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Development of space weather prediction algorithm using big data analysis

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To predict and forecast the occurrence of solar flares and coronal mass ejections automatically without human power is one of the major goals in the space weather forecast research. Many studies have been performed in space weather prediction until today; For example, there are heuristics studies from the correlation of flares and the physical quantity being observed from the shape of the each sunspot. We always have required human power in such studies.

In recent years, the accuracy of the satellite and observation equipment has been increasing with the development of technology. Given that observation data is fast increasing, it is difficult for us to directly survey all data. On the other hand, big data analysis has developed rapidly in the field of information processing technology; Methods of machine learning and processing of unstructured large amounts of data by the parallel/distributed processing have been widely adopted in various fields of science. Therefore, we began to research fully automated flare prediction methods, in aim to utilize entire exhaustively large amount of data available for space weather forecast research. We set our goal to predict the X-ray flux with GOES satellites (Geostationary Operational Environmental Satellite.) More specifically, our goal is to predict the maximum of the X-ray flux from the present to 24 hours in the future.

First, we tried to predict GOES X-ray flux from past data of GOES X-ray flux and magnetic field data (Helioseismic and Magnetic Imager HMI) with SDO (Solar Dynamics Observatory), then evaluated the flare prediction accuracy using HSS (Heidke Skill Score) and TSS (True Skill Statistic) (see figure). Next, we added the extreme ultraviolet data observed with SDO/AIA (Atmospheric Imaging Assembly, wavelength: 193$\mathring{A}$) to the original dataset that consists of HMI and GOES data, and evaluated the flare prediction accuracy in the same way.

The reason for adding the AIA data is twofold. First, flare prediction studies using extreme ultraviolet full-disk image data with SOHO (Solar and Heliospheric Observatory) have revealed that we can construct a good indicator of flare activity of active regions by integrating over only pixels brighter than certain threshold in extreme ultraviolet images (threshold integral). Second, we expected to improve prediction accuracy by adding the AIA data, because magnetic field data cannot capture precursory phenomena of flare occurring in the rim of the sun, while AIA data can.

By our comparison study we found that adding full-disk integral of the AIA images to the data set improve the prediction accuracy, particularly that of X- class flares. In this presentation, we will try flare prediction based on the data set with additional features obtained by preprocessing AIA images, such as the threshold integral values, and report the results. This study is a joint research program with BroadBand Tower, Inc.

Keywords: Space weather, Solar flare, Active region, SDO/AIA, SDO/HMI, GOES

		GOES+MHI	AIA+GOES+MHI
X class Flare	HSS*1	0.209	0.215
	TSS*2	0.551	0.581
M class flare	HSS	0.439	0.402
	TSS	0.500	0.470
C class flare	HSS	0.521	0.542
	TSS	0.627	0.605

*1HSS=Heidke Skill Score

*2TSS=True Skill Statistic