Updated Millstone Hill and Sondrestrom Incoherent Scatter Radars Convection Model

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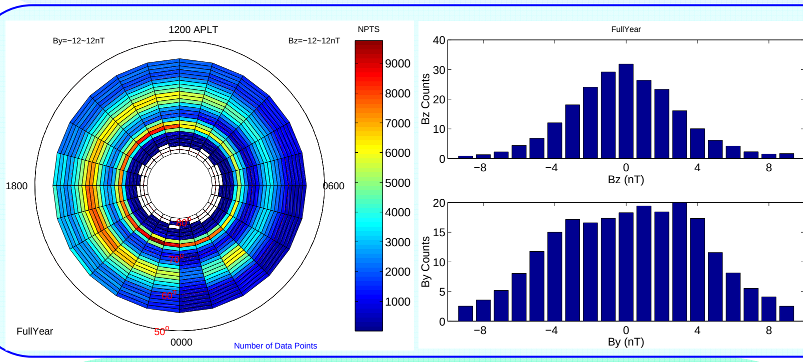
Introduction

High latitude convection electric fields play a central role in linking the solar wind and magnetosphere with the ionosphere and thermosphere processes. Statistical models of the convection have been obtained from satellite multiple pass data, data assimilation methods (AMIE), SuperDARN observations, and incoherent scatter radar observations. Based on long-term Millstone ISR and Sondrestrom ISR data, a high-latitude convection model, MHS, has been created [Holt et al., 1984; Foster et al., 1986.] The MHS is driven by Hemisphere Power Index or, alternatively, by IMF. It is regional as it is based solely on data from a single sector. This avoids smearing out features unique to a particular longitude which satellite based models may not be able to capture when data from many longitudes are combined. Millstone Hill lies near the equatorward boundary of most convection models, so the MHS model, which includes data near and to the south of Millstone, will help specify the low-latitude boundary of the magnetospheric convection pattern. Historically, the MHS has been used to provide the basis functions for the AMIE technique. It has been used also as a key high latitude input for the CTIM. The MHS can be used by the SuperDARN as an alternative background. Since MHS was published more than 1 decade ago, additional data from both sites have been collected. This paper reports the updated Millstone-Sondrestrom model. All available line-of-sight (LOS) Doppler ion drift measurements from the Millstone radar and the resolved ion drift velocities from the Sondrestrom radar are used to determine the northward and eastward ion drift components as a function of Apex latitude, local time, and season. The seasonal variation is a new feature of the model.

Method

Millstone LOS data are binned according to apex latitude, apex LT, season, and driving parameters By and Bz (or alternatively Kp and By). LT bin sizes are 1 hr, latitude bin sizes are 1°, and By and Bz bin sizes are 1 nT. The vector velocity for each bin is determined from the average LOS velocity. For Sondrestrom, we use the resolved vector velocity, which is binned using the same fashion for Millstone LOS data. An electrostatic potential is then fitted to the average vector velocities. The fit is extended over the polar cap by solving the Laplace's equation in that region. The potential is represented by a periodic bi-cubic spline function in apex latitude and apex LT.

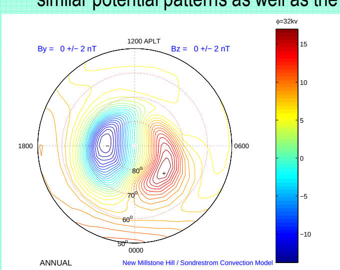


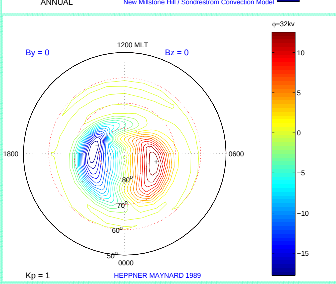
Data Distribution

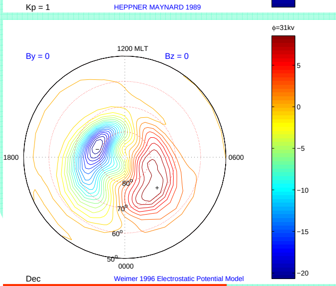
This figure on the left shows the number of data distributions vs apex latitude and apex LT. The broader bright area in the outside circles is the main area Millstone Radar covers, and the inner bright area is the main area Sondrestrom Radar covers. IMF By and Bz are well distributed with most data within ±4 nT (figure on the right).

Comparisons with Other Models

An example of comparisons among the new MHS, HMR model [Heppner and Maynard, 1987; Rich and Maynard, 1989], and Weimer [1996] model for the baseline conditions with By = Bz = 0, indicates many similarities. The cross polar cap potential is 32 kv for a two cell pattern; the dusk cell is centered near 77o magnetic latitude; the dawn cell is centered between 3-5MLT. However, the dusk potential is smaller for the regional model MHS than for the satellite based HMR and Weimer models. In general, when both By and Bz are negative, the three models, especially, the MHS and the HMR models, give similar potential patterns as well as the dawn-dusk potential drop.





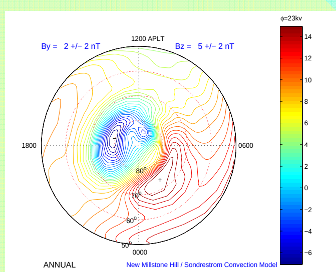


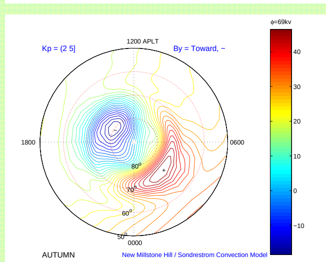
Some Results

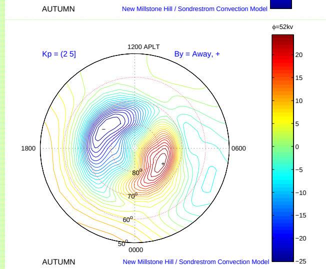
The new model now can capture a third vortex on the dayside when Bz is positive and By is positive or slightly negative (see Figure on the right).

The new model can be also driven by Kp and By. The next two figures on the right show two model patterns, obtained using Kp and By, to represent the move of the dusk cell towards lower latitudes and noon as a result of the change of By from negative to positive.

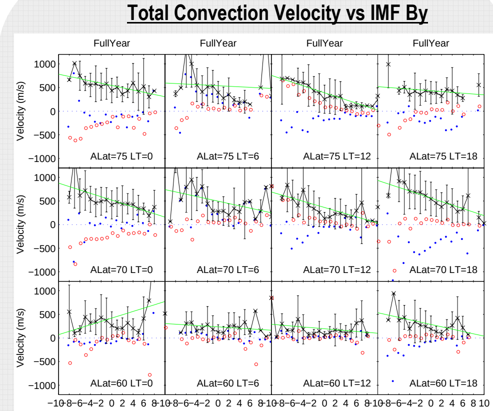
The new Millstone Hill and Sondrestrom model provides also results of the variability for convection velocities, or the standard deviation on the model averages.



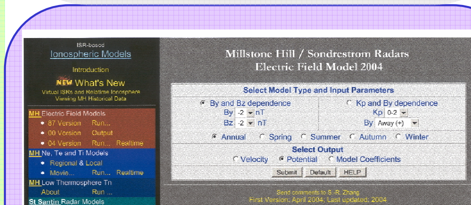




Total Convection Velocity vs IMF By



The above figure shows the response of the total convection velocity V (stars), averaged for a given Bz bin, to Bz for various APLT (00, 06, 12, 18) and APLAT (60, 70, 75°). V appears to decrease as Bz changes from negative towards positive. The velocity variability can be seen from the error bars representing the standard deviation on averages. Ve (eastward,blue) and Vn (northward, red) are shown also.



Model Availability from Internet

http://www.openmadrigal.com or

http://www.haystack.mit.edu/madriga/Models/

- Web interface: user's inputs
- Realtime convection pattern driven by near realtime IMF indices from ACE.

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