Dendrochronologia 33 (2015) 31–33

Contents lists available at ScienceDirect

Dendrochronologia

journal homepage: www.elsevier.com/locate/dendro

TECHNICAL NOTE

Dendrobox – An interactive exploration tool for the International Tree Ring Data Bank

Christian Zang[a,b,*]

[a] Technische Universität München, Chair of Ecoclimatology, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany
[b] Biological and Environmental Sciences, School of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK

ARTICLE INFO

Article history:
Received 15 July 2014
Accepted 25 October 2014

Keywords:
International Tree Ring Data Bank
Chronology
Data exploration
Response function analysis

ABSTRACT

The International Tree-Ring Data Bank (ITRDB) is the main public archive of digital tree-ring parameters. Due to its comprehensive spatio-temporal coverage, its ring-width data is acknowledged in many studies where high-resolution proxies of climate or tree-growth are needed on large scales.

A main drawback of existing approaches to browsing the ITRDB is the lack of an easy and interactive visualization of the records and their connection to the climate at point. Dendrobox aims at filling this gap, and provides a web-based interface to more than 2400 ring-width records in the ITRDB for exploring chronology characteristics and the dendroclimatological potential of the records.

Possible applications of Dendrobox include identifying records with a specific climate response, demonstrating the relations of tree-growth and climate in teaching, or simply playing with an impressive data set without the hassle of setting up analytical tools.

Introduction

The International Tree-Ring Databank (ITRDB; Grissino-Mayer and Fritts, 1997) is the main public archive of digital measurements of tree-ring parameters, and currently (July 2014) holds more than 3200 records of ring-widths. In a recent review, St. George (2014) honors the efforts that lead to this unique compilation of tree-ring data, and gives an overview over the main characteristics of the ring-width data set (restricted to the Northern Hemisphere) in terms of temporal and geographical coverage, main species, tree–climate relations and teleconnections with broader scale climate features. This review clearly demonstrates the potential of the ITRDB for a variety of applications as an invaluable data source for (paleo)climatologists, ecologists, and forest scientists. A look into the recent literature confirms that this potential is well exploited by the research community: tree-ring width data from the ITRDB has been used for a range of diverse research questions. Recent applications include the evaluation of the climate sensitivity of model-based forest productivity estimates (Babst et al., 2013), the validation of descriptors of time series properties (Bunn et al., 2013), the reconstruction of streamflows (Salas et al., 2014), the validation of forward modeling approaches (Breitenmoser et al., 2014), and the identification of spatio-temporal patterns of growth response to different time-scales of drought (Vicente-Serrano et al., 2014).

To explore and access the data from the ITRDB, there are currently two main takes: a web interface, and the file transfer protocol (FTP). The web interface of the ITRDB at http://hurricane.ncdc.noaa.gov/pls/paleox/f?p=518:1:0:::APP:PROXYTOSEARCH:18 offers a range of possibilities to select for specific authors, countries or locations, species and parameters. The matches of the database query link to detail pages comprising citation, data coverage, keywords, and a Google map area of detail. An alternative way to access the data is via FTP from the NOAA public servers at ftp://ftp.ncdc.noaa.gov/pub/data/paleo/treering/which is the preferable way to download larger selections of the data.

However, both ways of data access lack the possibility to instantaneously explore the data and its potential for dendroclimatological applications. To this end, the researcher has to download the data file for the record of interest, read it into her preferred analytical environment (such as R or Matlab) and plot it. Connecting the series with climate data requires additional work, including extraction of suitable series of temperature and precipitation and the computation of the record's climate response. Dendrobox, a new interactive website available at http://dendrobox.org, aims at providing a tool for delving into the ring-width records from the ITRDB and their connection to climate and to make these

* Correspondence to: Technische Universität München, Chair of Ecoclimatology, Hans-Carl-von-Carlowitz-Platz 2, 85354 Freising, Germany. Tel.: +49 8161714743.
E-mail address: christian.zang@wzw.tum.de

http://dx.doi.org/10.1016/j.dendro.2014.10.002
1125-7865/

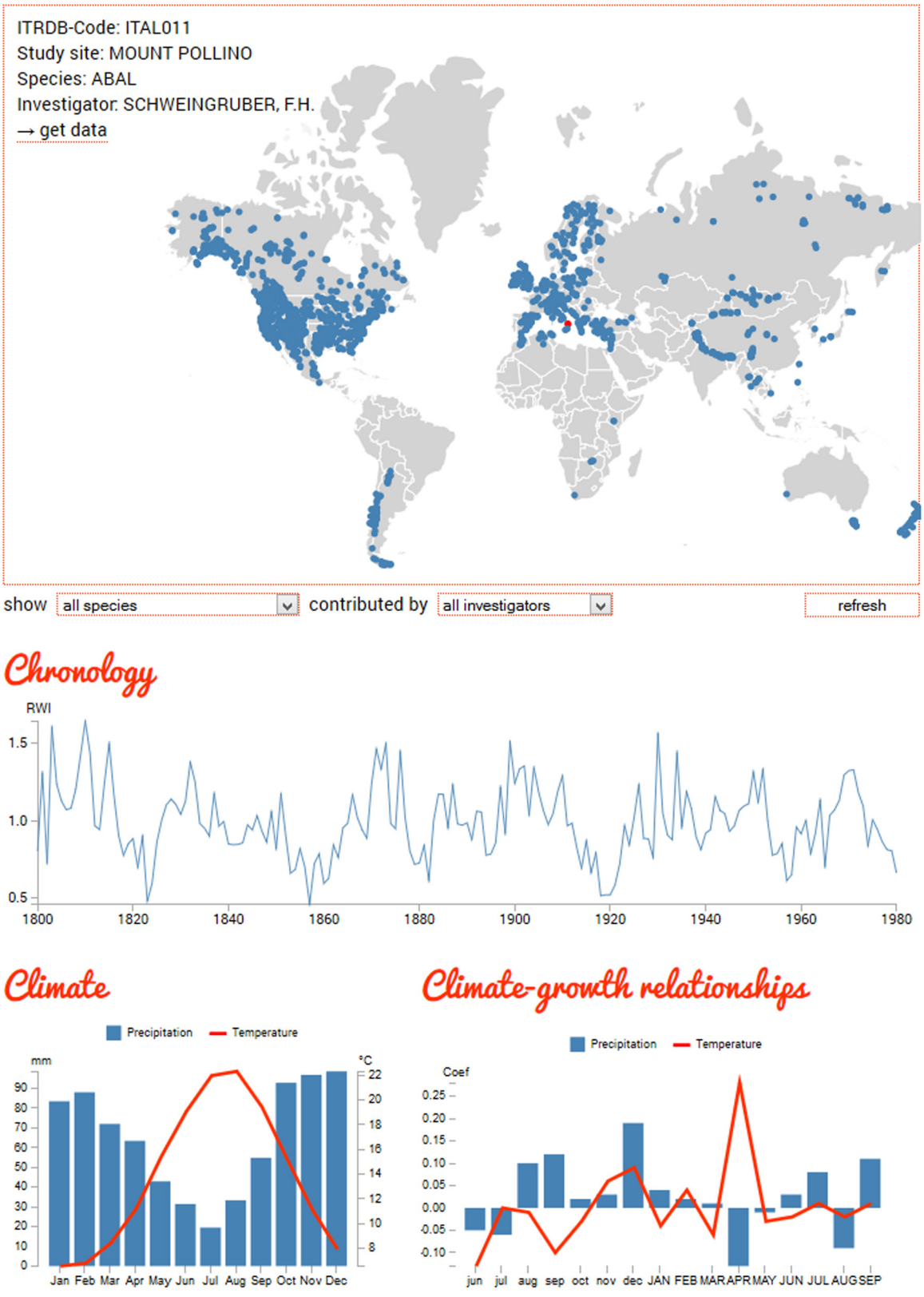

Fig. 1. Screenshot of Dendrobox, displaying the standard chronology for *Abies alba* (Mill.) at Mount Pollino (ITRDB ID: ITAL011, contributor F.H. Schweingruber), the long-term climate characteristics at point, and the results of a response function analysis using previous June through current September.

explorations as easy as possible by limiting the requirements to a modern web browser and an internet connection.

Dendrobox provides a basic zoomable world map, where the user can select records of interest. Additionally, Dendrobox allows filtering the entries for species and contributors. For the selected records, Dendrobox then displays the standard chronology (the individual years can be identified with the mouse, e.g. to explore pointer years), a climate diagram for the site and the dendroclimatological profile of the record as results of a response function analysis (Fig. 1). This makes it easy and straightforward to traverse the wealth of information contained in the ITRDB. Possible applications of Dendrobox include identifying records with a specific dendroclimatological potential, demonstrating the relations of tree-growth and climate in teaching, or simply playing with an impressive data set without the hassle of setting up analytical tools.

It is important to mention that Dendrobox deliberately offers no direct way to download the raw data of the original tree-ring records. Dendrobox instead links to the corresponding entries in the ITRDB, since the ITRDB is and should remain the central repository for these records. However, the site chronologies, climate characteristics and dendroclimatological response profiles are available for direct download.

Implementation

Tree-ring width data was obtained from the ITRDB via the FTP interface to the NOAA public servers. I downloaded all chronologies and the raw records, and obtained meta-data and coordinates for the records by parsing the Google Earth layer (KML) provided by the ITRDB. Records with incomplete meta-data were omitted from the data compilation. Wherever possible, I used the original standard chronologies provided by the ITRDB. When no standard chronologies were readily available, I computed them from the raw ring-width records, using robust averaging (Mosteller and Tukey, 1977) of the single series after detrending with cubic splines with a frequency cutoff of 50% at 67% of the series length (Cook and Peters, 1981) using R version 3.1.1 (R Development Core Team, 2014) and package dplR (Bunn, 2008). Following the approach of St. George (2014), I omitted records that could not be read into R with dplR due to errors or unusual formats. The remaining data set for Dendrobox comprises 2406 standard chronologies.

To obtain climate records related to the specific sites, I interpolated for each site the four nearest 0.5° grid cells of the CRU TS 3.21 gridded monthly precipitation and temperature data (Mitchell and Jones, 2005) using inverse distance weighting (Shepard, 1968) using R package tusk (Zang, 2014). Climate is characterized in terms of monthly mean precipitation sums and temperature means for the climate normal period 1961–1990.

The dendroclimatological profile of each chronology is computed as the bootstrapped response function (Guiot, 1991) of the chronology with monthly precipitation and temperature data for longest common time span. The sequence of response coefficients ranges from previous year's June to current year's September. I computed the bootstrapped response functions using R package treeclim (Zang and Biondi, in press).

The JavaScript libraries D3 (Bostock, 2014a) and TopoJSON (Bostock, 2014b) were used to create the interactive visualization of the data for the website. The website is hosted on GitHub (http://github.com/cszang/dendrobox) and deployed via Git (http://git-scm.com/). Dendrobox is released under the Creative Commons Attribution-ShareAlike License (https://creativecommons.org/licenses/by-sa/4.0/). Dendrobox requires a recent version of Mozilla Firefox, Opera, or Google Chrome.

Acknowledgements

I acknowledge funding by the European Research Council under the European Union's Seventh Framework Program (FP7/2007-2013)/ERC grant agreement no. [282250]. This tool would not exist without the numerous researchers involved in sharing their tree-ring measurements through the International Tree Ring Data Bank (ITRDB) maintained by the NOAA Paleoclimatology Program and the World Data Center for Paleoclimatology. I am especially grateful for their efforts to make their data publicly available.

References

Babst, F., Poulter, B., Trouet, V., Tan, K., Neuwirth, B., Wilson, R., Carrer, M., Grabner, M., Tegel, W., Levanic, T., Panayotov, M., Urbinati, C., Bouriaud, O., Ciais, P., Frank, D., 2013. Site- and species-specific responses of forest growth to climate across the European continent. Global Ecol. Biogeogr. 22, 706–717, http://dx.doi.org/10.1111/geb.12023.

Bostock, M., 2014a. D3.js – Data-Driven Documents. Version 3.4.10, http://d3js.org/

Bostock, M., 2014b. TopoJSON – An Extension to GeoJSON that Encodes Topology. Version 1.6.14, https://github.com/mbostock/topojson

Breitenmoser, P., Brönnimann, S., Frank, D., 2014. Forward modelling of tree-ring width and comparison with a global network of tree-ring chronologies. Clim. Past 10, 437–449, http://dx.doi.org/10.5194/cp-10-437-2014.

Bunn, A., 2008. A dendrochronology program library in R (dplR). Dendrochronologia 26, 115–124.

Bunn, A.G., Jansma, E., Korpela, M., Westfall, R.D., Baldwin, J., 2013. Using simulations and data to evaluate mean sensitivity (ζ) as a useful statistic in dendrochronology. Dendrochronologia 31, 250–254, http://dx.doi.org/10.1016/j.dendro.2013.01.004.

Cook, E., Peters, K., 1981. The smoothing spline: a new approach to standardizing forest interior tree-ring width series for dendroclimatic studies. Tree Ring Bull. 41, 45–53.

Grissino-Mayer, H.D., Fritts, H.C., 1997. The International Tree-Ring Data Bank: an enhanced global database serving the global scientific community. Holocene 7, 235–238, http://dx.doi.org/10.1177/095968369700700212.

Guiot, J., 1991. The bootstrapped response function. Tree Ring Bull. 51, 39–41.

Mitchell, T.D., Jones, P.D., 2005. An improved method of constructing a database of monthly climate observations and associated high-resolution grids. Int. J. Climatol. 25, 693–712, http://dx.doi.org/10.1002/joc.1181.

Mosteller, F., Tukey, J.W., 1977. Data Analysis and Regression. Addison-Wesley, Reading.

R Core Team, 2014. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/

Salas, J.D., Tarawneh, Z., Biondi, F., 2014. A hydrological record extension model for reconstructing streamflows from tree-ring chronologies. Hydrol. Process., http://dx.doi.org/10.1002/hyp.10160.

Shepard, D., 1968. A two dimensional interpolation function for regularly spaced data. In: Proceedings of the 1968 23rd ACM National Conference.

St. George, S., 2014. An overview of tree-ring width records across the Northern Hemisphere. Quaternary Sci. Rev. 95, 132–150, http://dx.doi.org/10.1016/j.quascirev.2014.04.029.

Vicente-Serrano, S.M., Camarero, J.J., Azorin-Molina, C., 2014. Diverse responses of forest growth to drought time-scales in the Northern Hemisphere. Global Ecol. Biogeogr., http://dx.doi.org/10.1111/geb.12183.

Zang, C., 2014. Tusk – Convenience Functions for Dealing with Gridded Climate data in netcdf Format. R Package Version 0.2, http://github.com/cszang/tusk

Zang, C., Biondi, F., 2014. *treeclim*: an R package for the numerical calibration of proxy–climate relationships. Ecography, http://dx.doi.org/10.1111/ecog.01335 (in press).