Package 'HydroMe'

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Type Package

Title Estimation of Soil Hydraulic Parameters from Experimental Data

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Description This package estimates the parameters in infiltration and water retention models by curve-fitting method. The models considered are those that are commonly used in soil science.

Depends nlme

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R topics documented:

`HydroMe-package` *A package for the estimation of soil hydraulic parameters using experimental data*

Description

This package uses experimental data for either infiltration or water retention and estimates hydraulic parameters contained in common infiltration and water retention models in soil science. The models considered include Philip's, Horton, and Green-Ampt among the infiltration functions and the van Genuchten, Brooks-Corey, Campbell, and Gardner's models among the water retention functions. The parameters of these functions are obtained by analytical curve-fitting method

Details

The functions are selfstarting but use nlme library for parameter estimation. They are coded as follows: SSphilip, SShort, and SSGampt, respectively for the Philip's, Horton's, and Green-Ampt's infiltration functions and SSvan, SSbrook, SScamp, and SSgard, respectively for the van Genuchten's, Brooks-Corey's, Campbell's, Gardner's, and new Biexponential models for water retention functions. The van Genuchten model is one in which m is 1 less the inverse of n

Author(s)

Omuto, Christian Thine

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References

Omuto, C.T. and Gumbe, L.O., 2007 *R codes for estimating water infiltration and retention parameters using mixed-effects* **Computers and Geosciences -Submitted**

`Infilt` *Infiltration test data from the Upper Athi River basin, Eastern Kenya*

Description

This data contains infiltration capacities(in cm/min), Time (min), and land use-land cover types in the Upper Athi river basin in Eastern Kenya. The infiltration tests were carried out using standard infiltrometers and the data sampled over many plots in the whole basin.

Usage

```
data(Infilt)
```

Format

A data frame with 1105 observations on the following 5 variables.

`Sample` a numeric vector of raws in the data

`PlotNo` an ordered factor of plocodes

`Erosion` a factor with levels `E0` `E1` `E2`

`Time` a numeric vector of the time of infiltration tests in minutes

`Rate` a numeric vector of infiltration capacities in cm/min

Source

Omuto, C.T. 2006 *Large-Area Soil Physical Degradation Assessment: The Use of GIS, Remote Sensing,and Infrared Spectroscopy in Arid and Semi-Arid Kenya* **PhD dissertation** Nairobi: University of Nairobi

References

Omuto, C.T., Minasny, B., McBratney, A.B., Biamah, E.K., 2006 *Nonlinear mixed effect modelling for improved estimation of water retention and infiltration parameters* **Journal of Hydrology, 330, 748-758**

Examples

```
data(Infilt)
summary(Infilt)
```

`infiltration` *Infiltration characteristics of Awach watershed in Lake Victoria Basin in Western Kenya*

Description

Part of infiltration characteristics from a study of soil physical properties in the Lake Victoria basin in Western Kenya

Usage

```
data(infiltration)
```

Format

A data frame with 4536 observations on the following 5 variables.

`Sample` a numeric vector of number of rows in the data

`Obj` an ordered factor with levels of sampling points

`Time` a numeric vector of time of infiltration

`Rate` a numeric vector of infiltration capacity

`Cumrate` a numeric vector of cummulative infiltration capacities

Source

Omuto, C.T. 2003 *Rapid Mapping of saturated hydraulic conductivity in tropical watersheds* **MSc Thesis** Nairobi: University of Nairobi

Examples

```
data(infiltration)
## summary(infiltration) ; plot(infiltration) ...
```

`isric` *Water retention characteristics of the ISRIC world databse*

Description

Part of the water retention data from several countries in the world as contained in the ISRIC world soil database. It contains names of the countries and sampling points as well

Usage

```
data(isric)
```

Format

A data frame with 320 observations on the following 6 variables.

`Sample` a factor with levels with codes for samples

`Country` a factor with levels with codefor countries

`BD` a numeric vector of subsoil bulk densities

`x` a numeric vector of suction potential in cm

`lnx` a numeric vector of logarithm of suction potential

`y` a numeric vector of moisture content in vol/vol

Details

The data for each point contain at least five entries for water retention charcateristics including zero and 15000 cm suction potentials

Source

www.isric.nl

Examples

```
data(isric)
## maybe summary(isric) ; plot(isric)
```

`pfdata` *Water retention data from the Upper Athi river basin in Eastern Kenya*

Description

Part of water retention data obtained from a study of soil physical degradation in the Upper Athi river basin in Eastern Kenya

Usage

```
data(pfdata)
```

Format

A data frame with 2196 observations on the following 6 variables.

`sample` a numeric vector of the number of rows in the data

`Level` an ordered factor with levels for sampling points

`Landuse` a factor with levels `Agroforestry` `Cropland` `Forest` `Grassland` `Shrubland` `Thicket`

`x` a numeric vector of suction potential in cm

`y` a numeric vector of moisture content in vol/vol

`lnx` a numeric vector of logarithm of suction potential

Source

Omuto, C.T. 2006 *Large-Area Soil Physical Degradation Assessment: The Use of GIS, Remote Sensing,and Infrared Spectroscopy in Arid and Semi-Arid Kenya* **PhD dissertation** Nairobi: University of Nairobi

References

Omuto, C.T., Minasny, B., McBratney, A.B., Biamah, E.K., 2006 *Nonlinear mixed effect modelling for improved estimation of water retention and infiltration parameters* **Journal of Hydrology, 330, 748-758**

Examples

```
data(pfdata)
## maybe summary(pfdata) ; plot(pfdata)
```

SSbrook *Selfstarting function for estimating hydraulic parameters in the Brooks-Corey model*

Description

This selfstarting function estimates the water retention hydraulic parameters contained in the Brooks-Corey model. It has an initial attribute that creates initial estimates of the parameters Thr, Ths, alp, and scal

Usage

```
SSbrook(input, Thr, Ths, alp, scal)
```

Arguments

`input`	A numeric vector of natural logarithm of the suction potentials.
`Thr`	A numeric parameter representing the residual moisture content.
`Ths`	A numeric parameter representing the saturated moisture content.
`alp`	A numeric parameter representing the inverse of air-entry potential.
`scal`	A numeric parameter representing the pore-size distribution index.

Details

The dataset should contain a column for logarithm of suction potential, taking care to place a very small numer for log (x) whenever x is zero. The function estimates the parameters in two parts: when product of alp and input is less than or eaual to unity and when this quantity is geater than unity

Value

A numeric vector of the same length as input. It is the value of the expression $Thr + (Ths - Thr)/((input * alp)^s cal)$. It represents the fitted estimates of moisture contents using the Brooks-Corey model

Note

If the model returns negative values for the residual moisture content, a zero value should be dopted for this parameter. One may need to adjust the nls controls incase of convergence problems.It is also important to note that some datasets do perform poorly with this function

Author(s)

Omuto, Christian Thine

References

Brooks, R.H., Corey, A.T., 1964 *Hydraulic properties of porous medium* **Hydrology Paper, Nr. 3** Colorado State University: fort Collins

See Also

SSvan, SSgard, SScamp

Examples

```
##---- Obtaine the data----
x <-c(0,log(10),log(31),log(100),log(200),log(500),log(2500),log(15000))# get log (x)
y <-c(0.362,0.353,0.294,0.230,0.206,0.182,0.148,0.136)
Brookdata <-data.frame(x,y)# make data frame
Brook.nls <-nls(y~SSbrook(x, Thr, Ths, alp, scal), Brookdata)# model for whole dataset
summary(Brook.nls)
```

SScamp — *A selfstarting function for estimating hydraulic parameters in the Campbell model*

Description

This selfstarting model evaluates the Campbells water retention function and its parameters. It has an initial attribute that evaluates initial estimates of the parameters Ths, alp, and scal for a given set of data

Usage

```
SScamp(input, Ths, alp, scal)
```

Arguments

`input`	numeric vector of natural logarithm of suction potential values at which to evaluate the model
`Ths`	a numeric parameter representing the saturated moisture content when suction potential is zero
`alp`	a numeric parameter representing the inverse of air-entry potential
`scal`	a numeric parameter representing the slope of the water retention curve. It is related to pore-size distribution index

Details

Campbell function is a three-parameter model that does not assume the residual moisture content. The function estimates the parameters in two parts: when the product of alp and input is less than or eaual to unity and when this quantity is geater than unity

Value

a numeric vector of the same length as input.It is the value of the Campbells expression $Ths*(alp*input)^(-scal)$. It represents the fitted estimates of moisture contents using the Campbell function

Author(s)

Omuto, Christian Thine

See Also

SSgard, SSbrook, SSvan

Examples

```
##---- use part of the Wret data ----
data(Wret)
nWret=nrow(Wret) # gets the number of rows need (there are 232 all together)
testW13 <-Wret[(nWret-231):(nWret-208), ] # choose the first 3 sets
Campbel.nls <-nls(y~SScamp(lnx, Ths, alp, scal), testW13)
Campbel.nlis <-nlsList(y~SScamp(lnx, Ths, alp, scal)|Points, testW13)
Campbel.nlme <-nlme(Campbel.nlis) # Estimate mixed-effects
```

SSGampt *A selfstarting function for estimating infiltration parameters in the Green-Ampt model*

Description

This selfstarting function estimates ks and (A) during infiltration. It has an initial attribute that creates initial estimates of the parameters ks and A

Usage

```
SSGampt(input, ks, A)
```

Arguments

`input`	a numeric vector of values at which to evaluate the model. It should contain the cummulative infiltration capacities
`ks`	a numeric parameter representing the asymptote to the cummulative-infiltration axis (when input values are very large)
`A`	a numeric parameter representing the integral measure of the potential of wetting front in increasing soil moisture during infiltration

Value

a numeric vector of the same length as input. It is the value of the expression $ks + (A/input)$. It represents the fitted estimates of infiltration rates

Note

It may be necessary to transform the instantaneous infiltration rates to avoid the function returning negative ks values

Author(s)

Omuto, Christian Thine

References

Green, W.A., Ampt, G.A., 1911 *Studies on soil physics: 1. the flow of air and water through soils* **Journal of Agricultural Science 4, 1-24**

See Also

SShort, SSphilip

Examples

```
##---- Use infiltration data----
data(infiltration)
Gampt.nls <-nls(log(Rate)~SSGampt(Cumrate, ks, A), data=infiltration)
summary(Gampt.nls)# Call summary to desplay the results
```

SSgard *A selfstarting function to estimate hydraulic parameters in the Gardners retention model*

Description

This selfstarting function estimates the water retention parameters contained in the Gardners function. It has an initial attribute that creates initial estimates of the parameters Thr, Ths, alp, and scal

Usage

```
SSgard(input, Thr, Ths, alp, scal)
```

Arguments

`input`	A numeric vector of the suction potential
`Thr`	A numeric parameter representing the residual moisture content
`Ths`	A numeric parameter representing the saturated moisture content
`alp`	A numeric parameter representing the inverse of air-entry potential
`scal`	A numeric parameter representing the pore-size distribution index

Details

The dataset should contain a column for logarithm of suction potential, taking care to place a very small numer for log (x) whenever x is zero. The function estimates the parameters in two parts: when the product of alp and input is less than or eaual to unity and when this quantity is geater than unity

Value

numeric vector of the same length as input. It is the value of the expression $Thr+(Ths-Thr)/(1+(alp*input^scal))$. It represents the fitted estimates of moisture contents using the Gardners model

Note

If the model returns negative values for residual moisture content, a zero value should be dopted for that residual moisture content. Also, if the model fails to converge, one may need to adjust the controls. It is also important to note that some datasets do perform poorly with this function

Author(s)

Omuto, Christian Thine

References

Gardner, W.R., 1958 *Some steady state solutions of the unsaturated moisture flow equation with application to evaporation from a water table* **Soil Science, 85, 228-232**

See Also

SSvan, SSbrook, SScamp

Examples

```
##-- Load pfdata--
data(pfdata)
gard.nlis <-nlsList(y~SSgard(x, Thr, Ths, alp, scal)|Level, data=pfdata)
cor(fitted(gard.nlis),pfdata$y, use="complete")^2 # To compute r^2
```

SShort — *A selfstarting function for estimating the parameters of the Hortons infiltration model*

Description

This selfstarting function estimates the infiltration parameters contained in the Hortons model. It has an initial attribute that creates initial estimates of the parameters fc, f0, and k

Usage

```
SShort(input, fc, f0, lrk)
```

Arguments

`input`	A numeric vector of Time
`fc`	A numeric parameter representing the final steady infiltration capacity
`f0`	A numeric parameter representing the initial infiltration capacity
`lrk`	A numeric parameter representing the logarithm of the decay constant

Value

a numeric vector of the same length as input. It is the value of the expression $fc + (f0 - fc) * exp(-input * lrk)$. It represents the fitted estimates of infiltration capacities using the Hortons model

Note

It may be necessary to transform the infiltration capacities to avoid negative values for the asymptotic final steady infiltration capacity

Author(s)

Omuto, Christian Thine

References

Horton , R.E., 1940 *An approach towards a physical interpretation of infiltration capacity* **Soil Science Society of America Proceedings 5, 227-237**

See Also

SSphilip, SSGampt

Examples

```
##-- Use infiltration data
data(infiltration)
hort.nls <-nls(Rate~SShort(Time, fc, f0, lrk), data=infiltration)
plot(hort.nls) # to view the assumption of constant variance of the residuals
```

`SSMgg` *A new function based on the biexponential model to estimate soil hydraulic paremeters of water retention*

Description

This selfstarting function estimates the water retention hydraulic parameters contained in the new biexponential function. It has an initial attribute that creates initial estimates of the parameters Ths1, alp1, Ths2, and alp1

Usage

```
SSMgg(input, Ths1, alp1, Ths2, alp2)
```

Arguments

`input`	A numeric vector of the suction potentials
`Ths1`	A numeric parameter representing the saturated moisture content in the structural pore-space (macropores)
`alp1`	A numeric parameter representing the inverse of air-entry potential in the structural component
`Ths2`	A numeric parameter representing the saturated moisture content in the textural pore-space (micropores)
`alp2`	A numeric parameter representing the inverse of air-entry potential in the textural component

Value

numeric vector of the same length as input. It is the value of the expression $Ths1*exp(-exp(alp1)*input) + Ths2*exp(-exp(alp2)*input)$. It represents the fitted estimates of moisture using the new biexponential model

Note

Note that the parameters representing the inverse of air-entry potentials are log-transformed. These coeficients need to be back-transformed using exponential function

Author(s)

Omuto, Christian Thine

References

Groenevelt, P.H. and Grant, C.D., 2004 *A new model for the soil-water retention curve that solves the problem of residual water contents* **European J.ournal of Soil Science, 55, 479-485**

See Also

SSvan, SSbrook, SScamp

Examples

```
##---- Load isric data----
data(isric)
nbiexp.nls <-nls(y~SSMgg(x, Ths1, alp1, Ths2, alp2), data=isric)
plot(nbiexp.nls, Country~resid(.), abline=0) # to observe effect of geographic locations
```

SSphilip — *A selfstarting function for estimating infiltration parameters in the Philips model*

Description

This selfstarting function estimates the infiltration parameters contained in the Philips model. It has an initial attribute that creates initial estimates of the parameters fc, and S

Usage

```
SSphilip(input, fc, S)
```

Arguments

`input`	A numeric vector of Time
`fc`	A numeric parameter representing the final steady infiltration capacity
`S`	a numeric parameter representing the slope of the infiltration characteristic curve at the early tmies of the infiltration process. It is the estimate of sorptivity at the supply moisture content

Value

a numeric vector of the same length as input. It is the value of the expression $fc+(0.5*S)/sqrt(input)$. It represents the fitted values by the Philips model

Author(s)

Omuto, Christian Thine

References

Philip, J.R., 1957 *The theory of infiltration 4: Sorptivity and algebraic infiltration equations* **Soil Science 84, 257-264**

See Also

SShort, SSGampt

Examples

```
##-- Use infiltration data
data(infiltration)
 philip.nls <-nls(Rate~SSphilip(Time, fc, S), data=infiltration)
plot(fitted(philip.nls)~infiltration$Rate) # Plot the fitted versus measured
```

SSvan — *A selfstarting function for estimating hydraulic parameters in the van Genuchten model*

Description

This selfstarting function estimates the water retention parameters contained in the van Genuchtens function. It has an initial attribute that creates initial estimates of the parameters Thr, Ths, alp, and scal

Usage

```
SSvan(input, Thr, Ths, alp, scal)
```

Arguments

`input`	A numeric vector of natural logarithm of the suction potentials
`Thr`	A numeric parameter representing the residual moisture content
`Ths`	A numeric parameter representing the saturated moisture content
`alp`	A numeric parameter representing the inverse of air-entry potential
`scal`	A numeric parameter representing the pore-size distribution index

Details

The dataset should contain a column for logarithm of suction potential, taking care to place zero for log (x) whenever x is zero. The function estimates the parameters in two parts: when the product of alp and input is less than or eaual to unity and when this quantity is geater than unity

Value

a numeric vector of the same length as input. It is the value of the expression $Thr + (Ths - Thr)/(1 + (input * exp(alp))^{s}cal)^{(}1 - (1/scal))$. It represents the fitted estimates of moisture retained using the van Genuchtens model

Note

This model relates to a case of van Genuchtens model where m is 1 less than the inverse of n. The parameter for inverse of air-entry potential has been transformed using natural logarithm. Thus, the coefficient for this parameter needs to be transformed back using exponential function. It is also important to note that some datasets do perform poorly with this function

Author(s)

Omuto, Christian Thine

References

Van Genuchten, M.T., 1980 *A closed-form Equation for predicting the hydraulic conductivity of unsaturated soils* **Soil Science Society of America Journal 44, 892-898**

See Also

SSgard, SSbrook, SScamp

Examples

```
data(isric)
van.nls <-nls(y~SSvan(x, Thr, Ths, alp, scal), isric)
coef(van.nls)## Obtain the parameter estimates
##       Thr        Ths        alp       scal
## 0.1747737  0.5010839 -2.9837774  1.3029102
```

Wret — *Water retention data from Awach watershed in the lake Victoria basin, Western Kenya*

Description

This is part of the water retention characteristics from a study of soil physical properties in the Lake Victoria basin in Western Kenya

Usage

```
data(Wret)
```

Format

A data frame with 232 observations on the following 6 variables

`Points` an ordered factor of plotcodes

`Depth` a factor with levels `Subsoil` `Topsoil`

`BULK` a numeric vector of bulk density in g/cm3

`x` a numeric vector of suction potential in cm

`y` a numeric vector of volumetric moisture content in vol/vol

`lnx` a numeric vector of logarithm of suction potential

Source

Omuto, C.T. 2003 *Rapid Mapping of saturated hydraulic conductivity in tropical watersheds* **MSc Thesis** Nairobi: University of Nairobi

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