Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MIS02-02 Room:203 Time:May 22 09:15-09:45

Comparison of ELF Inversion Methods for Global Lightning Activity

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The natural Earth-ionosphere waveguide provides a framework for global lightning detection at both ELF and VLF frequencies. Increased attention has been given recently to ELF methods, primarily because of the reduced attenuation and the smaller number of receiving stations required. In the inverse problem in the Schumann resonance band (4-40 Hz), measurements of background field spectra at multiple stations (giving a number of measured inputs N) are used to infer the global distribution of lightning sources (as a number M of unknown quantities). Two entirely independent approaches have been pursued over the last decade, and are to be compared in this study. The first inversion method (Shvets et al., 2010) involves a two -step process. The first step makes use of a forward model with a uniform Earth-ionosphere waveguide and lightning sources on each of 20 annuli (M=20) surrounding each receiving station but with spectral resolution of 0.1-0.2 Hz for a total N= 350 inputs from field spectra over the Schumann band. The solution is overdetermined. The second step, a tomographic procedure, makes use of 3 receiving stations with 20 source points each, for a total N =60-120. Unknown sources are mapped on a grid with 5o resolution (0.5 Mm) from 60oN to 60oS for a total M = 61 x 72 = 4392, in an underdetermined calculation. The second inversion approach (Mushtak and Williams, 2011) employs a non-uniform (day/night asymmetry) model for the waveguide, and a forward model with three dominant chimney sources: the Americas, Africa and the Maritime Continent. The input quantities for the iterative inversion are the modal peak intensities and frequencies for 3-4 resonant modes for all measured fields (at most, two magnetic and one electric) at 5-6 receiving stations, for a total N = 50 to 100. The unknown quantities are the source strengths and locations for each of three chimneys (M = 9) in an overdetermined calculation. Key features targeted for comparison are the relative strengths of the three dominant chimneys, the comparative strengths of secondary sources, and the day-to-day stability of the lightning activity in absolute units (C2km2/sec) on individual days in January 2009. Detailed results will be reported as they are available at conference time.

Keywords: Schumann resonances, inversion methods, global lightning, Earth-ionosphere cavity