Package 'dynatop'

April 13, 2022

Title An Implementation of Dynamic TOPMODEL Hydrological Model in R

Version 0.2.2

Description An R implementation and enhancement of the Dynamic TOPMODEL semi-distributed hydrological model originally proposed by Beven and Freer (2001) <doi:10.1002/hyp.252>. The 'dynatop' package implements code for simulating models which can be created using the 'dynatopGIS' package.

License GPL-2

Encoding UTF-8

LazyData true

ByteCompile true

Imports R6, zoo, xts, Rcpp

LinkingTo Rcpp

Depends R (>= 4.0.0)

BugReports https://github.com/waternumbers/dynatop/issues

URL https://waternumbers.github.io/dynatop/,
https://github.com/waternumbers/dynatop

RoxygenNote 7.1.2

Suggests raster, rgdal, knitr, rmarkdown, covr, bookdown, pkgdown, testthat (>= 3.0.0)

VignetteBuilder knitr

SystemRequirements C++11

Language en-GB

NeedsCompilation yes

Author Paul Smith [aut, cre] (<https://orcid.org/0000-0002-0034-3412>), Peter Metcalfe [aut]

Maintainer Paul Smith <paul@waternumbers.co.uk>

Repository CRAN

Date/Publication 2022-04-13 21:32:43 UTC

R topics documented:

`dynatop-package` *dynatop*

Description

This package contains the core code for the R implementation of dynamic TOPMODEL

`dynatop` *R6 Class for Dynamic TOPMODEL*

Description

R6 Class for Dynamic TOPMODEL

R6 Class for Dynamic TOPMODEL

Methods

Public methods:

- `dynatop$new()`
- `dynatop$add_data()`
- `dynatop$clear_data()`
- `dynatop$initialise()`
- `dynatop$sim_hillslope()`
- `dynatop$sim_channel()`
- `dynatop$sim()`
- `dynatop$get_channel_inflow()`
- `dynatop$plot_channel_inflow()`
- `dynatop$get_gauge_flow()`
- `dynatop$plot_gauge_flow()`
- `dynatop$get_obs_data()`
- `dynatop$get_model()`
- `dynatop$get_mass_errors()`
- `dynatop$get_states()`

- dynatop$plot_state()
- dynatop$clone()

Method `new()`**:** Creates a dynatop class object from the a list based model description as generated by dynatopGIS.

Usage:

```
dynatop$new(model, use_states = FALSE, delta = 1e-13)
```

Arguments:

`model` a dynamic TOPMODEL list object

`use_states` logical if states should be imported

`delta` error term in checking redistribution sums

`drop_map` logical if the map should be dropped

Details: This function makes some basic consistency checks on a list representing a dynamic TOPMODEL model. The checks performed and basic 'sanity' checks. They do not check for the logic of the parameter values nor the consistency of states and parameters. Sums of the redistribution matrices are checked to be in the range 1 +/- delta.

Returns: invisible(self) suitable for chaining

Method `add_data()`**:** Adds observed data to a dynatop object

Usage:

```
dynatop$add_data(obs_data)
```

Arguments:

`obs_data` an xts object of observed data

Details: This function makes some basic consistency checks on the observations to ensure they have uniform timestep and all required series are present.

Returns: invisible(self) suitable for chaining

Method `clear_data()`**:** Clears all forcing and simulation data except current states

Usage:

```
dynatop$clear_data()
```

Returns: invisible(self) suitable for chaining

Method `initialise()`**:** Initialises a dynatop object in the most simple way possible.

Usage:

```
dynatop$initialise(tol = 2 * .Machine$double.eps, max_it = 1000)
```

Arguments:

`tol` tolerance for the solution for the saturated zone

`max_it` maximum number of iterations to use in the solution of the saturated zone

Returns: invisible(self) suitable for chaining

Method `sim_hillslope()`**:** Simulate the hillslope output of a dynatop object

Usage:

```
dynatop$sim_hillslope(
  keep_states = NULL,
  sub_step = NULL,
  tol = 2 * .Machine$double.eps,
  max_it = 1000,
  ftol = Inf
)
```

Arguments:

`keep_states` a vector of POSIXct objects (e.g. from xts) giving the time stamp at which the states should be kept

`sub_step` simulation timestep in seconds, default value of NULL results in data time step

`tol` tolerance on width of bounds in the solution for the saturated zone

`max_it` maximum number of iterations to use in the solution of the saturated zone

`ftol` tolerance in closeness to 0 in the solution for the saturated zone

Details: Both saving the states at every timestep and keeping the mass balance can generate very large data sets!! While ftol is implemented it is currently set to `Inf` to mimic the behaviour of previous versions. This will change in the future.

Returns: invisible(self) for chaining

Method `sim_channel()`**:** Simulate the channel output of a dynatop object

Usage:

```
dynatop$sim_channel()
```

Returns: invisible(self) for chaining

Method `sim()`**:** Simulate the hillslope and channel components of a dynatop object

Usage:

```
dynatop$sim(
  keep_states = NULL,
  sub_step = NULL,
  tol = 2 * .Machine$double.eps,
  max_it = 1000,
  ftol = Inf
)
```

Arguments:

`keep_states` a vector of POSIXct objects (e.g. from xts) giving the time stamp at which the states should be kept

`sub_step` simulation timestep in seconds, default value of NULL results in data time step

`tol` tolerance on width of bounds in the solution for the saturated zone

`max_it` maximum number of iterations to use in the solution of the saturated zone

`ftol` tolerance in closeness to 0 in the solution for the saturated zone

`mass_check` Flag indicating is a record of mass balance errors should be kept

Details: Calls the sim_hillslope and sim_channel in sequence. Both saving the states at every timestep and keeping the mass balance can generate very large data sets!!

Returns: invisible(self) for chaining

Method `get_channel_inflow()`: Return channel inflow as an xts series or list of xts series

Usage:

```
dynatop$get_channel_inflow(total = FALSE, separate = FALSE)
```

Arguments:

`total` logical if plot total inflow is to be plotted

`separate` logical if the surface and saturated zone inflows should be returned separately

Method `plot_channel_inflow()`: Plot the channel inflow

Usage:

```
dynatop$plot_channel_inflow(total = FALSE, separate = FALSE)
```

Arguments:

`total` logical if total inflow is to be plotted

`separate` logical logical if the surface and saturated zone inflows should be plotted separately

Method `get_gauge_flow()`: Return flow at the gauges as an xts series

Usage:

```
dynatop$get_gauge_flow(gauge = colnames(private$time_series$gauge_flow))
```

Arguments:

`gauge` names of gauges to return (default is all gauges)

Method `plot_gauge_flow()`: Get the flow at gauges

Usage:

```
dynatop$plot_gauge_flow(gauge = colnames(private$time_series$gauge_flow))
```

Arguments:

`gauge` names of gauges to return (default is all gauges)

Method `get_obs_data()`: Get the observed data

Usage:

```
dynatop$get_obs_data()
```

Method `get_model()`: Return the model

Usage:

```
dynatop$get_model()
```

Method `get_mass_errors()`: Return the model

Usage:

```
dynatop$get_mass_errors()
```

Method `get_states()`: Return states

Usage:

```
dynatop$get_states(record = FALSE)
```

Arguments:

`record` logical TRUE if the record should be returned. Otherwise the current states returned

Method `plot_state()`**:** Plot a current state of the system

Usage:

```
dynatop$plot_state(state, add_channel = TRUE)
```

Arguments:

`state` the name of the state to be plotted

`add_channel` Logical indicating if the channel should be added to the plot

Method `clone()`**:** The objects of this class are cloneable with this method.

Usage:

```
dynatop$clone(deep = FALSE)
```

Arguments:

`deep` Whether to make a deep clone.

Examples

```
## the vignettes contains further details of the method calls.

data("Swindale") ## example data
ctch_mdl <- dynatop$new(Swindale$model) ## create with model
ctch_mdl$add_data(Swindale$obs) ## add observations
ctch_mdl$initialise() ## initialise model
ctch_mdl$sim() ## simulate model
```

---

evap_est — *Create sinusoidal time series of potential evapotranspiration input*

Description

Generate series of potential evapotranspiration

Usage

```
evap_est(ts, eMin = 0, eMax = 0)
```

Arguments

`ts`	as vector of POSIXct data/times
`eMin`	Minimum daily PE total (m or mm)
`eMax`	Maximum daily PE total (m or mm)

Details

Dynamic TOPMODEL requires a time series of potential evapotranspiration in order to calculate and remove actual evapotranspiration from the root zone during a run. Many sophisticated physical models have been developed for estimating potential and actual evapotranspiration, including the Priestly-Taylor (Priestley and Taylor, 1972) and Penman-Monteith (Montieth, 1965) methods. These, however, require detailed meteorological data such as radiation input and relative humidities that are, in general, difficult to obtain. Calder (1983) demonstrated that a simple approximation using a sinusoidal variation in potential evapotranspiration to be a good approximation to more complex schemes.

If the insolation is also taken to vary sinusoidally through the daylight hours then, ignoring diurnal meteorological variations, the potential evapotranspiration during daylight hours for each year day number can be calculated (for the catchment's latitude). Integration over the daylight hours allows the daily maximum to be calculated and thus a sub-daily series generated.

Value

Time series (xts) of potential evapotranspiration totals for the time steps given in same units as eMin and eMax

References

Beven, K. J. (2012). Rainfall-runoff modelling : the primer. Chichester, UK, Wiley-Blackwell.

Calder, I. R. (1986). A stochastic model of rainfall interception. Journal of Hydrology, 89(1), 65-71.

Examples

```
## Generating daily PET data for 1970
## the values of eMin and eMax may not by not be realistic
st <- as.POSIXct("1970-01-02 00:00:00",tz='GMT')
fn <- as.POSIXct("1971-01-01 00:00:00",tz='GMT')
daily_ts <- seq(st,fn,by=24*60*60)
dpet <- evap_est(daily_ts,0,1)

## create hourly data for the same period
st <- as.POSIXct("1970-01-01 01:00:00",tz='GMT')
fn <- as.POSIXct("1971-01-01 00:00:00",tz='GMT')
hour_ts <- seq(st,fn,by=1*60*60)
hpet <- evap_est(hour_ts,0,1)

## the totals should eb the same...
stopifnot(all.equal(sum(hpet), sum(dpet)))
```

`resample_xts` *Functions to resample an xts time series*

Description

Takes an xts time series object and resamples then to a new time step.

Usage

```
resample_xts(obs, dt, is.rate = FALSE)
```

Arguments

obs	A times series (xts) object with a POSIXct index.
dt	New time interval in seconds
is.rate	If TRUE then these are rates i.e m/h. Otherwise they are absolute values accumulated within the preceding time interval. Values are scaled before returning so resampling is conservative.

Details

Time series of observation data are often of different temporal resolutions, however the input to most hydrological models, as is the case with the Dynamic TOPMODEL, requires those data at the same interval. This provides a method to resample a collection of such data to a single interval.

Because of the methods used the results:

- are not accurate when the input data does not have a constant timestep. The code issues a warning and proceeds assuming the data are equally spaced with the modal timestep. - do not guarantee the requested time step but returns a series with the timestep computed from an integer rounding the ratio of the current and requested time step.

Value

An xts object with the new timestep

Examples

```
# Resample Swindale Rainfall to hourly intervals
require(dynatop)
data("Swindale")
obs <- Swindale$obs
cobs <- resample_xts(obs, dt=60*60) # hourly data
dobs <- resample_xts(cobs,dt=15*60) # back to 15 minute data
cdobs <- resample_xts(dobs,dt=60*60) # back to hourly data - checks time stamp conversion
obs <- obs[zoo::index(obs)<=max(zoo::index(cobs)),]

# check totals
stopifnot( all.equal(sum(obs),sum(cobs)) )
stopifnot( all.equal(sum(obs),sum(dobs)) )
stopifnot( all.equal(cobs,cdobs) )
```

`Swindale` *Example dynamic TOPMODEL setup*

Description

This data set contains a processed model and observation data for Swindale.

Usage

```
data(Swindale)
```

Format

An object of class `list` of length 2.

See Also

`dynatop`

Examples

```
require(dynatop)
data(Swindale)

# Show it
# plot(obs)
```

Index