MAGALERT: AUGUST 27, 1978

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On August 27, 1978, a major geomagnetic storm began which eventually resulted in short period geomagnetic fluctuations of over 500 gammas in Boulder, and sightings of aurora as far south as Santa Fe, New Mexico. This storm was not obviously precipitated by flare or coronal hole solar plasma, but was apparently associated with a large solar filament which abruptly disappeared on August 23, 1978. Preliminary results of a study inspired by this storm are that 16 of the 59 geomagnetic storms which have occurred since the beginning of the current 11 year solar cycle can only be traced to disappearing filaments and some of the other storms which have been blamed on flares or coronal holes are also associated with disappearing filaments. Filament eruptions have been identified with coronal mass ejections, especially those observed with the *Skylab* white-light coronograph. However, there are some points of difference between typical coronal transients and geoactive coronal transients which may suggest fruitful research.

The key word in the title, Magalert, is taken from a series of international warning words and implies that a major geomagnetic disturbance is in progress or is expected. A Magalert was issued on August 27, 1978, by The Space Environment Services Center in response to a truly significant geomagnetic storm. Figures 1-4 show the three components of the Boulder magnetic field for the days of interest. Figure 1 shows the extremely quiet conditions which existed before the storm onset; Figure 2 shows the sudden commencement at 0247 UT signaling the arrival of a solar shock; Figure 3 shows the most disturbed day of the storm (over 500 gammas of fluctuation of the magnetic field and coincident with sightings of aurora in Boulder and Santa Fe, New Mexico); and Figure 4 shows the decay and end of the storm. This event is significant not only for its geophysical effects principally on communications systems, but also because it was a surprise - no solar optical flare or appropriate coronal hole heralded its arrival. Since the SESC (operated jointly by the Space Environment Laboratory and the Air Weather Service of the U.S. Air Force) is the only U.S. facility dedicated to the real-time monitoring and prediction of the space environment, we have done some considerable postmortem work on this event.

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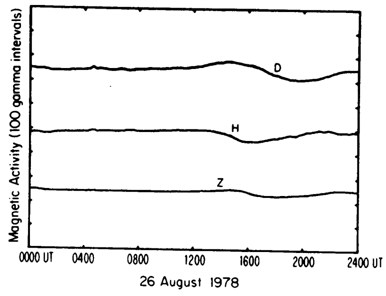

Figure 1. Pre-storm quiet conditions on 26 August 1978.

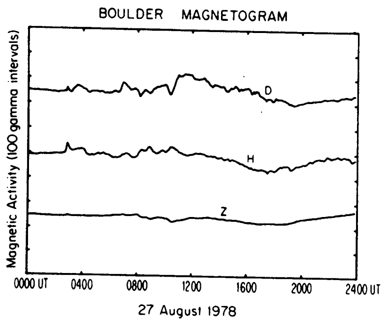

Figure 2. SSC at 0247 UT on 27 August 1978.

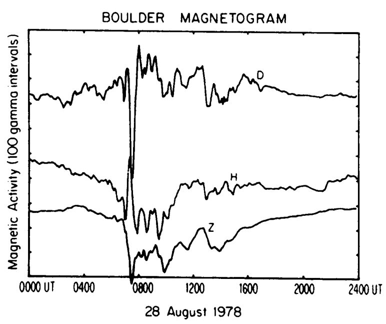

Figure 3. Peak of magnetic storm conditions on 28 August 1978.

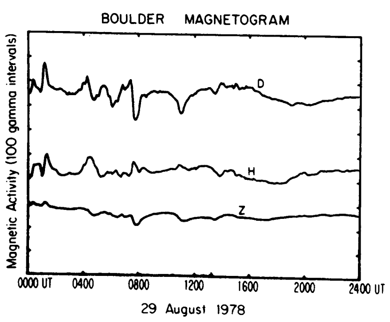

Figure 4. Storm decay on 29 August 1978.

First, we rechecked x-ray and solar radio data as well as flare reports and coronal hole maps. Only subflares were reported between August 22 and 27, and only 4 of those were associated with x-ray bursts above background. Importantly, those x-ray bursts were all well more than an order of magnitude below the signatures expected for potential geomagnetic effects. All radio bursts for a week preceding the storm were quite small and typical of normal quiescent solar behavior, and the only low solar latitude coronal hole was just approaching central meridian on August 27, fully four days before any geomagnetic effects are usually expected. However, an inspection of the daily H-alpha photos revealed that a filament disappeared between August 22 and 23 (Figures 5 and 6). The filament was still present at local Boulder sunset early on August 23, but Palahua Observatory, Hawaii, verified that the main filament disappeared totally between 0114 and 0128 UT on 23 August. If this filament disruption is indeed the source of the magnetic storm, the disturbance took approximately 4 days and 90 minutes to arrive at earth for an average speed of 427 km/s. This is in agreement with the "zero-order" near real-time solar wind speeds which were supplied by the University of California at San Diego using interplanetary scintillation techniques. Recently, preliminary ISEE-3 solar wind data supplied by S. Bame and published by Domingo et. al. (1979) shows a preshock velocity of approximately 300 km/s and a post shock velocity of approximately 450 km/s. Approximate pre and post shock solar wind densities are less than 10 cm^{-3} and greater than 40 cm^{-3}, respectively.

That filament eruptions could show up as geomagnetic storms really shouldn't have been surprising. The Skylab white-light coronograph experiment observed an association between sudden mass ejections from the sun with active and eruptive prominences and surges and significant mass and energy input into the solar wind (Gosling et. al., 1974). Gosling et. al. (1975) showed that eruptive prominence coronal events typically traveled out at speeds near 330 km/s, accelerated with height above the solar surface, and were not associated with metric wavelength type II and IV radio bursts which are correlated with faster moving flare-ejecta. However, obvious large-scale disappearing filaments such as the one shown here are not all that common in contrast with an estimate by Hildner et. al. (1976) that an average of 30 coronal transients per month occurred during the May 1973 to February 1974 Skylab period (although the transients did prefer helio longitudes where solar activity was high). In a study of a specific slowly ascending prominence and a more rapid accompanying loop-shaped coronal transient, Hildner et al. (1975) found that the bulk of the ejected material did not originate in the ascending prominence but must have come from the low corona above the prominence. They reported that the total event was far larger, more energetic, and longer lasting than would be inferred from the prominence observations alone. H-alpha filament eruptions have also been linked with long-delay enhancements in the x-ray emission or transient coronal holes (Rust, 1979). However, for this event, no

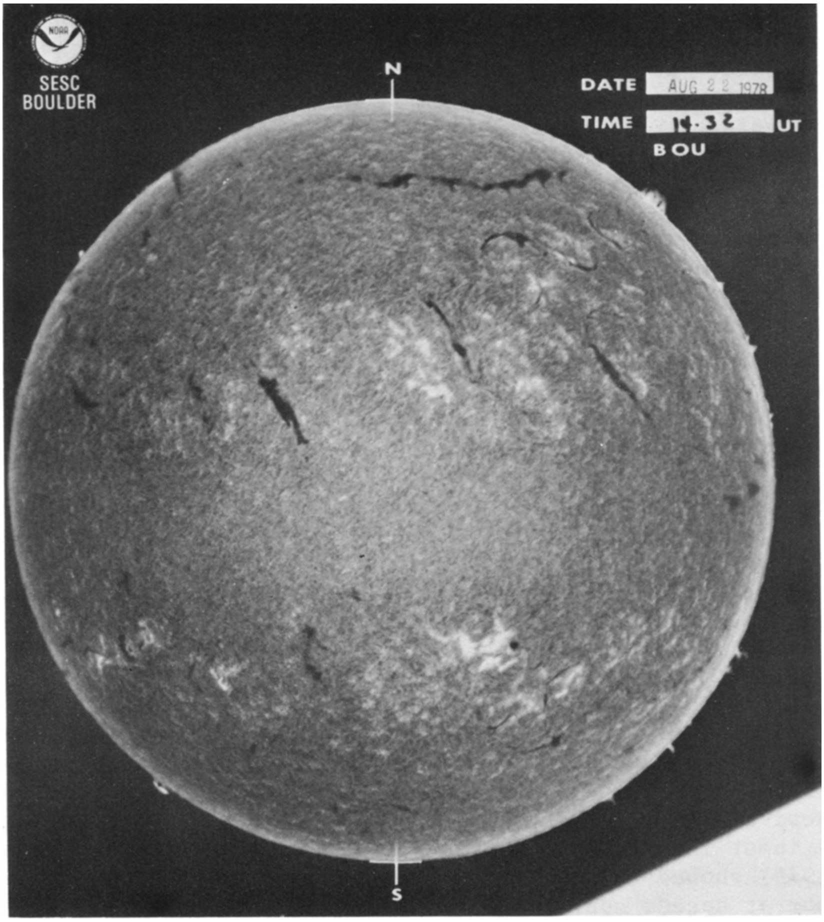

Figure 5. Low latitude Hα filament near central meridian at 1432 UT, 22 August 1978.

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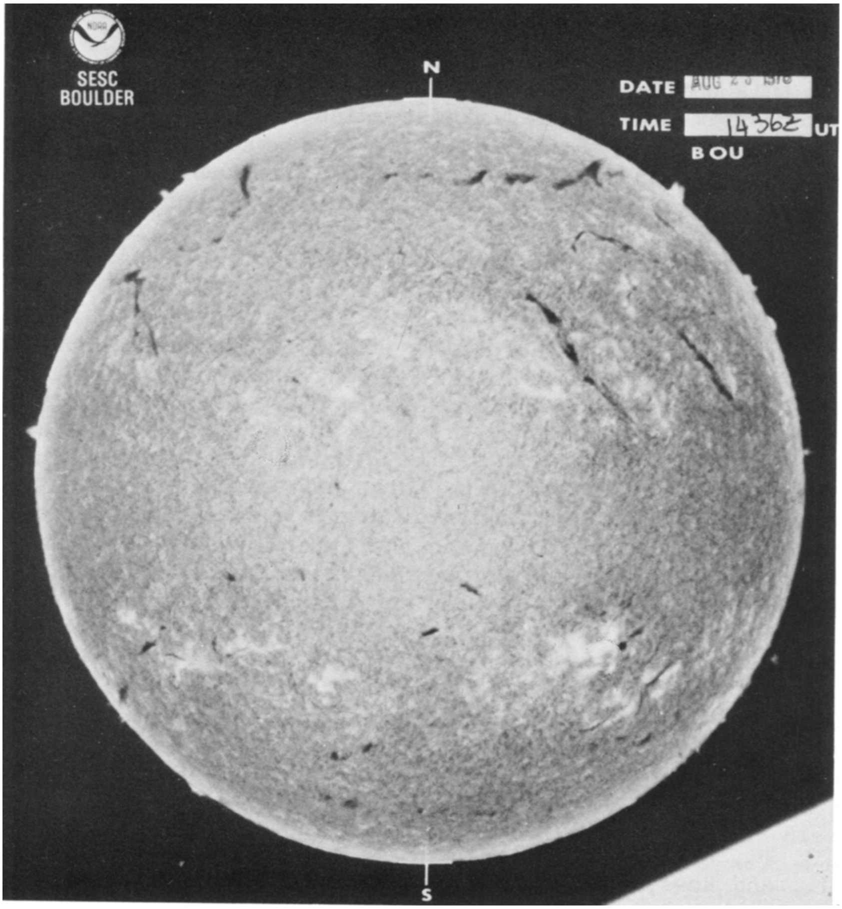

Figure 6. Patrol film at 1438 UT, 23 August 1978. Filament disappeared entirely between 0114 and 0128 UT.

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well-defined x-ray signature was observed and the solar wind speed is slower and the density much higher than that generally associated with coronal hole high speed streams.

Since this particular geomagnetic storm almost exactly one year ago, 9 other storms have been linked to disappearing filaments. And the preliminary results of a study in progress shows that of the 59 geomagnetic storms that have been recorded since the beginning of this solar cycle, 16 - including the 2 largest storms - can only be explained as the effects associated with a disappearing filament. The remaining storms find explanations in flares or coronal holes although some of those also occur in conjunction with disappearing filaments. Of course, there are disappearing filaments which are not connected with geomagnetic storms. We have not yet cataloged the differentiating factors between those filaments which link to geomagnetic storms and those which do not. I suspect the answers may not be obvious, especially in H-alpha photos.

We conclude that for the SESC, large disappearing filaments are surely worthy of note as harbingers of significant magnetic activity. We also submit that these storms and the interplanetary data between the coronal events and the earth may offer useful clues in understanding coronal dynamics and the underlying solar physics associated with coronal transients.

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DISCUSSION

Martres: We must not forget that: (1) a D.B. (disparition brusque) has always a cause (flare or new emerging flux), and this cause is very often to be found far from the filament (between some heliographic degrees to 60^{o} or more) and we observe only one solar hemisphere. (2) A D.B. is a slow event (duration one, two days) in the case of a quiescent prominence as your example is, and it never produces a shock into the coronal gas as geomagnetic storms ask.

Joselyn: (1) Since we do not really understand why (how) quiescent prominences exist, it seems that we also do not understand why they disappear. Flares and new emerging flux regions are daily occurrences, and yet quiescent filaments often exist for several rotations before they disappear. Of course, it is possible that the origin of this particular event may have been on the invisible solar hemisphere, but the statistics are building up. For 16 non-flare, non-coronal hole associated storms since January 1977, a large filament disappeared 3 to 5 days before the storm began. For another 4 storms, the explanation is not obvious and perhaps these might indicate that their source is on the backside of the sun.

(2) This D.B. was not a particularly slow event (14 minutes), but many do take hours to disappear completely and are apparently "shock-less." However, the relationships between solar events and geophysical effects, i.e., the necessary and/or sufficient conditions for geophysical effects, are not at all clear. Geometry is part of the answer and so is the southward component of the convected magnetic field, but there is much more to know about the physics of coronal transients and their interplanetary propagation.

McIntosh: (Comment) The distribution of disk positions of disappearing filaments followed by magnetic storms is too broad to permit a simple model of propagation of the transient density wave. It appears from a preliminary study that magnetic storm filament disruptions often occur on large-scale neutral lines that appear to be the solar source of an interplanetary sector boundary. The disappearing filaments may affect the Earth if they occur anywhere in a sector boundary that intersects the ecliptic plane near the sun-earth connection longitude; that is, the position of the disappearing filament may not be as important as the equator-crossing portion of its underlying neutral line.

Webb: I am surprised that this event had no soft X-ray signature. I have two questions: (1) Did you check both GEOS and Solrad X-ray data for the event; and (2) Did you check to see if the event had a microwave signature, which the Skylab results have shown in a characteristic of the thermal nature of filament eruptions?

Joselyn: I have consulted all the data available in the EDIS Solar-Geophysical Data publication. In addition, I have examined the 1 minute resolution X-ray plots from both of the NOAA satellites, GOES-2 and GOES-3. (The X-ray channels from these satellites are received in

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real-time at the Space Environment Services Center). There are no reports of microwave bursts for several days surrounding this event.

Ivanov (Comment): Now there are methods of determination of the shock normal from interplanetary data. You can determine the normal, if there are the corresponding data. And the normal shows the Sun's region from which the shock arrived.

Dryer (Comment): I want to repeat my earlier comment that the important fact is the magnitude of the energy release which triggered the eruption. This magnitude can be at the very low side of "release" spectrum which is insufficient to produce X-rays, Hα emission, radio spectral data, etc. The release of even such small amounts of energy perturbs the corona and solar wind and, provided the ΔV exceeds the appropriate characteristic speeds, eventually produces a finite amplitude MHD wave which may steepen into a shock wave (possibly a slow shock as suggested by Rosenau in his comment after Dr. Stewart's review paper).

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