Researching Solar Storms with Citizen Scientists

Engaging with Four Thousand Volunteer Research Assistants

C. Scott, S. Jones & L. Barnard
Introduction
Solar Storms, or Coronal Mass Ejections
Impacts of Solar Storms
The twin STEREO spacecraft
A lot of data!

Each spacecraft:
• One image every 40 minutes
• 36 images per day
• 13,140 images per year

Altogether, since launch:
• 184,000 images to look through and Identify Solar Storms

Complex features of Solar Storms difficult to identify automatically
Citizen Science Projects

The Solar Stormwatch Project

Solar Stormwatch II

Protect our Planet from Solar Storms
Seven Publications So Far

• The distribution of interplanetary dust between 0.96 and 1.04 au as inferred from impacts on the STEREO spacecraft observed by the heliospheric imagers, Davis+ 2012.

• The Solar Stormwatch CME catalogue: Results from the first space weather citizen science project, Barnard+ 2014.

• Validation of a priori CME arrival predictions made using real-time heliospheric imager observations, Tucker-Hood+ 2015.

• Observational Tracking of the 2D Structure of Coronal Mass Ejections Between the Sun and 1 AU, Savani+ 2015.

• Differences between the CME fronts tracked by an expert, an automated algorithm, and the Solar Stormwatch project, Barnard+ 2015.

• Testing the current paradigm for space weather prediction with heliospheric imagers, Barnard+ 2017.

• Tracking CMEs using data from the Solar Stormwatch project; observing deflections and other properties, Jones+ 2017.
The Solar Stormwatch CME catalogue: Results from the first space weather citizen science project

L. Barnard¹, C. Scott¹, M. Owens¹, M. Lockwood¹, K. Tucker-Hood¹, S. Thomas¹, S. Crothers², J. A. Davies², R. Harrison², C. Lintott³, R. Simpson³, J. O’Donnell³, A. M. Smith⁴, N. Waterson⁵, S. Bamford⁵, F. Romeo⁷, M. Kukula⁷, B. Owens⁷, N. Savani⁸, J. Wilkinson⁹, E. Baeten⁹, L. Poeffel⁹, and B. Harder⁹

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Anyone can get involved!
Which is more complicated?
Which is more complicated?

Image on the Left
Image on the Right
Which is more complicated?
Which is more complicated?
Ranking

Increasing Complexity
Result

![Graph showing relative complexity and total sunspots over time.]

- STEREO-A yearly means
- STEREO-B yearly means
- All STEREO-A storms
- All STEREO-B storms

Time:
- 2008 to 2017

Relative Complexity:
- Y-axis

Total Sunspots:
- X-axis

Graph illustrates the variation in relative complexity and total sunspots over the specified time period.
What do you see as a “complex” solar storm?

Thank you very much for all your help with our solar storm research over the past year—we’ve made some good progress, thanks to you!

Some of you might have seen our project “Protect our Planet from Solar Storms”, which we launched back in May with the Science Museum. Here citizen scientists compared images of two solar storms, and decided which was the most complex or complicated solar storm.

The Solar Stormwatch Blog and Forum
Problems & Benefits
Getting participants to do the right thing

Draw around the outermost storm front.

Draw around the **brightest** and **outermost** storm fronts.
Reduced Subjectivity
Unusual Events

#ghost

#dust
<table>
<thead>
<tr>
<th>Username</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>ciderboyafc</td>
<td>I've been using glasses for a while now. Just found solar stormwatch. I have suffered migraines and disturbed sleep patterns all my life and find it interesting you can match them up with solar flare activity. I would like to see if make a tool where would I find details of flare activity? It would be great to see if my occasional &quot;sleep-walking&quot; activities matched too! thanks...</td>
</tr>
<tr>
<td>Qualties</td>
<td>If any of you are interested in pursuing this further, I suggest you make a note of days when you suffer from migraines and have strange dreams for a month, and then compare that to the solar weather that occurred. Try to avoid looking at any real-time solar forecasts while you're recording data to reduce the chances of biasing the results in any way. I'd be happy to help analyzing trends, but you have to have some numbers to work with first.</td>
</tr>
<tr>
<td>ciderboyafc</td>
<td>Thanks for that. Will follow suggestion and get back at a later date. best wishes, ciderboyafc.</td>
</tr>
<tr>
<td>T.Roc</td>
<td>If you really want to give it a fair shake, as was suggested by Qualties, and in the spirit of this citizen-scientist program, you should post your results online here. I would not think that there is any need to 'prove' anything here, it's been studied by the correct specialists for many decades. One good summary paper is here: Geomagnetic Fields, their Fluctuations and Health Effects. regards, T.Roc.</td>
</tr>
</tbody>
</table>
Inspiration

High school student from USA wrote algorithm to identify storm fronts
And finally...
Open-access, peer-reviewed publications

Code online on GitHub
https://github.com/S-hannon/solar-stormwatch-track-it-back

Data online on figshare
doi: 10.6084/m9.figshare.5224936.v1
Thank you!