A multiproxy database of western North American Holocene paleoclimate records

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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 4,000 of the last 12,000 years (median duration = 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 kilannum (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, and 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 (Figure 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 moisture, 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 (Figure 1) were considered for inclusion in the database. They were obtained from public archives in PANGEA and NOAA's World Data Service 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 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 (Metcalfe 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., 2019) (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 two millennia (Rodysill et al., 2018; Shuman et al., 2017) (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 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 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 (°C) and precipitation units (mm). Other records are reported in their native proxy variables (e.g., $d^{18}O$, ‰, or sediment mass accumulation, $g/cm^2/yr$). Some calibrated records rely on statistical procedures to determine the relationship between proxy and instrumental data and to infer palaeoclimate 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 modelling and in some cases (e.g., $\delta^{18}O$) 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 in time-scale from 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. 4,000 years anytime between 0 and 12 ka. To focus on records that can resolve sub-millennial patterns, the database includes those with 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 3,000 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 (Supplementary Table 1) to facilitate analyses and re-use. The metadata included in this database are largely consistent with those developed and used in the Temperature 12k database (Kaufman et al., 2020), 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 ellipsoid and in units of decimal degrees. '*Country Ocean*' is generated based on NASA GCMD convention.

(2) Bibliographic information includes the DOI 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) Original data source '*Original Data Citation*' is the persistent identifier (URL or DOI) that connects to the publicly accessible repository (e.g. PANGAEA and WDS-NOAA Paleoclimatology when available). Fields with the entry '*wNAm*' 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, speleothem). '*Proxy General*' simplifies plotting figures by grouping similar proxies from '*Proxy Type*'. For example, '*Proxy General'* = '*other biomarkers*' includes '*Proxy Type'* TEX86 and GDGT, but not alkenones, which are treated separately. '*Proxy General'* = 'biophysical' includes biogenic silica, tree-ring width, total organic content, chlorophyll and macrofossils. '*Proxy General'* = '*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*' includes information from the original study to help users understand the proxy record.

(5) 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 '*Climate Variabile*' = 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 '*d18O*'). '*Units'* correspond to the measurement unit specified in '*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', '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*', '*El Nino*'), only the variable sensed was specified.

(6) Seasonality information has been separated into two fields '*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*', '*Annual*'). '*Season General'* distills season details into queryable seasons ('*Annual*', '*Summer Only*', '*Summer+*', '*Winter Only*', '*Winter+*'). Categories '*Summer+*' and '*Winter+*' indicate 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 ages.

(8) Quality control metadata includes (*'QC Certification'*) and (*'QC Comments'*). '*QC Certification*' includes 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 QC'er to improve reusability of the data.

(9) Data access and visualization includes a website link for viewing and downloading the data in .csv 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 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).

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 webpage ('*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 LiPDverse.org. This western North American Holocene paleoclimate database is a subset of the records that can be found by choosing "wNAm" in the LiPDverse browser. The full collection can also be accessed at http://lipdverse.org/wNAm/0_15_0/.

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 Supplementary Table 1 contains a row for each record. In total, this database comprises 184 sites and 381 records.

The records are derived from 9 archive types, and are based on 8 proxy categories (Supplementary Table 1). 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 et al. (2018), following the same methods applied for temperature reconstructions in Kaufman et al. (2020a). 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 fossil data. In the original paper (Harbert and Nixon 2018), an overall MAT 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 spatio-temporal 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 Supplementary Table 1.

The database contains 200 temperature sensitive records, 150 hydroclimate sensitive records (precipitation, P-E, flood frequency, 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 some aspect of summer.

Background information including the strengths, weaknesses, and underlying assumptions of the specific poxy 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 (Figure 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 mid-western 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 6,000 years, thereby including the frequently modeled 6 ka paleoclimate time slice. The median sample resolution of individual records in the database is 127 years (Figure 2).

3.4 Geochronology

Original geochronologic data for each record are included in the database. The database includes 2353 individual age control points (^{14}C, ^{210}Pb, tephras, etc.). Tree-ring age control points (two studies) were excluded from this number. These primary age control can be used to recalculate the age models for all of the ^{14}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 replacement approach (e.g. Boose et al., 2003; Routson et al., 2019), 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., 2019) by applying a single uncertainty estimate for each proxy type (Supplementary Table 1). 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; 2015; 2019; Herbart et al., 2018; Marsicek et al., 2013). For the 163 uncalibrated records we have estimated the error as ±1 SD 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 Supplementary Table 1, '*Proxy General*' were evaluated (Figure 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*' = '*annual*', OR '*summerOnly*', OR '*winterOny*'). 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 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 ka and 4 ka). Dominant hydroclimate proxies include other microfossil (n = 11), biophysical (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 (Figure 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 km^2) grids following Routson et al., (2019). 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 ka 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 wintertime.

4. 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 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 time scales. At finer time scales, 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 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 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.

Data and code 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. Supplementary Table 1 lists the essential metadata. Data can also be viewed and accessed at https://lipdverse.org/wNAm/1_0_0/. Code, including basic functions for analyzing LiPD files in three programming languages, is available on GitHub (https://github.com/nickmckay/LiPD-utilities).

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Author Contributions: CCR led the project, data collection, and data formatting. CCR, DSK, MPE, NPM, MEK, JPM, FSU, MSL, SHA, JRB, MFG, SEM, KJB, JMG, SCF, GS, JRR, JLM, DBW, RSA, BNS, JSM, BSC, and GJM contributed and certified data. CCR and MPE analyzed the database and produced the figures. NPM built the data infrastructure and performed data processing. CCR, DSK, and SHA did quality control, term standardization, and database cleaning. CCR and DSK wrote the manuscript with contributions from the other authors.

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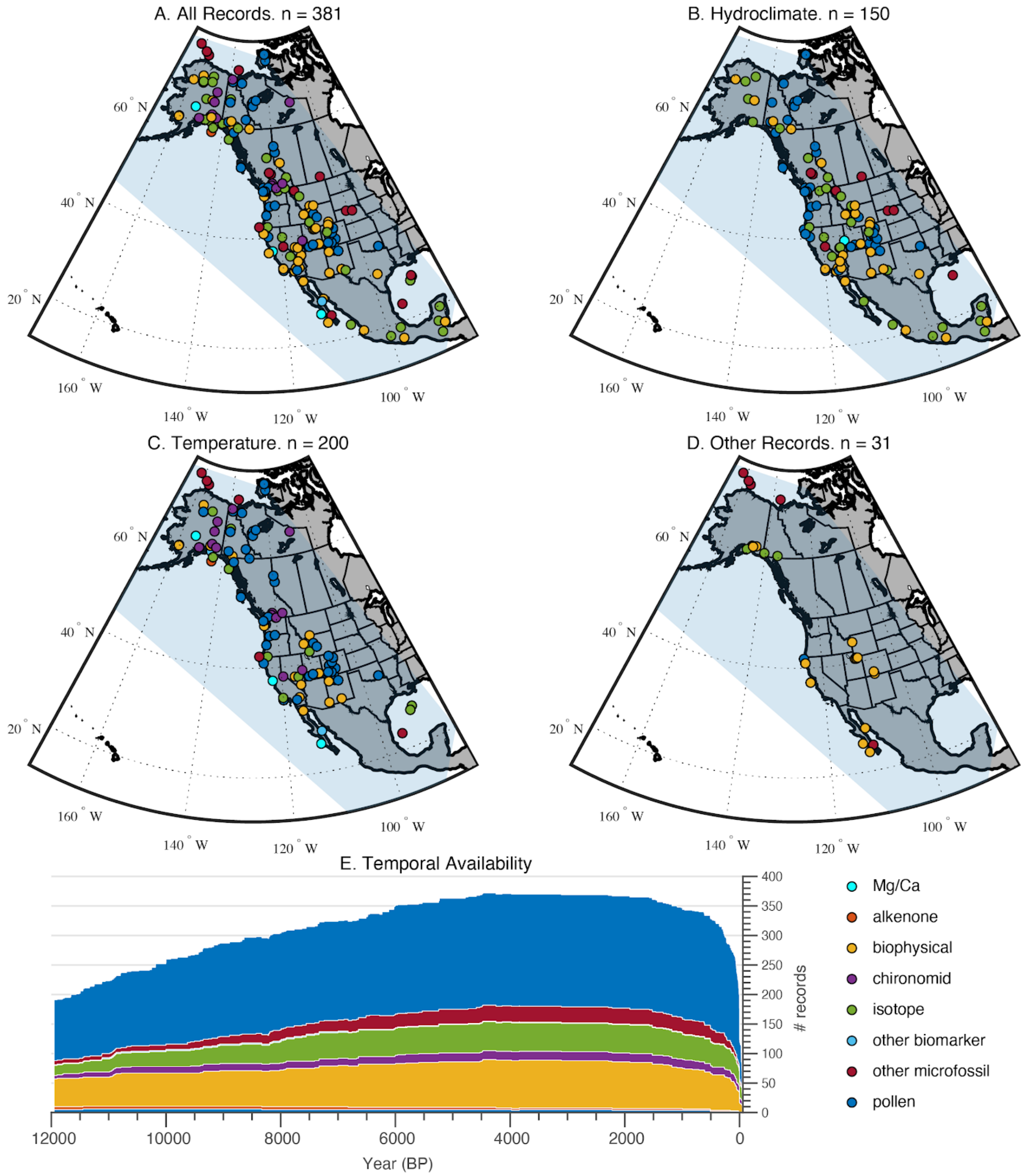

Figure 1. Spatiotemporal distribution of the western North American Holocene paleoclimate database. A) The database includes 381 proxy records from a variety of archive and proxy types. Records include those in calibrated climate units (e.g. °C) and records in their native proxy units (e.g. $\delta^{18}O$). 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 (Supplemental Table 1, '*Proxy General*') over the last 12 ka.

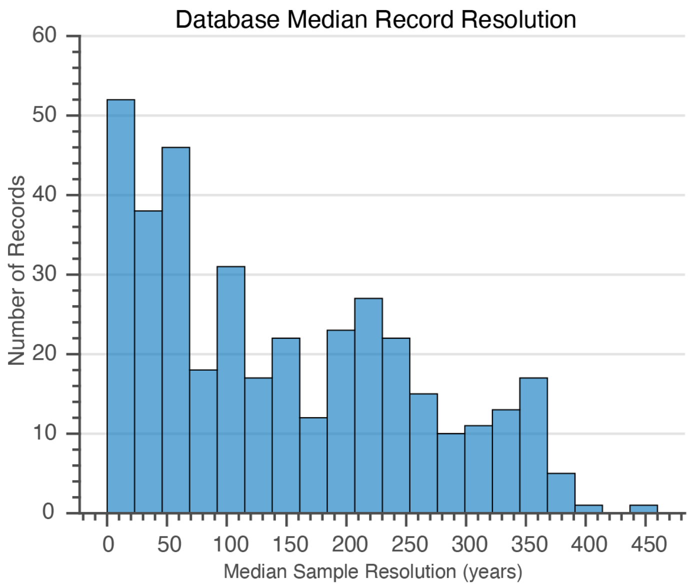

Figure 2: Median sample resolution for all records in the database (20-year intervals).

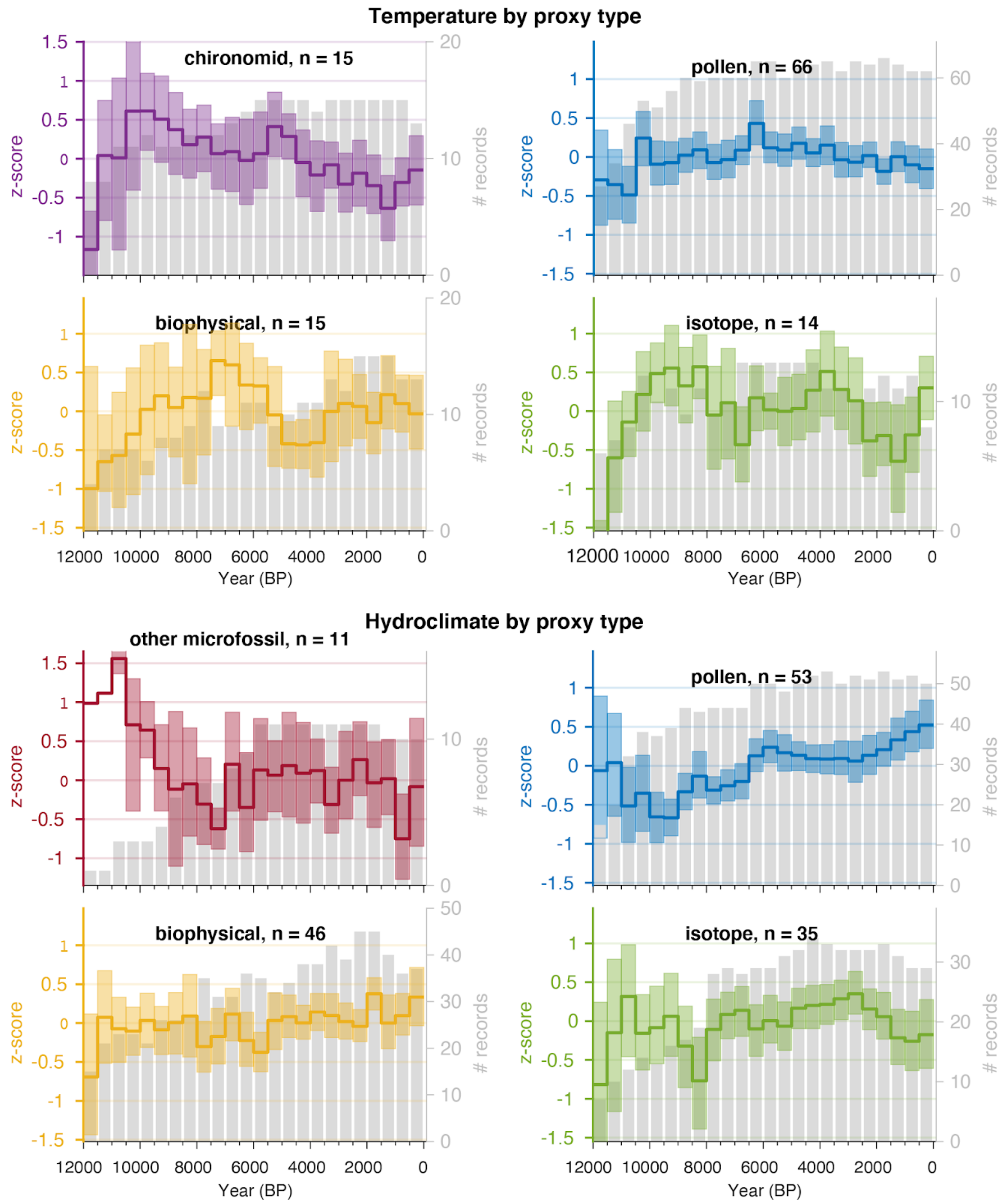

Figure 3: Temperature (top) and hydroclimate (bottom) composites by dominant proxy types (Supplementary Table 1, '*Proxy General*'). Only proxy types with n > 10 are shown. The composites are produced from normalized (standard deviation units) records to include both calibrated and uncalibrated time series. Records have been filtered by seasonality ('*Season General*' = '*annual*', '*summerOnly*', and '*winterOnly*'), to include one record per site. Shading shows the 95% bootstrapped confidence interval on the estimate on the mean over 1000 sampling with replacement iterations. Gray bars show the number of records contributing to each 500-year bin.

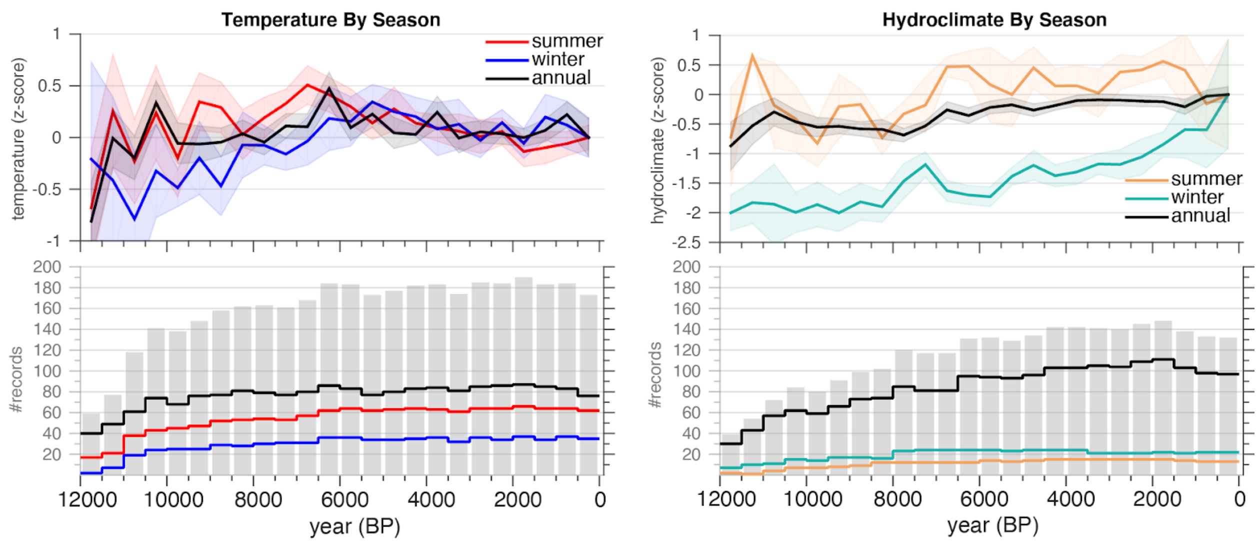

Figure 4: Comparison of seasonal temperature (left) and hydroclimate (right) composites. The composites are produced from binned (500-year bins) and normalized (standard deviation units) records averaged on an equal area grid. The most recent bin has been registered to zero to help compare the Holocene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

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

Site Name	Lat (°N)	Long (°W)	Archive Type	Proxy[a]	Original Data Citation	Reference
3M Pond	49.98	-121.22	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Pellatt et al., 2000
893A	34.29	-120.04	MarineSediment	d18O	www.ncdc.noaa.gov/paleo/study/27330	Kennett et al., 2007
Abalone	33.96	-119.98	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Cole and Liu, 1994
Alfonso Basin	24.65	-110.60	MarineSediment	coccolith	wNAm	Staines-Urías et al., 2015
Andy	64.65	-128.08	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/15444	Szeicz et al., 1995
Bald Lake	40.87	-110.49	LakeSediment	Eu/Zr	wNAm	Munroe et al., 2020
Banks Island -12	72.37	-119.83	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Gajewski et al., 2000
Banks Island -15	73.53	-120.22	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Gajewski et al., 2000
Battle Ground	45.80	-122.49	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Barnosky, 1985b
Beaver Lake	42.46	-100.67	LakeSediment	diatom	www.ncdc.noaa.gov/paleo/study/23075	Schmieder et al., 2011

Beef Pasture	37.47	-108.16	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Petersen, 1985
Begbie Lake	48.59	-123.68	LakeSediment	pollen	wNAm	Brown et al., 2019
Bells Lake	65.02	-127.48	LakeSediment	pollen	10.21233/N35G6P	Szeicz et al., 1995
Big Lake	51.67	-121.45	LakeSediment	diatom	www.ncdc.noaa.gov/paleo/study/23089	Cumming et al., 2002
Bison Lake	39.76	-107.35	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/10749	Anderson L., 2011
Blue Lake	37.24	-106.63	LakeSediment	XRF	www.ncdc.noaa.gov/paleo/study/27078	Routson et al., 2019
Boomerang Lake	49.18	-124.16	LakeSediment	pollen	wNAm	Brown et al., 2006
Boone	55.58	-119.43	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	White and Mathewes, 1986
Candelabra Lake	61.68	-130.65	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/15444	Cwynar and Spear, 2007
Carleton Lake	64.26	-110.10	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/16296	Upiter et al., 2014
Carp	45.92	-120.88	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Barnosky, 1985a
Cascade Fen	37.65	-107.81	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Maher, 1963
Castor Lake	48.54	-119.56	LakeSediment	reflectance	www.ncdc.noaa.gov/paleo/study/10310	Nelson et al., 2011
Castor Lake	48.54	-119.56	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/10310	Nelson et al., 2011
Chichancanab Lake	19.83	-88.75	LakeSediment	CaCO3	www.ncdc.noaa.gov/paleo/study/5483	Hodell et al., 1995
Chichancanab Lake	19.83	-88.75	LakeSediment	S	www.ncdc.noaa.gov/paleo/study/5483	Hodell et al., 1995
Chichancanab Lake	19.83	-88.75	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/5483	Hodell et al., 1995
Chihuahuenos Bog	36.05	-106.51	Peat	pollen	wNAm	Anderson RS et al., 2008a
Chitina loess section	61.54	-144.38	Loess	particle size	www.ncdc.noaa.gov/paleo/study/20529	Muhs et al., 2013
Cleland Lake	50.83	-116.39	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/21250	Steinman et al., 2016
Cleland Lake	50.83	-116.39	LakeSediment	d13C	www.ncdc.noaa.gov/paleo/study/21250	Steinman et al., 2016
Copley	38.87	-107.08	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Fall, 1997
Corser Bog	60.53	-145.45	Peat	GDGT	www.ncdc.noaa.gov/paleo/study/15444	Nichols et al., 2014
Corser Bog	60.53	-145.45	Peat	dD	www.ncdc.noaa.gov/paleo/study/15444	Nichols et al., 2014
Cottonwood Pass Pond	38.83	-106.41	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Fall, 1997
Crater Lake	37.67	-106.69	LakeSediment	particle size	wNAm	Arcusa et al., 2020
Crevice Lake	45.00	-110.58	LakeSediment	d18O	wNAm	Whitlock et al., 2012
Crevice Lake	45.00	-110.58	LakeSediment	CaCO3	wNAm	Whitlock et al., 2012
CuevaDiablo	18.18	-99.92	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/10670	Bernal et al., 2011
Cumbres Bog	37.02	-106.45	LakeSediment	pollen	wNAm	Johnson et al., 2013
Dempster Hwy Peatland	65.21	-138.32	Ice-other	d18O	www.ncdc.noaa.gov/paleo/study/27330	Porter et al., 2019
DJ6-93SF-6	37.63	-122.37	MarineSediment	Mg/Ca	wNAm	McGann, 2008

DSDP site 480	27.90	-111.65	MarineSediment	diatom	www.ncdc.noaa.gov/paleo/study/5855	Barron et al., 2004
DSDP site 480	27.90	-111.65	MarineSediment	BSi	www.ncdc.noaa.gov/paleo/study/5855	Barron et al., 2004
Dune	64.42	-149.90	LakeSediment	d13C	www.ncdc.noaa.gov/paleo/study/13076	Finney et al., 2012
Eldora Fen	39.94	-105.58	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	noPubOnRecord
Eleanor Lake	47.68	-124.02	LakeSediment	BSi	wNAm	Gavin et al., 2011
Emerald Lake	39.15	-106.41	LakeSediment	stratigraphy	www.ncdc.noaa.gov/paleo/study/23079	Shuman et al., 2014
Emerald Lake	39.15	-106.41	LakeSediment	pollen	wNAm	Jiménez-Moreno, et al., 2019
EN32_PC6	26.95	-91.35	MarineSediment	Mg/Ca	www.ncdc.noaa.gov/paleo/study/27330	Flower et al., 2004
EN32_PC6	26.95	-91.35	MarineSediment	d18O	www.ncdc.noaa.gov/paleo/study/27330	Flower et al., 2004
Enos Lake	49.28	-124.15	LakeSediment	pollen	wNAm	Brown et al., 2006
EW0408_66JC	57.87	-137.10	MarineSediment	alkenone	www.ncdc.noaa.gov/paleo/study/22400	Praetorius et al., 2015
EW0408_66JC	57.87	-137.10	MarineSediment	d18O	www.ncdc.noaa.gov/paleo/study/22400	Praetorius et al., 2015
EW0408_85JC	59.56	-144.15	MarineSediment	alkenone	www.ncdc.noaa.gov/paleo/study/21950	Praetorius et al., 2015
EW0408_85JC	59.56	-144.15	MarineSediment	d18O	www.ncdc.noaa.gov/paleo/study/21950	Praetorius et al., 2015
EW0408-87JC	58.77	-144.50	MarineSediment	alkenone	wNAm	Praetorius et al., 2020
Farewell Lake	62.55	-153.63	LakeSediment	Mg/Ca	www.ncdc.noaa.gov/paleo/study/15444	Hu et al., 1998
Felker Lake	51.95	-122.00	LakeSediment	diatom	wNAm	Galloway et al., 2011
Ferndale	34.41	-95.81	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Albert and Wyckoff, 1981
Foy Lake	48.20	-114.40	LakeSediment	diatom	www.ncdc.noaa.gov/paleo/study/6188	Stone and Fritz, 2006
Frozen Lake	49.60	-121.47	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Rosenberg et al., 2004
GGC19	72.16	-155.51	MarineSediment	dinocyst	www.ncdc.noaa.gov/paleo/study/15444	Farmer et al., 2011
Great Basin	38.00	-116.50	Wood	TRW	www.ncdc.noaa.gov/paleo/study/17056	Salzer et al., 2014
Greyling Lake	61.38	-145.74	LakeSediment	TOC	www.ncdc.noaa.gov/paleo/study/15444	McKay and Kaufman, 2009
Grutas del Ray Marcos	15.43	-90.28	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/28351	Winter et al., 2020
Guaymas Basin	27.48	-112.07	MarineSediment	dD	www.ncdc.noaa.gov/paleo/study/24890	Bhattacharya et al., 2018
Guaymas Basin	27.48	-112.07	MarineSediment	dD	www.ncdc.noaa.gov/paleo/study/24890	Bhattacharya et al., 2018
Gulf of Mexico	27.18	-91.42	MarineSediment	foraminifera	wNAm	Poore et al., 2005
Hail Lake	60.03	-129.02	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/15444	Cwynar and Spear, 2007
Hallet Lake	61.49	-146.24	LakeSediment	TOC	www.ncdc.noaa.gov/paleo/study/15444	McKay and Kaufman, 2009
Hallet Lake	61.49	-146.24	LakeSediment	BSi	www.ncdc.noaa.gov/paleo/study/15444	McKay and Kaufman, 2009
Hanging Lake	68.38	-138.38	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Cwynar, 1982

Harding Lake	64.42	-146.85	LakeSediment	TOC	www.ncdc.noaa.gov/paleo/study/15655	Finkenbinder et al., 2014
Harding Lake	64.42	-146.85	LakeSediment	MS	www.ncdc.noaa.gov/paleo/study/15655	Finkenbinder et al., 2014
Heal Lake	48.54	-123.46	LakeSediment	pollen	wNAm	Brown et al., 2006
Hermit Lake	38.09	-105.63	LakeSediment	pollen	wNAm	Anderson RS et al., 2019
Hidden Lake CA	38.26	-119.54	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Potito et al., 2006
Hidden Lake CO	40.51	-106.61	LakeSediment	stratigraphy	www.ncdc.noaa.gov/paleo/study/23077	Shuman et al., 2009
HLY0501	72.69	-157.52	MarineSediment	dinocyst	www.ncdc.noaa.gov/paleo/study/15444	de Vernal et al., 2013
Honeymoon	64.63	-138.40	LakeSediment	pollen	10.21233/N33Q7V	Cwynar and Spear, 1991
Hudson-AK	61.90	-145.67	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/15444	Clegg et al., 2011
Hunters Lake	37.61	-106.84	LakeSediment	pollen	wNAm	Anderson RS et al., 2008b
Jellybean Lake	60.35	-134.80	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/5445	Anderson L. et al., 2005
Jenny Lake	43.75	-110.73	LakeSediment	TIC	www.ncdc.noaa.gov/paleo/study/20128	Larsen et al., 2016
Jones Lake	47.05	-113.14	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/23076	Shapley et al., 2009
Keele	64.17	-127.62	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Szeicz et al., 1995
Keystone Iron Bog	38.87	-107.03	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Fall, 1985
Kirman Lake	38.34	-119.50	LakeSediment	diatom	dataverse.harvard.edu/dataverse/UCLAGMacDonald	MacDonald et al., 2016
Kite Lake	39.33	-106.13	LakeSediment	pollen	wNAm	Jiménez-Moreno and Anderson, 2013
KNR159_JPC26	26.37	-92.03	MarineSediment	Mg/Ca	www.ncdc.noaa.gov/paleo/study/27330	Antonarakou et al., 2015
KNR159_JPC26	26.37	-92.03	MarineSediment	d18O	www.ncdc.noaa.gov/paleo/study/27330	Antonarakou et al., 2015
Koksilah River	48.76	-123.68	LakeSediment	pollen	wNAm	Brown and Schoups, 2015
Kurupa Lake	68.35	-154.61	LakeSediment	chlorophyll	www.ncdc.noaa.gov/paleo/study/18995	Boldt et al., 2015
Kusawa	60.28	-136.18	LakeSediment	BSi	www.ncdc.noaa.gov/paleo/study/15444	Chakraborty et al., 2010
Lac Meleze	65.22	-126.12	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	MacDonald, 1987
Lago Minucua	17.08	-97.61	LakeSediment	MS	wNAm	Goman et al., 2018
Lago Minucua	17.08	-97.61	LakeSediment	varve	wNAm	Goman et al., 2018
Lago Puerto Arturo	17.53	-90.18	LakeSediment	d18O	wNAm	Wahl et al., 2014
Laguna De Aljojuca	19.09	-97.53	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/17735	Bhattacharya et al., 2015
Laguna de Juanacatlan	20.63	-104.74	LakeSediment	Ti	wNAm	Jones et al., 2015
Lake Elsinore	33.67	-117.35	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/30232	Kirby et al., 2019
Lake Elsinore	33.67	-117.35	LakeSediment	particle size	www.ncdc.noaa.gov/paleo/study/30232	Kirby et al., 2019
Lake of the Woods	43.48	-109.89	LakeSediment	stratigraphy	wNAm	Pribyl and Shuman, 2014

Lake of the Woods	49.05	-120.18	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Palmer et al., 2002
Lehman Caves	39.00	-114.22	Speleothem	d13C	www.ncdc.noaa.gov/paleo/study/19038	Steponaitis et al., 2015
Lehman Caves	39.00	-114.22	Speleothem	Mg/Ca	www.ncdc.noaa.gov/paleo/study/19038	Steponaitis et al., 2015
Leviathan	37.89	-115.58	Speleothem	d13C	www.ncdc.noaa.gov/paleo/study/16517	Lachniet et al., 2014
Leviathan	37.89	-115.58	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/16517	Lachniet et al., 2014
Lily	59.20	-135.40	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/15444	Cwynar, 1990
Lime Lake	48.87	-117.34	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/21250	Steinman et al., 2016
Lime Lake	48.87	-117.34	LakeSediment	d13C	www.ncdc.noaa.gov/paleo/study/21250	Steinman et al., 2016
Little	44.17	-123.58	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Worona and Whitlock, 1995
Little Molas Lake	37.74	-107.71	LakeSediment	pollen	wNAm	Toney and Anderson, 2006
Little Windy	41.43	-106.33	LakeSediment	stratigraphy	www.ncdc.noaa.gov/paleo/study/16096	Minckley et al., 2012
Logan	60.58	-140.50	GlacierIce	d18O	www.ncdc.noaa.gov/paleo/study/15444	Fisher et al., 2008
Lone Fox Lake	56.72	-119.72	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	MacDonald and Cwynar, 1985
Lonespruce	60.01	-159.14	LakeSediment	BSi	www.ncdc.noaa.gov/paleo/study/15444	Kaufman et al., 2012
Louise Pond	52.95	-131.76	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Pellatt and Mathewes, 1994
Lowder Creek Bog	37.66	-112.77	Peat	pollen	wNAm	Anderson RS et al., 1999
Lower Bear Lake	34.20	-116.90	LakeSediment	TOC	www.ncdc.noaa.gov/paleo/study/13215	Kirby et al., 2012
Lower Bear Lake	34.20	-116.90	LakeSediment	C/N	www.ncdc.noaa.gov/paleo/study/13215	Kirby et al., 2012
M Lake	68.27	-133.47	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Ritchie, 1977
Macal Chasm	16.88	-89.11	Speleothem	d13C	www.ncdc.noaa.gov/paleo/study/20506	Akers et al., 2016
Macal Chasm	16.88	-89.11	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/20506	Akers et al., 2016
Macal Chasm	16.88	-89.11	Speleothem	reflectance	www.ncdc.noaa.gov/paleo/study/20506	Akers et al., 2016
Marcella	60.07	-133.81	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/6066	Anderson L. et al., 2007
Marion	49.31	-122.55	LakeSediment	pollen	wNAm	Mathewes, 1973
Marshall Lake	40.68	-110.87	LakeSediment	Ca/Ti	wNAm	Munroe et al., 2020
MD02_2503	34.39	-120.04	MarineSediment	d18O	www.ncdc.noaa.gov/paleo/study/5582	Hill et al., 2006
MD02_2515	27.48	-112.07	MarineSediment	alkenone	10.1594/PANGAEA.861260	McClymont et al., 2012
MD02_2515	27.48	-112.07	MarineSediment	GDGT	10.1594/PANGAEA.861260	McClymont et al., 2012
MD02-2499	41.65	-124.94	MarineSediment	diatom	www.ncdc.noaa.gov/paleo/study/24150	Lopes and Mix, 2018
Meli Lake	68.68	-149.08	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/5469	Anderson L. et al., 2001
Mexican Marin	22.23	-107.05	MarineSediment	dD	www.ncdc.noaa.gov/paleo/study/24890	Bhattacharya et al., 2018

Mica Lake	60.95	-148.15	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/6202	Schiff et al., 2009
Midden Cluster 1	37.90	-110.13	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 2	36.38	-115.19	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 3	36.06	-108.08	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 4	43.65	-112.75	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 5	32.47	-106.02	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 6	32.47	-106.02	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 7	34.15	-116.00	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 8	32.31	-109.10	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Midden Cluster 9	31.64	-115.55	Midden	macrofossils	geochange.er.usgs.gov/midden/	Harbert and Nixon, 2018
Minnetonka Cave	42.09	-111.52	Speleothem	d13C	www.ncdc.noaa.gov/paleo/study/23097	Lundeen et al., 2013
Minnetonka Cave	42.09	-111.52	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/23097	Lundeen et al., 2013
Moose Lake	61.37	-143.60	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/15444	Clegg et al., 2010
Morris Pond	37.67	-112.77	LakeSediment	pollen	wNAm	Morris et al., 2013
Mv0811-14JC	34.30	-120.00	MarineSediment	stratigraphy	wNAm	Du et al., 2018
MV99_PC14	25.20	-112.72	MarineSediment	Mg/Ca	www.ncdc.noaa.gov/paleo/study/10415	Marchitto et al., 2010
MV99-GC31	23.47	-111.60	MarineSediment	BSi	10.1594/PANGAEA.824830	Barron et al., 2012
MV99-GC41/PC14	25.20	-112.72	MarineSediment	particle size	10.1594/PANGAEA.896898	Arellano-Torres et al., 2019
Natural Bridge Caverns	29.69	-98.34	Speleothem	Sr	wNAm	Wong et al., 2015
Nevada Climate Division 3	37.80	-115.80	Wood	TRW	www.ncdc.noaa.gov/paleo/study/6384	Hughes and Graumlich, 1996
North Crater Lake	49.07	-120.02	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Palmer et al., 2002
ODP_167_1019C	41.68	-124.93	MarineSediment	alkenone	10.1594/PANGAEA.841946	Barron et al., 2003b
ODP1019	41.68	-124.93	MarineSediment	diatom	www.ncdc.noaa.gov/paleo/study/24150	Lopes and Mix, 2018
ODP1019	41.68	-124.93	MarineSediment	CaCO3	www.ncdc.noaa.gov/paleo/study/5867	Barron et al., 2003b
ODP1019	41.68	-124.93	MarineSediment	pollen	www.ncdc.noaa.gov/paleo/study/5867	Barron et al., 2003b
Oregon Caves	42.08	-123.42	Speleothem	d13C	www.ncdc.noaa.gov/paleo/study/13543	Ersek et al., 2012
Oregon Caves	42.08	-123.42	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/13543	Ersek et al., 2012
Oro Lake	49.78	-105.35	LakeSediment	diatom	www.ncdc.noaa.gov/paleo/study/23073	Michels et al., 2007
OwensLake	36.44	-117.97	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/5472	Benson et al., 2002
P1B3	73.68	-162.66	MarineSediment	dinocyst	www.ncdc.noaa.gov/paleo/study/15444	de Vernal et al., 2005
Paradise	54.69	-122.62	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/21250	Steinman et al., 2016

Paradise	54.69	-122.62	LakeSediment	d13C	www.ncdc.noaa.gov/paleo/study/21250	Steinman et al., 2016
Park Pond 1	43.47	-109.96	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Lynch, 1998
Pink Panther	32.08	-105.17	Speleothem	d18O	www.ncdc.noaa.gov/paleo/study/9739	Asmerom et al., 2007
Pixie	48.60	-124.20	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Brown and Hebda, 2002
Pixie Lake	48.60	-124.20	LakeSediment	pollen	wNAm	Brown et al., 2006
Posy	37.94	-111.70	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Shafer, 1989
PS1410-06GC	37.33	-123.40	MarineSediment	pollen	wNAm	Barron et al., 2019
PS1410-06GC	37.33	-123.40	MarineSediment	BSi	wNAm	Barron et al., 2019
Pyramid Lake	40.07	-119.58	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/5472	Benson et al., 2002
Quartz	64.21	-145.81	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/15444	Wooller et al., 2012
Rainbow	60.72	-150.80	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/15444	Clegg et al., 2011
RainbowLake	44.94	-109.50	LakeSediment	stratigraphy	wNAm	Shuman and Marsicek, 2016
Ranger	67.15	-153.65	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/15444	Brubaker et al., 1983
Rantin Lake	60.03	-129.03	LakeSediment	CaCO3	www.ncdc.noaa.gov/paleo/study/13095	Pompeani et al., 2012
Rapid	42.73	-109.19	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Fall, 1988
RC12-10	23.00	-95.53	MarineSediment	foraminifera	www.ncdc.noaa.gov/paleo/study/27330	Poore et al., 2003
Red Rock	40.08	-105.54	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Maher, 1972
Rhamnus Lake	48.63	-123.72	LakeSediment	pollen	wNAm	Brown et al., 2006
San Juan River Discharge	48.58	-124.31	LakeSediment	pollen	wNAm	Brown and Schoups, 2015
Schellings Bog	40.28	-123.36	LakeSediment	pollen	wNAm	Barron et al., 2003a
Screaming Lynx Lake	66.07	-145.40	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/15444	Clegg et al., 2011
Silver Lake	35.37	-116.14	LakeSediment	particle size	www.ncdc.noaa.gov/paleo/study/20106	Kirby et al., 2015
Silver Lake	35.37	-116.14	LakeSediment	C/N	www.ncdc.noaa.gov/paleo/study/20106	Kirby et al., 2015
Southern California	33.77	-116.66	Peat	pollen	www.ncdc.noaa.gov/paleo/study/27330	Ohlwein and Wahl, 2012
Station 803	70.63	-135.88	MarineSediment	dinocyst	www.ncdc.noaa.gov/paleo/study/27910	Bringué and Rochon, 2012
Stella Lake	39.01	-114.32	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Reinemann et al., 2009
Stewart Bog	35.83	-105.72	Peat	pollen	wNAm	Jiménez-Moreno, et al., 2008
Stowell Lake	48.78	-123.44	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Lemmen and Lacourse, 2018
Swan Lake	42.16	-99.03	LakeSediment	diatom	wNAm	Schmieder et al., 2011
Swasey Lake	40.67	-110.47	LakeSediment	Ca/Ti	wNAm	Munroe et al., 2020
Takahula	67.35	-153.67	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/8663	Clegg and Hu, 2010

Tangled Up Lake	67.67	-149.08	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/5469	Anderson L. et al., 2001
Taylor Lake	40.79	-110.09	LakeSediment	Ca/Ti	wNAm	Munroe et al., 2020
Tiago Lake	40.58	-106.61	LakeSediment	pollen	wNAm	Jiménez-Moreno, et al., 2011
TN062-0550	40.87	-124.57	MarineSediment	pollen	www.ncdc.noaa.gov/paleo/study/27330	Barron et al., 2018
TN062-0550	40.87	-124.57	MarineSediment	BSi	www.ncdc.noaa.gov/paleo/study/27330	Addison et al., 2018
TN062-0550	40.87	-124.57	MarineSediment	d13C	www.ncdc.noaa.gov/paleo/study/27330	Addison et al., 2018
TN062-0550	40.87	-124.57	MarineSediment	d15N	www.ncdc.noaa.gov/paleo/study/27330	Addison et al., 2018
Trout Lake	68.83	-138.75	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/15444	Irvine et al., 2012
Upper Big Creek Lake	40.91	-106.62	LakeSediment	stratigraphy	wNAm	Shuman et al., 2015
Upper Fly	61.07	-138.09	LakeSediment	pollen	www.ncdc.noaa.gov/paleo/study/15444	Bunbury and Gajewski, 2009
Upper Pinto Fen	53.58	-118.02	Peat	DBD	www.ncdc.noaa.gov/paleo/study/13665	Yu et al., 2003
W8709-13PC	42.12	-125.75	MarineSediment	diatom	www.ncdc.noaa.gov/paleo/study/24150	Lopes and Mix, 2018
WA01	61.24	-136.93	LakeSediment	TOC	www.ncdc.noaa.gov/paleo/study/18435	Rainville and Gajewski, 2013
Waskey Lake	59.88	-159.21	LakeSediment	TOC	www.ncdc.noaa.gov/paleo/study/15444	Levy et al., 2004
Windy Lake	49.81	-117.88	LakeSediment	chironomid	www.ncdc.noaa.gov/paleo/study/27330	Chase et al., 2008
Wolverine Lake	67.10	-158.91	LakeSediment	MAR	www.ncdc.noaa.gov/paleo/study/23070	Mann et al., 2002
Yellow Lake	39.65	-107.35	LakeSediment	d18O	www.ncdc.noaa.gov/paleo/study/13120	Anderson L., 2012

[a]Abbreviations for proxy types: biogenic silica (BSi), calcium carbonate ($CaCO_3$), dry bulk density (DBD), glycerol dialkyle glycerol tetraethers (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 ($\delta^{13}C$), oxygen 18 isotopes ($\delta^{18}O$), and deuterium isotopes of leaf wax (dD).

Supplementary Table 1: Essential metadata for records in the western North America Holocene paleoclimate database, with links to data in LiPDverse. See text for explanation of fields.

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