Conventional global magnetic field maps, such as daily updated synoptic maps, have been constructed by merging together a series of observations from the Earth's viewing direction taken over a 27-day solar rotation period to represent the full surface of the Sun. It has limitations to predict real-time farside magnetic fields, especially for rapid changes in magnetic fields by flux emergence or disappearance. Here, we construct accurate synchronic magnetic field maps using frontside and AI-generated farside data. To generate the farside data, we train and evaluate our deep learning model with frontside SDO observations. We use an improved version of Pix2PixHD with a new objective function and a new configuration of the model input data. We compute correlation coefficients between real magnetograms and AI-generated ones for test data sets. Then we demonstrate that our model better generate magnetic field distributions than before. We compare AI-generated farside data with those predicted by the magnetic flux transport model. Finally, we assimilate our AI-generated farside magnetograms into the flux transport model and show several successive global magnetic field data from our new methodology.

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIP) (2018-0-01422, Study on analysis and prediction technique of solar flares).

[구 SS-04] Visual Explanation of a Deep Learning Solar Flare Forecast Model and Its Relationship to Physical Parameters

Kangwoo Yi, Yong-Jae Moon, Daye Lim, Eunsu Park and Harim Lee
School of Space Research, Kyung Hee University

In this study, we present a visual explanation of a deep learning solar flare forecast model and its relationship to physical parameters of solar active regions (ARs). For this, we use full-disk magnetograms at 00:00 UT from the Solar and Heliospheric Observatory/Michelson Doppler Imager and the Solar Dynamics Observatory/ Helioseismic and Magnetic Imager, physical parameters from the Space-weather HMI Active Region Patch (SHARP), and Geostationary Operational Environmental Satellite X-ray flare data. Our deep learning flare forecast model based on the Convolutional Neural Network (CNN) predicts "Yes" or "No" for the daily occurrence of C-, M-, and X-class flares. We interpret the model using two CNN attribution methods (guided backpropagation and Gradient-weighted Class Activation Mapping [Grad-CAM]) that provide quantitative information on explaining the model. We find that our deep learning flare forecasting model is intimately related to AR physical properties that have also been distinguished in previous studies as holding significant predictive ability. Major results of this study are as follows. First, we successfully apply our deep learning models to the forecast of daily solar flare occurrence with TSS = 0.65, without any preprocessing to extract features from data. Second, using the attribution methods, we find that the polarity inversion line is an important feature for the deep learning flare forecasting model. Third, the ARs with high Grad-CAM values produce more flares than those with low Grad-CAM values. Fourth, nine SHARP parameters such as total unsigned vertical current, total unsigned current helicity, total unsigned flux, and total photospheric magnetic free energy density are well correlated with Grad-CAM values. This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (MSIP) (2018-0-01422, study on analysis and prediction technique of solar flares).

[구 SS-05] Selection of Three (E)UV Channels for Solar Satellite Missions by Deep Learning

Daye Lim[1], Yong-Jae Moon[1,2], Eunsu Park[1] and Jin-Yi Lee[1]
[1]Department of Astronomy and Space Science, Kyung Hee University, [2]School of Space Research, Kyung Hee University

We address a question of what are three main channels that can best translate other channels in ultraviolet (UV) and extreme UV (EUV) observations. For this, we compare the image translations among the nine channels of the Atmospheric Imaging Assembly on the Solar Dynamics Observatory using a deep learning model based on conditional generative adversarial networks. In this study, we develop 170 deep learning models: 72 models for single-channel input, 56 models for double-channel input, and 42 models for triple-channel input. All models have a single-channel output. Then we evaluate the model results by pixel-to-pixel correlation coefficients (CCs) within the solar disk. Major results from this study are as follows. First, the model with 131 Å shows the best performance (average CC = 0.84) among single-channel models. Second, the model with 131 and 1600 Å shows the best translation (average CC = 0.95) among double-channel models. Third, among the triple-channel models with the highest average CC (0.97), the model with 131, 1600, and 304 Å is suggested in that the minimum CC (0.96) is the highest. Interestingly they are

representative coronal, photospheric, and chromospheric lines, respectively. Our results may be used as a secondary perspective in addition to primary scientific purposes in selecting a few channels of an UV/EUV imaging instrument for future solar satellite missions.

[구 SS-06] Halo CME mass estimated by synthetic CMEs based on a full ice-cream cone model

Hyeonock Na and Yong-Jae Moon
Department of Astronomy and Space Science, Kyung Hee University

In this study, we suggest a new method to estimate the mass of a halo coronal mass ejection (CME) using synthetic CMEs. For this, we generate synthetic CMEs based on two assumptions: (1) the CME structure is a full ice-cream cone, (2) the CME electron density follows a power-law distribution ($\rho_{cme}=\rho_0 r^{-n}$). The power-law exponent n is obtained by minimizing the root mean square error between the electron number density distributions of an observed CME and the corresponding synthetic CME at a position angle of the CME leading edge. By applying this methodology to 57 halo CMEs, we estimate two kinds of synthetic CME mass. One is a synthetic CME mass which considers only the observed CME region (M_{cme1}), the other is a synthetic CME mass which includes both the observed CME region and the occulted area larger than 4 solar radii (M_{cme2}). From these two cases, we derive conversion factors which are the ratio of a synthetic CME mass to an observed CME mass. The conversion factor for M_{cme1} ranges from 1.4 to 3.0 and its average is 2.0. For M_{cme2}, the factor ranges from 1.8 to 5.0 with the average of 3.0. These results imply that the observed halo CME mass can be underestimated by about 2 times when we consider the observed CME region, and about 3 times when we consider the region including the occulted area. Interestingly these conversion factors have a very strong negative correlation with angular widths of halo CMEs.We also compare the results with the CME mass estimated from STEREO observations.

This work was supported by Institute for Information & communications Technology Promotion (IITP) grant funded by the Korea government (2018-0-01422, Study on analysis and prediction technique of solar flares).

[구 SS-07] Quasi-Periodic Oscillations of Off-Limb Flaring Arcade Loops observed in the SDO/HMI Continuum

Il-Hyun Cho[1], Valery Nakariakov[1,2], Yong-Jae Moon[1], Jin-Yi Lee[1], Larisa Kashapova[3], Kyung-Suk Cho[4,5]
[1]Kyung Hee University, [2]University of Warwick, [3]SB Russian Academy of Science, [4]Korea Astronomy and Space Science Institute, [5]University of Science and Technology

In this study, we report oscillations of the total intensity of white light loops in the off-limb solar flare observed in 2017-Sep-10 with the SDO/HMI. The total intensity oscillations are correlated with the area of the flaring loop in the plane of the sky. The oscillatory pattern is well fitted by two consecutive damped oscillations. The period and damping time of the first oscillation are 12.9 minutes and 9.9 minutes, respectively. Those of the second oscillation are 11.7 minutes and 15.4 minutes. The excitation of the oscillations coincides with two consecutive type III radio bursts observed in meter range. Assuming the oscillations are magnetoacoustic waves in the flaring loops with the loop lengths ranging from 30 to 90 Mm, the temperature of the white light emitting loops could be in the range from 0.3 MK to 2.6 MK.

[구 SS-08] Sun-Earth Connection in Korean Historic Observations

Rok-Soon Kim[1,2], Hong-Jin Yang[1], Kyung-Suk Cho[1,2]
[1]Korea Astronomy and Space Science Institute, [2]University of Science and Technology

10세기부터 18세기까지 한국 역사서에 기록된 38개 흑점과 이와 연관된 것으로 보이는 25개의 적색 오로라를 조사하여 고대 흑점의 지구 영향성을 분석하였다. 고대 관측 시기를 1300년을 기준으로 이전의 온난기와 이후의 냉한기로 나누어 보면, 흑점의 관측 빈도는 두 기간에서 비슷하지만, 오로라는 냉한기에 집중적으로 관측된다. 특이하게도, 크기가 큰 흑점의 경우는 냉한기보다 온난기에서 관측 빈도가 세 배 이상 높다. 또한, 흑점과 관련된 오로라의 강도를 분석해보면 크기가 큰 흑점은 작은 흑점보다 2~3배 이상 지구영향성이 높다는 것을 알 수 있다. 우리는 1185년에 관측된 흑점이 수개월에 걸쳐 여러 차례 관측되었다는 것을 확인하였으며, 그 활동성 면에서 2003년 할로윈 이벤트와 유사했을 것으로 유추하였다. 향후 현대의 흑점 관측 스케치와 국제 흑점수의 관계를 정량화할 수 있다면, 유일하게 한국 역사서에만 찾아볼 수 있는 흑점의 크기 단위는 흑점수와 같이 태양활동의 지표로 사용될 수 있을 것으로 보인다.

[구 SS-09] Apophis Rendezvous Mission: I. Science Goals

Myung-Jin Kim[1], Hong-Kyu Moon[1], Young-Jun Choi[1,2], Minsup Jeong[1], Jin Choi[1], Youngmin