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## A multiproxy database of western North American Holocene paleoclimate records

**Cody C. Routson<sup>1</sup>, Darrell S. Kaufman<sup>1</sup>, Nicholas P. McKay<sup>1</sup>, Michael P. Erb<sup>1</sup>, Stéphanie H. Arcusa<sup>1</sup>,  
Kendrick J. Brown<sup>2,3</sup>, Matthew E. Kirby<sup>4</sup>, Jeremiah P. Marsicek<sup>5</sup>, R. Scott Anderson<sup>1</sup>,  
Gonzalo Jiménez-Moreno<sup>6</sup>, Jessica R. Rodysill<sup>7</sup>, Matthew S. Lachniet<sup>8</sup>, Sherilyn C. Fritz<sup>9</sup>,  
Joseph R. Bennett<sup>10</sup>, Michelle F. Goman<sup>11</sup>, Sarah E. Metcalfe<sup>12</sup>, Jennifer M. Galloway<sup>13</sup>,  
Gerrit Schoups<sup>14</sup>, David B. Wahl<sup>15</sup>, Jesse L. Morris<sup>16</sup>, Francisca Staines-Urías<sup>17</sup>, Andria Dawson<sup>18</sup>,  
Bryan N. Shuman<sup>19</sup>, Daniel G. Gavin<sup>20</sup>, Jeffrey S. Munroe<sup>21</sup>, and Brian F. Cumming<sup>22</sup>**

<sup>1</sup>School of Earth and Sustainability, Northern Arizona University, P.O. Box 4099 Flagstaff, AZ 86011, USA

<sup>2</sup>Canadian Forest Service, Natural Resources Canada, Victoria, BC V8Z 1M5, Canada

<sup>3</sup>Department of Earth, Environmental and Geographic Sciences, University of British Columbia,  
Okanagan, BC V1V 1V7, Canada

<sup>4</sup>Department of Geological Sciences, California State University, Fullerton, 800 N. State College Blvd.,  
Fullerton, CA 98324, USA

<sup>5</sup>Department of Geoscience, University of Wisconsin-Madison, 1215 W. Dayton St. Madison, WI 53706, USA

<sup>6</sup>Departamento de Estratigrafía y Paleontología, Universidad de Granada,  
Avda. Fuentenueva S/N, Granada 18002, Spain

<sup>7</sup>Florence Bascom Geoscience Center, United States Geological Survey,  
12201 Sunrise Valley Dr. MS926A, Reston, VA 20192, USA

<sup>8</sup>Department of Geoscience, University of Nevada, Las Vegas,  
4505 S. Maryland Parkway, Las Vegas, NV 89154, USA

<sup>9</sup>Department of Earth and Atmospheric Sciences, University of Nebraska-Lincoln, Lincoln, NE 68540, USA

<sup>10</sup>Department of Biology, Carleton University, 1125 Col By Drive, Ottawa, ON K1S 5B6, Canada

<sup>11</sup>Department of Geography, Environment, and Planning, Sonoma State University,  
1801 E. Cotati Ave, Rohnert Park, CA 94928, USA

<sup>12</sup>School of Geography, University of Nottingham, University Park,  
Nottingham, Nottinghamshire, NG7 2RD, UK

<sup>13</sup>Geological Survey of Canada (Commission géologique du Canada), 3303 33rd St. NW,  
Calgary, AB T2L 2A7, Canada

<sup>14</sup>Water Resources Management, Delft University of Technology, P.O. Box 5048,  
Delft, 2600 GA, the Netherlands

<sup>15</sup>Geology, Minerals, Energy, and Geophysics Science Center, United States Geological Survey, 345  
Middlefield Rd., Menlo Park, CA 94025, USA

<sup>16</sup>Department of Geography, University of Utah, 260 Central Campus Dr #4625,  
Salt Lake City, UT 84112, USA

<sup>17</sup>Department of Marine Geology, Geological Survey of Denmark and Greenland (GEUS),  
Oester Voldgade 10, Copenhagen K, 1350, Denmark

<sup>18</sup>Department of General Education, Mount Royal University,  
4825 Mt Royal Gate SW, Calgary, AB T3E6K6, Canada

<sup>19</sup>Department of Geology and Geophysics, University of Wyoming, 1000 E. University Ave.,  
Laramie, WY 82071, USA

<sup>20</sup>Department of Geography, University of Oregon, 1251 University of Oregon, Eugene, OR 97403, USA

<sup>21</sup>Geology Department, Middlebury College, 276 Bicentennial Way, Middlebury, VT 05753, USA

<sup>22</sup>Department of Biology, Queen's University, 116 Barrie St., Kingston, ON K7L3J9, Canada

**Correspondence:** Cody C. Routson (cody.routson@nau.edu)

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**Abstract.** Holocene climate reconstructions are useful for understanding the diverse features and spatial heterogeneity of past and future climate change. Here we present a database of western North American Holocene paleoclimate records. The database gathers paleoclimate time series from 184 terrestrial and marine sites, including 381 individual proxy records. The records span at least 4000 of the last 12 000 years (median duration of 10 725 years) and have been screened for resolution, chronologic control, and climate sensitivity. Records were included that reflect temperature, hydroclimate, or circulation features. The database is shared in the machine readable Linked Paleo Data (LiPD) format and includes geochronologic data for generating site-level time-uncertain ensembles. This publicly accessible and curated collection of proxy paleoclimate records will have wide research applications, including, for example, investigations of the primary features of ocean–atmospheric circulation along the eastern margin of the North Pacific and the latitudinal response of climate to orbital changes. The database is available for download at <https://doi.org/10.6084/m9.figshare.12863843.v1> (Routson and McKay, 2020).

## 1 Introduction

Reconstructing past climate is challenging because it is spatially and temporally complex and because all paleoclimate records are influenced by factors other than climate. Although rarely done, taking advantage of the full breadth of paleoclimatic evidence provides the best possibility of discerning signal from noise. Of all the geologic epochs, the paleoclimate of the Holocene (11.7 kiloannum (ka) to present) has been investigated most extensively. Studying the Holocene is useful, in part, because it serves as a baseline from which to assess natural versus human-forced climate changes. A keyword search on “Holocene” and “climate” returns approximately 21 000 studies globally on the Web of Science. The volume of this previous work, as well as the evolving scientific understanding that it represents, generates organizational challenges related to data validation, extraction, and application.

Here we present a new database of Holocene paleoclimate records from western North America and the adjacent eastern Pacific Ocean. The spatial domain (Fig. 1) extends from tropical Mexico to Arctic Alaska. This region was chosen because (1) it encompasses the large latitudinal range necessary to study effects of orbital changes, the primary climate forcing during the Holocene; (2) it is affected by the major modes of modern Pacific climate variability including the Pacific Decadal Oscillation (Mantua et al., 1997), El Niño–Southern Oscillation (ENSO) (Redmond and Koch, 1991), and the Northern Annular Mode (McAfee and Russell, 2008), among others; (3) it represents a range of climatologies, especially hydroclimate as influenced by the Pacific westerlies and North American monsoon (Adams and Comrie, 1997); (4) it features multiple sources of proxy climate information, including marine sediment, caves, glaciers, and lakes, which are sensitive to changes in wintertime mois-

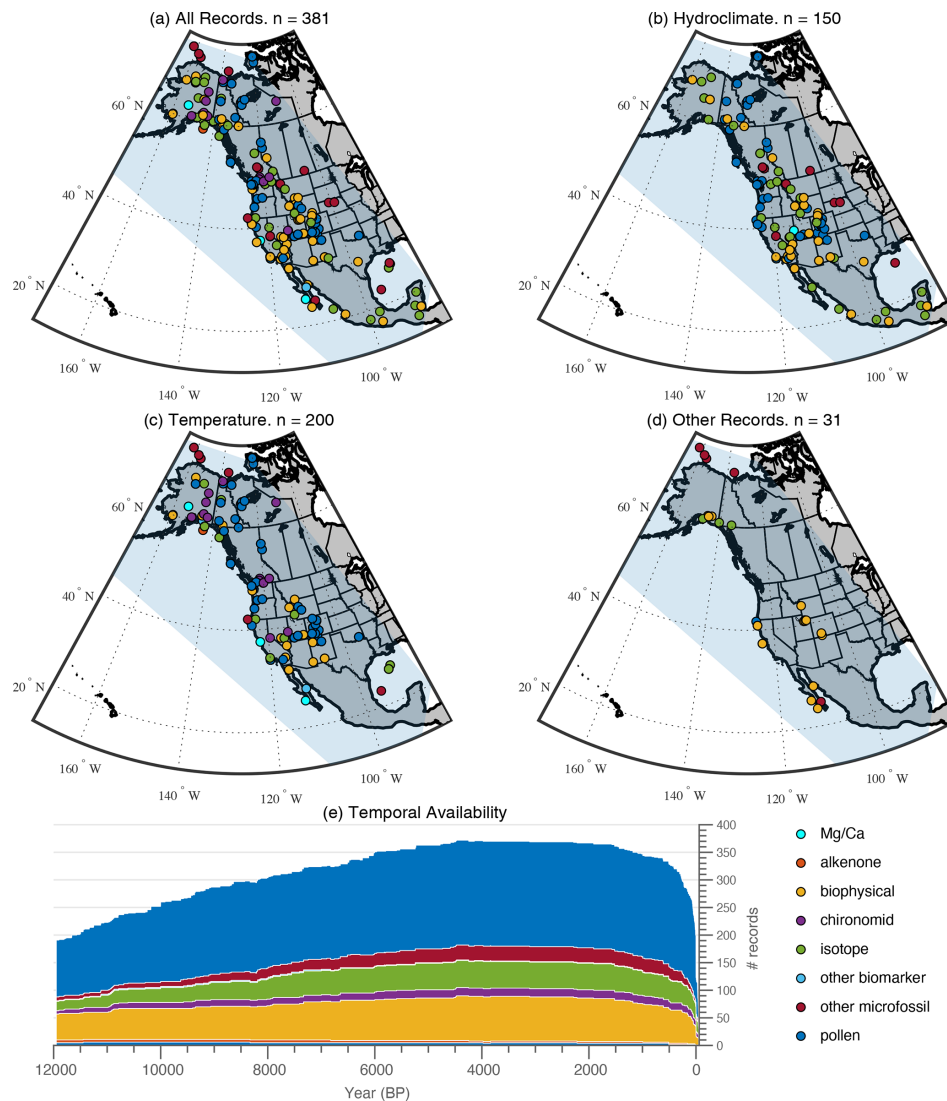
ture, a key variable for tracking the primary variability of North Pacific ocean–atmospheric circulation; and (5) it is a region of concern for future climate change, considering the large population growth and climate hazards related to, for example, water scarcity in the southern tier (Garfin, 2013) and changing wildfire hazards throughout (e.g., Marlon et al., 2012; Power et al., 2008).

This database is composed of records from individual site-level studies and records that were compiled by previous summaries. Many (42 %) of the records in this database are also included in version 1 of the global Temperature 12k database (Kaufman et al., 2020a). This database adds another 39 temperature-sensitive records, plus 179 records that reflect hydroclimate and circulation changes. The added data were published in various formats and often with little metadata to inform the reuse of the data. Together, this geographically distributed collection of proxy climate records integrates marine and terrestrial realms and forms a network from which to assess the spatial variability of regional climatic change and ocean–atmospheric circulation and to compare with climate model simulations of past climate states.

## 2 Data and methods

### 2.1 Data collection

Paleoclimate records located in western North America and the adjacent Pacific Ocean (Fig. 1) were considered for inclusion in the database. They were obtained from public archives in PANGEA and NOAA’s World Data Service (WDS) for Paleoclimatology using the keyword search “Holocene” and record duration searches on NOAA’s paleoclimate search engine. The remainder were obtained through either the supplements of publications or directly from individual data generators and are now being made available in



**Figure 1.** Spatiotemporal distribution of the western North American Holocene paleoclimate database. **(a)** The database includes 381 proxy records from a variety of archive and proxy types. Records include those in calibrated climate units (e.g., °C) and records in their native proxy units (e.g.,  $\delta^{18}\text{O}$ ). **(b)** Distribution of records sensitive to hydroclimate including precipitation, flood frequency, and  $P-E$  ( $n = 150$ ). **(c)** Spatial distribution of the subset of records sensitive to temperature ( $n = 200$ ) and **(d)** the spatial distribution of other records including upwelling, sea ice, glacier extent, dust, circulation, and climate modes ( $n = 31$ ). **(e)** Temporal availability of the records in the database by proxy type (proxy general in Supplement Table S1) over the last 12 ka.

digital form as part of this data product. This database builds on several previously published paleoclimate data compilations overlapping the spatial domain encompassed by this study. These include the global Holocene temperature reconstruction of Marcott et al. (2013) ( $n = 4$  records in western North America), Arctic Holocene Transitions database (Sundqvist et al., 2014) ( $n = 30$  records in western North America), a collection compiled to characterize Holocene North American monsoon variability (Metcalf et al., 2015) ( $n = 8$  records in common with this database), the Northern Hemisphere dataset used to reconstruct Holocene temperature gradients and mid-latitude hydroclimates (Routson et

al., 2019a) ( $n = 55$  records in common with this database), a network of Holocene pollen reconstructions (Marsicek et al., 2018) ( $n = 71$  records in common with this study), two collections of records focused on the last 2 millennia (Rodysill et al., 2018; Shuman et al., 2018) ( $n = 18$  and  $n = 16$  records in common with this study respectively), and the global Temperature 12k database (Kaufman et al., 2020a) ( $n = 161$  records in common with this database). Two dust deposition records were included from the global dust compilation (Albani et al., 2015). This database also complements the recently published PAGES (Past Global Changes) global multiproxy database for temperature reconstructions of the

Common Era (PAGES 2k Consortium, 2017) and the PAGES global database for water isotopes over the Common Era (Konecky et al., 2020), which are both structured in the same format as this database. A few of the records were not available from the original data generators, and therefore the time series data were digitized from the source publication (as noted in the metadata) using the MATLAB program `digitize2.m` (Anil, 2020). Digitized records were mainly included to fill geographic gaps in the network of proxy sites.

Other Holocene paleoclimate records were considered but ultimately excluded because they did not satisfy the selection criteria. The majority of excluded records either (1) lacked a clear relation between proxy and climate, (2) were of insufficient duration, (3) possessed large gaps between chronologic control points, or (4) did not meet the sampling resolution criteria. In some instances selection criteria were eased to fill geographic gaps or for reasons justified by the authors in the QC (quality control) comments metadata. Removing records from the database for subjective reasons, such as removing records with outliers, was avoided.

## 2.2 Relation between proxy and climate

Only records with a demonstrated relation to a climate variable were included, as interpreted by the original authors of the site-level studies, but some records are not calibrated to a climate variable. Calibrated records, for example, are presented in temperature units ( $^{\circ}\text{C}$ ) and precipitation units (mm). Other records are reported in their native proxy variables (e.g.,  $\delta^{18}\text{O}$ , ‰, or sediment mass accumulation,  $\text{g}/\text{cm}^2/\text{yr}$ ). Some calibrated records rely on statistical procedures to determine the relationship between proxy and instrumental data and to infer paleoclimate change, assuming that the processes that control the proxy signal remain constant down core (Tingley et al., 2012; Von Storch et al., 2004). Other calibrations rely on transfer functions based on the correlation of contemporary environmental gradients (e.g., Juggins and Birks, 2012) or the modern analogue technique, which uses the similarity between modern and fossil assemblages (e.g., Guiot and de Vernal, 2007). The original species assemblage data (primarily pollen) for these records are not included in this data product. However, a link to the Neotoma Paleoecology Database dataset ID is provided where available. The Neotoma Paleoecology Database is a community-curated database that is a primary repository for assemblage and other paleoecology data (Williams et al., 2018).

The database also includes proxy records that have not been calibrated to a specific climate variable but that display a clear relation between the proxy and climate. These “relative” climate indicators are useful because they (1) attest to the timing and relative magnitude of change, which is sufficient for many statistical reconstruction methods, especially those that do not assume linearity between proxy and climate variables; (2) can be used in proxy system modeling and in

some cases (e.g.,  $\delta^{18}\text{O}$ ) can be compared directly to the output of climate models; and (3) provide more complete spatial coverage.

## 2.3 Record duration and resolution

The database aims to document paleoclimate variability that ranges on the timescale of multi-millennial trends to centennial excursions. However, not all records encompass the entire Holocene epoch. To be included, records must span a duration of ca. 4000 years anytime between 0 and 12 ka. To focus on records that can resolve sub-millennial patterns, the database includes those with a sample resolution finer than 400 years (i.e., the median spacing between consecutive samples in the time series is less than 400 years over the past 12 000 years or over the full record length, if shorter).

## 2.4 Chronologic control

Age control is a fundamental variable underlying proxy records. The database includes the chronologic data necessary for reproducing original age–depth models for records from sediment and speleothem archive types. Chronologic data include depth, uncalibrated radiometric or other dates, analytical errors, and associated corrections where applicable. Other metadata, including material type analyzed and sample identifiers, were included when available. Time series with a maximum of 3000 years between dates within the 0–12 ka interval or with five or more relatively evenly distributed Holocene dates were included in the database. Overall, the age control screening retained a high proportion of available records while recognizing that such coarse age control often precludes the ability to address questions that require fine temporal-scale accuracy (Blaauw et al., 2018).

## 2.5 Metadata

The database includes a large variety of metadata (Supplement Table S1) to facilitate analyses and reuse. The metadata included in this database are largely consistent with those developed and used in the Temperature 12k database (Kaufman et al., 2020a), with some refinement for hydroclimate-related records. Predominant metadata are subdivided into the following categories:

1. Geographic information includes “site name”, “latitude”, “longitude”, and “elevation”. Geodetic data are relative to the WGS84 (World Geodetic System 1984) ellipsoid and in units of decimal degrees. “Country ocean” is generated based on the NASA GCMD (Global Change Master Directory) convention.
2. Bibliographic information includes the DOI (digital object identifier) when available. The original study is typically referenced in “publication 1”. “Publication 2” generally corresponds to subsequent publications contributing to record development or reuse.

3. The original data source (“original data citation”) is the persistent identifier (URL, Uniform Resource Locator, or DOI) that connects to the publicly accessible repository (e.g., PANGAEA and NOAA WDS paleoclimatology when available). Fields with the entry “wNA<sub>m</sub>” correspond to records transferred to a public repository for the first time by this study. “Neotoma ID” includes the Neotoma dataset ID when available for the original assemblage data.
4. Metadata describing the proxy record include “archive type”, “proxy general”, “proxy type”, “proxy detail”, “calibration method”, and “paleo data notes”. Archive type corresponds to the physical archive (e.g., lake sediment, marine sediment, peat, and speleothem). Proxy general simplifies plotting figures by grouping similar proxies from proxy type. For example, proxy general for “other biomarkers” includes proxy type TEX86 (tetraether index of 86 carbon atoms) and GDGT (glycerol dialkyl glycerol tetraether) but not alkenones, which are treated separately. Proxy general for “biophysical” includes biogenic silica, tree-ring width, total organic content, chlorophyll, and macrofossils. Proxy general for “other microfossil” includes coccolith, diatom, dinocyst, and foraminifera. Pollen and chironomid records are treated separately. Proxy detail corresponds to specific species or material types. “Calibration method” is the statistical method used for proxy calibration. Paleo data notes include information from the original study to help users understand the proxy record.
5. For climate interpretation, primary “climate variables” include “*T*” (temperature), “*P*” (precipitation), and “*P-E*” (precipitation minus evaporation). Other climate indicators include “MODE” (climate modes such as ENSO), “upwelling” (coastal upwelling), “DUST” (dust deposition), “ICE” (sea ice extent), and “ELA” (glacier equilibrium line altitude). The “interpretation direction” is the sign relation (“positive” or “negative”) between the proxy value and the climate variable. Proxy records originally reported as *E-P* were cataloged as the climate variable of *P-E*, and the field interpretation direction was inverted from the original interpretation. “Variable name” corresponds to the specific variable type (e.g., “temperature” or “ $\delta^{18}\text{O}$ ”; oxygen-18 isotopes). “Units” correspond to the measurement unit specified in the variable name (e.g., “degC” or “permil”). “Climate variable detail” refines the climate variable field. Temperature records follow the structure of the variable sensed (e.g., “air”) at a specific level (e.g., “surface”). Examples include “air@surface”, “air@condensation”, and “sea@surface”. Hydroclimate and some other record types do not always conform as well to this format. Climate variable detail for these records specifies the variable sensed (e.g., “lake level”, “runoff”, “river flow”, and “amount”), at a specific level (e.g., surface). Examples include “lakeLevel@surface” and “runoff@surface”. If the variable sensed is the same as the climate variable (e.g., “precipitation”), the field is left blank. In these cases only the level is specified (e.g., “@surface”). In cases where the level was ambiguous, not specified, or not applicable (e.g., “soil moisture”, “lake salinity”, or “El Niño”), only the variable sensed was specified.
6. Seasonality information has been separated into two fields of “seasonality” and “seasonality general”. Seasonality includes the most specific seasonal information available including specific months in number format (July = “7”) or reconstructed seasons (e.g., “warmest month”, “summer”, “growing season”, “winter”, and “annual”). “Season general” distills season details into queryable seasons (“annual”, “summer only”, “summer+”, “winter only”, and “winter+”). Categories summer+ and winter+ indicate that another season (or annual) has also been reconstructed from the same site.
7. Metadata describing the underlying time series data include the youngest and oldest sample ages (“min year” and “max year”), the median sample resolution (“resolution”) over the past 12 000 years, and the frequency of age control points (“ages per kyr”), which includes radiocarbon and U-series (uranium) ages.
8. Quality control metadata include (“QC certification”) and (“QC comments”). QC certification includes the initials of the co-author of this data descriptor who was responsible for reviewing the screening criteria for records included in the data product. QC comments were written by the person who completed QC to improve reusability of the data.
9. Data access and visualization includes a website link for viewing and downloading the data in .csv (comma-separated value) or LiPD format (“link to LiPDverse”).

## 2.6 Database structure and format: Linked Paleo Data (LiPD)

The site-level data and metadata are formatted in the LiPD structure. The LiPD framework comprises JSON-formatted files that are machine-readable with MATLAB, Python, and R packages that enable rapid querying and data extraction (McKay and Emile-Geay, 2016). LiPD encodes the database into a structured hierarchy that allows for explicit descriptions at any level and aspect of the database. Code packages for evaluating the database can be accessed on GitHub (<https://github.com/nickmckay/LiPD-utilities>, last access: 29 March 2021).

## 2.7 Data visualization

A one-page dashboard for each record is included as a Supplement to this article. The dashboards include the primary information associated with each record including the location, the time series plot, bibliographic reference, and proxy data information (Supplemental dashboards). Each record is also linked to a web page (link to LiPDverse) where the data can be visualized and downloaded in LiPD or text versions. A globally distributed collection of paleoclimate LiPD files is housed at <https://lipdverse.org/> (last access: 29 March 2021). This western North American Holocene paleoclimate database is a subset of the records that can be found by choosing wNA in the LiPDverse browser. The full collection can also be accessed at [http://lipdverse.org/wNA/1\\_0\\_0/](http://lipdverse.org/wNA/1_0_0/) (last access: 29 March 2021).

## 3 Summary of database contents

### 3.1 Proxy records and climate variables

The western North American Holocene paleoclimate database includes proxy climate records from 184 different sites. Many “sites” (locations) are represented by more than one proxy “record” (time series). Multiple records from one site often represent different climate variables or reconstruction methods. Pollen assemblages, for example, are often translated into both temperature and moisture variables, sometimes for different seasons. The list of sites is shown by row in Table 1, whereas Supplement Table S1 contains a row for each record. In total, this database comprises 184 sites and 381 records.

The records are derived from nine archive types and are based on eight proxy categories (Supplement Table S1). The database includes 259 records from lake sediments, 58 records from marine sediment, and 64 other terrestrial.

The western North America database includes 84 records that are being transferred to a publicly accessible data repository for the first time with this data product. These include 61 “new” records as follows. Pollen ratio time series reflecting changes in the position of forest boundaries and long-term temperature change were calculated for 23 records. These ratios were computed by the original data generators following methods and rationale described in Jiménez-Moreno et al. (2019) and Johnson et al. (2013). The database also includes 20 precipitation records, which were generated by Marsicek et al. (2018) but not released with that publication. Finally, we have included 18 hydroclimate records based on subsets of packrat midden sites from Harbert and Nixon (2018), following the same methods applied for temperature reconstructions in Kaufman et al. (2020b). Briefly, the Climate Reconstruction Analysis using Coexistence Likelihood Estimation (CRACLE) method was used to infer absolute precipitation given the modern relationship between WorldClim climate data and packrat midden fos-

sil data. In the original paper (Harbert and Nixon, 2018), an overall MAT (mean annual temperature) anomaly that combines all sites is presented. This MAT is calculated by subtracting the WorldClim calibration data for each site and then averaging all inferred temperatures (across space) in discrete time intervals. Here we provide the absolute precipitation from CRACLE, without spatiotemporal averaging, and note that some of the inferred absolute precipitation appears more extreme than precipitation reconstructed from other proxies. For further details and code, please refer to Harbert and Nixon (2018). These midden records are noted in the QC comments column of Supplement Table S1.

The database contains 200 temperature-sensitive records; 150 hydroclimate sensitive records (e.g., precipitation, *P-E*, flood frequency, and streamflow); and 31 other records including upwelling, dust, climate mode, and sea ice extent. Marine records are primarily sea surface temperatures, but there are several marine records of other variables including sea ice extent, upwelling strength, and flood frequency. Many (228) of the proxy records are interpreted by the original authors to represent mean annual values of specific climate variables. Others represent individual seasons, primarily with some aspect of summer. Background information including the strengths, weaknesses, and underlying assumptions of the specific proxy types can be found in textbooks devoted to the topic (e.g., Bradley, 2015).

### 3.2 Geographic coverage

The geographic distribution of records within western North America is far from uniform (Fig. 1). The density of all sites is comparatively high in Alaska and the conterminous western United States. In contrast, Mexico is represented by few study sites, mainly because many studies failed to meet the inclusion criteria. Hydroclimate records have the most uniform coverage, albeit with a spatial gap in Mexico. The spatial distribution of temperature records has gaps in Canada, the midwestern United States, Texas, and continental Mexico.

### 3.3 Record length and temporal resolution

Median record duration is 10 725 years, not counting the duration of records beyond 12 000 years. Most of the records (94 %) extend back at least 6000 years, thereby including the frequently modeled 6 ka paleoclimate time slice. The median sample resolution of individual records in the database is 127 years (Fig. 2).

### 3.4 Geochronology

Original geochronologic data for each record are included in the database. The database includes 2353 individual age control points ( $^{14}\text{C}$ ,  $^{210}\text{Pb}$ , tephtras, etc.). Tree-ring age control points (two studies) were excluded from this number.

**Table 1.** Proxy records included in the database, listed alphabetically. See Supplement Table S1 for expanded metadata and links to the proxy time series and chronology data.

| Site name                                 | Lat   | Long    | Archive type   | Proxy*                | Original data citation (last access: 29 March 2021)                                                 | Reference                     |
|-------------------------------------------|-------|---------|----------------|-----------------------|-----------------------------------------------------------------------------------------------------|-------------------------------|
| 3M Pond                                   | 49.98 | −121.22 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Pellatt et al. (2000)         |
| 893A                                      | 34.29 | −120.04 | MarineSediment | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Kennett et al. (2007)         |
| Abalone                                   | 33.96 | −119.98 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Cole and Liu (1994)           |
| Alfonso Basin                             | 24.65 | −110.60 | MarineSediment | Coccolith             | wNA                                                                                                 | Staines-Urías et al. (2015)   |
| Andy                                      | 64.65 | −128.08 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Szeicz et al. (1995)          |
| Bald Lake                                 | 40.87 | −110.49 | LakeSediment   | Eu/Zr                 | wNA                                                                                                 | Munroe et al. (2020)          |
| Banks Island (74MS12)                     | 72.37 | −119.83 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Gajewski et al. (2000)        |
| Banks Island (74MS15)                     | 73.53 | −120.22 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Gajewski et al. (2000)        |
| Battleground                              | 45.80 | −122.49 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Barnosky (1985b)              |
| Beaver Lake                               | 42.46 | −100.67 | LakeSediment   | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/23075">http://www.ncdc.noaa.gov/paleo/study/23075</a> | Schmieder et al. (2011)       |
| Beef Pasture                              | 37.47 | −108.16 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Petersen (1985)               |
| Begbie Lake                               | 48.59 | −123.68 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown et al. (2019)           |
| Bells Lake                                | 65.02 | −127.48 | LakeSediment   | Pollen                | <a href="https://doi.org/10.21233/N35G6P">https://doi.org/10.21233/N35G6P</a>                       | Szeicz et al. (1995)          |
| Big Lake                                  | 51.67 | −121.45 | LakeSediment   | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/23089">http://www.ncdc.noaa.gov/paleo/study/23089</a> | Cumming et al. (2002)         |
| Bison Lake                                | 39.76 | −107.35 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/10749">http://www.ncdc.noaa.gov/paleo/study/10749</a> | L. Anderson (2011)            |
| Blue Lake                                 | 37.24 | −106.63 | LakeSediment   | XRF                   | <a href="http://www.ncdc.noaa.gov/paleo/study/27078">http://www.ncdc.noaa.gov/paleo/study/27078</a> | Routson et al. (2019b)        |
| Boomerang Lake                            | 49.18 | −124.16 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown et al. (2006)           |
| Boone                                     | 55.58 | −119.43 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | White and Mathewes (1986)     |
| Candelabra Lake                           | 61.68 | −130.65 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Cwynar and Spear (2007)       |
| Carleton Lake                             | 64.26 | −110.10 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/16296">http://www.ncdc.noaa.gov/paleo/study/16296</a> | Upton et al. (2014)           |
| Carp                                      | 45.92 | −120.88 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Barnosky (1985a)              |
| Cascade Fen                               | 37.65 | −107.81 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Maher (1963)                  |
| Castor Lake                               | 48.54 | −119.56 | LakeSediment   | Reflectance           | <a href="http://www.ncdc.noaa.gov/paleo/study/10310">http://www.ncdc.noaa.gov/paleo/study/10310</a> | Nelson et al. (2011)          |
| Castor Lake                               | 48.54 | −119.56 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/10310">http://www.ncdc.noaa.gov/paleo/study/10310</a> | Nelson et al. (2011)          |
| Chichancanab Lake                         | 19.83 | −88.75  | LakeSediment   | $\text{CaCO}_3$       | <a href="http://www.ncdc.noaa.gov/paleo/study/5483">http://www.ncdc.noaa.gov/paleo/study/5483</a>   | Hodell et al. (1995)          |
| Chichancanab Lake                         | 19.83 | −88.75  | LakeSediment   | S                     | <a href="http://www.ncdc.noaa.gov/paleo/study/5483">http://www.ncdc.noaa.gov/paleo/study/5483</a>   | Hodell et al. (1995)          |
| Chichancanab Lake                         | 19.83 | −88.75  | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5483">http://www.ncdc.noaa.gov/paleo/study/5483</a>   | Hodell et al. (1995)          |
| Chihuahuenos Bog                          | 36.05 | −106.51 | Peat           | Pollen                | wNA                                                                                                 | R. S. Anderson et al. (2008a) |
| Chitina Loess                             | 61.54 | −144.38 | Loess          | Particle size         | <a href="http://www.ncdc.noaa.gov/paleo/study/20529">http://www.ncdc.noaa.gov/paleo/study/20529</a> | Muhs et al. (2013)            |
| Cleland Lake                              | 50.83 | −116.39 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21250">http://www.ncdc.noaa.gov/paleo/study/21250</a> | Steinman et al. (2016)        |
| Cleland Lake                              | 50.83 | −116.39 | LakeSediment   | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21250">http://www.ncdc.noaa.gov/paleo/study/21250</a> | Steinman et al. (2016)        |
| Copley                                    | 38.87 | −107.08 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Fall (1997)                   |
| Corser Bog                                | 60.53 | −145.45 | Peat           | GDGT                  | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Nichols et al. (2014)         |
| Corser Bog                                | 60.53 | −145.45 | Peat           | $\delta\text{D}$      | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Nichols et al. (2014)         |
| Cottonwood Pass Pond                      | 38.83 | −106.41 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Fall (1997)                   |
| Crater Lake                               | 37.67 | −106.69 | LakeSediment   | Particle size         | wNA                                                                                                 | Arcusa et al. (2020)          |
| Crevice Lake                              | 45.00 | −110.58 | LakeSediment   | $\delta^{18}\text{O}$ | wNA                                                                                                 | Whitlock et al. (2012)        |
| Crevice Lake                              | 45.00 | −110.58 | LakeSediment   | $\text{CaCO}_3$       | wNA                                                                                                 | Whitlock et al. (2012)        |
| Cueva Diablo                              | 18.18 | −99.92  | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/10670">http://www.ncdc.noaa.gov/paleo/study/10670</a> | Bernal et al. (2011)          |
| Cumbres Bog                               | 37.02 | −106.45 | LakeSediment   | Pollen                | wNA                                                                                                 | Johnson et al. (2013)         |
| Dempster Hwy Peatland                     | 65.21 | −138.32 | Ice-other      | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Porter et al. (2019)          |
| DJ6-93SF-6                                | 37.63 | −122.37 | MarineSediment | Mg/Ca                 | wNA                                                                                                 | McGann (2008)                 |
| DSDP (Deep Sea Drilling Project) Site 480 | 27.90 | −111.65 | MarineSediment | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/5855">http://www.ncdc.noaa.gov/paleo/study/5855</a>   | Barron et al. (2004)          |
| DSDP Site 480                             | 27.90 | −111.65 | MarineSediment | BSi                   | <a href="http://www.ncdc.noaa.gov/paleo/study/5855">http://www.ncdc.noaa.gov/paleo/study/5855</a>   | Barron et al. (2004)          |
| Dune                                      | 64.42 | −149.90 | LakeSediment   | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/13076">http://www.ncdc.noaa.gov/paleo/study/13076</a> | Finney et al. (2012)          |
| Eldora Fen                                | 39.94 | −105.58 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | No publication on record      |
| Eleanor Lake                              | 47.68 | −124.02 | LakeSediment   | BSi                   | wNA                                                                                                 | Gavin et al. (2011)           |
| Emerald Lake                              | 39.15 | −106.41 | LakeSediment   | Stratigraphy          | <a href="http://www.ncdc.noaa.gov/paleo/study/23079">http://www.ncdc.noaa.gov/paleo/study/23079</a> | Shuman et al. (2014)          |
| Emerald Lake                              | 39.15 | −106.41 | LakeSediment   | Pollen                | wNA                                                                                                 | Jiménez-Moreno et al. (2019)  |
| EN32_PC6                                  | 26.95 | −91.35  | MarineSediment | Mg/Ca                 | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Flower et al. (2004)          |
| EN32_PC6                                  | 26.95 | −91.35  | MarineSediment | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Flower et al. (2004)          |
| Enos Lake                                 | 49.28 | −124.15 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown et al. (2006)           |
| EW0408_66JC                               | 57.87 | −137.10 | MarineSediment | Alkenone              | <a href="http://www.ncdc.noaa.gov/paleo/study/22400">http://www.ncdc.noaa.gov/paleo/study/22400</a> | Praetorius et al. (2015)      |
| EW0408_66JC                               | 57.87 | −137.10 | MarineSediment | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/22400">http://www.ncdc.noaa.gov/paleo/study/22400</a> | Praetorius et al. (2015)      |
| EW0408_85JC                               | 59.56 | −144.15 | MarineSediment | Alkenone              | <a href="http://www.ncdc.noaa.gov/paleo/study/21950">http://www.ncdc.noaa.gov/paleo/study/21950</a> | Praetorius et al. (2015)      |
| EW0408_85JC                               | 59.56 | −144.15 | MarineSediment | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21950">http://www.ncdc.noaa.gov/paleo/study/21950</a> | Praetorius et al. (2015)      |
| EW0408-87JC                               | 58.77 | −144.50 | MarineSediment | Alkenone              | wNA                                                                                                 | Praetorius et al. (2020)      |
| Farewell Lake                             | 62.55 | −153.63 | LakeSediment   | Mg/Ca                 | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Hu et al. (1998)              |
| Felker Lake                               | 51.95 | −122.00 | LakeSediment   | Diatom                | wNA                                                                                                 | Galloway et al. (2011)        |
| Ferndale                                  | 34.41 | −95.81  | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Albert and Wyckoff (1981)     |
| Foy Lake                                  | 48.20 | −114.40 | LakeSediment   | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/6188">http://www.ncdc.noaa.gov/paleo/study/6188</a>   | Stone and Fritz (2006)        |
| Frozen Lake                               | 49.60 | −121.47 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Rosenberg et al. (2004)       |
| GGC19                                     | 72.16 | −155.51 | MarineSediment | Dinocyst              | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Farmer et al. (2011)          |
| Great Basin                               | 38.00 | −116.50 | Wood           | TRW                   | <a href="http://www.ncdc.noaa.gov/paleo/study/17056">http://www.ncdc.noaa.gov/paleo/study/17056</a> | Salzer et al. (2014)          |
| Greyling Lake                             | 61.38 | −145.74 | LakeSediment   | TOC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | McKay and Kaufman (2009)      |
| Grutas del Rey Marcos                     | 15.43 | −90.28  | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/28351">http://www.ncdc.noaa.gov/paleo/study/28351</a> | Winter et al. (2020)          |
| Guaymas Basin                             | 27.48 | −112.07 | MarineSediment | $\delta\text{D}$      | <a href="http://www.ncdc.noaa.gov/paleo/study/24890">http://www.ncdc.noaa.gov/paleo/study/24890</a> | Bhattacharya et al. (2018)    |
| Guaymas Basin                             | 27.48 | −112.07 | MarineSediment | $\delta\text{D}$      | <a href="http://www.ncdc.noaa.gov/paleo/study/24890">http://www.ncdc.noaa.gov/paleo/study/24890</a> | Bhattacharya et al. (2018)    |
| Gulf of Mexico                            | 27.18 | −91.42  | MarineSediment | Foraminifera          | wNA                                                                                                 | Poore et al. (2005)           |
| Hail Lake                                 | 60.03 | −129.02 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Cwynar and Spear (2007)       |
| Hallet Lake                               | 61.49 | −146.24 | LakeSediment   | TOC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | McKay and Kaufman (2009)      |
| Hallet Lake                               | 61.49 | −146.24 | LakeSediment   | BSi                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | McKay and Kaufman (2009)      |
| Hanging Lake                              | 68.38 | −138.38 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Cwynar (1982)                 |
| Harding Lake                              | 64.42 | −146.85 | LakeSediment   | TOC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15655">http://www.ncdc.noaa.gov/paleo/study/15655</a> | Finkenbinder et al. (2014)    |
| Harding Lake                              | 64.42 | −146.85 | LakeSediment   | MS                    | <a href="http://www.ncdc.noaa.gov/paleo/study/15655">http://www.ncdc.noaa.gov/paleo/study/15655</a> | Finkenbinder et al. (2014)    |
| Heal Lake                                 | 48.54 | −123.46 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown et al. (2006)           |
| Hermit Lake                               | 38.09 | −105.63 | LakeSediment   | Pollen                | wNA                                                                                                 | R. S. Anderson et al. (2019)  |
| Hidden Lake, CA                           | 38.26 | −119.54 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Potito et al. (2006)          |

Table 1. Continued.

| Site name                 | Lat   | Long    | Archive type   | Proxy*                | Original data citation (last access: 29 March 2021)                                                                       | Reference                          |
|---------------------------|-------|---------|----------------|-----------------------|---------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| Hidden Lake, CO           | 40.51 | −106.61 | LakeSediment   | Stratigraphy          | <a href="http://www.ncdc.noaa.gov/paleo/study/23077">http://www.ncdc.noaa.gov/paleo/study/23077</a>                       | Shuman et al. (2009)               |
| HLY0501                   | 72.69 | −157.52 | MarineSediment | Dinocyst              | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | de Vernal et al. (2013)            |
| Honeymoon                 | 64.63 | −138.40 | LakeSediment   | Pollen                | <a href="https://doi.org/10.21233/N33Q7V">https://doi.org/10.21233/N33Q7V</a>                                             | Cwynar and Spear (1991)            |
| Hudson, AK                | 61.90 | −145.67 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | Clegg et al. (2011)                |
| Hunters Lake              | 37.61 | −106.84 | LakeSediment   | Pollen                | wNAam                                                                                                                     | R. S. Anderson et al. (2008b)      |
| Jellybean Lake            | 60.35 | −134.80 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5445">http://www.ncdc.noaa.gov/paleo/study/5445</a>                         | L. Anderson et al. (2005)          |
| Jenny Lake                | 43.75 | −110.73 | LakeSediment   | TIC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/20128">http://www.ncdc.noaa.gov/paleo/study/20128</a>                       | Larsen et al. (2016)               |
| Jones Lake                | 47.05 | −113.14 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/23076">http://www.ncdc.noaa.gov/paleo/study/23076</a>                       | Shapley et al. (2009)              |
| Keele                     | 64.17 | −127.62 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Szeicz et al. (1995)               |
| Keystone Iron Bog         | 38.87 | −107.03 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Fall (1985)                        |
| Kirman Lake               | 38.34 | −119.50 | LakeSediment   | Diatom                | <a href="http://dataverse.harvard.edu/dataverse/UCLAGMacDonald">http://dataverse.harvard.edu/dataverse/UCLAGMacDonald</a> | MacDonald et al. (2016)            |
| Kite Lake                 | 39.33 | −106.13 | LakeSediment   | Pollen                | wNAam                                                                                                                     | Jiménez-Moreno and Anderson (2013) |
| KNR159_JPC26              | 26.37 | −92.03  | MarineSediment | Mg/Ca                 | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Antonarakou et al. (2015)          |
| KNR159_JPC26              | 26.37 | −92.03  | MarineSediment | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Antonarakou et al. (2015)          |
| Koksilah River            | 48.76 | −123.68 | LakeSediment   | Pollen                | wNAam                                                                                                                     | Brown and Schoups (2015)           |
| Kurupa Lake               | 68.35 | −154.61 | LakeSediment   | Chlorophyll           | <a href="http://www.ncdc.noaa.gov/paleo/study/18995">http://www.ncdc.noaa.gov/paleo/study/18995</a>                       | Boldt et al. (2015)                |
| Kusawa                    | 60.28 | −136.18 | LakeSediment   | BSi                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | Chakraborty et al. (2010)          |
| Lac Meleze                | 65.22 | −126.12 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | MacDonald (1987)                   |
| Lago Minucua              | 17.08 | −97.61  | LakeSediment   | MS                    | wNAam                                                                                                                     | Goman et al. (2018)                |
| Lago Minucua              | 17.08 | −97.61  | LakeSediment   | Varve                 | wNAam                                                                                                                     | Goman et al. (2018)                |
| Lago Puerto Arturo        | 17.53 | −90.18  | LakeSediment   | $\delta^{18}\text{O}$ | wNAam                                                                                                                     | Wahl et al. (2014)                 |
| Laguna de Aljojuca        | 19.09 | −97.53  | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/17735">http://www.ncdc.noaa.gov/paleo/study/17735</a>                       | Bhattacharya et al. (2015)         |
| Laguna de Juancatlan      | 20.63 | −104.74 | LakeSediment   | Ti                    | wNAam                                                                                                                     | Jones et al. (2015)                |
| Lake Elsinore             | 33.67 | −117.35 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/30232">http://www.ncdc.noaa.gov/paleo/study/30232</a>                       | Kirby et al. (2019)                |
| Lake Elsinore             | 33.67 | −117.35 | LakeSediment   | Particle size         | <a href="http://www.ncdc.noaa.gov/paleo/study/30232">http://www.ncdc.noaa.gov/paleo/study/30232</a>                       | Kirby et al. (2019)                |
| Lake of the Woods         | 43.48 | −109.89 | LakeSediment   | Stratigraphy          | wNAam                                                                                                                     | Pribyl and Shuman (2014)           |
| Lake of the Woods         | 49.05 | −120.18 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Palmer et al. (2002)               |
| Lehman Caves              | 39.00 | −114.22 | Speleothem     | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/19038">http://www.ncdc.noaa.gov/paleo/study/19038</a>                       | Steponaitis et al. (2015)          |
| Lehman Caves              | 39.00 | −114.22 | Speleothem     | Mg/Ca                 | <a href="http://www.ncdc.noaa.gov/paleo/study/19038">http://www.ncdc.noaa.gov/paleo/study/19038</a>                       | Steponaitis et al. (2015)          |
| Leviathan                 | 37.89 | −115.58 | Speleothem     | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/16517">http://www.ncdc.noaa.gov/paleo/study/16517</a>                       | Lachniet et al. (2014)             |
| Leviathan                 | 37.89 | −115.58 | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/16517">http://www.ncdc.noaa.gov/paleo/study/16517</a>                       | Lachniet et al. (2014)             |
| Lily                      | 59.20 | −135.40 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | Cwynar (1990)                      |
| Lime Lake                 | 48.87 | −117.34 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21250">http://www.ncdc.noaa.gov/paleo/study/21250</a>                       | Steinman et al. (2016)             |
| Lime Lake                 | 48.87 | −117.34 | LakeSediment   | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21250">http://www.ncdc.noaa.gov/paleo/study/21250</a>                       | Steinman et al. (2016)             |
| Little                    | 44.17 | −123.58 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Worona and Whitlock (1995)         |
| Little Molas Lake         | 37.74 | −107.71 | LakeSediment   | Pollen                | wNAam                                                                                                                     | Toney and Anderson (2006)          |
| Little Windy              | 41.43 | −106.33 | LakeSediment   | Stratigraphy          | <a href="http://www.ncdc.noaa.gov/paleo/study/16096">http://www.ncdc.noaa.gov/paleo/study/16096</a>                       | Minckley et al. (2012)             |
| Logan                     | 60.58 | −140.50 | Glacierice     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | Fisher et al. (2008)               |
| Lone Fox Lake             | 56.72 | −119.72 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | MacDonald and Cwynar (1985)        |
| Lone Spruce               | 60.01 | −159.14 | LakeSediment   | BSi                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | Kaufman et al. (2012)              |
| Louise Pond               | 52.95 | −131.76 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Pellatt and Mathewes (1994)        |
| Lowder Creek Bog          | 37.66 | −112.77 | Peat           | Pollen                | wNAam                                                                                                                     | R. S. Anderson et al. (1999)       |
| Lower Bear Lake           | 34.20 | −116.90 | LakeSediment   | TOC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/13215">http://www.ncdc.noaa.gov/paleo/study/13215</a>                       | Kirby et al. (2012)                |
| Lower Bear Lake           | 34.20 | −116.90 | LakeSediment   | C/N                   | <a href="http://www.ncdc.noaa.gov/paleo/study/13215">http://www.ncdc.noaa.gov/paleo/study/13215</a>                       | Kirby et al. (2012)                |
| M Lake                    | 68.27 | −133.47 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Ritchie (1977)                     |
| Macal Chasm               | 16.88 | −89.11  | Speleothem     | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/20506">http://www.ncdc.noaa.gov/paleo/study/20506</a>                       | Akers et al. (2016)                |
| Macal Chasm               | 16.88 | −89.11  | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/20506">http://www.ncdc.noaa.gov/paleo/study/20506</a>                       | Akers et al. (2016)                |
| Macal Chasm               | 16.88 | −89.11  | Speleothem     | Reflectance           | <a href="http://www.ncdc.noaa.gov/paleo/study/20506">http://www.ncdc.noaa.gov/paleo/study/20506</a>                       | Akers et al. (2016)                |
| Marcella                  | 60.07 | −133.81 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/6066">http://www.ncdc.noaa.gov/paleo/study/6066</a>                         | L. Anderson et al. (2007)          |
| Marion                    | 49.31 | −122.55 | LakeSediment   | Pollen                | wNAam                                                                                                                     | Mathewes (1973)                    |
| Marshall Lake             | 40.68 | −110.87 | LakeSediment   | Ca/Ti                 | wNAam                                                                                                                     | Munroe et al. (2020)               |
| MD02_2503                 | 34.39 | −120.04 | MarineSediment | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5582">http://www.ncdc.noaa.gov/paleo/study/5582</a>                         | Hill et al. (2006)                 |
| MD02_2515                 | 27.48 | −112.07 | MarineSediment | Alkenone              | <a href="https://doi.org/10.1594/PANGAEA.861260">https://doi.org/10.1594/PANGAEA.861260</a>                               | McClymont et al. (2012)            |
| MD02_2515                 | 27.48 | −112.07 | MarineSediment | GDGT                  | <a href="https://doi.org/10.1594/PANGAEA.861260">https://doi.org/10.1594/PANGAEA.861260</a>                               | McClymont et al. (2012)            |
| MD02-2499                 | 41.65 | −124.94 | MarineSediment | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/24150">http://www.ncdc.noaa.gov/paleo/study/24150</a>                       | Lopes and Mix (2018)               |
| Meli Lake                 | 68.68 | −149.08 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5469">http://www.ncdc.noaa.gov/paleo/study/5469</a>                         | L. Anderson et al. (2001)          |
| Mexican Marin             | 22.23 | −107.05 | MarineSediment | $\delta\text{D}$      | <a href="http://www.ncdc.noaa.gov/paleo/study/24890">http://www.ncdc.noaa.gov/paleo/study/24890</a>                       | Bhattacharya et al. (2018)         |
| Mica Lake                 | 60.95 | −148.15 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/6202">http://www.ncdc.noaa.gov/paleo/study/6202</a>                         | Schiff et al. (2009)               |
| Midden Cluster 1          | 37.90 | −110.13 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 2          | 36.38 | −115.19 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 3          | 36.06 | −108.08 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 4          | 43.65 | −112.75 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 5          | 32.47 | −106.02 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 6          | 32.47 | −106.02 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 7          | 34.15 | −116.00 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 8          | 32.31 | −109.10 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Midden Cluster 9          | 31.64 | −115.55 | Midden         | Macrofossils          | <a href="http://geochange.er.usgs.gov/midden/">http://geochange.er.usgs.gov/midden/</a>                                   | Harbert and Nixon (2018)           |
| Minnetonka Cave           | 42.09 | −111.52 | Speleothem     | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/23097">http://www.ncdc.noaa.gov/paleo/study/23097</a>                       | Lundeen et al. (2013)              |
| Minnetonka Cave           | 42.09 | −111.52 | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/23097">http://www.ncdc.noaa.gov/paleo/study/23097</a>                       | Lundeen et al. (2013)              |
| Moose Lake                | 61.37 | −143.60 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a>                       | Clegg et al. (2010)                |
| Morris Pond               | 37.67 | −112.77 | LakeSediment   | Pollen                | wNAam                                                                                                                     | Morris et al. (2013)               |
| Mv0811-14JC               | 34.30 | −120.00 | MarineSediment | Stratigraphy          | wNAam                                                                                                                     | Du et al. (2018)                   |
| MV99_PC14                 | 25.20 | −112.72 | MarineSediment | Mg/Ca                 | <a href="http://www.ncdc.noaa.gov/paleo/study/10415">http://www.ncdc.noaa.gov/paleo/study/10415</a>                       | Marchitto et al. (2010)            |
| MV99-GC31                 | 23.47 | −111.60 | MarineSediment | BSi                   | <a href="https://doi.org/10.1594/PANGAEA.824830">https://doi.org/10.1594/PANGAEA.824830</a>                               | Barron et al. (2012)               |
| MV99-GC41/PC14            | 25.20 | −112.72 | MarineSediment | Particle size         | <a href="https://doi.org/10.1594/PANGAEA.896898">https://doi.org/10.1594/PANGAEA.896898</a>                               | Arellano-Torres et al. (2019)      |
| Natural Bridge Caverns    | 29.69 | −98.34  | Speleothem     | Sr                    | wNAam                                                                                                                     | Wong et al. (2015)                 |
| Nevada Climate Division 3 | 37.80 | −115.80 | Wood           | TRW                   | <a href="http://www.ncdc.noaa.gov/paleo/study/6384">http://www.ncdc.noaa.gov/paleo/study/6384</a>                         | Hughes and Graumlich (1996)        |
| North Crater Lake         | 49.07 | −120.02 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a>                       | Palmer et al. (2002)               |
| ODP_I67_1019C             | 41.68 | −124.93 | MarineSediment | Alkenone              | <a href="https://doi.org/10.1594/PANGAEA.841946">https://doi.org/10.1594/PANGAEA.841946</a>                               | Barron et al. (2003b)              |

Table 1. Continued.

| Site name                | Lat   | Long    | Archive type   | Proxy*                | Original data citation (last access: 29 March 2021)                                                 | Reference                     |
|--------------------------|-------|---------|----------------|-----------------------|-----------------------------------------------------------------------------------------------------|-------------------------------|
| ODP1019                  | 41.68 | −124.93 | MarineSediment | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/24150">http://www.ncdc.noaa.gov/paleo/study/24150</a> | Lopes and Mix (2018)          |
| ODP1019                  | 41.68 | −124.93 | MarineSediment | CaCO <sub>3</sub>     | <a href="http://www.ncdc.noaa.gov/paleo/study/5867">http://www.ncdc.noaa.gov/paleo/study/5867</a>   | Barron et al. (2003b)         |
| ODP1019                  | 41.68 | −124.93 | MarineSediment | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/5867">http://www.ncdc.noaa.gov/paleo/study/5867</a>   | Barron et al. (2003b)         |
| Oregon Caves             | 42.08 | −123.42 | Speleothem     | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/13543">http://www.ncdc.noaa.gov/paleo/study/13543</a> | Ersek et al. (2012)           |
| Oregon Caves             | 42.08 | −123.42 | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/13543">http://www.ncdc.noaa.gov/paleo/study/13543</a> | Ersek et al. (2012)           |
| Oro Lake                 | 49.78 | −105.35 | LakeSediment   | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/23073">http://www.ncdc.noaa.gov/paleo/study/23073</a> | Michels et al. (2007)         |
| Owens Lake               | 36.44 | −117.97 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5472">http://www.ncdc.noaa.gov/paleo/study/5472</a>   | Benson et al. (2002)          |
| P1B3                     | 73.68 | −162.66 | MarineSediment | Dinocyst              | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | de Vernal et al. (2005)       |
| Paradise                 | 54.69 | −122.62 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21250">http://www.ncdc.noaa.gov/paleo/study/21250</a> | Steinman et al. (2016)        |
| Paradise                 | 54.69 | −122.62 | LakeSediment   | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/21250">http://www.ncdc.noaa.gov/paleo/study/21250</a> | Steinman et al. (2016)        |
| Park Pond 1              | 43.47 | −109.96 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Lynch (1998)                  |
| Pink Panther             | 32.08 | −105.17 | Speleothem     | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/9739">http://www.ncdc.noaa.gov/paleo/study/9739</a>   | Asmerom et al. (2007)         |
| Pixie                    | 48.60 | −124.20 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Brown and Hebda (2002)        |
| Pixie Lake               | 48.60 | −124.20 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown et al. (2006)           |
| Posy                     | 37.94 | −111.70 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Shafer (1989)                 |
| PS1410-06GC              | 37.33 | −123.40 | MarineSediment | Pollen                | wNA                                                                                                 | Barron et al. (2018)          |
| PS1410-06GC              | 37.33 | −123.40 | MarineSediment | BSi                   | wNA                                                                                                 | Barron et al. (2018)          |
| Pyramid Lake             | 40.07 | −119.58 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5472">http://www.ncdc.noaa.gov/paleo/study/5472</a>   | Benson et al. (2002)          |
| Quartz                   | 64.21 | −145.81 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Wooler et al. (2012)          |
| Rainbow                  | 60.72 | −150.80 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Clegg et al. (2011)           |
| Rainbow Lake             | 44.94 | −109.50 | LakeSediment   | Stratigraphy          | wNA                                                                                                 | Shuman and Marsicek (2016)    |
| Ranger                   | 67.15 | −153.65 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Brubaker et al. (1983)        |
| Rantin Lake              | 60.03 | −129.03 | LakeSediment   | CaCO <sub>3</sub>     | <a href="http://www.ncdc.noaa.gov/paleo/study/13095">http://www.ncdc.noaa.gov/paleo/study/13095</a> | Pompeani et al. (2012)        |
| Rapid                    | 42.73 | −109.19 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Fall (1988)                   |
| RC12-10                  | 23.00 | −95.53  | MarineSediment | Foraminifera          | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Poore et al. (2003)           |
| Red Rock                 | 40.08 | −105.54 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Maher (1972)                  |
| Rhamnus Lake             | 48.63 | −123.72 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown et al. (2006)           |
| San Juan River Discharge | 48.58 | −124.31 | LakeSediment   | Pollen                | wNA                                                                                                 | Brown and Schoups (2015)      |
| Schellings Bog           | 40.28 | −123.36 | LakeSediment   | Pollen                | wNA                                                                                                 | Barron et al. (2003a)         |
| Screaming Lynx Lake      | 66.07 | −145.40 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Clegg et al. (2011)           |
| Silver Lake              | 35.37 | −116.14 | LakeSediment   | Particle size         | <a href="http://www.ncdc.noaa.gov/paleo/study/20106">http://www.ncdc.noaa.gov/paleo/study/20106</a> | Kirby et al. (2015)           |
| Silver Lake              | 35.37 | −116.14 | LakeSediment   | C/N                   | <a href="http://www.ncdc.noaa.gov/paleo/study/20106">http://www.ncdc.noaa.gov/paleo/study/20106</a> | Kirby et al. (2015)           |
| Southern California      | 33.77 | −116.66 | Peat           | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Ohlwein and Wahl (2012)       |
| Station 803              | 70.63 | −135.88 | MarineSediment | Dinocyst              | <a href="http://www.ncdc.noaa.gov/paleo/study/27910">http://www.ncdc.noaa.gov/paleo/study/27910</a> | Bringué and Rochon (2012)     |
| Stella Lake              | 39.01 | −114.32 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Reinemann et al. (2009)       |
| Stewart Bog              | 35.83 | −105.72 | Peat           | Pollen                | wNA                                                                                                 | Jiménez-Moreno et al. (2008)  |
| Stowell Lake             | 48.78 | −123.44 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Lemmen and Lacourse (2018)    |
| Swan Lake                | 42.16 | −99.03  | LakeSediment   | Diatom                | wNA                                                                                                 | Schmieder et al. (2011)       |
| Swasey Lake              | 40.67 | −110.47 | LakeSediment   | Ca/Ti                 | wNA                                                                                                 | Munroe et al. (2020)          |
| Takahula                 | 67.35 | −153.67 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/8663">http://www.ncdc.noaa.gov/paleo/study/8663</a>   | Clegg and Hu (2010)           |
| Tangled Up Lake          | 67.67 | −149.08 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/5469">http://www.ncdc.noaa.gov/paleo/study/5469</a>   | L. Anderson et al. (2001)     |
| Taylor Lake              | 40.79 | −110.09 | LakeSediment   | Ca/Ti                 | wNA                                                                                                 | Munroe et al. (2020)          |
| Tiago Lake               | 40.58 | −106.61 | LakeSediment   | Pollen                | wNA                                                                                                 | Jiménez-Moreno et al. (2011)  |
| TN062-0550               | 40.87 | −124.57 | MarineSediment | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Barron et al. (2018)          |
| TN062-0550               | 40.87 | −124.57 | MarineSediment | BSi                   | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Addison et al. (2018)         |
| TN062-0550               | 40.87 | −124.57 | MarineSediment | $\delta^{18}\text{C}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Addison et al. (2018)         |
| TN062-0550               | 40.87 | −124.57 | MarineSediment | $\delta^{15}\text{N}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Addison et al. (2018)         |
| Trout Lake               | 68.83 | −138.75 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Irvine et al. (2012)          |
| Upper Big Creek Lake     | 40.91 | −106.62 | LakeSediment   | Stratigraphy          | wNA                                                                                                 | Shuman et al. (2015)          |
| Upper Fly                | 61.07 | −138.09 | LakeSediment   | Pollen                | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Bunbury and Gajewski (2009)   |
| Upper Pinto Fen          | 53.58 | −118.02 | Peat           | DBD                   | <a href="http://www.ncdc.noaa.gov/paleo/study/13665">http://www.ncdc.noaa.gov/paleo/study/13665</a> | Yu et al. (2003)              |
| W8709-13PC               | 42.12 | −125.75 | MarineSediment | Diatom                | <a href="http://www.ncdc.noaa.gov/paleo/study/24150">http://www.ncdc.noaa.gov/paleo/study/24150</a> | Lopes and Mix (2018)          |
| WA01                     | 61.24 | −136.93 | LakeSediment   | TOC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/18435">http://www.ncdc.noaa.gov/paleo/study/18435</a> | Rainville and Gajewski (2013) |
| Waskey Lake              | 59.88 | −159.21 | LakeSediment   | TOC                   | <a href="http://www.ncdc.noaa.gov/paleo/study/15444">http://www.ncdc.noaa.gov/paleo/study/15444</a> | Levy et al. (2004)            |
| Windy Lake               | 49.81 | −117.88 | LakeSediment   | Chironomid            | <a href="http://www.ncdc.noaa.gov/paleo/study/27330">http://www.ncdc.noaa.gov/paleo/study/27330</a> | Chase et al. (2008)           |
| Wolverine Lake           | 67.10 | −158.91 | LakeSediment   | MAR                   | <a href="http://www.ncdc.noaa.gov/paleo/study/23070">http://www.ncdc.noaa.gov/paleo/study/23070</a> | Mann et al. (2002)            |
| Yellow Lake              | 39.65 | −107.35 | LakeSediment   | $\delta^{18}\text{O}$ | <a href="http://www.ncdc.noaa.gov/paleo/study/13120">http://www.ncdc.noaa.gov/paleo/study/13120</a> | L. Anderson (2012)            |

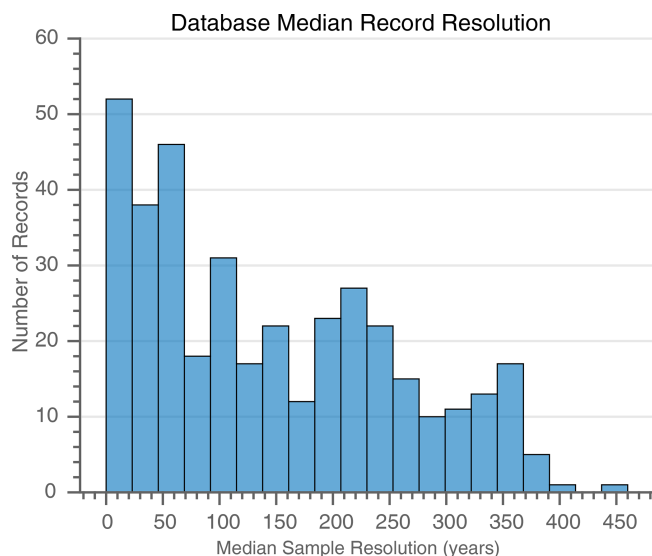
\* Abbreviations for proxy types: biogenic silica (BSi), calcium carbonate (CaCO<sub>3</sub>), dry bulk density (DBD), glycerol dialkyl glycerol tetraether (GDGT), mass accumulation rate (MAR), magnesium/calcium (Mg/Ca), sulfur (S), strontium (Sr), total organic carbon (TOC), tree-ring width (TRW), titanium (Ti), carbon-13 isotopes ( $\delta^{13}\text{C}$ ), oxygen-18 isotopes ( $\delta^{18}\text{O}$ ), and deuterium isotopes of leaf wax ( $\delta\text{D}$ ).

These primary age controls can be used to recalculate the age models for all of the  $^{14}\text{C}$ -based sedimentary sequences and U-series-based speleothems using a systematic approach to addressing age uncertainty.

### 3.5 Uncertainties

A variety of approaches have been used to characterize uncertainties in paleoclimate variables, and there is no standard procedure for either calculating or reporting uncertainties (Sweeney et al., 2018). Generally, calibration and other uncertainties are large relative to the small amplitude of most

Holocene climate change, but these uncertainties are less important when investigating the relative magnitude of climate changes rather than the absolute value of a climate variable. Uncertainty arising from differences among records can be explored using a bootstrapped sampling with a replacement approach (e.g., Boos, 2003; Routson et al., 2019a); however, these ranges reflect a combination of record-level uncertainty and regional climate heterogeneity. In this database we are following other syntheses (Kaufman et al., 2020b; Marcott et al., 2013; Routson et al., 2019a) by applying a single uncertainty estimate for each proxy type (Supplement Table S1).



**Figure 2.** Median sample resolution for all records in the database (20-year intervals).

Proxy-specific uncertainties for temperature records follow Kaufman et al. (2020b), as did our approach for calculating uncertainty estimates for the hydroclimate records. For the calibrated hydroclimate records (primarily pollen based), we have calculated average RMSE values from the following references within or adjacent to the study region (Brown et al., 2006; Brown and Schoups, 2015, 2019; Harbert and Nixon, 2018; Marsicek et al., 2013). For the 163 uncalibrated records we have estimated the error as  $\pm 1$  SD (standard deviation) of the Holocene values.

### 3.6 Summarizing major trends

Recognizing major climatological differences across the study domain (spanning from tropical Mexico to Arctic Alaska), we have summarized some dominant patterns in the database including climate variables (temperature and hydroclimate), proxy group, and season. Dominant temperature and hydroclimate patterns by proxy group as specified in proxy general in Supplement Table S1 were evaluated (Fig. 3). Only proxy groups with more than 10 records were considered. The records were screened by season to include one record per site (“season general” for “annual” or “summer only” or “winter only”). Records were then binned to 500-year resolution by averaging data points within respective intervals, normalized to a mean of zero and 1 SD variance ( $z$  scores), and composited using the median to minimize the influence of outliers. Dominant temperature proxies include chironomids ( $n = 15$ ), biophysical ( $n = 17$ ), pollen ( $n = 130$ ), and isotopes ( $n = 14$ ). Chironomids show peak warmth in the Early Holocene (ca. 10 ka), followed by a Holocene cooling trend. Biophysical records have more variability, with peak warming at ca. 7 ka. Pollen records show

relatively low Holocene variability, with peak warming at ca. 6 ka. Isotopes have the highest Holocene variability and the lowest sample depth and show two intervals of warming (ca. 9 and 4 ka). Dominant hydroclimate proxies include other microfossils ( $n = 11$ ), biophysical records ( $n = 46$ ), pollen ( $n = 57$ ), and isotopes ( $n = 35$ ). Other microfossils show variable Holocene conditions, with the wettest period in the Early Holocene. This interval however, has very low sample depth. Biophysical records show only small Holocene hydroclimate changes. Pollen records show a strong Holocene wetting trend, whereas isotope records show variable conditions.

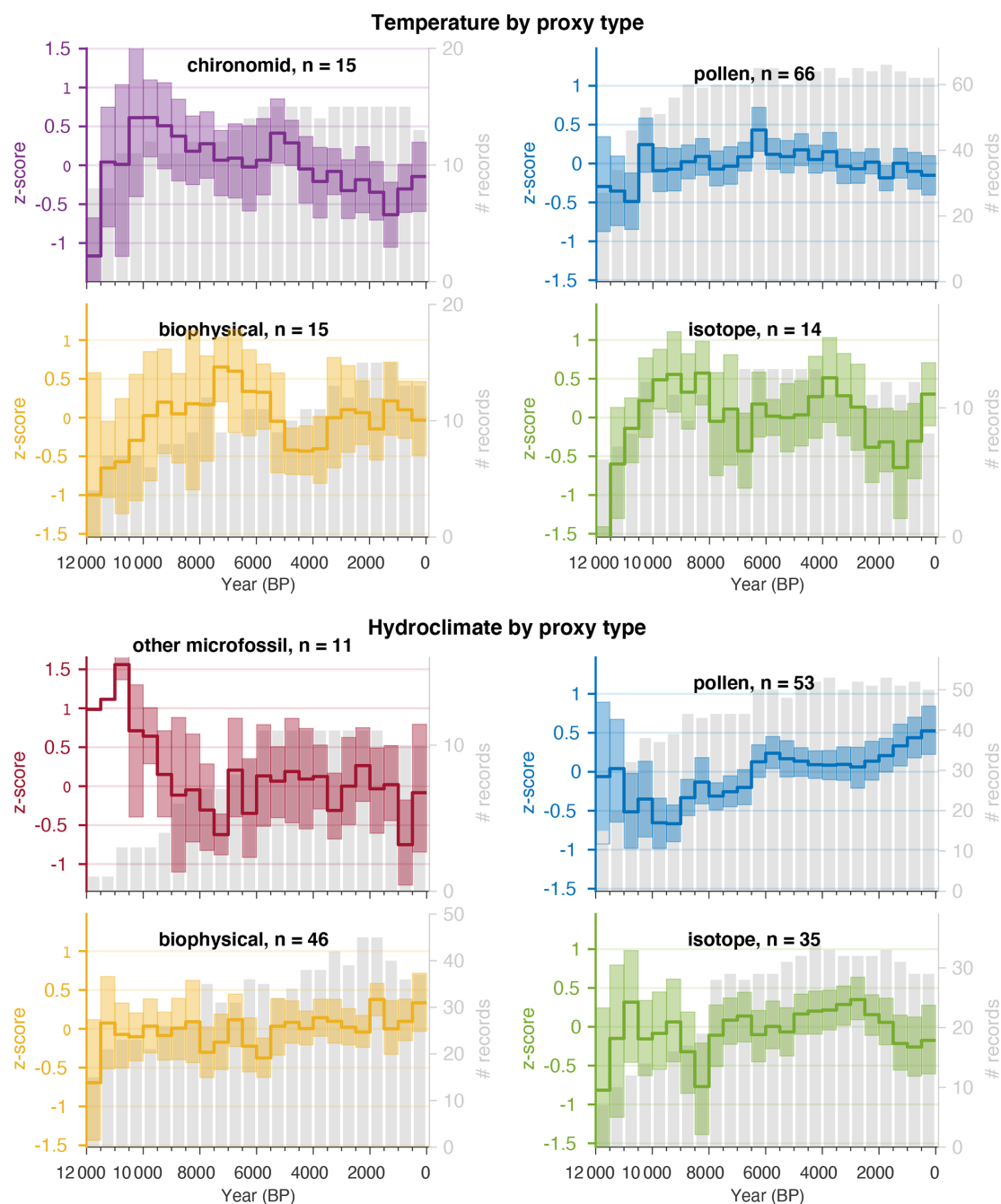
Temperature and hydroclimate trends were compared by summer, winter, and annual seasons (Fig. 4). The records were binned to 500-year resolution by averaging data points within respective intervals and normalized to a mean of zero and 1 SD variance ( $z$  scores). Records were then averaged into equal-area ( $127\,525\text{ km}^2$ ) grids following Routson et al. (2019a). The grids were then combined into a single composite using the median. The most recent 500-year bin was then subtracted, registering the present end to zero. This was done to help compare the seasonal Holocene evolutions. In the Early to Middle Holocene (ca 12 to 6 ka), summertime and annual temperatures warmed faster than wintertime temperatures, consistent with Northern Hemisphere seasonal insolation forcing (Berger and Loutre, 1991). Temperatures in all seasons show a cooling pattern from ca. 6 ka to the present. Hydroclimate composites show a Holocene-length wetting trend in all seasons, with the largest trend in winter-time.

## 4 Code and data availability

The database is available for download at <https://doi.org/10.6084/m9.figshare.12863843.v1> (Routson and McKay, 2020), with serializations for MATLAB and R. We recommend accessing the database through the WDS-NOAA landing page where any subsequent versions will be made available: <https://www.ncdc.noaa.gov/paleo/study/30535> (last access: 8 April 2021). Supplement Table S1 lists the essential metadata. Data can also be viewed and accessed at [http://lipdverse.org/wNA/m/1\\_0\\_0/](http://lipdverse.org/wNA/m/1_0_0/) (last access: 29 March 2021). Code, including basic functions for analyzing LiPD files in three programming languages, is available on GitHub (<https://github.com/nickmckay/LiPD-utilities>, last access: 15 April 2021) and Zenodo (<https://doi.org/10.5281/zenodo.1256889>, Heiser et al., 2018).

## 5 Use and limitations

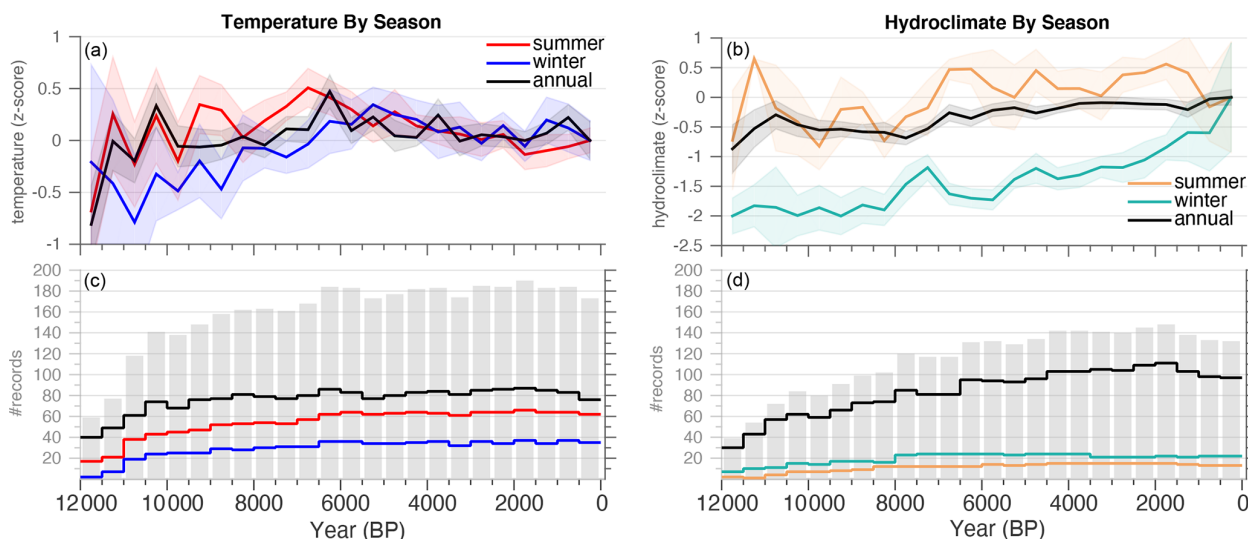
The machine-readable database includes multiple parameters for searching and screening records. The data compilation will form the foundation of new analyses of Holocene



**Figure 3.** Temperature (top) and hydroclimate (bottom) composites by dominant proxy types (proxy general in Supplement Table S1). Only proxy types with  $n > 10$  are shown. The composites are produced from normalized (units of standard deviation) records to include both calibrated and uncalibrated time series. Records have been filtered by seasonality (season general for annual, summer only, and winter only), to include one record per site. Shading shows the 95 % bootstrapped confidence interval on the estimate of the mean over 1000 (sampling with replacement) iterations. Gray bars show the number of records contributing to each 500-year bin.

climate variability in western North America and will help identify future research priorities, including data-sparse regions. The 381 records in this database will enable studies of Holocene climate on centennial to multi-millennial timescales. At finer timescales, the number of records with

sufficient resolution and geochronological control is more limited. For example, 170 records have a median sampling resolution of better than 100 years, and only 26 sites have resolution finer than 10 years. The accuracy and precision of age control can also limit inferences involving correlations



**Figure 4.** Comparison of seasonal temperature (a, c) and hydroclimate (b, d) composites. The composites are produced from binned (500-year bins) and normalized (units of standard deviation) records averaged on an equal area grid. The most recent bin has been registered to zero to help compare the Holocene trends with respect to preindustrial conditions. Both calibrated and uncalibrated time series are included. Shading shows the bootstrapped confidence interval of 1 standard deviation on the estimate of the mean over 1000 (sampling with replacement) iterations. Gray bars (c, d) show the total number of records (all seasons) in each 500-year bin, whereas the time series (c, d) show the number of records contributing to each composite by color.

and spectral properties of the time series. The availability of the raw chronology data for each record in this database allows users to quantify and incorporate aspects of chronologic uncertainty into their analyses.

This database represents a concerted effort to generate a comprehensive data product but is an ongoing effort, with newly published records continuing to be added. Some published records that meet the criteria might have been inadvertently overlooked. Readers who know of missing datasets or who find errors in this version are asked to contact one of the authors so that future versions of the database will be more complete and accurate. Rather than issuing errata to this publication, errors and additions will be included in subsequent versions of the database.

**Supplement.** The supplement related to this article is available online at: <https://doi.org/10.5194/essd-13-1613-2021-supplement>.

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