

PAGES 2k Global Temperature Database A Plan to Complete Version 2

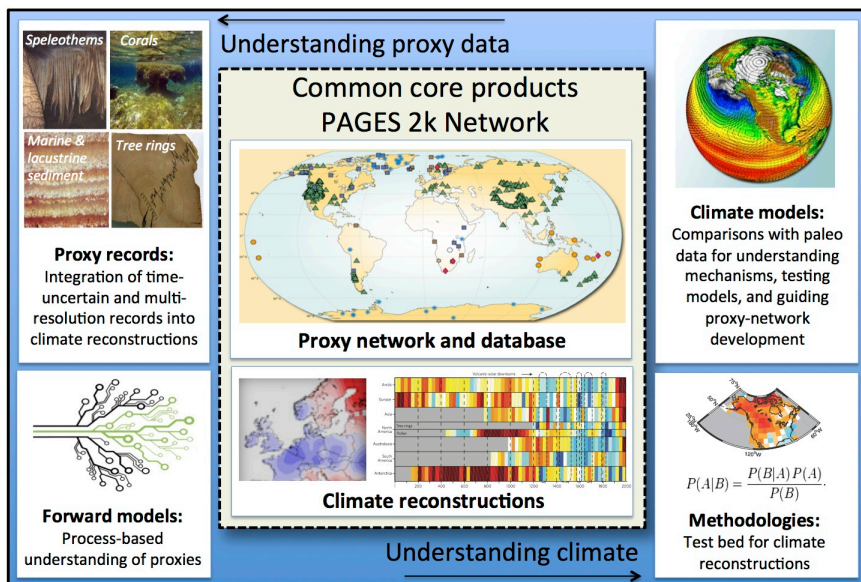
Update February 2015

PAGES 2k Phase 2 global temperature (T) database now contains 915 records, a major expansion relative to Phase 1. This tremendous response by regional groups will take longer to fully assimilate than was originally proposed in September. We are still working to format some of the records that have been submitted, and to round up missing metadata, so they can be entered into the database.

The next step is the quality control of the database. For this purpose, “Quality Control Plots” including some basic metadata for each of the records will be prepared to enable the 2k community to efficiently recognize and correct errors. The quality-controlled database will then be released, along with a “data descriptor” – a brief explanation of the data set with basic diagnostics of its content. For more information about the intended publication outlet and authorship policy, see the project plan ([link](#)).

Although the deadline for including records in version 2 of the T database has passed, the database is constantly expanding. Subsequent database versions will be available once a sufficient number of new records are added. Contact your [regional data manager](#) or Nick (Nicholas.McKay@nau.edu) if you are aware of records that should be added to the database.

The PAGES 2k Project invites you to join a worldwide effort to update and publish the next generation database of temperature-sensitive proxy climate records. The global database is needed to address a range of research questions relevant to climate of the last two millennia, and to build on the results of the [PAGES 2k Consortium \(2013\)](#). This compilation of temperature-sensitive records is the first step toward a more comprehensive database, which has been identified by the PAGES 2k Project as one of its five leading goals (Figure, *Eos-Transitions*, in press). The new dataset will be used to generate a rudimentary global temperature reconstruction, which will be published along with the database. Here, we outline a plan for achieving this goal, including guidelines for authorship and a timeline. Anyone with interest in and knowledge of climate change during the past two millennia is welcome to join this effort to build a community-wide resource.



The PAGES 2k community has developed recommendations aimed at facilitating a global synthesis of proxy climate information. Near-term goals are aimed at generating a uniform suite of core products (center). In tandem, efforts are underway to improve understanding of proxy records, including new process-based approaches (left), and understanding of climate variability and change, including new climate reconstruction methods and comparison with climate simulations (right).

Publication outlet

We have chosen the Nature Group's publication, *Scientific Data* as the intended outlet. This is among the new wave of data-oriented journals ([see example](#): v1.1 of the Arctic2k proxy temperature database). The text for this journal focuses on the dataset itself along with a "data descriptor" — a description of the data and a "technical validation". For version 2 of the PAGES 2k proxy temperature database, we intend to use the data descriptor to feature a global mean temperature time series (not a spatial/gridded reconstruction) along with an analysis of uncertainties. Big science conclusions cannot be included in a *Scientific Data* article. Instead, the goal is a simple diagnostic to fit the data-oriented scope of the journal. Validation will likely involve applying several reconstruction techniques to the same proxy dataset to compare their similarities and differences.

Authorship

We have chosen to use the pseudonym, "PAGES 2k Consortium" as the first author (as we did for the 2013 *Nature Geosciences* article) followed by a list of authors who make up the loosely defined and constantly evolving 2k Consortium. Bibliographic databases (Google Scholar, Web of Science, Research Gate) will credit each of the co-authors with the publication. In addition, we will use the "author contribution" section to list individual's specific roles (e.g., assembled datasets; analyzed data; etc). The author list will likely be subdivided into two parts, with co-authors listed alphabetically within each: (1) a primary group of data compilers, analysts, and presenters, followed by (2) data contributors and reconstruction team participants. Because *Scientific Data* is a data-oriented publication, contributing to the database qualifies for co-authorship. The PAGES 2k Network Coordinators will confer with regional group leaders to apply uniform criteria for authorship designation, while recognizing that formatting proxy data sets and generating the metadata required for the NOAA/PAGES 2k data-entry template is a substantial undertaking.

Timeline (completion dates) and procedure

- 31 Oct 2014: Identify all records that meet PAGES 2k criteria
- 15 Nov 2014: Data submitted to PAGES (password-protected; accessible by all co-authors)
- 18 Dec 2014 (AGU): Public showing of initial iteration of the global temperature reconstruction
- 18 Dec 2014 (AGU): Call for follow-up proxy datasets
- 15 Jan 2015: Follow-up proxy data submitted to PAGES 2k/NOAA
- 15 Feb 2015: Submit manuscript to *Scientific Data*
- April (approximately) 2015: Publication and public release of database

To join this effort

We encourage anyone with knowledge of temperature-sensitive proxy records that are not already in the PAGES 2k database (as published in *Nature Geosciences* and [available here](#)), and that meet the [criteria for the PAGES 2k project](#) to join this open group effort. Entering the

metadata, including the seasonality and other descriptors, requires expertise with proxies and knowledge of the published interpretations. Participants will work with established regional [group leaders](#) and [data managers](#) (contact information listed below), and with NOAA-Paleoclimatology, to obtain and enter the data using the PAGES 2k/NOAA template. Climate reconstruction experts are invited to generate global mean time series using v2 of the database.

More information about the PAGES 2k Network

No membership is required to participate in this constantly evolving scientific community. The [PAGES 2k Network](#) comprises nine regional groups (including the oceans), along with other task groups focused on reconstruction methods and data-model comparisons. An article soon to be published in *Eos-Transactions* by the PAGES 2k project presents a strategy for the next generation of climate reconstructions (appended below). Version 2 of the PAGES 2k proxy temperature database and associated temperature reconstruction will no doubt serve as a springboard to address a wide range of scientific questions related to the causes of climate change and the capabilities of the proxy records.

PAGES 2k Network Coordinators and Regional Leaders

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Recommendations for community-driven climate reconstructions during the past two millennia

PAGES 2k Consortium: An international scientific community
with no formal membership and constantly evolving participation
Excerpted from a provisional draft — *Eos Transactions*, in press

Introduction

Proxy-based reconstructions of past climate provide insights into externally-forced and intrinsic variability over regional to global scales, and can be used to place recent trends in a long-term context. Comparisons between these reconstructions and the output of earth-system models provide evaluation opportunities to improve our understanding of climate forcings on time scales that are not adequately represented by the instrumental record. They also provide a heuristic tool to explore mechanisms of climate variability, with implications for future climate projections [Schmidt et al., 2014].

The 2k Network of the Past Global Changes (PAGES) project aims to improve understanding of climate variability over the past 2000 years (the Common Era, CE), a period when climate was relatively similar to today, and for which proxy records are relatively abundant. A global synthesis of continental-scale temperature changes during the CE was published recently by the PAGES 2k Consortium [2013] (PAGES2k-13), a group comprising 77 co-authors from 24 countries. The synthesis contributed to the larger assessment of climate change as part of the latest IPCC report [Masson-Delmotte et al., 2013], and comparisons with paleoclimate simulations are underway [Jungclaus et al., 2014].

Here, we propose a set of near-term recommendations and long-term goals to facilitate a global synthesis of proxy climate information. This includes developing a database with global coverage and broad applicability to research questions that address a wide range of spatial and temporal scales. This will enable comparisons between climate reconstructions and model simulations, and advance climate reconstruction techniques. Meanwhile, regional working groups – the building blocks of the PAGES 2k Network – will continue to pursue climate reconstructions to address key questions about climate change that are most relevant and feasible within specific regions. Other PAGES working groups are addressing longer-term challenges. Collectively, these activities will provide a millennial-scale, spatiotemporal, and process-based perspective on recent and projected future climate change and variability.

Goal 1: Build a Uniform Open-Access Proxy Climate Database

PAGES 2k envisions a publicly accessible, comprehensive database from which researchers can address a broad variety of scientific questions. An initial relatively inclusive [screening strategy](#) has already been developed, and a [data-entry template](#) has been created in collaboration with NOAA-Paleoclimatology. The database will include all proxy records that meet these broad criteria, not only those that are used for a particular analysis or that meet more strict criteria. Complete geochronological data will be included for time-uncertain proxy records. Moving toward a self-describing, open and universal data archive system

will encourage more complete use of existing paleoclimate information, enhance reproducibility, and provide increased transparency [Emile-Geay and Eshleman, 2013].

Goal 2: Integrate Multi-Resolution Proxy Records

Proxy records that cover the entire CE are needed to investigate decadal to centennial-scale responses of climate to changes in radiative forcing, as well as internal variability at these time scales. Many proxy records that span the last 2000 years are not annually resolved, however, and in some regions, most of the available records of any length lack annual resolution. While combining annual and lower-resolution time series is an important goal, accurately calibrating lower-resolution and time-uncertain proxy records to specific climate variables remains an area of active research. We therefore recommend that PAGES 2k regional groups generate two independent reconstructions: one based on annually (to seasonally) resolved proxies and the other at lower resolution. Fully independent reconstructions will allow mutual validation during their overlapping time intervals and spectral ranges, and will help test methods for fusing high- and low-resolution paleoclimate data. In the long term, we recommend the continued development of methods that incorporate network, observational, and chronological uncertainty into quantitative estimates of past climate variability, including approaches that allow for quantitative calibration and validation of low-frequency variability.

Goal 3: Develop Multivariate Climate Reconstructions

The next generation of PAGES 2k climate reconstructions should target reconstructions of hydroclimate as well as temperature. In some cases, it may be possible to reconstruct specific hydroclimate variables. In many cases, however, it may be impossible to distinguish the combined influences of temperature and precipitation in the proxy records. In these cases we recommend the reconstruction of targets that combine multiple climate influences. An alternative approach is to exploit covariances between temperature and hydroclimate using multiple proxies with response to bivariate climate variability in order to simultaneously infer the joint distribution of both target variables [Tolwinski-Ward et al., 2014]. In the long term, forward, process-based models of proxy formation are needed for explicitly representing multivariate, nonlinear, and potentially non-stationary relationships between the proxy and climate systems [Evans et al., 2013]. Forward models are also an important component of hierarchical methods [Tingley et al., 2012] and data assimilation [Steiger et al., 2014], allowing process-based understanding to be incorporated into reconstruction techniques.

Goal 4: Improve the Spatial Resolution of the Reconstructions

To facilitate a timely global synthesis of uniform reconstructions that includes areas where data coverage is relatively sparse, we recommend the reconstruction of climate means over large-scale (sub-continental and oceanic) areas, while parallel progress is made in developing the next generation of CFR methods. These sub-continental spatial units can be chosen to coincide not only with regions of high observational density, but also with spatial domains defined by large-scale climate features. This will increase the spatial degrees of freedom beyond that of the PAGES2k-13 synthesis and provide clear targets for observation—model comparisons while honoring limitations imposed by current data availability. Error analysis must take into account the analytical and inherent uncertainties of the input data, and propagate them through the entire inference and reconstruction process. Simultaneously, efforts are progressing to advance reconstruction methods, and we foresee substantial progress within the next few years. New Climate Field Reconstruction methods, forward models, improved age-depth modeling and improvements

in incorporating age uncertainty will bring consistency to efforts by the regional groups, as well as benefits to the reconstructions themselves.

Goal 5: Broaden Participation

The PAGES 2k Network encourages participation by all investigators interested in this community-wide project. PAGES 2k working groups continue to grow from the broad paleoclimate science community. PAGES 2k is committed to providing researchers opportunities to integrate their work into high-impact, multi-authored papers that address big-picture research questions. Data managers and group leaders for each region work with project participants to ensure that datasets are published in ways that enable tracking and accurate citation. Data-oriented publications and international data repositories now issue DOIs or other unique identifiers for datasets that can be cited as part of future synthesis products. For more information and to join this effort, please visit the [PAGES 2k website](#) to sign up for circulars and to find contact information for regional working groups.

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Author Information

These recommendations were developed by PAGES 2k regional group leaders, leaders of recent PAGES 2k workshops and other proactive participants who represent this product of the PAGES 2k Consortium — an international scientific community with no formal membership and constantly evolving participation.

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