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Inversion of Multi-Station Schumann Resonance Background Records for Global Lightning Activity in Absolute Units

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Every lightning flash contributes energy to the TEM mode of the natural global waveguide that contains the Earth's Schumann resonances. The modest attenuation at ELF (0.1 dB/Mm) allows for the continuous monitoring of the global lightning with a small number of receiving stations worldwide. In this study, nine ELF receiving sites (in Antarctica (3 sites), Hungary, India, Japan, Poland, Spitsbergen and USA) are used to provide power spectra at 12-minute intervals in two absolutely calibrated magnetic fields and occasionally, one electric field, with up to five resonance modes each. The observables are the extracted modal parameters (peak intensity, peak frequency and Q-factor) for each spectrum. The unknown quantities are the geographical locations of three continental lightning 'chimneys' and their lightning source strengths in absolute units (C^2 km^2/sec). The unknowns are calculated from the observables by the iterative inversion of an evolving 'sensitivity matrix' whose elements are the partial derivatives of each observable for all receiving sites with respect to each unknown quantity. The propagation model includes the important day-night asymmetry of the natural waveguide. To overcome the problem of multiple minima (common in inversion problems of this kind), location information from the World Wide Lightning Location Network has been used to make initial guess solutions based on centroids of stroke locations in each chimney. Results for five consecutive days in 2009 (Jan 7-11) show UT variations with the African chimney dominating on four of five days, and America dominating on the fifth day. The amplitude variations in absolute source strength exceed that of the 'Carnegie curve' of the DC global circuit by roughly twofold. Day-to-day variations in chimney source strength are of the order of tens of percent. Examination of forward calculations performed with the global inversion solution often show good agreement with the observed diurnal variations at individual receiving sites, lending confidence to the 3-chimney model for global lightning.