SEVENTH FRAMEWORK PROGRAMME

SPECS

Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

GOBIERNO DE ESPAÑA · MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

VOLCADEC

ANR MORDICUS

Modulation of the climate response to a volcanic eruption by the Atlantic Multidecadal Variability

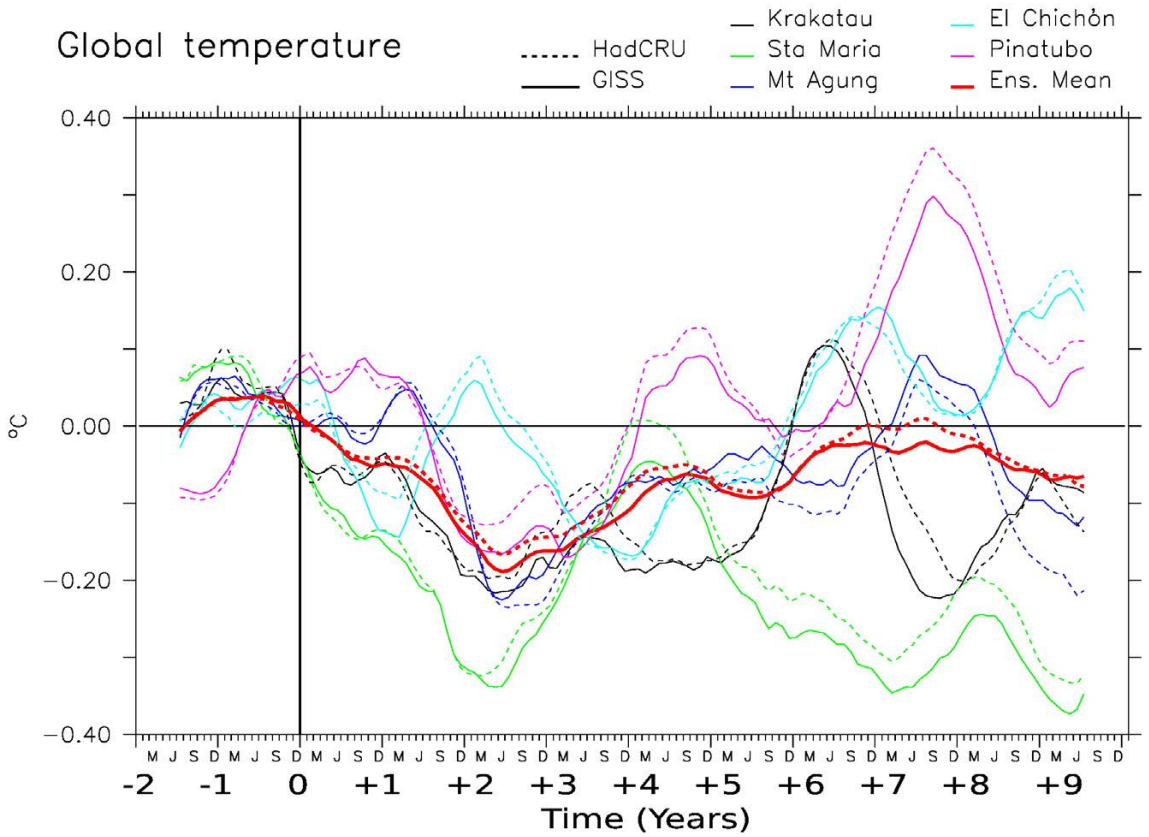
Martin Ménégoz, Christophe Cassou, Didier Swingedouw, Francisco Doblas-Reyes

AMOC conference, Brest, May 2017

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Introduction

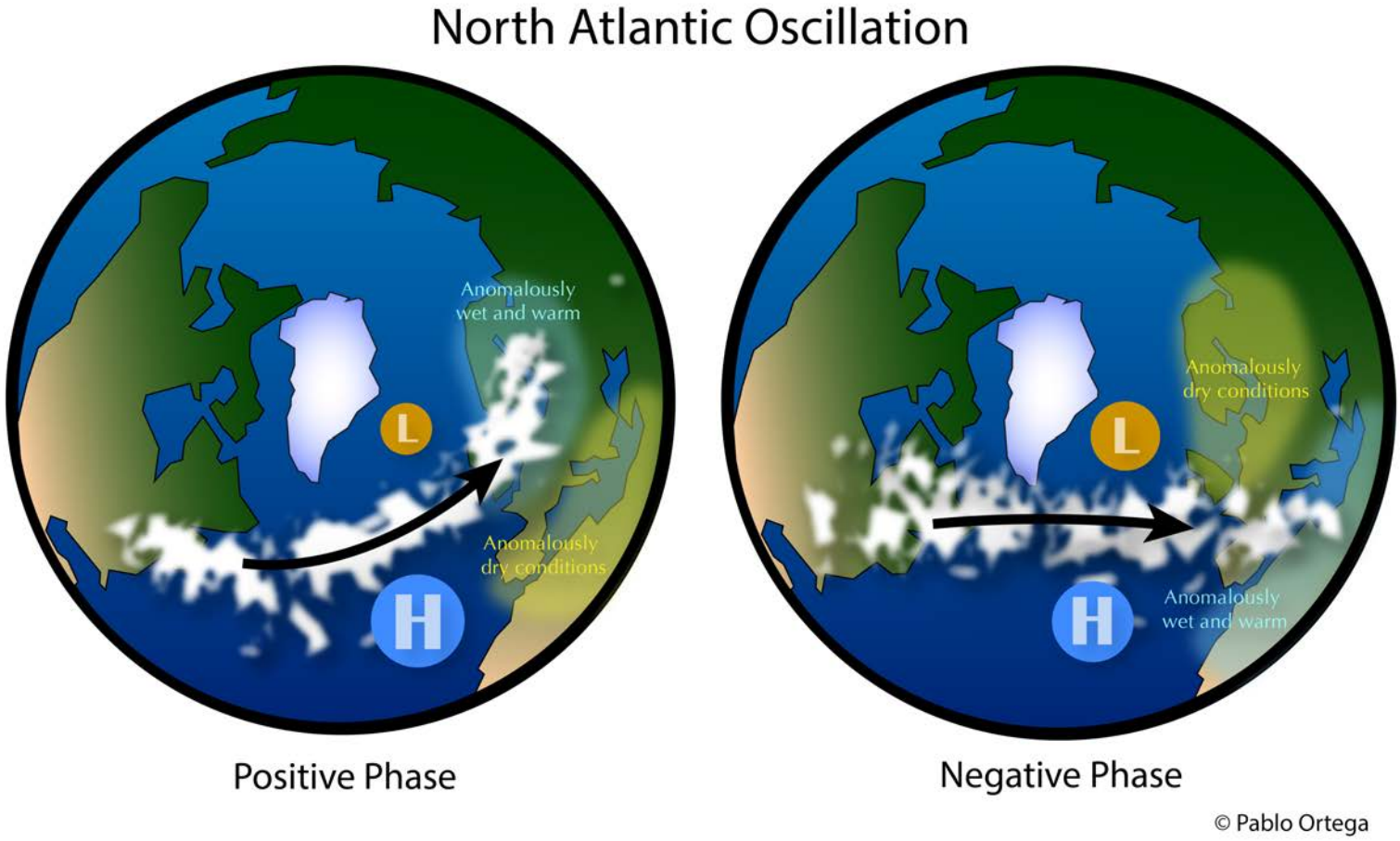
→ **Global cooling observed after large volcanic eruptions**



(Swingedouw et al., 2017)

Introduction

→ **The NAO is the main mode of climate variability in the North Atlantic**



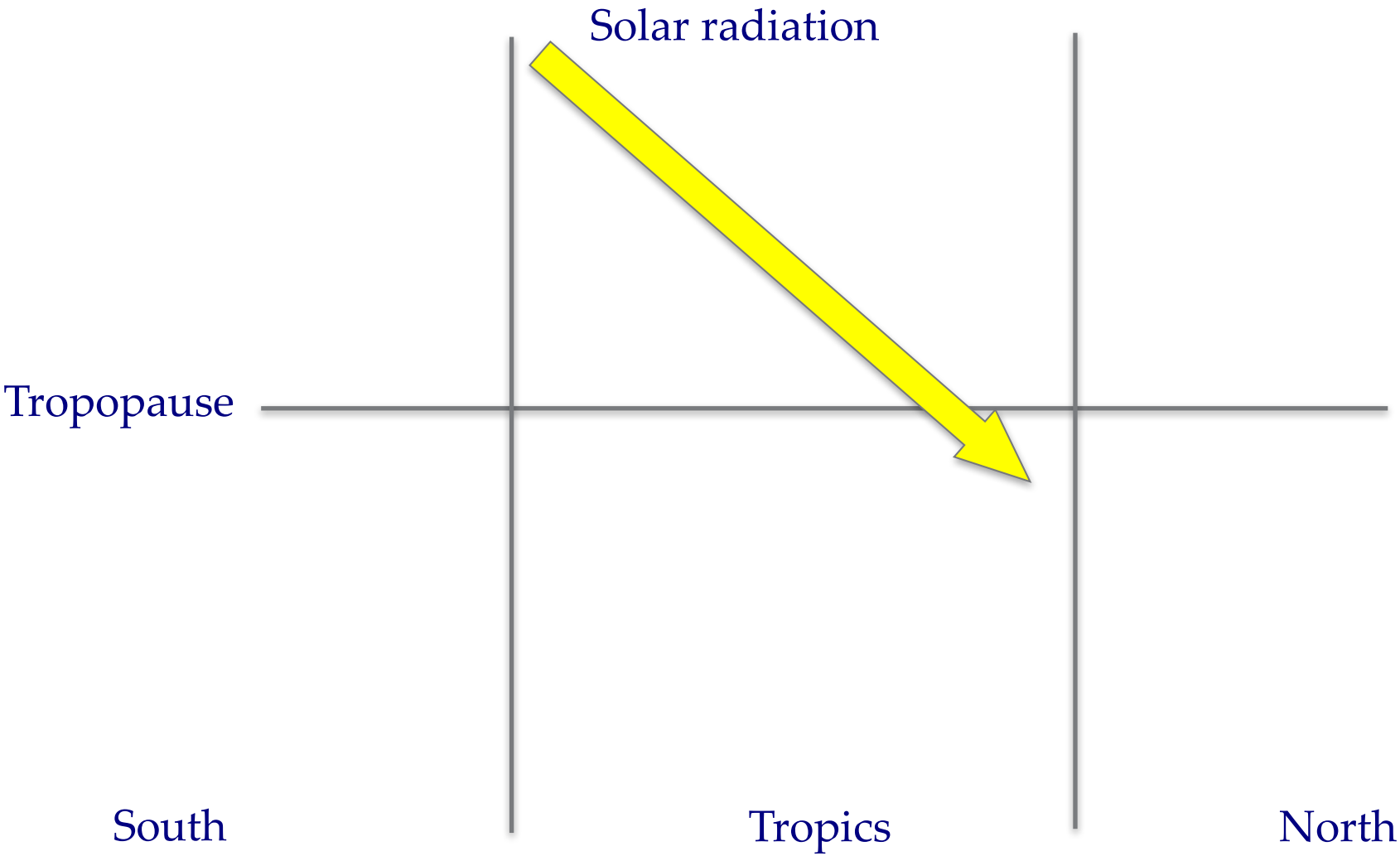
Introduction

→ Positive NAO conditions observed during the two winters following the Pinatubo eruption in 1991…

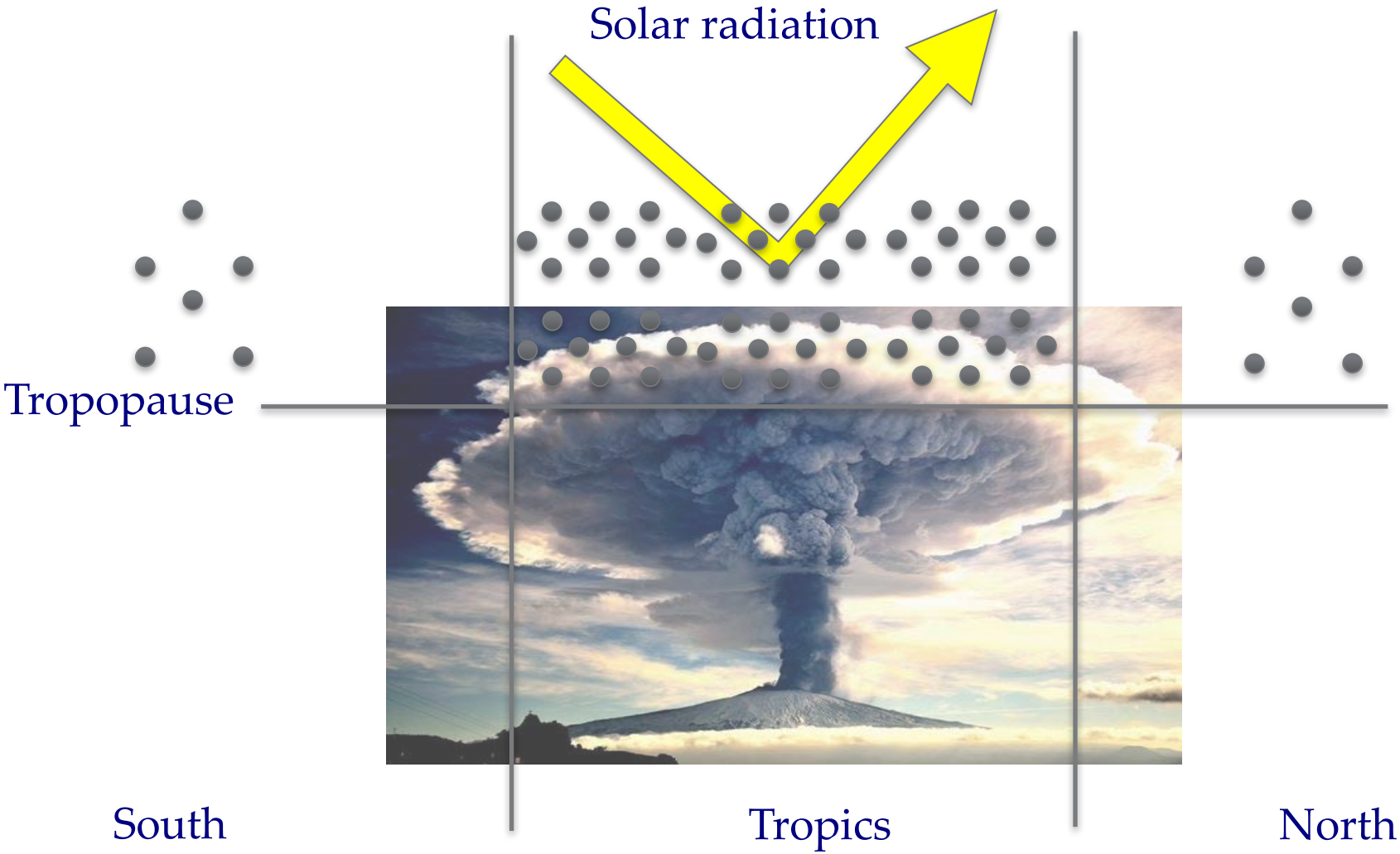
and

… the beginning of a passionate and unclosed debate!!!

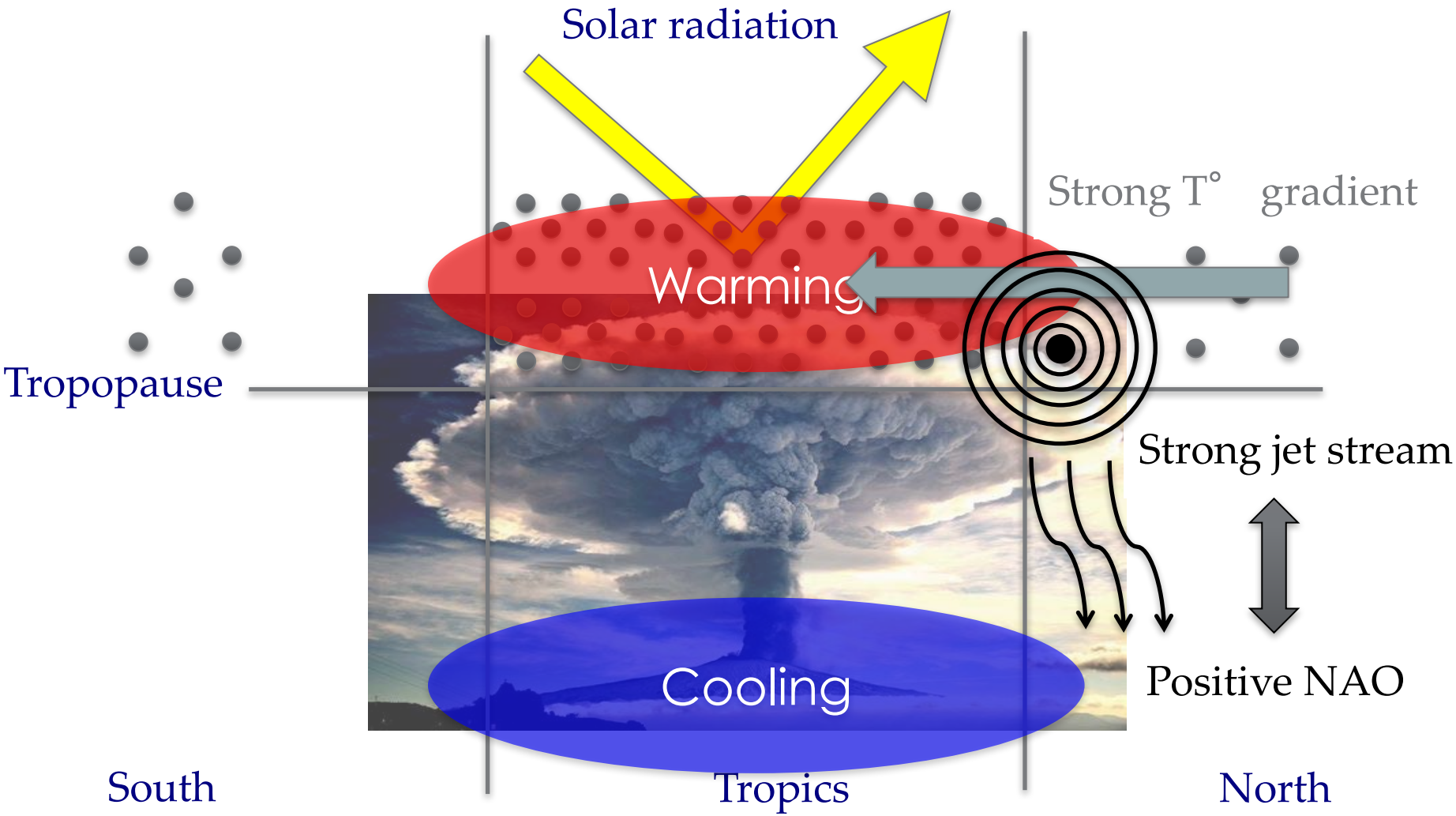
Mechanisms



Mechanisms

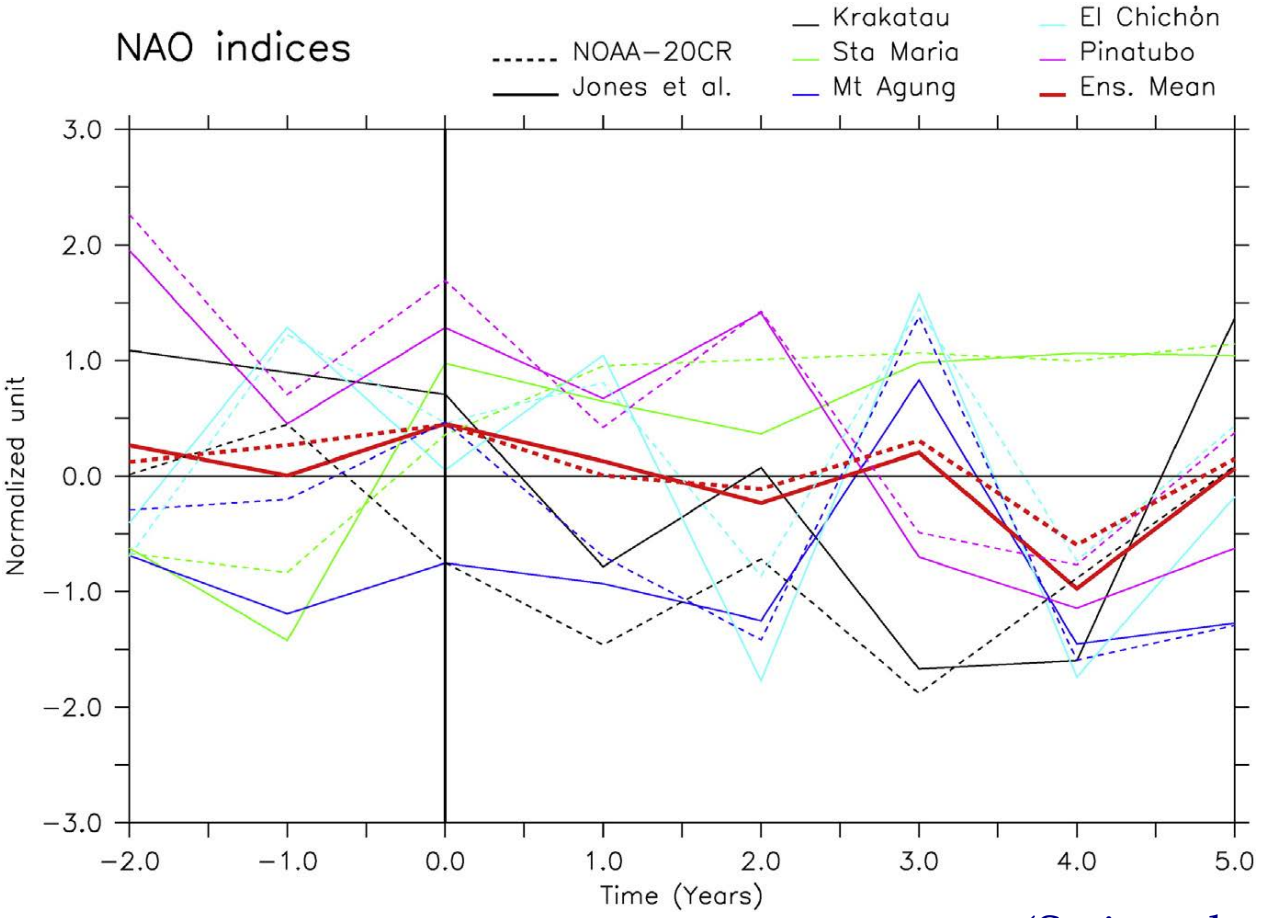


Mechanisms


Solar radiation
Strong T° gradient
Warming
Tropopause
Strong jet stream
Cooling
Positive NAO
South
Tropics
North

Observations

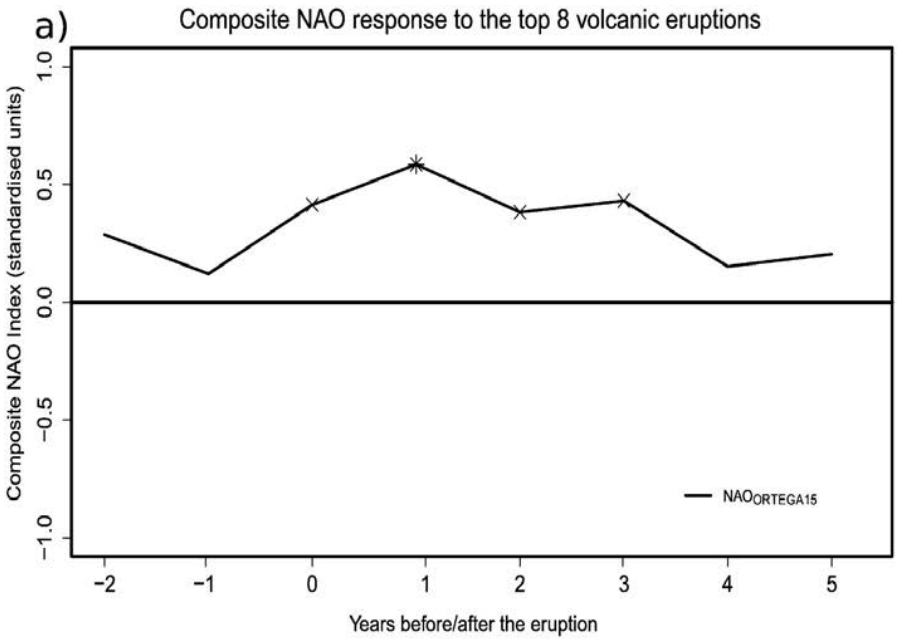
→ No evidence for any winter NAO signal after the last five major eruptions!



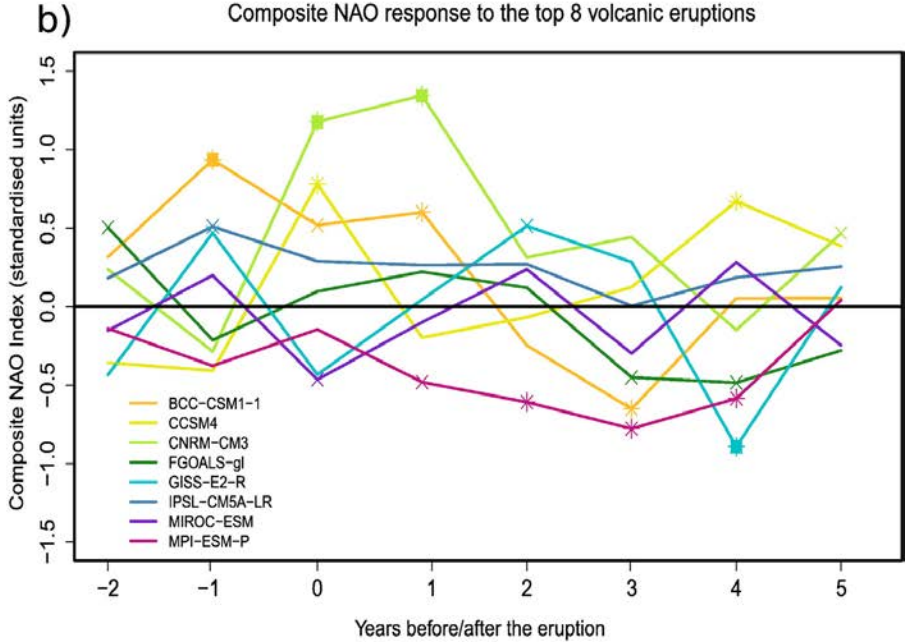
(Swingedouw et al., 2017)

Observations

→ **But positive NAO signal after the 8 major eruptions of the last 1000 years (very large eruptions, stronger than the Pinatubo)**



Observations



Not reproduced by all the models!

(Ortega et al., 2015; Swingedouw et al., 2017)

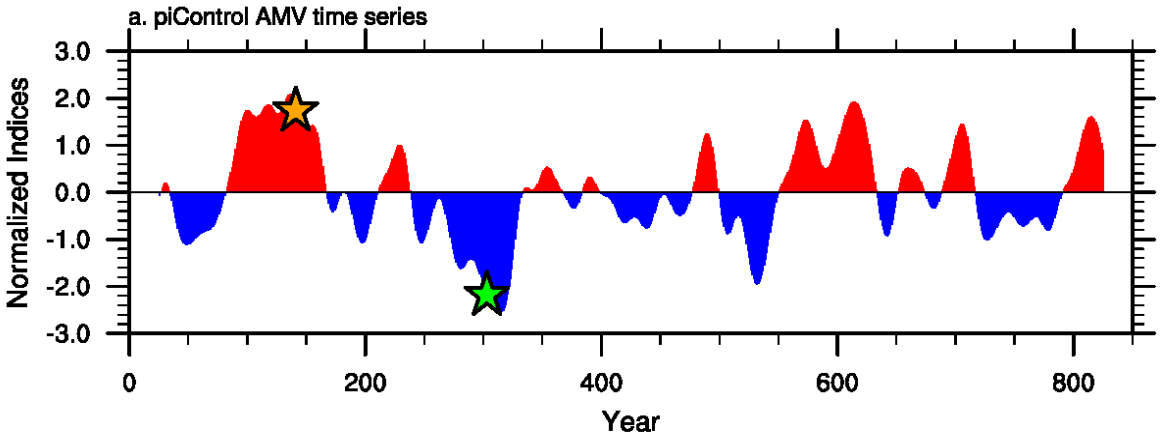
Model experiments

→ **Does the NAO response depend on the climate conditions in the Atlantic?**

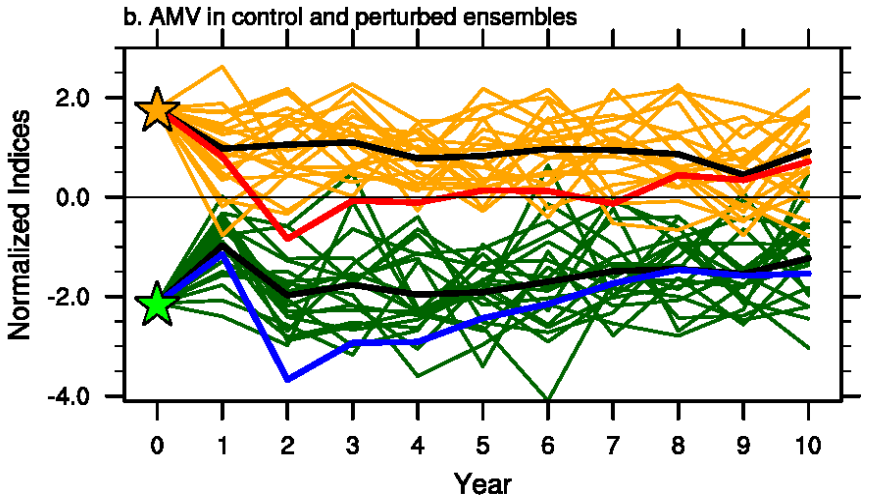
→ **Can we detect this signal from the internal variability?**

Model experiments

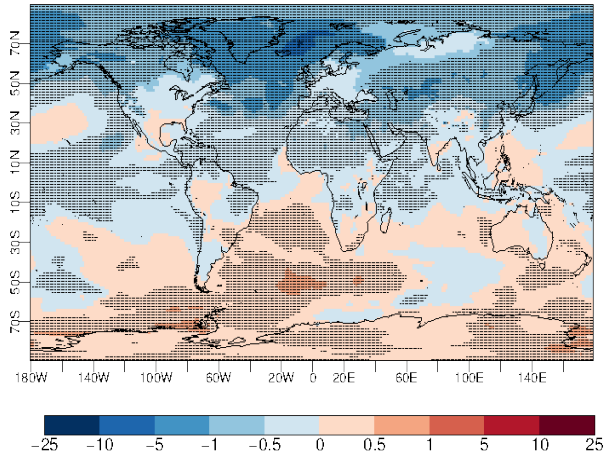
→ 850 years control experiment



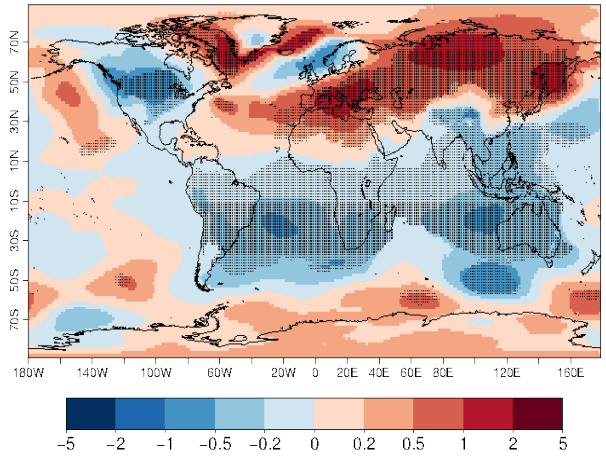
→ Simulating a Pinatubo under warm/cold phases of the AMV



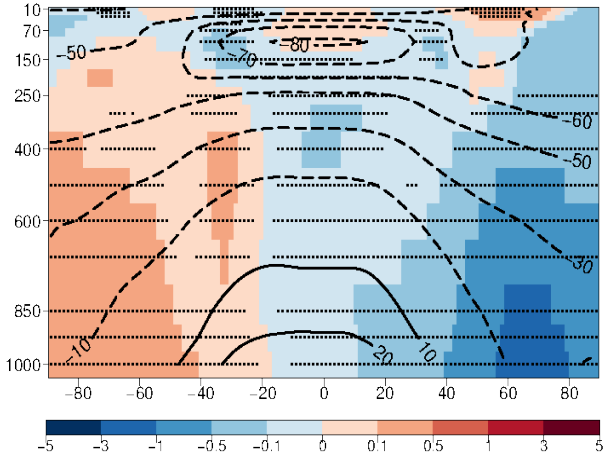
AMV- versus AMV+



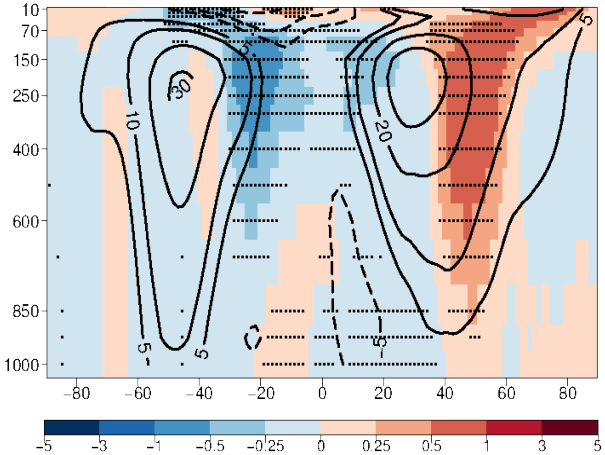
Surface T°



Sea level pressure



Zonal mean temperature

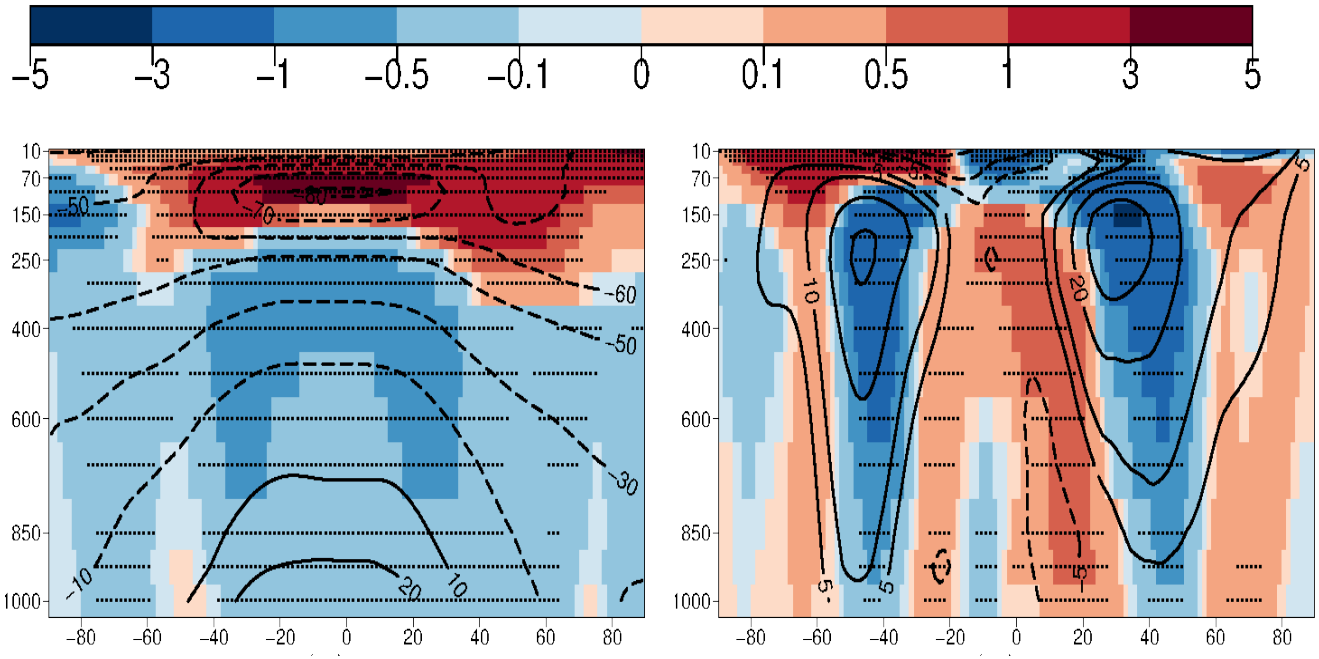


Zonal mean wind

Winter ensemble mean differences between simulations run under warm and cold AMO conditions (36 members)

Model experiments

First winter anomalies after a Pinatubo eruption, cold AMV case



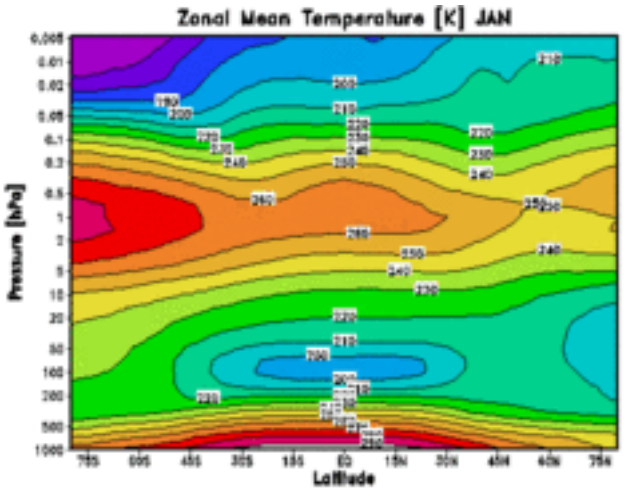
Temperature (° C)

Zonal wind ($m.s^{-1}$)

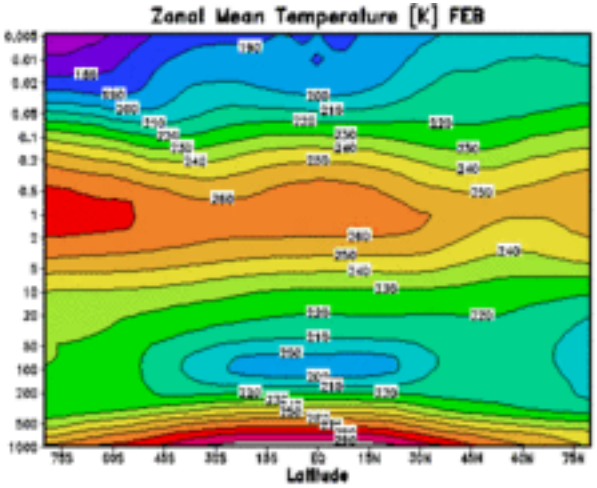
Climatology (contours) and anomalies (shading), from Ménégoz et al. (in rev.)

Stratospheric observations

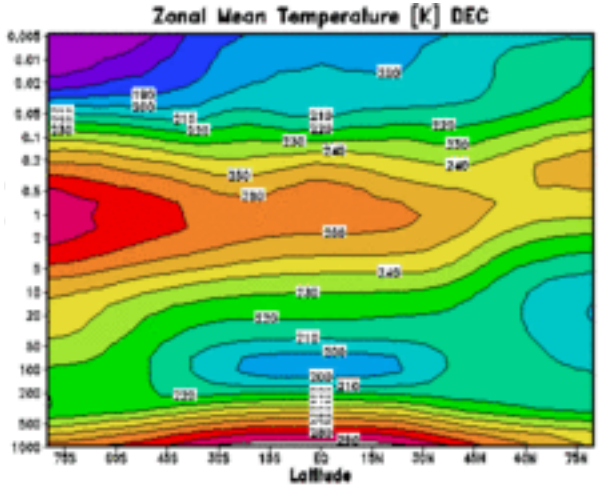
Climatology of the zonal mean of temperature:



January



February



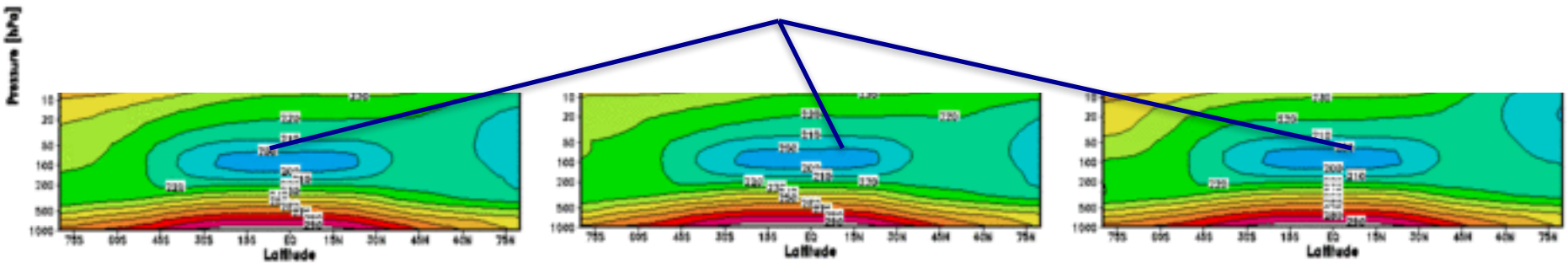
March

SPARC dataset (http://www.sparc-climate.org/)

Stratospheric observations

Climatology of the zonal mean of temperature:

At 100 hPa, the stratosphere is cooler in the Tropics than in the high latitudes

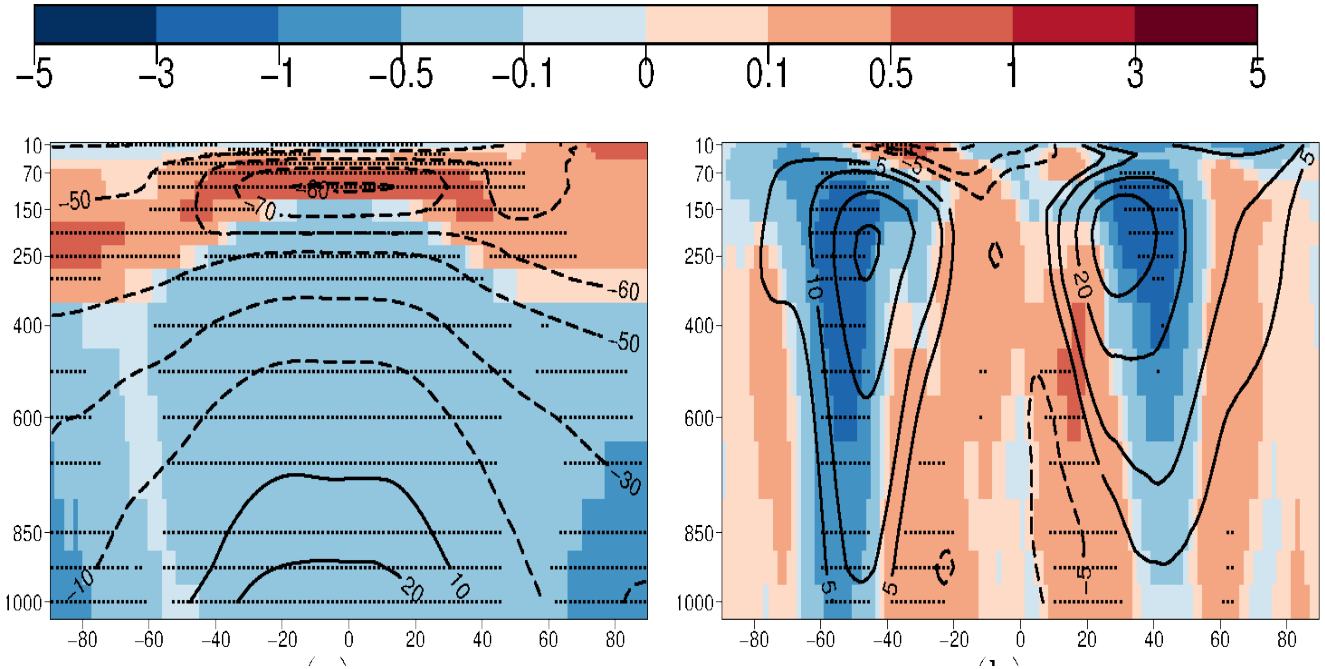


January February March

SPARC dataset (http://www.sparc-climate.org/)

Model experiments

Second winter anomalies after a Pinatubo eruption, cold AMV case



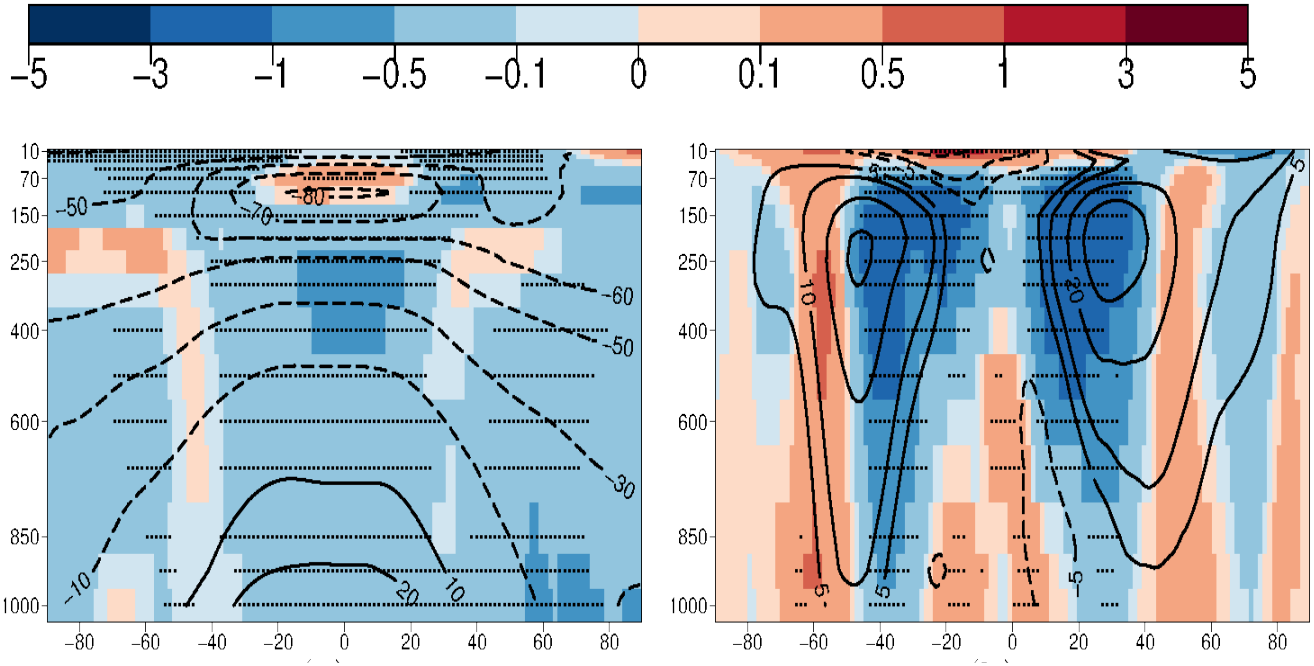
Temperature (° C)

Zonal wind (m.s^{-1})

Climatology (contours) and anomalies (shading), from Ménégoz et al. (in rev.)

Model experiments

Third winter anomalies after a Pinatubo eruption, cold AMV case

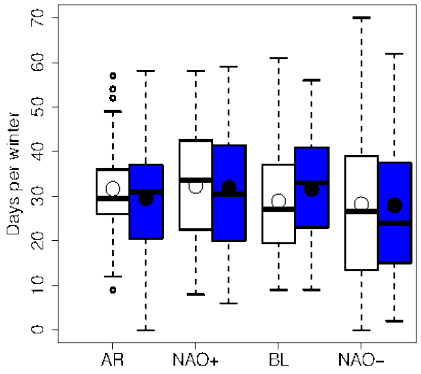


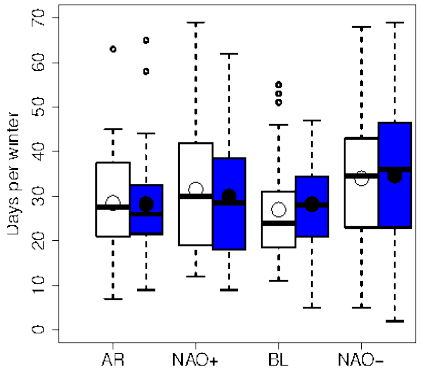
Temperature (° C) Zonal wind ($m.s^{-1}$)

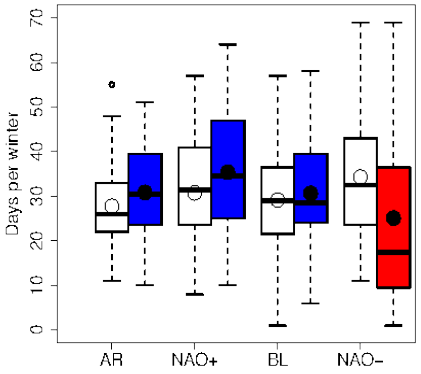
Climatology (contours) and anomalies (shading), from Ménégoz et al. (in rev.)

Weather regimes changes

Cold AMV

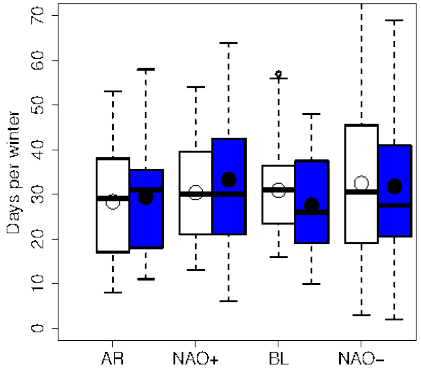


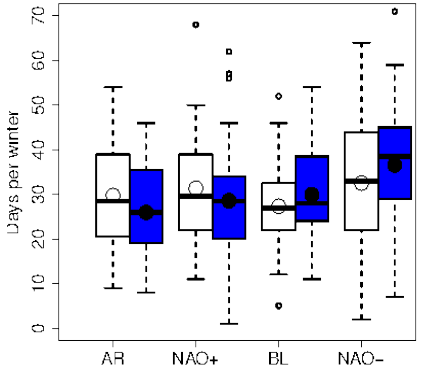


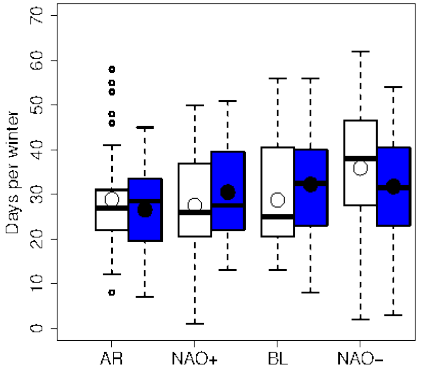


Winter 1 ***Winter 2*** ***Winter 3***

Warm AMV

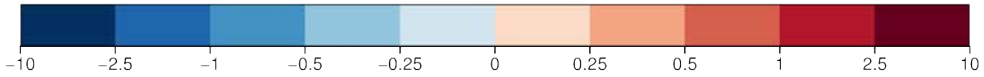


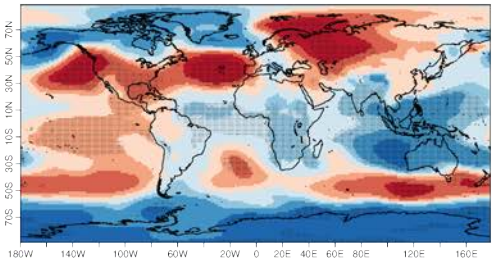


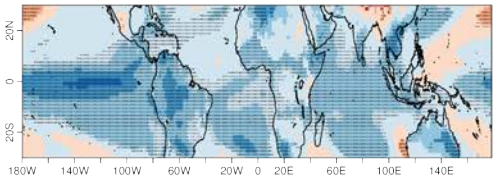


Weather regime occurrences simulated the first winter after eruptions simulated under cold (up) and warm (bottom) AMV conditions.

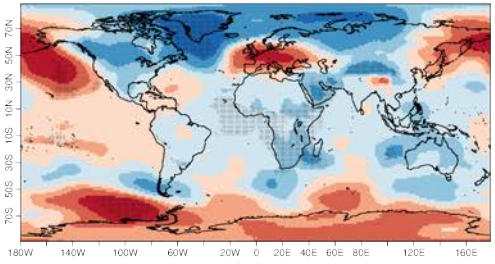
Cold tropics under cold AMV

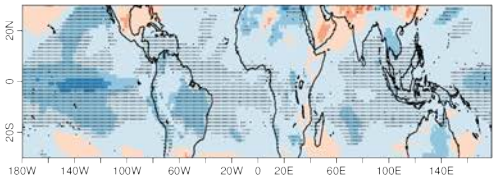




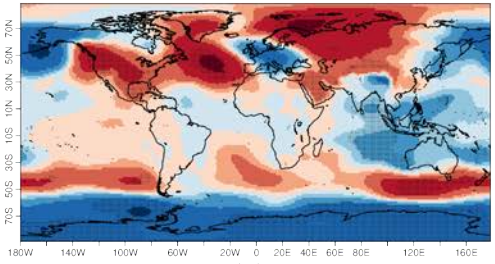


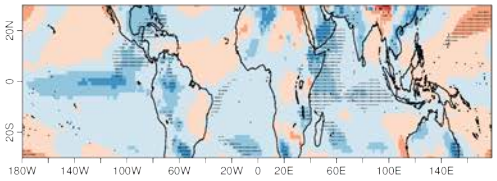
Cold AMV





Warm AMV

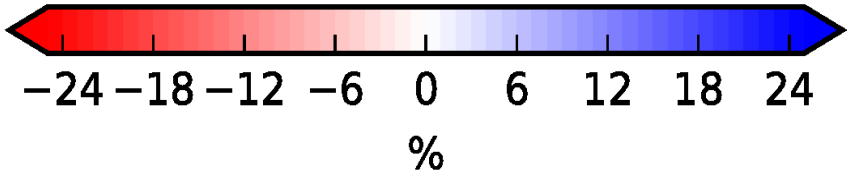


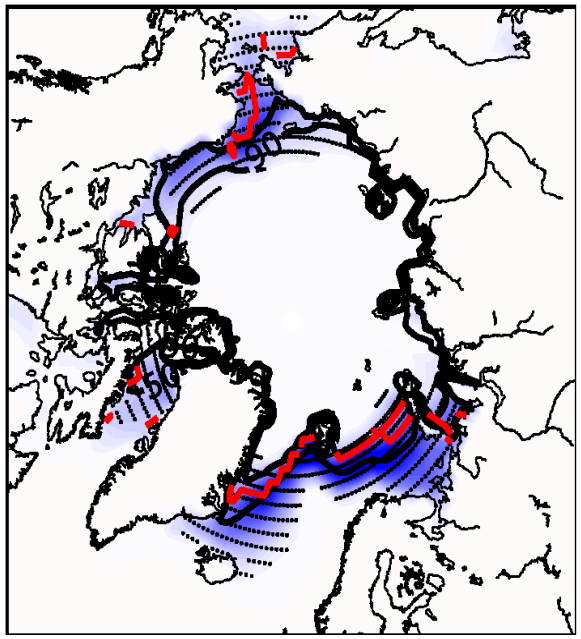


Cold – warm AMV

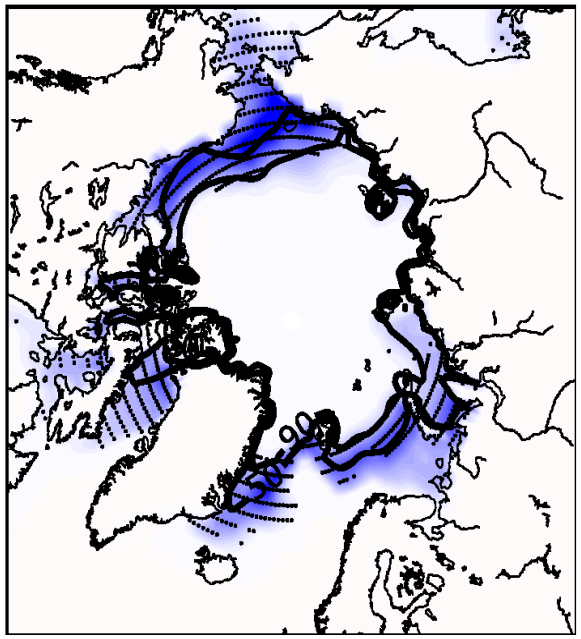
SLP anomaly *T° anomaly* *(3rd winter after the eruption)*

Sea-ice anomalies





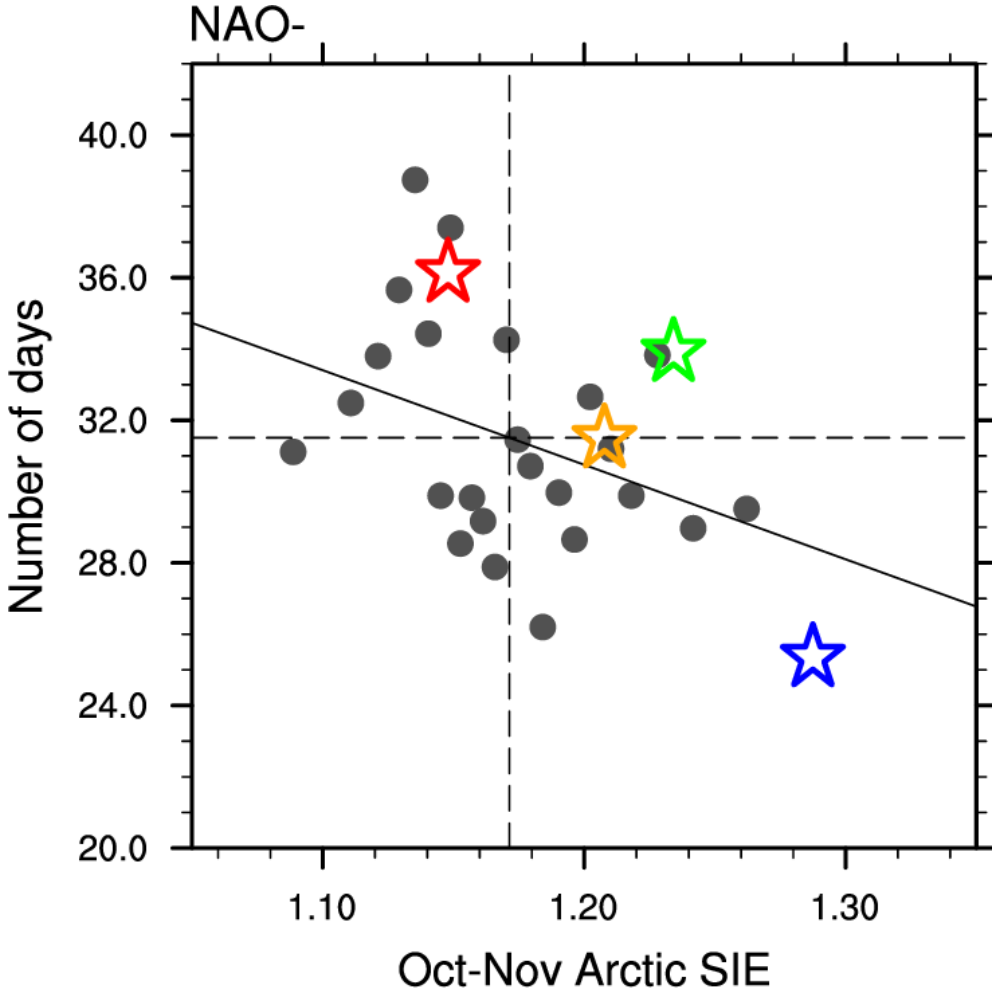
Cold AMV



Warm AMV

Sea-ice anomalies simulated the third autumn after a Pinatubo eruption. South of the red line, the response is stronger in the case of the cold AMV situation

Autumn sea-ice versus winter NAO- regime



- *36 year samples from the millennium simulation*
- *Control under warm AMV*
- *Pinatubo under warm AMV*
- *Control under cold AMV*
- *Pinatubo under cold AMV*

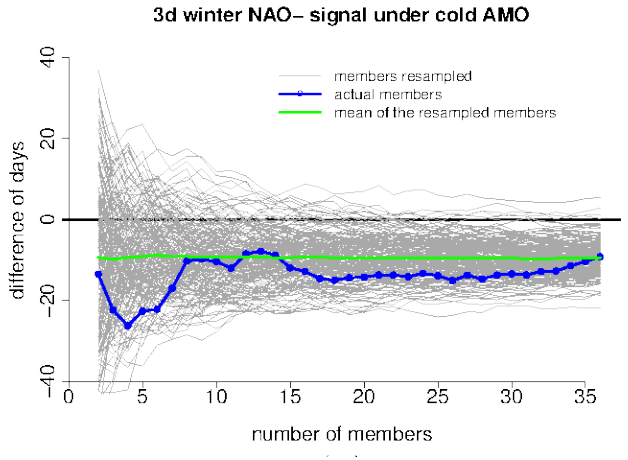
NAO- change the third winter

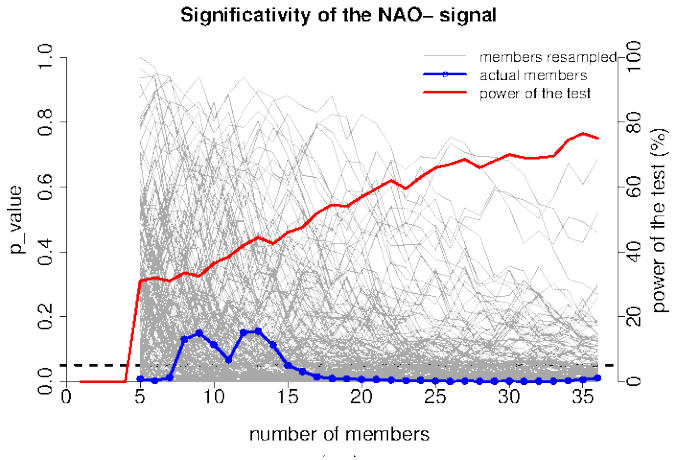
Cold AMO

Actual members

Members resampled

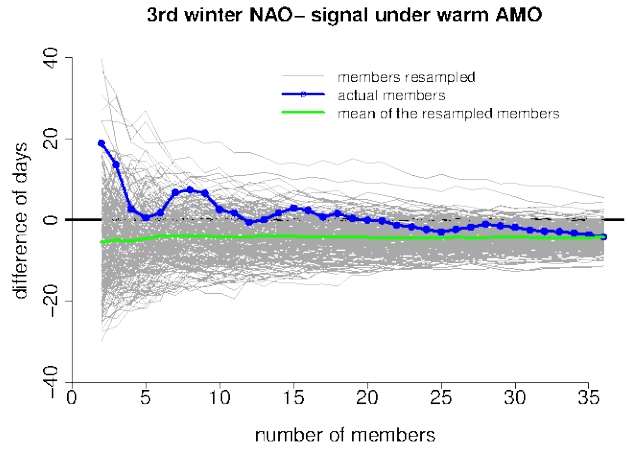
Warm AMO

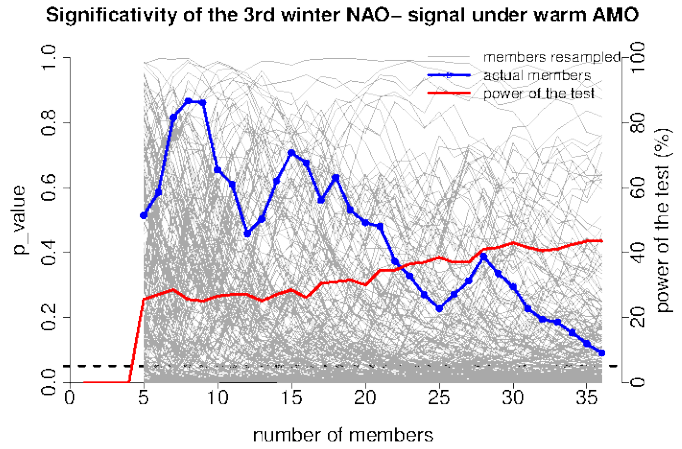




Volcanic signal / member mean (days)

P-value / power



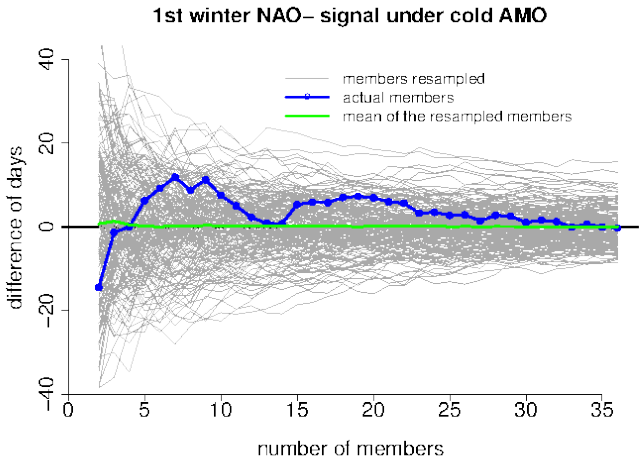


NAO- change the first winter

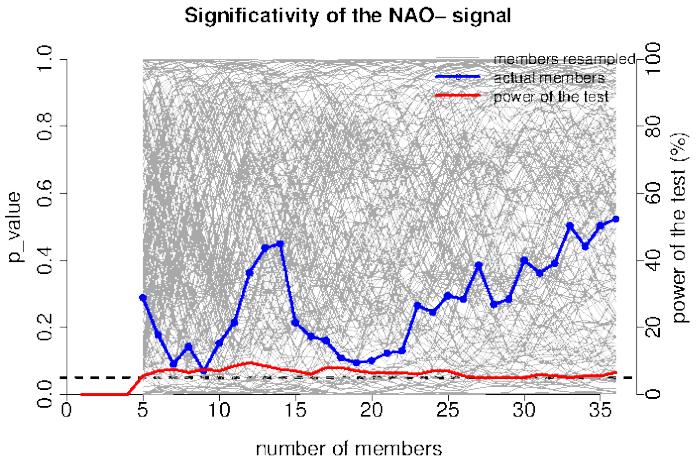
Cold AMO

Actual members

Members resampled



Volcanic signal / member mean (days)



P-value / power

Conclusions

→ Observational evidence for a positive NAO signal persisting three winters after the largest eruptions of the last millennium.

→ Significant decrease of the NAO- occurrence the third winter after a Pinatubo eruption in the CNRM-CM5 model.

→ This NAO- signal is related to surface feedbacks: cooler Tropics and sea-ice anomalies, especially pronounced under cold AMV conditions.

→ Detecting the NAO response to volcanic eruptions is challenging (low signal-noise ratio). Small ensemble experiments can give misleading results!

- Swingedouw, D., Mignot, J., Ortega, P., Khodri, M., Ménégoz, M., Cassou, C., Hanquiez, V., 2017, Impact of explosive volcanic eruptions on the main climate variability modes, *Global and Planetary Change, Vol. 150, P. 24–45.*
- Ménégoz, M., Cassou, C., Swingedouw, D., Bretonnière, P.-A., Doblas-Reyes, F., Modulation of the climate response to a volcanic eruption by the Atlantic Multidecadal Variability, in revision for Climate Dynamics.

Thank you