Amplitude-frequency characteristics of Atlantic Equatorial Mode variations from long-term observations

Mokhov I.I.[1,2], Medvedev N.N.[2]

[1]A.M. Obukhov Institute of Atmospheric Physics RAS

[2]Lomonosov Moscow State University

mokhov@ifaran.ru

In the Atlantic basin, the Atlantic Equatorial Mode (AEM) is manifested as an analogue of ENSO, which is formed in the Pacific basin [1–4]. We present here results of the analysis of the amplitude-frequency characteristics of the AEM variability detected by variations in the ocean surface temperature in the Atlantic 3 region (20W-0, 3S-3N) [1] (see also [2, 3]). The analysis used monthly means of the AEM index from January 1870 to December 2022 (https://www.metoffice.gov.uk/hadobs/hadisst/data/HadISST_sst.nc.gz).

Wavelet analysis [5] was used to describe the features of AEM variations. Changes in the characteristic periods (P) and amplitudes (A) of the AEM were also estimated using the method proposed in [6] (see also [7,8]). In particular, the AEM characteristic periods and amplitudes were estimated at different moving averages of the data (I_s) and for different moving time intervals (I_0).

Figure 1 shows local and integral wavelet spectra for AEM index variations in 1870-2022. There are three ranges of intradecadal and interdecadal AEM variations. On the integral spectrum, the most significant variations of the AEM index are distinguished with periods ranging from 2 to 7 years and with a maximum of about 12-13 years. There are also statistically less significant variations with a maximum around 25 years.

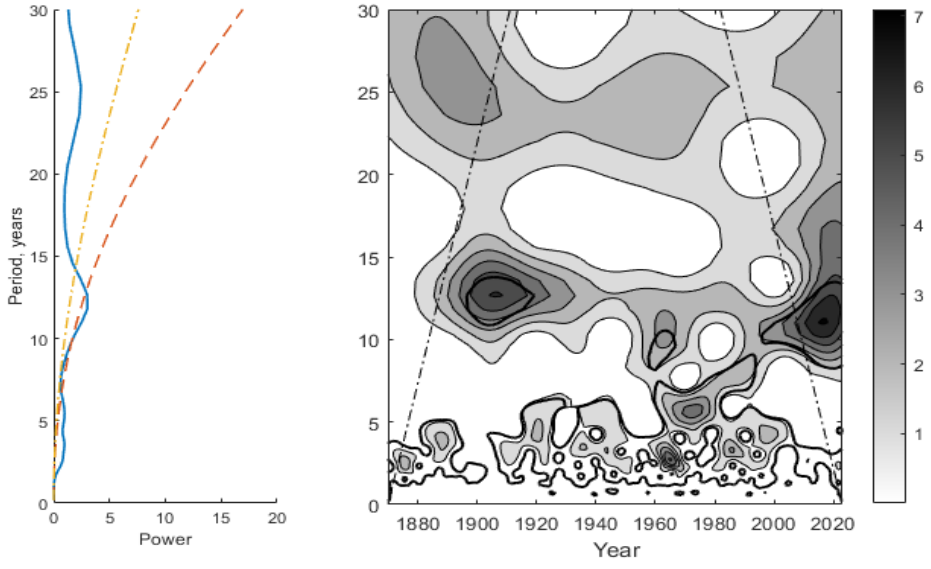

Fig. 1. Integral (left) and local (right) wavelet spectra for AEM index by the data for 1870-2022. In the integral spectrum, the dashed lines show the 95% quantile of power for a red noise model and the dotted and dashed lines indicate its mean value. The dotted and dashed lines in local spectrum separate regions of edge effects, and the thick lines bound regions where the signal power is greater than expected for a “stationary red noise model” at the significance level $p = 0.05$.

Local spectral features (Fig. 1), along with three ranges of AEM variations noted in the integral spectrum, reveal significant variations with periods from 2 to 10 years in the second half of the 20th century. Also, since the beginning of the 21st century an increase in decadal and longer-term AEM variations is revealed.

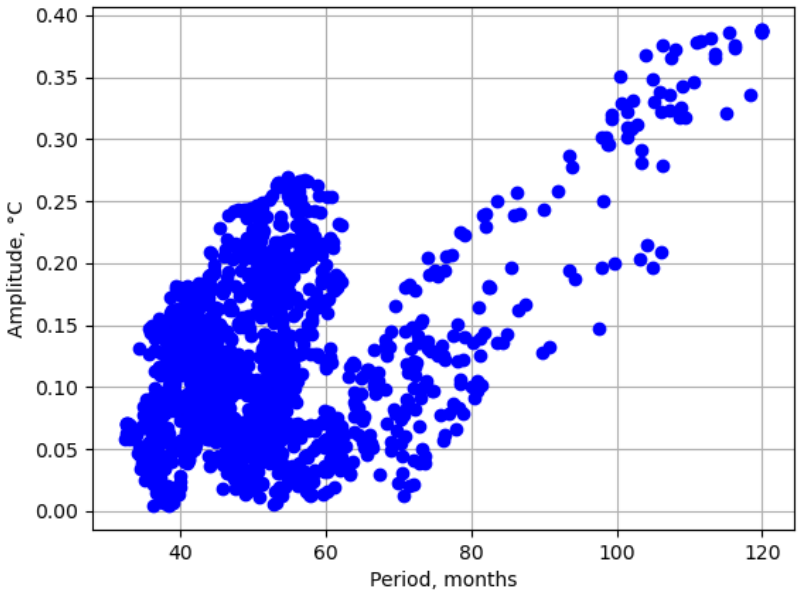

Fig. 2. Dependence of amplitudes on periods of the AEM index variations by the data for 1870–2022 at I_s = 24 months and I_0 = 120 months.

According to Fig. 2, two branches of the A-P dependence for AEM appear - for variations with *P* from 3 to 5 years and for variations with *P* more than 5 years. Different A-P dependences in Fig. 2 correspond to two ranges of periods of the AEM intradecadal and decadal variations noted in Fig. 1.

References

1. Zebiak S.E. Air-sea interaction in the equatorial Atlantic region. *J. Clim.*, 1993, **6**, 1567–1586.
2. Keenlyside N.S., Latif M. Understanding equatorial Atlantic interannual variability. *J. Clim.*, 2007, **20**, 131-142.
3. Mokhov I.I., Bezverkhny V.A., Karpenko A.A., Keenlyside N.S., Kozlenko S.S. Cross-wavelet analysis of coherence and time lags between El Nino and Atlantic equatorial mode. *Research Activities in Atmospheric and Oceanic Modelling*, J. Cote (ed.). WMO TD-No.1397, 2007, 2, 19-20.
4. Kozlenko S.S., Mokhov I.I., Smirnov D.A. Analysis of the cause and effect relationships between El Niño in the Pacific and its analog in the equatorial Atlantic. *Izv., Atmos. Oceanic Phys.*, 2009, **45** (6), 704–713.
5. Jevrejeva S., Moore J., Grinsted A. Influence of the Arctic Oscillation and El Niño-Southern Oscillation (ENSO) on ice conditions in the Baltic Sea: The wavelet approach. *J. Geophys. Res.*, 2003, **108** (D21), 4677, doi:10.1029/2003JD003417.
6. Mokhov I.I. Climate changes: Analyses of global cycles. *Ann. Geophys.* 1993, **12** (Suppl. II), C334.
7. Mokhov I.I., Medvedev N.N. Changes of the El Niño quasi-cyclic dynamics from the analysis of phase portraits. *Research Activities in Earth System Modelling*, E. Astakhova (ed.), 2021, Rep. 51, 2, 13-14.
8. Mokhov I.I., Medvedev N.N. The amplitude–frequency features of different El Nino types and their changes in recent decades. *Moscow Univ. Phys. Bull.*, 2022, **77** (3), 542–548.