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On Estimation Strategies in an Inverse ELF Problem

Vadim Mushtak (1), Earle Williams (1), Robert Boldi (2), and Tamas Nagy (3)

(1) Massachusetts Institute of Technology, Parsons Laboratory, Cambridge, MA 02139 USA, (2) University of Bahrain, Zallaq, Kingdom of Bahrain, (3) Geodetic and Geophysical Research Institute, Hungarian Academy of Sciences, Sopron, H-9401, POB 5. Hungary

Since 1965 when Balser and Wagner, the pioneer ELF experimentalists, noticed the reflection of the properties of global lightning activity in their measurements, one of the most important and challenging tasks in the ELF research is the monitoring of the world-wide lightning activity from observations in the Schumann resonance (SR) frequency range (5 to about 40 Hz). Known attempts in this direction have been undertaken using a simplified theory of ELF propagation in a spherically symmetrical Earth-ionosphere cavity. Yet numerical simulations with more realistic ELF techniques show that incorporating into the theory the cavity's major asymmetry, the day/night one, not only improves the accuracy of the monitoring procedure, but also enhances its efficiency. The reason is that the presence of asymmetries provides - via the positions of sources and observer relative not only to each other, but also to the day/night terminator, - additional "dimensions" to the task in comparison with the symmetrical case, which, in its turn, improves the convergence of the inversion procedure.

The realization of the theoretically achievable efficiency of such an inversion with real SR data depends critically on the quality of measurements. After collecting and analyzing ELF data from SR stations in various regions of the globe, it was found that even under seemingly most favorable experimental conditions the SR characteristics directly estimated from ELF observations rarely have a quality acceptable for use in the inversion. A three-stage rectifying algorithm has been developed and tested in the inversion procedure. In the first stage, the data – in the form of time series, - instead of being directly Fourier-transformed for estimating the SR characteristics, are divided into shorter segments, and histograms of the segments' energy content (EC) are considered for revealing the possible presence of various interferences and the "non-systematic" (i.e. not incorporated into the source model) components. On the basis of statistical properties of the EC histograms, "credibility diagrams" – the SR characteristics vs. the segments' EC threshold - are being computed and analyzed, the characteristics' stability (respectively, instability) with the threshold being an indicator of low (respectively, high) presence of the interference/non-systematic constituent. If the diagrams are not stable enough, a more detailed analysis is being carried out in the third stage for revealing and eliminating as far as possible the instability's cause. The efficiency of the rectifying procedure is demonstrated via an improved convergence of the inversion procedure with real-world data from a global network of SR stations in Europe, North America, Asia, and Antarctica.

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