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OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Insights from paleo-climate modelling

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Outline

- Climate modelling
  - Definition
  - The problem
  - How?
- Paleo examples
  - Interpretation of proxy reconstructions
  - Process understanding: transition MCA -LIA
  - New reconstruction of the NAO
- Conclusions

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Definition

Model?

- a composition of concepts
- a **simplification** of relevant aspects of a situation in the real world for its systematic study

Climate model?

- Application of **quantitative methods** to simulate the interactions of the atmosphere, oceans, land surface, ice, etc.

The problem

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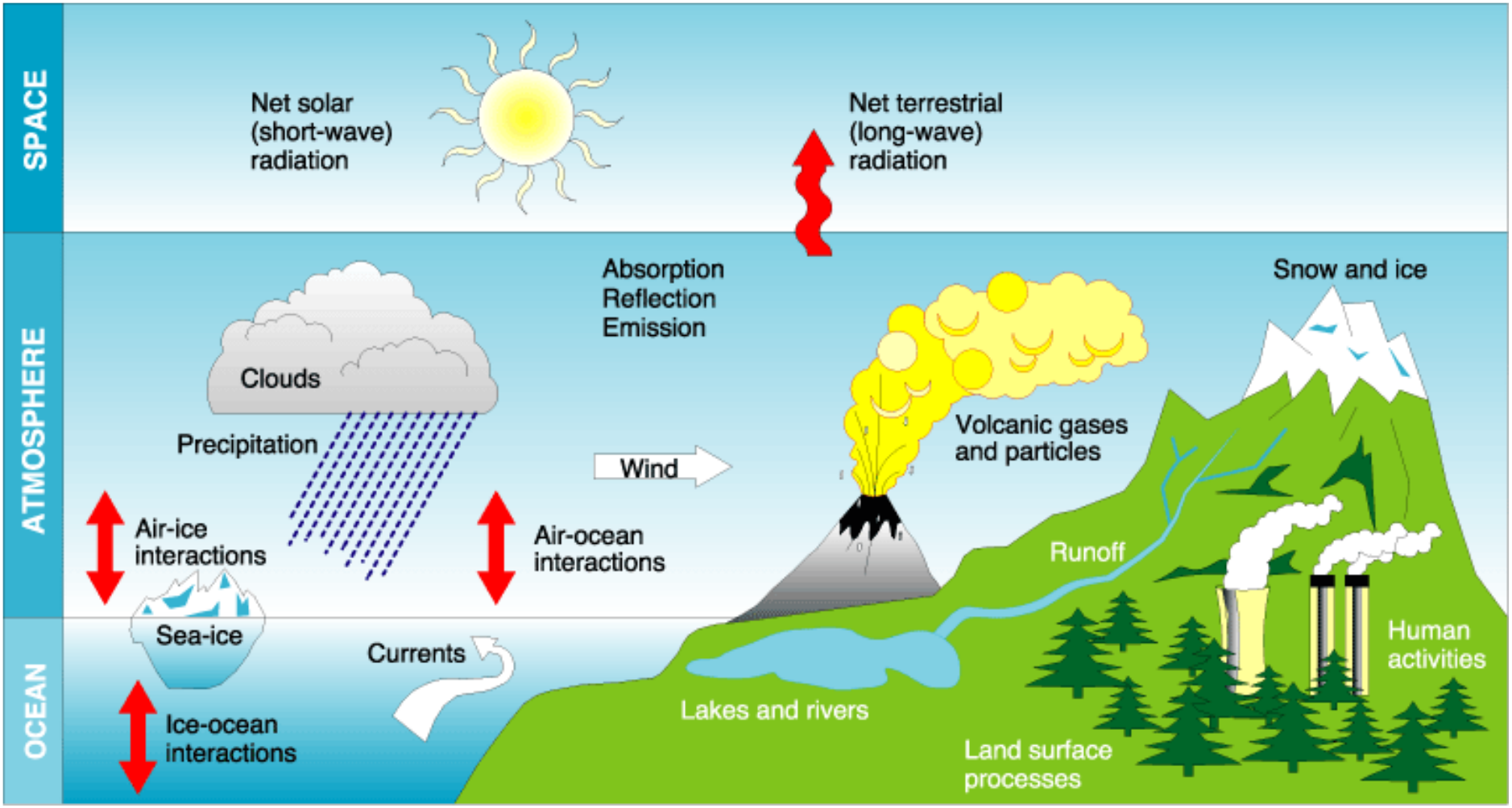


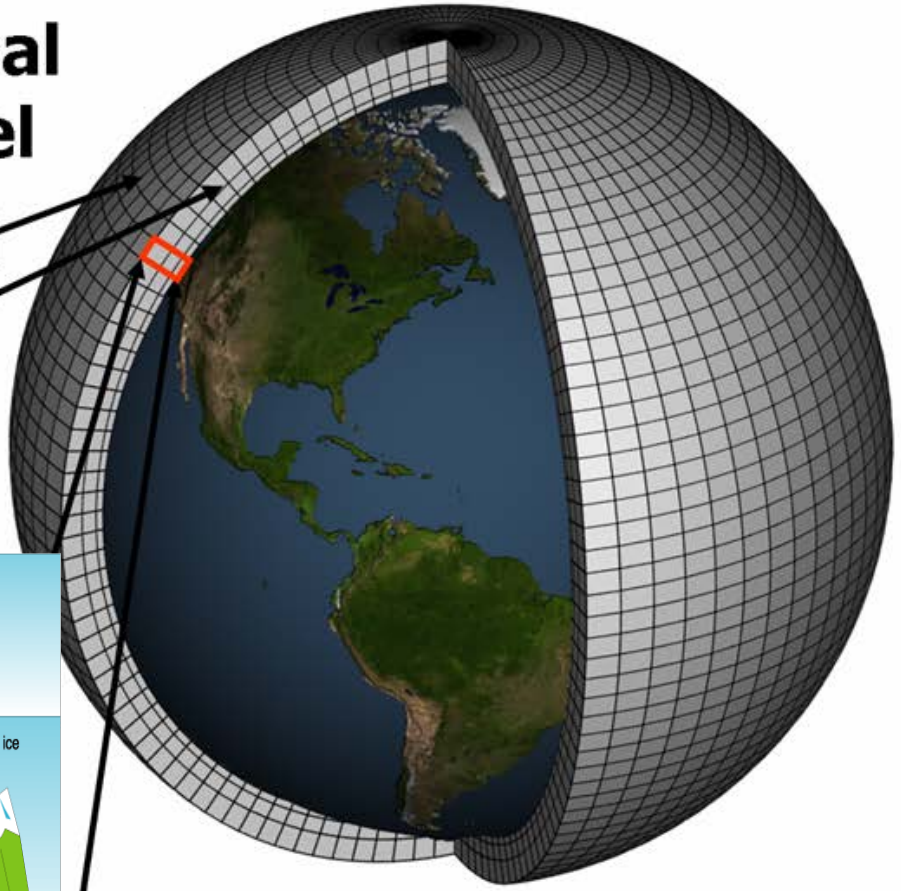
Karl and Trenberth, (2003)

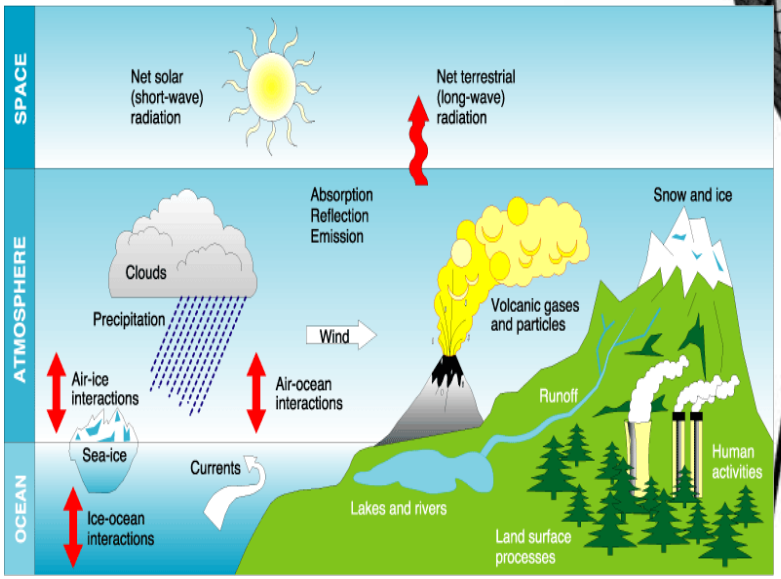
How???

Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)

Vertical Grid (Height or Pressure)





Limitations

- Not reality
- Model uncertainties
- Grid boxes have a certain resolution
- Parameterizati… sub grid proc… clouds, turbule…e, …
- Numerical implications

Why?

Limitations / Advantages

- Not reality
- Model uncertainties
- Grid boxes have a certain resolution
- Parameterization of sub grid processes like clouds, turbulence, …
- Numerical implications

- Simplification on purpose
- Overcome limitations of temporal and spatial coverage
- More realizations of model reality possible (ensemble approach)
- Sensitivity experiments
- Predictions and projections

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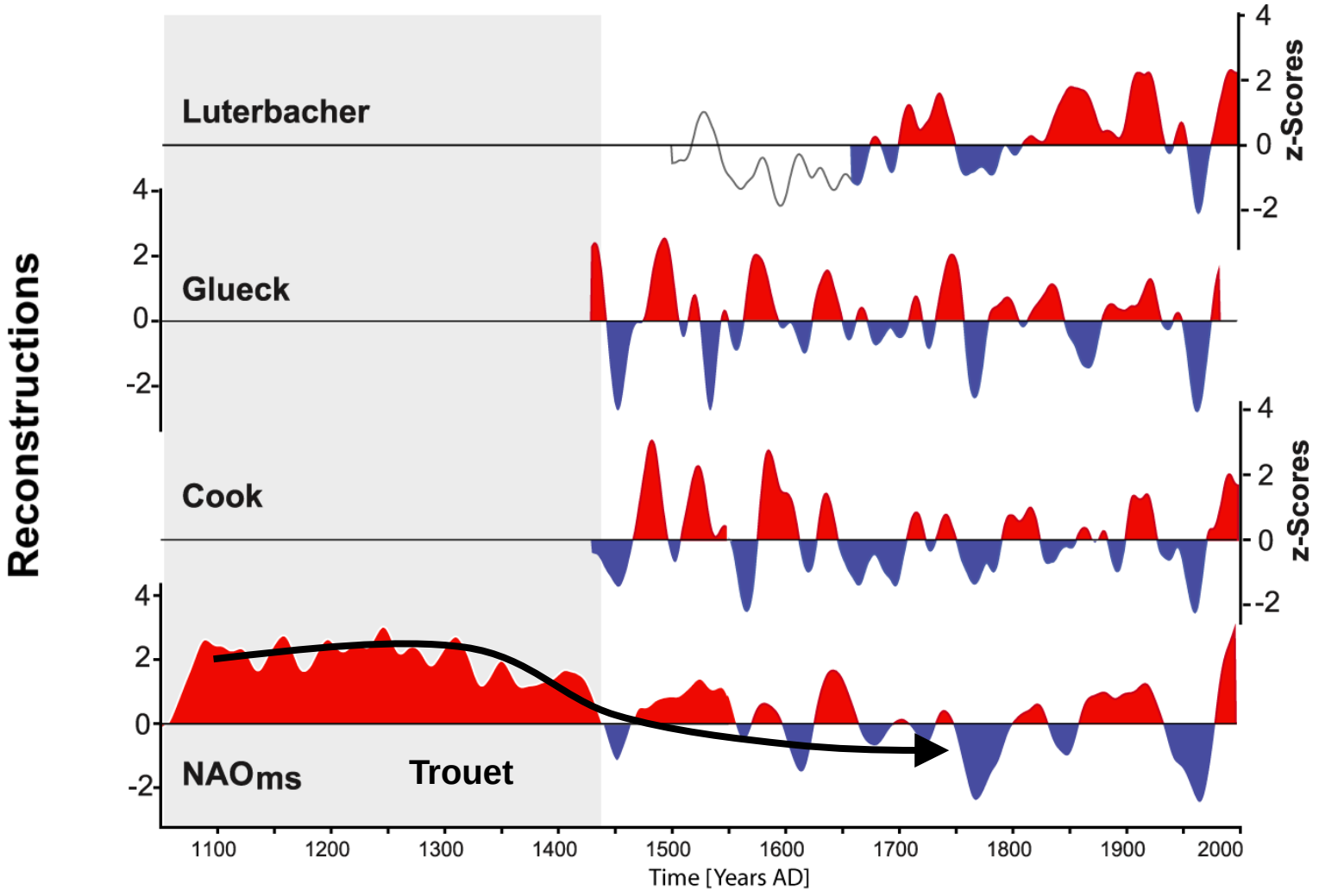
NAO reconstructions (only a selection)



modified from Trouet et al. (2009)

Multi-model ensemble approach: Past

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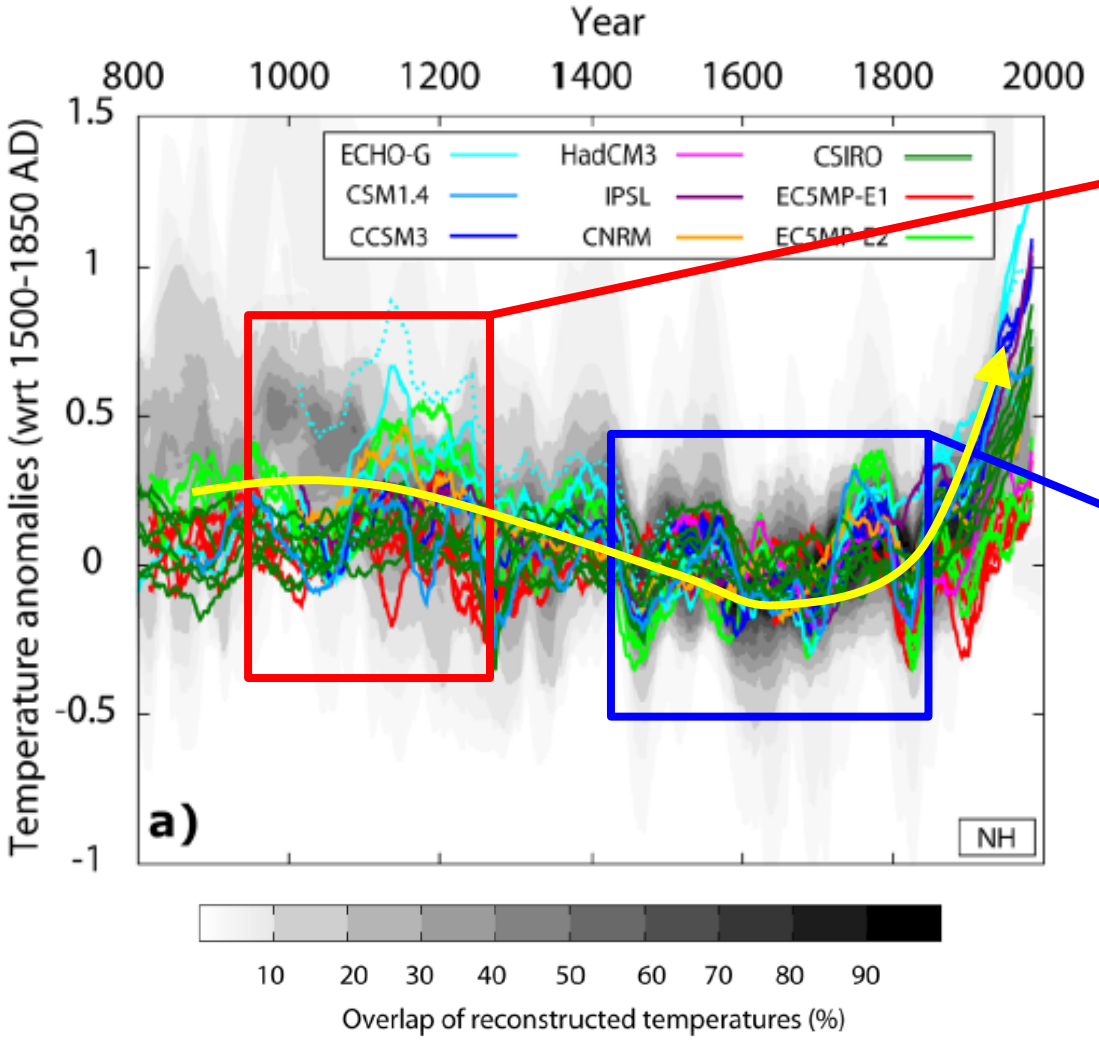
Reconstructed and simulated temperatures



MUD:

Medieval Unperturbed Decades

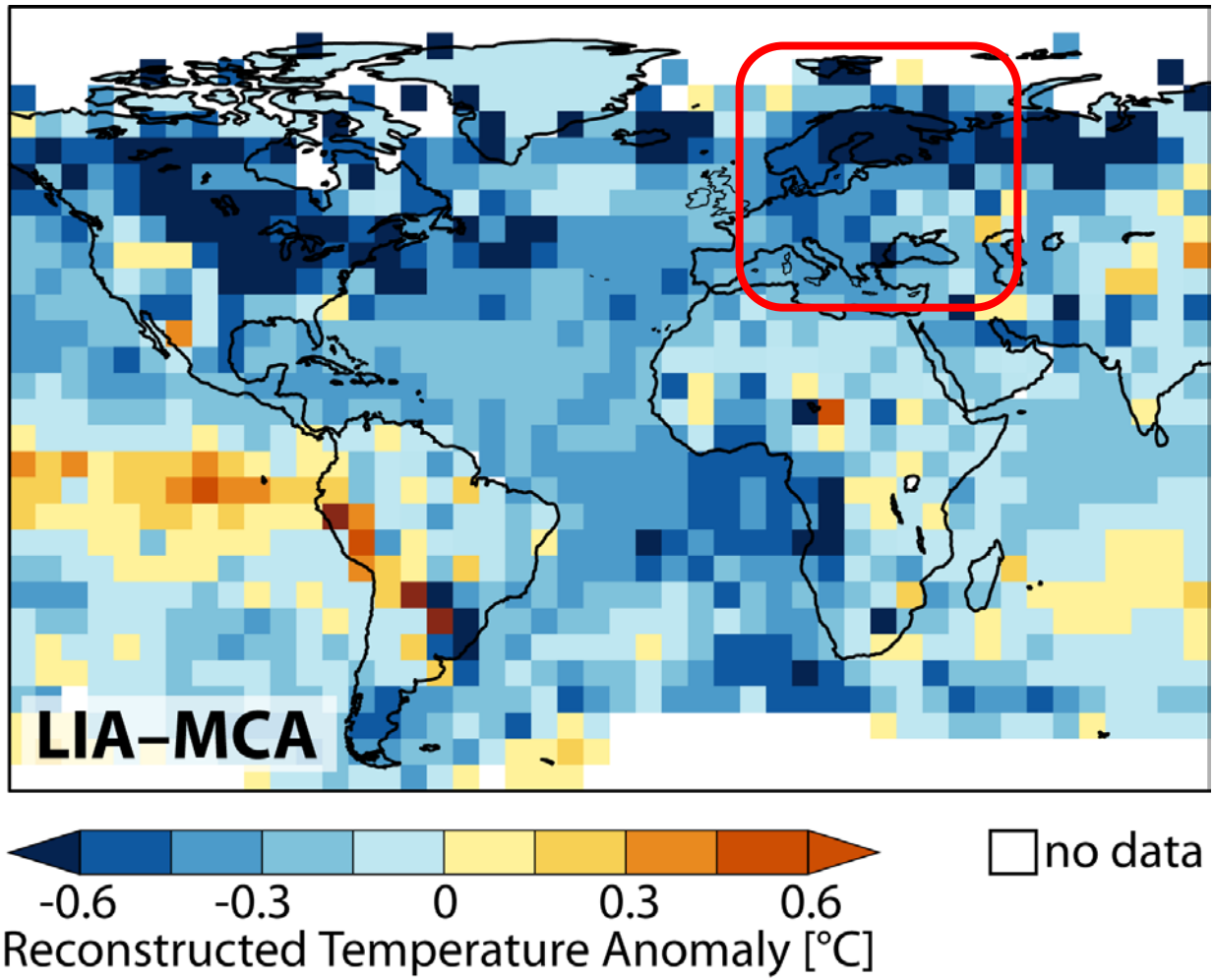
Little Ice Age

(LIA)

What caused this?

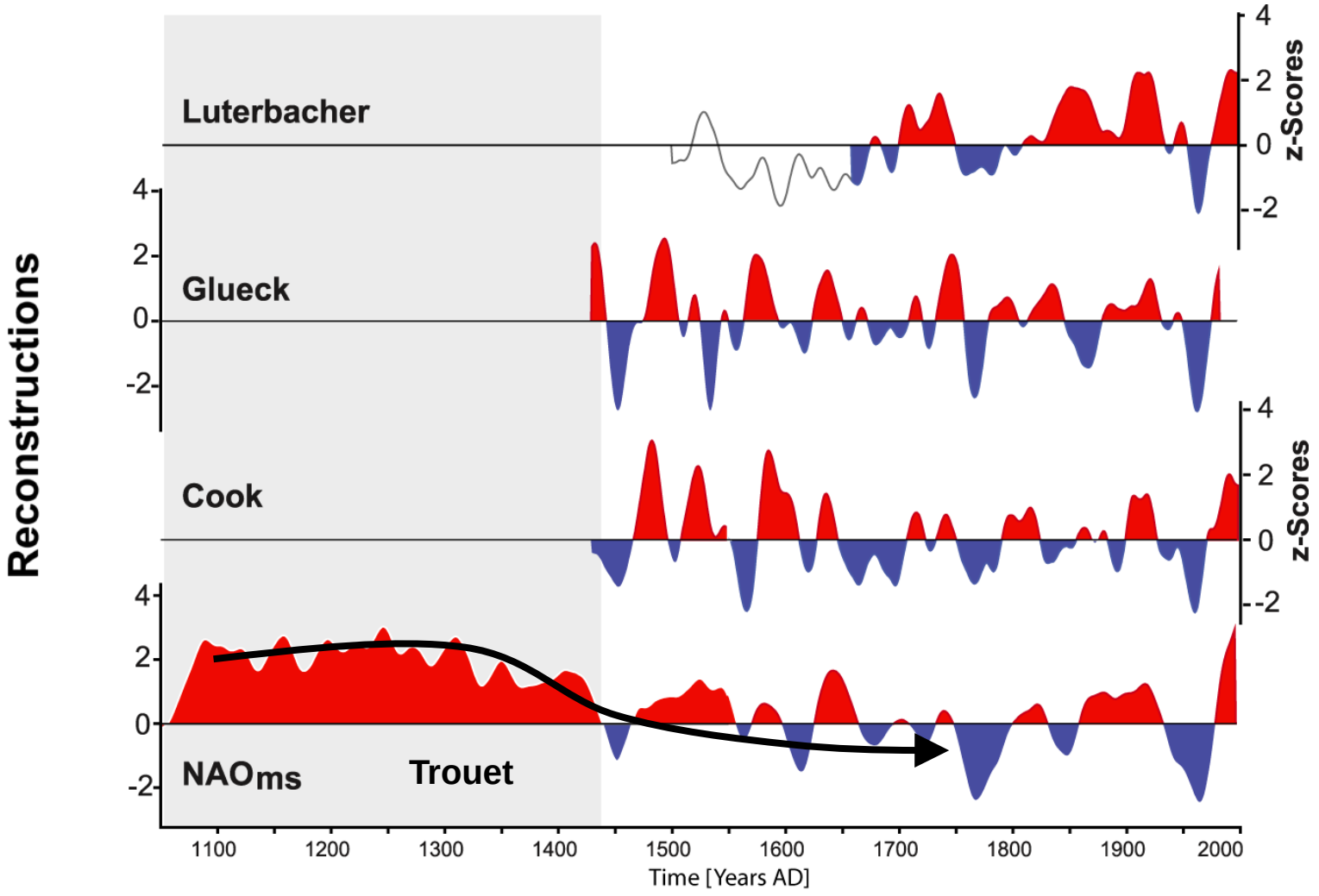
Medieval Quiet Period (MQP): ~950 - 1250 AD

Little Ice Age (LIA): ~1400 - 1700 AD



modified from Mann et al. (2009)

Hypothesis: NAO plays a role



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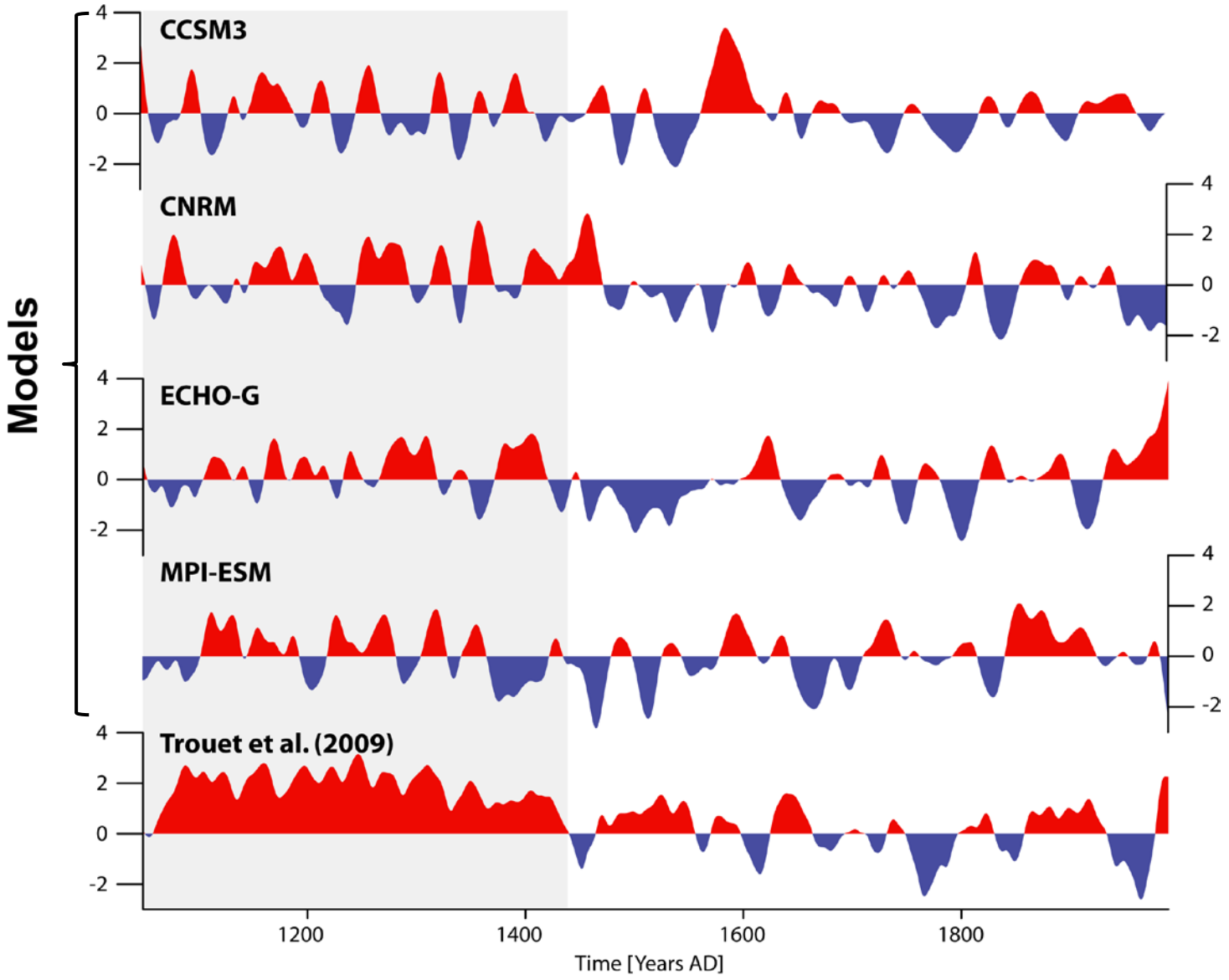
Simulations disagree



modified from Lehner et al.(2012)

Transition from the MQP - LIA

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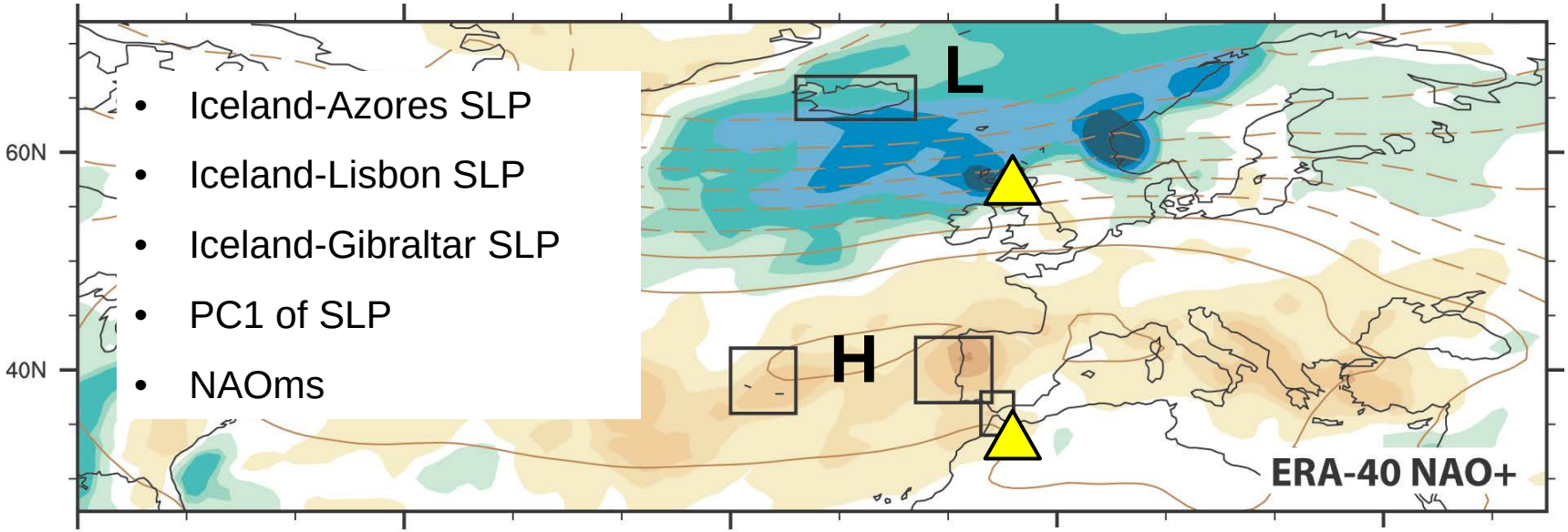
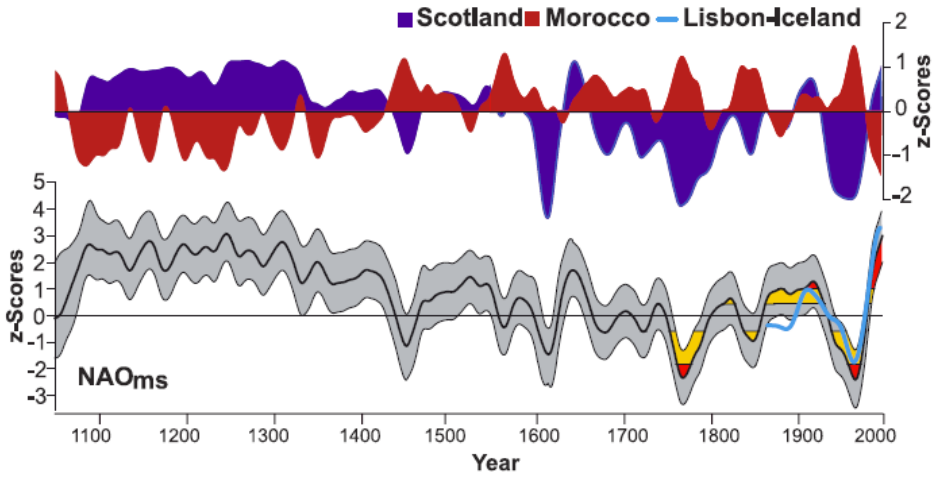
NAO indices: Pseudo-proxy approach

- Iceland-Azores SLP
- Iceland-Lisbon SLP
- Iceland-Gibraltar SLP
- PC1 of SLP
- NAOms



→ **NAO**ms



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NAO indices: Pseudo-proxy approach

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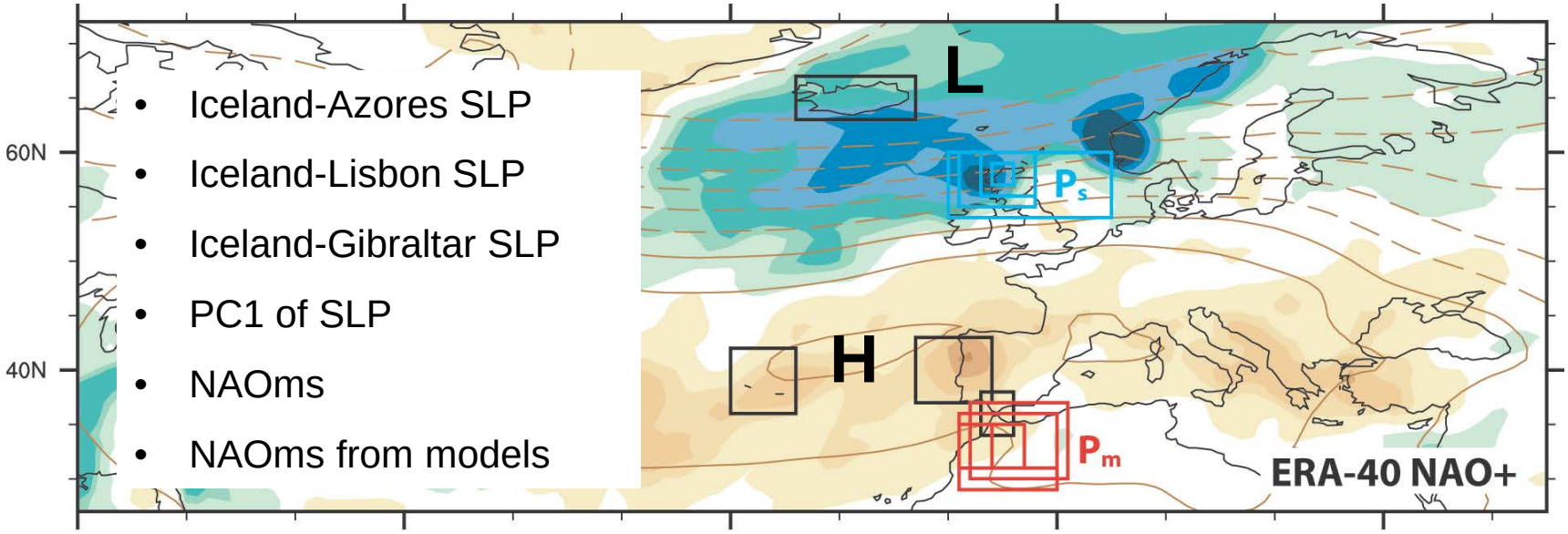
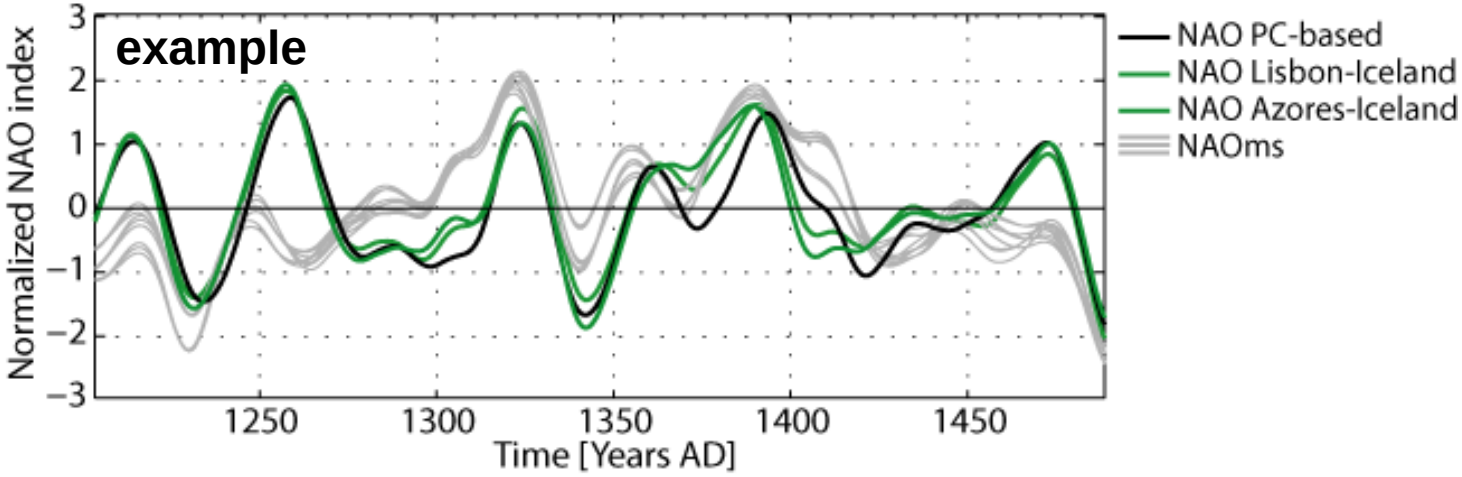
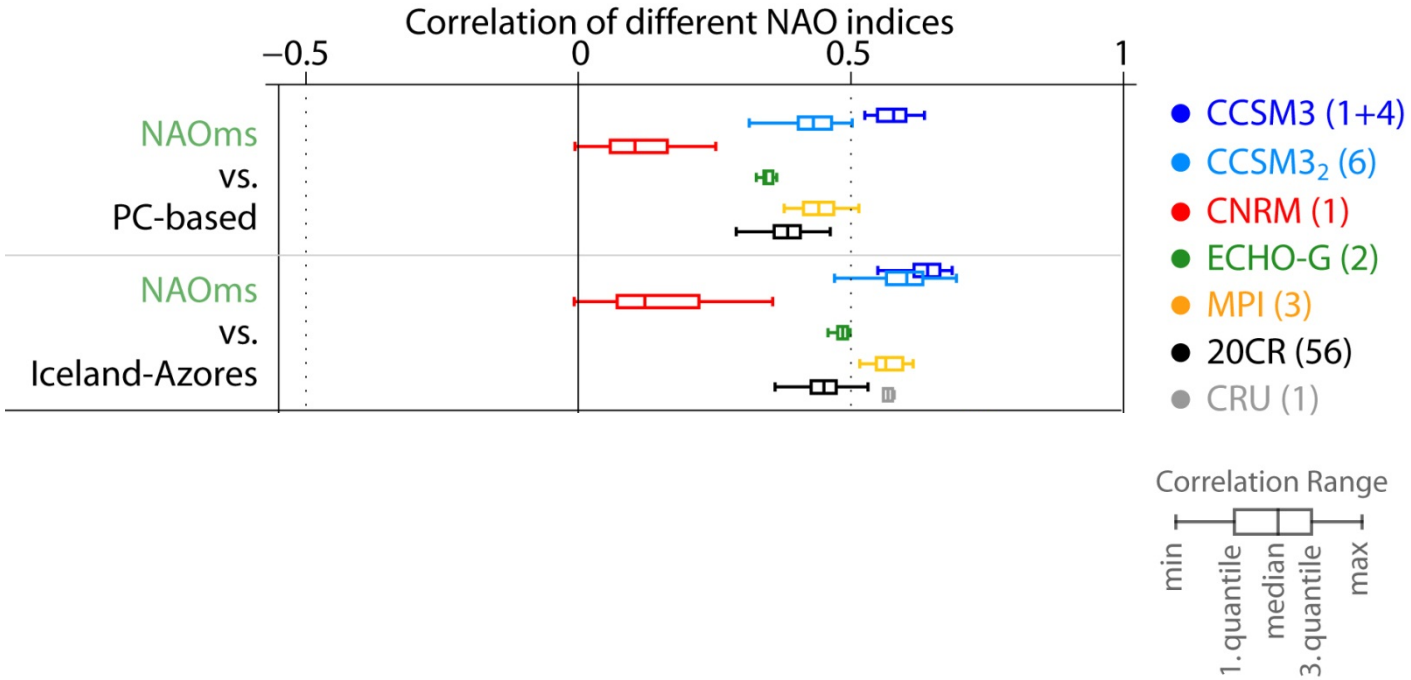
- PC1 of SLP
- NAOms
- NAOms from models





Lehner et al. (2012)

Transition from the MQP – LIA



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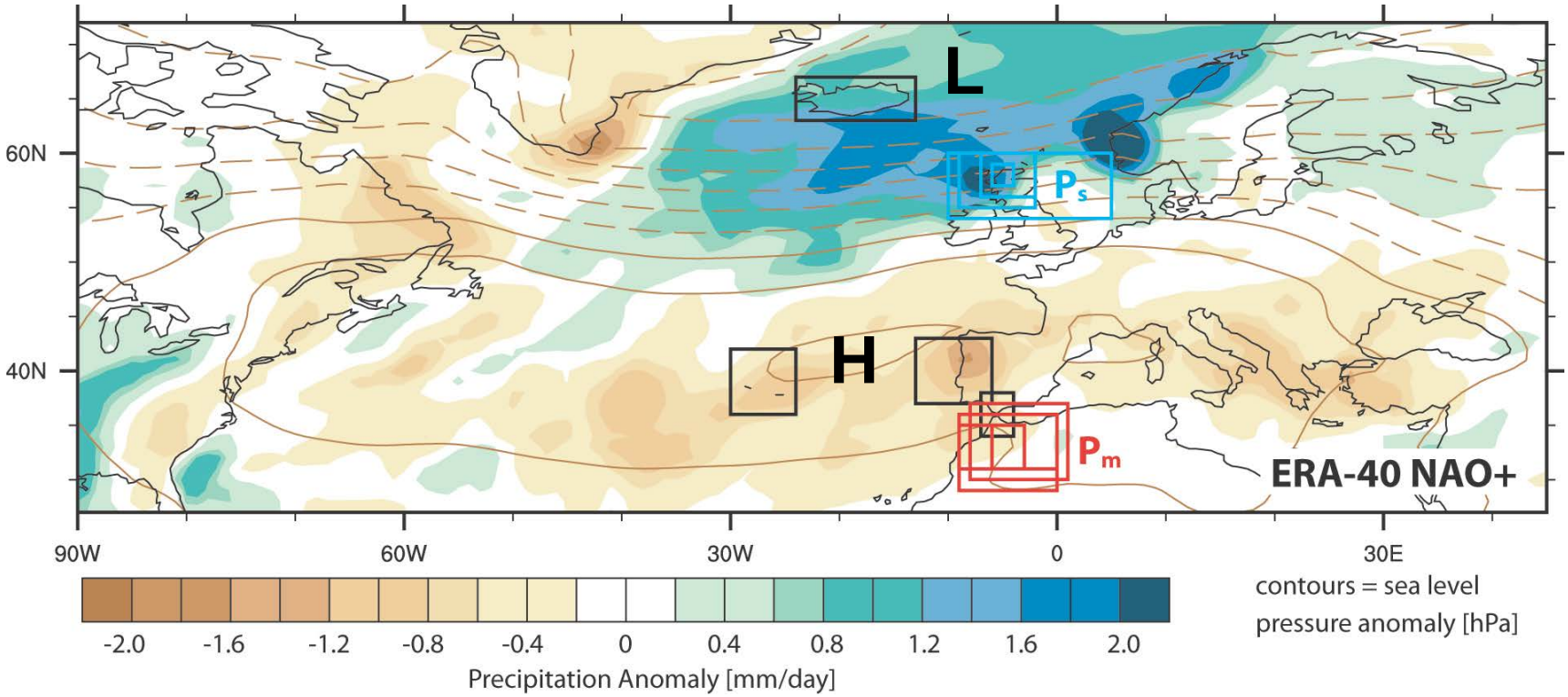

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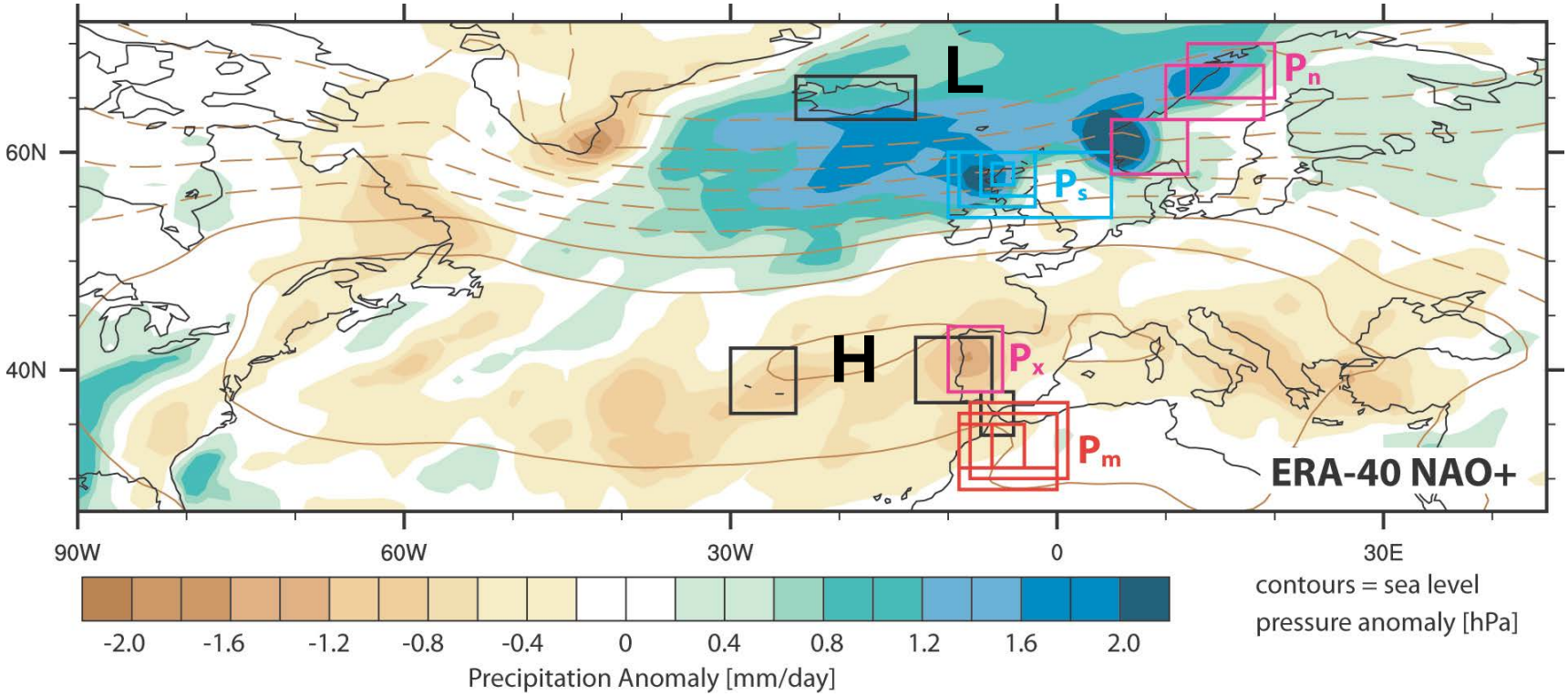
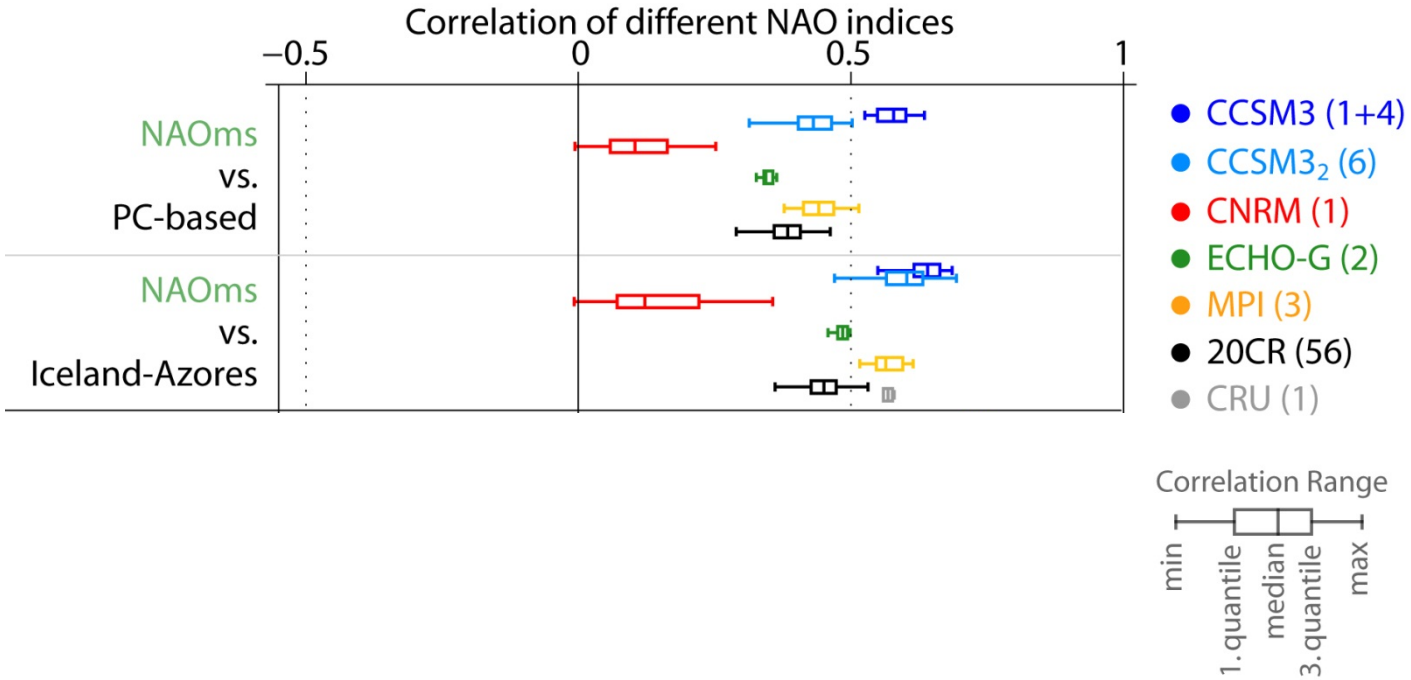


→ new **NAO**msxn

Transition from the MQP – LIA



Conclusion on NAO details – part I

- The suggested two proxy sites seems to be not sufficient to constrain the NAO
- Model simulations can serve to test reconstruction methods

➢ Is a simple index definition of a mode adequate?

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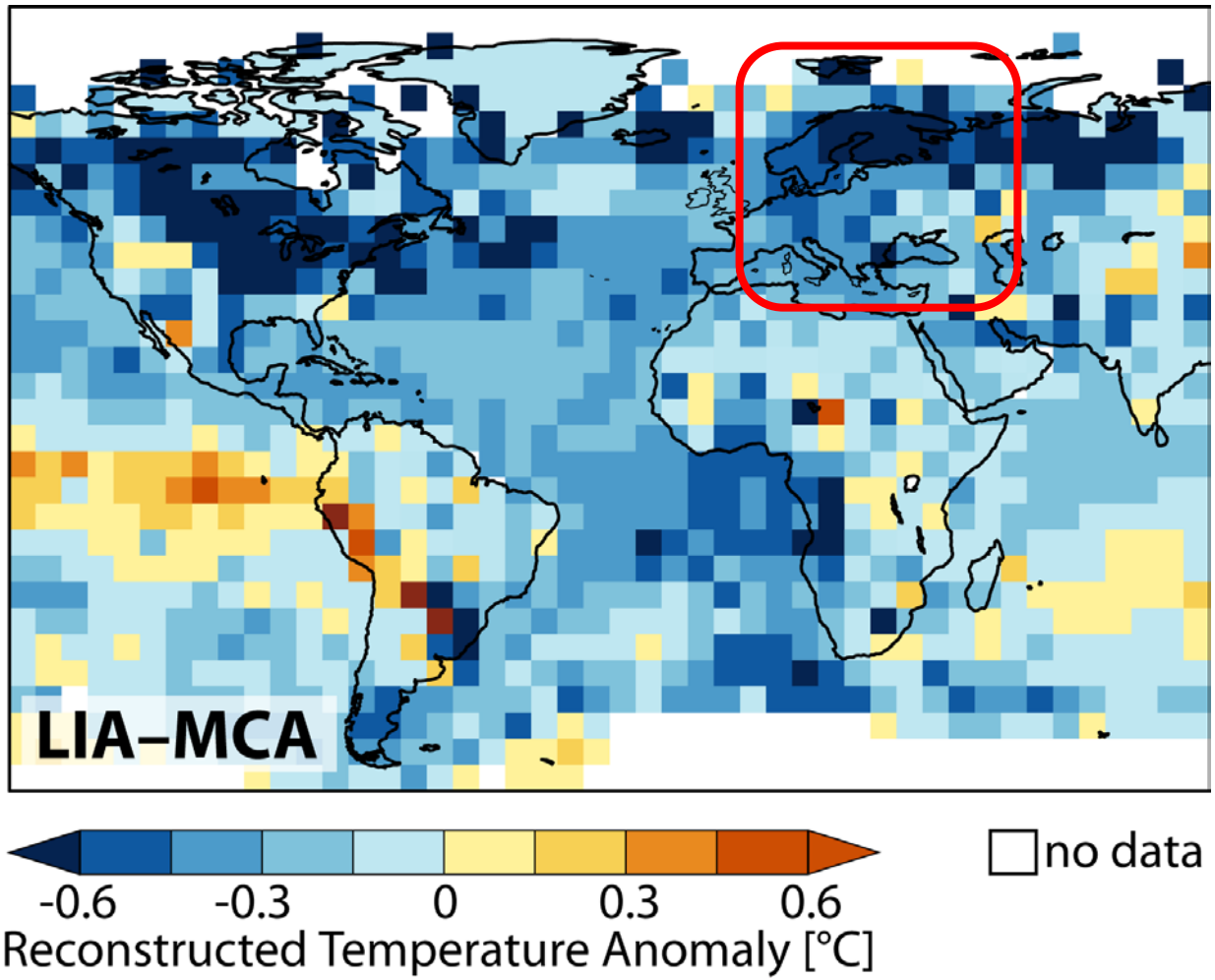
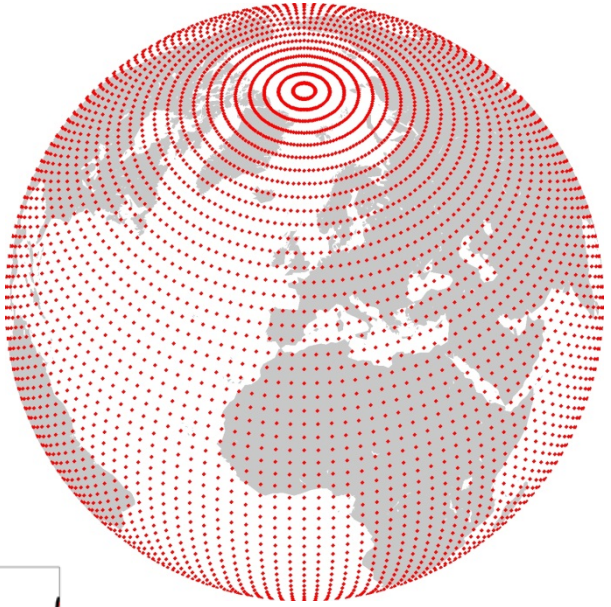


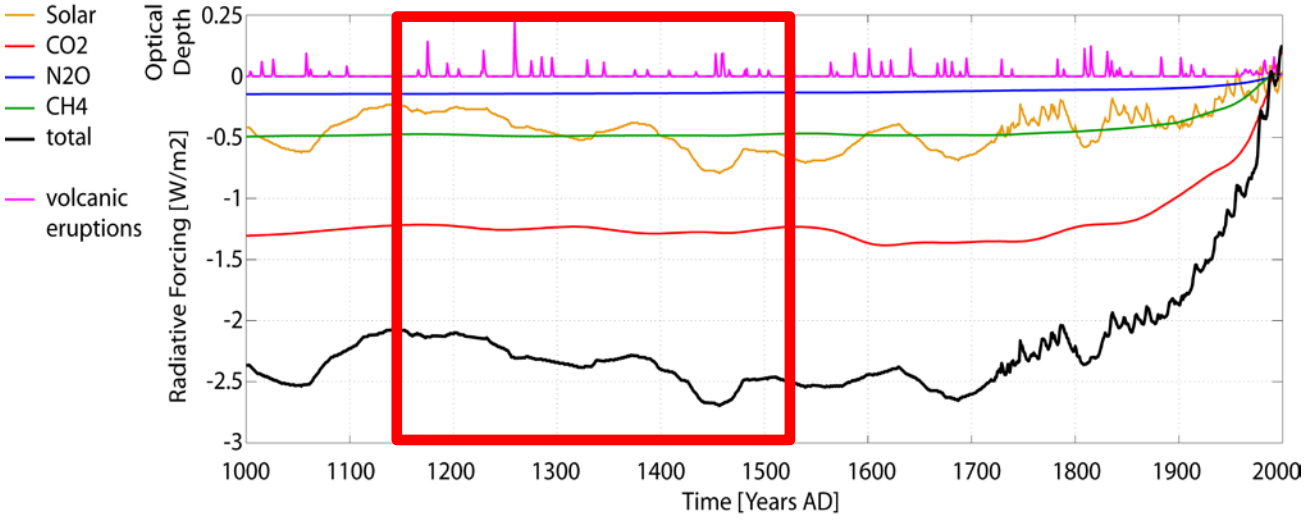
modified from Mann et al. (2009)

Model

CCSM3 (2004)

T42x1 → 2.8° (atm), 1° (ocn)





Lehner et al. (2013)

LIA–MQP: surface climate [November-April]

Little Ice Age (LIA) - Medieval Climate Anomaly (MCA)
1450-1500 AD 1150-1200 AD

LIA–MQP: surface climate [November-April]

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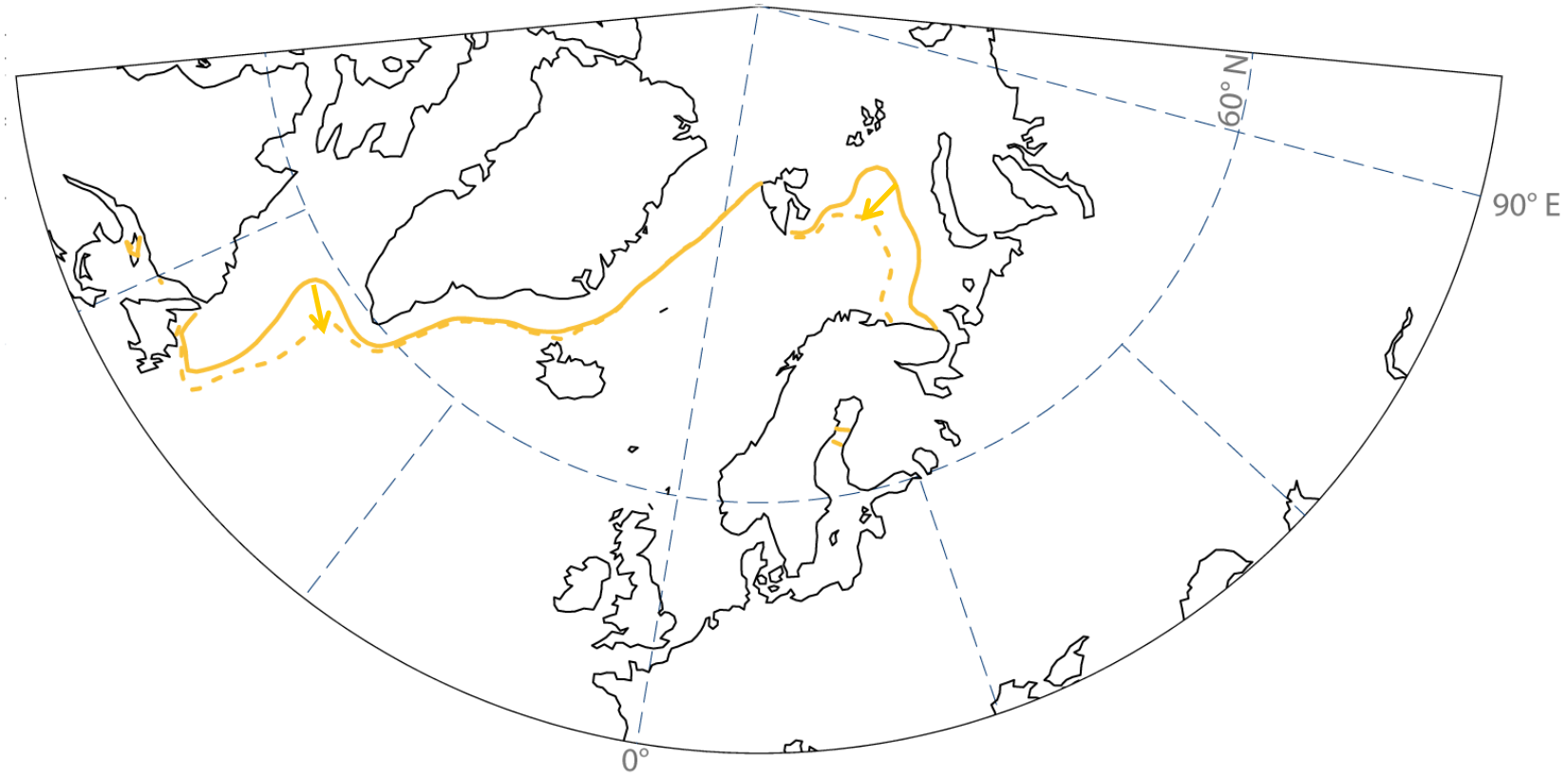

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LIA–MQP: surface climate [November-April]

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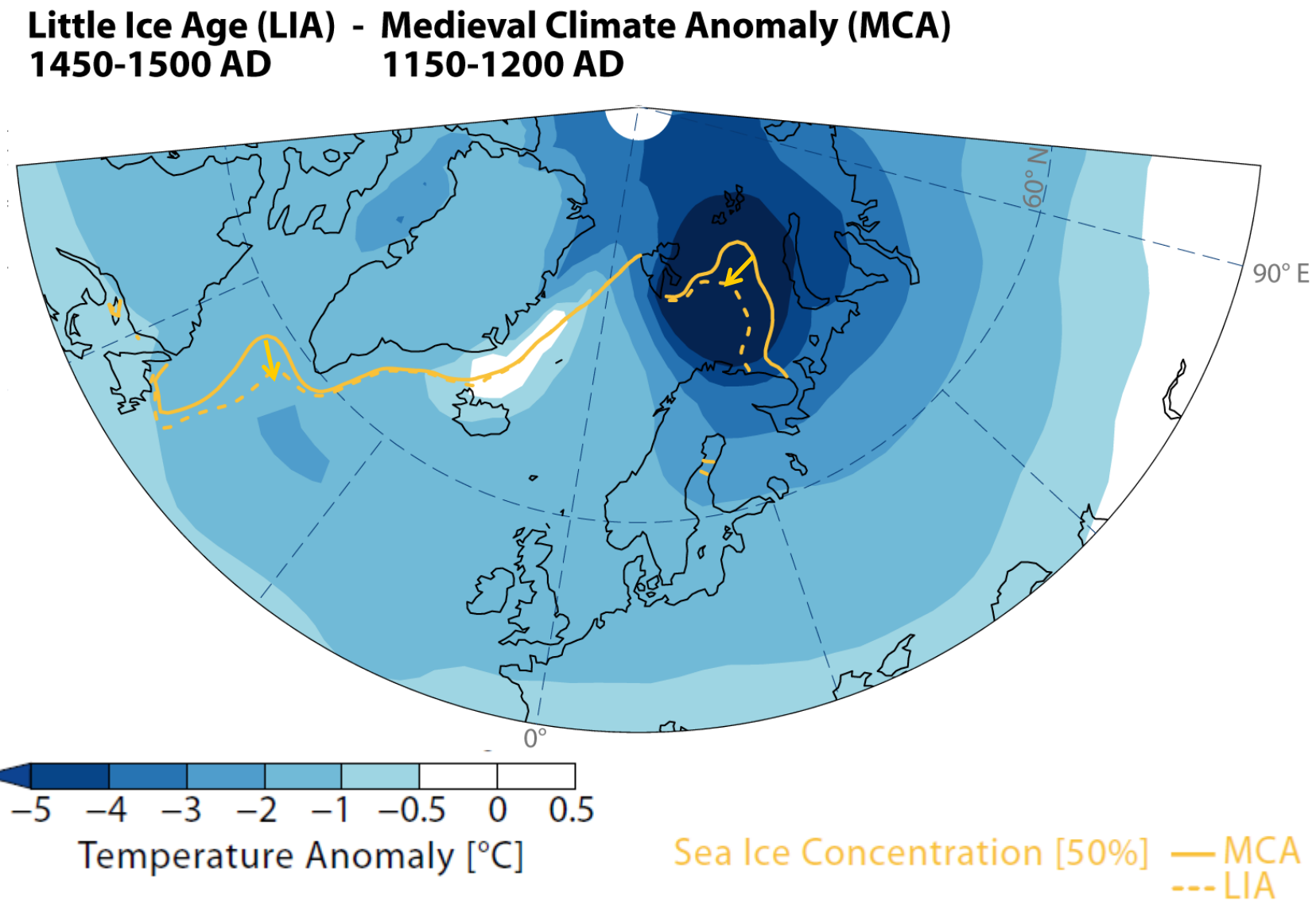

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LIA–MQP: surface climate [November-April]

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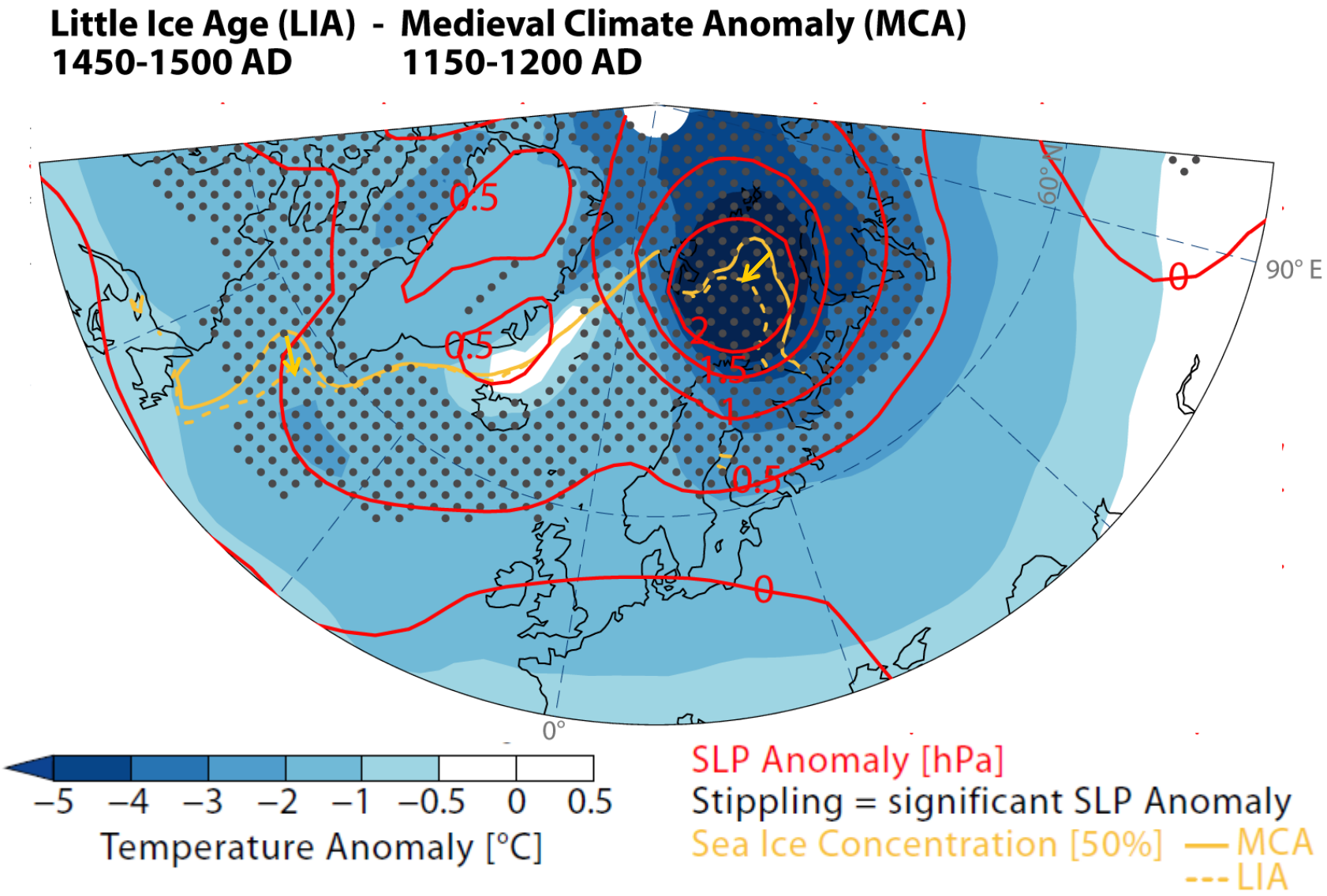
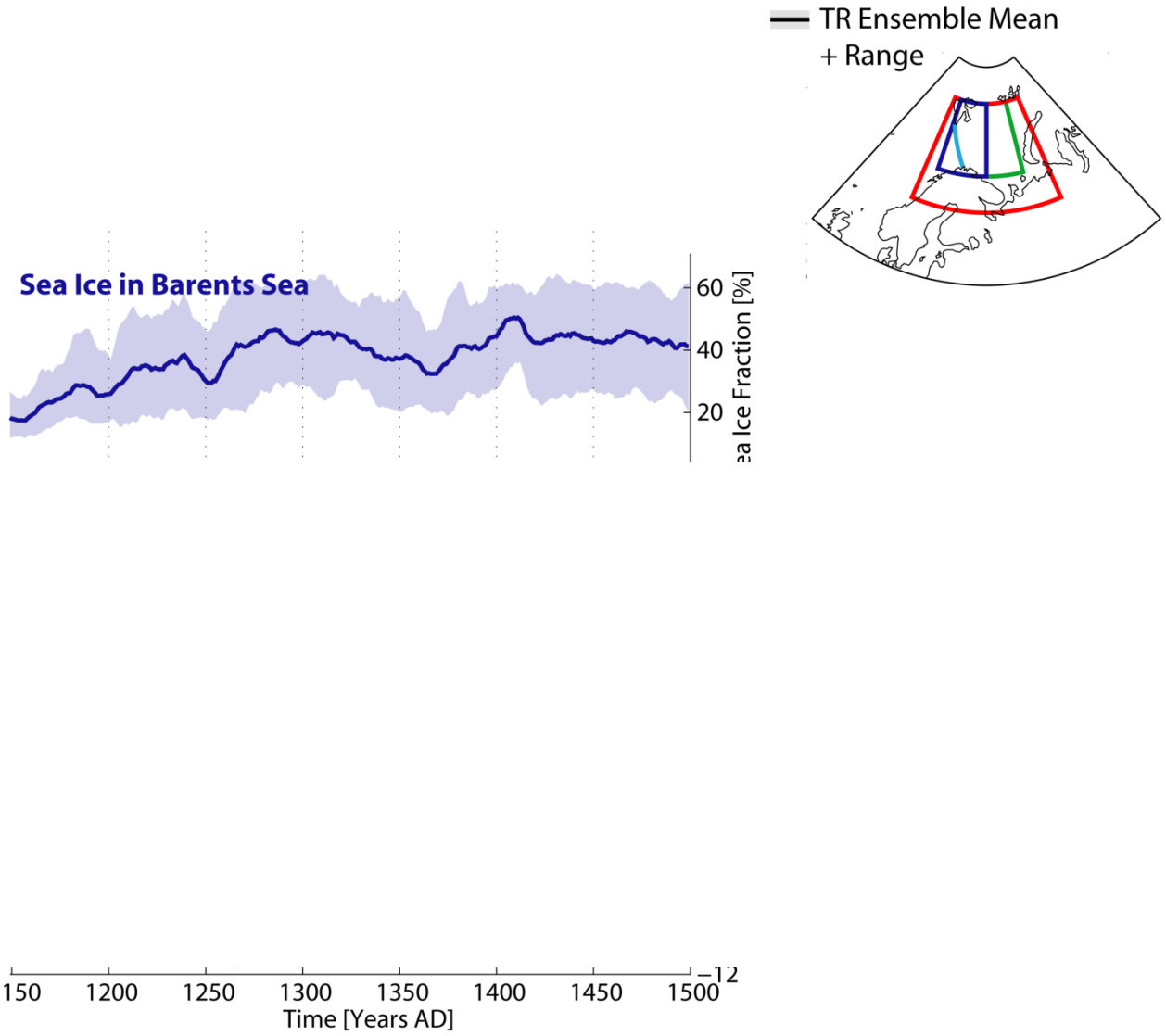


Lehner et al. (2013)

MQP-LIA: feedbacks?



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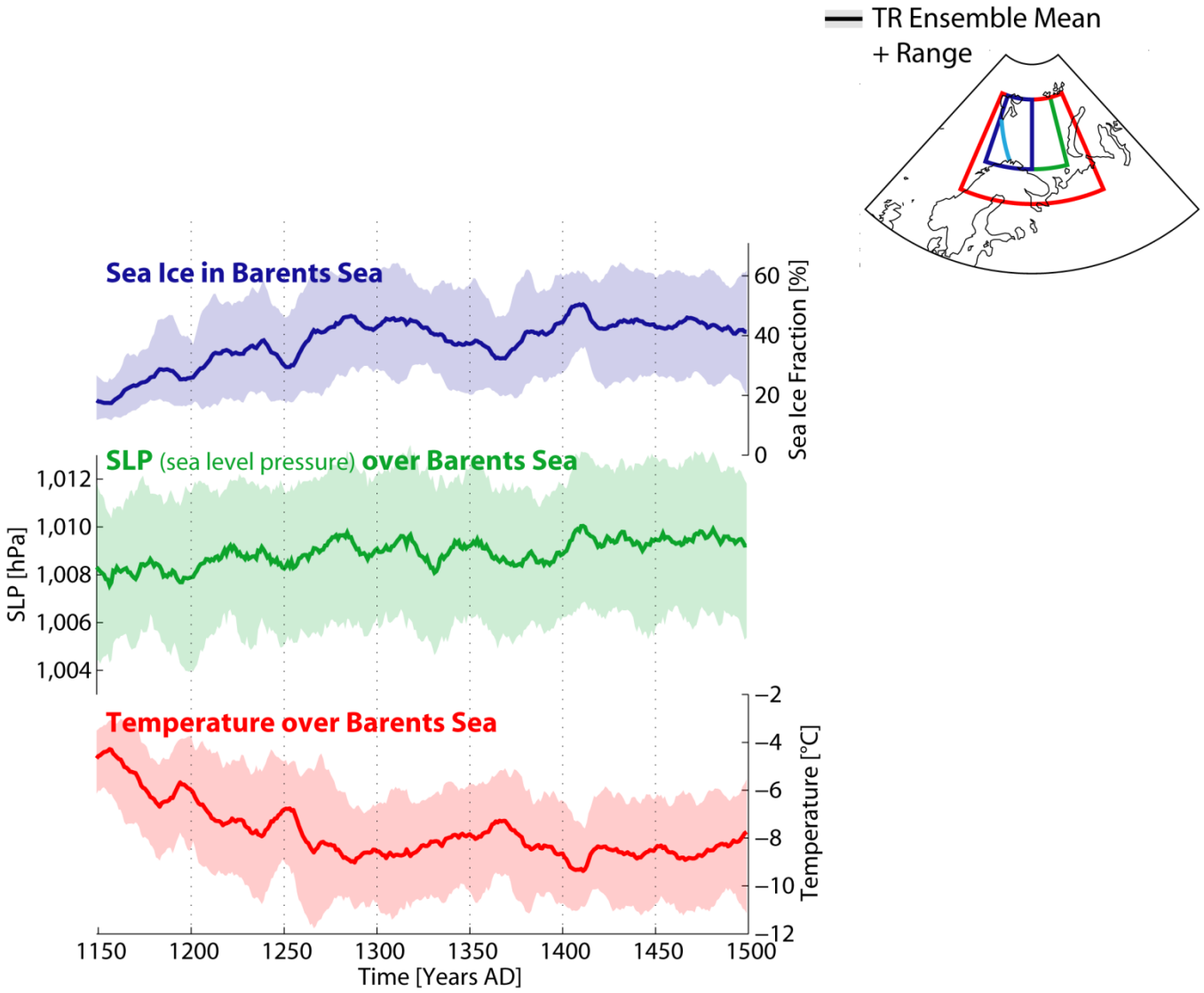

Lehner et al. (2013)

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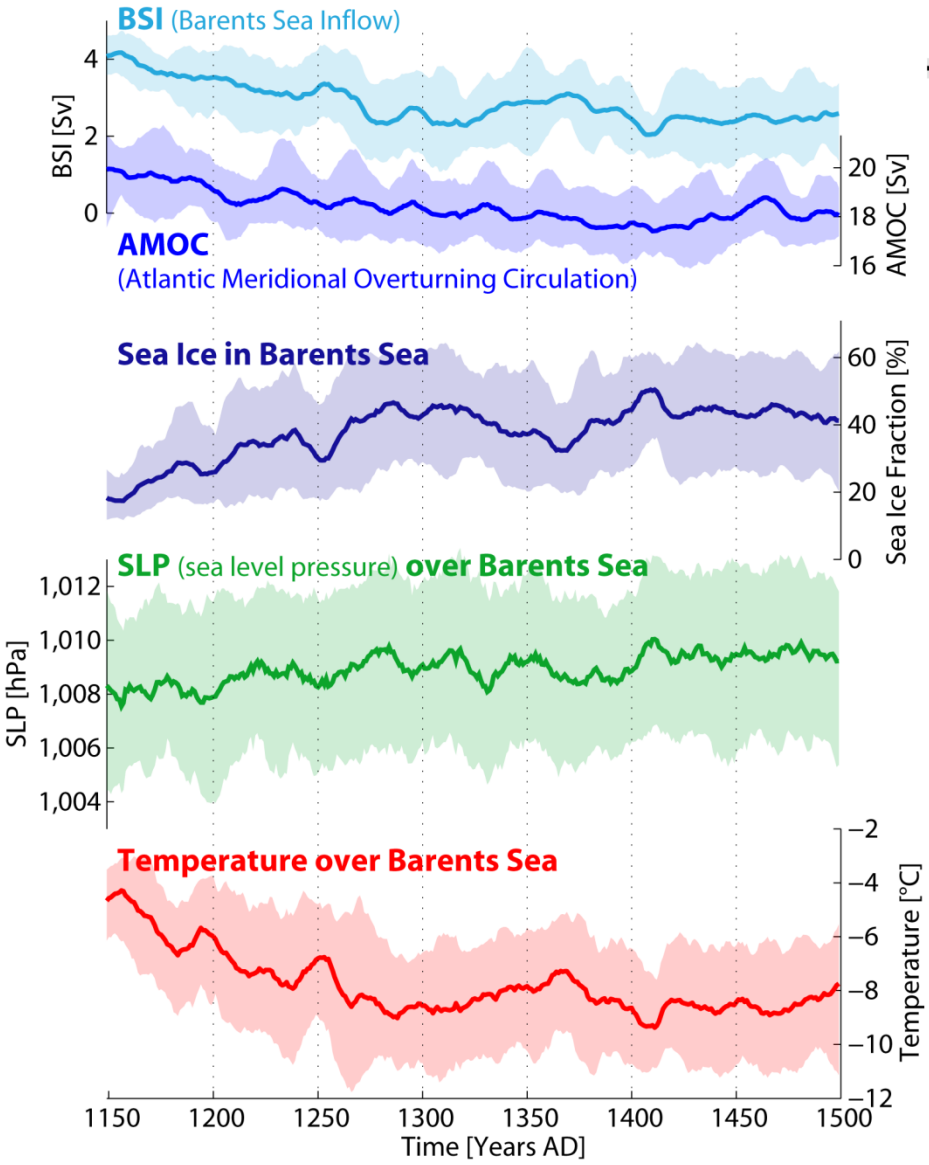
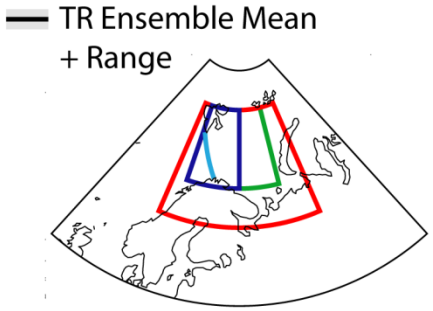
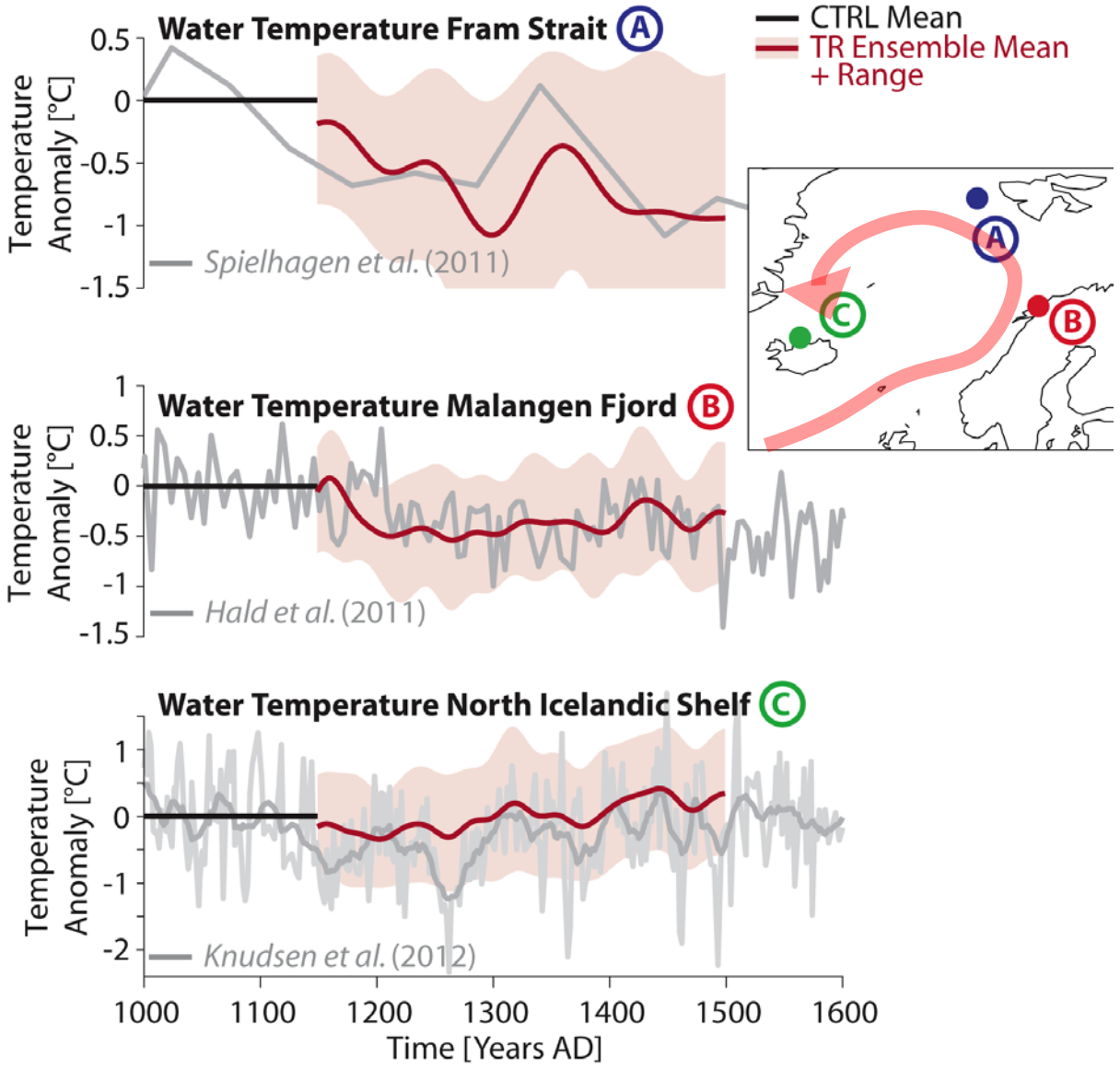


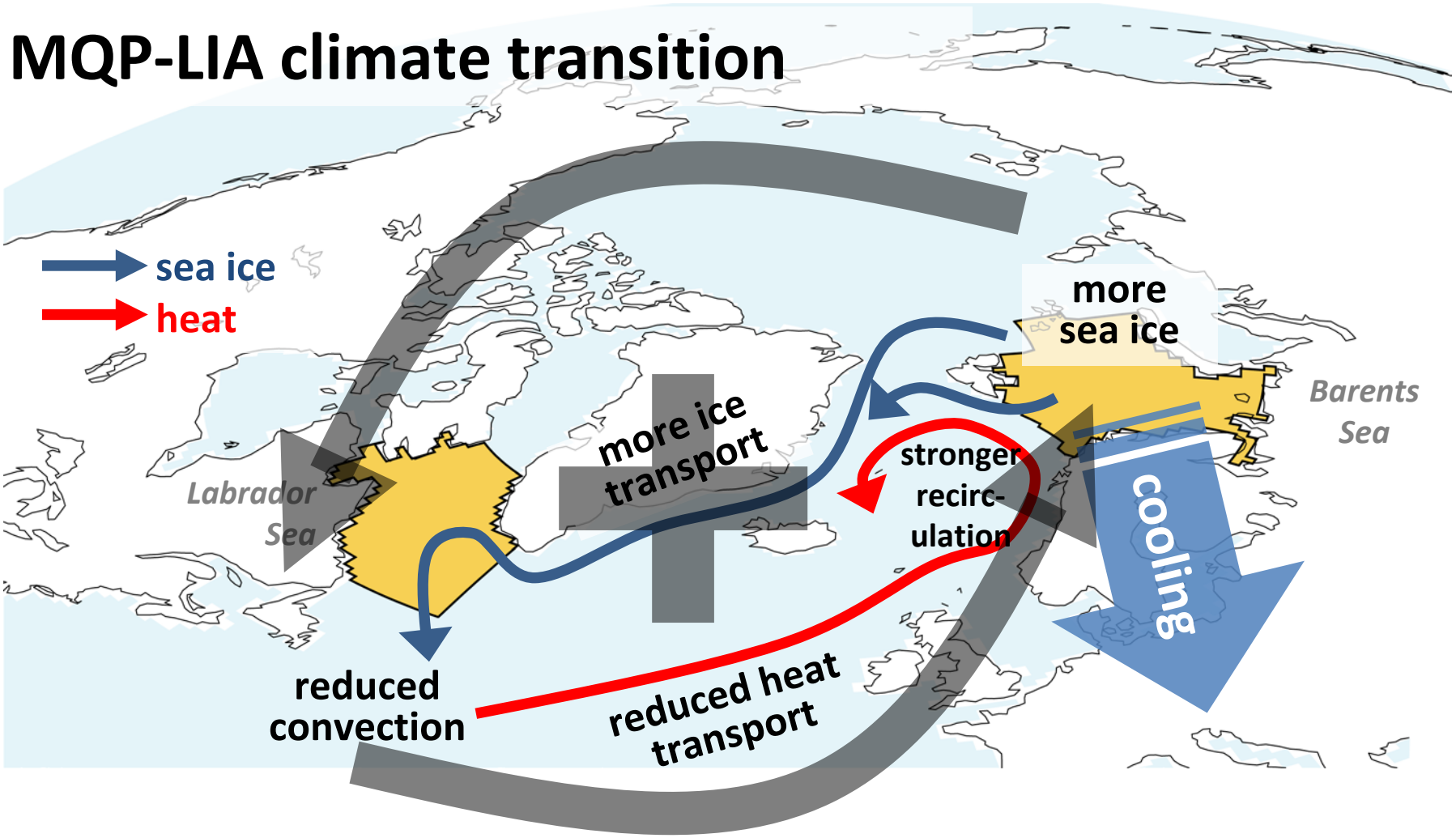


Lehner et al. (2013)

LIA–MQP SST: support from proxies



Hypothesis



Lehner et al. (2013)

Artificial sea ice growth

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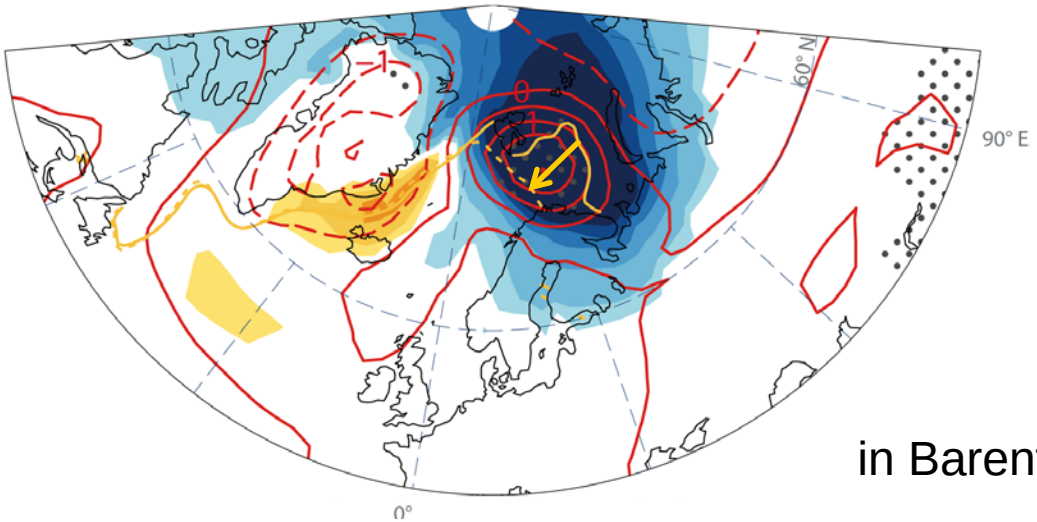

in Barents Sea

SLP anomaly [hPa]
stippling = significant SLP anomaly
Sea ice concentration [50%] — CTRL
--- year 50-99

Lehner et al. (2013)

Artificial sea ice growth

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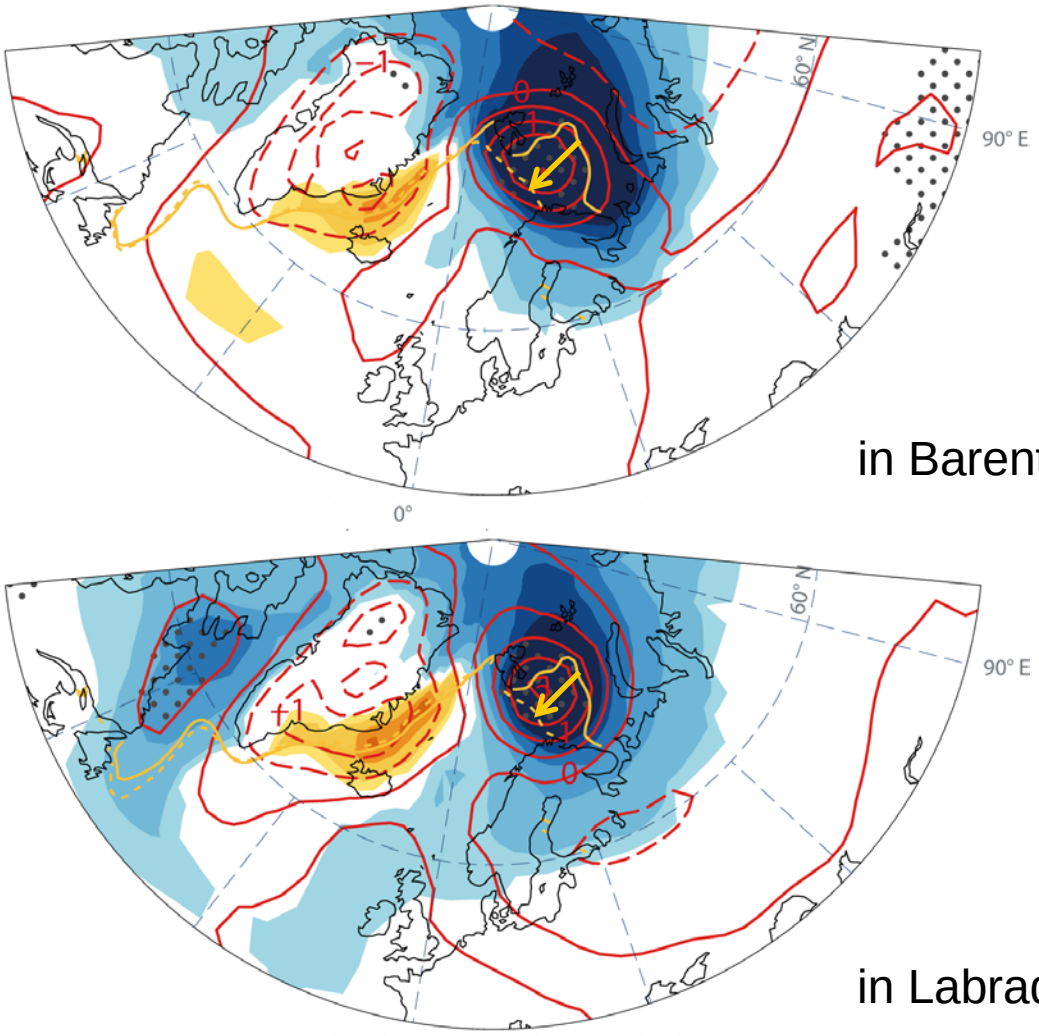

in Barents Sea

in Labrador Sea

Lehner et al. (2013)

Conclusions: Forcing triggering

- Potential crucial role of sea ice in MQP-LIA transition (atmospheric circulation, temperature)
- Northern Europe proxies are affected
- Mechanism for MQP-LIA climate transition that does not need a significant shift in NAO

➢ Forcing might trigger internal feedbacks and lead to long lasting climate shifts

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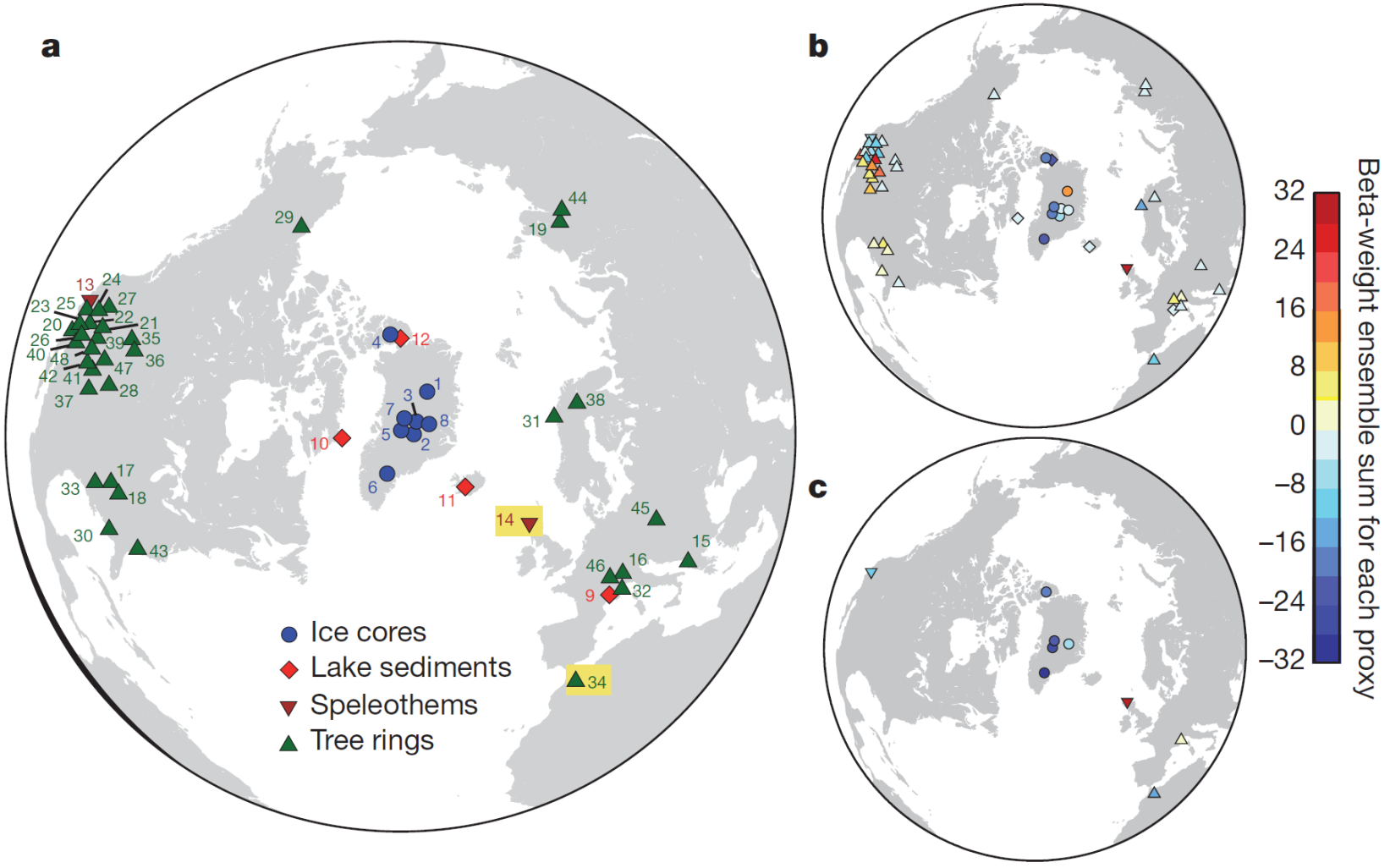
Can we do better than Trouet et al?

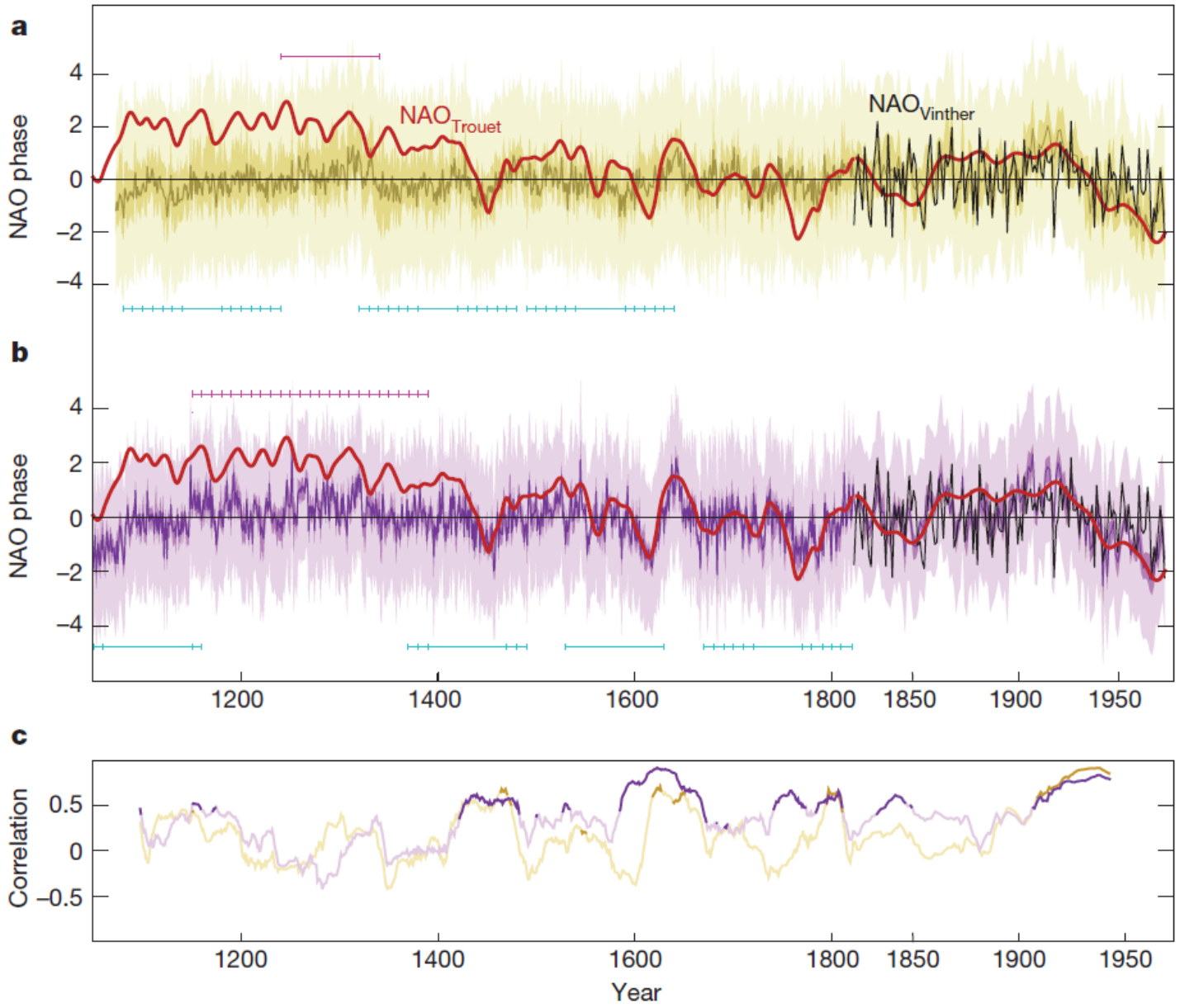


Ortega et al. (2013)

New NAO reconstruction

NAO_{cc}

NAO_{mc}

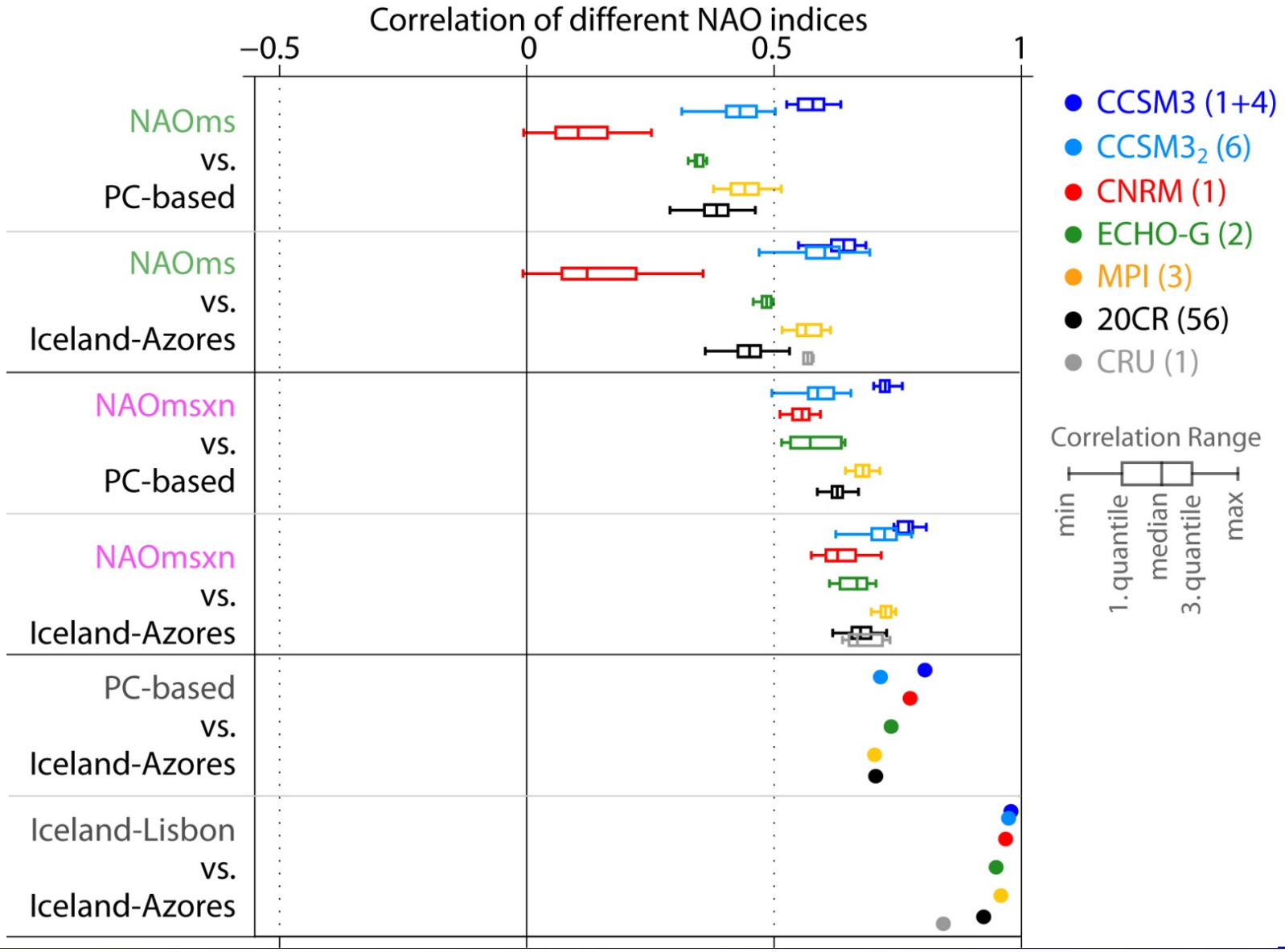


Correlation

50yr running window

Ortega et al. (2013)

Is the new NAO index useful?



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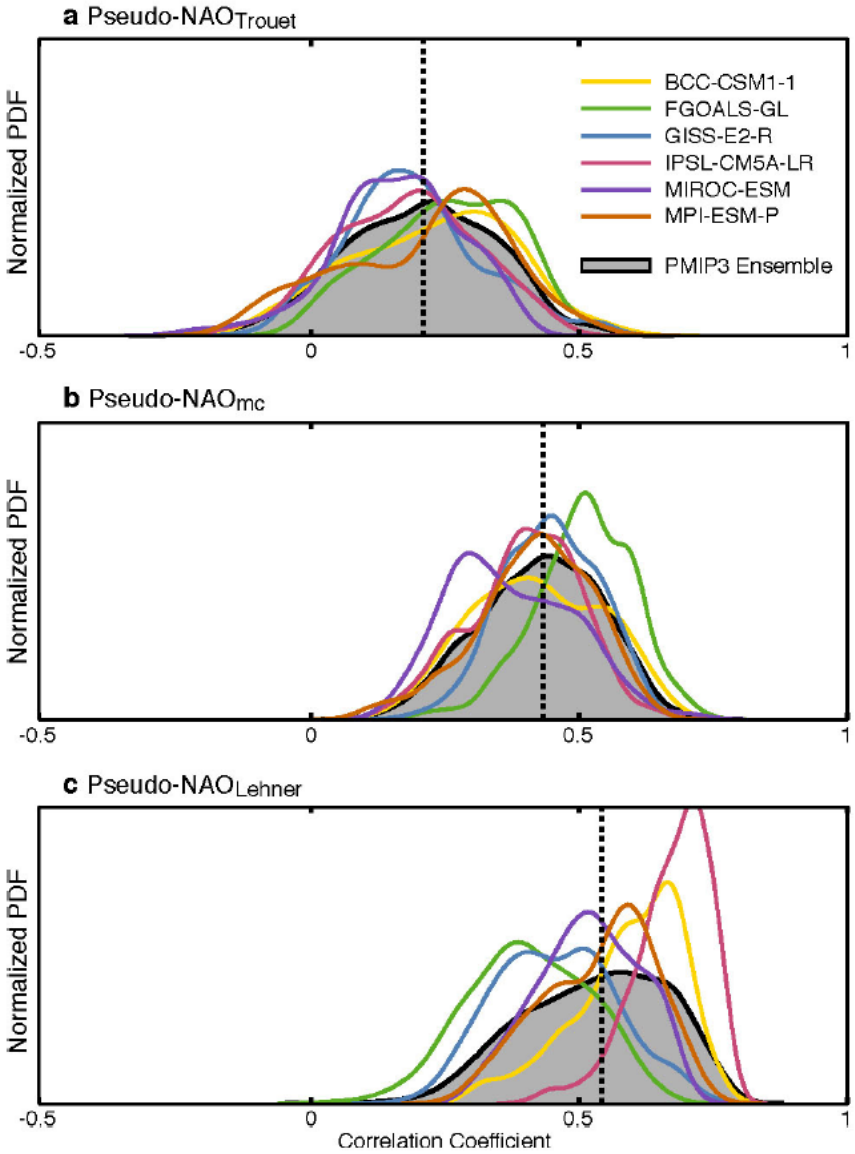

Ortega et al. (2013)

Conclusions III

- The multi-proxy approach delivers a better constraint NAO reconstruction than just using 2 proxy records
- Models may help in the selection of appropriate proxy records (additional model constraint)
- A prolonged positive phase of the NAO during the MCA is not found in the new reconstruction

➢ There is still room for improvement!

Take-home message

Models are useful tools to

- Identify important processes
- Help in the interpretation of proxy reconstruction
- Test reconstructions methods
- Assess climate variability (forced and unforced component)
- ….