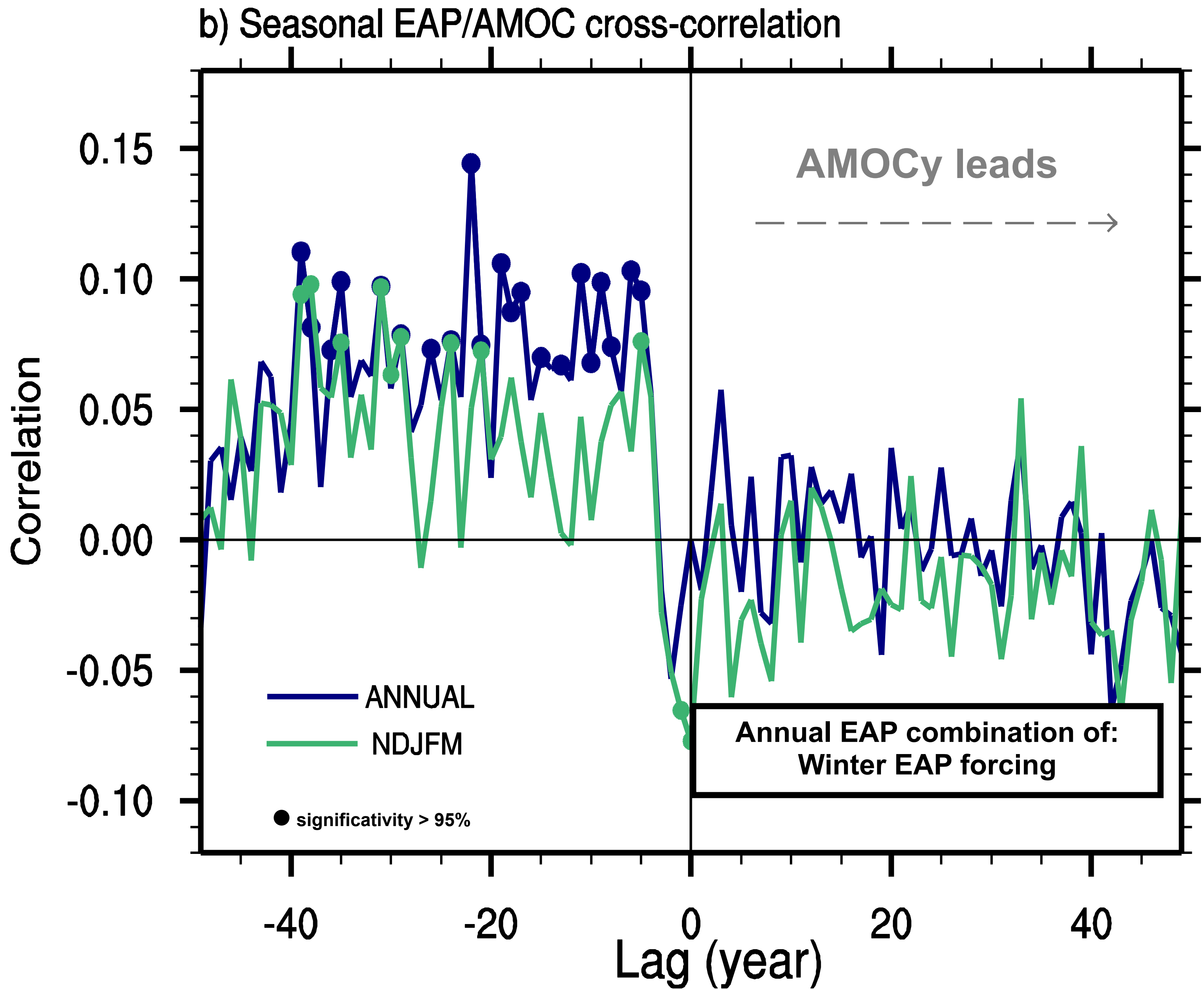

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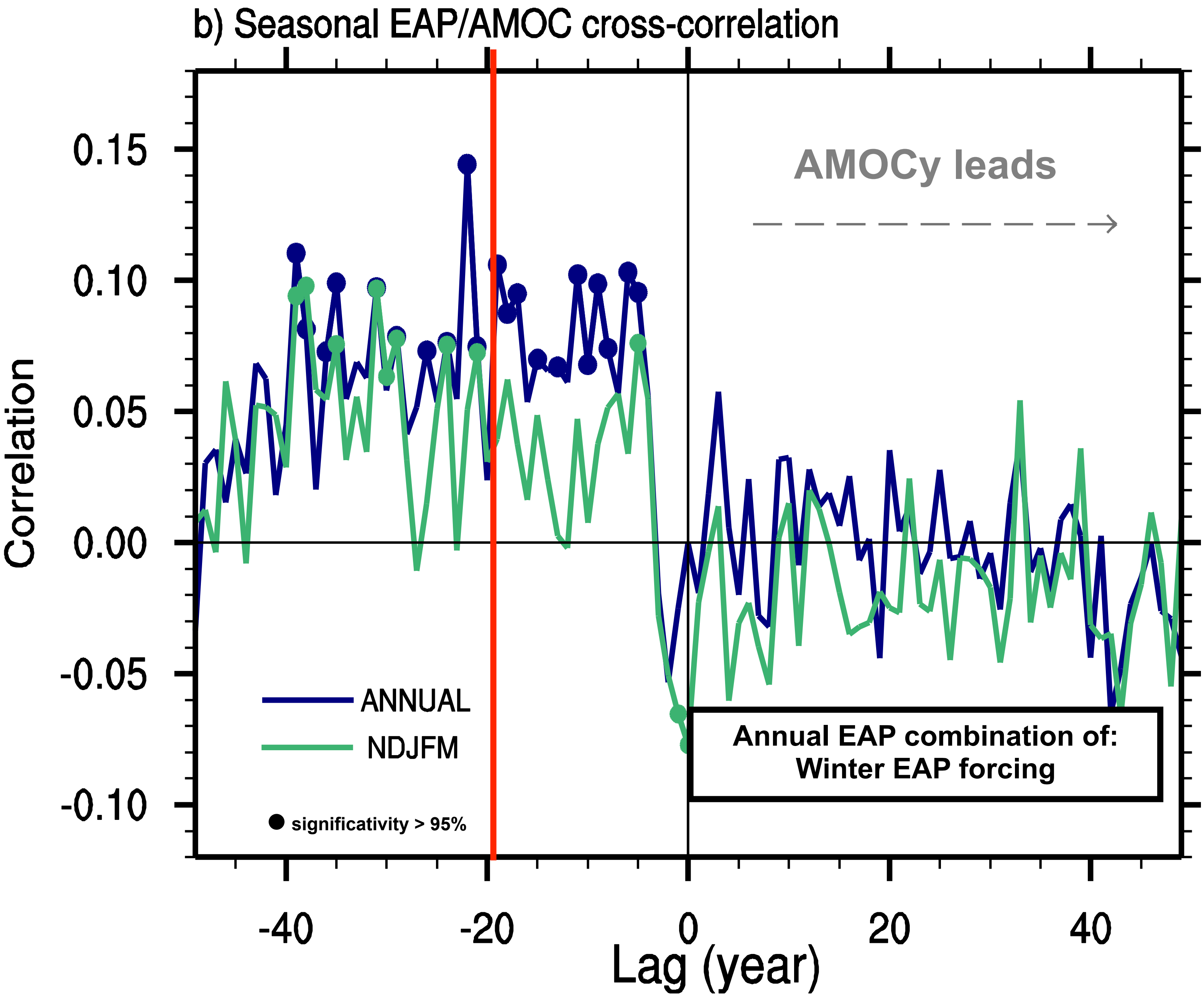

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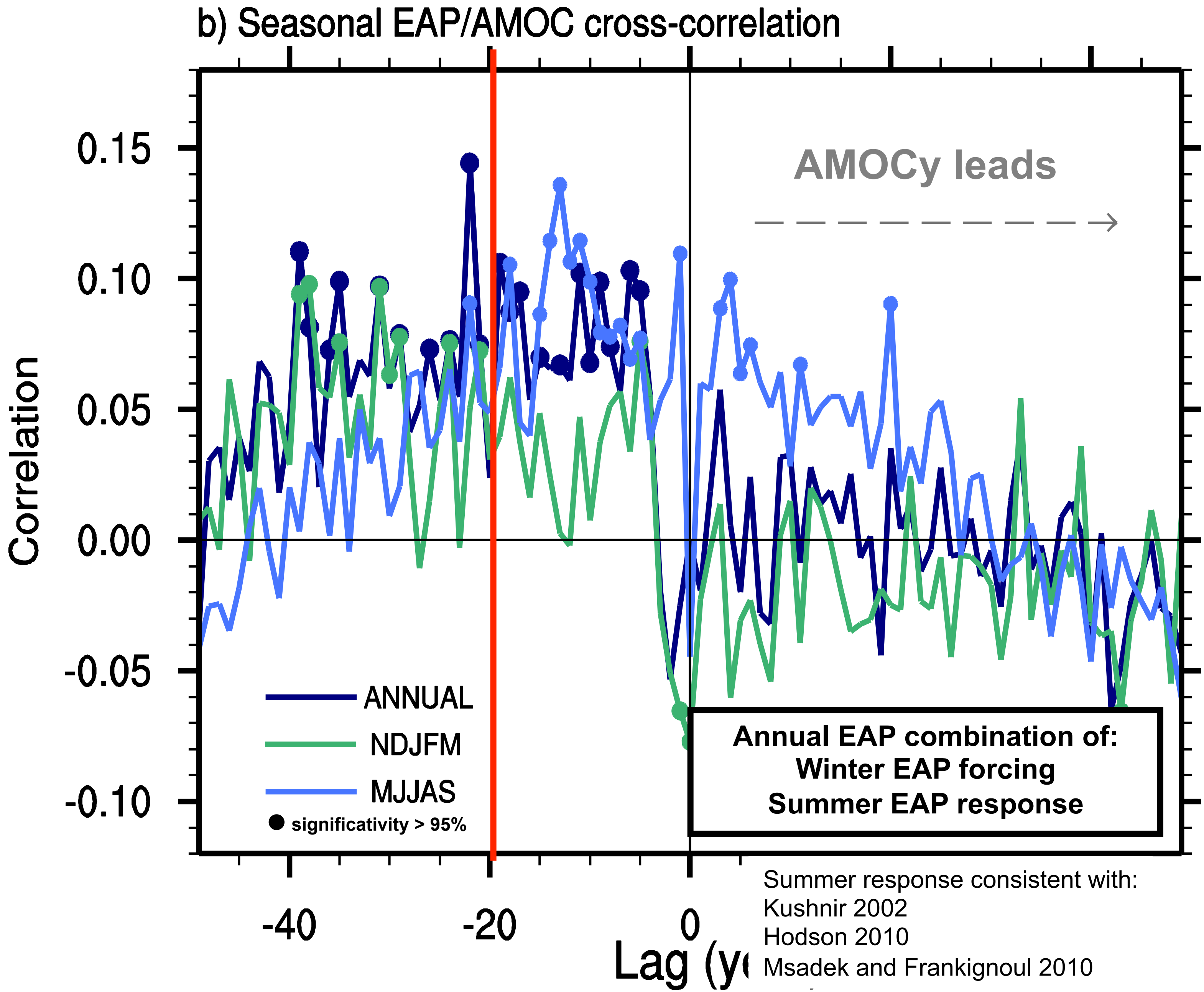

Summer response consistent with:
Kushnir 2002
Hodson 2010
Msadek and Frankignoul 2010

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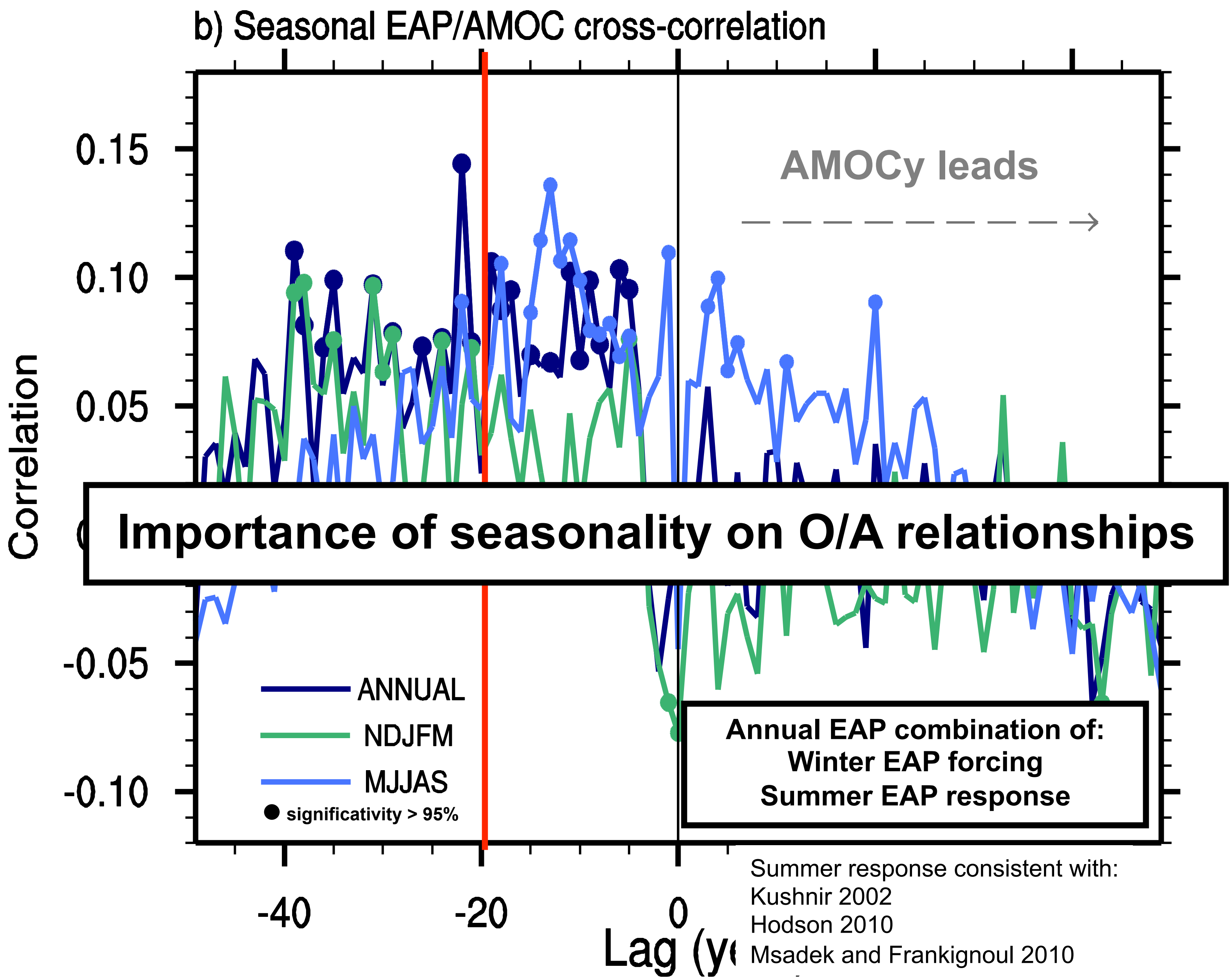
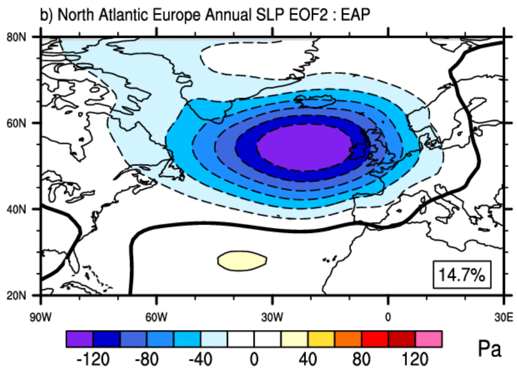


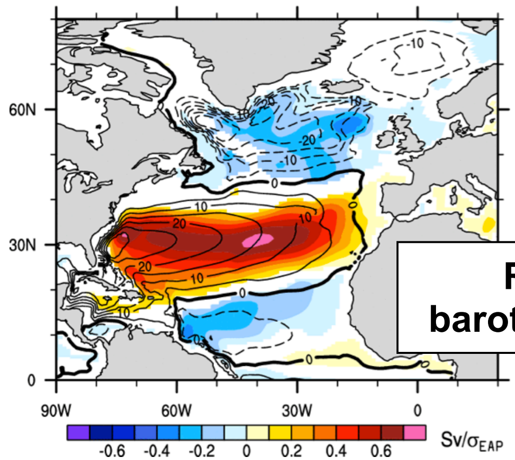
Importance of seasonality on O/A relationships

Annual EAP combination of:
Winter EAP forcing
Summer EAP response

Summer response consistent with:
Kushnir 2002
Hodson 2010
Msadek and Frankignoul 2010

The winter EAP forcing [-40yr;-20yr]





Regression of annual barotropic STF on winter EAP

Msadek and Frankignoul 2009
Barrier et al. 2013

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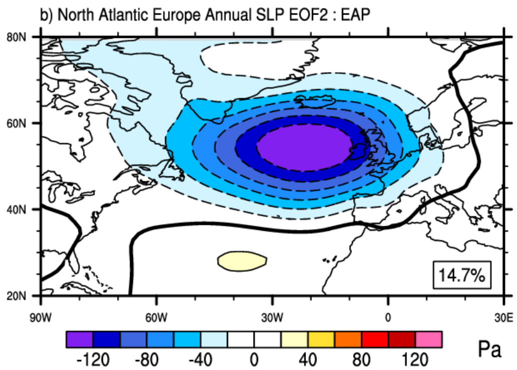

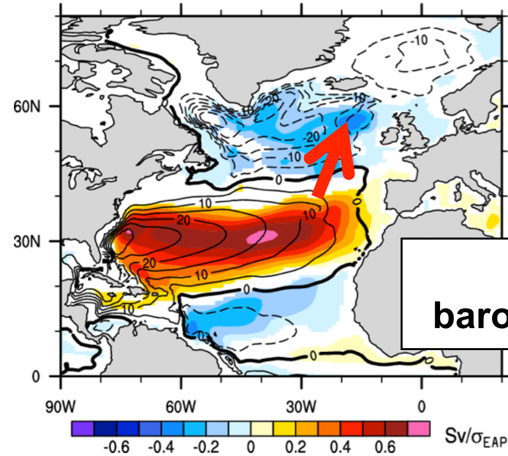

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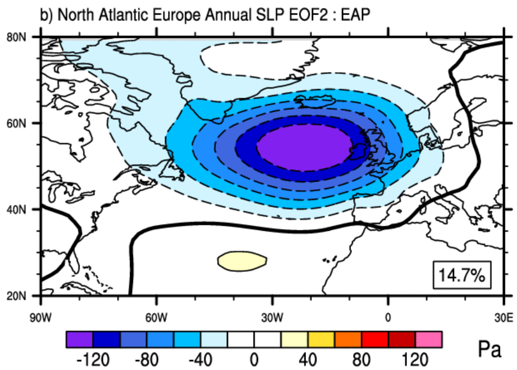

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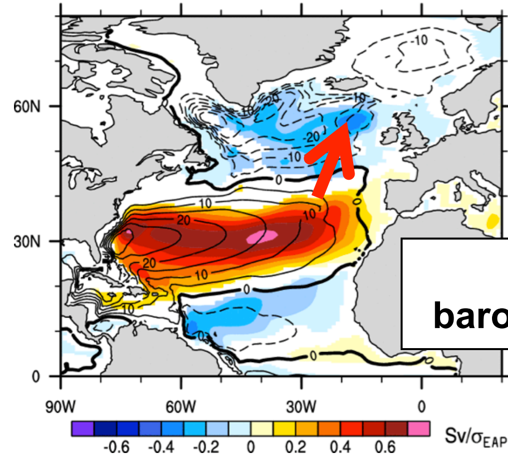
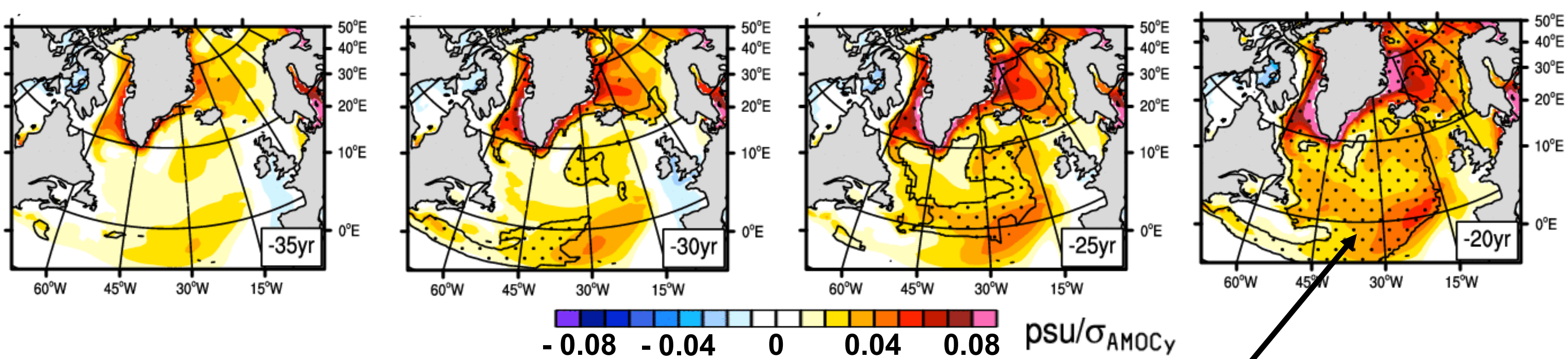


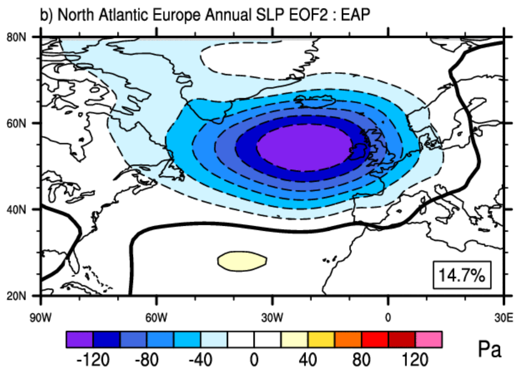
Regression of annual barotropic STF on winter EAP

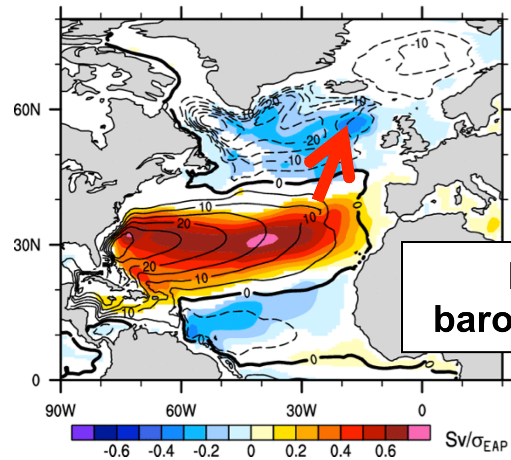
Regression of salt@0-200m on AMOCy



Significativity > 95%

The winter EAP forcing [-40yr;-20yr]





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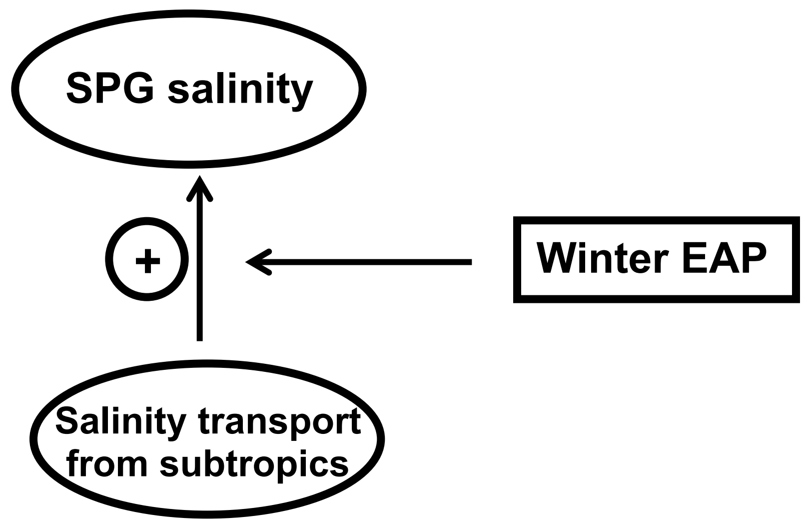

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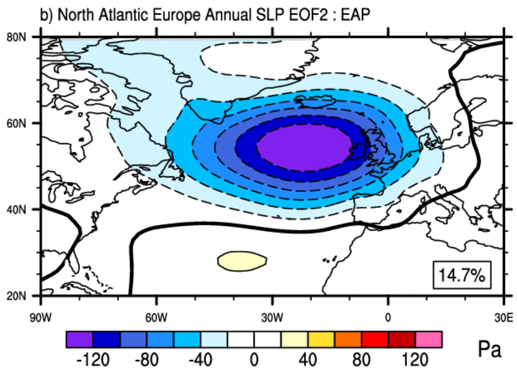

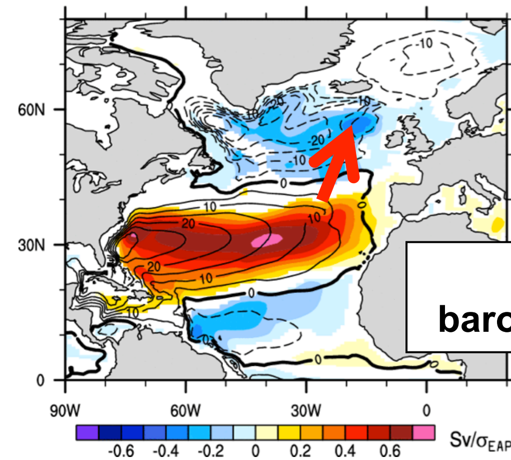

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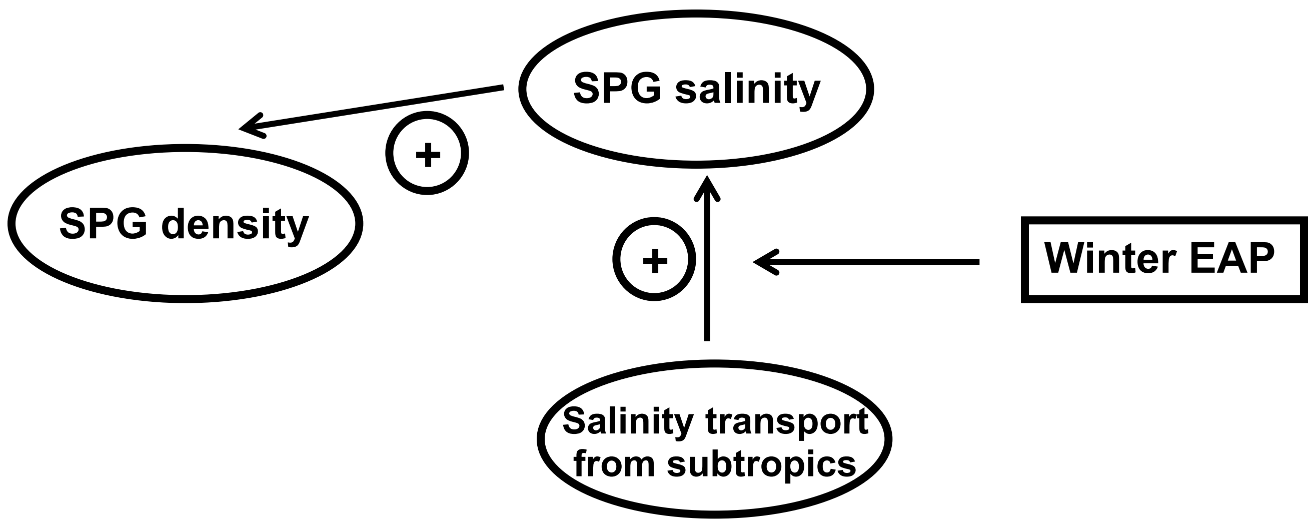

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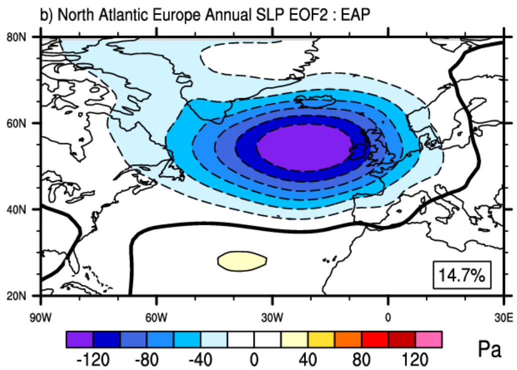

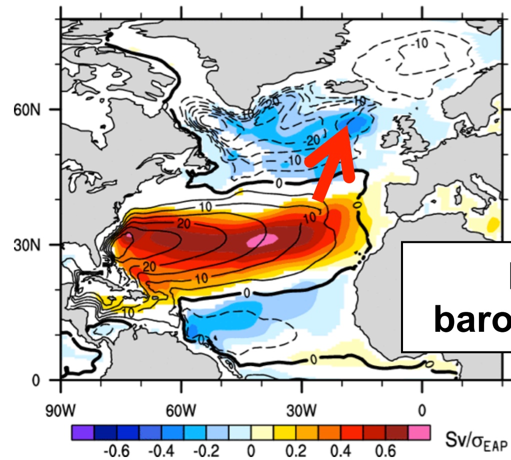

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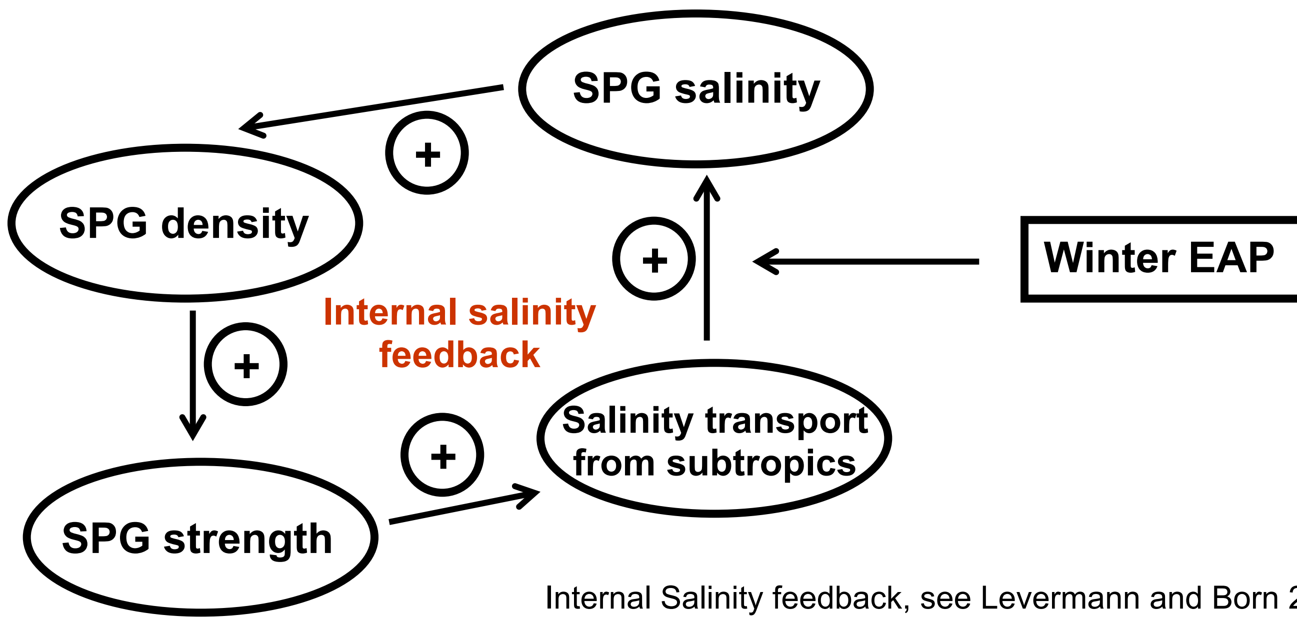

Internal Salinity feedback, see Levermann and Born 2007

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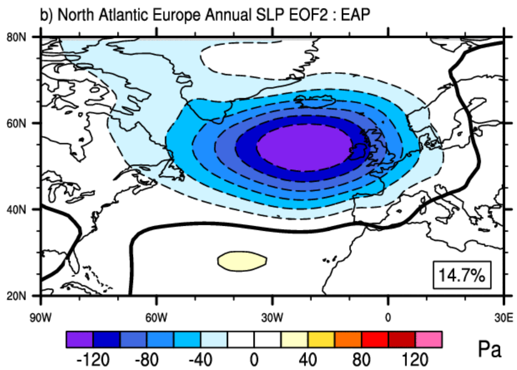

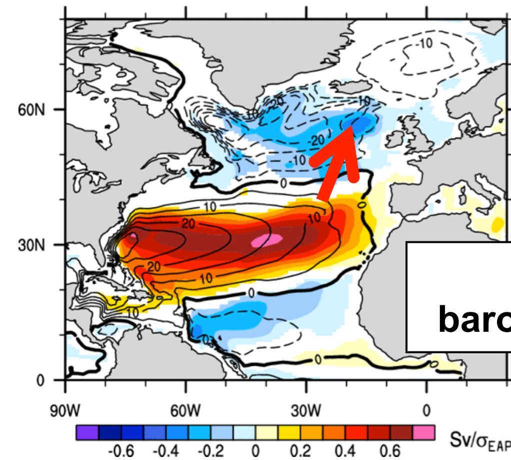

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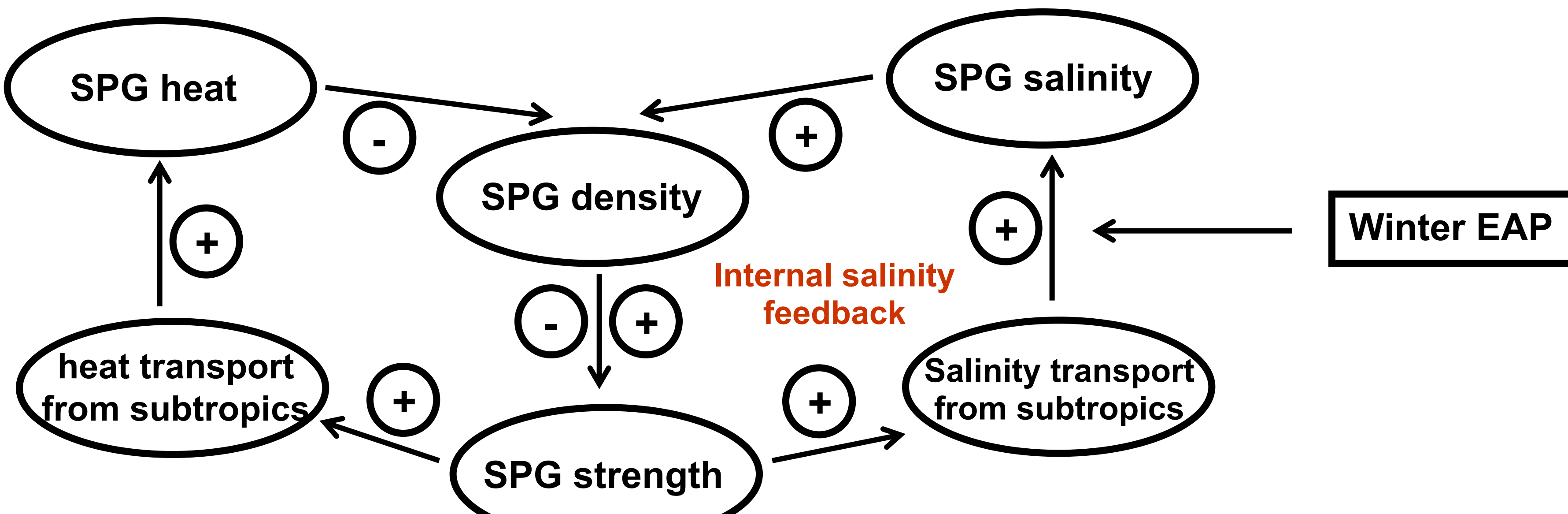

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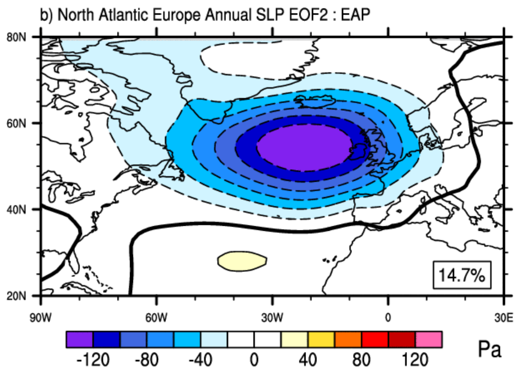
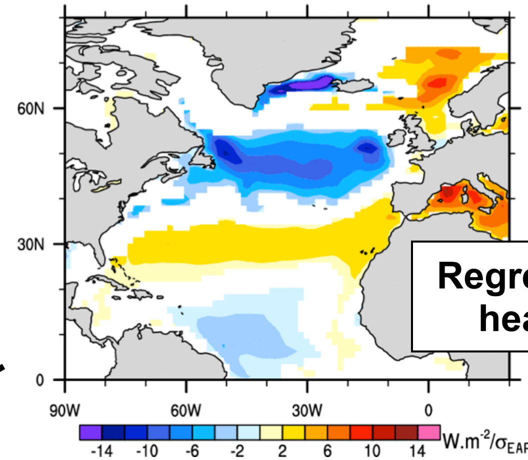
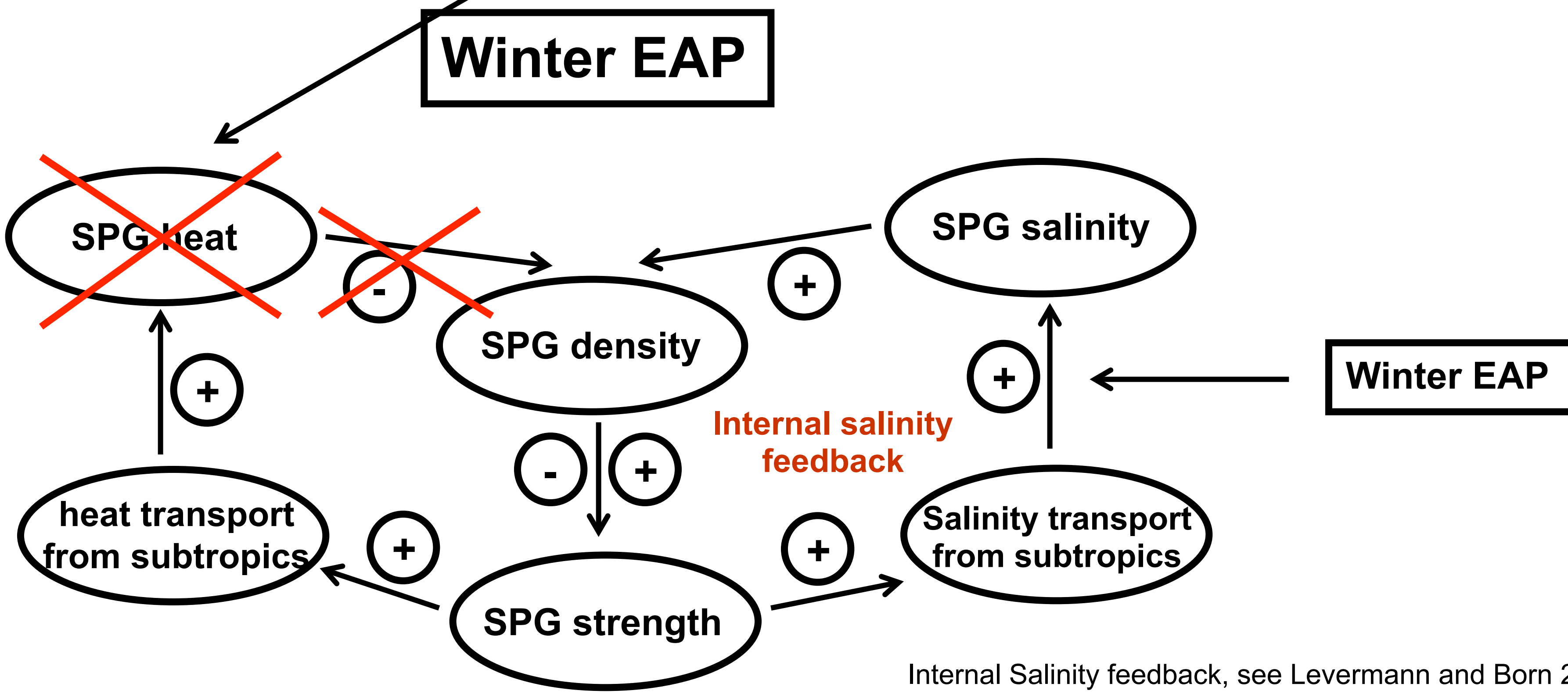




Regression of winter turbulent heat fluxes on winter EAP

Positive flux means ocean heating



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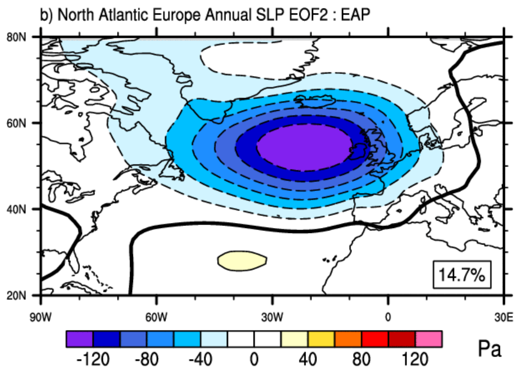

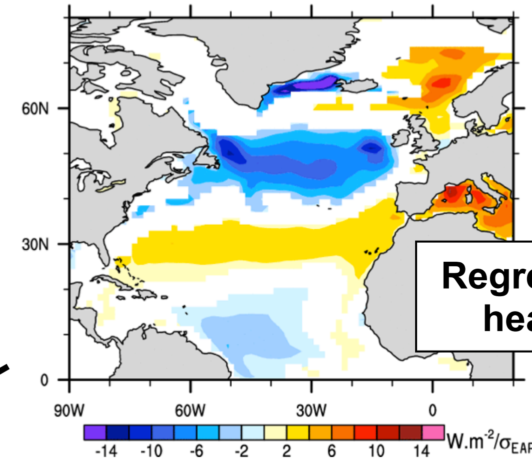

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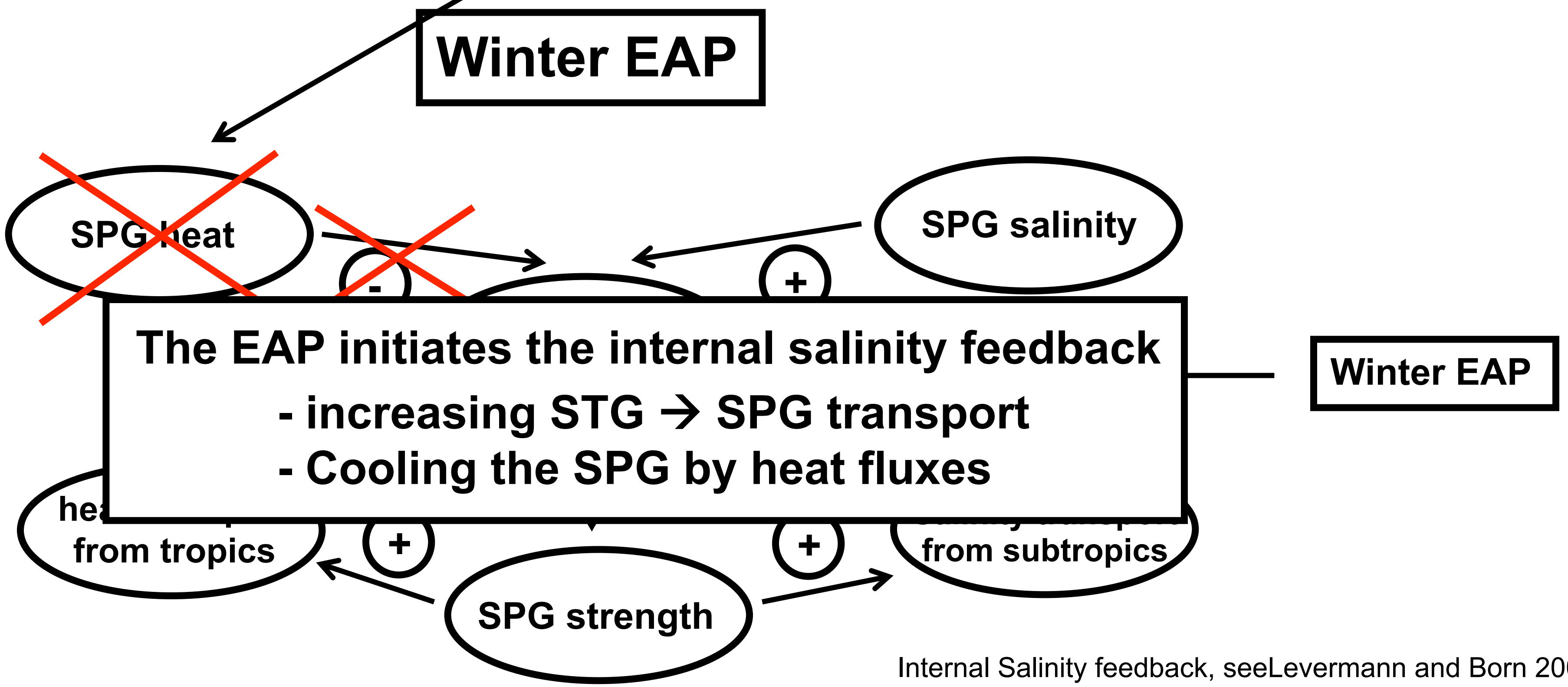


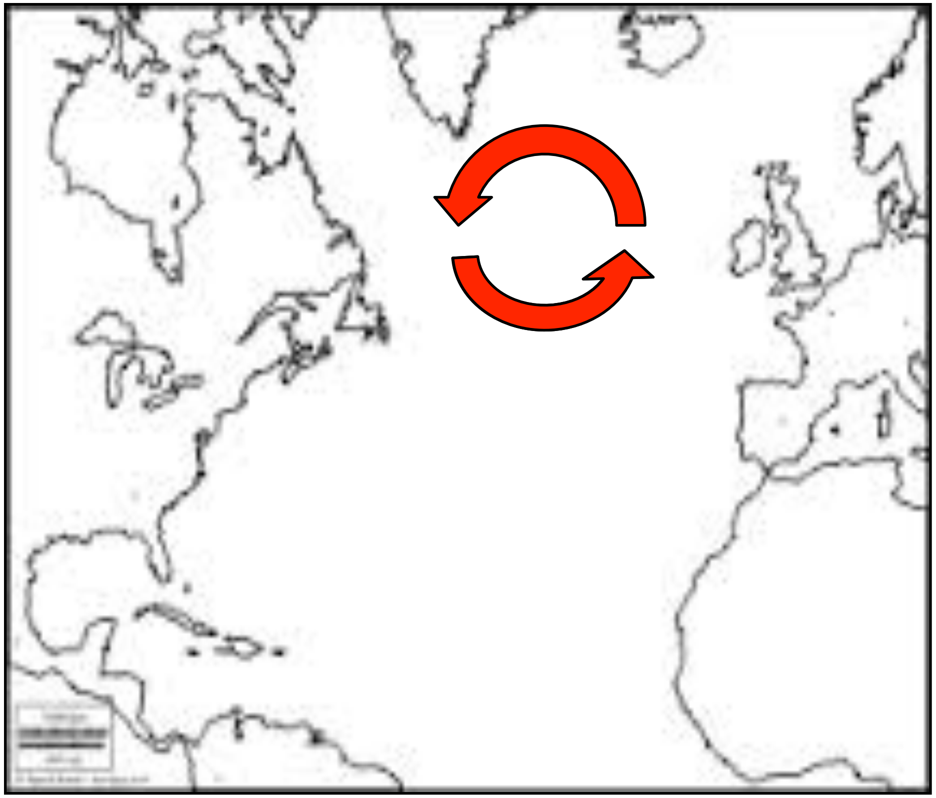
The EAP initiates the internal salinity feedback

- increasing STG → SPG transport

- Cooling the SPG by heat fluxes

Internal Salinity feedback, seeLevermann and Born 2007

The AMOC upper branch accelerarion [-20yr;+10yr]



Current southward propagation ~10yr

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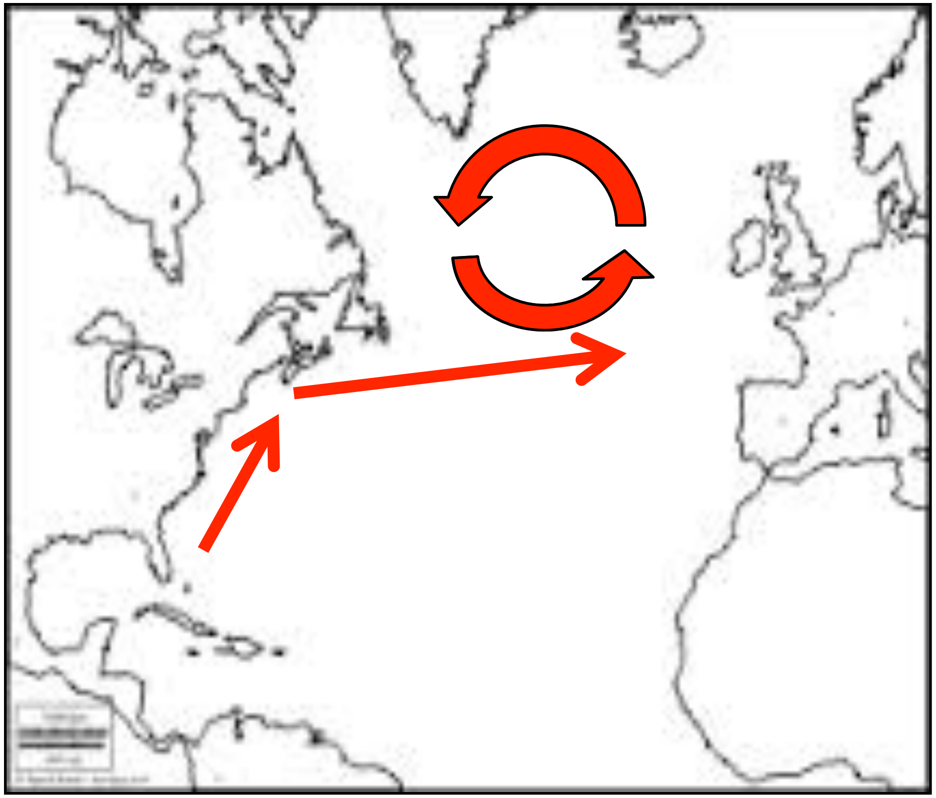

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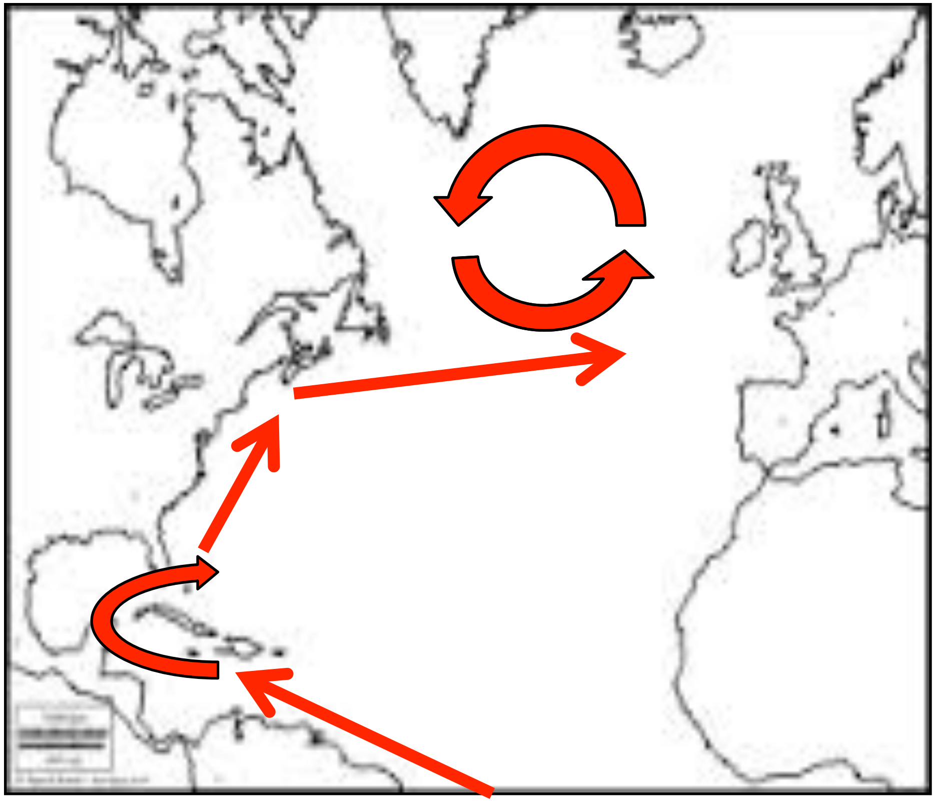

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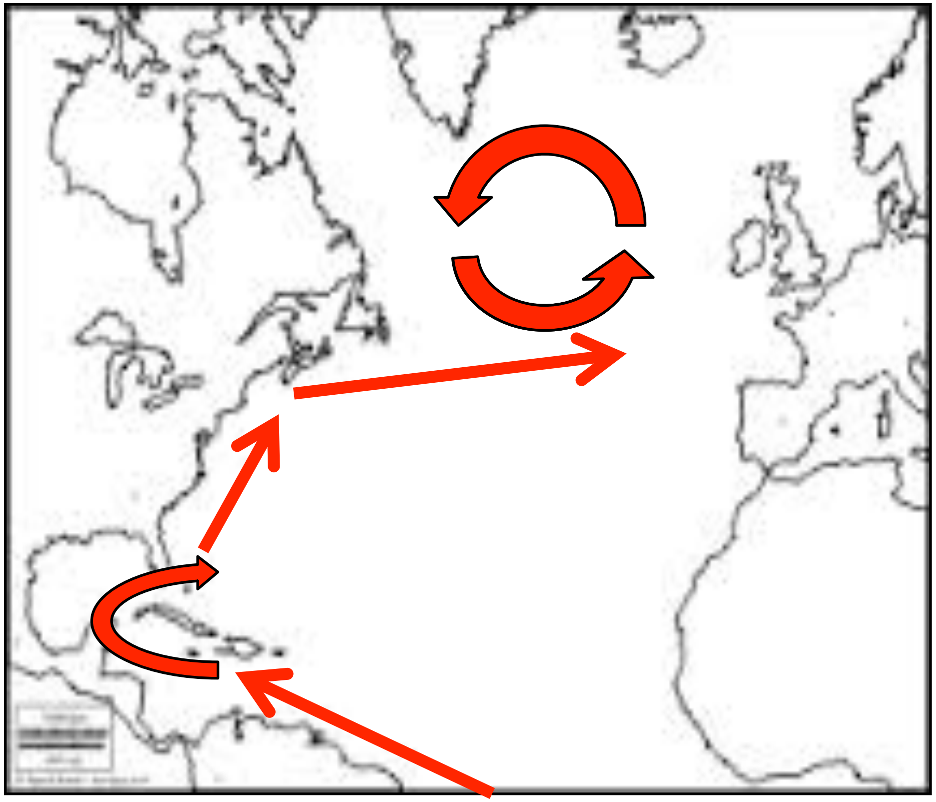

Current southward propagation ~10yr

<u>AMOC decline :</u>

- Heat SPG increase
  (advection + surface fluxes)
- Advection of Arctic freshwater
- Advection of tropical freshwater

More details in *Ruprich-Robert and Cassou 2013* submitted to Clim Dyn

AMOC variability summary

In CNRM-CM5, the AMOC internal variability is a multidecadal non oscillating mode **(taking ~40 years for build-up and ~20 years to be damped)**

→ Main precursor of the internal AMV **(leading by ~5 years, correlation of 0.91)**

→ initiated by the integration of atmospheric white noise forcing : the **winter EAP** **(Hakkinen et al. 2011)**

→ timescale controlled by oceanic processes

→ leads to weak atmospheric response **(summer EAP, winter NAO, summer NAO)**

→ AMOC variability mainly impacted by the **SPG density** fluctuations

→ AMOC conditional predictability mainly comes from **SPG density**

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Many thanks for your attention

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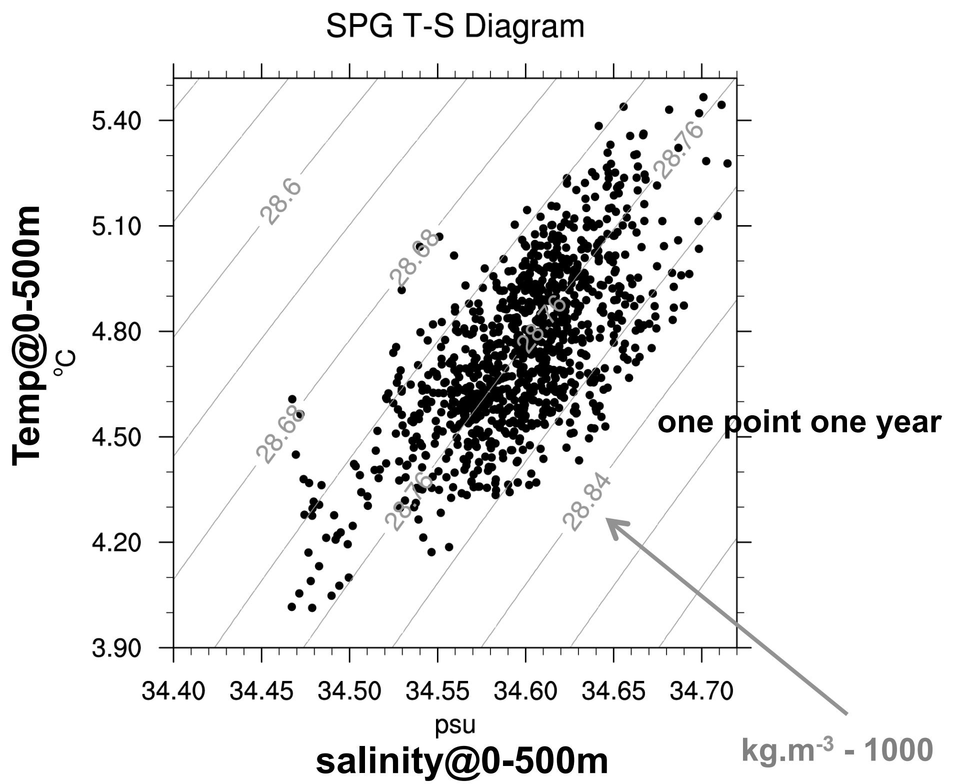

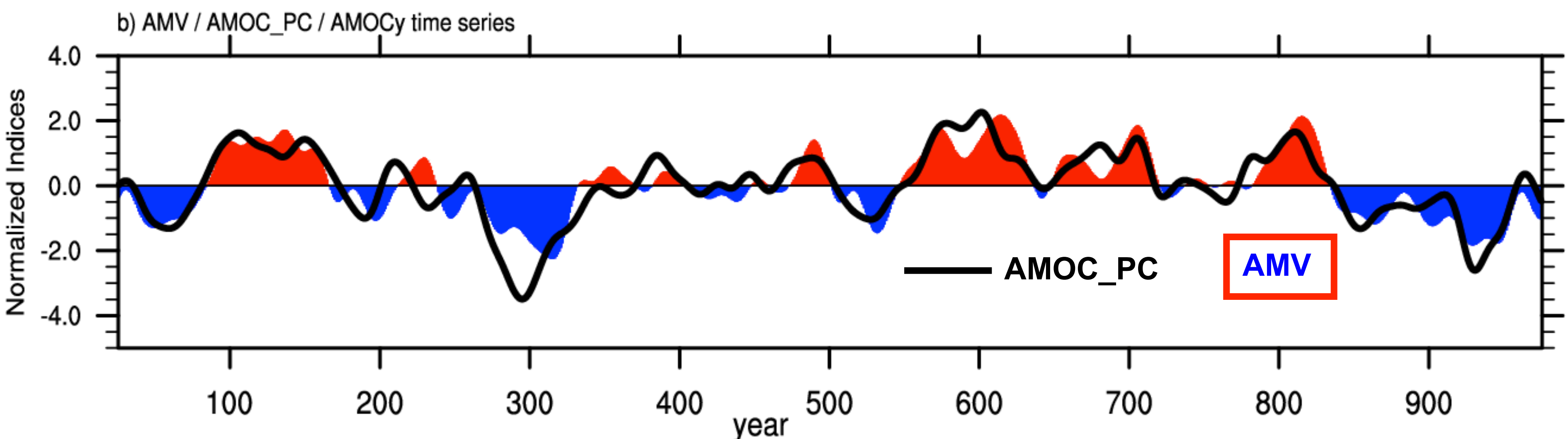

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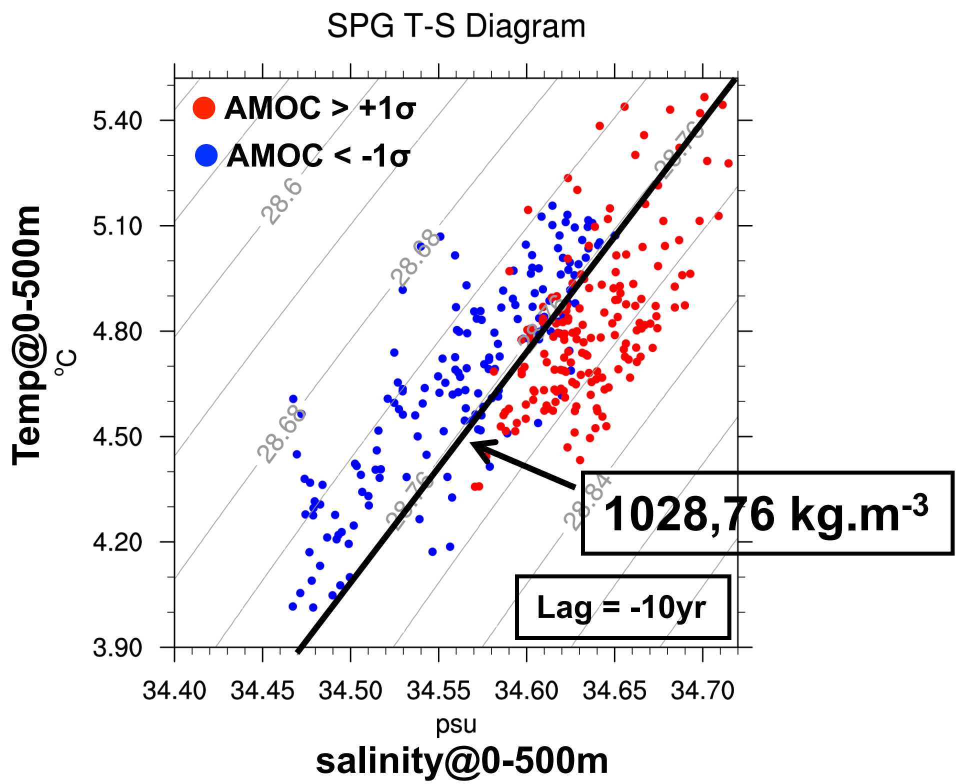

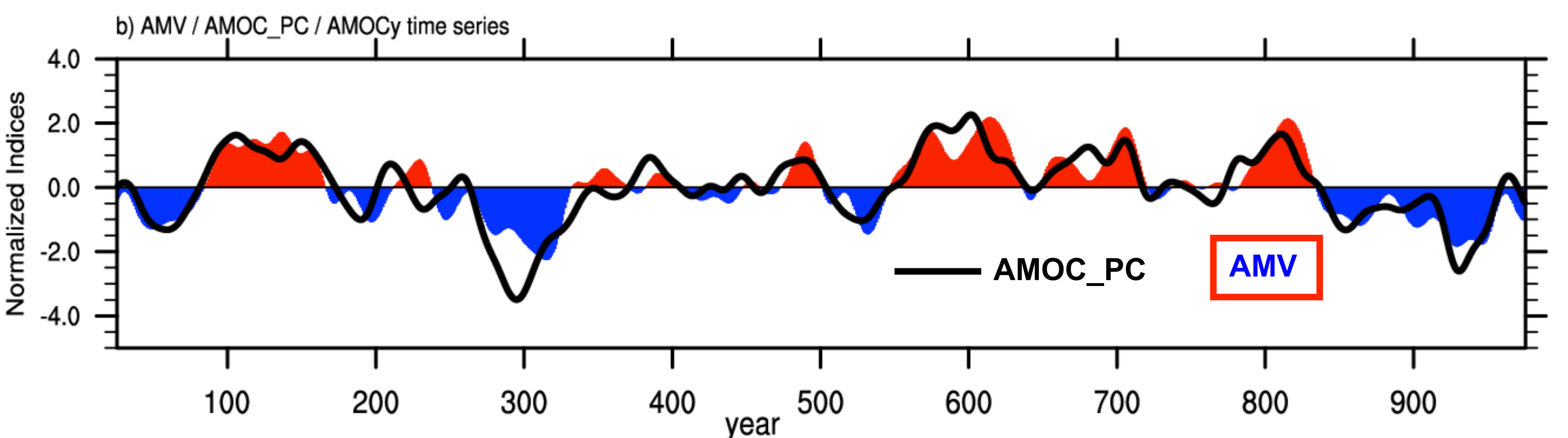

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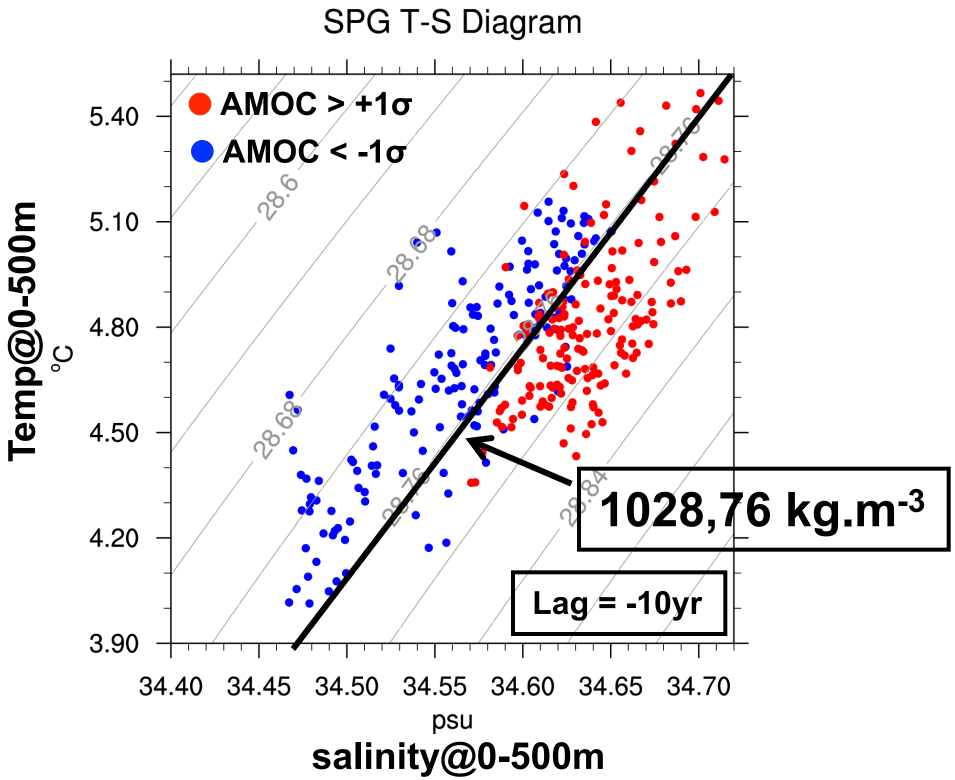
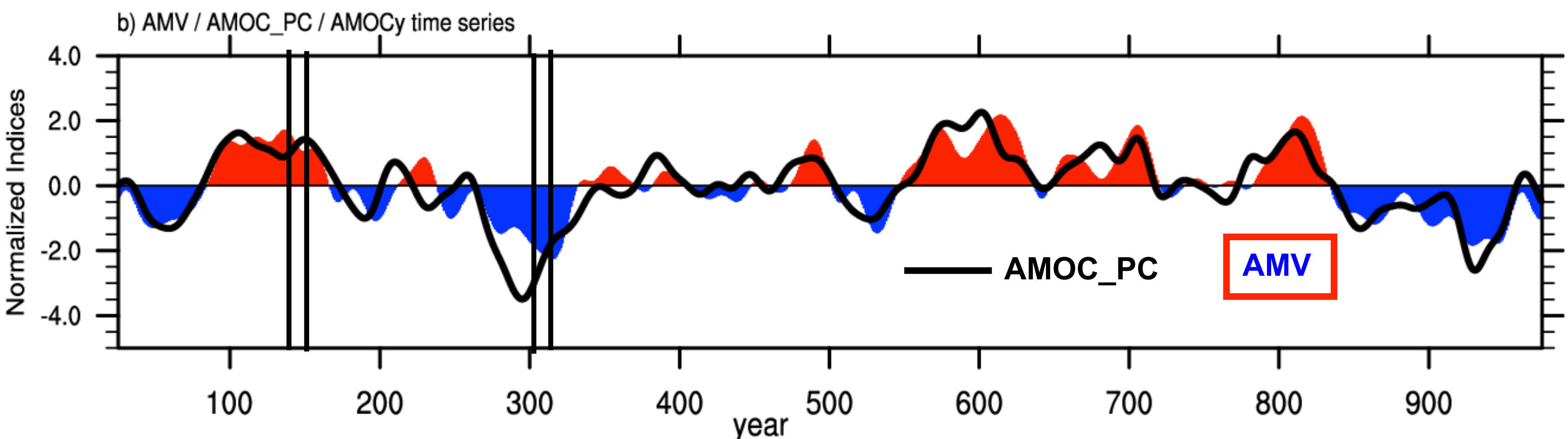
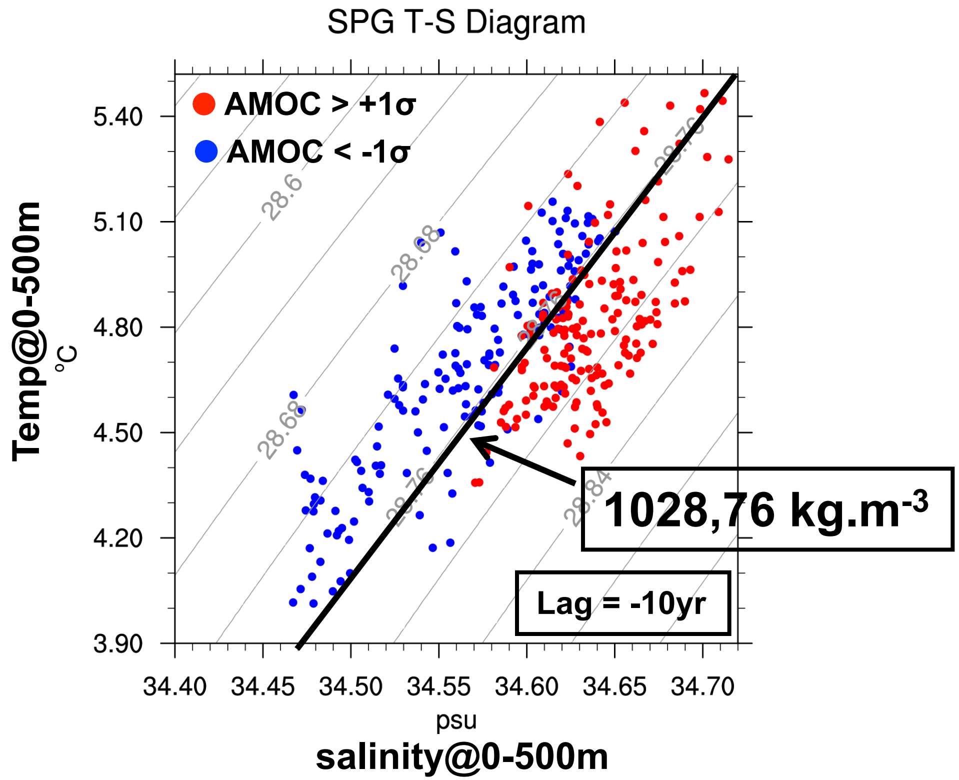
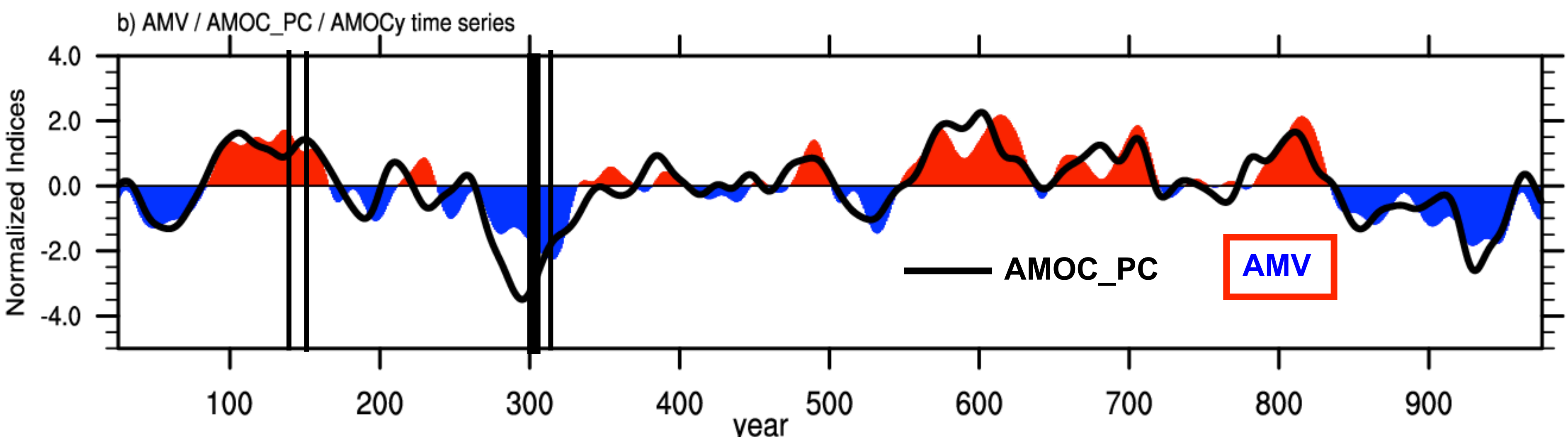




Importance of the SPG density





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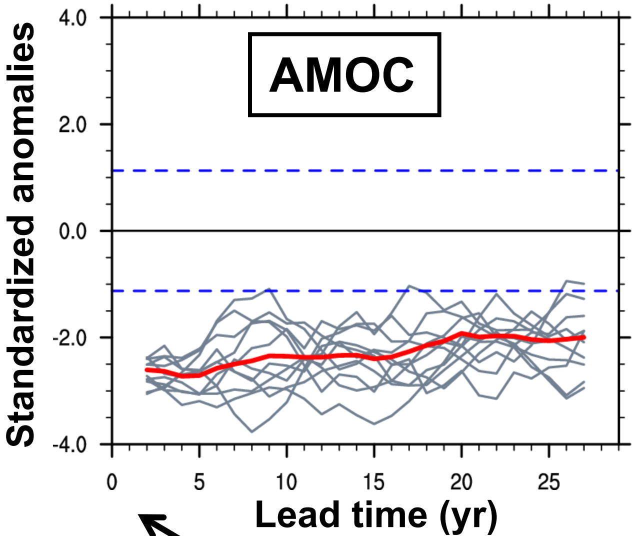

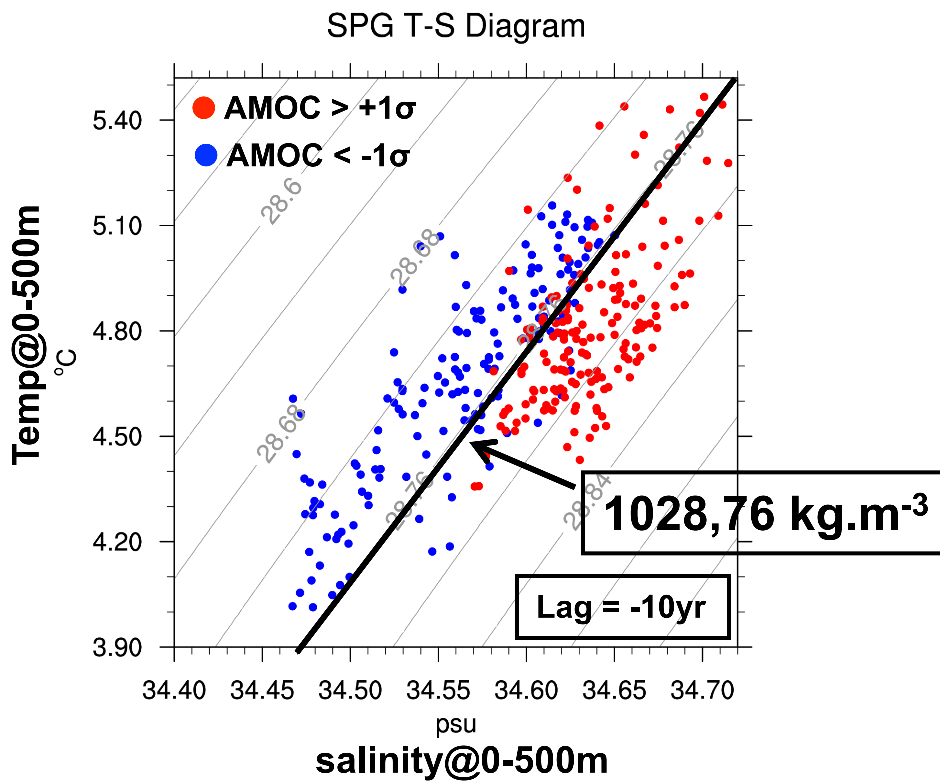

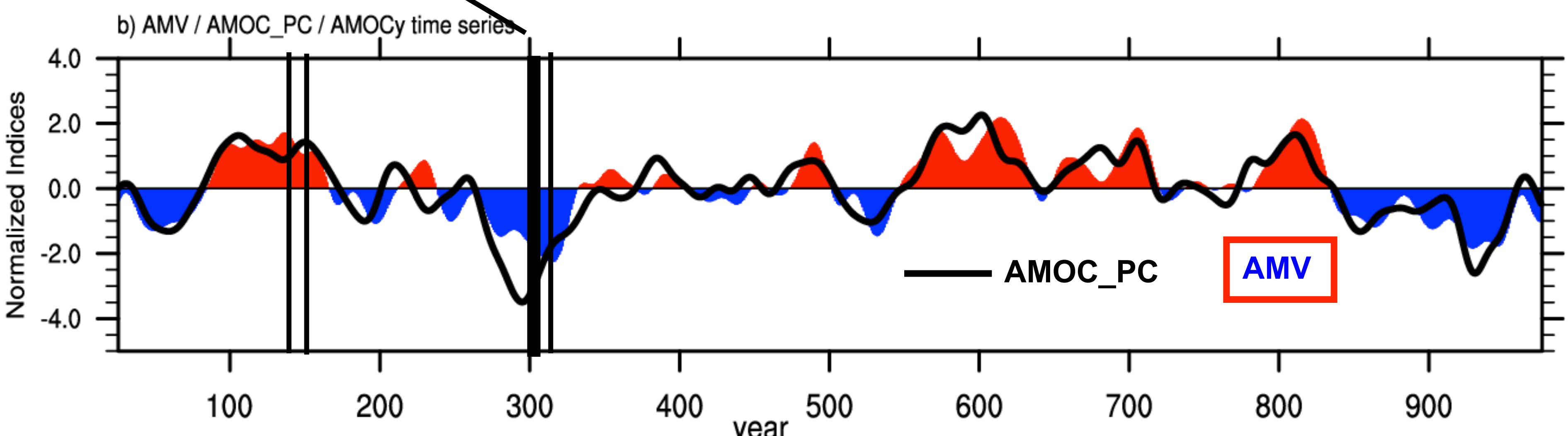

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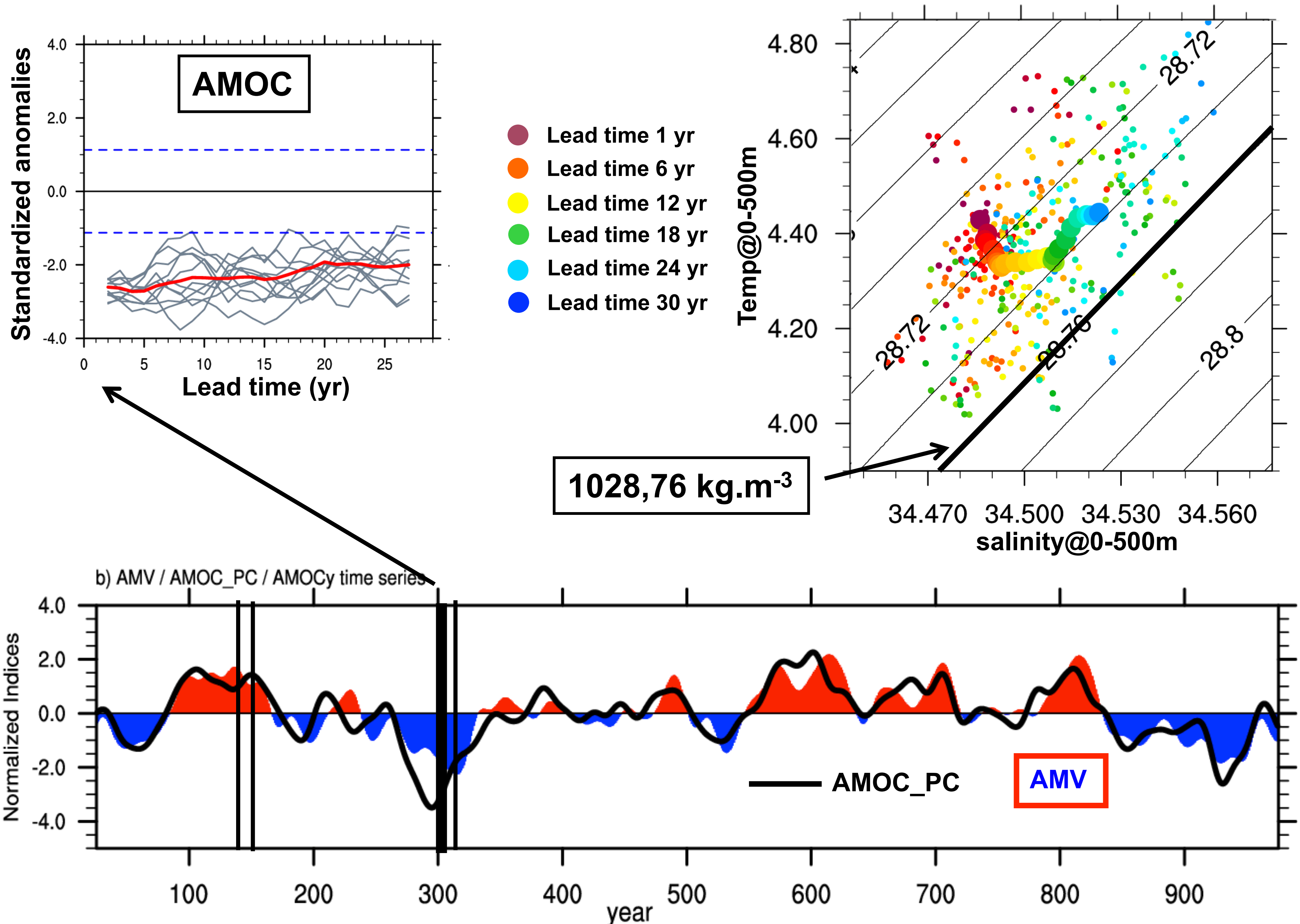
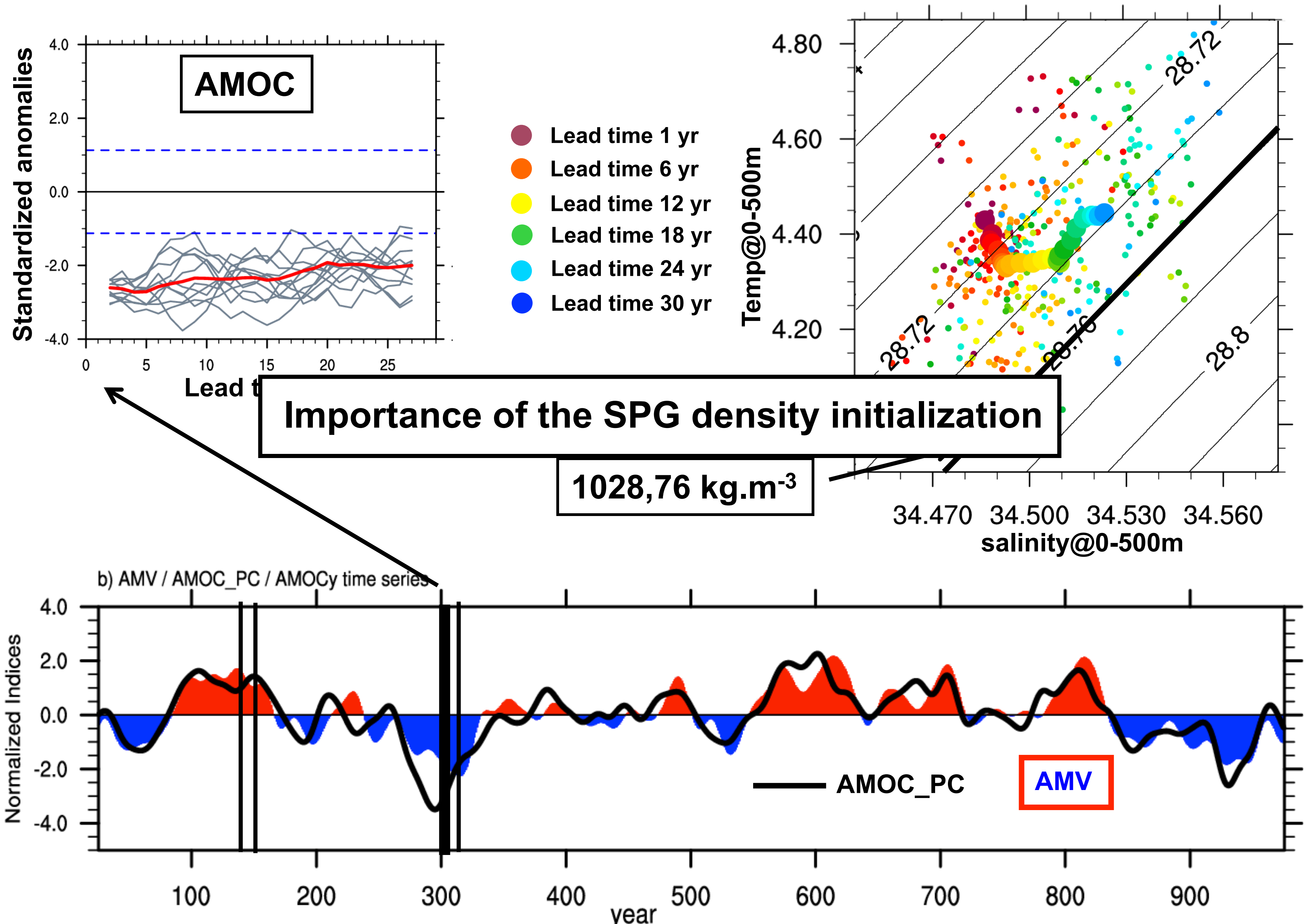


Importance of the SPG density



AMOC variability summary

In CNRM-CM5, the AMOC internal variability is a multidecadal non oscillating mode **(taking ~40 years for build-up and ~20 years to be damped)**

→ Main precursor of the internal AMV **(leading by ~5 years, correlation of 0.91)**

→ initiated by the integration of atmospheric white noise forcing : the **winter EAP**
(Hakkinen et al. 2011)

→ timescale controlled by oceanic processes

→ leads to weak atmospheric response **(summer EAP, winter NAO, summer NAO)**

→ AMOC variability mainly impacted by the **SPG density** fluctuations

→ AMOC conditional predictability mainly comes from **SPG density**

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Many thanks for your attention