

Package ‘tidync’

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Title A Tidy Approach to 'NetCDF' Data Exploration and Extraction

Version 0.2.3

Description Tidy tools for 'NetCDF' data sources. Explore the contents of a 'NetCDF' source (file or URL) presented as variables organized by grid with a database-like interface. The `hyper_filter()` interactive function translates the filter value or index expressions to array-slicing form. No data is read until explicitly requested, as a data frame or list of arrays via `hyper_tibble()` or `hyper_array()`.

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tidync-package	<i>Tidy tools for NetCDF data.</i>
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Description

Provides easy to use idioms for working with NetCDF data for extraction, manipulation and visualization. NetCDF is Network Common Data Form <https://www.unidata.ucar.edu/software/netcdf/>.

Details

See `print.tidync()` for details on the printed version of a tidync object.

There is a family of functions "hyper_verb" around exploring and extracting data.

<code>active</code>	report the currently active grid
<code>activate</code>	active a grid
<code>tidync</code>	core NetCDF source object for tidync functions
<code>hyper_filter</code>	apply dimension expressions to specify array slices
<code>hyper_array</code>	extracts a raw data array based on a NetCDF index
<code>hyper_tbl_cube</code>	extracts data as a dplyr tbl_cube
<code>hyper_tibble</code>	extracts data as a data frame with all dimension values
<code>hyper_transforms</code>	extract the active (or all) dimension transforms
<code>hyper_vars</code>	information on active variables
<code>hyper_dims</code>	information on active dimensions
<code>hyper_grids</code>	information on grids

The scheme generally processes dimension filters into NetCDF extraction indexes and these are always available to each function, and are expressed in printed output.

Examples

```

argofile <- system.file("extdata/argo/MD5903593_001.nc", package = "tidync")
argo <- tidync(argofile)
argo %>% active()
argo %>% activate("D3,D8") %>% hyper_array()
argo %>% hyper_filter(N_LEVELS = index < 4)
argo %>% hyper_tbl_cube()
argo %>% hyper_tibble(select_var = c("TEMP_QC"))
argo %>% hyper_transforms()
argo %>% hyper_vars()
argo %>% hyper_dims()
argo %>% hyper_grids()

```

activate	<i>Activate a NetCDF grid</i>
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Description

A grid in NetCDF is a particular shape and size available for array variables, and consists of sets of dimensions. To activate a grid is to set the context for downstream operations, for querying, summarizing and reading data. There's no sense in performing these operations on more than one grid at a time, but multiple variables may exist in a single grid. There may be only one significant grid in a source or many, individual dimensions are themselves grids.

Usage

```

activate(.data, what, ..., select_var = NULL)

## S3 method for class 'tidync'
activate(.data, what, ..., select_var = NULL)

## S3 method for class 'tidync'
active(x)

active(x)

## Default S3 method:
active(x)

active(x) <- value

## Default S3 replacement method:
active(x) <- value

```

Arguments

.data	NetCDF object
-------	---------------

what	name of a grid or variable
...	reserved, currently ignored
select_var	optional argument to set selected state of variable/s by name
x	NetCDF object
value	name of grid or variable to be active

Details

There may be more than one grid and one is always activated by default. A grid may be activated by name in the form of 'D1,D0' where one or more numbered dimensions indicates the grid. The grid definition names are printed as part of the summary of in the tidync object and may be obtained directly with [hyper_grids\(\)](#) on the tidync object.

Activation of a grid sets the context for downstream operations (slicing and reading data) from NetCDF, and as there may be several grids in a single source activation allows a different choice of available variables. By default the largest grid is activated. Once activated, all downstream tasks apply to the set of variables that exist on that grid.

If [activate\(\)](#) is called with a variable name, it puts the variable first. The function [active\(\)](#) gets and sets the active grid. To restrict ultimate read to particular variables use the `select_var` argument to [hyper_filter\(\)](#), [hyper_tibble\(\)](#) and [hyper_tbl_cube\(\)](#).

Scalar variables are not currently available to tidync, and it's not obvious how activation would occur for scalars, but in future perhaps `activate("S")` could be the right way forward.

Value

NetCDF object

See Also

[hyper_filter](#) [hyper_tibble](#) [hyper_tbl_cube](#)

Examples

```
if (!tolower(Sys.info()[["sysname"]]) == "sunos") {
  l3file <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
  rnc <- tidync(system.file("extdata", "oceandata", l3file,
    package = "tidync"))
  activate(rnc, "palette")

  ## extract available grid names
  hyper_grids(rnc)
}
```

hyper_array	<i>Extract NetCDF data as an array</i>
-------------	--

Description

Extract the raw array data as a list of one or more arrays. This can be the entire variable/s or after dimension-slicing using `hyper_filter()` expressions. This is a delay-breaking function and causes data to be read from the source into R native arrays. This list of arrays is lightly classed as `tidync_data`, with methods for `print()` and `tidync()`.

Usage

```
hyper_array(x, select_var = NULL, ..., raw_datavals = FALSE,
           force = FALSE, drop = TRUE)
```

```
hyper_slice(x, select_var = NULL, ..., raw_datavals = FALSE,
           force = FALSE, drop = TRUE)
```

```
## S3 method for class 'tidync'
hyper_array(x, select_var = NULL, ...,
           raw_datavals = FALSE, force = FALSE, drop = TRUE)
```

```
## S3 method for class 'character'
hyper_array(x, select_var = NULL, ...,
           raw_datavals = FALSE, drop = TRUE)
```

Arguments

<code>x</code>	NetCDF file, connection object, or <code>tidync</code> object
<code>select_var</code>	optional vector of variable names to select
<code>...</code>	passed to <code>hyper_filter()</code>
<code>raw_datavals</code>	logical to control whether scaling in the NetCDF is applied or not
<code>force</code>	ignore caveats about large extraction and just do it
<code>drop</code>	collapse degenerate dimensions, defaults to TRUE

Details

The function `hyper_array()` will act on an existing `tidync` object or a source string.

By default all variables in the active grid are returned, use `select_var` to specify one or more desired variables.

The transforms are stored as a list of tables in an attribute ‘transforms’, access these with `hyper_transforms()`.

See Also

`print.tidync_data` for a description of the print summary, `hyper_tbl_cube()` and `hyper_tibble()` which are also delay-breaking functions that cause data to be read

Examples

```
f <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
l3file <- system.file("extdata/oceandata", f, package= "tidync")

## extract a raw list by filtered dimension
library(dplyr)
araw1 <- tidync(l3file) %>%
  hyper_filter(lat = between(lat, -78, -75.8),
              lon = between(lon, 165, 171)) %>%
  hyper_array()

araw <- tidync(l3file) %>%
  hyper_filter(lat = abs(lat) < 10,
              lon = index < 100) %>%
  hyper_array()

## hyper_array will pass the expressions to hyper_filter
braw <- tidync(l3file) %>%
  hyper_array(lat = abs(lat) < 10, lon = index < 100)

## get the transforms tables (the axis coordinates)
lapply(attr(braw, "transforms"),
       function(x) nrow(dplyr::filter(x, selected)))
## the selected axis coordinates should match in order and in size
lapply(braw, dim)
```

hyper_filter

Subset NetCDF variable by expression

Description

The `hyper_filter()` acts on a `tidync` object by matching one or more filtering expressions like with `dplyr::filter`. This allows us to lazily specify a subset from a NetCDF array without pulling any data. The modified object may be printed to see the effects of subsetting, or saved for further use.

Usage

```
hyper_filter(.x, ...)

## S3 method for class 'tidync'
hyper_filter(.x, ...)
```

Arguments

```
.x          NetCDF file, connection object, or tidync object
...         currently ignored
```

Details

The function `hyper_filter()` will act on an existing `tidync` object or a source string.

Filter arguments must be named as per the dimensions in the variable in form `dimname = dimname < 10`. This is a restrictive variant of `dplyr::filter()`, with a syntax more like `dplyr::mutate()`. This ensures that each element is named, so we know which dimension to apply this to, but also that the expression evaluated against can do some extra work for a nuanced test.

There are special columns provided with each axis, one is 'index' so that exact matching can be done by position, or to ignore the actual value of the coordinate. That means we can use a form like `dimname = index < 10` to subset by position in the array index, without necessarily knowing the values along that dimension.

Value

data frame

Examples

```
f <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
l3file <- system.file("extdata/oceandata", f, package= "tidync")
## filter by value
tidync(l3file) %>% hyper_filter(lon = lon < 100)
## filter by index
tidync(l3file) %>% hyper_filter(lon = index < 100)

## be careful that multiple comparisons must occur in one expression
tidync(l3file) %>% hyper_filter(lon = lon < 100 & lon > 50)

## filter in combination/s
tidync(l3file) %>% hyper_filter(lat = abs(lat) < 10, lon = index < 100)
```

hyper_tbl_cube	<i>A dplyr cube tbl</i>
----------------	-------------------------

Description

Produce a `tbl_cube` from NetCDF. This is a delay-breaking function and causes data to be read from the source into the `tbl` cube format defined in the `dplyr` package.

Usage

```
hyper_tbl_cube(x, ...)

## S3 method for class 'tidync'
hyper_tbl_cube(x, ...)

## S3 method for class 'character'
hyper_tbl_cube(x, ...)
```

Arguments

x tidync object
 ... arguments for [hyper_filter\(\)](#)

Details

The tbl cube is a very general and arbitrarily-sized array that can be used with tidyverse functionality. Dimension coordinates are stored with the tbl cube, derived from the grid [transforms](#).

Value

tbl_cube
 dplyr::tbl_cube

See Also

[hyper_array\(\)](#) and [hyper_tibble\(\)](#) which are also delay-breaking functions that cause data to be read

Examples

```
f <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
l3file <- system.file("extdata/oceandata", f, package= "tidync")
(cube <- hyper_tbl_cube(tidync(l3file) %>%
  activate(chlor_a), lon = lon > 107, lat = abs(lat) < 30))
ufile <- system.file("extdata", "unidata", "test_hgroups.nc",
  package = "tidync", mustWork = TRUE)

## some versions of NetCDF don't support this file
## (4.1.3 tidync/issues/82)
group_nc <- try(tidync(ufile), silent = TRUE)
if (!inherits(group_nc, "try-error")) {
  res <- hyper_tbl_cube(tidync(ufile))
  print(res)
} else {
  ## the error was
  writeLines(c(group_nc))
}
```

hyper_tibble

Extract NetCDF data as an expanded table.

Description

Extract the raw array data as an expanded data frame. This can be the entire variable/s or after dimension-slicing using [hyper_filter](#) expressions with dimension values expanded appropriately for each element in the arrays (one row per element).

Usage

```
hyper_tibble(x, ..., na.rm = TRUE)

## S3 method for class 'character'
hyper_tibble(x, ..., na.rm = TRUE)

## S3 method for class 'tidync'
hyper_tibble(x, ..., na.rm = TRUE)
```

Arguments

x	NetCDF file, connection object, or tidync object
...	arguments to 'hyper_filter'
na.rm	if TRUE these rows are not included in the output when all variables are NA

Details

The function `hyper_array` will act on an existing `tidync` object or a source string. By default all variables in the active grid are returned, use `select_var` to limit.

Value

a `tbl_df`

See Also

[hyper_array\(\)](#) and [hyper_tbl_cube\(\)](#) which are also delay-breaking functions that cause data to be read

Examples

```
l3file <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
f <- system.file("extdata", "oceandata", l3file, package = "tidync")
rnc <- tidync(f)
hyper_filter(rnc)
library(dplyr)
lapply(hyper_array(f, lat = lat > 0, lon = index > 3000), dim)

ht <- hyper_tibble(rnc) %>%
  filter(!is.na(chlor_a))
ht
library(ggplot2)
ggplot(ht %>% filter(!is.na(chlor_a)),
  aes(x = lon, y = lat, fill = chlor_a)) + geom_tile()
```

hyper_transforms	<i>Axis transforms</i>
------------------	------------------------

Description

Axis 'transforms' are data frames of each dimension in a NetCDF source. `hyper_transforms` returns a list of the active transforms by default,

Usage

```
hyper_transforms(x, all = FALSE, ...)
```

```
## Default S3 method:
```

```
hyper_transforms(x, all = FALSE, ...)
```

Arguments

<code>x</code>	tidync object
<code>all</code>	set to TRUE to return all transforms, not only active ones
<code>...</code>	ignored

Details

Each transform is available by name from a list, and each data frame has the coordinate of the dimension, its index, and a 'selected' variable set by the filtering expressions in `hyper_filter` and used by the read-functions `hyper_array` and `hyper_tibble`.

Use `hyper_transforms` to interrogate and explore the available dimension manually, or for development of custom functions.

Value

list of axis transforms

Examples

```
l3file <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
f <- system.file("extdata", "oceandata", l3file, package = "tidync")
ax <- tidync(f) %>% hyper_transforms()
names(ax)
lapply(ax, dim)

## this function returns the transforms tidync knows about for this source
str(tidync(f)$transforms)
names(hyper_transforms(tidync(f), all = TRUE))
```

 hyper_vars

Grid status

Description

Functions to report on the current status of the active grid. Information on the active dimensions and variables are listed in a data frame with multiple columns.

Usage

```
hyper_vars(x, ...)
```

```
hyper_dims(x, ...)
```

```
hyper_grids(x, ...)
```

Arguments

x	tidync object
...	ignored

Details

The dimensions and variables of the active grid are identified in the [print](#) method of the tidync object, these functions exist to provide that information directly.

hyper_vars() will list the ids, data type, name, dimension number, number of attributes and and coordinate status of the variables on the currently active grid.

hyper_dims() will list the names, lengths, start/count index, ids, and status of dimensions on the currently active grid. records on the currently active dimensions.

hyper_grids() will list the names, number of dimension, and number of variables and active status of each grid in the source.

Value

data frame

Examples

```
f <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
l3file <- system.file("extdata/oceandata", f, package= "tidync")
tnc <- tidync(l3file)
hyper_vars(tnc)
hyper_dims(tnc)
hyper_dims(tnc %>% hyper_filter(lat = lat < 20))
```

```
print.tidync          Print tidync object
```

Description

Provide a summary of variables and dimensions, organized by their 'grid' (or 'shape') and with a summary of any slicing operations provided as 'start' and 'count' summaries for each dimension in the active grid.

Usage

```
## S3 method for class 'tidync'
print(x, ...)
```

Arguments

x	NetCDF object
...	reserved

Details

See [tidync](#) for detail about the object, and [hyper_vars](#) for programmatic access to the active grid's variable and dimension information.

The print summary is organized in two sections, the first is available grids (sets of dimensions) and their associated variables, the second is the dimensions, separated into active and inactive. All dimensions may be active in some NetCDF sources.

Individual *active* dimensions include the following components: * 'dim' - dimension label, D0, D1, D2, ... * 'name' - dimension name * 'length' - size of the dimension * 'min' - minimum value of the dimension * 'max' - maximum value of the dimension * 'start' - start index of subsetting * 'count' - length of subsetting index * 'dmin' - minimum value of the subset dimension * 'dmax' - maximum value of the subset dimension * 'unlim'

- indicates whether dimension is unlimited (spread across other files, usually the time-step) * 'coord_dim' - indicates whether dimension is a coordinate-dimension (i.e. listed as a 1-D grid)

The *inactive* dimension summary does not include 'start', 'count', 'dmin', 'dmax' as these are identical to the values of 1, 'length', 'min', 'max' when no array subsetting has been applied.

Examples

```
argofile <- system.file("extdata/argo/MD5903593_001.nc", package = "tidync")
argo <- tidync(argofile)
print(argo)
```

```
## the print is modified by choosing a new grid or running filters
argo %>% activate("D7,D9,D11,D8")
```

```
argo %>% hyper_filter(N_LEVELS = index > 300)
```

print.tidync_data	<i>Print tidync data</i>
-------------------	--------------------------

Description

Print method for the 'tidync_data' list of arrays returned by [hyper_array\(\)](#).

Usage

```
## S3 method for class 'tidync_data'  
print(x, ...)
```

Arguments

x	'tidync_data' object (from hyper_array())
...	reserved args

Details

The output lists the variables and their dimensions of an object from a previous call to [tidync\(\)](#), and possibly [hyper_filter\(\)](#). The available data will differ from the source in terms of variables (via `select_var` in [hyper_array](#)) and the lengths of each dimension (via named expressions in [hyper_filter\(\)](#)).

Value

the input object invisibly

See Also

[tidync_data](#)

Examples

```
argofile <- system.file("extdata/argo/MD5903593_001.nc", package = "tidync")  
argodata <- tidync(argofile) %>% hyper_filter(N_LEVELS = index < 5) %>%  
  hyper_array(select_var = c("TEMP_ADJUSTED", "PRES"))  
print(argodata)
```

tidync

*Tidy NetCDF***Description**

Connect to a NetCDF source and allow use of `hyper_*` verbs for slicing with `hyper_filter()`, extracting data with `hyper_array()` and `[hyper_tibble()]` from an activated grid. By default the largest *grid* encountered is activated, see `activate()`.

Usage

```
tidync(x, what, ...)

## S3 method for class 'character'
tidync(x, what, ...)

## S3 method for class 'tidync_data'
tidync(x, what, ...)
```

Arguments

<code>x</code>	path to a NetCDF file
<code>what</code>	(optional) character name of grid (see <code>ncmeta::nc_grids</code>) or (bare) name of variable (see <code>ncmeta::nc_vars</code>) or index of grid to activate
<code>...</code>	reserved for arguments to methods, currently ignored

Details

The print method for `tidync` includes a lot of information about which variables exist on which dimensions, and if any slicing (`hyper_filter()`) operations have occurred these are summarized as 'start' and 'count' modifications relative to the dimension lengths. See `print` for these details, and `hyper_vars` for programmatic access to this information

Many NetCDF forms are supported and `tidync` tries to reduce the interpretation applied to a given source. The NetCDF system defines a 'grid' for storing array data, where 'grid' is the array 'shape', or 'set of dimensions'). There may be several grids in a single source and so we introduce the concept of grid 'activation'. Once activated, all downstream tasks apply to the set of variables that exist on that grid.

NetCDF sources with numeric types are chosen by default, even if existing 'NC_CHAR' type variables are on the largest grid. When read any 'NC_CHAR' type variables are exploded into single character elements so that dimensions match the source.

Grids

A grid is an instance of a particular set of dimensions, which can be shared by more than one variable. This is not the 'rank' of a variable (the number of dimensions) since a single data set

may have many 3D variables composed of different sets of axes/dimensions. There's no formality around the concept of 'shape', as far as we know.

A dimension may have length zero, but this is a special case for a "measure" dimension, we think. (It doesn't mean the product of the dimensions is zero, for example).

Limitations

Files with compound types are not yet supported and should fail gracefully. Groups are not yet supported.

We haven't yet explored 'HDF5' in detail, so any feedback is appreciated. Major use of compound types is made by <https://github.com/sosoc/croc>.

Examples

```
## a SeaWiFS (S) Level-3 Mapped (L3m) monthly (MO) chlorophyll-a (CHL)
## remote sensing product at 9km resolution (at the equator)
## from the NASA ocean colour group in NetCDF4 format (.nc)
## for 31 day period January 2008 (S20080012008031)
f <- "S20080012008031.L3m_MO_CHL_chlor_a_9km.nc"
l3file <- system.file("extdata/oceandata", f, package= "tidync")
## skip on Solaris
if (!tolower(Sys.info()[["sysname"]]) == "sunos") {
  tnc <- tidync(l3file)
  print(tnc)
}

## very simple Unidata example file, with one dimension
## Not run:
uf <- system.file("extdata/unidata", "test_hgroups.nc", package = "tidync")
recNum <- tidync(uf) %>% hyper_tibble()
print(recNum)

## End(Not run)
## a raw grid of Southern Ocean sea ice concentration from IFREMER
## it is 12.5km resolution passive microwave concentration values
## on a polar stereographic grid, on 2 October 2017, displaying the
## "hole in the ice" made famous here:
## https://tinyurl.com/ycbchcgn
ifr <- system.file("extdata/ifremer", "20171002.nc", package = "tidync")
ifrnc <- tidync(ifr)
ifrnc %>% hyper_tibble(select_var = "concentration")
```

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