IL NUOVO CIMENTO VOL. 20 C, N. 4 Luglio-Agosto 1997
NOTE BREVI

Electronic density contours and gravity waves

M. PIETRELLA, C. BIANCHI and C. SCOTTO
Istituto Nazionale di Geofisica - Via di Vigna Murata 605, 00143, Roma, Italy

(ricevuto il 10 Giugno 1996; approvato il 16 Maggio 1997)

Summary. — A campaign of ionospheric vertical sounding with an interval of 10 minutes between all the ionograms was performed in November 1995 in the station of Rome. High-repetition soundings are more useful than the routine soundings for a more precise analysis of the MSTIDs. Isodensity contours of real height *vs.* time were obtained. The periods of oscillations observed and the upward phase propagation suggest the existence of gravity waves in the ionosphere.

PACS 94.20 – Physics of the ionosphere.
PACS 92.60 – Meteorology.

1. – Introduction

Oscillations in time of isoelectronic contours have been known for a long time as travelling ionospheric disturbaces (TIDs) since Martyn discussed them in terms of cellular waves in 1950. Since that time many works have been done on this subject. Among these a particularly important work is the one in which it was established that TIDs are the manifestation of gravity waves (GWs) in the neutral atmosphere [1]. Nowadays the observations available have pointed out that there are two types of TIDs, one being large scale (LS) and the other medium scale (MS). LS TIDs have long periods (2–4 hours), lasting for a few cycles and a horizontal velocity of 700 m/s. MS TIDs have shorter periods and the horizontal velocity is smaller. It is considered that these different types of TIDs are excited differently. LS TIDs are nowadays identified as the ionospheric effect of GWs in the neutral atmosphere. They are produced by Joule heating and/or by Lorentz force at the auroral electrojet during magnetic substorms. The occurrence which depends on the intensity of the magnetic activity has been established [2-4]. On the contrary, the mechanism of excitation of MS TIDs is not clearly known. Only some mechanisms have been well understood. For example, it is well known that various meteorological disturbances generate GWs in the lower atmosphere, and these GWs travel upwards to the ionosphere producing TIDs [5-8]. The presence of GWs near the terminator has also been studied by many authors (for a review, see [9]). As to unusual sources of GWs, the Sun's shadow motion during an eclipse [10] and nuclear detonations are also taken into consideration [11, 12]. However, the general mechanism of excitations of MS TIDs has not been

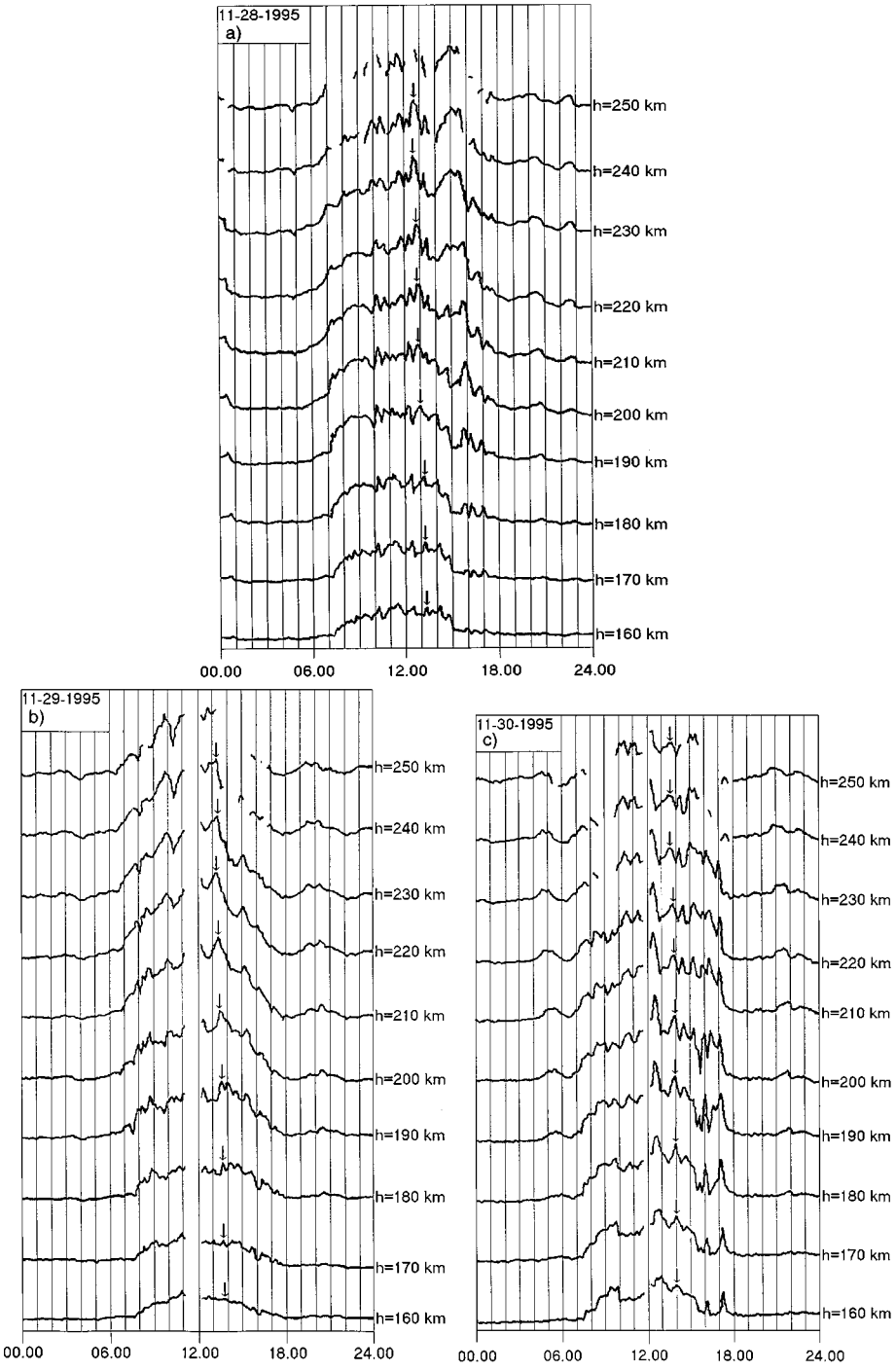

Fig. 1. – $N(h)$ contours for three days of November 1995. The vertical phase propagation is shown by the position of the arrows at different heights.

still clearly identified. For this reason an efficacious strategy is still necessary to understand the quasi-periodic ionospheric oscillations at short periodicity observed in the $N(h)$ contours that are related with neutral atmosphere coupling. In this paper we want to show some electronic isodensity contours during a moderate magnetic activity.

2. – Experimental observations and discussion

In this paper we have analysed three days during November 1995 in which the geomagnetic activity index was $K_p > 28$. A high-repetition ionospheric sounding campaign (ten minutes between each ionogram) was performed.

The ionograms were taken by the chirp modulated Barry ionosonde. Then these data were semiautomatically digitized, and electron density profiles were obtained. This procedure was necessary because a great accuracy in the scaling of ionogram traces is required. The inversions from the ionogram traces to the electron density profiles were performed by the POLAN program (Titheridge). From the electron density profiles we obtained $N(h)$ *vs.* time at several true heights ($N(h)$ contours) as shown in fig. 1a), b) and c).

By observing the figures we noted the presence of oscillations in the isodensity curves. Such oscillations show different periods and amplitudes depending on time. In night-time the periods of oscillations tend to increase with respect to the daytime periods. Moreover, the phase lets us infer a vertical propagation as is shown by the position of the peaks at different heights. The periods of the oscillations suggest the GW activity in the ionosphere as is confirmed by observations of vertical phase propagation.

* * *

The authors gratefully acknowledge prof. P. DOMINICI for his helpful discussions and contributions to this paper.

REFERENCES

[1] HINES C. O., *Internal atmospheric gravity waves at ionospheric heights, Can. J. Phys.*, **38** (1960) 1441-1481.
[2] TITHERIDGE J. E., *Nonperiodic irregularities in the ionosphere, J. Geophys. Res.*, **76** (1971) 6955-6960.
[3] TESTUD J., *Gravity waves generated during magnetic substorm, J. Atmos. Terr. Sci.*, **32** (1970) 1793-1805.
[4] HUNSUCKER R. D., *Atmospheric gravity waves generated in high-latitude ionosphere: A rewiew, Rev. Geophys. Space Phys.*, **20** (1982) 293-315.
[5] JORDAN A. R., *Atmospheric gravity waves from winds and storms, J. Atmos. Terr. Sci.*, **29** (1972) 445-456.
[6] HUNG R. J. and SMITH R. E., *Dynamic of severe storm through the study of thermospheric-tropospheric coupling, J. Geomag. Geoelectr.*, **31** (1979) 183-194.
[7] BERTIN F., TESTUD J. and KERSELEY L., *Medium scale gravity waves in the ionospheric regions and their possible origin in weather disturbances, Planet. Space Sci.* **23** (1975) 493-507.
[8] BERTIN F., TESTUD J., KERSELEY L. and RESS P. R., *The meteorological jet stream as a source of medium scale gravity waves in the thermosphere, An experimental study, J. Atmos. Terr. Phys.*, **40** (1978) 1161-1183.
[9] SOMSIKOV V. S., *Waves in the atmosphere caused by the solar terminator* (*a review*), *Geomagn. Aeron.*, **31** (1991) 1-8.

[10] JONES B. W., MISELDINE G. J. and LAMBOURNE R. J. A., *A possible atmospheric pressure wave from the total solar eclipse of 22 July 1990, J. Atmos. Terr. Phys.*, **54** (1992) 113-115.
[11] BLANC E., *Observations in the upper atmosphere of infrasonic waves from natural or artificial sources: A summary, Ann. Geophys.*, **3** (1985) 673-668.
[12] NAGORSKIY P. M., TARASHCHUK Y. E. and TIMCHENKO N. I., *Dynamic of the F2 layer during a surface explosion by the "Massa" project, Geomagn. Aeron.*, **27** (1987) 113-115.