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Variation of *F*-region nighttime neutral temperatures with equatorial spread-*F* activity

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Abstract. Nighttime *F*-region temperatures have been obtained over Mount Abu (24·6° N, 72·7° E geographic, 15·0° geomagnetic latitude) by monitoring OI 6300 Å line widths, using Fabry–Perot spectrometer. Enhancement in neutral temperatures associated with spread-*F* activity over Thumba (8·5° N, 76·8° E geographic, 0·6° S geomagnetic), which is on the magnetic equator were reported earlier. Additional data over Mt Abu for seven days bring out the following major features. (i) In the *F*-region over Mt Abu, the neutral temperature enhancements upto 200° K are observed on most of the nights when there is spread-*F* activity over the magnetic equator. (ii) There are no occasions which show temperature enhancements over Mt Abu without spread-*F* activity over the equator. On such occasions the observed atmospheric temperatures agree very well with those calculated on the basis of the Jachhia atmospheric model, both for magnetically quiet as well as disturbed days. (iii) There is a good indication that the increase in *F*-region temperature over Mt Abu is delayed with respect to the onset of spread-*F* over Thumba by approximately 15–30 min.

Keywords. Nighttime neutral temperature; equatorial spread-*F*.

1. Introduction

In our earlier publication (Rajaraman *et al* 1978) we described preliminary results of *F*-region nighttime temperatures obtained with a pressure scanned Fabry-Perot spectrometer operated from Mount Abu. These results showed very good correlation between occurrence of spread-*F* over an equatorial station, Thumba (8·5° N, 76·8° E geographic, 0·6° S geomagnetic) and an observed increase in temperature over Mt Abu (24·6° N, 72·7° E geographic, 15·0° geomagnetic) as determined from the Doppler width of 6300 Å night airglow line. This essentially confirmed the idea that the dissipation of turbulent electric fields thought to be associated with spread-*F* in equatorial regions cause significant heating of neutral atmosphere (Cole 1974). Subsequently, we have acquired further temperature data from Mt Abu which entirely confirm this conclusion. It is the purpose of this paper to describe and discuss these observations.

The data reduction procedure has also been subsequently modified and refined as follows. After acquiring the profile of the airglow line (in steps of approximately 0·0015 Å, four repeated scans being usually taken to obtain good signal-to-noise ratio), the instrument control profile is then obtained using He–Ne 6328 Å laser line. The instrument profile is then convolved with a series of Doppler profiles ranging from 700° K to 1200° K in steps of 100° K, appropriate to oxygen atom to generate the synthetic profiles. Smoothened airglow profile is then compared with the synthetic profiles to get the temperature as well as the probable error. Figure 1 shows a typical set of synthetic profiles and a comparison of an observed airglow profile with the same ($T = 930°$ K, probable error $\pm$ 40°).

2. Results

The observations cover 7 nights from 8 December 1977 to 14 December 1977 for which complete data reduction has been done.

Figures 2 to 5 show the following:

(i) observed temperatures which have been indicated by (+) sign;
(ii) Jachhia (1970) model atmosphere temperatures are shown by a continuous line; and
(iii) time and duration of spread-*F* over an equatorial station (Thumba/Kodaikanal).

These observations conclusively show that a temperature increase of $\simeq$ 200° K over Mt Abu is associated with occurrence of spread-*F* over Thumba. There is also a fairly good indication that the increase in the temperature is delayed with respect to the onset of spread-*F* by about 15–30 min.

3. Discussion

Whereas the basic mechanism of heat input can be attributed to the Joule dissipation of the electric currents associated with turbulent electric fields at the time of equatorial spread-*F*, the exact process through which the increase in temperature takes place at the altitude of emission, is not clear. In this respect it is important to note that on all these seven nights, no spread-*F* occurrence till midnight was recorded by ionosonde located at Ahmedabad at a distance of approximately 150 km to the south of Mt Abu. It seems possible, however, that the heating in *F*-region over Mt Abu takes place through heat conveyed by charged particles from spread-*F* region downwards along the magnetic field line. 250–300 km altitude field lines over Mt Abu connect with 700 km region over the magnetic equator, hence the spread-*F* activity in the topside ionosphere over the magnetic equator is expected to contribute to the increase in the *F*-region temperature over Mt Abu. Top-side ionospheric soundings have shown (Krishnamurthy 1966) that the occurrence of spread-*F* in the top-side is very well correlated with the spread-*F* in the bottom-side. Simultaneous observations of Doppler width temperatures from two appropriately located stations on the same longitude should help in properly understanding the exact mechanism responsible for the heating of *F*-region over Mt Abu.

The important conclusion of these investigations is as follows. There is a heating source at *F*-region altitudes for low latitude stations, whose spatial extent and

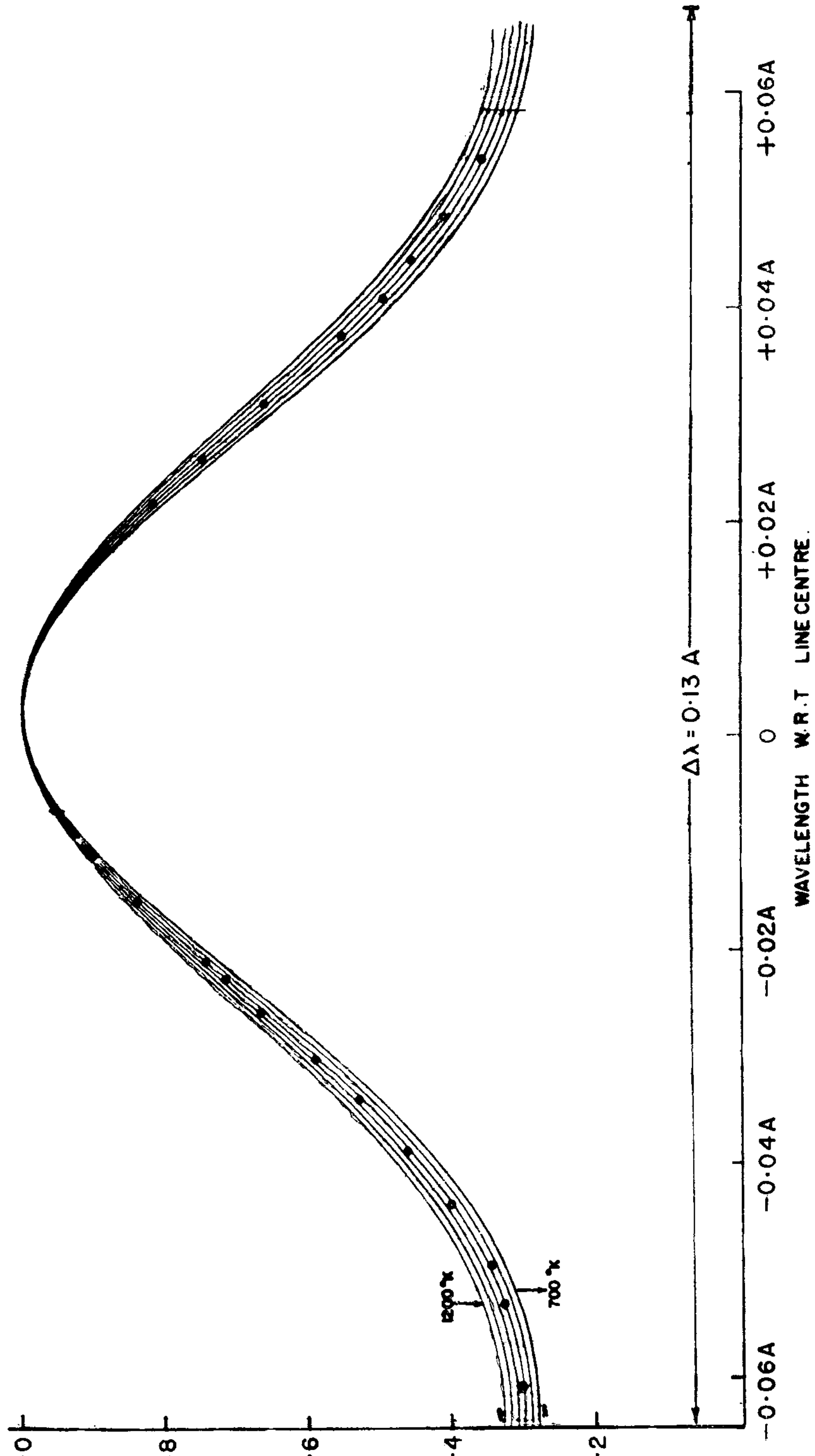

Figure 1. A comparison of the observed 6300 Å night airglow profiles with a set of synthetic profiles. Date 8 December 1977.

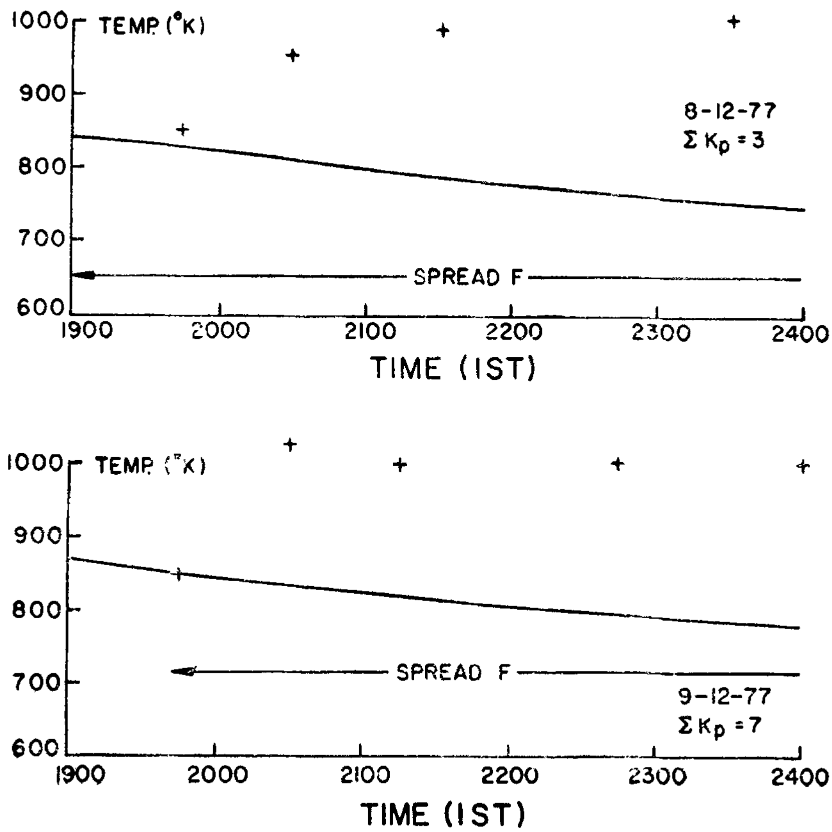
TEMP (°K)
1000
900
800
700
600
8-12-77
Σ Kp = 3
SPREAD F
1900
2000
2100
2200
2300
2400
TIME (IST)
TEMP (°K)
1000
900
800
700
600
SPREAD F
9-12-77
Σ Kp = 7
1900
2000
2100
2200
2300
2400
TIME (IST)

Figure 2.

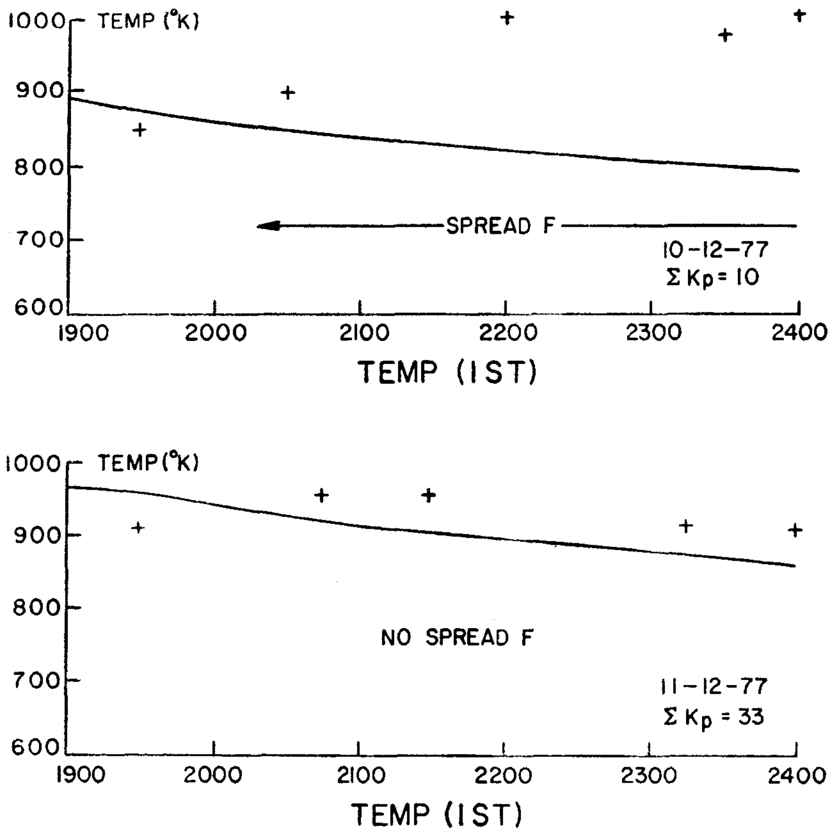
1000
TEMP (°K)
900
800
700
600
SPREAD F
10-12-77
Σ Kp = 10
1900
2000
2100
2200
2300
2400
TEMP (IST)
1000
TEMP(°K)
900
800
NO SPREAD F
700
11-12-77
Σ Kp = 33
600
1900
2000
2100
2200
2300
2400
TEMP (IST)

Figure 3.

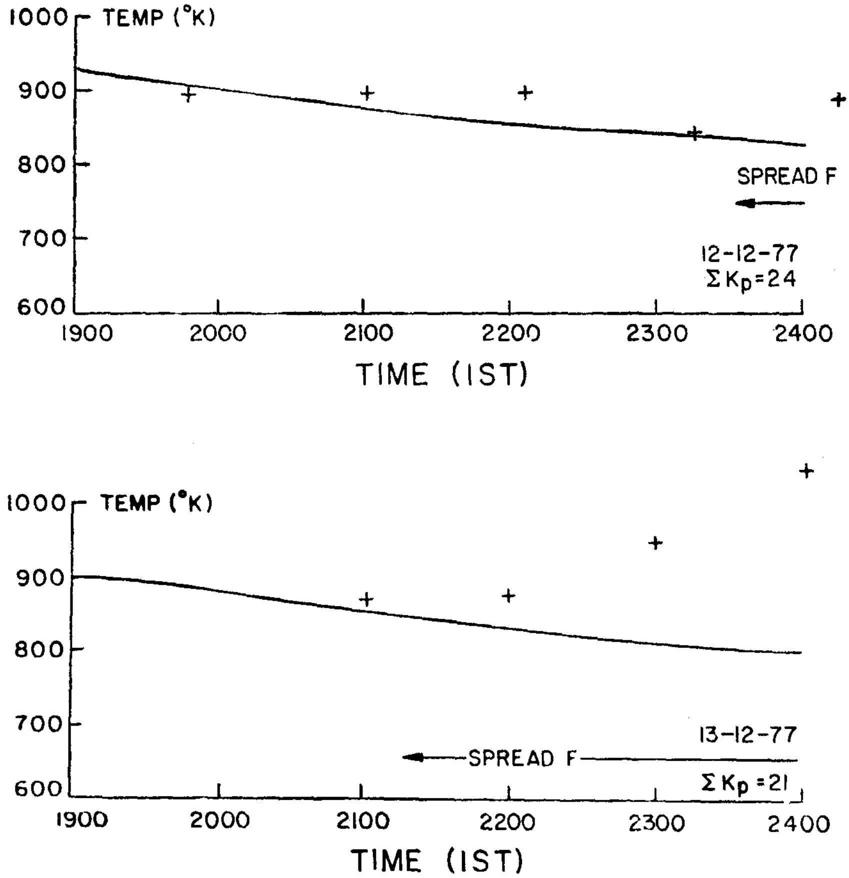

Figure 4.

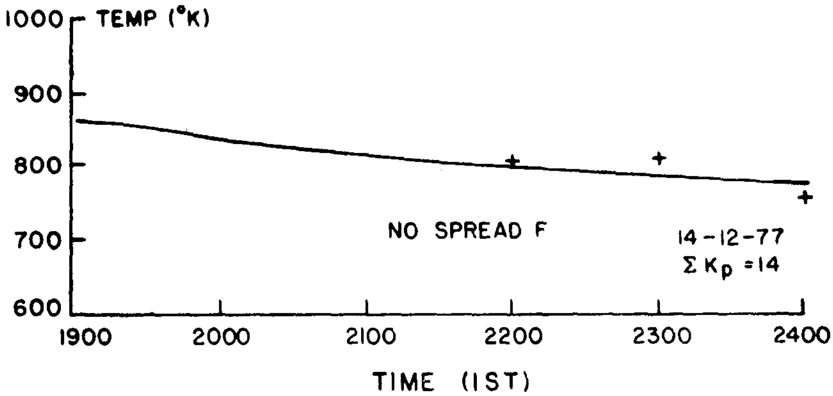

Figure 5.

Figures 2 to 5. Observed and the model atmospheric (Jachhia-70) temperatures versus IST. Onset times for bottom-side spread-*F* events are also shown.

time variations are required to be investigated further. Since the observed excess temperatures are fairly large, its implications on the dynamics of the neutral atmosphere are important.

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