

University of Potsdam Earth Scientists Study Ancient Climates Using Sophisticated Time Series and Spatial Analysis Methods

Researchers and students at the University of Potsdam are reconstructing Earth’s environment as it existed millions of years ago. By analyzing algae and organisms in sediment samples taken from ancient lakes in East Africa, they make inferences about the environment long ago, including the salinity of lakes, water depths, and abundance of nutrients.

Using MATLAB® and companion toolboxes, they apply multiple techniques to analyze spatially and temporally sampled environmental data. They then link environmental changes with known jumps in human and animal evolution to predict how present-day climate changes will affect the biosphere.

“There is no better tool for establishing links in the data than MATLAB,” says Dr. Martin Trauth, associate professor at University of Potsdam. “MATLAB makes the process efficient for our researchers and students because they only have to learn one tool to work with everything from algae communities to digital elevation models.”



Dr. Trauth on location in Kenya.

Trauth and his team must incorporate spatial data and image data on widely different scales—from satellite images and 3D contouring of spatial data to microscope images. They often must combine different methods of spatial and image analysis in order to study large data sets collected in the field.

“We wanted to do everything in one environment and to quickly get to the science instead of becoming bogged down in programming,” explains Trauth. “Equally important, we needed a tool that students could learn quickly and then use for sophisticated data analysis, both in the lab and in the field.”

THE CHALLENGE

Teach earth sciences students advanced data analysis methods as they study changes to Earth’s environment over millions of years

THE SOLUTION

Use MathWorks tools to perform time series analysis, process satellite and microscope images, and gain insight into climate change

THE RESULTS

- Transferable skills acquired
- Sophisticated analysis methods quickly learned
- Researcher collaboration fostered

THE CHALLENGE

The time series data acquired from lake sediment typically shows long-term climate trends, sudden events, or recurring rainfall cycles in East Africa.

To identify cycles and patterns in this data, researchers apply methods of linear and nonlinear spectral analysis, frequency selective and adaptive filters, and time-variable deconvolution techniques. Before using MATLAB, Trauth had tried to use Fortran routines to perform the analysis, but this approach was error-prone.

THE SOLUTION

University of Potsdam faculty and students use MATLAB, Image Processing Toolbox™, Signal Processing Toolbox™, and other MathWorks products not only in earth sciences but also in bioinformatics, biology, physics, astronomy, and ecology.

In a data processing course, students use MATLAB to manage, manipulate, and convert earth science data between different formats. Later, in a data analysis course, they build on this work, using MATLAB

and Statistics Toolbox™ to calculate means and variances, draw histograms, and perform linear regressions. The students learn how to explore and analyze images using Image Processing Toolbox and to create maps with Mapping Toolbox™.

Seniors and graduate students continue with a course based on Trauth's book *MATLAB Recipes for Earth Sciences*. Trauth also uses the book to teach short courses for Ph.D. and postdoctoral students at universities in Kiel, Bremen, Ghent, London, Munich, Stockholm, and Nairobi.

Students in these courses identify cycles and trends in climate time series data by using Signal Processing Toolbox to calculate power spectral densities. They perform the same analysis by applying a Lomb-Scargle algorithm and wavelet-based algorithms from Wavelet Toolbox™.

Using Image Processing Toolbox, students analyze satellite images of Earth, which leads into spatial data analysis, 3D contouring, and computing drainage networks in MATLAB. On a much smaller scale, students count pollen particles in microscope images and identify charcoal in lake sediments.

In his own research, Trauth used MATLAB and companion toolboxes to analyze time series of environmental change reaching back as far as 5 million years. He found that episodes of wetter conditions were characterized by a mere 25% increase in rainfall, which can mean the difference between a dry lake bed and a 300-meter-deep lake.

Trauth and his colleagues also used MATLAB to develop a hydrological model of East African lake beds that enables them to estimate variations in rainfall during the last several millions of years.

“You can apply advanced mathematical methods very easily with MATLAB. I frequently show students who are struggling with a problem in a spreadsheet how easily it can be solved in MATLAB, which can be used for many different types of data analysis.”

Dr. Martin Trauth, University of Potsdam

THE RESULTS

■ **Transferable skills acquired.** “The data processing and analysis methods that students learn are valuable in many fields,” Trauth says. “One student who used MATLAB for stress analysis of Earth’s crust now works for an aircraft manufacturer performing stress analysis on aircraft wings.”

■ **Sophisticated analysis methods quickly learned.** “With just one week of training on MathWorks tools, you can use them for research,” says Trauth. “For example, a student participant in one of my courses in Barcelona had learned, within half an hour, to use MATLAB to compute a power spectrum using three different methods. The student had tried doing this for two months using other tools, without success.”

■ **Researcher collaboration fostered.** “MATLAB is growing more popular in earth sciences, and I can easily exchange MATLAB scripts and files with other researchers,” says Trauth. “I also use MATLAB as a shared language to collaborate with colleagues in other fields, for example with theoretical physicists on non-linear time series analysis.”

Learn more about the Department of Earth and Environmental Sciences:
www.geo.uni-potsdam.de

INDUSTRY

- Academia

APPLICATIONS

- Data analysis
- Mathematical modeling
- Algorithm development
- Image and video processing

PRODUCTS USED

- MATLAB®
- Image Processing Toolbox™
- Mapping Toolbox™
- Signal Processing Toolbox™
- Statistics Toolbox™
- Wavelet Toolbox™

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