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Special Collection:
Impact of Space Weather Events on Transportation System

Did Space Weather Delay the 10:05 p.m. Train Departure From Exeter on 18 October 1841?

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Key Points:

- A reported 1841 train delay in England attributed to geomagnetic disturbance is inconsistent with the opening date of the railway affected
- The integration of contemporary observations and archival records points to the event occurring on 18 October 1848 rather than 1841
- The Exeter case remains a very early example of space weather affecting technology but is not the first recorded event

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Abstract Although the Carrington Event of 1859 is typically cited as the first extreme space weather event of the scientific era, it is not the earliest example of modern human technology being impacted by geomagnetic activity. The literature includes reliable accounts of disturbances to telegraph equipment during geomagnetic storms dating to the late 1840s, but the rediscovery by Cade III (2013, https://doi.org/10.1002/swe.20091) of a report published in the journal Nature (1871, https://doi.org/10.1038/004441a0) suggests that the first recorded space weather impact may have occurred in 1841. The *Nature* article reports interference in the telegraph system of the South Devon Railway Company (England) on 18 October 1841 due to a "very intense magnetic disturbance" which caused the departure of the 10:05 p.m. express train from Exeter to Newton Abbot to be delayed by 16 min. However, our research reveals that the railway line from Exeter to Newton Abbot was not opened until 1846, so the timing of the events reported in Nature (some 30 years after the event) cannot be correct. In this study, we present the results of an investigation into contemporary records and geomagnetic observations that suggest the misreported 1841 event occurred several years later, on 18 October 1848. This places it after the first recorded event: the interference in electric telegraph systems of the Midland Railway in England during the auroral display of 19 March 1847. Nevertheless, the Exeter event still represents one of the earliest recorded examples of space weather impacting technical infrastructure.

Plain Language Summary Although the famous Carrington Event of 1859 is often described as the first major space weather event to affect technology, earlier incidents did occur. Historical records show that telegraph systems were disrupted by geomagnetic storms as early as the late 1840s. A previously rediscovered report even suggested such an impact happened in 1841, when a railway telegraph system in southern England was said to have malfunctioned and delayed a train at Exeter. However, our investigation found that this account cannot be correct because the railway line mentioned did not exist at that time. By examining original documents and geomagnetic data, we determined that the event most likely took place on 18 October 1848, not 1841. This means it was not the earliest known example, but the Exeter event remains one of the first clear cases of space weather affecting human technology, highlighting that the relationship between solar activity and technological systems has been important for longer than is often assumed. This study also highlights the importance of using a range of data and archival resources when assessing and comparing historical accounts of space weather events and their impacts on society.

1. Introduction

Space weather is recognized as a societal hazard that has evolved alongside the development of modern human technologies and infrastructure over the last two hundred years (Buzulukova & Tsurutani, 2022; Cade & Chan-Park, 2015; Hapgood et al., 2021). The Carrington event of 1859 is recognized as one of the most powerful geomagnetic storms in the scientific record (Beggan et al., 2024; Hayakawa et al., 2022; Love et al., 2024) and was associated with the earliest and greatest solar flare ever recorded (Hayakawa et al., 2023; Hudson et al., 2025). Although the Carrington storm caused widespread disruption to the electric telegraph systems of the day (Boteler, 2006), it was not the first reported instance of solar activity interfering with the operation of technological infrastructure. One of the earliest reported events was presented to the Royal Society (London) in May 1848. Barlow (1849) cites the occurrence of "spontaneous electrical currents" in the electric telegraph equipment of the Midland Railway during the evening of 19 March 1847, when "a brilliant aurora was seen" over

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the British Isles. Railways were therefore among the first modern infrastructure to be impacted by space weather, due their reliance on electric telegraph technology for signalling purposes.

Almost two centuries later, the impact of space weather on railways remains the subject of investigation, although the technological vulnerabilities have evolved to include signaling track circuit misoperations, electrical grid and traction power dependencies (affected by geomagnetically induced currents (GIC)), and disruption to global navigations satellite systems and wireless communication systems (affected by ionospheric influences) (Patterson et al., 2023; Pilipenko, 2021; Wik et al., 2009; Xue et al., 2024).

An event, apparently taking place even earlier than the 19 March 1847 disturbance reported by Barlow (1849), was described in an anonymous article published in the 5 October 1871 issue of *Nature* and rediscovered by Cade (2013). It includes a report of an incident on 18 October 1841, when the departure of an express train on a railway line from Exeter, on the southern coast of England, was delayed. The cause of the delay is attributed to magnetic disturbances interfering with the needle telegraph equipment used by signalers to indicate whether a section of line was clear or occupied. This technology allowed signalers separated by several miles to manually communicate the clear/occupied status of a section of line using needle telegraph apparatus. In this case, the status of the line between Exeter and the nearby village of Starcross could not be established, causing the train's departure to be delayed. An account of the event, apparently contemporary, was included in the *Nature* report:

> "On the 18th of October 1841, a very intense magnetic disturbance was recorded, and amongst other curious facts mentioned is that of the detention of the 10.5 p.m. express train at Exeter sixteen minutes, as from the magnetic disturbance it was impossible to ascertain if the line was clear at Starcross. The superintendent at Exeter reported the next morning that some one was playing tricks with the instruments, and would not let them work."

If accurate, the 18 October 1841 incident reported in Nature (1871) is the earliest reported space weather impact on a technological system that we are aware of. However, as discussed in the following section, there are elements of this report (published 30 years after the events in question) that are not factual.

2. A Re-evaluation of the Evidence

The railway between Exeter and Plymouth was originally built and operated by the South Devon Railway Company. At the time of its construction, it was a broad gauge (7ft ¼in) line employing a novel "atmospheric railway" propulsion system that used compressed air to propel trains. Crucially, the Act of Parliament to establish a railway line between Exeter and Plymouth was only granted Royal Assent (approval) in July 1844 (South Devon Railway Act, 1844), with the railway being built in stages. The first section of line, between the city of Exeter and the town of Teignmouth, including the station at the village of Starcross approximately 6 km south of Exeter, opened on 30 May 1846 (*Trewman's Exeter Flying Post*, page 2, 4 June 1846), with the line ultimately reaching the town of Newton Abbot by December 1846 (*Trewman's Exeter Flying Post*, page 2, 31 December 1846). In short, the documentary evidence indicates that the railway line in question did not open until almost five years after the alleged events of 18 October 1841 reported in Nature (1871). As such, the *Nature* report cannot be accurate.

The journal *Nature* was first published by MacMillan in November 1869, with the scientist and astronomer Sir Norman Lockyer serving as the founding editor. But in the early years of the journal, the author(s) of reports published in the Journal were not always shown. Enquiries indicate neither the *Nature* archives, nor the Lockyer Archive at the University of Exeter, hold the original source material for the 1871 article. However, the publisher's original copy of the journal is annotated with a name that is likely to be that of the author. As shown in Figure 1, the handwritten annotation reads "N. ? Holmes", with the middle initial most likely being "J." Our research suggests that this individual is probably Nathaniel John Holmes, a prominent electrical engineer of the early Victorian era (Roberts, 2012). Around 1870, Holmes was active in the deployment of undersea telegraph cables across parts of the North Sea, including links to Denmark, Norway and the Northern Isles. This suggests he might have an incentive to explore the impacts of geomagnetically induced current (GIC) impacts on cable systems and the other technologies of the day. The 1871 census shows Holmes at age of 47, living in Hampstead where he was likely well-connected into London intellectual circles of that era. At that time, Lockyer lived in West Hampstead, about a mile away. Contemporary newspapers also show "Nathanial J. Holmes, Esq, London" delivering a lecture on "The Chemical Effects of the Solar Spectrum" to a public audience in Scotland (*The Brechin Advertiser*, page

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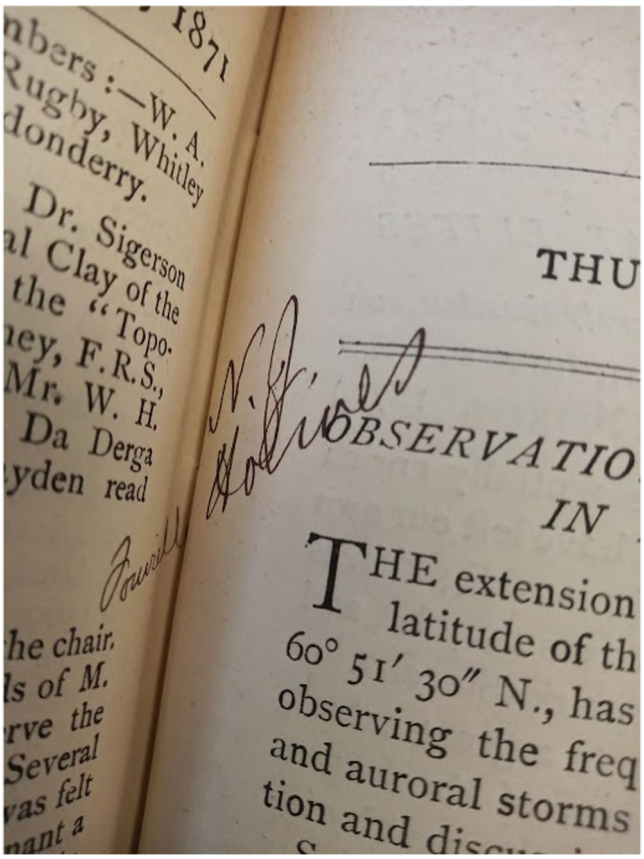


Figure 1. The cover page of "Observations Upon Magnetic Storms in Higher Latitudes", published in Nature (1871). A handwritten annotation suggests the author of the report is "N. J. Holmes." Image reproduced with the permission of Macmillan Archive.

1, 8 November 1870), revealing his interest in solar activity and his familiarity with Lockyer's work, which included the discovery of helium lines in solar spectra. This hints at a link between Holmes and the *Nature* editor at the time of the 1871 report, which is further supported by a letter in 1877 from Holmes to Lockyer suggesting that the two men were in a business relationship and inviting Lockyer to visit Holmes (1877).

The documentary evidence hints that the likely author of the 1871 *Nature* article citing the impact of magnetic disturbances on railway telegraph systems on 18 October 1841 was a telegraph engineer with an interest in astronomy, who was also an acquaintance of the journal's editor. However, the absence of the original manuscript, or directly relevant correspondence between the author and the journal, does not allow us to conclusively resolve the mystery over the reported date of the event predating the opening of the railway by almost 5 years.

We note that the account of the delayed 10:05 p.m. train from Exeter presented in the Nature (1871) article, makes reference to an apparently first-hand report from the railway "superintendent at Exeter." Despite the publication of this article some 30 years after the claimed date of the event, no citation is provided that would enable an investigation into the veracity of the statement. The remarkable claim that they "reported next morning that some one was playing tricks with the instruments" hints that this account may have originated from a contemporary newspaper report or suchlike, but we have been unable to find any report that included this phrase or any language to this effect.

3. Revisiting Contemporary Observations

If a significant geomagnetic disturbance impacting southern England had occurred on 18 October 1841, it is reasonable to expect to find evidence in contemporary records. The earliest continuous magnetograms recorded at the Greenwich magnetic observatory (London) start in 1846, however the observatory's yearbook (Airy, 1849) contains records of "extraordinary" observations of the magnetic field that correspond to strong geomagnetic storms dating back to 1840. There is no unusual activity noted on 18 October 1841 and a later "Catalogue of the auroras seen in Europe below Lat. 55° from 1700 to 1890", incorporated as an Appendix to Angot (1897), does not include any reports of aurora in England on 18 October 1841, although aurora were sighted in Prague (Czech Republic) on that date.

In order to narrow the search for evidence of space weather disturbances that might have impacted this region, we have exploited the contextual information included in the Nature (1871) report. The reference to the "the detention of the 10.5 p.m. express train at Exeter" provides an opportunity to cross reference against the railway timetables for services on this line that were routinely published in local weekly newspapers. Looking for departures from Exeter towards Starcross at 10:05 p.m., we have identified a window between 11 March 1848 and 26 July 1849 in which the timetable included the departure of a 10:05 p.m. train, as shown in Figure 2.

Furthermore, our examination of contemporary magnetograms reveals clear evidence of powerful geomagnetic activity in the days surrounding 18 October 1848, that is, the same day and month as the event cited in the Nature (1871) report, but in a different year (1848 instead of 1841). As presented in Figure 3, magnetic field records from the Greenwich magnetic observatory reveal strong disturbances in the magnetic field (British Geological Survey, 2013). The magnetogram records variations in the Horizonal (H) component and Declination (Dec) of the field as a function of astronomical time. Scaling information (not included on the daily magnetogram) indicates that maximum change in the Horizontal field on the magnetogram, recorded between approximately 22:00–22:20 UT as there is a gap beforehand, is approximately 310 nT, which corresponds to a rate of change of ∼15 nT/min. The large peak-to-peak variation in the declination, from slightly off-page at 21:45 UT to 22.07 UT, corresponds to a ∼1.3° change in Declination over 22 min. These very large changes in Declination and Horizontal strength would be sufficient to create an induced geoelectric field in the south of England, assuming Exeter

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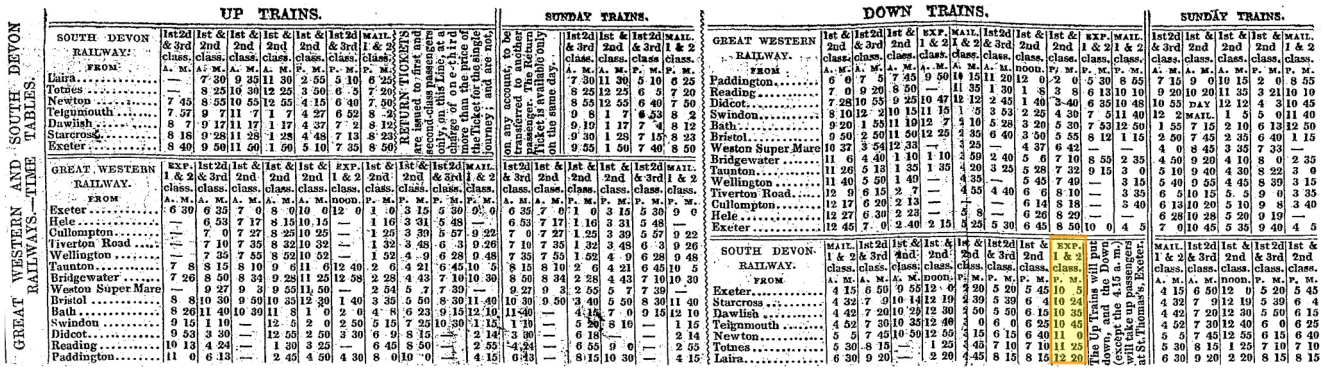


Figure 2. The weekly passenger timetable for Great Western and South Devon Railways services (*Trewman's Exeter Flying Post*, page 7, 12 October 1848). The weekday 10:05 p.m. (written "10 5") Exeter departure from to Plymouth towards Starcross is highlighted. Image courtesy of The British Newspaper Archive created by Findmypast and the British Library (available in the public domain).

(50.5°N) experienced the same variation of the magnetic field as observed at Greenwich (51.6°N), that is, at a similar geographic latitude around 250 km to the east.

Contemporary newspaper articles and accounts published retrospectively are consistent with several days of disturbed space weather in the second half of October 1848. For example, a letter from an Exeter resident to the *Exeter and Plymouth Gazette* (page 6, 21 October 1848) suggests a large Earthward-pointing active region on the solar disc at this time:

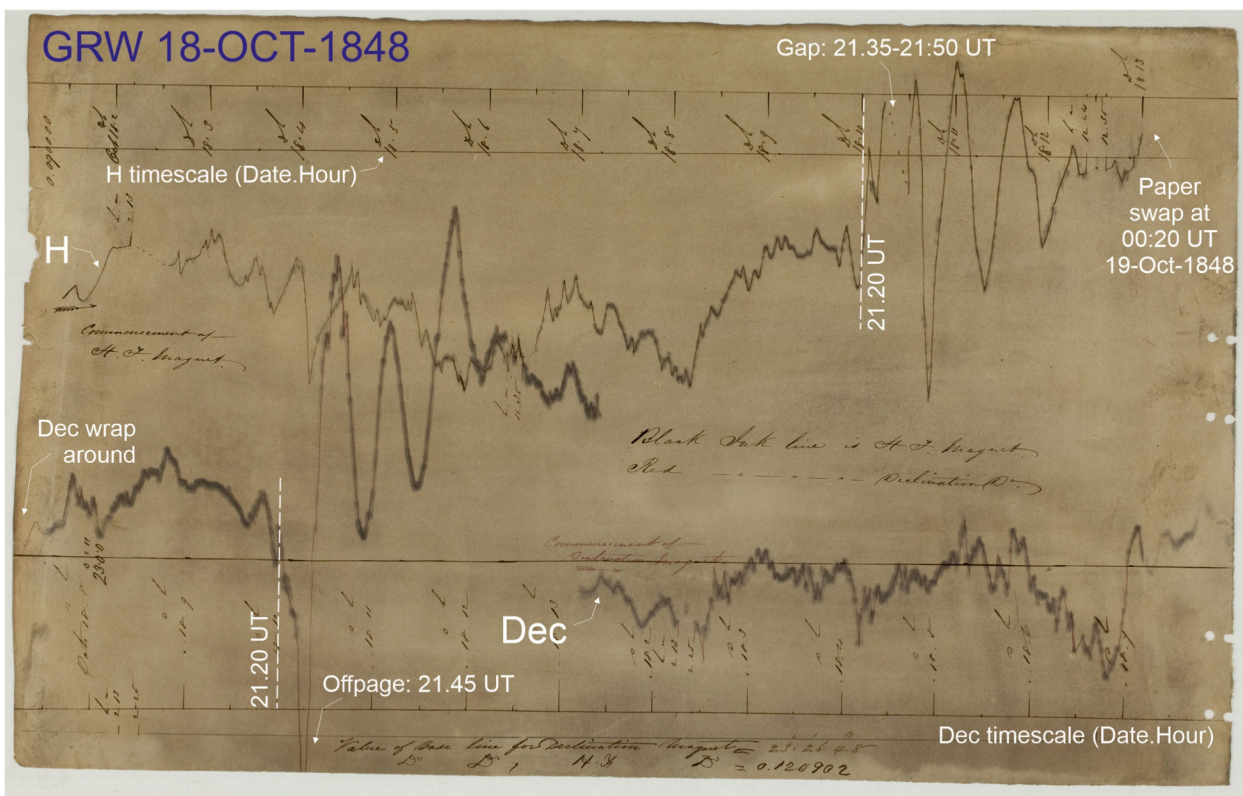


Figure 3. The magnetogram recorded at Greenwich Magnetic Observatory (London) from 11:20 UT on 18 October 1848 to 00:20 UT on 19 October 1848. The upper trace tracks the variation in the horizontal force of the magnetic field (which can be converted to nano-Tesla) and the lower trace records the declination angle of the horizontal magnetic field. In the original record, time is recorded in astronomical time, such that 0 h is noon in Göttingen mean solar time (40 min ahead of GMT/UT) and the upper and lower traces are offset in time with respect to each other. Powerful geomagnetic disturbances are apparent on the evening of 18 October 1848 from 21:20 UT.

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Figure 4. Sunspot observations, made at 10:25 a.m. on 19 October 1848 by the British clergyman, astronomer and mathematician Temple Chevallier. A large group of sunspots spans the central Earth-facing meridian. In this projected image of the Sun, the arrow on the left-hand side of the drawing indicates the direction in which the Sun appears to move across the sky due to the Earth's rotation. The western side of the Sun is in the upper left of this drawing (at approximately the 10 o'clock position) and north is towards to the upper right (at approximately the 1 o'clock position). Image reproduced with permission of the Royal Astronomical Society.

> "On observing a transit of the Sun to-day [19 October 1848], a group of dark spots merging into each was distinctly visible; the whole space from East to West took five seconds passing the meridian line of the instrument; the whole disc of the Sun passed in two minutes and eleven seconds, which if we assume its real diameter to be 800,000 miles, would indicated the darkened space to be nearly 31,000 miles in length; the appearance was immediately below the Sun's equator."

Between 1847 and 1849, the noted British clergyman, astronomer and mathematician Temple Chevallier was making regular observations of sunspots from the observatory at Durham University (England). These records, preserved in the collection of the Royal Astronomical Society, include the drawing of the solar disc observed on 19 October 1848 presented in Figure 4, showing the large sunspot group referred to in above newspaper report (Chevallier, 1848).

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Meanwhile, auroral displays were observed widely over the UK in the days throughout this period, with reports included in newspapers published in Cheshire, Lancashire and Norfolk (among others). A weekly Exeter newspaper covering both local and national news re-published an account of an auroral display from an observer near Leeds in northern England (*Trewman's Exeter Flying Post,* page 4, 26 October 1848):

> "Being at Bolton-park on Wednesday night, I had a good opportunity of observing a very unusual appearance of the Northern Lights. The whole heavens, with the exception of a very few degrees of the south, were vividly illuminated. The centre of the illumination was about five degrees south of the zenith, whence in all directions radii of light darted with the rapidity of lightning."

Given the time taken to receive and print this report, it is likely that "Wednesday night" was 18 October 1848, the same night as the powerful geomagnetic disturbance recorded at the Greenwich magnetic observatory (as shown in Figure 3). This account suggests that auroral activity was brightest to the south of Leeds, over central and southern England.

Furthermore, the 26 October 1848 *Flying Post* report of the auroral sightings near Leeds concludes with an editorial note:

> "On Saturday night about eight o'clock, the Northern Lights were seen from this city [Exeter], although they were but faint compared with the grandeur above described."

The Saturday prior to the publication of this issue of the *Flying Post* was 21 October 1848, just a few days after the storm presented in Figure 3. In addition, an article in *The Western Times* (page 5, 28 October 1848), another regional newspaper covering south-west England and published in Exeter, reported auroral sightings near Exeter on the night of 22 October 1848.

Although not a contemporary source, the subsequent catalogue of Angot (1897) records auroral sighting in the UK on 17, 18, 19, 20, 22, 24, 25, 27, and 30 October 1848. This source also notes auroral sightings in Austria, Belgium, France, Germany, Italy and Poland, and reports from ships in the North Atlantic, between 17 and 31 October 1848. The catalogue of auroral sightings compiled by the Spanish physicist Rico Sinobas in 1855 includes records of distant red aurora observed in the northerly direction from northwest Spain on 18 Oct 1848 (Vaquero et al., 2003, 2007). Ptitsyna et al. (2012) similarly reported widespread geomagnetic disturbances across the full longitudinal expanse of the Russian empire from St. Petersburg to Sitka (the latter now being part of Alaska USA) on 23–26 October 1848. It was clearly a period of active space weather. Certainly, the observations of a large solar active region and mid-latitude geomagnetic activity on 18 October 1848 presented here provide some closure for the question over "Known magnetic storms?" for this date raised in Table 1 of Vaquero et al. (2007).

As further historical context to the train disruption in Exeter (England) that we assert occurred on 18 October 1848, we note the report of interruptions to telegraph communications between Florence and Pisa (Italy) by Carlo Matteucci occurred nearly one month after this event, on 17 November 1848 (Odenwald, 2007; Prescott, 1860). This coincided with reports of aurora observed from Spain on the same date (Vaquero et al., 2003, 2007) and extraordinary aurora visible at the unusually low latitude of St. Croix island in the Caribbean British Virgin Islands (Knipp et al., 2021; Lang, 1849; Lockwood et al., 2025). Solar observations for 17 November 1848 (Chevallier, 1848) include a large sunspot group near the central meridian, consistent with the same active region responsible for the Exeter event surviving at least one solar rotation and triggering geomagnetic disturbance 30 days later.

Also worth noting are some inconsistencies in the historical literature regarding Matteucci's observations, which has led to some errors in the more recent literature that should also be addressed here, alongside the apparent typographical error in the Nature (1871) report. While Angot's (1897) aurora sightings catalogue includes the 17 November 1848 event, it is incorrectly stated earlier in the book that "Matteucci, at the time of the aurora borealis of 28 October 1848, remarked the coincidence of this phenomenon with interruptions in telegraphic communications, produced by telluric currents." Similarly, following a list of "extraordinarily heavy disturbances" published by Preece (1892, 1894), Burbank (1905) suggested that 27 October 1848 should be added to that list, most likely meaning to add Matteucci's 17 November 1848 event instead. Together, these early reports led to 27–28 October 1848 being listed among the magnetic disturbances that affected electrical systems in the Appendix of Boteler et al. (1998). However, our review the British Geological Survey's historical magnetometer data

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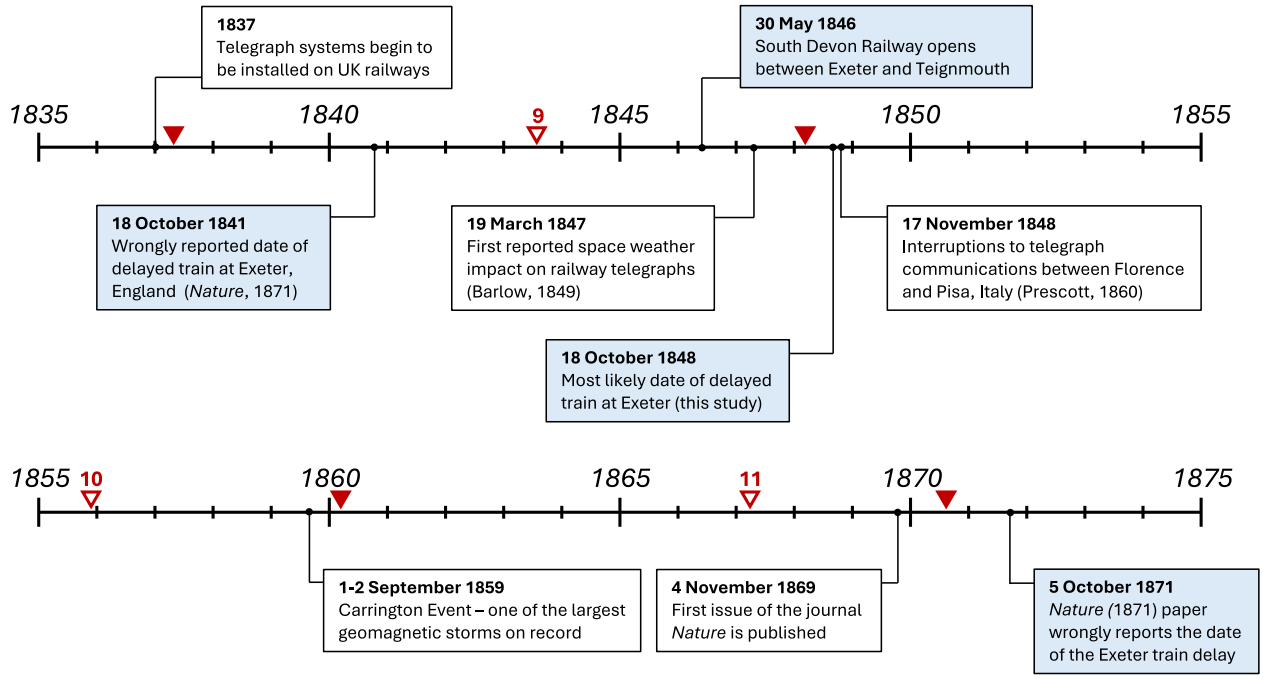


Figure 5. A summary timeline of key dates relevant to this investigation spanning the years 1835–1875. The shaded entries highlight events of particular significance to the delayed train in Exeter, as reported in Nature (1871). Unfilled (filled) triangles indicate the timings of solar minima (maxima). Solar minima are labelled with the number of the following solar cycle.

archive, found no significant disturbance on 27–28 October 1848. Further complicating the interpretation of these historical accounts is the fact that Matteucci himself also published the incorrect year for this event, stating "This phenomenon first appeared in the telegraph wires of Tuscany on 17 November 1847, when a beautiful aurora borealis appeared on the horizon" (Matteucci, 1864, translated from French).

Considering the numerous apparent errors in the literature, the account in Barlow (1849) appears to be the first accurate report of aurora impacting telegraph infrastructure, in which he referred to an event on 19 March 1847; an account also supported by the Angot (1897) aurora sightings catalogue.

4. Conclusions

A timeline of events that summarizes the key dates in this investigation is presented in Figure 5. The report in Nature (1871) includes an account, apparently contemporary, of space weather disturbances alleged to have impacted railway telegraph systems near Exeter (England) on 18 October 1841. If authentic, this would be the earliest reported example of space weather affecting human technological infrastructure. However, these events cannot have occurred as reported since the claimed date of the storm is almost 5 years prior to the opening of the relevant railway line. We also find no contemporary evidence of heighted geomagnetic activity in the UK at that time. Using contextual information and railway timetables to narrow our search to a four-month window in 1848, we find solar observations, geomagnetic records and contemporary newspaper accounts pointing towards a period of disturbed space weather conditions affecting the UK on and around 18 October 1848. This corresponds to the same day and month as that stated in the *Nature* article, but taking place exactly seven years later. The compelling circumstantial evidence points to a typographical error in the date of the event reported in *Nature* with "1848" being mis-printed as "1841"; a problem found to be common to a few other historical accounts of space weather events occurring around this time. This being the case, the interesting account of the detention of the 10:05 p.m. express train from Exeter on 18 October 1848 due to the effects of geomagnetic disturbances on the signalling telegraph system remains one of the earliest space weather impacts on record, but it is not the first recorded event. The account presented in Barlow (1849) of geomagnetic disturbances affecting the telegraph system of the Midland Railway near Derby (England) on 19 March 1847 remains the earliest credible report on record.

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Its timing, along with the later reports from Exeter (as we assert here) and other locations such as Tuscany (Italy), is a great example of how rising solar activity can expose the space weather vulnerability of an emerging technology. The first electric telegraph systems were invented in the 1830s but it was not till the development of Daniell's and Grove's batteries in 1843, allowing transmission over significant distances, that the invention became of practical use. The following rapid growth of telegraph systems occurred during the solar minimum period between cycles 8 and 9; the sharp rise of solar cycle 9 during 1847, and its high activity during 1848 then exposed its vulnerability to space weather.

Importantly, this analysis highlights the significant value in using a range of data and bibliographic resources when assessing and comparing historical accounts of space weather events and their impacts on society. In places where the historical scientific literature has not been completely reliable (and there were a few), contemporary accounts published in local newspapers were shown to be invaluable, particularly when combined with archival scientific observations.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Availability Statement

The scanned yearbooks for the UK observatories (1840–2002) including Greenwich are available at: https://geomag.bgs.ac.uk/data_service/data/yearbooks/yearbooks.html. The scanned archive of historic magnetograms (1846–1983) can be viewed at: https://www.bgs.ac.uk/information-hub/scanned-records/magnetograms/. The 1871 census records were accessed via Findmypast (https://www.findmypast.co.uk/) and contemporary newspaper articles were accessed from British Library Newspapers, via the National Library of Australia's eResources Catalogue (https://catalogue.nla.gov.au/). Solar cycle data from WDC–SILSO, Royal Observatory of Belgium, International Sunspot Number, Version 2, DOI: 10.24414/qnza-ac80 (CC-BY-NC).

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