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Low-frequency climate variability in the Atlantic basin during the 20th century

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Low-Frequency Climate Variability in the Atlantic Basin during the 20th Century

Y. M. Tourre, S. Paz, Y. Kushnir, W. White
MTS/SVD
DATA & METHOD

Monthly SST and SLP gridded datasets (Kaplan et al 1998, 2000) for the Atlantic basin north of 30°S and for the 20th century.

MTM/SVD analysis developed by Mann and Park (1999) which analyses the coherent spatial patterns in the frequency domain, in narrow spectral bands, after the application of an MTM spectral analysis.
Tourre, Y. M., B. Rajagopolan and Y. Kushnir 1999: Dominant Climate Signals in the Atlantic Ocean during the last 136 Years. J. Climate, 8, 2285-2299.
Atlantic Ocean: Multidecadal Variability or AMO

See also: Delworth & Mann (2000)
NAO Modulation
&
SST
North Atlantic
Tripole Structure
&
Equatorial
Dipole Structure

Tourre, Y. M., B.Rajagopalan and Y.Kushnir 1999: Dominant Climate Signals in the Atlantic Ocean during the last 136 Years. J. Climate, 8, 2285-2299.
Spatio-Temporal Evolutions of AMO & QDO

Multi-decadal Signal (40-60 Years)  Quasi-Decadal Signal (8-12 Years)
POTENTIAL PHYSICAL MECHANISMS

AMO

• Oceanic signal memory: Heat content
• ‘Doming effect’ in the anticyclonic gyre
• THC & Subpolar wind stress & Oceanic convective activity
• Meridional heat flux & Meridional Overturning Circulation
• Negative feedback onto the atmosphere & modulated NAO

QDO

• Air-sea interaction fluxes & north Atlantic SST tripole pattern
• Slow oceanic advection & non-stationary tropical SST dipole
• Anomalous SLP gradients & westerlies/north easterlies & modulated NAO
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<td>AMM</td>
<td>Atlantic Meridional Mole</td>
<td>Chiang and Vimont 2004</td>
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<td>AMO</td>
<td>Atlantic Multi-decadal Oscillation</td>
<td>Kerr 2000; Enfield et al 2001; Knight et al 2005</td>
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<td>Atlantic Thermohaline Circulation</td>
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<td>Tropical Northern Atlantic Index</td>
<td>Rajagopalan et al 1998; Tourre et al 1999; Enfield et al 2001</td>
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<td>Tropical Southern Atlantic Index</td>
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<td>TNA-TSA</td>
<td>SST difference between the tropical North and South Atlantic</td>
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AMO and QDO during the 20th Century

TNA-TSA = QDO proxy

Sahelian rainfall (2nd Varimax Mode)

Similarity between AMO & TNA Low-Frequency Variability
Induced Similarity between TNA-TSA (QDO proxy) & ITCZ Latitudinal Variability
JAS AMM (SST, blue) & AMO (red)

\[ r = 0.72 \]

SST Atlantic Meridional Mode (AMM) as THC proxy & AMO

Sahelian drought
Wind Atlantic Meridional Mode (AMM) and Sahelian Rainfall

Potential Linkages between AMM/Wind and ITCZ Low-Frequency Variability
Conclusions

• Combining our results with that from other scientists & from proxy and modelling studies, AMO and QDO are two robust low-frequency ‘natural’ climate signals in the Atlantic Basin

• Both signals associated with the NAO

• Both signals associated with changes in Sahel rainfall

• Both signals are associated with long-term changes in Atlantic Hurricane intensity
Ratio of Variance

Forced/Total variability in IPCC AR4 models (CMIP5 runs). Results are based on 6 model ensemble with # members ≥ 4.

Ting et al (in press)
AMV and Global Warming

1. Annual SST anom. averaged over the N. Atl. in observations (solid black) and 6 CGCMs ensembles. Dashed line is the multi-model average.

2. Solid line is the same as above. Colored lines are the projections of N. Atl. SST on each model’s S/N maximizing PCs of global surface air temperatures (the externally forced signal).

Ting et al (in press)
Pattern of AMV

1. Time series of annual mean SST averaged over the N. Atl. minus the externally forced signal estimated using S/N maximizing PC analysis (each color represents a different model estimate of the forced signal).

2. The projection of annual mean surface air temperature on the time series in (1).

Ting et al (in press)
1. Time series of annual mean SST averaged over the N. Atl. minus the externally forced signal estimated using S/N maximizing PC analysis (each color represents a different model estimate of the forced signal).

2. The projection of annual mean surface air temperature on the time series in (1).

Colored areas are statistically significant at the 5% level