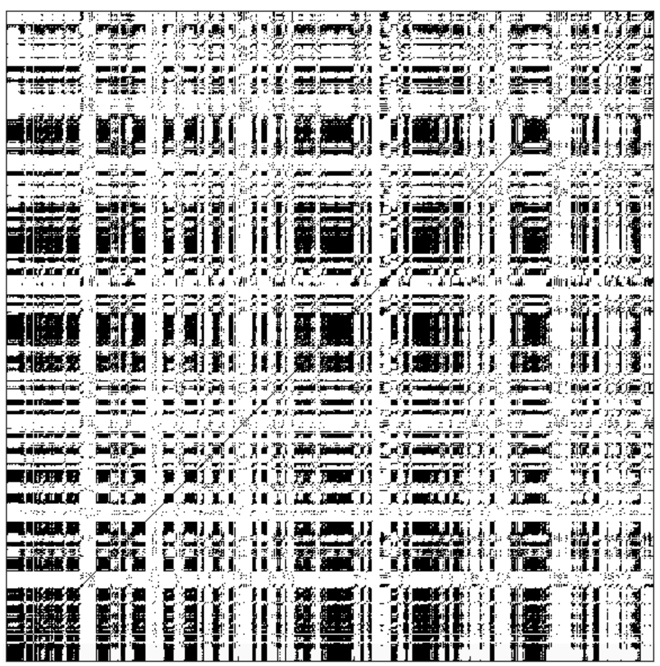


The HSPDP TSA Team

# Roundtable Discussion II: Time Series Analyses

Who is doing TSA?

What are we looking for?

What software do you use?

What methods do you use?

What are the challenges to reach the goals?

Sharing/discussion code?

Publishing TSA results with code?

# What are we looking for?

- Unmixing mixed signals
- Trends (in measures of central tendency
  and dispersion) (linear, nonlinear)
- Transitions (dito) (stepwise, tipping points)
  and precursors to transitions
- Cycles (Milankovitch)
- More complex patterns

# What software do you use?

- MATLAB (Martin, René, Hauke, Walter, Norbert, Mona, Jim … )
- Python (Hauke, Norbert) free
- C++ (Nadine) free
- Fortran (Manfred) free
- Other …

# What are the challenges to reach the goals?
## Gaps, age models, outliers ...

- What are we looking for (input from others)?
  ➛ trends, cycles, transitions in
  central tendency + dispersion, trend, variability
- Measurement errors, outliers ...
  ➛ replicate measurements, adaptive filtering ...
- Gaps
  ➛ filling gaps; using LS method ...
- Uncertainties of age models
  ➛ Bootstrapping of 10,000 samples of the age model
- Extracting prestine signal from proxy records with various overprints (e.g. pedogenic, diagentic ... )
  ➛ unmixing (PCA, ICA) ...
- ...

# Sharing/discussion code?

# Emailing MATLAB Live Editor files!

## Recurrence Plot Experiments

by M.H. Trauth, 29 April 2012, with text fragments from Marwan et al. 2007 and Trauth 2015.

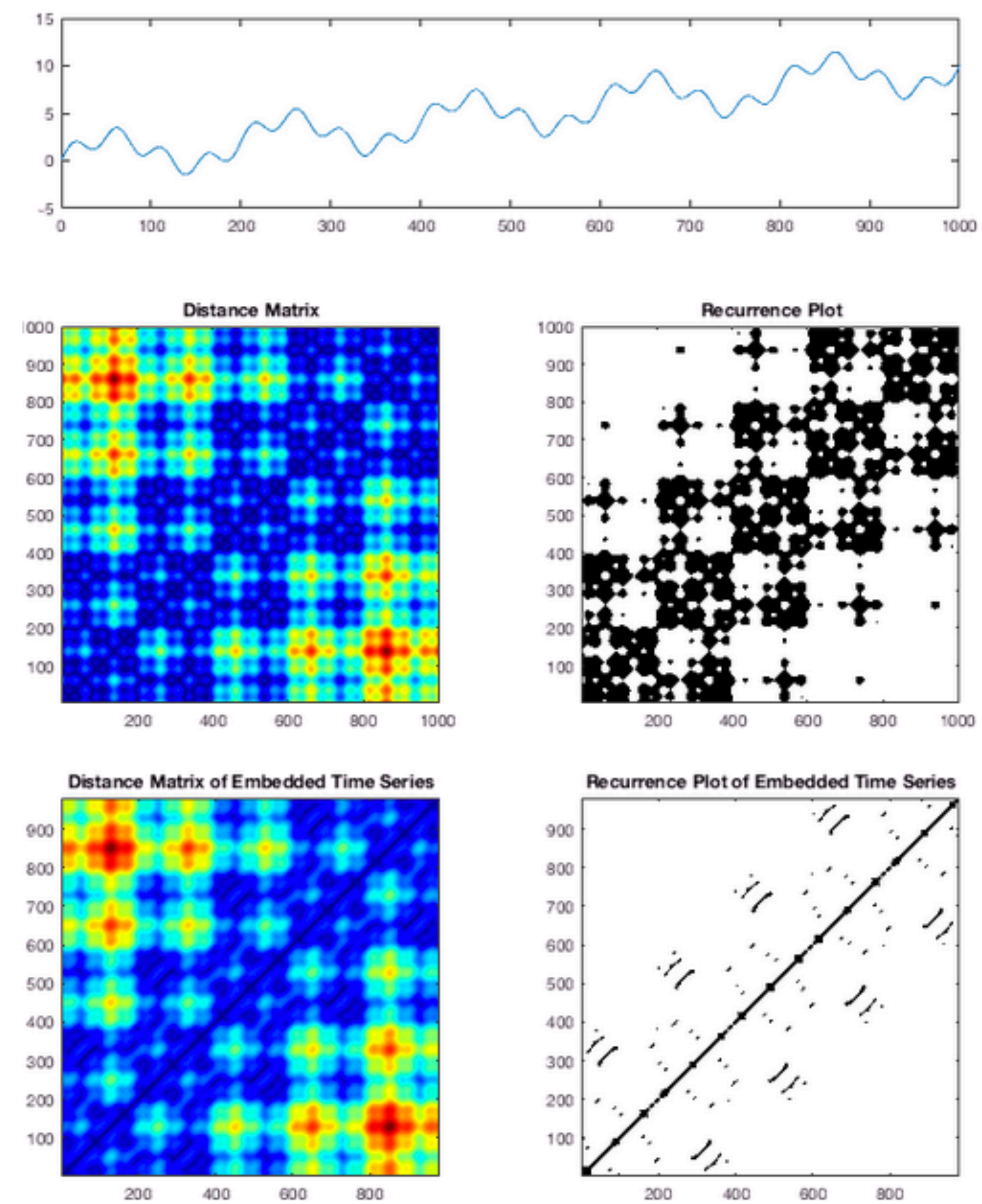
### Recurrence Plots

The phase space trajectories of dynamic systems that have more than three dimensions are difficult to portray visually. Recurrence plots provide a way of analyzing systems with higher dimensions. They can be used, e.g., to detect transitions between different regimes, or to detect interrelationships or synchronisations between different systems (Marwan et al. 2007). The method was first introduced by Eckmann and others (1987). The recurrence plot is a tool that displays the recurrences of states in the phase space through a two-dimensional plot.

$$R_{i,j} = \begin{cases} 0 & \|x_i - x_j\| > \varepsilon \\ 1 & \|x_i - x_j\| < \varepsilon \end{cases}$$

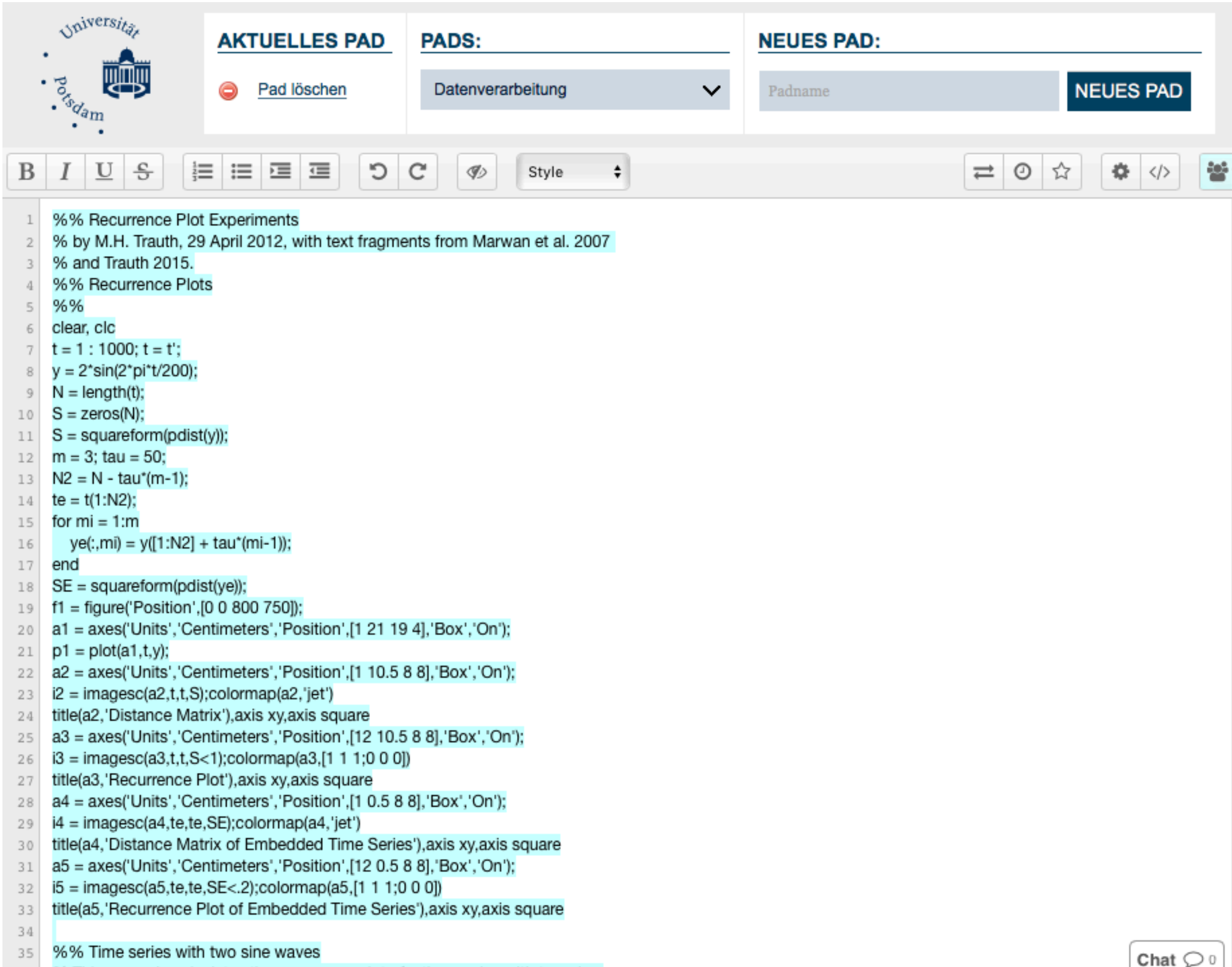
If the distance between two states, $i$ and $j$, on the trajectory is smaller than a given threshold $\varepsilon$, the value of the recurrence matrix $R$ is one; otherwise it is zero. This analysis is therefore a pairwise test of all states. For $N$ states we compute $N^2$ tests. The recurrence plot is then the two-dimensional display of the $N$-by-$N$ matrix, where black pixels represent $R_{i,j} = 1$ and white pixels indicate $R_{i,j} = 0$, with a coordinate system representing two time axes. Such recurrence plots can help to find a preliminary characterization of the dynamics of a system or to find transitions and interrelationships within a system.

```
clear, clc
t = 1 : 1000; t = t';
y = 2*sin(2*pi*t/200) + 2*sin(2*pi*t/50);
N = length(t);
S = zeros(N);
S = squareform(pdist(y));
m = 3; tau = 10;
N2 = N - tau*(m-1);
te = t(1:N2);
for mi = 1:m
ye(:,mi) = y([1:N2] + tau*(mi-1));
end
```



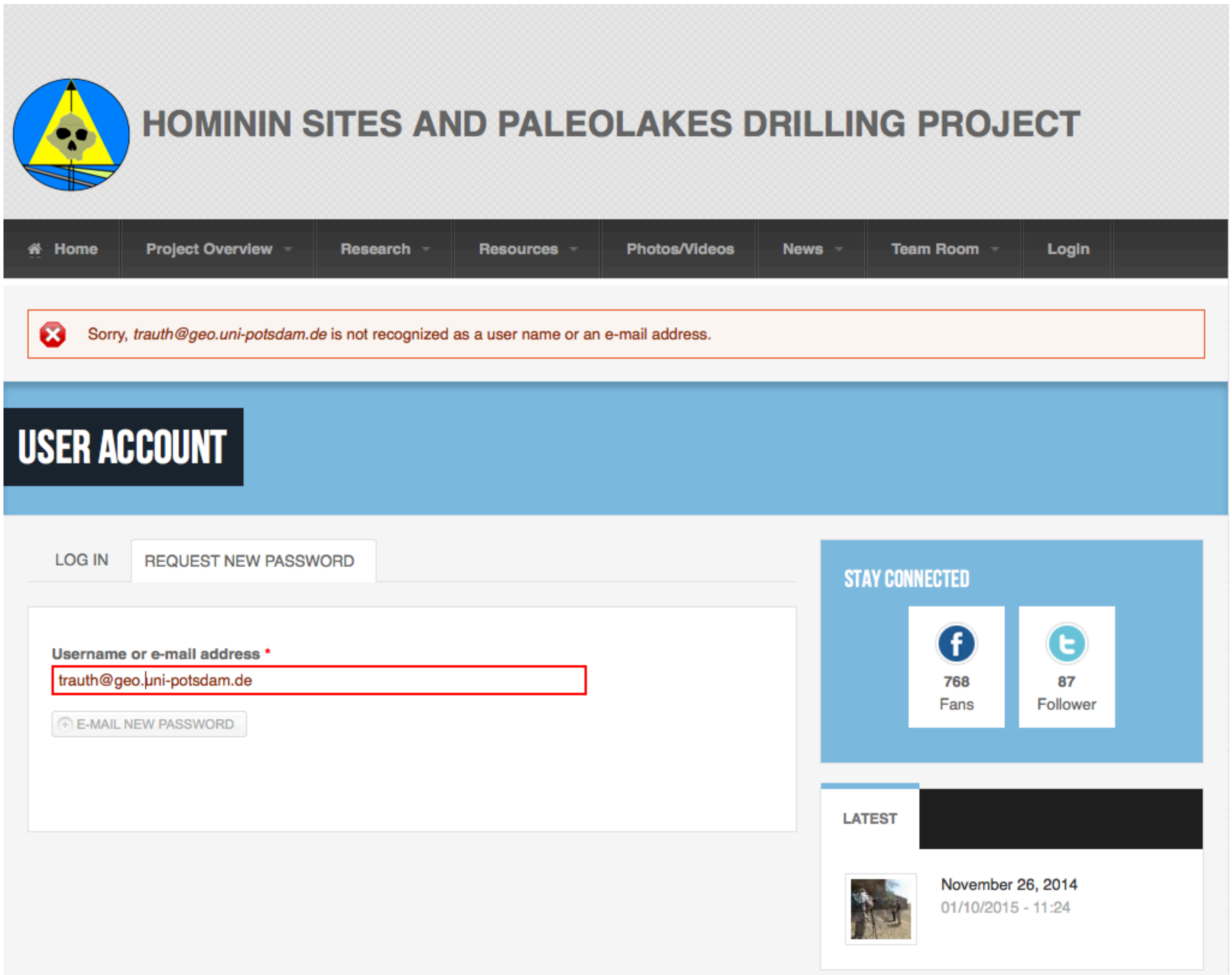
# Sharing/discussion code?

## In real time with Etherpad/Chat!



# Sharing/discussion code?

# The HSPDP forum!



# Publishing with code
# Yes!

Quaternary Geochronology 22 (2014) 65–71

Contents lists available at ScienceDirect

Quaternary Geochronology

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

Research paper

## A new probabilistic technique to build an age model for complex stratigraphic sequences

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A R T I C L E I N F O

*Article history:*
Received 25 June 2013
Received in revised form
18 February 2014
Accepted 4 March 2014
Available online 20 March 2014

*Keywords:*
Age-depth modelling
Stratigraphy
Sedimentation rate
Hiatus
MATLAB

A B S T R A C T

The age models of fluvio-lacustrine sedimentary sequences are often subject of discussions in paleo-climate research. The techniques employed to build an age model are very diverse, ranging from visual or intuitive estimation of the age-depth relationship over linear or spline interpolations between age control points to sophisticated Bayesian techniques also taking into account the most likely deposition times of the type of sediment within the sequence. All these methods, however, fail in detecting abrupt variations in sedimentation rates, including the possibility of episodes of no deposition (*hiatus*), which is the strength of the method presented in this work. The new technique simply compares the deposition time of equally thick sediment slices from the differences of subsequent radiometric age dates and the unit deposition times of the various sediment types. The percentage overlap of the distributions of these two sources of information, together with the evidence from the sedimentary record, helps to build an age model of complex sequences including abrupt variations in the rate of deposition including one or many hiatuses.



### 1. Introduction

A precise age-depth model is an important prerequisite for the interpretation of high-resolution paleoclimate records. Unfortunately, these methods, although often published with downloadable computer code, guidelines and work-through examples, are hardly used in paleoclimate research (Blaauw, 2010). Many paleoclimate studies do not provide any information on the algorithm used in calculating the age model, if they ever use one, or they do not provide any information about the ambiguity and uncertainties of the result. The available age-depth modelling techniques used range from (1) visual or intuitive estimation of the age-depth relationship (e.g. Brown and Feibel, 1991; Trauth et al., 2001; Behrensmeyer et al., 2002), (2) linear, polynomial or spline interpolation or regression between the radiometric age dates (e.g. Maher, 1972; Blaauw and Heegaard, 2012), (3) calibrating the stratigraphy to insolation or orbital target curves (e.g. Partridge et al., 1997; Joordens et al., 2011), (4) forward modelling of facies variations in cyclic sections (e.g. Kominz and Bond, 1990, 1992), (5) Monte-Carlo modelling of age distributions along sediment cores (Hercman and Pawlak, 2012) to (6) Bayesian age-depth models (e.g. Steier and Rom, 2000; Steier et al., 2001; Blaauw and Christen, 2011; Blaauw and Heegaard, 2012).

The weakness of many of these techniques is mainly due to a lack of a suitable algorithm for consideration of abrupt changes in the sedimentation rate within stratigraphic sections or cores, including even the possibility of the complete lack of sedimentary layers at certain times (*hiatus*). Building an age model in these situations is complicated by the fact that the sedimentation rates depend strongly on the observed time resolution, with a very strong negative relationship between expected sedimentation rate and averaging time (e.g. Sadler, 1981, 1999) (Fig. 1). Such changes, however, are very common in stratigraphic sequences, for instance in the tectonically-active sedimentary basins of Eastern Africa (e.g. Brown and Feibel, 1991; Trauth et al., 2001; Behrensmeyer et al., 2002). In these basins, the sedimentation rates range from less than 0.1 m $kyr^{-1}$ for diatomite (a sediment composed of the skeletons of silica algae, see Table 1), and 0.1–10 m $kyr^{-1}$ for clastic sediments in lakes (Einsele, 2000; Hinderer and Einsele, 2001), to more than >10 m/kyr for sands (Einsele, 2000), and several meters of volcanic air fall deposits per within a couple of hours, followed by a longer time of no deposition (Fisher and Schmincke, 1984). Whereas the sedimentation rates of most sediment types are well known for lakes in Eastern Africa, the significance of hiatuses are subject passionate discussions (Trauth et al., 2005; Trauth and Maslin, 2009; Owen et al., 2009).

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http://dx.doi.org/10.1016/j.quageo.2014.03.001


## Age-Depth Modeling (DFG)

The age models of fluvio-lacustrine sedimentary sequences are often subject of discussions in paleo- climate research. The techniques employed to build an age model are very diverse, ranging from visual or intuitive estimation of the age-depth relationship over linear or spline interpolations between age control points to sophisticated Bayesian techniques also taking into account the most likely deposition times of the type of sediment within the sequence. All these methods, however, fail in detecting abrupt variations in sedimentation rates, including the possibility of episodes of no deposition (hiatus), which is the strength of the method presented in this work. The new technique simply compares the deposition time of equally thick sediment slices from the differences of subsequent radiometric age dates and the unit deposition times of the various sediment types. The percentage overlap of the distributions of these two sources of information, together with the evidence from the sedimentary record, helps to build an age model of complex sequences including abrupt variations in the rate of deposition including one or many hiatuses.

**Publications:**

Trauth, M.H. (2014) A new probabilistic technique to build an age model for complex stratigraphic sequences. **Quaternary Geochronology**, 22, 65-71.

**How to use the MATLAB Script:**

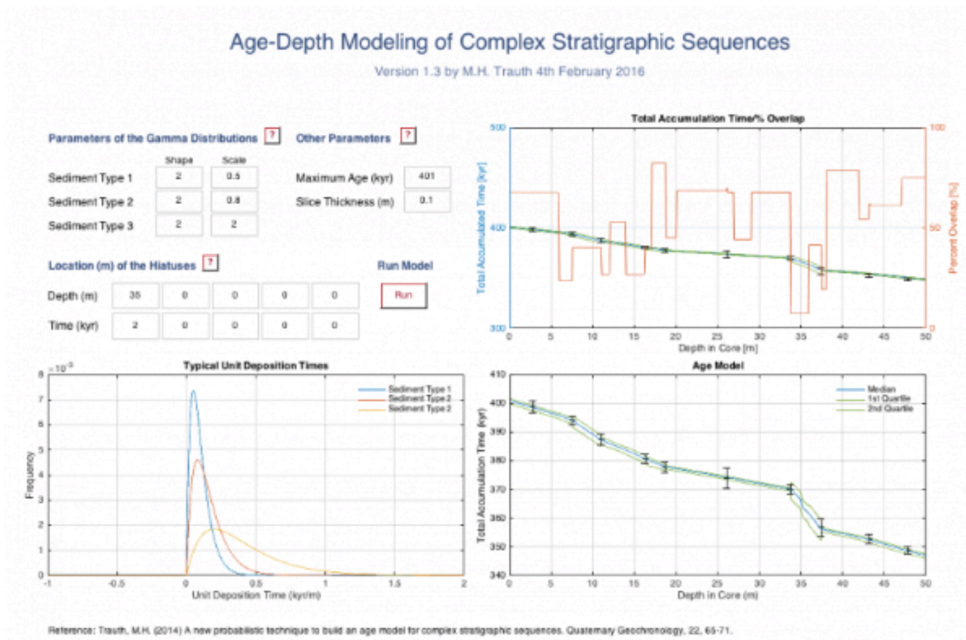
MATLAB Script, Input Ages, Input Section

Save the three files script.txt, input_ages.txt and input_section.txt in your MATLAB search path, rename script.txt into script.m. Then launch MATLAB and type the command script after the prompt, press return. Read the paper and understand the use of the script.

**How to use the MATLAB GUI Script:**

MATLAB GUI Script, MATLAB GUI Interface, Input Ages, Input Section

Save the four files trauthagemodeling_m.txt, trauthagemodeling_fig.txt, input_ages.txt and input_section.txt in your MATLAB search path, rename trauthagemodeling_m.txt into trauthagemodeling.m and trauthagemodeling_fig.txt into trauthagemodeling.fig. Then launch MATLAB and type the command script after the prompt, press return. Read the paper and understand the use of the script.



End