Simulating climate variability over the last millennium at Climate and Environmental Physics, Bern

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Experiments with CCSM3 or CESM1.0

- **Control simulations** (500-1000yrs)
  - 1990 AD
  - 1500 AD
  - 1000 AD
  - 850 AD with C-cycle

- **Transient simulations**
  - 4 x 1500-2100 AD
  - 5 x 1000-1500 AD
  - 1 x 1000-2100 AD
  - 6 x 1150-1450 AD
  - 1 x 850 -2100 AD (in progress) with C-cycle

**GHG+Solar (Crowley scaled with Lean)**

**Volcanoes (Crowley)**
Examples of research activity

Teleconnection and modes of variability

Southern Hemisphere climate variability

Freshwater budgets

Interpretation of proxy data
Example 1:

Testing NAO reconstructions

Lehner et al, submitted
Example: testing NAO reconstructions

How well can we reconstruct NAO from proxies?

- Trouet et al, 2009: NAO reconstruction based on proxy records from Scotland and Morocco

- Reconstruct NAO from model results using a range of models, reanalysis data and methods

- (Model-based) NAO-indices to be compared:
  - PC-EOF analysis; Iceland-Azore pressure difference
  - Precip at two stations: Morocco-Scotland (Trouet et al)
  - Precip at four stations
Composite of NAO+ in ERA-40 data

Precipitation (color) and pressure (lines) for NAO+ state

Classical station to determine NAO (Island-Azores-Portugal)

Location of reconstruction by Trouet (Scotland-Marocco)
NAO reconstructed from two proxy locations

Example 1

Trouet et al. (2009)
Correlation between «two location-index» and PC-EOF index or Iceland-Azores index as sampled in a range of models and reanalysis data is only around 0.5
Adding more proxy locations

+ Scandinavia
+ Portugal
Adding more proxy locations helps

Two locations

Four locations
Problem from precipitation anomalies

**NAO (PC-EOF)**

**NAO_ms**
Problem from precipitation anomalies

NAO (PC-EOF)

NAO+ pressure field:
but, no precip. anomaly in Marocco and dry instead of wet anomaly in Scotland

Lehner et al. (submitted)
Concluding remarks

Examples:

- NAO reconstruction based on two proxy locations is not very robust
- Improvements require additional proxy locations
- But, problem remain as precipitation proxies is not pressure field
Example 2:

NAO and biogeochemical cycles

Keller et al, in prep.
NAO affects Biogeochemical Cycles

Composite anomaly patterns of DIC for positive/negative NAO (DJF)
NAO affects Biogeochemical Cycles

Composite pattern for positive/negative NAO (DJF) for six models and DIC and phosphate
Mechanisms for positive phase

**Physics**
- NAO+
  - Wind stress
  - Gyre circulation
  - Upwelling
  - Mixed layer depth
  - Entrainment

**Biogeochemistry**
- DIC
- Phosphate
- pH
- OmegaA
- pCO₂
- Air-sea CO₂ flux
- Export production

Subpolar gyre
Subtropical gyre

Conclusion
Concluding remarks

• NAO causes substantial variability in biogeochemistry
• Response in the model is driven by local changes in wind stress – upwelling – nutrient entrainment
• Large scale horizontal transport appears to play little role for NAO associated anomalies

Outlook:

• CESM simulation from 850-2100 AD; all components in ~1° x 1° resolution and interactive carbon cycle
Thank you
Example 1: polar regions, temperature

Bekrayaev et al. (2010)  Lehner et al. (2011)
Example 1: polar regions, freshwater

Arctic Basin Freshwater Budget
(units: km$^3$)

Serreze et al. (2006) Lehner et al. (2011)
Example 1: polar regions, freshwater

Lehner et al. (2011)
Example 1: polar regions, freshwater

Lehner et al. (2011)