# Is the Madden–Julian Oscillation reliably detectable in Schumann Resonances?


ASK ME!

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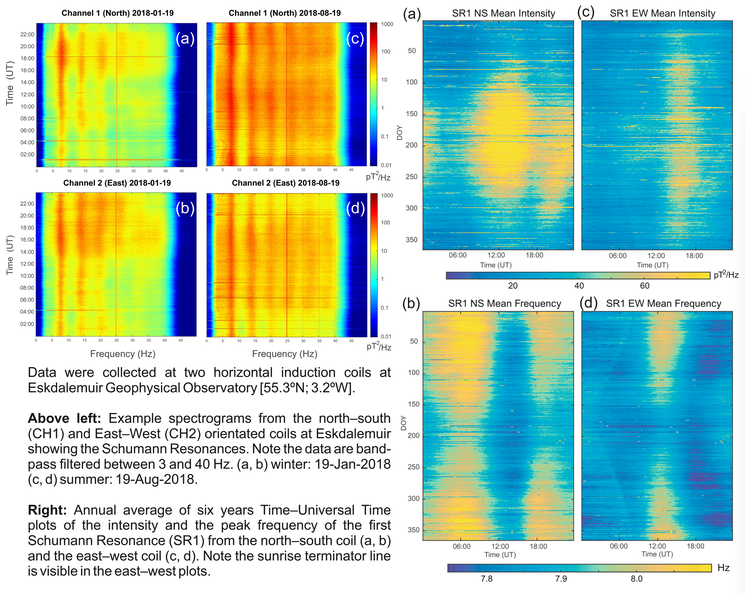
## 1. Induction Coil Data from the UK

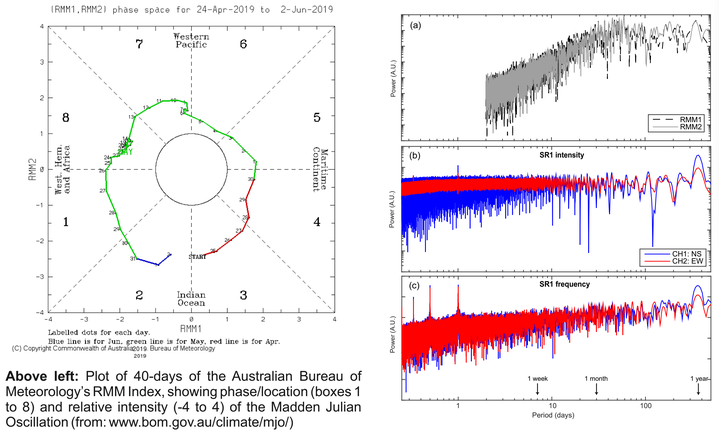



Data were collected at two horizontal induction coils at Eskdalemuir Geophysical Observatory [55.3°N; 3.2°W].

**Above left:** Example spectrograms from the north–south (CH1) and East–West (CH2) orientated coils at Eskdalemuir showing the Schumann Resonances. Note the data are band-pass filtered between 3 and 40 Hz. (a, b) winter: 19-Jan-2018 (c, d) summer: 19-Aug-2018.

**Right:** Annual average of six years Time–Universal Time plots of the intensity and the peak frequency of the first Schumann Resonance (SR1) from the north–south coil (a, b) and the east–west coil (c, d). Note the sunrise terminator line is visible in the east–west plots.

## 2. The Real-Time Multivariate MJO Index







**Above left:** Plot of 40-days of the Australian Bureau of Meteorology's RMM Index, showing phase/location (boxes 1 to 8) and relative intensity (-4 to 4) of the Madden Julian Oscillation (from: www.bom.gov.au/climate/mjo/)

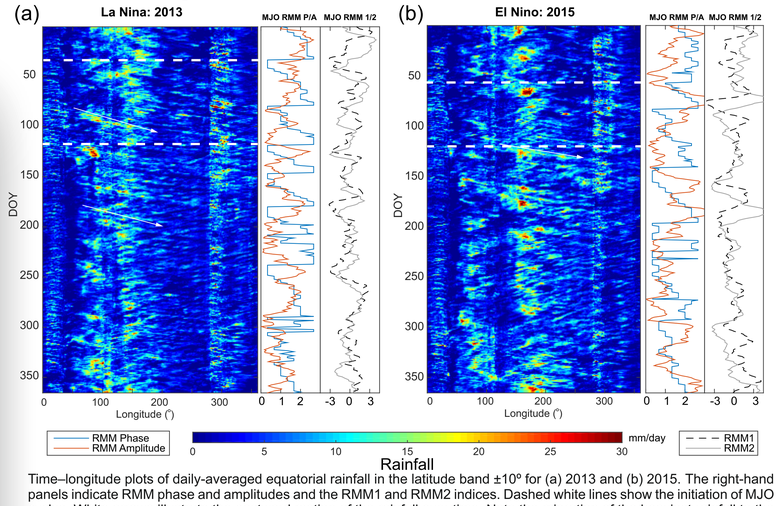
**Right:** Lomb–Scargle periodograms of six years of data from Sep 2012 to Sep 2018 for (a) the RMM indices, (b) the intensity variation and (c) the frequency variation of the first Schumann Resonances shown in the figure of Section 1. There is no obvious corresponding ~3 month peak in the (b) and (c) as compared to (a).

## Key Points

The Madden–Julian Oscillation (MJO) is a quasi-periodic (~30–90 days) eastward-moving atmospheric mode which primarily modifies rainfall patterns in the equatorial regions from Africa to the Pacific Ocean.

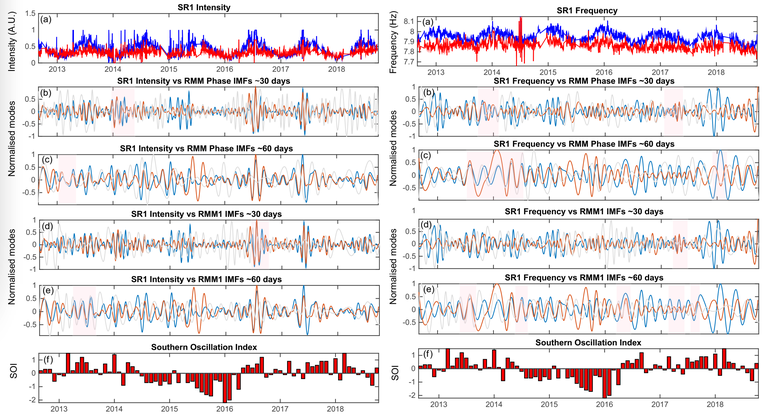
- It has been **proposed that its signature is detectable** within the intensity variations of the Schumann Resonances (SR) due to changes in the location and magnitude of the major lightning centres.
- Using **six years of induction coil data** recorded at the Eskdalemuir Observatory in the UK, we investigate whether the MJO is detectable in the first Schumann Resonance.
- We extract the **frequency and intensity** values from each resonance every 10 min, averaged to a daily value and compare them to the Realtime Multivariate MJO (RMM) index.
- We use **Empirical Mode Decomposition** (EMD) to determine if modes correlate between the SR and RMM.
- The relationship is **not wholly consistent**, implying that robust and reliable detection of the MJO in SR data remains challenging.

## 3. Equatorial Rainfall and the MJO




Time–longitude plots of daily-averaged equatorial rainfall in the latitude band ±10° for (a) 2013 and (b) 2015. The right-hand panels indicate RMM phase and amplitudes and the RMM1 and RMM2 indices. Dashed white lines show the initiation of MJO cycles. White arrows illustrate the eastward motion of the rainfall over time. Note the migration of the heaviest rainfall to the Pacific in El Niño years. Daily rainfall data are from the Global Precipitation Climatology Project (GPCP) at University of Maryland (http://eagle1.umd.edu/GPCP_ICDR/GPCP_Monthly.html)

## 4. Empirical Model Decomposition




Empirical Mode Decomposition (EMD) is a data-based technique for identifying non-stationary, quasi-periodic signals in time-series data. It produces a set of Intrinsic Mode Functions (IMFs) which contain signals for a particular frequency.

The figures show the comparison of the Intrinsic Mode Functions (IMF) from the decomposition of the first Schumann Resonance (SR1) intensity (**left**) and frequency (**right**) with the RMM phase time-series. (a) SR1 intensity/frequency in the north–south coil (blue) and east–west coil (red). (b, c) IMF curves for SR1 intensity/ frequency (blue, red) and RMM phase (grey). (d, e) IMF curves for SR1 intensity frequency (blue, red) and RMM1 (grey). (f) Southern Oscillation index; negative values indicate El Niño periods. Pink highlighted regions indicate times when the IMFs beat in-phase.

Highlighted regions are generally during La Niña periods which we suggest is when the SR are most responsive to the relative **change in the source–receiver distance** between Eskdalemuir and the motion of the main lightning centres.

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**References:**
Anyamba, E., at al. (2000). The manifestation of the Madden-Julian Oscillation in global deep convection and in the Schumann Resonance intensity. J. Atmos. Sci. 57, 1029–1044.
Beggan, C.D. and M. A. Musur (2019), Is the Madden–Julian Oscillation reliably detectable in Schumann Resonances?, J. Atmos. Solar-Terrestrial Phys.,190, 108-116