Are observed/modelled ENSO teleconnections robust?

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KNMI, De Bilt
ENSO = El Niño – Southern Oscillation

Source: NOAA
NINO-3 and SO indices
Correlation and Regression

Time series \( a(t) \) and \( b(t) \)

Covariance \( \sigma_{ab} = \langle a(t) \ b(t) \rangle \)

Variance \( \sigma_{aa} = \sigma_a^2 \)

Correlation \( \text{corr}(a,b) = \frac{\sigma_{ab}}{\sigma_a \sigma_b} \)

symmetric, independent of amplitude

Regression \( \text{regr}(a,b) = \frac{\sigma_{ab}}{\sigma_a^2} \)

unsymmetric, “change of \( b \) per unit change of \( a \)”
ERA-40
NINO3.4
Z_{500}
January
teleconnection robust
= teleconnection stationary
= correlation stationary
Concept - 1

\( p(t) \) – signal, \( N_{34}(t) \) – NINO\(_{3.4}\) index

\[ r = \text{regr}(N_{34}, p), \quad c = \text{corr}(N_{34}, p) \]

\[ p = r \cdot N_{34} + [p - r \cdot N_{34}] \]

\[ = r \cdot N_{34} + \sigma_p \sqrt{(1-c^2)} \cdot \eta \]

\[ \text{corr}(N_{34}, \eta) = 0, \quad <\eta> = 0, \quad \sigma_\eta = 1 \]
Concept - II

\[ p = r N_{34} + \sigma_p \sqrt{1-c^2} \, \eta \]

draw \( \eta \in N(0,1) \Rightarrow \) synthetic series \( p_s \)
moving correlation: \( c(t) = corr(N_{34}, p_s)(t) \)
simulate PDF of \( \Delta c = c_{\text{max}} - c_{\text{min}} \)

Is observed \( \Delta c \) within PDF ?
Datasets

• **obs**: HadSLP1
• **reanalysis**: ERA-40
• **AGCM**: SPEEDY (20-member ensemble)
• **CGCM**: Challenge (62-member ensemble)
• **CGCM**: ECHAM5/MPI-OM (CONTROL + A2)
Area(signif > 0.9) = $A_{\text{sig}} = 9.2\%$
ERA-40 SLP - jan

$A_{\text{sig}} = 8.3\%$
Significance of changes in strength of ENSO-SLP teleconnections

SPEEDY
(Dis-)continuity in time
Obs:
- small $A_{\text{sig}}$

Speedy:
- large differences between members
- small $A_{\text{sig}}$ for whole ensemble
- no month-to-month consistency

=> No change; teleconnection stationary
### Challenge ensemble - I

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</tr>
</tbody>
</table>

Table 4: $A_{\text{sig}}$ for $z_{500}$ in the CCSM 1.4-ensemble. Statistically significant values ($> 18.5\%$, see Table 1) are in boldface.
Challenge ensemble - II

$A_{\text{sig}}$ large, but ... larger for historical period than for future large differences between runs no month-to-month consistency

$\Rightarrow$ no conclusive evidence
ECHAM5/MPI-OM ensemble
ECHAM5/MPI-OM ensemble

large $A_{\text{sig}}$ values for SLP
small values for $z_{500}$
month-to-month consistency
largest changes over 21st century
differences between members

$\Rightarrow$ changes in ENSO teleconnections possible
Conclusions

• obs: no change

• Speedy: no change
  (no consistency between month & members)

• Challenge: questionable

• ECHAM5: possible

• better diagnostics needed