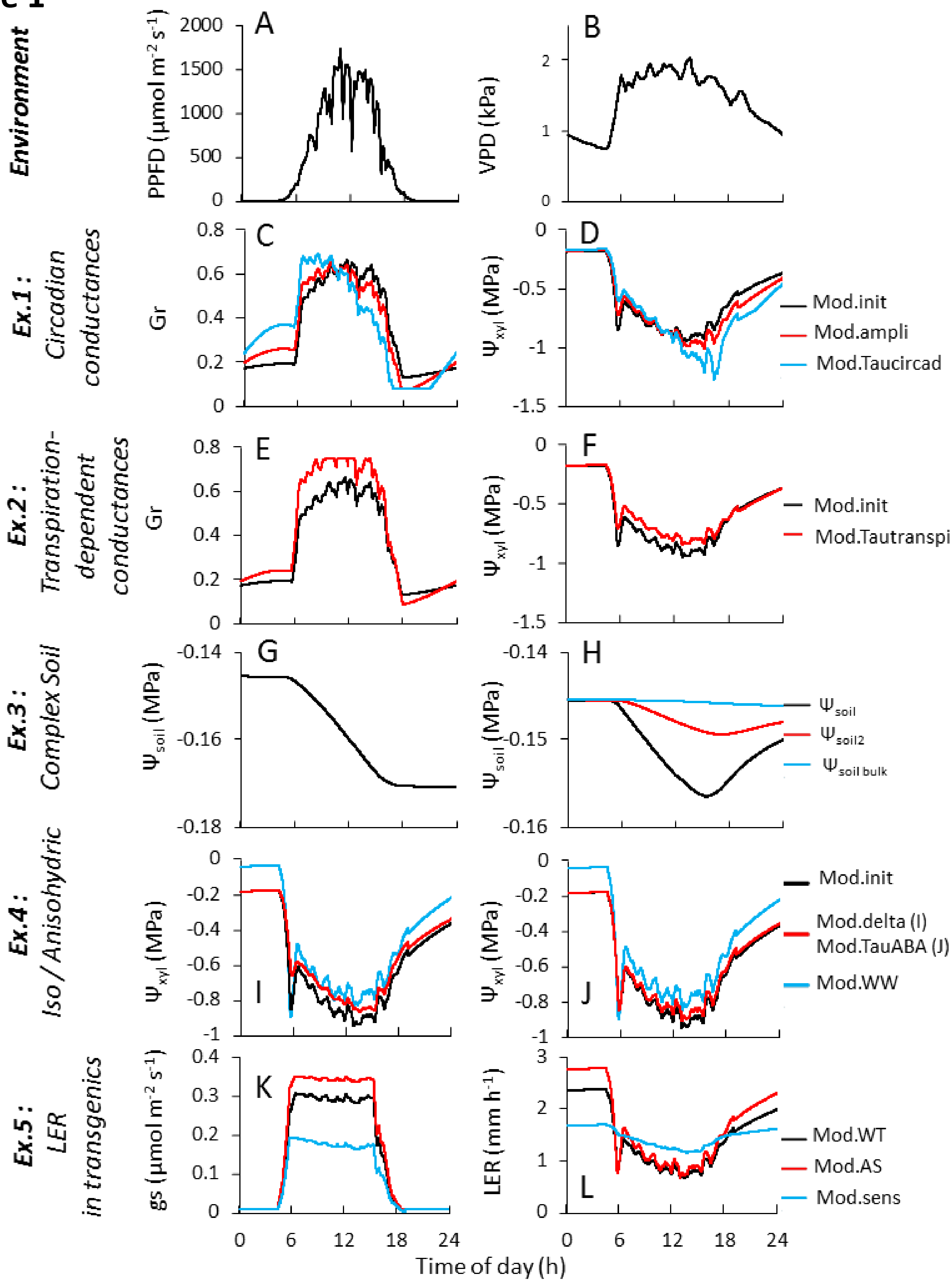
SI Figure 1



SI Fig.1: Examples of environmental conditions (A,B) in the default dataset (climate) and output variables (C to L) of simulations carried out in the 5 examples provided in the help file of the function modelhydro(). I. Simulations with changed delta value. Red (line) J. Simulations with changed t_{ABA} values.

`Modelhydro`

Description

Compute the model of water transfer and leaf elongation described in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015.

Usage

```
modelhydro  (data, ...)
```

Default:

```
modelhydro (data , complexsoil = FALSE, growth = FALSE, ampliinit = 0.4 , paragRs = list(alpha = 0.1826 , gsmin = 0.005 , beta = -0.003 , delta = -1 , ga=0.17) , paragr = list (Gr0 = 0.08 , Grmin = 0.08 , Grmax  = 0.75, Tautranspigr = 1.2,  Taucircadgr = 0.08 , TauABAgr = 0.01), paragc  = list (Gc0 = 0.08 , Gcmin = 0.08 , Gcmax  = 0.75, Tautranspigc = 1.2,  Taucircadgc = 0.08 , TauABAgc = 0.01), paragxl = list (Gxl0 = 0.8 , Gxlmin = 0.2 , Gxlmax  = 2.5, Tautranspigxl = 0.05,  Taucircadgxl = 0.08 , TauABAgxl = 0.01), paracap = list(ncap = 1.5, alphacap = 0.075), parasoil = list(Teta = 0.25 , soildepth = 0.5 , rcol = 0.1 , soilw = 7.6 , Nplant = 3) , parasoil2 = list (soildepth2 = 0.54 , rcol2 = 0.14 , soilwcol2 = 8.5 , soilwbulk = 183), parahydrodyn = list(n = 1.209321 , al = 3.21473540706308 , Tetasat = 0.56 , Ks = 1 , p = 0.5) , pararoot = list(r = 0.0001 ,  Lv=2000), surface = 0.02, shading = 0.2 , parav = list(Vsat = 11000 , Vres = 1100) ,paragro = list(aLER = 4.1 , cLER = 0.8 , arABA = 0.433) ,  paraba = list( a = -600, constit = 1, b = 4)
```

Arguments

`data` a data frame with environmental conditions. It must contain at least:

`$hour`	time (h)
`$PPFD`	Photosynthetic Photon Flux Density (µmol m^{-2} s^{-1})
`$T`	Temperature (°C)
`$VPD`	Vapor Pressure Deficit (kPa)

`complexsoil` a logical value indicating whether if soil is modeled with a single column (`FALSE`) or the three nested columns (`TRUE`)

`growth` a logical value indicating if leaf elongation rate (LER) should be calculated (for maize only)

`ampliinit` amplitude of Psi.xyl before beginning of periode (MPa) parags a list of parameters for stomatal conductance and aerodynamic conductance (equation 1 and 2 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015)

$alpha	α in equation 1
$gsmin	gs_{min} in equation 1
$beta	β in equation 1
$delta	δ in equation 1
$ga	α in equation 2

paracap parameters for the pressure-volume curve, fitted with Van Genuchten equation (Van Genuchten, 1980) ; equation 11 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015)

$ncap	n_{cap} in equation 11
$alphacap	α_{cap} in equation 11

paragr a list of parameters for the sensitivities of root hydraulic conductance Gr to transpiration (equation 8 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015), amplitude of water potential (equation 7) and ABA (equation 9).

$Gr0	Gr_0 in equation 8
$Grmin	minimum value of Gr
$Grmax	maximum value of Gr
$Taucircadgr	τ_{circad} for Gr (equation 7)
$Tauevapgr	τ_{evap} for Gr (equation 7)
$TauABAgr	τ_{ABA} for Gr (equation 7)

paragc a list of parameters for the sensitivities of hydraulic conductance Gc to transpiration (equation 8 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015), amplitude of water potential (equation 7) and ABA (equation 9).

$Gc0	Gc_0 in equation 8
$Gcmin	minimum value of Gc
$Gcmax	maximum value of Gc
$Taucircadgc	τ_{circad} for Gc (equation 7)
$Tauevapgc	τ_{evap} for Gc (equation 7)
$TauABAgc	τ_{ABA} for Gc (equation 7)

paragxl a list of parameters for the sensitivities of hydraulic conductance Gxl to transpiration (equation 8 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015), amplitude of water potential (equation 7) and ABA (equation 9).

$Gxl0	Gxl_0 in equation 8
$Gxlmin	minimum value of Gxl
$Gxlmax	maximum value of Gxl
$Taucircadgxl	τ_{circad} for Gxl (equation 7)
$Tauevapgxl	τ_{evap} for Gxl (equation 7)

$TauABAgxl τ_{ABA} for Gxl (equation 7)

parasoil a list of parameters for soil characteristics in the main soil column (rhizosphere)

- $Teta initial value of soil humidity (g g^{-1})
- $soildepth column depth (m)
- $rcol column radius (m)
- $soilw soil dry weight (kg)
- $Nplant number of plants in the column

parasoil2 a list of parameters for the second and third soil column (if complexsoil = TRUE)

- $soildepth2 second column depth (m)
- $rcol2 second column radius (m)
- $soilwcol2 soil dry weight (kg) in column 2 surrounding column 1
- $soilwbulk soil dry weight (kg) in column 3 (bulk)

parahydrodyn a list of parameters for soil hydrodynamic properties (equation 4 and 5 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015)

- $n n in equation 4 , 5
- $al α_v in equation 4 , 5
- $Tetasat θsat, soil humidity at soil saturation
- $Ks ks in equation 5
- $p p in equation 5

pararoot a list of parameters for roots

- $r root radius, m
- $Lv root length per soil volume, m m^{-3}

surface Plant leaf area (m^2).

shading a value from 0 to 1 considering selfshading

parav a list of parameters for leaf volume (equation 11 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015)

- $Vsat leaf volume at saturation (mm^2)
- $Vres leaf residual water volume (mm^2).

paragro a list of parameters for leaf elongation rate (equation 12 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015)

- $aLER max leaf elongation rate (mm h^{-1}). a_LER in equation 12
- $cLER sensitivity to xylem water potential. c_LER in equation 12

$arABA sensitivity to ABA. a_r_aba in equation 12

paraba a list of parameters for ABA biosynthesis (equation 3 in Tardieu, Simonneau and Parent, Journal of Experimental Botany, 2015)

$a a in equation 3

$constit $ABA_{constit}$ in equation 3

$b b in equation 3

Value

The model is computed and a data.frame with all variables at the time step of one minute is returned.

$hour	time (h)
$hourday	hour of the day (h)
$Tetacol1	humidity in first soil column (rhizosphere), g g^{-1}
$T	Temperature (°C)
$PPFD	Photosynthetic Photon Flux Density (µmol m^{-2} s^{-1})
$VPD	Vapour Pressure Deficit (kPa)
$gs	Stomatal conductance (mol m^{-2} s^{-1})
$J	Transpiration flux per plant (mg s^{-1})
$Jtot	Transpiration flux per column (mg s^{-1})
$Jxc	Flux (mg $plant^{-1}$ s^{-1}) between mature tissues and bundle sheaths
$Psisoil	Soil water potential (MPa) in soil column (rhizosphere)
$Psir	Root water potential (MPa)
$Psixyl	Xylem water potential (MPa)
$Psicel	Water potential in cells considered as a capacitance (MPa)
$Psievap	Water potential in cells of evaporative sites (MPa)
$ABA	ABA concentration in xylem (pmol m^{-3})
$Gr	Root hydraulic conductance (mg MPa^{-1} s^{-1})
$Gc	Hydraulic conductance between capacitance and evaporative sites (mg MPa^{-1} s^{-1})
$Gxl	Hydraulic conductance xylem and evaporative sites (mg MPa^{-1} s^{-1})
$Jsoil1	Flux from column 2 (surrounding column 1) and column 1 (if complexsoil = TRUE)
$Jsoil1	Flux from bulk soil (surrounding column 2) and column 2 (if complexsoil = TRUE)
$Psisoil2	Soil water potential (MPa) in column 2 (if complexsoil = TRUE)
$Psibulk	Soil water potential (MPa) in bulk soil (if complexsoil = TRUE)
$LER	Leaf Elongation Rate (mm h^{-1}) (if growth = TRUE)

References

Tardieu F., Simonneau T., Parent B. 2015. Modelling the coordination of the controls of stomatal aperture, transpiration, leaf growth and abscissic acid: update and extension of the Tardieu Davies model. Journal of Experimental Botany.

Exemples

Some outputs of these examples are presented in SI. Fig. 1

######### *Example 1 : Simulations with different former amplitudes of Ψ_l or varying options for circadian influences on conductances Gr, Gc and Gxl (SI. Fig. 1CD in Tardieu et al., 2015)*

#The first simulation (`mod.init`) is obtained by running the model with the example dataset (`climate`) and default parameter values (for maize, mainly genotype B73).

```
mod.init <- modelhydro (data = climate) ## this can take a few minutes
```

Changing the amplitude of Ψ_l on former days (`mod.ampli`), from 0.4 MPa (the default value) to 1.4 MPa:

```
mod.ampli <- modelhydro (data = climate , ampliinit = 1.4 )
```

Changing the sensitivity of Gr, Gc and Gxl to the amplitude of Ψ_l (respectively `paragr$Taucircadgr`, `paragc$Taucircadgc` and `paragxl$Taucircadgxl`) from default values (0.08) to respectively 0.15, 0.15 and 0.2.

```
mod.Taucircad  <- modelhydro (data = climate , ampliinit = 1.4  , paragr = list (Gr0 = 0.08 , Grmin = 0.08 , Grmax  = 0.75, Tautranspigr = 1.2,  Taucircadgr = 0.15 , TauABAgr = 0.01),  paragc  = list (Gc0 = 0.08 , Gcmin = 0.08 , Gcmax  = 0.75, Tautranspigc = 1.2,  Taucircadgc = 0.15 , TauABAgc = 0.01) ,  paragxl = list (Gxl0 = 0.8 , Gxlmin = 0.2 , Gxlmax  = 2.5, Tautranspigxl = 0.05,  Taucircadgxl = 0.2 , TauABAgxl = 0.01) )
```

#########*Example 2 : Simulations with different sensitivities of conductances Gr and Gc to transpiration (paragr$Tautranspigr, paragc$Tautranspigc) either with the default values (1.2,* `mod.init`*) or increased values (1.5;* `mod.Tautranspi`*). (SI. Fig. 1EF in Tardieu et al., 2015)*

```
mod.Tautranspi  <- modelhydro (data = climate ,  paragr = list (Gr0 = 0.08 , Grmin = 0.08 , Grmax  = 0.75, Tautranspigr = 1.5,  Taucircadgr = 0.2 , TauABAgr = 0.01),  paragc  = list (Gc0 = 0.08 , Gcmin = 0.08 , Gcmax  = 0.75, Tautranspigc = 1.5,  Taucircadgc = 0.2 , TauABAgc = 0.01))
```

##########*Example 3. Simulations with either considering a simple soil column (rhizosphere, default value,* `mod.init` *) or with the complex soil system with three nested columns (rhizosphere, intermediate and bulk soil;* `mod.complexsoil`*).*

```
mod.complexsoil <- modelhydro (data = climate , complexsoil = TRUE)
```

######### *Example 4. Simulations for simulating plant behaviours closer to isohydric behaviour, either by modifying δ value (*`parags$delta`*) from -1 to -2 or changing the sensitivities of conductances Gr, Gc and Gxl to [ABA]$_{xyl}$.*

##Simulation in well-watered conditions

```
mod.WW <- modelhydro (data = climate , parasoil = list(Teta = 0.5 , soildepth = 0.5 , rcol = 0.1 , soilw = 7.6 , Nplant = 3))
```

##Simulation with varying δ *value (*`parags$delta`*)*

```
mod.delta <- modelhydro (data = climate , parags = list(alpha = 0.1826 , gsmin = 0.005 , beta = -0.003 , delta = -2 , ga=0.17) )
```

Simulation with sensitivities of conductances to *[ABA]$_{xyl}$*.

```
mod.TauABA <- modelhydro(data = climate , paragr = list (Gr0 = 0.08 , Grmin = 0.08 , Grmax = 0.75, Tautranspigr = 1.2, Taucircadgr = 0.08 , TauABAgr = 0.2) , paragc = list (Gc0 = 0.08 , Gcmin = 0.08 , Gcmax = 0.75, Tautranspigc = 1.2, Taucircadgc = 0.08 , TauABAgc = -0.2) , paragxl = list (Gxl0 = 0.8 , Gxlmin = 0.2 , Gxlmax = 2.5, Tautranspigxl = 0.05, Taucircadgxl = 0.15 , TauABAgxl = -0.2) )
```

#########*Example 5. Simulations with transgenic plants affected on ABA biosynthesis as in Parent et al., 2009.* Parameters of ABA biosynthesis (`paraba`), leaf area (`surface`) and root length (`pararoot`) are affected.

```
geno <- c ("AS" , "WT" , "sens")
mulroot <- c(1 , 1 , 0.4)
mulS <- c (1 , 1 , 0.2)
a.geno <- c (-200 , -600 , -50)
constit.geno <- c (0 , 0 , 150)

for (i in 1:3){
    mod <- modelhydro (data = climate , complexsoil = TRUE , growth = TRUE, surface = 0.02 * mulS[i] , paraba = list( a = a.geno[i], constit = constit.geno[i], b = 4) , pararoot = list(r = 0.0001 , Lv = 2000 * mulroot[i]) )
    assign (paste ("mod" , geno[i] , sep = ".") , mod )
} ## this can take a few minutes
```