Machine Learning Efforts on Solar Flare Predictions by UoM Team

Yang Chen[1]

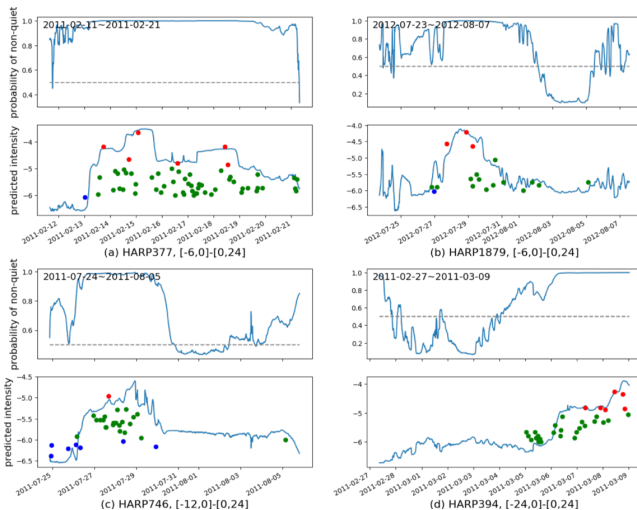[1]University of Michigan

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Abstract

In this talk, we present our machine learning efforts, which show great promise towards early predictions of solar flare events. (1) We present a data pre-processing pipeline that is built to extract useful data from multiple sources – Geostationary Operational Environmental Satellites (GOES) and Solar Dynamics Observatory (SDO)/Helioseismic and Magnetic Imager (HMI) and SDO/Atmospheric Imaging Assembly (AIA) – to prepare inputs for machine learning algorithms. (2) For our strong/weak flare classification model, case studies show a significant increase in the prediction score around 20 hours before strong solar flare events, which implies that early precursors appear at least 20 hours prior to the peak of a flare event. (3) We develop a mixed Long Short Term Memory (LSTM) regression model to predict the maximum solar flare intensity within a 24-hour time window. (4) Our ongoing and future work will also be briefly mentioned.

Solar Storms & Terrestrial Impacts Center (SOLSTICE)

- Lead PI: Tamas Gombosi, University of Michigan

- Yang Chen: Co-PI, lead on flare prediction and related ML tasks

- Our progress (in flare prediction) so far
    - identifying precursors of flares, Chen et al. Space Weather 2019.
    - solar cycle dependence, Wang et al. ApJ 2019.
    - flare intensity prediction, Jiao et al. Space Weather 2020.
    - interpreting flare prediction, Sun et al. Arxiv: 1912.12360.

- Current and ongoing: stay tuned.

Results from Mixed LSTM Regression

(a) HARP377, [-6,0]-[0,24]

(b) HARP1879, [-6,0]-[0,24]

(c) HARP746, [-12,0]-[0,24]

(d) HARP394, [-24,0]-[0,24]

References

- Y. Chen, W.B. Manchester, A.O. Hero, G. Toth, B. DuFumier, T. Zhou, X. Wang, H. Zhu, Z. Sun, and T.I. Gombosi, *Identifying Solar Flare Precursors Using Time Series of SDO/HMI Images and SHARP Parameters*, Space Weather (2019), 17(10), 1404–1426..

- X. Wang, Y. Chen, G. Toth, W. B. Manchester, T. I. Gombosi, A. O. Hero, Z. Jiao, H. Sun, M. Jin, Y. Liu, *Predicting solar flares with machine learning: investigating solar cycle dependence*, The Astrophysical Journal (2020), 895(1), 3.

- Z. Jiao, H. Sun, X. Wang, W. Manchester, T. Gombosi, A. Hero, Y. Chen, *Solar Flare Intensity Prediction with Machine Learning Models*, Space Weather 18.7 (2020): e2020SW002440.

- H. Sun, W. Manchester, Z. Jiao, X. Wang, Y. Chen, *Interpreting LSTM Prediction on Solar Flare Eruption with Time-series Clustering*, arXiv:1912.12360.