

# Open Science Improvements in Dendrochronology and Data Processing Pipelines for Quantitative Wood Anatomy

Julie Edwards (she/her)

University of Arizona, Laboratory of Tree-Ring Research

Nov 29<sup>th</sup> 2023

# Roots for Resilience (R4R)



Arizona Institute  
for Resilience

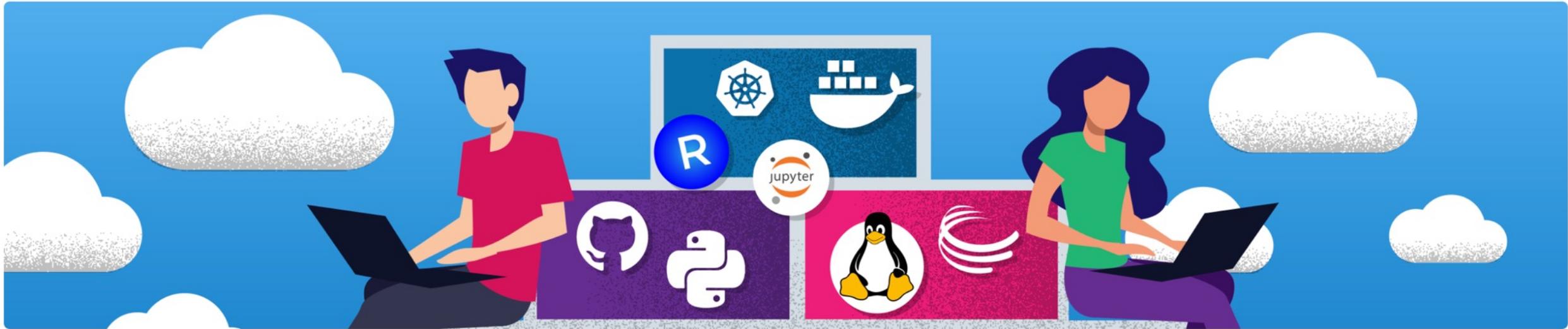


RESEARCH, INNOVATION & IMPACT

Data Science Institute

# Roots for Resilience (R4R)

- Develop data science capabilities across the AIR participating departments and research groups
- Accelerate research projects of participating fellows and their home department research groups
- Build professional networks for addressing large-scale challenges and research questions of interest to AIR faculty
- Develop new interdisciplinary collaborations across AIR, DSI, CyVerse, and other academic units for writing new proposals
- Develop a cohort among participants (and Data Science Ambassadors) to support each other in their own research and efforts to engage their departments



## Foundational Open Science Skills

CyVerse's 8-week virtual workshop teaches you the principles, practices, and how-tos for doing collaborative open science using cutting-edge, open source cyberinfrastructure, in a collaborative, hands-on setting. To see how our FOSS workshop can support your work, check out the [curriculum](#).

# YEAR OF OPEN SCIENCE



A row of classical columns with text labels overlaid on a semi-transparent band. The columns are white with fluted shafts and decorative capitals, receding into the distance on a reflective surface. A semi-transparent white band is overlaid across the middle of the image, containing six text labels in bold black font, each centered over a column.

**Open Access  
Publications**

**Open Data**

**Open  
Educational  
Resources**

**Open  
Methodology**

**Open Peer  
Review**

**Open Source  
Software**

Be

**FAIR**

**Findable Accessible Interoperable Reusable**

and

**CARE**

**Collective Benefit Authority to Control Responsibility Ethics**

# Examples of Open Science In Dendrochronology



# ITRDB

## International Tree-Ring Data Bank

### GENERAL SEARCH ⓘ

Enter search text...

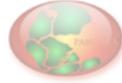
#### Data Publisher



Neotoma



NOAA/WDS for Paleoclimatology



PANGAEA

#### Data Type

Borehole  
 Climate Forcing  
 Climate Reconstructions  
 Corals And Sclerosponges  
 Fire History  
 Historical  
 Ice Cores  
 Insect  
 Instrumental

Tree Ring

Search

Clear

### ADVANCED SEARCH ⓘ

#### Investigators

investigator filter...

Ababneh, L.  
Abel, K.  
Abrams, M.D.  
Ackerman, D.





## Programs

Name	Function
ARSTAN*	Chronology development, plotting and analysis
SigFree*	Signal Free Chronology development, plotting and analysis
Cofecha <sup>‡</sup>	Dating and Measurement Quality Control
Xdate	Date floating series
Ind2Col	Reformat chronology files to space delimited column files.
Column	Reformat ring-width decade files to space delimited files
MakeRec	Reports the content of increment and chronology files

# Tree-Ring Matlab Toolbox

- [Description](#)
- [Requirements](#)
- [Notation](#)
- [Function List](#)



# openDendro

Advanced open-source tools for paleoenvironmental reconstruction  
Andy Bunn, Kevin Anchukaitis, Tyson Swetnam, Ed Cook, Ifeoluwa Godwin Ale, and Michele Cosi



AGS - 2054514

# openDendro

## Motivation (1)

Legacy, platform-specific  
compiled code

```

..... program turbo-
c MODIFICATIONS -- 12/2006-
c ..... subr. robsum, fixed bug when dealing with chronologies containing large gaps. ERC-
c ..... subr. scale, calculates optimum plot limits and tic interval-
c ..... ALGORITHM AS 96 -- APPL. STATIST. (1976) VOL. 25, NO. 1-
c-
c NOTES:-
c-
c *** mxy = maximum number of chronology years ***
c *** mxs = maximum number of tree-ring series ***
c ..... !!! Before recompiling for different platforms !!!
c *** The character variable (dev) must be set to "MacI" for plotting on Macs-
c ..... and "win3" for plotting on pc's. The value of dev is case sensitive.-
c *** change these parameters to suit your needs ***
c-
..... parameter (mxy=5000, mxs=1500, mxplts=20) !msx=500
..... real*4 x(mxy, mxs), y(mxy, 16), f(mxy), stats(mxs, 12), crn(mxy), corr(mxs, mxs)-
..... real*4 wrk1(mxy), wrk2(mxy), wrk3(mxy), wrk4(mxy), wrk5(mxy), wrk6(mxy)-
..... real*4 phi(12), cof(12, mxs), rxm(mxy, 7, 4), rxm1(mxy, 7), eq(7)-
..... real*4 bierr(mxy), acr(12), pac(12), seac(12), shl(mxy), shh(mxy)-
..... real*4 a(mxs, mxs), b(mxs, mxs), c(mxs, mxs)-
..... integer idate(mxs+2, 10), ns(mxy), nss(mxy), mask(mxs)-
..... integer nshft(mxs), keep(mxs)-
..... character fil*40, fil2*40, tit*85, line*50, line1*60
..... character id*8, ident(mxs)*8, id1(mxs)*8, tab, crc, bif, ans-
..... character fil4*40, title*80, datum1*6, datum2*6, datum3*6, frm*20
..... character tit1*85, tag*3, md, jtrdb(3)*85
c-
c *** common block variables-
c-
..... integer jems(30, 5), ndd .....
..... character go, cpm*8, cpm1*8, pixels, bd, bf, q*2, qq*2, -
..... * q3*2, cvp, fill*40, itrdb(3)*85
c-
c *** common block chunks-
c-
..... common /logunits/ iu9, iu10, iu11, iu12, iu13, iu14, iu15, iu16, -
..... * iu17, iu18, iu19, iu20, iu21, iu30, iu31, iu32, iu33, iu34, -
..... * iu35, iu36, iu37, iu38, iu39-
..... common /commands/ go, cpm, cpm1, pixels, bd, bf, -
..... * q, qq, q3, cvp, fill, itrdb-
..... common /icommands/ jems, ndd ..... !new pj-
..... common /ts11/ x, crn, idate, ident, nc-
..... common /ts12/ y-

```

Advanced techniques

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

ELSEVIER

Dendrochronologia 26 (2008) 71–86

DENDROCHRONOLOGIA

[www.elsevier.de/dendro](http://www.elsevier.de/dendro)

ORIGINAL ARTICLE

**A “signal-free” approach to dendroclimatic standardisation**

Thomas M. Melvin\*, Keith R. Briffa

*Climatic Research Unit, School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK*

Received 12 July 2007; accepted 27 December 2007

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

ELSEVIER

Dendrochronologia 25 (2007) 65–69

DENDROCHRONOLOGIA

[www.elsevier.de/dendro](http://www.elsevier.de/dendro)

TECHNICAL NOTE

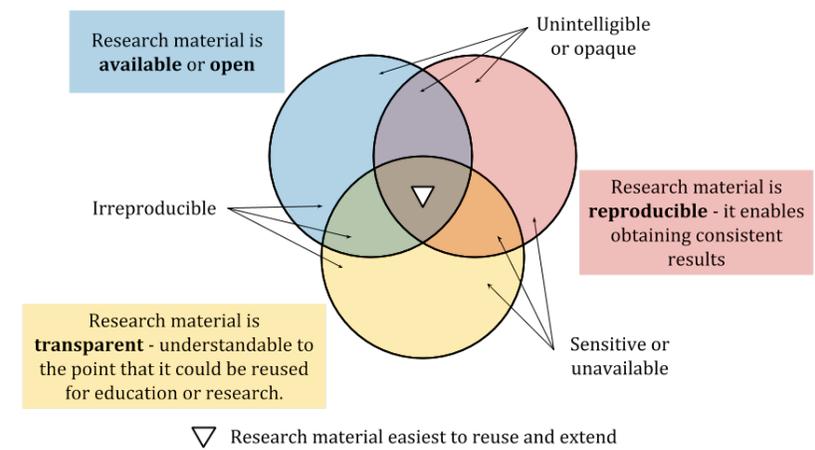
**Time-varying-response smoothing**

Thomas M. Melvin<sup>a,\*</sup>, Keith R. Briffa<sup>a</sup>, Kurt Nicolussi<sup>b</sup>, Michael Grabner<sup>c</sup>

<sup>a</sup>*Climatic Research Unit, Department of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK*  
<sup>b</sup>*Institute of Geography, University of Innsbruck, Innrain 52, A-6020 Innsbruck, Austria*  
<sup>c</sup>*BOKU—University of Natural Resources and Applied Life Sciences, Vienna*

Received 31 March 2006; accepted 18 January 2007

Reproducible research



# openDendro

## Motivation (2)

cloud-based analysis

xDateR 1. Introduction and Upload

**Upload RWL**  
Upload (drag or browse) a standard file of ring widths (.rwf) readable by `read.rwf` (e.g., Tucson, Heidelberg, compact, TRiDaS format).

**Dated Series**  
Browse... No file selected

Or use example data

Welcome to the beta version of **xDateR** – a Shiny app for crossdating tree-ring data. This app will help you do initial quality control on a set of (usually) ring widths and potentially identify dating problems. The idea for this app is to use existing functions in the package `dpIR` to provide an interactive environment for assessing dating quality and potentially fixing problems.

[A video showing how to use some of the functions is on YouTube.](#)

This app contains tools for crossdating data uploaded in an accepted standard `rwf` file format. You should start by uploading a file using the widget on the left. If you want to use an example data set you can check the “Or use example data” box. The example data are ring-width data where the dates in some of the series have been deliberately corrupted.

After uploading, standard descriptive statistics and plots are produced in the **Describe RWL Data** tab. This is the beginning of the cross-dating process. The **Correlations Between Series** tab produces standard correlation graphs and statistics based on segment length and other options specified by the user. The **Individual Series Correlations** tab allows individual series to be further investigated via running and cross-correlation analyses. Rings can be added and deleted using the **Edit Series** tab. Reports can be saved at every step and a `rwf` file can be written.

Preliminary functionality to work with undated series (floaters) is available as well. To access those features, first load a dated (master) `rwf` file. After that, you can then upload a `rwf` file with arbitrary dates. Once you do so, the **Undated Series** tab will appear. There you can try to find dates for each of those series as compared to the dated `rwf` file. As before, you can use a demo data.

[This project is on GitHub](#) as is `dpIR`.

Please cite `dpIR` if you use this app in any published work:

- Bunn AG (2008). “A dendrochronology program library in R (`dpIR`).” *Dendrochronologia*, 26(2), 115-124. ISSN 1125-7865, doi: 10.1016/j.dendro.2008.01.002 (URL: <http://doi.org/10.1016/j.dendro.2008.01.002>).
- Bunn AG (2010). “Statistical and visual crossdating in R using the `dpIR` library.” *Dendrochronologia*, 28(4), 251-258. ISSN 1125-7865, doi: 10.1016/j.dendro.2009.12.001 (URL: <http://doi.org/10.1016/j.dendro.2009.12.001>).

This app is still in development. Suggestions are welcome!

*Remember! Users should never rely purely on statistical crossdating but always go back to the wood to verify what is actually happening.*

–Andy Bunn



Tools ▾ Services ▾ Learn ▾ Collaborate ▾ About ▾ Search

Sign up ▾

## The Open Science Workspace for Collaborative Data-driven Discovery

Create Account



PANGEO

A community platform for Big Data geoscience

# openDendro

## Motivation (3)

collaborative open source software development

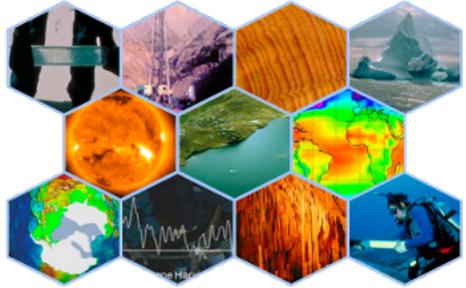
### **dplR: Dendrochronology Program Library in R**

Perform tree-ring analyses such as detrending, chronology building, and cross dating. Read and write standard file formats used in dendrochronology.

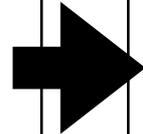
Version: 1.7.4  
Depends: R (≥ 3.5.0)  
Imports: graphics, grDevices, grid, stats, utils, [lattice](#) (≥ 0.13-6), [Matrix](#) (≥ 1.0-3), [digest](#) (≥ 0.2.3), [matrixStats](#) (≥ 0.50.2), [png](#) (≥ 0.1-2), [R.utils](#) (≥ 1.32.1), [stringi](#) (≥ 0.2-3), [stringr](#) (≥ 0.4), [XML](#) (≥ 2.1-0), [plyr](#) (≥ 1.8), [signal](#), [boot](#)  
Suggests: [Cairo](#) (≥ 1.5-0), [dichromat](#) (≥ 1.2-3), [foreach](#), [forecast](#) (≥ 3.6), [gmp](#) (≥ 0.5-5), [iterators](#), [knitr](#), [RColorBrewer](#), [rmarkdown](#), [testthat](#) (≥ 0.8), [tikzDevice](#), [waveslim](#)  
Published: 2022-06-23  
Author: Andy Bunn [aut, cph, cre, trl], Mikko Korpela [aut, cph, trl], Franco Biondi [aut, cph], Filipe Campelo [aut, cph], Pierre Mérian [aut, cph], Fares Qeadan [aut, cph], Christian Zang [aut, cph], Allan Buras [ctb], Alice Cecile [ctb], Manfred Mudelsee [ctb], Michael Schulz [ctb], Stefan Klesse [ctb], David Frank [ctb], Ronald Visser [ctb], Ed Cook [ctb], Kevin Anchukaitis [ctb]  
Maintainer: Andy Bunn <bunna at wwu.edu>  
License: [GPL-2](#) | [GPL-3](#) [expanded from: GPL (≥ 2)]

# openDendro

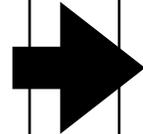
## Workflow



Acquire raw data from online databases



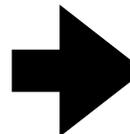
Develop chronologies



Make and analyze reconstructions



Machine Learning/AI



Visualization

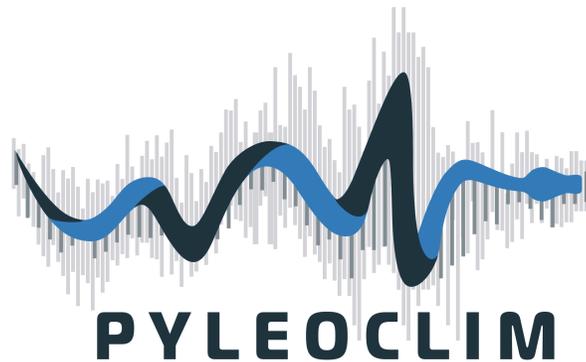
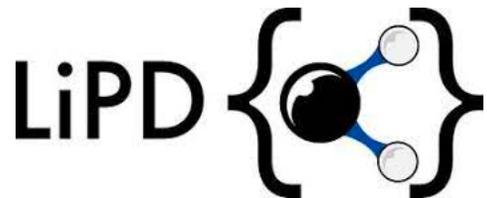


larger Python/R ecosystems

**dplR**

**pcRecon**

**dplPy**



# Bootcamp

*[Register Now!](#)*

*openDendro Bootcamp*

*Jan 8<sup>th</sup>-9<sup>th</sup> 2024*

*Laboratory of Tree-Ring Research*

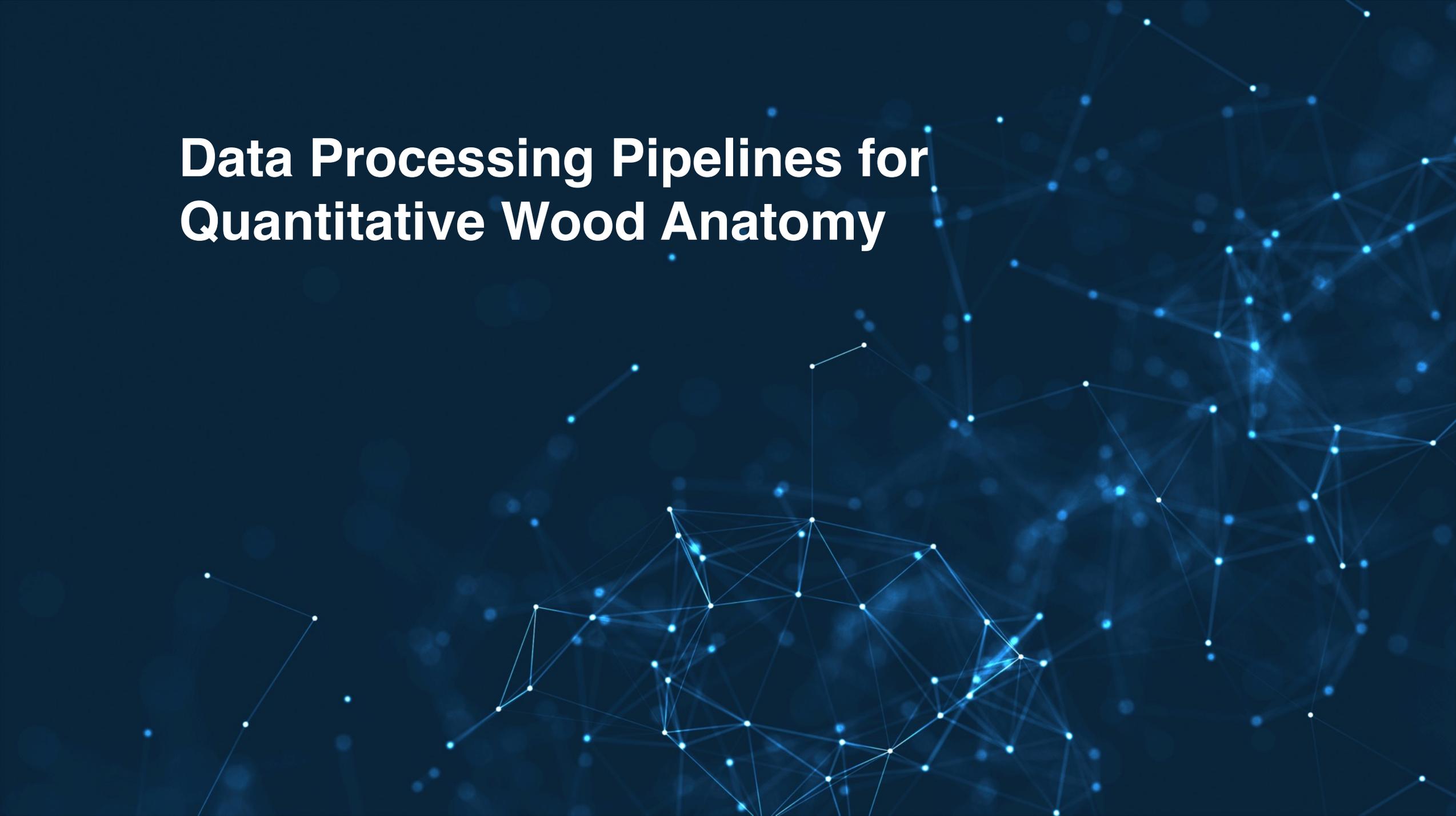
*University of Arizona*

## Announcement

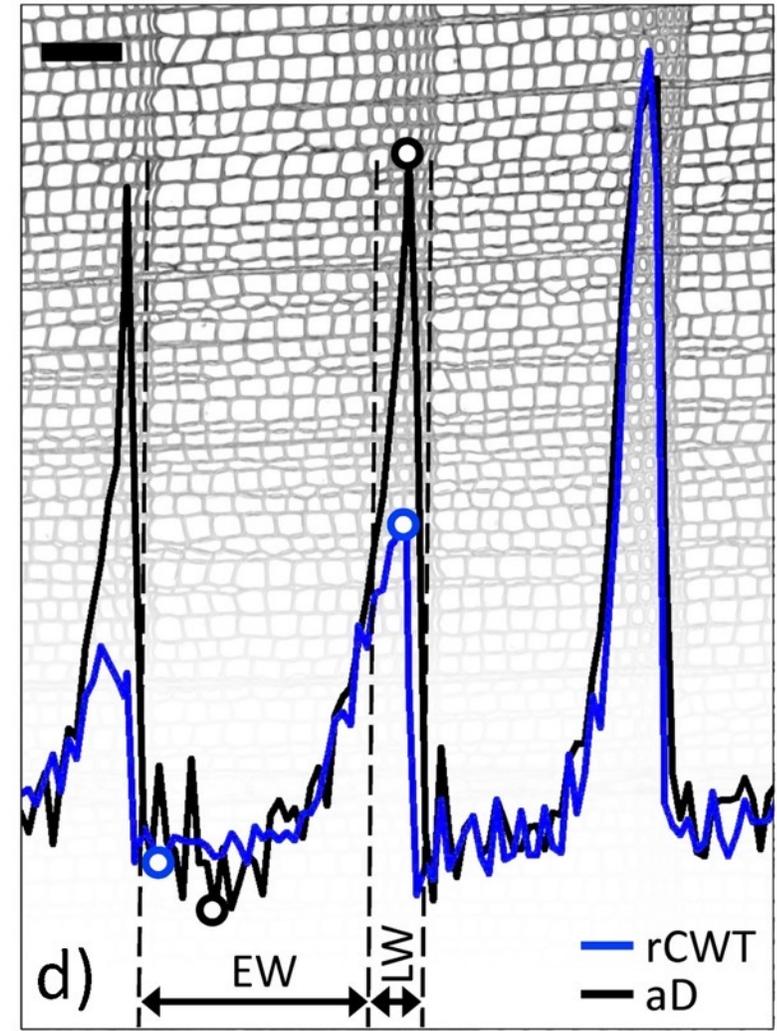
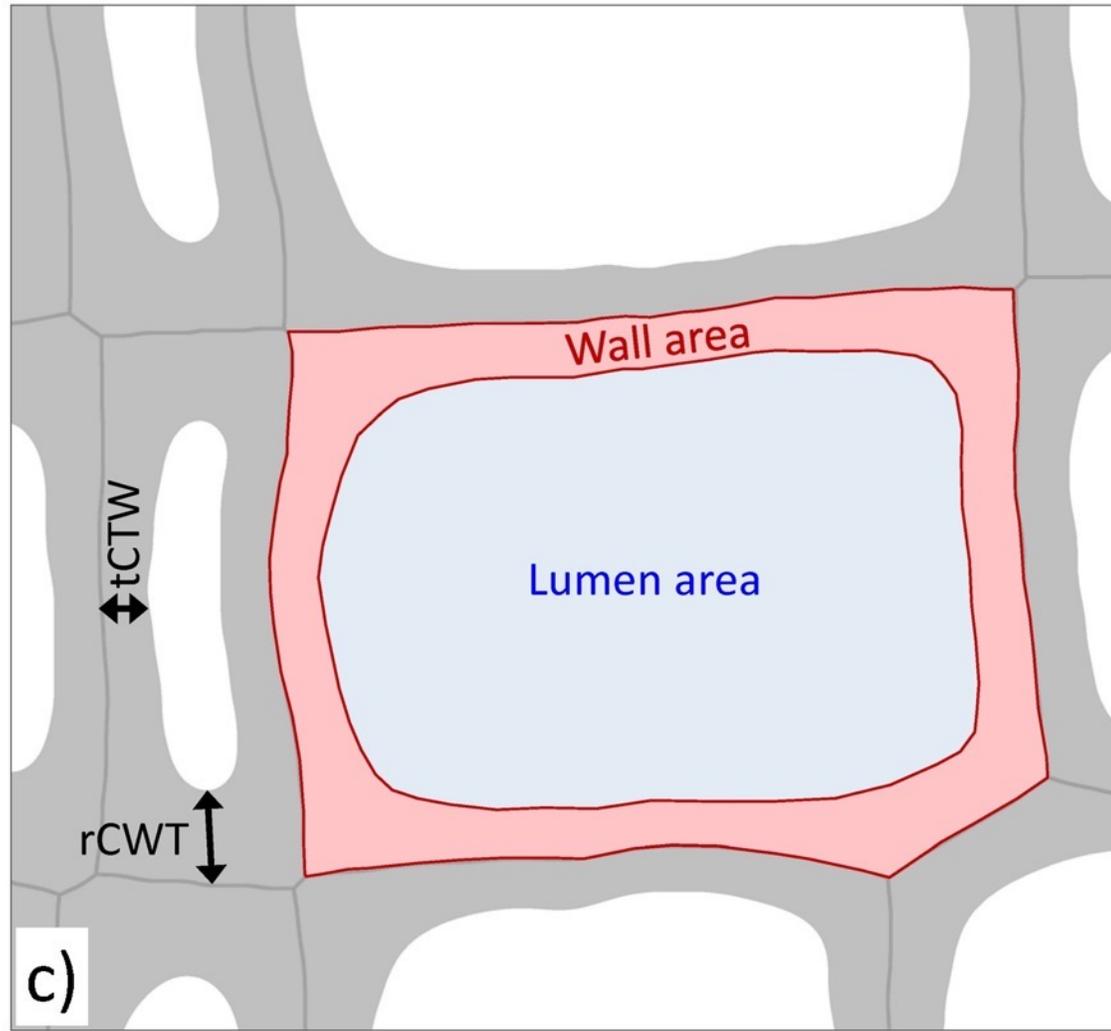
We are pleased to announce a comprehensive two-day bootcamp focused on openDendro. This event will provide participants with valuable hands-on training in the R and Python programming languages, using openDendro for analysis in dendrochronology.



# Data Processing Pipelines for Quantitative Wood Anatomy



# Cell measurements



Growth direction (pith-bark)

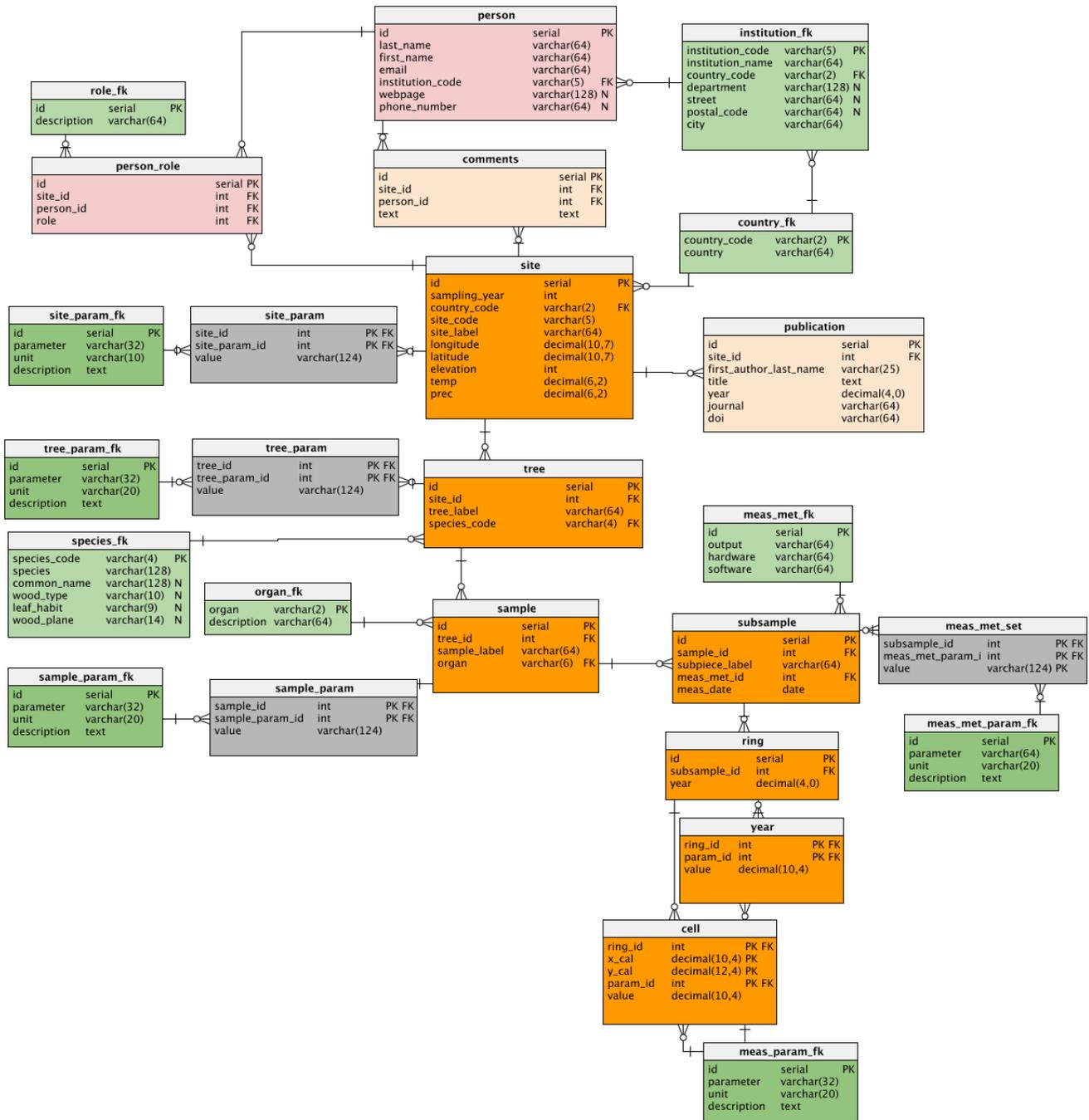
**Xcell**

**Eidg. Forschungsanstalt WSL**

Forschung für Mensch und Umwelt



global_table			
site_id	int		
site_code	varchar(5)	PK	
year	int	PK	
site_label	varchar(64)		
manip	varchar(5)	PK	
country_code	varchar(2)		
longitude	decimal(10,7)		
latitude	decimal(10,7)		
elevation	int		
temp	decimal(6,2)		
prec	decimal(6,2)		
species_code	varchar(4)	PK	
wood_type	varchar(124)		
leaf_habit	varchar(124)		
wood_plane	varchar(124)		
organ	varchar(2)	PK	
output	varchar(64)	PK	
hardware	varchar(64)	PK	
software	varchar(64)	PK	
last_name	varchar(64)		
first_name	varchar(64)		
email	varchar(64)		
institution_code	varchar(5)		
n_trees	int		
n_radli	int		
n_rings	int		
n_obs	int	N	
from	int		
to	int		
ring_width	decimal(10,4)	N	
la	decimal(10,4)	N	
ldrad	decimal(10,4)	N	
ldtan	decimal(10,4)	N	
cwtrad	decimal(10,4)	N	
cwttan	decimal(10,4)	N	
cwa	decimal(10,4)	N	



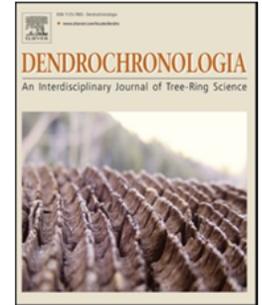


ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

# Dendrochronologia

journal homepage: [www.elsevier.com/locate/dendro](http://www.elsevier.com/locate/dendro)



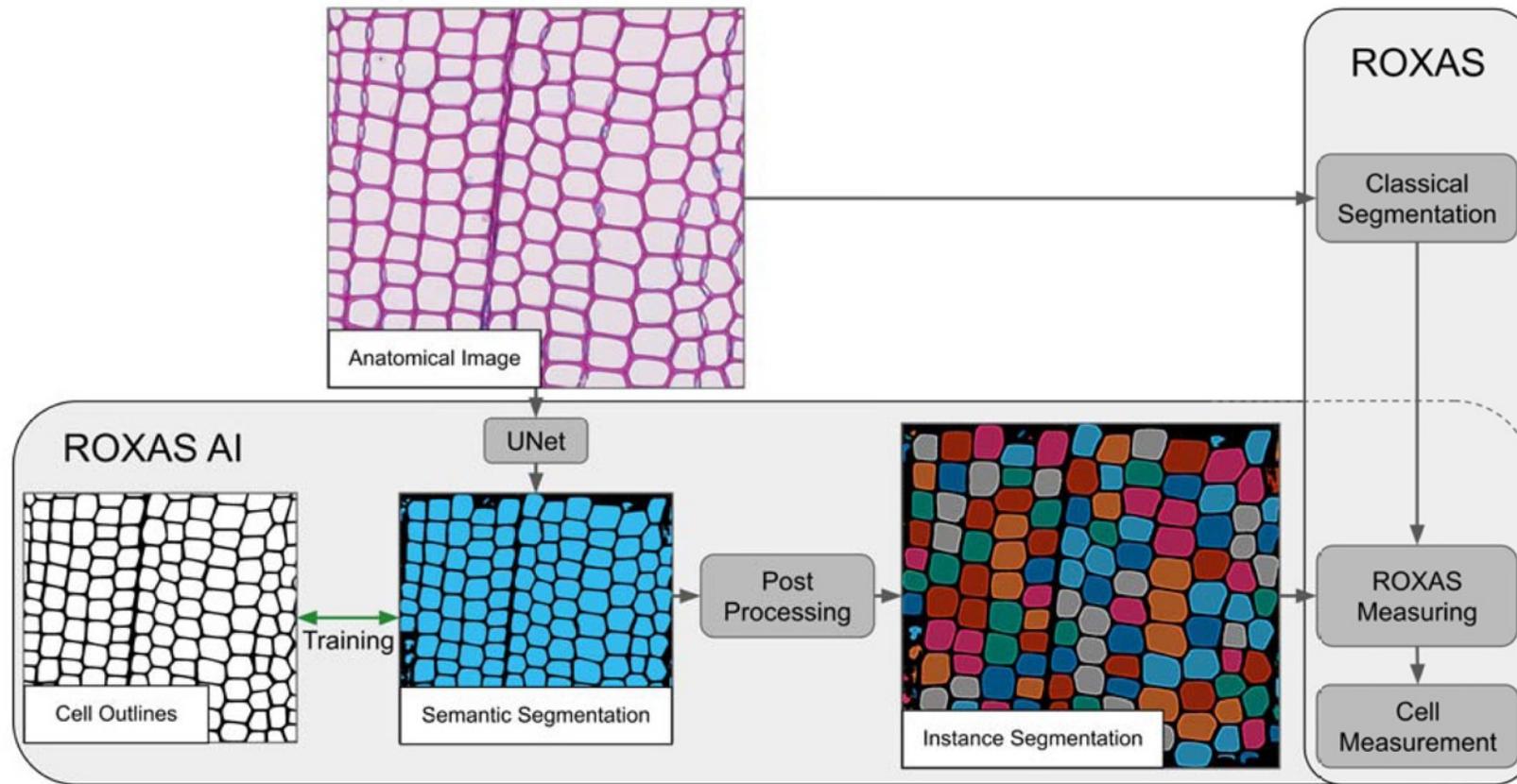
## Towards ROXAS AI: Deep learning for faster and more accurate conifer cell analysis

Marc Katzenmaier<sup>a,b,\*</sup>, Vivien Sainte Fare Garnot<sup>a</sup>, Jesper Björklund<sup>b,c</sup>, Loïc Schneider<sup>b,c</sup>,  
Jan Dirk Wegner<sup>a</sup>, Georg von Arx<sup>b,c</sup>

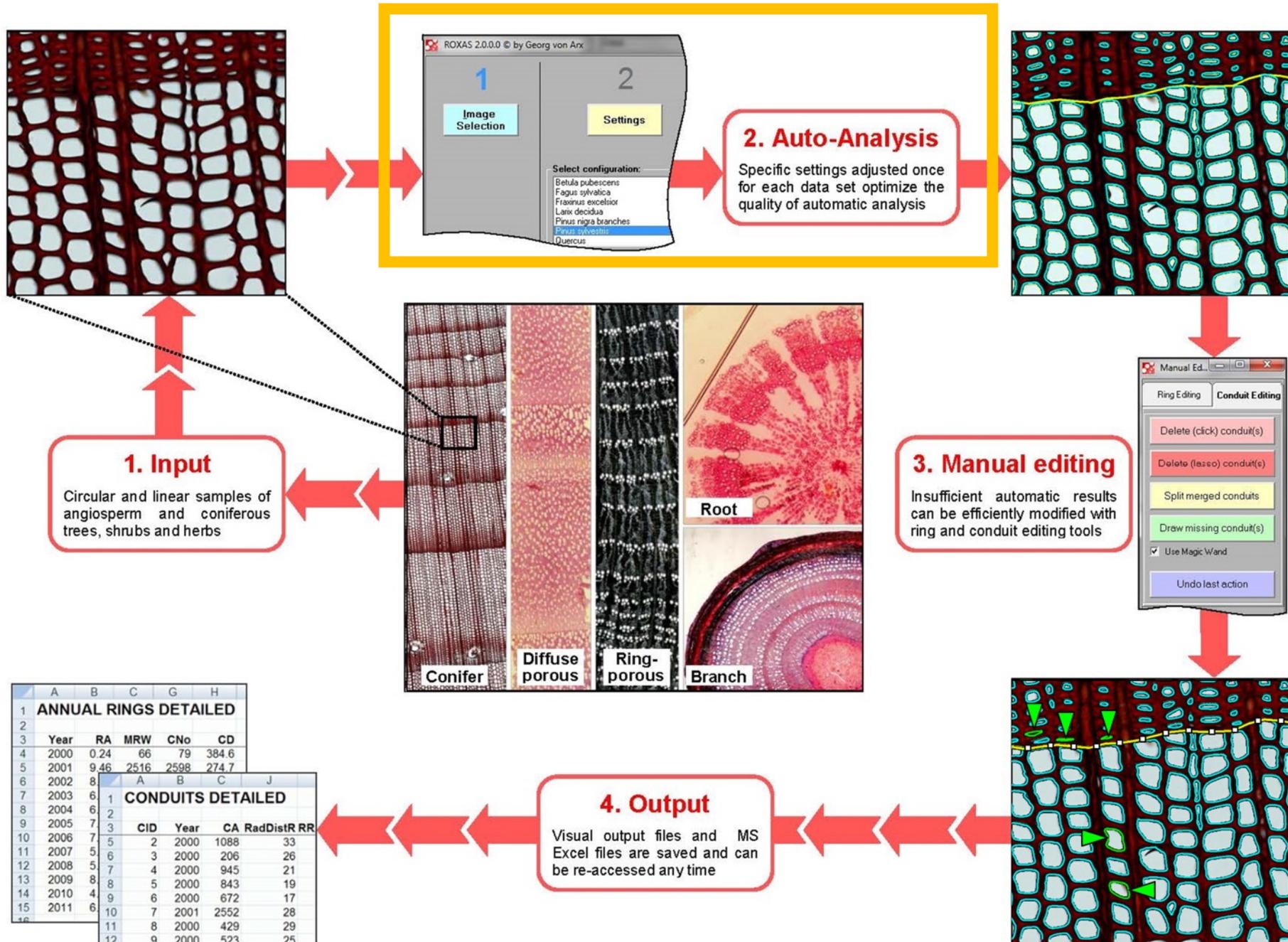
<sup>a</sup> Institute for Computational Science, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland

<sup>b</sup> Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Zuercherstrasse 111, 8903 Birmensdorf, Switzerland

<sup>c</sup> Oeschger Centre for Climate Change Research, University of Bern, Hochschulstrasse 4, 3012 Bern, Switzerland



# ROXAS analysis cycle

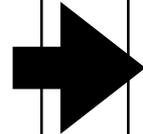


# openDendro

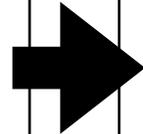
## Workflow



Acquire raw data from online databases



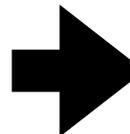
Develop chronologies



Make and analyze reconstructions



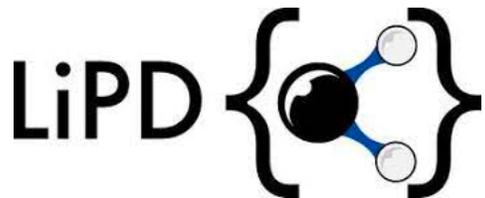
Machine Learning/AI



Visualization



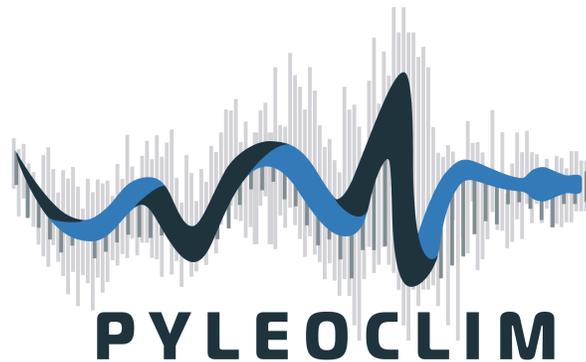
larger Python/R ecosystems



**dplR**

**dplPy**

**pcRecon**





☰ README.md

## Install

---

create a python environment and run the following command to install all requirements

```
pip install torch torchvision opencv-python numpy pytorch-lightning segmentation-models-pytorch
```



## Usage

---

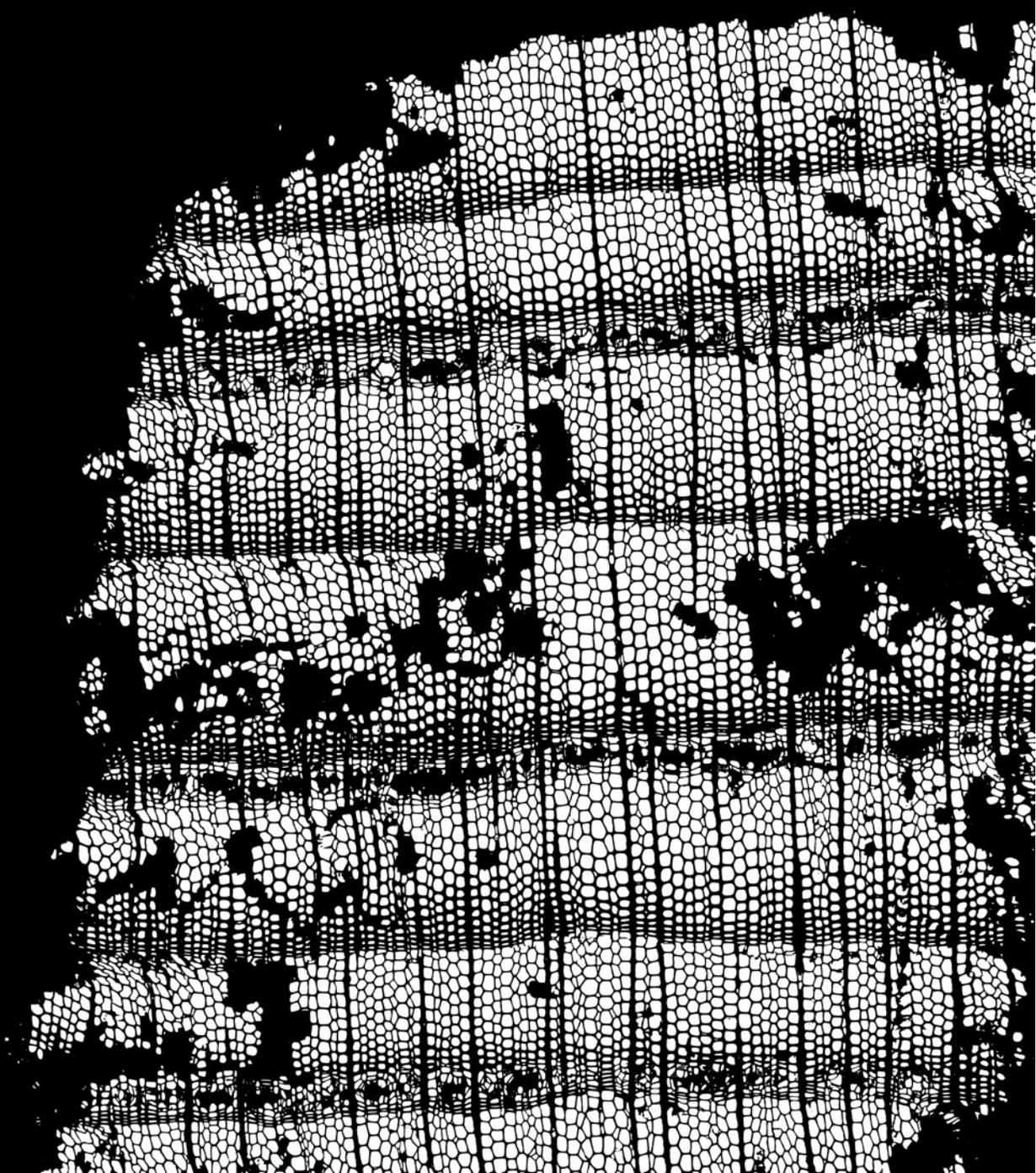
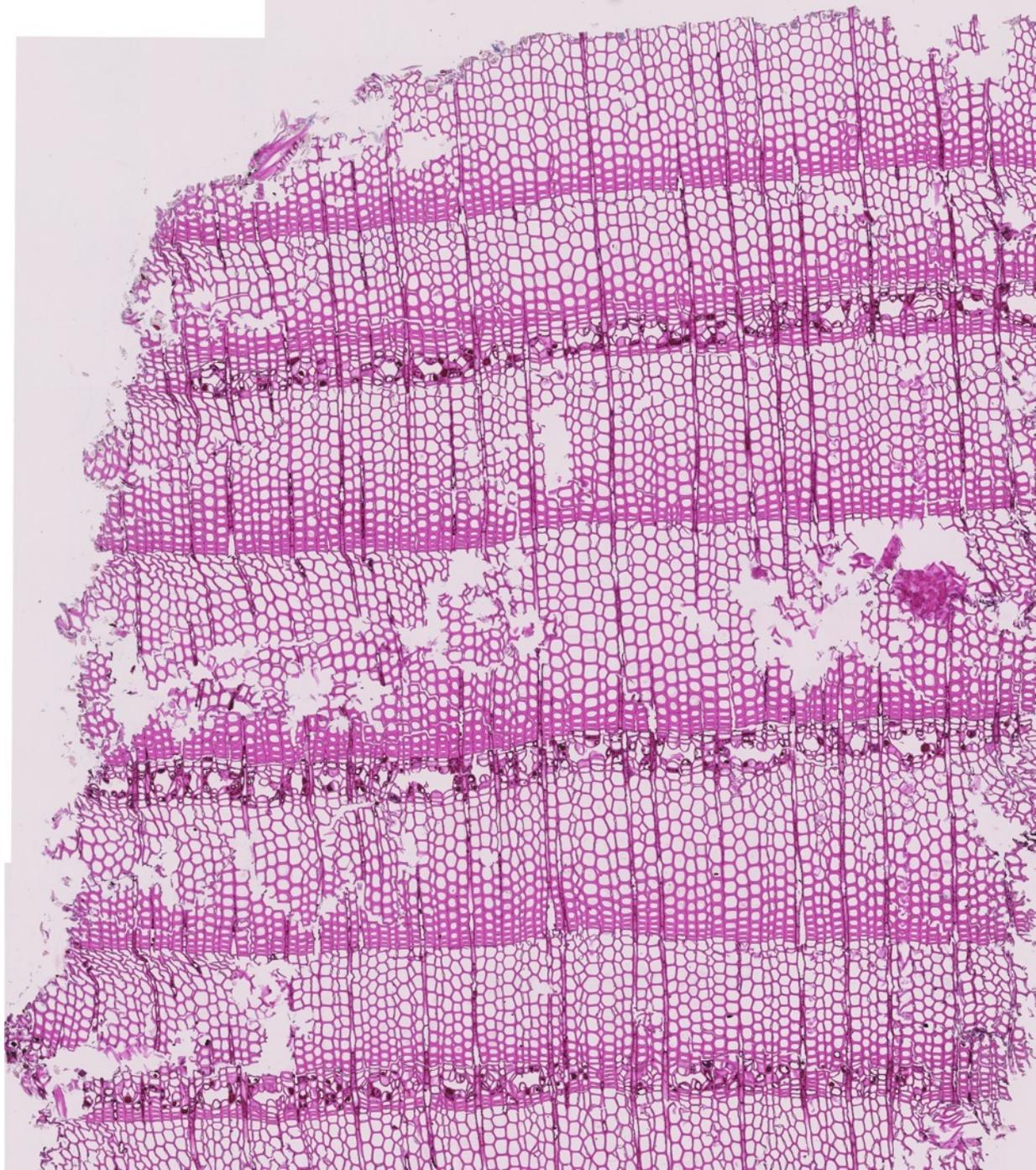
Download the model from [here](#) and run the model with

```
python run_model.py --input=./input/001.jpg --output=./output/001.png
```



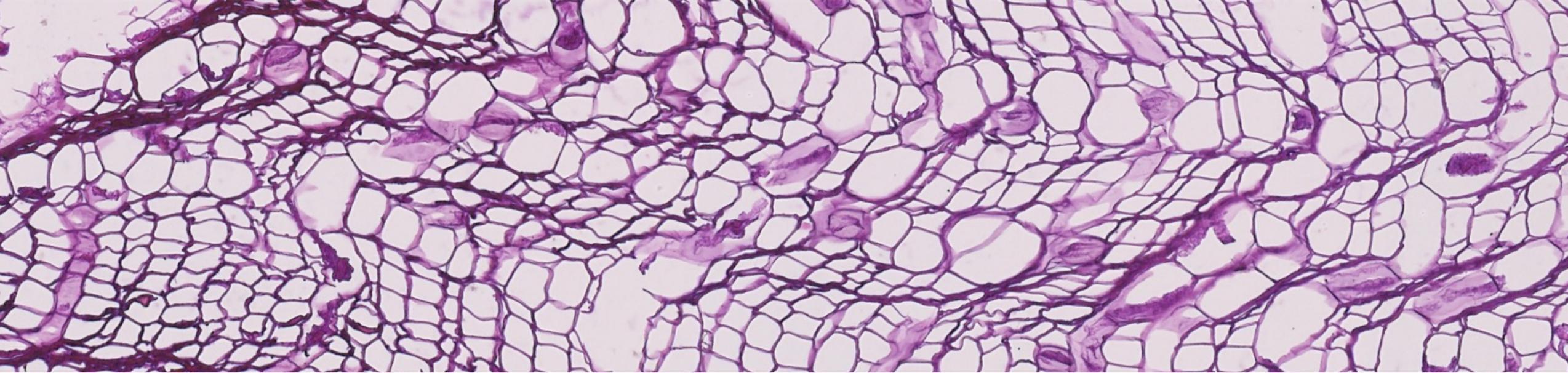
```
Last login: Sun Nov 26 17:12:38 on ttys000
(base) julieedwards@JuliesMacBookPro ~ % cd Documents/Projects/QWAcod/TowardsRoxasAI-main/input
(base) julieedwards@JuliesMacBookPro input % ls
001.jpg          002.jpg          TAC03A_2_1.jpg
(base) julieedwards@JuliesMacBookPro input % cd ..
(base) julieedwards@JuliesMacBookPro TowardsRoxasAI-main % ls
README.md          index.html
_config.yml        input
assets             output
final_semseg_coniferen_model.pth  run_model.py
(base) julieedwards@JuliesMacBookPro TowardsRoxasAI-main % conda activate ROXASAI
(ROXASAI) julieedwards@JuliesMacBookPro TowardsRoxasAI-main % python run_model.py --input=./input/001.jpg --output=./output/001.png
load model
run model

save output
finished successfully
(ROXASAI) julieedwards@JuliesMacBookPro TowardsRoxasAI-main % _
```



# Data Processing Pipelines for Quantitative Wood Anatomy

**DEMO**



The University of Arizona is on the land and territories of Indigenous peoples, with Tucson being home to the O'odham and the Yaqui

# Thank you!

julieedwards@arizona.edu



RESEARCH, INNOVATION & IMPACT  
Data Science Institute



Arizona Institute  
for Resilience



CYVERSE®