Our explosive star puts on a fine show

Flares are intense magnetic explosions on the sun – the biggest bang in our solar system. A recent solar flare was the third largest ever recorded. On 28 October 2003 it launched a stream of high energy protons toward the Earth at close to the speed of light, taking about 15 minutes to reach Earth and be recorded by neutron monitors installed and operated by the Australian Antarctic Division at Mawson and Kingston.

The flare came from solar active region (SAR) 10486, which had grown to one of the largest sunspots (upper left) seen by the Solar and Heliospheric Observatory (SOHO), a cooperative project between the US National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). SAR 10486's spectacular show projected a series of powerful flares and associated plasma eruptions into space called coronal mass ejections (CME), one of which can be seen as a bright flash in (upper right). It was associated with a CME (lower left), which sent a large plasma cloud directly towards Earth. The expanding CME cloud and the effect of the high energy protons on the SOHO imager (multiple white spots) can be seen in the lower right image. The fast-moving cloud reached Earth's magnetosphere a mere 19 hours later, almost a record speed for a CME – greater than 2000 km per second.

As a result of this solar storm, an impressive sudden magnetic impulse was detected on all our station magnetometers that also recorded the subsequent intense geomagnetic storms. High energy protons caused a series of Polar Cap Absorption (PCA) events as detected on our station riometers. These space weather events were reported to impact upon space and ground based technologies: two spacecraft were significantly damaged by the high energy particle bombardment; a disturbed ionosphere impacted on HF communications; and some 20,000 homes lost power in Malmoe, in southern Sweden as a consequence of induced currents tripping circuit breakers in the power grid.

The auroral oval expanded considerably and moved away from our Antarctic stations, over Macquarie Island and Tasmania (as observed by the TIGER radar on Bruny Island) and then equatorward. Auroras were seen as far north as Perth and Wollongong. But persistent cloud cover over Hobart and Kingston meant that only the occasional glimpse could be seen through gaps in the cloud – and only then by a keen auroral observer like the AAD's John Innis, who reported his observations to IPS Radio and Space Services:

The auroras we have seen through the gaps looked quite active at times. The best I have seen (most colourful and active) was a short (10 minute) glimpse we had on Friday night (31 October), about 10: 45 pm local summer time … To the south a large window in the clouds opened, and we had a bright white-green glow topped with red, but otherwise unstructured, and a series of fast growing, narrow, and short lived rays. The glow extended to perhaps 30 degrees about the south horizon, with the tops of the rays extending to around 60 degrees. The lower border of the glow was not determinable due to cloud. The rays grew and decayed in around 10 seconds, at times less, and were less than about 1 degree in apparent width.

The association of solar activity and tropospheric climate in the pre-industrial era suggests that about a third of global warming observed through the twentieth century results from increased solar activity. Our routine geophysical observations in Antarctica form a climatological baseline extending back to 1958 at Mawson and Casey, and for two decades at Davis and Macquarie Island. Because the upper atmosphere changes rapidly from one location to another, each of the four sites makes a unique contribution to the climate archive. There is accumulating evidence linking climate to solar variability. Further research is needed to address the questions 'how do we forecast space weather events?' and 'how do solar events affect climate?'

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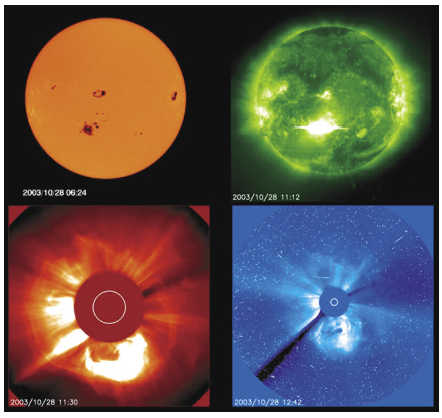
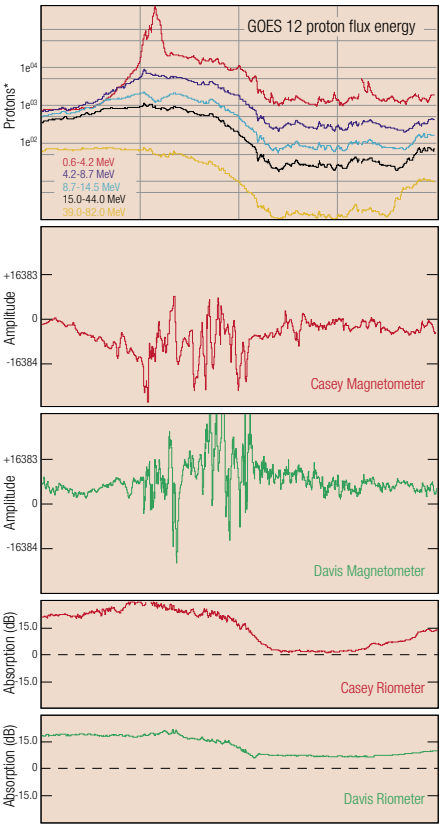


SOHO/EIT AND LASCO INSTRUMENTS

RAY MORRIS



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From top to bottom: 1. A montage of solar images, courtesy of SOHO/EIT and LASCO instruments. 2. An aurora over Kingston resulting from a similar X-ray flare and CME event during November 2001.
3. Stacked plots of GOES-12 satellite proton flux energy bands resulting from the X-ray flare and CME of 29 October 2003 (topmost panel). The resulting magnetic storm and polar cap absorption events recorded at Casey and Davis for the CME of 28 October 2003 are shown in the lower four panels. Refer to the GOES-12 data posted at <http://spidr.ngdc.noaa.gov/spidr/>.