Introduction/Motivation

The Dst index is based on 4 magnetometers, which are widely spaced in longitude and also located away from the equator to avoid the magnetic perturbations from the equatorial electrojet, see Figure below. They are adjusted to remove the quiet time Sq ionospheric current perturbations and the secular variation of the magnetic field due to changes in the internal currents of the Earth.

The Dst index is widely used to determine the onset and strength of magnetic storms

It has been known since the work of Burton et al.[1975] that the Dst can be well modeled and predicted using the solar wind as input. Since then, many scientists have tested and improved the prediction.

The motivation for attempting such improvements is usually a combination of a desire to understand which features of the interaction between the solar wind and the magnetosphere are most important in producing magnetic storms, including the 2003 `Halloween storm that was the largest super magnetic storm with good solar wind measurements during 1995-2003, from the same run (fixed model parameters).

Model Description

\[
\text{Model: } Dst = \text{dst}_1 + \text{dst}_2 + \text{dst}_3 + (\text{pressure}) + (\text{direct IMF } b_y) + \text{offset}
\]

\[
\text{dst}_x(t+dt) = \text{dst}_x(t) + (\text{driver term}) + (\text{decay term}), \text{ the driver term is similar for all three, which are a strong function of } V_x, B_y, N_s, \text{ the clock angle and the angle between } V_x \text{ and the dipole axis. The decay terms are quite different.}
\]

\[
(\text{pressure}) = \left[ p_b b^2 + n(p_v^2/\sin^2(\Phi) + p_T) \right]^{1/2}, \text{ includes IMF pressure and a term proportional to the solar wind density in addition to the dynamic pressure.}
\]

\[
(\text{direct IMF } b_y) = 0.478 b_1 \sin(\pi t/yr + s)_t + s_1 t + s_2 t + s_3 t, \text{ may compensate for a portion of the secular variation that may not have been removed in Dst.}
\]

Results

The 2003 `Halloween' storm

Relevant solar wind parameters and the components of the predicted Dst and the Dst Index from Kyoto WDC for 60 days in 1998 (Temerin and Li, 2002).

Comparison of predicted Dst with Kyoto Dst for the largest magnetic storms with good solar wind measurements during 1995-2003, from the same run (fixed model parameters).

Summary

- Given solar wind conditions, large-scale magnetospheric activities are predictable; the magnetosphere has an organized way to respond.
- For reliable and accurate forecast of magnetospheric activities, reliable and accurate solar wind measurements are absolutely necessary.
- Based on our model, a very fast solar wind with a very large negative IMF Bz can produce a super magnetic storm with minimum Dst less than -1600 nT.

Future Work

- Using the Dst prediction model as a tool, study the detailed physical processes governing the large scale responses of the magnetosphere to solar wind variations.

References:


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