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83 Simultaneous measurements of the atomic oxygen nightglow emissions at 777.4 nm and 630.0 nm have been used in the past few years to determine the ionospheric F-layer peak electron density and peak height, and to investigate the pattern of F-layer depleted plasma regions, or ionospheric transequatorial plasma bubbles, and their associated irregularities In the tropical ionosphere. Meridional scanning observations of these emissions at low latitudes are presented, in the form of computer generated three-dimensional perspective views, showing the spatial north-south and temporal intensity variations of the 0I emissions, for both normal conditions and in the presence of magnetic field-aligned large scale plasma irregularities or bubbles. Significant features of these observations are discussed. This remote sensing airglow techniq"e is very useful to study ionospheric plasma dynamical processes and to investigate the pattern of large scale plasma irregularities in the nighttime tropical ionosphere.
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87 OXIGENIO
87 IONOSFERA
87 CAMADA F
87 BOLHA DE PLASMA
91 FDB-20000107
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IONOSPHERIC F-LAYER PLASMA IRREGULARITIES FROM ATOMIC OXYGEN NIGHTGLOW EMISSIONS

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ABSTRACT

Simultaneous measurements of the atomic oxygen nightglow emissions at 777.4 nm and 630.0 nm have been used in the past few years to determine the ionospheric F-layer peak electron density and peak height, and to investigate the pattern of F-layer depleted plasma regions, or ionospheric transequatorial plasma bubbles, and their associated irregularities in the tropical ionosphere. Meridional scanning observations of these emissions at low latitudes are presented, in the form of computer generated three-dimensional perspective views, showing the spatial north-south and temporal intensity variations of the OI emissions, for both normal conditions and in the presence of magnetic field-aligned large scale plasma irregularities or bubbles. Significant features of these observations are discussed. This remote sensing airglow technique is very useful to study ionospheric plasma dynamical processes and to investigate the pattern of large scale plasma irregularities in the nighttime tropical ionosphere.

RESUMO

Medidas simultâneas das emissões de luminiscência noturna do oxigênio atômico em 777.4 nm e 630.0 nm têm sido usadas durante os últimos anos para determinar a densidade eletrônica e a altura do pico da camada F ionosférica, e para investigar a morfologia das regiões de depleção de plasma na camada F, ou bolhas de plasma ionosférico transequatoriais, e as irregularidades associadas na ionosfera tropical. Observações de varredura meridional destas emissões em baixas latitudes são apresentadas, na forma de vistas em perspectiva tridimensionais geradas por computador, mostrando as variações de intensidade temporal e espacial norte-sul das emissões do oxigênio atômico para condições normais e na presença de irregularidades em grande escala ou bolhas de plasma alinhadas ao longo do campo magnético. As características significativas destas observações são discutidas. Esta técnica de sensoriamento remoto que utiliza luminiscência é bastante útil para estudar processos dinâmicos no plasma ionosférico e para investigar a morfologia das irregularidades de plasma em grande escala na ionosfera tropical noturna.

INTRODUCTION

The distribution of ionization around the magnetic equator, in the tropical ionospheric F-region, is strongly dependent on the dynamical transport processes. Two regions of enhanced plasma concentration are produced at about 15° on either side of the magnetic equator, as a result of the combined effects of magnetic field-aligned plasma diffusion, electromagnetic E x B plasma drift and thermospheric neutral wind drag (e.g., Anderson, 1973 a, b; Matuura, 1979). Associated with this ionization distribution about the dip -equator there is an asymmetrical intensity distribution of the atomic oxygen tropical airglow emissions which arise from ionization recombination processes (e..g., Reed et al., 1973; Bittencourt and Tinsley, 1976).

The atomic oxygen airglow emissions which result mainly from radiative recombination (such as 130.4 nm, 135.6 nm, 777.4 nm) are strongly dependent on the F-region peak electron density nm(e), whereas the emissions which arise from dissociative recombination (such as 630.0 nm) are very sensitive to variations in both nm(e) and the F-region peak height hm. Simultaneous measurements of one of the radiative recombination emissions (e.g., 777.4 nm) with the 630.0 nm emission are therefore very useful for remote sensing of ionospheric F-region plasma properties and can be used to determine nm(e) and hm (Tinsley and Bittencourt, 1975; Sahai at al., 1981a).

This remote sensing technique can also be used to investigate and to map large scale F-region plasma irregularities (Bittencourt et al., 1983) and to study F-region dynamical processes, since hm is a very sensitive indicator of ionospheric motions (Bittencourt and Sahai, 1978). Variations or perturbations in the ionospheric F-region parameters as a result of thermospheric neutral wind effects, or due to the presence of wave phenomena, and ionospheric modifications produced by geomagnetic disturbances can also be determined through the observations of these atomic oxygen nightglow emissions.

In this paper we present and discuss simultaneous north-south geomagnetic meridional scanning measurements of the atomic oxygen 777.4 nm and 630.0 nm emissions, as a function of local time, obtained at a low-latitude station at Cachoeira Paulista (geomagnetic latitude 12.0°S; geographic coordinates 22.7°S, 45.0°W). The results illustrate the importance of ground based simultaneous scanning observations of these emissions for determining the spatial structure associated with F-region field-aligned irregularities or plasma bubbles over a large geographical region of the sky.

F-REGION PLASMA IRREGULARITIES AND ATOMIC OXYGEN NIGHTGLOW EMISSIONS

Experimental and theoretical investigations of depleted plasma regions, or ionospheric transequatorial plasma bubbles, and their associated ionospheric irregularities in the tropical ionosphere have been made, in the past few years, using simultaneous observations of the OI emissions at 777.4 nm and 630.0 nm (e.g., Sahai et al., 1981b; Sahai et al., 1983). Simultaneous meridional scanning measurements of these emissions, or all-sky imaging measurements, can be used to construct maps showing the north-south and local time variations of the intensity of these emissions and the corresponding ionospheric F-region parameters nm(e) and hm, during quiet and during magnetically disturbed conditions, and in the presence of large scale ionospheric plasma irregularities.

Figures 1 and 2 illustrate the observed intensity variations for the 777,4 nm and 630.0 nm atomic oxygen emissions, respectively, as a function of local time and zenith distance in the magnetic north-south meridian, for the nights of October 02/03 and 04/05, 1980, measured at Cachoeira Paulista. The results are presented in the form of computer generated three-dimensional perspective views. Large scale field-aligned airglow depletions or patches are seen in both the emissions on the night 02/03, at about 21:30 LT and 23:30 LT, which are the optical signatures of intertropical transequatorial ionospheric plasma bubbles in the height range of the airglow emissions (e.g., Moore and Weber, 1989; Mendillo et al., 1985). These airglow depletions are not present on the night 04/05.

(FIGURES 1 AND 2)

The characteristics of magnetic field-aligned plasma bubbles in the nighttime tropical ionosphere have been investigated by Tsunoda (1980, 1981) using measurements of both incoherent scatter and backscatter from ionospheric plasma irreularities made with the ALTAIR radar. These measurements have shown that the plasma bubbles are aligned along the magnetic field lines and also allowed the determination of the upward bubble velocity (which is of the order of 100 m/s). Determination of plasma bubble vertical rise velocities, using spaced ionosonde observations, have been presented by Abdu et al. (1983). All-sky imaging nightglow measurements have also been made by Moore and Weber (1981) and Mendillo and Baumgardner (1982), who deseribed the development and motion of F-region nightglow depletions as associated with the magnetic field-aligned low density plasma bubbles which develop in the post-sunset ionosphere, after a rapid upward lifting of the ionospheric layer caused by an enhanced E x B plasma drift velocity. These plasma depletions drift toward the east in the equatorial ionosphere and are often tilted or curved to the west of the magnetic meridian because of the upward motion of the bubble. The associated airglow depletions often show a westward tilt with respect to the magnetic meridian, which must be the optical manifestation of the westward tilts of plasma depletion plumes recorded by incoherent scatter radar (Woodman and LaHoz, 1976; Tsunoda, 1980, 1981) and by in situ probes (McClure et al., 1977). This curvature is most apparent away from the magnetic equator, for magnetic latitudes greater than about 12 . The combination of the angle between the depletion axis and the magnetic meridian, with the eastward drift produces an apparent north-south velocity in ground-based photometer records scanning along the magnetic meridian. This type of behavior can be seen in the airglow patches shown in Figures 1 and 2 on the night 02/03, around 21:30 LT, where the depletion appears first in the north and gradually moves to the south. Another interesting feature can be observed about 23:30 LT, which is possibly due to a wishbone type structure. Bifurcation of a buoyantly rising bubble has been investigated theoretically, using a computer simulation technique, by Zalesak et al. (1982).

CONCLUSIONS

Atomic oxygen nightglow emissions which result primarily from radiative recombination and from dissociative recombination processes are very useful for remote sensing of the ionospheric F-region peak electron density and peak height. Simultaneous measurements of these emissions provide a very useful and powerful technique to study dynamical processes in the tropical F-region and, in particular, to study the spatial and local time variations of large scale plasma irregularities or transequatorial field-aligned plasma bubbles.

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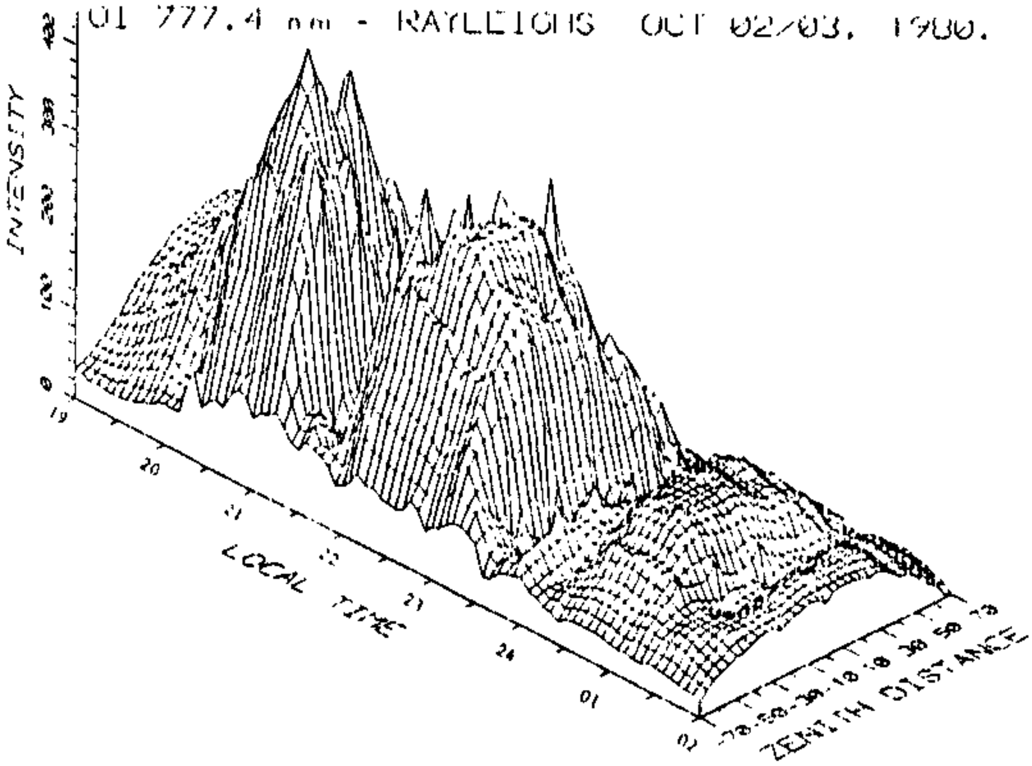
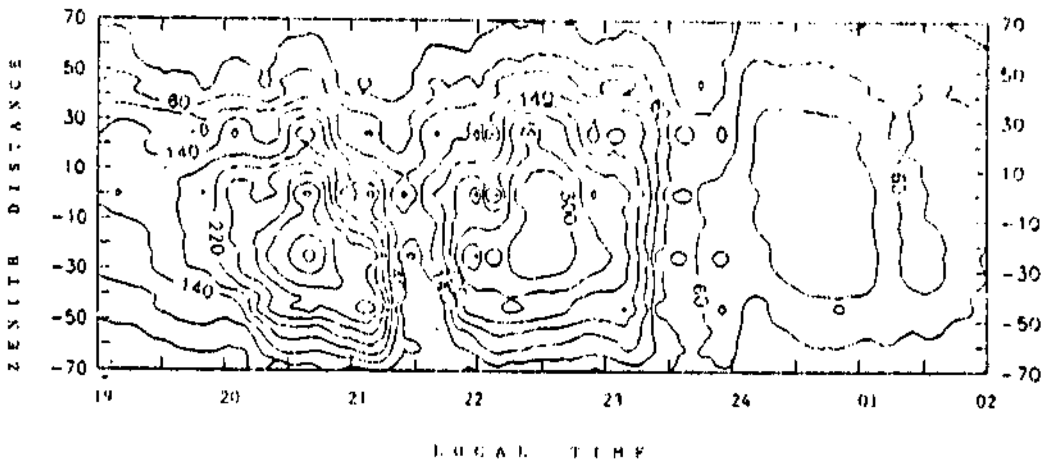
FIGURE CAPTIONS

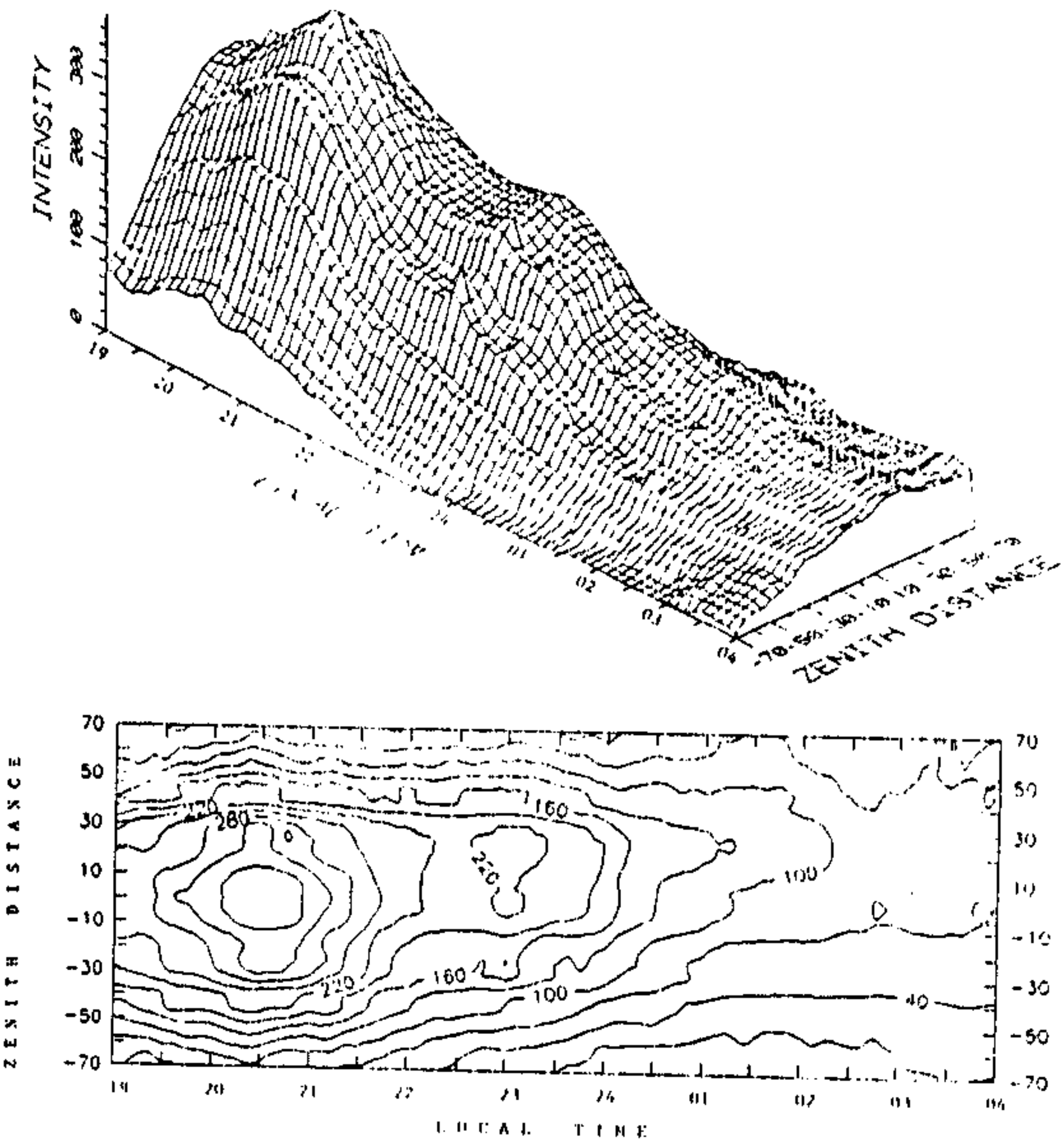
Figure 1 - Observed intensities for the OI 777.4 nm emission as a function of local time and zenith distance scanned along the magnetic north-south meridian, at Cachoeira Paulista.

Figure 2 - Observed intensities for the OI 630.0 nm emission as a function of local time and zenith distance scanned along the magnetic north-south meridian, at Cachoeira Paulista.


OI 777.4 nm - RAYLEIGHS OCT 02/03, 1980.
INTENSITY
LOCAL TIME
ZENITH DISTANCE


ZENITH DISTANCE
LOCAL TIME

OI 777.4 nm - RAYLEIGHS OCT 04/05, 1980.



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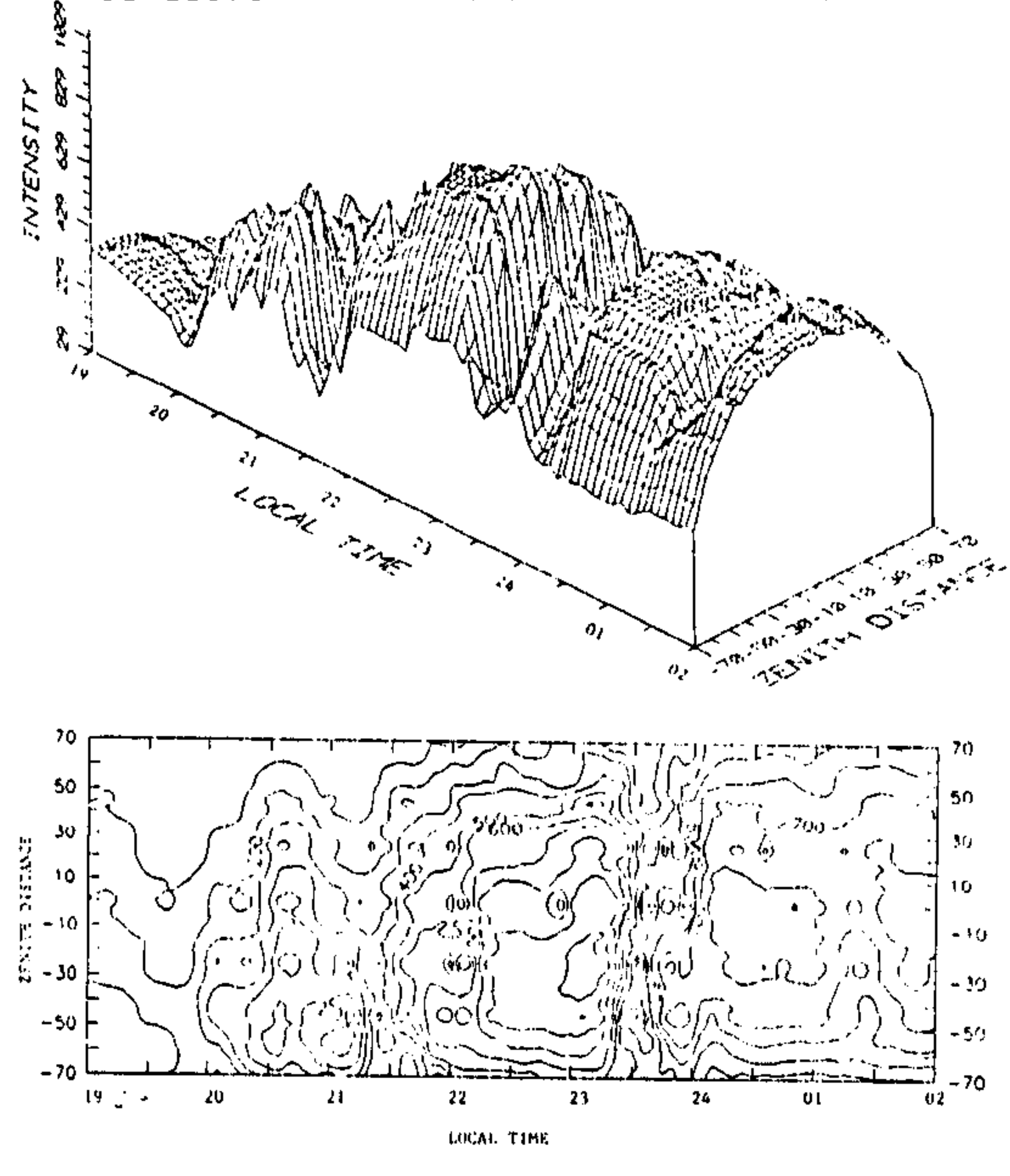

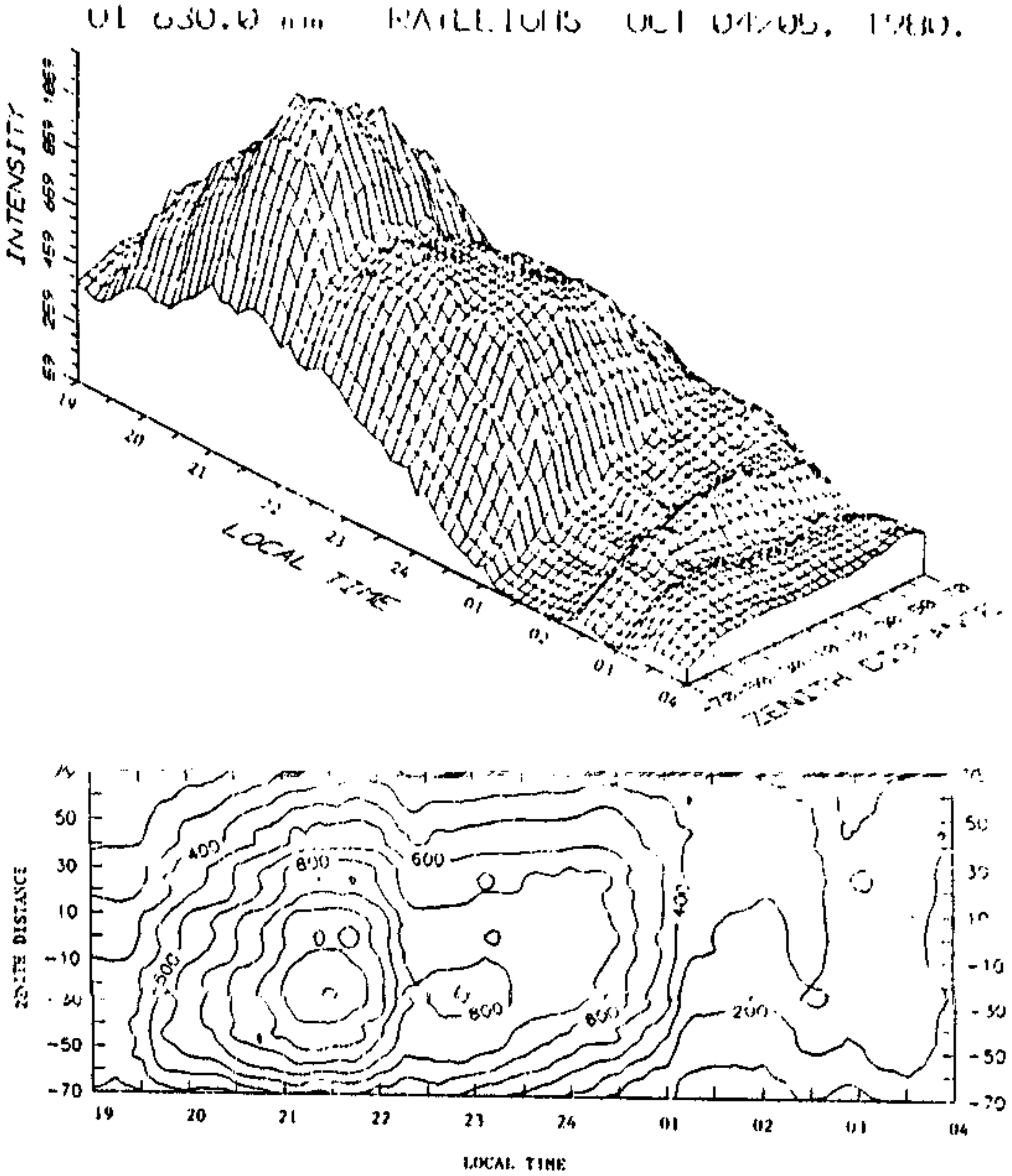

OI 630.0 nm
OCT 04/05, 1980.
INTENSITY
LOCAL TIME
19
20
21
22
23
24
01
02
03
04
ZENITH DISTANCE
50
30
10
-10
-30
-50
-70
400
800
600
500
200
LOCAL TIME