Project Details

ROSES ID: NNH08ZDA001N
Selection Year: 2009
Program Element: Data, Tools, & Methods

Topic: Measure the properties of the solar dynamo that affect solar irradiance and active region generation.

Project Title:
A Scheme for Real-Time Forecasting of the Intensity and Timing of Magnetic Storms at Earth based on Observations of Magnetic Clouds at L1

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Summary:
The interplanetary magnetic field (IMF), in addition to electromagnetic and particulate radiation, plays a major role in Sun-Earth connection through a process which is well explained by Dungey's reconnection model. During a prolonged period of a large southward (in GSM) component of the IMF, often associated with magnetic clouds (MCs), a major magnetic storm will usually occur and pose a threat to communications, electric power grids, and Earth's orbiting satellites. In response to NASA's Living With a Star program, which is designed to address this problem as a first priority, we plan to develop a scheme that is able to forecast in real-time the magnetic field structure associated with a magnetic cloud of a N-to-S type and the intensity and timing of a magnetic storm that it drives. N-to-S types, which started around mid 2005, are most common at this time and are expected to continue for about ~seven more years. The proposed investigation will be built upon our knowledge gained from our intensive work on MCs in the past. The scheme contains a series of programs that operate on data from a spacecraft upstream of Earth, at L1 in this case (e.g., ACE): (1) one that automatically identifies a MC-candidate in real time (Program #1), (2) one that does preliminary MC parameter fitting using a variety of boundary trials, guided by those from Program #1 (and a later program that sends pertinent information back to Program #2), primarily to obtain a good estimate of the MC's axis and MC type, (3) one that estimates a refined MC front boundary time (called t_B*) using higher resolution data, (4) one that uses t_B* to carry out a more advanced MC parameter fitting (called the Comprehensive program), including MC expansion and compression, (5) one that finds the "best estimate" of B_z,GSM(MIN) within the MC and its occurrence time, t_MIN, (6) one that calculates the delay time from the observing time at L1 to arrival time at Earth (Delta T_L1-E), and finally (7) one that estimates Dst_min (or other magnetic storm indices) using Bz,GSM(MIN), V_SW, t_MIN, and Delta T_L1-E. Under favorable circumstances for the most common MC durations, say around 18 6 hours, a N-to-S MC will give about a 5.4 1.8 hours warning-time, where Delta T_L1-E is assumed to be about one hour. This is in contrast to the much longer, and therefore more desirable, warning times upon using solar imaging data, where several days are obtained, but usually with quite unreliable or inaccurate results. This is also preferred over current major Dst prediction models which offer only a lead time of ~1 hour. After completion, we will provide the scheme to the community and will set up a designated space weather website to host the predictions, as well as add any new MC information to the presently existing WIND/MFI Website.

Publication References:

Summary: no summary

Reference: Lepping, R. P.; Wu, C.-C.; Berdichevsky, D. B.; Szabo, A.; (2011), Magnetic Clouds at/near the 2007 - 2009 Solar Minimum: Frequency of Occurrence and Some Unusual Properties, Solar Physics, Volume 274, Issue 1-2, pp. 345-360, doi: 10.1007/s11207-010-9646-9