THE IONOSPHERIC CRITICAL FREQUENCY IN THE CREST ZONE OF APPLETON ANOMALY IN CHINA

HUANG Tian-xi
Wuhan Institute of Physics, Academia Sinica, Wuhan, China

INTRODUCTION

The F-region is the main part of the ionosphere. Because the F-region possesses complicated thermodynamic, electrodynamic and photochemical characteristics, its structure and motion regularities as well as its long-term variations have been much concerned with by the aeronomical society.

In China, ionospheric investigation stared around 1936 at Wuhan and in the Southeast China but was irregular in some early years. Through almost a half century, observations of the ionospheric behaviour at the low latitude of Wuhan in the East Asian sector have been made on the radio wave propagation in the ionosphere, spread-F, sporadic E, solar ecliptic effect on the ionosphere and propagation, the ionospheric response to the geomagnetic activity, the forenoon bite-out, the regular and random movements, the transient, diurnal, seasonal and perennial variations, the ionospheric electron content and concentration, the ionospheric absorption, drift and irregularities, re-entry plasma sheath, satellite telecommunications, etc.

The purpose of this paper is to study the main features in nearly three solar-cycle variations of midday foF2 from 1954 to 1985 and its response to solar phases at a typical South China station, Wuhan (30.5°N, 114.4°E; Magnetic Dip Lat. 26°N).

SOLAR CYCLE VARIATION

Figure 1 shows the solar cycle and seasonal variations in $\overline{foF2}$ at midday (12 LT) as well as at midnight (00 LT) over Wuhan during a long period from January 1954 throughout February 1985 by using a reasonable and suitable method of the smoothed ten-day mean of midday foF2 (Huang and Wu, 1984) in which a ten-day interval is taken as the fundamental unit for averaging. Among each of 374 months the first ten days are grouped as the first set of data, the middle ten days as the second, and the last ten or eleven days (or eight or nine days if in February) as the third. At Wuhan, the data before June 1957 were from the manual ionosonde observations and since July 1957 the ionogram records have been made by using the

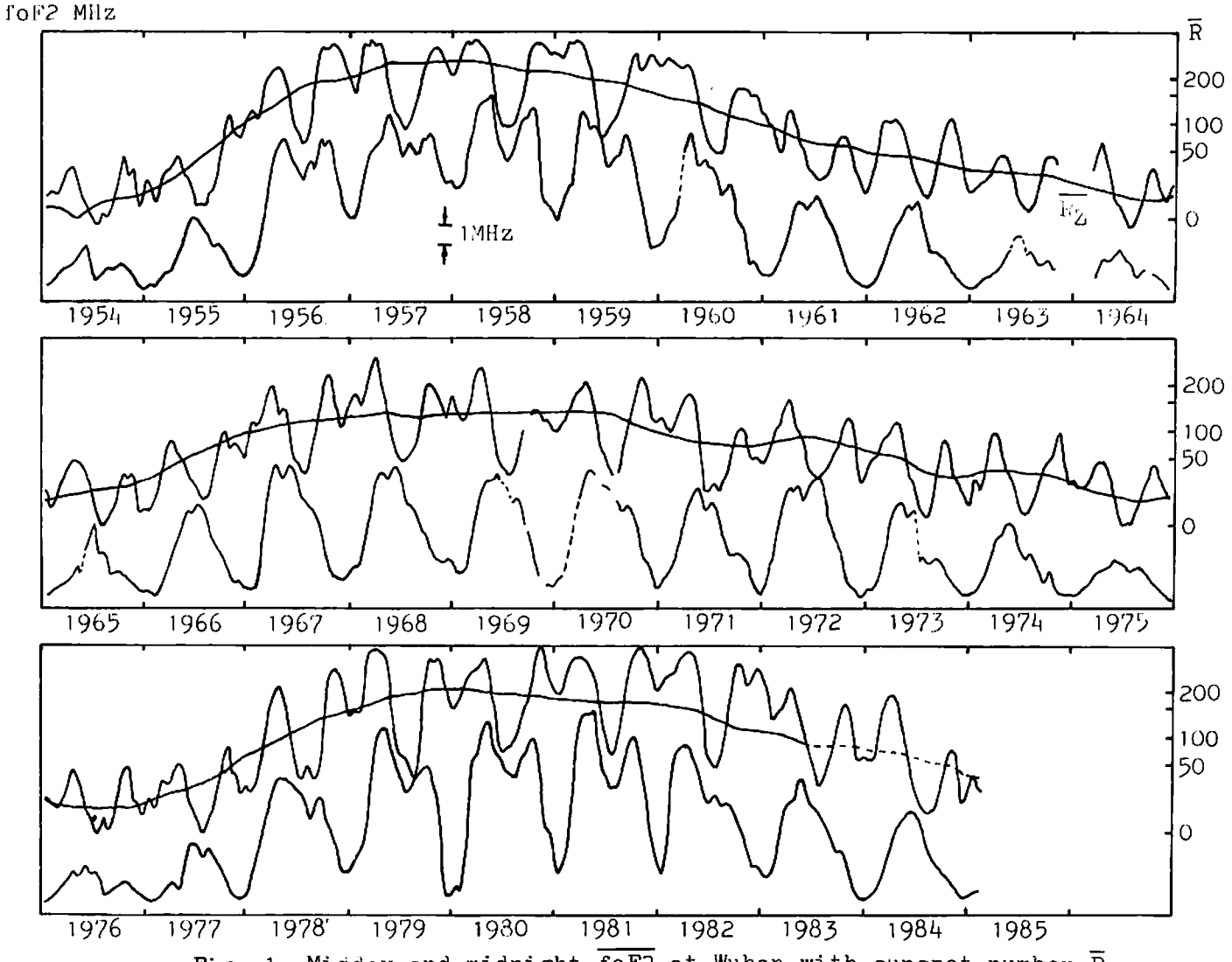

Fig. 1. Midday and midnight $\overline{foF2}$ at Wuhan with sunspot number $\overline{R}$

advanced automatic ionosondes. The curve of $\overline{foF2}$ in the Figure 1 for almost three complete solar cycles is from more than 11200 midday and midnight data and consists of 1120 data of smoothed ten-day mean $\overline{foF2}$. Also given in the Figure 1 are smoothed monthly mean Zurich sunspot numbers (or International sunspot numbers after January 1981) $\overline{R_Z}$. The relationship between midday $\overline{foF2}$ at Wuhan and $\overline{R_Z}$ over thirty-one years can be expressed by an empirical formula:

$$\overline{foF2} = \sqrt{\overline{R_Z}} / 1.6 + 5.1 \text{ (MHz)}.$$

It is very interesting to outline a number of characteristics of the long-term $\overline{foF2}$ variation at Wuhan.

(a) The seasonal variation from one summer to the next at solar maxima has a prominent M-shaped characteristic with two peaks near autumnal and vernal equinoxes and a valley around winter solstice. The formation of this M-shaped characteristic is conspicuous by the fact of the particularly low $\overline{foF2}$ in summer comparing with all other seasons. It is anomalously low summer midday $\overline{foF2}$ rather than the winter one that makes the seasonal anomaly and may be called the foF2 summer anomaly. This is one of midday $\overline{foF2}$ features.

(b) The midday $\overline{foF2}$ seasonal variation during solar minima appears to have a semiannual 'sawtoothed' feature, the presence of which is because of winter $\overline{foF2}$ becoming lower.

(c) Among four midday extreme values in a year the relative superiority between the two $\overline{foF2}$ peaks occurring in spring and in autumn is determined by the solar phase (ascending or descending epoch): if solar activity is rising the autumnal $\overline{foF2}$ peak generally outstrips the vernal one in the same year and is lower than the next vernal one in the following year, and vice versa. However, the summer $\overline{foF2}$ minimum is always more depressed than the winter one.

(d) The interval from the vernal peak to the autumnal peak during the same year is more than 6.5 months statistically, but the interval from the autumnal maximum to the following vernal maximum is shorter than 5.5 months.

(e) As for midnight $\overline{foF2}$, it can be seen from Figure 1 that during solar maxima it behaves the similar M-shaped characteristic from winter to winter which shifts half a year from that for midday $\overline{foF2}$. However, during the low sunspot years the seasonal variation turns to an annual 'quasi-sinusoid' feature. During summer the difference between midday $\overline{foF2}$ and midnight $\overline{foF2}$ decreases which is far apart from the situation during other seasons especially winter.

The long-term behaviour of the midday extreme values in different seasons discussed above may be illustrated more directly in Figure 2. The semiyearly mean variation of the smoothed monthly mean sunspot numbers during 1954-1984 is shown in Fig. 5a. 5b and 5c give the variations of differences between the mean values of vernal and autumnal maxima and the summer minima sandwiched, and between the mean values of the preceding and succeeding winter maxima and the summer in between, respectively. It is quite evident that both of these present positive correlation on the whole with the sunspot numbers.

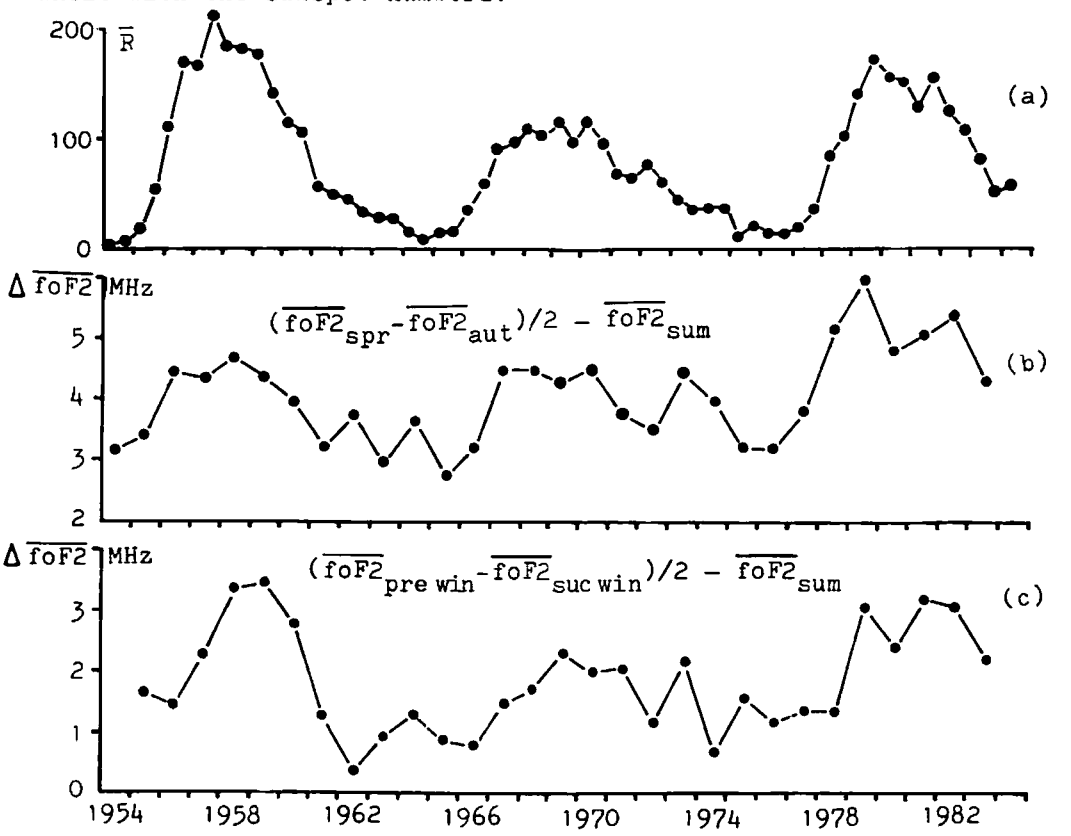

Fig. 2. The relationship between the seasonal differences of midday $\overline{foF2}$ extreme values and the solar activity at Wuhan from 1954 to 1984

REFERENCE

Huang Tian-xi and Wu Guang-hui, 1984, Some studies of the ionospheric F-layer behaviour over Wuhan and its relationship with solar activity, 7th International Symposium on Equatorial Aeronomy, Hong Kong, March 1984, Vol. 2, 6-16.