`soilwaterptf`, pedotransfer functions for soil hydraulic properties

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1 Forewords

1.1 What is `soilwaterptf`?

`soilwaterptf` is an R[2] package providing functions that implements Wösten et al. 1999[4] pedotransfer functions for predicting the parameters of the Mualem (1976)[1] and the van Genuchten (1980)[3] water retention function and hydraulic conductivity function.

Both class and continuous pedotransfer functions are provided.

These functions are used to predict soil hydraulic properties when no measurement are available, apart measured soil physico-chemical properties or soil survey information.

1.2 Credits and License

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2 Working with `soilwaterptf`

2.1 Install and load `soilwaterpf`

Method 1: If you have the latest R version, open R, and then type:

```
install.packages(
    pkgs  = "soilwaterptf",
    repos = "http://R-Forge.R-project.org" )
```

Method 2: Otherwise, try to install the package from the binaries. First download the binaries from `http://soilwater.r-forge.r-project.org/`. Save the package binaries in your working directory, and then open R and type:

```
install.packages(
    pkgs  = "soilwaterptf_1.0.1.zip",
    repos = NULL )
```

Then you can load `soilwaterptf`:

```
library( "soilwaterptf" )
```

2.2 Dataset of soil properties

The package does not come with any dataset of 'real' soil properties. We can create one:

```
# Create a dummy dataset of soil properties
dtf <- expand.grid(
    "bulkD"   = seq(1,1.6,.2),
    "om"      = seq(1,3,.25),
    "clay"    = seq(10,50,10),
    "silt"    = seq(10,50,10),
    "topSoil" = 0:1
)   #
#
# And inspect the result:
colnames( dtf )
```

```
[1] "bulkD"   "om"      "clay"    "silt"    "topSoil"
```

```
dim( dtf )
```

```
[1] 1800    5
```

```
head( dtf )
```

```
  bulkD   om clay silt topSoil
1   1.0 1.00   10   10       0
2   1.2 1.00   10   10       0
3   1.4 1.00   10   10       0
4   1.6 1.00   10   10       0
5   1.0 1.25   10   10       0
6   1.2 1.25   10   10       0
```

```
tail( dtf )
```

```
     bulkD   om clay silt topSoil
1795   1.4 2.75   50   50       1
1796   1.6 2.75   50   50       1
1797   1.0 3.00   50   50       1
1798   1.2 3.00   50   50       1
1799   1.4 3.00   50   50       1
1800   1.6 3.00   50   50       1
```

Notice that it is important that the column names of your table exactly corrrespond to the names used above. Remember R is case sensitive. Additional columns will be ignored.

2.3 Predicting soil hydraulic properties

Now predicting soil hydraulic properties is fairly easy. We use the function `ptf.wosten()`:

```
res <- ptf.wosten( soilprop = dtf, units = c("-","m","day") )
```

The `units` option specify the unit in which the hydraulic conductivity is output:

- The fist item is the [Volumic water content] unit, and its possible values are "-" (m3 of water . m-3 of bulk soil, between 0 and 1) or "%" (percent of water, between 0 and 100). It is used for the thetaS parameter.
- The second item is the [time] unit, and its possible values are "mm", "cm" or "m". It is used for the alpha and kSat parameters.
- The third item is the [time] unit, and its possible values are "sec", "min", "hour", "day". It is used for the kSat.

We can have a look at the result table:

```
colnames( res )
[1] "thetaS" "alpha"  "n"      "l"      "kSat"
dim( res )
[1] 1800    5
head( res )
        thetaS    alpha        n          l      kSat
[1,] 0.5418810 2.111633 1.400966 -0.9783902 1.8073608
[2,] 0.4811684 4.769596 1.359378 -1.2522226 1.1106747
[3,] 0.4204558 7.414085 1.344501 -1.5241604 0.6317305
[4,] 0.3597432 7.931336 1.317027 -1.7938098 0.3325675
[5,] 0.5414482 2.243163 1.386640 -1.1766495 1.7594525
[6,] 0.4806765 4.945248 1.348094 -1.4372054 1.0722269
tail( res )
           thetaS    alpha        n          l       kSat
[1795,] 0.4506870 1.666040 1.101310 -3.6671635 0.09114478
[1796,] 0.3846084 1.045390 1.080263 -4.8862612 0.04046487
[1797,] 0.5817504 1.438194 1.154773 -0.8991287 0.35242610
```

```
[1798,] 0.5156126 1.859725 1.119962 -2.3414116 0.18112383
[1799,] 0.4494748 1.654979 1.099446 -3.6875066 0.08615612
[1800,] 0.3833370 1.013560 1.079141 -4.8948769 0.03793146
```

Notice that each row in `dtf` correspond to a set of soil properties (for example a soil core or a soil layer / horizon) and each row in `res` is the resulting properties.

2.4 Plotting soil hydraulic function with the package `soilwaterfun`

We can now plot the water retention function (van Genuchten 1980 [3]), for one of the soil sample (nb 438):

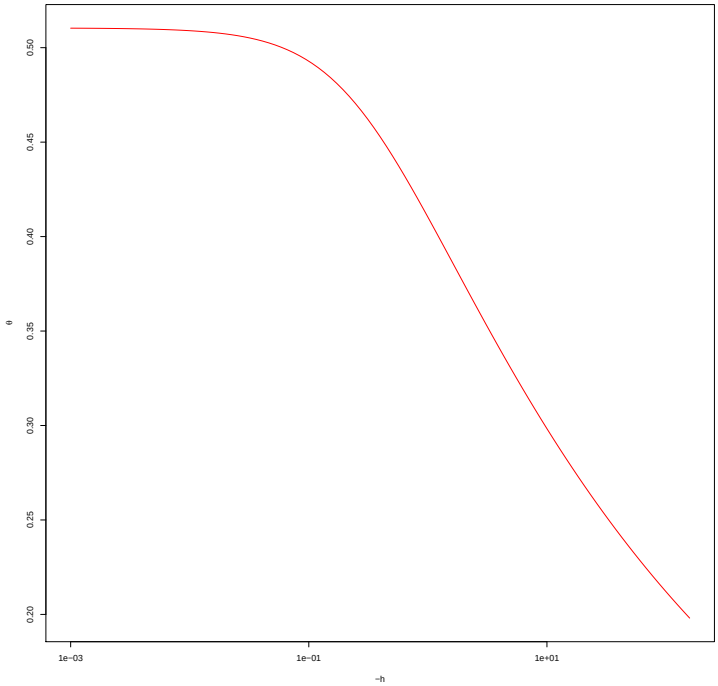
```
# Load soilwaterfun (installed separately):
library("soilwaterfun")
#
# Look at the soil properties:
dtf[438,]
```

```
    bulkD   om clay silt topSoil
438   1.2 1.25   30   30       0
```

```
res[438,]
```

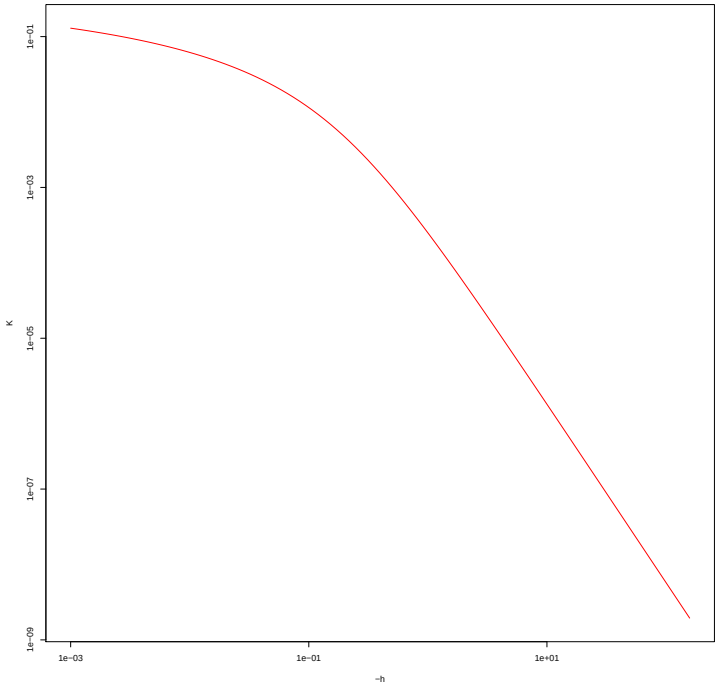
```
    thetaS      alpha          n          l       kSat
 0.5104267  3.6125905  1.1491501 -2.8059016  0.4012957
```

```
#
curve(
    fun.vangenuchten.theta.h(
        h       = -x,                 # in [meter]
        alpha   = res[438,"alpha"],   # in [meter-1]
        n       = res[438,"n"],       # [-]
        thetaS  = res[438,"thetaS"],  # [-]
        thetaR  = 0
    ),  #
    xlim = c(0.001,158),
    col  = "red",
    log  = "x",
    xlab = "-h",
    ylab = expression( theta )
)   #
```



And then plot the hydraulic conductivity function (Mualem 1976[1]), for the same soil sample:

```
curve(
    fun.mualem.vangenuchten.K.h(
        h       = -x,               # in [meter]
        Ks      = res[438,"kSat"],  # in [meter.T-1], here T = day
        alpha   = res[438,"alpha"], # in [meter-1]
        n       = res[438,"n"]      # [-]
    ),  #
    xlim = c(0.001,158),
    col  = "red",
    log  = "xy",
    xlab = "-h",
    ylab = "K"
)   #
```



References

[1] Y. Mualem. A new model for predicting the hydraulic conductivity of unsaturated porous media. *Water Resources Research*, 12:513–522, 1976.

[2] R Development Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2011. ISBN 3-900051-07-0.

[3] M. Th. van Genuchten. A closed form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Science Society of America Journal*, 44:892–898, 1980.

[4] J.H.M. Wösten, A. Lilly, A. Nemes, and C. Le Bas. Development and use of a database of hydraulic properties of european soils. *Geoderma*, 90:169–185, 1999.