Package 'RTOMO'

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Type Package

Title Visualization for seismic tomography

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Description Created mainly for use with seismic tomography, this program plots tomographic images, and allows one to interact and query three-dimensional tomographic models. Vertical cross-sectional cuts can be extracted by mouse click. Geographic information can be added easily.

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`RTOMO-package` *Plot and Interact with Tomographic Images*

Description

Created mainly for use with seismic tomography, this program plots tomographic images, and allows one to interact and query three-dimensional tomographic models. Vertical cross-sectional cuts can be extracted by mouse click. Geographic information can be added easily.

Details

Package:	RTOMO
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License:	GPL

Visualization for seismic tomography, includes:

TOMO3D.drive Interactive tomography exploration

SHOWTOMO show tomographic model in multi-panel display

FANCY.TOMO Tomographic plot of one layer

pltomo plot one horizontal slice of tomogram

XSEC.drive Interactive plot of vertical cross section

PLOT.TOMOXSEC plot Cross section of tomographic model

TOMOXSEC Vertical Cross section through model

Model I/O:

GXMA3D Get 3D perturbation model in geotouch format

GXMA3DV Get 3D velocity model in geotouch format

makeMOD Make 3D synthetic model

Utilities:

tomo.colors color palette for tomography

TOMOinfo Information about the tomographic layers

MOD2VEC Convert 3D model to single long vector

VEC2MOD Convert single long vector to 3D model

get2Drayblox get 2D ray blocks

get3Drayblox get 3D ray blocks

Author(s)

Jonathan M. Lees Maintainer: Jonathan M. Lees <jonathan.lees@unc.edu>

References

J. M. Lees. Geotouch: Software for three and four dimensional GIS in the earth sciences. *Computers and Geosciences* , 26(7):751–761, 2000.

See Also

RSEIS

Examples

```
data(HELMOD)
data(HELMAP)

TOMO3D.drive(HELMOD, MAP=HELMAP)
```

FANCY.TOMO *Show horizontal tomographic section layer by layer*

Description

Show horizontal tomographic section layer by layer

Usage

```
FANCY.TOMO(MOD, i, COL = NULL, LIM = NULL, MAP = NULL, MAPLIM = NULL,
STA = NULL, staparams = list(col = "green", pch = 6, cex = 0.8, name =
FALSE), PTS = NULL, ptsparams = list(col = "green", pch = 6, cex = 0.8,
name = FALSE), TIT = "Layer", mainTIT="Layer", UNITS = "", bkgr = "DarkSlateGray4")
```

Arguments

MOD	MODEL list
i	layer number
COL	color palette
LIM	Limit
MAP	Map list (GEOmap)
MAPLIM	Geographic limits on map
STA	station list (name, lat lon z)
staparams	graphical parameters for plotting stations
PTS	points list, e.e. earthquakes (lat lon z)
ptsparams	graphical parameters for plotting points
TIT	Title
mainTIT	Main Title
UNITS	units
bkgr	background color for NA in image

Value

Graphical Side effects

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

SHOWTOMO

Examples

```
data(HELMOD)
data(HELMAP)

for(i in 1:length(HELMOD$MOD))
{
##  i = 4
FANCY.TOMO(HELMOD, i, MAP=HELMAP, bkgr="beige")

locator()


}
```

get2Drayblox *Get 2D block from model description and ray path*

Description

Uses x-y coordinates of points to determine the indecies and lengths of rays penetrating the model.

Usage

```
get2Drayblox(x1, y1, x2, y2, xo, yo, NODES = FALSE, PLOT = FALSE)
```

Arguments

x1	x coordinate of starting block
y1	y coordinate of starting block
x2	x coordinate of ending block
y2	y coordinate of ending block
xo	x block divisions
yo	y block divisions
NODES	logical, whether xo, yo ae nodes or edges
PLOT	logical, TRUE=plot ray

Value

ix	x index
iy	y index
iz	layer index
lengs	length in each block
mids	midpoints of sections
nodes	nodes of a 2D vector representation of layer
LX	x-divisions
LY	y-divisions

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

get3Drayblox

Examples

```
xo = seq(from=0.5, by=1, length=100)
yo = seq(from=0.5, by=1, length=100)

IYZ = get2Drayblox(10, 4, 64, 50, xo, yo , NODES=FALSE, PLOT=FALSE)
```

`get3Drayblox` *Get blocks from 3D ray path*

Description

Get blocks from 3D ray path

Usage

```
get3Drayblox(XNOD, YNOD, ZNOD, xo, yo, ztop, slowness = NULL)
```

Arguments

`XNOD`	x-coordinates along raypath
`YNOD`	y-coordinates along raypath
`ZNOD`	z-coordinates along raypath
`xo`	x block divisions
`yo`	y block divisions
`ztop`	vector, topsof layers
`slowness`	vector, Slowness model

Value

`ix`	x index
`iy`	y index
`iz`	layer index
`r`	length in each block
`tt`	travel time along whole raypath

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

get2Drayblox

Examples

```
xo = seq(from=0.5, by=1, length=100)
yo = seq(from=0.5, by=1, length=100)
 ztop = seq(from=0, to=24, by=4)



Xp = c(11.5, 70.2)
Yp = c(3.5, 50.2)
Zp = c(18.4, 0.0)

dee = sqrt(  (Xp[2]-Xp[1])^2 + (Yp[2]-Yp[1])^2 +  (Zp[2]-Zp[1])^2 )
deexy = sqrt(  (Xp[2]-Xp[1])^2 + (Yp[2]-Yp[1])^2  )

fi  = findInterval(Zp, ztop)

ZNOD = c(Zp[1], ztop[fi[1]:fi[2]])


alpha = asin(deexy/dee)

RN = deexy-ZNOD*tan(alpha)

XNOD = Xp[1]+RN*(Xp[2]-Xp[1])/deexy
YNOD = Yp[1]+RN*(Yp[2]-Yp[1])/deexy

IYZ = get3Drayblox(XNOD, YNOD, ZNOD, xo, yo, ztop, slowness = NULL)
```

GXMA3D *Read a geotouch image file*

Description

Read a geotouch image file

Usage

```
GXMA3D(name)
```

Arguments

name	file name

Details

name Model Structure

A location information list: lat lon nx ny nz dx dy skip

D vector, tops of layers

V vector, velocity of layers

MOD 3D MODEL list

x x nodes

y y nodes

Value

MOD	Model Structure

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

FANCY.TOMO

Examples

```
## Not run:
HELMOD = GXMA3DV("H4vel.xmco")

## End(Not run)
```

HEL1D *One dimensional velocity model for Mt. St. Helens*

Description

1D velocity model used for earthquake locations at Mt. St. Helens in the 1980's

Usage

```
data(HEL1D)
```

Format

The format is: List of 8

zp depths to tops of P-wave model, km

vp P velocity in layers, km/s

ep uncertainty in P velocity

zs depths to tops of S-wave model, km

vs S velocity in layers, km/s

es uncertainty in S velocity

name anme of file where model is stored

descriptor text desription of model

References

Lees, J. M. (1992): The magma system of Mount St. Helens: Non-linear high resolution P-wave tomography, J. Volc. Geoth. Res., 53(1-4), 103-116.

Examples

```
data(HEL1D)
## maybe str(HEL1D) ; plot(HEL1D) ...
```

HELEQ *Mount Saint Helens Earthquake Cluster associated with the 1980 Eruption*

Description

Mount Saint Helens Earthquake Cluster associated with the 1980 Eruption

Usage

```
data(HELEQ)
```

Format

List:

yr year

mo Month

dom Day of Month

hr Hour

mi Minute

sec Second

jd Julian Day

lat latitude, signed decimal degree (West is negative)

lon longitude, signed decimal degree

z depth, km

mag magitude

gap gap

delta distance to nearest station

rms root, mean square error

hozerr horrizontal uncertainty, km

Details

This is a small selection of the events associated with the eruption.

References

Lees, J. M. (1992): The magma system of Mount St. Helens: Non-linear high resolution P-wave tomography, J. Volc. Geoth. Res., 53(1-4), 103-116.

Lees, J. M. and R. S. Crosson (1989): Tomographic inversion for three-dimensional velocity structure at Mount St. Helens using earthquake data, J. Geophys. Res., 94(B5), 5716-5728.

Examples

```
data(HELEQ)
## maybe str(HELEQ) ; plot(HELEQ) ...
```

HELMAP *Geographic map of Mt. St. Helens Summit region*

Description

Geographic map of Mt. St. Helens Summit region. Lnes showing water shed and outline of tree line prior to 1980 eruption.

Usage

```
data(HELMAP)
```

Format

STROKES list of meta data for map
nam name of stroke
num number of points
index starting index
col color
style style, 1,2,3
code geographic code
LAT1 Lower left latitude
LAT2 upper right latitude
LON1 Lower left longitude
LON2 upper right longitude
POINTS points structure
lat latitudes
lon longitudes
PROJ projection list
type type of projection, 2=UTM
LAT0 origin latitude
LON0 origin longitude
LAT1 other parameters that depend on projection
LAT2 other parameters that depend on projection
LATS other parameters that depend on projection
S other parameters that depend on projection
N other parameters that depend on projection
LONS other parameters that depend on projection
E other parameters that depend on projection
W other parameters that depend on projection
DLAT other parameters that depend on projection
DLON other parameters that depend on projection
FE false easting
FN false northing
name name of projection

References

Lees, J. M. (1992): The magma system of Mount St. Helens: Non-linear high resolution P-wave tomography, J. Volc. Geoth. Res., 53(1-4), 103-116.

Examples

```
data(HELMAP)
## maybe str(HELMAP) ; plot(HELMAP) ...
```

HELMOD *Tomographic Model of Mt. Saint Helens subsurface*

Description

Three-dimensional Tomographic Model of Mt. Saint Helens subsurface

Usage

```
data(HELMOD)
```

Format

name name of file

A list origin information

lat latitude, signed decimal degree (West is negative)

lon longitude, signed decimal degree

nx dimension or number of nodes in x-direction

ny dimension or number of nodes in y-direction

nz dimension or number of nodes in z-direction

dx delta x

dy delta y

skip skipping flag

D depths in Z, km

V background model for 1D structure

MOD 3D model structure

x x divisions (nodes in x, km)

y y divisions (nodes in y, km)

References

Lees, J. M. (1992): The magma system of Mount St. Helens: Non-linear high resolution P-wave tomography, J. Volc. Geoth. Res., 53(1-4), 103-116.

Examples

```
data(HELMOD)
## maybe str(HELMOD) ; plot(HELMOD) ...
```

HELsta *Station locations near Mt. Saint Helens, WA*

Description

Station locations near Mt. Saint Helens, WA: LAT, LON, Elevation

Usage

```
data(HELsta)
```

Format

name character, station name

lat latitude, signed decimal degree (West is negative)

lon longitude, signed decimal degree

z elevation, km

References

Lees, J. M. (1992): The magma system of Mount St. Helens: Non-linear high resolution P-wave tomography, J. Volc. Geoth. Res., 53(1-4), 103-116.

Examples

```
data(HELsta)
## maybe str(HELsta) ; plot(HELsta) ...
```

HOZscale *add horizontal color scale*

Description

Add horizontal color scale to existing plot.

Usage

```
HOZscale(z, col, units = "", SIDE = 1, s1 = 0.4, s2 = 0.95)
```

Arguments

z	image matrix
col	color palette
units	character string, units
SIDE	Side of the plot
s1	percent of margin for bottom
s2	percent of margin for top

Value

Graphical Side effect

Author(s)

Jonathan M. Lees<jonathan.lees.edu>

Examples

```
data(volcano)
image(volcano, col=terrain.colors(100))

HOZscale(volcano,terrain.colors(100) , units = "", SIDE = 1, s1 = 0.4, s2 = 0.95)
```

---

jstats *statistics of a vector*

Description

returns relevant stats

Usage

```
jstats(d)
```

Arguments

d	vector

Details

Program calls R routines to gather important statistics for later use.

Value

list:

mean	mean value
std	standard deviation
med	median
qdist	quartile distance
bstats	boxplot quantiles
mstats	vector of mean and std
N	number of points

Author(s)

Jonathan M. Lees<jonathan.lees.edu>

See Also

boxplot, mean, median

Examples

```
x  = rnorm(100, m=43)
jstats(x)
```

---

makeMOD *Make a 3D model*

Description

Create a three-dimensional synthetic model for use in predicting travel-times.

Usage

```
makeMOD(xo, yo, ztop, x, y, z, r, v, bg)
```

Arguments

xo	x-nodes
yo	y-nodes
ztop	tops of layers
x	x-coordinates of balls
y	y-coordinates of balls
z	z-coordinates of balls
r	radii of balls
v	velocity of balls
bg	background velocity for 1-D model

Details

Balls are spherical - this may change in future implementations to ellipsoids.

Value

Model List

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

GXMA3D, SHOWTOMO

Examples

```
data(HELMOD)
data(HEL1D)

xo = HELMOD$x
yo = HELMOD$y
ztop=HEL1D$zp[1:15]
bg = HEL1D$vp[1:15]
x = 10
y = 15
z = 6
r = 6
v = 3



TM1 = makeMOD(xo, yo, ztop , x, y, z, r, v , bg )
SHOWTOMO(TM1)
```

---

meshgrid *Create a mesh grid like in Matlab*

Description

Creates 2D matrices for accessing images and 2D matrices

Usage

```
meshgrid(a, b)
```

Arguments

a	x vector components
b	y vector components

Details

returns outer product of x-compnents and y-components for use as index arrays

Value

x	length(y) by length(x) matrix of x indicies
y	length(y) by length(x) matrix of y indicies

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

Examples

```
meshgrid(1:5, 1:3)
```

PLOT.TOMOXSEC *Plot a tomographic cross section*

Description

Plot a tomographic cross section that has been extracted from the model previously with TOMO3D.drive

Usage

```
PLOT.TOMOXSEC(XZSEC, depth = c(-25, 0), COL = NULL, LIM = NULL, STA = NULL, ADD = FALSE)
```

Arguments

XZSEC	Cross section list
depth	Depth range
COL	color palette
LIM	limits for values in image
STA	stations to be projected
ADD	logical, TRUE=add to existing plot

Value

Graphical Side Effects

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

TOMOXSEC, XSEC.drive

Examples

```
data(HELMOD)

### after L = locator(2)
L=list()
L$x=c( 4.21883807095,23.99298268599)
L$y=c(15.8014536521,11.4951858659)

###  create the cross section:
XZ = TOMOXSEC(HELMOD, L$x[1], L$y[1], L$x[2],  L$y[2] , zmax=20, COL=tomo.colors(100), PLOT=FALSE)


###  Now plot the cross section
PLOT.TOMOXSEC(XZ)
```

---

pltomo *plot a layer in 3D tomogram*

Description

Simple plot of a layer in 3D tomogram

Usage

```
pltomo(x,y,MOD,i, colmap=rainbow(100), zlim=NULL, bkgr="DarkSlateGray4", ...)
```

Arguments

x	x nodes
y	y nodes
MOD	Model Structure
i	layer to plot
colmap	color palette
zlim	vector (v1, v2) limit of z values
bkgr	background color for NA values
...	graphical parameters from par()

Details

Does not set the projection, does not add any markup - all this does is start the plotting set up and puts the image on the plot.

Value

Graphical Side effects

Note

This routine is used by SHOWTOMO

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

FANCY.TOMO, SHOWTOMO, GXMA3DV

Examples

```
data(HELMOD)
 pltomo(HELMOD$x,HELMOD$y,HELMOD$MOD,5, col=tomo.colors(100), zlim=NULL,  bkgr="white" )
```

SHOWTOMO *Show many layers of tomoggraphic model*

Description

Plots a row of layers for quick view of tomographic results with map overlay.

Usage

```
SHOWTOMO(MOD, colmap = topo.colors(100), zlim = NULL, MAP = NULL, I = 1, J = 2, bkgr="white")
```

Arguments

MOD	MODEL list
colmap	color palette
zlim	Limit
MAP	Map list (GEOmap)
I	first lay index
J	last layer index
bkgr	background color

Value

Graphical Side effects

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

FANCY.TOMO

Examples

```
data(HELMOD)
data(HELMAP)
SHOWTOMO(HELMOD, MAP=HELMAP,  bkgr="beige", I=1, J=15)
```

---

tomo.colors *Tomography Colors*

Description

Color Palette ranging from red to blue through black.

Usage

```
tomo.colors(n, alpha = 1)
```

Arguments

n	number of colors
alpha	hsv color parameter

Value

color palette

Author(s)

Jonathan M. Lees<jonathan.lees.edu>

See Also

rainbow, colors, hsv

Examples

```
tomo.colors(25, alpha = 1)
```

TOMO3D.drive *Interactive Exploration of 3D tomographic inversion*

Description

Interactive Exploration of 3D tomographic inversio

Usage

```
TOMO3D.drive(MOD, COL = NULL, LIM = NULL, MAP = NULL, MAPLIM = NULL,  ZLIM=c(0, 30), STA = NULL, TOPO = NU
```

Arguments

MOD	Model List
COL	color palette
LIM	Value limits for colors
MAP	Map strcuture (GEOmap)
MAPLIM	Boundary for map limits
ZLIM	Limits in Depth
STA	Station File
TOPO	Topographic Structure
STDLAB	vector of menu items

Details

Interactive display of tomographic model

Value

Graphical Side Effect

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

SHOWTOMO

Examples

```
data(HELMOD)
data(HELMAP)

TOMO3D.drive(HELMOD, MAP=HELMAP)
```

TOMOinfo *Dump tomogram information*

Description

Dump tomogram information

Usage

```
TOMOinfo(MOD, PLOT=FALSE)
```

Arguments

MOD	Model Structure
PLOT	logical, TRUE=plot boxplot

Value

Side Effects. Shows velocity, tops, mean value and slowness

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

Examples

```
data(HELMOD)
TOMOinfo(HELMOD)
```

TOMOXSEC *Plot Tomographic Cross Section*

Description

Plot Tomographic Cross Section (non-interactive)

Usage

```
TOMOXSEC(MOD, x1, y1, x2, y2, zmax = 100, depth = c(-25, 0), COL = rainbow(100), LIM = NULL, STA = NULL, P
```

Arguments

MOD	Model List
x1	x-coordinate for point 1
y1	y-coordinate for point 1
x2	x-coordinate for point 2
y2	y-coordinate for point 2
zmax	maximum depth
depth	depth for scale
COL	color palette
LIM	Value limits for colors
STA	station list
PLOT	logical, TRUE=plot

Value

xz	list of a cross section

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

PLOT.TOMOXSEC, FANCY.TOMO

Examples

```
data(HELMOD)

### after L = locator(2)
L=list()
L$x=c( 4.21883807095,23.99298268599)
L$y=c(15.8014536521,11.4951858659)

XZ = TOMOXSEC(HELMOD, L$x[1], L$y[1], L$x[2],  L$y[2] , zmax=20, COL=tomo.colors(100), PLOT=TRUE)
```

VEC2MOD *Convert representation of a 3D models*

Description

Convert a single vector representation of a 3D model to a list, or a list to a single vector.

Usage

```
VEC2MOD(VEC)
MOD2VEC(MOD)
```

Arguments

VEC	vector with attributes x,y,D describing the coordinates
MOD	List model

Details

The two functions are used to convert models for different uses.

Value

MOD	List model

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

GXMA3D

Examples

```
data(HELMOD)

names(HELMOD)

VV = MOD2VEC(HELMOD)

NMOD = VEC2MOD(VV)
```

XSEC.drive *Interactive Cross Section View*

Description

Plot a cross section of a tomogram and interact

Usage

```
XSEC.drive(MOD, x1, y1, x2, y2, zmax = 100, COL = tomo.colors(100), LIM = NULL, STA = NULL, TOP =NULL , ST
```

Arguments

MOD	Model List
x1	x-coordinate for point 1
y1	y-coordinate for point 1
x2	x-coordinate for point 2
y2	y-coordinate for point 2
zmax	maximum depth
COL	color
LIM	Limits for colors
STA	stations
TOP	Topography
STDLAB	labels

Value

Graphical Side Effects

Author(s)

Jonathan M. Lees<jonathan.lees@unc.edu>

See Also

PLOT.TOMOXSEC, TOMOXSEC, FANCY.TOMO

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