A statistical analysis on the relationship between thunderstorms and Sporadic E Layer over Rome

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Meteorological processes (cold fronts, mesoscale convective complexes, thunderstorms) in the troposphere can generate upward propagating waves in the neutral atmosphere affecting the ionosphere behaviour. One type of these waves are the internal atmospheric gravity waves (AGWs) which can be often generated by thunderstorms. Davis and Johnson found in low pressure systems that a localized intensification of the sporadic E layer can be attributed to lightnings. To confirm this result, we have performed a statistical analysis using the time series of the critical frequency foEs and height h'Es of sporadic E Layer and meteorological observations (lightnings, radar, InfraRed maps) over the ionospheric station of Rome (41.9° 12.5°).

1. Introduction

A connection between thunderstorms and the ionosphere has been hypothesized since the mid-1920s [1]. Meteorological processes (cold fronts, mesoscale convective complexes, thunderstorms) in the lower atmosphere can affect the ionosphere mainly through two mechanisms: (i) electrical and electromagnetic phenomena (red sprites, blue jets etc.) and (ii) upward propagating waves in the neutral atmosphere [2]. One type of these waves are the internal atmospheric gravity waves (AGWs) which can often be generated by thunderstorms in the troposphere [3] but they are also generated by strong atmospheric fronts irrespective of lightnings [4]. The one-to-one correspondence between a meteorological phenomenon in the lower atmosphere and AGW in the mesopause is directly observable in the nighttime airglow images [5]. Davis and Johnson demonstrated that the ionospheric 'sporadic E' layer - transient, localized patches of relatively high electron density in the mid-ionosphere E layer, which significantly affect radio-wave propagation - shows a statistically significant intensification and descent in altitude directly above thunderstorms. They found no ionospheric response to low-pressure systems without lightnings, consequently this localized intensification of the sporadic E layer can be attributed to lightnings [6]. Besides a superposed epoch analysis (SEA) by Kumar et al. [6] showed that the direction of arrival of the thunderstorm is very important too. When the AGWs sources are located in the direction antiparallel to mean neutral wind flow, the effects of thunderstorms on the ionosphere are dominant [7]. Simultaneous images of sprites and OH airglow, modulated by gravity waves, were observed over a very active thunderstorm in Nebraska [8]. The separate calculation of the energy in a sprite based on optical emission intensities showed that the energy deposited by a sprite in the mesosphere is well below that required to produce a detectable perturbation in the OH emissions. On the other hand, there is evidence that the recorded AGWs were generated by the underlying thunderstorm which passed through below.

2. Data analysis

In this study a statistical analysis concerning data of the critical frequency (foEs), height (h'Es) of the sporadic E Layer, and meteorological activity observations (lightnings, radar, IR maps) over the ionospheric station of Rome (41.9° 12.5°) is perfomed to evaluate troposphere-lower ionosphere coupling phenomena in the mediterranean area. Direction of arrival of thunderstorms is also taken into account. A possible confirmation of the modulation of sporadic E-layer by the thunderstorms generated AGWs [6] coluld be achieved.

Manually validated hourly data recorded by the ionosonde (DPS-42) installed at the mid-latitude station of Rome, Italy, (41.8 N, 12.5 E) are used in this work. The first results of this analysis are presented.

3. References

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