Short-term Ionospheric Variability in Statistical Models of Incoherent Scatter Radar Data.

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ABSTRACT

All Millstone Hill incoherent scatter radar data collected since 1978 are available through the Madrigal Database at MIT Haystack Observatory. A set of empirical models for basic and derived incoherent scatter parameters, including electron density Ne, electron and ion temperatures Te and Ti, electric field and parallel ion drift has been developed from this extensive data set. Such models of the average behavior of key ionosphere-thermosphere (IT) parameters, based on long term accumulated data, are important for space weather studies not only in terms of quantitative descriptions of the IT system but also in terms of clarifying several outstanding scientific problems.

MODELS

All Millstone Hill incoherent scatter radar data collected since 1978 are available through the Madrigal Database at MIT Haystack Observatory. A large body of data from the Sondrestrom and Arecibo incoherent scatter radars is also available. A set of empirical models for basic and derived incoherent scatter parameters, including electron density Ne, electron and ion temperatures Te and Ti, electric field and parallel ion drift is being developed from this extensive data set [1]. Such models of the average behavior of key ionosphere-thermosphere (IT) parameters, based on long term accumulated data, are important for space weather studies not only in terms of quantitative descriptions of the IT system but also in terms of clarifying several outstanding scientific problems.
Three models have been developed:

1. A local E and F-region model of electron density, Te, Ti, electric field and geomagnetic field-aligned drift from 100-1000 km (fig. 1).
2. A regional F-region model of electron density, Te and Ti from 200-600 km altitude and 32-55 degrees latitude(Fig. 2).
3. A model of ExB convection drifts.

The binning parameters for the models are local time (0000-2400 LT), day of year (season) and, for the first two models, altitude. Each data point has a corresponding solar flux index F107 and geomagnetic activity index Ap. A least-squares fit to all the data in each bin is computed to determine the modeled parameters as a function of F107 and Ap. A convection

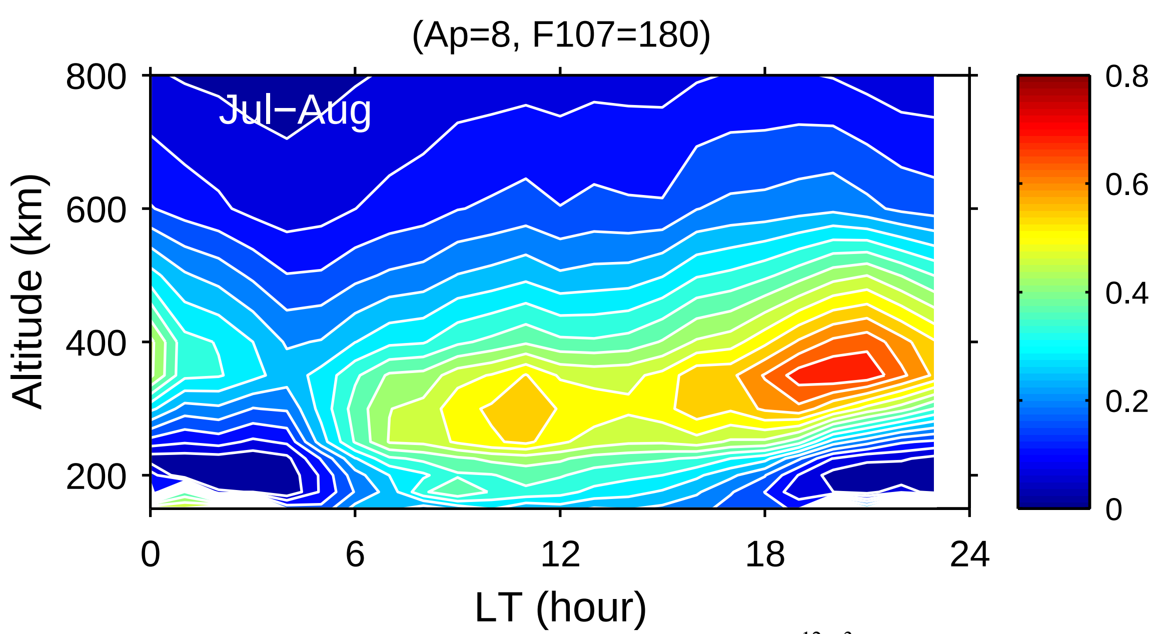

Fig. 1. Local model electron density contours ($10^{12}m^3$)

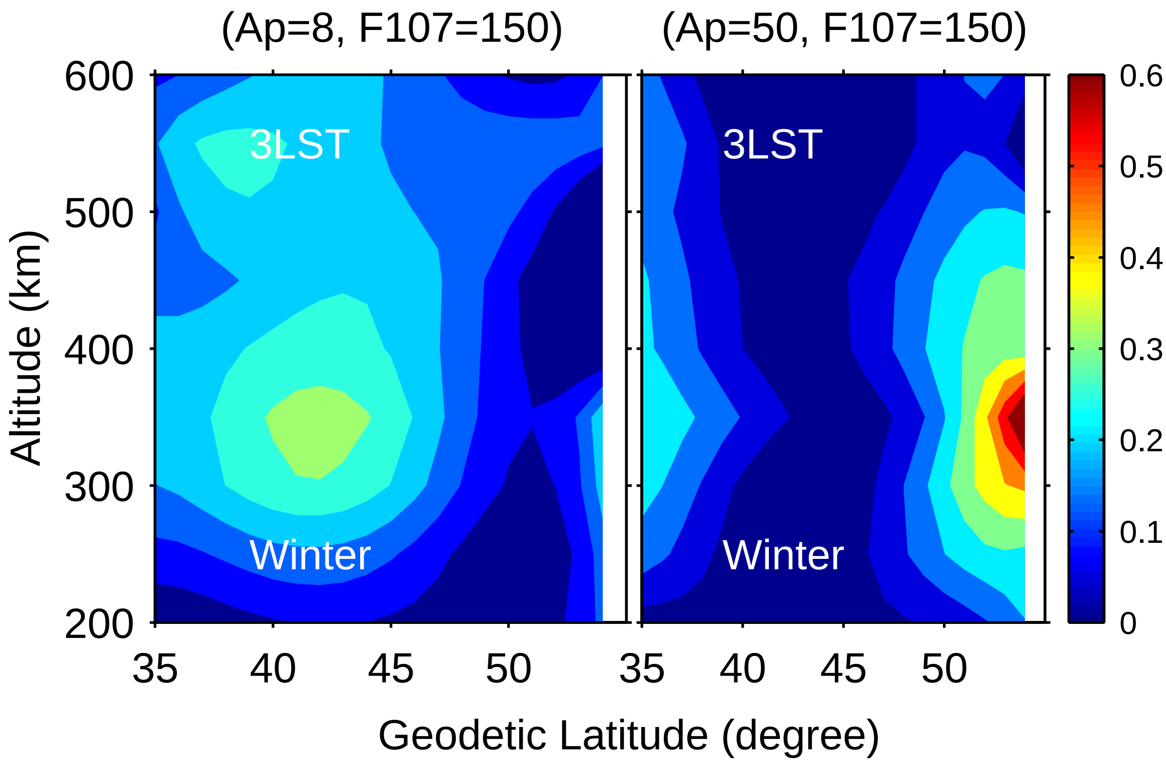

Fig. 2. Ionospheric trough at 0300 LT in winter ($10^{12}m^3$).

model based on the measured interplanetary magnetic field (IMF) has also be computed. These models, based as they are on a very large number of measurements, provide a very accurate representation of the long-term seasonal and solar cycle variability of the ionosphere.

SHORT-TERM VARIABILITY

The models also provide important information about the short-term variability of the ionosphere. The F107 dependence [Fig. 3] provides information about the day-to-day variations of the ionosphere due to changes in EUV flux, and the 3-hour Ap or IMF dependence provides information about the hour-to hour response of the ionosphere to changes in the solar wind. We have also investigated a variety of F107 and Ap parameterizations (to determine, for example, the optimum lag between F107 or Ap and the measurement), as well as alternative solar flux and geomagnetic indices, such as MgII and E107.

The variances of each fit are also computed and saved, and these provide another important source of information on short-term variability. For example, Codrescu et al. [2] showed that for an electric field model with a Gaussian distribution of small-scale variability around the mean, the average field and the variability have equal contributions to Joule heating generation.

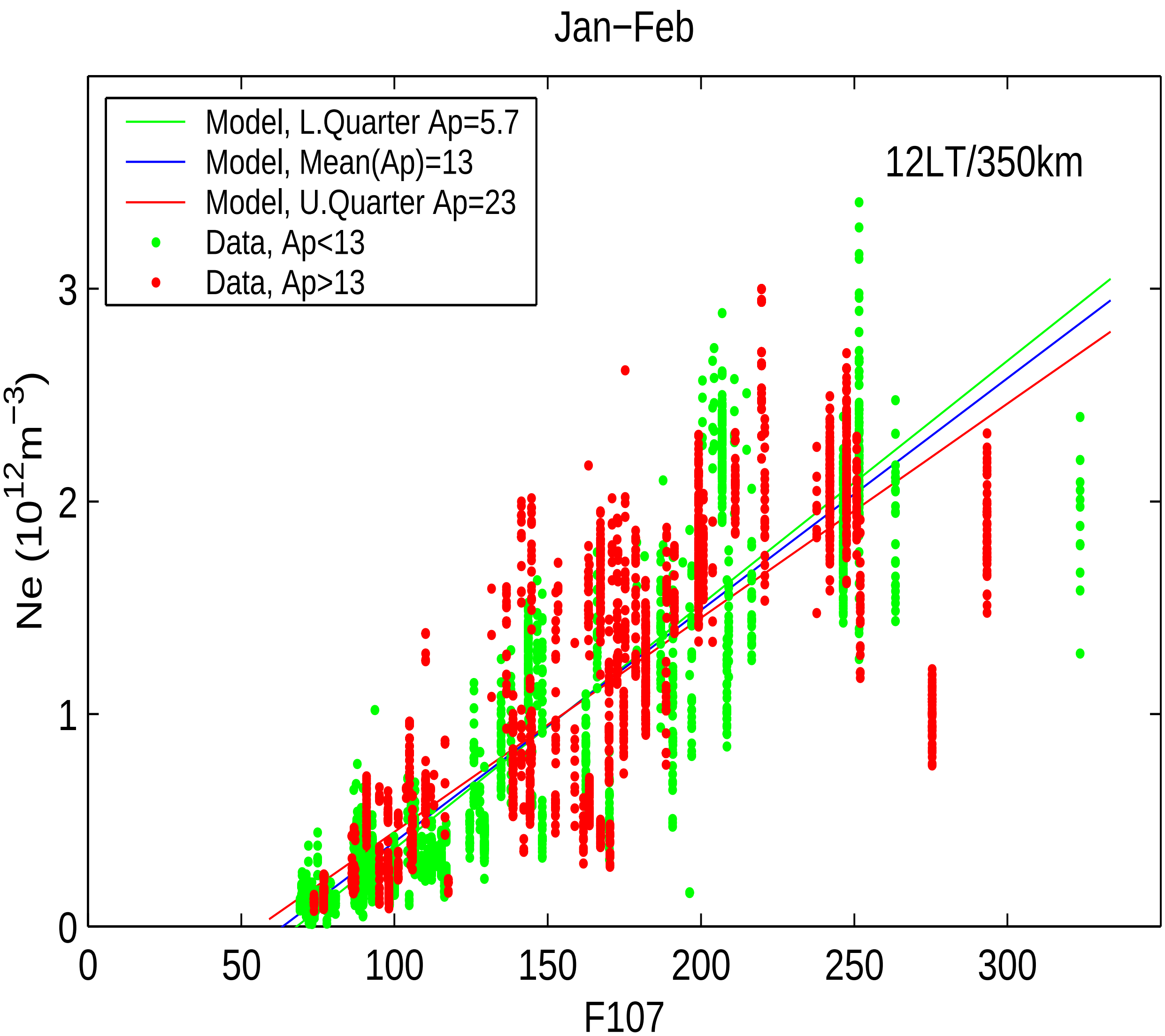

Fig. 3 Variation of electron density with $f_{10..7}$

REFERENCES

[1] Holt, J. M., S. Zhang and M. J. Buonsanto, Regional and local ionospheric models based on Millstone Hill incoherent scatter radar data, in press.

[2] Codrescu, M.V., T.J. Fuller-Rowell, J.C. Foster, J.M. Holt, and S.J. Cariglia, Electric field variability associated with the Millstone Hill electric field model, *J. Geophys. Res.*, 105, 5265-5273, 2000