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MAGNETIC DECLINATION CONTROL OF THE EQUATORIAL F-REGION DYNAMO ELECTRIC FIELD DEVELOPMENT AND SPREAD-F

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ABSTRACT

We have carried out a comparative study of the evening prereversal enhancements in the equatorial F-region vertical ionization drift velocities (V_z) over Fortaleza (4°S, 38°W), Brazil, and Jicamarca (12°S, 77°W), Peru, two magnetic equatorial stations in the American zone. The results show profound dissimilarities in the seasonal trends in the time and widths of the V_z prereversal peak, that reflect in the spread F characteristics as well, at the two stations. The dissimilarities are shown to be arising mainly from the difference in the magnetic field declination angles that causes differences in the conjugate E region sunset durations and, hence, in the F-region polarization electric field development rates, at the two stations.

Revised August, 1981

INTRODUCTION

Close connection between the vertical movements of the equatorial evening ionosphere and the occurrence of ionospheric irregularities, that give rise to the VHF radar scatter echoes and spread F traces in ionograms, has been well documented in the literature (Booker and Wells, 1938; Farley et al., 1970; Woodman, 1970). The daytime equatorial F-layer ionization moves upwards due to the $\tilde{E} \times \tilde{B}$ drift arising from the E region dynamo induced eastward electric field that gets reversed at night, causing a reversal also in the ionization drift velocity (V_z) to downward. Before its reversal, however, the V_z undergoes a rapid enhancement giving rise to a prereversal maximum in the V_z, believed to be caused by the build up of the F-region polarization electric field (namely, F-region dynamo field produced by thermospheric winds) that arises from the decrease in the E-layer conductivity following sunset (Rishbeth, 1971, 1977). The amplitude of this prereversal V_z peak influences in a significant way the occurrence and duration of the spread F events (Woodman, 1970). Spread F has been observed to occur also following nighttime reversals to upwards in the F region drift velocity, presumably due to electric field reversals originating from high latitude sources(Fejer et al., 1976; Rastogi and Woodman, 1978).

This paper is concerned with some observations of the evening prereversal V_z enhancements and its possible implications on the development of the F-region dynamo field. We have compared vertical F-region drift velocities, deduced from ionograms over Fortaleza (4^oS, 38^oW), with those measured by VHF radar over Jicamarca (12^oS, 77^oW), for different seasons. The results show remarkable difference in the prereversal V_z enhancement features at the two stations, which could be arising from the differences in the magnetic field declination angles that cause significant differences in the conjugate E-region sunset durations and, hence, in differing rates of F-region polarization electric field developments at the two stations.

RESULTS AND DISCUSSION

Figure 1 presents monthly mean diurnal variations of vertical F-layer velocities (V_z) deduced as d(h'F)/dt from ionograms over Fortaleza (see Abdu et al., 1981) representing summer (sourthern solstice), equinoxes and winter (northern solstice) months. The velocities deduced here as the derivative of h'F would be a valid representation for the $\underset{\sim}{E} \times \underset{\sim}{B}$ vertical drift velocity when the low lying ionization is small, which is nearly true in the nighttime ionograms, and when the recombination is small at these heights. Bittencourt and Abdu (1981) have shown theoretically that the threshold height, above which the recombination is small enough to make equal the true velocity and that deduced from the movement of the iso-electron density contour (i.e. d(h'F)/dt), is in the vicinity of 300 km. Our discussion in this paper is restricted to the evening hours, when h'F over Fortaleza is usually above 300 km. Presented together for comparison, in Figure 1, are the mean local time variations for different seasons of the vertical ionization drift velocities, measured by the Jicamarca radar, for the period 1968-71, taken from Fejer et al. (1979). The V_z values deduced from Fortaleza ionograms, after about 23 LT in summer and equinoctial months, and after about 01 LT in winter, are underestimated because of the recombination process, since the h'F values at these times are below the threshold altitude of 300 km (see Figure 4 of Abdu et al., 1981).

We may notice, in Figure 1, that the evening prereversal maximum in V_z has highest amplitude in summer (and lowest in winter) months at both Fortaleza and Jicamarca. This feature has its counterpart in the seasonal variations in the occurrence rates of range type spread F that show large summer values (with a winter minimum) at Fortaleza and Huancayo. During equinoxes the V_z peak as well as the range type spread F are high at both the stations.

The amplitude of the V_z evening prereversal peak seems to have significant influence on the appearence of post sunset range type spread F as seen from the results of Woodman (1970) that suggested a general absence of the spread F occurrence over Huancayo on days when the prereversal V_z peak measured by Jicamarca radar was very weak or absent, and also presence of spread F when a prereversal V_z enhancement was present. Rastogi (1978) presented results that supported such a dependence. More recently, a statistical study of one year data over Fortaleza showed that the spread F indices, in the post sunset hours on individual days, has a pronounced dependence on the amplitude of the V_z prereversal maximum on the same day determined from ionograms (Medeiros, 1981). The seasonal mean trends of the V_z peak and spread F occurrence rates, presented in Figures (1) and (2),therefore, lead to a conclusion, in agreement with the previous results, that the probability of the range type spread F occurrence is in general heigher for larger amplitude of the V_z prereversal peak.

Such a dependence on V_z prereversal amplitude does not seem to be present in the case of the frequency type spread F occurrence. These two types of the spread F events seem to be associated with irregularities generated under different conditions of the equatorial ionosphere. For example, Rastogi and Woodman (1978) have presented some results suggesting that VHF radar returns over Jicamarca arise from irregularities that coexist with those responsible for range type spread F, but not frequency type spread F in the ionograms of Huancayo (see, also, Cohen and Bowles, 1961; Abdu et al., 1981).

The most outstanding feature of Figure 1 is the seasonal trends in the times and, to some extent, in the widths of the prereversal V_z peaks that show exactly opposite behaviour at the two stations. Over Jicamarca the V_z peak occurs earlier in winter and later in summer, as would be expected from the seasonal trends in the local sunset time. Over Fortaleza, situated closer to the geographic equator, also, in the shouthern hemisphere and ~38^o eastward of

Jicamarca, a similar trend but to a lesser degree would be expected, whereas the observed trend in Figure 1 is exactly opposite. As a counterpart to this feature we may notice, in Figure 2, that the occurrence rate of frequency type spread F presents a summer maximum over Huancayo, whereas Fortaleza presents a winter maximum. The late occurrence, with larger width, of the V_z prereversal peak results in high h'F values in premidnight period, which seems to be responsible for the higher incidence rate of frequency type spread F seen relatively more pronounced in winter over Fortaleza than in summer over Huancayo. The monthly mean characteristics at the two stations, presented here, seem to suggest that while larger amplitude of the prereversal V_z peak in general, occur in association with higher spread F occurrence rates, the V_z peak would be sharper when the probability of range type spread F is high, whereas it would be broader when the occurrence of frequency type spread F is high (this point should, however, be confirmed from more detailed study involving individual events which we are presently carrying out).

The opposite seasonal trends, in the characteristics of the V_z prereversal enhancements discussed above, seems to be an important aspect of the spread F related F-region dynamics, since these pronounced differences are observed over two stations separated by only ~38^o of longitude in the American zone. From the following considerations, it would appear that important influential factors causing these differences might lie in the large differences in the magnetic declination angles at the two stations (being 20^o W at Fortaleza and 4^o E at Jicamarca) and also, to some extent, on their relative separation from the geographic equator.

The daytime upward ionization drift and its reversal at sunset, in the equatorial F region, are caused by eastward and westward electric fields, respectively. This east-west electric field arises from the E-layer dynamo field that is mapped onto the F-region by the highly conducting field lines. Apart from this, vertical polarization electric field is generated in the F-region by the zonal component of the thermospheric winds, that gets short-circuited during the day, by the high conductivity of the E-region, through magnetic field lines, causing the flow of field-aligned currents. At night the small E-region conductivity causes the short-circuiting effect to disappear, or a certain decoupling of the E and F regions occurs, leading to a build up of F-region polarization electric field as discussed by Rishbeth (1971, 1977; see also Haerendel et al., 1967; Waldman and da Rosa, 1973). This electric field, which is normally vertical during the night, has an east west component near sunset and sunrise when the rapid change in the E-region conductivity affects significantly the current distribution (Rishbeth, 1981). This east west component produces vertical drift. Theoretical study by Heelis et al. (1974) has demonstrated that the evening enhancements, or the prereversal maxima, in the upward drift velocity, such as that measured by the Jicamarca radar (Woodman, 1970), could be satisfactorily explained by this decoupling process. Thus, we could see that the times of the prereversal maximum in V_z should be determined by the sunset times at the low latitude magnetic conjugate E layers that are coupled to the equatorial F-region by magnetic field lines. We have calculated these sunset times for Fortaleza and Jicamarca considering conjugate E-regions to be at $\pm 12^{o}$ magnetic latitude, corresponding to the field line that has apex at around 350 km over the magnetic equator. We have assumed in the calculation that the solar radiation responsible for the E-layer ionization is completely absorbed above 80 km (namely, a screening altitude of 80 km).

The sunset times so calculated are marked in Figure 1 in the form of rectangles (marked F and J for Fortaleza and Jicamarca, respectively), whose lengths in time represent the duration of the sunset starting from one conjugate E-layer and ending at the other (the rectangles are divided into two at the points corresponding to the local E-region sunset times, at the respective stations). For summer (southern solstice) conditions over Fortaleza, the sunset duration between the conjugate E-layers is very small, being only 11 minutes, due to the large declination angle of the field lines over Fortaleza, whereas for Jicamarca the sunset duration is significantly longer, being 108 minutes. We may note that the width of the prereversal peak in V_z is correspondingly smaller over Fortaleza and larger over Jicamarca. This trend is exactly reversed in winter months, when the sunset duration is largest for Fortaleza (117 minutes) and significantly smaller (41 minutes) for Jicamarca, with corresponding differences in the widths of the prereversal V_z peaks also present at the two stations. In equinoctial months, the difference in the sunset durations does not appear to be significantly pronounced to reflect as differences in the V_z peak widths. The opposite seasonal trend in the times (and widths) of the V_z peaks, at the two stations, is clearly present in the calculated sunset durations. Thus, we may observe that there does appear to be present a definite dependence of the width and time of the prereversal F-region drift velocity peaks on the duration of the sunset between the conjugate E-regions. This relationship, we may point out here, in fact seems to provide an experimental verification of the theoretical predictions on the role of F-region dynamo (Rishbeth, 1971; Heelis et al., 1974) in the evening V_z enhancements. Such a verification is made possible because of the large difference in the magnetic declination angle between Jicamarca and Fortaleza. Thus, the gross features of the equatorial spread F occurrences, vis-a-vis F-region height variations and their control by the thermospheric winds, through the generation of the F-region dynamo, seem to depend in a significant way on the magnetic field declination. We shoud point out, however, that the E region contribution to the F region electric field at Jicamarca and Fortaleza could be a little different, since the corresponding field lines map to different geographic latitudes and, hence, factors other than magnetic declination angle might also contribute to the observed differences in the drift velocity characteristics at the two stations.

The general tendency in the V_z curves in Figure 1 is that the evening enhancements of the drift velocities start a little before the onset of sunset at the first conjugate E-region, and the post maximum decrease starts immediately following the termination of the sunset at the other conjugate E-region. However, we may notice that this pattern has a certain alteration in winter over Fortaleza, where the V_z enhancement starts somewhat later after the initiation of sunset, and the maximum is reached well after the termination of sunset at the conjugate E-region. The reason for this delay, in the V_z enhancement features, is not clear to us. However, we speculate over possible presence, in this month, of sufficiently large conductivities at the northern conjugate E-region, even after the initiation of the sunset at the southern conjugate E-region, unlike in summer months when the sunset duration between the conjugate E-regions is very small. Further, we may point out that at the southern conjugate E-region itself, appreciable conductivity might have been present even at sunset hours, due possibly to particle produced ionization in the South Atlantic geomagnetic anomaly. In fact, during evening hours in some winter months, secondary peaks in the occurrence of sporadic E layers of blanketing type presumably produced by charged particle precipitation in the anomaly region have been reported over Cachoeira Paulista (22^oS, 45^oW) (Abdu and Batista, 1977). Another possible cause of this delay could be in the role of thermospheric zonal winds in driving inter-hemisphere ionization fluxes, which is strongly controlled by the magnetic declination angles, as the recent Atmosphere Explorer satellite results indicate (Heelis and Hanson, 1980), and their seasonal dependence.

CONCLUSIONS

The vertical ionization drift velocities in the evening equatorial F-region over Jicamarca and Fortaleza, two stations located south of the geographic equator and separated by $\sim 38^o$ in longitude in the American zone, present significantly different seasonal characteristics, namely, the times and the durations of the evening prereversal maximum in the drift velocities show exactly opposite seasonal trends at the two stations. Similar differences are observed also in the spread F (specially the frequency spread type) occurrence characteristics at the two stations. An attempt is made to qualitatively explain the differences in the V_z prereversal enhancements as being caused by differences in the F region polarization electric field developments at the two stations. The different magnetic field declination angles, at these stations, cause the conjugate E-region sunset times and their durations, for the respective stations, to be significantly different and to occur with exactly opposite seasonal trends in much the same way as the observed seasonal trends in the V_z prereversal peak parameters. Thus, the present results seem to provide an experimental verification of the theoretical predictions on the development of the F-layer dynamo electric field and V_z enhancements occurring as a result of the electrical decoupling of the E and F layer following the sunset. Thus, the gross features of the spread F characteristics seems to be indirectly dependent upon magnetic field declination angle. The undue delay observed in the prereversal V_z enhancement in winter months over Fortaleza apparently does not seem to agree with the F-region dynamo theory and it merits further study. Investigation is continuing using theoretical modelling and data from Fortaleza, Huancayo and Jicamarca to elucidate the different aspects of the longitudinal differences in the spread F and related F-region dynamics in the American zone.

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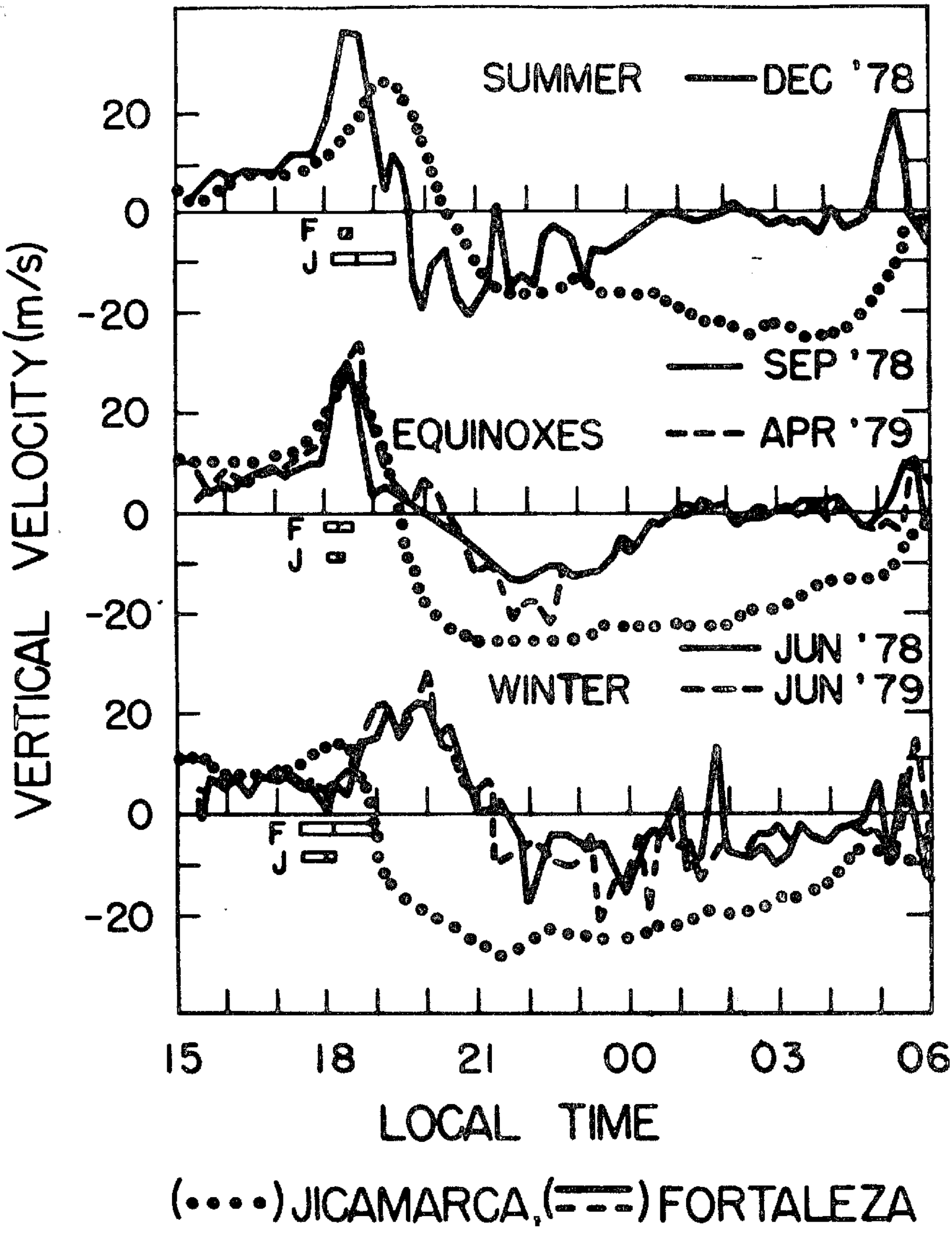
FIGURE CAPTIONS

Figure 1 - F region vertical drift velocities measured by Jicamarca radar (taken from Fejer et al., 1979) and those deduced from Fortaleza ionograms, presented for summer, equinoctial and winter months. The open rectangles, near the evening hours, represent sunset durations between magnetic conjugate E regions and are divided into two at the points corresponding to the local E-region sunset times (see text for further details).

Figure 2 - Comparison of the range type and frequency type spread F for Fortaleza and Huancayo. The Fortaleza results were reduced from local ionograms, while Huancayo results were taken from Rastogi (1978).



SUMMER
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SEP '78
EQUINOXES
APR '79
JUN '78
WINTER
JUN '79
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20
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-20
VERTICAL VELOCITY (m/s)
15
18
21
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LOCAL TIME
(••••) JICAMARCA, (═══) FORTALEZA

Fig. 1

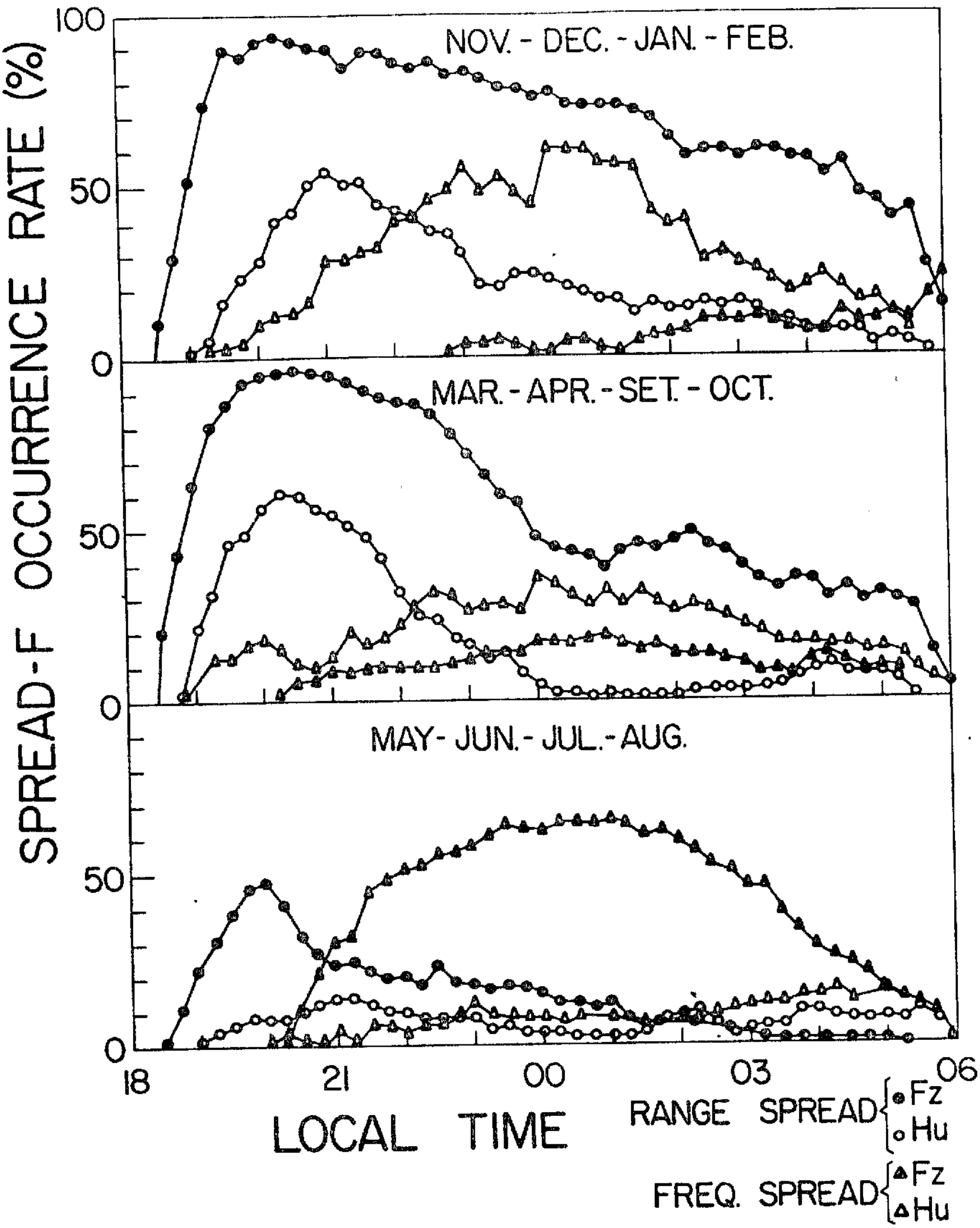
SPREAD-F OCCURRENCE RATE (%)
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Fig. 2

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10 Batista, Inez Staciarine
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87 equador magnético
87 região F
87 propagação F
87 teoria de dinamo
87 campos elétricos
87 polarização
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MAGNETIC DECLINATION CONTROL OF THE EQUATORIAL F REGION DYNAMO ELECTRIC FIELD DEVELOPMENT AND SPREAD F

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Results and Discussion

Figure 1 presents monthly mean diurnal variations of vertical F layer velocities (V_z) deduced as d(h'F)/dt from ionograms over Fortaleza [see Abdu et al., 1981] representing summer (southern solstice) equinoxes and winter (northern solstice) months. The velocities deduced here as the derivate of h'F would be a valid representation for the E x B vertical drift velocity when the low-lying ionization is small, which is nearly true in the nighttime ionograms, and when the recombination is small at these heights. Bittencourt and Abdu [1981] have shown theoretically that the threshold height, above which the recombination is small enough to make equal the true velocity and that deduced from the movement of the iso-electron density contours (i.e., d(h'F)/dt), is in the vicinity of 300 km. Our discussion in this paper is restricted to the evening hours, when h'F over Fortaleza is usually above 300 km. Presented together for comparison in Figure 1 are the mean local time variations for different seasons of the vertical ionization drift velocities, measured by the Jicamarca radar, for the period 1968-1971, taken from Fejer et al. [1979]. The V_z values deduced from Fortaleza ionograms, after about 2300 LT in summer and equinoctical months and after about 0100 LT in winter, are underestimated because of the recombination process, since the h'F values at these times are below the threshold altitude of 300 km (see Figure 4 of Abdu et al. [1981]).

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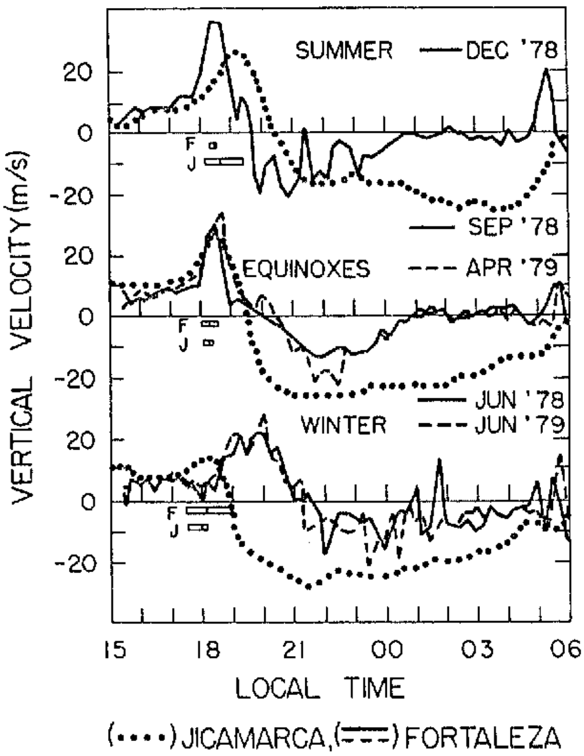

Fig. 1. F region vertical drift velocities measured by Jicamarca radar (taken from Fejer et al. [1979]) and those deduced from Fortaleza ionograms, presented for summer, equinoctial, and winter months. The open rectangles near the evening hours represent sunset durations between magnetic conjugate E regions and are divided into two at the points corresponding to the local E region sunset times (see text for further details).

presence of spread F when a prereversal V_z enhancement was present. Rastogi [1978] presented results that supported such a dependence. More recently, a statistical study of 1 year data over Fortaleza showed that the spread F indices, in the postsunset hours on individual days, have a pronounced dependence on the amplitude of the V_z prereversal maximum on the same day determined from ionograms [Medeiros, 1981]. The seasonal mean trends of the V_z peak and spread F occurrence rates presented in Figures 1 and 2, therefore, lead to a conclusion, in agreement with the previous results, that the probability of the range type spread F occurrence is in general higher for larger amplitude of the V_z prereversal peak.

Such a dependence on V_z prereversal amplitude does not seem to be present in the case of the frequency type spread F occurrence. These two types of the spread F events seem to be associated with irregularities generated under different conditions of the equatorial ionosphere. For example, Rastogi and Woodman [1978] have presented some results suggesting that VHF radar returns over Jicamarca arise from irregularities that coexist with those responsible for range type spread F, but not frequency type spread F in the ionograms of Huancayo (see also Cohen and Bowles [1961], Abdu et al., [1981]).

The most outstanding feature of Figure 1 is the seasonal trends in the times and, to some extent, in the widths of the prereversal V_z peaks that show exactly opposite behavior at the two stations. Over Jicamarca the V_z peak occurs earlier in winter and later in summer, as would be expected from the seasonal trends in the local sunset time. Over Fortaleza, situated closer to the geographic equator, also, in the southern hemisphere and ~ 38° eastward of Jicamarca, a similar trend but to a lesser degree would be expected, whereas the observed trend in Figure 1 is exactly opposite. As a counterpart to this feature we may notice in Figure 2 that the occurrence rate of frequency type spread F presents a summer maximum over Huancayo, whereas Fortaleza presents a winter maximum. The late occurrence, with larger width, of the V_z prereversal peak results in high h'F values in premidnight period, which seems to be responsible for the higher incidence rate of frequency type spread F seen to be relatively more pronounced in winter over Fortaleza than in summer over Huancayo. The monthly mean characteristics at the two stations, presented here, seem to suggest that while larger amplitude of the prereversal V_z peak in general occurs in association with higher spread F occurrence rates, the V_z peak would be sharper when the probability of range type spread F is high, whereas it would be broader when the occurrence of frequency type spread F is high (this point should, however, be confirmed from more detailed study involving individual events, which we are presently carrying out).

The opposite seasonal trends, in the characteristics of the V_z prereversal enhancements discussed above, seems to be an important aspect of the spread F related F region dynamics, since these pronounced differences are observed over two stations separated by only ~ 38° of longitude in the American zone. From the following considerations, it would appear that important influential factors causing these differences might lie in the large differences in the magnetic declination angles at the two stations (being 20°W at Fortaleza and 4°E at Jicamarca) and also, to some extent, on their relative separation from the geographic equator.

The daytime upward ionization drift and its reversal at sunset, in the equatorial F region, are caused by estward and westward electric fields, respectively. This east-west electric field arises from the E layer dynamo field that is mapped onto the F region by the highly conducting field lines. Apart from this, vertical polarization electric field is generated in the F region by the zonal component of the thermospheric winds that gets short-circuited during the day by the high conductivity of the E region through magnetic field lines, causing the flow of field-aligned currents. At night the small E region conductivity causes the short-circuiting effect to disappear, or a certain decoupling of the E and F regions occurs, leading to a buildup of F region polarization electric field as discussed by Rishbeth [1971, 1977] (see also Haerendel et al. [1967], Waldman and da Rosa [1973]). This electric field, which is normally vertical during the night, has an east-west component near sunset and sunrise when the rapid change in the E region conductivity affects significantly the current distribution [Rishbeth, 1981]. This east-west component produces vertical drift. Theoretical study by Heelis et al. [1974] has demonstrated that the evening enhancements or the prereversal maxima in the upward drift velocity, such as that measured by the Jicamarca radar [Woodman, 1970], could be satisfactorily explained by this decoupling process. Thus we could see that the times of the prereversal maximum in V_z should be determined by the sunset times at the low-latitude magnetic conjugate E layer that are coupled to the equatorial F region by magnetic field lines. We have calculated these sunset times for Fortaleza and Jicamarca considering conjugate E regions to be at ±12° magnetic latitude, corresponding to the field line that has apex at around 350 km over the magnetic equator. We have assumed in the calculation that the solar radiation responsible for the E layer ionization is completely absorbed above 80 km (namely, a screening altitude of 80 km).

The sunset times so calculated are marked in Figure 1 in the form of rectangles (marked F and J for Fortaleza and Jicamarca, respectively), whose lengths in time represent the duration of the sunset starting from one conjugate E layer and ending at the other (the rectangles are divided into two at the points corresponding to the local E region sunset times at the respective stations). For summer (southern solstice) conditions over Fortaleza, the sunset duration between the conjugate E layers is very small, being only 11 min owing to the large declination angle of the field lines over Fortaleza, whereas for Jicamarca the sunset duration is significantly longer, being 108 min. We may note that the width of the prereversal peak in V_z is correspondingly smaller over Fortaleza and larger over Jicamarca. This trend is exactly reversed in winter months, when the sunset duration is largest for Fortaleza (117 min) and significantly smaller (41 min) for Jicamarca, with corresponding differences in the widths of the prereversal V_z peaks also present at the two stations. In equinoctial months, the difference in the sunset durations does not appear to be significantly pronounced to reflect as differences in the V_z peak widths. The opposite seasonal trend in the times (and widths) of the V_z peaks at the two stations is clearly present in the calculated sunset durations. Thus we may observe that there does appear to be present a definite dependence of the width and time of the prereversal F region drift velocity peaks on the durations of the sunset between the conjugate E regions. This relationship, we may point out here, in fact seems to provide an experimental verification of the theoretical predictions on the role of F region dynamo [Rishbeth, 1971; Heelis et al., 1974] in the evening V_z enhancements. Such a verification is made possible because of the large difference in the magnetic declination angle between Jicamarca and Fortaleza. Thus the gross features of the equatorial spread F occurrences vis-a-vis F region height variations and their control by the thermospheric winds, through the generation of the F region dynamo seem to depend in a significant way on the magnetic field declination. We should point out, however, that the E region contribution to the F region electric field at Jicamarca and Fortaleza could be a little different, since the corresponding field lines map to different geographic latitudes and, hence, factors other than magnetic declination angle might also contribute to the observed differences in the drift velocity characteristics at the two stations.

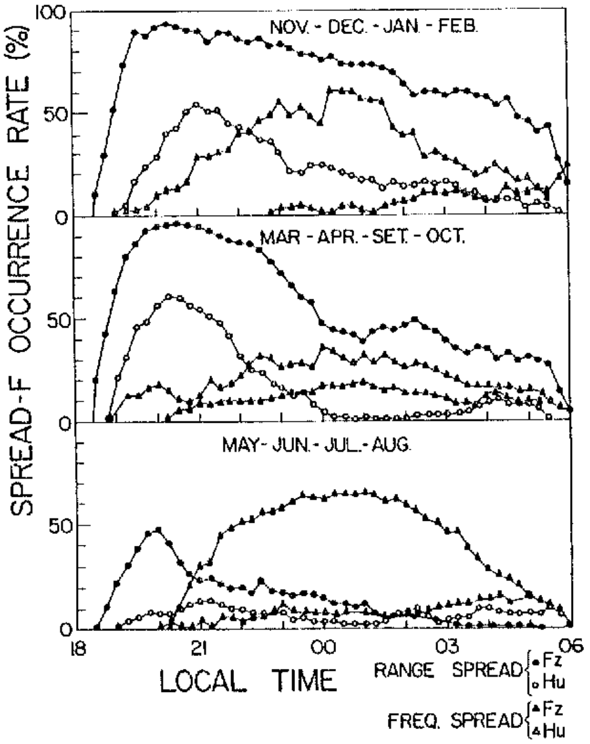

Fig. 2. Comparison of the range type and frequency type spread F for Fortaleza and Huancayo. The Fortaleza results were reduced from local ionograms, while Huancayo results were taken from Rastogi [1978].

The general tendency in the V_z curves in Figure 1 is that the evening enhancements of the drift velocities start a little before the onset of sunset at the first conjugate E region, and the post maximum decrease starts immediately following the termination of the sunset at the other conjugate E region. However, we may notice that this pattern has a certain alteration in winter over Fortaleza, where the V_z enhancements starts somewhat later after the initiation of sunset and the maximum is reached well after the termination of sunset at the conjugate E region. The reason for this delay in the V_z enhancement feature is not clear to us. However, we speculate over possible presence in this month of sufficiently large conductivities at the northern conjugate F region, even after the initiation of the sunset at the southern conjugate E region, unlike in summer months when the sunset duration between the conjugate E regions is very small. Further, we may point out that at the southern conjugate E region itself, appreciable conductivity might have been present even at sunset hours, due possibly to particle produced ionization in the South Atlantic geomagnetic anomaly. In fact, during evening hours in some winter months, secondary peaks in the occurrence of sporadic E layers of blanketing type presumably produced by charged particle precipitation in the anomaly region have been reported over Cachoeira Paulista (22°S, 45°W) [Abdu and Batista, 1977]. Another possible cause of this delay could be in the role of thermospheric zonal winds in driving interhemisphere ionization fluxes, which is strongly controlled by the magnetic declination angles, as the recent Atmosphere Explorer satellite results indicate [Heelis and Hanson, 1980], and their seasonal dependence.

Conclusions

The vertical ionization drift velocities in the evening equatorial F region over Jicamarca and Fortaleza, two stations located south of the geographic equator and separated by ~ 30° in longitude in the American zone, present significantly different seasonal characteristics, namely, the times and the durations of the evening prereversal maximum in the drift velocities show exactly opposite seasonal trends at the two stations. Similar differences are observed also in the spread F (specially the frequency spread type) occurrence characteristics at the two stations. An attempt is made to qualitatively explain the differences in the V_z prereversal enhancements as being caused by differences in the F region polarization electric field developments at the two stations. The different magnetic field declination angles at these stations cause the conjugate E region sunset times and their durations for the respective stations to be significantly different and to occur with exactly opposite seasonal trends in much the same way as the observed seasonal trends in the V_z prereversal peak parameters. Thus the present results seem to provide an experimental verification of the theoretical predictions on the development of the F layer dynamo electric field and V_z enhancements occurring as a result of the electrical decoupling of the E and F layers following the sunset. Thus the gross features of the spread F characteristics seem to be indirectly dependent upon magnetic field declination angle. The undue delay observed in the prereversal V_z enhancement in winter months over Fortaleza apparently does not seem to agree with the F region dynamo theory, and it merits further study. Investigation is continuing using theoretical modeling and data from Fortaleza, Huancayo, and Jicamarca to elucidate the different aspects of the longitudinal differences in the spread F and related F region dynamics in the American zone.

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