Abstract

The ionospheric environment has become a focal point in the study of earthquake-related anomalies. In particular, both electromagnetic anomalies and particle bursts have been detected in the ionosphere and proposed as potential seismo-related phenomena. This thesis addresses the challenges in distinguishing earthquake-induced electromagnetic anomalies from the complex and variable background of ionospheric signals. Utilizing data from the CSES-01 satellite, this work introduces a robust methodology for characterizing both medium-long and short-duration electromagnetic signals in the ionosphere. A new approach to defining ionospheric EM background is proposed, considering temporal and geographical variations, and a statistically rigorous definition of anomalies is introduced. Additionally, a novel algorithm is developed for the efficient detection of short-duration whistler waves, revealing significant insights into their spatiotemporal distributions. To explore the coupling mechanisms between electromagnetic anomalies and particle bursts, numerical simulations using a hybrid particle-in-cell code were conducted, simulating ionospheric plasma interactions with small amplitude Alfvén waves. The results demonstrate modifications in ion velocity distributions and the emergence of fast ion beams, providing the first estimates of time delays between the impact of the electromagnetic waves and plasma disturbances. This research advances the understanding of seismo-ionospheric coupling, offering valuable tools for the identification of earthquake-related anomalies.

Keywords: Ionosphere, Electromagnetic anomalies, Earthquakes, CSES-01 satellite, Electromagnetic waves, Hybrid particle-in-cell simulations