Package 'RadTran'

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Type Package

Title Radon and Soil Gas Transport in 2D Porous Medium

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Depends R (>= 2.10), ReacTran

Imports rootSolve

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Description Contains 4 different functions for radon and soil gas transport in a porous medium.

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NeedsCompilation no

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R topics documented:

`RadTran-package` *Radon and Soil Gas Transport in 2D*

Description

Contains 4 different cases for radon and soil gas steady-state transport in a porous medium. Only steady-state conditions are taken into account. Package contains: RnDif.hom (Steady diffusion of radon in a 2D homogeneous porous medium.), RnDif.het (Steady diffusion of radon in a 2D heterogeneous porous medium.), RnDifAdv.hom (Steady diffusion & advection of radon in a 2D homogeneous column of sand.), SoilAdv.hom (Steady advection of soil gas (Darcy Flow) in a 2D homogeneous column of sand).

Details

Package: RadTran Type: Package Version: 1.0 Date: 2014-10-16 License: GNU Public License 2 or above

Note

At the moment there is no provision to deal with cross-diffusion between x and y-axis.

The concentrations of radon and disturbances pressure values are only computed at the center of each grid cell, this implies that their exact value in a cell interface (or in a boundary domain) will not be shown. Thus, the closest value is taken as an approximation at this locations.

All the radon and soil gas fluxes are computed at the interface of each grid cell.

Author(s)

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References

Andersen CE. Radon Transport Modelling: Users guide to RnMod3d. Riso National Laboratory, Roskilde, Denmark, 2000.

Andersen CE, Albarracin D, Csige I, van der Graaf ER, Jiranek M, Rehs B, Svoboda Z, Toro L. ERRICCA radon model intercomparison exercise. Riso-R-1120 (EN), Riso National Laboratory, DK-4000 Roskilde, Denmark (available as a internet publication at www.risoe.dk), 1999.

Soetaert K., Meysman F., 2012. R-package ReacTran: Reactive Transport Modelling in R.

Soetaert K., Meysman F., 2011. Reactive transport in aquatic ecosystems: Rapid model prototyping in the open source software R.

Soetaert K., Meysman F., 2009. Solving partial differential equations, using R package ReacTran.

RnDif.het *2D Steady-state radon diffusion in a heterogeneous porous medium.*

Description

Calls function RnDif.het for 2D steady diffusion of radon. Gives the radon concentrations and fluxes in a heterogeneous porous medium.

Usage

```
RnDif.het(lx, ly, nx, ny, rho, x.poro, x.hum,
y.poro, y.hum, bdc_top, rn_lam, rn_ema, rn_dif,
rn_sol, solution, ...)
```

Arguments

`lx`	x axis length of the soil column [L].
`ly`	y axis length (depth) of the soil column [L]. Only positive values are accepted.
`nx`	Number of grid cells in the x direction.
`ny`	Number of grid cells in the y direction.
`rho`	Soil grain material density [M/L2]. A constant value over the entire column.
`x.poro`	Soil porosity in the x direction [-]. A constant value input.
`x.hum`	Soil moisture [-] in the x direction. A constant value input.
`y.poro`	Soil porosity in the y direction [-]. A function input that describes the porosity profile in the y-axis.
`y.hum`	Soil moisture in the y direction [-]. A function input that describes the moisture profile in the y-axis.
`bdc_top`	Fixed value in the upstream boundary in y-direction (top of the soil column) for a constant value of radon concentration [(1/T)*(1/L3)].
`rn_lam`	Radon decay constant [1/T].
`rn_ema`	Radon emanation ratio [atoms (1/L3)*(1/T)].
`rn_dif`	Radon diffusivity in free air [L2/T].
`rn_sol`	Radon solubility in water [-].
`solution`	Type of solution to be computed. Only "steady" is avaiable at the moment.
`...`	...

Details

To optimize the code: The number of grid cells (nx,ny) will depend on the user's own computer capability. Higher numbers will give a closer approximation to the exact solution. The quantity for ny should be larger than nx, this allows a greater discretization in the y-axis.

Boundary conditions: Fixed value for radon concentration in the upstream boundary in y-direction (a negative y axis is considered), while the downstream boundary remains open. All the otther boundaries are closed off for transport.

Fluxes output: The output of the fluxes indicates the flow direction in correspondence with y-axis. In the case where a negative y-axis is considered, a negative flux value represents upward flow (from bottom to top). If the y-axis considered is positive, then a negative flux value represents downward flow (from top to bottom). The radon fluxes are computed at the interface of each grid cell.

Value

A list containing:

`x.axis`	X axis vector (1:nx) for radon concentrations and fluxes [L].
`y.axis.conc`	Y axis vector (1:ny) for the radon concentrations output [L].
`y.axis.flux`	Y axis vector (1:ny+1) for the radon fluxes output [L].
`conc`	Radon concentrations in the center of each grid cell, a [1:nx,1:ny] matrix [(1/T)*(1/L3)].
`flux`	Radon fluxes in the interface of each grid cell in the y-direction, a [1:nx,1:ny+1] matrix [1/T2].

Note

At the moment there is no provision to deal with cross-diffusion between x and y-axis.

The concentrations of radon are only computed at the center of each grid cell, this implies that the exact value in a cell interface (or in a boundary domain) will not be shown. Thus, the closest value is taken as an approximation at this locations.

Author(s)

Francisco Lopes <fmlopes@fc.ul.pt>

References

Andersen CE. Radon Transport Modelling: Users guide to RnMod3d. Riso National Laboratory, Roskilde, Denmark, 2000.

Andersen CE, Albarracin D, Csige I, van der Graaf ER, Jiranek M, Rehs B, Svoboda Z, Toro L. ERRICCA radon model intercomparison exercise. Riso-R-1120 (EN), Riso National Laboratory, DK-4000 Roskilde, Denmark (available as a internet publication at www.risoe.dk), 1999.

Soetaert K., Meysman F., 2012. R-package ReacTran: Reactive Transport Modelling in R.

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Soetaert K., Meysman F., 2009. Solving partial differential equations, using R package ReacTran.

See Also

`p.lin` `p.exp` `p.sig`

Examples

```
################################################
#####---- Direct input for the function ----#####
################################################

###--defining porosity and moisture functions for y-axis profiles--###
###---------------------------examples-----------------------------###

require(RadTran)

#porosity linear decrease until 3m depth
y.poro  =  function(X,Y)
           return(p.lin(Y,x.L=1.0,y.0=0.5,y.inf=0.3,x.att=0))


#moisture non-linear decrease until 3m depth, function input is m(z)=-0.4z+2.0
lin.inc  =  function(x,y.0=0,y.inf=0.5,x.L=0,x.att=2)
            return(1 - p.lin(x,y.0,y.inf,x.L,x.att))

y.hum=function(X,Y)
return(lin.inc(Y,y.0=0.8,y.inf=0))


Dif=RnDif.het(lx=1,ly=3,nx=50,ny=100,rho=2.65e3,x.poro=0.3,
x.hum=0.4,y.poro=y.poro,y.hum=y.hum,bdc_top=1000,rn_lam=2.09838e-6,
rn_ema=10,rn_dif=1.1e-5,rn_sol=0.3565,solution="steady")
```

RnDif.hom *2D Steady-state radon diffusion in a homogeneous porous medium.*

Description

Calls function RnDif.hom for 2D steady diffusion of radon. Gives the radon concentrations and fluxes in a homogeneous porous medium.

Usage

```
RnDif.hom(lx, ly, nx, ny, e, m, rho, bdc_top,
rn_lam, rn_ema, rn_dif, rn_sol, solution, ...)
```

Arguments

lx	x axis length of the soil column [L].
ly	y axis length (depth) of the soil column [L]. Only positive values are accepted.
nx	Number of grid cells in the x direction.
ny	Number of grid cells in the y direction.

e	Soil porosity [-]. A constant value over the entire column.
m	Soil moisture [-]. A constant value over the entire column.
rho	Soil grain material density [M/L2]. A constant value over the entire column.
bdc_top	Fixed value in the upstream boundary in y-direction (top of the soil column) for a constant value of radon concentration [(1/T)*(1/L3)].
rn_lam	Radon decay constant [1/T].
rn_ema	Radon emanation ratio [atoms (1/L3)*(1/T)].
rn_dif	Radon diffusivity in free air [L2/T].
rn_sol	Radon solubility in water [-].
solution	Type of solution to be computed. Only "steady" is avaiable at the moment.
...	...

Details

To optimize the code: The number of grid cells (nx,ny) will depend on the user's own computer capability. Higher numbers will give a closer approximation to the exact solution. The quantity for ny should be larger than nx, this allows a greater discretization in the y-axis.

Boundary conditions: Fixed value for radon concentration in the upstream boundary in y-direction (a negative y axis is considered), while the downstream boundary remains open. All the otther boundaries are closed off for transport.

Fluxes output: The output of the fluxes indicates the flow direction in correspondence with y-axis. In the case where a negative y-axis is considered, a negative flux value represents upward flow (from bottom to top). If the y-axis considered is positive, then a negative flux value represents downward flow (from top to bottom). The radon fluxes are computed at the interface of each grid cell.

Value

A list containing:

x.axis	X axis vector (1:nx) for radon concentrations and fluxes [L].
y.axis.conc	Y axis vector (1:ny) for the radon concentrations output [L].
y.axis.flux	Y axis vector (1:ny+1) for the radon fluxes output [L].
conc	Radon concentrations in the center of each grid cell, a [1:nx,1:ny] matrix [(1/T)*(1/L3)].
flux	Radon fluxes in the interface of each grid cell in the y-direction, a [1:nx,1:ny+1] matrix [1/T2].

Note

At the moment there is no provision to deal with cross-diffusion between x and y-axis.

The concentrations of radon are only computed at the center of each grid cell, this implies that the exact value in a cell interface (or in a boundary domain) will not be shown. Thus, the closest value is taken as an approximation at this locations.

Author(s)

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References

Andersen CE. Radon Transport Modelling: Users guide to RnMod3d. Riso National Laboratory, Roskilde, Denmark, 2000.

Andersen CE, Albarracin D, Csige I, van der Graaf ER, Jiranek M, Rehs B, Svoboda Z, Toro L. ERRICCA radon model intercomparison exercise. Riso-R-1120 (EN), Riso National Laboratory, DK-4000 Roskilde, Denmark (available as a internet publication at www.risoe.dk), 1999.

Soetaert K., Meysman F., 2012. R-package ReacTran: Reactive Transport Modelling in R.

Soetaert K., Meysman F., 2011. Reactive transport in aquatic ecosystems: Rapid model prototyping in the open source software R.

Soetaert K., Meysman F., 2009. Solving partial differential equations, using R package ReacTran.

Examples

```
#################################################
#####---- Direct input for the function ----#####
#################################################

require(RadTran)

Dif=RnDif.hom(lx=1,ly=3,nx=50,ny=100,e=0.3,m=0.0,rho=2.65e3,bdc_top=1000,
rn_lam=2.09838e-6,rn_ema=10,rn_dif=1.1e-5,rn_sol=0.3565,solution="steady")
```

RnDifAdv.hom — *2D Steady-state radon diffusion & advection in a homogeneous column of sand.*

Description

Calls function RnDifAdv.hom for 2D steady diffusion & advection of radon. Gives the radon concentrations and fluxes in a homogeneous column of sand.

Usage

```
RnDifAdv.hom(lx, ly, nx, ny, e, m, bdc_top,
rn_lam, rn_sol, k_soil, d_bulk, miu, dp, solution, ...)
```

Arguments

`lx`	x axis length of the medium column [L].
`ly`	y axis length (depth) of the medium column [L]. Only positive values are accepted.
`nx`	Number of grid cells in the x direction.
`ny`	Number of grid cells in the y direction.
`e`	Medium porosity [-]. A constant value over the entire column.
`m`	Medium moisture [-]. A constant value over the entire column.
`bdc_top`	Fixed value in the upstream boundary in y-direction (bottom of the sand column) for a constant value of radon concentration [(1/T)*(1/L3)].
`rn_lam`	Radon decay constant [1/T].
`rn_sol`	Radon solubility in water [-].
`k_soil`	The gas permeability of the sand [L2].
`d_bulk`	bulk diffusivity [L2/T].
`miu`	Air viscosity [M*(1/L*T)].
`dp`	Fixed value in the upstream boundary in y-direction (bottom of the sand column) for a constant value of disturbance pressure [M*(1/L*1/T2)].
`solution`	Type of solution to be computed. Only "steady" is avaiable at the moment.
`...`	...

Details

To optimize the code: The number of grid cells (nx,ny) will depend on the user's own computer capability. Higher numbers will give a closer approximation to the exact solution. The quantity for ny should be larger than nx, this allows a greater discretization in the y-axis.

Boundary conditions: Fixed value for radon concentration and disturbance pressure in the upstream boundary in y-direction (a positive y axis is considered). All the otther boundaries are closed off for transport.

Fluxes output: The output of the fluxes indicates the flow direction in correspondence with y-axis. In the case where a negative y-axis is considered, a negative flux value represents upward flow (from bottom to top). If the y-axis considered is positive, then a negative flux value represents downward flow (from top to bottom). The radon fluxes are computed at the interface of each grid cell.

Backward finite differences approximation is used for the advection flow.

Value

A list containing:

`x.axis`	X axis vector (1:nx) for radon concentrations and fluxes [L].
`y.axis.conc`	Y axis vector (1:ny) for the radon concentrations output [L].
`y.axis.flux`	Y axis vector (1:ny+1) for the radon fluxes output [L].
`conc`	Radon concentrations in the center of each grid cell, a [1:nx,1:ny] matrix [(1/T)*(1/L3)].
`flux`	Radon fluxes in the interface of each grid cell in the y-direction, a [1:nx,1:ny+1] matrix [1/T2].

Note

At the moment there is no provision to deal with cross-diffusion&advection between x and y-axis.

The concentrations of radon are only computed at the center of each grid cell, this implies that the exact value in a cell interface (or in a boundary domain) will not be shown. Thus, the closest value is taken as an approximation at this locations.

Author(s)

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References

Andersen CE. Radon Transport Modelling: Users guide to RnMod3d. Riso National Laboratory, Roskilde, Denmark, 2000.

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Soetaert K., Meysman F., 2012. R-package ReacTran: Reactive Transport Modelling in R.

Soetaert K., Meysman F., 2011. Reactive transport in aquatic ecosystems: Rapid model prototyping in the open source software R.

Soetaert K., Meysman F., 2009. Solving partial differential equations, using R package ReacTran.

Examples

```
#################################################
#####---- Direct input for the function ----#####
#################################################

require(RadTran)

AdvDif=RnDifAdv.hom(lx=1,ly=5,nx=50,ny=100,e=0.3,m=0.0,bdc_top=5000,
rn_lam=2.09838e-6,rn_sol=0.3565,k_soil=1e-11,d_bulk=1e-6,miu=17.5e-6,
dp=-100,solution="steady")
```

`SoilAdv.hom` *2D Steady-state soil gas advection (Darcy Flow) in a homogeneous column of sand.*

Description

Calls function SoilAdv.hom for 2D steady advection of soil gas. Gives the disturbance pressures and fluxes in a homogeneous column of sand.

Usage

```
SoilAdv.hom(lx, ly, nx, ny, e, k_soil, miu, dp_bot, dp_top, solution, ...)
```

Arguments

lx	x axis length of the medium column [L].
ly	y axis length (depth) of the medium column [L]. Only positive values are accepted.
nx	Number of grid cells in the x direction.
ny	Number of grid cells in the y direction.
e	Sand porosity [-]. A constant value over the entire column.
k_soil	The gas permeability of the sand [L2].
miu	Air viscosity [M*(1/L*T)].
dp_bot	Fixed value in the downstream boundary in y-direction (bottom of the sand column) for a constant value of disturbance pressure [M*(1/L*1/T2)]. Only positive (or zero) values are accepted, otherwise the steady state will not be reached.
dp_top	Fixed value in the upstream boundary in y-direction (top of the sand column) for a constant value of disturbance pressure [M*(1/L*1/T2)]. Only negative (or zero) values are accepted, otherwise the steady state will not be reached.
solution	Type of solution to be computed. Only "steady" is avaiable at the moment.
...	...

Details

To optimize the code: The number of grid cells (nx,ny) will depend on the user's own computer capability. Higher numbers will give a closer approximation to the exact solution. The quantity for ny should be larger than nx, this allows a greater discretization in the y-axis.

Boundary conditions: Fixed values for the disturbance pressure in the upstream and downstream boundary in y-direction (a negative y axis is considered). All the otther boundaries are closed off for transport.

Fluxes output: The output of the fluxes indicates the flow direction in correspondence with y-axis. In the case where a negative y-axis is considered, a negative flux value represents upward flow (from bottom to top). If the y-axis considered is positive, then a negative flux value represents downward flow (from top to bottom). The soil gas fluxes are computed at the interface of each grid cell.

Value

A list containing:

x.axis	X axis vector (1:nx) for disturbances pressure and fluxes [L].
y.axis.press	Y axis vector (1:ny) for the disturbances pressure output [L].
y.axis.flux	Y axis vector (1:ny+1) for the radon fluxes output [L].
press	Disturbance pressures in the center of each grid cell, a [1:nx,1:ny] matrix [M*(1/L*1/T2)].
flux	Soil gas fluxes in the center of each grid cell in the y-direction, a [1:nx,1:ny+1] matrix [L3/T].

Note

At the moment there is no provision to deal with cross-advection between x and y-axis.

The disturbances pressure values are only computed at the center of each grid cell, this implies that the exact value in a cell interface (or in a boundary domain) will not be shown. Thus, the closest value is taken as an approximation at this locations.

Author(s)

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References

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Soetaert K., Meysman F., 2009. Solving partial differential equations, using R package ReacTran.

Examples

```
################################################
#####---- Direct input for the function ----#####
################################################

require(RadTran)

Adv2D=SoilAdv.hom(lx=1,ly=3,nx=50,ny=100,e=0.1,k_soil=2e-10,miu=17.5e-6,
dp_bot=0,dp_top=-3,solution="steady")
```

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