STATNARY 1.2

Mean and variance evolution from unevenly spaced paleoclimatic time series

Manual (October 2004)

This program has been placed in the public domain. You should feel free to pass the program to your colleagues as long as you do not charge for it and you include each of the original files in unaltered form. The latest version of the program can be found at the following web site: `http://www.palmod.uni-bremen.de/~mschulz/`

The program has been tested, though not rigorously, and is correct to the best of my knowledge. If you find any errors or have any suggestions, I would appreciate if you would let me know:

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1. Program Description

STATNARY estimates the time-dependent mean and variance of a time series using a sliding rectangular window of width `Tseg`. The window is shifted consecutively by one data point along the time axis of the input time series. Estimated mean and variance are saved versus the average of the observations times in each window. Temporal changes in mean and variance can be used as a first-order check if a time series is weakly stationary (hence, the name of the program). The estimation of time-dependent mean values is equivalent to a box-car (or running-average) low-pass filter with cut-off frequency 1/`Tseg`. STATNARY can process unevenly spaced time series directly, that is, without the requirement of interpolation. Note that in case of unevenly spaced time series, windows are of equal duration (`Tseg`) but do not necessarily contain the same number of data points.

2. Installation/Contents of the ZIP Archive

Copy the ZIP-archive to an empty directory and unpack it, e.g. by entering the following command at the DOS prompt:

```
pkunzip statnary12.zip
```

This should result in the following files in the STATNARY directory:

`statnary.exe`	Executable file
`statnary.cfg`	Configuration file
`usage.pdf`	Manual (this file)
`example.cfg`	Configuration file for example
`ODP659oxy.dat`	Example data file
`ODP659oxy.plt`	Example results

3. Running STATNARY

SATNARY requires Win9x, NT, 2000 or above and a Pentium III or better CPU (versions for older CPUs are available upon request). All program options and parameters are set in a configuration file that is passed to STATNARY via the command line. An example configuration file (`statnary.cfg`) is included.

To run the program, open a DOS-Box, change to the STATNARY directory and enter a command line of the following structure:

```
statnary myfile.cfg
```

3.1 Configuration File Format

The configuration file is in ASCII format and can be edited with any text editor. It is recommended that you copy the original `statnary.cfg` file to a working file in order to have a backup. The configuration file contains a Fortran 90 namelist, e.g.:

```
&cfg
    fnin = 'c:/data/foo.dat',
   fnout = 'c:/data/foo.plt',
    tseg = 50.0,
 varconf = T,
   alpha = 0.01
/
```

(If you are unfamiliar with namelists, please note the following:

- a string `&cfg` in the first line and a single slash in the last line
- each data line, except the last, ends with a comma
- filenames must be enclosed in `'...'` or `"..."`
- directories are marked by a normal slash and NOT by the usual DOS backslash
- namelist entries can be in lower or upper case
- comment lines are marked by a leading "!"
- namelist entries can appear in any order)

The parameters in the namelist have the following meaning:

`fnin` Input filename (full path!) with time series data.

`fnout` Results are written to this file (ASCII-formatted GNUPLOT script file).

`tseg` Window width (same time unit as input data).

`varconf` Toggle calculation of confidence band for variance:
if set to `T`: estimate confidence interval (default),
if set to `F`: skip estimation.

`alpha` Level of significance for variance confidence band [default = 0.05]

Except `varconf` and `alpha` all parameters must be specified.

3.2 Input Data Format

Time series data are read from space- or tab-delimited ASCII files of the following format:

```
# comment lines
# .
# .
t(1)   x(1)
t(2)   x(2)
 .       .
 .       .
t(N)   x(N)
```

where `t(1)` < `t(2)` < ... < `t(N)` denote sampling times, which can be geological ages or physical times. The sampling times can be evenly or unevenly spaced. The maximum number of data points *N* is limited to 25,000. Program versions for larger values of *N* are available upon request.

The input file must not contain more than two data columns. Make sure that the file contains no blank lines at the end of the file and within the data section. Comment lines are indicated by a leading # and are only allowed at the beginning of the file. The number of comment lines is unlimited.

4. Output

Estimated parameters are written to the file defined by `FNOUT`. The output file is an ASCII-formatted script file for the GNUPLOT graphic package. Alternatively, it can be imported into most spreadsheets for plotting. The contents of the file should be largely self explanatory:

1. The header section lists the main settings from the configuration file.

2. GNUPLOT section: The lines from `set title` to `plot '-' u 1:2` are for controlling GNUPLOT and can be deleted if another plot package is used.

3. The data section consists of the following four columns:

`Time`	Average of the sampling times (or age) within the moving window for which the instantaneous mean and variance are estimated.
`Mean`	Estimated instantaneous mean. Values have the same physical unit as the input data.
`Var`	Estimated instantaneous variance. Unit is identical to the physical unit of the input data squared.
`Np`	Number of points in window on which the estimated mean and variance are based.
`VarLo`	Lower confidence level for variance estimated at the level of significance `alpha`, specified in the configuration file. Only calculated if `varconf` is set to `T`.
`VarHi`	As before but for upper confidence level.

Usually one plots `Mean` or `VarLo` and `VarHi` *vs.* time. Note that the estimation of mean values is equivalent to a box-car (or running-average) low-pass filter with cut-off frequency 1/`Tseg`.

5. Example Computation

The test data set (`ODP659oxy.dat`) consists of the benthic oxygen-isotope record from ODP Site 659 off northwest Africa (Tiedemann et al., 1994; Paleoceanography 9, 619-638). To estimate the evolution of the mean $\delta^{18}O$ and its variance over the last 5 My for a window width of `Tseg = 300` [ky], open a DOS-Box, change to the STATNARY directory and enter the following command:

```
statnary example.cfg
```

The results of the computation will be written to the file `example.plt`, which should be identical to the file `ODP659oxy.res`. The attached Figures 1 and 2 show the estimated mean and the 95-% confidence band for the estimated variance, respectively.

6. Known Bugs

The calculation of the variance confidence band is limited to less than 2,500 input data. For analyzing larger data sets (up to 25,000), set `varconf = F` in the configuration file.

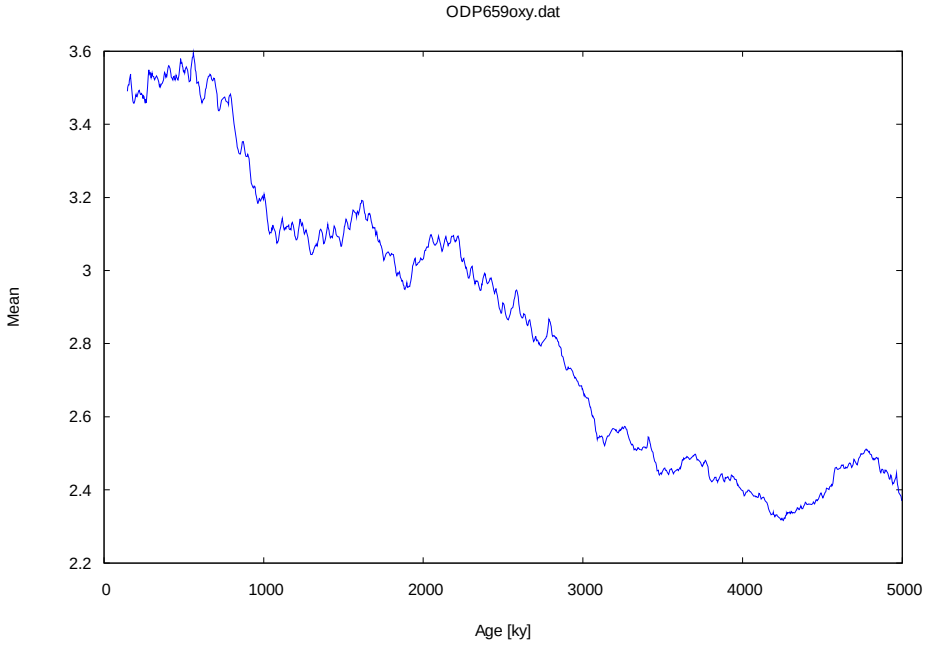

Fig. 1: Estimated mean of the benthic $\delta^{18}O$ values from ODP site 659, using a 300-ky wide window. Note the jumps towards heavier values during the Pliocene at 2.9 My and Pleistocene at ~900 ky.

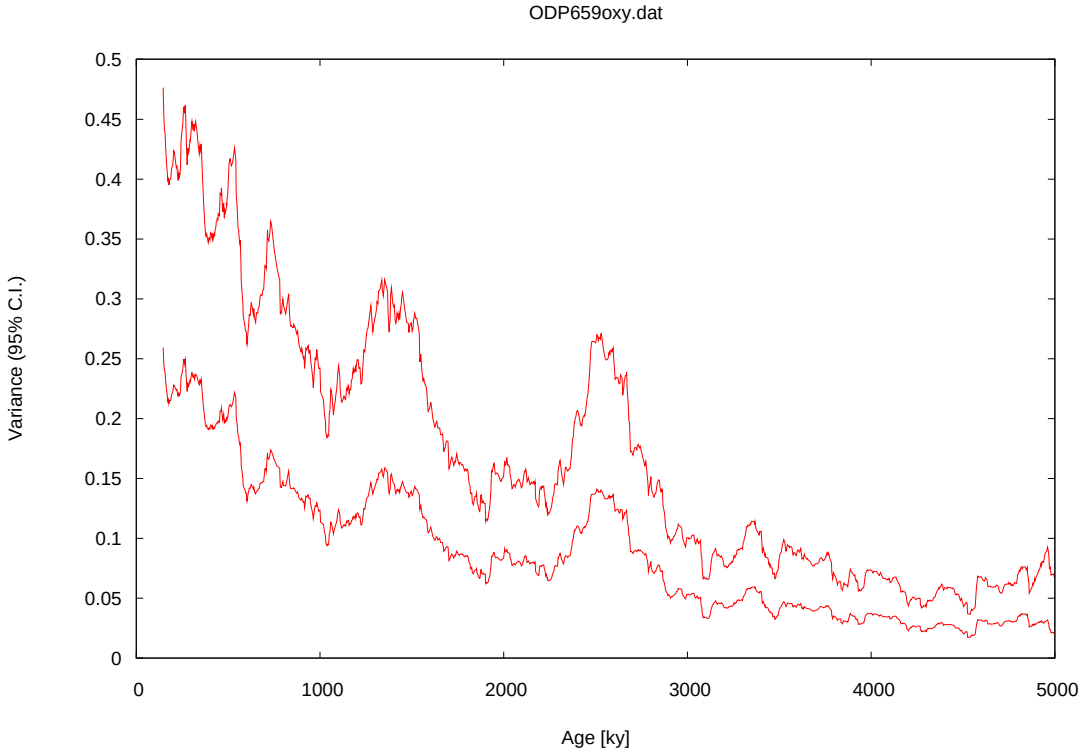

Fig. 2: Estimated variance evolution of the benthic $\delta^{18}O$ values from ODP site 659, using a 300-ky wide window. Shown is the 95-% confidence band.