STEREO – Heliospheric Imagers

- HI status and operation *nominal*
STEREO – Heliospheric Imagers

- Products: Images and movies, J-plots, c-maps
  - see http://www.sstd.rl.ac.uk/stereo/

- Exploitation – 67 publications known to the PI team
  - Includes 19 distinct institutes
  - Encompasses CME onsets, CME propagation and impacts at Earth and on other solar system bodies, cometary impacts, asteroids, stellar variability, CIRs, streamer ‘blobs’, dust…
STEREO – Heliospheric Imagers – ‘Products’

- J-plots – Fitting elongation-time profiles to determine both speed and direction with respect to the Sun-Earth line (see Davies et al., 2009)
STEREO – Heliospheric Imagers

- 109 HI ICMEs catalogued for 2007 and 2008 (see HI web site) – J-plot technique used to study the passage of CMEs in 3D (Harrison et al., in prep)

Example product-set for 29 Feb 2008 ICME from event list – J-plot analysis appears to show Earth-impact - 12 similar impacts identified for 2008
STEREO – Heliospheric Imagers

- 3D distribution of the 109 HI ICMEs from 2007 and 2008
STEREO – Heliospheric Imagers – ‘Products’

- c-map – a Carrington style map showing the streamer belts and CME activity
STEREO – Heliospheric Imagers – ‘Products’

- c-map – a Carrington style map showing the streamer belts and CME activity – a differenced version reveals fine structure in the streamer belts
STEREO – Heliospheric Imagers – Stellar Photometry Calibrations

- Measured response to star determined by aperture photometry
- Compared with predicted response calculated by folding stellar spectrum through instrument response function
  - Many 100’s of stars of various spectral types and known spectra used (903 and 541 for HI-1A and HI-1B, respectively)

Note: The outliers with large intensities lie below the fitted lines due to saturation effects. Including/excluding these has negligible effect on the fits.
STEREO – Heliospheric Imagers – Large-Scale Flat Field Responses

- Slope of line calibrates absolute errors in the instrument response function (i.e. systematics such as absolute value of CCD QE, filter responses, CEB gain …)
  - 0.93 for HI-1A; 0.98 for HI-1B
- Drift of stars across FOV enables flat-field calibration (for aperture photometry)

- Surface plots of pre-launch & optimised large-scale flatfield for HI-1A (top left & right) and HI-1B (bottom left & right)
STEREO – Heliospheric Imagers – Calibration Factors for Diffuse Flux

• Need conversion factors from DN $s^{-1} \text{pixel}^{-1}$ to MSB ($B_O$), S10 units and SI units
  ➢ 1 S10 unit corresponds to flux of $10^m$ star (of solar spectral type) spread over 1 square deg of sky
  ➢ SI units measured in $W \text{m}^{-2} \text{s}^{-1}$ over 300-1080 nm (overall waveband of HI-1)

• Solar spectrum data of Neckel & Labs (1984) folded through calibrated HI-1 instrument response
  ➢ Gives total response $I_O$ in DN $s^{-1}$ if instrument were to view solar disk.

• Procedure to obtain conversion factor $C_{MSB}$ (from DN $s^{-1} \text{pixel}^{-1}$ to $B_O$) is then
  
  $$C_{MSB} = \frac{n_{pix}}{I_O}$$
  where $n_{pix}$ is number of pixels imaging solar disc, and

  $$n_{pix} = \pi \left(\frac{D_O}{2d_{pix}}\right)$$
  where $d_{pix}$ is angular dimension of pixel.

• Similar procedures for other two conversion factors.
• Conversion factors from DN s$^{-1}$ pixel$^{-1}$ to diffuse flux units –

<table>
<thead>
<tr>
<th></th>
<th>$C_{MSB}$</th>
<th>$C_{S10}$</th>
<th>$C_{SI}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HI-1A</td>
<td>8.99 x 10^{-14}</td>
<td>199.8</td>
<td>1.40 x 10^{-6}</td>
</tr>
<tr>
<td>HI-1B</td>
<td>9.04 x 10^{-14}</td>
<td>200.9</td>
<td>1.41 x 10^{-6}</td>
</tr>
</tbody>
</table>

• Note these are values on-axis; the pixel size varies significantly off-axis for HI

• Can derive the off-axis correction to these factors using the HI image projection -

$$ R = \frac{F_p (\mu+1) \sin \alpha}{\mu + \cos \alpha} $$

where $F_p$ is the paraxial focal length

$\mu$ is a distortion param (Brown et al., 2009)

• This is effectively an additional flat-field correction to be applied for diffuse objects in addition to the FF correction derived from stellar photometry.
Solar scientists need you!
Help them spot explosions on the Sun and track them across space to Earth. Your work will give astronauts an early warning if dangerous solar radiation is headed their way. And you could make a new scientific discovery.

WHY SCIENTISTS NEED YOU
Watch our solar scientists explain why your contributions are vital, and find out what they're doing with your results behind the scenes.

MISSION BRIEFING
Explore our interactive mission briefing to get up to speed with solar science, zoom in on the STEREO spacecraft and meet our science team.

TALK ABOUT IT
Share your discoveries on the forum and Flickr, check out the space weather forecast on Twitter, and read our blog for all the latest news and challenges.

Featured member
Hannah Hutchins
Member since: August 2008
I love being able to contribute to science, it's fun and there are so many amazing things to learn about. The forum is a very nice and friendly place to be a part of and you get to meet the people in person at the Galaxy Zoo meet-ups.

Achievements
New recruit, Spot trained

For teachers
If you're a teacher, we've got all you need to include Solar Stormwatch in your lessons at Key stages 3 and 4
**SPOT**

**QUESTION**
When did the front of the solar storm get to the dotted halfway line in the STEREO Ahead camera?

**INSTRUCTIONS**
Play the video until the front of the solar storm is roughly at the dotted halfway line. Then use the nudge FORWARD and BACK buttons to find exactly when the storm reached it. Press the HALFWAY NOW button to record your answer.

**YOUR ANSWER**
STEREO AHEAD
HALFWAY NOW

**Hints & tips**
- If you think there is more than one solar storm in this clip, just pick your favourite. You'll get a chance to record another one at the end.
- Remember, solar storms begin from the outside edge of the cameras, and move towards the middle.
- Watch a How to... screencast.

**Extra Info**
What's the point of this measurement?
First we're asking you to mark when your solar storm gets halfway across the camera. Next you'll get to spot when it first appears. From these measurements we can make a rough estimate of its speed and, if you're making measurements in both cameras, its direction.

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**QUICK LINKS**
- Teachers resources
- Why scientists need you
- Sun, Earth & space
- The STEREO spacecraft
- Solar Stormwatch forum

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- Royal Observatory Greenwich
- Science & Technology Facilities Council
- Rutherford Appleton Laboratory
- ZOO™ UNIVERSE
WHAT'S THAT?

**QUESTION**
Can you spot comets, particle strikes or anything else interesting?

**INSTRUCTIONS**
Watch the video. If you spot something, pause it, then use the nudge FORWARD and BACK buttons to find the frame when it's most visible. Then press the relevant RECORD button in the answer section.

**STEREO BEHIND**

**STEREO AHEAD**

**PLAY**

**PAUSE**

**BACK**

**FORWARD**

**YOUR ANSWER**

**COMET**

**PARTICLE STRIKE**

**OPTICAL EFFECT**

**SOMETHING ELSE**

**ADD CLIP TO FAVOURITES**

**TIME STAMPED:**

**NOTHING TO SEE**

**Hints & tips**
- Want to double-check what each feature should look like? OK.
  - Comet
  - Particle strike
  - Optical effects
  - See more examples on Flickr (opens in a new window)
- It's ok if something appears more than once, just record both times it appears.
- You can record more than one type of feature per video clip.
- Watch a How to... screenscast.

**Extra info**
Why do scientists want me to spot these features?
STEREO's heliospheric imagers capture a wide-angle view of space, which means they snap all sorts of interesting and unexpected things besides solar storms. But so far scientists don't know what's common and what's not. Your work will help provide the answers.
Earth – Sun – Spacecraft separation angle

Impacts per bin
CME launched on 14\textsuperscript{th} March predicted to arrive at 1 AU at 12 UT on 18\textsuperscript{th} March ± 5 hours travelling at a longitude of -21 ± 17 degrees