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Characteristics of spread-F at a temperate latitude station, Jamaica

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The characteristics of spread-F at a temperate latitude station vis-a-vis those at an equatorial station in the same longitude zone are described. Temperate latitude spread signature on the ionogram is shown to be due to a number of off-vertical reflections superimposed over the normal vertical *p'-f* trace. At temperate latitude, the background F region ionization seems to increase during spread-F conditions. Onset time of spread-F seems to increase with distance from the equator, being about 1930 hrs at the equator, about 2200 hrs at the anomaly crest region, and about 0000 hrs at temperate latitudes.

Spread-F irregularities were first discovered at equatorial station Huancayo by Booker and Wells[1]. Extensive studies have been made of equatorial spread-F by direct examination of ionograms at Singapore by Osborne[2], at Kodaikanal by Bhargava[3], at Baguio by Marasigan[4], at Ibadan by Lyon *et al.*[5], and at Thumba by Chandra and Rastogi[6]. Cohen and Bowles[7] have described the features of equatorial spread-F as observed through VHF backscatter radar. Woodman and LaHoz[8] have described the F region irregularities over Jicamarca through the backscatter echo power maps, a very powerful technique to study the irregularities below as well as above the F2 layer peak. Rastogi[9] has described the simultaneous observations of F region irregularities at Huancayo through HF ionosonde records and at Jicamarca through VHF backscatter echo power maps. Argo and Kelley[10] have described interesting features of equatorial spread-F by simultaneous observations of data from digital ionosonde VHF backscatter radar and rocketborne instruments.

Comparatively little attention has been paid to the study of spread-F irregularities at tropical and subtropical latitudes. Extensive studies of spread-F have been made at Brisbane since 1956 and are still being continued, improving continuously the techniques[11-14]. Rastogi and Kulkarni[15] described for the first time spread-F irregularities at a station very close to the crest of F region anomaly belt. It was found that during the pre-midnight hours when the background ionization was large, spread-F characteristics were mainly of range spreading over the complete frequency range of the ionograms. During the post-midnight hours, when the F region ionization was low, the spread-F was generally of the frequency spreading type. Huang[16] has described the range and frequency types of spread-F at Taipei, a station close to the F region anomaly crest zone. Detailed seasonal and solar cycle variations of frequency and range type of spread-F at Taipei/Chungli have been described by Huang *et al.*[17] Rastogi[18] suggested that the spread-F observed within the low latitude anomaly belt is the result of a fountain of plasma irregularities initiated over the magnetic equator after sunset on certain days with favourable conditions. This communication describes the characteristics and development of spread-F at a temperate and an equatorial station situated on the same longitude zone. Actual ionograms were examined for Huancayo (dipole lat. 1°S), Bogota (dipole lat. 16°N) and Jamaica (dipole lat. 29°N) for January 1964, a period of low solar activity. It may be mentioned that Huancayo lies at the trough of F region equatorial anomaly belt, while Bogota is close to the crest and Jamaica outside the anomaly belt.

First of all we compare in Fig. 1 the characteristics of spread-F at tropical latitude Jamaica with those at Huancayo, an equatorial station in the same longitude zone. Fig. 1(a) representing range type equatorial spread-F shows layers at a number of altitudes, none of these traces show sign of group retardation and hence are due to scattering rather than reflection of radio waves. Heights of

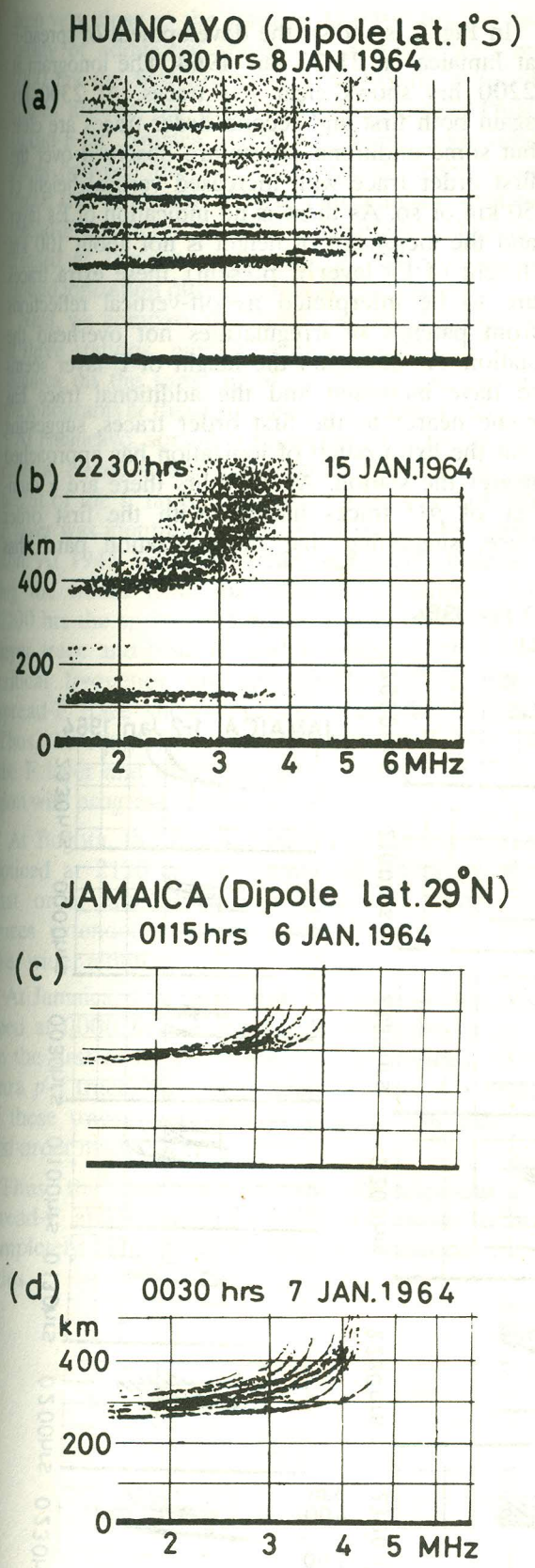

Fig. 1 – Examples of range and frequency types of spread-F at equatorial and temperate latitude stations

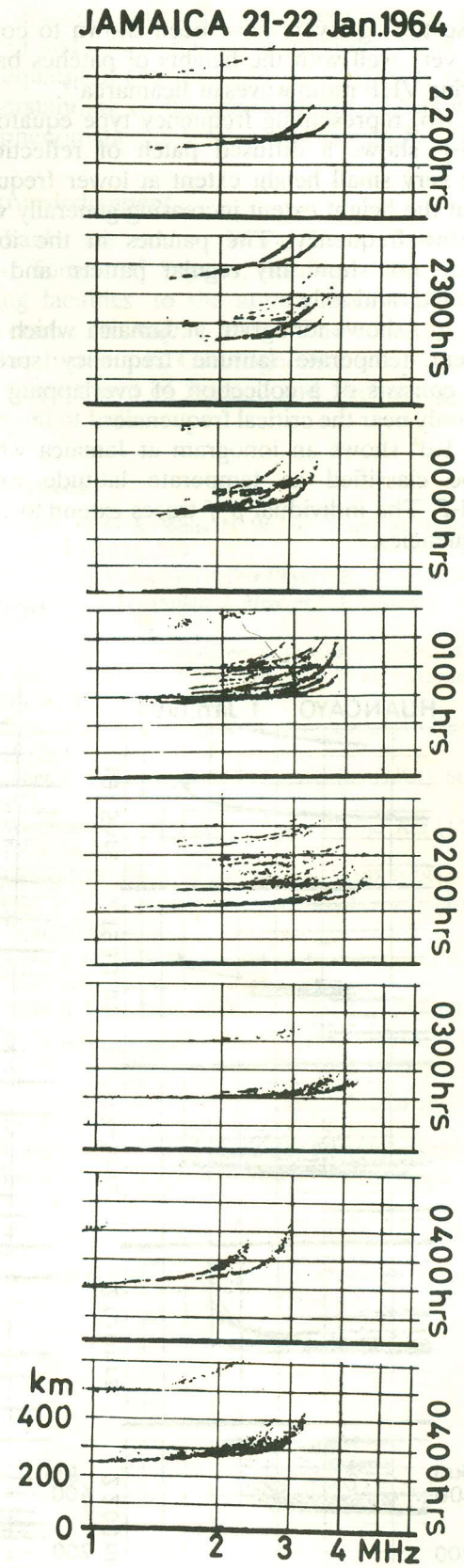

Fig. 2 – Development of spread-F at Jamaica on 21-22 Jan. 1964

these scattering layers have been shown to correspond very well with the heights of patches backscattering VHF radio waves at Jicamarca[19].

Fig. 1(b) representing frequency type equatorial spread-F shows a diffused patch of reflections, having very small height extent at lower frequencies but the height extent increasing generally with increasing frequency. The patches in the ionogram do not show any regular pattern and are distributed randomly.

Fig. 1(c) shows ionogram at Jamaica which can represent temperate latitude frequency spread, and it consists of a collection of overlapping p'-f traces only near the critical frequencies.

Fig. 1(d) shows an ionogram at Jamaica which can be classified as temperate latitude range spread-F. The individual p'-f traces extend to lower frequencies.

In Fig. 2 is shown the development of spread-F at Jamaica on 21-22 Jan. 1964. The ionogram at 2200 hrs shows clear p'-f traces. At 2300 hrs again both first and second order traces are clear but some additional traces are observed over the first order trace with increased vertical height of 50 km or so. As there is no indication of Es layer and the increment of height is not about 100 km (height of Es layer if present), these extra traces are to be interpreted as off-vertical reflections from patches of irregularities not overhead the station. At 0000 hrs the height of F layer seems to have increased and the additional trace has come nearer to the first order traces, suggesting that the extra patch of ionization has approached nearer the station. At 0100 hrs there are a number of p'-f traces merged with the first order trace, suggesting that the ionization patch has

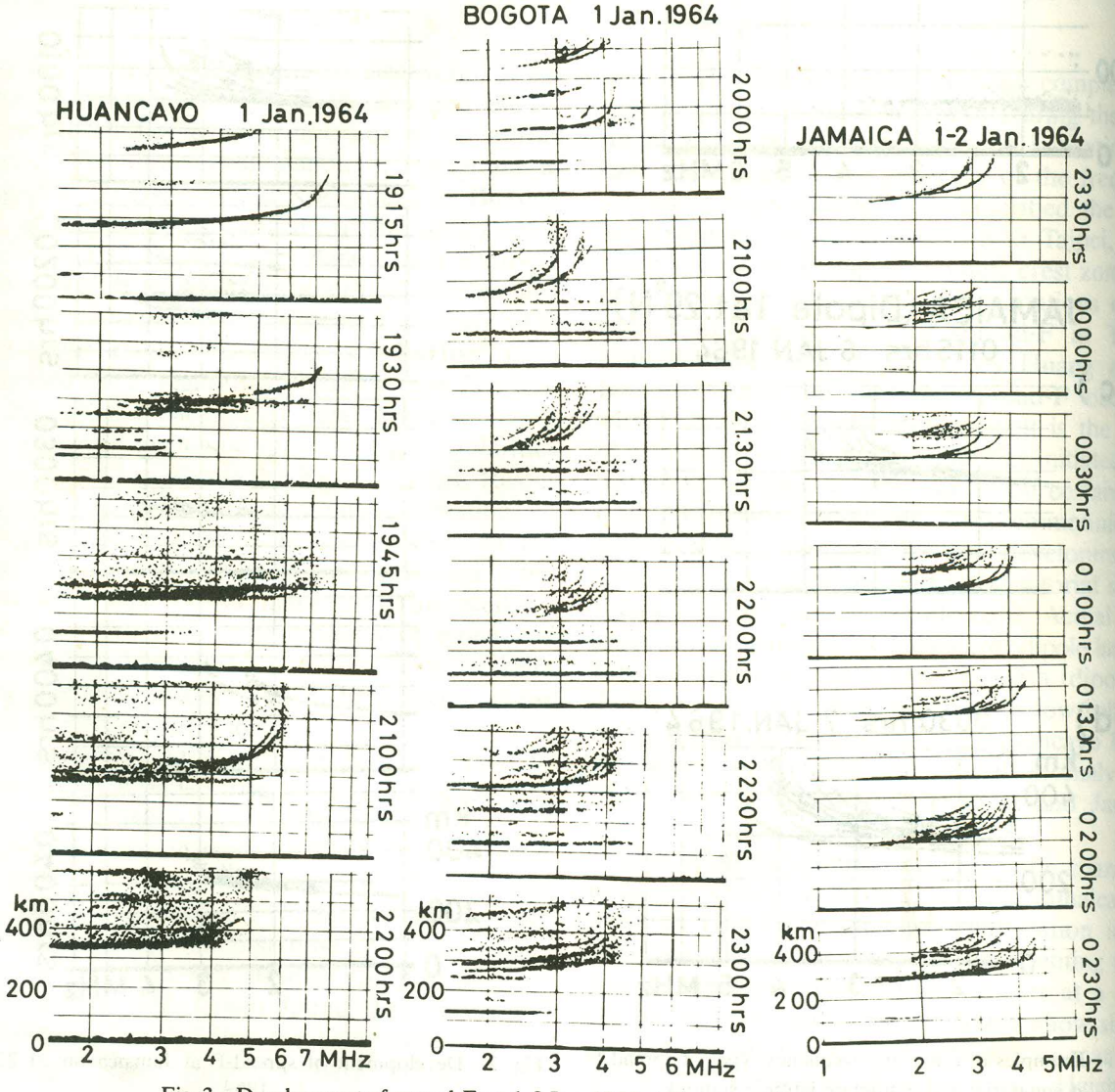

Fig. 3 – Development of spread-F on 1-2 Jan. 1964 at Huancayo, Bogota and Jamaica

been very close to the station. At 0200 hrs the intensity of additional traces is reduced and by 0300 hrs the first order trace has some diffused echoes around the main reflection traces. Thus, spread-F at Jamaica starts with some additional traces between the first and second order main traces. It is important to note that with the start of spread-F condition the critical frequencies had increased at Jamaica, suggesting increase of background ionization during spread-F condition.

Next, we compare the development of spread-F at three stations, namely, Huancayo, Bogota and Jamaica on the same night. In Fig. 3 are shown the ionograms at these stations on 1-2 Jan. 1964.

At Huancayo, spread-F started at 1930 hrs as additional traces at and below the minimum virtual height of the F layer, the critical frequency of the F layer was identifiable under the spread-F condition. At 1945 hrs, the spread increased obliterating the traces near the critical frequencies. At 2100 hrs the spread-F trace is clearly below the F layer trace and both o- and x-components of the critical frequency are identifiable. At no time spread-F trace showed group retardation effects. Thus, the equatorial spread-F starts at the base of the F layer and may extend throughout the F region with progress of time.

At Bogota, the first indication of spread-F was noticed at 2130 hrs as additional traces on the first order trace. At later time the additional traces extended towards lower frequencies and over wider altitudes.

At Jamaica, first indication of spread-F was noticed at 0000 hrs as additional off-vertical traces on the first order p'-f trace. The identification of extra p'-f traces was clear and the vertical heights of these traces were always greater than that of first order main trace.

Thus, the characteristics and development of spread-F at temperate latitudes are shown to be completely different from those at equatorial latitudes.

A detailed study of actual ionograms at a number of stations in the same longitude zone within the equatorial anomaly belt would greatly help the understanding of the development of this important phenomenon of low latitude spread-F.

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