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Newspaper reporting of space weather: End of a golden age

Sten Odenwald[1,2]

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[1] The reporting of the human impacts of space weather phenomena as a significant American newspaper story has passed through a golden age, which ended just after World War II. Prior to this time, significant geomagnetic storms and solar flare events were reported in considerable detail, with specific references made to actual impacts to telegraph, wireless, and radio communications systems among others. After World War II, news stories shrank dramatically in terms of the size of the article, the location of the story in the newspaper, and the number of items mentioned in the article. This paper is an historical analysis of the scope of newspaper reporting on 52 major storms with AA* > 170 occurring in American newspapers since 1870 and the changing trends in how the events were covered. I will show that even before the advent of news reporting on the World Wide Web, there was a precipitous decline in space weather reporting during the postwar period from ca. 1945–1990. The reason for this decline is not immediately obvious, but a few suggestions will be provided. I also publish 141 excerpts from the newspaper sample highlighting a variety of ''human impacts'' caused by this complete sample of storm events, along with a small collection of interesting illustrations that accompanied a few of the articles.

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1. Introduction

[2] Space weather researchers consider ''solar storms'' very serious business, and we all recognize the potential that each storm carries in causing disruptions to our technology, human operation in space, and a variety of other impacts. We also tend to consider the current level of news reporting for major events to be the norm and are often grateful when major newspapers relinquish a few column inches to report on the latest major storm event, rather than the more urgent sociopolitical or even entertainment issues of the day.

[3] Since the 1960s, we have come to expect that news stories in the print media focus almost entirely on what the aurora look like and where they are sighted, revealing virtually nothing about the actual impacts that the storms had upon humans. Sometimes a critical story is not even considered newsworthy at all. One of the biggest space weather impacts, the Quebec Blackout of 14 March 1989, which affected 3 million people and cost $2 billion in Gross Domestic Product (as much as a major tornado) was only mentioned in two major metropolitan newspapers, the *Boston Globe* (14 March 1989, p. 6), and the *Montreal Gazette* (12–16 March 1989). The aurora borealis itself was, however, mentioned in the *San Francisco Chronicle* (15 March, p. A3), the *Los Angeles Times* (14 March, p. 2), the *Philadelphia Inquirer* (14 March, p. 17A), the *Baltimore Sun* (13 March, p. 3A, 14 March, p. 8B, 15 March, p. 4A), and the *Fairbanks Daily News* (12 March, p. E10, 14 March, p. 3, 15 March, p. 1). According to the report in the *Fairbanks Daily News*, ''NBC News in Los Angeles asked to use five minutes worth of film (from a color movie of the aurora taken from Poker Flats) on the Nightly News Monday, but (Niel Brown, Director of the Poker Flats Research Range) doesn't know if the film was shown on national television.'' One obvious question to ask is whether the current level of space weather reporting in major newspapers has always been as we know it today or whether previous decades and centuries were more enthusiastic in their reporting of solar storm events.

[4] In this paper, I will conduct an historical assessment of the kinds of newspaper reports that were filed for major solar storms events between 1870 and 2006 in American newspapers published during this time. The content will be assessed on the basis of the number of human impacts cited, not on the basis of the often duplicative eyewitness descriptions of auroral forms, colors, and other observational issues. I will also not include in the assessment the number of scientific descriptions (often wrong) of the causes of auroral events. These two restrictions alone drastically reduce the verbiage in individual news articles and focuses only on the collateral impacts (psychological, technological, physical) of severe space weather events. Moreover, this also allows the actual republication of these comments, in this article, for the most part in their entirety.

[5] I will concentrate on newspaper accounts, primarily because of the long history of this medium. In the English-speaking world, the first true newspaper was the *London*

[1]Catholic University of America, Washington, D. C., USA.
[2]NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.

Table 1. Storms With AA* >= 170 (1870–2006) and Their Newspaper Reportage[a]

Date	AA*	NY	LA	CT	WP	BG	Lines
1870-9-25	173	–	N/A	–	N/A	N/A	0
1870–10-24	189	10–27,p.4 10–25,p.1	N/A	10–26 p.1	N/A	N/A	137
1872-2-4	229	2–17,p.2 2–29,p.2	N/A	2–5 p.1	N/A	N/A	36
1872-10-17	177	–	N/A	–	N/A	–	0
1882-4-17	292	4–18,p. 5 4–17,p.5	N/A	4–17 p.5	4–17 p.4	4–17 p.1	513
1882-11-17	304	11–18 p.1 11–20 p.1	11–18 p.1	11–20 p.3	11–18 p.1 11–19 p.1 11–20 p.1 11–21 p.1	11–18 p.4	464
1892-2-13	179	2–14 p.1	2–14 p.1	2–14 p.1	2–14 p.1	2–11 p.1	611
1894-7-20	221	–	–	–	–	–	0
1894-8–20	198	–	–	8–20 p.1	–	–	17
1903–10-31	308	11–2 p.7 11–1 p.1 11–1 p.3 11–1 p.8 11–8 p.A45	11–1 p. 2	Damaged	–	–	627
1909-9-25	329	9–26,p.12 9–26,p.B4 9–26,p.6 9–26,p.17 9–26,p.3	–	–	236	–	738
1915-6-17	196	6–18 p. I3 6–20 p. 12	6–18 p. 3	6–18 p.1	–	–	565
1919-8-11	180	8–12 p.8	8–12 p.19	missing	8–12 p.2	–	111
1921-5-15	257	5–26,p.23 5–15,p.1 5–16,p.1,2 5–18,p.12 5–17,p.1 5–18,p.12	5–16 p.1	5–15 p.12 5–16 p.4 5–17 p.5	46 5–16 p.3 5–17 p.1	5–17 p.6 5–16 p.14	807
1926-10-15	223	10–16 p. 11 10–17 p. 3	10–16 p. 2	–	10–16 p.3	10–16 p.1	334
1928-7-8	278	7–8 p.18	7–8 p.3	7–8 p.2	7–8 p.1	missing	197
1938-1-22	239	1–26,p.25 1–30 p.43	1–26 p. 1	1–26,p.2	–	100	493
1938-4-16	180	4–17 p.21	4–17 s..II–17	4–16 p.1	–	4–16 p.1 4–16 p.3 financial	258
1940-3-24	223	3–25 p. 1 3–26 p. 18	3–25 p. 1	3–25 p.1	3–25 p. 1	3–25 p.1	615
1940-3-25	242	3–25,p.1 3–26,p.18 3–31 p.I–34	3–25,p.1	3–26 p.7	3–25,p.1	3–26 p.3	1326
1940-3-30	179	–	–	4–1 p.3	–	–	9
1941-3-1	250	–	3–2 p. 3	3–2 p. II8	3–2 p.4	missing	95
1941-7-5	302	7–6 p. 20 7–8 p.18 7–8 p.10 7–13 p.23	7–6 p. 18	7–5 p.10	7–6 p. 4	7–5 p.1	439
1941-9-18	349	9–19,p.25 9–20,p.19	9–19,p.1 9–21,p.7	9–19,p.1 9–22,p.10	9–19,p.1 9–21,p.1	9–19 p.1	652
1946-2-7	184	2–3 p.26 2–8 p. 18	–	–	–	39	208
1946-3-25	194	3–24 p. 13 3–27 p. 13	–	–	3–24 p.1	–	77
1946-3-28	322	3–27 p.13	3–29 p.1	–	–	–	55
1946-9-22	272	–	9–24 p.4	–	–	–	8
1949-1-25	193	1–28 p. 42	–	–	–	–	37
1949-5-12	175	–	–	5–14 p.1	–	–	21
1957-9-3	159	–	–	9–5 p. 1	9–5 p.1	–	39
1957-9-23	184	–	9–23 p.1	9–23 p. 2	–	9–23 p.1	38
1958-2-11	298	2–11 p. 62 2–12 p. 16	2–11 p. 1	2–11 p. 4	2–11 p A1	2–11 p.1	323

Table 1. (continued)

Date	AA*	NY	LA	CT	WP	BG	Lines
1958-7-8	304	7–8,p.55	7–8 p.4	–	–	–	127
1959-7-15	347	–	7–17 p.1	7–16 p.C9	7–17 p.A2	–	202
1960-4-1	299	4–2 p.47	–	–	4–1 p, A1	–	33
1960-4-30	201	5–1 p.17	–	–	–	–	49
1960-10-6	219	10–7 p. 68	–	10–7 p.1	–	–	56
1960-11-13	352	11–14 p. 14 11–13 p.3	11–14 p.1	11–14 p. 1 11–16 p. 16	11–13 p. A1 11–14 p. A3	11–13 p.1	302
1970-3-8	172	–	–	–	–	–	0
1972-8-5	215	–	8–5 p.15 8–6 p.C4	8–6 p.12	8–5 p.A2	8–6 p.24	252
1982-7-13	177	–	–	–	–	–	0
1982-9-6	204	–	–	–	–	–	0
1986-2-8	243	–	–	–	–	–	0
1989-3-14	348	3–13,p.B5 3–15,p.A16	3–13 p.2 3–14 p.2	–	–	–	207
1989-11-17	174	–	–	–	–	–	0
1991-6-5	212	6–6 p. A16	–	6–6 p.16	–	–	176
1992-5-10	189	–	–	–	–	–	0
2000-7-15	207	7–16 p. 21 7–17 p.A17	7–15 p.A17	7–15 p.1	–	7–17 p.A7	345
2003-5-11	381	–	–	–	–	–	0
2003-10-29	298	10–30 p.A19	10–29 p.A10 10–30 p.A15 10–31 p.A34	10–30 p.12	10–29 p.A3 10–30 p.2 10–31 p.A13	10–29 p.2	888
2003-11-20	227	–	–	–	–	–	0

[a]Note: The indicated entries "N/A" indicate that the paper was not published during these years.

Gazette of 1666, followed in 1704 by the *Boston News-Letter*. By the end of the Revolutionary War there were some 43 newspapers in print and regular circulation. With the ratification of the Bill of Rights and the First Amendment, a rapid growth in newspaper publications began. By 1814 there were 346 newspapers, and by 1850 the number had grown to 2526 according to the U. S. Census, and 11,314 by 1880. With so many daily outlets for news reportage, it became substantially easier for auroral sightings and any ancillary impacts to find themselves into the popular literature and historical documents [*Stephens*, 2007].

2. History Post-1870

[6] The dates of the previous major storms between 1870 and 2006 can be determined from the AA* index (National Geophysical Data Center, Major magnetic storms 1868–2006 according to the AA* criteria, http://www.ngdc.noaa.gov/stp/GEOMAG/aastar.shtml, 2007). It is a simple, though tedious, task to search archival American newspaper records to extract accounts of past storm events and statistics about their reportage. The Library of Congress Periodical and Newspaper Reading Room, in Washington, D.C., contains one of the most extensive and complete collections of all major American newspapers published since ca. 1800 and is the perfect venue for researching this issue.

[7] Table 1 presents the reportage of all major storms for which AA* > 170 since 1870 and gives the date and page of the associated newspaper account in a selection of five major American (e.g., United States) newspapers that were continuously in press during the 1870–2006 period: the *New York Times* (NY:1851), the *Los Angeles Times* (LA:1881+), the *Chicago Tribune* (CT:1859+), the *Washington Post* (WP:1877+), and the *Boston Globe* (BG:1872+). Microform copies of each paper were examined beginning on the date of the AA* value exceeding 170 and up to 4 days later or until the news "thread" ended.

[8] Virtually all stories appeared with well-identifiable, though modest-sized, column headlines announcing an aurora, sunspot, or magnetic storm. In one unique instance, on 25 March 1940, the *Boston Globe* ran the story "above the fold" with spectacular 2-inch letters in a banner headline "U.S. Hit by Magnetic Storm," a style previously only matched by announcements of major World War II battles and reflecting an urgency to space weather impacts that has never been rivaled or exceeded since then. Reports that were not headlined or were integrated into the body of other stories were not included in this study.

3. Statistics

[9] Intuitively, one might expect that the stronger the storm, the more articles will be written about it and the closer to "page one" it will appear. Figure 1 compares the number of articles appearing in the five selected newspapers in Table 1 against the AA* for the event. There is indeed a perceptible correlation with increasing storm severity.

[10] How important were these storms considered by editors compared to other pressing news of the day? Figure 2 presents the average page on which the story was published. Since the 1870s, there has been a growing

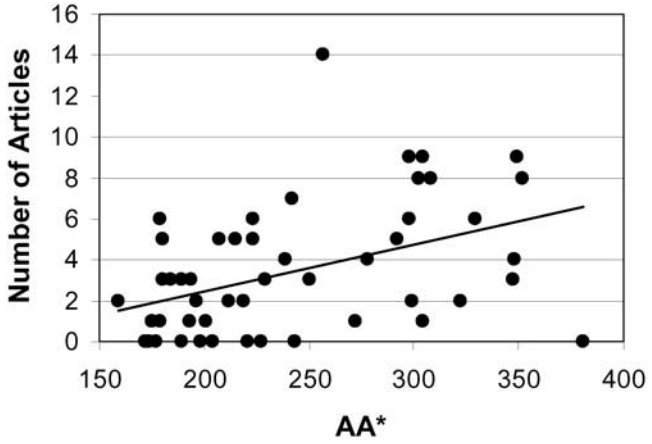

Figure 1. Cumulative number of articles published on major storms between 1870 and 2006 compared to the geomagnetic storm index.

tendency to present reports of significant space weather events on increasingly later pages in the daily newspaper.

[11] An additional indicator of the importance of the story is the number of column inches (e.g., words or lines) that were devoted to the story. We have counted the number of text lines in each story, and present in Table 1, column 8 the aggregate number of lines for each storm event. We see in Figure 3 that with the exception of the major storm events of 25 March 1940 (AA* = 223; Lines = 1,326) and 29 October 2003 (AA* = 298, Lines = 888) there has been a generally declining trend the amount of column space devoted to significant storm events since the post-World War II period ca. 1950. This agrees with the previous trend in the average page of publication, which also indicates that these stories have been pushed farther from ''page one'' and now occupy briefer news stories since ca. 1950.

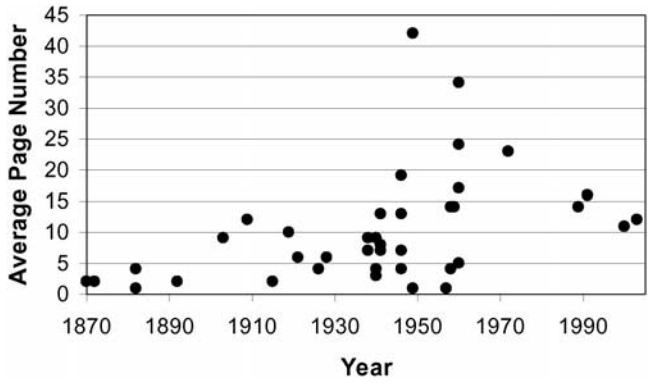

Figure 2. Average page number on which a storm article is published among the five surveyed newspapers.

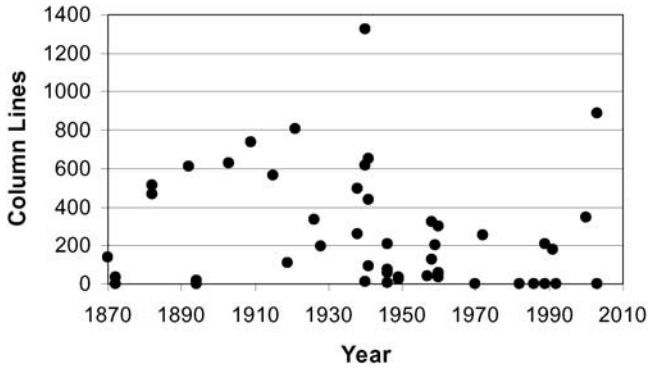

Figure 3. Total number of story lines published by the five newspapers in this survey for storms occurring each year.

[12] The content of newspaper articles is nearly as important as whether the event is covered. We have examined the kind of information presented by the *New York Times* in a single article, for a series of storm events since 1870 as shown in Table 2 in terms of the number of lines of print. The percentages are given in parenthesis. Since 1882, the largest topic area reported has been the various technological impacts (telegraphy, wireless, radio, satellites, electrical systems, radiation effects), with a sharply declining share held by descriptions of the aurora from different observers. Reports of aurora interpretation from folklore or omens have largely fallen out of favor and have been replaced by an increasing share given to scientific descriptions and interpretations. However, although the share of impacts reported has steadily increased, since the 1960s, reports of specific impacts (a common staple of pre-1960 reporting) have been replaced by increasingly generic statements that lack specificity. For example, specific details of a telegraph line from Chicago to New York being affected for several hours in news reports of the late 1800s is replaced by modern, generic, statements that ''storms of this strength may affect shortwave radio transmission and satellite operations.'' This, combined with the shrinking column space allocated to space weather events, implies a dramatic reduction in the useful quality and specificity of modern-day newspaper reports.

[13] For significant storms reported by multiple newspapers, it is very common to find similar anecdotes or topics shared by multiple news stories. In Table 3 I compare the

Table 2. Topic Distribution for *New York Times* Storm Articles

Topic Area	10-27-1870	4-18-1882	5-15-1921	3-25-1940	10-30-2003
Description	21 (32%)	2 (2%)	45 (27%)	17 (7%)	0
Location	16 (25)	2 (2)	14 (8)	20 (8)	0
Impact	0 (0)	89 (94)	68 (41)	149 (59)	70 (67)
Omens, etc.	5 (8)	0	4 (2)	10 (4)	0
Science	22 (34)	2 (2)	35 (22)	58 (23)	35 (33)
Total lines	64	95	166	254	105

Table 3. Coverage of Specific Topics for 25 March 1940 Storm

Issue Mentioned	NY	LA	WP	CT	BG
Physical origin of aurora	x	x	x	x	x
AT&T landlines are affected across N. America	x	x	x	x	x
Transatlantic cables affected	x	x	x	x	x
Pacific radio to far-east affected	x	x	x	x	x
Short-wave radio outage US-Europe	x	x	x	x	
William Barton comments about flares, spots etc	x	x	x	x	
Large voltages on telegraph lines 200–750 volts	x	x		x	x
AP and UP wire services badly affected	x	x		x	x
Daytime or morning event	x	x	x		
Transatlantic radio-telephone connections outage.	x	x	x		
Easter messages to Europe curtailed, delayed	x	x	x		
Teletype operations lost or scrambled	x		x	x	
Postal Telegraph operators claim it's a rare event	x		x	x	
Telegraph service lost	x	x			x
Air traffic radio systems disrupted	x		x		
Long-wave radio conditions reported by Engineers	x			x	
Description of the aurora in the sky				x	x
Pilot Captain Stanton observations	x				
Press Wires describe short wave conditions to Europe	x				
CBS broadcast of Pope's Easter message disrupted	x				
NBC cancels European broadcast	x				
Telephone service not affected	x				
NY railroads affected by loss of telegraphic comm..	x				
Seth Nicolson - Mt Wilson		x			
John Flemming - Dept. Terrestrial Magnetism.			x		
Fletcher Watson - Harvard interview					x
Donald Menzel - Harvard					x
Compasses unaffected					x
Total points covered =	22	13	13	12	11
Column-lines =	247	160	181	117	337
Verbosity =	11	12	14	10	31
Creativity =	6	1	1	0	3

notable ''talking points'' from front page stories about the 25 March 1940 storm as reported by the *New York Times* (247 lines), the *Los Angeles Times* (160 lines), the *Washington Post* (181 lines), the *Boston Globe* (337 lines), and the *Chicago Tribune* (117 lines). To get a sense of the relative quality of the reporting, I divided the number of column lines by the number of unique ideas to gage the verbosity of the article. A large number indicates that either the article went into more detail on each point or simply used more verbiage to relay essentially the same information. I also measured the creativity of the article by the number of points that are reported but were not covered by other newspapers. From the points covered, verbosity and creativity, the *New York Times* is at the top of the reporting, with low verbosity and high creativity. The *Chicago Tribune* is near the bottom of these categories, at least for this particular storm.

[14] If the major, national/international newspapers do not cover it, what is the chance that a local paper will independently do so? One of the consistent leaders in reporting space weather events since the early 1800s has been the *New York Times*. It is clear from Table 1 that out of the 52 significant storms with AA* > 170, the *New York Times* has reported 32 of these events. Out of the remaining 20 storms, 10 were not reported by any newspaper, but the remaining 10 were covered by at least one newspaper in our sample.

[15] Figure 4 shows the total column lines published for each story since 1870. It is apparent that the *New York Times* may have relinquished its role as a trendsetter in reporting these stories after ca. 1945. If the *New York Times* is, indeed, the trendsetter, this explains why stories about space weather events have been so underreported in newspapers during the post-World War II period. Alternatively, it may also suggest that a collective sea change

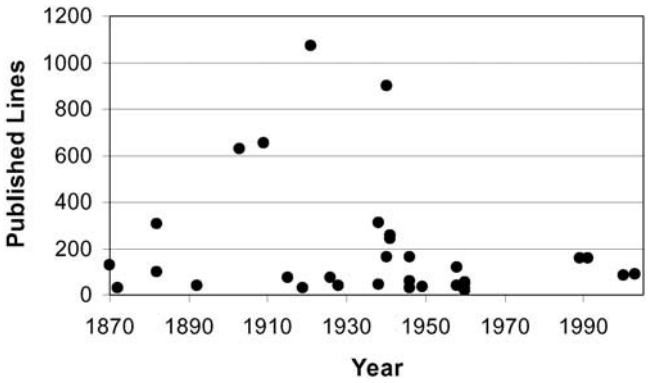

Figure 4. Total number of column lines published by the *New York Times* for significant storm events since 1870.

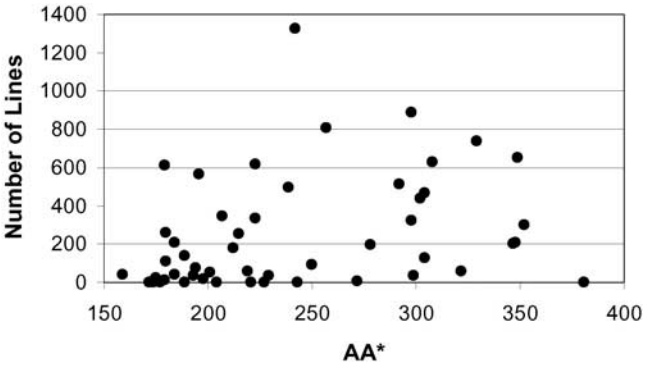

Figure 5. A comparison of the number of column lines published in the five surveyed newspapers with the geomagnetic severity of each storm since 1870 for AA* > 170.

occurred at this time among newspaper editors regarding these types of stories.

[16] Is AA* the only thing that matters in determining whether an event is reported or how much column space is devoted to its description? Generally, the larger the AA*, the more dramatic will be the resulting auroral event; however, there appear to be other factors in play that severely affect how an event will be reported. Figure 5 presents the number of column lines published compared with the AA* for each of the 52 events tracked. Remarkably, a relatively weak storm with AA* = 180 (e.g., 13 February 1892) is as likely to produce a ~600-line story as a far more significant storm with AA* = 350 (e.g., 18 September 1941). The dispersion among the lines printed for storms with AA* > 325 ranges from zero to ~800 for the storms occurring in 1909, 1941, 1946, 1959, 1960, 1989, and 2003, which spans over 90 a in writing styles, technological impacts, and editorial guidance.

[17] The most extreme example of a major event that was not covered as a news item occurred on 11 May 2003. It had the largest AA* index (e.g., 381) of all the events in this sample; however, it produced not a single news report in the papers surveyed. What was so peculiar about this event that it raised little interest? This event was caused by high-speed streams from a coronal hole. Unlike typical CME passages that last a few hours, these coronal hole conditions persisted for several days and caused aurora seen in Canada, North Dakota, and Michigan. There were no sunspots near solar meridian, so conditions for the more technologically disruptive CME and solar proton events were nonexistent, leading to no reportable impacts.

4. Human Impacts

[18] The most common reporting often involved very detailed accounts of what the aurora looked like and where they were spotted. Currently, only some of these reports have any scientific value because of the heterogeneity of the observations. Sometimes the date and local time were mentioned but usually not. The most interesting historical accounts of lasting value are the ones that cover the various human and technological impacts of the various storm events. The 141 commentaries are sufficiently brief that I will present complete excerpts in this section, classified according to the type of impact. The excerpts are complete for the five newspapers that are the primary focus of this paper but also include accounts from additional newspapers for selected storm events in the sample.

[19] Each quotation is referenced to a specific newspaper using the following code BG = *Boston Globe*, BS = *Baltimore Sun*, BT = *Bismark Tribune*, CT = *Chicago Tribune*, FD = *Fairbanks Daily News*, FT = *Florida Times Union*, HW = *Harper's Weekly*, KS = *Kansas City Evening Star*, LA = *Los Angeles Times*, LT = *Louisville Times,* MG = *Montreal Gazette*, MH = *Miami Herald*, NO = *New Orleans Daily Picayune*, NY = *New York Times*, OH = *Omaha Herald*, PI = *Philadelphia Inquirer*, SN = *Savannah Morning News*, WP = *Washington Post*.

4.1. People Amazed

[20] Both ancient and modern reports mention how amazed observers were of the colors and movement of the aurora. Curiously, this very basic response is so obvious that reporters often fail to cite the dimensions of this reaction in their stories. Some of these reports do suggest a large-scale impact.

1. "Paris - During the evening it was warm enough to sit out of doors along the boulevards, and gossip would have had its swing had not a splendid aurora polaris, to use the latest expression, come to furnish a subject of conversation and curiosity, and to direct attention from the topics of the day. . .Nearly everyone fancied that it was the reflection of a vast incendiary beyond les Invalides, or toward Autruil,. . .It was not equal, however,to the grand aurora of 1870, and conversation turned upon recollections of the three October nights when the sky was blood-red from horizon to horizon." (NY, 2-29-1872, p. 2)

2. "Dinner tables all over [Plainfield, NJ] were deserted and the people stood in shivering groups on lawns and sidewalks watching nature's masterpiece." (NY, 2-14-1882, p. 1)

3. ". . .half of New York seemed to be out of bed watching the skies. Attractive as the aurora or northern lights always are, seldom if ever were they viewed with greater interest or by larger numbers than on Sunday night." (NY, 4-18-1882, p. 5)

4. "The phenomenon was seen as far south as Vienna, and in Holland crowds awaiting the birth of Princess Juliana's baby cheered is as a lucky omen." (NY, 1-26-1938, p. 25)

5. "Washington area residents jammed telephone circuits to the Weather Bureau and newspapers last night following a spectacular display of aurora borealis. . .The phenomena, which originates in the Arctic region, was also observed as far south as Miami." (WP, 11-13-1960, p. A1)

6. "It was hardly the end of the world but many Chicago residents who bombarded newspapers, radio and television stations, and police departments with calls last night were startled by the splashes of green and yellow lights in the northern sky." (CT, 7-6-1974, p. F3)

4.2. People Afraid

[21] Fear of the aurora borealis, officially called auroraphobia by psychologists, is a common if not rampant visceral reaction to seeing the blood-red and fiery colors of aurora. The vast majority of legends and folklore consider aurora to be bad omens or portends of wars or cold weather.

7. "Mr. Hood was told by one of the partners of the North = west Company, that he 'once saw the coruscations of the Aurora Borealis so vivid and low, that the Canadians fell on their faces and began praying and crying, fearing they should be killed." (*Salem Gazette,* 9-11-1832, p. 2)

8. "Several *Paddies* in Boston at the time of the late Aurora Borealis, though the day (or night) of judgment had come, and fell upon their knees and went to praying vehemently." (*Barre Gazette,* 2-10-1837, p. 2)

9. "...Several old women were nearly frightened to death, thinking it announced the end of the world, and immediately took to saying their prayers. A fat old citizen tremblingly stated that this was the avant courier of a dreadful epidemic, like the cholera of 1833, whilst a French gentleman pooh-poohed, and gravely assured us this was the well known sign of revolution in Paris, requesting us to make a note of the date of the month." (NO, 8-30-1859, p. 5)

10. "The Columbus Statesman (newspaper) says that a young lady, aged about sixteen, of considerable intelligence and prepossessing appearance, is now residing with the Sheriff of Ottawa County, preparatory to her removal to the lunatic asylum, having become insane from viewing the aurora borealis a short time ago, which she was induced to believe betokened the approaching end of the world." (HW, 10-8-1859, p. 647)

11. "Cleveland, OH - The electrical condition which produced the extraordinary auroral display last night, more or less seriously effected (sic) a great many persons here, particularly those troubled with nervous disorders. The Rev O. L. Blinkey, pastor of the Prospect Street Methodist Episcopal Church, was prostrated in his pulpit while praying, by what was first supposed to be paralysis. Ladies fainted in the churches during the services, and people who were out of doors as well as in complain generally of strangely oppressive sensations similar to those attendant upon an earthquake." (NY, 4-18-1882, p. 5)

12. "Peasants in outlying country fled, thinking judgment day had arrived." (NY, 3-11-1926, p. 1)

13. "The aurora borealis, rarely seen in Southern or Western Europe, tonight spread fear in parts of Portugal and lower Austria, while thousands of Britons were brought running into the streets in wonderment." (FT, 1-26-1938, p. 1)

14. "Superstitious folks of the Scottish lowlands shook their heads and declared the northern lights always spelled an ill-omen for Scotland." (NY, 1-26-1938, p. 25)

15. "The aurora borealis - northern lights - put on a spectacular display in the Chicago area last night, causing many residents to call The Tribune to seek information or to report that they had seen plane crashes, flying saucers, sky rockets, and balloons." (CT, 10-7-1960, p. 1)

16. "...Most of the callers thought it was probably a missile fired from Vandenberg Air Force base or something like that...but there were a couple of callers who said they were afraid we were being invaded or something." (LA, 3-14-1989, p. 2)

17. "Confused sky watchers jammed police lines with reports of falling debris from the space shuttle Discovery after spotting northern lights for the first time." (MG, 3-15-1989, p. A3)

4.3. Brilliance

[22] Aurora are generally faint, but on occasion "superluminal" aurora have occurred. The most frequent accounts involve the 1859, 1882, 1860, and 1921 aurora.

18. "The Brightness of the Sky was so very great that the smallest Print might plainly be discern'd. But as to the Cause of this Phenomenon, notwithstanding the Lights, we are altogether in the dark." (*Pennsylvania Gazette*, 11-12-1730, p. 1)

19. "On the night of August 1 [sic] we were high up on the Rocky Mountains sleeping in the open air. A little after midnight we were awakened by the auroral light, so bright that one could easily read common print. Some of the party insisted that it was daylight and began the preparation of breakfast. The light continued until morning, varying in intensity in different parts of the heavens, and slowly changing position." (*Rocky Mountain News*, 9-17-1859, p. 3)

20. "Sept. 2nd, between 2 and 3 A.M., the aurora displayed itself in greater splendor than it did on the 28th. Many persons were awakened from their slumbers by the intense light which entered their chambers." [*American Journal of Science (AJS)*, 1860a]

21. "The light was equal to that of daybreak, but was not sufficient to eclipse the light of the stars. The sea reflected the color, and appeared as if of blood." [*AJS*, 1860b]

22. "Singular as it may appear, a gentleman actually killed three birds with a gun this morning about 1 o'clock - a circumstance which perhaps never had its like before, and may never happen again. The birds were killed while the beautiful aurora borealis was at its height, and being a very early species - larks - were no doubt deceived by the light appearance of everything and came forth innocently supposing it was day." (*Pittsfield Sun*, 9-22-1859, p. 1)

23. "At Omaha on Friday evening the aurora was very brilliant, the illumination rendering the night almost as bright as day. At St. Paul the sky was of blood-red color...Cheyenne reports the illumination as that point last night as bright as day." (PE, 11-20-1882, p. 1)

24. "...While it was at the brightest, a paper might have been read in the open streets. The city was bathed in the blood-red light which streamed down from the firmament and painted the silent, deserted streets and structures. The effect was beautiful in the extreme and entranced those who saw it." (NY, 4-18-1882, p. 5)

25. "Petersburgh, VA - The display of the aurora borealis last night was one of the most magnificent sights ever witnessed here, and lasted until 4 o'clock this morning. The light resembled a great conflagration, and was so brilliant that the street lamps could easily have been dispenced (sic) with." (NY, 4-18-1882, p. 5)

26. "Until after midnight crowds stood in Broadway watching the phenomenon...Even the intense lights of the electric signs along Broadway could not dim the brilliance of the flaring skies." (NY, 5-15-1921, p. 1)

27. "The aurora...was bright enough to be visible from Washington itself - despite the brightness of the city's own lights." (WP, 5-27-1967, p. B3)

28. "...Although not visible in the New York area, the aurora was so brilliant over Europe that it aroused fears of conflagrations." (NY, 2-12-1958, p. 16)

4.4. False Fires

[23] Among the oldest interpretations involve false fires in distant towns (Ostia ca. 74 AD). This interpretation is still quite alive and has surfaced as recently as 1981 in reports from Kern County, California.

29. "The Aurora Borealis has lately been unusually bright at the North. The Boston fire companies recently turned out to quench one of them, under the impressions we suppose that the town was on fire. They couldn't reach it." (*Vermont Gazette*, 8-3-1830, p. 4)

30. "Between 7 and 8 o'clock Wednesday evening, we had quite a brisk alarm of fire. Bells rang in various parts of the town (Philadelphia), and the cry was given in that deep, determined and startling tone, which informs the practiced ear that he who utters it is satisfied that he has reason for his clamor." (*Rhode-Island Republican*, 2-1-1837, p. 2)

31. "...according to another account, the city firemen were led a chase more energetic than agreeable in the deep snow, after supposed fires. The northern and eastern portions of the heavens were lit up by a deep crimson glow like the reflections of an immense fire - and the bells rung, and away went men and boys to look at it, or extinguish it. But when they arrived at the jumping off place at the North End, the fire was as far off as ever." (*New Bedford Mercury*, 1-27-1837, p. 2)

32. "The consternation in the metropolis was very great, thousands of persons were running in the direction of the supposed awful catastrophe. The engines belonging to the Fire Brigade stations in Baker street, Farringdon street, Watiing street, Waterloo road, and likewise those belonging to the West of England station, in fact every fire engine in London, were horsed and galloped after the supposed scene of destruction, with more than ordinary energy, followed by carriages, horsemen and vast mobs." (*Newport Mercury*, 10-19-1839, p. 1)

33. "...The watchmen were much alarmed at the colored light with which the southern part of the sky was covered, which gave rise to the belief hat a small village about three leagues south of Santiago was on fire. This seems to be the first time that a polar light has been seen at Santiago." [*AJS*, 1860c]

34. "A traveler who happened to be in Leichestershire at the time found the inhabitants of a certain village gazing intently at the phenomenon...The traveler was rather taken aback, but found upon inquiry that the villagers all believed the red light in the sky to be the reflection of Paris on fire..." (HW, 1870, v 12/17, p. 819)

35. "Hundreds of persons in this city [New York] started on a run for the West Side thinking there was a big fire over in New Jersey. When they reached the river, however, and the light was as far away as ever, and they for the first time noticed the white auroral streamers, the more ignorant became afraid...Many thought it was a sign that the world was coming to an end." (NY, 2-14-1892, p. 1)

36. "Bostonians thought all Cambridge was afire, and the Boston Fire Department actually got in readiness to respond to a call to save the Harvard University buildings." (NY, 2-14-1892, p. 1)

37. "Residents along the New Jersey coast generally attributed the glow in the sky to the prevalence of forest fires in the interior of the state." (NY, 2-14-1892, p. 1)

38. "The whole fire department of Salzburg was called out last night to quench the northern lights. It was the first time the aurora borealis had ever been seen here and so many alarms were turned in from all parts of Salzburg that the bewildered firemen thought the whole city was simultaneously in flames and helped to increase the panic by dashing about in all directions." (NY, 3-11-1926, p. 1)

39. "The tocsin was sounded at 4 o'clock this morning in the village of Musiege in Haute Savoie, bringing out the fire brigade and all the villagers, who saw immense flames rising to the sky above a neighboring village. They dashed to the rescue, but upon arriving at the spot they found the villagers asleep and no fire. Then they discovered that nature had played a joke. A beautiful aurora borealis hovering over the village had given the impression from afar of a huge conflagration. The villagers chaffed the fireman, asking them to extinguish the aurora borealis." (NY, 2-26-1927, p. 15)

40. "United States forest officials at Descanso, forty miles east of here [San Diego] were routed out of bed early today by reports of a 'great fire in the back country'. They found it was only the aurora borealis, last seen here in February 1888." (NY, 1-23-1938, p. 29)

41. "Hamilton Bermuda - The sky was brilliantly lighted with dark red streamers, flashing like searchlights. Many persons thought the light was caused by a ship afire at sea... Steamship agents took the precaution of checking with wireless stations to learn if there had been any SOS calls." (NY, 1-26-1938, p. 25)

42. "It was only the Aurora Borealis on the blink again that kept fireman dashing about much of Europe into the early morning hours today." (*Louisville Times*, 1-26-1938, p. 1)

43. "In Sofia Bulgaria...there was a flaming track of fire in the heavens and in several places in the provinces, and even in Sofia, fire brigades were called out. A less brilliant display was seen in Yugoslavia." (NY, 3-26-1940, p. 18)

44. "Telephone lines to police, fire departments and newspapers were clogged as hundreds inquired as to the cause of the brilliant glow. Most thought it was a huge fire in the distance." (BG, 2-11-1958, p. 1)

45. "One firehouse reported that even rookie firemen were calling in, confessing they'd never seen it before and figured it must be fire." (WP, 11-14-1960, p. A3)

46. "Dozens of calls were received at the Globe. Some thought it was the reflection of a five-alarm fire in Malden. A Navy veteran compared it to the hues cast by burning tankers torpedoed on the Atlantic during World War II." (BG, 11-13-1960, p. 1)

47. "The unusual southerly display of the aurora borealis Sunday night colored skies along the eastern edge of California, causing a flood of calls to police and prompting one Fire Department to send out firefighters in search of a blaze...The Kern County Fire Department sent a unit to a reported fire in the Caliente area but learned the glow was not a fire, a dispatcher said." (LA, 4-13-1981, p. 1)

48. "In Brownsville Texas, the southernmost city in the continental United States, police Sgt.Rudy Limas said, 'People say they're seeing something red or orange in color in the sky, like a fire.'" (PI, 3-14, p. 17A)

4.5. Telegraph Service

[24] The advent of the electric telegraph by Joseph Henry in 1830 and its perfection by Samuel F.B. Morse in ca. 1838 was followed by the recognition that it could be affected by magnetic storms once the telegraph network

had reached a large-enough geographic capacity. In 1848, Carlo Matteucci (1811–1868) the Director of Telegraphs in Pisa observed the iron armatures of the electric telegraph connecting Pisa and Florence behave in an unexpected manner during a brilliant aurora on 17 November 1848. The electromagnets remained powered even without the battery attached. This behavior ceased once the aurora dimmed. This effect was extensively reported by newspapers during the August–September 1859 storm. It would be repeated in telegraph systems around the world for the next 100 a, during which time extensive citations of interruptions in telegraph service can be found. The longest disruption probably involved the 26 January 1938 storm which caused disruptions for a ''few days.''

49. ''During the splendid aurora borealis of Monday evening very singular phenomena were noticed on the telegraph wires. . .Strong magnetic currents seemed to pass from the ground into the wires, at times so powerful as to overcome the batteries on the line, and reverse the magnetic poles, making queer work, and causing some perplexity among the operators. The magnetic currents were evidently joining in the merry dance of their brilliant partners in the sky.'' (*Weekly Eagle*, 10-2-1851, p. 2)

50. ''On the 19 of February, 1852, there was a brilliant display of the northern aurora, and while it continued the telegraph lines were singularly affected; on the Boston and Montreal lines the batteries were disconnected and messages sent wholly by the auroral current.'' (*Farmer's Cabinet*, 9-28-1858, p. 2)

51. ''The Manager of the Electric telegraph Company in Glasgow, Scotland, states that the transmission of intelligence over the wires was suspended in consequence of an aurora borealis, which prevailed at the time.'' (*Barre Patriot*, 1-14-1853, p. 1)

52. ''The atmosphere was so strongly impregnated with electricity that communication was kept up for some time with New York, Boston and Montreal over the Western Union telegraph wires without the use of a battery.'' (CT, 5-29-1877, p. 2)

53. ''It very seriously affected the workings of the telegraph lines both on the land and in the sea, and for three hours from 9 AM until noon telegraph business east of the Mississippi and north of Washington was at a stand-still. . .While no great damage was done, there was very much annoyance by reason of the delay in the transmission of business, and at 4 o'clock, when the trouble seemed to have ceased entirely, every instrument and every operator was busy in rushing off the accumulated business.'' (NY, 11-17-1882, p. 1)

54. ''Telegraph and telephone lines in the British Isles and throughout all northern Europe have been seriously interrupted by the great magnetic storm which virtually paralyzed wire transmission in the United States Saturday night and Sunday.'' (MH, 5-17-1921, p. 2)

55. ''Slow transmission of market transactions between Wall Street and London was caused by the magnetic disturbance yesterday morning.'' (NY, 10-16-1926, p. 11)

56. ''Telegraphic communications throughout the United States - including the Associated Press network of 300,000 miles of leased wires, have caught the dickens during the last couple of days. The static was so intense that when operators sent out such a phrase as 'diplomatic sources' the words arrived as 'awgxvm kvkpvaqvu'.'' (*Florida Times Union*, 1-26-1938, p. 1)

57. ''A crippling blow to telegraph service for five hours on a day when the lines are bogged down with Easter messages.'' (NY, 3-25-1940, p. 1)

4.6. Cables

[25] The strongest geomagnetic storms can generate ground currents, which when coupled to long conductors, can induce electric fields from 1 to 10 volts/km. This leads to thousands of volts on subocean or ground telegraph and telephone cables.

58. ''The underground wires and cables seemed to be as seriously affected as the land lines. . .The electric disturbances also prevented service over the Mexican and Cuban cables as well as the Atlantic cables.'' (NY, 11-17-1882, p. 1)

59. ''Officials of the cable companies, in describing the effect on the cables beneath fathoms of ocean, declared that one enterprise that ordinarily received from twenty-five to thirty cables every day had received only one up to late last night.'' (NY, 3-23-1920, p. 13)

60. ''Three of the eight transatlantic cables owned by Western Union were affected by earth currents accompanying the aurora. . .Two of these were in full operation again, but the third, although not entirely out of commission, was not back to normal. . .the cost of repairing even a small fault in a cable in deep water would reach $200,000..'' (NY, 5-18-1921, p. 12)

4.7. Navigation Errors

[26] The fact that magnetic storms could affect compass needles was first shown by *Gellibrand* [1634], in his treatise ''A Discourse mathematical on the Variation of the Magnetical Needle together with its admirable Diminution lately discovered'' and later studied in detail by Anders Celcius (1701–1744) and his student Olof Hiorter (1696–1750) who in 1741 uncovered a correlation between magnetic ''activity'' and auroral sightings near Uppsala, Sweden and London.

[27] Navigation errors caused by magnetic storms are the simplest to identify and should be the most direct impact of severe space weather events. Identifying reports of actual instances during which compass bearings were affected is, however, a challenge. The most likely documentation might be expected from the numerous ships logs recorded daily during the 1800s by the thousands of ships that annually plied the oceans. Identifying these reports would be a monumental, and extraordinarily tedious, process. There are, however, scattered newspaper reports from 1837 that claim that compasses were, indeed, actually affected by magnetic storm events producing deviations as high as 10 degrees in a few hours, deviations easily detected by maritime systems.

61. ''The magnetic needle shifted its position more than a degree in the course of five minutes, and the common focus was supposed to be about the pole of the dipping needle.'' (*Pittsfield Sun*, 11-26-1835, p. 2)

62. ''As usual in brilliant exhibitions of the Aurora Borealis, the Magnetic Needle was exceedingly disturbed. . .It often moved

30 minutes in three seconds.Its entire range was nearly six degrees.'' (*Connecticut Courant*, 11-25-1837, p. 2)

63. ''During the Great Auroral Display of September 2, 1859, the disturbances of the magnetic needle were very remarkable...At Toronto, in Canada, the declination of the needle changed nearly four degrees in half an hour.'' (*Harper's New Monthly Magazine*, June 1869, vol. XXXIX, p. 12)

64. ''Generally the magnetic disturbances are too small to be noticed with an ordinary compass; but sometimes the deviations amount to several degrees, vastly to the discernment of any unlucky surveyor who may happen to be running a farm-line at the time - for aurora occur by day as of ten as by night.'' (NY, 10-23-1872, p. 4)

65. ''A magnetic storm, sweeping in from stellar space and bringing two huge sunspots to the sun's surface, played strange tricks yesterday across a wide part of the earth as compass needles on ships at sea trembled erratically, teletype machines tapped messages that had no meaning, and short-wave communications between the United States and Europe went into a temporary 'blackout'...'' (NY, 2-3-1946, p. 26)

66. ''Brussels, Sept. 23 (AP), Budget Minister Joseph Merlot today said 'abnormal weather conditions and the aurora borealis' might have put the instruments out of order on the Sabena airlines plane that crashed near Cander (sic), N.F, killing 26 persons.'' (LA, 9-24-1946, p. 4)

4.8. Weird Sounds

[28] There have been persistent accounts of aurora causing audible sounds that could be perceived by observers under certain conditions. Often dismissed as a sympathetic reaction to seeing moving fire in the sky, there may be situations in which sounds can occur. The easiest to understand are sounds produced by ''aurora'' in which technology is used as a transducer. Ground currents can be exceptionally strong and infiltrate themselves into telephone and radio systems. Although not directly associated with aurora, ''whistlers'' can be detected on long-wave systems under proper conditions.

67. ''An observer informs us that he distinctly heard the sound which not infrequently accompany this phenomenon, a slight flapping sound, in quick succession like that made by the waving of heavy drapery.'' (*Republican Star*, 5-3-1831, p. 3)

68. ''The telephone lines of the Metropolitan Telephone Company also refused to work during the greater part of the day...People who attempted to use the telephone lines heard a buzzing, ringing noise, rather than any well-defined sound...'' (NY, 11-17-1882, p. 1)

69. ''A dispatch from Albany states that during the continuance of the aurora at that place a peculiar rustling noise was plainly heard at the telephones...'' (NY, 2-14-1892, p. 1)

70. ''In lonely northern districts, where other noises do not interrupt, particularly brilliant polar lights that appear to flash low to the ground are said to be accompanied by a swishing and crackling sound.'' (NY, 5-15-1921, p. 1)

71. ''Operators of the local wireless station (Berezov, Tobolsk Province Siberia) report that while watching the aurora borealis they heard melodic sounds. The sounds rose and fell in consonance with the fluctuations of the aurora.'' (NY, 10-5-1927, p. 24)

4.9. Air Travel

[29] All reports of impacts to air travel involve some aspect of space weather affecting radio communications systems. In one instance, however, auroral interference with magnetic navigation was suggested as a contributing cause to a fatal crash on 23 September 1946.

72. ''Some pilots on landing said that they had relayed messages from one plain to another; thus a plane some distance away from the airport would make contact with another plane near the airport and notify the field that the farther plane was coming in.'' (NY, 3-25-1940, p. 1)

73. ''Long-range radio communications have been so seriously disrupted by the aurora borealis that transatlantic planes have in many cases been seriously delayed, according to airline reports yesterday. Thirteen planes operated by major transocean airlines were held up during the day. Six Europe-bound planes were stalled in Gander, Newfoundland, and seven west-bound ones in Shannon, Eire.'' (NY, 3-27-1946, p. 13)

74. ''The first trans-Atlantic plane to break through an almost complete blackout of radio communications caused by the aurora borealis since March 22 arrived at La Guardia Field at 5 P.M. (E.S.T.) March 27. The plane which arrived was a liner from Paris. It had been held at Shannon Airport, Eire, 15 hours. Officials at La Guardia Field said unusual radio conditions would continue, although they are not expected to be severe.'' (*Christian Science Monitor*, 3-29-1946, p. 13)

75. ''Long-range radio communications have been so seriously disrupted by the aurora borealis in the last few days that trans-Atlantic planes have in many cases been seriously delayed, according to airline reports yesterday. Thirteen planes operated by major transocean airlines were held up during the day.Six Europe-bound planes were stalled in Gander, Newfoundland, and seven westbound ones at Shannon, Eire.'' (NY, 3-27-1946, p. 13)

76. ''Brussels, Sept. 23 (AP), Budget Minister Joseph Merlot today said 'abnormal weather conditions and the aurora borealis' might have put the instruments out of order on the Sabena airlines plane that crashed near Cander (sic), N.F, killing 26 persons.'' (LA, 9-24-1946, p. 4)

77. ''Yesterday's blackout...paralysed (sic) Dorval airport, delaying flights.'' (MG, 3-14-1989, p. 1)

4.10. Rail Service

[30] Impacts to rail service invariably involve problems with electric signaling equipment; however, in one instance ground currents may have been involved in an actual power failure in 1903.

78. ''In Geneva, all the electrical street cars were brought to a sudden standstill, and the unexpected cessation of the electric current caused consternation at the generating works, where all efforts to discover the cause were fruitless.'' (NY, 11-2-1903, p. 7)

79. ''It may have contributed to a short circuit in the New York Central signal system, followed by a fire in the Fifty-seventh Street signal tower.'' (NY, 5-17-1921, p. 1)

80. ''Brewster NY - A fire which destroyed the Central New England Railroad station, here, Saturday night, was caused by the Aurora Borealis, in the opinion of the railroad officials. Telegraph Operator Hatch says he was driven away from his instrument by a flare of

flame which enveloped the switchboard and ignited the building. The loss was $6,000." (NY, 5-17-1921, p. 1)

81. "The sunspot which caused the brilliant Aurora on Saturday night and the worst electrical disturbances in memory on the telegraph systems was credited with an unprecedented thing at 7:04 o'clock yesterday morning, when the entire signal and switching system of New York Central railroad below 125th Street was put out of operation, followed by a fire in the control tower at Fifty-seventh Street and Park Avenue...While all outgoing and incoming trains were stopped, the Fire Department extinguished the fire in the tower, but not until residents of many Park Avenue apartment houses were coughing and choking from the suffocating vapors which spread for blocks." (NY, 5-16-1921, p. 2)

82. "The phenomenon was also the cause of delay to express trains on the L.N.F.R. Manchester-Sheffeld line. At 7:48 PM, the signaling apparatus in both the parallel Woodhead Tunnels was found to be out of order. The working of the trains through the tunnels was stopped. An official said that the failure was apparently due to the electrical disturbances caused by the Aurora Borealis." (LT, 1-27-1938, p. 2)

4.11. Voltages

[31] A common complaint involves the detection of unusually large voltages and currents on telegraphic systems. The presumed mechanism has ground currents invading open "one-line" telegraph circuits, which can produce 200–700 V. The most intense event occurred during the 1921 geomagnetic storm when voltages exceeding 1000 V were reported, and electric field strengths in the range of 20 V/km cited [*Kappenman*, 2004]. During the 1989 Quebec blackout, electric fields of 1.7 V/km were detected for 20 s at the station near Louvincourt [*Bolduc*, 2002]. During the 4 August 1972 event, a strength of 7.4 V/km was measured at the Meanook Magnetic Observatory near Edmonton, Alberta (Space Weather Canada, Geomagnetic effects on comunications cables, available at http://www.spaceweather.gc.ca/cable_e.php, 2006).

83. "An electric lamp attached to a St. Paul wire made a brilliant illumination without the use of a battery." (CT, 11-18-1882, p. 2)

84. "The telegraph system of this country has, since Friday morning last, been disturbed in a way that far exceeds anything of the kind that has ever happened before...The electric storm commenced on Thursday, but reached its climax on Friday morning (November 17) between 10 and 11 a.m. The currents measured over 50 milliamperes, which is five times greater than the ordinary working currents." (Nature, 11-23-1882, p. 82)

85. "...at its climax [31 October 1903] there were 675 volts of electricity - enough to kill a man - in the wires without the batteries attached..." (NY, 11-1-1903, p. 1)

86. "During the height of the electrical disturbance the measuring instruments in the telegraph offices in this city [New York] registered the presence on the wires of upward of 500 volts of electric current from the unknown source." (NY, 9-26-1909, p. 12)

87. "The electrical disturbance was so marked that wire traffic chiefs at the Chesapeake and Potomac telephone headquarters reported that meters registered more than 1,000 volts..." (NY, 5-16-1921, p. 1)

88. "The Consolidated Edison System reported that at the height of the trouble Sunday morning "voltage dips" of 1,500 volts were recorded at its three main generator stations in Brooklyn and the Bronx. The dips, a spokesman explained, represented power loss in the strength of electrical power being generated." (NY, 3-26-1940, p. 18)

89. "Postal Telegraph officials said they had not seen anything like this in twenty-five years. The current of the electrical disturbance in the earth measured from 200 to 400 volts, they said." (NY, 3-25-1940, p. 1)

90. "From Newfoundland came reports that magnetism from the aurora has caused the voltage in electric circuits to vary in a range of 320 volts. Utility companies in many parts of the United States reported similar disruptions." (NY, 2-11-1958, p. 62)

91. "The telephone company reported the cosmic display caused more than usual havoc this time. Voltage meters all over the system suddenly shot up...trouble lights flashed on." (BG, 2-11-1958, p. 1)

92. "The Alaskan power utilities are completing a north-south tie linking the coastal power grid centered on Anchorage, with the interior one based at Fairbanks. Auroral-induced fluctuations have already been recorded in the tie linking a coal-burning power plant at the Healy mine near Alaska Range and Fairbanks." (NY, 2-4-1986, p. C3)

4.12. Weather

[32] The relationship between auroral sightings and weather has a long history but is mostly folkloric and cannot be dated to determine their origins. Newspaper reports of aurora in the 1700s already seem eager to make this connection but apparently not for the first time.

93. "On the evening of the 17th instant, a very bright Aurora Borealis rendered the northern part of the heavens luminous...The 15th and 16th were cold days, the wind generally from the north-east." (*Boston Patriot*, 7-17-1814)

94. "The weather to-day has been very cold for the season. Brilliant auroral displays are apt to be followed by cold weather and frosts, and this instance is no exception. For ZA week past the press at the West has alluded to the show of Northern Lights, and at the same time to extraordinarily cold weather." (*Rochester Advertiser*, 9-2-1859, p. 2)

95. "Thus far it remains uncertain whether the earth as a whole is warmer or colder; but there is a slight balance of probability in favor of the former supposition, the greater activity of the solar surface when the spots are most numerous, probably ore than compensating for the diminution of luminous area." (NY, 7-16-1873, p. 4)

96. "The humidity of the atmosphere, which has been so apparent for several weeks, has resulted in a density most favorable to electrical phenomena. An aurora borealis was the first evidence of the overcharging of the atmosphere with electrical fluid." (NY, 11-18-1882, p. 1)

97. "Sir Oliver Lodge and Sir Norman Lockyer were interviewed on the matter (of the telegraph interference) and agreed in attributing the cause to sun spots and an increase in solar activity, which would also account for the unusual wet season now being experienced." (NY, 11-2-1903, p. 7)

98. "The ionospheric disturbances, a reaction from storms on the sun, have prevented proper reflection of radio waves.The weather here, meantime, continued unseasonably warm...With the beginning of rain during the afternoon the mercury started to fall." (NY, 3-27-1946, p. 13)

4.13. Politics/Warfare

[33] Although the earliest accounts suggest that the aurora were omens for wars, the practical consequence seems to be in providing additional light with which to change the outcome of a particular battle. Recently, however, the short-wave radio interruptions produced communication blackouts during which time important information could not be transmitted.

99. "Owing to unfavorable static conditions, in the North Atlantic, which have handicapped wireless communication between this country and Germany, the German Government for some time has found it practically impossible to send messages here without having them pass first into the hand of the British censors in London...Germany may thus remain isolated from the rest of the world for several weeks. It has been estimated that the static disturbances now occurring often increase the wireless distance between Nauen and Sayville by the equivalent of 2,000 miles." (NY, 5-25-1915, p. 3)

100. "At the radio station in the Brooklyn Navy Yard, information as to the effect of the freakish electrical show on the wireless operation was refused on the ground that all information of any character regarding wireless operation had to be furnished through official channels at Washington." (NY, 5-9-1918,, p. 9)

101. "Seven or eight German airplanes made a raid over England last night. Eleven persons were known to have been killed and forth-six injured in the metropolitan district...There was a remarkable display of the auroras borealis last night, and it is believed by many that this furnished conditions under which the air raiders could work more effectively than under a clear star-lit sky." (NY, 3-9-1918, p. 3)

102. "The aurora borealis was blamed today by scientists for the failure of President Coolidge's speech a the International Oratorical Contest last night to get out through the air to radio listeners...The engineers looked for the cause but could find no mechanical trouble." (NY, 10-17-1926, p. 3)

103. "Korean war news began flowing again last night after a blackout for half a day...This made possible resumption of Korean war coverage from General MacArthur's headquarters." (NY, 8-20-1950, p. 5)

104. "The United Press quoted University of Chicago scientists as calling the cosmic ray shower the greatest ever recorded...The Admiralty speculated today that cosmic disturbances caused a full-scale naval alarm for a British submarine feared missing. The submarine Acheron due to report her position at 10:05 A.M. (5:05 A. M. Eastern standard time) while on an Arctic trial, failed to make radio contact...Four hours later Acheron was heard from and the search was abandoned." (NY, 2-25-1957, p. L21)

105. "Sunspots delayed accounts of the Allied landing today (September 3) in Italy. Wireless technicians attributed to the spots the faulty transmission from the Mediterranean area to the United States. Dispatches piled up beside the operators as they tried various wave lengths in an effort to get through." (NY, 9-4-1943, p. 2)

106. "Radio Free Europe said yesterday that its engineers found no indication the Kremlin had resumed jamming it or its sister station, Radio Liberty, to block reports on demonstrations in the Soviet Union...Radio Free Europe spokesman Bob Redlich said that an effect similar to jamming could have been caused by recent increases in solar activity, which can hamper radio reception." (BS, 3-15-1989, p. 4A)

4.14. Radio Reception

[34] Radio transmissions via short-wave are severely disrupted by changes in the ionospheric *D* layer during solar flares, causing shortwave fadeouts. During geomagnetic storms, particle precipitation enhances electron density in the *E* and *F* layers over large geographic regions, and ionospheric currents cause plasma irregularities, which lead to radio wave scattering. These problems became increasingly severe after ca. 1930 when higher-frequency broadcasting technology became more commonplace, supplanting the older long-wave systems that were popular between 1905 and 1929.

107. "Curiously, however, the disturbance that tied up the land wires seemed to strengthen the signals of wireless apparatus, which were unusually clear during the period of heaviest land wire disturbance." (*Bismark Tribune*, 5-17-1921, p. 8)

108. "Magnetic storms hovering over the Atlantic are bothering the radio engineers who are striving to pick up European programs for rebroadcasting in America...Last Sunday Lady Astor spoke in London and was heard with remarkable clearness as her words crossed the sea on the American Telephone and Telegraph circuit for rebroadcasting over WABC's system. A half hour later the WEAF-WJZ network with WOR linked into the hook-up tried to rebroadcast from Holland, but the bombardment of the magnetic storms ruined the clarity...Twice last week WEAF-WJZ's attempts to relay European programs in this country were defeated by magnetic storms, which attached the programs coming from England and Germany and made it impossible to pick up on this side of the ocean." (NY, 3-2-1930, p. 133)

109. "A virtually complete blanking of short-wave communication between the United States and Europe, and partial disturbances of service to South America." (NY, 3-25-1940, p. 1)

110. "During the day, thousands of Brooklyn Dodger fans expressed themselves forcibly when a broadcast of the game with the Pittsburg Pirates at Pittsburg went off the air with the score 0-0...while Red Barber was broadcasting the story of the game over WOR. The broadcast was inaudible for fifteen minutes and when it resumed the Pirates had piled up four runs. Thousands of Brooklyn followers meanwhile had telephoned the station and displayed little satisfaction with the explanation that the sun was to blame." (NY, 9-19-1941, p. 25)

111. "Electrical disturbances during the day affected transatlantic short-wave radio channels, disrupting traffic almost completely." (NY, 9-19-1941)

112. "RCA technical men reported no effect on television during the height of the magnetic storm." (NY, 9-20-1941, p. 19)

113. "Radio listeners heard some spicy and unscheduled telephone conversations yesterday and the trouble was laid to the current magnetic storm caused by sun spots...WAAT during the first period, was broadcasting a program of recorded songs by Bing Crosby, when a conversation between two men was interjected suddenly and quite clearly into the background...A few minutes later the trouble was back, this time with a mysterious conversation between two girls who were talking about a 'blind' date." (NY, 9-20-1941, p. 19)

114. "...the Columbia Broadcasting System yesterday reported that the sun spots had caused an almost complete blackout in radio reception of overseas short-wave broadcasts for the second consecutive day." (NY, 2-8-1946, p. 18)

115. "Radio and TV listeners and viewers spent a hectic three hours as their sets blanked out, changed stations, or went completely haywire." (BG, 2-11-1958, p. 1)

116. "The aurora was accompanied by an electric storm that ended all radio communications between the United States and other countries and that disrupted telephone, teletype and electric circuits." (NY, 2-11-1958, p. 62)

117. "Solar radiation bombarding the earth's atmosphere at speeds of 3,000 feet a second caused magnetic storms around the world that washed out radio communications." (NY, 11-14-1960, p. 14)

118. "One monitoring station reported that short wave radio contact between New York and London was all but impossible." (CT, 11-16-1960, p. 16)

119. "Scientists at the National Oceanic and Atmospheric Administration reported that the solar flare had already caused some effects on Earth, including some radio blackouts." (NY, 7-16-2000 p. 21)

4.15. Crime

[35] Any documented reports of criminal activity almost certainly involve collateral issues not directly caused by the aurora or flares. Only one rather humorous example has been found to date.

120. "Last evening, while Charles F. Krebs stood outdoors admiring the aurora borealis, the money-drawer was taken from his saloon, and all the cash it contained, to the amount of between $3 and $4, stolen." (CT, 5-30-1877, p. 10)

4.16. Electric Shocks

[36] Related to the very large voltages and currents reported during some exceptional storms have been reports of humans actually being shocked and injured by currents flowing in telegraph wires. In the instance of the 25 September 1909 event, a telegraph operator in Lulea, Sweden actually experienced a severe shock that paralyzed her hand [*Stenquist*, 1914]. A similar injury may have befallen Frederick Royce during the 1859 storm. There are no actual reports of shocks having actually electrocuted someone, especially after 1909 when these types of accounts suddenly disappeared from being newsworthy. Possibly technological solutions to this problem made such events rare.

121. "...The effect was different than that of Aug. 28th. There was an intensity of current which gave a severe shock when testing..." [*AJS*, 1860d]

122. "...During the auroral display, I was calling Richmond, and had one hand on the iron plate. Happening to lean towards the sounder, which is against the wall, my forehead grazed a ground wire. Immediately I received a very severe electric shock, which stunned me for an instant. An old man who was sitting facing me, and but a few feet distant, said that he saw a spark of fire jump from my forehead to the sounder." [*AJS*, 1860e]

4.17. Ozone and the Atmosphere

[37] Aurora and solar flares cause considerable upper atmosphere changes, but there are no documented mechanisms in which these effects can reach the surface. One specific account in Versailles in 1859 can probably be dismissed as a statistical fluctuation seen under the "streetlamp" of the 1859 storm. Meanwhile, recent studies by *Thomas et al.* [2007] have suggested that a considerable reduction occurred in the ozone layer during this storm.

123. "Regular observations were made at Versailles on the amount of ozone in the atmosphere. During the auroras of Aug 28th and Sept. 2, the quantity of ozone was decidedly greater than usual." [*AJS*, 1860f]

124. "At Springfield...during the display of August 28th...The electrotype plates at the office of the 'Republican' at that place were so seriously affected by the aurora, that they could not be printed from during the continuance of the phenomenon." [*Prescott*, 1860]

4.18. Equipment Fires

[38] Telegraph systems "overcharged" by ground currents are frequently seen to produce sparks, so it is not surprising to hear of the occasional fire. Frequent mentions of this appear in the 1859, 1882, and 1921 storms, indeed, during the 1921 storm a telegraph office in Karlstad, Sweden was actually burned to the ground.

125. "...On the Albany and Springfield circuit, a flash passed across from the break key of the telegraph apparatus to the iron frame, the flame of which was about half the size of an ordinary jet of gas. It was accompanied by a humming sound similar to a heavy current passing between two metal points almost in contact. The heat was sufficient to cause the smell of scorched wood and paint to be plainly perceptible." [*AJS*, 1860g]

126. "The switch-board in the Western Union (telegraph) office here ignited half a dozen times. Several instruments were melted. The duplex and quadruplex wires were rendered useless, and only one wire out of fifteen between Chicago and New York was in operation by noon...Reports from offices all over the Northwest told of damaged switch-boards and melted keys." (CT, 11-18-1882, p. 2)

127. "The storm reached as far as Augusta Kentucky. Wires were worked here to Columbus and St Louis without batteries at this end. The wires were very heavily charged, a flame appearing when the contact was broken." (CT, 11-18-1882, p. 2)

128. "The switch board in the Western Union Telegraph office there [Chicago] was set on fire several times and much damage was done to the telegraph apparatus. From Milwaukee a report comes that the volunteer electric current was at one time strong enough to light up an electric lamp." (*Savanna Morning News*, 11-18-1882, p. 1)

129. "The switch board here (Chicago) was on fire a dozen times during the forenoon, and half a dozen keys of the instruments were melted by the current." (*Kansas City Evening Star*, 11-18-1882, p. 1)

130. "It was reported to the Western Union office in New York that the switch in the Springfield Mass. Office was set on fire." (NY, 4-18-1882, p. 5)

131. "President Newcomb Carlton of the Western Union Telegraph Company said yesterday that the magnetic disturbance accompanying the aurora borealis on Sunday morning had blown out fuses,

injured electrical apparatus and done other things which had never been caused by any ground and ocean currents known in the past.'' (NY, 5-17-1921, p. 1)

132. ''The disturbance was reported by cable to have burned out a telephone station in Sweden.'' (NY, 5-17-1921, p. 1)

133. ''East and west long distance telephone traffic for the entire country is handled through the switchboard here [Washington DC]. Nothing went through last night...High voltage caused by atmospheric electricity coming in on the wires burns out our fuses as fast as we replace them, the wire chief said.'' (*Kansas City Star*, 5-15-1921, p. 1)

134. ''The disturbance is believed to have caused a fire which destroyed a telephone exchange at Karlstad, a Swedish town about 160 miles west of Stockholm.'' (*Miami Herald*, 5-17-1921, p. 2)

135. ''Some of the strange results of the magnetic bombardment included the burning out near Bangor Maine of lightning arrestors that Western Union engineers had thought were immune to anything but lightning...(including) the complete fusing at Neche, North Dakota of the Fargo-to-Winnipeg cable.'' (NY, 3-26-1940, p. 18)

4.19. Electricity Outages

[39] Outright electrical outages or blackouts are, fortunately, very rare. The earliest event occurred in Geneva on 31 October 1903. The most famous occurred in Quebec on 14 March 1989 affecting over 3 million people. The most recent occurred in southern Sweden during the 2003 ''Halloween'' storm when the city of Malmö, Sweden suffered from a power blackout that affected 50,000 customers [*Pulkkinen*, 2004]. All these events are attributable to excessive ground currents.

136. ''The motors furnishing the electricity for the telegraph wires acted strangely throughout the period, it was reported at the Western Union offices. Just how the electricity in the air operated to interfere with the electrical apparatus could not be explained, but the effect was to change continually the quality of the current.'' (NY, 5-9-1918, p. 9)

137- ''Delivery of 195,000 of yesterday's Gazette around Montreal after a power failure shut down the presses. The Gazette had to borrow the press at La Presse in a different part of the city that still had power.'' (MG, 3-12-1989, p. A3)

138. ''Hydro-Quebec is blaming yesterday's massive power failure on the stars. Officials at the utility are citing a magnetic storm - touched off by an explosion on ths sun and marked by a spectacular display of the northern lights - as the main culprit in the third province-wide blackout in less than a year....Yesterday's blackout closed schools and businesses, kept the Metro shut down during the morning rush hour and paralyzed Dorval airport, delaying flights. It cost Quebec businesses tens of millions of dollars as it stalled production, idled workers and spoiled products.'' (MG, 3-14-1989, p. 1)

139. ''No major problems were reported at Montreal hospitals because they are powered by emergency generators in the event of a blackout. Still, the Montreal Children's Hospital cancelled elective surgery, ''We didn't want to be in a situation where everything goes black for a few minutes before the generator goes on'', said Dr. Nicholas Steinmetz, the hospital's executive director...Roger Dufor, director of security at St. Luc Hospital said that for about a half-hour, three or four patients in intensive care had to have air pumped into their lungs manually when a back-up generator powering the respiratory machines failed briefly.'' (MG, 3-14-1989, p. A3)

140. ''The General Motors car-assembly plant in Boisbraid lost production of $6.4 million worth of automobiles...The Montreal Stock Exchange, located in Place Victoria, was forced to operate on emergency power...most trades had to be completed manually...Sidbec-Dosco, Inc., a Quebec-owned steel company...estimated timated yesterday's production loss at between $500,000 and $1.5 million, ''All the steel that was already on the line in the hot rolling mills is scrap''... Cascades, Inc., a pulp and paper company based in Kingsey Falls, said the power shutdown would cost his company between $200,000 and $300,000...the amount doesn't include salaries.'' (MG, 3-14-1989, p. A3)

141. ''...the utility consortium that serves most of Pennsylvania, New Jersey and Maryland, said that monitors had detected unusual intermittent electric currents in the earth and that if the currents became sustained the utilities would reduce long-distance transmission of electricity.'' (NY, 6-6-1991, p. A16)

5. Artwork

[40] Considering that the aurora borealis is such a dramatic sight and that 19th Century newspaper illustration techniques were more than adequate to render a sketch of an ''exhibition,'' it is puzzling that so few illustrations could be found. The 11 February 1892 edition of the *Boston Daily Globe* included a front-page sketch (Figure 6) of the solar surface showing a full disk view and a close-up of the large sunspot rendered from telescopic observations.

[41] Despite the many descriptions of the mechanisms responsible for major aurora borealis sightings, the first actual illustration (Figure 7) showing some of the relevant components to the process was not published until 15 May 1921 when the *Chicago Daily Tribune* carried a background article on page 12 ''Why the Wires Went Dead.'' The illustration and explanation describe how streams of electrons emitted by sunspots, travel across interplanetary space, and are attracted to Earth's polar regions to cause the aurora. Two additional illustrations were published on page 7 by the *Chicago Tribune* on 26 March 1940 and on page 3 by the *Boston Daily Globe* on 5 July 1941. These illustrations are protected by copyright and cannot be reproduced in this article. In each case, they show clouds of particles from the sun engulfing Earth and causing aurora and radio blackouts. The illustrations are all exceedingly primitive in execution.

[42] In the 8 August 1954 edition of the *New York Times* (p. SM25) columnist Barbara Adler Buchman's article ''Naughty Aurora'' includes an uncredited photograph of the aurora on 24 April 1937 taken from Shreveport, Louisiana.

[43] On 29 October 2003 the *Washington Post* carried a detailed sketch of the solar and terrestrial system, including a coronal mass ejection, the solar wind, a shock front, and a sketch of Earth's magnetosphere, magnetotail, and polar regions. The included text describes ''A solar eruption that began yesterday morning is predicted to hit Earth today with a blast of hot gas and charged particles. Many

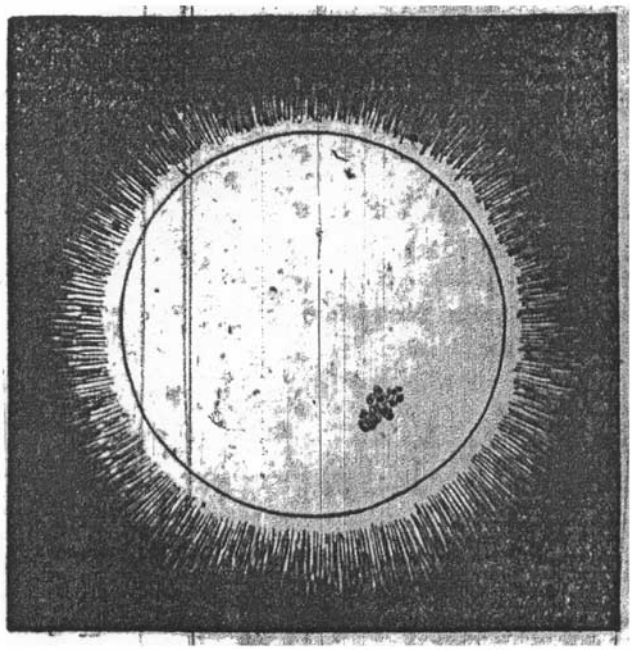

Figure 6. Sketch from the *Boston Daily Globe*, 11 February 1892, of the solar surface to show the large sunspot group responsible for the geomagnetic storms during this period.

kinds of technologies could be disrupted.'' Also ''The sun emits charged particles which travel across space as the solar wind. Earth's magnetic field - or magnetosphere - deflects the solar wind and creates a protective shell. When the sun ejects hot ionized particles from its corona, it can send a shock wave through the solar wind. The blast can distort Earth's magnetosphere, causing a disruptive magnetic storm.'' Once again, copyright restrictions prevent its reproduction in this article. Meanwhile, in the *Boston Globe* on the same day, reporter Scott Allen included a SOHO picture of the 28 October 2003 solar flare. This public domain ''historic'' image (Figure 8) was also used in other local newspaper stories across the country.

6. Why Are These Stories No Longer Covered?

[44] First of all, the modern equivalent of the 19th century news media is far more complex and diversified across many modalities beyond newsprint. One of the biggest competitors to newsprint that entered the arena in the postwar years was television. As Figure 9 shows, the growth in the number of homes that owned at least one television, underwent a substantial change during the period from 1945 to 1955 when the largest change is seen in the publication of space weather events in Figure 3 and 4.

[45] According to data from the Newspaper Association of America (2007), during the period after ca. 1970, there has been a steady decline in regular newspaper readership. Surveys indicate that, today, about 25% of young Americans (ages < 25) and nearly 50% of older Americans (ages > 25), rely on TV news reportage as their primary source of information, rather than newsprint. Radio news reports also eclipse print as a secondary way to get news information, with 40% of young people and 60% of older people favoring radio news broadcasts on a daily basis (M. Olander, Media use among young people, available at http://www.civicyouth.org/research/products/youth_index_2006.htm, 2006). To avoid competing with the evening news services, most newspapers bias their reporting to fill the morning editions. This growth of the morning paper has continued for nearly 30 a. Approximately six morning copies are sold for every evening edition (Project for Excellence in Journalism, The state of the news media: 2004, available at www.journalism.org).

[46] The impact that these changes have had on the reporting of phenomena only of interest to nighttime aurora observers in the United States is that space weather stories may be more often placed in the evening editions of newspapers where the competition is relatively intense to attract the sagging numbers of readers who purchase the evening editions. More dramatic stories are selected to engage readers' attention, at the expense of in-depth coverage of the comparatively benign impacts of space weather events. Meanwhile, it is not clear that the rise in television news coverage has taken up the slack in reporting space weather events during the immediate postwar period. The relevant, archival, data are not available to assess this point.

[47] The second factor that may explain the lost ground in space weather news reportage in the postwar era is that, according to Leonard David, Senior Space Writer for Space.com, increasingly, reporters need to be fed information in order to write a story. Most reporters do not have either the time or inclination to dig for the facts themselves. If a press release is not available on a particular science story, a reporter has to have a strong motiva-

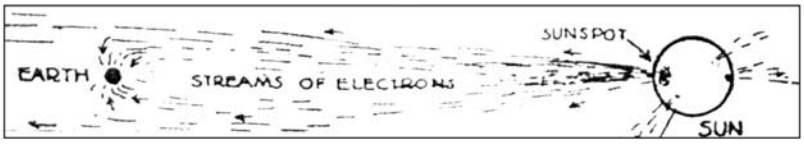

Figure 7. Illustration from the 15 May 1921 *Chicago Daily Tribune* (page 12) showing how sunspots create the aurora borealis.

tion to write the story from scratch. That motivation usually requires that there be some compelling human impact, disaster, or scientific angle involved that is immediately apparent and could be generally understood and appreciated by the public. The Halloween Storm of 29 October 2003 was supported by press releases from NASA, and proactive work by the NASA Public Affairs Office, and NOAA's Space Environment Center, through their e-mail distribution networks that reaches over 1000 news reporters. Yet despite this Herculean effort to get the story out to the news media, the actual number of column lines that resulted (Table 1: 888) is only comparable to similar severe storms reported between 1870 and 1950. Moreover, unlike the earlier newspaper stories, the modern-day stories did not report on specific impacts, but focused primarily on the more scientific elements of the phenomenon, consistent with the content provided by the NASA and NOAA/SEC press releases.

[48] A reporter also needs to be savvy enough to call science contacts that can provide new information, in a timely manner, for a novel story that has to be written under a deadline. This runs into the predictable problem in space weather in which most sources inside NASA, the Department of Defense, the national power industry, or commercial satellite owners, do not want to talk about their various problems. Without access to actual stories of significant impacts, there is literally no other story that can be written other than purely descriptive, and far less compelling, accounts from eyewitnesses. Modern-day technological impacts are vastly underreported compared to those 50–100 a ago because there are fewer commercial and government sources now willing to admit their vulnerability to the public.

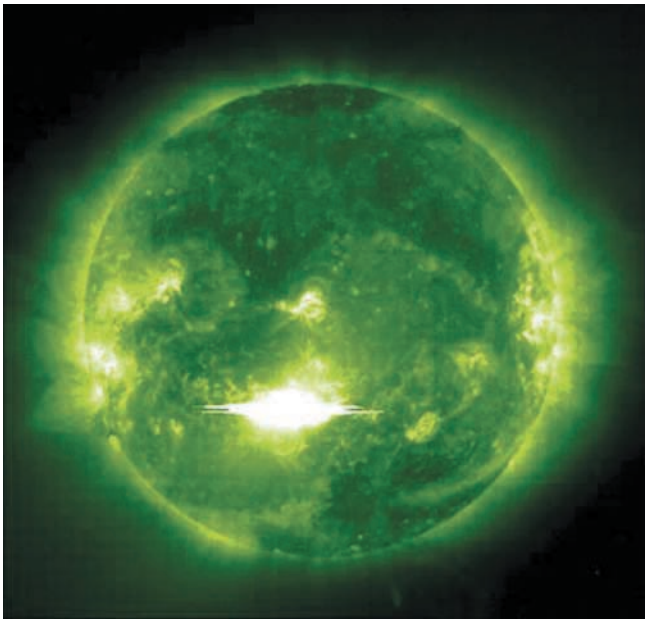

Figure 8. Illustration of the large solar flare on 28 October 2003 provided by NASA/SOHO used in the 29 October 2003 article published in the *Boston Globe*.

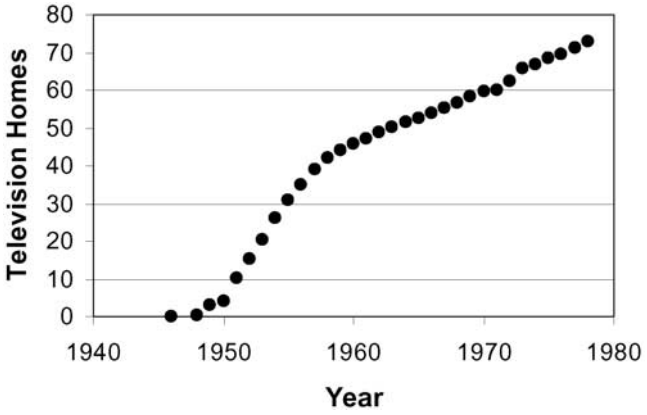

Figure 9. The growth of television sets, in millions, showing the 1940–1960 period when an abrupt change in space weather story quantity and quality was identified.

[49] Even when a story is well-written and compelling, there is a final hurdle to be surmounted. The more familiar the Sun has become to the public, thanks to a constant stream of real-time imagery from NASA, the more familiar it has become to editors and therefore the less compelling. "Didn't we do a Sun story last week?"

7. Conclusion

[50] The last 200 a in reporting auroral impacts has passed through many stages and fads as new impacts revealed themselves and old ideas passed out of scientific fashion. Earlier accounts in the newspapers were more inclined to report problems because the impacts directly effected how news stories themselves were circulated (telegraph, wireless, teletype). Also, the public impact was greater and harder to camouflage as telegraph and wireless systems failed for significant fractions of the day. In fact, the vast majority of the accounts involved the very equipment that reporters used to gather and transmit their news reports. During the postwar period, there are a broad array of communications media available to transmit and receive news stories, so any given space weather event causes little interruption in the flow of information; therefore the obvious impacts are more subtle and difficult to apprehend. When this is coupled with the lack of timely information on satellite, power grid, or radio anomalies from institutions locked in intense competitive struggles, and attempting to demonstrate high reliability, the present dearth in impact reporting is understandable.

[51] Yet, considering that there are far more technological connections to space weather conditions today than there were 50 a ago, it is puzzling that the "Golden Years"

of space weather reportage has indeed passed and the mediocre reporting of today is almost universally considered normal.

[52] **Acknowledgments.** I would like to thank the referees for recognizing the importance to future researchers in publishing the complete, verbatim historical accounts of space weather social impacts, although this required a somewhat longer paper to publish, and that as one of the referees put it ''It is rather important that the psychology of public opinion and of the makers of mass media is much better acknowledged [in the research literature].'' I also thank the referees for their helpful comments in improving the clarity of the physical description of solar flares and radio propagation. This paper was supported, in part, through NSF Magnetospheric Physics Program, Small Exploratory Research grant ATM-0650825.

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S. Odenwald, NASA Goddard Space Flight Center, Code 612.4, Greenbelt, MD 20771, USA. (odenwald@astronomycafe.net)