Package 'astrochron'

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`astrochron-package` *astrochron: A Computational Tool for Astrochronology*

Description

'astrochron' is a computational tool for astrochronology. It includes routines for astrochronologic testing, astronomical time scale construction, and time series analysis. Also included are a range of statistical analysis and modeling routines that are relevant to time scale development and paleoclimate analysis.

Details

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Type:	Package
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Note

Please note that this version of 'astrochron' is undergoing BETA TESTING.

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TO CITE PACKAGE 'astrochron' IN PUBLICATIONS, PLEASE USE:

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Also cite the original research papers that document the relevant algorithms, as referenced on the help pages for specific functions.

Author(s)

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Examples

```
### EXAMPLES OF SOME FUNCTIONS AVAILABLE IN 'astrochron':

### This demo will use a model (series are usually read using the function 'read').
data(modelA)

### Interpolate the model stratigraphic series to its median sampling interval
modelAInterp=linterp(modelA)

### Calculate MTM spectrum using 2pi Slepian tapers, include AR1 condfidence level estimates,
###  plot power with linear scale
mtm(modelAInterp,tbw=2,ar=TRUE,pl=2)

### Perform Evolutive Harmonic Analysis using 2pi Slepian tapers, a window of 8 meters,
###  pad to 1000 points, and output Harmonic F-test confidence level results
fCL=eha(modelAInterp,win=8,pad=1000,output=4)

### Extract Harmonic F-test spectrum at approximately 22 meters height
spec=extract(fCL,22)
### In this extracted spectrum, identify F-test peak maxima exceeding 90% confidence level
freqs=peak(spec,level=0.9)[2]
### Conduct ASM testing on these peaks
# set Rayleigh frequency in cycles/m
rayleigh=0.1245274
# set Nyquist frequency in cycles/m
nyquist=6.66597
# set orbital target in 1/ky
target=c(1/405.47,1/126.98,1/96.91,1/37.66,1/22.42,1/18.33)
# execute ASM
asm(freq=freqs,target=target,rayleigh=rayleigh,nyquist=nyquist,sedmin=0.5,sedmax=3,numsed=100,
    linLog=1,iter=100000,output=FALSE)

# Check to see if this is an interactive R session, for compliance with CRAN standards.
# YOU CAN SKIP THE FOLLOWING LINE IF YOU ARE USING AN INTERACTIVE SESSION.
```

```
if(interactive()) {

### Interactively track obliquity term in EHA harmonic F-test confidence level results
freqs=trackFreq(fCL,fmin=1.2,fmax=2.4,threshold=0.8)

### Convert the spatial frequencies to sedimentation rates
sedrate=freq2sedrate(freqs,period=37.66)

### Convert the sedimentation rate curve to a time-space map
time=sedrate2time(sedrate)

### Tune the stratigraphic series using the time-space map
modelATuned=tune(modelAInterp,time)

### Interpolate the tuned series
modelATunedInterp=linterp(modelATuned)

### Perform Evolutive Harmonic Analysis on the tuned series
eha(modelATunedInterp)

}
```

---

anchorTime *Anchor a floating astrochronology to a radioisotopic age*

Description

Anchor a floating astrochronology to a radioisotopic age. The floating astrochronology is centered on a given ('floating') time datum and assigned the 'anchored' age.

Usage

```
anchorTime(dat,time,age,timeDir=1,flipOut=F,verbose=T,genplot=T)
```

Arguments

dat	Stratigraphic series. First column should be location (e.g., depth), second column should be data value.
time	'Floating' time datum to center record on. Units should be ka.
age	Radioisotopic age (or othwerwise) for anchoring at floating 'time' datum. Units should be ka.
timeDir	Direction of 'floating' time in input record; 1 = elapsed time towards present; 2 = elapsed time away from present
flipOut	Flip the output (sort so the ages are presented in decreasing order)? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

ar1 *Generate AR(1) surrogates*

Description

Generate AR(1) surrogates. Implement shuffling algorithm of Meyers (2012) if desired.

Usage

```
ar1(npts=1024,dt=1,mean=0,sdev=1,rho=0.9,shuffle=F,nsim=1,genplot,verbose)
```

Arguments

npts	number of time series data points
dt	sampling interval
mean	mean value for AR1 surrogate series
sdev	standard deviation for AR1 surrogate series
rho	AR(1) coefficient
shuffle	Apply secondary shuffle of Gaussian deviates before AR modeling
nsim	Number of AR1 surrogate series to generate
genplot	generate summary plots (T or F)
verbose	verbose output (T or F)

Details

These simulations use the random number generator of Matsumoto and Nishimura [1998]. If shuffle = T, the algorithm from Meyers (2012, pg. 11) is applied: (1) two sets of random sequences of same the length are generated, (2) the first random sequence is then sorted, and finally (3) the permutation vector of the sorted sequence is used to reorder the second random number sequence. This is done to guard against potential shortcomings in random number generation that are specific to spectral estimation.

References

S.R. Meyers, 2012, *Seeing red in cyclic stratigraphy: Spectral noise estimation for astrochronology*: Paleoceanography, v. 27, PA3328.

ar1etp *AR(1) + ETP simulation Routine*

Description

Simulate a combined AR(1) + ETP signal, plot spectrum and confidence levels

Usage

```
ar1etp(etpdat=NULL,nsim=100,rho=0.9,wtAR=1,sig=90,tbw=2,padfac=5,ftest=F,fmax=0.1,
       speed=0.5,pl=2,graphfile=0)
```

Arguments

etpdat	Eccentricity, tilt, precession astronmical series. First column = time, second column = ETP. If not entered will use default series from Laskar et al. (2004), spanning 0-1000 kyr.
nsim	Number of simulations.
rho	AR(1) coefficient for noise modeling.
wtAR	Multiplicative factor for AR1 noise (1= eqivalent to ETP variance).
sig	Demarcate what confidence level (percent) on plots?
tbw	MTM time-bandwidth product.
padfac	Pad with zeros to (padfac*npts) points, where npts is the number of data points.
ftest	Include MTM harmonic f-test results? (T or F)
fmax	Maximum frequency for plotting.
speed	Set the amount of time to pause before plotting new graph, in seconds.
pl	Plot log power (1) or linear power (2)?
graphfile	Output a pdf or jpg image of each plot? 0 = no, 1 = pdf, 2 = jpeg. If yes, there will be no output to screen. Individual graphic files will be produced for each simluation, for assembling into a movie.

Details

Note: Setting wtAR=1 will provide equal variance contributions from the etp model and the ar1 model. More generally, set wtAR to the square root of the desired variance contribution (wtAR=0.5 will generate an AR1 model with variance that is 25% of the etp model).

Note: You may use the function etp to generate eccentricity-tilt-precession models.

References

Laskar, J., Robutel, P., Joutel, F., Gastineau, M., Correia, A.C.M., Levrard, B., 2004, *A long term numerical solution for the insolation quantities of the Earth*: Astron. Astrophys., Volume 428, 261-285.

See Also

getLaskar, and etp

Examples

```
# run simulations using the default settings
ar1etp()

# compare with a second model:
# generate etp model spanning 0-2000 ka, with sampling interval of 5 ka.
ex1=etp(tmin=0,tmax=2000,dt=5)
# run simulations, with rho=-.7, and scaling noise to have 50% of the etp model variance
ar1etp(etpdat=ex1,rho=0.7,wtAR=sqrt(0.5))
```

---

arcsinT *Arcsine Transformation of Stratigraphic Series*

Description

Arcsine transformation of stratigraphic series

Usage

```
arcsinT(dat,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for arcsine transformation. First column should be location (e.g., depth), second column should be data value for transformation.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

demean, detrend, divTrend, logT, prewhiteAR, and prewhiteAR1

armaGen *Generate Autoregressive Moving-average Model*

Description

Generate an Autoregressive Moving-average time series model

Usage

```
armaGen(npts=1024,dt=1,m=0,std=1,rhos=c(0.9),thetas=c(0),genplot=T,verbose=T)
```

Arguments

npts	Number of time series data points.
dt	Sampling interval.
m	Mean value of final time series.
std	Standard deviation of final time series.
rhos	Vector of AR coefficients for each order.
thetas	Vector of MA coefficients for each order.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

asm *Average Spectral Misfit*

Description

Calculate Average Spectral Misfit with Monte Carlo spectra simulations, as updated in Meyers et al. (2012).

Usage

```
asm(freq,target,fper=NULL,rayleigh,nyquist,sedmin=1,sedmax=5,numsed=50,
    linLog=1,iter=100000,output=F,genplot=T)
```

Arguments

freq	A vector of candidate astronomical cycles observed in your data spectrum (cycles/m). Maximum allowed is 500.
target	A vector of astronomical frequencies to evaluate (1/ka). These must be in order of increasing frequency (e.g., e1,e2,e3,o1,o2,p1,p2). Maximum allowed is 50 frequencies.
fper	A vector of uncertainties on each target frequency (1/ka). Values should be from 0-1, representing uncertainty as a percent of each target frequency. The order of the uncertainties must follow that of the target vector. By default, no uncertainty is assigned.
rayleigh	Rayleigh frequency (cycles/m).
nyquist	Nyquist frequency (cycles/m).
sedmin	Minimum sedimentation rate for investigation (cm/ka).
sedmax	Maximum sedimentation rate for investigation (cm/ka).
numsed	Number of sedimentation rates to investigate in ASM optimization grid. Maximum allowed is 500.
linLog	Use linear or logarithmic scaling for sedimentation rate grid spacing? (0=linear, 1=log)
iter	Number of Monte Carlo simulations for significance testing. Maximum allowed is 100,000.
output	Return output as a new data frame? (T or F)
genplot	Generate summary plots? (T or F)

Details

This function will caculate the Average Spectral Misfit between a data spectrum and astronomical target spectrum, following the approach outlined in Meyers and Sageman (2007), and the improvements of Meyers et al. (2012).

Value

A data frame containing: Sedimentation rate (cm/ka), ASM (cycles/ka), Null hypothesis significance level (0-100 percent), Number of astronomical terms fit.

References

S.R. Meyers and B.B. Sageman, 2007, *Quantification of Deep-Time Orbital Forcing by Average Spectral Misfit*: American Journal of Science, v. 307, p. 773-792.

S.R. Meyers, B.B. Sageman and M.A. Arthur, 2012, *Obliquity forcing of organic matter accumulation during Oceanic Anoxic Event 2*: Paleoceanography, 27, PA3212, doi:10.1029/2012PA002286.

See Also

eAsm

Examples

```
## these frequencies are from modelA (type '?astrochron' for more information). Units are cycles/m
freq <- c(0.1599833,0.5332776,1.5998329,2.6797201,3.2796575,3.8795948,5.5194235,6.5459830)
freq <- data.frame(freq)

## Rayleigh frequency in cycles/m
rayleigh <- 0.1245274

## Nyquist frequency in cycles/m
nyquist <- 6.66597

## orbital target in 1/ky. Predicted periods for 94 Ma (see Meyers et al., 2012)
target <- c(1/405.47,1/126.98,1/96.91,1/37.66,1/22.42,1/18.33)

## percent uncertainty in orbital target
fper=c(0.023,0.046,0.042,0.008,0.035,0.004)

asm(freq=freq,target=target,fper=fper,rayleigh=rayleigh,nyquist=nyquist,sedmin=0.5,sedmax=3,
    numsed=100,linLog=1,iter=100000,output=FALSE)
```

---

autoPlot *Automatically plot multiple stratigraphic series, with smoothing if desired*

Description

Automatically plot and smooth specified stratigraphic data, versus location. Data are smoothed with a Gaussian kernel.

Usage

```
autoPlot(dat,cols=NULL,nrows=NULL,ydir=-1,smooth=0,xgrid=1,output=F,genplot=T,verbose=T)
```

Arguments

dat	Your data frame; first column should be location identifier (e.g., depth).
cols	A vector that identifies the columns to extract (first column automatically extracted).
nrows	Number of rows in figure.
ydir	Direction for y-axis in plots (depth,height,time). -1 = values increase downwards, 1 = values increase upwards
smooth	Width (temporal or spatial dimension) for smoothing with a Gaussian kernel (0 = no smoothing); the Gaussian kernel is scaled so that its quartiles (viewed as probability densities, that is, containing 50 percent of the area) are at +/- 25 percent of this value.

xgrid	For kernal smoothing: (1) evaluate on ORIGINAL sample grid, or (2) evaluate on EVENLY SPACED grid covering range.
output	Output data frame of smoothed values? (T or F)
genplot	generate summary plots (T or F)
verbose	verbose output (T or F)

---

bandpass *Bandpass Filter Stratigraphic Series*

Description

Bandpass filter stratigraphic series using rectangular, Gaussian or tapered cosine window

Usage

```
bandpass(dat,padfac=2,flow=NULL,fhigh=NULL,win=0,alpha=3,p=0.25,demean=T,
         detrend=F,addmean=T,output=1,xmin=0,xmax=Nyq,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for bandpass filtering. First column should be location (e.g., depth), second column should be data value.
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
flow	Lowest frequency to bandpass.
fhigh	Highest frequency to bandpass.
win	Window type for bandpass filter: 0 = rectangular , 1= Gaussian, 2= Cosine-tapered window.
alpha	Gaussian window parameter: alpha is 1/stdev, a measure of the width of the Dirichlet kernel. Choose alpha >= 2.5.
p	Cosine-tapered window parameter: p is the percent of the data series tapered (choose 0-1).
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
addmean	Add mean value to bandpass result? (T or F)
output	Output: (1) filtered series, (2) bandpass filter window.
xmin	Smallest frequency for plotting.
xmax	Largest frequency for plotting.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Value

bandpassed stratigraphic series.

See Also

lowpass, noKernel, noLow, prewhiteAR, prewhiteAR1, and taner

Examples

```
# generate example series with 3 precession terms and noise
ex <- cycles(noisevar=.0004,dt=5)
# bandpass precession terms using cosine-tapered window
res_ex <- bandpass(ex,flow=0.038,fhigh=0.057,win=2,p=.4)
```

---

bergerPeriods *Obliquity and Precession Periods of Berger et al. (1992)*

Description

Determine the predicted precession and obliquity periods based on Berger et al. (1992). Values are determined by piecewise linear interpolation.

Usage

```
bergerPeriods(age,genplot=T)
```

Arguments

age	Age (millions of years before present)
genplot	Generate summary plots? (T or F)

References

A. Berger, M.F. Loutre, and J. Laskar, 1992, *Stability of the Astronomical Frequencies Over the Earth's History for Paleoclimate Studies*: Science, v. 255, p. 560-566.

cb *Combine Multiple Vectors*

Description

Bind two vectors together and return result as a data frame. Alternatively, extract specified columns from a data frame, bind them together, and return result as a data frame.

Usage

```
cb(a,b)
```

Arguments

a	first input vector OR a data frame with >1 column.
b	second input vector OR if a is a data frame with > 1 column, a list of columns to bind.

Examples

```
# example dataset
x<-rnorm(100)
dim(x)<-c(10,10)
x<-data.frame(x)

# bind two columns
cb(x[1],x[5])

# bind five columns
cb(x,c(1,2,4,7,9))
```

clipIt *Create non-linear response by clipping stratigraphic series*

Description

Create non-linear response by clipping stratigraphic series below a threshold value. Alternatively, mute response below a threshold value using a contant divisor. Both approaches will enhance power in modulator (e.g., eccentricity) and diminish power the carrier (e.g., precession).

Usage

```
clipIt(dat,thresh=NULL,clipval=NULL,clipdiv=NULL,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series. First column should be location (e.g., depth), second column should be data value.
thresh	Clip below what theshold value? By default will clip at mean value.
clipval	What number should be assigned to the clipped values? By default, the value of thresh is used.
clipdiv	Clip using what divisor? A typical value is 2. By default, clipdiv is unity.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

---

constantSedrate *Apply a constant sedimentation rate model to transform a spatial series to temporal series*

Description

Apply a constant sedimentation rate model to transform a spatial series to temporal series.

Usage

```
constantSedrate(dat,sedrate,begin=0,timeDir=1,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series. First column should be location (e.g., depth), second column should be data value.
sedrate	Sedimentation rate, in same spatial units as dat.
begin	Time value to assign to first datum.
timeDir	Direction of floating time in tuned record: 1 = elapsed time increases with depth/height; -1 = elapsed time decreases with depth/height)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

cosTaper *Apply Cosine Taper to Stratigraphic Series*

Description

Apply a "percent-tapered" cosine taper (a.k.a. Tukey window) to a stratigraphic series.

Usage

```
cosTaper(dat,p=.25,rms=T,demean=T,detrend=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for tapering. First column should be location (e.g., depth), second column should be data value. If no data is identified, will output a 256 point taper to evaluate the spectral properties of the window.
p	Cosine-tapered window parameter: p is the percent of the data series tapered (choose 0-1). When p=1, this is equivalent to a Hann taper.
rms	Normalize taper to RMS=1 to preserve power for white process? (T or F)
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

dpssTaper, gausTaper, and hannTaper

cycles *Generate Harmonic Model*

Description

Make a time series with specified harmonic components and noise

Usage

```
cycles(freqs=NULL,phase=NULL,amp=NULL,start=0,end=499,dt=1,noisevar=0,genplot=T,
       verbose=T)
```

Arguments

freqs	Vector with frequencies to model ('linear' frequencies).
phase	Vector with phases for each frequency (phase in radians). Phases are subtracted.
amp	Vector with amplitudes for each frequency.
start	First time/depth/height for output.
end	Last time/depth/height for output.
dt	Sampling interval.
noisevar	Variance of additive Gaussian noise.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Value

modeled time series.

Examples

```
## test signal on pg 38 of Choudhury, Shah, and Thornhill (2008)
freqs=c(0.12,0.18,0.30,0.42)
phase=c(-pi/3,-pi/12,-pi/4,-3*pi/8)
amp=c(1,1,1,1)

cycles(freqs,phase,amp,start=0,end=4095,dt=1,noisevar=0.2)
```

---

delPts *Interactively Delete Points in Plot*

Description

Interactively delete points in x,y plot.

Usage

```
delPts(dat,del=NULL,ptsize=1,xmin=NULL,xmax=NULL,ymin=NULL,ymax=NULL,plotype=1)
```

Arguments

dat	Data frame with two columns
del	A vector of indices indicating points to delete. If specified, the interactive plot is disabled.
ptsize	Size of plotted points.
xmin	Minimum x-value (column 1) to plot

xmax	Maximum x-value (column 1) to plot
ymin	Minimum y-value (column 2) to plot
ymax	Maximum y-value (column 2) to plot
plotype	Type of plot to generate: 1= points and lines, 2 = points, 3 = lines

See Also

idPts, iso, trim and trimAT

---

demean *Remove Mean Value from Stratigraphic Series*

Description

Remove mean value from stratigraphic series

Usage

```
demean(dat,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for mean removal. First column should be location (e.g., depth), second column should be data value.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

arcsinT, detrend, divTrend, logT, prewhiteAR, and prewhiteAR1

---

detrend *Subtract Linear Trend from Stratigraphic Series*

Description

Remove linear trend from stratigraphic series

Usage

```
detrend(dat,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for linear detrending. First column should be location (e.g., depth), second column should be data value.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

arcsinT, demean, divTrend, logT, prewhiteAR, and prewhiteAR1

---

divTrend *Divide by Linear Trend in Stratigraphic Series*

Description

Divide data series value by linear trend observed in stratigraphic series

Usage

```
divTrend(dat,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for div-trending. First column should be location (e.g., depth), second column should be data value.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

arcsinT, demean, detrend, logT, prewhiteAR, and prewhiteAR1

---

dpssTaper *Apply DPSS Taper to Stratigraphic Series*

Description

Apply a single Discrete Prolate Spheroidal Sequence (DPSS) taper to a stratigraphic series

Usage

```
dpssTaper(dat,tbw=1,num=1,rms=T,demean=T,detrend=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for tapering. First column should be location (e.g., depth), second column should be data value. If no data is identified, will output a 256 point taper to evaluate the spectral properties of the window.
tbw	Time-bandwidth product for the DPSS
num	Which one of the DPSS would you like to use?
rms	Normalize taper to RMS=1 to preserve power for white process? (T or F)
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

cosTaper, gausTaper, and hannTaper

---

eAsm *EXPERIMENTAL: Evolutive Average Spectral Misfit*

Description

EXPERIMENTAL: Calculate Evolutive Average Spectral Misfit with Monte Carlo spectra simulations, as updated in Meyers et al. (2012).

Usage

```
eAsm(spec,siglevel=0.9,target,fper=NULL,rayleigh,nyquist,sedmin=1,sedmax=5,
      numsed=50,linLog=1,iter=100000,ydir=1,output=4,genplot=F)
```

Arguments

spec	Time-frequency spectral results to evaluate. Must have the following format: column 1=frequency; remaining columns (2 to n)=probability; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eha.
siglevel	Threshold level for filtering peaks.
target	A vector of astronomical frequencies to evaluate (1/ka). These must be in order of increasing frequency (e.g., e1,e2,e3,o1,o2,p1,p2). Maximum allowed is 50 frequencies.
fper	A vector of uncertainties on each target frequency (1/ka). Values should be from 0-1, representing uncertainty as a percent of each target frequency. The order of the uncertainties must follow that of the target vector. By default, no uncertainty is assigned.

rayleigh	Rayleigh frequency (cycles/m).
nyquist	Nyquist frequency (cycles/m).
sedmin	Minimum sedimentation rate for investigation (cm/ka).
sedmax	Maximum sedimentation rate for investigation (cm/ka).
numsed	Number of sedimentation rates to investigate in ASM optimization grid. Maximum allowed is 500.
linLog	Use linear or logarithmic scaling for sedimentation rate grid spacing? (0=linear, 1=log)
iter	Number of Monte Carlo simulations for significance testing. Maximum allowed is 100,000.
ydir	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards.
output	Return output as a new data frame? (0 = nothing, 1 = Ho-SL, 2 = ASM, 3 = # astronomical terms, 4 = everything)
genplot	Generate summary plots? (T or F)

Details

Please see function asm for details.

References

S.R. Meyers and B.B. Sageman, 2007, *Quantification of Deep-Time Orbital Forcing by Average Spectral Misfit*: American Journal of Science, v. 307, p. 773-792.

S.R. Meyers, 2012, *Seeing Red in Cyclic Stratigraphy: Spectral Noise Estimation for Astrochronology*: Paleoceanography, 27, PA3228, doi:10.1029/2012PA002307.

S.R. Meyers, B.B. Sageman and M.A. Arthur, 2012, *Obliquity forcing of organic matter accumulation during Oceanic Anoxic Event 2*: Paleoceanography, 27, PA3212, doi:10.1029/2012PA002286.

See Also

asm, eAsmTrack and eha

Examples

```
# use modelA as an example
data(modelA)

# interpolate to even sampling interval
modelAInterp=linterp(modelA)

# perform EHA analysis, save harmonic F-test confidence level results to 'spec'
spec=eha(modelAInterp,win=8,step=2,pad=1000,output=4)

# perform Evolutive Average Spectral Misfit analysis, save results to 'res'
res=eAsm(spec,target=c(1/405.47,1/126.98,1/96.91,1/37.66,1/22.42,1/18.33),rayleigh=0.1245274,
```

```
        nyquist=6.66597,sedmin=0.5,sedmax=3,numsed=100,siglevel=0.8,iter=10000,output=4)

# identify minimum Ho-SL in each record and plot
pl(1)
eAsmTrack(res[1],threshold=0.05)

# extract Ho-SL result at 18.23 m
HoSL18.23=extract(res[1],get=18.23,pl=1)

# extract ASM result at 18.23 m
asm18.23=extract(res[2],get=18.23,pl=0)
```

`eAsmTrack` *EXPERIMENTAL: Track ASM Null Hypothesis significance level minima in eASM results*

Description

EXPERIMENTAL: Track ASM Null Hypothesis significance level minima in eASM results.

Usage

```
eAsmTrack(res,threshold=.5,ydir=-1,genplot=T,verbose=T)
```

Arguments

`res`	eAsm results. Must have the following format: column 1=sedimentation rate; remaining columns (2 to n)=Ho-SL; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eAsm.
`threshold`	Threshold Ho-SL value for analysis and plotting.
`ydir`	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards.
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

Details

Please see function eAsm for details.

eha *Evolutive Harmonic Analysis*

Description

Evolutive Harmonic Analysis using the Thomson Multitaper Method

Usage

```
eha(dat,tbw=2,pad,fmin,fmax,step,win,demean=T,detrend=T,siglevel=0.90,
    sigID=F,ydir=1,output=0,pl=1,xlab,ylab,genplot=2,verbose=T)
```

Arguments

dat	Stratigraphic series to analyze. First column should be location (e.g., depth), second column should be data value.
tbw	MTM time-bandwidth product (<=10)
pad	Pad with zeros to how many points? Must not factor into a prime number >23. Maximum number of points is 200,000.
fmin	Smallest frequency for analysis and plotting.
fmax	Largest frequency for analysis and plotting.
step	Step size for EHA window, in units of space or time.
win	Window size for EHA, in units of space or time.
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
siglevel	Significance level for peak identification/filtering (0-1)
sigID	Identify signficant frequencies on power, amplitude, and probabilty plots. Only applies when one spectrum is calculated. (T or F)
ydir	Direction for y-axis in EHA plots (depth,height,time). -1 = values increase downwards (slower plotting), 1 = values increase upwards
output	Return output as new data frame? 0=no; 1=all results; 2=power; 3=amplitude; 4=probability; 5=significant frequencies (only for one spectrum); 6=significant frequencies and their probabilities (only for one spectrum)
pl	Plot logarithm of spectral power (1) or linear spectral power (2)?
xlab	Label for x-axis. Default = "Frequency"
ylab	Label for y-axis. Default = "Location"
genplot	Plotting options. 0= no plots; 1= power, amplitude, f-test, probability; 2=data series, power, amplitude, probability; 3= data series, power, normalized amplitude (maximum in each window normalized to unity), normalized amplitude filtered at specified siglevel; 4= data series, normalized power (maximum in each window normalized to unity), normalized amplitude (maximum in each window normalized to unity), normalized amplitude filtered at specified siglevel
verbose	Verbose output? (T or F)

See Also

extract, trackFreq and traceFreq

Examples

```
## as an example, evaluate the modelA
data(modelA)

## interpolate to even sampling interval of 0.075 m
ex1=linterp(modelA, dt=0.075)

## perform EHA with a time-bandwidth parameter of 2, using an 7.95 meter window, 0.15 m step,
## and pad to 1000 points
## set labels for plots (optional)
eha(ex1,tbw=2,win=7.95,step=0.15,pad=1000,xlab="Frequency (cycles/m)",ylab="Height (m)")

## for comparison generate spectrum for entire record, using time-bandwidth parameter of 3, and
## pad to 5000 points
## start by making a new plot
pl(1)
eha(ex1,tbw=3,win=38,pad=5000,xlab="Frequency (cycles/m)")
```

---

etp *Generate Eccentricity-Tilt-Precession Models*

Description

Calculate eccentricity-tilt-precession time series using the theoretical astronomical solutions. By default, the Laskar et al. (2004) solutions will be downloaded. Alternatively, one can specify the astronomical solution.

Usage

```
etp(tmin=0,tmax=1000,dt=1,eWt=1,oWt=1,pWt=1,esinw=T,solution=NULL,standardize=T,
    genplot=T,verbose=T)
```

Arguments

tmin	Start time (ka before present, J2000) for ETP.
tmax	End time (ka before present, J2000) for ETP.
dt	Sample interval for ETP (ka). Minimum = 1 ka.
eWt	Relative weight applied to eccentricity solution.
oWt	Relative weight applied to obliquity solution.
pWt	Relative weight applied to precession solution.

esinw	Use e*sinw in ETP calculation? (T or F). If set to false, sinw is used.
solution	A data frame containing the astronomical solution to use. The data frame must have four columns: Time (ka, positive and increasing), Precession Angle, Obliquity, Eccentricity.
standardize	Standardize (subtract mean, divide by standard deviation) precession, obliquity and eccentricity series before applying weight and combining? (T or F)
genplot	Generate summary plots? (T or F).
verbose	Verbose output? (T or F).

Details

Note: If you plan to repeatedly execute the etp function, it is advisable to download the astronomical solution once using the function getLaskar.

Note: It is common practice to construct ETP models that have specified variance ratios (e.g., 1:1:1 or 1:0.5:0.5) for eccentricity, obliquity and precession. In order to construct such models, it is necessary to choose 'standardize=T', and to set the individual weights (eWt, oWt, pWt) to the square root of the desired variance contribution.

Value

Eccentricity + tilt + precession.

References

Laskar, J., Robutel, P., Joutel, F., Gastineau, M., Correia, A.C.M., Levrard, B., 2004, *A long term numerical solution for the insolation quantities of the Earth*: Astron. Astrophys., Volume 428, 261-285.

Laskar, J., Fienga, A., Gastineau, M., Manche, H., 2011, *La2010: A new orbital solution for the long-term motion of the Earth*: Astron. Astrophys., Volume 532, A89.

Laskar, J., Gastineau, M., Delisle, J.-B., Farres, A., Fienga, A.: 2011, *Strong chaos induced by close encounters with Ceres and Vesta*: Astron. Astrophys., Volume 532, L4.

See Also

getLaskar

Examples

```
# create an ETP model from 10000 ka to 20000 ka, with a 5 ka sampling interval
# this will automatically download the astronomical solution
ex=etp(tmin=10000,tmax=20000,dt=5)

# alternatively, download the astronomical solution first
ex2=getLaskar()
ex=etp(tmin=10000,tmax=20000,dt=5,solution=ex2)
```

`extract` *Extract record from EHA time-frequency output or eAsm output*

Description

Extract record from EHA time-frequency output or eAsm output: Use interactive graphical interface to identify record.

Usage

```
extract(spec,get=NULL,xmin=NULL,xmax=NULL,ymin=NULL,ymax=NULL,h=6,w=4,ydir=1,pl=0,
        ncolors=100,genplot=T,verbose=T)
```

Arguments

`spec`	Time-frequency spectral results to evaluate, or alternatively, eAsm results to evaluate. For time-frequency results, must have the following format: column 1=frequency; remaining columns (2 to n)=power, amplitude or probability; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eha. For eAsm results, must have the following format: column 1=sedimentation rate; remaining columns (2 to n)=Ho-SL or ASM; titles for columns 2 to n must be the location (depth or height).
`get`	Record to extract (height/depth/time). If no value given, graphical interface is activated.
`xmin`	Minimum frequency or sedimentation rate for PLOTTING.
`xmax`	Maximum frequency or sedimentation rate for PLOTTING.
`ymin`	Minimum depth/height for PLOTTING.
`ymax`	Maximum depth/height for PLOTTING.
`h`	Height of plot in inches.
`w`	Width of plot in inches.
`ydir`	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards.
`pl`	An option for the color plots (0=do nothing; 1=plot log of value [useful for plotting power], 2=normalize to maximum value [useful for plotting amplitude]).
`ncolors`	Number of colors to use in plot.
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

See Also

eha

flip — *Flip stratigraphic series*

Description

Flip the stratigraphic order of your data series (e.g., convert stratigraphic depth series to height series, relative to a defined datum.)

Usage

```
flip(dat,begin=0,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series. First column should be location (e.g., depth), second column should be data value.
begin	Depth/height value to assign to (new) first stratigraphic datum.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

freq2sedrate — *Convert record of local spatial frequency (from EHA) to sedimentation rate curve*

Description

Convert record of local spatial frequency (from EHA) to sedimentation rate curve

Usage

```
freq2sedrate(freqs,period=NULL,ydir=1,genplot=T,verbose=T)
```

Arguments

freqs	Data frame containing depth/height in first column (meters) and spatial frequencies in second column (cycles/m)
period	Temporal period of spatial frequency (ka)
ydir	Direction for y-axis in plots (depth,height). -1 = values increase downwards (slower), 1 = values increase upwards
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

gausTaper *Apply Gaussian Taper to Stratigraphic Series*

Description

Apply a Gaussian taper to a stratigraphic series

Usage

```
gausTaper(dat,alpha=3,rms=T,demean=T,detrend=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for tapering. First column should be location (e.g., depth), second column should be data value. If no data is identified, will output a 256 point taper to evaluate the spectral properties of the window.
alpha	Gaussian window parameter: alpha is 1/stdev, a measure of the width of the Dirichlet kernel. Larger values decrease the width of data window, reduce discontinuities, and increase width of the transform. Choose alpha >= 2.5.
rms	Normalize taper to RMS=1 to preserve power for white process? (T or F)
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

References

Harris, 1978, *On the use of windows for harmonic analysis with the discrete Fourier transform*: Proceedings of the IEEE, v. 66, p. 51-83.

See Also

cosTaper, dpssTaper, and hannTaper

---

getColor *Query R for color information*

Description

Query R for color information.

Usage

```
getColor(color)
```

Arguments

color	The name of the color you are interested in, in quotes.

`getLaskar` *Download Laskar et al. (2004, 2011a, 2011b) astronomical solutions*

Description

Download Laskar et al. (2004, 2011a, 2011b) astronomical solutions.

Usage

```
getLaskar(sol="la04")
```

Arguments

sol	A character string that specifies the astronomical solution to download: "la04","la10a","la10b","la10c","la

Details

la04 : three columns containing precession angle, obliquity, and eccentricity of Laskar et al. (2004)

la10a : one column containing the la10a eccentricity solution of Laskar et al. (2011a)

la10b : one column containing the la10b eccentricity solution of Laskar et al. (2011a)

la10c : one column containing the la10c eccentricity solution of Laskar et al. (2011a)

la10d : one column containing the la10d eccentricity solution of Laskar et al. (2011a)

la11 : one column containing the la11 eccentricity solution of Laskar et al. (2011b; please also cite 2011a)

References

J. Laskar, P. Robutel, F. Joutel, M. Gastineau, A.C.M. Correia, and B. Levrard, B., 2004, *A long term numerical solution for the insolation quantities of the Earth*: Astron. Astrophys., Volume 428, 261-285.

Laskar, J., Fienga, A., Gastineau, M., Manche, H., 2011a, *La2010: A new orbital solution for the long-term motion of the Earth*: Astron. Astrophys., Volume 532, A89.

Laskar, J., Gastineau, M., Delisle, J.-B., Farres, A., Fienga, A.: 2011b, *Strong chaos induced by close encounters with Ceres and Vesta, Astron*: Astrophys., Volume 532, L4.

hannTaper *Apply Hann Taper to Stratigraphic Series*

Description

Apply a Hann (Hanning) taper to a stratigraphic series

Usage

```
hannTaper(dat,rms=T,demean=T,detrend=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for tapering. First column should be location (e.g., depth), second column should be data value. If no data is identified, will output a 256 point taper to evaluate the spectral properties of the window.
rms	Normalize taper to RMS=1 to preserve power for white process? (T or F)
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

cosTaper, dpssTaper, and gausTaper

headn *List Column Numbers for Each Variable*

Description

Execute 'head' function, with column numbers indicated for each variable. (useful for functions such as 'autopl')

Usage

```
headn(dat)
```

Arguments

dat	Your data frame.

hilbert *Hilbert Transform of Stratigraphic Series*

Description

Calculate instantaneous amplitude (envelope) via Hilbert Transform of stratigraphic series

Usage

```
hilbert(dat,padfac=2,demean=T,detrend=F,output=T,addmean=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series to Hilbert Transform. First column should be location (e.g., depth), second column should be data value.
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
output	Return results as new data frame? (T or F)
addmean	Add mean value to instantaneous amplitude? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Examples

```
# generate example series with 3 precession terms and noise
ex <- cycles(noisevar=.0004,dt=5)
# bandpass precession terms using cosine-tapered window
res_ex <- bandpass(ex,flow=0.038,fhigh=0.057,win=2,p=.4)
# hilbert transform
hil_ex <- hilbert(res_ex)
```

idPts *Interactively Identify Points in Plot*

Description

Interactively identify points in x,y plot.

Usage

```
idPts(dat1,dat2=NULL,ptsize=1,xmin=NULL,xmax=NULL,ymin=NULL,ymax=NULL,
       logx=F,logy=F,plotype=1,annotate=1,output=1,verbose=T)
```

Arguments

dat1	Data frame with one or two columns. If one column, dat2 must also be specified.
dat2	Data frame with one column.
ptsize	Size of plotted points.
xmin	Minimum x-value (column 1) to plot
xmax	Maximum x-value (column 1) to plot
ymin	Minimum y-value (column 2) to plot
ymax	Maximum y-value (column 2) to plot
logx	Plot x-axis using logarithmic scaling? (T or F)
logy	Plot y-axis using logarithmic scaling? (T or F)
plotype	Type of plot to generate: 1= points and lines, 2 = points, 3 = lines
annotate	Annotate plot with text indicating coordinates?: 0=none, 1=annotate above point, 2=annotate below point
output	Return identified points as a data frame? (0) no, (1) return x and y, (2) return index, x and y
verbose	Verbose output? (T or F)

See Also

delPts, iso, trim and trimAT

---

integratePower *Determine the total power within a given bandwidth*

Description

Determine the total power within a given bandwidth, and also the ratio of this power to the total power in the spectrum (or up to a specified frequency). If bandwidth is not specified, generate interactive plots for bandwidth selection. For use with the function eha, integratePower can process spectrograms (time-frequency) or single spectra.

Usage

```
integratePower(spec,flow=NULL,fhigh=NULL,fmax=NULL,unity=F,f0=T,xmin=NULL,
            xmax=NULL,ymin=NULL,ymax=NULL,npts=NULL,pad=NULL,ydir=1,ncolors=100,
               h=6,w=9,ln=F,genplot=T,verbose=T)
```

Arguments

spec	Spectral results to evaluate. If the data frame contains time-frequency results, it must have the following format: column 1=frequency; remaining columns (2 to n)=power; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eha. If the data frame contains one spectrum, it must have the following format: column 1=frequency, column 2=power.
flow	Low frequency cutoff for integration. If flow or fhigh are not specified, interactive plotting is activated.
fhigh	High frequency cutoff for integration. If flow or fhigh are not specified, interactive plotting is activated.
fmax	Integrate total power up to this frequency.
unity	Normalize spectra such that total variance (up to fmax) is unity. (T of F)
f0	Is f(0) included in the spectra? (T or F)
xmin	Minimum frequency for PLOTTING.
xmax	Maximum frequency for PLOTTING.
ymin	Minimum depth/height/time for PLOTTING. Only used if processing time-frequency results.
ymax	Maximum depth/height/time for PLOTTING. Only used if processing time-frequency results.
npts	The number of points in the processed time series window. This is needed for proper spectrum normalization.
pad	The total padded length of the processed time series window. This is needed for proper spectrum normalization.
ydir	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards. Only used if processing time-frequency results.
ncolors	Number of colors to use in plot. Only used if processing time-frequency results.
h	Height of plot in inches.
w	Width of plot in inches.
ln	Plot natural log of spectral results? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Details

Depending on the normalization used, you may want to preprocess the power spectra prior to integration.

See Also

eha

Examples

```
# generate etp signal over past 10 Ma
ex=etp(tmax=10000)

# evolutive power
pwr=eha(ex,win=500,fmax=.1,pad=2000,output=2,pl=2)

# integrate power from main obliquity term
integratePower(pwr,flow=0.02,fhigh=0.029,npts=501,pad=2000)
```

`iso` *Isolate Data from a Specified Stratigraphic Interval*

Description

Isolate a section of a uni- or multi-variate stratigraphic data set for further analysis

Usage

```
iso(dat,xmin,xmax,col=2,logx=F,logy=F,genplot=T,verbose=T)
```

Arguments

`dat`	Data frame containing stratigraphic variable(s) of interest. First column must be location (e.g., depth).
`xmin`	Minimum depth/height/time for isolation. If xmin is not specified, it will be selected using a graphical interface.
`xmax`	Maximum depth/height/time for isolation. If xmax is not specified, it will be selected using a graphical interface.
`col`	If you are using the graphical interface to select xmin/xmax, which column would you like to plot? (default = 2).
`logx`	Plot x-axis using logarithmic scaling? (T or F)
`logy`	Plot y-axis using logarithmic scaling? (T or F)
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

See Also

`delPts`, `idPts`, `trim` and `trimAT`

linage *Tune stratigraphic series to an astronomical target using graphical interface*

Description

Tune stratigraphic series to an astronomical target using graphical interface similar to Analyseries 'Linage' routine (Paillard et al, 1996).

Usage

```
linage(dat,target,extrapolate=F,xmin=NULL,xmax=NULL,tmin=NULL,tmax=NULL,size=1,plotype=1,
       output=1,genplot=T)
```

Arguments

dat	Stratigraphic series for tuning, with two columns. First column is depth/height.
target	Astronomical tuning target series. First column is time.
extrapolate	Extrapolate sedimentation rates above and below 'tuned' interval? (T or F)
xmin	Minimum height/depth to plot.
xmax	Maximum height/depth to plot.
tmin	Minimum time value to plot.
tmax	Maximum time value to plot.
size	Multiplicative factor to increase or decrease size of symbols and fonts.
plotype	Type of plot to generate: 1= points and lines, 2 = points, 3 = lines
output	Return which of the following? 1 = tuned stratigraphic series; 2 = age control points; 3 = tuned stratigraphic series and age control points
genplot	Generate additional summary plots (tuned record, time-space map, sedimentation rates)? (T or F)

References

Paillard, D., L. Labeyrie and P. Yiou, 1996), *Macintosh program performs time-series analysis*: Eos Trans. AGU, v. 77, p. 379.

Examples

```
# Check to see if this is an interactive R session, for compliance with CRAN standards.
# YOU CAN SKIP THE FOLLOWING LINE IF YOU ARE USING AN INTERACTIVE SESSION.
if(interactive()) {

# generate example series with 3 precession terms and noise using function 'cycles'
# then convert from time to space using sedimentation rate that increases from 1 to 7 cm/ka
ex=sedRamp(cycles(start=1,end=400, dt=2,noisevar=.00005),srstart=0.01,srend=0.07)
```

```
# create astronomical target series
targ=cycles(start=1,end=400,dt=2)

## manually tune
tuned=linage(ex,targ)

## should you need to flip the direction of the astronomical target series, use function 'cb':
tuned=linage(ex,cb(targ[1]*-1,targ[2]))

}
```

`linterp` *Piecewise Linear Interpolation of Stratigraphic Series*

Description

Interpolate stratigraphic series onto a evenly sampled grid, using piecewise linear interpolation

Usage

```
linterp(dat,dt,start,genplot=T,verbose=T)
```

Arguments

`dat`	Stratigraphic series for piecewise linear interpolation. First column should be location (e.g., depth), second column should be data value.
`dt`	New sampling interval.
`start`	Start interpolating at what time/depth/height value? By default, the first value of the stratigraphic series will be used.
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

`logT` *Log Transformation of Stratigraphic Series*

Description

Log transformation of stratigraphic series.

Usage

```
logT(dat,c=0,opt=1,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for log transformation. First column should be location (e.g., depth), second column should be data value for transformation.
c	Constant to add prior to log transformation. Default = 0.
opt	(1) use natural logarithm, (2) use log10. Default = 1.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

arcsinT, demean, detrend, divTrend, prewhiteAR, and prewhiteAR1

---

lowpass *Lowpass Filter Stratigraphic Series*

Description

Lowpass filter stratigraphic series using rectangular, Gaussian or tapered cosine window [cosine window is experimental]

Usage

```
lowpass(dat,padfac=2,fcut=NULL,win=0,demean=T,detrend=F,addmean=T,alpha=3,p=0.25,
        xmin=0,xmax=Nyq,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for lowpass filtering. First column should be location (e.g., depth), second column should be data value.
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
fcut	Cutoff frequency for lowpass filtering.
win	Window type for bandpass filter: 0 = rectangular , 1= Gaussian, 2= Cosine-tapered window.
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
addmean	Add mean value to bandpass result? (T or F)
alpha	Gaussian window parameter: alpha is 1/stdev, a measure of the width of the Dirichlet kernal. Larger values decrease the width of data window, reduce discontinuities, and increase width of the transform. Choose alpha >= 2.5.
p	Cosine-tapered window parameter: p is the percent of the data series tapered (choose 0-1).
xmin	Smallest frequency for plotting.

xmax	Largest frequency for plotting.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

bandpass, noKernel, noLow, prewhiteAR, and prewhiteAR1

Examples

```
# generate example series with periods of 405 ka, 100 ka and 20 ka, plus noise
ex=cycles(freqs=c(1/405,1/100,1/20),noisevar=.1,dt=5)
# lowpass filter using cosine-tapered window
res_ex=lowpass(ex,fcut=.02,win=2,p=.4)
```

---

lowspec *Robust Locally-Weighted Regression Spectral Background Estimation*

Description

LOWSPEC: Robust Locally-Weighted Regression Spectral Background Estimation

Usage

```
lowspec(dat,decimate=NULL,tbw=3,padfac=5,detrend=F,siglevel=0.9,setrho,
        lowspan,b_tun,output=0,CLpwr=T,xmin,xmax,pl=1,sigID=F,genplot=T,
        verbose=T)
```

Arguments

dat	Stratigraphic series for LOWSPEC. First column should be location (e.g., depth), second column should be data value.
decimate	Decimate statigraphic series to have this sampling interval (via piecewise linear interpolation). By default, no decimation is performed.
tbw	MTM time-bandwidth product (2 or 3 permitted)
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
detrend	Remove linear trend from data series? This detrending is performed following AR1 prewhitening. (T or F)
siglevel	Significance level for peak identification.
setrho	Define AR1 coefficient for pre-whitening (otherwise calculated). If set to 0, no pre-whitening is applied.
lowspan	Span for LOWESS smoothing of prewhitened signal, usually fixed to 1. If using value <1, the method is overly conservative with a reduced false positive rate.

b_tun	Robustness weight parameter for LOWSPEC. By default, this will be estimated internally.
output	What should be returned as a data frame? (0=nothing; 1=spectrum + background + CLs; 2=sig peaks)
CLpwr	Plot LOWSPEC noise confidence levels on power spectrum? (T or F)
xmin	Smallest frequency for plotting.
xmax	Largest frequency for plotting.
pl	Plot logarithm of spectral power (1) or linear spectral power (2)?
sigID	Identify signficant frequencies on power and probabilty plots? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Details

LOWSPEC is a 'robust' method for spectral background estimation, designed for the identification of potential astronomical signals that are imbedded in red noise (Meyers, 2012). The complete algoritm implemented here is as follows: (1) initial pre-whitening with AR1 filter (default) or other filter as appropriate (e.g., see function prewhiteAR), (2) power spectral estimation via the multitaper method (Thomson, 1982), (3) robust locally weighted estimation of the spectral background using the LOWESS-based (Cleveland, 1979) procedure of Ruckstuhl et al. (2001), (4) assignment of confidence levels using a Chi-square distribution.

NOTE: If you choose to pre-whiten before running LOWSPEC (rather than using the default AR1 pre-whitening), specify setrho=0.

Candidiate astronomical cycles are subsequently idenitified via isolation of those frequencies that achieve the required (e.g., 90 percent) LOWSPEC confidence level and MTM harmonic F-test confidence level. Allowance is made for the smoothing inherent in the MTM power spectral estimate as compared to the MTM harmonic spectrum. That is, an F-test peak is reported if it achieves the required MTM harmonic confidence level, while also achieving the required LOWSPEC confidence level within +/- half the power spectrum bandwidth resolution. One additional criterion is included to further reduce the false positive rate, a requirement that significant F-tests must occur on a local power spectrum high, which is parameterized as occurring above the local LOWSPEC background estimate. See Meyers (2012) for futher information on the algorithm.

In this implementation, the 'robustness criterion' ('b' in EQ. 6 of Ruckstuhl et al., 2001) has been optimized for 2 and 3 pi DPSS, using a 'span' of 1. By default the robustness criterion will be estimated. Both 'b' and the 'span' can be expliclty set using parameters 'b_tun' and 'lowspan'. Note that it is permissible to decrease 'lowspan' from its default value, but this will result in an overly conservative false positive rate. However, it may be necessary to reduce 'lowspan' to provide an approporiate background fit for some stratigraphic data. Another option is to decimate the data series prior to spectral estimation.

Value

If option 1 is selected, a data frame containing the following is returned: Frequency, Prewhitened power, LOWSPEC background, LOWSPEC CL, F-test CL.

If option 2 is selected, the 'significant' frequencies are returned (as described above).

References

W.S. Cleveland, 1979, *Locally weighted regression and smoothing scatterplots*: Journal of the American Statistical Association, v. 74, p. 829-836.

S.R. Meyers, 2012, *Seeing Red in Cyclic Stratigraphy: Spectral Noise Estimation for Astrochronology*: Paleoceanography, 27, PA3228, doi:10.1029/2012PA002307.

A.F. Ruckstuhl, M.P Jacobson, R.W. Field, and J.A. Dodd, 2001, *Baseline subtraction using robust local regression estimation*: Journal of Quantitative Spectroscopy & Radiative Transfer, v. 68, p. 179-193.

D.J. Thomson, 1982, *Spectrum estimation and harmonic analysis*: IEEE Proceedings, v. 70, p. 1055-1096.

See Also

spec.mtm, rfbaseline, mtm, mtmAR, mtmML96, and periodogram

Examples

```
# generate example series with periods of 400 ka, 100 ka, 40 ka and 20 ka
ex = cycles(freqs=c(1/400,1/100,1/40,1/20),start=1,end=1000,dt=5)

# add AR1 noise
noise = ar1(npts=200,dt=5,sd=.5)
ex[2] = ex[2] + noise[2]

# LOWSPEC analysis
pl(1, title="lowspec")
lowspec(ex)

# compare to MTM spectral analysis, with conventional AR1 noise test
pl(1,title="mtm")
mtm(ex,ar1=TRUE)

# compare to ML96 analysis
pl(1, title="mtmML96")
mtmML96(ex)

# compare to amplitudes from eha
pl(1,title="eha")
eha(ex,tbw=3,win=1000,pad=1000)
```

---

modelA *Example stratigraphic model series*

Description

Example stratigraphic model series.

Usage

```
modelA
```

Format

Height (meters), weight percent CaCO3

`mtm` *Multitaper Method Spectral Analysis*

Description

Multitaper Method (MTM) Spectral Analysis

Usage

```
mtm(dat,tbw=3,ntap=NULL,padfac=5,demean=T,detrend=F,siglevel=0.9,ar1=T,output=0,
     CLpwr=T,xmin,xmax,pl=1,sigID=F,genplot=T,verbose=T)
```

Arguments

`dat`	Stratigraphic series for MTM spectral analysis. First column should be location (e.g., depth), second column should be data value.
`tbw`	MTM time-bandwidth product.
`ntap`	Number of DPSS tapers to use. By default, this is set to (2*tbw)-1.
`padfac`	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
`demean`	Remove mean from data series? (T or F)
`detrend`	Remove linear trend from data series? (T or F)
`siglevel`	Significance level for peak identification.
`ar1`	Estimate conventional AR(1) noise spectrum and confidence levels? (T or F)
`CLpwr`	Plot AR(1) noise confidence levels on power spectrum? (T or F)
`output`	What should be returned as a data frame? (0=nothing; 1=spectrum + CLs + AR1 fit; 2=sig peak freqs; 3=sig peak freqs + prob; 4=all)
`xmin`	Smallest frequency for plotting.
`xmax`	Largest frequency for plotting.
`pl`	Plot logarithm of spectral power (1) or linear spectral power (2)?
`sigID`	Identify signficant frequencies on power and probabilty plots? (T or F)
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

References

Rahim, K.J. and Burr W.S. and Thomson, D.J., 2014, *Appendix A: Multitaper R package in "Applications of Multitaper Spectral Analysis to Nonstationary Data"*, PhD diss., Queen's Univieristy, pp 149-183. http://hdl.handle.net/1974/12584

Thomson, D. J., 1982, *Spectrum estimation and harmonic analysis*, Proc. IEEE, 70, 1055-1096, doi:10.1109/PROC.1982.12433.

See Also

spec.mtm, lowspec, and periodogram

Examples

```
# generate example series with periods of 400 ka, 100 ka, 40 ka and 20 ka
ex = cycles(freqs=c(1/400,1/100,1/40,1/20),start=1,end=1000,dt=5)

# add AR1 noise
noise = ar1(npts=200,dt=5,sd=.5)
ex[2] = ex[2] + noise[2]

# MTM spectral analysis, with conventional AR1 noise test
pl(1,title="mtm")
mtm(ex,ar1=TRUE)

# compare to ML96 analysis
pl(1, title="mtmML96")
mtmML96(ex)

# compare to analysis with LOWSPEC
pl(1, title="lowspec")
lowspec(ex)

# compare to amplitudes from eha
pl(1,title="eha")
eha(ex,tbw=3,win=1000,pad=1000)
```

---

mtmAR *Intermediate spectrum test of Thomson et al. (2001)*

Description

Perform the 'intermediate spectrum test' of Thomson et al. (2001).

Paraphrased from Thomson et al. (2001): Form an intermediate spectrum by dividing MTM by AR estimate. Choose an order P for a predictor. A variety of formal methods are available in the

literature, but practically, one keeps increasing P (the order) until the range of the intermediate spectrum Si(f) (equation (C4) of Thomson et al., 2001) stops decreasing rapidly as a function of P. If the intermediate spectrum is not roughly white, as judged by the minima, the value of P should be increased.

Usage

```
mtmAR(dat,tbw=3,ntap=NULL,order=1,method="mle",CItype=1,padfac=5,demean=T,detrend=F,
      output=1,xmin=0,xmax=Nyq,pl=1,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for analysis. First column should be location (e.g., depth), second column should be data value.
tbw	MTM time-bandwidth product.
ntap	Number of DPSS tapers to use. By default, this is set to (2*tbw)-1.
order	Order of the AR spectrum.
method	AR method ("yule-walker", "burg", "ols", "mle", "yw")
CItype	Illustrate (1) one-sided or (2) two-sided confidence intervals on plots
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
output	Output (1) intermediate spectrum and confidence levels, (2) intermediate spectrum, (3) confidence levels
xmin	Smallest frequency for plotting.
xmax	Largest frequency for plotting.
pl	Plot logarithm of spectral power (1) or linear spectral power (2)?
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

References

Thomson, D. J., L. J. Lanzerotti, and C. G. Maclennan, 2001, *The interplanetary magnetic field: Statistical properties and discrete modes*, J. Geophys.Res., 106, 15,941-15,962, doi:10.1029/2000JA000113.

See Also

spec.mtm, mtm, mtmML96, lowspec, and periodogram

`mtmML96` *Mann and Lees (1996) robust red noise MTM analysis*

Description

Mann and Lees (1996) robust red noise MTM analysis. This function implements several improvements to the algorithm used in SSA-MTM toolkit, including faster AR1 model optimization, and more appropriate 'edge-effect' treatment.

Usage

```
mtmML96(dat,tbw=3,ntap=NULL,padfac=5,demean=T,detrend=F,medsmooth=0.2,
         opt=1,linLog=2,siglevel=0.9,output=0,CLpwr=T,xmin=0,xmax=Nyq,
         sigID=F,pl=1,genplot=T,verbose=T)
```

Arguments

`dat`	Stratigraphic series for MTM spectral analysis. First column should be location (e.g., depth), second column should be data value.
`tbw`	MTM time-bandwidth product.
`ntap`	Number of DPSS tapers to use. By default, this is set to (2*tbw)-1.
`padfac`	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
`demean`	Remove mean from data series? (T or F)
`detrend`	Remove linear trend from data series? (T or F)
`medsmooth`	ML96 median smoothing parameter (1 = use 100 percent of spectrum, 0.20 use 20 percent)
`opt`	Optimization method for robust AR1 model estimation (1=Brent's method:fast, 2=Gauss-Newton:fast, 3=grid search:slow)
`linLog`	Optimize AR1 model fit using (1) linear power or (2) log(power)?
`siglevel`	Significance level for peak identification.
`output`	What should be returned as a data frame? (0=nothing; 1=spectrum + CLs + AR1 fit + median smoothed spectrum; 2=sig peak freqs; 3=sig peak freqs + prob; 4=all)
`CLpwr`	Plot ML96 AR(1) noise confidence levels on power spectrum? (T or F)
`xmin`	Smallest frequency for plotting.
`xmax`	Largest frequency for plotting.
`sigID`	Identify signficant frequencies on power and probabilty plots? (T or F)
`pl`	Plot logarithm of spectral power (1) or linear spectral power (2)?
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

Details

This function conducts the Mann and Lees (1996; ML96) "robust red noise" analysis, with an improved median smoothing approach. The original Mann and Lees (1996) approach applies a truncation of the median smoothing window to include fewer frequencies near the edges of the spectrum; while truncation is required, its implementation in the original method often results in an "edge effect" that can produce excess false positive rates at low frequencies, commonly within the eccentricity-band (Meyers, 2012).

To help address this issue, an alternative median smoothing approach is applied that implements Tukey's robust end-point rule and symmetrical medians (see the function runmed for details). Numerical experiments indicate that this approach produces an approximately uniform false positive rate across the spectrum. It should be noted that the false positive rates are still inflated with this method, but they are substantially reduced compared to the original ML96 approach. For example, simulations using rho=0.9 (using identical parameters to those in Meyers, 2012) yield median false positive rates of 1.7%, 7.3% and 13.4%, for the 99%, 95% and 90% confidence levels (respectively). This compares with 4.7%, 11.4% and 17.8% using the original approach (see Table 2 of Meyers, 2012).

NOTE: If the (fast) Brent or Gauss-Newton methods fail, use the (slow) grid search approach.

This version of the ML96 algorithm was first implemented in Patterson et al. (2014).

References

Mann, M.E., and Lees, J.M., 1996, *Robust estimation of background noise and signal detection in climatic time series*, Clim. Change, 33, 409-445.

Meyers, S.R., 2012, *Seeing red in cyclic stratigraphy: Spectral noise estimation for astrochronology*, Paleoceanography, 27, PA3228.

Patterson, M.O., McKay, R., Naish, T., Escutia, C., Jimenez-Espejo, F.J., Raymo, M.E., Meyers, S.R., Tauxe, L., Brinkhuis, H., and IODP Expedition 318 Scientists, 2014, *Response of the East Antarctic Ice Sheet to orbital forcing during the Pliocene and Early Pleistocene*, Nature Geoscience, v. 7, p. 841-847.

Thomson, D. J., 1982, *Spectrum estimation and harmonic analysis*, Proc. IEEE, 70, 1055-1096, doi:10.1109/PROC.1982.12433.

http://www.meteo.psu.edu/holocene/public_html/Mann/tools/MTM-RED/

Tukey, J.W., 1977, *Exploratory Data Analysis*, Addison.

See Also

runmed, spec.mtm, mtmAR, lowspec, and periodogram

Examples

```
# generate example series with periods of 400 ka, 100 ka, 40 ka and 20 ka
ex = cycles(freqs=c(1/400,1/100,1/40,1/20),start=1,end=1000,dt=5)

# add AR1 noise
noise = ar1(npts=200,dt=5,sd=0.5)
ex[2] = ex[2] + noise[2]
```

```
# run ML96 analysis
pl(1, title="mtmML96")
mtmML96(ex)

# compare to analysis with conventional AR1 noise test
pl(1,title="mtm")
mtm(ex)

# compare to analysis with LOWSPEC
pl(1, title="lowspec")
lowspec(ex)

# compare to amplitudes from eha
pl(1,title="eha")
eha(ex,tbw=3,win=1000,pad=1000)
```

---

noKernel *Remove Gaussian Kernel Smoother from Stratigraphic Series*

Description

Estimate trend and remove from stratigraphic series using a Gaussian kernel smoother

Usage

```
noKernel(dat,smooth=0.1,sort=F,output=1,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for smoothing. First column should be location (e.g., depth), second column should be data value.
smooth	Degree of smoothing with a Gaussian kernal (0 = no smoothing); for a value of 0.5, the kernel is scaled so that its quartiles (viewed as prob densities) are at +/- 25 percent of the data series length. Must be > 0.
sort	Sort data into increasing depth (required for ksmooth)? (T or F)
output	1= output residual values; 2= output Gaussian kernel smoother.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

bandpass, lowpass, noLow, prewhiteAR, and prewhiteAR1

noLow *Fit and Remove Lowess Smoother from Stratigraphic Series*

Description

Fit and remove lowess smoother from stratigraphic series

Usage

```
noLow(dat,smooth=.20,output=1,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for lowess smoother removal. First column should be location (e.g., depth), second column should be data value.
smooth	Lowess smoothing parameter.
output	1= output residual values; 2= output lowess fit
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

bandpass, lowpass, noKernel, prewhiteAR, and prewhiteAR1

pad *Pad Stratigraphic Series with Zeros*

Description

Pad Stratigraphic Series with Zeros ("zero padding")

Usage

```
pad(dat,zeros,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for mean removal. First column should be location (e.g., depth), second column should be data value.
zeros	Number of zeros to add on the end of the series. By default, the number of points will be doubled.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

peak *Identify maxima of peaks in series, filter at desired threshold value*

Description

Identify maxima of peaks in any 1D or 2D series, filter at desired threshold value.

Usage

```
peak(dat,level,genplot=T,verbose=T)
```

Arguments

dat	1 or 2 dimensional series. If 2 dimesions, first column should be location (e.g., depth), second column should be data value.
level	Threshold level for filtering peaks. By default all peak maxima reported.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Examples

```
ex=cycles(genplot=FALSE)
peak(ex,level=0.02)
```

periodogram *Simple Periodogram*

Description

Calculate periodogram for stratigraphic series

Usage

```
periodogram(dat,padfac=2,demean=T,detrend=F,nrm=1,xmin=0,xmax=Nyq,pl=1,output=0,
            f0=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series to analyze. First column should be location (e.g., depth), second column should be data value.
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points. padfac will automatically promote the total padded series length to an even number, to ensure the Nyquist frequency is calculated. However, if padfac is set to 0, no padding will be implemented.
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
nrm	Power normalization: 0 = no normalization; 1 = divide Fourier transform by npts.
xmin	Smallest frequency for plotting.
xmax	Largest frequency for plotting.
pl	Power spectrum plotting: 1 = log power, 2 = linear power
output	Return output as new data frame? (0= no; 1= frequency,amplitude,power,phase; 2= frequency,real coeff.,imag. coeff)
f0	Return results for the zero frequency? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

mtm and lowspec

Examples

```
# ***** PART 1: Demonstrate the impact of tapering
# generate example series with 10 periods: 100, 40, 29, 21, 19, 14, 10, 5, 4 and 3 ka.
ex=cycles(c(1/100,1/40,1/29,1/21,1/19,1/14,1/10,1/5,1/4,1/3),amp=c(1,.75,0.01,.5,.25,
            0.01,0.1,0.05,0.001,0.01))

# set zero padding amount for spectral analyses
# (pad= 1 results in no padding, pad = 2 will pad the series to two times its original length)
# start with pad = 1, then afterwards evaluate pad=2
pad=1

# calculate the periodogram with no tapering applied (a "rectangular window")
res=periodogram(ex,output=1,padfac=pad)

# save the frequency grid and the power for plotting
freq=res[1]
pwr_rect=res[3]

# now compare with results obtained after applying four different tapers:
#  Hann, % cosine taper, DPSS with a time-bandwidth product of 1, and DPSS
#  with a time-bandwidth product of 3
```

```
pwr_hann=periodogram(hannTaper(ex,demean=FALSE),output=1,padfac=pad)[3]
pwr_cos=periodogram(cosTaper(ex,p=.3,demean=FALSE),output=1,padfac=pad)[3]
pwr_dpss1=periodogram(dpssTaper(ex,tbw=1,demean=FALSE),output=1,padfac=pad)[3]
pwr_dpss3=periodogram(dpssTaper(ex,tbw=3,demean=FALSE),output=1,padfac=pad)[3]

# now plot the results
ymin=min(rbind (log(pwr_rect[,1]),log(pwr_hann[,1]),log(pwr_cos[,1]),log(pwr_dpss1[,1]),
          log(pwr_dpss3[,1]) ))
ymax=max(rbind (log(pwr_rect[,1]),log(pwr_hann[,1]),log(pwr_cos[,1]),log(pwr_dpss1[,1]),
          log(pwr_dpss3[,1]) ))

pl(2)
plot(freq[,1],log(pwr_rect[,1]),type="l",ylim=c(ymin,ymax),lwd=2,ylab="log(Power)",
      xlab="Frequency (cycles/ka)",
      main="Comparison of rectangle (black), 30% cosine (blue) and Hann (orange) taper",
      cex.main=1)
lines(freq[,1],log(pwr_hann[,1]),col="orange",lwd=2)
lines(freq[,1],log(pwr_cos[,1]),col="blue")
points(c(1/100,1/40,1/29,1/21,1/19,1/14,1/10,1/5,1/4,1/3),rep(ymax,10),cex=.5,
       col="purple")

plot(freq[,1],log(pwr_rect[,1]),type="l",ylim=c(ymin,ymax),lwd=2,ylab="log(Power)",
      xlab="Frequency (cycles/ka)",
      main="Comparison of rectangle (black), 1pi DPSS (green) and 3pi DPSS (red) taper",
      cex.main=1)
lines(freq[,1],log(pwr_dpss1[,1]),col="green")
lines(freq[,1],log(pwr_dpss3[,1]),col="red",lwd=2)
points(c(1/100,1/40,1/29,1/21,1/19,1/14,1/10,1/5,1/4,1/3),rep(ymax,10),cex=.5,
       col="purple")


# ***** PART 2: Now add a very small amount of red noise to the series
#               (with lag-1 correlation = 0.5)
ex2=ex
ex2[2]=ex2[2]+ar1(rho=.5,dt=1,npts=500,sd=.005,genplot=FALSE)[2]

# compare the original series with the series+noise
pl(2)
plot(ex,type="l",lwd=2,lty=3,col="black",xlab="time (ka)",ylab="signal",
      main="signal (black dotted) and signal+noise (red)"); lines(ex2,col="red")
plot(ex[,1],ex2[,2]-ex[,2],xlab="time (ka)",ylab="difference",
      main="Difference between the two time series (very small!)")

# calculate the periodogram with no tapering applied (a "rectangular window")
res.2=periodogram(ex2,output=1,padfac=pad)

# save the frequency grid and the power for plotting
freq.2=res.2[1]
pwr_rect.2=res.2[3]

# now compare with results obtained after applying four different tapers:
#  Hann, % cosine taper, DPSS with a time-bandwidth product of 1, and DPSS
#  with a time-bandwidth product of 3
```

```
pwr_hann.2=periodogram(hannTaper(ex2,demean=FALSE),output=1,padfac=pad)[3]
pwr_cos.2=periodogram(cosTaper(ex2,p=.3,demean=FALSE),output=1,padfac=pad)[3]
pwr_dpss1.2=periodogram(dpssTaper(ex2,tbw=1,demean=FALSE),output=1,padfac=pad)[3]
pwr_dpss3.2=periodogram(dpssTaper(ex2,tbw=3,demean=FALSE),output=1,padfac=pad)[3]

# now plot the results
ymin=min(rbind (log(pwr_rect.2[,1]),log(pwr_hann.2[,1]),log(pwr_cos.2[,1]),
         log(pwr_dpss1.2[,1]),log(pwr_dpss3.2[,1]) ))
ymax=max(rbind (log(pwr_rect.2[,1]),log(pwr_hann.2[,1]),log(pwr_cos.2[,1]),
         log(pwr_dpss1.2[,1]),log(pwr_dpss3.2[,1]) ))

pl(2)
plot(freq.2[,1],log(pwr_rect.2[,1]),type="l",ylim=c(ymin,ymax),lwd=2,ylab="log(Power)",
     xlab="Frequency (cycles/ka)",
     main="Comparison of rectangle (black), 30% cosine (blue) and Hann (orange) taper",
     cex.main=1)
lines(freq.2[,1],log(pwr_hann.2[,1]),col="orange",lwd=2)
lines(freq.2[,1],log(pwr_cos.2[,1]),col="blue")
points(c(1/100,1/40,1/29,1/21,1/19,1/14,1/10,1/5,1/4,1/3),rep(ymax,10),cex=.5,
        col="purple")

plot(freq.2[,1],log(pwr_rect.2[,1]),type="l",ylim=c(ymin,ymax),lwd=2,ylab="log(Power)",
      xlab="Frequency (cycles/ka)",
      main="Comparison of rectangle (black), 1pi DPSS (green) and 3pi DPSS (red) taper",
      cex.main=1)
lines(freq.2[,1],log(pwr_dpss1.2[,1]),col="green")
lines(freq.2[,1],log(pwr_dpss3.2[,1]),col="red",lwd=2)
points(c(1/100,1/40,1/29,1/21,1/19,1/14,1/10,1/5,1/4,1/3),rep(ymax,10),cex=.5,
      col="purple")
```

`pl` *Set Up Plots*

Description

Open new device and set up for multiple plots, output to screen or PDF if desired.

Usage

```
pl(n,r,c,h,w,mar,file,title)
```

Arguments

`n`	Number of plots per page (1-25). When specified, this parameter takes precedence and the default settings for r and c are used (the r and c options below are ignored).
`r`	Number of rows of plots.
`c`	Number of columns of plots.

h	Height of new page (a.k.a. "device").
w	Width of new page (a.k.a. "device").
mar	A numerical vector of the form c(bottom, left, top, right) which gives the margin size specified in inches.
file	PDF file name, in quotes. If a file name is not designated, then the plot is output to the screen instead.
title	Plot title (must be in quotes)

---

plotEha *Create color time-frequency plots from eha results*

Description

Create color time-frequency plots from eha results.

Usage

```
plotEha(spec,xmin=NULL,xmax=NULL,ymin=NULL,ymax=NULL,h=6,w=4,ydir=1,pl=0,norm=NULL,
      xaxis=c("Frequency (cycles/ka)"),yaxis=c("Time (ka)"),ncolors=100,colorscale=F,
        filetype=0,output=T,verbose=T)
```

Arguments

spec	Time-frequency spectral results to evaluate. Must have the following format: column 1=frequency; remaining columns (2 to n)=power, amplitude or probability; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eha.
xmin	Minimum frequency for PLOTTING.
xmax	Maximum frequency for PLOTTING.
ymin	Minimum depth/height for PLOTTING.
ymax	Maximum depth/height for PLOTTING.
h	Height of plot in inches.
w	Width of plot in inches.
ydir	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards.
pl	An option for the color plots (0=do nothing; 1=plot log of value [useful for plotting power], 2=normalize to maximum value [useful for plotting amplitude], 3=use normalization provided in norm.
norm	Optional amplitude normalization divisor, consisting of a single column dataframe. This option is provided in case you'd like to normalize a set of EHA results using the same scheme (e.g., before and after removal of spectral lines).
xaxis	Label for x-axis.
yaxis	Label for y-axis.

ncolors	Number of colors to use in plot.
colorscale	Include a color scale in the plot? (T or F)
filetype	Generate .pdf, .jpeg or .png file? (0=no; 1=pdf; 2=jpeg; 3=png)
output	If amplitude is normalized (pl = 2), output normalization used? (T or F)
verbose	Verbose output? (T or F)

---

plS *Set default plotting parameters for vertical stratigraphic plots*

Description

Set default plotting parameters for vertical stratigraphic plots. This is ususally invoked after function pl.

Usage

```
plS(f=T,s=1)
```

Arguments

f	Are you plotting the first (leftmost) stratigraphic plot? (T or F)
s	Size of the symbols and text on plot. Default = 1

---

prewhiteAR *Prewhiten Stratigraphic Series with Autoregressive Filter, Order Selected by Akaike Information Criterion*

Description

Prewhiten stratigraphic series using autoregressive (AR) filter. Appropriate AR order can be automatically determined using the Akaike Information Criterion, or alternatively, the order may be predefined.

Usage

```
prewhiteAR(dat,order=0,method="mle",aic=T,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for prewhitening. First column should be location (e.g., depth), second column should be data value for prewhitening. Series must have uniform sampling interval.
order	AR order for prewhitening (if aic=F), or alternatively, the maximum AR order to investigate (if aic=T). If order is set to <=0, will evaluate up to maximum default order (this varies based on method).
method	Method for AR parameter estimation: ("yule-walker", "burg", "ols", "mle", "yw")
aic	Select model using AIC? if F, will use order. AIC is only strictly valid if method is "mle".
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

References

Akaike, H. (1974), *A new look at the statistical model identification*, IEEE Trans. Autom. Control, 19, 716-723, doi:10.1109/TAC.1974.1100705.

See Also

ar, arcsinT, bandpass, demean, detrend, divTrend, logT, lowpass, noKernel, and prewhiteAR1

---

prewhiteAR1 — *Prewhiten Stratigraphic Series with AR1 filter, using 'Standard' or Unbiased Estimate of rho*

Description

Prewhiten stratigraphic series using autoregressive-1 (AR1) filter. Rho can be estimated using the 'standard' approach, or following a bias correction.

Usage

```
prewhiteAR1(dat,setrho=NULL,bias=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for prewhitening. First column should be location (e.g., depth), second column should be data value for prewhitening. Series must have uniform sampling interval.
setrho	Specified lag-1 correlation coefficient (rho). By default, rho is calculated.
bias	Calculate unbiased estimate of rho, as in Mudelsee (2010, eq. 2.45). (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

References

M. Mudelsee, 2010, *Climate Time Series Analysis: Classical Statistical and Bootstrap Methods*, 474 pp., Springer, Dordrecht, Netherlands.

See Also

arcsinT, bandpass, demean, detrend, divTrend, logT, lowpass, noKernel, and prewhiteAR

---

rankSeries *Create lithofacies rank series from bed thickness data*

Description

Create lithofacies rank series from bed thickness data.

Usage

```
rankSeries(dat,dt,genplot=T,verbose=T)
```

Arguments

dat	First column should be bed thickness, and second column should bed lithofacies rank.
dt	Sampling interval for piecewise linear interpolation.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Examples

```
# generate example series with random bed thicknesses
exThick=rnorm(n=20,mean=10,sd=2)
# assign alternating rank of 1 and 2
rank=double(20)
rank[seq(from=1,to=19,by=2)] <- 1
rank[seq(from=2,to=20,by=2)] <- 2

# combine into a dataframe
ex=cb(exThick,rank)

# generate lithofacies rank series
rankSeries(ex)
```

read *Read Data from File*

Description

Read stratigraphic data series from a file, either tab-delimited, CSV, or semicolon-delimited. First column must contain location data (depth, height, time). The function will remove missing entries, sort by location, average duplicate values, and generate summary plots.

Usage

```
read(d=1,h="auto",srt=T,ave=T,genplot=T)
```

Arguments

d	What column delimiter is used? (0 = tab/.txt, 1 = comma/.csv, 2 = semicolon). CSV is the default option, which interfaces well with EXCEL.
h	Does the data file have column titles/headers? ("yes", "no", "auto"). "auto" will auto detect column titles/headers, which must be single strings and start with a character.
srt	Sort data values by first column? (T or F)
ave	Average duplicate values? (T or F). Only applies if input file has 2 columns
genplot	generate summary plots (T or F).

Details

Missing values (in the file that you are reading from) should be indicated by 'NA'. If you have included characters in the column titles that are not permitted by R, they will be modified!

readMatrix *Read Data Matrix from File*

Description

Read data matrix from a file, either tab-delimited, CSV, or semicolon-delimited.

Usage

```
readMatrix(d=1,h="auto",output=1,genplot=F)
```

Arguments

d	What column delimiter is used? (0 = tab/.txt, 1 = comma/.csv, 2 = semicolon). CSV is the default option, which interfaces well with EXCEL.
h	Does the data file have column titles/headers? ("yes", "no", "auto"). "auto" will auto detect column titles/headers, which must be single strings and start with a character.
output	Return data as: 1= matrix, 2=data frame
genplot	generate summary plots (T or F).

Details

Missing values (in the file that you are reading from) should be indicated by 'NA'. If you have included characters in the column titles that are not permitted by R, they will be modified!

---

repl0 *Replace Values < 0 with 0*

Description

Replace all variable values < 0 with 0. If first column is location ID (depth/height/time), it will not be processed. Any number of variables (columns) permitted.

Usage

```
repl0(dat,ID=T,genplot=T,verbose=T)
```

Arguments

dat	Data series to process. If location is included (e.g., depth), it should be in the first column.
ID	Is a location ID included in the first column? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

replEps *Replace Values <= 0 with Smallest Positive Value*

Description

Replace all variable values <= 0 with the smallest positive floating-point number (eps) that can be represented on machine. If first column is location ID (depth/height/time), it will not be processed. Any number of variables (columns) permitted.

Usage

```
replEps(dat,ID=T,genplot=T,verbose=T)
```

Arguments

dat	Data series to process. If location is included (e.g., depth), it should be in the first column.
ID	Is a location ID included in the first column? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

resample *Resample Stratigraphic Series*

Description

Resample a stratigraphic series using a new (variably sampled) time or space axis. Values are piecewise-linearly interpolated from original data.

Usage

```
resample(dat,xout,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for resampling. First column should be location (e.g., depth), second column should be data value.
xout	Vector of new sampling locations.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

s *Standardize variable in Stratigraphic Series*

Description

Standardize variable in Stratigraphic Series (subtract mean value and divide by standard deviation)

Usage

```
s(dat,genplot=F,verbose=T)
```

Arguments

dat	Stratigraphic series for standardization. First column should be location (e.g., depth), second column should be data value.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

sedRamp *Apply 'ramping' sedimentation rate model to convert time to stratigraphy*

Description

Apply a linearly increasing (or decreasing) sedimentation rate model to convert time to stratigraphy.

Usage

```
sedRamp(dat,srstart=0.01,srend=0.05,genplot=T,verbose=T)
```

Arguments

dat	Time series. First column should be time (in ka), second column should be data value.
srstart	Initial sedimentation rate (in m/ka).
srend	Final sedimentation rate (in m/ka).
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Value

modeled stratigraphic series.

Examples

```
# generate example series with 3 precession terms using function 'cycles'
# then convert from time to space using sedimentation rate that increases from 1 to 7 cm/ka
ex=sedRamp(cycles(),srstart=0.01,srend=0.07)
```

`sedrate2time` *Integrate sedimentation rate curve to obtain time-space map*

Description

Integrate sedimentation rate curve to obtain time-space map.

Usage

```
sedrate2time(sedrates,timedir=1,genplot=T,verbose=T)
```

Arguments

`sedrates`	Data frame containing depth/height in first column (meters) and sedimentation rates in second column (cm/ka).
`timedir`	Floating time scale direction: 1= time increases with depth/height; 2= time decreases with depth/height.)
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

`sortNave` *Remove Missing Entries, Sort Data, Average Duplicates*

Description

Sort and average duplicates in stratigraphic series, as performed in 'read' function.

Usage

```
sortNave(dat,sortDecr=F,ave=T,genplot=T,verbose=T)
```

Arguments

`dat`	Stratigraphic series for processing. First column should be location (e.g., depth), second column should be data value.
`sortDecr`	Sorting direction? (F=increasing, T=decreasing)
`ave`	Average duplicate values? (T or F)
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

stepHeat *Ar/Ar Geochronology: Generate an Ar/Ar age spectrum and calculate step-heating plateau age.*

Description

The stepHeat function will evaluate data from stepwise heating experiments, producing an Ar/Ar age spectrum, a weighted mean age with uncertainty, and other helpful statistics/plots (with interactive graphics for data culling). The function includes the option to generate results using the approach of IsoPlot 3.70 (Ludwig, 2008) or ArArCALC (Koppers, 2002).

Usage

```
stepHeat(dat,unc=1,lambda=5.463e-10,J=NULL,Jsd=NULL,CI=2,cull=T,del=NULL,output=F,
         idPts=T,size=NULL,unit=1,setAr=95,color="black",genplot=T,verbose=T)
```

Arguments

dat	dat must be a data frame with six columns, as follows: (1) %Ar39 released, (2) date, (3) date uncertainty (one or two sigma), (4) K/Ca, (5) %Ar40*, (6) F, and (7) F uncertainty (one or two sigma). NOTE: F is the ratio Ar40*/Ar39K (see Koppers, 2002).
unc	What is the uncertainty on your input dates? (1) one sigma, or (2) 2 sigma. DEFAULT is one sigma. This also applies to the F uncertainty, and the J-value uncertainty (if specified)
lambda	Total decay constant of K40, in units of 1/year. The default value is 5.463e-10/year (Min et al., 2000).
J	Neutron fluence parameter
Jsd	Uncertainty for J-value (neutron fluence parameter; as one or two sigma)
CI	Which convention would you like to use for the 95% confidence intervals? (1) ISOPLOT (Ludwig, 2008), (2) ArArCALC (Koppers, 2002)
cull	Would you like to remove one or more dates using the graphical interface? (T or F)
del	A vector of indices indicating dates to remove from weighted mean calculation. If specified, this takes precedence over cull.
output	Return weighted mean results as new data frame? (T or F)
idPts	Identify datum number on each point? (T or F)
size	Multiplicative factor to increase or decrease size of symbols and fonts. The default is 1.4
unit	The time unit for your results. (1) = Ma, (2) = Ka
setAr	Set the %Ar40* level to be illustrated on the plot. The default is 95%.
color	Color to use for symbols. Default is black.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Details

This function performs weighted mean age calculations, including estimation of age uncertainties, mean square weighted deviation, and probability of fit.

The following plots are produced:

(1) %Ar40* versus %Ar39 released

(2) K/Ca versus %Ar39 released

(3) Ar/Ar age spectrum, with 2 sigma uncertainties for each step, and weighted mean with 95% confidence interval (in red)

If the J-value and its uncertainty are input, stepHeat will calculate and include the uncertainty associated with J. The uncertainty is calculated and propagated following equation 18 of Koppers (2002).

References

A.A.P. Koppers, 2002, *ArArCALC- software for 40Ar/39Ar age calculations*: Computers & Geosciences, v. 28, p. 605-619.

K.R. Ludwig, 2008, *User's Manual for Isoplot 3.70: A Geochronological Toolkit for Microsoft Excel*: Berkeley Geochronology Center Special Publication No. 4, Berkeley, 77 p.

I. McDougall and T.M. Harrison, 1991, *Geochronology and Thermochronology by the 40Ar/39Ar Method*: Oxford University Press, New York, 269 pp.

K. Min, R. Mundil, P.R. Renne, and K. Ludwig, 2000, *A test for systematic errors in 40Ar/39Ar geochronology through comparison with U/Pb analysis of a 1.1-Ga rhyolite*: Geochimica et Cosmochimica Acta, v. 64, p. 73-98.

I. Wendt and C. Carl, 1991, *The statistical distribution of the mean squared weighted deviation*: Chemical Geology, v. 86, p. 275-285.

See Also

wtMean

Examples

```
# Check to see if this is an interactive R session, for compliance with CRAN standards.
# YOU CAN SKIP THE FOLLOWING LINE IF YOU ARE USING AN INTERACTIVE SESSION.
if(interactive()) {

# Sample MT-09-09 incremental heating Ar/Ar data from Sageman et al. (2014).
perAr39 <- c(4.96,27.58,19.68,39.9,6.25,1.02,0.42,0.19)
age <- c(90.08,89.77,89.92,89.95,89.89,89.55,87.71,86.13)
sd <- c(0.18,0.11,0.08,0.06,0.14,0.64,1.5,3.22)
KCa <- c(113,138,101,195,307,27,17,24)
perAr40 <- c(93.42,99.42,99.64,99.79,99.61,97.99,94.64,90.35)
Fval <- c(2.148234,2.140643,2.144197,2.145006,2.143627,2.135163,2.090196,2.051682)
Fsd <- c(0.00439,0.00270,0.00192,0.00149,0.00331,0.01557,0.03664,0.07846)
ex <- data.frame(cbind(perAr39,age,sd,KCa,perAr40,Fval,Fsd))
```

```
stepHeat(ex)

# plot without points identified
stepHeat(ex,size=0,idPts=FALSE,cull=FALSE)

}
```

`strats` *Summary Statistics for Stratigraphic Series*

Description

Summary statistics for stratigraphic series: sampling interval and proxy values.

Usage

```
strats(dat,output=0,genplot=1)
```

Arguments

`dat`	Stratigraphic series to evaluate. First column should be location (e.g., depth), second column should be data value.
`output`	Output: (0) nothing, (1) cumulative dt as percent of data points, (2) cumulative dt as percent of total interval duration, (3) dt by location
`genplot`	Generate summary plots? (0) none, (1) include plot of cumulative dt, (2) include dt histogram/density plot

Details

This function will generate a range of summary statistics for time series, including sampling interval information and the statistical distribution of proxy values.

`surrogates` *Generate phase-randomized surrogate series as in Ebisuzaki (1997)*

Description

Generate phase-randomized surrogate series as in Ebisuzaki (1997).

Usage

```
surrogates(dat,nsim=1,preserveMean=T,std=T,genplot=T,verbose=T)
```

Arguments

dat	Data series with one or two columns. If two columns, first should be location (e.g., depth), second column should be data value.
nsim	Number of phase-randomized surrogate series to generate.
preserveMean	Should surrogate series have the same mean value as data series? (T or F)
std	Standardize results to guarantee equivalent variance as data series? (T or F)
genplot	Generate summary plots? Only applies if nsim=1. (T or F)
verbose	Verbose output? (T or F)

Details

This function will generate phase-randomized surrogate series as in Ebisuzaki (1997). It is an R-translation of the Matlab code by V. Moron (see link below), with modifications and additional features.

References

W. Ebisuzaki, 1997, *A Method to Estimate the Statistical Significance of a Correlation When the Data Are Serially Correlated*: Journal of Climate, v. 10, p. 2147-2153.

Matlab code by V. Moron: http://www.mathworks.com/matlabcentral/fileexchange/10881-weaclim/content/ebisuzaki.m

Original C-code by W. Ebisuzaki: http://www.ftp.cpc.ncep.noaa.gov/wd51we/random_phase/

Examples

```
# generate example series with 3 precession terms and noise
ex <- cycles(start=0,end=500,noisevar=.0004,dt=5)

# generate phase-randomized surrogates
ran_ex <- surrogates(ex,nsim=1)

# compare periodograms of data and surrogates
res1 <- periodogram(ex,padfac=0,output=1,genplot=FALSE)
res2 <- periodogram(ran_ex,padfac=0,output=1,genplot=FALSE)

pl(2)
plot(ex,type="l",main="black=original; red=surrogate")
lines(ran_ex,col="red",lty=4)
plot(res1[,1],res1[,2],type="l",lwd=2,main="black=original; red=surrogate")
lines(res2[,1],res2[,2],col="red",lwd=2,lty=4)
```

taner *Apply Taner Bandpass or Lowpass Filter to Stratigraphic Series*

Description

Apply Taner bandpass or lowpass filter to stratigraphic series.

Usage

```
taner(dat,padfac=2,flow=NULL,fhigh=NULL,roll=10^3,demean=T,detrend=F,addmean=T,
      output=1,xmin=0,xmax=Nyq,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for bandpass filtering. First column should be location (e.g., depth), second column should be data value.
padfac	Pad with zeros to (padfac*npts) points, where npts is the original number of data points.
flow	Lowest frequency cut-off (half power point). If this value is not set (NULL), it will default to -1*fhigh, which will create a lowpass filter.
fhigh	Highest frequency cut-off (half power point).
roll	Roll-off rate, in dB/octave. Typical values are 10^3 to 10^12, but can be larger.
demean	Remove mean from data series? (T or F)
detrend	Remove linear trend from data series? (T or F)
addmean	Add mean value to bandpass result? (T or F)
output	Output: (1) filtered series, (2) bandpass filter window.
xmin	Smallest frequency for plotting.
xmax	Largest frequency for plotting.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Value

bandpassed stratigraphic series.

References

http://www.rocksolidimages.com/pdf/attrib_revisited.htm#_Toc328470897

See Also

bandpass, lowpass, noKernel, noLow, prewhiteAR, and prewhiteAR1

Examples

```
# generate example series with 3 precession terms and noise
ex <- cycles(noisevar=.0004,dt=5)
# bandpass precession terms using Taner window
res_ex <- taner(ex,flow=0.038,fhigh=0.057)

# generate example series with periods of 405 ka, 100 ka and 20 ka, plus noise
ex2=cycles(freqs=c(1/405,1/100,1/20),noisevar=.1,dt=5)
# lowpass filter using Taner window
res_ex2=taner(ex2,fhigh=.02,roll=10^4)
```

`testPrecession` *Astrochronologic testing via the amplitude modulation approach of Zeeden et al. (2015).*

Description

Astrochronologic testing via the amplitude modulation approach of Zeeden et al. (2015).

Usage

```
testPrecession(dat,nsim=1000,gen=1,rho=NULL,esinw=NULL,output=T,genplot=T,verbose=T)
```

Arguments

`dat`	Stratigraphic series to analyze. First column should be location (time in kyr, a positive value), second column should be data value.
`nsim`	Number of Monte Carlo simulations (phase-randomized surrogates or AR1 surrogates).
`gen`	Monte Carlo simulation generator: (1) use phase-randomized surrogates, (2) use AR1 surrogates.
`rho`	Specified lag-1 correlation coefficient (rho). This value is only used if gen=2. If rho is not specified, it will be calculated within the function.
`esinw`	Theoretical target 'eccentricity * sin(omega)' used for astrochronologic testing. By default this is automatically determined within the function, using the solution of Laskar et al. (2004).
`output`	Return results as a new data frame? (T or F)
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

Details

This astrochronologic testing method compares observed precession-scale amplitude modulations to those expected from the theoretical eccentricity solutions. It is applicable for testing astrochronologies spanning 0-50 Ma. The technique implements a series of filters to guard against artificial introduction of eccentricity modulations during tuning and data processing, and evaluates the statistical significance of the results using Monte Carlo simulation (Zeeden et al., 2015).

The astronomically-tuned data series under evaluation should consist of two columns: time in kiloyears & data value. Note that time must be positive. The default astronomical solutions used for the astrochronologic testing come from Laskar et al. (2004).

When reporting a p-value for your result, it is important to consider the number of simulations used. A factor of 10 is appropriate, such that for 1000 simulations one would report a minimum p-value of "p<0.01", and for 10000 simulations one would report a minimum p-value of "p<0.001".

Please be aware that the kernel density estimate plots, which summarize the simulations, represent 'smoothed' models. Due to the smoothing bandwidth, they can sometimes give the impression of simulation values that are larger or smaller than actually present. However, the reported p-value does not suffer from these issues.

Value

When nsim is set to zero, the function will output a data frame with five columns:

1=time, 2=precession bandpass filter output, 3=amplitude envelope of (2), 4=lowpass filter output of (3), 5=theoretical eccentricity (as extracted from precession modulations using the filtering algorithm)

When nsim is > 0, the function will output the correlation coefficients for each simulation.

References

C. Zeeden, S.R. Meyers, L.J. Lourens, and F.J. Hilgen, 2015 (accepted), *Testing astronomically tuned age models*: Paleoceanography.

J. Laskar, P. Robutel, F. Joutel, M. Gastineau, A.C.M. Correia, and B. Levrard, B., 2004, *A long term numerical solution for the insolation quantities of the Earth*: Astron. Astrophys., Volume 428, 261-285.

Examples

```
### as a test series, use the three dominant precession terms from Berger et al. (1992)
ex<-cycles(start=0,end=1000,dt=2)

### now conduct astrochronologic testing
res1=testPrecession(ex)


### if you plan to run testPrecession repeatedly, it is advisable to download the astronomical
### solution and construct esinw first
ex2<-getLaskar()
ex3<-etp(tmin=0,tmax=1000,dt=2,eWt=0,oWt=0,pWt=1,esinw=TRUE,solution=ex2,standardize=FALSE)
```

```
### now conduct astrochronologic testing
res2<-testPrecession(ex,esinw=ex3)
```

`tones` *Calculate all possible difference and combinations tones*

Description

Determine all possible difference and combinations tones from a set of frequencies, and find the closest one to a specified frequency

Usage

```
tones(a=NULL,freqs=NULL,f=T)
```

Arguments

`a`	The frequency you seeking to match, in cycles/ka.
`freqs`	The vector of frequencies from which to calculate difference and combination tones, in cycles/ka.
`f`	Output results as frequencies (cycles/ka)? If false, will output results as periods (ka). (T or F)

`traceFreq` *Frequency-domain minimal tuning: Use interactive graphical interface to trace frequency drift*

Description

Frequency-domain minimal tuning: Use interactive graphical interface to trace frequency drift.

Usage

```
traceFreq(spec,color=2,h=6,w=4,ydir=1,xmin=NULL,xmax=NULL,ymin=NULL,ymax=NULL,ncolors=100,
          pl=1,ln=F)
```

Arguments

spec	Time-frequency spectral results to evaluate. Must have the following format: column 1=frequency; remaining columns (2 to n)=power, amplitude or probability; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eha.
color	Line color for tracing. 1 = transparent black; 2 = transparent white; 3 = transparent yellow
h	Height of plot in inches.
w	Width of plot in inches.
ydir	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards.
xmin	Minimum spatial frequency to plot.
xmax	Maximum spatial frequency to plot.
ymin	Minimum depth/height to plot.
ymax	Maximum depth/height to plot.
ncolors	Number of colors to use in plot.
pl	How do you want to represent the spatial frequency path?: 1=lines and points; 2=lines; 3=points
ln	Plot natural log of spectral results? (T or F)

See Also

eha and trackFreq

Examples

```
# Check to see if this is an interactive R session, for compliance with CRAN standards.
# YOU CAN SKIP THE FOLLOWING LINE IF YOU ARE USING AN INTERACTIVE SESSION.
if(interactive()) {

# Generate example series with 3 terms using function 'cycles'.
# Then convert from time to space with sedimentation rate that increases from 1 to 5 cm/ka, using
# function 'sedramp'.
# Finally interpolate to median sampling interval using function 'linterp'.
dat=linterp(sedRamp(cycles(freqs=c(1/100,1/40,1/20),start=1,end=2500,dt=5)))

# EHA anlaysis, output amplitude results
out=eha(dat,output=3)

## Interactively track frequency drift
freq=traceFreq(out)

}
```

trackFreq *Frequency-domain minimal tuning: Use interactive graphical interface and sorting to track frequency drift*

Description

Frequency-domain minimal tuning: Use interactive graphical interface and sorting algorithm to track frequency drift.

Usage

```
trackFreq(spec,threshold=NULL,pick=T,fmin=NULL,fmax=NULL,dmin=NULL,dmax=NULL,xmin=NULL,
        xmax=NULL,ymin=NULL,ymax=NULL,h=6,w=4,ydir=1,ncolors=100,genplot=T,verbose=T)
```

Arguments

spec	Time-frequency spectral results to evaluate. Must have the following format: column 1=frequency; remaining columns (2 to n)=power, amplitude or probability; titles for columns 2 to n must be the location (depth or height). Note that this format is ouput by function eha.
threshold	Threshold level for filtering peaks. By default all peak maxima reported.
pick	Pick the peaks of interest using a graphical interface? (T or F). Only activated if genplot=T.
fmin	Minimum frequency for analysis.
fmax	Maximum frequency for analysis.
dmin	Minimum depth/height for analysis. NOT ACTIVATED YET!
dmax	Maximum depth/height for analysis. NOT ACTIVATED YET!
xmin	Minimum frequency for PLOTTING.
xmax	Maximum frequency for PLOTTING.
ymin	Minimum depth/height for PLOTTING.
ymax	Maximum depth/height for PLOTTING.
h	Height of plot in inches.
w	Width of plot in inches.
ydir	Direction for y-axis in plots (depth or height). -1 = values increase downwards (slower plotting!), 1 = values increase upwards.
ncolors	Number of colors to use in plot.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

eha and traceFreq

Examples

```
# Check to see if this is an interactive R session, for compliance with CRAN standards.
# YOU CAN SKIP THE FOLLOWING LINE IF YOU ARE USING AN INTERACTIVE SESSION.
if(interactive()) {

# Generate example series with 3 terms using function 'cycles'.
# Then convert from time to space with sedimentation rate that increases from 1 to 5 cm/ka, using
# function 'sedramp'.
# Finally interpolate to median sampling interval using function 'linterp'.
dat=linterp(sedRamp(cycles(freqs=c(1/100,1/40,1/20),start=1,end=2500,dt=5)))

# EHA anlaysis, output probability results
out=eha(dat,output=4)

## Isolate peaks with probability >= 0.9
freq=trackFreq(out,0.9)

}
```

`trim` *Remove Outliers from Stratigraphic Series*

Description

Automatically remove outliers from stratigraphic series, using 'boxplot' algorithm.

Usage

```
trim(dat,c=1.5,genplot=T,verbose=T)
```

Arguments

`dat`	Stratigraphic series for outlier removal. First column should be location (e.g., depth), second column should be data value.
`c`	'c' defines the 'coef' variable for boxplot.stats. For more information: ?boxplot.stats
`genplot`	Generate summary plots? (T or F)
`verbose`	Verbose output? (T or F)

See Also

`delPts`, `idPts`, `iso` and `trimAT`

trimAT *Remove Outliers from Stratigraphic Series*

Description

Remove outliers from stratigraphic series, using specified threshold value.

Usage

```
trimAT(dat,thresh=0,dir=2,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for outlier removal. First column should be location (e.g., depth), second column should be data value.
thresh	Threshold value for outlier detection.
dir	Remove values (1) smaller than or (2) larger than this threshold?
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

See Also

delPts, idPts, iso and trim

trough *Identify minima of troughs in series, filter at desired threshold value*

Description

Identify minima of troughs in any 1D or 2D series, filter at desired threshold value.

Usage

```
trough(dat,level,genplot=T,verbose=T)
```

Arguments

dat	1 or 2 dimensional series. If 2 dimesions, first column should be location (e.g., depth), second column should be data value.
level	Threshold level for filtering troughs. By default all trough minima reported.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Examples

```
ex=cycles(genplot=FALSE)
trough(ex,level=-0.02)
```

---

tune *Tune Stratigraphic Series*

Description

Tune stratigraphic series from space to time, using specified control points

Usage

```
tune(dat,controlPts,extrapolate=F,genplot=T,verbose=T)
```

Arguments

dat	Stratigraphic series for tuning. First column should be location (e.g., depth), second column should be data value.
controlPts	Tuning control points. A data frame or matrix containing two columns: depth, time
extrapolate	Extrapolate sedimentation rates above and below 'tuned' interval? (T or F)
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

---

writeCSV *Write CSV File*

Description

Write data frame as file with comma separated values

Usage

```
writeCSV(filename,output)
```

Arguments

filename	Desired filename, in quotes: "result.csv"
output	Data frame to write to file.

writeT *Write Tab-delimited File*

Description

Write data frame as file with tab-delimited values

Usage

```
writeT(filename,output)
```

Arguments

filename	Desired filename, in quotes: "result.tab"
output	Data frame to write to file.

wtMean *Ar/Ar Geochronology: calculate weighted mean age, age uncertainty, and other associated statistics/plots (with interactive graphics for data culling).*

Description

The wtMean function will calculate weighted mean age, age uncertainty, and other helpful statistics/plots (with interactive graphics for data culling). The function includes the option to generate results using the approach of IsoPlot 3.70 (Ludwig, 2008) or ArArCALC (Koppers, 2002).

Usage

```
wtMean(dat,sd=NULL,unc=1,lambda=5.463e-10,J=NULL,Jsd=NULL,CI=2,cull=T,del=NULL,
        sort=1,output=F,idPts=T,size=NULL,unit=1,setAr=95,color="black",
        genplot=T,verbose=T)
```

Arguments

dat	dat must contain one of the following: (1) a vector of dates for weighted mean calculation, (2) a matrix with two columns: date and uncertainty (one or two sigma), or (3) a matrix with six columns, as follows: date, date uncertainty (one or two sigma), K/Ca, %Ar40*, F, and F uncertainty (one or two sigma). NOTE: F is the ratio Ar40*/Ar39K (see Koppers, 2002). See "details" for more information.
sd	Vector of uncertainties associated with each date in 'dat', as one or two sigma. This option is ignored if dat has more than one column

unc	What is the uncertainty on your input dates? (1) one sigma, or (2) 2 sigma. DEFAULT is one sigma. This also applies to the F uncertainty, and the J-value uncertainty (if specified)
lambda	Total decay constant of K40, in units of 1/year. The default value is 5.463e-10/year (Min et al., 2000).
J	Neutron fluence parameter
Jsd	Uncertainty for J-value (neutron fluence parameter; as one or two sigma)
CI	Which convention would you like to use for the 95% confidence intervals? (1) ISOPLOT (Ludwig, 2008), (2) ArArCALC (Koppers, 2002)
cull	Would you like to remove one or more dates using the graphical interface? (T or F)
del	A vector of indices indicating dates to remove from weighted mean calculation. If specified, this takes precedence over cull.
sort	Sort dates? (0=no; 1=sort into increasing order; 2=sort into decreasing order)
output	Return weighted mean results as new data frame? (T or F)
idPts	Identify datum number on each point? (T or F)
size	Multiplicative factor to increase or decrease size of symbols and fonts.
unit	The time unit for your results. (1) = Ma, (2) = Ka
setAr	Set the %Ar40* level to be illustrated on the plot. The default is 95%.
color	Color to use for symbols. Default is black.
genplot	Generate summary plots? (T or F)
verbose	Verbose output? (T or F)

Details

This function performs weighted mean age calculations, including estimation of age uncertainties, mean square weighted deviation, and probability of fit, following the approaches used in IsoPlot 3.70 (Ludwig, 2008) and ArArCALC (Koppers, 2002).

The function accepts input in three formats:

(1) each date and its uncertainty can be entered as individual vectors ('dat' and 'sd').

(2) a two column matrix can be input as 'dat', with each date (first column) and its uncertainty (second column).

(3) a six column matrix can be input as 'dat', with each date, its uncertainty, the associated K/Ca value, %Ar40*, F, and F uncertainty (one or two sigma). This option must be used if you wish to calculate and include the uncertainty associated with J. The uncertainty is calculated and propagated following equation 18 of Koppers (2002).

The following plots are produced:

(1) A normal Q-Q plot for the dates (in essence this is the same as IsoPlot's linearized probability plot).

(2) A cumulative Gaussian plot for the dates (a.k.a. cumulative probability plot). This is derived by summing the individual normal distributions for each date.

(3) A plot of each date with its 2-sigma uncertainties.

In addition, K/Ca and Ar40* data are plotted if provided.

References

A.A.P. Koppers, 2002, *ArArCALC- software for 40Ar/39Ar age calculations*: Computers & Geosciences, v. 28, p. 605-619.

K.R. Ludwig, 2008, *User's Manual for Isoplot 3.70: A Geochronological Toolkit for Microsoft Excel*: Berkeley Geochronology Center Special Publication No. 4, Berkeley, 77 p.

I. McDougall and T.M. Harrison, 1991, *Geochronology and Thermochronology by the 40Ar/39Ar Method*: Oxford University Press, New York, 269 pp.

K. Min, R. Mundil, P.R. Renne, and K. Ludwig, 2000, *A test for systematic errors in 40Ar/39Ar geochronology through comparison with U/Pb analysis of a 1.1-Ga rhyolite*: Geochimica et Cosmochimica Acta, v. 64, p. 73-98.

I. Wendt and C. Carl, 1991, *The statistical distribution of the mean squared weighted deviation*: Chemical Geology, v. 86, p. 275-285.

See Also

stepHeat

Examples

```
# Check to see if this is an interactive R session, for compliance with CRAN standards.
# YOU CAN SKIP THE FOLLOWING LINE IF YOU ARE USING AN INTERACTIVE SESSION.
if(interactive()) {

# Sample NE-08-01 Ar/Ar data from Meyers et al. (2012) supplement
age <- c(93.66,94.75,94.6,94.22,86.87,94.64,94.34,94.03,93.56,93.85,88.55,93.45,93.84,
          94.39,94.11,94.48,93.82,93.81,94.18,93.78,94.41,93.49,95.07,94.19)
sd2<- c(5.83,4.10,8.78,2.5,8.86,3.37,4.63,3.18,8.35,5.73,4.23,2.56,2.3,1.7,3.1,2.78,
         1.62,.92,.98,1.41,1.21,1.38,1.48,0.93)
sd <- sd2/2
wtMean(age,sd)

}
```

---

xplot *Generate Cross-plot with Density Estimates on Axes*

Description

Generate a Cross-plot with Density Estimates on Axes. Custom axes titles optional.

Usage

```
xplot(x,y,xlab=NULL,ylab=NULL,main=NULL,fill=T)
```

Arguments

x	Variable 1
y	Variable 2
xlab	Label for the x-axis, in quotes
ylab	Label for the y-axis, in quotes
main	Label for the plot, in quotes
fill	Use gray fill for density plots? (T or F)

Examples

```
# random numbers from a normal distribution
ex1<-rnorm(1000)
# random numbers from an exponential distribution
ex2<-rexp(1000)

xplot(ex1,ex2)
```

---

zoomIn *Dynamically explore cross-plot, zoom-in into specified region*

Description

Dynamically explore cross-plot, zoom-in into specfied region. Accepts one dataframe/matrix with two columns, or two dataframes/vectors with one column.

Usage

```
zoomIn(dat1,dat2=NULL,ptsize=1,xmin=NULL,xmax=NULL,ymin=NULL,ymax=NULL,plotype=1,
       verbose=T)
```

Arguments

dat1	Data frame with one or two columns. If one column, dat2 must also be specified.
dat2	Data frame with one column.
ptsize	Size of plotted points.
xmin	Minimum x-value (column 1) to plot
xmax	Maximum x-value (column 1) to plot
ymin	Minimum y-value (column 2) to plot
ymax	Maximum y-value (column 2) to plot
plotype	Type of plot to generate: 1= points and lines, 2 = points, 3 = lines
verbose	Verbose output? (T or F)

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