Characterizing the role of internal variability in Regional Climate Paleosimulations

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1. Motivation: *tools*

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- There are two main tools in palaeoclimatology:
  - **reconstructions** of past climate from proxy data
  - **simulations** with climate models
- Reconstructions fit to the actual evolution of climate, whereas models fit to physical laws and ensure self-consistency
- Exercises blending both approaches present a great potential in palaeoclimatic studies for assessing the uncertainties in both approaches
- Since climate models are used for future climate change projections, evaluation of their performance is a key point

1. Motivation: *dynamic downscaling*

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- Proxy records contain regional-induced climate signal
- State-of-the-art GCMs present too coarse resolution precluding a realistic simulation
- Dynamic downscaling bridges the gap between both approaches
- Regional paleosimulations need as input data:
  - a GCM simulation driving the simulation
  - the evolution of external forcings

2. Simulations: *forcings*

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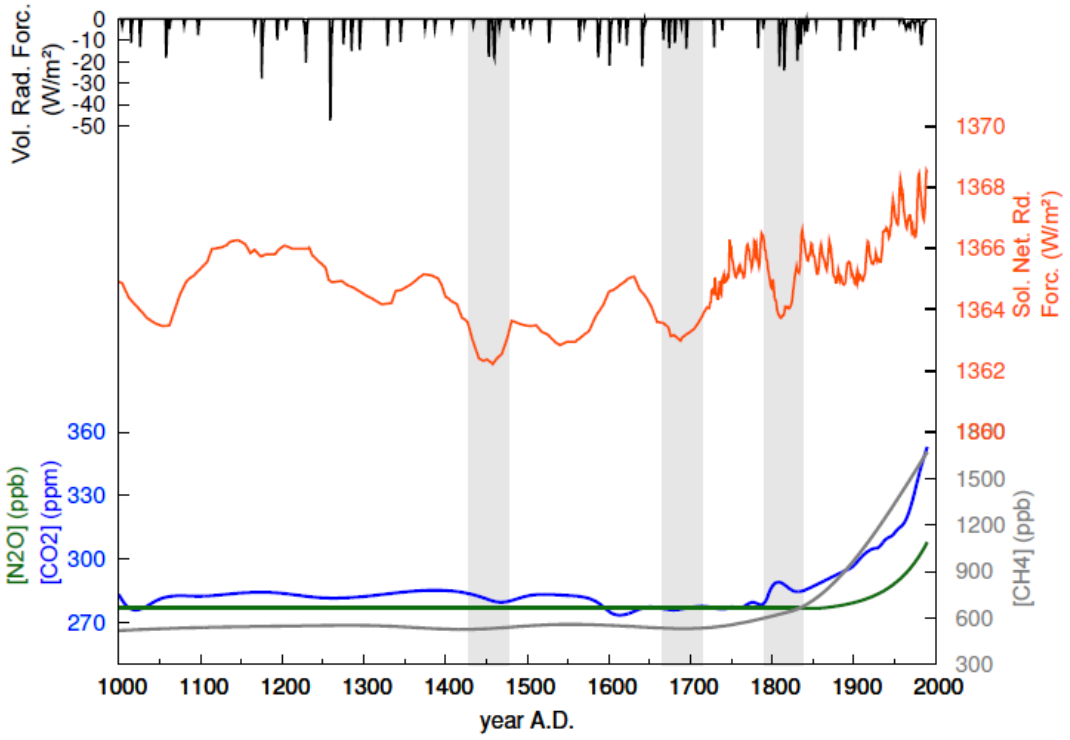

Crowley (2000)

- Conducting a paleo-simulation implies use some forcing reconstructions
- In our case:
  - Solar irradiance
  - GHG concentration
  - Volcanoes
  - ~~Aerosols~~
  - ~~Land use changes~~

2. Simulations: *regional domains*

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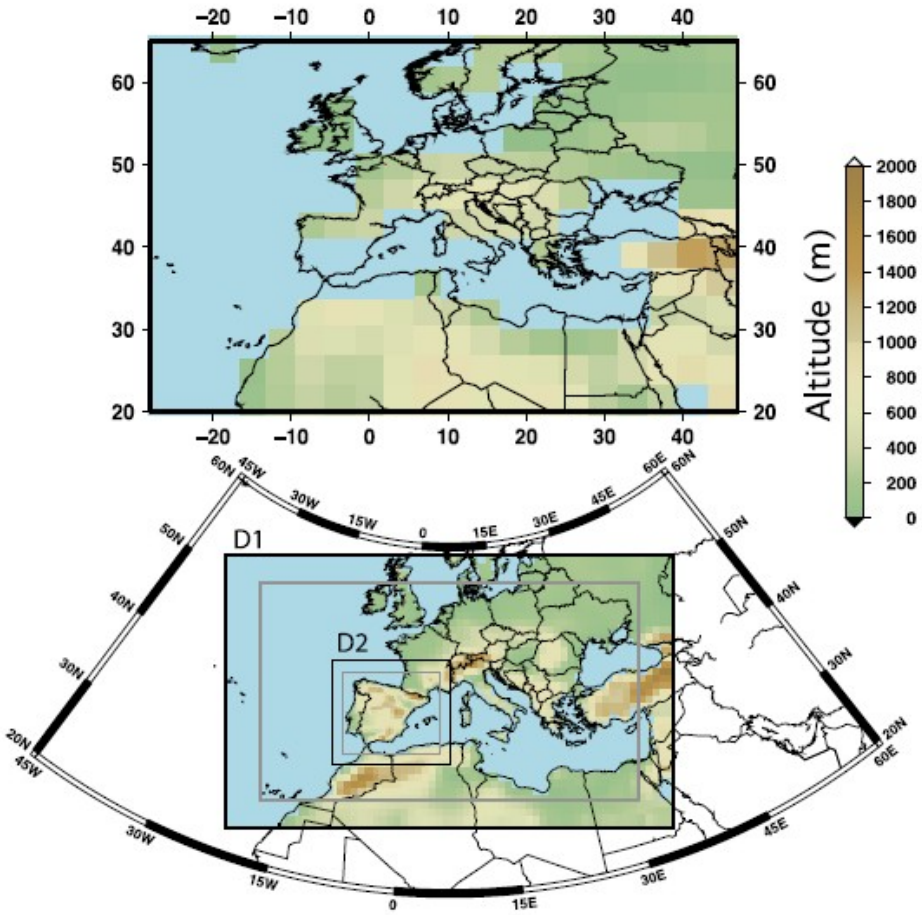

- Global Circulation Model **ECHO-G**
- Coupled to the Regional Climate Model **MM5**
- Sharing the same forcings
- 2 nested domains with spatial resolution of 90 and 30 km
- **Gómez-Navarro et *al*. Climate of the Past, 2011**

2. Simulations: *initial conditions*

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- 2 millennial simulations (1000-1990) downscaled
- The GCM simulations differ just in the initial condition
- Simulations are not identical because of the internal variability (which is an expression of the chaotic behaviour of the climate system)
- Simulation is partly driven by forcings, and partly by random behaviour: at what extent?

2. Simulations: *internal variability*

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- Internal variability hampers the comparison between model simulations and reconstructions
- Having several simulations using the same forcings, the role of the internal variability can be assessed

$$T = \alpha W + f$$

$$\mathrm{cor}(T_i, T_j) = \frac{\mathrm{Var}(f)}{\mathrm{Var}(f) + \alpha^2}$$

3. Results: *SAT variability*

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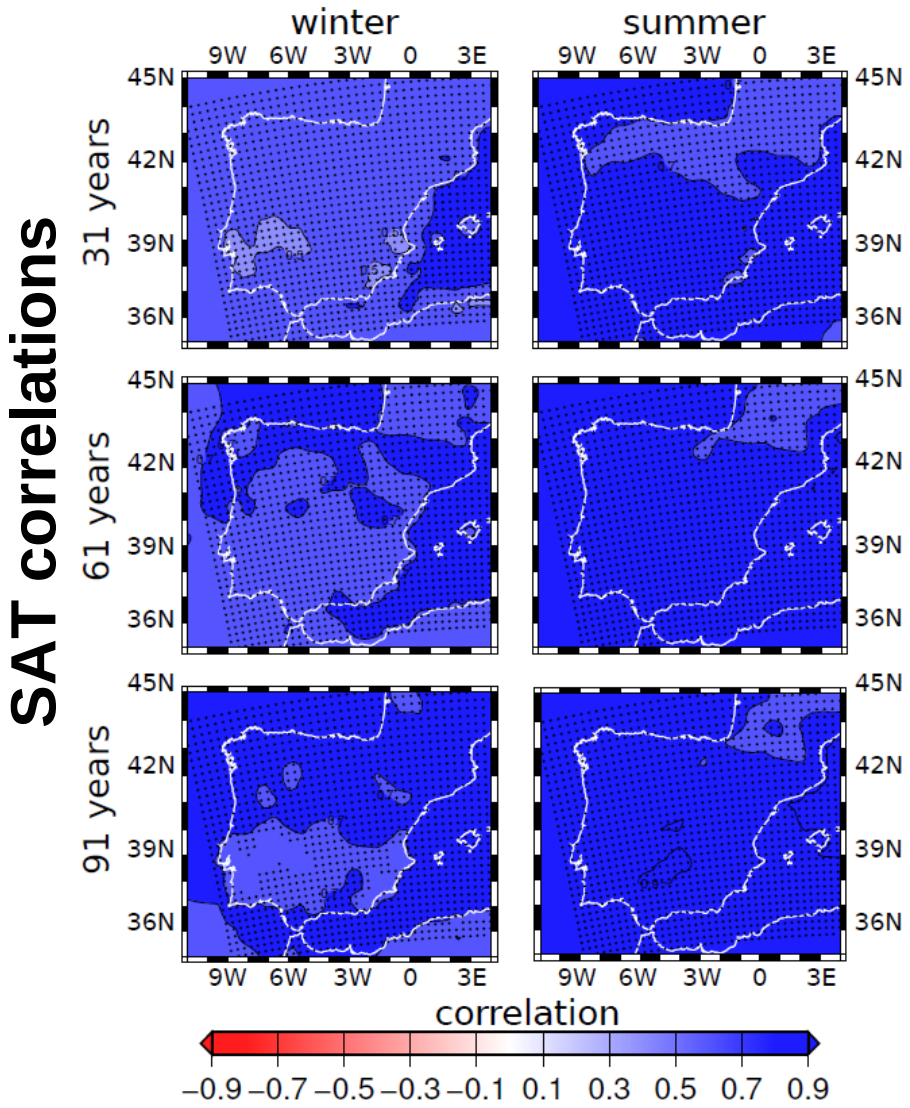

- SAT is tightly driven by the external forcings
- If a disagreement between model and recons. is found then either:
  - SAT recons. are wrong
  - Forcings recons. Are wrong
  - The model is wrong

3. Results: *PRE variability*

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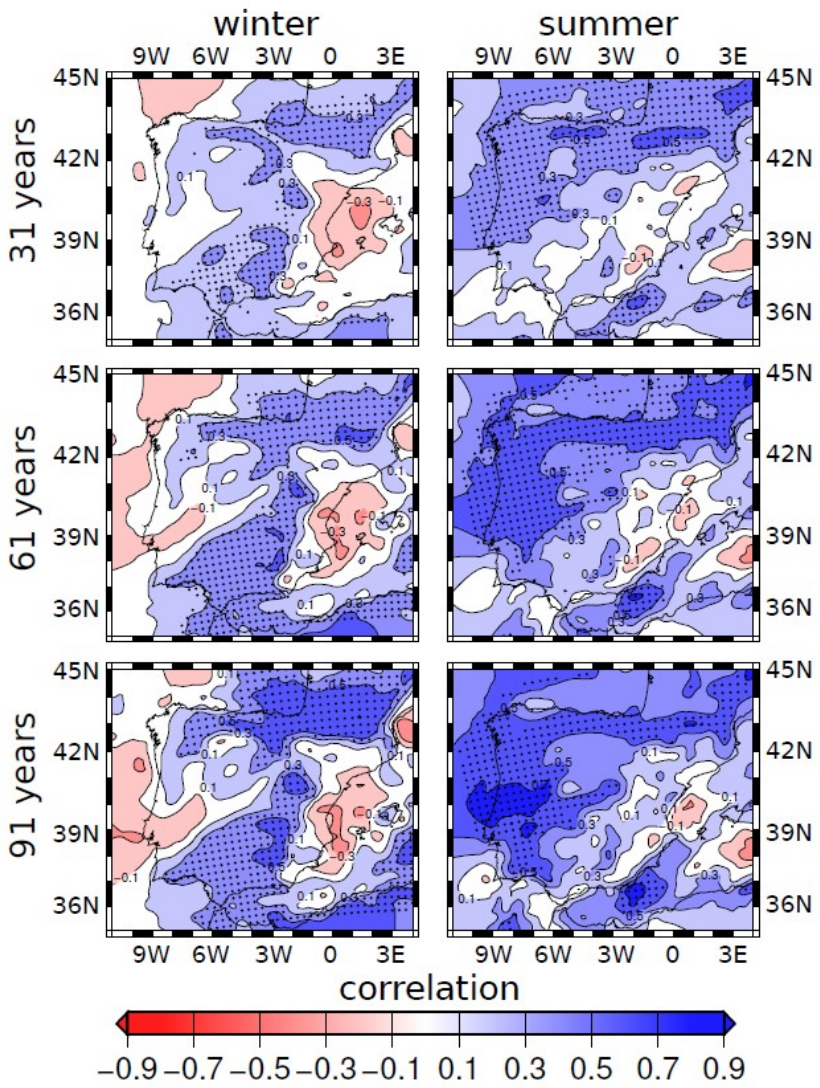
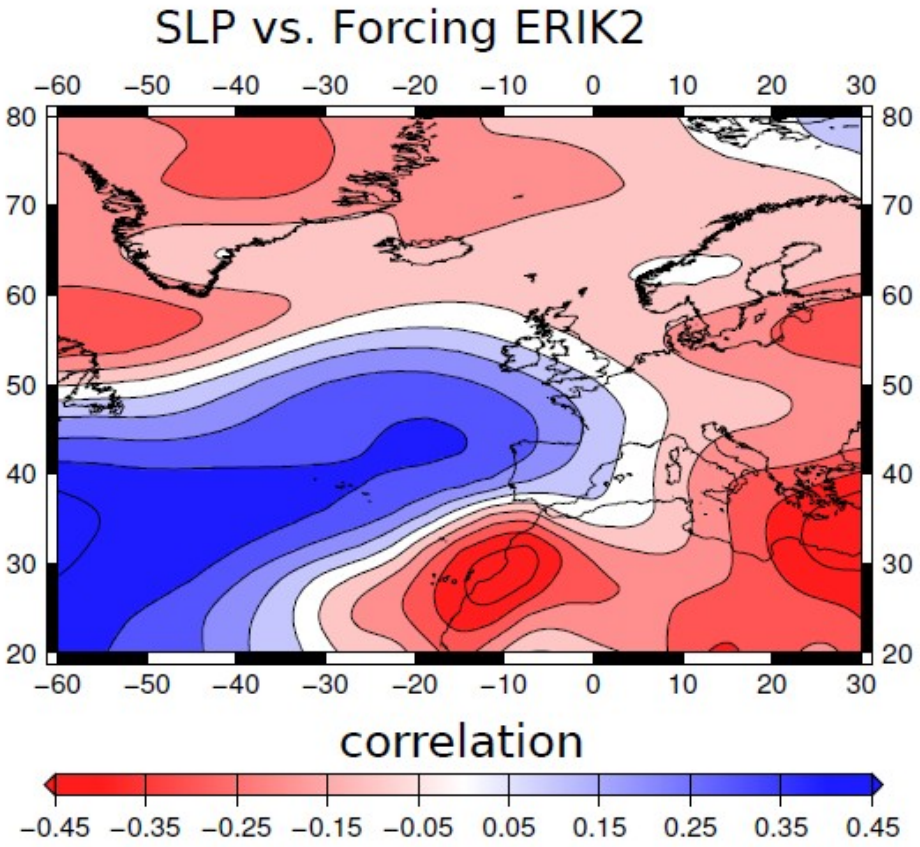
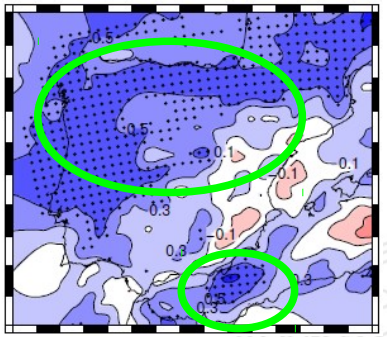
PRE correlations



- PRE is not so tightly driven by the external forcings, internal variability plays an important role (through large-scale circulation)
- If a disagreement between model and reconstructions is found... ???

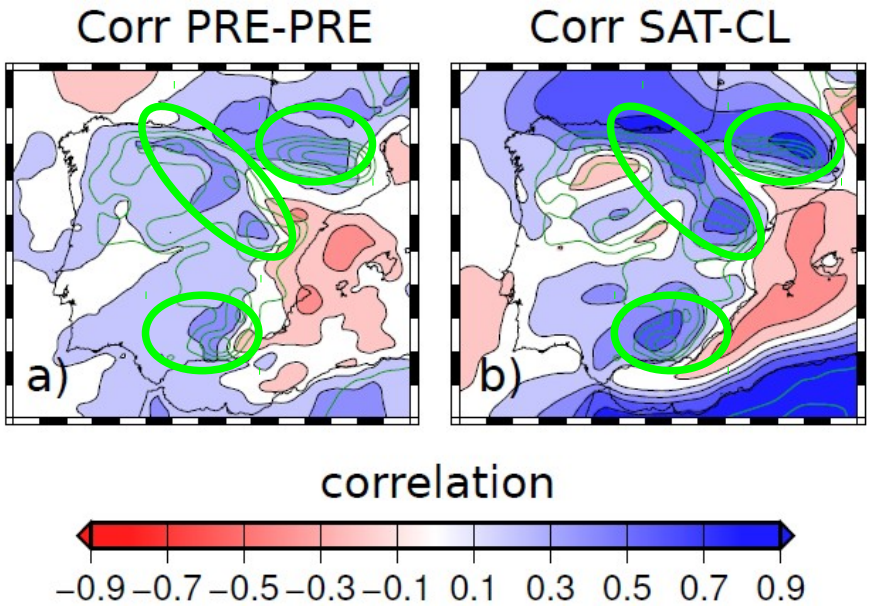
3. Results: *summer SLP*





- Large-scale circulation responds to forcing in summer (in both simulations)
- SLP mediates the link between forcing and PRE

3. Results: *winter condenstation level*



- Winter PRE depends on NAO, which is uncorrelated
- Interaction with the orography (through sinking the condensation level) modulates precipitation
- This interaction is lost in in a GCM simulation

4. Conclusions

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- Internal variability of climate models difficulties the cross-validation between simulations and reconstructions
- Over the IP, SAT is clear and homogeneously driven by the forcings, whereas evolution of PRE is at great extent driven by random variability
- Several simulations allow to locate areas where the forcings modulate evolution of SAT and PRE, but more importantly to identify the underlying physical mechanisms
- Physical mechanisms involve regional scales, and thus can only be reproduced through dynamic downscaling procedures

See the full description of the work in
Gómez-Navarro et al. 2011. Climate of the Past submitted

Thanks for the attention!

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3. Results: *added value by the RCM*

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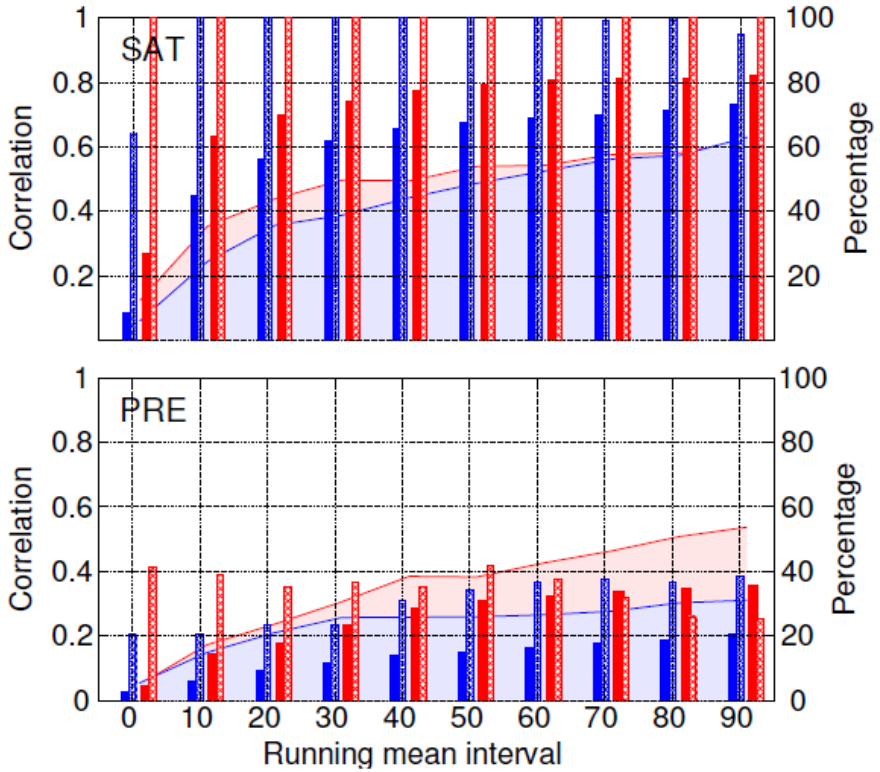
Different running-means correlations



- There are however several areas where precipitation is able to respond to forcings

why?

- Further, these areas are different for summer and winter

3. Results: *summer PRE*

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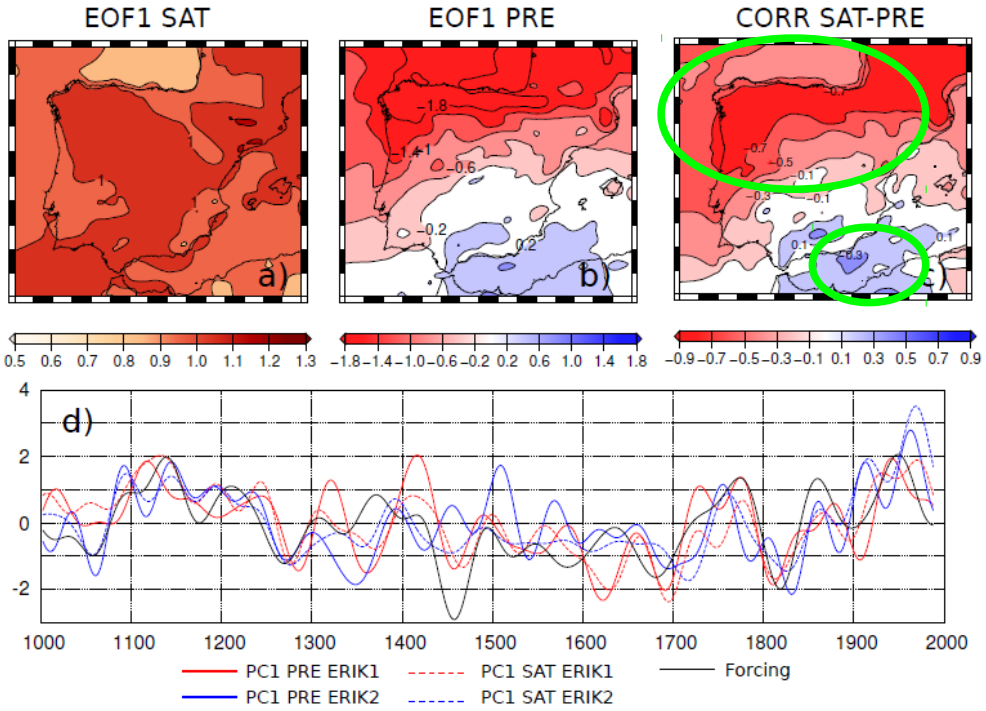
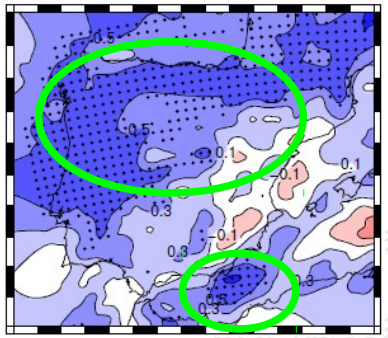
EOF-analysis





- Low-frequency variations in summer reveal a “seesaw” in PRE, and homogeneous behaviour of SAT

3. Results: *winter PRE*

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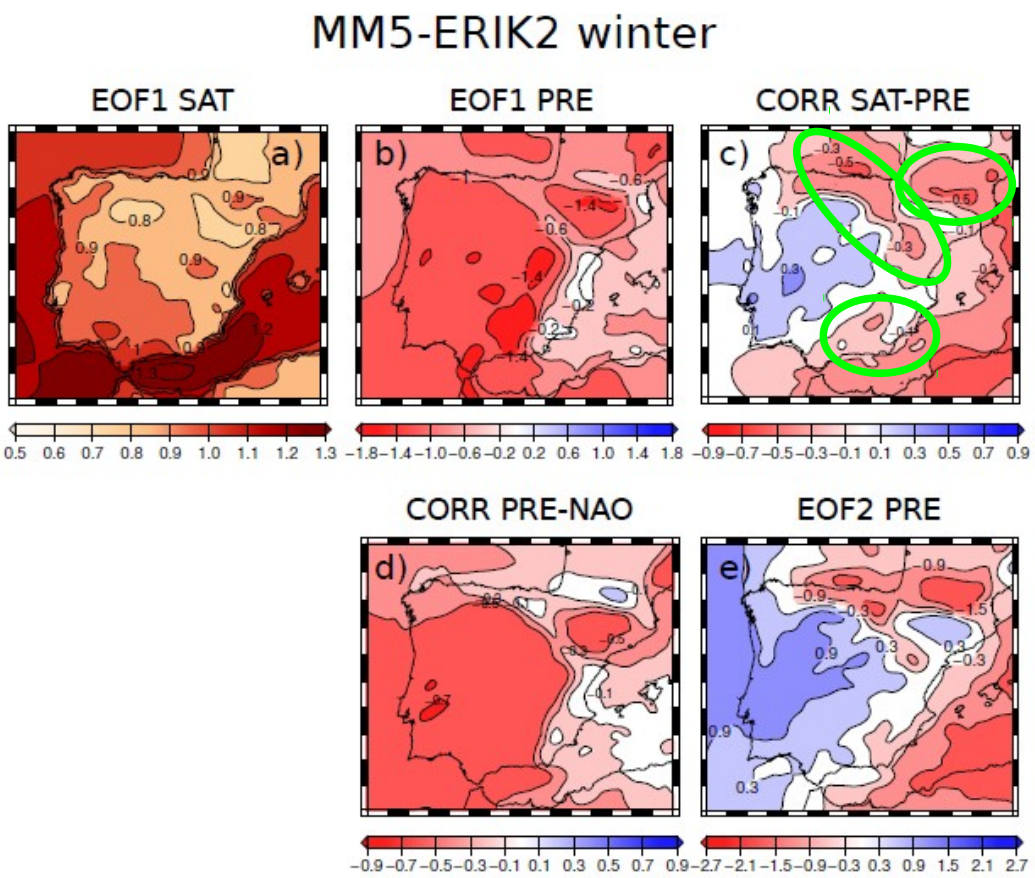

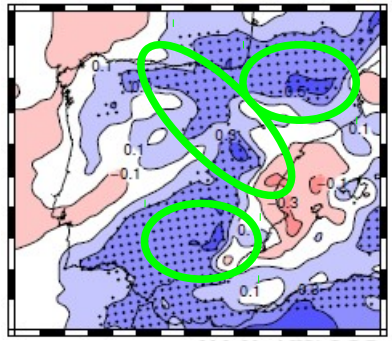

- Winter is more complicated
- NAO (non forced) dominates variability
- Interaction with orography