

Package ‘RTOMO’

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Type Package

Title Visualization for Seismic Tomography

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Depends R (>= 2.12)

Imports RPMG, GEOmap, RSEIS, splancs

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Description Aimed at seismic tomography, the package 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.

License GPL (>= 2)

NeedsCompilation no

Repository CRAN

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RTOMO-package	<i>Plot and Interact with Tomographic Images</i>
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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.

Details

Package: RTOMO
 Type: Package
 Version: 1.0-9
 Date: 2012-07-30-15
 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 indices and lengths of rays penetrating the model.

Usage

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

Arguments

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

Value

<code>ix</code>	x index
<code>iy</code>	y index
<code>iz</code>	layer index
<code>lengs</code>	length in each block
<code>mids</code>	midpoints of sections
<code>nodes</code>	nodes of a 2D vector representation of layer
<code>LX</code>	x-divisions
<code>LY</code>	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, tops of 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	<i>Mount Saint Helens Earthquake Cluster associated with the 1980 Eruption</i>
-------	--

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 magnitude
gap gap
delta distance to nearest station
rms root, mean square error
hozerr horizontal 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	<i>Station locations near Mt. Saint Helens, WA</i>
--------	--

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	<i>add horizontal color scale</i>
----------	-----------------------------------

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))

H0Zscale(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-components 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 tomographic 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", linyty = 1, linywd = 1, ptpch=".", ptcex=1)
```

Arguments

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

linewidth	line width, for GEOMap
ptpch	plotting character for strokes (style=1) that are plotted as points, for GEOMap
ptcex	character expansion factor for style=1 strokes, for GEOMap

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 = NULL, STDLAB = c("DONE", "QUIT"))
```

Arguments

MOD	Model List
COL	color palette
LIM	Value limits for colors
MAP	Map structure (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, PLOT = TRUE)
```

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 , STDLAB = c("DONE", "QUIT"))

```

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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