Travelling Ionospheric Disturbances & Their Possible Correlation with Jet Stream Activity

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Quasi-periodic fluctuations in TEC extracted from Faraday angle records at Delhi and Pilani are interpreted in terms of medium scale gravity waves travelling in the ionospheric F-region. It appears that the jet streams at meteorological heights act as potential sources and excite the observed ionospheric waves. The neutral winds present at the F-region heights are responsible for the observed diurnal variation in the occurrence of TIDs.

1. Introduction
Travelling ionospheric disturbances (TIDs) have been observed by various workers during the past three decades using a variety of experimental techniques. The TIDs have been classified by Georges into two groups, the large scale and the medium scale. The large scale TIDs are characterized by high horizontal speeds (400-1000 m/sec) and long periods (30 min-3 hr) whereas the medium scale TIDs are characterized by lower speeds (50-250 m/sec) and shorter periods (15 min-1 hr). The hypothesis that all the TIDs are ionospheric manifestations of atmospheric gravity waves has received nearly complete acceptance. However, identification of sources of these waves has always been a difficult problem. The relative infrequency of the large scale TIDs and their equatorward propagation permits their occurrence to be related to specific geophysical events like auroral substorms. Medium scale TIDs on the other hand occur much more frequently and are difficult to be related to specific sources. Many investigators turn their attention to meteorological sources such as Lee waves in the mountain, weather frontal systems, instabilities and distortions in the jet streams and severe thunderstorms.

The present paper is concerned with a study of medium scale TIDs with an attempt to identify their source mechanism. For this purpose continuous records of Faraday angle at 140 MHz from the geostationary satellite ATS-6, recorded at the University of Delhi, Delhi, (geog. lat. 28'6 N, 77'7 E) and from mid-Apr. 1976 to July 1976 at CEERI, Pilani. Since Pilani is situated within about 160 km from Delhi, the general characteristics of the TIDs are expected to be the same for both the stations.

2. Procedure
Continuous recording of the polarization angle rotation were made using the 140 MHz transmission from the geostationary satellite ATS-6. The equipment used for this purpose was the rotating antenna polarimeter, described in an earlier communication. The measurements were made from Aug. 1975 to Mar. 1976 at the University of Delhi, Delhi, (geog. lat. 28'6 N, 77'7 E) and from mid-Apr. 1976 to July 1976 at CEERI, Pilani. Since Pilani is situated within about 160 km from Delhi, the general characteristics of the TIDs are expected to be the same for both the stations.

3. Results
The polarization rotation $\Omega$ is directly proportional to the ionospheric electron content which contains the maximum contribution from the F-layer peak. The quasi-periodic fluctuations in $\Omega$ having periodicities between 10 and 100 min, superimposed over the diurnal trend, were extracted and interpreted as medium scale TIDs propagating in the F-region. The justification for such an interpretation is given by Gupta et al. using ionosonde observations of $f_0F2$. The occurrences of TIDs show marked diurnal and seasonal variations. This behaviour is summarized in the histogram (Fig. 1). A sharp peak is observed around noon in winter with almost no occurrences before 0600 and after 1800 hours LMT. In the summer months TIDs occur much less frequently. In this peak frequency is nearly half of that in winter and occurrence is confined to ± 3 hrs about midnight. The daytime occurrences are nearly constant
throughout the day. Typical records of day and nighttime during winter and summer time are shown in Figs. 2 and 3.

4. Interpretation of Results and Discussion

According to Francis most of the medium scale TIDs are inducted freely propagating waves travelling obliquely up to the F-region. The slope for upward propagation increases with the decrease of periodicity of the wave. Hence, with increasing horizontal range from the source the periodicity of the observed wave in the F-region should increase linearly. This necessitates the sources to be within a few thousand km from the point of observation. In the present paper we have confined our attention to the various possible meteorological sources only. With a single station data the speed and direction of the observed TIDs cannot be obtained. In the absence of this information, source identification by the reverse ray-tracing of the gravity wave path is not possible as has been done by some workers. So it is our endeavour to identify some meteorological events occurring around the same time within a radius of about a thousand kilometres from our point of observation. For this purpose the synoptic weather charts prepared by the India Meteorological Department have been examined. It has been found that the weather frontal systems are totally absent over the tropical belt near our region of concern. On the other hand, the jet stream activity is very predominant and its occurrence undergoes a marked seasonal variation. During the winter months there is an intense westerly jet stream activity over the southern part of India on almost all the days. It is felt that the observed medium scale TIDs during the winter time are mostly due to this phenomenon. Fig. 4 shows a typical winter time synoptic chart on which the westerly jet stream is clearly seen. In the hatched eye region the core speed and the wind shears are maximum and the motion is strongly ageostrophic. It is suggested that the source of the observed TIDs lies around this region. This is supported by the suggestion of Bertin et al. that ageostrophic perturbation on the neutral wind can produce gravity waves. The jet stream in winter is observed always to the north of our observing point. Hence, the waves produced must have a southward component of speed to be observable. This is in conformity with our earlier conclusions that the winter time TIDs have a tendency of propagating southwards.

During summer months the westerly jet stream activity is absent over the southern part of India. This is replaced by a relatively weaker easterly jet stream activity over the southern part of India. This is replaced by a relatively weaker easterly jet stream activity over the southern part of India. This is replaced by a relatively weaker easterly jet stream activity over the southern part of India. This is replaced by a relatively weaker easterly jet stream activity over the southern part of India. This is replaced by a relatively weaker easterly jet stream activity over the southern part of India.
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tant source during summer, though probably not as
effective because of the larger distance from the point
of observation.

Having suggested that the TIDs are closely
related to the jet stream activity we have still to ex­
plain the diurnal observed occurrences. For this
purpose we have invoked the neutral wind filtering
mechanism, as proposed by Cowling et al.16 It has
been shown by these authors that strong thermo­
spheric neutral winds can act as directional filters
allowing gravity wave propagation only through
selected channels. In general, they have found that
the probability of a wave reaching the F-region is
maximum when it is propagating against the neutral
wind. The wind data are not available over our
location and we have used the wind measure­
ments of Vasseur17 shown in Fig. 6. This is not very
much unjustified since the winds generated theoreti­
cally by Lumb18 using Jacchia19 model atmosphere
show reasonably similar behaviour as far as the direc­
tions are concerned although the magnitudes may
differ. In winter the TIDs occur mostly around
midday whereas the jet stream shown in Fig. 4 for a
typical day is present throughout day and night.
However, the neutral wind is directed towards north
during the day and thereby aids propagation of TIDs
towards south. At night the southward propagating
waves are inhibited by the wind which is strongly
southward. A similar wind filtering mechanism aids
the waves propagating towards north at night but however the inhibition during daytime is
not very effective since the daytime neutral wind
magnitude is very weak. In this way the generation
and propagation of TIDs observed at Delhi and
Pilani make a consistent picture with the mecha­
nism mentioned above. It is to be noted that
TIDs of quite low periods noted occasionally
during summer cannot be explained with only the jet
stream as the source. In such cases, much nearer
local sources, possibly thunderstorms, may have
to be invoked.

The above interpretation, it must be remembered,
is based on single station data. A thorough confirma­
tion is required basing interpretations on the multi­
station data which is fortunately now available
over the Indian subcontinent. It may also be added
that there is no enhanced TID activity either at sun­
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References