ANNALI DI GEOFISICA, VOL. XXXVII, N. 1, April 1994

Preliminary results on the ionospheric structure at dawn time observed during HRIS campaigns

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Abstract
Several campaigns of ionospheric vertical soundings with short-time interval between them (HRIS) have been recently performed at the ionospheric station in Rome. Some preliminary results concerning periods around local sunrise are presented. A clear fading effect, due to the defocusing phenomena in the upper ionosphere, has been observed in different seasons.

Key words *atmospheric gravity waves – travelling ionospheric disturbances*

1. Introduction

At the ionospheric station in Rome (41.8°N, 12.5°E) several high repetition ionospheric soundings (HRIS) campaigns, with ionograms taken every 10, 5 or 2.5 min, have been recently performed for studying some dynamical ionospheric and thermospheric phenomena. In particular, data from these campaigns, carried out around local sunrise in various epochs of the year, have been utilized in order to reveal ionospheric wavelike perturbations eventually occurring at dawn.

The existence of wavelike oscillations of both critical frequency and virtual/real height of the ionospheric layers is nowadays a well known fact and the same is for their association with atmospheric gravity waves (AGW's). These phenomena, considered travelling ionospheric disturbances (TID's), are described in a vast literature reviewed in some articles (Yeh and Liu, 1974; Francis, 1975; Sugiyama, 1988; Williams *et al.*, 1988; Mishin *et al.*, 1991).

The morphology of TID's at mid-latitude can be briefly summarized: a) large-amplitude (large percentage variation from normal values of critical frequency and virtual/real hight) and long-period (some hours) TID's occur every day in all ionospheric layers, independently of ionospheric and geomagnetic conditions, apparently starting around local sunrise (Dominici *et al.*, 1988); b) these large TID's are superimposed on a «noise» of short-period (from minutes to less than one hour) and suddenly phase-changing small-amplitude waves.

Moreover, current opinions about these TID's are: c) the «noise» waves are related to AGW due to the highly incoherent tropospheric and auroral activity (Kazimirovski, 1985; Williams *et al.*, 1988);

d) the large night-time TID's are produced by precipitation of magnetospheric particles (Williams *et al.*, 1988; Hajkowicz, 1990); e) the large and almost permanent day-time TID's are related to AGW excited by the passage of the solar terminator (firstly, Beer, 1973). The study of this latter kind of TID's (solar terminator waves, STW) has been the main aim of HRIS data analysis around local sunrise.

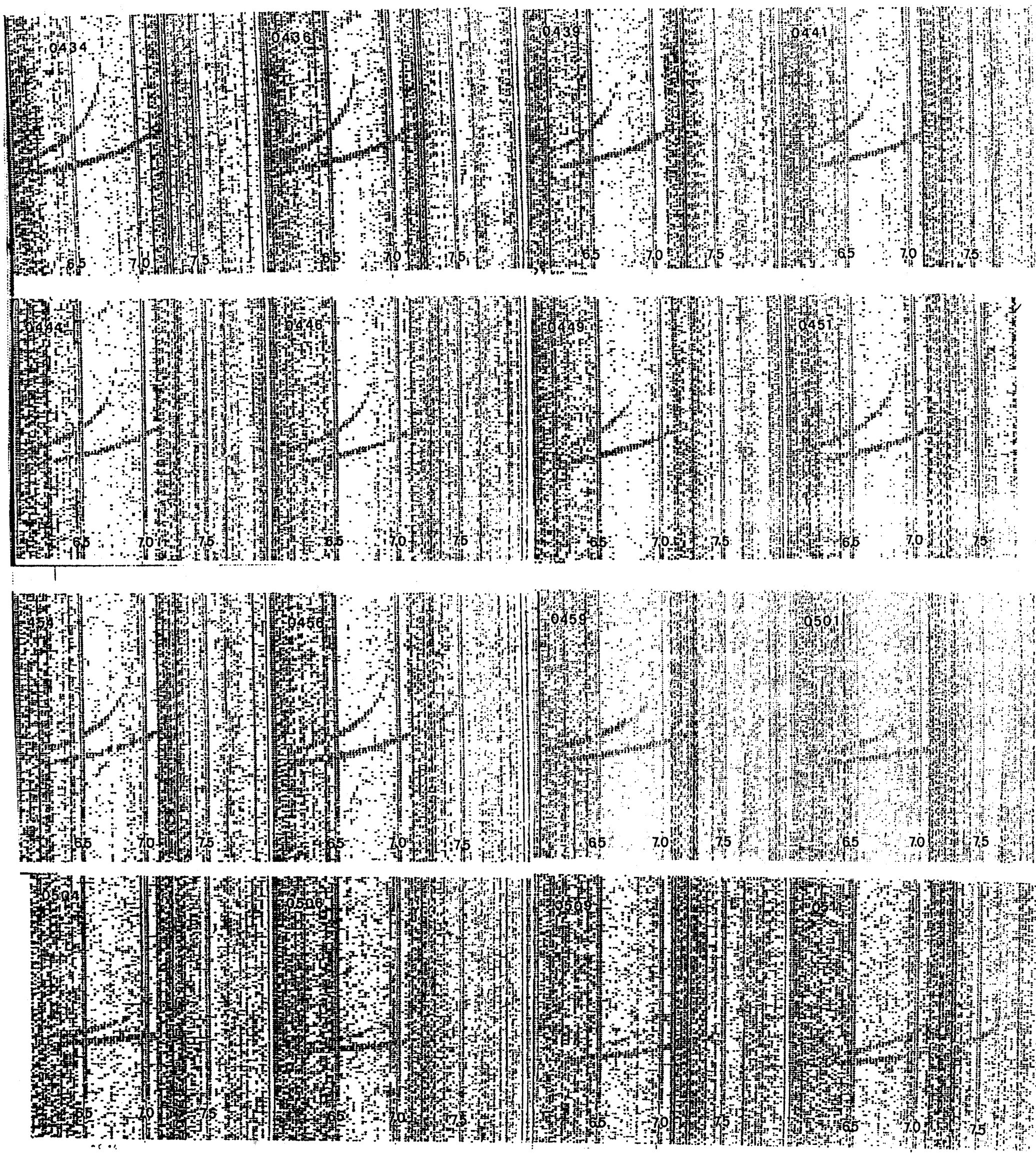

Fig. 1a. Series of ionograms taken during the dawn period of the HRIS campaigns.

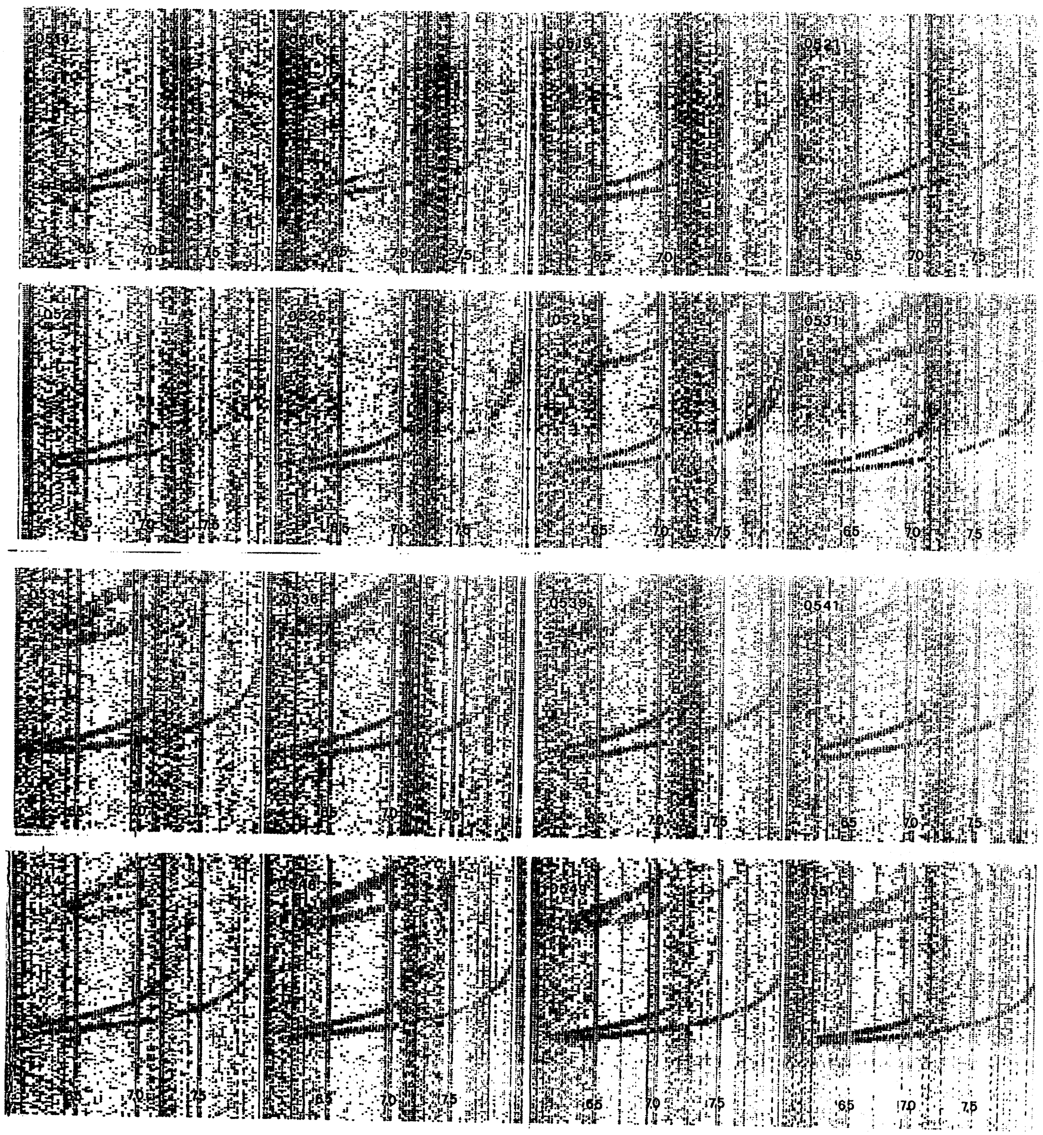

Fig. 1b. Series of ionograms taken during the dawn period of the HRIS campaigns.

2. Observations

During the HRIS campaigns of December 1989, March 1990 and May 1992 vertical ionospheric soundings were performed every 10 or 2.5 min at the ionospheric station in Rome over periods of ten days (from 15th to 24th). These periods were geomagnetically quiet except one day in December and two days in March 1990.

The ionograms were taken using the Digisonde 128P which gives also the relative amplitude of signal in a dynamic range of 64 dB. The frequency resolution was in-

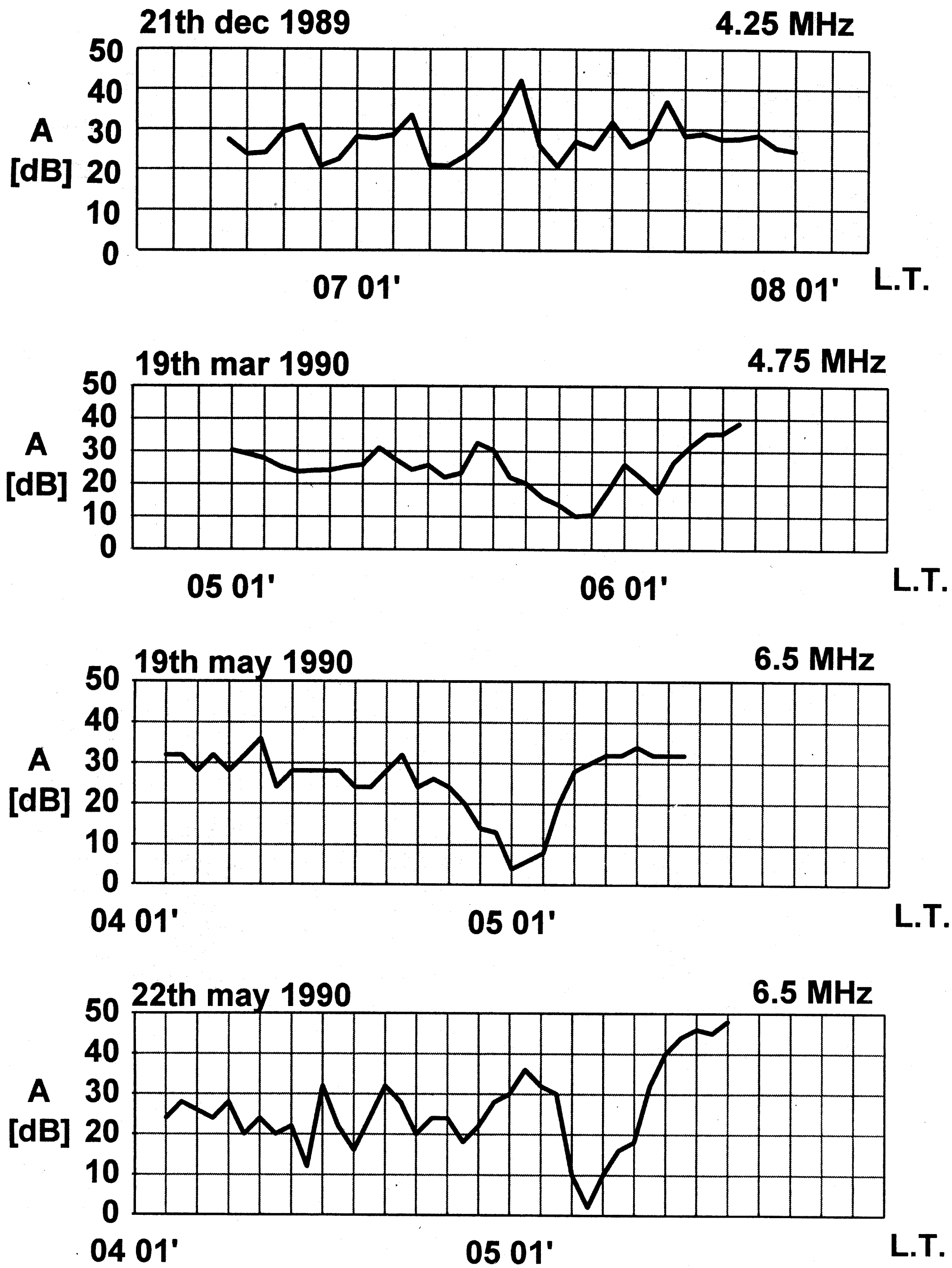

Fig. 2. Time behaviour of the relative amplitude level of the received signal measured at 6.5 MHz, 4.75 MHz and 4.25 MHz during sunrise in four different days.

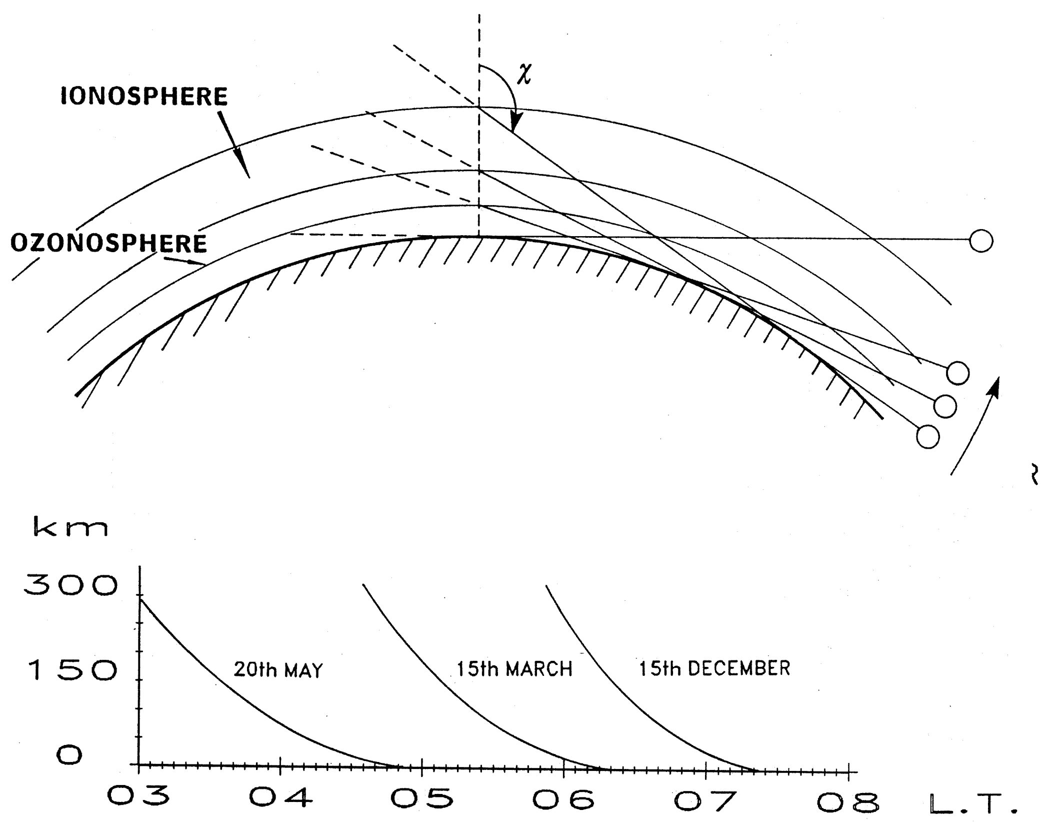

Fig. 3. Above, simplified scheme of the related geometry of the local sunrise neglecting refraction effects. Below, time behaviour of the altitude of the astronomical sunrise for three different epochs of the year.

creased, from 100 kHz of the routine measurement to 50 and 25 kHz, to reduce the scaling difficulty due to the rapidly changing structure of the ionosphere around sunrise in this last campaign.

The excitation of oscillations during the passage of the solar terminator is not always evident, especially the cases without quiet night-time conditions in the three epochs considered.

Moreover, there are many difficulties to deduce a sufficiently accurate value of the start time and hence the corresponding height of the «trigger» ionospheric sunrise. We came to the same conclusions analysing the time behaviour of the differences between the f_0F2 critical frequency and the corresponding 7-values symmetrical running mean or investigating spectral Fourier diagrams.

On the contrary, an important indication of the passage of the solar terminator is found from HRIS data: a large fading effect at dawn hours has been observed in every day of the campaigns. This fading is clearly seen, for example in fig. 1a,b with the strong attenuation of the signal shown in the series of ionograms taken during dawn period of 22nd May 92 between 4.59 and 5.31 h. Figure 2 shows the time behaviour of the relative amplitude level of the received signal measured at 6.5 MHz, 4.75 MHz and 4.25 MHz during sunrise in four different days of three different epochs.

This effect begins some minutes before the time of the ground sunrise (the local passage of the solar terminator on the terrestrial surface), lasting about twenty to forty minutes. It is important to note that this phenomenon adds more difficulties to the ionogram scaling and the error of the measurement of f_0F2 increases just during the solar terminator passage. Nevertheless, we can observe that the height of the above «trigger» ionospheric sunrise seems to be relatively low, namely of few tens of kilometers. Even if the HRIS data clearly show this effect, the number of days does not allow a significant time statistics. It should be noted that a similar effect was not observed around sunset during HRIS campaigns.

3. Discussion and conclusions

In the last years many studies on TID's occurring around local sunrise have been performed (Somsikov, 1991 and the references therein), and two aspects of the previously shown preliminary results of our HRIS campaigns can be pointed out.

First the association of such TID's with the movement and the geometry of the solar terminator (ST) and hence the correctness of the acronym STW can be assumed (Dominici *et al.*, 1988; Dominici and Cander, 1990; Mishin *et al.*, 1991). Secondly the principal, and probably exclusive origin of STW appears to be the thermic excitation of atmospheric waves by the sudden absorption of the incoming solar radiation. This process is localized inside the ozonosphere, namely at an altitude of about 30 km (Cot and Teitelbaum, 1980; Lott *et al.*, 1991). Then STW, propagating through the upper ionosphere, causes a defocusing of the received signal induced by isodensity surfaces oscillations. This agrees with the measurement of the above attenuation effect and especially with time. Figure 3 shows a very simplified scheme of the related geometry and the time behaviour of the altitude of the astronomical sunrise, neglecting effects of refraction, for three different epochs of the measurements. Further analysis of this fading effect is necessary to know the behaviour of ionosphere during the passage of solar terminator.

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(received July 27, 1993;
accepted December 24, 1993)