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ELF inversion of Global Lightning Activity and a Comparison with VLF Methods

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The Earth's Schumann resonances (SR), electromagnetic waves contained within the spherical cavity bounded by the conductive Earth and the conductive ionosphere, are continuously maintained by global lightning activity. The fundamental mode of SR has a wavelength equal to the Earth's circumference and a frequency of around 8 Hz.

We are presently involved with an inversion calculation based on multi-station SR observations to find the distribution of global lightning sources and to study its correlation with global surface temperature on hourly time scales. The measurable parameters in this problem are the extracted from the observed SR spectra at each measurement station. These parameters are the intensities, peak frequencies and quality factors for each of the first four resonant modes, for each and every field component being measured.

The unknowns in this inversion problem are the geographical locations (latitude and longitude) and a lightning activity for each of the major continental lightning zones on the Earth. ELF methods for lightning characterization do not count distinct lightning strokes and flashes. Instead, a lightning activity in absolute units ($Coul^2km^2sec^{-1}$) is derived from the inversion calculations, for every continental source region considered in the forward model. This inversion problem has been addressed with initial guess solutions that come from independent synchronous GLD360 VLF network observations which can accurately locate lightning strokes in multiple continental regions. However, these observations may be non-uniform in their global detection efficiency on account of the notably greater attenuation at VLF than ELF. The method is named as FULLGEAR inversion.

This study summarizes the work on the inversion based on 28th April 2017 data from six ELF stations operated by the HeartMath Institute. These magnetic stations are located in California, Canada, Lithuania, Saudi Arabia, South Africa and New Zealand. For the present run, the initial guess for the inversion is obtained from the GLD360 database maintained by Vaisala. The absolute activity in three major lightning source regions shows good consistency with the climatological lightning activity derived from space-based observation. An alternative scheme for inversion based on Nelson (1967) that has for unknowns only the three chimney source strengths has also been run for comparison. The results for the diurnal variations of source strengths are similar to those obtained with FULLGEAR for this single day of inter-comparison.