Impact of the Equatorial Atlantic Cold Tongue Mode on the atmospheric circulation over the North Atlantic

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Equatorial cold tongue anomalies can excite the East Atlantic pattern in boreal winter. The mechanism is investigated in the SPEEDO CGCM. In wintertime, a circumglobal Rossby wave response provides a link from equatorial SST anomalies to the North Atlantic circulation.

1. SPEEDO

- Atmosphere: Speedy AGCM T30, 7 layers, simplified parameterizations
- Atlantic Ocean: (40S-50N) MICOM OGCM, 22 layers, 1 degree resolution.
  Elsewhere: climatological prescribed SST.

2. Atlantic cold tongue mode

The coupled SPEEDO model gives a realistic simulation of the cold tongue mode (Fig. A). The amplitude of this mode is largest during late boreal summer.

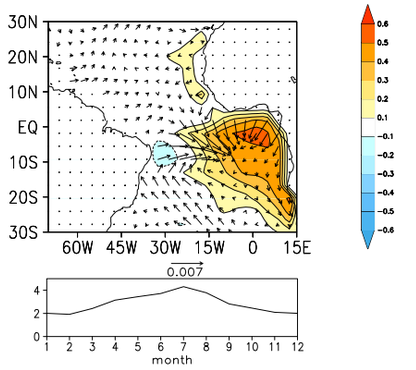

Figure A. *Regression of the principle component (PC) of the cold tongue mode onto SST[K] and wind stress [N/m^2](top). The patterns are normalized to one standard deviation of the PC. Annual variation of the variance of the PC (bottom).*

3. Lagged co-variability

SPEEDO shows a lagged co-variability between the cold tongue in late summer and the East Atlantic pattern in early winter which is similar to observed (Figure B).

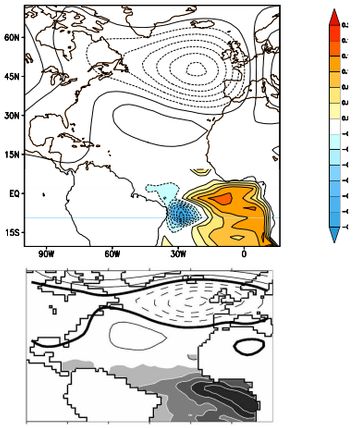

Figure B. *Lagged MCA analysis of SST (JAS) and Z500 (OND) for a 80-yr coupled SPEEDO run (top) and for the NCEP/NCAR reanalysis (bottom; from Frankignoul and Kestenare 2005).*

The lagged co-variability is caused by to the persistence of the cold tongue anomaly and the southward movement of the ITCZ which enhances the the atmospheric response in NDJ (Figure C).

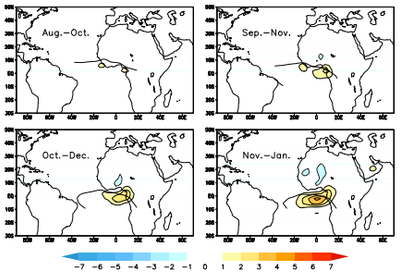

Figure C. *Response in boreal fall of the 200 hPa divergence [$10^{-6}s^{-1}$] to a 2σ anomaly of the cold-tongue mode in a 100-yr atmospheric Speedy run. The solid line is the position of the ITCZ.*

4. Rossby Wave propagation

The Rossby wave response is circumglobal. It is trapped in the South Asian subtropical jet and propagates circumglobal before it reaches the North Atlantic (Figs. D and Fig. E). The circumglobal response is also visible in the ERA40 re-analysis. (Fig. F)

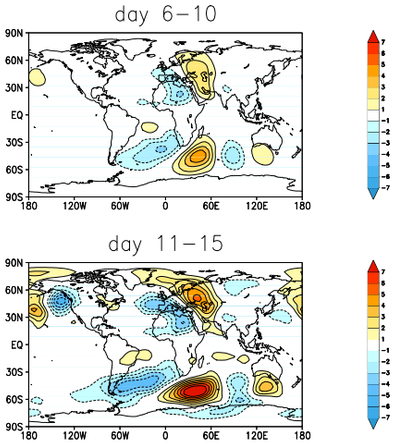

Figure D. *Development of the response in Z500 [m], determined from a 200-member ensemble of 30 day atmospheric runs forced by a cold tongue SST anomaly.*

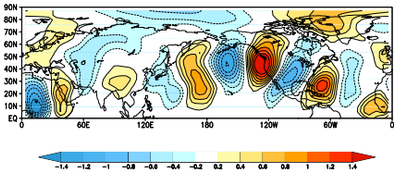

Figure E. *Ensemble mean response of V at 300 hPa averaged over the period 16-30 days*

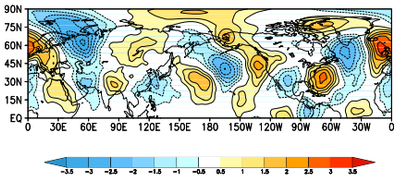

Figure F. *Regression of the ATL3 index with the ERA40 300hPa V wind for the period NDJ*

The response over the North Atlantic is enhanced by transient-eddy feedbacks (Fig. G).

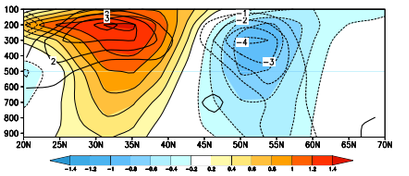

Figure G. *Anomalous $\overline{u}$ (colors) and $-Td\,\overline{u'v'}/dy$ (contours) in m/s for T=2weeks, zonally averaged over the North Atlantic (50W-25E, 20S-70N).*

5. Conclusion

- **Persistent equatorial Atlantic cold tongue anomalies last from JAS to OND**
- **SST anomaly generates Rossby wave response when the ITCZ is over the equator**
- **Rossby wave response circumglobal**
- **Response East Atlantic pattern amplified by non-linear effects**

References

Haarsma, R.J. and W. Hazeleger, Extra-tropical atmospheric response to equatorial Atlantic cold tongue anomalies, submitted.

Frankignoul, C. and E. Kestenare 2005: Observed Atlantic SST anomaly impact on the NAO: An update. J. Climate, 18, 4089-4094.

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