Package ‘TUWmodel’

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Title Lumped Hydrological Model for Education Purposes
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Description The model, developed at the Vienna University of Technology, is a lumped conceptual rainfall-
runoff model, following the structure of the HBV model.  
The model runs on a daily or shorter time step and consists of a snow routine, a soil mois-
ture routine and a flow routing routine.  
See Parajka, J., R. Merz, G. Bloeschl (2007) <DOI:10.1002/hyp.6253> Uncertainty and multi-
ple objective calibration in regional water balance modelling: case study in 320 Austrian catch-
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Description
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Usage

data(example_TUWmodel)

Format
The data are time series for the river Vils at Vils (Laende):

1. Q_Vils vector of observed daily discharges [mm/day];
2. P_Vils matrix of observed daily precipitation [mm/day] for 6 zones;
3. T_Vils matrix of observed daily temperatures [degC] for 6 zones;
4. PET_Vils matrix of potential evapotranspiration [mm/day] for 6 zones;
5. SWE_Vils matrix of observed snow water equivalent [mm] for 6 zones;
6. areas_Vils areas of the 6 zones.

Examples

data(example_TUWmodel)

ls()

t <- as.Date(rownames(P_Vils))
plot(t, apply(P_Vils, 1, weighted.mean, w=areas_Vils), type="S", xlab="", ylab="Precipitation [mm/day]")
plot(t, apply(PET_Vils, 1, weighted.mean, w=areas_Vils), type="l", xlab="", ylab="Potential evapotranspiration [mm/day]")
plot(t, T_Vils[,1], type="l", xlab="", ylab="Temperature [degC]")
lines(t, T_Vils[,6], col=3)
plot(t, SWE_Vils[,6], col=3, type="l", xlab="", ylab="Snow water equivalent [mm]")
lines(t, SWE_Vils[,1], col=1)
plot(as.Date(names(Q_Vils)), Q_Vils, type="l", xlab="", ylab="Runoff [mm/day]")
TUWmodel

Lumped hydrological model developed at the Vienna University of Technology for education purposes

Description

TUWmodel is a lumped conceptual rainfall-runoff model, following the structure of the HBV model. The model runs on a daily or shorter timestep and consists of a snow routine, a soil moisture routine and a flow routing routine. See Parajka, J., R. Merz, G. Blöschl (2007) Uncertainty and multiple objective calibration in regional water balance modelling: case study in 320 Austrian catchments, Hydrological Processes, 21, 435-446.

Usage

TUWmodel (prec, airt, ep, area=1,
param=c(1.2,1.2,2,-2,0.9,100,3.3,0.5,9,105,50,2,10,26.5),
incon=c(50,0,2.5,2.5), itsteps=NULL)

Arguments

prec vector/matrix of precipitation input [mm/timestep] (ncol = number of zones)
airt vector/matrix of air temperatures [degC]
ep vector/matrix of potential evapotranspiration [mm/timestep]
area if more zones, vector of the percentage of area for each zone (or proportional to it, i.e., if the sum is different from 1, it will be rescaled to be 1)
param vector/matrix of parameters (ncol = number of zones):
1. SCF snow correction factor [-] (e.g., 0.9-1.5);
2. DDF degree day factor [mm/degC/timestep] (e.g., 0.0-5.0 mm/degC/day);
3. Tr threshold temperature above which precipitation is rain [degC] (e.g., 1.0-3.0 degC);
4. Ts threshold temperature below which precipitation is snow [degC] (e.g., -3.0-1.0 degC);
5. Tm threshold temperature above which melt starts [degC] (e.g., -2.0-2.0 degC);
6. LPrat parameter related to the limit for potential evaporation [-] (e.g., 0.0-1.0);
7. FC field capacity, i.e., max soil moisture storage [mm] (e.g., 0-600 mm);
8. BETA the non linear parameter for runoff production [-] (e.g., 0.0-20.0);
9. k0 storage coefficient for very fast response [timestep] (e.g., 0.0-2.0 days);
10. k1 storage coefficient for fast response [timestep] (e.g., 2.0-30.0 days);
11. k2 storage coefficient for slow response [timestep] (e.g., 30.0-250.0 days);
12. lsuz threshold storage state, i.e., the very fast response start if exceeded [mm] (e.g., 1.0-100.0 mm);
13. \texttt{cperc} constant percolation rate [mm/timestep] (e.g., 0.0-8.0 mm/day);
14. \texttt{bmax} maximum base at low flows [timestep] (e.g., 0.0-30.0 days);
15. \texttt{croute} free scaling parameter [timestep^2/mm] (e.g., 0.0-50.0 days^2/mm);

\texttt{incon} vector/matrix of initial conditions for the model (nco1 = number of zones): SSM0 soil moisture [mm]; SWE0 snow water equivalent [mm]; SUZ0 initial value for fast (upper zone) response storage [mm]; SLZ0 initial value for slow (lower zone) response storage [mm]

\texttt{itsteps} length of the output (if NULL all the time series are used)

**Details**

More details about the model structure are given in the Appendix of

An example of using \texttt{TUWmodel}, including R scripts for automatic calibration, can be found in the Supplement of

**Value**

\texttt{TUWmodel} gives a vector of simulated runoff as \texttt{q} [mm/timestep], and the following vector/matrices:

1. \texttt{qzones} simulated runoff for each zone [mm/timestep];
2. \texttt{q0} surface runoff [mm/timestep];
3. \texttt{q1} subsurface runoff [mm/timestep];
4. \texttt{q2} baseflow [mm/timestep];
5. \texttt{rain} liquid precipitation [mm/timestep];
6. \texttt{snow} solid precipitation [mm/timestep];
7. \texttt{melt} snowmelt [mm/timestep];
8. \texttt{moist} soil moisture [mm];
9. \texttt{swe} snow water equivalent [mm];
10. \texttt{eta} actual evapo-transpiration [mm/timestep];
11. \texttt{suz} upper storage zone [mm];
12. \texttt{slz} lower storage zone [mm];

**Examples**

```r
## Load the data
data(example_TUWmodel)

## Simulate runoff and plot observed vs simulated series
## Lumped case (weighted means of the inputs)
```
TUWmodel

```
simLump <- TUWmodel(prec=apply(P_Vils, 1, weighted.mean, w=areas_Vils),
  airt=apply(T_Vils, 1, weighted.mean, w=areas_Vils),
  ep=apply(PET_Vils, 1, weighted.mean, w=areas_Vils),
  area=sum(areas_Vils),
  param=c(1.02,1.70,2.0,-0.336,
           0.934,121,2.52,
           0.473,9.06,142,
           50.1,2.38,10.25))

plot(as.Date(names(Q_Vils)), Q_Vils, type="l", xlab="", ylab="Discharges [mm/day]")
lines(as.Date(rownames(T_Vils)), simLump$q, col=2)
legend("topleft", legend=c("Observations","Simulations"), col=c(1,2), lty=1, bty="n")

plot(as.Date(rownames(SWE_Vils)), apply(SWE_Vils, 1, weighted.mean, w=areas_Vils),
     type="l", xlab="", ylab="Snow Water Equivalent [mm]"
    )
lines(as.Date(rownames(T_Vils)), simLump$swe, col=2)

## Distribute input case (6 zones)
simDist <- TUWmodel(prec=P_Vils, airt=T_Vils, ep=PET_Vils, area=areas_Vils/sum(areas_Vils),
                      param=c(1.02,1.70,2.0,-0.336,
                      0.934,121,2.52,
                      0.473,9.06,142,
                      50.1,2.38,10.25))

plot(as.Date(names(Q_Vils)), Q_Vils, type="l", xlab="", ylab="Discharges [mm/day]")
lines(as.Date(rownames(T_Vils)), simDist$q, col=2)
legend("topleft", legend=c("Observations","Simulations"), col=c(1,2), lty=1, bty="n")

plot(as.Date(rownames(SWE_Vils)), apply(SWE_Vils, 1, weighted.mean, w=areas_Vils),
     type="l", xlab="", ylab="Snow Water Equivalent [mm]"
    )
lines(as.Date(rownames(T_Vils)), apply(simDist$swe, 1, weighted.mean, w=areas_Vils), col=2)

## Distributed input and parameters case
parametri <- matrix(rep(c(1.02,1.70,2.0,-0.336,
                            0.934,121,2.52,
                            0.473,9.06,142,
                            50.1,2.38,10.25), 6), ncol=6)
parametri[2,] <- c(1.4, 1.7, 1.9, 2.2, 2.4, 3.0)
simDist2 <- TUWmodel(prec=P_Vils,
                      airt=T_Vils,
                      ep=PET_Vils,
                      area=areas_Vils/sum(areas_Vils),
                      param=parametri)

plot(as.Date(names(Q_Vils)), Q_Vils, type="l", xlab="", ylab="Discharges [mm/day]")
lines(as.Date(rownames(T_Vils)), simDist2$q, col=2)
legend("topleft", legend=c("Observations","Simulations"), col=c(1,2), lty=1, bty="n")
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