Picking out the details (interpreting recent images of the Sun)

Although astronomers have been able to observe sunspots on the surface of the Sun since the first telescopes were built in the 17th century, some solar features have only been observed recently. The imaging equipment on the Solar Dynamics Observatory (SDO) satellite and the Hinode satellite has much greater resolution than on earlier satellites, such as the Solar and Heliospheric Observatory, SoHO. This increased spatial resolution allows scientists to see features that would previously have been too small to pick out. X-ray Bright Points (called ‘solar fireflies’ on Sun|trek) are areas of intense, very short wavelength (X-ray and UV) light. They were observed in the 1990s by YOHKOH, a Japanese satellite, and seen clearly by the X-ray telescope on the Hinode satellite. They can also be seen in the image from the SDO satellite, taken on March 30, 2010.

In this activity you will examine images of the Sun taken by instruments on Hinode and on SDO and find out the size of features that were being observed. To learn more, go to the ‘Solar fireflies’ section of the ‘Magnetic Sun’ adventure on the Sun|trek website.

Part A: An image of the Sun from the Hinode satellite (fig 1)

Hinode’s X-ray Telescope (XRT) can see the details in some of the X-ray Bright Points and allows scientists to see small regions of hot gas (one million degrees Celsius) trapped in magnetic loops. In the ‘Hinode’ image on the separate sheet, individual X-ray Bright Points are circled in green.

(Note: in astronomy angles are often quoted in arc seconds (arcsec) where 1 degree = 3600 arc seconds)

Questions about the Hinode image
1. If the diameter of the Sun is 1800 arc seconds, and the Sun has a diameter of 1,392,000 km, what is the scale of the image in kilometres per arc second?
2. The image is 300 pixels wide, equivalent to 300 arc seconds (each pixel is 1 arc second). How many kilometres is the width of the image equivalent to?
3. Measure the width of the image in millimetres. How many kilometres does each millimetre of image represent?
4. What is the size, in kilometres, of the smallest circled Bright Point in the image?

Part B: An image from the SDO satellite (fig 2)

The SDO image shows a full-disk, multi-wavelength, extreme ultraviolet image of the Sun taken by the AIA (Atmospheric Imaging Assembly) instrument. False colours are used to show different gas temperatures, and so pick out different features:
- reds are relatively cool plasma heated to 60,000 °C
- blues, greens and white are hotter plasma with temperatures around 1 million °C.

Questions about the SDO image
5. The diameter of the Sun is 1,392,000 kilometres. Measure the diameter of the Sun in the SDO image in millimetres. What is the scale of the SDO image in kilometres/millimetre?
6. What are the smallest features you can find on this image, and how large are they in kilometres? How does this compare to the size of the Earth if the diameter of Earth is 12,756 kilometres?
7. Where are the brightest regions (hottest gas) located in this image?
Part C: A solar active region seen by SoHO/EIT and SDO/AIA

The SDO image shows a full disk image with a small area identified by a box. Two larger images of this area are shown from the EUV Imaging Spectrometer (EIT) on SoHO and the SDO/AIA. The images are both taken in the same wavelength band, and show an active region, with large loops of hot plasma being guided by the Sun’s magnetic field. The scale in arcsec is given on the x-axis and y-axis. Each pixel of the SoHO/EIT is 2.6 arcsec. In contrast, each pixel of SDO/AIA is 0.6 arcsec. Notice how much the spatial resolution has improved between SoHO and SDO, and how much more detail can be seen in the SDO images. (Thanks to Caroline Alexander for providing these images).

8. What is the scale of the SDO image of the active region in arcsec/millimetre?
9. Measure the size of one of the loops in millimetres (this can be done with a piece of string!).
   Convert this into arcseconds, and then into kilometres (using the answer from Question 1.)
10. How does this compare to the size of the Earth, if the diameter of Earth is 12,756 kilometres?
Fig. 1 - Hinode/XRT image

This Hinode/XRT image was taken on March 16, 2007. The image is 300 x 300 pixels in size. Each pixel views an area on the Sun that is 1 arc second x 1 arc second.

This image of the Sun was taken by SDO on March 30, 2010. It uses false colour to show different gas temperatures:
- reds are relatively cool plasma heated to 60,000 °C
- blues, greens and white are hotter plasma around 1 million °C

See: http://www.suntrek.org/blog/solar-dynamics-observatory-sdo for information on the SDO satellite.
This image of the Sun was taken by SDO/AIA in the wavelength band around 17.1nm. It uses a false colour (yellow) to show hot plasma at around 2 million °C. Below are two images of the active region shown in the box on the Full Sun image. The left hand image is taken with SoHO/EIT and the right hand image is taken with SDO/AIA.
See: http://www.suntrek.org/blog/solar-dynamics-observatory-sdo for information on the SDO satellite.

See: http://sdowww.lmsal.com/ for daily images from the AIA instrument of the SDO satellite.


See: http://sohowww.nascom.nasa.gov/data/realtime-images.html for daily images from the SoHO satellite.

Image credits

Hinode/XRT image, March 16 2007
False colour SDO/AIA image, March 30 2010
SDO/AIA image of whole Solar disk, June 12 2010
SoHO/EIT and SDO/AIA images of active region, June 12 2010