Correctly featurizing **time series data** that describes the **solar magnetic field** is critical for predicting **solar flares**.

Time Series Analysis of Flaring Active Regions

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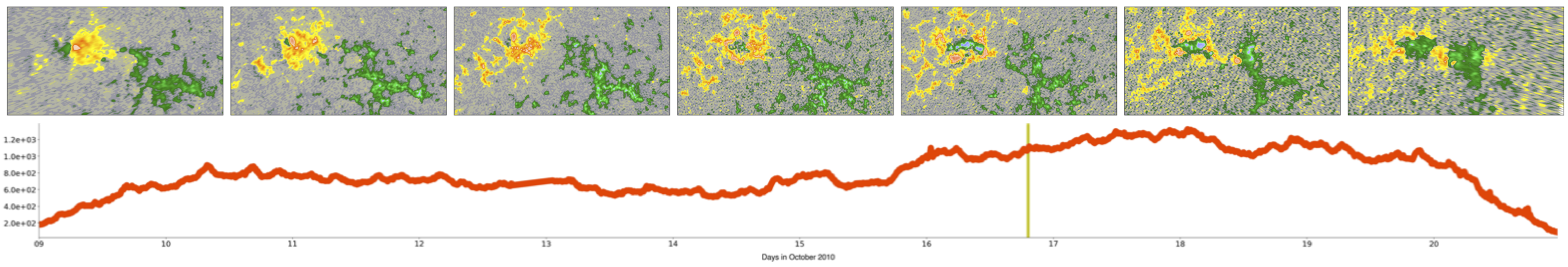
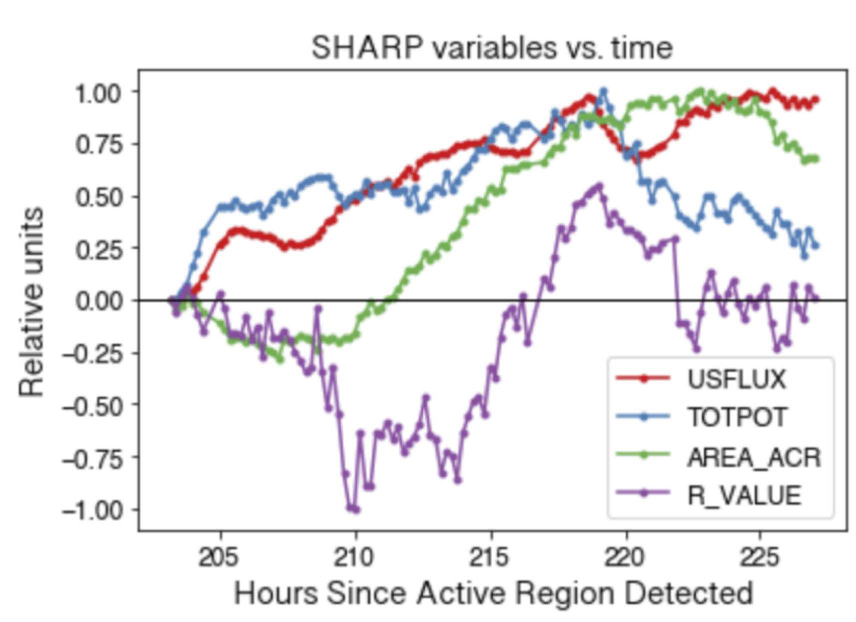


Figure 1: Flux vs. time
Top row: HMI photospheric magnetic field data for NOAA Active Region 11112, which produced an M2.9-class flare on October 16, 2010
Bottom row: time versus current helicity data for the same active region (time aligned with the pictures); the yellow line represents the flare

INTRODUCTION

- Solar flares are sudden releases in energy due to rapidly changing magnetic fields.
- Since flares are the result of a buildup of energy over time, we can we analyze time series data to forecast and understand flares.
- We analyzed many variables that characterize solar active regions such as magnetic flux, electric current, and free magnetic energy.

Figure 2: HMI variables (flux, free energy, area, and polarity inversion line flux) over time for 24 hour period



METHODS

Positive and negative classes for training

- Positive class: 24-hour period before a flare.
- Negative class: 24-hour period without flares in a flaring active region.

Feature extraction

- Polynomial fits have high error on the edges of data due to Rudge's phenomenon.
- Used cubic spline fitting model: fit multiple polynomials to data.

Learning model

- Stochastic gradient descent: fast, easy to interpret.
- AdaBoost: boosting algorithms have high accuracy.

RESULTS

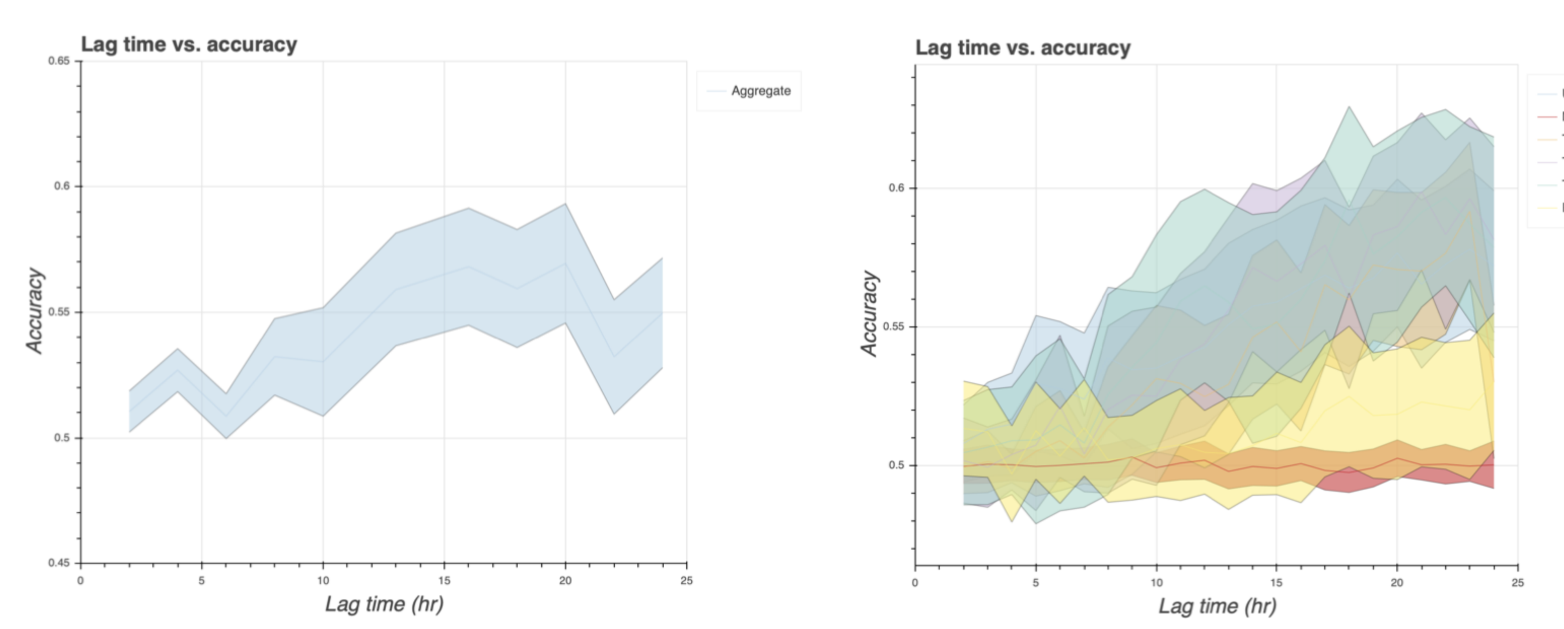


Figure 3: Model accuracies vs. lag time
Left figure: combined feature model accuracies vs. lag time
Right figure: individual feature model accuracies vs. lag time

CONCLUSIONS

- Over time, the testing accuracies for the single-variable models increase over time.
- Training on a model with all the HMI features consistently performs better than any single feature, showing that time series analysis is important for flare prediction models.
- The highest-performing features are total magnetic flux, total electric current, and free energy.
- The lowest-performing features are mean electric current and polarity inversion line flux.

FUTURE WORK

1. More robust model: state space modeling to capture variability.
2. Change negative case to assert that there are no flares for some time after the data ends.
3. Predicting different solar events with time series data.

The code to obtain these results and an accompanying research note in RNAAS will be uploaded in the next week.