Improving the Forecasting of Space Weather by Improving MagPy

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Introduction

MagPy is a computer program which uses Helioseismic and Magnetic Imager (HMI) vector magnetograms to forecast major space weather events such as major solar flares, coronal mass ejections (CMEs), and solar particle events (SPEs). MagPy is written in Python and is an upgraded version of the computer program MAG4. From vector magnetograms, various free-energy proxies are calculated for active regions on the Sun. These free-energy proxies are then converted into predicted event rates for each active region[1]. MagPy, compared to MAG4, was improved by varying multiple thresholds to optimize forecast accuracy as measured by True and Heidke Skill Scores (TSS and HSS)[1]. For skill scores, a one is a perfect score, and a zero means that a prediction cannot be accurately made. The thresholds used are 1) Smooth factor, 2) Br Magnitude, 3) Potential Field, and 4) Flux Br Magnitude Thresholds. We have investigated to determine if these optimals thresholds are real or are just noise.

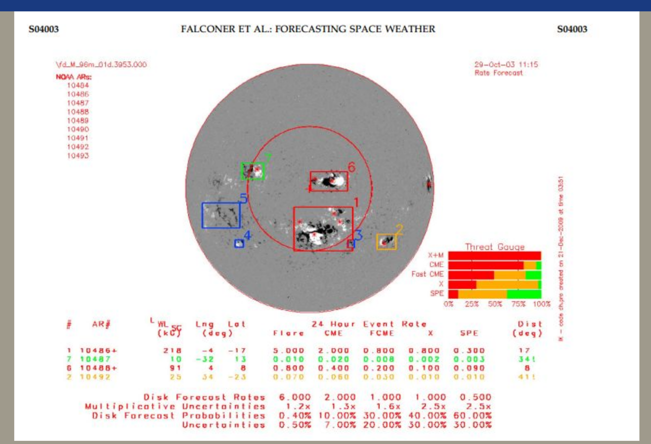

Figure 1: An example of a full forecast produced by MAG4[2].

Methods

In order to investigate if the found optimals of MagPy are real or simply just noise, we used two different methods of plotting the data to look for maintained shapes within the structure of the different forms of plots.

Method 1:

The first method was using Python to find the maximum HSS and TSS for each proxy. These were then used to find the optimal thresholds for each proxy using their max HSS and TSS. These thresholds were then plotted versus the skill scores, allowing each threshold in the optimal thresholds to vary one at a time. This was done for all of the proxies in order to examine the shape which the graphs had over the range of the proxies. If the shape is maintained throughout the entire range, it would suggest that the data does seem to have a real optimal.

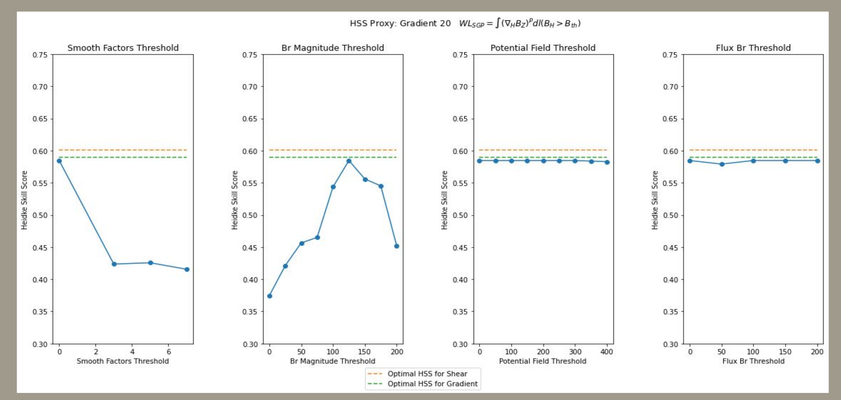

Figure 2: A plot of the different thresholds, as they vary, versus HSS.

Method 2:

The second method was graphing the smooth versus the Br Magnitude thresholds and coloring the graphs by skill score. Using a colormap allows for an optimal peak to be looked at from a different view by seeing if the colormap actually genuinely has a peak. For method 2 there are two different qualifications to look for an optimal. If over the range of proxies, the peak does not vary significantly then it would suggest the data has an optimal. Along with this, if the peak does not vary significantly as the different thresholds are varied then it would also suggest the data has an optimal.

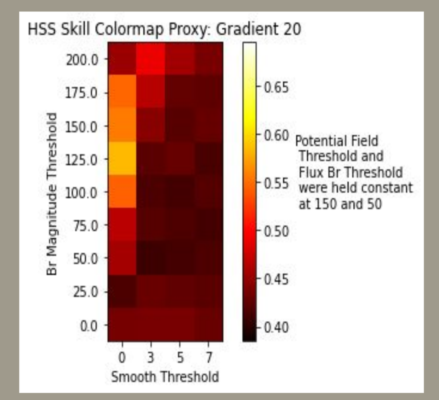

Figure 3: A colormap of the smooth versus Br magnitude thresholds colored by skill score.

Results

HSS Graphs:

Gradient: Shear:

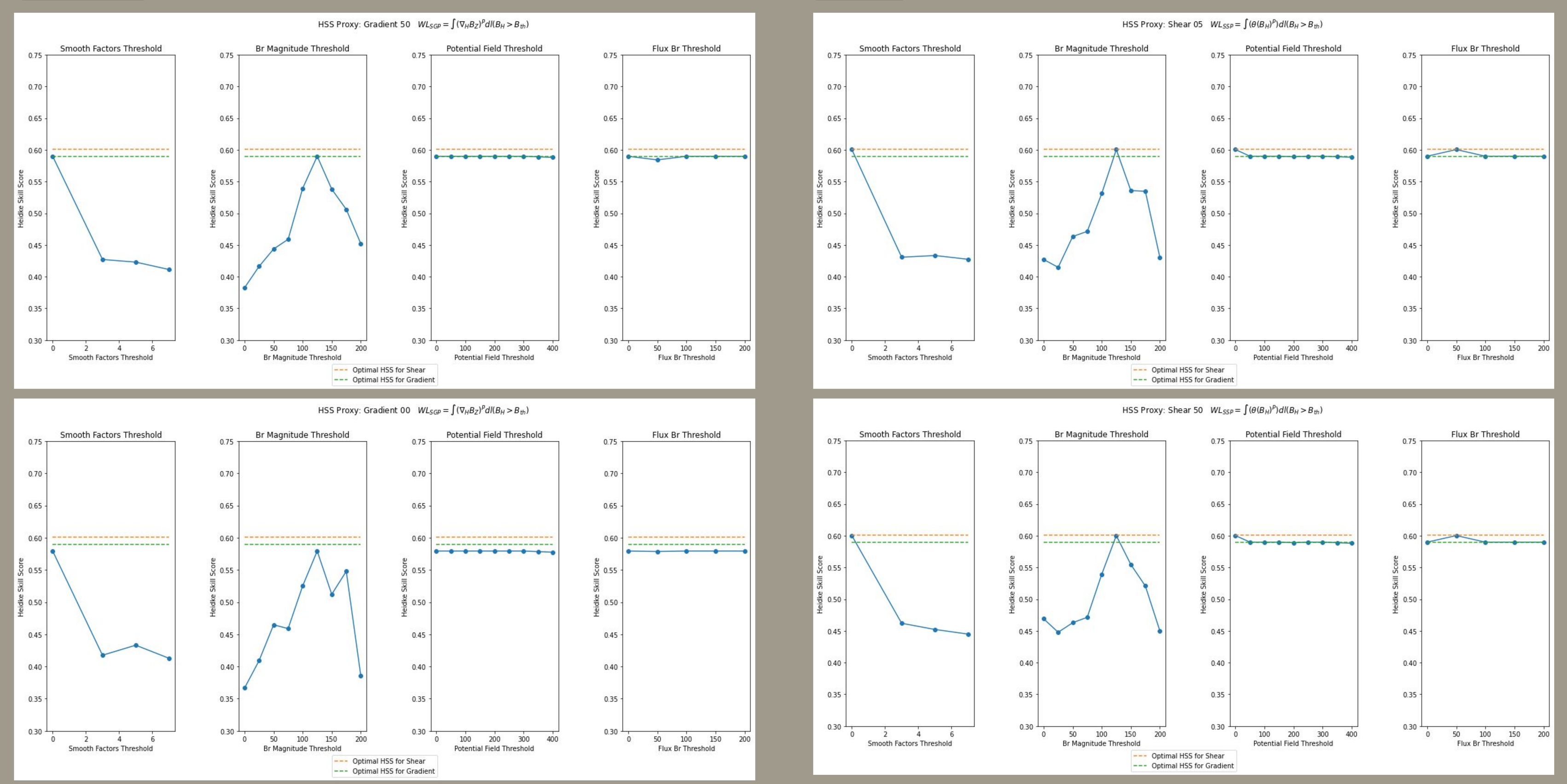

Figure 4: These are graphs of the HSS as the different thresholds vary for the shear and gradient proxy families.

Gradient: Shear:

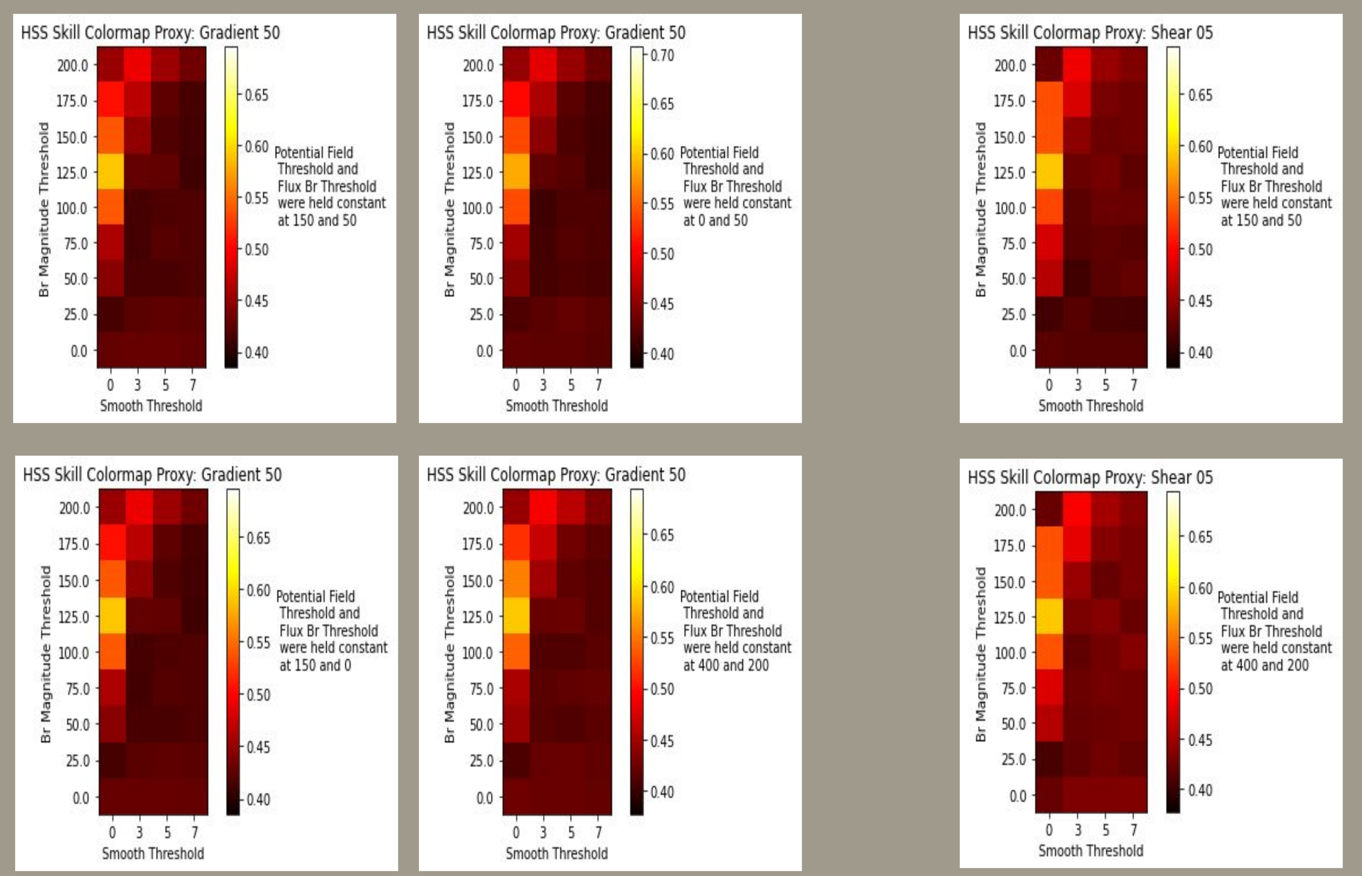

Figure 6: These are colormaps colored by HSS as the smooth and BR magnitude thresholds vary, and potential field and flux BR thresholds are constant.

TSS Graphs:

Gradient: Shear:

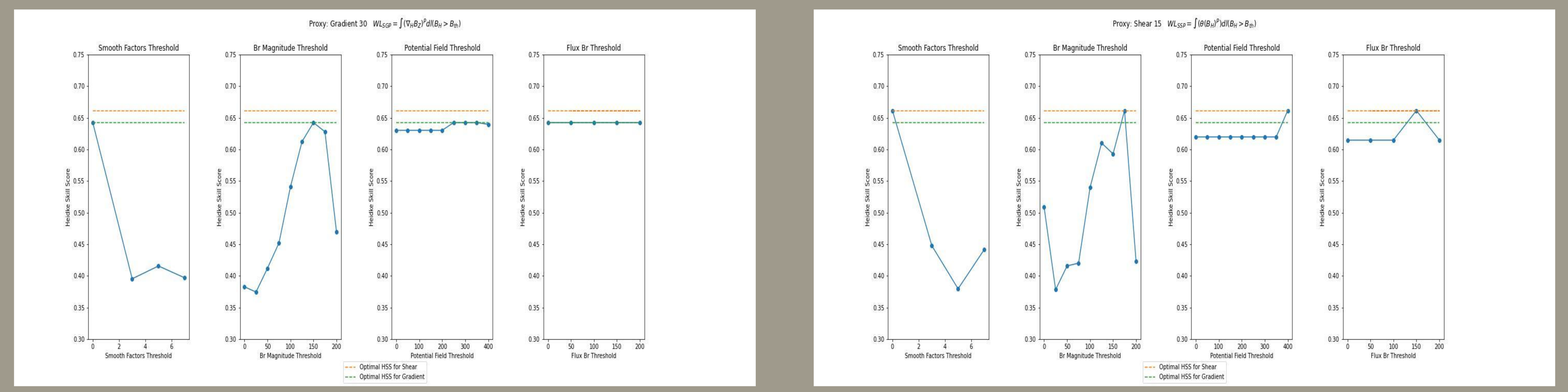

Figure 5: These are graphs of the TSS as the different thresholds vary for the shear and gradient proxy families.

Gradient: Shear:

Figure 7: These are colormaps colored by TSS as the smooth and BR magnitude thresholds vary, and potential field and flux BR thresholds are constant.

For method one, figure 4 and 5, as the different graphs were produced for the various proxies the shape for the smooth and BR magnitude thresholds maintained relatively the same shape, for HSS and TSS. The potential field and flux BR thresholds, however stayed relatively constant, or flat.

For method 2, figures 6 and 7, the smooth and BR magnitude thresholds varied as the potential field and flux BR were held constant. The shape of the peak stays relatively the same using this method. Allowing the last two thresholds to vary also produces similar results.

Conclusions and Future Work

From examining the graphs, it appears that the smooth and the Br magnitude thresholds hold significance to the MagPy data. The potential field and flux Br thresholds, however, do not appear to have significant effects on the data. This was determined because the first two thresholds seem to maintain a relatively constant shape over the entire range of the different proxies. This shows that there is some optimal in the data, however, we cannot confirm which proxy specifically is the optimal for forecasting because there are simply not enough data points. It can also be concluded that the potential field and flux Br thresholds do not have significant effects on the data because the shapes of the graphs over the range of the proxies remains relatively flat with little to no significant fluctuation, indicating that there is most likely no optimal. The smooth and Br magnitude thresholds were further examined using colormaps to confirm that the optimal, or peak, is actually in the data and not just noise. From the colormaps, it was determined that there is an actual optimal in the data because over the range of proxies the peak seems to stay relatively the same. This result is also obtained when letting the potential field and flux Br thresholds vary.

For future work, when we obtain data with more data points, we plan on examining the data over the range of proxies to determine which specific proxy and which combination of thresholds are the conditions to optimize MagPy on.

References

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