NAO index values estimated from earth orientation functions

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Outline

• Motivation
• Technique
• Results
• Significance testing and Skill
• Conclusion
Motivation:

Calculate climate index from earth orientation functions
=> independent of climate model

Test case: rebuild well-known climate index from geophysical excitation functions
  => North Atlantic Oscillation (NAO) index
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Geodätische Woche 2011  Nürnberg, Germany 27-29 September 2011

Pressure pattern over North Atlantic
Icelandic low / Azore high

Effects:
- Pressure
- Wind
- Sea surface temperatures
- Storm track
- Precipitation
- Oceanic transport

NAO influences all „subsystems“
relevant for AAMs / OAMs!
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NAO influence on integrated, one-dimensional polar motion excitation functions?

=> Use climate model to separate NAO influence

Model and Data used:
• Coupled Atmosphere/Ocean model ECHAM5/OM1
• 20th century run (IPCC AR4 – 20C_3 run)
• 1901-1999 („model years“)
• winter (DJF) mean only => annual data
• PC-based annual NAO index calculated via RPCA technique (rotated EOFs at 500 hPa)
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Determine NAO influence on polar motion excitation

Calculate partial $\chi$ functions from NAO - correlated points

$\Rightarrow \ " \chi_{\text{NAO}}\ "$

Identify common "key bands" where $\chi_{\text{NAO}}$ coheres with full, global $\chi$

Build NAO Index using key bands from full, global $\chi$ functions
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Icelandic low

NAO correlation with Chi2 AAM mass function

NAO pattern clearly visible

AAM pressure not meaningful over ocean for non-pressure-forced ocean model

Use only contributions from areas with cor > 0.25 (> 0.4 for AAM mass)
– highly significant > 99.99 and in accordance with known physical effects

Sum up to form partial, NAO-correlated excitation functions
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   $\Rightarrow \chi_{NAO}$
3. Identify common "key bands" where $\chi_{NAO}$ coheres with full, global $\chi$
4. Build NAO Index using key bands from full, global $\chi$ functions
Fourier coherence between AAM / OAM mass and motion contribution and full, globally integrated Chi functions.

Significance threshold determined through bootstrap with $10^4$ white noise time series.
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Build NAO Index using key bands from full, global $\chi$ functions
Extract relevant frequencies from \( \text{Chi1}, \text{Chi2} \) (Butterworth filter)
Generalized Linear regression Model (GLM) with AIC minimization, using the atmospheric NAO index from the model

Significance and Skill:
=> rule out filter effects by testing against \(10^4\) white noise time series
=> do not use whole set earth orientation data to estimate NAO index
=> instead, use only 30 years for calibration and estimate the rest
=> shift 30-year period by one year and calculate correlation and skill scores
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Shown: best of all possible regressions using 30% of the data available
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NAO index: PC-based

Correlation 0.77

Shown: best of all possible regressions using 30% of the data

ERA Interim/OMCT: Atmospheric vs. geophysical NAO index
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Shown: best of all possible regressions using 30 % of the data available

Correlation 0.68
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Significance testing:

Skill scores:

- PC (Percent correct)
- POD (hit rate)
- Heidke Skill score
- Correlation

Tested for
- different calibration lengths
- different data periods
- calibration period only
- forecast period only
- whole TS

Skill scores and correlation for IERS C01 1906-2000
Significance testing:

Skill scores show decreasing values for certain periods

=> independent of data quality
⇒ GCM model data shows similar structures
⇒ possible connection with PNA (Pacific North American Pattern)

Skill scores and correlation for IERS C01 1906-2000
Conclusions

- Index calculation from geophysical $\chi$ functions possible in coupled model ECHAM5/OM1

- very good results for ERAInterim/OMCT model and for observations (IERS C01)
  - correlations $> 0.7$ (99.99 significance level)
  - hit rates $> 0.8$
  - also for early data periods

- NAO signal in earth orientation functions is disturbed at certain periods, possibly by strongly negative PNA signals

$=>$ Combined NAO-PNA index ?
Thank you for your attention!