



ClimEx

Natural Variability in nested Climate Models:

The North Atlantic Oscillation and its Implications on Central European Climate Patterns

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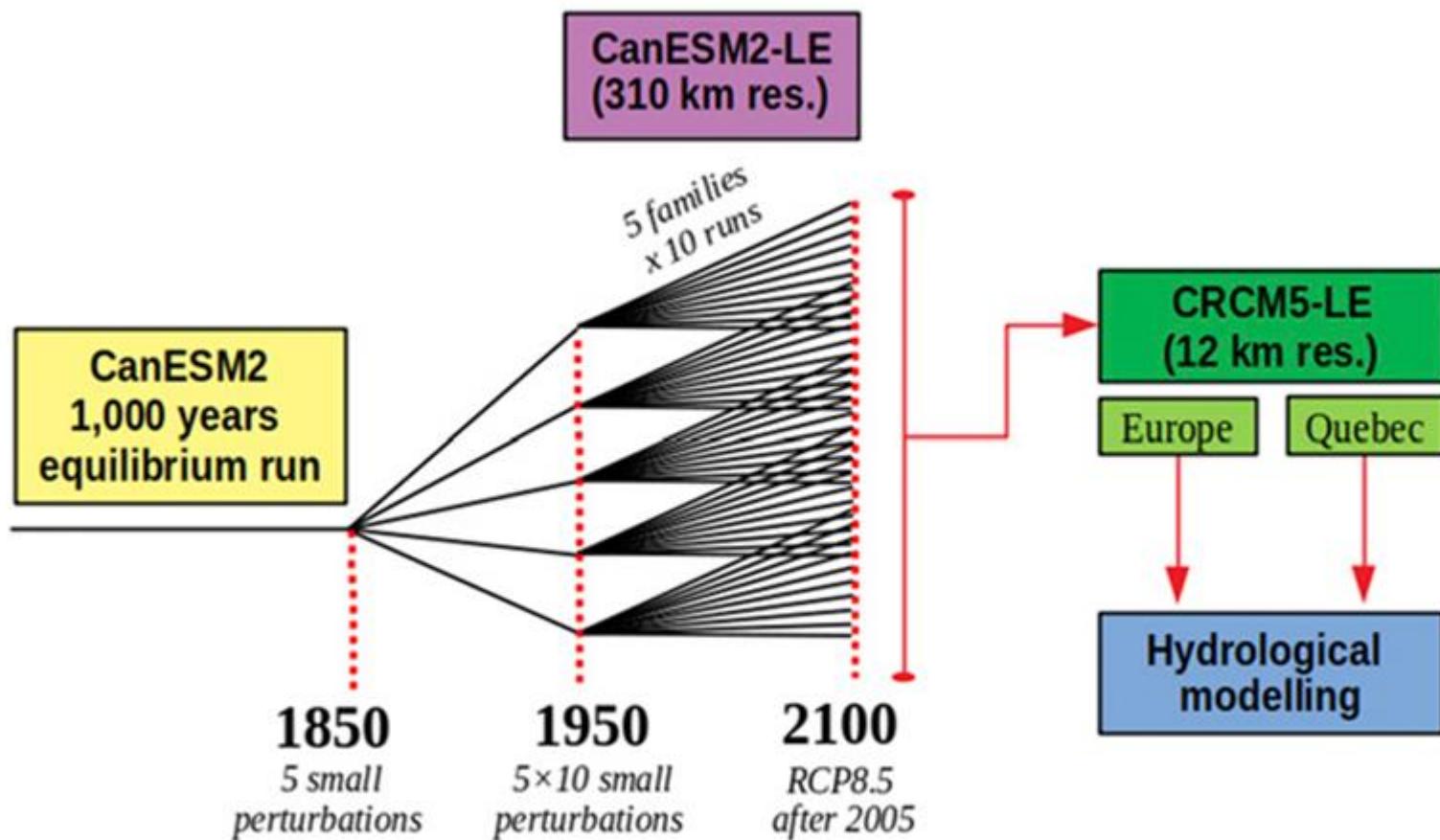
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EMS Annual Meeting 2019

Climate Change and Hydrological Extremes (ClimEx) project



- 50 members of a single model initial-condition large ensemble (LE)
- 7500 simulated years: natural variability and (hydro-)meteorological extremes

Leduc et al. (2019)



North Atlantic Oscillation (NAO) as an important mode of climate variability in Europe

How is the ensemble spread of NAO response patterns altered during the nesting process?

Key points of this study:

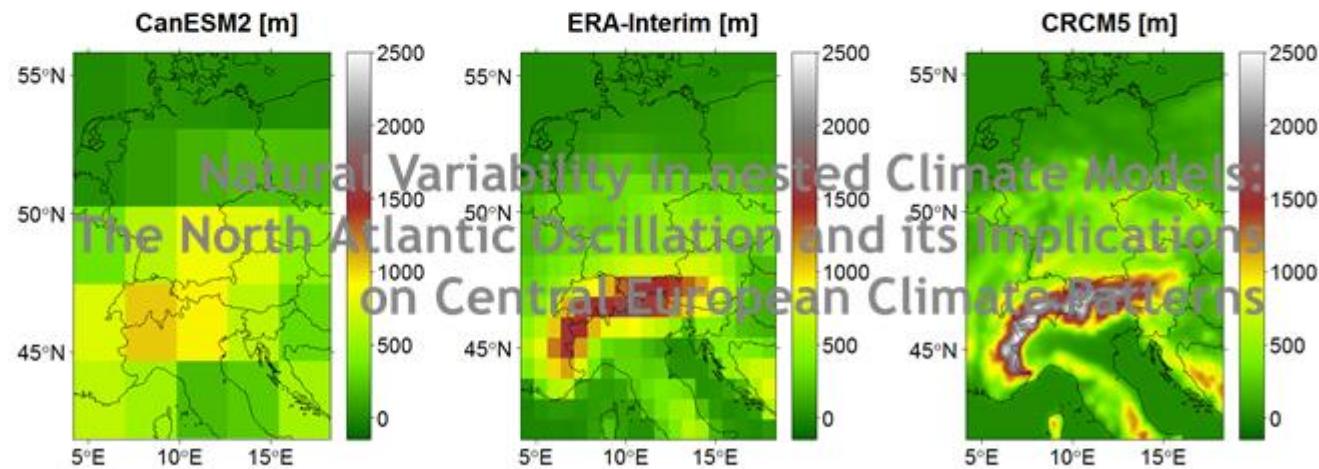
1. General performance of the climate model chain
2. Internal variability
3. Nesting approach
4. Climate change

Time horizons:
winter (DJFM)
1981-2010
2070-2099

LE of 50 members

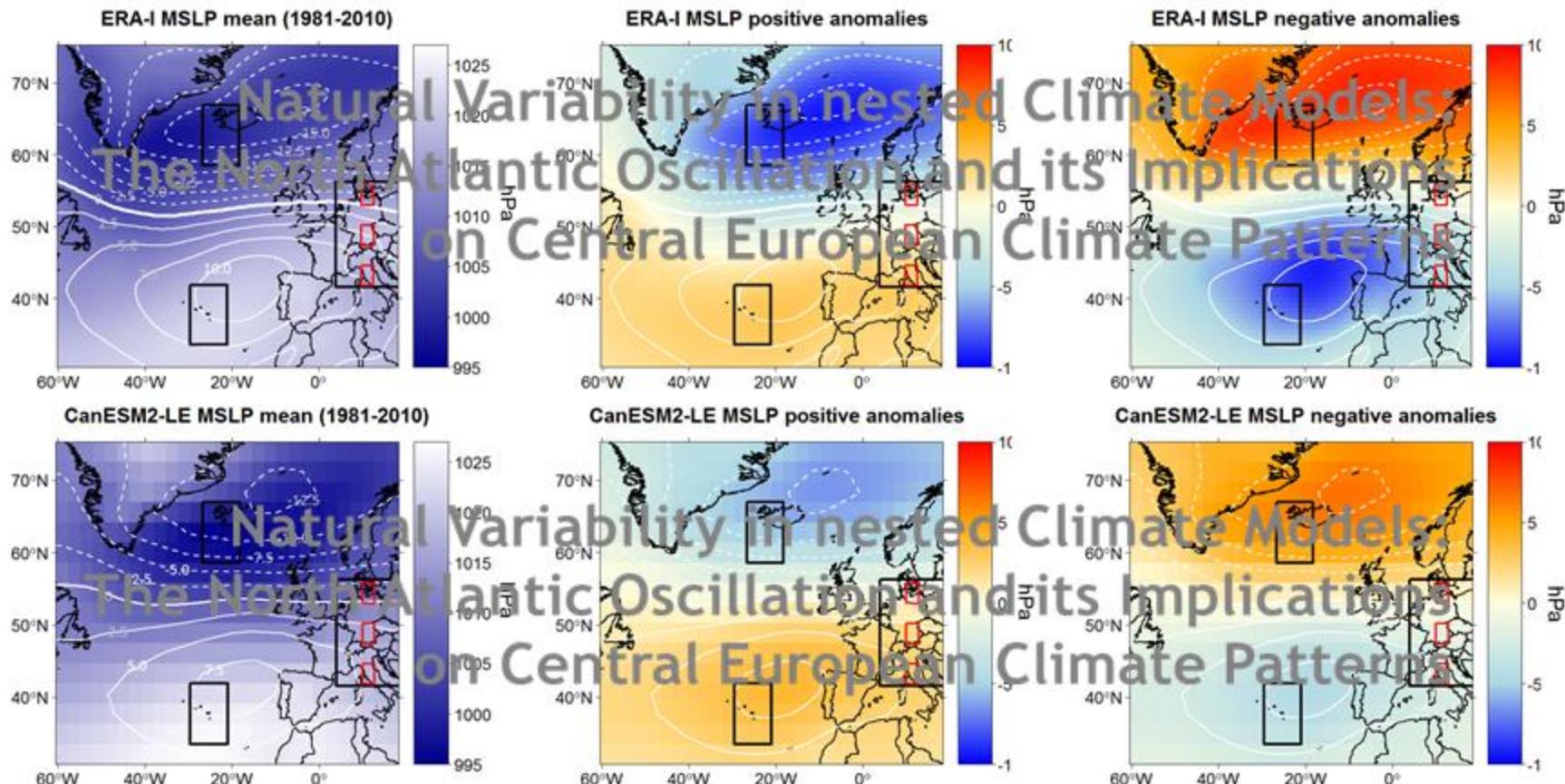
Domain altitude of
Central European
domain
⇒ NAO responses

Data name	Type	Spatial resolution	Variables
ERA-I Reanalysis	REF	$0.75^\circ \times 0.75^\circ$	msl [Pa], t2m [K], tp [m]
CRCM5/ERA-I	RCM	$0.11^\circ \times 0.11^\circ$	tas [K], pr [$\text{kg m}^{-2} \text{s}^{-1}$]
CanESM2-LE	GCM	$2.8^\circ \times 2.8^\circ$	psl [Pa], tas [K], pr [$\text{kg m}^{-2} \text{s}^{-1}$]
CRCM5-LE	RCM	$0.11^\circ \times 0.11^\circ$	tas [$^\circ\text{C}$], pr [mm d^{-1}]



Methods: NAO quantification

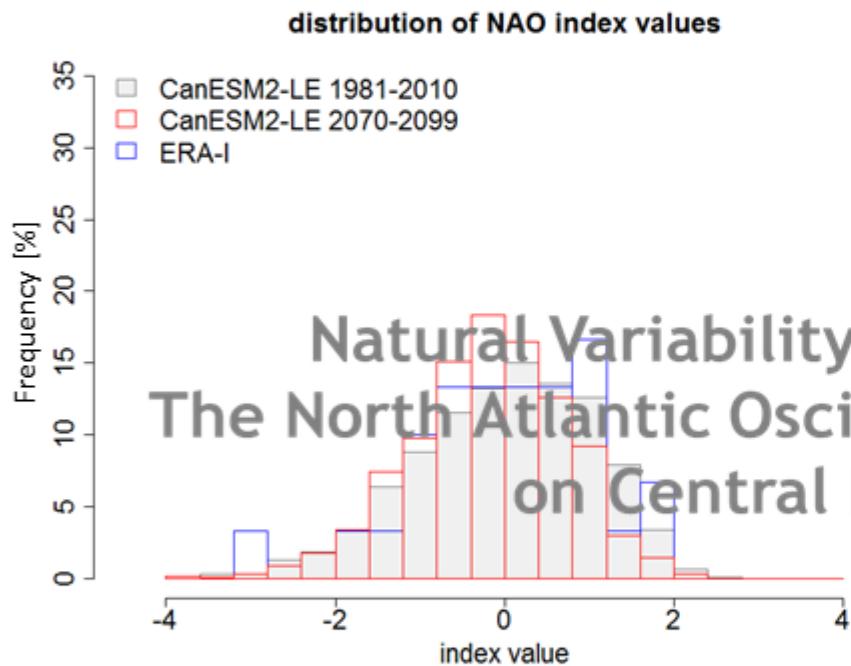
Mean sea level pressure distribution over the North Atlantic (winters 1981-2010)



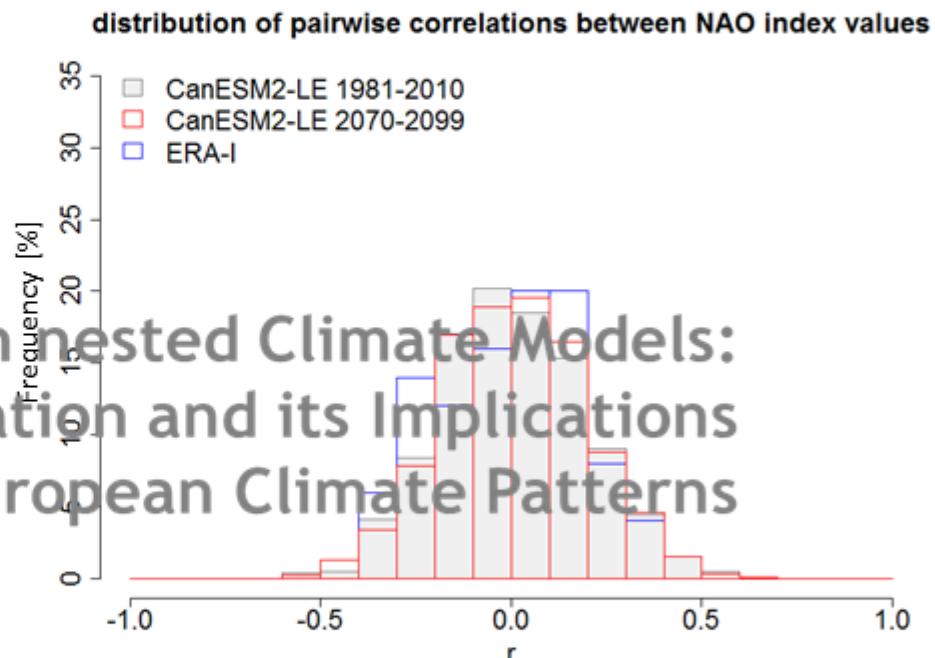
⇒ More zonal structure in GCM than in ERA-I

⇒ Weaker NAO phases in GCM than in ERA-I

NAO index as found in the study data



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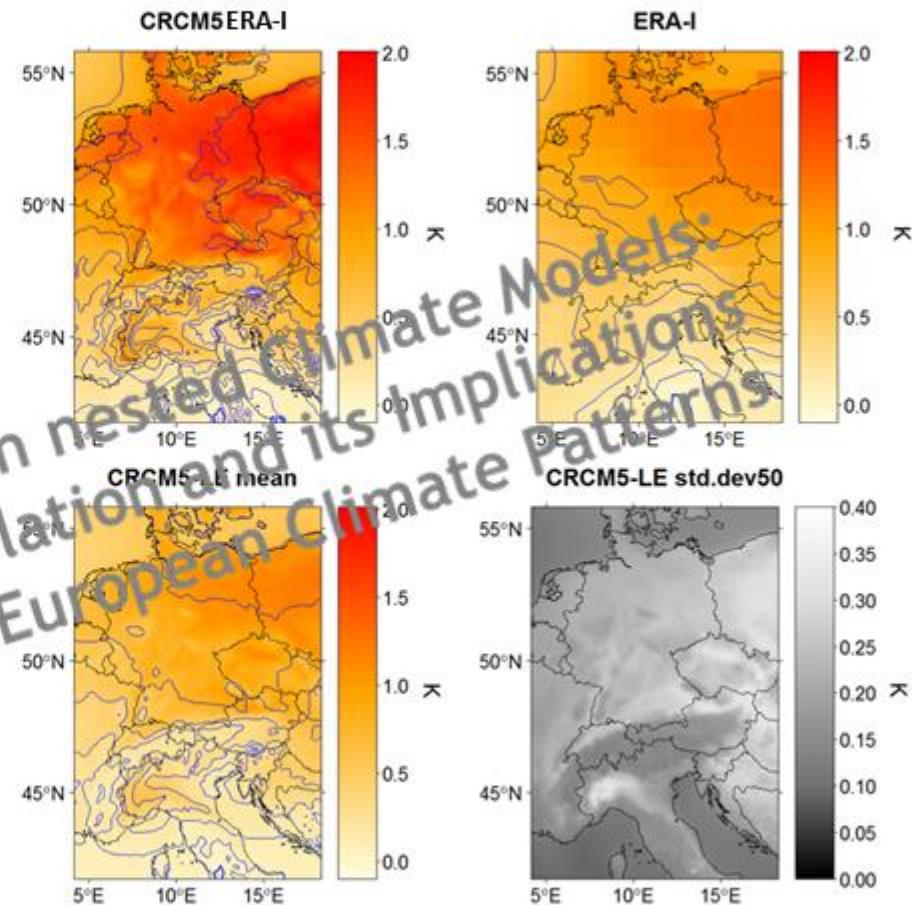
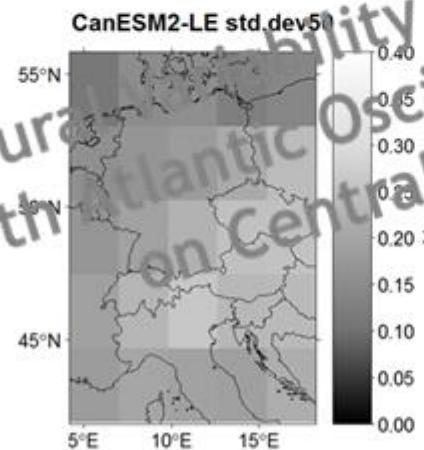
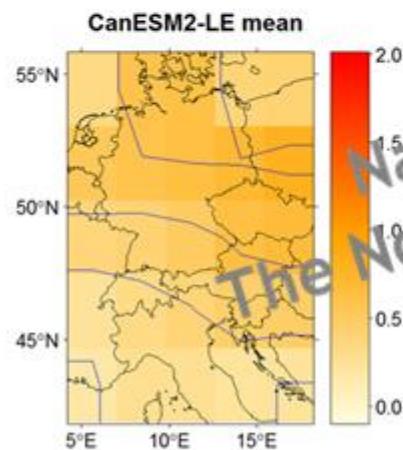
⇒ NAO index values & characteristics met well by the ensemble

Results: Changes of tas

Change of mean winter temperature (1981-2010) with unit index change

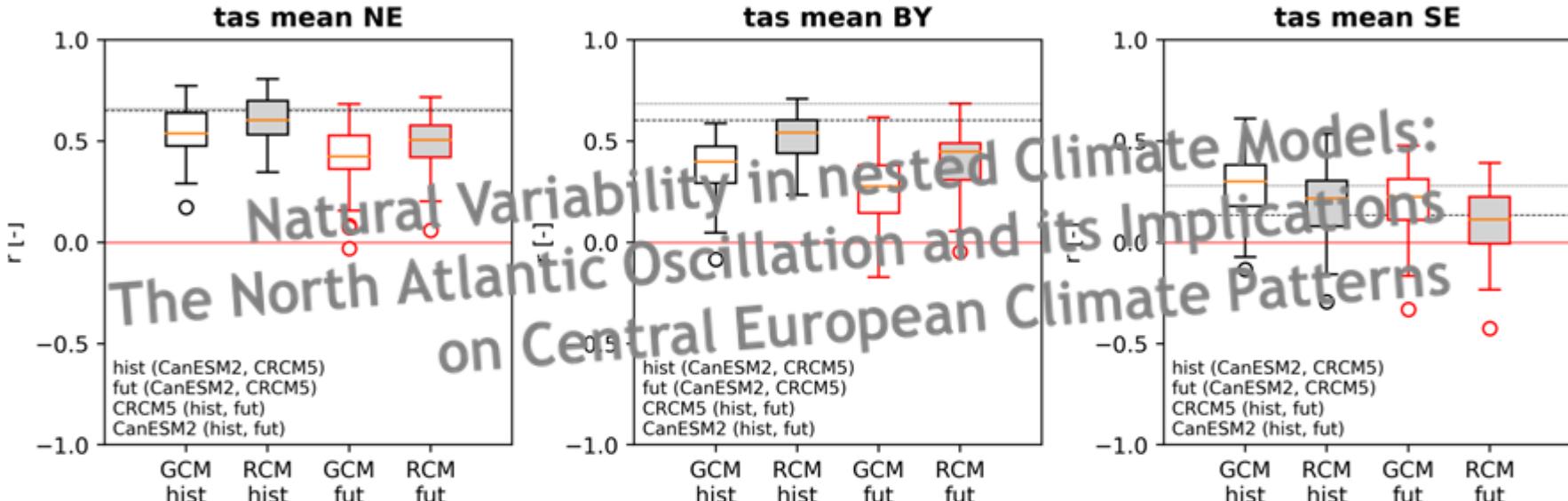
Regression coefficients of winter temperatures
for all data sources.

Grey maps: sd of all members.



Results: strength of relationship (tas)

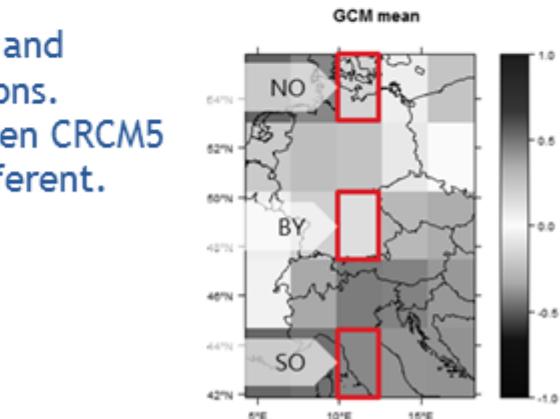
Comparison of subset regions: GCM and RCM, 1981-2010 and 2070-2099



- ◻ 1981-2010 CanESM2
- ◻ 1981-2010 CRCM5
- ◻ 2070-2099 CanESM2
- ◻ 2070-2099 CRCM5

Boxplots showing r between NAO index and precipitation time series of subset regions.
Dashed (dotted) lines: ERA-I (ERA-I driven CRCM5 run) value. Textboxes: significantly different.

- Lower correlations in GCM than RCM
- Reduction of correlations under future conditions

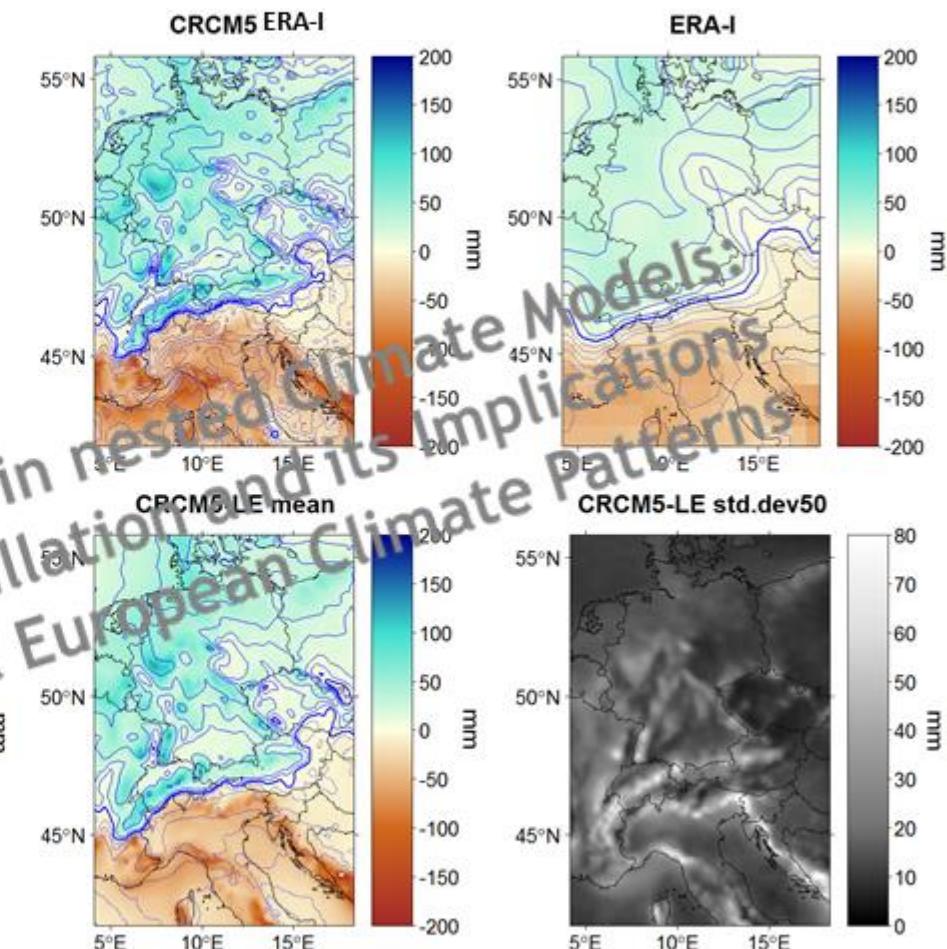
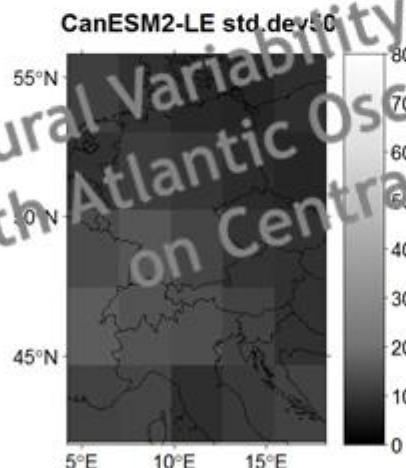
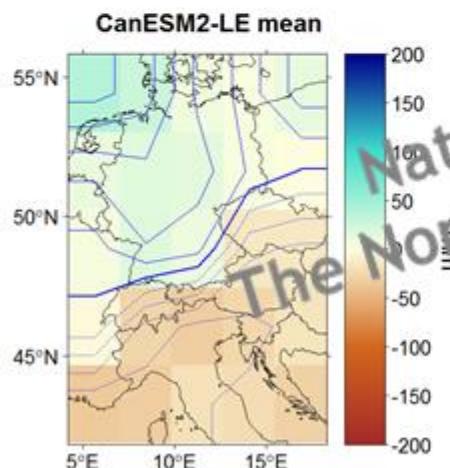


Results: Changes of pr

Change of mean winter precipitation sums (1981-2010) with unit index change

Regression coefficients of winter precipitation
for all data sources.

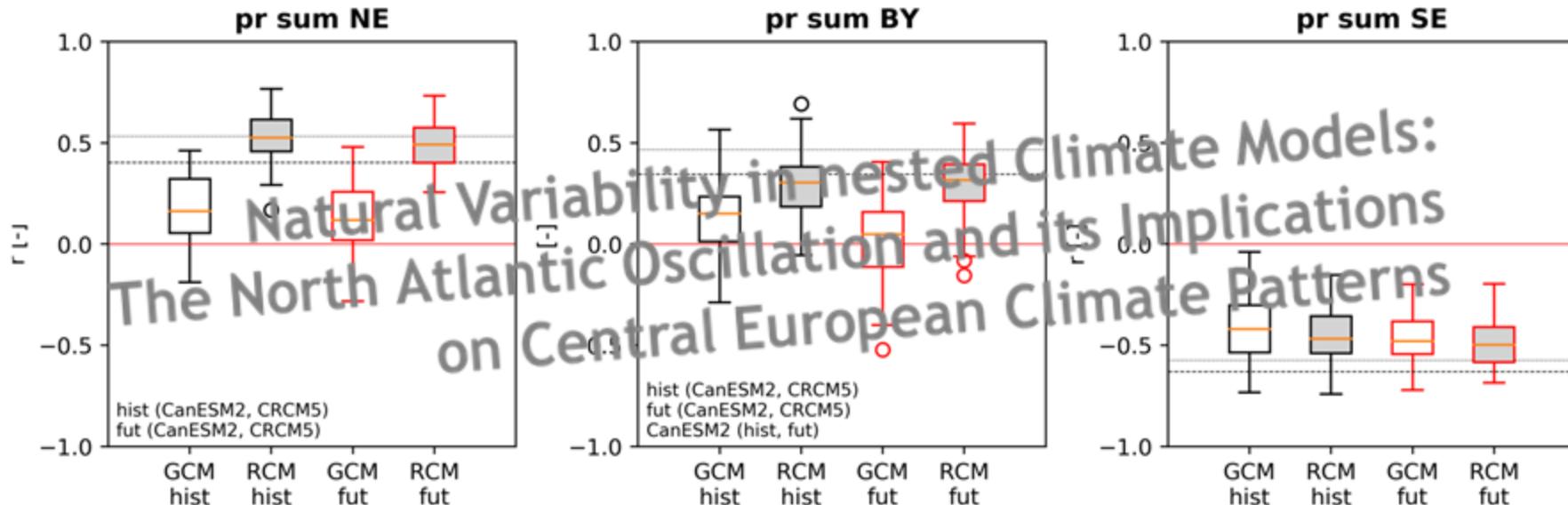
Grey maps: sd of all members.



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Results: strength of relationship (pr)

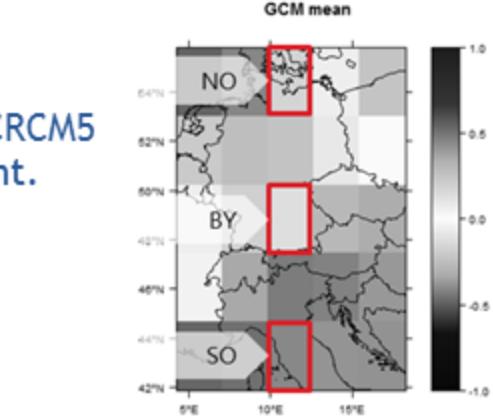
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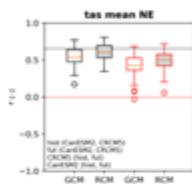
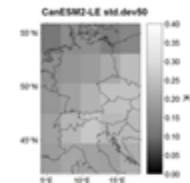
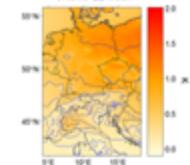


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Boxplots showing r between NAO index and precipitation time series of subset regions. Dashed (dotted) lines: ERA-I (ERA-I driven CRCM5 run) value. Textboxes: significantly different.

- Lower correlations in GCM than RCM
- Reduction of correlations under future conditions





1. Realistic NAO and NAO response patterns in the GCM and the RCM
2. A large range of possible NAO-response patterns within both inter-member spreads (variability)
3. No change in the amplitude of the inter-member spread, but a shift towards a stronger relationship in the RCM (propagation)

⇒ Spread of internal variability propagates correctly from the GCM to the RCM



4. Future changes:
 - a) NAO index shift towards more negative values
 - b) Reduction of correlations in subset regions (tas, pr, RCM, GCM)
 - c) Spatial patterns of changes: see P170 ...

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Further information:

Böhnisch, A., Ludwig, R., and Leduc, M.: Using a nested single-model large ensemble to assess the internal variability of the North Atlantic Oscillation and its climatic implications for Central Europe, *Earth Syst. Dynam. Discuss.*, <https://doi.org/10.5194/esd-2019-58>, in review, 2019.