Study reveals structures of solar wind as it travels toward, impacts Earth (w/ video)

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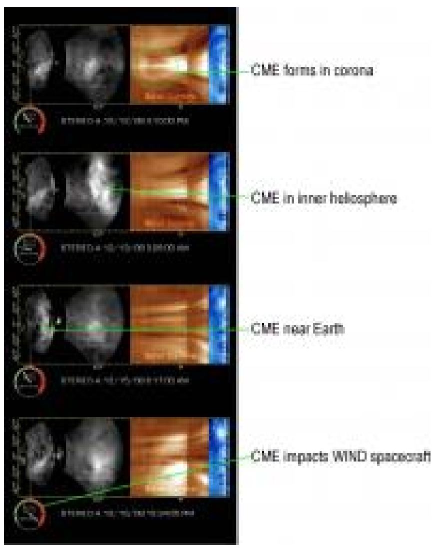

Newly reprocessed archival data from STEREO-A/SECCHI show details of the first Earth-directed coronal mass ejection (CME) of the STEREO mission, from inception on December 12, 2008, to Earth impact on December 15, 2008. New processing enables following the details of the CME with the wide-field heliospheric imager cameras, out to impact with the Earth 93 million miles from the Sun. Courtesy SwRI/NASA

Using data collected by NASA's STEREO spacecraft, researchers at Southwest Research Institute and the National Solar Observatory have developed the first detailed images of solar wind structures as plasma and other particles from a coronal mass ejection (CME) traveled 93 million miles and impacted Earth.

The images from a December 2008 CME event reveal an array of dynamic interactions as the solar wind, traveling at speeds up to a million miles per hour, shifts and changes on its three-day journey to Earth, guided by the magnetic field lines that spiral out from the Sun's surface. Observed structures include the solar wind piling up at the leading edge of a CME, voids in the interior, long thread-like structures, and rear cusps. Quiet periods show a magnetic disconnection phenomenon called a plasmoid, "puffs" that correlate with in-situ density fluctuations, and V-shaped structures centered on the current sheet — a heliospheric structure in which the polarity of the Sun's magnetic field changes from north to south.

"For the first time, we can see directly the larger scale structures that cause blips in the solar wind impacting our spacecraft and Earth," said SwRI's Dr. Craig DeForest, lead author of an *Astrophysical Journal* article released online yesterday. "There is still a great deal to be learned from these data, but they are already changing the way we think about the solar wind."

"For 30 years," said co-author Dr. Tim Howard, also of SwRI, "we have been trying to understand basic anatomy of CMEs and magnetic clouds, and how they correspond to their source structures in the solar corona. By tracking these features through the image data we can establish what parts of a space weather storm came from which parts of the solar corona, and why."

The team used a combination of image processing techniques to generate the images over a distance of more than 1 AU (astronomical unit), overcoming the greatest challenge in heliospheric imaging, that of extracting faint signals amid far brighter foreground and background signals. Small "blobs" of solar wind tracked by the team were more than 10 billion times fainter than the surface of the full Moon and 10 thousand times fainter than the starfield behind them.

"These data are like the first demonstration weather satellite images that revolutionized meteorology on Earth," said DeForest. "At a glance it is possible to see things from a satellite that cannot be extracted from the very best weather stations on the ground. But both types of data are required to understand how storms develop."

In particular, the new images reveal the shape and density of Jupiter-sized clouds of material in the so-called empty space between planets; in contrast, in-situ probes such as the WIND and ACE spacecraft reveal immense detail about the solar wind, at a single point in space.

More information: The paper, "Observations of Detailed Structure in the Solar Wind at 1 AU with STEREO/HI-2," by DeForest, Howard and S.J. Tappin (National Solar Observatory) was published online yesterday for the September 1, 2011 print issue of the *Astrophysical Journal*.

Provided by Southwest Research Institute