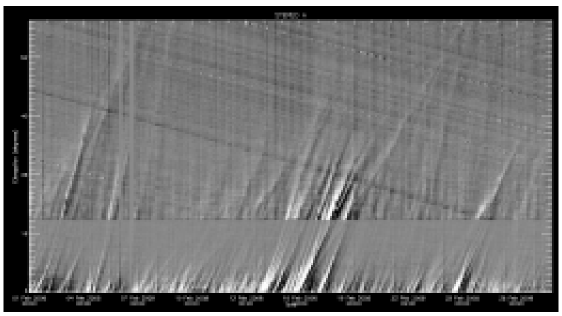
ACE measurements and STEREO vision build space weather forecasting system

April 14 2010, by Anita Heward



An example J-map produced from a series of running difference images from HI on STEREO-A for the month of February 2008. Many tracks are visible on the sunward edge (the base) of the J-map with a few tracks clearly extending to much greater elongations. Also visible are some background stars which have not been fully removed in processing the images. Credit: AO Williams/University of Leicester/STEREO/NASA

(PhysOrg.com) -- Scientists from the University of Leicester have used observations from NASA's STEREO and ACE satellites to come up with more accurate predictions of when blasts of solar wind will reach Earth, Venus and Mars. Anthony Williams will present the results at the RAS National Astronomy Meeting in Glasgow.

We have recently been experiencing an unusually quiet and long-lasting solar minimum, and solar storms caused by Coronal Mass Ejections have been scarce. Despite this, high pressure pulses of solar wind, called

Coronal Interaction Regions (CIRs) have been keeping the space weather unpredictable.

CIRs arise when fast moving solar wind particles gushing out of a coronal hole catch a slower flow ahead and the plasma becomes compressed. As the CIRs reach the upper layers of planetary atmospheres, they can cause high levels of activity in the ionosphere. To date, predictions when CIR events will arrive at planets have been flawed, in that observations of the features close to the Sun underestimate the speed that they are moving by the time they cross Earth's orbit.

The Leicester team has been using a suite of instruments carried by spacecraft spread across the inner Solar System to refine the prediction techniques. During a period from 1st July 2007 to 31st August 2008, they were able to monitor around 30 CIR events using the twin STEREO spacecraft (STEREO-A sits ahead of the Earth in its orbit and STEREO-B lags behind) and the ACE spacecraft, which orbits in a gravitational balance point that gives it an uninterrupted view of the Sun. In addition, they used the ASPERA instruments carried by Mars Express and Venus Express spacecraft to monitor the effects of the CIRs at Mars and Venus.

The team looked for signatures of CIRs - a high-density area of plasma followed by a region of increased windspeed - in the ACE and STEREO data and then tried to see if there was a relationship with increased activity at Mars and Venus. They also used data from STEREO's Heliospheric Imagers (HI) to build up maps from strips of images that they could use to track the speed and direction of the features over time and determine the velocity. Finally, they looked for identifiable structures in the CIRs that could be used as markers to track the structures.

Using the in-situ measurements from ACE and STEREO, the team were able to work out the velocity of the CIRS and provide good estimates of when they would arrive at locations around the inner Solar System.

"Our estimates from ACE and STEREO are in good agreement with data from Mars Express. However, by the time these in-situ measurements are made, the CIRs are already crossing the Earth's orbital path. To develop a good forecasting system, we need to be able to track the features much closer to the Sun. We are working on two promising ways of doing this with the HI data," said Williams.

The team have modelled the path of CIRs close to the Sun using the velocities measured by ACE and overlaid them on the maps built up from HI images. They have found that there is good agreement between the modelled tracks and the HI observations, but not all the predicted tracks are visible in the maps.

"Electrons in the solar wind act a bit like raindrops, scattering the light like a rainbow. This means that some tracks appear much brighter than others, depending on the orientation of the STEREO spacecraft. At the moment, we have been able to match the brightest tracks to the predictions, but it's much harder to pick out the dimmer tracks where the light has been most scattered. The STEREO spacecraft are moving apart and, as the distance from Earth increases, the Earth-bound tracks are becoming brighter. We have a huge amount of data that we are working through, so we haven't yet had a chance to study the period when the brightest tracks will be heading towards the Earth, although this is planned," said Williams.

The team also found evidence of small 'blobs' that appear to be trapped in the CIR structure, providing a clear tracer of the location of the CIR as it travels radially outward. They evaluated the reliability of these markers against in-situ observations from ACE and STEREO A and B.

"There are some problems - we need to improve our estimates of the radial velocity of the CIRs - but there are a great many cases where both these methods work. With further work and a greater understanding of these techniques, they could become valuable tools for space weather forecasting," said Williams.

Provided by Royal Astronomical Society

Citation: ACE measurements and STEREO vision build space weather forecasting system (2010, April 14) retrieved 10 April 2024 from https://phys.org/news/2010-04-ace-stereo-vision-space-weather.html