Teleconnections: internal versus forced variability (EC-Earth ensemble simulations)

Susanna Corti

Contributions from

Irene Mavilia[1], Paolo Davini[2,1],Chunxue Yang[1] and Jost von Hardenberg[1]

[1]Istituto di Scienze dell'Atmosfera e del Clima,
Coniglio Nazionale delle Ricerche, Bologna, Torino, Italy
[2]Laboratoire de Météorologie Dynamique,
École Normale Supérieure, Paris

ICTP/ECMWF/Univ. L'Aquila Workshop on OpenIFS

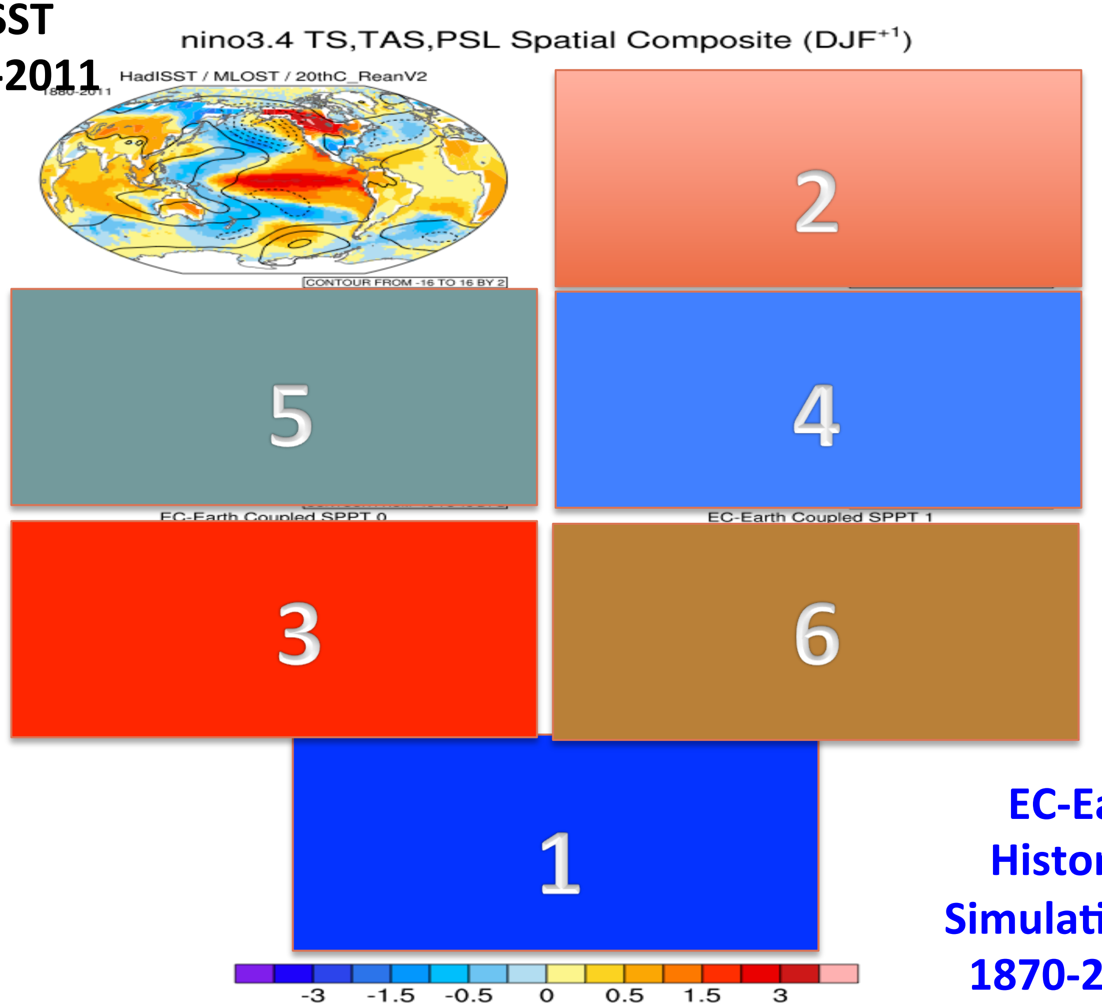
5-9 June 2016, Trieste

Consiglio Nazionale delle Ricerche

Istituto di Scienze dell'Atmosfera e del Clima

Teleconnections: The "Old Queen" : El Niño-PNA (or PNA-like)

HadISST 1880-2011



EC-Earth Historical Simulations 1870-2011

AMV(or AMO)

Environ. Res. Lett. **9** (2014) 034018 Y Peings and G Magnusdottir

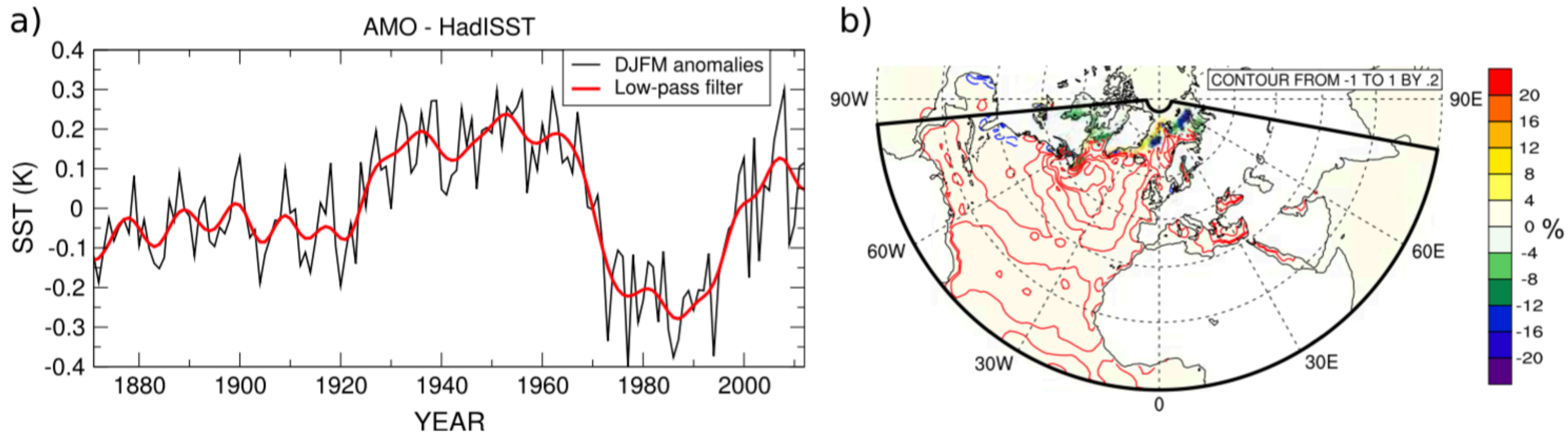


Figure 1. AMO signature in the observations. (a) Winter (DJFM) AMO time series from the HadISST dataset (red). Seasonal anomalies are shown in black. (b) SST (contours in K, positive contours in red, negative contours in blue) and SIC anomalies (shading in %) associated with the AMO signal in observations over 1951–2012 (difference between positive and negative phases of the AMO, based on composite analysis to select positive and negative AMO years). The domain on which the AMO anomalies are imposed in the model is also shown.

AMV index: yearly anomalies of the North Atlantic SSTs between 75° W–5° W and 0° –70° N minus 10-year running mean of the global SSTs (area-averaged between 60° S and 60° N) (Trenberth and Shea 2006).

AMO(or AMV) & The Euro-Atlantic Flow Regimes Frequencies

Environ. Res. Lett. **9** (2014) 034018
Y Peings and G Magnusdottir

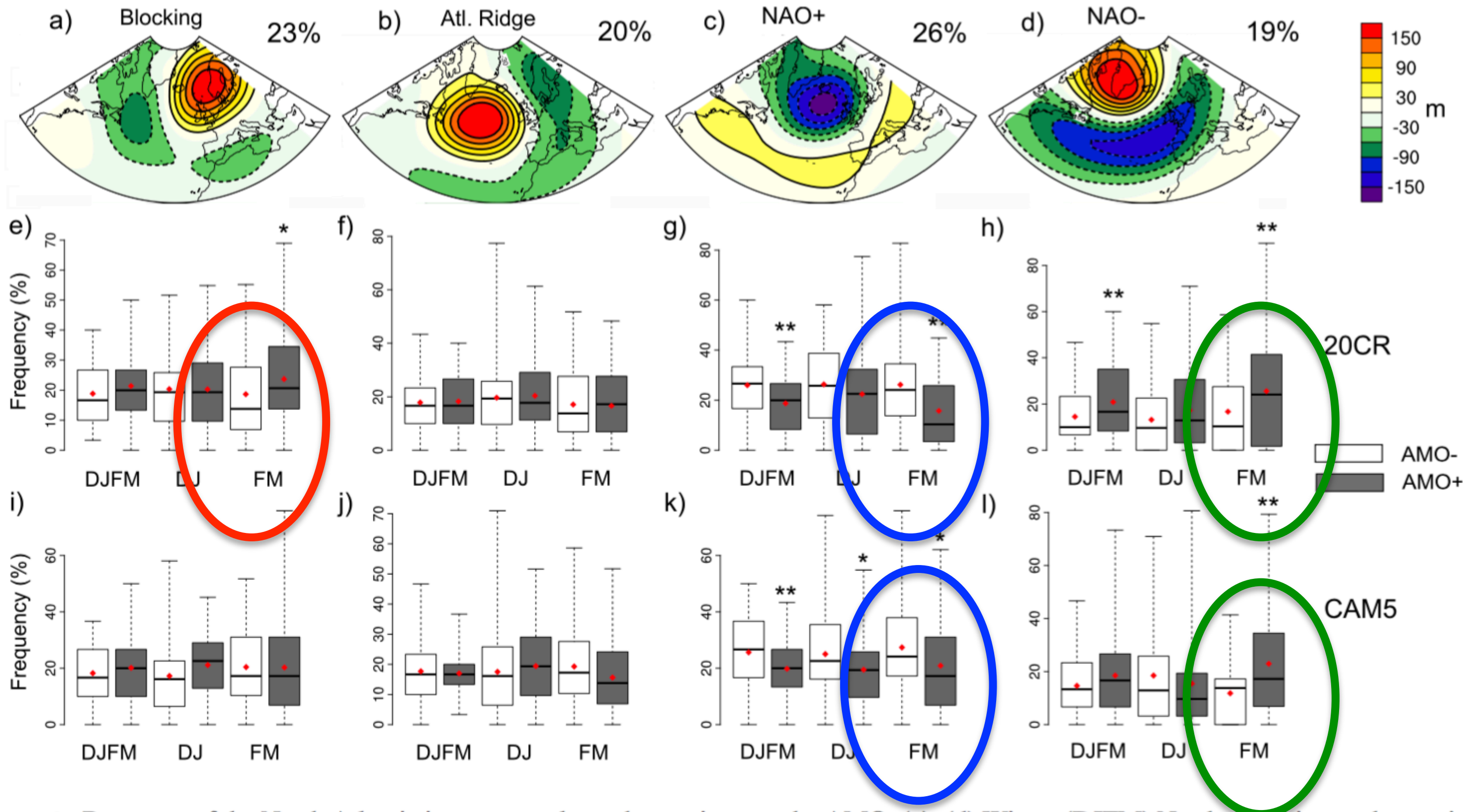


Figure 3. Response of the North Atlantic intraseasonal weather regimes to the AMO. (a)–(d) Winter (DJFM) North Atlantic weather regimes computed over 1901–2010 from the Z500 anomalies (in m) of 20CR. Frequencies of occurrence over the 1901–2010 wintertime days are indicated in %. (e)–(h) Distribution of seasonal regime frequencies in 20CR over 1901–2010, during AMO− (53 years, white boxplots) and AMO+ (57 years, gray boxplots) for winter (DJFM), early (DJ) and late (FM) winter. (i)–(l) same as (e)–(h) except for CAM5 (AMOn in white and AMOp in gray, 50 years for each experiment). Boxplots indicate the maximum, upper-quartile, median, lower-quartile and minimum of the distribution (horizontal bars). The mean of the distribution is shown by red diamonds, and asterisks indicate the significance level of the difference of the mean between AMO− and AMO+ (AMOn and AMOp for the simulations): *: $p < 0.1$; **: $p < 0.05$ (t-test).

AMO(or AMV) &
The Euro-Atlantic Blocking

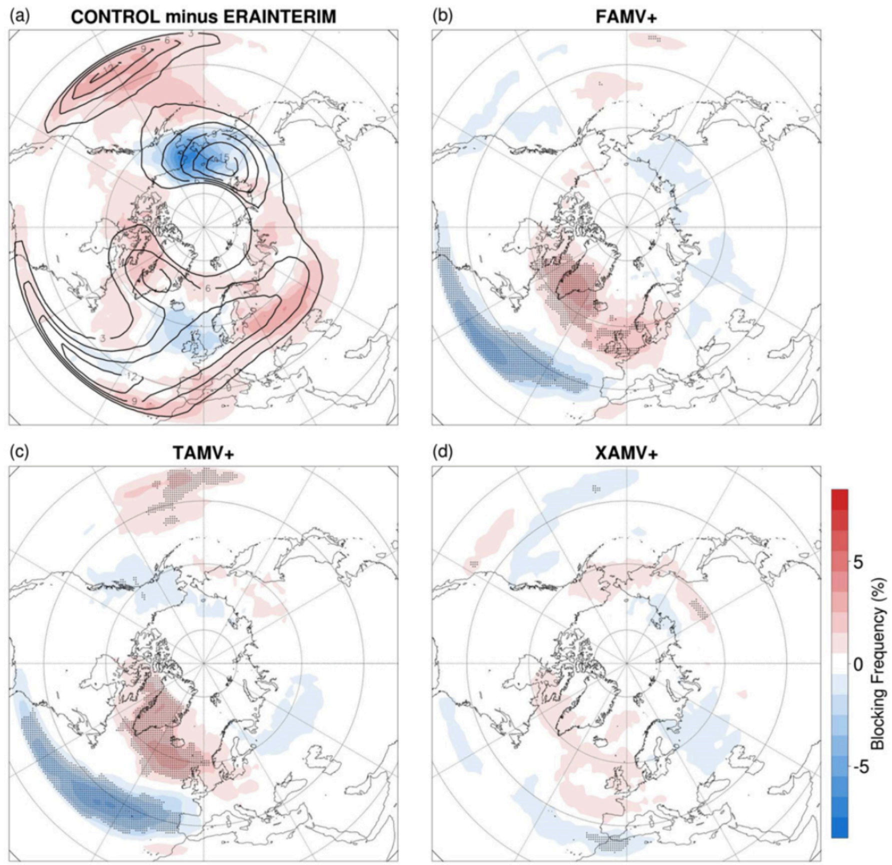


Figure 2. (a) DJFM Blocking frequency bias for the CONTROL experiment with respect to the ERA-INTERIM reanalysis (colors) and CONTROL blocking frequencies (contours). DJFM Blocking frequency anomalies shown as positive minus negative phase for (b) FAMV, (c) TAMV and (d) XAMV experiments. All are expressed as percentage of blocked days per season. In (a) contours are drawn each 3%. Stippled regions show significance at the 2% level.

Questions

- How well are the teleconnection patterns "reproduced" in climate models?
- What is the degree of "reproducibility" of these teleconnection patterns in a set of climatological sister simulations?
- What are the factors that might weaken or strengthen a teleconnection pattern (or the regime sensitivity to "decadal oscillations")?

Climate SPHINX *(Stochastic Physics High Resolution Experiments)* ***is a PRACE EU project which aims at investigating the sensitivity of climate simulations to model resolution and stochastic parameterizations****, and to determine if very high resolution is truly necessary to facilitate the simulation of the main features of climate variability.*

SPHINX is a project by **ISAC-CNR**, led by Jost von Hardenberg, in collaboration with Oxford University (Tim Palmer and Antje Weisheimer group).

20 millions of core hours have been run on **Supermuc** @ LRZ Computing Center, Garching, Germany for a single-year PRACE project ended in **March 2016.**

EC-Earth Earth System Model **version 3.1** has been used.
Website and data access: (http://sansone.to.isac.cnr.it/sphinx/)

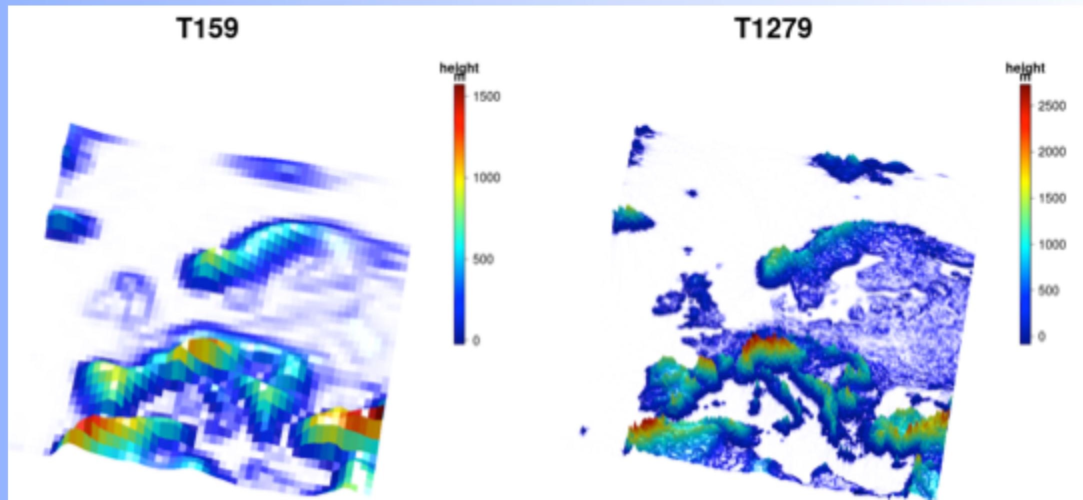
EXPERIMENTS & RESOLUTIONS

Atmospheric-only:
5 horizontal resolutions

Present day
1979-2008

Future Scenario
2039-2068 RCP85

Coupled: T255L91
1850-2100, historical + RCP8.5



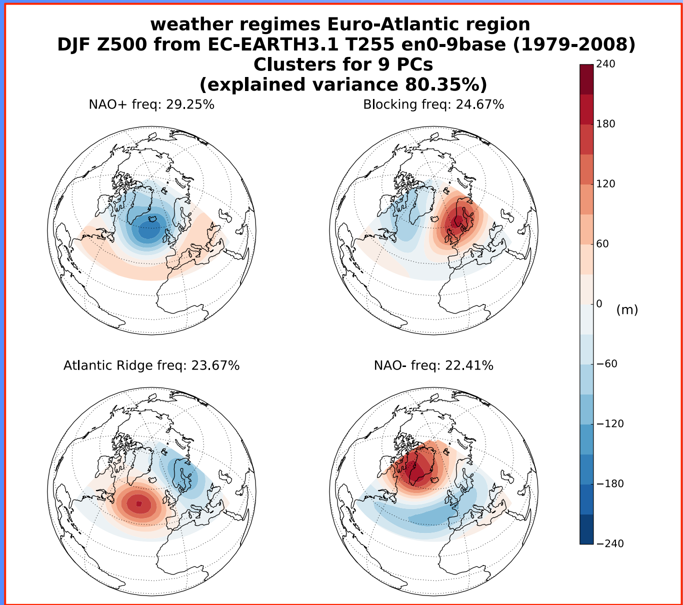
Tuning has been performed once only for T255L91 with no stochastic physics!

More than 110 simulations available!

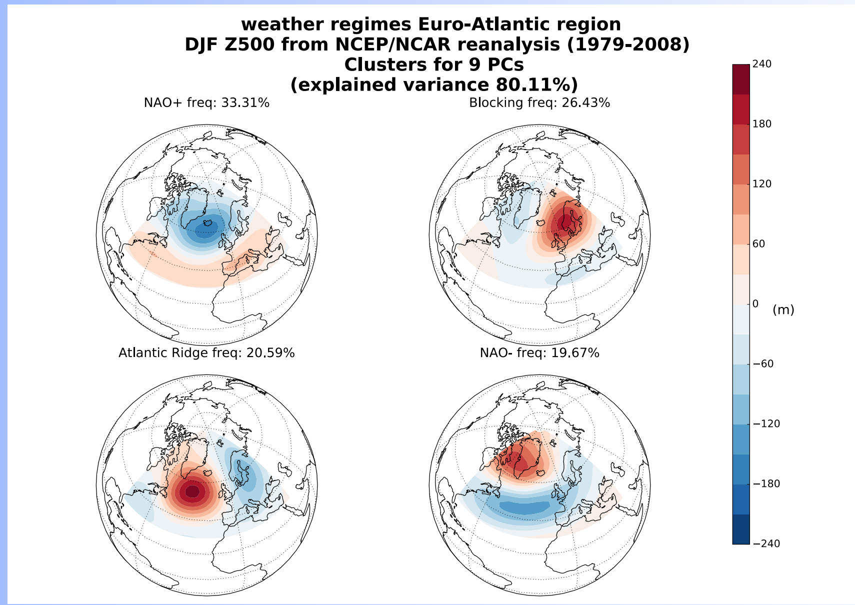
T159L91 (125km): 10+10 ensemble members
T255L91 (80km): 10+10
T511L91 (40km): 6+6
T799L91 (25km): 3+3
T1279L91 (16km): 1+1

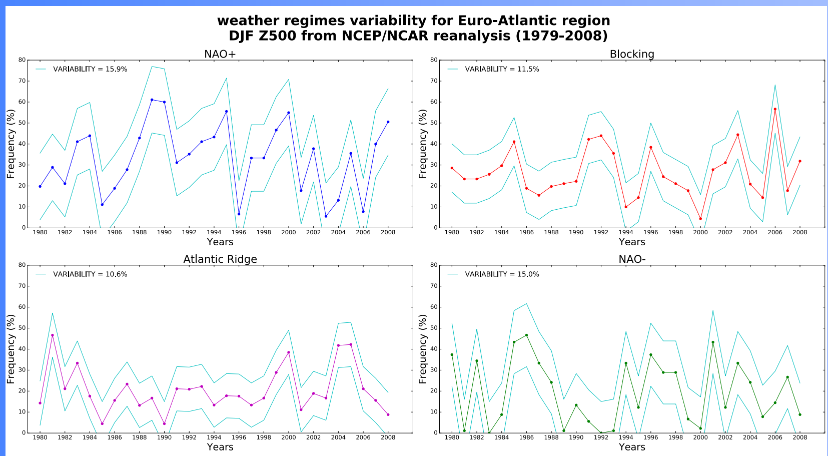
Euro-Atlantic Weather regimes
AMIP T255 [10 ensemble members]

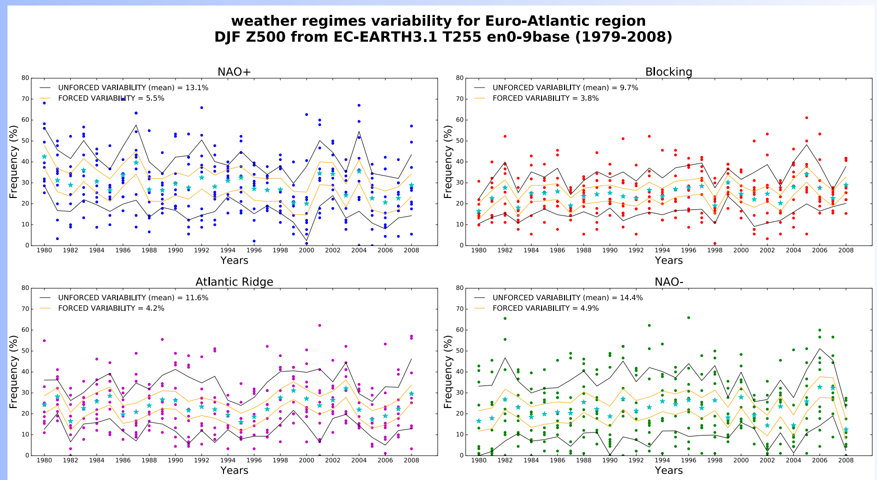
EC-Earth



NCEP

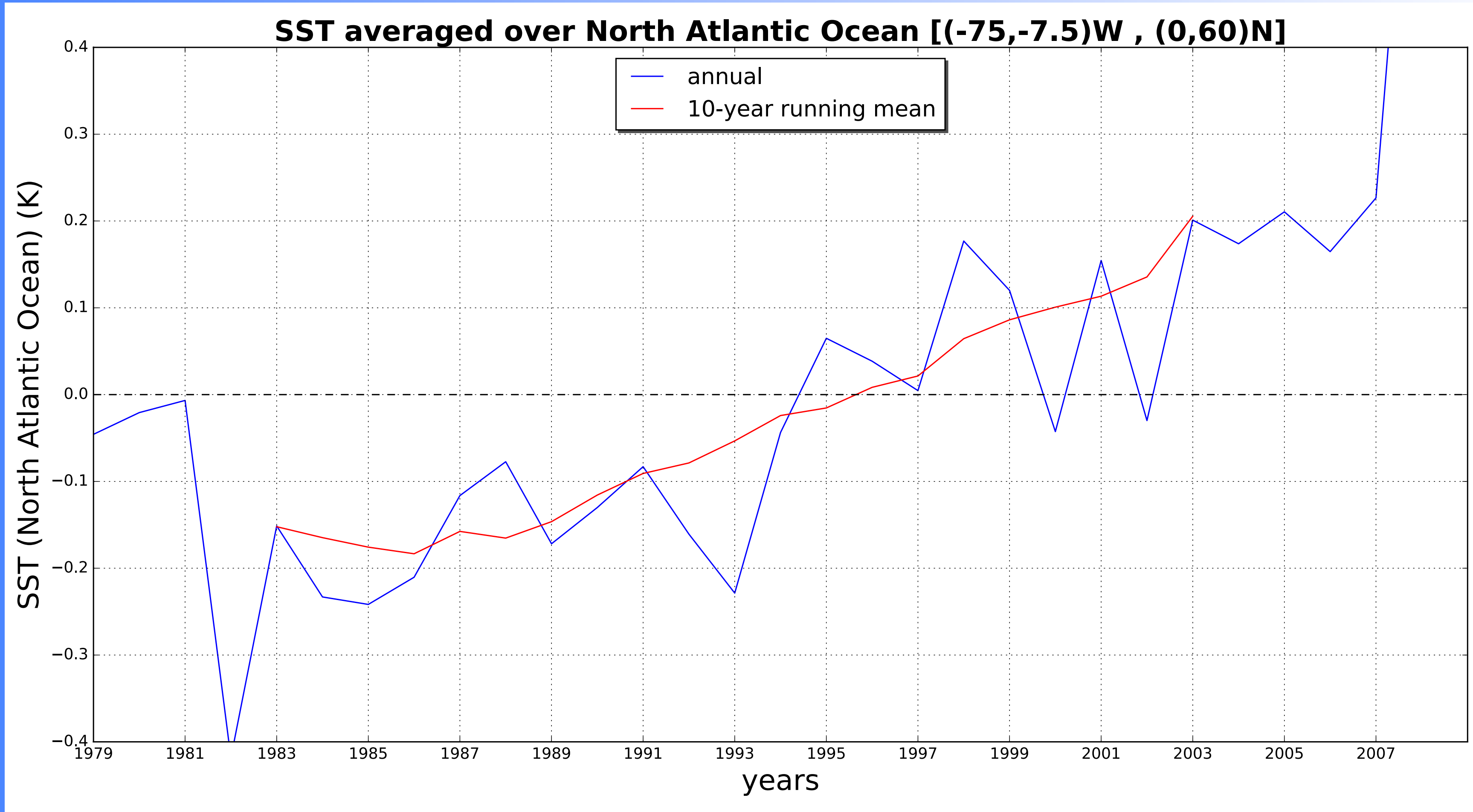




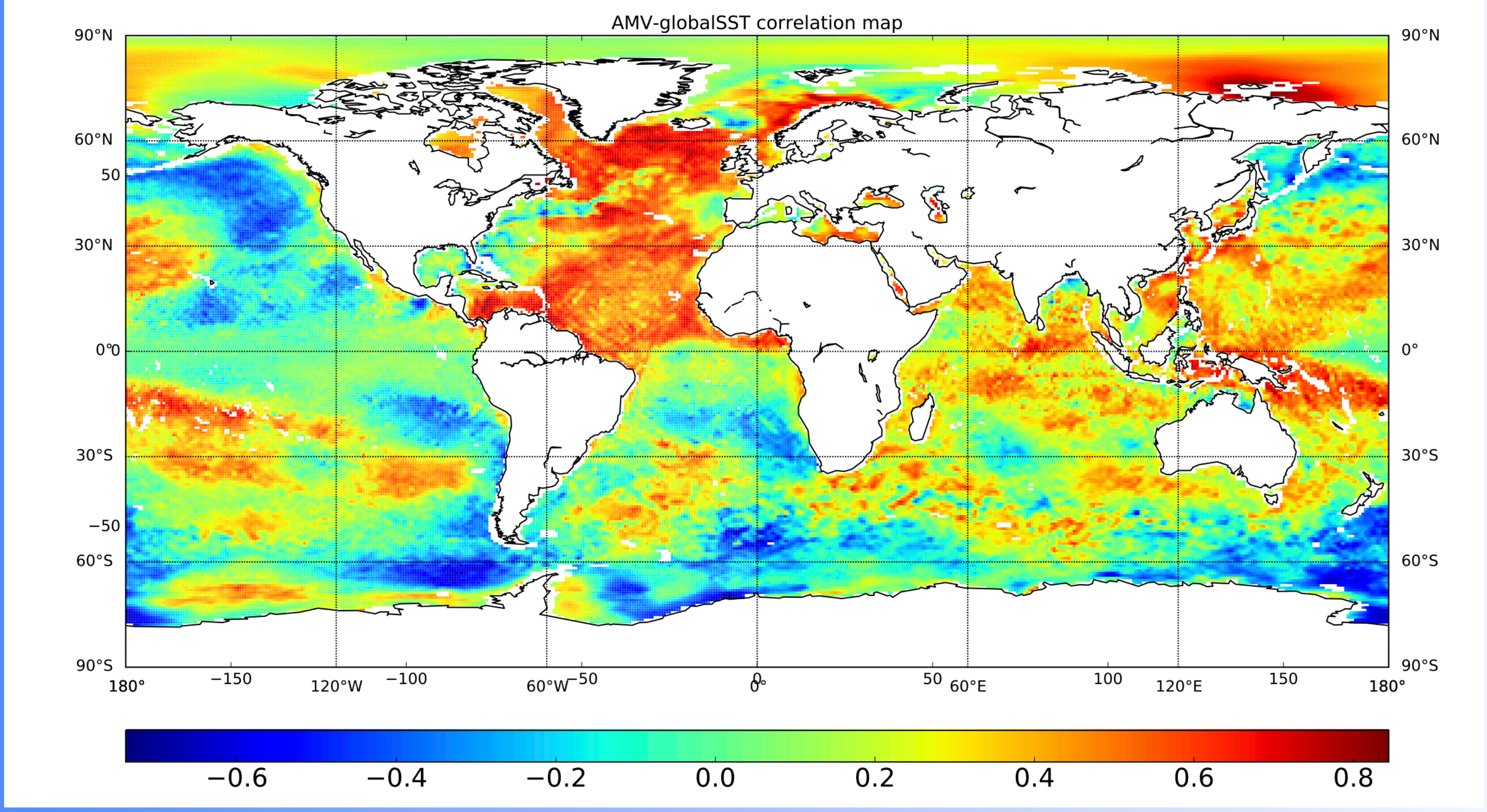


Atlantic Multidecadal Variability (AMV)

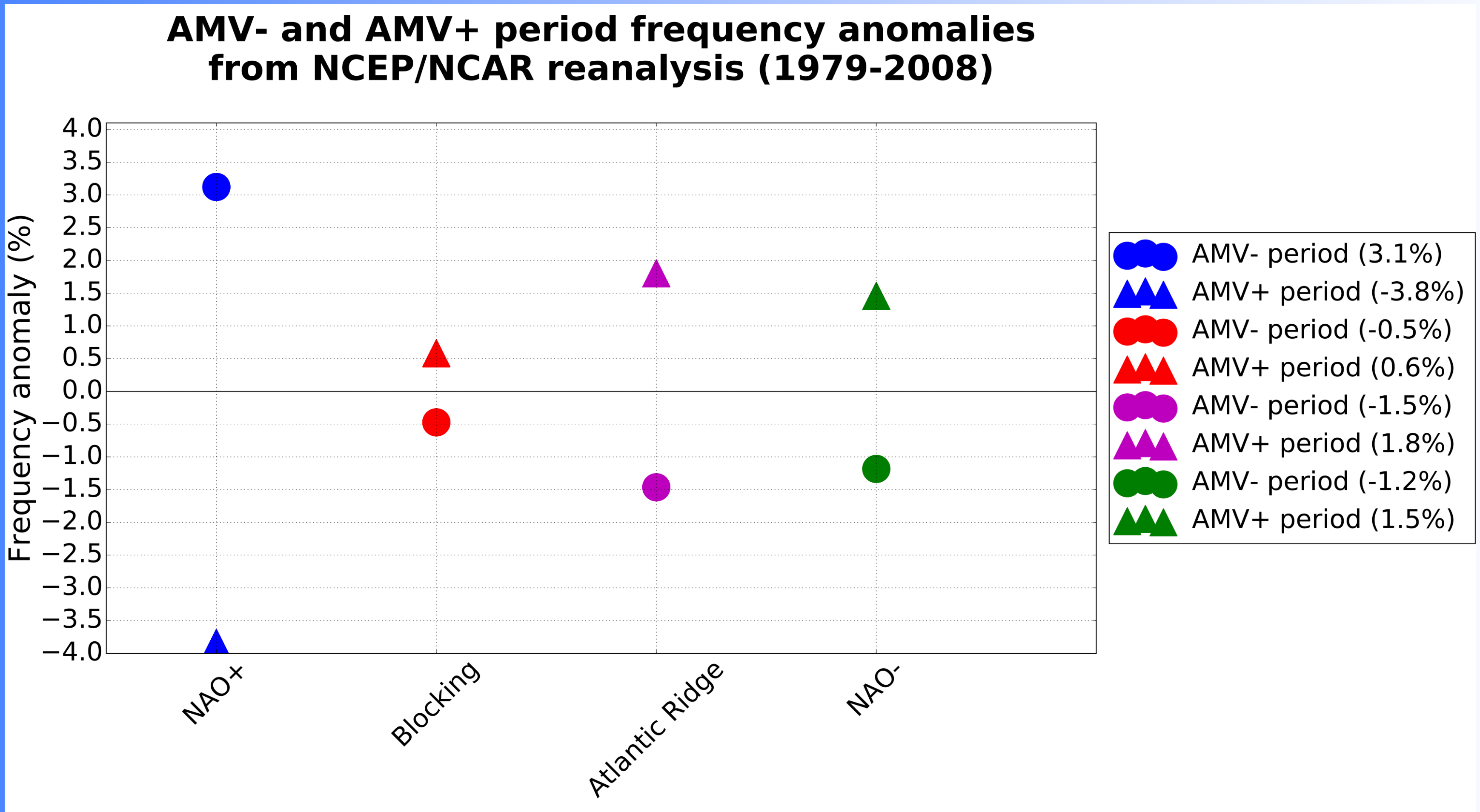
AMV- (1979-1995) AMV+ (1996-2008)



AMV & global SSTs



Sensitivity of Euro-Atlantic Weather regimes Frequency to AMV (NCEP)



Sensitivity of Euro-Atlantic Weather regimes Frequency to AMV (EC-Earth-AMIP)

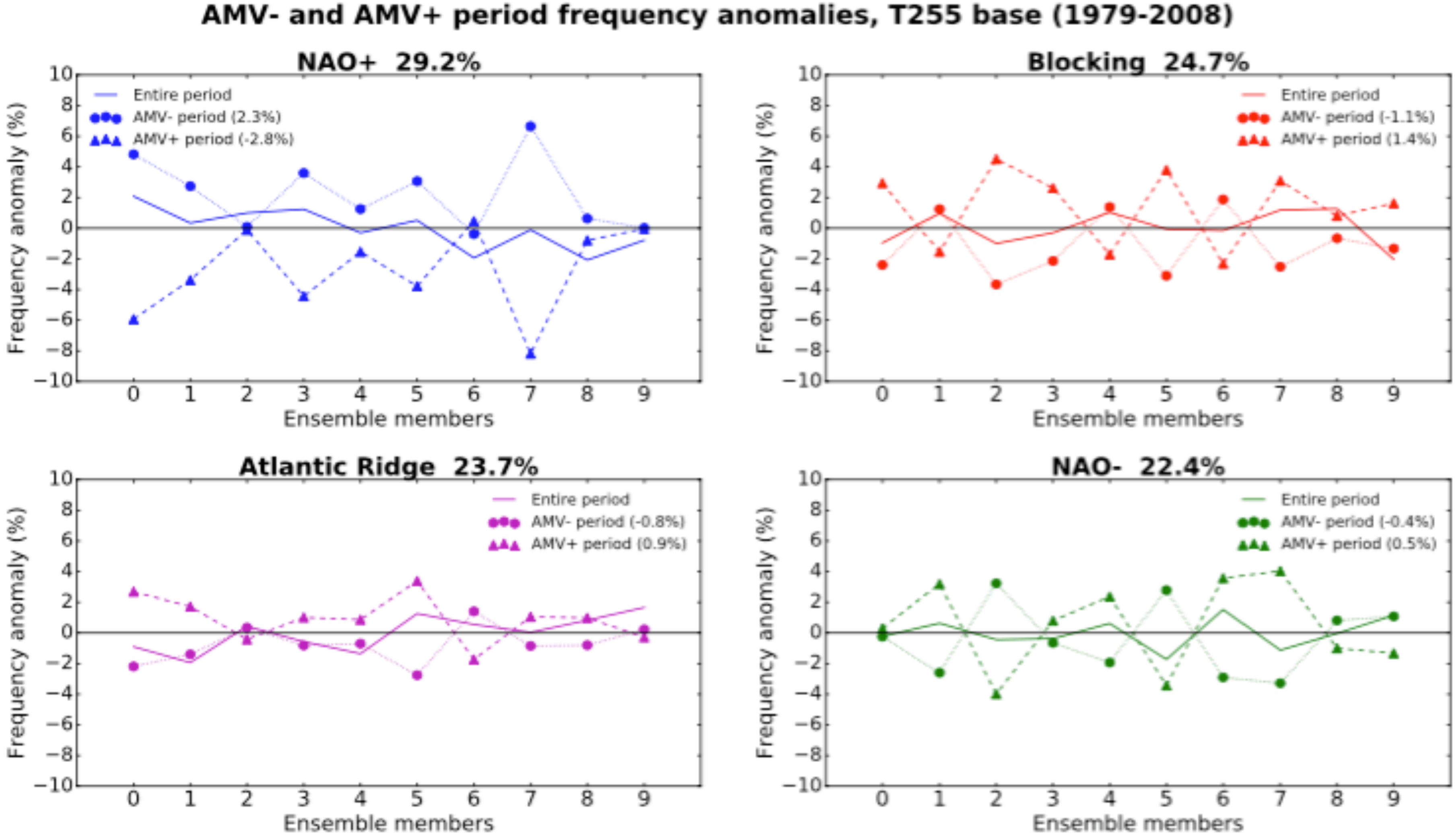
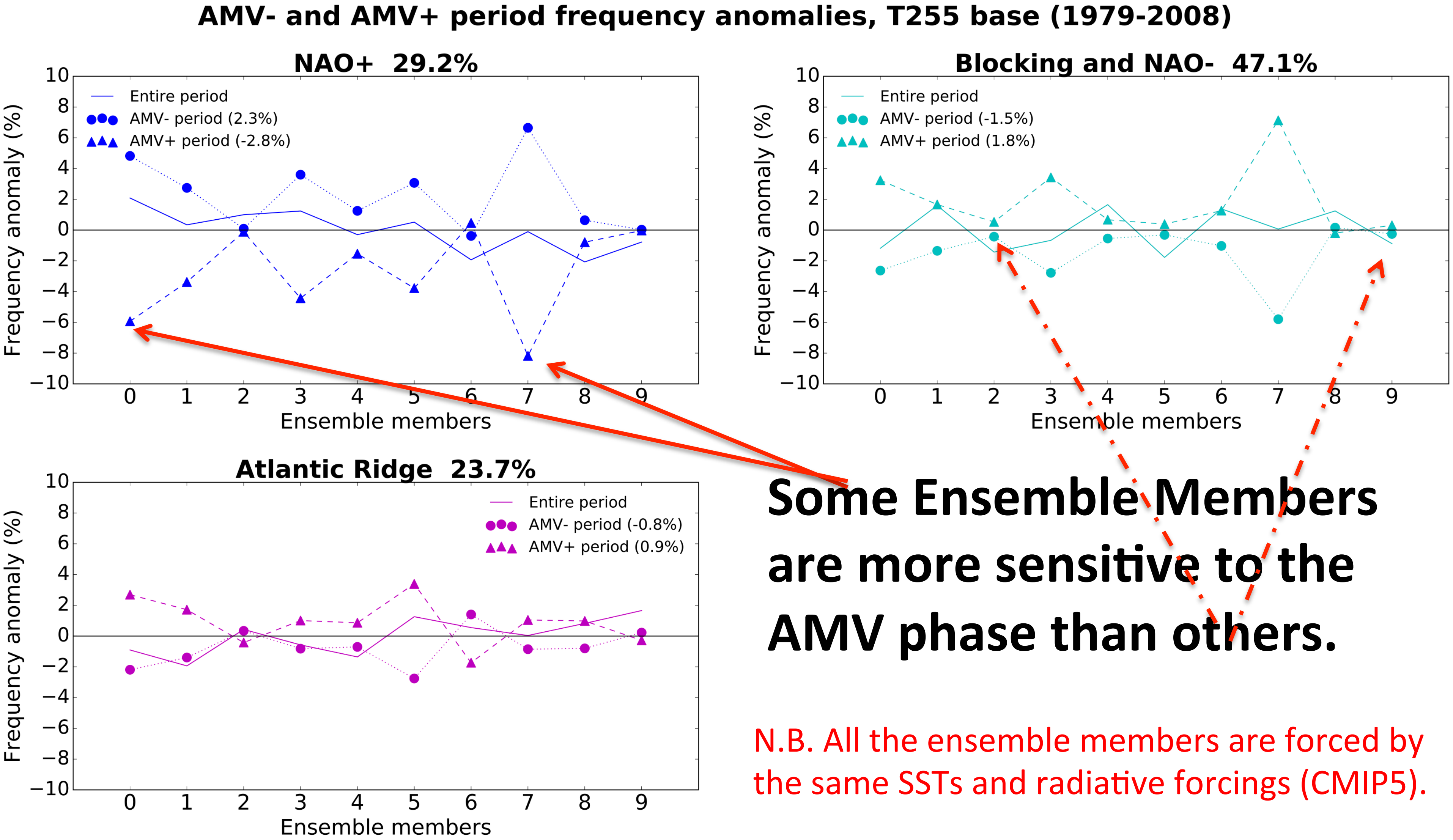


Figure 2: Regime frequencies anomalies with respect to the entire period (1979-2008) shown in solid line; during AMV- (1979-1995) in circles and during AMV- (1996-2008) in triangles.

Sensitivity of Euro-Atlantic Weather regimes Frequency to AMV (EC-Earth-AMIP)



Some Ensemble Members are more sensitive to the AMV phase than others.

N.B. All the ensemble members are forced by the same SSTs and radiative forcings (CMIP5).

Sensitive and Insensitive ensemble members

What are the factors that might amplify (or inhibit) the regime sensitivity to AMV in an "AMIP-world"?

Possible candidates: Eurasian Snow anomalies and/or Stratospheric Warming events in (or not in) phase with the AMV

Positive anomaly of Eurasian Snow Depth in Autumn/Winter → NAO-

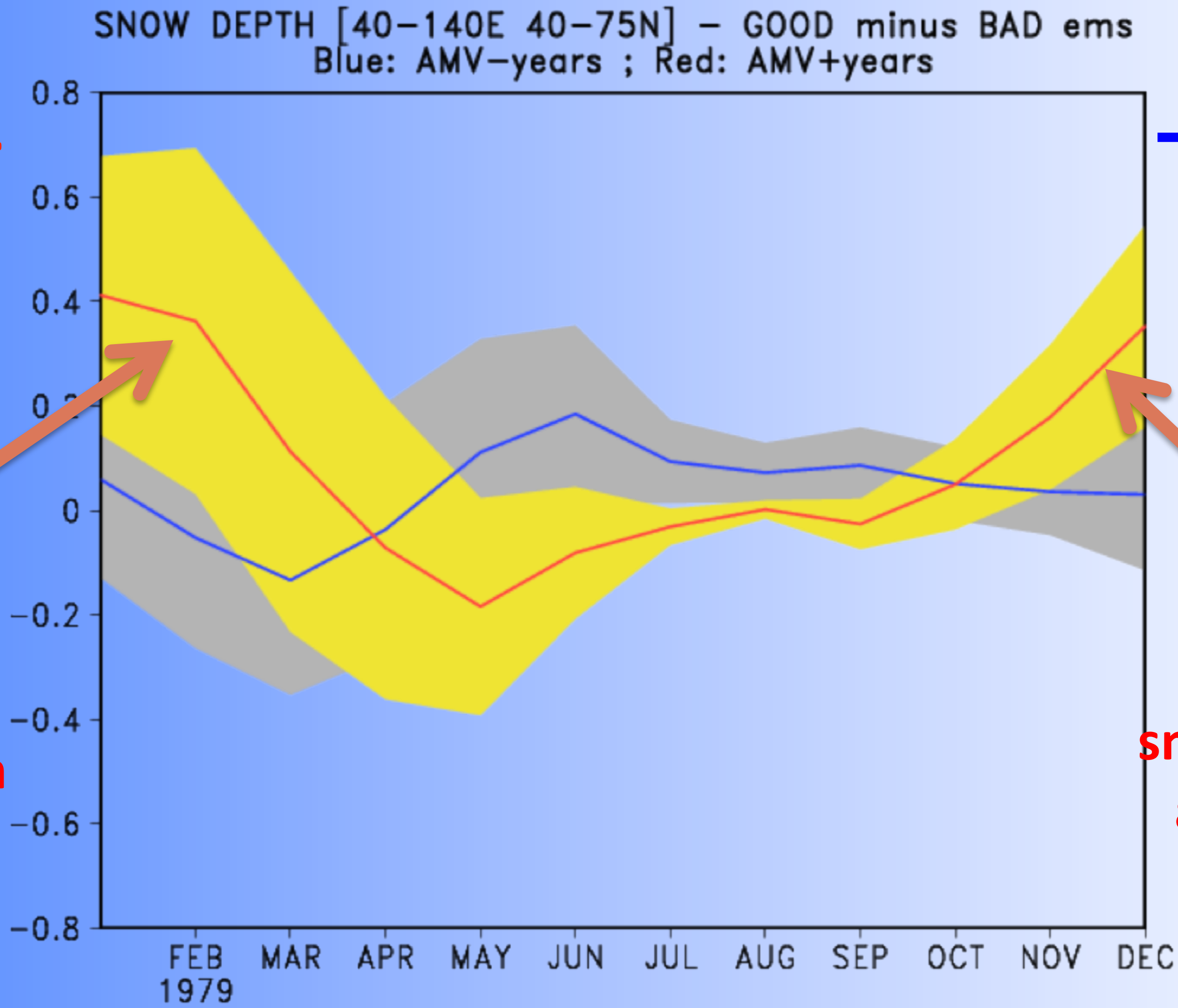
Stratospheric Warming events → NAO-

Strategy: Split the ensemble in 5 good (i.e. most AMV sensitive) and 5 bad (i.e. least AMV sensitive) ensemble members and look at the differences in snow depth and T50hPa climatology for AMV+ and AMV- years.

Eurasian Snow Depth
Good minus BAD

RED
AMV+
years
→NAO-

BLUE
AMV-
years
→NAO+



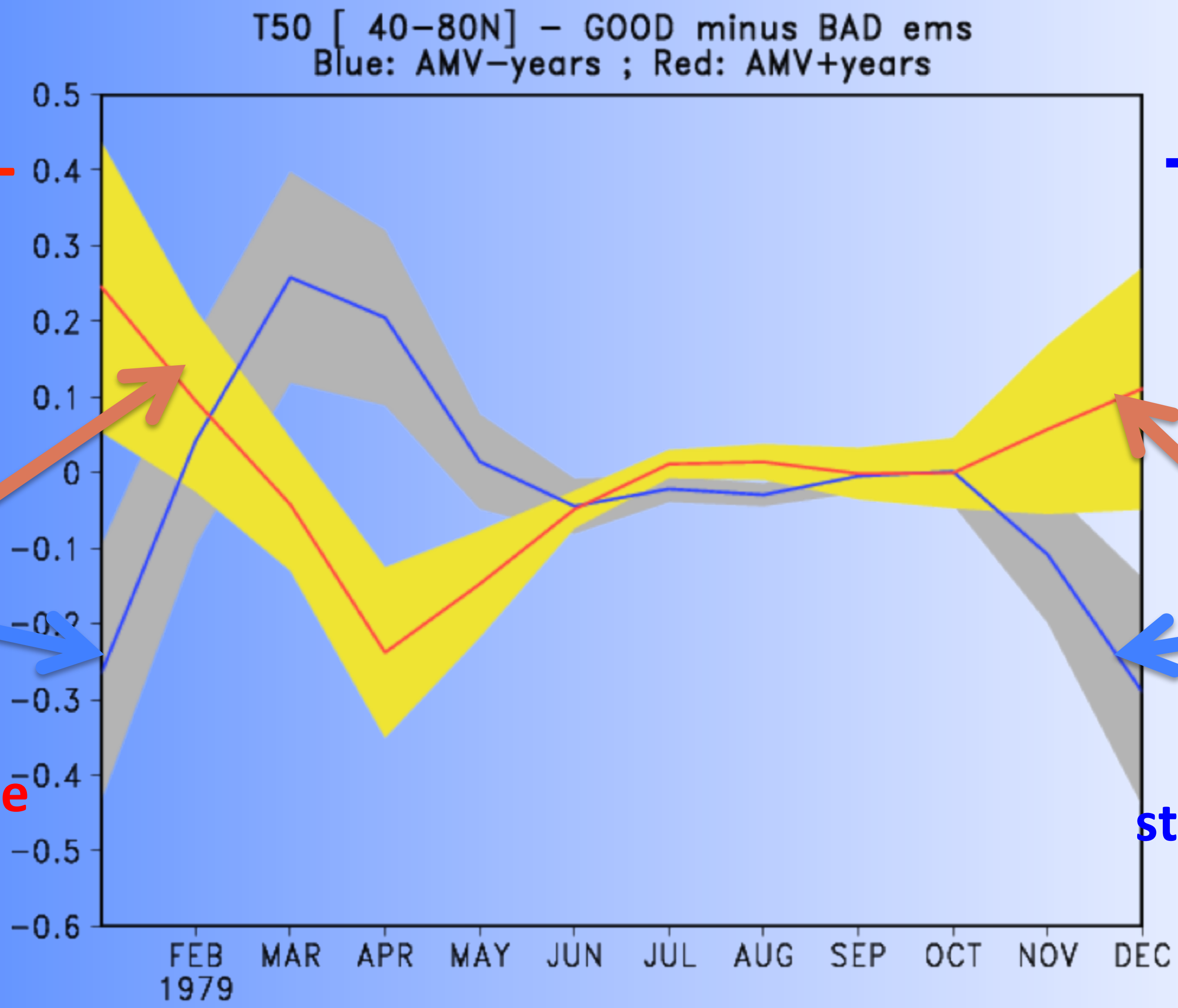
Positive snow depth anomalies →NAO-

Positive snow depth anomalies →NAO-

Temperature at 50hPa [40-80N]
Good minus BAD

RED
AMV+
years
→NAO-

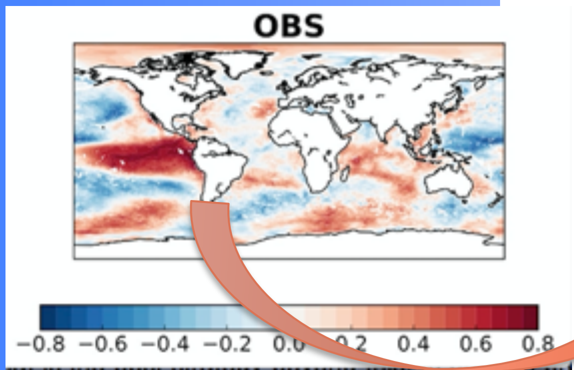
BLUE
AMV-
years
→NAO+

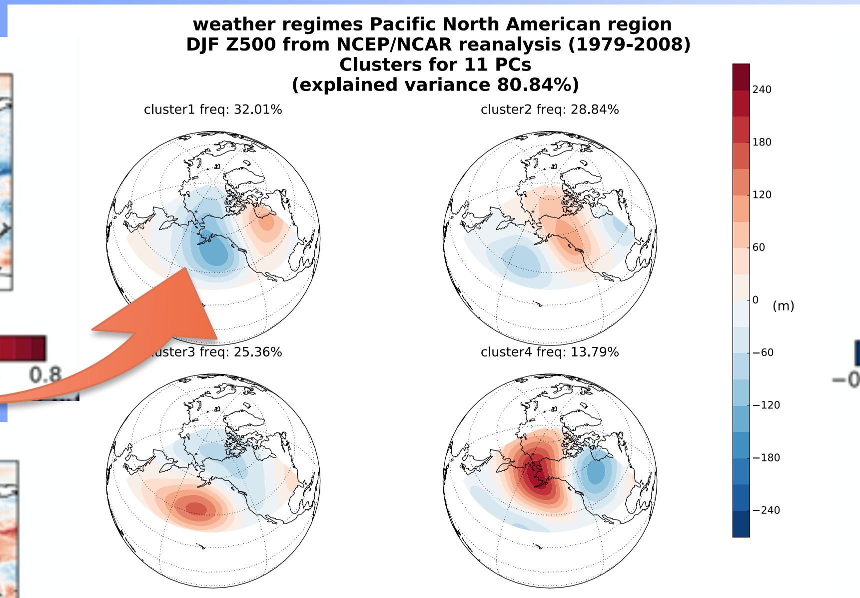


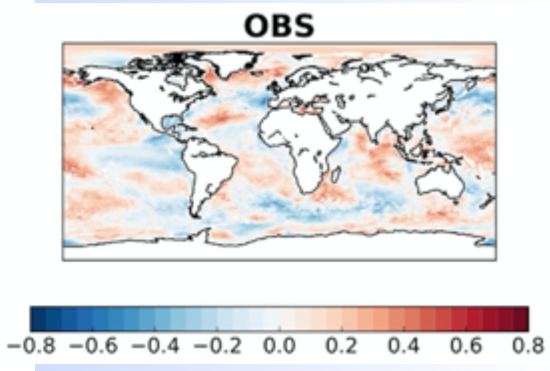
Warm
stratosphere
→NAO-

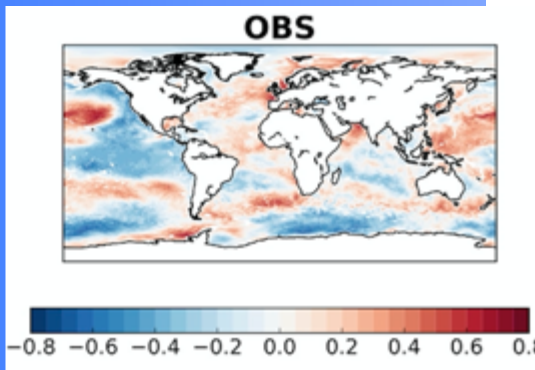
Cold
stratosphere
→NAO+

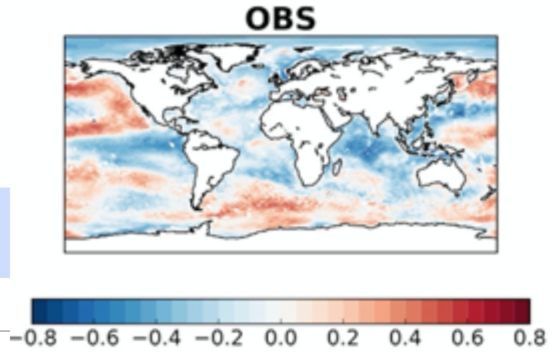
Pacific-North America Weather regimes NCEP

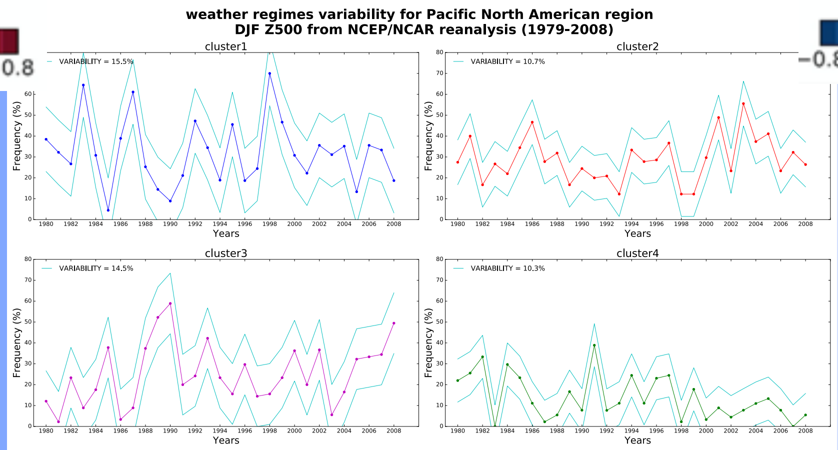






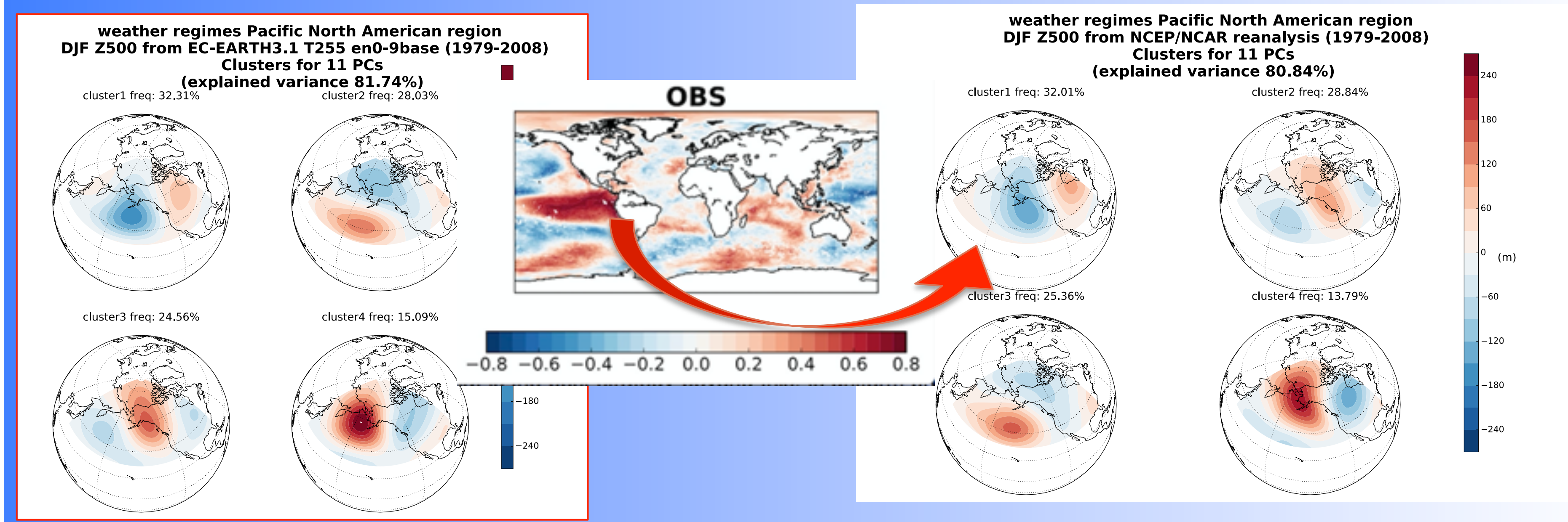


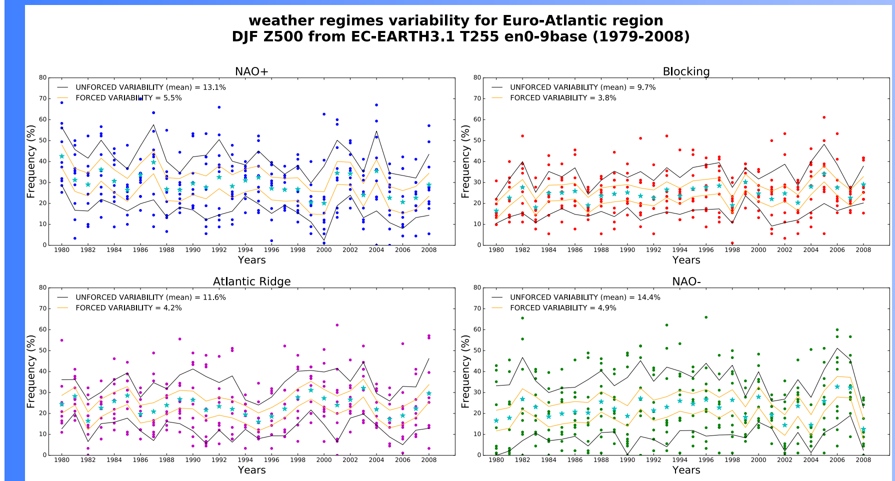


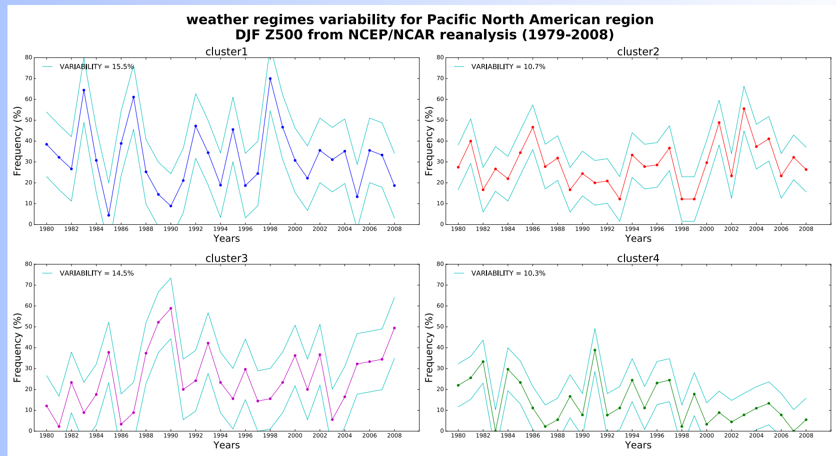


Pacific-North America Weather regimes
AMIP T255 [10 ensemble members]

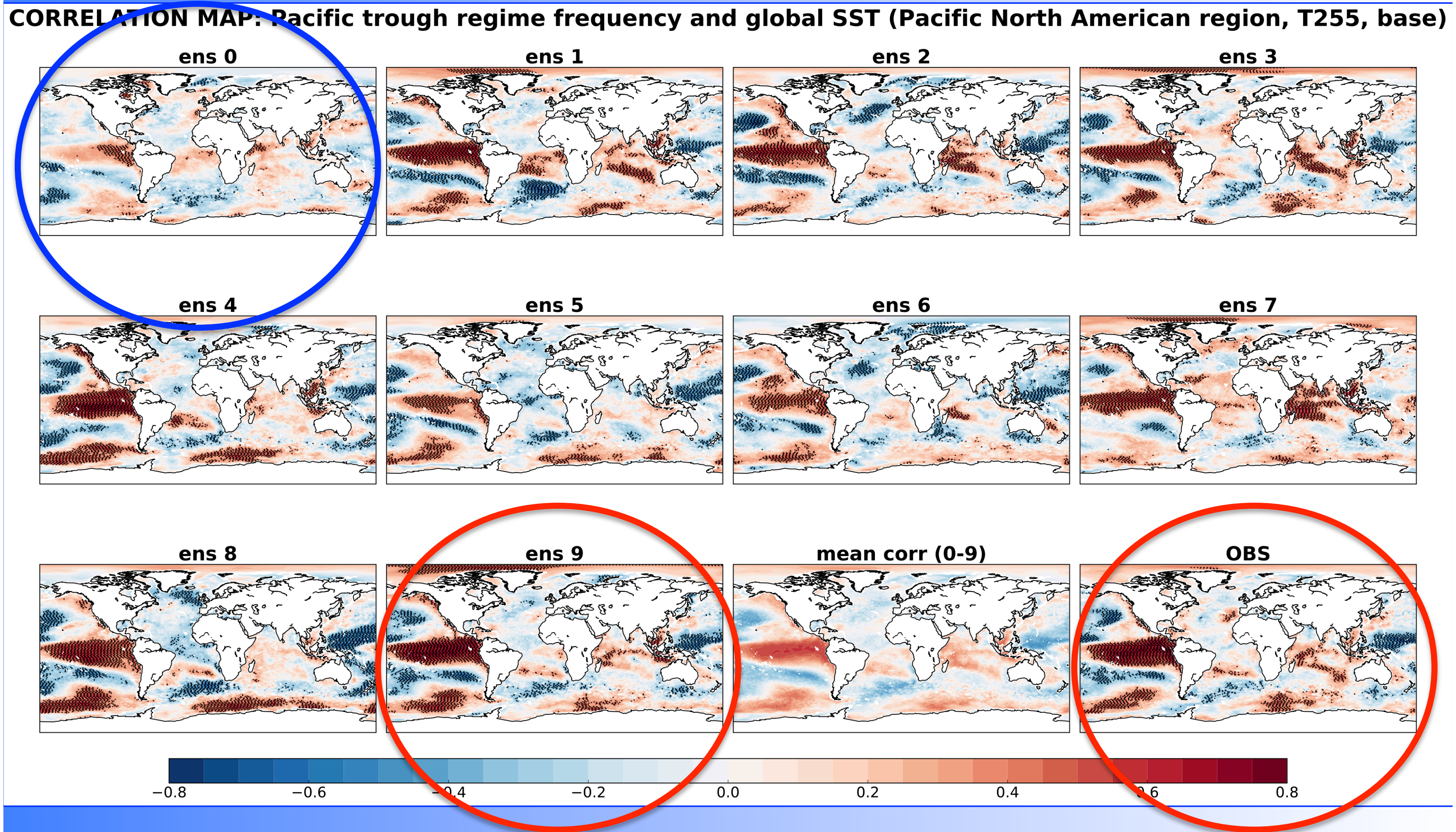
EC-Earth **NCEP**







Pacific Trough Frequency & Global SST T255 DJF



Possible influence of the stratosphere

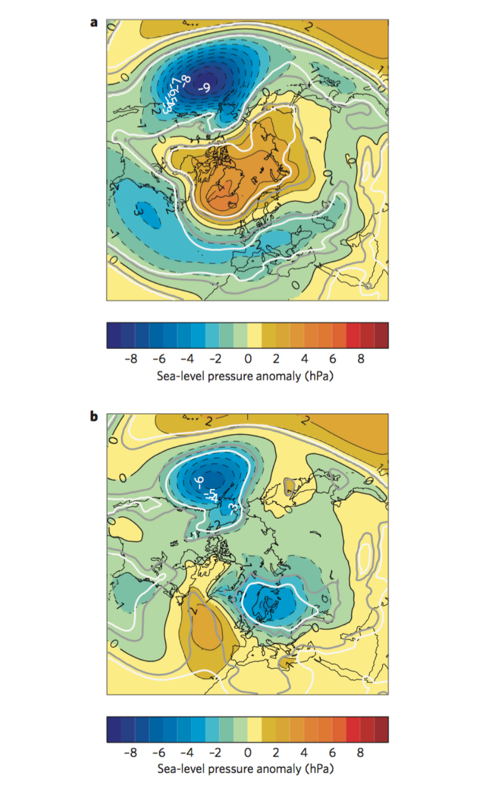
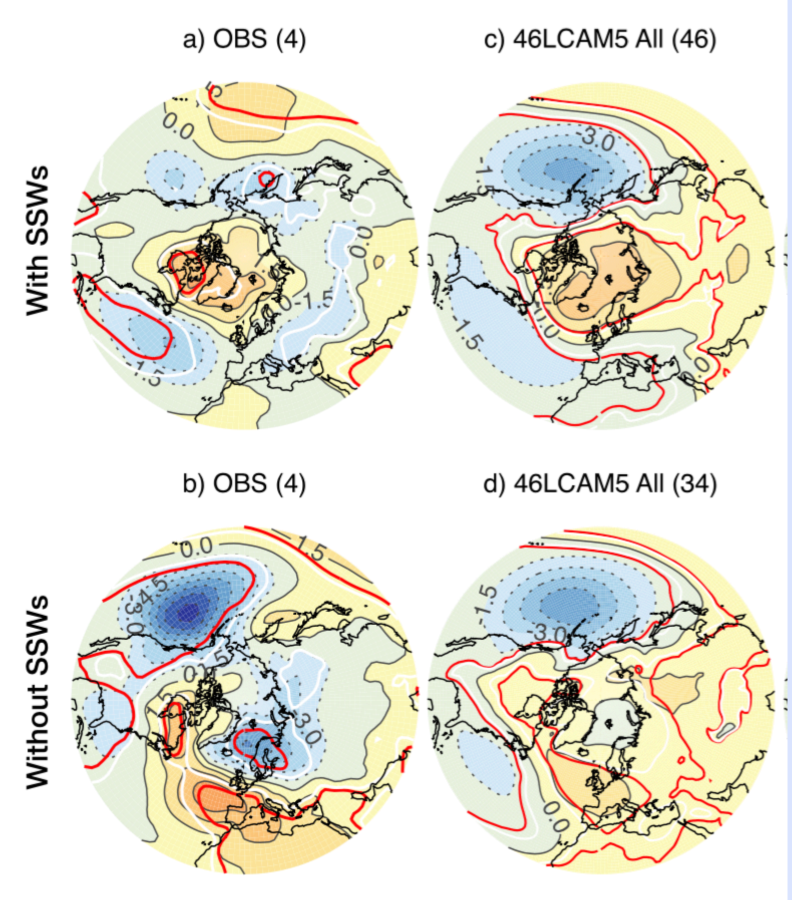


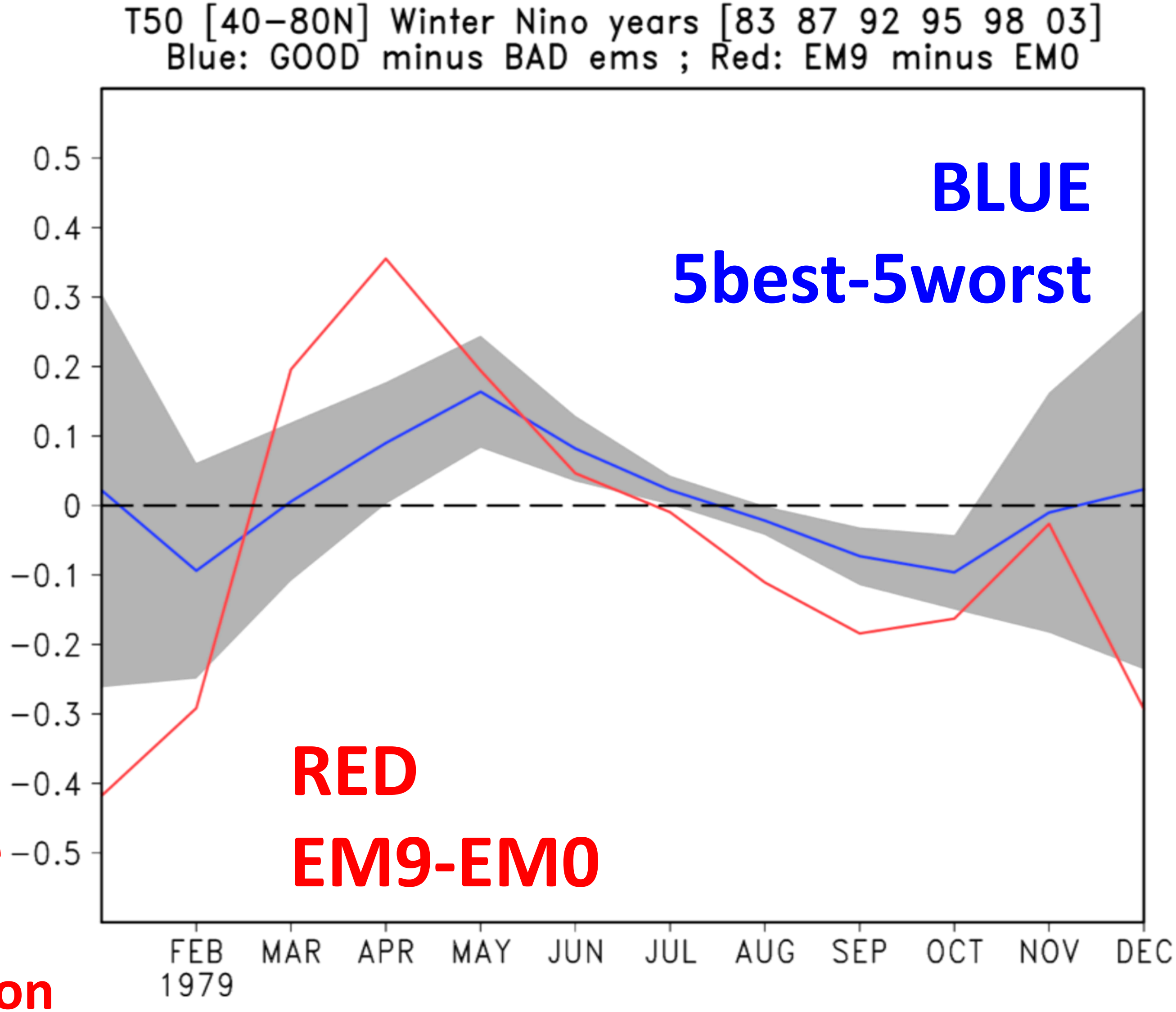
Figure 5 | Modelled surface climate response to El Niño associated with a weak and strong polar vortex. a,b, Composite sea-level pressure anomaly (hPa) for El Niño years with sudden stratospheric warmings (**a**) and El Niño years with no sudden stratospheric warmings (**b**). Anomalies are for January–March as in Fig. 1. Grey and white contours indicate significance at the 95% and 99% confidence levels.



Ineson and Scaife 2009
Nature GeoScience

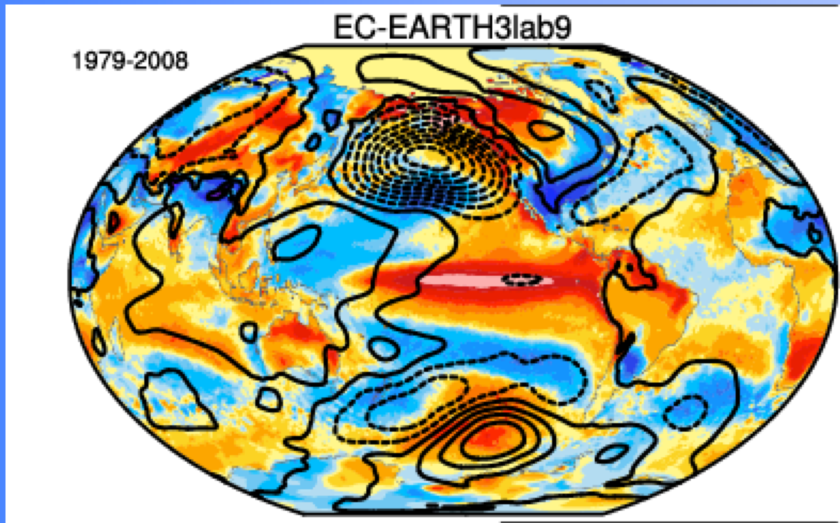
Richter et al. 2015 ERL

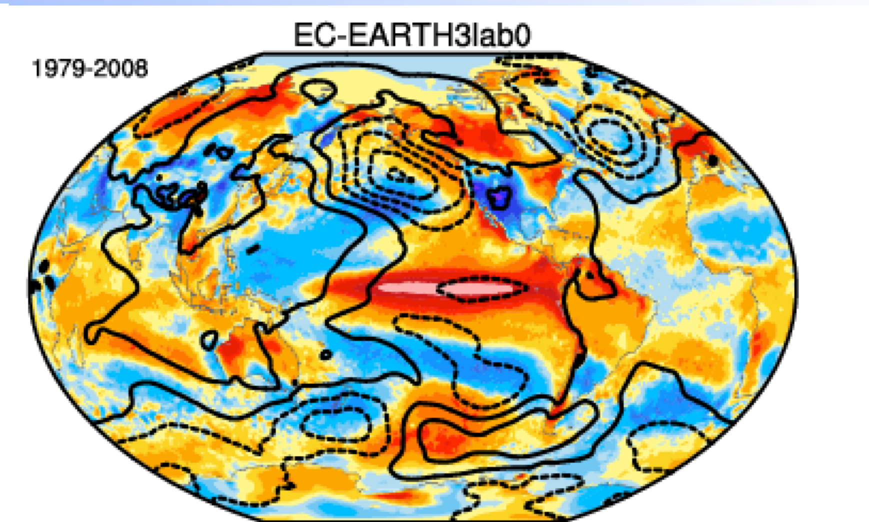
Temperature at 50hPa [40-80N]
Good minus BAD – NIÑO WINTERS



Warm stratosphere →Week teleconnection

Nino3.4 Teleconnection in ens9 and ens0





Concluding remarks

- Euro-Atlantic and Pacific-American Regime patterns are well simulated.
- As in Peings and Magnusdottir [2014] and Davini et al. [2015], the observations show an increased blocking and NAO- frequency during AMV + period and a decreased NAO+ frequency during AMV-: there is an opposite sign relationship between the polarities of the AMV and the NAO.
- In AMIP simulations, the sensitivity to the AMV phase changes largely according to the ensemble member. The most sensitive ensemble members are those with positive anomalies in Eurasian Snow Depth and Temperature in the Stratosphere in DJF
- The DJF PNA-Niño teleconnection exhibits a non-negligible inter-ensemble variability as well.
- The stratosphere might play a role in amplifying or inhibiting the teleconnection. During El Niño winters the best ensemble member has a colder stratosphere than the worst. However the signal is only partially coherent among ensemble members and winters and further investigation is needed to drive conclusions.