Statistical Prediction of Solar Flares Using Line of Sight (LOS) Magnetogram Data

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Outline

- Importance of Solar Flare Prediction
- Data and Method Used
- Special Considerations
- Data Preparation
- Results
- Summary
- Areas for Further Research
Importance of Solar Flare Prediction

• Cannot “Now-Cast” as effects travel at speed of light
  - Cause damage at same time as detection
• Satellite disruption
• Astronaut Safety
• X-Ray radiation alters ionosphere
  - Loss of communication
    • Especially in short-wave bands
Data and Process

• **Data Being Used**
  - MDI Line of Sight (LOS) Magnetogram Data
  - Observations from 1996-2004
  - 204 x 204 pixel images centered on every active region observed

• **Statistical Technique**
  - Discriminant Analysis
    • Same technique being used for the IVM data
Special Considerations: LOS Data

• Advantages
  − Nearly 20,000 raw data points, with between 6,000 and 10,000 points with good data
  − Large sample sizes needed for statistics (especially non-parametric)

• Disadvantages
  − Cannot calculate many of the parameters available for vector magnetogram data (e.g. $J_z$, $H_c$, $\psi_{NL}$)
  − Data further from disc center less reliable due to observing angle correction factor
Example

Fairly good data...

...gets worse and worse.
Data-Checking

• Data had to be pared down before analysis
  - Removal of bad instrument data
    • 11586 good points out of 19295 total points: 60% of data
  - Created IDL keywords to specify different limits to place on the data
    • Distance from disk center to throw out magnetogram
    • Distance from disk center to zero out data
  - Allows greater control over the analysis
Results

- Predictive Power of DA varies year to year
  - Why?

- Quantification of Unreliability Further from Disk Center
  - Decrease of nearly 200% from Disk Center to 45 degrees out

- Potential Field Correction Does Not Improve Results
  - Although it is an improvement on observing angle correction
Variation with Year

• One Hypothesis
  - More magnetograms give better results
  - Weak trend to support this as more data seems to give a higher skill score

• Not the only possible explanation
Variation with Year

- First hypothesis called into question by “All Data” anomaly
- Weak possible trend not supported

- Alternative Explanation
  - Predictive power somehow tied to solar cycle
  - Need more data to confirm
Decrease in Skill Score with Distance from Disk Center
Differences in Data

Includes data within 45° of disk center

Includes data within 60° of disk center
Who Cares?

• Researchers want large datasets
  – Often try to stretch the limits with LOS data

• Many say up to 60 degrees is acceptable using observing angle correction
  – Definitely not the case
  – Even 45 degrees is questionable
Potential Field Correction

• “Mu Correction” not an accurate measure of magnetic field on the sun
• Potential field correction method models active regions as potential fields instead of assuming all magnetic field is perpendicular
• Approximation produced similar results to the mu correction
Mu Correction vs. Potential Field

- In some cases, mu does better, in some cases, potential field does better (black crosses are mu, blue stars are PF)
Not the Final Word

- Consistently greater difference between the potential field correction and observing angle correction further from disk center
Comparison with Peer Parameters

• R Parameter posited by Schrijver in 2007 paper
  - Locations of strong opposite-polarity magnetic fields adjacent to each other
  - Declared as proxy for photospheric electrical currents

• Uses Data Set from 1999 – 2006
• Implemented in Code, but still working out bugs
  - Unable to compare results
Summary of my Summer

• Analysis Code Edited to Allow User to Choose Data Limits
• Discovered annual variations in predictive power
• Quantitatively confirmed unreliability of data far from disk center
• Investigated difference between observing angle correction and potential field correction
Future Research Possibilities

• Add more data to flush out reason behind annual variations
• See how far potential field correction can be extended beyond observing angle correction
• Fix code for Schrijver's R parameter and investigate differences in results
• Compare four-year results for similar parameters with IVM data
• Analyze differences in results between parametric and non-parametric DA
  - LOS ideal for NPDA because of large dataset