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Understanding weather futures based on the past: a case of Stornoway, Outer Hebrides

N. Macdonald[a], S. Naylor[b], J. P. Bowen[a], A. Harvey-Fishenden[a] and E. Graham[c]

[a]Department of Geography & Planning, School of Environmental Sciences, University of Liverpool, Liverpool, UK; [b]School of Geographical and Earth Sciences, University of Glasgow, Glasgow, UK; [c]UHI Outer Hebrides, University of the Highlands and Islands, Stornoway, UK

ABSTRACT
We present a weather history for Stornoway in the Outer Hebrides, an island chain off the northwest coast of Scotland. It combines a new 164-year composite rainfall record representative of the settlement of Stornoway (1857–2019), alongside descriptive accounts of weather harvested from the school logbooks from the Nicolson Institute in Stornoway (1873–1974). The school logbooks record the experiences of the school, school children and wider community throughout the seasons. We describe the construction of the rainfall record for the period 1857–2019 and present analyses of long-term annual and seasonal variability, with a particular focus on wet/dry extremes. In examining instrumental and qualitative sources together, we consider not just climate, but also the impacts and responses of extreme weather on the communities of the Outer Hebrides and specifically Stornoway. The climate of the late nineteenth century in the Outer Hebrides was climatologically and meteorologically challenging, with harsh storms, severe cold, and droughts with notable societal impacts. School logbooks provide the opportunity to examine societal responses to past climate variability, enabling a better understanding of how future climates may be adapted and responded too.

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Precipitation; School log books; Outer Hebrides

Introduction

Long instrumental observations and climatic records offer valuable insights into how variables such as temperature, precipitation and pressure have fluctuated over time (Brázdil et al., 2010; Brönnimann et al., 2019). Individual records derived from single-site meteorological series provide detail on small scale and local changes in climate, but also support larger-scale analysis of climate change (Camuffo et al., 2013; Hawkins et al., 2022) and contribute to understandings of longer term regional and global climate variability (Blöschl et al., 2020). There is a long history of reconstructing climatic variables for either single or multiple sites (Camuffo, Becherini, et al., 2020), enabling long-term analysis of change and trends (Dobrovolný et al., 2010), with such series

CONTACT N. Macdonald Neil.Macdonald@liverpool.ac.uk Department of Geography & Planning, School of Environmental Sciences, University of Liverpool, Liverpool L69 7ZT, UK

being developed in the UK, for Carlisle (Todd et al., 2015), Durham (Burt & Burt, 2022), Oxford (Burt, 2021; Burt & Burt, 2019), and construction of regional series, such as the Central England Temperature Series (Parker et al., 1992) and derivative series examining river flows (Jones et al., 2006; O'Connor et al., 2021) and droughts (Noone et al., 2017; Todd et al., 2013). However, whilst such series are valuable they have tended to focus on well-documented regions, with only a limited number exploring more remote sites. This pattern is also replicated at a European scale, with networks covering 'central' Europe (Camuffo, della Valle, et al., 2020). Beyond Europe and North America long instrumental climate series become more sparse (Brönnimann et al., 2019), with limited series available for analysis in Africa (e.g. Ndebele et al., 2020), Asia (Tang et al., 2020) or Australasia (e.g. Ashcroft et al., 2014; Gergis et al., 2021). International efforts to identify and preserve records where they exist is led by the international Atmospheric Circulation Reconstructions over the Earth (ACRE; Allan et al., 2016).

Historical geographers, environmental historians and historical climatologists are starting to extend on instrumental series through the use of documentary materials in a range of forms, such as diaries, letters, estate records, administrative accounts and governmental documents (Sangster et al., 2018). The use of citizen science approaches in processing large amounts of historical information detailing past weather offer considerable opportunities to make historical weather records more accessible (Craig & Hawkins, 2020; Hawkins et al., 2022). Recent studies have demonstrated that documentary sources can have great value in the reconstruction of weather histories and can be more representative of the weather for local areas than instrumental series from more distant locations (Harvey-Fishenden & Macdonald, 2021), whilst also offering insights into how individuals, communities and societies responded to and built resilience based on past experiences (Endfield & Morris, 2012; Metcalfe et al., 2020). In this paper we will be using instrumental records alongside school logbooks to present a weather history for Stornoway on the Island of Lewis, part of the Outer Hebrides island chain.

The Outer Hebrides is an archipelago of islands off the west coast of Scotland, stretching almost 200 km, from Barra Head in the south to the Butt of Lewis in the north, with 15 inhabited islands and over 50 that are now uninhabited, though some had communities historically, such as St. Kilda and Scarp. The environment varies from machair to mountainous, with the largest settlement being Stornoway on Lewis (Figure 1). The islands of the Outer Hebrides were for a long period of European history perceived as the 'Edge of the World' (Maclean & Buchanan, 2006); however such a view fails to recognise the integral role the islands played in early cultural development of the British Isles, and their significance to early Scandinavian kingdoms (Haswell-Smith, 2015). The archipelago has until the last century been relatively poorly connected with mainland Scotland, developing local adaptive and coping capacities as often exhibited by peripheral communities (Bridges & McClatchey, 2009; Mcnamaraid et al., 2022; Nunn & Kumar, 2019).

The islands today are relatively sparsely populated and have historically experienced the brunt of Atlantic storms reaching northern Europe, with several storms recording wind speeds in excess of 160 kmh (100 mph) at or near sea level. There are limited written accounts of weather and climate from the islands, and those that do exist often offer second-hand insights, with few primary documentary accounts prior to the twentieth century. This absence of written records reflects the long oral history tradition of

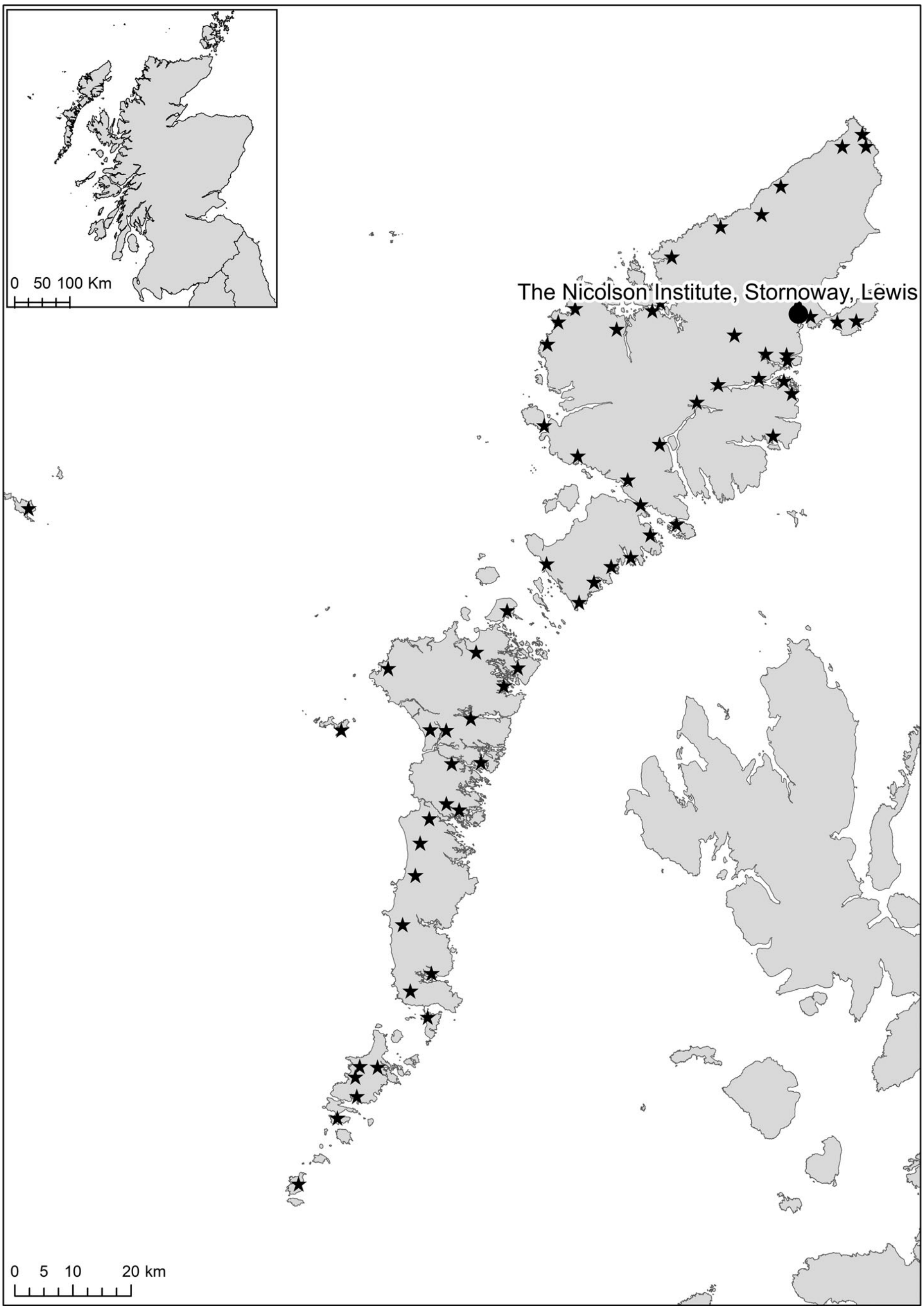

Figure 1. Location of the Nicolson School, Stornoway, and distribution of the school logbooks reviewed across the Outer Hebrides in relation to weather to date. The map was generated by the authors and contains OS data © Crown copyright and database right 2022.

the islands, high levels of Gaelic spoken, relatively high levels of illiteracy until the late-nineteenth century and limited local (island) record keeping. However, more than 170 school logbooks survive from across the islands of the Outer Hebrides (Figure 1), spanning the period from 1872 to the late twentieth century, with many held by the *Tasglann nan Eilean Siar* (Hebridean Archives). Whilst historians of education have used school logbooks to examine educational and professional development, and explored issues of gender, language and literacy (McDermind, 2003), logbooks have received little interest from an environmental history perspective, until recent work by Naylor et al. (2022) in the Outer Hebrides and Foley (2022) in the Orkney Islands.

The front page of the logbooks usually contained a printed sheet that detailed and justified the expectations of the record and record keeper. For example, the first page of the logbook for Knock (1892–) states:

> The log-book must be stoutly bound and contain no less than 300 ruled pages. It must be kept by the principal teacher, who is required to enter in it from time to time such events as the introduction of new books, apparatus, or courses of instruction, any plan of lessons approved by the inspector, the visits of managers, absence, illness or failure of duty on the part of any school staff, or any special circumstances affecting the school, that may, for the sake of future reference or for any other reason, deserve to be recorded. (Extracts from New Code, 1882)

It is notable that the school log books produced in the 1950s still contained the same instructions (e.g. Kyles Stockinish, 1953), reflecting a long record of logbooks being stored by schools, or little change in the expectations. The school logbooks were normally completed weekly, the 'Instructions for Keeping a Log Book' in the Tarbert (1878–) school logbook, stating, 'The principal teacher must make at least one a week in the Log Book an entry' (based on the Scottish Education Code, 1876). As observed in the quote from the instructions, teachers used the logbooks to documents absences and reasons for those absences. The weather was often a reason for pupils not attending school, either because it was poor – heavy rain, storms, rough seas or snow – or it was clement and children were kept at home to help with croft work and subsistence activities – gathering fuel, tending livestock or picking crops for instance. Poor weather often coincided with illness amongst the student population and was documented as such. The 'special circumstances' mentioned in the Knock logbook guidance included the effects of severe weather on the school buildings and surrounding community, including damage from storms. This paper examines the recording of the weather in one specific set of school logbooks for the Nicolson Institute, Stornoway, with cross comparison to a newly reconstructed precipitation series at Stornoway (1857–2019) and derived drought series. In doing so, it provides an opportunity to consider how weather has been recorded and experienced, offering insights into how future weather and climate may impact these island communities.

Station records and logbooks in Stornoway

A long instrumental precipitation series is reconstructed from meteorological records taken at Stornoway. The data are derived from several locations, with the earliest records starting in 1857 held at the Meteorological Office, Edinburgh. In addition to precipitation records, additional weather parameters were often also recorded, including barometer (air pressure), thermometer (temperature), hydrometer (humidity), wind direction and strength, cloud cover, sunshine (hours), sea temperature, ozone (measured on 1–10 score) and a general description of the weather. These early records were submitted to the first edition of the journal *British Rainfall* (Symons, 1862), with the reporting ascribed to Sir James Matheson. Matheson had purchased the Isle of Lewis in 1844 and constructed Lews Castle (completed in 1851) on the site of the previous estate house, clearing the land and removing many of the tenants. He had been elected to the Royal Society of London in 1846 and raised to a baronetcy in 1851 (Grace, 2018). The meteorological station was situated, according to *British Rainfall*

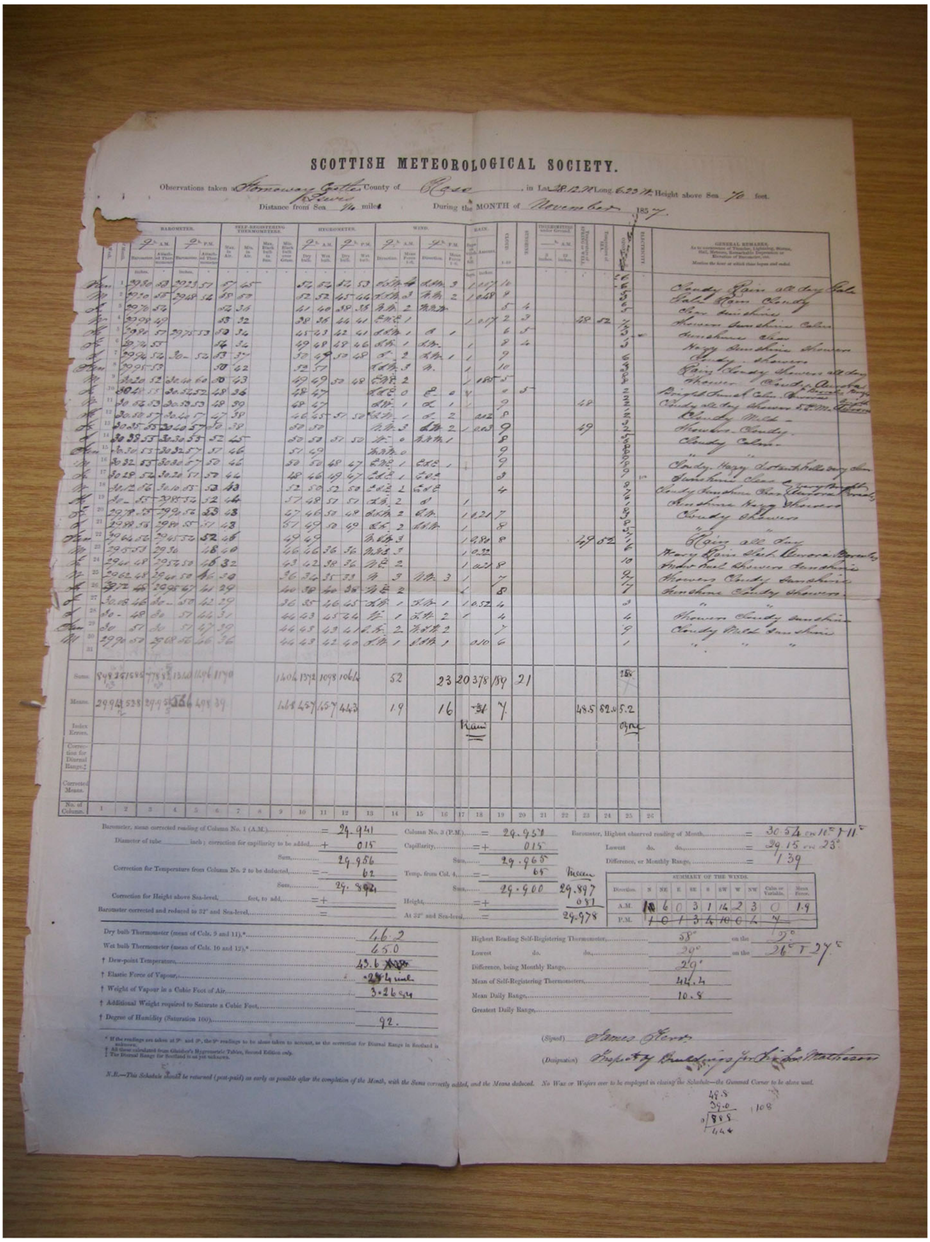

Figure 2. Example recording sheet, November 1857, notably 23 November records a combination of Heavy Rain, Sleet and Aurora Borealis.

(1862), 3 in. above the ground and 70 ft above sea level, corroborating the details on the recording sheet photographed at the Meteorological Office (Figure 2). There are no missing climatological return forms from the series. From 1866 the climatological forms were retrieved from digitised versions from the Meteorological Office, Edinburgh (1867–1913) and the National Records of Scotland (1873–1920). Four books covering the period 1913–1930 were viewed at the Meteorological Office in Edinburgh (not digitised), with the data from 1930 onwards available digitally from the Meteorological Office; this period coincides with several local station relocations. The recording station at Stornoway moved to Stornoway Airport in 1968, from where the record continues today; although the station has moved within the airport grounds. No other long precipitation series exist over this extended period within the Outer Hebrides. Many of the oldest weather records within the UK and Scotland are from large urban centres or from rural settings, such as country estates and vicarages for instance, and collected by enthusiastic amateur meteorologists. For comparison purposes and to ensure that broadly similar trends are followed the long precipitation series available from Inverness is used, which covers the full study period (personal communication David Lister and Phil Jones, UEA, 2021). However, this station is a substantial distance away (~150 km to the east) and reflects different geographical and topographical exposures to the Atlantic coast. A shorter series from Portree, Skye (1860–1881), previously used by Macdonald and Phillips (2006) in analysing long-term (1860-1991) precipitation variability across Scotland is also considered, as this station offers a more regional climate series (89 km SSE of Stornoway). The distance from Stornoway and local topographical conditions of the series at Portree, Skye are considerable but offers an opportunity to ensure broadly similar precipitation trends.

Many of the school logbooks from across the Outer Hebrides are held by the *Tasglann nan Eilean Siar* (Hebridean Archives). Within this study, we use those of the Nicolson Institute (the name was changed from the Nicolson Public School, to Nicolson Institute in 1901) as they offer the longest and most complete set of logbooks closest to the instrumental station – an unbroken documentary source of the weather in Stornoway from 1873 to 1974. During its first 50 years the school had a settled leadership, with three headmasters/rectors, John Sutherland (1873–1881), John Forbes (1882–1894), William J. Gibson (1894–1925) (who was succeeded by John Macrae); with the leadership provided by Gibson particularly notable as he was awarded a CBE for his leadership in education, the first awarded in Scotland. The settled nature of the school leadership is helpful in assessing the logbooks, as the logbooks appear consistent in nature of record and detail provided. The accounts document pupil attendance and often record factors that impact their education or the school's operation, including the weather. For example, the entry for 25 January 1884 notes: 'Attendance very unsteady this week – weather very boisterous. Today there is a heavy fall of snow. On Wednesday afternoon, school did not meet – weather so cold & attendance very small' (Figure 3).

Precipitation series for Stornoway 1857–present

The mean precipitation over the period 1857–2019 at Stornoway is 1416.4 mm a^{-1}, with a mean over the period 1970–2019 of 1220.4 mm a^{-1}; however this decrease is likely a function of the move to the airport in 1968 (Kidd et al., 2021). Modelling and radar studies

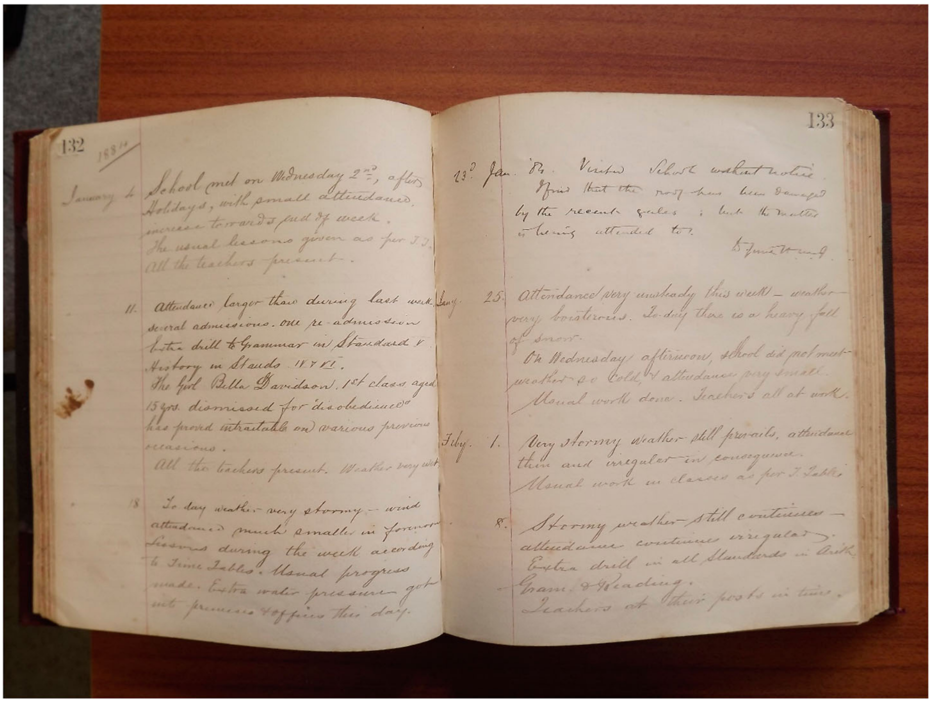

Figure 3. Nicolson school logbook, 25 January 1884: 'Attendance very unsteady this week – weather very boisterous. Today there is a heavy fall of snow. On Wednesday afternoon, school did not meet – weather so cold & attendance very small.' (p. 133)

having identified a precipitation gradient across the island of Lewis from west to east (Graham & Petricca, 2020), with a 5-6% increase in recorded precipitation since the 1970s at the airport (Graham et al., 2018). The analysis of long climate series can be challenging where no other local instrumental series exist. Whilst metadata can be used to examine and support changes in site or instrument, such information is often absent. Thankfully, some details are preserved that document the practices at Stornoway. The original station height was given as 70 feet above sea level, although in 1875 this was recorded as 72 feet, with a change of handwriting noted (this may not necessarily mean a change in site or instrument, but a change in recorder and/or accuracy in station information). The first documented change in location occurred in 1895, with the arrival of the telegraphic station and a new station situated 29.5 ft above mean sea level in Stornoway. It was also noted within the meteorological sheets that the recorder changed at several points. Whilst this was not always explicitly stated or recorder details noted, changes in handwriting (for instance, 1895) are a good indication of such changes, with several recorders' names detailed in the 1900s (A. Mackenzie) and W. Grant in the 1920s.

Analysis of the precipitation series identifies that the annual totals between 1865–1873 are persistently lower than for much of the remaining series, with a precipitation amount (607 mm a^{-1}) for 1869 less than half the long-term average. It is difficult to determine whether any particular month/year is abnormally low in the absence of other local precipitation series, however there are several months and years within this period that raise concern. Anecdotal evidence is provided by Whiteford (2017) who suggests that an incorrect measuring gauge was used by the head gardener/meteorological observer, which may explain the under-catch. Analysis of the precipitation series from Inverness (monthly) and Portree (annual) identify similar patterns to rainfall during the early 1860s, with neither demonstrating the significant reduction in several of the years identified at Stornoway. The precipitation data for the years 1865 and 1868–1873 appears anomalously low and is therefore adjusted upwards, however the increase is not uniform as no discernible trend could be identified. The increase applied for 1865, 1870, 1871, 1872 and 1873 is 33%, and 100% for 1868 and 1869. It is notable that 1868 is one of the wettest in both the Inverness and Portree precipitation series during the nineteenth century, with these stations receiving 121.6% and 134% of the respective long-term mean precipitation, with near average precipitation recorded in 1869 at both stations. In undertaking adjustments, mean precipitation at Stornoway (1970–2019) is used. The data available from both Inverness and Portree enhance confidence that a natural rainfall deficit is unlikely and that the low precipitation values recorded at Stornoway are likely a function of human error or suboptimal rain-gauge siting. The adjustments (increases) and subsequent amended series present a more comparable dataset to that experienced at Inverness and Portree when considering the deviation from the long-term means. Careful consideration was given to the precipitation of the years 1878–1880 as 1879 (788.1 mm) is the lowest on the record, representing a 35.4% reduction from the 1970–2019 mean. That said, this period was also witness to a reduction of 31.8% in precipitation at Portree, with a well-documented drought during these years, such that no adjustments are made.

In the absence of other local series and of any metadata that may explain why under-catch or under-recording may have taken place it is difficult to determine whether instrument siting was suboptimal, as many early instruments and sites often suffered from under-catch (Murphy et al., 2020a), particularly prior to the development of rainfall observation guidance in *British Rainfall* and *Symons' Monthly Meteorological Magazine* (Pedgley, 2002). There is no evidence in the metadata to suggest that notable changes to the instrumentation siting took place during this early phase, or details of other factors that may explain the low precipitation of the 1860 and 1870s. Rainfall in the later 1870s and 1880s appears comparable to the series at Inverness and Stornoway, with the first documented change in instrument location taking place in 1895.

The daily data are retained for analysis of extreme events, but also aggregated to monthly timescales to support wetness/dryness analysis and to enable the creation of a standardised precipitation index (SPI) for analysis purposes (Mckee et al., 1993). The original reconstructed precipitation series is presented within Figure 4(a), with comparison to the Inverness series (Figure 4(b)). A cumulative precipitation plot of the two series suggests good agreement, plotting close to the 1:1 line, irrespective of the distance between the two gauged sites (Figure 4(b) inset figure), the only deviation is in the early phase which corresponds with the amended rainfall period (1865–1873) and the purported mismeasurement.

School logbook analysis

Between 1873 and 1974 there are 401 entries relating to the weather in the Nicolson school logbooks. Using the classification scheme pioneered by Pfister (1984), each of these entries

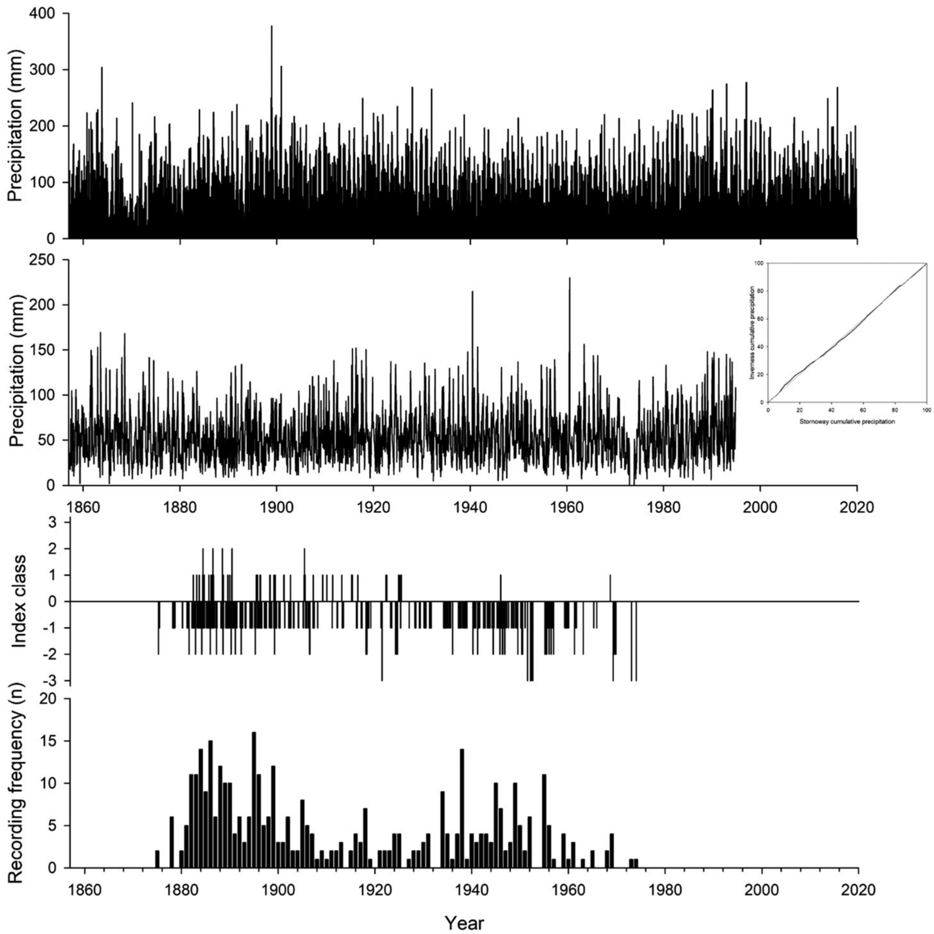

Figure 4. (a) Monthly precipitation reconstruction for Stornoway, 1857-2019; (b) Monthly precipitation series from Inverness, 1857-1994, with inset cumulative probability relationship to Stornoway; (c) Indices derived from the descriptions contained within the school log books; (d) frequency of records that relate to the weather each year.

has been classified using a 7-point scale (Figure 4(c)), with −3 being severe/cold weather, 0 normal and +3 hot/dry weather (Table 1), with each individual account detailing the weather assigned an index score. There has been a long history of using ordinal indices for characterising descriptive accounts of the weather, flooding and drought impacts

Table 1. Descriptive text used in the classification of documentary accounts of the weather to indices.

Indices class	Descriptors
+3	Drought, Heat
+2	Warm, fine, pleasant
+1	Pleasant
0	Normal
−1	Wet, cold, wind, breeze
−2	Storm, snow, hail, thunderstorm; minor structural damage; storm-stayed, ice
−3	Gales; hurricane; snow drift; snowstorm; thick ice; fatalities (multiple animal/ human); shipwreck; loss of roof

and a recognition that indices offer a valuable opportunity for the analysis of descriptive materials (Brázdil et al., 2010; Pfister & White, 2018), with recent studies exploring uncertainty assessment (Adamson et al., 2022) and comparability to instrumental series (Harvey-Fishenden & Macdonald, 2021). The index scores were assigned by a single individual to reduce the potential for inconsistencies in approach or interpretation. However, Nash et al. (2021) note that no single consistent approach is currently applied in quantifying weather severity or impacts. The frequency of the school accounts detailing the weather itself varied through time (Figure 4(d)), reflecting the balance between perceived vulnerability, severity and impacts of the weather, shaped in turn by both exposure and past experiences of the weather in a particular location. As many of the teachers in the Outer Hebrides arrived from the Scottish mainland, their perceptions and expectations were likely to reflect their own experiences, although these may have changed or differed subject to their length of time on the islands. In considering the nature of school logbook recording, a greater propensity of records of bad weather (346) compared to good weather (55) exists, possibly a function of bad weather having a greater impact on school attendance than good. Some crofting activities such as peat cutting or animal husbandry tended to occur during good weather and are noted as a reason for absenteeism from school in logbooks, as noted on 28 August 1885: 'The attendance this week was more irregular and broken – The weather being good, peats &c. were being attended to' (p. 156). This is the only account in the Nicolson logbook of peat cutting, but in other school logbooks it was more frequently recorded as a reason for poor attendance.

The language used to describe the weather is subjective and as such is based on a perception, which may be shaped by various socio-cultural conditions. It does though offer an opportunity to consider the nature of the weather experienced by the school, students, and staff. On rare occurrences such as that of 15th January 1952, specific details or measurements are added: 'A very severe gale, wind reaching 109 mph [175 kmph], occurred during the night. Some minor damage was done to school buildings' (p. 10); with a similar account of 12th December 1956 commenting that winds '… reaching 100 mph [161 kmph] at times'. The seasonality of the records is skewed to the winter months, with 13.3%; 24.1% and 13.3% in December, January and February respectively, with few (3%) accounts in the summer months (June, July and August).

Analysis of the types of weather recorded within the logbooks (% of the accounts relating to different weather types) was initially based on all descriptions, with these grouped into those accounts detailing stormy/boisterous/stormy and wet (33%); inclement/unfavourable (24%); cold/snow (13%); cold and stormy/snowstorm (13%); wet (2%); good/fine (14%) and very good/excellent (1%). However, if the analysis is repeated but for only those events classed as −2 or −3 within the index, then stormy/boisterous/stormy and wet accounts for 30%; inclement/unfavourable (4%); cold/snow (15%); cold and stormy/snowstorm (46%); wet (6%); good/fine (0%) and very good/excellent (0%). Examination of the most severe events identifies that the majority are associated with stormy and cold/snowstorm conditions. There is a notable temporal difference in the distribution of the two groups, with all the stormy events classified as −2 and −3 occurring after 1920, while the cold and stormy/snowstorm are distributed throughout the period from 1880-1974, although a concentration does exist during the period 1880-1900. Interestingly, the cold events classified as −2 or −3 fall within three windows, 1882–1887 and 1944–1945 and 1955–1956.

Drought reconstruction at Stornoway

The Standardised Precipitation Index (SPI) is widely used internationally to assess drought because it requires a limited number of input parameters and is comparable between locations. The World Meteorological Organization recommends the use of SPI over other drought measures because of its relative ease of use and applicability (World Meteorological Organization (WMO), 2012); within the analysis of long series, the limited climatic parameters required presents a distinct advantage (Tang et al., 2020). Importantly the SPI can be calculated at multiple timescales (1– to 12–months normally), which enables the analysis of different types of droughts. Typically, meteorological drought is a short timescale response (1–2 months), agricultural drought is determined over a slightly longer timescale (1–6 months), with hydrological and socioeconomic drought typically depicting longer timescale deficiencies (6+ months) (Vicente-Serrano et al., 2012).

The SPI generated from the original (Figure 5(a)) and amended precipitation series (Figure 5(b)) identifies a notable drought phase at the start of the instrumental record, overlapping with the start of the school logbooks. However, it is difficult to determine

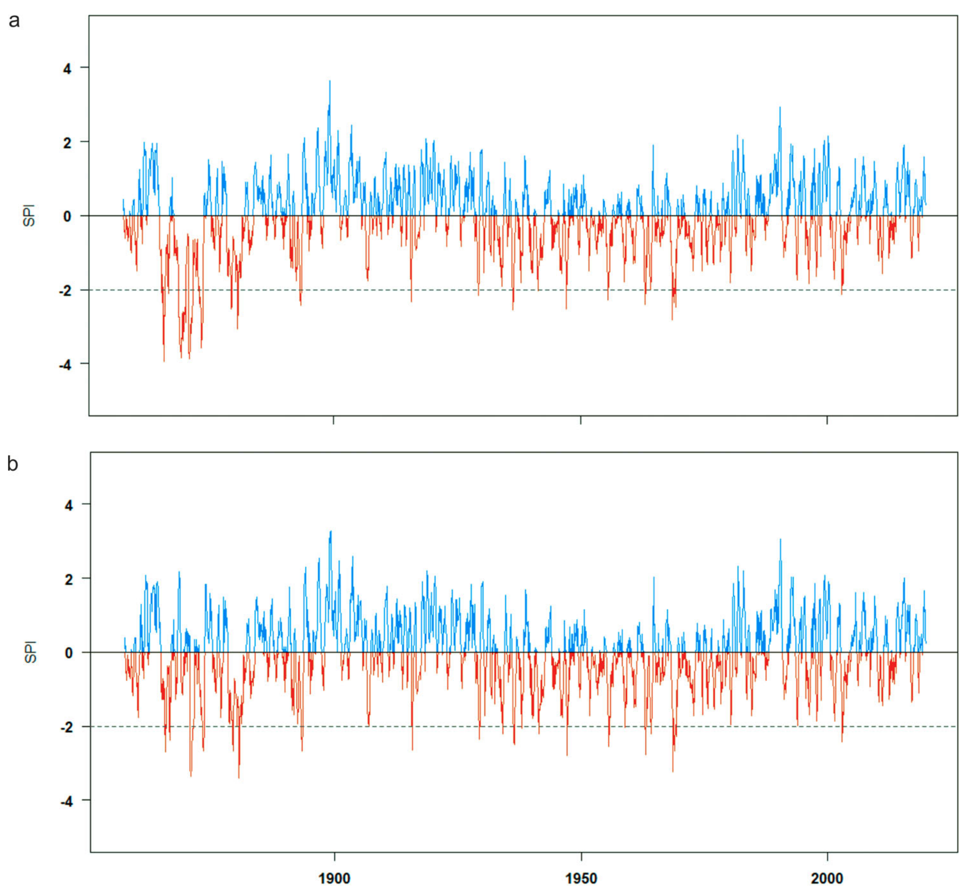

Figure 5. Standardised precipitation index (SPI) for Stornoway, (a) original data, (b) amended data with increases to precipitation applied (years 1865, 1868-1873).

whether the severity of this event is accurately replicated in the series, whilst the drought of 1864–1866 coincides with the period for which the absolute magnitude is not yet fully elucidated because of potential mismeasurement. The drought of 1879–1882 is the most severe and longest duration event in the series (43 months SPI < 0, −3.4), followed by 1864–1866 (26 months, −2.69); 1971–1973 (24 months, −1.71); 2002–2004 (24 months, −2.4); 1962–1964 (23 months, −2.75) and 1940–1942 (21 months, −2.2) all other droughts lasted for less than 20 months. In considering the severity of the drought events, 1879–1882 was the most severe, followed by 1870–1871 (11 months, −3.35), 1968–1969 (17 months, −3.23), 1946–1947 (9 months, −2.8) and 1962–1964 (23 months, −2.75). The absence of documentary records from Stornoway during this early period makes it challenging to ascertain the true severity of the droughts during this period, although records from other areas of Scotland document rivers running dry and severe impacts on agriculture in the period 1879–1882. There are no accounts within the school logbooks during this period describing the weather in a positive (good/dry) manner, however, the severe drought of 1881 is identified by Murphy et al. (2020b) as the most severe of the nineteenth century in Scotland, supporting the approach undertaken here to retain the original dataset and avoid any uplift in the data for this particular period.

Discussion

The reconstructed precipitation series for Stornoway, in combination with the school logbooks, offers valuable insights into the history of storms, precipitation and droughts for a region poorly represented by other sources of weather information. The reconstruction demonstrates that the early period was one that can be considered as drought–rich with the most severe and longest–duration drought occurring in 1879–1882, whilst other notable droughts experienced in other parts of Scotland also appear in Stornoway, such as the 1971–1974 drought identified by Murphy et al. (2020b), demonstrating that the region reflected larger patterns of drought behaviour. The reconstructed series also demonstrates that multi-seasonal droughts impacted the climate and environment in these areas, which were usually perceived as particularly wet. Whilst the analysis identifies a series of prolonged drought events – a function of water deficit – they do not identify whether these periods were particularly cold or stormy. For such information, we need to consider the logbooks. As Dawson et al. (2004) note, the 1880s were characterised as being particularly stormy, while the 1860s and 1870s were relatively calm (low storminess) in Scotland. This trend in storminess is captured well within the frequency of recordings of the weather (Figure 4(d)), with a defined peak in recording frequency around the 1940s also evident within Dawson et al.'s (2004) accounts of Atlantic storminess. However, the peak they identified around 1910 is less discernible within the school logbook information. In considering more severe weather events recorded within the logbooks (those classed as either −2 or −3), a clear pattern of snowstorms and cold and stormy weather emerges, with 46.6% of the severest events represented by these types of weather events, with a clustering of these events within the periods 1880–1900 and 1940–1960.

The impact of strong winds on the communities is noted in the school logbooks, as captured following the storm of 16 March 1921: 'A gale this morning blew up to hurricane force about 11 o'clock. Some damage was done to the school buildings; a considerable amount of the lead ridging was stripped from the roofs, some panes of glass were blown out, the coping of two of the chimneys fell, and a considerable length of the play ground wall was blown down.' Few long wind records exist from across the UK, with a focus historically on precipitation and temperature reconstruction (Janković, 2001; Todd et al., 2013). However, re-analysis of pressure gradients from the northeast Atlantic determined that maximum storminess was reached in the 1880s (Wang et al., 2009), with a declining trend in storminess and wind speed observed (1958–2011; Watson et al., 2015) – perspectives supported by the analysis of the logbooks. Current understanding in historical climatology identifies no compelling trends in storminess based on maximum wind speed over the last five decades (Kendon et al., 2019); however climate re-analysis projects anticipate that windspeeds may increase around the British and Irish Isles (Outten & Sobolowski, 2021), presenting a greater future threat to settlements and communities.

In considering the use of the Nicolson school logbooks and reconstructed precipitation series at Stornoway, it appears that precipitation excess and deficit are poorly represented within the documentary accounts. Storms and cold weather are more frequently captured within the records, reflecting difficulties the weather presents to the schools and specifically for travel to school. Many of the accounts capture inclement or poor weather (24%), which are unlikely to result in severe impacts, and may be a combination of different types of weather, but sufficient to hinder student attendance. As the largest urban settlement, the students at the Nicolson School in Stornoway may have been less prone to the vagaries of the weather than other schools across the Outer Hebrides, with more locally based students and more lodging in local hostels during term, with the town itself relatively well protected on the east coast than settlements on the west coast of the archipelago. The seasonality of work and demands of the students to undertake tasks as part of the family unit may also help explain the distribution of good weather accounts within the logbooks, with accounts of good weather predominantly recorded during the period 1880-1920. This reduction in records of 'good' weather after 1920 may reflect a reduced expectation for students to undertake seasonal work at the expense of their studies, with a reduction in instances of absenteeism as a result. This demonstrates the challenge and advantage of examining the weather through school logbooks, as they record socio-cultural activities and practices dependent on the weather and seasons.

Concluding comments

The combination of the Nicolson school logbooks and instrumental station data at Stornoway offers a rare opportunity to examine the way weather impacted the Outer Hebrides over a long timeframe, including the frequency of particular weather types and changing trends and patterns in the weather. For instance, the logbooks demonstrate that the weather of the 1880s and 1890s was particularly severe, supporting arguments previously made by Dawson et al. (2004) and Outten and Sobolowski (2021). The spatial distribution and depth in time covered by the school logbooks offers considerable opportunity for further analysis of the weather for a region where few other sources are available. However, the production of a single homogenised precipitation series for

Stornoway is a challenging one as it will require careful analysis of all metadata concerning each station location and re-location as well as a more detailed understanding of the complex geophysical and hydrometeorological processes that result in precipitation patterns across the island of Lewis.

As discussed above and as we have shown in more depth in a complementary paper (Naylor et al., 2022), the logbooks are also invaluable sources for a qualitative reconstruction of the various effects the weather had on local communities across the islands and how people responded to them. The school logbooks record the local impacts of weather on individuals and communities, from the extreme to the mundane, as well as seasonal shifts in working and living patterns and practices closely tied to weather and the seasons. Good weather and the change of the seasons meant children were kept away from school to help on the croft, work on fishing boats or to gather subsistence materials. Bad weather prevented attendance as pupils and teachers were 'storm stayed', snow or floods made paths inaccessible or school buildings were rendered unusable. Adaptations also took place, as teachers made adjustments around seasonal activities and school boards provided better clothing to children so that they did not spend the day in school in wet clothes. The logbooks also help us to appreciate how interactions between local communities and local weather have changed through time – the reduction in instances of absence due to seasonal work in the twentieth century being one example of this.

The logbooks' detailed records of vulnerabilities and exposure to the weather enable us to explore how trajectories of vulnerability to events have changed over time. As García-Acosta (2002, p. 65) notes, 'disasters serve as social laboratories, detailing the different ways people have evolved survival mechanisms by boosting resilience to extreme natural events and providing insights into the structure of societies living in vulnerable locations'. In considering the multidimensionality of disasters in the past, present and future, as expressed in the concept of socially-constructed vulnerability (Riede, 2014), researchers can deepen our own knowledge of social response to environmental changes. Geographical context shapes how individuals and communities experience environments and landscapes, with responses defined by lived and past experiences of extreme weather and climate variability (Oliver-Smith & Hoffman, 1999). Extremes are also relative to place, in that what is understood as extreme and how extremes are responded to are partly shaped by local context. Understanding the ways in which locally situated social groups have been affected by past events is central to the development of appropriate climate change risk communication strategies (Marx et al., 2007), given that it is 'increasingly acknowledged that the [climate change] agenda needs to include consideration of the strategies for human adjustment to future changes' and the factors that may contribute to relative vulnerability or resilience (Curtis & Oven, 2012, p. 656). Understanding the local impacts of weather in the past and how local communities historically grappled with challenges of weather and climate uncertainty can help present-day communities develop better understandings of what climate change might feel like and what their local climate future might look like, as well as coping strategies for those possible futures.

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