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AURORAL/GEOMAGNETIC ACTIVITY AND ITS EFFECT ON MW DX RECEPTION

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The close statistical relationship between geomagnetic disturbances and MW reception quality was apparently recognized quite early in the history of radio research. As early as 1927 Pickard[1] reported on extensive measurements of received field strengths of stations on frequencies ranging from long wave to SW and concluded, "It appears that reception in the frequency band of 500-1500 kilocycles shows higher correlation with solar activity and terrestrial magnetism than does any other investigated portion of the (radio) spectrum."

The attention of MW DX'ers was focussed on the close connection between geomagnetic activity and MW DX conditions by Gray Scrimgeour in 1968 who observed that the reception of TA's on the West Coast in 1965-1967 occurred primarily during extended periods of geomagnetic quiet[2]. The present author made similar observations relating East Coast receptions of high latitude Scandinavian and Far East stations with geomagnetically quiet periods. We also demonstrated that the long-observed geographical pattern of "auroral conditions" in which reception from the south is highly favored while skywave signals from the north, east, and west are greatly weakened can be explained in terms of the geographical pattern of ionospheric absorption associated with charged particle precipitation along the southern edge of the auroral oval[3,4].

Since that time the publication of geomagnetic indices in DX bulletins has become routine and most active MW DX'ers monitor the WWV transmissions of geomagnetic data at 18 minutes after the hour to get an indication of the onset of auroral conditions.

The precise relationship between a particular geomagnetic index such as the Boulder A_{80} value transmitted by WWV and MW reception quality on a particular path is very complex and it is only within the past few years with the advent of powerful new computer and satellite techniques that some of these details are becoming understood.

Several years ago we conducted an important experiment which greatly clarified certain aspects of the relationship between geomagnetic indices and high latitude reception quality. Reception quality on 32 different high latitude MW signal paths determined every 3 hours for a one month period was compared with both high latitude satellite photographs showing the precise location of the auroral oval relative to the signal paths at the times of reception and with geomagnetic indices simultaneously measured at a variety of different ground sites near the signal paths. The southern edge of the auroral oval which marks the equator-ward boundary of active charged particle precipitation into the E and D regions of the ionosphere was seen to exert a very strong influence on MW DX reception: during the entire month not a single reception occurred on any path which intersected or passed within 2° of the auroral oval boundary as seen from the satellite. Movement of the oval boundary was shown to be strongly but not perfectly correlated with a variety of geomagnetic indices. Generally speaking both reception quality and the degree of visible auroral oval expansion show the best correlation with the planetary 3 hour K indices which represent worldwide average measures of auroral/geomagnetic disturbance levels rather than with indices from individual stations such as Boulder or Fredericksburg.

As we have suggested previously, one limitation on the practical usefulness of readily available geomagnetic indices is the method used to calculate the daily A index from the eight daily values of the 3-hour K index[5]. A similar problem exists with regard to the choice of a single station index as an approximation to the more useful planetary indices such as A_p, K_p, AE, and Q, none of which unfortunately is available for some months after the fact. Based upon this and related work we here present some guidelines for those interested in relating geomagnetic indices with DX reception.

1. TA reception shows a definite statistical tendency to peak just prior to or during the initial plases of a geomagnetic disturbance. Look for particularly good reception about the time of onset of a major disturbance. This effect is believed to be due to a redistribution of electrons in the base of the E region.

2. Planetary indices are more closely related to MW absorption than are individual station indices.

3. Poor reception frequently continues for upwards of a week following a major disturbance even though the geomagnetic indices may have returned to normal. This is believed to be due to the phenomenon of parasitic cyclotron resonance between radiation belt electrons and naturally occuring ELF noise generated within the magnetosphere by the original disturbance which persists up to a week.

4. The tendency for solar disturbances to repeat every solar rotation period (27 days) frequently permits a good deal of predictive ability by means of simple graphical techniques. In particular the nights of outstanding reception which tend to occur about the time of onset of some disturbances will tend to repeat every 27 days.

5. The parameter most closely related to MW absorption is the number and energy of the charged particles which are precipitating at particular locations along the signal path. These quantities can be measured by satellite and recent observations suggest that major geomagnetic disturbances fall into several different categories depending upon the number and energy of precipitating electrons and protons. The majority of disturbances are of the hard variety in which precipitation effects penetrate the ionosphere deeply enough to effect the entire broadcast band. Some storms however, feature precipitating energy spectra which can increase some high band signal strengths at times by altering the vertical signal path trajectory. Both hard and soft auroral precipitation events usually produce the same or at least very similar geomagnetic effects and probably can only be differentiated by satellite observations.

6. Reception along some transpolar paths such as Sinkiang-1525 can be significantly enhanced by geomagnetic/auroral disturbances of both hard and soft varieties. This is apparently due to the trapping of the signal between the auroral sporadic E layer and the F layer.

7. The influence of the statistical behavior of MW DX signals must be taken into account when interpreting MW DX data. Generally speaking the median value of the received signal strength is depressed much more by a geomagnetic/auroral disturbance than are the lower decile values. This means that while the average or median value of the signal may be reduced by say 15 dB due to a particular disturbance, the peak level that the signal reaches during the course of the evening may be only a few dB below what it attains on a good undisturbed night. Thus, for short periods of time, near-normal signal strengths may be experienced during even severly disturbed conditions.

8. It is now believed that geomagnetic/auroral disturbances are triggered by a reversal in the polarity of the interplanetary magnetic field between the earth and sun. This parameter is currently monitored from satellites and holds considerable promise for the eventual prediction of geomagnetic/auroral disturbances.

REFERENCES

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