Research in the Prediction of Solar Activity

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LONG-TERM GOAL

Our long term goal is to understand the physics and relationship among flares, filament eruptions and Coronal Mass Ejections (CMEs); to understand their impact on the magnetosphere and ionosphere of the earth; and to predict them accurately.

OBJECTIVES

We predict solar flares in our continuation of the BEARALERT program, and intend to issue more detailed alerts with general information on the state of solar activity. This will be especially important since the solar activity is approaching its maximum. Secondly, we investigate the relation between erupting filaments observed at Big Bear and Coronal Mass Ejections (CMEs) observed from Large Angle Spectroscopic Coronagraph (LASCO). If such an relationship is established, filament eruptions can be used as a proxy to predict arrival of high energy particles and geomagnetic disturbances. In addition, we have been monitoring the ultraviolet solar flux by daily issuance of our K- line index.

APPROACH

We use Big Bear magnetograms and high resolution Halpha movies to evaluate magnetic structures of active regions and issue BearAlerts when we believe that flares will occur soon; we compare Big Bear full disk Halpha movies with SOHO LASCO movies to study the relationship between filament eruptions and Coronal Mass Ejections; We obtain daily full-disk CaK images and compile our K-line index to compare with ultraviolet solar flux. People involved in the projects are: Bill Marquette (BearAlerts and Kline index), Hal Zirin (BearAlert), Phil Goode (Comparison of BBSO and LASCO

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movies) Haimin Wang (Filament Eruption and CMEs, Temperature Structure of Erupting Filaments), Guo Yang (Filament studies), Carsten Denker (Full Disk Halpha Image Processing) and Anders Johanneson (Kline index).

WORK COMPLETED

Halpha full disk images have been improved significantly after flat-field corrections and removal of limb darkening. They are posted on the web everyday, and become a valuable source for activity prediction by Space Environment Lab and planning of space missions like SOHO and TRACE;

- K-Line indices are on line at BBSO web page, and updated daily. Associated Kline images are archived in our ftp site;
- Filament eruption list from 1991 to 1994 has been compiled and studied; similar list from 1994 to 1998 is being compiled;
- Over 40 filament eruptions from 1996 to 1998 have been compared with LASCO movies.
- BearAlerts have been improved, and the feedback from the community is excellent.
- Polar magnetograms are obtained regularly as a supplement to full disk magnetograms from WSO and NSO, for implementing Sheeley-Wang model.

RESULTS

1. We have improved our BearAlerts, which predict solar flares and filament activation. It is more accurate and more quantitative. The success rate is above 80%. We often compare our predictions with those from NOAA. Such a success is attributed to the experience of well-trained staff and improvement of our data quality.

2. We have improved our Halpha full disk images, which are obtained by our 2K by 2K camera, with a cadence of 1 minutes. Image are enhanced significantly (Denker et al., 1998). Such a synoptic data set is the heart of the monitoring of solar activity. Sample images can be found in http://bbso.njit.edu. They are being used as daily planning reference for missions like SOHO and TRACE. We have used the data to derive the solar differential rotations, statistics of mini-filament eruptions, temperature structure of prominences, and prediction of solar activity.

3. We have developed software to automatically detect filament eruptions and flares. The development is the Master thesis of one of our graduate students. Automation of the system will facilitate the prediction of the space weather, as it takes many hours to days for the magnetic cloud and high energy particles to arrive at 1AU. The major parts of the software in already in place, and will be completed by the December 1998.

4. More than 40 filament eruptions have been studied in detail, to establish the relationship between filament eruptions and CMEs. At this monen, we obtained quite confusing results: about 50% of filament eruptions are associated with CMEs, and other 50% do not. Continuing study of them may shed light on the physical reason behind it. Over 1000 filament eruptions from 1991 to 1994 have

been identified and archived at http://solar.njit.edu., and events after 1994 are being compiled (Wang et al., 1998).

5. We continue to obtain daily CaK images with our 1024X1024 Kodak Megaplus camera. Each day, the flat field images are obtained, so photometry data can be done with high accuracy. Over 95% of correlation between the BBSO Calcium Index and the Lyman-alpha flux has been found. Thus BBSO K index can be used as good proxy of solar irradiance.

6. To predict solar activity more accurately, Li et al. (1998) studied relationship between evolution of magnetic fields and solar flares in a super active region. They found that the occurance of flares are closely associated with new flux emergence and excess of electric currents in one polarity.

IMPACT/APPLICATION

The prediction of solar activity is so important in many areas since magnetic eruptions can have deleterious effects on satellites, upper atmosphere communications and even the North American power grid. Thus, it is critical to have the most reliable early warning system possible. For the Navy, the important factor appears to be their effects on VLF communication and on satellites, such as those involved in communication, surveillance and the global positioning system.

TRANSITIONS

Our data on World Wide Web has been used wide in the world to monitor solar activity. Our BearAlert has helped been highly regarded in the community. The filament list and daily K-index compiled by us have been used by scientists.

RELATED PROJECTS

The PI has been awarded a Space Weather grant by NSF, which established automated early warning system of filament eruption. A computer program is being developed to automatically recognize the structure of filaments. When a filament disappears, this news will be immediately broadcast via E-mail to researchers who are interested in the project and are on our BEARALERT mailing list. The broadcast information will include the time of eruption, and the coordinates and size of the filament.

Based on the list of filament eruptions recorded by the automated program, a filament index (as a function of time) will be established

The PI also obtained a NASA SRT grant, which supports a study of comparison BBSO and Yohkoh data to understand X-ray structure associated with the filament eruptions.

PUBLICATIONS

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