Intraseasonal Modulation of the Schumann Resonances by the MJO, CCEWs and EWs

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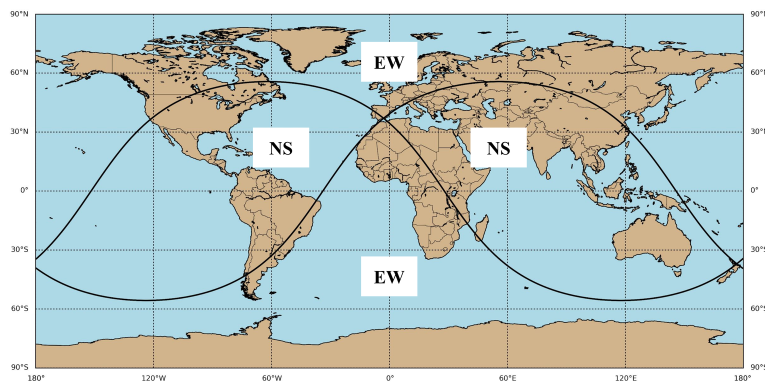
ABSTRACT

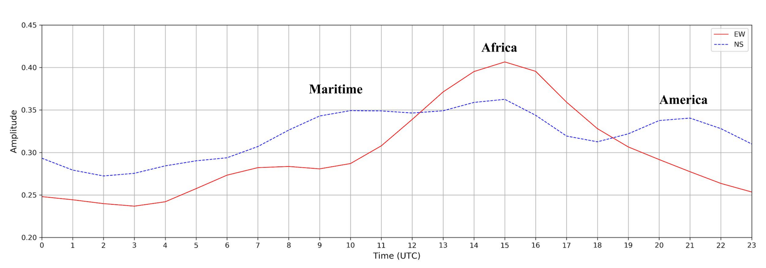
The Schumann resonances (SRs) are electromagnetic waves of zonal wavenumber one trapped in the cavity between the Earth and the Ionosphere and mainly caused by the excitation of terrestrial electromagnetic fields due to electric discharges that occur inside deep convective clouds. Füllekrug & Fraser-Smith (1996) found a periodicity of 20 to 30 days in SRs data that they associated with geomagnetic activity in the magnetosphere, and that could be related to the sunspot cycle. Anyamba, Williams, Susskind, Fraser-Smith, & Fullekrug (2000) explored the possibility of the influence of MJO in the modulation of SRs. However, works such as Beggan & Musur (2019) showed difficulty in detecting a relationship of MJO with SRs.

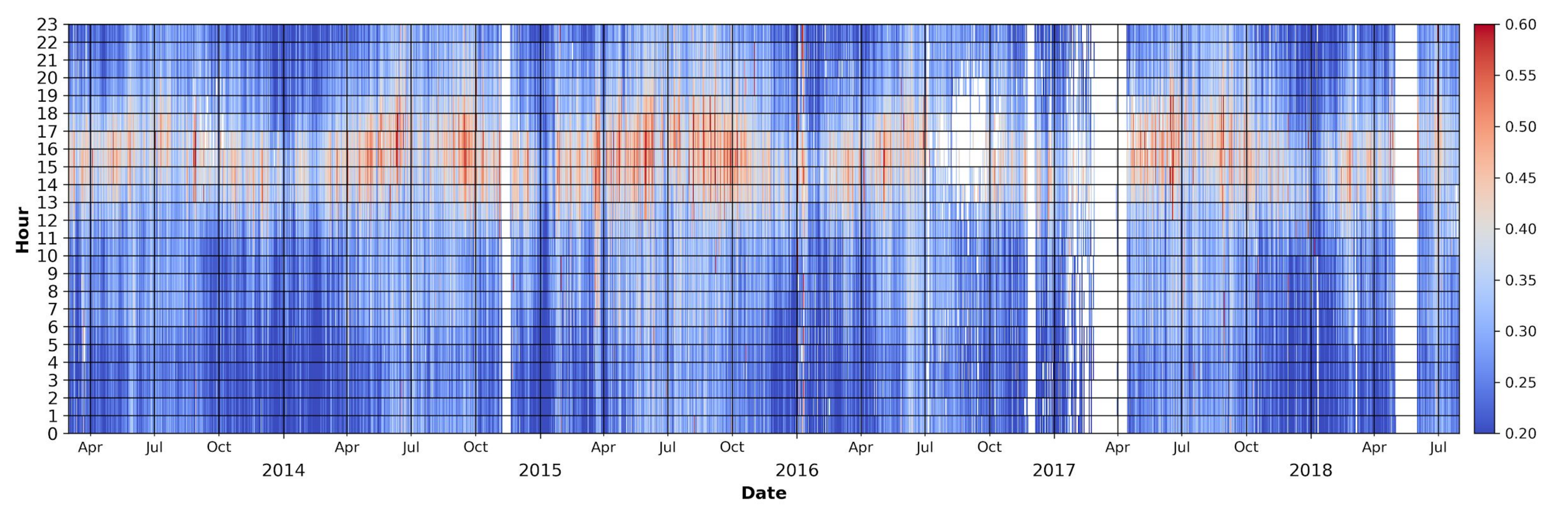
In the present study, we analyze data from the Sierra Nevada Extremely Low-Frequency Station in Spain. We explore the hypothesis that, due to the relationship between deep convection and SRs, it is expected that atmospheric phenomena associated with intra-seasonal modulation of deep convection like the MJO have an inherent effect on the modulation of SR. We also explore the possibility of SRs modulation by other intra-seasonal modes like the Convectively Coupled Equatorial Waves (CCEWs) and the Easterly Waves (EWs).

DATA

We analyzed the amplitudes of the First Three modes of the SR measured from two antennas located in the heart of the Sierra Nevada Mountains, in Granada, Spain (37°02'N, 3°19'W). The antennas are directed horizontally along the north-south (NS) and east-west (EW) directions. This localization gives the possibility to separate out the lightning activity from different source regions by using NS and EW magnetic components independently at different UTC times during the day.



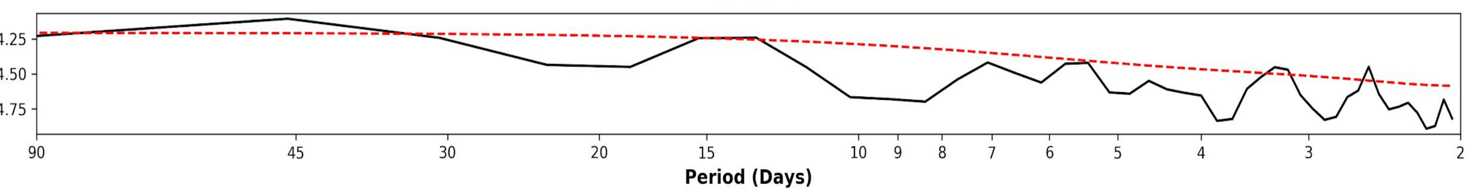




METHODS

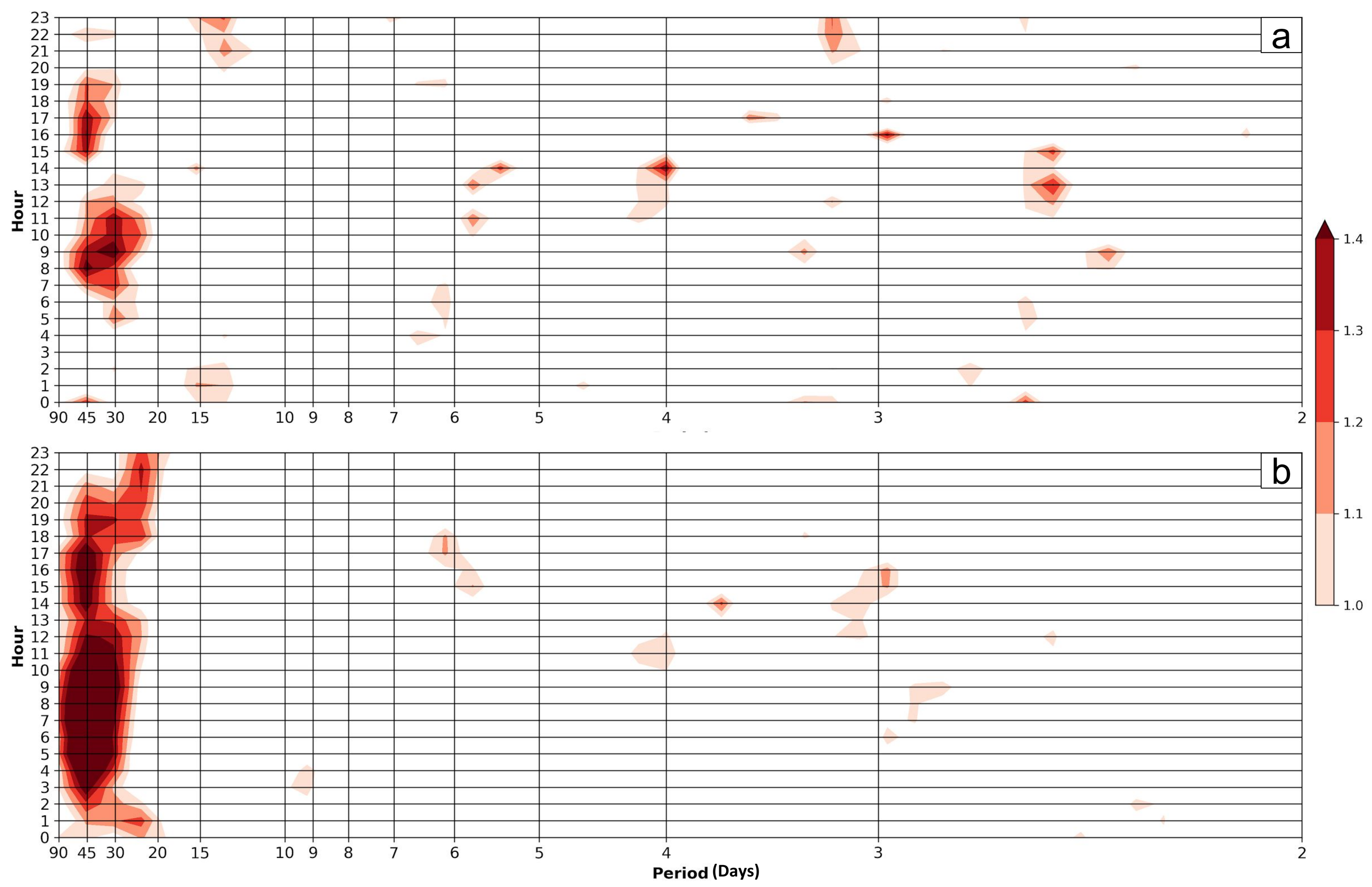
1. Windowed Fourier Transform and Estimated Background

We applied Spectral Analysis to each hourly time series in 96-day windows. We estimated a Red Noise background by smoothing the average power to remove any periodic signals and thus characterize random or nonperiodic processes only.



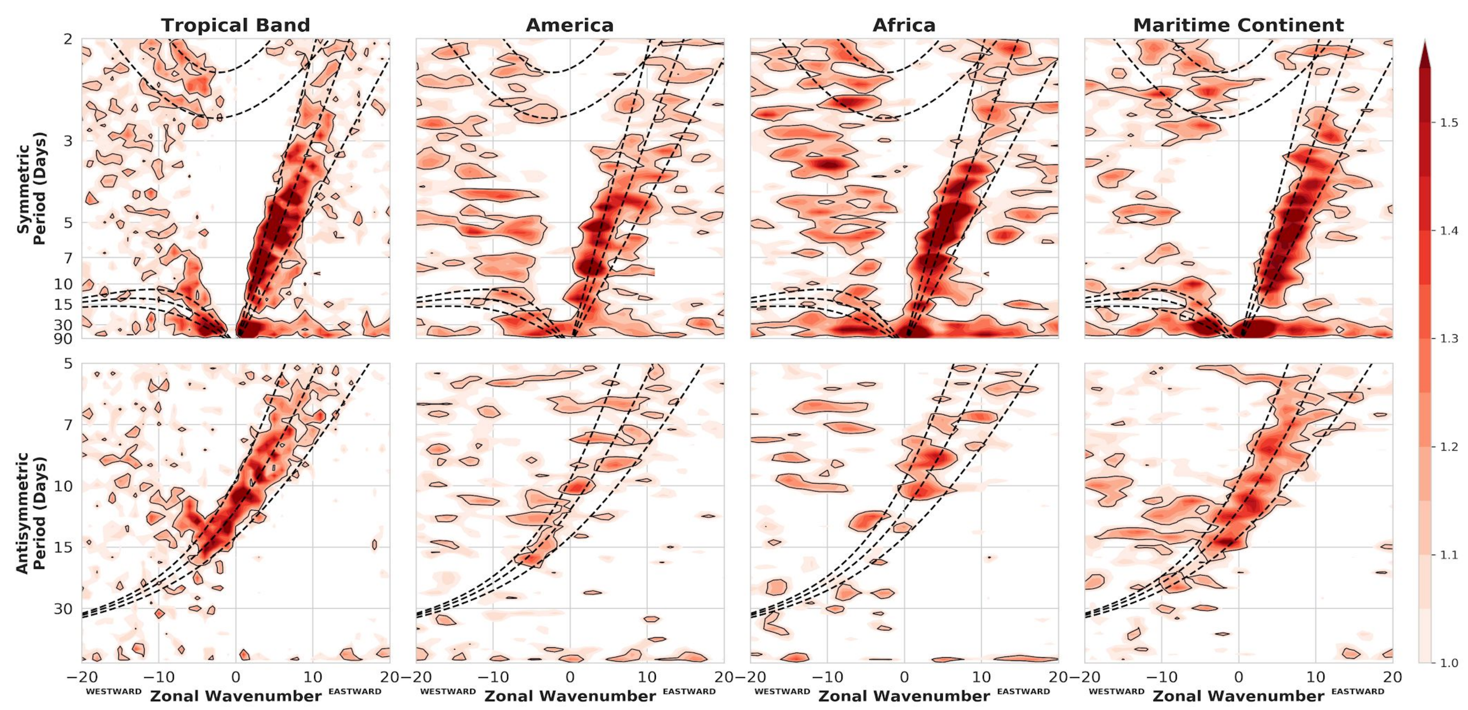
Average Spectral Power for an hourly series (black). Upper 95% confidence limit for the estimated red noise background (red).

2. Significant Spectral Peaks



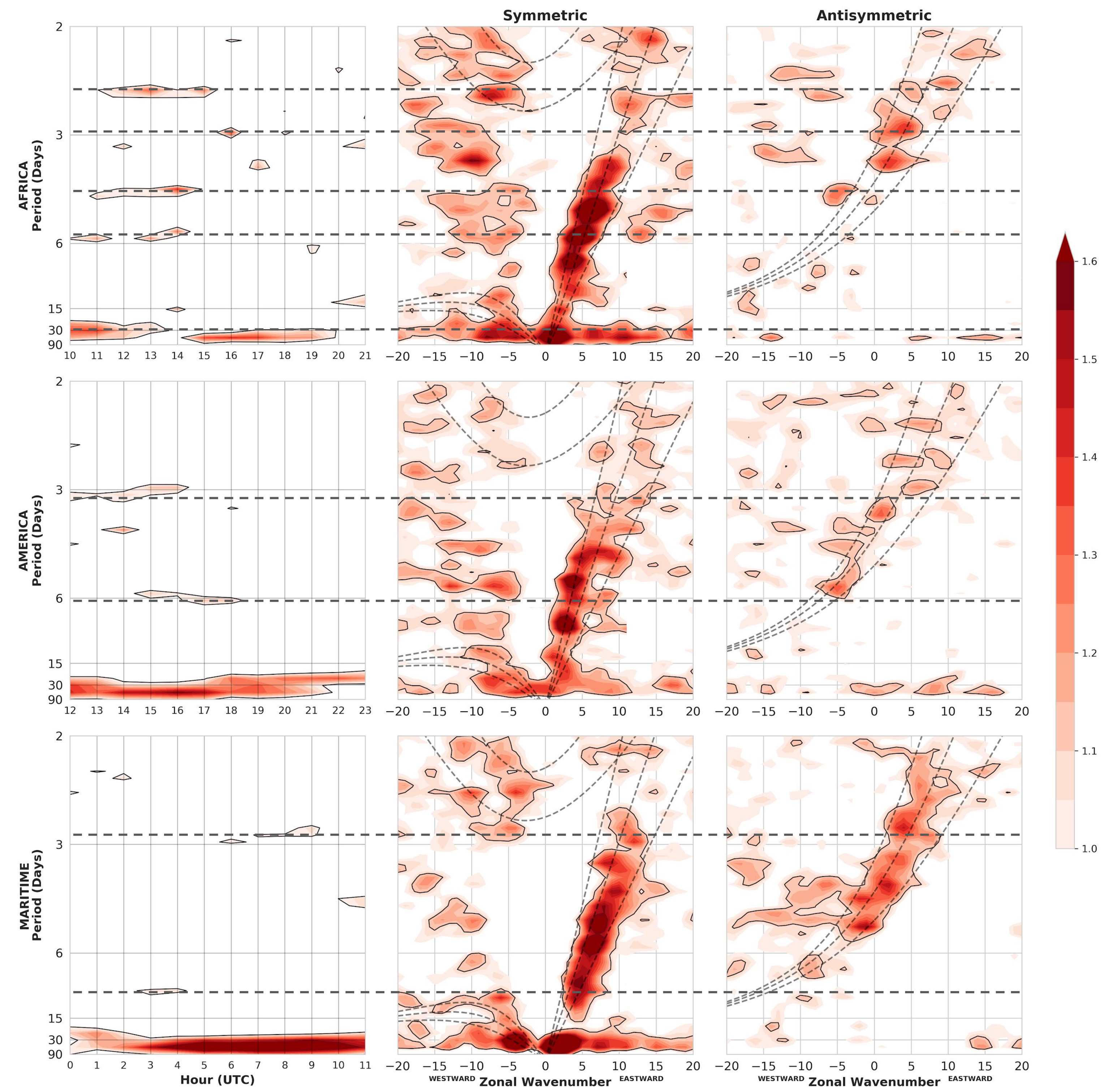
Ratio of the spectral power over the upper 95% confidence limit of the red noise background for each hourly time series, representing the significant spectral peaks (a) EW (b) NS.

3. Regional Wheeler-Kiladis Spectra



Wheeler-Kiladis spectra for the Symmetric and Antisymmetric components of NOAA-OLR, for the regions between 15°N-15°S in the Complete Tropical band, and for 100° longitude windows centered in America, Africa and the Maritime Continent.

RESULTS



Comparison of significant spectral peaks for the UTC regions related with lightning activity from Africa, America and the Maritime Continent with the corresponding Wheeler-Kiladis Spectra for each of the longitude windows.

CONCLUSIONS

- Intraseasonal variability of the amplitude of the first three modes of SR shows significant spectral peaks that can be related to spectral peaks in deep convection associated with the MJO, CCEWs, and EWs.
- While the spectral peaks related to the lightning activity over Africa show a large variety of possible tropical modes, America shows only peaks mainly related to EWs, Kelvin, and the MJO. On the other hand, the maritime Continent only shows a leading contribution from the MJO.
- This work shows that a relationship between deep convective tropical modes and the SR intraseasonal variability can be established.

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