



Discussion Paper	Discussion Paper	Discussion Paper	Discussion Paper
------------------	------------------	------------------	------------------

11, 3799–3851, 2015

A. M. Lorrey and P. R.  
Chappell

Published by Copernicus Publications on behalf of the European Geosciences Union.



Abstract

Reverend Richard Davis (1790–1863) was a Colonial-era missionary stationed in the Far North of New Zealand who was a key figure in the early efforts of the Church Mission Society. He kept meticulous meteorological records for the early settlements of Waimate North and Kaikohe, and his observations are preserved in a two-volume set in the rare manuscripts archive at the Auckland City Library. The Davis diary volumes are significant because they constitute some of the earliest land-based meteorological measurements that were continually chronicled for New Zealand.

The diary measurements cover nine years within the 1839–1851 timespan that are broken into two parts: 1839–1844 and 1848–1851. Davis’ meteorological recordings include daily 9 AM and noon temperatures and mid-day pressure measurements. Qualitative comments in the diary note prevailing wind flow, wind strength, cloud cover, climate variability impacts, bio-indicators suggestive of drought, and notes on extreme weather events. “Dirty weather” comments scattered throughout the diary describe disturbed conditions with strong winds and driving rainfall.

The Davis diary entries coincide with the end of the Little Ice Age (LIA) and they indicate southerly and westerly circulation influences and cooler winter temperatures were more frequent than today. A comparison of climate field reconstructions derived from the Davis diary data and tree ring-based winter temperature reconstructions are supported by tropical coral palaeotemperature evidence. Davis’ pressure measurements were corroborated using ship log data from vessels associated with iconic Antarctic exploration voyages that were anchored in the Bay of Islands, and suggest the pressure series he recorded are robust and can be used as ‘station data’. The Reverend Davis meteorological data are expected to make a significant contribution to the Atmospheric Circulation Reconstructions across the Earth (ACRE) project, which feeds the major data requirements for the longest historical reanalysis – the 20th Century Reanalysis Project (20CR). Thus these new data will help extend surface pressure-

CPD

11, 3799–3851, 2015

The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





with the long-term observations held by the National Institute of Water and Atmospheric Research (NIWA).

Australasian weather and climate accounts prior to the mid 1850s are sparse in general (Gergis, 2008; Holland et al., 2009; Gergis et al., 2009, 2010; Ashcroft et al., 2012, 2014). As such, additional information that can improve our understanding of past weather and climate for the region are important. Of significance, historic weather observations are being sought by the Atmospheric Circulation Reconstructions across Earth (ACRE) initiative (Allan et al., 2011), which is recovering, digitizing and feeding old synoptic pressure observations into the 20th Century Reanalysis Project (20CR), a reanalysis without data input from radiosondes, aircraft or satellites (Compo et al., 2011; Cram et al., 2015). In this regard, there is a prominent opportunity to link New Zealand historic weather observations with massive data assimilation undertaken by supercomputers to provide realistic representations of regional atmospheric circulation spanning the Southwest Pacific and wider Southern Hemisphere. That effort is posed to make a significant contribution to our understanding of past weather and climate change.

As part of a search to identify early weather observations for New Zealand that could be supplied to the ACRE initiative, the National Register of Archives in New Zealand yielded a reference for an historic weather diary that was kept by Reverend Richard Davis, a missionary who lived north of Auckland (Lorrey et al., 2011a, 2011b). In this study, we have analyzed that record and we demonstrate the value of the meteorological observations that Reverend Richard Davis kept. To date, the Davis weather diary is the earliest reported quantitative meteorological account for New Zealand that was continuously kept over multiple years. We provide an analysis and modern climatological context for the Davis weather diary data (Fig. 1), and are able to quantify conditions he experienced to deduce similarities and differences in weather and climate relative to today.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





## 2 Background on Reverend Richard Davis and the climate of Northland, New Zealand

### 2.1 Richard Davis biographical notes

Reverend Richard Davis (born 18 January 1790, Dorset, England; died 28 May 1863, Waimate North, New Zealand) was associated with the Church Mission Society (CMS) of England. He sailed to New Zealand in 1823-24 via Parramatta, Sydney and Hobart (along with crew, other clergymen and convicts) and arrived in the Bay of Islands on 15 August 1824 on the brig Governor Macquarie (Fig. 1). He was largely self-educated, but received additional tuition through his clerical training. Davis could read Hebrew, and had wide-ranging interests in geology, mechanics, geometry and spherical trigonometry. He also had learned surveying and navigational skills, including uses of a theodolite and sextant. Richard Davis spent much of his time in northern New Zealand and was stationed for significant periods of time in the settlements of Waimate North (Fig. 1) and Kaikohe in Northland. In 1831, Davis arrived at Waimate North and established a farm. Davis was also ordained a deacon in Waimate North in the mid-1840s. He was a prolific writer and observer of the natural environment, evidenced by hundreds of letters sent back to England and the CMS that included commentary on physical geography and astronomy (noting the occurrences of comets and the Aurora australis). Davis also documented social perspectives of Colonial era settlers and interactions of Europeans with Māori, as well as general activities that occurred near the settlements of Russell, Marsden Vale, Kawakawa and Paihia (Coleman, 1865).

### 2.2 Physical geography and climate of Northland

Northland is a long peninsula of land that extends southeast-to-northwest (~ 34.425–36.325° S) from north of the Auckland Isthmus to the most northern extent of New Zealand (Fig. 2). The region contains multiple deep-water harbors that intersect the coastline which were prized (though treacherous at times) during the Colonial era for

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





per year may cause torrential rain and damaging winds (Lorrey et al., 2013b). Cold, showery weather occurs in Northland with southwesterly and southerly winds, following the passage of a depression from the northwest or west. Easterly winds associated with an anticyclone to the south of Northland may also cause showery weather. Fine weather in Northland mainly occurs when an anticyclone moves slowly over the North Island, and during phases of anticyclone replacement (which typically last two to three weeks during summer). Most parts of Northland receive about 2000 hours of sunshine per year, with northern and eastern areas recording more sunshine hours than western and southern areas. It can be very windy in exposed areas, and occasionally Northland experiences gales, sometimes in association with the passage of depressions of tropical origin (Chappell, 2013).

### 3 Data and methods

#### 3.1 Locating and “rescue” of the Reverend Richard Davis Diary

A key word search of the term “meteorology” within the New Zealand National Register of Archives in 2008 (now called the Community Archive: National Register of Archives and Manuscripts; thecommunityarchive.org.nz) yielded the Davis Diary entry (Ref # NZ/MS/14, NZ/MS/378 held by Auckland City Libraries, Tamaki Patoka Korero). This source was considered as an important prospect to follow through on because the entry for the Davis diary was one of only a few search items that mentioned meteorological tables. Details for the Davis Diary showed it was held by the Auckland City Library (ACL), and a viewing to assess the quality of the meteorological measurements (in terms of physical state of the document, temporal completeness, legibility, and content) was undertaken. The collective components of the Davis meteorological diary numbered in the thousands in terms of entries and comments, and these are outlined in the results section. We describe the scanning and transcription procedure in the supplement.

CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Discussion Paper	Discussion Paper	Discussion Paper	Discussion Paper
------------------	------------------	------------------	------------------

5  
10

15  
20

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell



## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



from the Davis weather diary aside from describing his twice-daily temperature series, both of Davis' temperature recordings were transformed to be equivalent to VCSN  $T_{\max}$  and  $T_{\min}$  using an established relationship between the VCSN daily extremes and 09 a.m. and noon temperature measurements from Kaikohe.  $T_{\max}$  and  $T_{\min}$  were then derived from the Davis diary recordings, and were subsequently used to derive Tmean. As to not introduce an interdependence element to the derived VCSN reconstruction, we were also able to produce a time series of 09 a.m. temperatures independently for the VCSN grid using 09 a.m. vapor pressure and the Antoine equation<sup>1</sup>. We also used monthly mean pressure measurements from nearby sites (Whangarei and Kerikeri) for comparative purposes.

The Davis reconstructed temperatures were compared to extant tree ring proxy data sourced from the Past Global Changes (PAGES) Australasia database. These data have recently been collated for the purpose of undertaking global temperature reconstructions and were already vetted (Neukom and Gergis, 2012) using five different standardization techniques. We have used the “signal free” (Melvin and Briffa, 2008) chronology produced by Neukom and Gergis (2012) for three cedar (*Libocedrus bidwillii*) tree ring records to establish new, significant correlations to austral cool season (and winter) temperatures (Lorrey, unpublished data) from Takapari, Moa Park and Flanagan's Hut chronologies (Xiong and Palmer, 2000) to corroborate the Davis diary winter observations. The relationship between cedar tree rings and temperature was established via correlating the standardized signal free chronologies to the closest VCSN grid at a monthly level, then aggregating monthly temperatures into seasonal and longer composite averages and re-running the correlations to achieve the strongest correlation. This exercise clearly indicated that the cedar tree ring growth is sensitive to austral cold season and winter temperatures. The regression equations from these correlations allowed the standardized index values to be transformed to a quantitative temperature, which was then converted to an anomaly relative to the modern period (1972–2010).

<sup>1</sup>09 a.m. vapor pressure is independently derived from  $T_{\max}$  and  $T_{\min}$ .

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



The collective temperature anomaly reconstructions from the Davis diary and the tree ring–based temperature conditions for 1839–1843 and 1848–1851 were fed into the Past Interpretation of Climate Tool (PICT) to derive local, southwest Pacific and Southern Hemisphere climate fields. The PICT reconstruction approach is a modern analog spatial field method that uses detrended gridded local and global data (Tait et al., 2006; Kalnay et al., 1996), whereby a reconstructed temperature anomaly for a proxy site is compared directly to detrended climatological temperature quintiles for a corresponding grid point. All of the analog seasons that fall within each quintile are then selected and composited with equal weighting to produce mean geopotential height patterns, which are based on detrended daily NCEP1 reanalysis data (Kalnay et al., 1996). The fact that several sites are then compiled into an ensemble, and that each of the proxies associates with different analogs helps to provide weighting toward the most commonly selected analog seasons. The synoptic types are classified according to Kidson (2000) and later Renwick (2011) based on the daily output. Full details of the PICT method, the significance testing of the synoptic type changes and differences of the mean geopotential height patterns relative to modern are described further in Lorrey et al. (2013a). This approach was used to (a) provide a comparative national-scale context for the temperature anomalies recorded by Davis and (b) provide a wider atmospheric regime context for the observed temperatures. These results are brought to bear in the discussion to contextualize the mean climate conditions recorded by Reverend Davis.

## 4 Results

### 4.1 Components of the Davis diary and “dirty weather” comments

Reverend Richard Davis’ weather diary consists of two parts: 1839–1844 and 1848–1851. A partial year of weather observations were made by Davis for both 1844 and 1851 and we have transcribed them; 1844 is not considered further in this study be-

cause it constitutes less than half a year of observations. The temporal break in the diary corresponds to the time when Davis was ordained as a Deacon and left Te Waimate Mission Station to establish Kaikohe Mission Station. The diary break also marks a period when tumultuous activity occurred in Northland that relates to the onset of the Maori Land Wars (King, 2003). There is mention by Davis in his personal diary of an insurrection in Kaikohe being “crushed” in January 1846. To our knowledge, the collective observations and measurements made by Davis comprise the earliest historic land-based meteorological register for New Zealand that has survived to date. It significantly pre-dates other informal weather observations for New Zealand that come from personal diaries as noted by previous researchers (Holland and Mooney, 2006). However, it is possible that earlier missionaries (i.e. Samuel Marsden, who resided in New Zealand from 1816), military personnel, or people involved in agriculture and viticulture (i.e. the viticulturist James Busby; who is mentioned by Davis as having provided him with 50 grape plants on 8 December 1835) could have kept similar quantitative records that are even older.

The two Davis diary components collectively contain > 13 000 meteorological measurements and local environmental observations. Quantitative instrumental observations include 09 a.m. and 12 noon temperature and noon pressure recordings. Qualitative observations include daily wind direction, which are divided into eight basic compass bearings relative to true north, and an additional category termed “variable” (where multi-directional wind flow was noted). Climatology for the instrumental measurements and qualitative observations (both temporal intervals integrated) are presented below (Fig. 3). The comments column within the meteorological register includes mention of frost, ice, hail, wind strength, relative rainfall, cloud, snowfall, thunder, lightning, sunsets, and wildlife behavior (including bio-indicators about migratory waterfowl and insect life).

The Davis diary also includes 67 remarks about “dirty weather” spread throughout the two-volume meteorological register. Davis commonly associated dirty weather with atmospheric circulation from northern and eastern quadrants and in connection

## CPD

## The “Dirty Weather” diaries of Reverend Richard Davis

Title Page



to southerly quadrant flow. Rainfall was common during days characterized as having dirty weather, with strong, blustery winds and low cloud cover. The general indication is that the dirty weather remarks made by Davis were indicative of generally gloomy conditions.

## 4.2 Pressure

### 4.2.1 Davis' barometer

Analysis of Davis' personal diary entries (Davis, Richard: Letters and Journals, 1824–1863, MS-1211, sourced from Hocken Heritage Collections, Dunedin, New Zealand) was undertaken to try and gain knowledge about the type of barometer he used, where it was purchased, how he received it and how it may have been calibrated. A mention of the word “barometer” was made five times in Davis' personal diary. Two of the entries associated with that word are:

- 9 February 1836: In a letter to Rev. W. Jowett in London (clerical secretary of the CMS), a request was made for Davis' friend Nicholas Broughton to obtain a barometer and send it to New Zealand (MS-1211).
- 11 April 1839: a comment is made by Davis about inclusion of three months of barometer and thermometer data with the letter to Rev. W. Jowett (MS-1211).

Contact with archivists at the CMS of England did not yield any leads about the purchase of the barometer Davis used. We have also made an enquiry with the Clarke Family in Northland (George Clarke was a fellow missionary with Davis at Te Waimate), as well as Heritage New Zealand, who are the curators of the mission house that Davis was based at (to no avail). We do know that Davis' friend who he often wrote to, Mr. Nicholas Broughton, lived at Swanyard in Holbourn Bridge, London. A census from that era indicates many skilled tradesmen who participated in the manufacture of chronometers, timepieces and ship instruments circa 1835 (The Horological Foundation, 2015) resided in Holbourn Bridge, which included a hive of barometer makers who

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





were based locally. It seems likely that Mr. Broughton would have purchased equipment there. A common type of barometer made in the mid-1830s that was highly portable was a mercury “wheel” barometer of “banjo” morphology. Davis mentions a “screw” as part of the metadata associated with his observations, which is consistent with that type of equipment. There are no other entries that indicate how the instrument was calibrated.

## 4.2.2 Comparison of Davis pressure measurements with ships at anchorage

The monthly climatology for noon pressure indicates an annual cycle with lower pressure in austral winter and spring and the highest average pressure for late summer and autumn (Fig. 3). Prior to discussing the observed climatology and extreme pressure values, we outline a corroboration of Davis pressure measurements. Several ships of exploration transited through New Zealand waters or were based in New Zealand on military operations report being anchored east of Waimate North and Kaikohe in the Bay of Islands (Fig. 2). Three separate occasions in 1840 are used to compare the Davis pressure measurements to parallel observations made on British, American and French vessels (the *HMS Erebus*, the *USS Vincennes*, and the *Astrolabe* (and *Zelee*), respectively; Data provided from ACRE by Rob Allan, UKMO). As such, the Davis pressure series and the shipboard observations comprise a measurement pair ( $n = 29$ ) that can be examined to see a.) how inland/upland station pressure and ‘near sea level’ pressure compare and b.) to determine how the Davis pressure measurements (see Fig. 4 top panel) compare in general to other reference series. The common pattern of variability for the aggregated ship data and Davis measurements and their correlation are significant ( $r = 0.93$ ; Fig. 4, middle panel). The Davis daily pressure observations are consistently offset lower than those reported by all of the shipboard observations (by an average of  $-0.64 \pm 0.10$  inches of mercury). This average pressure measurement offset corresponds to the expected negative pressure departure due to the altitude increase from the harbour where the ships were anchored to the site where Davis’ land-based measurements were made (Fig. 1). The variance for the Davis and ship-

board pressure measurements is also similar (0.19 and 0.25, respectively). As such, we consider the pressure measurements recorded by Reverend Davis to be a robust indication of surface pressure at both sites where he was located, and note that these measurements can be employed as station data which are not corrected for temperature, gravity or reduced to sea level.

### 4.2.3 Climatology of pressure measurements

Davis’s pressure measurements indicate an annual mean value of 1016.47 hPa (when adjusted to sea level), which is similar to average annual values for modern measurements recorded at nearby stations (Kerikeri Aero, 1016.85 hPa; Whangarei Aero, 1016.81 hPa) of equivalent latitude. Across the year, Davis’ meteorological diary indicates the highest pressures were most frequent from January–April, with a decrease to the lowest values in winter (Fig. 3; Table 1). Seasonal average pressures recorded by Davis also compare similarly to modern pressure values for autumn, but suggest summer pressures in the early-mid 1800s were higher than present, and lower than present for winter and spring. There are significant intra-seasonal and inter-annual variations in the pressure observations recorded by Davis (Fig. 4), which can be attributed to the wide range of synoptic weather systems he witnessed (supported by qualitative descriptions of clouds, precipitation, wind direction and wind strength). Davis also notes some key occurrences of unusually low pressures associated with specific storms (see Fig. 4), which are discussed below along with other observations of weather extremes.

Davis also made comments about unusually high pressures during the first five months of 1848, and he suggested that the screw on the bottom of the barometer might have been adjusted without his knowledge to cause an artificial inflation of pressure observations by 4/10ths of an inch. This particular period corresponds to the re-initiation of observations being made after a key temporal break in his meteorological diary. We describe the context of these “high” pressure anomalies noted by Davis in the discussion.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



## 4.3 Temperature

### 4.3.1 Temperature recordings and thermometer metadata

Davis recorded twice-daily (09 a.m. and noon) temperature at the Te Waimate mission house grounds and Kaikohe (Figs. 1 and 3), and several comments related to temperature recordings are made by Davis in his writings to others and in his personal diary. Davis also made sporadic observations about soil temperature and contrasted temperature measurements in the direct sunlight as well as in the shade. The general commentary from Davis (below) suggests that the thermometer was kept in a ventilated shed in the shade.

- 4 November 1833: “Today the thermometer stood at 80 in the shade; this I have never known it to do before since I have been in the country.” (MS-1211).
- 9 November 1833: “In the shed the thermometer stood at 78; plunged into the garden soil in the sun it stood at 110.” (MS-1211)
- 18 January 1834: “Thermometer stood at 82 in the shade and at 125 in the sun.” (MS-1211)

We note here that there could be some issues with regard to radiation errors (Nakamura and Mahrt, 2005) for these temperature measurements in the absence of metadata about where the thermometer was positioned in the shed.

### 4.3.2 Climatology and extremes from 09 a.m. and noon temperature

09 a.m. and noon temperatures recorded by Davis (Fig. 3, Table 1) ranged from a maximum in January to a minimum in July (19.3 to 8.9 °C for 09 a.m.; 22.2 to 11.4 °C for noon). Mean 09 a.m. vapor pressure and the Antoine equation were used to derive a local 09 a.m. temperature from the VCSN relative humidity values (instantaneous)

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



to compare to climatic means calculated from the Davis diary<sup>2</sup>. Mean annual 09 a.m. temperature (based on only the years with fully complete measurements; 1839–1843; 1848–1850) indicates an average of 14.4 °C, which is 2 °C lower when compared to a VCSN average 09 a.m. temperature of 16.4 °C (Table 2). Monthly 09 a.m. temperature variance was greatest for December and lowest for March in the Davis record. The 09 a.m. temperature derived from the VCSN grid closest to the Waimate and Kaikohe sites, also indicates that Davis’ measurements of maximum extreme monthly 09 a.m. temperature were categorically cooler than those observed during the modern era (1972–2012). In addition, many of the 09 a.m. minimum extreme temperatures appear cooler than present day, with the exception of February–April, June and October (Table 2).

### 4.3.3 $T_{\max}$ , $T_{\min}$ and $T_{\text{mean}}$ derived from Davis temperature measurements

Comparisons between local high-resolution hourly temperature measurements at Kaikohe and the corresponding Kaikohe VCSN grid were used to generate correlation functions for  $T_{\max}$  and  $T_{\min}$ , where use of noon and 09 a.m. temperatures as measured by Davis were converted to  $T_{\max}$  and  $T_{\min}$  respectively. This was done so the Davis diary measurements could be directly compared to a modern VCSN-based climatology representative of the Waimate North and Kaikohe sites where Davis took temperature measurements. The fidelity of the correlation functions (and therefore the VCSN reconstructed temperatures from the Davis diary) are better for noon temp and  $T_{\max}$  than for 09 a.m. temp and  $T_{\min}$ . In addition, correlations are strongest for the Austral cool season ( $T_{\max}$  vs. noon  $r > 0.75$  for April–October inclusive;  $T_{\min}$  vs. 09 a.m.  $r > 0.65$  for

<sup>2</sup>This was done because the VCSN temperature data include minimum and maximum values that can occur at any time during a day rather than a set time.  $T_{\text{mean}}$  can be calculated from those categories; however, use of  $T_{\text{mean}}$ ,  $T_{\max}$  or  $T_{\min}$  to compare to Davis 09 a.m. temperature creates an interdependence issue when subsequent correlation exercises will employ 09 a.m. Davis data to reconstruct  $T_{\text{mean}}$  anomalies relative to present day.









1 March 1840. Future work will focus on the other extreme pressure values recorded by Davis, which may have a polar rather than a tropical origin.

### 4.6.3 Extreme temperatures

A comparison of the monthly average  $T_{\text{mean}}$ ,  $T_{\text{max}}$  and  $T_{\text{min}}$ , 09 a.m. average, minimum single-day and maximum single-day extreme temperatures are shown for the Davis diary with reference to the VCSN for the same location (Table 2 and 3). For the mean extreme high monthly values, the Davis diary is categorically cooler across all months relative to present day by an average of  $-2^{\circ}\text{C}$ . For 09 a.m. single day maximum 09 a.m. temperatures, none of the extreme values from the Davis diary exceed extreme temperatures for the modern era. On average across the year, the VCSN 09 a.m. single-day extreme high temperatures for each month are  $2.9^{\circ}\text{C} \pm 1.6^{\circ}\text{C}$  higher than those Davis recorded, with significantly larger differences in the monthly 09 a.m. extreme relative to the modern era in March–May and July–September (Table 4). However, it is interesting to note that for extreme 09 a.m. temperatures, the modern period has some occurrences of colder mornings for February–April, June and October relative to the time Davis was residing in the Far North.

### 4.6.4 Frost, ice, hail and snow

Several qualitative remarks related to cold temperatures and frost can be found in Davis's personal and meteorological diaries. Davis's sent a letter to John Coleman dated 21 June 1834 (Coleman, 1865: 180): "Last night was our first night of frost this year. The ice this morning was the thickness of a shilling" (approximately 1.2 mm thick). Davis again mentions ice in the meteorological diary on 15 July 1839 indicating "ice 1/4 inch thick" (6.35 mm), presumably observed on the surface of the millpond at the Wai-mate North site. Frost is noted 106 times by Davis spanning nine years. His observations suggest no frosts occurred during November–March and that the frostiest month was July, with more than half of the frost events occurring in winter (June–August).

## The "Dirty Weather" diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





## CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Hail was also observed by Richard Davis for all seasons except summer (Fig. 6), with a peak occurrence in winter (July), dropping away to no hail accounts in December. Snowfall was also mentioned in the Davis meteorological diary once as an isolated event spanning two days for 30–31 July 1849. For the two days of snow that were mentioned, Davis's meteorological diary comments are:

- (30 July 1849) Hail storms. This morning the southern hills and Poutahi covered with snow.
- (31 July 1849) This morning the hills were again covered with snow.

In a personal letter to a friend in England, Davis also affords a parallel description (Coleman, 1865: 350):

- (30 July 1849) The hills were covered with snow, the first ever seen by the natives inhabiting this part of New Zealand. The Putahi (sic) was also covered.
- (31 July 1849) This morning the hills were again white with snow.

Contrary to widely held belief that it never snows in northern New Zealand, there are six historic accounts of frozen precipitation for Auckland/Northland (Fig. 7a and b) that can be brought to bear for reference. Two of the events (1939 and 2011) are noted as having delivered at least some light snow to high elevations. Geographic coverage of eyewitness accounts for the occurrence of frozen precipitation including snow (and/or sleet and/or graupel) related to six historic Auckland/Northland events (Fig. 7a) suggests the 1849 snow seen by Davis may have been akin to the 1939 event, which saw snowfall on isolated ridges as far north as Cape Reinga, with the next closest analog being the 2011 event. The similarities and diagnostics for these analogs are brought to bear in the next section.

Title Page

## Abstract

## Introduction

## Conclusions

## References

## Tables

## Figures



▶

▶

[Back](#)

Close

Full Screen / Esc

[Printer-friendly Version](#)

## Interactive Discussion



5 Discussion

5.1 How similar or different are Reverend Davis’ weather observations of the early Colonial era from today?

The Reverend Davis meteorological diary from Waimate North and Kaikohe contains years of continuous daily instrumental and qualitative observations for several key variables. The most notable components of this diary are quantitative measurements of temperature and barometric pressure (Fig. 3). A comparison of the barometric pressure from Waimate North to reference series from ships (Fig. 4) suggest the Davis’ pressure measurements can be used as station data. When compiled into a climatology and compared to reference data series derived from the VCSN, there are elements of the Davis meteorological register that undeniably indicate he was making faithful measurements of local conditions. The annual cycle pattern is evident in all three instrumental data sets, and their patterns are phase locked in terms of the timing of the peaks and troughs seen in modern climatology records. The relative temperature changes for the 09 a.m. and noon temperature climatology (Fig. 3) between summer and winter are also quite similar to the modern era, with a change of ~ 10 °C between summer and winter. The distinctions of the Davis diary observations with respect to modern times, however, are observed for the overall offsets in mean monthly temperatures and some of the daily temperature extremes (Tables 1–3).

5.2 Can we corroborate the general indications of past temperature anomalies noted in the Davis diary and determine their cause?

Recent work of the Australasia palaeoclimate research community has gathered high-resolution climate proxy data (Neukom and Gergis, 2012) and made it available in a centralized database (Kaufman et al., 2014). There is thus an opportunity to examine some of those proxy data, which in the case of New Zealand constitute tree ring chronologies, alongside the reconstructed temperatures for 1839–1851 (exclusive of

The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

AbstractIntroduction

ConclusionsReferences

TablesFigures

◀▶

◀▶

BackClose

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





mean climate state is robust. Looking further afield at the wider Southern Hemisphere z1000 field (Fig. 10) the atmospheric circulation is characterized by an anomalous high pressure in the Bellinghausen Sea paired with a low pressure east of the Drake Passage. This configuration has a spatial pattern similar to what is observed for the Pacific-South American mode (PSA; Mo and Paegle, 2001). Overall, the indication from the PICT spatial field projections are that at least two key teleconnections and climate drivers may have had an important influence on the “dirty weather” that Reverend Davis observed during 1839–1851. Some parts of the observed pattern (Fig. 9 and 10) are similar to what has been implicated for mean summer conditions based on 22 equilibrium line altitude temperature reconstructions for the LIA (Lorrey et al., 2013a). The integration with tree ring evidence also lends to an interpretation that the Davis meteorological diaries provide a crucial eyewitness account for the end of this recent but (locally) poorly understood climate episode.

### 5.3 How different are the mean and extreme conditions observed by Davis relative to today?

#### 5.3.1 Temperatures and the presence of ice

The direct 09 a.m. temperature comparison of the VCSN and the Davis recordings suggest that categorically the 09 a.m. average temperature and the most extreme 09 a.m. temperature that Davis experienced was colder than the modern era (Table 2). The transformation of the Davis diary 09 a.m. and 12 noon temperature recordings to be directly comparable to the VCSN modern climatology of daily mean temperature and temperature extremes ( $T_{\max}$ ,  $T_{\min}$  and  $T_{\text{mean}}$ ) indicates the most significant differences were colder daily mean and daily extreme temperatures for May–August. These anomalies are congruent with wider climate change syntheses that have recognized long-term warming trends in minimum temperatures (Pittock and Wratt, 2001). The Davis diary also suggests that average monthly temperatures were relatively warmer for November–March, with the clearest signature of warm anomalies for December and

CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



January (Table 3). In the context of climate driver associations, proxy evidence of past El Niño Southern Oscillation (ENSO) activity indicates swings occurred between El Niño and La Niña episodes in the early-to-mid 1800s when Davis was making observations. This probably means the climatological mean values presented here ‘blend’ successive ENSO events (and anomalies for Northland) via the averaging process. It may be likely that one particularly strong El Niño and/or a protracted event could skew this perception. While we have opted to not analyze the individual seasonal climate anomalies from the Davis diary in this study, future work looking further afield using Australian weather diary records could prove fruitful for integration, corroboration and delineation of past ENSO teleconnections and activity.

The documentation of surface ice on two separate occasions by Reverend Davis appears unusual. The 15 July 1839 ice event indicates temperatures at 09 a.m. were 4.4 °C. This is not the coldest 09 a.m. temperature noted by Davis. Omission of other ice comments may indicate something to the effect that observations of ice as a phenomenon may have been sporadic, infrequent, confounded with frost, or only noted for highly significant events. The alternative is that the conditions for ice formation and/or persistence into the early morning may have only been amenable during the days when Davis noted its presence where he was living. The 09 a.m. temperatures from the Davis diary indicate an extreme low value of 1.7 °C occurred on 8 July 1850, which is clearly colder than the temperature on 15 July 1839. In consideration of the fact that early morning temperatures are typically colder than those at 09 a.m., our VCSN-based  $T_{\min}$  reconstructed temperature of −1.4 °C for 8 July 1850 suggests that freezing temperatures at nighttime (and associated surface ice formation) probably occurred episodically during the early Colonial era in Northland. While little photo-documentary information about freezing cold and past ice presence in Northland exists, evidence from other undiscovered historic weather journals might shed more light on this phenomenon. Moreover, traditional Maori knowledge has suggested surface ice formation in the recent past that coincided with the early part of the instrumental observation

CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)


period may have been more frequent than the present day (King et al., 2008), and that sentiment is congruent with palaeoclimate proxy interpretations.

### 5.3.2 Snowfall (frozen precipitation)

Extended reanalysis integrations that are meaningful for New Zealand are not available yet for 1868, and in general past daily weather depictions are data sparse within the 20th Century reanalysis for the pre-1950 interval. The 1904 snowfall analog cannot be fairly compared to the other analogs due to data sparseness (and this sentiment is probably applicable to the 1939 analog because of high latitude data sparseness). However there are similarities in terms of the geopotential spatial field signatures of the 1939, 1976, and 2011 events (Fig. 7b). A significant “low” anchored south of the Chatham Islands extending to the fringe of the Ross Sea (which was potentially blocked to the east) and a strong “high” over southeast Australia and Tasmania are common to those three analogs. The general atmospheric circulation pattern for each of the snowfall events facilitated a corridor of strong southerly air drawn off of the Antarctic continent fringe that was transmitted to northern New Zealand. The connection of modern day events that overlap the satellite-observation period which have a similar depiction in reanalysis data indicate the 30–31 July 1849 event was probably of similar origin.

### 5.3.3 Pressure observation metadata

In the Davis diary, there is a written note underneath January 1844 (before January 1848) that states:

- “Note: in the following pages, from Jan. 1 1848 to August the 1st 1848 the barometer was caused to range 40 parts of an inch higher than usual from an alteration having been made in the bottom stopper screw by some unknown hand. This was not found until August 2 1848. The month of July was arranged in copying.”

The range of pressure observations that were made during the January-June interval in question appear higher than normal relative to the rest of the record. We have no reason to not trust the metadata comment by Reverend Davis found in the diary. As such, we have corrected the first six months of data in 1848 by subtracting 4/10ths of an inch of pressure prior to converting the measurements to hectopascals and analyzed these data according to the corrected version. Future work that will see those measurements integrated into the International Surface Pressure Databank (ISPD; Cram et al, 2015) will mean the scale of the pressure adjustments can be tested in subsequent reanalyses and this will afford an additional opportunity to examine the Davis pressure series (including means, variability and extremes) in more detail.

## 6 Conclusions

The observations in Reverend Richard Davis's two-volume meteorological diary represent some of the oldest surviving instrumental observations from the Colonial era in New Zealand. The data in this historical register are not as comprehensive as the observations subsequently taken by the Royal Engineers in Auckland during the early to mid 1850s (thrice daily), or those from James Hector's fledgling meteorological service network of the late 1860s. However it is fitting that Davis should be recognized as having made some of the most significant and earliest contributions to New Zealand meteorology and climatology. The extent and breadth of the observations as well as their general antiquity suggests Reverend Richard Davis probably deserves the title of New Zealand's first meteorologist.

When Davis' temperature observations are transformed to be comparable to modern day VCSN  $T_{\text{mean}}$ ,  $T_{\text{max}}$  and  $T_{\text{min}}$  observations, it appears as though temperatures were categorically cooler during winter when he was resident in the Far North. The wind observations that are provided by Reverend Davis also suggest southerly-quadrant flow was more frequent than present day. The timing and descriptions of monthly and seasonal climate anomalies, when compared to tree ring and coral proxy data (Figs. 8–

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





10) suggest a connection to ENSO and potentially the PSA existed for New Zealand climate during the mid 19th century. It is likely that these two climate drivers guided some of the local anomalies and synoptic variability that Reverend Davis observed. With the addition of new data fed into an extended reanalysis, the depiction of past conditions will be clearer, and these hypotheses can be tested more rigorously.

Extreme temperature values, potentially linked to a subtly different mean climate state (Mann et al., 2009), suggest Davis experienced a relatively higher proportion of what are normally uncommon occurrences of frost and rare events (freezing, ice, snow) that do not typify the modern climate and weather of Northland. Overall, the “dirty weather” comments Davis penned with his extensive instrumental observations provide an eyewitness account of the Little Ice Age conclusion in New Zealand. The LIA culmination is notoriously indicated by historic photos and paintings of ice margin positions with juxtaposed moraines along the Southern Alps margin that unequivocally show glaciers were much more extensive relative to today (Chinn et al., 2012). Extended evidence from the Southern Alps using equilibrium line altitude-based summer temperature reconstructions (Lorrey et al., 2013a) similarly suggest generally cooler conditions existed during Davis’s time in the Far North, with other proxy evidence demonstrating seasonal variability – including both cold and warm temperatures – was associated with enhanced ENSO activity (Fowler et al., 2012). As such, the anomalies of colder winters and warmer summers on average during Davis’ time are not unexpected, and this evidence enriches our understanding that early settlers may have faced significant climate anomalies (such as drought and deluge) that New Zealanders continue to grapple with today.

The “discovery” of this meteorological gem in a local archive raises the interesting point that future prospects for historic climate work in New Zealand are numerous. There are clear indications that historical documents contain instrumental weather observations and some of these observations overlap and even antedate the Davis diary, based on initial investigations about ships that transited into New Zealand waters during the Colonial era (Chappell and Lorrey, 2013). Our expectation is that extension of his-

CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)




toric climate work utilizing a range of documentary archives will enrich the knowledge about the range of natural weather and climate variations that are possible, and this endeavor is requisite for contextualizing past-to-present historic trends and for making adequate preparations for future changes.

5 **The Supplement related to this article is available online at  
doi:10.5194/cpd-11-3799-2015-supplement.**

*Acknowledgements.* We thank Kate D’Courcy at Auckland Central City Library for her assistance in allowing access to the Davis diary in the rare manuscripts collection and for her invaluable help in facilitating permissions for the scanning the diary. Rob Allan, Philip Brohan, and Gil Compo are thanked for fruitful discussions about this work. Gregor Macara is thanked for supplying VCSN data from the NIWA climate database. Comparison pressure series from ship logs was obtained via the French Pacific Fund project “Recovery, safeguarding and dissemination of historic French meteorological and climatological data: a Pacific component of the international ACRE programme of Atmospheric Circulation Reconstructions over the Earth (Récupération, sauvegarde et diffusion des données historiques françaises de météorologie et de climatologie : une composante Pacifique du programme international ACRE de reconstitution de la circulation atmosphérique terrestre)” This work was supported by the NIWA core funded project “Climate Present and Past” CAO1501.

## References

- 20 Allan, R., Brohan, P., Compo, G.P., Stone, R., Luterbacher, J., and Bronnimann, S.: The International Atmospheric Circulation Reconstructions over the Earth (ACRE) Initiative, B. Am. Meteorol. Soc., 92, 1421–1425, 2011.
- Allan, R. J. and D’Arrigo, R. D.: “Persistent” ENSO Sequences: How unusual was the recent El Nino?, Holocene, 9, 101–118, 1999.
- 25 Ashcroft, L., Karoly, D., and Gergis, J.: Temperature variations of southeastern Australia, 1860–2011, Aust. Meteorol. Oceanogr. J., 62, 227–245 2012.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



- Ashcroft, L., Karoly, D., and Gergis, J.: Southeastern Australian climate variability 1860–2009: a multivariate analysis, *Int. J. Climatol.*, 34, 1928–1944, 2014.
- Banks, J.: The Endeavour Journal of Sir Joseph Banks, available at: <http://gutenberg.net.au/ebooks05/0501141h.html> (last access: 22 May 2015), 17680–1771.
- 5 Chappell, P. R.: The climate and weather of Northland, NIWA Science and Technology Series, 59, 40 pp., 2013.
- Chappell, P. R. and Lorrey, A. M.: Identifying New Zealand, Southeast Australia, and Southwest Pacific historical weather data sources using Ian Nicholson’s Log of Logs, *Geosci. Data J.*, 0, 1–12, 2013.
- 10 Chinn, T., Fitzharris, B. B., Willsman, A., and Salinger, M. J.: Annual ice volume changes 1976–2008 for the New Zealand Southern Alps, *Global Planet. Change*, 92–93, 105–118, 2012.
- Coleman, J.: A memoir of the Rev. Richard Davis, for thirty-nine years a missionary in New Zealand, James Nisbet and Co., London, 492 pp., 1865.
- Compo, G. P., Whitaker, J. S., Sardeshmukh, P. D., Matsui, N., Allan, R. J., Yin, X., Gleason, Jr., B. E., Vose, R. S., Rutledge, G., Bessemoulin, P., Bronnimann, S., Brunet, M., Crouthamel, R. I., Grant, A. N., Groisman, P. Y., Jones, P. D., Kruk, M. C., Kruger, A. C., Marshall, G. J., Maugeri, M., Mok, H. Y., Nordli, O., Ross, T. F., Trigo, R. M., Wang, X. L., Woodruff, S. D., and Worley, S. J.: The Twentieth Century Reanalysis Project, *Quarterly J. Roy. Meteorol. Soc.*, 137, 1–28, 2011.
- 15 Compo, G. P., Whitaker, J. S., Sardeshmukh, P. D., Matsui, N., Allan, R. J., Yin, X., Gleason, Jr. B. E., Vose, R. S., Whitaker, J. S., Matsui, N., Ashcroft, L., Auchmann, R., Bessemoulin, P., Brandsma, T., Brohan, P., Brunet, M., Comeaux, J., Crouthamel, R., Gleason, Jr B. E., Groisman, P. Y., Hersbach, H., Jones, P. D., Jónsson, T., Jourdain, S., Kelly, G., Knapp, K. R., Kruger, A., Kubota, H., Lentini, G., Lorrey, A., Lott, N., Lubker, S. J., Luterbacher, J., Marshall, G. J., Maugeri, M., Mok, H. Y., Nordli, O., Rodwell, M. J., Ross, T. F., Schuster, D., Srnc, L., Valente, M. A., Viz, Z., Wang, X. L., Westcott, N., Woollen, J. S., and Worley, S. J.: The International Surface Pressure Databank, *Geosci. Data J.* accepted, 2, 31–46, doi:10.1002/gdj3.25, 2015.
- 20 Dell, R. K.: “Hector, James”, from the Dictionary of New Zealand Biography, Te Ara – the Encyclopedia of New Zealand, available at: <http://www.TeAra.govt.nz/en/biographies/1h15/hector-james> (last access: 22 May 2015), 2013.
- 25 Delong, K. L., Quinn, T. M., Taylor, F. W., Lin, K., and Shen, C.-C.: Sea surface temperature variability in the southwest tropical Pacific since AD 1649, *Nature Climate Change*, 2, 799–804, doi:10.1038/NCLIMATE1583, 2012.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Dunbar, R. B., Wellington, G. M., Colgan, M. W., and Glynn, P. W.: Eastern Pacific sea surface temperature since 1600 A.D.: the  $\delta^{18}\text{O}$  record of climate variability in Galapagos corals, *Paleoceanography*, 9, 291–315, 1994.

Fouhy, E., Coutts, L., McGann, R., Collen, B.216 pp., 1992.

5 Fowler, A. M., Boswijk, G., Lorrey, A. M., Gergis, J., Pirie, M., McCloskey, S. P. J., Palmer, J. G., and Wunder, J.: Multi-centennial tree-ring record of ENSO-related activity in New Zealand, *Nature Climate Change*, 2, 172–176, 2012.

Gergis, J., Brohan, P., and Allan, R.: The weather of the First Fleet voyage to Botany Bay, 1787–1788, *Weather*, 65, 315–319, 2010.

10 Gergis J., Karoly D. J., and Allan R.: A climate reconstruction of Sydney Cove, New South Wales, using weather journal and documentary data, 1788–1791, *Aust. Meteorol. Oceanogr. J.*, 58, 83–98, 2009.

Gergis, J. and Fowler, A.: A history of El Niño–Southern Oscillation (ENSO) events since A.D. 1525: implications for future climate change, *Climatic Change*, 92, 343–387, 2009.

15 Gergis, J.: Documentary accounts of the impacts of past climate variability on the early colony of New South Wales, 1788–1791: a preliminary analysis, *B. Aust. Meteorol. Oceanogr. Soc.*, 58, 83–98, 2008.

Hessell, J. W. D.: The climate and weather of the Auckland region, New Zealand Meteorological Service Miscellaneous Publication, 115, 35 pp., 1988.

20 Holland, P. G. and Mooney, W. B.: Wind and water: environmental learning in early colonial New Zealand, *New Zealand Geographer*, 62, 39–49, 2006.

Holland, P. G., Wood, V., and Dixon, P.: Learning about the weather in early colonial New Zealand, *Weather Climate*, 29, 3–23, 2009.

25 Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, L., Iredell, M., Saha, S., White, G., Woollen, J., Zhu, Y., Leetmaa, A., Reynolds, R., Chelliah, M., Ebisuzaki, W., Higgins, W., Janowiak, J., Mo, K. C., Ropelewski, C., Wang, J., Jenne, R., and Joseph, D.: The NCEP/NCAR 40-Year Reanalysis Project, *B. Am. Meteor. Soc.*, 77, 437–471, 1996.

Kaufman, D., Anchukaitis, K., Bu ?entgen, U., Emile-Geay, J., Evans, M., Goosse, H., Luterbacher, J., Smerdon, J., Tingley, M., von Gunten, L., Anderson, D., Cook, E., Gonzalez-Rouco, F., Gergis, J., Grosjean, M., Hormes, A., Lorrey, A., McKay, N., Neukom, R., Tierney, J., Wahl, E., Wanner, H., and Werner, J.: A community-driven framework for climate reconstruc-  
30 tions, *EOS Trans. AGU*, 95, 361, 2014.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



- Kidson, J. W.: An analysis of New Zealand synoptic types and their use in defining weather regimes, *Int. J. Climatol.*, 20, 299–316, 2000.
- King, D. N. T., Skipper, A., and Tawhai, W. B.: Maori environmental knowledge of local weather and climate change in Aotearoa – New Zealand, *Climatic Change*, 90, 385–409, 2008.
- 5 King, M.: The Penguin history of New Zealand, Penguin Books, Auckland, 563 pp., 2003.
- Lorrey, A. M.: An overview of the Past Interpretation of Climate Tool (PICT), 3rd PAGES Australasia 2k workshop, Melbourne Australia, 26–27 June, 2014.
- Lorrey, A. M., Chappell, P., Allan, R., Brohan, P., and Compo, G. P.: The “Dirty Weather” diaries of Reverend Davis reveals climate variability of the Colonial Era in Northern New Zealand, 1839–1851, *Extreme Weather 2011: Joint Conference of the New Zealand Meteorological Society and the Australian Meteorological and Oceanographic Society*, February 9–11, Te Papa, Wellington, 200 pp., 2011a.
- 10 Lorrey, A. M., Chappell, P., Allan, R., Brohan, P., and Compo, G. Late Little Ice Age climate variability in New Zealand documented by the Reverend Davis “Dirty Weather” diaries, XVIII INQUA Congress, 21–27 July, Bern, Switzerland, 2011b.
- Lorrey, A. M., Fauchereau, N., Stanton, C., Chappell, P. R., Phipps, S. J., Mackintosh, A., Renwick, J. A., and Fowler, A. M.: The Little Ice Age climate of New Zealand reconstructed from Southern Alps cirque glaciers: a synoptic type approach, *Climate Dynamics*, 42, 3039–3060, doi:10.1007/s00382-013-1876-8, 2013a.
- 20 Lorrey, A. M., Griffiths, G., Fauchereau, N., Diamond, H. J., Chappell, P. R., and Renwick, J.: An ex-tropical cyclone climatology for Auckland, New Zealand, *Int. J. Climatol.*, 34, 1157–1168, doi:10.1002/joc.3753, 2013b.
- Mann, M.E, Zhang, Z., Rutherford, S., Bradley, R. S., Hughes, M. K., Shindell, D., Ammann, C., Faluvegi, G., and Ni, F.: Global signatures and dynamical origins of the Little Ice Age and Medieval Climate Anomaly, *Science*, 326, 1256–60, doi:10.1126/science.1177303, 2009.
- 25 Melvin, T. M. and Briffa, K. R.: A “signal-free” approach to dendroclimatic standardisation, *Dendrochronologia*, 26, 71–86, 2008.
- Mo, K. C. and Paegle, J. N.: The Pacific-South American modes and their downstream effects, *Int. J. Climatol.*, 21, 1211–1229, 2001.
- 30 Moir, R. W., Collen, B., and Thompson, C. S.: The climate and weather of Northland, New Zealand Meteorological Service Miscellaneous Publication, 115, 37 pp., 1986.
- Nakamura, R. and Mahrt, L.: Air temperature measurement errors in naturally ventilated radiation shields, *J. Atmos. Ocean. Technol.*, 22, 1046–1058, 2005.

Neukom, R. and Gergis, J.: Southern Hemisphere high-resolution palaeoclimate records of the last 2000 years, *Holocene*, 22, 501–524, 2012.

Pittock, B. and Wratt, D.: Australia and New Zealand, Chap. 12 of: *Climate Change 2001: Impacts, Adaptation and Vulnerability*, Contribution of Working Group II to the Third Annual Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, 591–639, 2001.

Renwick, J. A.: Kidson's synoptic weather types and surface climate variability over New Zealand, *Weather Climate*, 31, 3–23, 2011.

Tait, A., Henderson, R., Turner, R., and Zheng, X. G.: Thin plate smoothing spline interpolation of daily rainfall for New Zealand using a climatological rainfall surface, *Int. J. Climatol.*, 26, 2097–2115, 2006.

The Horological Foundation: available at: [www.antique-horology.com](http://www.antique-horology.com), last access: 22 May 2015.

Wilmshurst, J. M., Hunt, T. L., Lipo, C. P., and Anderson, A. J.: High-precision radiocarbon dating shows recent and rapid initial human colonisation of East Polynesia, *P. Natl. Acad. Sci.*, 108, 1815–1820, 2011.

Xiong, L. and Palmer, J. G.: *Libocedrus bidwillii* tree ring chronologies in New Zealand, *Tree-Ring Bulletin*, 56, 1–16, 2000.

CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



**Table 1.** Monthly average 09 a.m. temperature, Noon temperature and Noon pressure from the Reverend Richard Davis meteorological diary converted from Fahrenheit to Celsius and inches of mercury to hectopascals.

Thermometer 09 a.m.	January	February	March	April	May	June	July	August	September	October	November	December
1839	17.4	18.4	18.4	14.8	12.4	10.4	9.1	9.3	11.7	12.7	16.2	15.6
1840	17.9	18.4	18.1	16.8	12.5	11.0	10.2	9.5	10.7	14.0	14.6	20.5
1841	21.0	18.5	18.3	14.4	11.7	8.8	8.2	10.0	11.6	15.5	16.3	18.4
1842	20.6	19.4	17.4	15.4	11.0	8.8	8.1	8.3	11.2	13.2	16.6	18.0
1843	18.5	19.0	17.6	14.9	11.5	9.4	8.6	10.2	11.8	13.0	16.1	18.8
1848	19.8	18.5	17.7	15.5	12.8	11.6	10.3	11.0	12.2	12.8	16.7	19.1
1849	19.0	19.3	19.1	15.9	13.0	9.9	9.6	9.2	12.1	14.3	16.0	18.7
1850	20.5	20.8	18.4	14.7	12.2	10.4	7.2	10.5	11.9	13.4	16.6	18.3
1851	20.5	20.9	19.5	13.8	12.7	10.4	9.2	10.1	12.9			
Average	19.5	19.2	18.3	15.1	12.2	10.1	8.9	9.8	11.8	13.6	16.1	18.4

Thermometer noon	January	February	March	April	May	June	July	August	September	October	November	December
1839	21.6	22.5	22.0	19.0	15.1	13.6	12.1	12.1	14.4	15.9	19.0	19.6
1840	21.7	20.7	21.3	19.3	16.4	14.0	12.5	11.9	13.0	17.5	17.3	24.7
1841	25.1	22.4	21.0	17.4	14.6	12.3	11.3	12.5	14.6	18.2	18.3	20.5
1842	23.4	22.5	20.7	17.4	14.3	11.5	11.5	11.6	14.7	15.9	19.3	21.5
1843	21.1	21.4	20.5	16.8	14.1	12.2	11.2	12.9	14.6	14.8	18.6	21.2
1848	21.5	20.0	19.5	17.4	14.0	13.3	13.0	12.7	13.6	14.8	18.8	20.7
1849	20.9	20.8	20.6	17.6	14.3	11.6	10.9	10.9	13.6	15.7	17.4	20.6
1850	22.2	21.6	19.6	16.0	13.8	11.6	9.1	11.8	13.6	15.0	18.3	19.6
1851	22.2	22.7	20.6	15.6	14.3	11.9	11.2	12.1	14.7			
Average	22.2	21.6	20.7	17.4	14.5	12.5	11.4	12.1	14.1	16.0	18.4	21.0

Barometer noon	January	February	March	April	May	June	July	August	September	October	November	December
1839	990.7	994.9	997.4	997.3	999.9	994.6	990.3	993.0	997.4	991.5	992.8	992.7
1840	996.6	993.9	994.8	992.8	994.7	992.7	994.9	987.8	993.0	998.2	993.1	1000.1
1841	992.5	995.1	997.8	996.7	996.1	990.9	992.7	996.2	997.9	995.7	991.8	988.7
1842	996.5	997.9	997.0	992.5	990.8	990.4	993.5	992.8	994.5	987.7	990.6	994.1
1843	992.7	999.0	998.3	996.0	998.1	991.7	991.5	992.6	988.9	986.7	993.4	996.3
1848	1015.7	1006.6	1013.6	1009.8	1005.0	1003.0	993.8	995.6	993.6	999.5	1000.7	1007.7
1849	1011.1	1007.4	1008.5	1002.9	995.8	993.8	990.5	995.5	994.1	996.8	995.5	994.8
1850	993.5	994.9	994.5	997.7	992.2	988.1	993.4	996.0	996.8	993.6	994.4	994.0
1851	993.6	996.3	990.0	999.7	992.9	988.3	988.3	989.3	992.0			
Average	998.1	998.5	999.1	998.4	996.2	992.6	992.1	993.2	994.2	993.7	994.0	996.0

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



# The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

**Table 2.** VCSN-equivalent temperatures from the Davis diary for 09 a.m. mean, 09 a.m. extreme minimum and 09 a.m. extreme maximum values with reference to VCSN 09 a.m. temperature data.

9am mean	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Davis	19.3	19	18.1	15.3	12.1	10	8.9	9.7	11.7	13.6	16.1	18.4
VCSN	19.8	20.3	19.5	17.7	15.6	13.7	12.7	13.1	14.1	15.1	16.6	18.5
Difference	−0.5	−1.3	−1.4	−2.4	−3.5	−3.7	−3.8	−3.4	−2.4	−1.5	−0.5	−0.1
Davis era	colder	colder	colder	colder	colder	colder	colder	colder	colder	colder	colder	colder
9am extreme min	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Davis	11.1	13.9	12.2	5.6	5.6	3.9	1.7	2.2	5.6	8.3	8.9	8.9
VCSN	11.2	9.9	9.7	2.9	6.3	2.1	3.9	5.2	6.5	5.9	9.7	9.2
Difference	−0.1	4	2.5	2.7	−0.7	1.8	−2.2	−3	−0.9	2.4	−0.8	−0.3
Davis era	colder	warmer	warmer	warmer	colder	warmer	colder	colder	colder	warmer	colder	colder
9am extreme max	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Davis	26.7	24.4	23.9	21.1	19.4	20	15.6	16.1	16.7	21.1	22.2	24.4
VCSN	27.5	26.3	27.3	24.8	23.8	21.5	19.8	21.1	21.9	22.8	24.3	24.9
Difference	−0.8	−1.9	−3.4	−3.7	−4.4	−1.5	−4.2	−5	−5.2	−1.7	−2.1	−0.5
Davis era	colder	colder	colder	colder	colder	colder	colder	colder	colder	colder	colder	colder

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)


# The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

**Table 3.** VCSN-equivalent average monthly  $T_{\min}$ ,  $T_{\max}$ ,  $T_{\text{mean}}$  and diurnal temperature range based on Reverend Davis 09 a.m. and Noon temperatures compared to modern climatology. Bold (italic) highlighting indicates warmer (colder) differences of more than 0.5 °C for Davis observations relative to the present.

Davis – reconstructed	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
$T_{\min}$ (C)	14.5	14.7	14.1	12.0	9.1	7.0	6.0	6.4	7.8	9.4	11.4	13.6	10.5
$T_{\max}$ (C)	24.4	24.1	22.8	19.5	16.5	14.5	13.5	14.1	16.0	18.1	20.4	23.0	18.9
$T_{\text{mean}}$ (C)	19.5	19.4	18.5	15.7	12.8	10.7	9.8	10.3	11.9	13.8	15.9	18.3	14.7
Diurnal range	9.9	9.4	8.7	7.6	7.4	7.4	7.6	7.4	8.2	8.7	9.0	9.4	8.4
VCSN modern	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
$T_{\min}$ (C)	14.0	14.5	13.5	11.8	9.9	8.0	7.1	7.3	8.3	9.4	10.9	12.7	10.6
$T_{\max}$ (C)	23.3	23.7	22.2	19.8	17.3	15.2	14.5	14.8	16.2	17.6	19.5	21.6	18.8
$T_{\text{mean}}$ (C)	18.6	19.1	17.9	15.8	13.6	11.6	10.8	11.1	12.2	13.5	15.2	17.1	14.7
Diurnal range	9.3	9.2	8.7	8	7.5	7.2	7.3	7.5	7.9	8.2	8.6	8.9	8.2
Davis era difference	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
$T_{\min}$ (C)	<b>0.6</b>	0.2	<b>0.6</b>	0.1	<i>-0.8</i>	<i>-1.0</i>	<i>-1.2</i>	<i>-0.9</i>	<i>-0.5</i>	0.0	0.5	<b>0.9</b>	-0.1
$T_{\max}$ (C)	<b>1.1</b>	0.4	<b>0.6</b>	-0.3	<i>-0.8</i>	<i>-0.8</i>	<i>-0.9</i>	<i>-0.8</i>	<i>-0.2</i>	0.5	<b>0.9</b>	<b>1.4</b>	0.1
$T_{\text{mean}}$ (C)	<b>0.8</b>	0.3	<b>0.6</b>	-0.1	<i>-0.8</i>	<i>-0.9</i>	<i>-1.0</i>	<i>-0.8</i>	<i>-0.4</i>	0.2	<b>0.7</b>	<b>1.1</b>	0.0
Diurnal range	<b>0.6</b>	0.2	0.0	-0.4	-0.1	0.2	0.3	-0.1	0.3	0.5	0.4	0.5	0.2

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)




**Table 4.** Percentage frequency per month (and averaged by season) for qualitative wind direction observations by Reverend Richard Davis for the entire span of his observations.

Month	N	NE	E	SE	S	SW	W	NW	VRB
Jan	11.1	2.9	10.0	5.0	14.3	16.8	14.7	6.5	18.6
Feb	10.2	5.9	11.4	13.0	16.5	12.2	9.1	5.5	16.1
Mar	7.9	4.3	16.1	12.2	15.4	14.3	12.2	6.5	11.1
Apr	8.9	5.2	7.4	9.3	24.4	15.6	11.5	9.6	8.1
May	7.9	3.6	4.3	5.7	21.9	20.4	13.6	14.7	7.9
Jun	13.0	2.2	6.3	9.3	15.9	15.9	17.8	12.2	7.4
Jul	9.7	5.7	4.3	11.1	19.0	12.2	15.4	12.2	10.4
Aug	10.0	4.7	6.1	13.3	13.6	17.9	16.1	9.0	9.3
Sep	12.1	7.1	8.8	6.7	12.9	10.8	17.1	12.9	11.7
Oct	9.3	2.4	6.5	5.2	13.7	16.5	23.8	16.1	6.5
Nov	17.1	7.9	3.8	3.8	10.0	13.8	21.3	12.1	10.4
Dec	7.7	8.5	11.3	4.8	12.5	13.7	17.7	7.3	16.5
AVG	10.4	5.0	8.0	8.3	15.9	15.0	15.9	10.4	11.2
SON	12.8	5.8	6.3	5.2	12.2	13.7	20.7	13.7	9.5
DJF	9.7	5.7	10.9	7.6	14.5	14.3	13.8	6.4	17.1
MAM	8.2	4.4	9.3	9.1	20.6	16.8	12.4	10.3	9.0
JJA	10.9	4.2	5.6	11.2	16.2	15.3	16.4	11.1	9.0

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

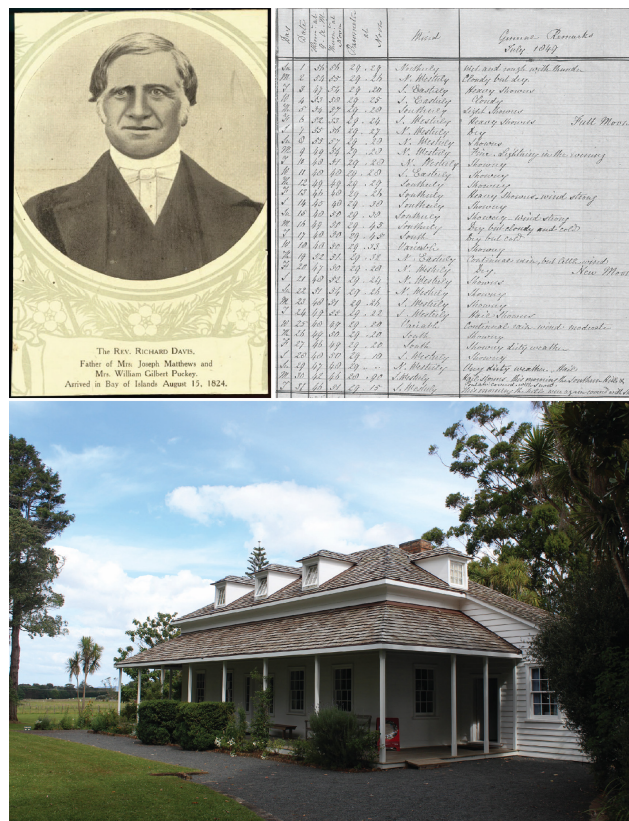
Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





**Figure 1.** (top, left) Print of a photomechanical portrait of Reverend Richard Davis taken ca. 1860, from the file print collection, Box 16. Ref: PAColl-7344-97, Alexander Turnbull Library, Wellington, New Zealand sourced from <http://natlib.govt.nz/records/23073407> (top, right) a digital scan of the Davis meteorological diary for July 1849 which also includes commentary about dirty weather and snow (bottom) The Waimate North mission house in the Far North of New Zealand.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

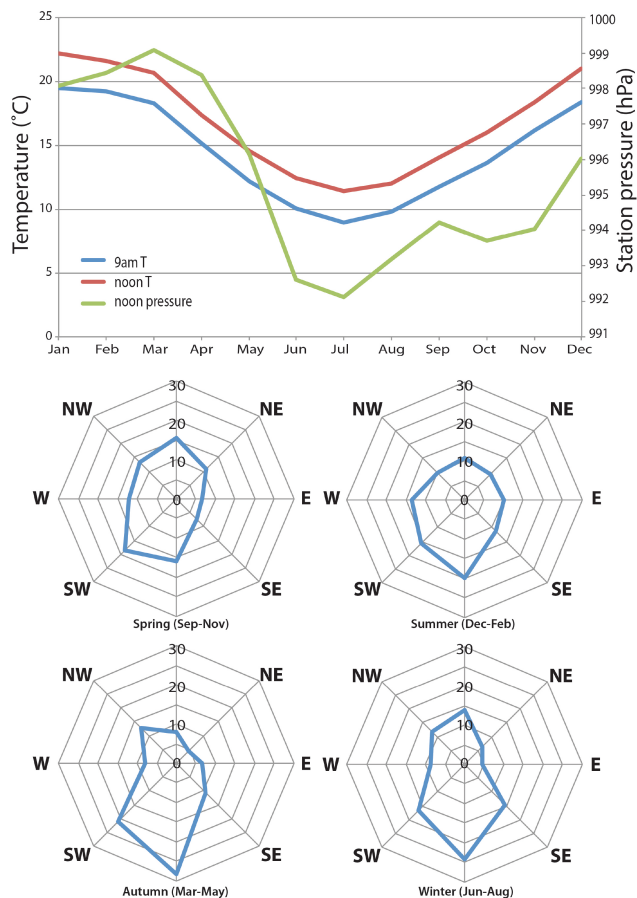
Close

Full Screen / Esc

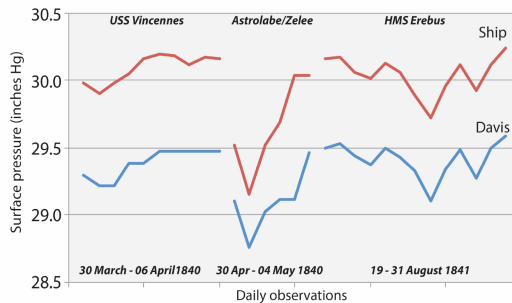
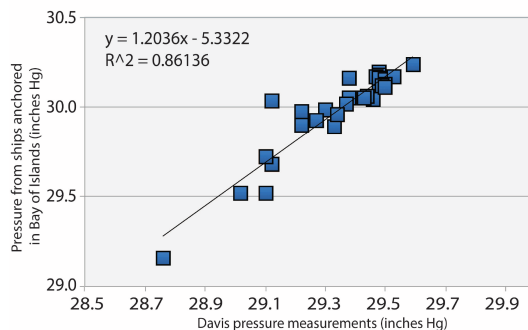
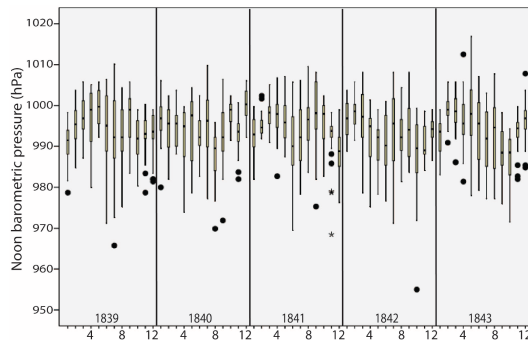
Printer-friendly Version

Interactive Discussion





**Figure 3.** (top) Climatology of 09 a.m. temperature and noon temperature and pressure measured by Reverend Richard Davis at Waimate North and Kaikohe (means for 1939–1843 and 1848–1851 inclusive). (bottom) Seasonal wind climatology (% frequency observation) for the same sites and interval.



# CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



**Figure 4.** (top) Monthly pressure observations from the Reverend Richard Davis (RRD) meteorological diary for 1839–1843. Number on  $x$  axis denotes month of each year. Circles represent values that are 1.5 to 3 times the interquartile range away from the middle 50 % of all of the data, while stars represent extremes are more than 3 times the interquartile range away (middle) comparison of pressure observation in inches mercury from RRD relative to ship data in the Bay of Islands for the same day (bottom) RRD pressure observation vs. expedition measurements (leader noted in parenthesis) from USS Vincennes (Wilkes), the corvettes Astrolabe & Zelee (D'Urville) and the HMS Erebus (Ross). There are 29 pairs of daily observations and so the  $x$  axis simply shows the comparisons of Davis' record to the three ships in a sequence with the specific intervals noted.

## CPD

11, 3799–3851, 2015

### The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

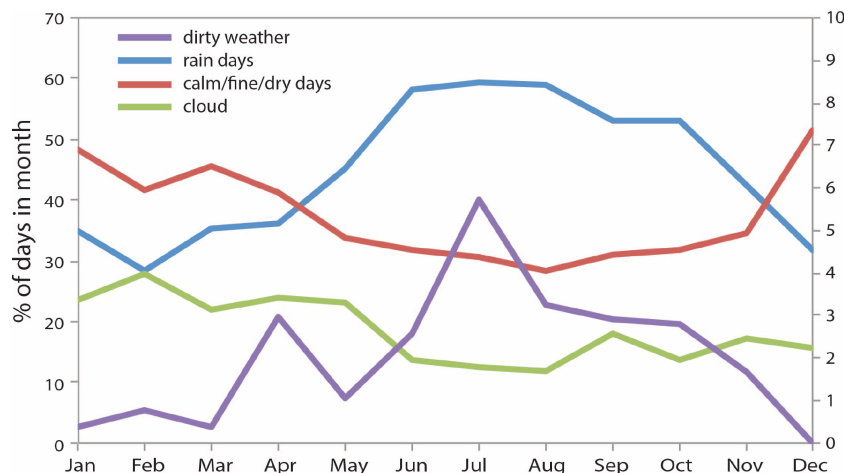
Printer-friendly Version

Interactive Discussion



# The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

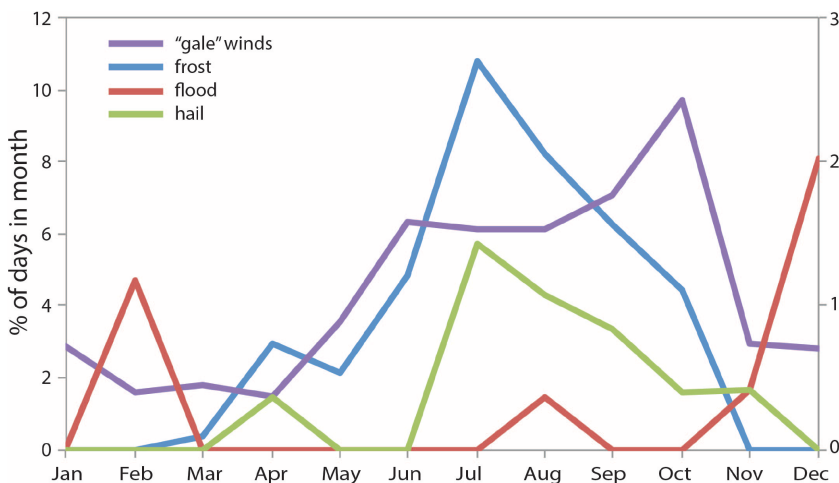


**Figure 5.** Climatology of qualitative observation for “dirty weather”, rain days and “dry” days (left hand scale) vs. “dirty weather” and cloud (right hand scale) percentage of days per month in the Reverend Davis meteorological diary.

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)

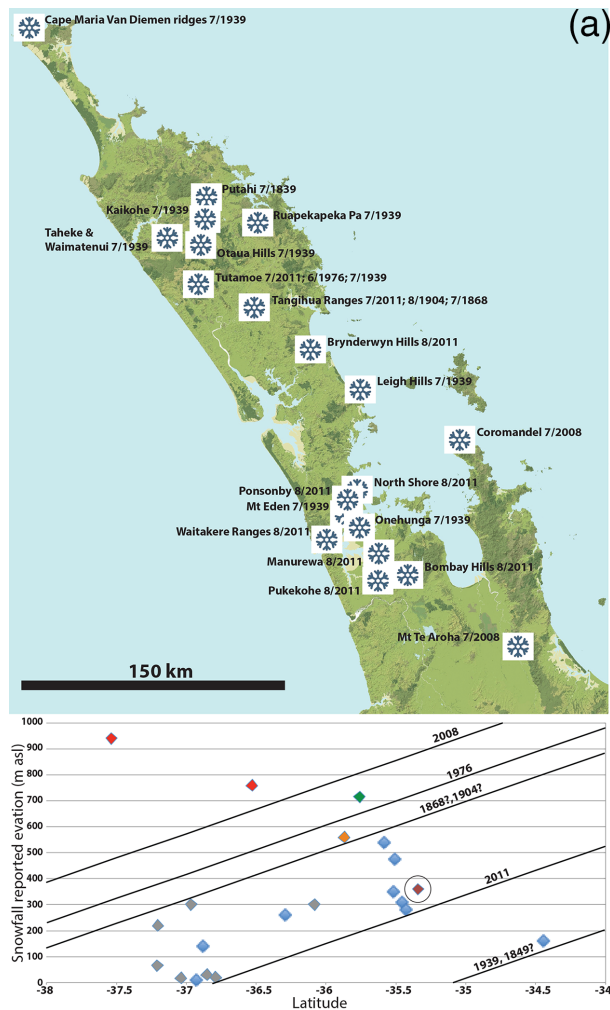

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell



**Figure 6.** Climatology of qualitative observation for “gale” winds and frost days (left hand scale) with flood and hail (right hand scale) percentage of days per month in the Reverend Davis’ meteorological diary.





# The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

**Figure 7. (a)** (top, left) Distribution of historic frozen precipitation events (snowfall, sleet and graupel) for northern New Zealand. (bottom, left) Reported elevations for the eyewitness accounts above plotted by latitude, with demarcation lines separating the minimum estimated settling elevation for frozen precipitation for each event. The diamond colors note evidence for distinct events: red – 2008, green – 1976, orange – 1868 & 1904, grey – 2011, blue – 1939. The maroon (encircled) diamond indicates the 30-31 July 1839 event recorded by Reverend Davis for the Putahi volcanic cone when he was living at Waimate North. **(b)** 500 hPa wind strength and streamlines for the aforementioned snowfall events, courtesy of the 20th Century reanalysis v2.

The “Dirty Weather”  
diaries of Reverend  
Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

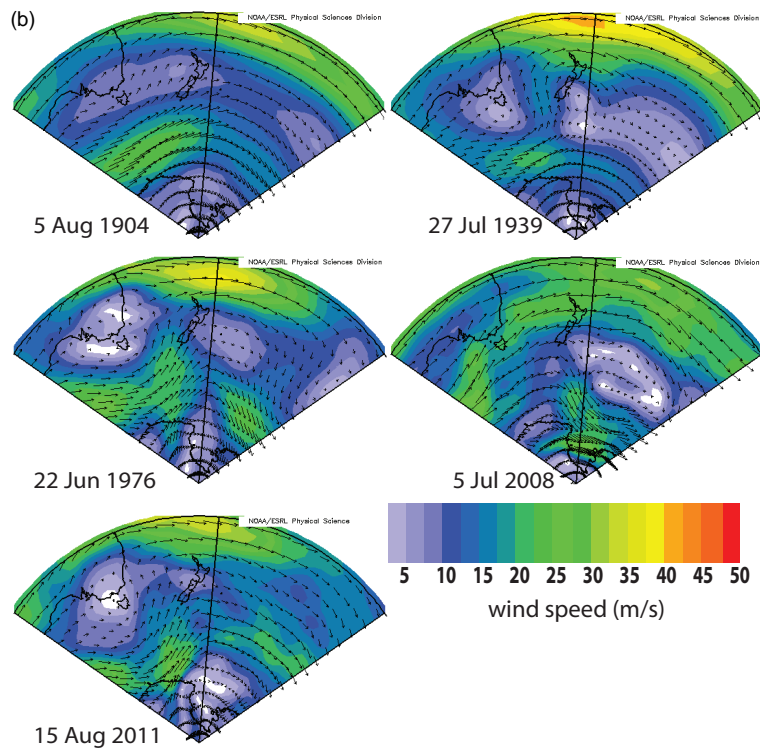
Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





**Figure 7.** Continued.

# The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

## CPD

11, 3799–3851, 2015

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell

Title Page

## Abstract

## Introduction

## Conclusions

## References

## Tables

## Figures



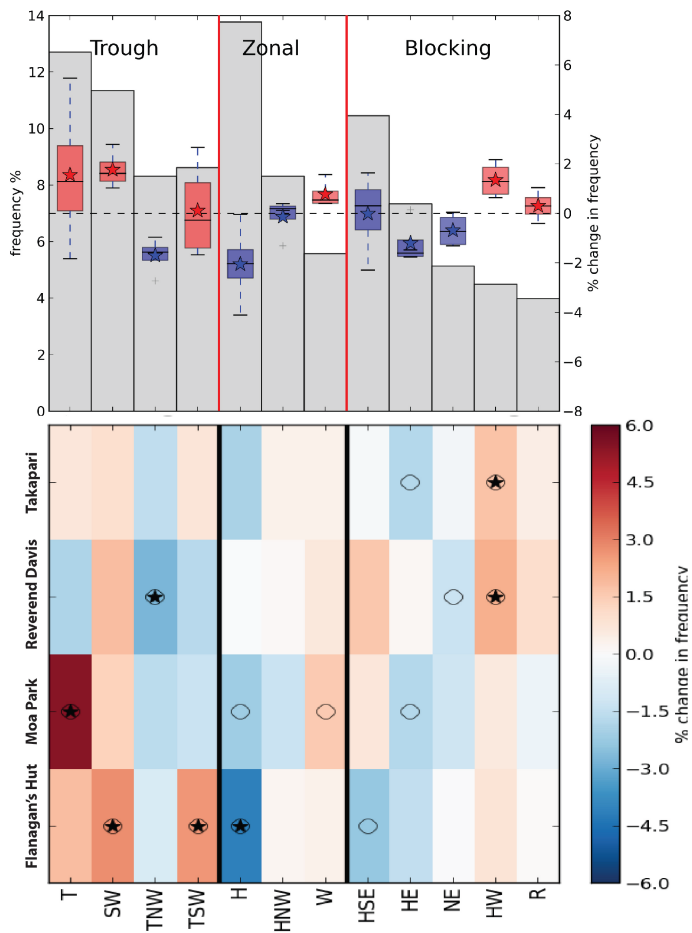
[Back](#)

Close

Full Screen / Esc

[Printer-friendly Version](#)

## Interactive Discussion



**Figure 8.** (Top) Frequency of New Zealand synoptic types ( $x$  axis) during austral winter as determined by an ensemble composite of reconstructions from three tree ring proxy sites and the Reverend Richard Davis weather diary for 1839 CE – 1851 CE. Grey bars indicate climatological frequencies in terms of percentage ( $y$  axis, left), box and whiskers indicate distribution of anomalies in terms of change in frequency ( $y$  axis, right) indicated by the ensemble reconstruction. The black horizontal line in each box is the median bound by the 25th and 75th percentile while whiskers are 5th and 95th percentile. Synoptic type abbreviations follow Kidson (2000). (Bottom) Heat map of New Zealand synoptic type ( $x$  axis) frequency changes with respect to climatology for individual site members ( $y$  axis) of the ensemble composite for 1839 CE – 1851 CE. Significance of synoptic type frequency changes was assessed using a Monte Carlo approach. 10 000 simulations of synoptic type evolution were realized based on Markov chains constrained by the observed frequency and transition probabilities between Kidson’s (2000) synoptic types observed during the modern reanalysis era (1972–Present). Circles and stars represent anomalies significant at the 90th and 95th level, respectively. Figures generated using the Past Interpretation of Climate Tool (PICT) courtesy of National Institute of Water and Atmospheric Research (NIWA). See Lorrey et al. (2014) and <http://pict.niwa.co.nz> for details.

The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

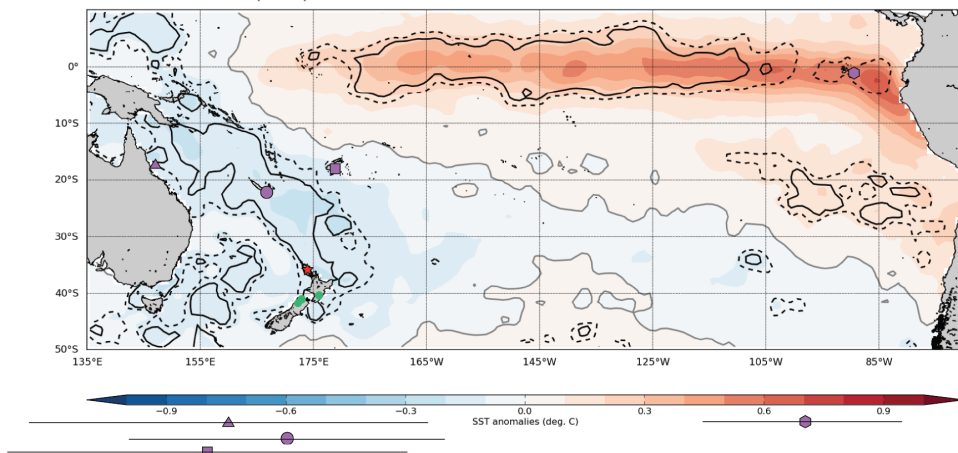
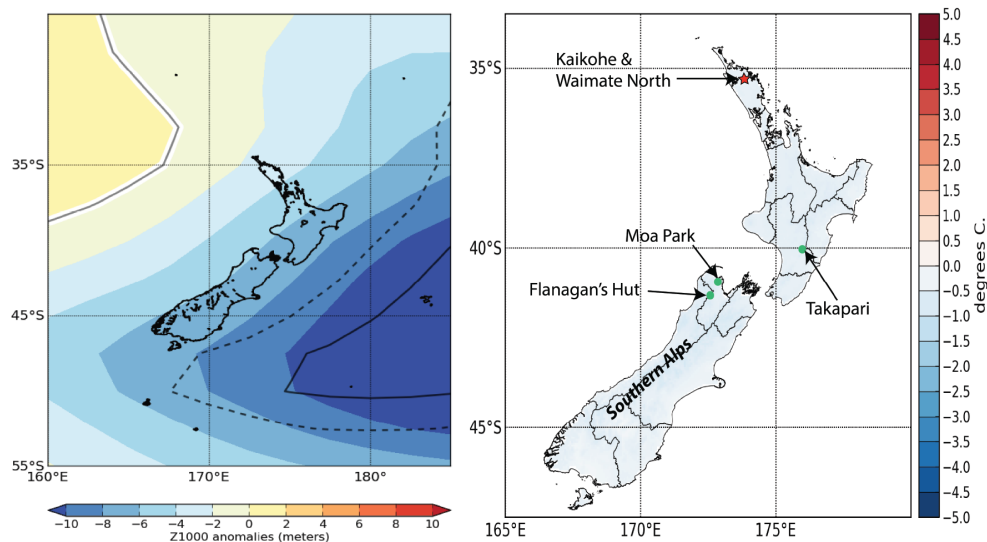
Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





# The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

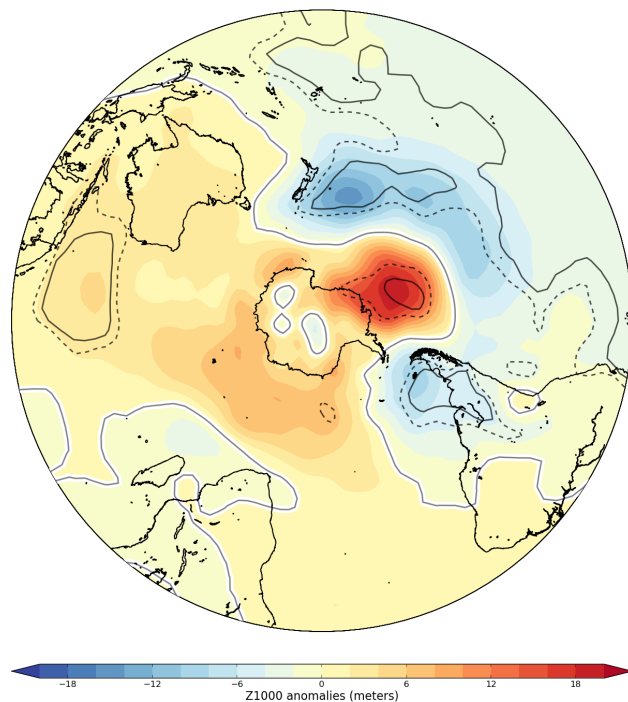
Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion





**Figure 10.** June–August geopotential height anomaly at 1000 hPa (z1000) over the Southern Hemisphere for 1839 CE – 1851 CE determined by an ensemble composite of reconstructions from the Reverend Davis diary temperatures and three tree-ring proxy data series (same as Fig. 9). Anomaly height is in meters. Reanalysis data is courtesy of the National Centers for Environmental Prediction (NCEP). Confidence intervals (90th and 95th) are noted with black (dashed and solid) contour lines. Fig. generated using the Past Interpretation of Climate Tool (PICT) courtesy of National Institute of Water and Atmospheric Research (NIWA). See Lorrey et al. (2014) and <http://pict.niwa.co.nz> for details.

## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R. Chappell

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

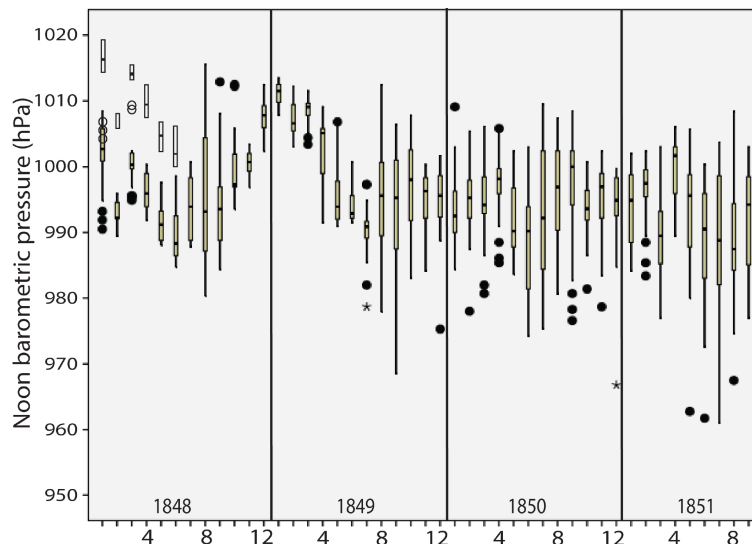
Interactive Discussion





## The “Dirty Weather” diaries of Reverend Richard Davis

A. M. Lorrey and P. R.  
Chappell



**Figure 11.** Pressure series for the second half of the Reverend Richard Davis meteorological record showing adjusted and unadjusted (clear/white boxes) pressure series for January – June 1848. Circles represent values that are 1.5 to 3 times the interquartile range away from the middle 50 % of all of the data, while stars represent extremes are more than 3 times the interquartile range away.

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)
