

Package ‘dynatopGIS’

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Title Algorithms for Helping Build Dynamic TOPMODEL Implementations from Spatial Data

Version 0.2.2

Description A set of algorithms based on Quinn et al. (1991) <[doi:10.1002/hyp.3360050106](https://doi.org/10.1002/hyp.3360050106)> for processing river network and digital elevation data to build implementations of Dynamic TOPMODEL, a semi-distributed hydrological model proposed in Beven and Freer (2001) <[doi:10.1002/hyp.252](https://doi.org/10.1002/hyp.252)>. The 'dynatop' package implements simulation code for Dynamic TOPMODEL based on the output of 'dynatopGIS'.

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Encoding UTF-8

Imports R6, raster, rgeos, methods, jsonlite

Depends R (>= 4.0.0)

BugReports <https://github.com/waternumbers/dynatopGIS/issues>

URL <https://waternumbers.github.io/dynatopGIS/>,
<https://github.com/waternumbers/dynatopGIS>

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R topics documented:

dynatopGIS	2
Index	9

Description

This package contains the code for setting up a dynamic TOPMODEL implementation

Methods

Public methods:

- `dynatopGIS$new()`
- `dynatopGIS$get_meta()`
- `dynatopGIS$get_working_directory()`
- `dynatopGIS$set_working_directory()`
- `dynatopGIS$add_dem()`
- `dynatopGIS$add_channel()`
- `dynatopGIS$add_layer()`
- `dynatopGIS$get_layer()`
- `dynatopGIS$plot_layer()`
- `dynatopGIS$sink_fill()`
- `dynatopGIS$compute_areas()`
- `dynatopGIS$compute_properties()`
- `dynatopGIS$compute_flow_lengths()`
- `dynatopGIS$classify()`
- `dynatopGIS$combine_classes()`
- `dynatopGIS$create_model()`
- `dynatopGIS$get_version()`
- `dynatopGIS$get_class_method()`
- `dynatopGIS$clone()`

Method `new()`: Initialise a project, or reopen an existing project

Usage:

```
dynatopGIS$new(meta_file, check = TRUE, verbose = TRUE)
```

Arguments:

`meta_file` filename and path of the meta data file
`check` logical, should checks be performed [TRUE]
`verbose` printing of checking output [TRUE]

Details: This loads the meta data file found at `meta_path`, or creates it with a warning if no file is present. If `check` is TRUE then the meta data file contents are checked with the level of returned information being controlled by `verbose`.

Returns: A new 'dynatopGIS' object

Method `get_meta()`: Get project meta data

Usage:

```
dynatopGIS$get_meta()
```

Method `get_working_directory()`: Get current working directory

Usage:

```
dynatopGIS$get_working_directory()
```

Details: Newly generated layers are added to the working directory. By default this is the directory containing the meta date file.

Method `set_working_directory()`: Set current working directory

Usage:

```
dynatopGIS$set_working_directory(file_path, create = TRUE)
```

Arguments:

`file_path` the path to the new directory to create

`create` should the directory be created if it doesn't exist

Details: Newly generated layers are added to the working directory. By default this is the directory containing the meta date file.

Method `add_dem()`: Import a dem to the 'dynatopGIS' object

Usage:

```
dynatopGIS$add_dem(dem, fill_na = TRUE, verbose = FALSE)
```

Arguments:

`dem` a raster layer object or the path to file containing one which is the DEM

`fill_na` should NA values in dem be filled. See details

`verbose` Should additional progress information be printed

Details: If not a raster the DEM is read in using the raster package. If `fill_na` is TRUE all NA values other then those that link to the edge of the dem are filled so they can be identified as sinks.

Returns: suitable for chaining

Method `add_channel()`: Import channel data to the 'dynatopGIS' object

Usage:

```
dynatopGIS$add_channel(
  channel,
  property_names = c(length = "length", startNode = "startNode", endNode = "endNode",
    width = "width"),
  default_width = 2
)
```

Arguments:

`channel` a `SpatialLinesDataFrame`, `SpatialPolygonsDataFrame` or file path containing the channel information

`property_names` named vector of columns of the spatial data frame to use for channel properties - see details

`default_width` default width of a channel if not specified in `property_names`. Defaults to 2 metres.

Details: Takes the input channel converts it a `SpatialPolygonDataFrame` with properties `length`, `startNode` and `endNode`. The variable names in the `sp_object` data frame which corresponding to these properties can be specified in the `property_names` vector. In the channel is a `SpatialLinesDataFrame` (or read in as one) an additional property `width` is used to buffer the lines and create channel polygons. If required the `width` property is created using the default value. Note that any columns called `length`, `startNode`, `endNode` and `width` are overwritten. Any column called `id` is copied to a column `original_id` then overwritten.

Returns: suitable for chaining

Method `add_layer()`: Add a layer of geographical information

Usage:

```
dynatopGIS$add_layer(layer_name, file_path)
```

Arguments:

`layer_name` name to give to the layer

`file_path` the location of the file containing the new layer

Details: The file given is read by the `raster` package and checked against the project meta data. Only layer names not already in use (or reserved) are allowed. If successful the meta data for the project are altered to reflect the new layer name and file location.

Returns: suitable for chaining

Method `get_layer()`: Get a layer of geographical information or a list of layer names

Usage:

```
dynatopGIS$get_layer(layer_name = character(0))
```

Arguments:

`layer_name` name of the layer give to the layer

Returns: a 'raster' layer of the requested information if `layer_name` is given else a vector of layer names

Method `plot_layer()`: Plot a layer

Usage:

```
dynatopGIS$plot_layer(layer_name, add_channel = TRUE)
```

Arguments:

`layer_name` the name of layer to plot

`add_channel` should the channel be added to the plot

Returns: a plot

Method `sink_fill()`: The sink filling algorithm of Planchona and Darboux (2001)

Usage:

```

dynatopGIS$sink_fill(
  min_grad = 1e-04,
  max_it = 1e+06,
  verbose = FALSE,
  hot_start = FALSE
)

```

Arguments:

min_grad Minimum gradient between cell centres
max_it maximum number of replacement cycles
verbose print out additional diagnostic information
hot_start start from filled_dem if it exists

Details: The algorithm implemented is that described in Planchona and Darboux, "A fast, simple and versatile algorithm to fill the depressions in digital elevation models" Catena 46 (2001).

A pdf can be found at (https://horizon.documentation.ird.fr/exl-doc/pleins_textes/pleins_textes_7/sous_copyright/01003)

Method compute_areas(): Computes area maps and presence of channel in dem pixels

Usage:

```

dynatopGIS$compute_areas()

```

Details: The algorithm calculates the land and channel area for each DEM pixel assigning a channel_id to each pixel with a channel area.

Method compute_properties(): Computes statistics e.g. gradient, log(upslope area / gradient) for raster cells

Usage:

```

dynatopGIS$compute_properties(min_grad = 1e-04, verbose = FALSE)

```

Arguments:

min_grad gradient that can be assigned to a pixel if it can't be computed
verbose print out additional diagnostic information

Details: The algorithm passed through the cells in decreasing height. Min grad is applied to all cells. It is also used for missing gradients in pixels which are partially channel but have no upslope neighbours.

Method compute_flow_lengths(): Computes flow length for each pixel to the channel

Usage:

```

dynatopGIS$compute_flow_lengths(verbose = FALSE)

```

Arguments:

verbose print out additional diagnostic information

Details: The algorithm passed through the cells in increasing height. For measures of flow length to the channel are computed. The shortest length (minimum length to channel through any flow path), the dominant length (the length taking the flow direction with the highest fraction for each pixel on the path) and expected flow length (flow length based on sum of downslope flow lengths based on fraction of flow to each cell) and band (strict sequence to ensure that all contributing cell have a higher band value). By definition cells in the channel that have no land area have a length (or band) of NA.

Method `classify()`: Create a catchment classification based cutting an existing layer into classes

Usage:

```
dynatopGIS$classify(layer_name, base_layer, cuts)
```

Arguments:

`layer_name` name of the new layer to create

`base_layer` name of the layer to be cut into classes

`cuts` values on which to cut into classes. These should be numeric and define either the number of bands (single value) or breaks between band (multiple values).

Details: This applies the given cuts to the supplied landscape layer to produce areal groupings of the catchment. Cuts are implemented using `raster::cut` with `include.lowest = TRUE`. Note that is specifying a vector of cuts values outside the limits will be set to NA.

Method `combine_classes()`: Combine any number of classifications based on unique combinations and burns

Usage:

```
dynatopGIS$combine_classes(layer_name, pairs, burns = NULL)
```

Arguments:

`layer_name` name of the new layer to create

`pairs` a vector of layer names to combine into new classes through unique combinations. Names should correspond to raster layers in the project directory.

`burns` a vector of layer names which are to be burnt on

Details: This applies the given cuts to the supplied landscape layers to produce areal groupings of the catchment. Burns are added directly in the order they are given. Cuts are implemented using `raster::cut` with `include.lowest = TRUE`. Note that is specifying a vector of cuts values outside the limits will be set to NA.

Method `create_model()`: Compute a Dynamic TOPMODEL

Usage:

```
dynatopGIS$create_model(
  layer_name,
  class_layer,
  dist_layer,
  transmissivity = c("exp", "bexp", "cnst", "dexp"),
  channel_solver = c("histogram"),
  dist_delta = 0,
  rain_layer = NULL,
  rain_label = character(0),
  pet_layer = NULL,
  pet_label = character(0),
  verbose = FALSE
)
```

Arguments:

`layer_name` name for the new model and layers

class_layer the layer defining the topographic classes
 dist_layer the layer defining the distances to the channel
 transmissivity transmissivity profile to use
 channel_solver channel solver to use
 dist_delta used in computing flow linkages see details
 rain_layer the layer defining the rainfall inputs
 rain_label Prepend to rain_layer values to give rainfall series name
 pet_layer the layer defining the pet inputs
 pet_label Prepend to pet_layer values to give pet series name
 verbose print more details of progress

Details: The class_layer is used to define the HRUs. Flow between HRUs is based on the distance to a channel. For each HRU the shortest distance to a channel is computed. Flow from a HRU can only go to a HRU with a lower shortest distance to the channel. Flow from a HRU can occur from any raster cell within the HRU whose distance to the channel is within dist_delta of the shortest distance within the HRU. Setting the transmissivity and channel_solver options ensure the model is set up with the correct parameters present. The rain_layer (pet_layer) can contain the numeric id values of different rainfall (pet) series. If the value of rain_layer (pet_layer) is not NULL the weights used to compute an averaged input value for each HRU are computed, otherwise an input table for the models generated with the value "missing" used in place of the series name.

Method get_version(): get the version number

Usage:

dynatopGIS\$get_version()

Details: the version number indicates the version of the algorithms within the object

Returns: a numeric version number

Method get_class_method(): get the cuts and burns used to classify

Usage:

dynatopGIS\$get_class_method(layer_name)

Arguments:

layer_name the name of layer whose classification method is returned

Returns: a list with two elements, cuts and burns

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

Usage:

dynatopGIS\$clone(deep = FALSE)

Arguments:

deep Whether to make a deep clone.

Examples

```

## The vignettes contains more examples of the method calls.

## create tempport directory for output
demo_dir <- tempfile("dygis")
dir.create(demo_dir)

## initialise processing
ctch <- dynatopGIS$new(file.path(demo_dir,"meta.json"))

## add digital elevation and channel data
dem_file <- system.file("extdata", "SwindaleDTM40m.tif", package="dynatopGIS", mustWork = TRUE)
dem <- raster::raster(dem_file)
ctch$add_dem(dem)
channel_file <- system.file("extdata", "SwindaleRiverNetwork.shp",
package="dynatopGIS", mustWork = TRUE)
sp_lines <- rgdal::readOGR(channel_file)
property_names <- c(channel_id="identifier",endNode="endNode",startNode="startNode",length="length")
ctch$add_channel(sp_lines,property_names)

## compute properties
ctch$compute_areas()
ctch$sink_fill() ## fill sinks in the catchment

ctch$compute_properties() # like topographic index and contour length
ctch$compute_flow_lengths()

## classify and create a model

ctch$classify("atb_20","atb",cuts=20) # classify using the topographic index
ctch$get_class_method("atb_20") ## see the details of the classification
ctch$combine_classes("atb_20_band",c("atb_20","band")) ## combine classes
ctch$create_model("new_model","atb_20_band","band") ## create a model
list.files(demo_dir,pattern="new_model*") ## look at the output files for the model

## tidy up
unlink(demo_dir)

```

Index

[dynatopGIS](#), [2](#)