UNIVERSITÉ DE LAUSANNE

DOCTORAL THESIS

Software and Numerical Tools for Palaeoclimate Analysis

Author:
Philipp S. SOMMER

Supervisor:
Dr. Basil A. S. Davis

A thesis submitted in fulfillment of the requirements for the degree of Doctor of Science

in the

The Davis Group
Institute of Earth Surface Dynamics (IDYST)

August 13, 2019

Declaration of Authorship

I, Philipp S. SOMMER, declare that this thesis titled, "Software and Numerical Tools for Palaeoclimate Analysis" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

"Thanks to my solid academic training, today I can write hundreds of words on virtually any topic without possessing a shred of information, which is how I got a good job in journalism."

Dave Barry

UNIVERSITÉ DE LAUSANNE

Abstract

Faculty of Geosciences and Environment (FGSE)
Institute of Earth Surface Dynamics (IDYST)

Doctor of Science

Software and Numerical Tools for Palaeoclimate Analysis

by Philipp S. SOMMER

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

The acknowledgments and the people to thank go here, don't forget to include your project advisor...

Contents

For/Dedicated to/To my…

Chapter 1

Introduction

1.1 Learning from the past – Why we study Palaeoclimates

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Aliquam ultricies lacinia euismod. Nam tempus risus in dolor rhoncus in interdum enim tincidunt. Donec vel nunc neque. In condimentum ullamcorper quam non consequat. Fusce sagittis tempor feugiat. Fusce magna erat, molestie eu convallis ut, tempus sed arcu. Quisque molestie, ante a tincidunt ullamcorper, sapien enim dignissim lacus, in semper nibh erat lobortis purus. Integer dapibus ligula ac risus convallis pellentesque.

1.2 The importance of software and numeric for climate science

1. History of Software development in Earth System Science
   - Development of Climate models
   - Statistics
   - Visualization
   - Distribution and Synthesis of Data
   - Quantitative and large-scale reconstructions through proxies
2. An overview on open-source Software Development
   - Version control
   - Transparency
   - Automated tests through Continuous Integration
   - Accessible and extensive documentation
   - Distribution of Software through Package managers (conda, PyPi, Docker)

1.3 Challenges tackled by this

- Visual analysis of large amounts of data (psyplot)
- Synthesizing and Distributing large amounts of proxy data (straditize, EMPD/POLNET viewer)
- Understanding and modelling past climates with statistical methods (Teleconnections, GWGEN)
- Thesis structure:

1. Software tools: Chapters 2, 3, 4
2. Numerical tools: Chapters 5, 6
3. Appendix

Chapter 2

Psyplot

A flexible framework for interactive data analysis

- Summary (from JOSS Paper)
- Other visualization frameworks (short review)
- The psyplot framework design
- Integration into a graphical user interface

Chapter 3

Straditize

A digitization software for pollen diagrams

- quaternary paper
- straditize builds upon the psyplot GUI
- fill the gaps for large-scale climate reconstructions

Chapter 4

The EMPD- and POLNET web-interface to pollen data

- quaternary paper
- straditize builds upon the psyplot GUI
- fill the gaps for large-scale climate reconstructions

Chapter 5

GWGEN

A global weather generator for daily climate

- GMD paper

Chapter 6

A model analysis on the stability of northern hemispheric teleconnections

- still too write…

Chapter 7

Conclusions

- New tools that have been developed
- Quality standards of the tools
- Further development and potential usage

Appendices

List of Figures

List of Tables

List of Abbreviations

LAH	**L**ist **A**bbreviations **H**ere
WSF	**W**hat (it) **S**tands **F**or

List of Symbols

a	distance	m
P	power	W ($\mathrm{J\,s^{-1}}$)
ω	angular frequency	rad

Appendix A

Computing climate-smart urban land use with the Integrated Urban Complexity model (IUCm 1.0)

Write your Appendix content here.

Appendix B

Publications and Conference contributions

B.0.1 Peer-reviewed

Cremades, R. and P. S. Sommer (2019). "Computing climate-smart urban land use with the Integrated Urban Complexity model (IUCm 1.0)". In: *Geoscientific Model Development* 12.1, pp. 525–539. DOI: 10.5194/gmd-12-525-2019. URL: https://www.geosci-model-dev.net/12/525/2019/.

Sommer, Philipp, Dilan Rech, Manuel Chevalier, and Basil Davis (2019). "straditize: Digitizing stratigraphic diagrams". In: *Journal of Open Source Software* 4.34, p. 1216. DOI: 10.21105/joss.01216. URL: https://doi.org/10.21105/joss.01216.

Weitzel, Nils, Sebastian Wagner, Jesper Sjolte, Marlene Klockmann, Oliver Bothe, Heather Andres, Lev Tarasov, Kira Rehfeld, Eduardo Zorita, Martin Widmann, Philipp S. Sommer, Gerd Schädler, Patrick Ludwig, Florian Kapp, Lukas Jonkers, Javier García-Pintado, Florian Fuhrmann, Andrew Dolman, Anne Dallmeyer, and Tim Brücher (2018). "Diving into the past – A paleo data-model comparison workshop on the Late Glacial and Holocene". In: *Bulletin of the American Meteorological Society*. DOI: 10.1175/bams-d-18-0169.1.

Sommer, Philipp S (2017). "The psyplot interactive visualization framework". In: *The Journal of Open Source Software* 2.16. DOI: 10.21105/joss.00363. URL: https://doi.org/10.21105/joss.00363.

Sommer, Philipp S. and Jed O. Kaplan (2017). "A globally calibrated scheme for generating daily meteorology from monthly statistics: Global-WGEN (GWGEN) v1.0". In: *Geosci. Model Dev.* 10.10, pp. 3771–3791. DOI: 10.5194/gmd-10-3771-2017.

B.0.2 Conference contributions

Sommer, P. S., B. A. S. Davis, and M. Chevalier (2019). "Github and Open Research Data; an example using the Eurasian Modern Pollen Database". In: *EGU General Assembly Conference Abstracts*. Vol. 21. EGU General Assembly Conference Abstracts, p. 5669. URL: https://meetingorganizer.copernicus.org/EGU2019/EGU2019-5669.pdf.

Sommer, Philipp S., Basil A. S. Davis, Manuel Chevalier, Jian Ni, and John Tipton (2019). "The HORNET project: applying 'big data' to reconstruct the climate of the Northern Hemisphere during the Holocene". In: *20th Congress of the International Union for Quaternary Research (INQUA)*. International Union for Quaternary Research. URL: https://app.oxfordabstracts.com/events/574/program-app/submission/94623.

Sommer, P. S. (2018). "Psyplot: Interactive data analysis and visualization with Python". In: *EGU General Assembly Conference Abstracts*. Vol. 20. EGU General Assembly Conference Abstracts. Provided by the SAO/NASA Astrophysics Data System, p. 4701. URL: http://adsabs.harvard.edu/abs/2018EGUGA..20.4701S.

Sommer, P. S., B. A. S. Davis, and M. Chevalier (2018). "STRADITIZE: An open-source program for digitizing pollen diagrams and other types of stratigraphic data". In: *EGU General Assembly Conference Abstracts*. Vol. 20. EGU General Assembly Conference Abstracts. Provided by the SAO/NASA Astrophysics Data System, p. 4433. URL: http://adsabs.harvard.edu/abs/2018EGUGA..20.4433S.

Sommer, Philipp S., Manuel Chevalier, and Basil A. S. Davis (2018). "STRADITIZE: An open-source program for digitizing pollen diagrams and other types of stratigraphic data". In: *AFQUA - The African Quaternary*. Nairobi (Kenya): AFQUA. URL: https://afquacongress.wixsite.com/afqua2018.

Sommer, P. and J. Kaplan (2017). "Quantitative Modeling of Human-Environment Interactions in Preindustrial Time". In: *PAGES OSM 2017, Abstract Book*, pp. 129–129.

Sommer, P. (2016). "Psyplot: Visualizing rectangular and triangular Climate Model Data with Python". In: *EGU General Assembly Conference Abstracts*. Vol. 18. EGU General Assembly Conference Abstracts. Provided by the SAO/NASA Astrophysics Data System, p. 18185. URL: http://adsabs.harvard.edu/abs/2016EGUGA..1818185S.

Sommer, P. and J. Kaplan (2016a). "Fundamental statistical relationships between monthly and daily meteorological variables: Temporal downscaling of weather based on a global observational dataset". In: *EGU General Assembly Conference Abstracts*. Vol. 18. EGU General Assembly Conference Abstracts. Provided by the SAO/NASA Astrophysics Data System, EPSC2016–18183. URL: http://adsabs.harvard.edu/abs/2016EGUGA..1818183S.

— (2016b). "Fundamental statistical relationships between monthly and daily meteorological variables: Temporal downscaling of weather based on a global observational dataset". In: *Workshop on Stochastic Weather Generators*. Vannes (France): University of Bretagne Sud. URL: https://www.lebesgue.fr/content/sem2016-climate-program.

Appendix C

New Software Tools - An Overview

This section mainly contains the latest version of the package, a short summary and an information table about where to find everything (Documentation, source code, etc.)

C.1 Main packages

- psyplot
  - psy-simple
  - psy-maps
  - psy-reg
  - psyplot-gui
  - psy-strat
- straditize
- gwgen
- iucm
- EMPD
  - EMPD-admin
  - EMPD-viewer
  - EMPD-data
- POLNET
  - POLNET-viewer
  - POLNET-data

C.2 Other packages

- docrep
- sphinx-nbexamples
- model-organization
- funcargparse
- autodocsumm