On sanitizing background Schumann resonance observations from strong transient events for inversion calculations

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The necessity and methodology of sanitizing Schumann resonance (SR) background observations from strong transient events are considered in connection with the inversion problem of estimating the global background lightning activity from SR electromagnetic measurements. It is shown that the seemingly natural assumption that the lightning parenting the transients directly presents the tail of the background distribution is not correct (which by no means excludes the strong indirect relationship found in earlier probes). A specially developed technique of SR stabilization diagrams determines the statistical "boundary" between the background and strong transient components in SR observations, providing a rule for the suppression of the contaminating effects of the transients.

1. Methodology

The inversion problem is based on the use of SR modal characteristics (SRMCs), extracted from observations at a world-wide net of ELF stations, to assess the global lightning activity. To exclude the contribution of local interference of both man-made and natural origin, a special sanitizing procedure has been developed. The procedure divides 12-min observational periods into 5-s segments and eliminates segments whose spectral power contents (SPCs) exceed a certain limiting level (LL). To determine the LL, we analyse stabilization diagrams presenting the dependence of the SRMCs on the SPC threshold for the given period. The typical form of a stabilization diagram is an initial interval of variations of the SRMCs followed by a stabilization interval and then, in the presence of a strong non-background (interference) component, an interval of their destabilization. It was found that when a segment's SPC (SSPC) is expressed as the number of standard deviations (SD) of the sample distribution of SSPCs, the threshold of 16 SDs is typically located within the stabilization interval and so can be used as the sought-for limiting level. It has also been found that the presence of strong transient signatures within the given period can cause a destabilization of the SRMCs comparable to that from local interference, despite their different origins and natures.

2. Experiment and discussion

The latter circumstance motivates a revisitation of the relationship between the background and transient SR signals [1]. Observations from two stations (Belsk, Poland and Nagycenk, Hungary), separated by a small (in ELF terms) distance of about 550 km, provide an excellent opportunity to both exclude local interference and to maintain the similarity of global signals. After analyzing two weeks of electric time series recorded at both stations in January 2009, it has been found that transients that make the SSPC to exceed 16 SDs would cause a significant destabilization of the SRMCs, making them unsuitable for use in the inversion procedure. (The objectivity of this finding has been confirmed by the fact that the transient-to-background ratios at these two stations exhibited correlation coefficients as high as 0.83 to 0.98.) Thus, the transient activity can present a genuine interference factor in SR background observations. On the other hand, statistically significant correlation has been found between the daily numbers of transients and the general levels of background lightning activity. The resolution of this seeming contradiction, similar to that noticed in [1], may rest on the meteorological tendency for late afternoon convective scale thunderstorms to amalgamate into late evening mesoscale convective systems. The former entities are excellent producers of background SR signal, whereas the latter ones are exceptional generators of energetic transients of the kind we have observed as "spoilers" in our experiment.

3. References

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