Ionospheric Models Based on ISR Observations at Millstone Hill, St. Santin, and Shigaraki

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Local Models

The model prameters are Ne, Te and Ti (and parallel ion drift for Millstone). The data were binned by month and local time in 1-hour increments. Least squares fits for model parameter profiles were then computed for each of the months by local time bins. Model profiles are piecewise-linear with nodes in the E and F regions (Millstone and St Santin) or only in the F region (Shigaraki). To improve the statistics at the expense of some smoothing, in the St Santin and Shigaraki cases, each of the 12 monthly bins contains data from the preceding, current and following months; for the Shigaraki temperature models, we have further included data within 3 hours for each hourly bin. The parameters are assumed to be linear in F10.7 for the previous day and the Ap index for the previous 3 hour period. The least squares fit yields model coefficients for each parameter. A 3×3 median filter in local time and season is then applied to these coefficients. All models are online at http://www.haystack.mit.edu/madrigal/Models/.

Millstone Hill (digital form data from 1970)
The model is based on Millstone Hill data collected between 1970 and 2001, and archived in the Madrigal Database (http://www.openmadrigal.org). Altogether 5,013,606 measurements were included in the model.

**St Santin (data between 1966-1987)**
The St Santin data are archived in the CEDAR database and also are imported into the the Madrigal system.

Shigaraki (data from 1986)
The MU Radar Ionosphere Model is based on the MU radar IS experiments taken at Shigaraki between 1986 - 2003, and archived in the Madrigal Database

Arecibo (digital form data from 1966) under development
Sondrestorm (data from 1990) under development
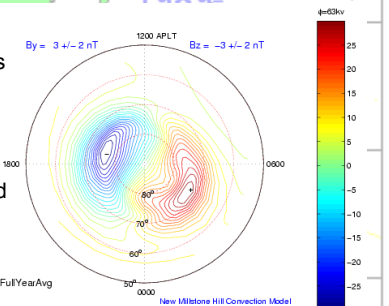**EISCAST/ESR and others**: planned
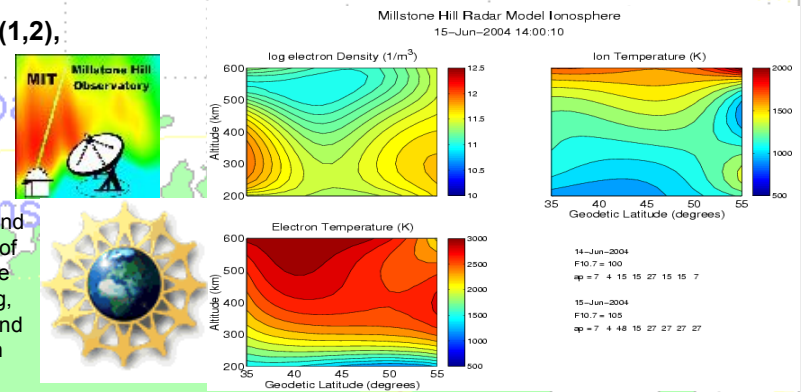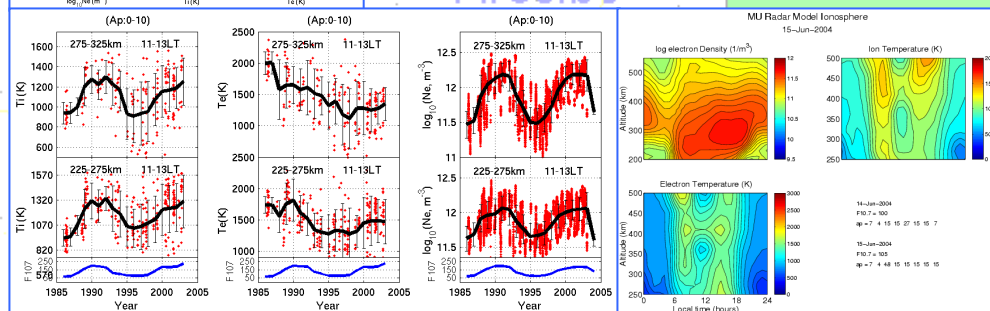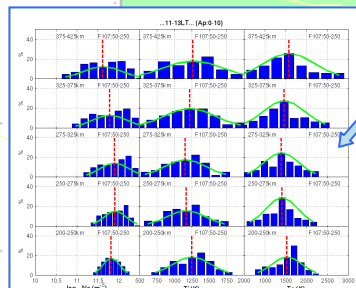
Millstone Hill Regional Model

The regional model has a latitude coverage of 32-55° geodetic and an altitude coverage of 200-600 km. Data are binned in season, local time, altitude, and latitude. Similar to the local models, a linear assumption is made for each bin to quantify the F107 and ap dependences of Ne, Te and Ti, and linear coefficients are obtained by least-squares fitting. The coefficients for each bin are further smoothed and represented using a 4-D analytic function, where A periodic B-spline basis is used for local time and seasonal (day number) variations, a B-spline basis function is used for height variations, and a cubic basis is used for latitude changes.

New Millstone Hill ISR Convection Model

Millstone Hill Electric Field Model 2004 provide electrostatic potential patterns and the corresponding ExB plasma drifts over the apex magnetic latitude range of 50° through 80°, based on data from the complete Millstone database. Line of sight Doppler ion drift measurements are used to determine the northward and eastward ion drift components as a function of Apex latitude, local time, and season. The drifts in each of these bins are grouped according to magnetic activity conditions represented by e.g., IMF By and Bz values or Kp and IMF By. Statistical averages therefore are obtained for each temporal, spatial, and magnetic activity bin.
This model is still under development, and will be combined with Sondrestrom ISR data to get better results in polar regions.

Other Types of Models (online)

MUIDM: MU Radar Ion Drift Model (Zhang et al., 2001)
HWMMU: HWM-like MU Radar Wind Model (Kawamura et al., 2000)
First-Principles Ionospheric Model (Zhang and Huang, 1995)

Virtual Incoherent Scatter Radars   http://www.haystack.mit.edu/madrigal/Models/

Ionospheric model plots for the current date, time and geophysical conditions are generated and are updated every 15 minutes. The models are evaluated using recent measured and predicted values of F10.7 and ap (or Ap). Convection model potential plots are generated and updated every 1 hour, based on near real-time IMF By and Bz data from the ACE Satellite made available by SEC/NOAA.