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An automatic method for detection and classification of Ionospheric Alfvén Resonances using signal and image processing techniques

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Induction coils permit us to measure the very rapid changes of the magnetic field. In June 2012, the British Geological Survey Geomagnetism team installed two high frequency (100 Hz) induction coil magnetometers at the Eskdalemuir Observatory (55.3° N, 3.2° W, L∼3), in the Scottish Borders of the United Kingdom. The Eskdalemuir Observatory is one of the longest running geophysical sites in the UK (beginning operation in 1908) and is located in a rural valley with a quiet magnetic environment.

The coils record magnetic field changes over an effective frequency range of about 0.1–40Hz, and encompass phenomena such as the Schumann resonances, magnetospheric pulsations and Ionospheric Alfvén Resonances (IAR). In this study we focus on the IAR, which are related to the vibration of magnetic field lines passing through the ionosphere, believed to be mainly excited by lower atmospheric electrical discharges.

The IAR typically manifest as a series of spectral resonances structures (SRS) within the 1-6Hz frequency range, usually appearing a fine bands or fringes in spectrogram plots. The SRS tend to occur daily between 18.00–06.00UT at the Eskdalemuir site, disappearing during the daylight hours. They usually start as a single low frequency before bifurcating into 5–10 separate fringes, increasing in frequency until around midnight. The fringes also widen in frequency before fading around 06.00UT. Occasionally, the fringes decrease in frequency slightly around 03.00UT before fading.

In order to quantify the daily, seasonal and annual changes of the SRS, we developed a new method to identify the fringes and to quantify their occurrence in frequency (f) and the change in frequency (Δf). The method uses short time-series of 100 seconds to produce an FFT spectral plot from which the non-stationary peaks are identified using the residuals from a best-fit six order spline. This is repeated for an entire day of data. The peaks from each time-slice are placed into a matrix which is then treated as an image. In combination with the spectrogram image of that day, the SRS are identified using image processing techniques. The peaks can now be mapped as continuous lines throughout the spectrogram. Finally, we can investigate the f and Δf statistics over the entire length of the dataset.

We intend to run the coils as a long term experiment. The data and code are available on request.