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LARGE-SCALE DISTURBANCES ORIGINATING FROM REMOTE EARTHQUAKES IN THE PLASMA AT MESOSPHERIC HEIGHTS

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ABSTRACT

The results are discussed of MF radar remote sensing of disturbances caused by strong earthquakes at great distances in the plasma at mesospheric heights, and a mechanism is advanced for the development of such large-scale disturbances in ionospheric plasma parameters, which is a large-scale mesospheric electric potential redistribution due to an increase in the atmospheric conductivity over a seismic region.

INTRODUCTION

The authors of [1] were the first who observed the development of large-scale ionospheric disturbances caused by a strong seismic activity for a few days and during the Chile May 22, 1960, earthquake with a magnitude of 9.6; the measurements were taken using a net of 18 MHz riometers in North America and spaced by thousands kilometers from each other. Among other things, increases in the signal amplitude by a factor of up to 2 over a background noise were observed to correlate with the seismic disturbances. Similar effects were observed before and during the January 17, 1995, Kobe earthquake with 7.2 magnitude [2]. In the latter case, two sequence of 22 MHz radio bursts were observed at a distance of 77 km from the epicenter. Such seismic phenomena have not found a satisfactory explanation yet.

In this paper, we present some observations of disturbances caused by remote earthquakes in the lower ionosphere, and discuss possible mechanisms of their development.

EXPERIMENTAL RESULTS

The lower ionosphere disturbance diagnostics at distances of up to a few thousand kilometers from strong earthquakes included records of f=2–3.5 MHz noise and 25 μs MF radar pulses scattered from the $z \sim 60 \sim 85$ km altitude region.

Fig. 1 represents time dependences of $R = A_-^2 / A_+^2$ obtained for different altitudes at the National Kharkiv V. Karazin University Radiophysical Observatory approximately 11,000 km away from a 5.7 magnitude earthquake which occurred at a 33 km depth near Western New Guinea, 3.37 S latitude and 135.1 E longitude, at 12:48:54 LT on March 20, 1995; the arrow marks the time of the earthquake. Here A_+^2 and A_-^2 are the ordinary and extraordinary, respectively, MF radar signal intensities averaged over successive 1-min intervals.

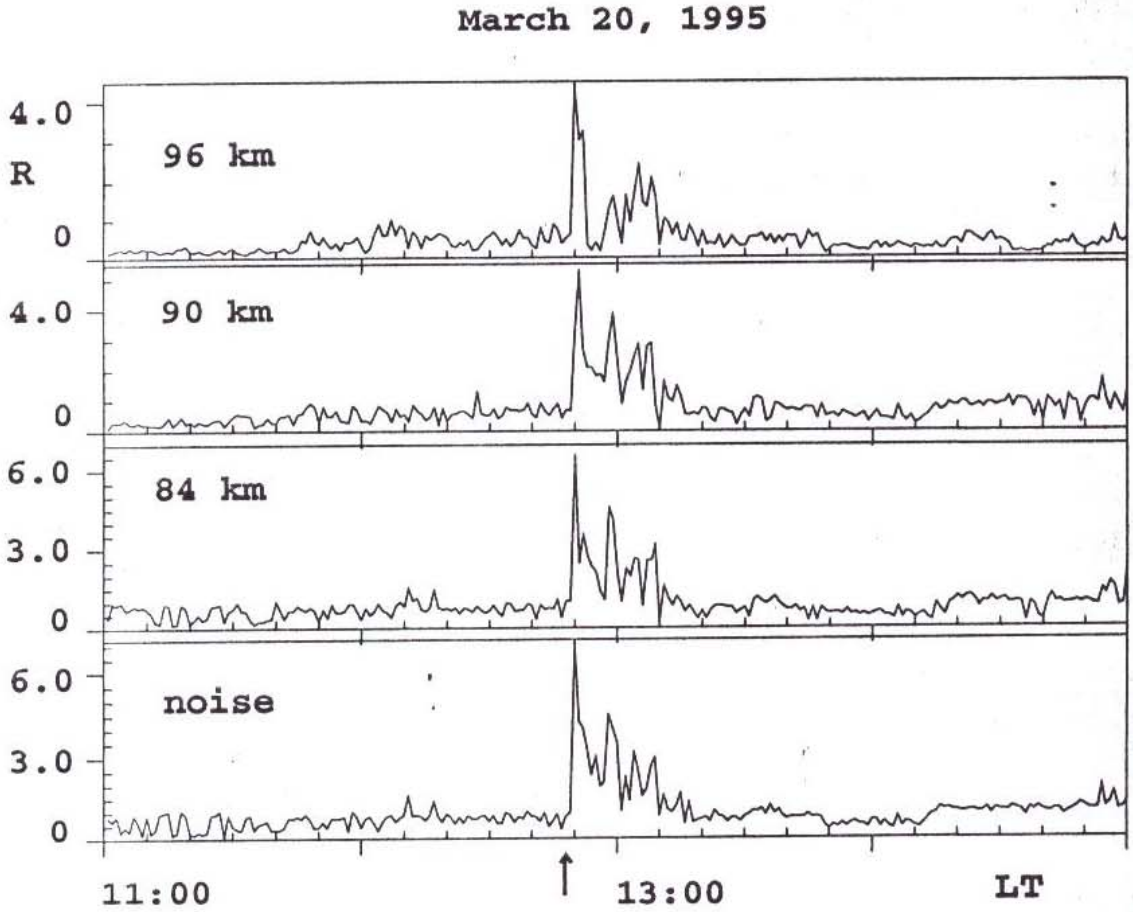

Figure 1. Time dependences of R for 2.3 MHz signals scattered from 84 km, 90 km, 96 km altitudes at Kharkiv during the March 20, 1995, West New Guinea earthquake; the time of earthquake is marked by the arrow.

The small characteristic time scale of the disturbance development (less than a few seconds) can indicate that the changes in MF radar signals were caused by the corresponding changes in the electron temperature A_-^2 and the effective collision frequency ν_e in the ionospheric D region. The similarity between the dependences of R on time and height mean that the main ionospheric disturbance was localized below the 84-km altitude where the signal-to-noise ratio was low and prevented the detection of MF radar signals. As a whole, it is clearly seen that the remote earthquake caused a sharp increase in the value of R, which could result from a decrease in the total absorption of signals and noise below the 84-km altitude.

DISCUSSION

The detection of strong mesospheric electric fields at mesospheric heights (see, for example, [3, 4]) provides a new opportunity to explain electrodynamic interactions between the troposphere, the mesosphere, and the ionosphere. Thus, for example, the existence of such fields over a seismically active area makes possible the following mechanism. A big increase (by one or two orders of magnitude) in the tropospheric conductivity over the seismic area results in a decrease in strong mesospheric electric field intensities due to troposphere-mesosphere electrical coupling (see, for example, [5, 6]). This causes a rapid decrease in T_e and ν_e as well as the corresponding changes in mesospheric conductivity. The last effect results in rapid changes in radio propagation conditions in the lower ionosphere over the seismic area.

It should be noted that considerable changes in the mesospheric electric potential over a remote earthquake can result in a change in the difference in electric potential voltage between mesospheric potentials over the remote earthquake and over the observation site, which is equivalent to changes in mesospheric electric field intensities over the observation site. Therefore the development could also be expected of disturbances in the plasma at mesospheric heights. For the experiment depicted in Fig. 1, the remote earthquake should have decreased the large-scale difference in the electric potential voltage, which has resulted in a decrease of T_e, ν_e, and the total absorption of the signals and noise below the 84-km altitude.

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