Package ‘gdalcubes’

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Title Earth Observation Data Cubes from Satellite Image Collections
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Description Processing collections of Earth observation images as on-demand multispectral, multitemporal raster data cubes. Users define cubes by spatiotemporal extent, resolution, and spatial reference system and let ‘gdalcubes’ automatically apply cropping, reprojection, and resampling using the ‘Geospatial Data Abstraction Library’ (‘GDAL’). Implemented functions on data cubes include reduction over space and time, applying arithmetic expressions on pixel band values, moving window aggregates over time, filtering by space, time, bands, and predicates on pixel values, exporting data cubes as ‘netCDF’ or ‘GeoTIFF’ files, plotting, and extraction from spatial and or spatiotemporal features.
All computational parts are implemented in C++, linking to the ‘GDAL’, ‘netCDF’, ‘CURL’, and ‘SQLite’ libraries.

Depends R (>= 3.4)
Imports Rcpp, jsonlite, ncdf4
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- gdalcubes_gdalformats ........................................ 35
- gdalcubes_gdalversion ....................................... 35
- gdalcubes_gdal_has_geos .................................... 36
- gdalcubes_options ............................................ 36
- gdalcubes_selection .......................................... 38
- gdalcubes_set_gdal_config .................................. 40
- gdalcubes_version ............................................ 40
- image_collection ............................................. 41
- image_mask .................................................... 41
- json_cube ...................................................... 43
- memsize ......................................................... 45
- names.cube ..................................................... 46
- nbands .......................................................... 46
- ncdf_cube ....................................................... 47
- nt ............................................................... 48
- nx ............................................................... 49
- ny ............................................................... 50
- pack_minmax ..................................................... 50
- plot.cube ....................................................... 51
- print.cube ....................................................... 53
- print.cube_view ............................................... 54
- print.image_collection ....................................... 55
- proj4 ............................................................ 55
- raster_cube ..................................................... 56
- read_chunk_as_array ......................................... 57
- reduce_space ................................................... 59
- reduce_space.array .......................................... 60
- reduce_space.cube ............................................ 61
- reduce_time .................................................... 62
- reduce_time.array ............................................ 63
- reduce_time.cube ............................................. 64
- rename_bands .................................................. 66
- select_bands ................................................... 67
- select_time ..................................................... 68
- size ............................................................. 69
- slice_space ..................................................... 70
- slice_time ...................................................... 71
- srs ............................................................. 72
- stack_cube ...................................................... 73
- stac_image_collection ....................................... 74
- st_as_stars.cube ............................................... 76
- window_time .................................................... 77
- window_time.cube ............................................. 78
- write_chunk_from_array ...................................... 79
- write_ncdf ...................................................... 80
- write_tif ....................................................... 82

Index 84
.copy_cube Create a data cube proxy object copy

Description
Copy a data cube proxy object without copying any data

Usage
.copy_cube(cube)

Arguments
cube source data cube proxy object

Details
This internal function copies the complete processing chain / graph of a data cube but does not copy any data. It is used internally to avoid in-place modification for operations with potential side effects on source data cubes.

Value
copied data cube proxy object

add_collection_format Download and install an image collection format from a URL

Description
Download and install an image collection format from a URL

Usage
add_collection_format(url, name = NULL)

Arguments
url URL pointing to the collection format JSON file
name optional name used to refer to the collection format

Details
By default, the collection format name will be derived from the basename of the URL.
add_images

Examples

```r
add_collection_format(
  "https://raw.githubusercontent.com/appelmar/gdalcubes/dev/formats/Sentinel1_IW_GRD.json"
)
```

---

**add_images**  
*Add images to an existing image collection*

**Description**

This function adds provided files or GDAL dataset identifiers and to an existing image collection by extracting datetime, image identifiers, and band information according to the collection’s format.

**Usage**

```r
add_images(
  image_collection,
  files,
  unroll_archives = TRUE,
  out_file = "",
  quiet = FALSE
)
```

**Arguments**

- `image_collection`: image_collection object or path to an existing collection file
- `files`: character vector with paths to image files on disk or any GDAL dataset identifiers (including virtual file systems and higher level drivers or GDAL sub-datasets)
- `unroll_archives`: automatically convert .zip, .tar archives and .gz compressed files to GDAL virtual file system dataset identifiers (e.g. by prepending /vsizip/) and add contained files to the list of considered files
- `out_file`: path to output file, an empty string (the default) will update the collection in-place, whereas images will be added to a new copy of the image collection at the given location otherwise.
- `quiet`: logical; if TRUE, do not print resulting image collection if return value is not assigned to a variable

**Value**

image collection proxy object, which can be used to create a data cube using `raster_cube`
Examples

```r
L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
  ".TIF", recursive = TRUE, full.names = TRUE)
L8_col = create_image_collection(L8_files[1:12], "L8_L1TP")
add_images(L8_col, L8_files[13:24])
```

---

### aggregate_time

**Aggregate data cube time series to lower temporal resolution**

### Description

Create a proxy data cube, which applies an aggregation function over pixel time series to lower temporal resolution.

### Usage

```r
aggregate_time(cube, dt, method = "mean", fact = NULL)
```

### Arguments

- `cube`: source data cube
- `dt`: character; new temporal resolution, datetime period string, e.g. "P1M"
- `method`: aggregation method, one of "mean", "min", "max", "median", "count", "sum", "prod", "var", and "sd"
- `fact`: simple integer factor defining how many cells become aggregated to a single new cell, can be used instead of `dt`

### Details

This function can be used to aggregate time series to lower resolution or to regularize a data cube with irregular (labeled) time axis. It is possible to change the unit of the temporal resolution (e.g. to create monthly composites from daily images). The size of the cube may be expanded automatically if the original temporal extent is not divisible by the new temporal size of pixels.

### Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

### Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
} else {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files[1:12], "L8_L1TP", file.path(tempdir(), "L8.db"), full.names = TRUE)
  add_images(L8_col, L8_files[13:24])
```
```r
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), srs="EPSG:32618", nx = 497, ny=526, dt="P3M", aggregation = "median")
L8.cube = raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.two_monthly = aggregate_time(L8.rgb, "P6M", "min")
L8.two_monthly

plot(L8.two_monthly, rgb=3:1, zlim=c(5000,12000))
```

---

**animate**

*Animate a data cube as an image time series*

**Description**

This function can animate data cube time series as mp4 videos or animated GIFs. Depending on the desired output format, either the `av` or the `gifski` package is needed to create mp4 and GIF animations respectively.

**Usage**

```r
animate(
  x, 
  ..., 
  fps = 1, 
  loop = TRUE, 
  width = 800, 
  height = 800, 
  save_as = tempfile(fileext = ".gif"), 
  preview = interactive()
)
```

**Arguments**

- **x** a data cube proxy object (class `cube`)
- **...** parameters passed to `plot.cube`
- **fps** frames per second of the animation
- **loop** how many iterations, TRUE = infinite
- **width** width (in pixels) of the animation
- **height** height (in pixels) of the animation
- **save_as** character path where the animation shall be stored, must end with ".mp4" or ".gif"
- **preview** logical; preview the animation
apply_pixel

Details
Animations can be created for single band data cubes or RGB plots of multi-band data cubes (by providing the argument rgb) only.

Value
character; path pointing to the the created file

See Also
plot.cube

Examples

```r
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                         bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"), 
                         srs="EPSG:32618", nx = 497, ny=526, dt="P16D")

animate(select_bands(raster_cube(L8.col, v), c("B02", "B03", "B04")), rgb=3:1, 
         zlim=c(0,20000), fps=1, loop=1)

animate(select_bands(raster_cube(L8.col, v), c("B05")), col=terrain.colors, key.pos=1)
```

apply_pixel

Apply a function over (multi-band) pixels

Description
This generic function applies a function on pixels of a data cube, an R array, or other classes if implemented.

Usage
apply_pixel(x, ...)

Arguments

<table>
<thead>
<tr>
<th>x</th>
<th>input data</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>additional arguments passed to method implementations</td>
</tr>
</tbody>
</table>
Value

return value and type depend on the class of x

See Also

apply_pixel.cube
apply_pixel.array

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

v = cube_view(extent=list(left=388941.2, right=766552.4,
                           bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

L8.col = image_collection(file.path(tempdir(), "L8.db"))
apply_pixel(raster_cube(L8.col, v), "(B05-B04)/(B05+B04)", "NDVI")

d <- c(4,16,128,128)
x <- array(rnorm(prod(d)), d)
y <- apply_pixel(x, function(v) {
})

---

apply_pixel.array  Apply a function over pixels in a four-dimensional (band, time, y, x) array

Description

Apply a function over pixels in a four-dimensional (band, time, y, x) array

Usage

## S3 method for class 'array'
apply_pixel(x, FUN, ...)

apply_pixel.array

Apply a function over pixels in a four-dimensional (band, time, y, x) array

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

v = cube_view(extent=list(left=388941.2, right=766552.4,
                           bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

L8.col = image_collection(file.path(tempdir(), "L8.db"))
apply_pixel(raster_cube(L8.col, v), "(B05-B04)/(B05+B04)", "NDVI")

d <- c(4,16,128,128)
x <- array(rnorm(prod(d)), d)
y <- apply_pixel(x, function(v) {
})
apply_pixel.cube

Arguments

- **x**
  - four-dimensional input array with dimensions band, time, y, x (in this order)

- **FUN**
  - function that receives a vector of band values in a one-dimensional array

- **...**
  - further arguments passed to FUN

Details

FUN is expected to produce a numeric vector (or scalar) where elements are interpreted as new bands in the result.

Note

This is a helper function that uses the same dimension ordering as gdalcubes. It can be used to simplify the application of R functions e.g. over time series in a data cube.

Examples

```r
D <- c(4, 16, 32, 32)
x <- array(rnorm(prod(D)), D)
y <- apply_pixel(x, function(v) {
})
dim(y)
```

apply_pixel.cube  Apply arithmetic expressions over all pixels of a data cube

Description

Create a proxy data cube, which applies arithmetic expressions over all pixels of a data cube. Expressions may access band values by name.

Usage

```r
## S3 method for class 'cube'
apply_pixel(x, expr, names = NULL, keep_bands = FALSE, ..., FUN)
```

Arguments

- **x**
  - source data cube

- **expr**
  - character vector with one or more arithmetic expressions (see Details)

- **names**
  - optional character vector with the same length as expr to specify band names for the output cube

- **keep_bands**
  - logical; keep bands of input data cube, defaults to FALSE, i.e. original bands will be dropped

- **...**
  - not used

- **FUN**
  - user-defined R function that is applied on all pixels (see Details)
**apply_pixel.cube**

**Details**

The function can either apply simple arithmetic C expressions given as a character vector (`expr` argument), or apply a custom R reducer function if `FUN` is provided.

In the former case, gdalcubes uses the tinyexpr library to evaluate expressions in C / C++, you can look at the library documentation to see what kind of expressions you can execute. Pixel band values can be accessed by name.

`FUN` receives values of the bands from one pixel as a (named) vector and should return a numeric vector with identical length for all pixels. Elements of the result vectors will be interpreted as bands in the result data cube.

**Value**

a proxy data cube object

**Note**

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         
".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

# 1. Apply a C expression
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
L8.ndvi = apply_pixel(L8.cube, 
"(B05-B04)/(B05+B04)", "NDVI")
L8.ndvi

plot(L8.ndvi)

# 2. Apply a user defined R function
L8.ndvi.noisy = apply_pixel(L8.cube, names="NDVI_noisy",
FUN=function(x) {
  rnorm(1, 0, 0.1) + (x["B04"]-x["B04"])/(x["B05"]+x["B04"])
})
L8.ndvi.noisy
```
apply_time

apply_time(x, ...)

Arguments

x: input data
...
additional arguments passed to method implementations

Value

return value and type depend on the class of x

See Also

apply_time.cube
apply_time.array

Examples

# 1. input is data cube
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
V = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, V)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
apply_time.array

L8.ndvi = apply_pixel(L8.cube, "(B05-B04)/(B05+B04)", "NDVI")

# Apply a user defined R function
apply_time(L8.ndvi, names="NDVI_residuals",
    FUN=function(x) {
        y = x["NDVI",]
        if (sum(is.finite(y)) < 3) {
            return(rep(NA,ncol(x)))
        }
        t = 1:ncol(x)
        return(predict(lm(y ~ t)) - x["NDVI",])
    })

# 2. input is array
d <- c(4,16,32,32)
x <- array(rnorm(prod(d)), d)
z <- apply_time(x, function(v) {
    y = matrix(NA, ncol=ncol(v), nrow=2)
    y[1,] = (v[1,] + v[2,]) / 2
    y[2,] = (v[3,] + v[4,]) / 2
    y
})
dim(z)

apply_time.array

Apply a function over pixel time series in a four-dimensional (band, time, y, x) array

Description

Apply a function over pixel time series in a four-dimensional (band, time, y, x) array

Usage

## S3 method for class 'array'
apply_time(x, FUN, ...)

Arguments

x four-dimensional input array with dimensions band, time, y, x (in this order)
FUN function that receives a vector of band values in a one-dimensional array
... further arguments passed to FUN

Details

FUN is expected to produce a matrix (or vector if result has only one band) where rows are interpreted as new bands and columns represent time.
Note

This is a helper function that uses the same dimension ordering as gdalcubes. It can be used to simplify the application of R functions e.g. over time series in a data cube.

Examples

d <- c(4,16,32,32)
x <- array(rnorm(prod(d)), d)
z <- apply_time(x, function(v) {
  y = matrix(NA, ncol=ncol(v), nrow=2)
  y[1,] = (v[1,] + v[2,]) / 2
  y[2,] = (v[3,] + v[4,]) / 2
  y
})
dim(z)

apply_time.cube

Apply a user-defined R function over (multi-band) pixel time series

Description

Create a proxy data cube, which applies a user-defined R function over all pixel time series of a data cube. In contrast to reduce_time, the time dimension is not reduced, i.e., resulting time series must have identical length as the input data cube but may contain a different number of bands / variables. Example uses of this function may include time series decompositions, cumulative sums / products, smoothing, sophisticated NA filling, or similar.

Usage

## S3 method for class 'cube'
apply_time(x, names = NULL, keep_bands = FALSE, FUN, ...)

Arguments

- **x**: source data cube
- **names**: optional character vector to specify band names for the output cube
- **keep_bands**: logical; keep bands of input data cube, defaults to FALSE, i.e., original bands will be dropped
- **FUN**: user-defined R function that is applied on all pixel time series (see Details)
- **...**: not used

Details

FUN receives a single (multi-band) pixel time series as a matrix with rows corresponding to bands and columns corresponding to time. In general, the function must return a matrix with the same number of columns. If the result contains only a single band, it may alternatively return a vector with length identical to the length of the input time series (number of columns of the input).
as_array

Value

a proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                          bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"), 
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
L8.ndvi = apply_pixel(L8.cube, 
                       "(B05-B04)/(B05+B04)", "NDVI")
L8.ndvi.resid = apply_time(L8.ndvi, names="NDVI_residuals", 
                           FUN=function(x) {
                           y = x["NDVI",]
                           if (sum(is.finite(y)) < 3) {
                               return(rep(NA,ncol(x)))
                           }
                           t = 1:ncol(x)
                           return(predict(lm(y ~ t)) - x["NDVI",])
                       })
plot(L8.ndvi.resid)

as_array

Convert a data cube to an in-memory R array

Description

Convert a data cube to an in-memory R array
Usage

`as_array(x)`

Arguments

`x`  
data cube

Value

Four dimensional array with dimensions band, t, y, x

Note

Depending on the data cube size, this function may require substantial amounts of main memory, i.e. it makes sense for small data cubes only.

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-05"),
              srs="EPSG:32618", nx = 100, ny=100, dt="P1M")

as_array(select_bands(raster_cube(L8.col, v), c("B04", "B05")))
```

Description

gdalcubes uses a graph (currently a tree) to serialize data cubes (including chains of cubes). This function gives a JSON representation, which will be communicated to gdalcubes_server instances to create identical cube instances remotely.

Usage

`as_json(obj)`
bands

Arguments

obj a data cube proxy object (class cube)

Value

A JSON string representing a graph (currently a tree) that can be used to create the same chain of gdalcubes operations.

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-04"),
                          srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
cat(as_json(select_bands(raster_cube(L8.col, v), c("B04", "B05"))))
```

---

## bands

Query data cube properties

### Description

Query data cube properties

### Usage

```
bands(obj)
```

### Arguments

- **obj** a data cube proxy object (class cube)

### Value

A data.frame with rows representing the bands and columns representing properties of a band (name, type, scale, offset, unit)
chunk_apply

Apply an R function on chunks of a data cube

Description

Apply an R function on chunks of a data cube

Usage

chunk_apply(cube, f)

Arguments

cube source data cube
f R function to apply over all chunks

Details

This function internally creates a gdalcubes stream data cube, which streams data of a chunk to a new R process. For reading data, the function typically calls x <- read_chunk_as_array() which then results in a 4 dimensional (band, time, y, x) array. Similarly write_chunk_from_array(x) will write a result array as a chunk in the resulting data cube. The chunk size of the input cube is important to control how the function will be exposed to the data cube. For example, if you want to apply an R function over complete pixel time series, you must define the chunk size argument in raster_cube to make sure that chunk contain the correct parts of the data.

Value

a proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.
Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
f <- function() {
  x <- read_chunk_as_array()
  out <- reduce_time(x, function(x) {
    cor(x[1,], x[2,], use="na.or.complete", method = "kendall")
  })
  write_chunk_from_array(out)
}
L8.cor = chunk_apply(L8.cube, f)
```

---

**collection_formats**  
**List predefined image collection formats**

**Description**

gdalubes comes with some predefined collection formats e.g. to scan Sentinel 2 data. This function lists available formats including brief descriptions.

**Usage**

collection_formats(print = TRUE)

**Arguments**

- **print**: logical; should available formats and their descriptions be printed nicely, defaults to TRUE

**Details**

Image collection formats define how individual files / GDAL datasets relate to an image collection, i.e., which bands they contain, to which image they belong, and how to derive acquisition date/time. They are described as a set of regular expressions in a JSON file and used by gdalcubes to extract this information from the paths and/or filenames.
Value

data.frame with columns name and description where the former describes the unique identifier that can be used in `create_image_collection` and the latter gives a brief description of the format.

Examples

```r
collection_formats()
```

`create_image_collection`

*Create an image collection from a set of GDAL datasets or files*

Description

This function iterates over files or GDAL dataset identifiers and extracts datetime, image identifiers, and band information according to a given collection format.

Usage

```r
create_image_collection(
  files,
  format = NULL,
  out_file = tempfile(fileext = ".sqlite"),
  date_time = NULL,
  band_names = NULL,
  use_subdatasets = FALSE,
  unroll_archives = TRUE,
  quiet = FALSE
)
```

Arguments

- **files**: character vector with paths to image files on disk or any GDAL dataset identifiers (including virtual file systems and higher level drivers or GDAL subdatasets)
- **format**: collection format, can be either a name to use predefined formats (as output from `collection_formats`) or a path to a custom JSON format description file
- **out_file**: optional name of the output SQLite database file, defaults to a temporary file
- **date_time**: vector with date/time for files; can be of class character, Date, or POSIXct (argument is only applicable for image collections without collection format)
- **band_names**: character vector with band names, length must match the number of bands in provided files (argument is only applicable for image collections without collection format)
- **use_subdatasets**: logical; use GDAL subdatasets of provided files (argument is only applicable for image collections without collection format)
unroll_archives

automatically convert .zip, .tar archives and .gz compressed files to GDAL virtual file system dataset identifiers (e.g. by prepending /vsizip/) and add contained files to the list of considered files

quiet

logical; if TRUE, do not print resulting image collection if return value is not assigned to a variable

Details

An image collection is a simple SQLite database file that indexes and references existing image files / GDAL dataset identifiers.

Collections can be created in two different ways: First, if a collection format is specified (argument format), date/time, bands, and metadata are automatically extracted from provided files / GDAL datasets. Second, image collections can be created without collection format by manually specifying date/time of images (argument date_time) and (optional) names of bands. In this case, however, all provided images must contain the same bands. If this is not possible for a dataset, a collection format must be used.

Value

image collection proxy object, which can be used to create a data cube using raster_cube

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

crop

Crop data cube extent by space and/or time

Description

Create a proxy data cube, which crops a data cube by a spatial and/or temporal extent.

Usage

crop(cube, extent = NULL, iextent = NULL, snap = "near")
Arguments

- **cube**: source data cube
- **extent**: list with numeric items left, right, top, bottom, and character items t0 and t1, or a subset thereof, see examples
- **iextent**: list with length-two integer items named x, y, and t, defining the lower and upper boundaries as integer coordinates, see examples
- **snap**: one of 'near', 'in', or 'out'; ignored if using iextent

Details

The new extent can be specified by spatial coordinates and datetime values (using the **extent** argument), or as zero-based integer indexes (using the **iextent** argument). In the former case, **extent** expects a list with numeric items left, right, top, bottom, t0, and t1, or a subset thereof. In the latter case, **iextent** is expected as a list with length-two integer vectors x, y, and t as items, defining the lower and upper cell indexes per dimension.

Notice that it is possible to crop only selected boundaries (e.g., only the right boundary) as missing boundaries in the **extent** or NA / NULL values in the **iextent** arguments are considered as "no change". It is, however, not possible to mix arguments **extent** and **iextent**.

If **extent** is given, the **snap** argument can be used to define what happens if the new boundary falls within a data cube cell.

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P3M", aggregation = "median")
L8.rgb = select_bands(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.cube = raster_cube(L8.rgb, mask=image_mask("BQA", bits=4, values=16))

# crop by integer indexes
L8.cropped = crop(L8.rgb, iextent = list(x=c(0,400), y=c(0,400), t=c(1,1)))

# crop by spatiotemporal coordinates
L8.cropped = crop(L8.rgb, extent = list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"), snap = "in")
L8.cropped
```
L8.cropped = crop(L8.rgb, extent = list(left=388941.2, right=766552.4, bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"), snap = "near")
L8.cropped

plot(L8.cropped, rgb = 3:1, zlim=c(5000,10000))

---

**cube_view**

Create or update a spatiotemporal data cube view

**Description**

Data cube views define the shape of a cube, i.e., the spatiotemporal extent, resolution, and spatial reference system (srs). They are used to access image collections as on-demand data cubes. The data cube will filter images based on the view’s extent, read image data at the defined resolution, and warp / reproject images to the target srs automatically.

**Usage**

```r
cube_view(
  view,  # if provided, update this cube_view object instead of creating a new data cube view where fields that are already set will be overwritten
  extent,  # spatioptemporal extent as a list e.g. from extent or an image collection object, see Details
  srs,  # target spatial reference system as a string; can be a proj4 definition, WKT, or in the form "EPSG:XXXX"
  nx,  # number of pixels in x-direction (longitude / easting)
  ny,  # number of pixels in y-direction (latitude / northing)
  nt,  # number of pixels in t-direction (time)
  dx,  # size of pixels in x-direction (longitude / easting)
  dy,  # size of pixels in y-direction (latitude / northing)
  dt,  # size of pixels in t-direction (time)
  aggregation,  # aggregation method if any
  resampling,  # resampling method if any
  keep.asp = TRUE  # if TRUE, keep the attribute set consistence
)```

**Arguments**

- **view**: if provided, update this cube_view object instead of creating a new data cube view where fields that are already set will be overwritten.
- **extent**: spatioptemporal extent as a list e.g. from `extent` or an image collection object, see Details.
- **srs**: target spatial reference system as a string; can be a proj4 definition, WKT, or in the form "EPSG:XXXX".
- **nx**: number of pixels in x-direction (longitude / easting).
- **ny**: number of pixels in y-direction (latitude / northing).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nt</td>
<td>number of pixels in t-direction</td>
</tr>
<tr>
<td>dx</td>
<td>size of pixels in x-direction (longitude / easting)</td>
</tr>
<tr>
<td>dy</td>
<td>size of pixels in y-direction (latitude / northing)</td>
</tr>
<tr>
<td>dt</td>
<td>size of pixels in time-direction, expressed as ISO8601 period string (only 1 number and unit is allowed) such as &quot;P16D&quot;</td>
</tr>
<tr>
<td>aggregation</td>
<td>aggregation method as string, defining how to deal with pixels containing data from multiple images, can be &quot;min&quot;, &quot;max&quot;, &quot;mean&quot;, &quot;median&quot;, or &quot;first&quot;</td>
</tr>
<tr>
<td>resampling</td>
<td>resampling method used in gdalwarp when images are read, can be &quot;near&quot;, &quot;bilinear&quot;, &quot;bicubic&quot; or others as supported by gdalwarp (see <a href="https://gdal.org/programs/gdalwarp.html">https://gdal.org/programs/gdalwarp.html</a>)</td>
</tr>
<tr>
<td>keep.asp</td>
<td>if TRUE, derive ny or dy automatically from nx or dx (or vice versa) based on the aspect ratio of the spatial extent</td>
</tr>
</tbody>
</table>

**Details**

The `extent` argument expects a simple list with elements `left`, `right`, `bottom`, `top`, `t0` (start date/time), `t1` (end date/time) or an image collection object. In the latter case, the `extent` function is automatically called on the image collection object to get the full spatiotemporal extent of the collection. In the former case, datetimes are expressed as ISO8601 datetime strings.

The function can be used in two different ways. First, it can create data cube views from scratch by defining the extent, the spatial reference system, and for each dimension either the cell size (dx, dy, dt) or the total number of cells (nx, ny, nt). Second, the function can update an existing data cube view by overwriting specific fields. In this case, the extent or some elements of the extent may be missing.

In some cases, the extent of the view is automatically extended if the provided resolution would end within a pixel. For example, if the spatial extent covers an area of 1km x 1km and dx = dy = 300m, the extent would be enlarged to 1.2 km x 1.2km. The alignment will be reported to the user in a diagnostic message.

**Value**

A list with data cube view properties

**Examples**

```r
L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
  ".TIF", recursive = TRUE, full.names = TRUE)
L8.col = create_image_collection(L8_files, "L8_L1TP")

# 1. Create a new data cube view specification
v = cube_view(extent=extent(L8.col,"EPSG:4326"), 
  srs="EPSG:4326", dt="P1M", 
  nx=1000, ny=500, aggregation = "mean", resampling="bilinear")

# 2. overwrite parts of an existing data cube view
vnew = cube_view(v, dt="P1M")
```
dim.cube

Query data cube properties

Description
Query data cube properties

Usage

```r
## S3 method for class 'cube'
dim(x)
```

Arguments

- `x` a data cube proxy object (class `cube`)

Value

size of a data cube (number of cells) as integer vector in the order `t, y, x`

See Also

- `size`

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                           bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

dim(raster_cube(L8.col, v))
```
dimensions  

Query data cube properties

Description

Query data cube properties

Usage

dimensions(obj)

Arguments

obj  
a data cube proxy object (class cube)

Details

Elements of the returned list represent individual dimensions with properties such as dimension boundaries, names, and chunk size stored as inner lists

Value

Dimension information as a list

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
dimensions(raster_cube(L8.col, v))
dimension_bounds

Query coordinate bounds for all dimensions of a data cube

Description

Dimension values give the coordinates bounds the spatial and temporal axes of a data cube.

Usage

dimension_bounds(obj, datetime_unit = NULL)

Arguments

obj    a data cube proxy (class cube)
datetime_unit    unit used to format values in the datetime dimension, one of "Y", "m", "d", "H", "M", "S", defaults to the unit of the cube.

Value

list with elements t,y,x, each a list with two elements, start and end

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                         bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
dimension_bounds(raster_cube(L8.col, v))

dimension_values

Query coordinate values for all dimensions of a data cube

Description

Dimension values give the coordinates along the spatial and temporal axes of a data cube.

Usage

dimension_values(obj, datetime_unit = NULL)
Arguments

obj  a data cube proxy (class cube), or a data cube view object

datetime_unit  unit used to format values in the datetime dimension, one of "Y", "m", "d", "H", "M", "S", defaults to the unit of the cube.

Value

list with elements t,y,x

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
dimension_values(raster_cube(L8.col, v))
extract_geom

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
estent(L8.col,"EPSG:32618")
cube_view(extent=extent(L8.col,"EPSG:32618"),
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

---

Extract values from a data cube by spatial or spatiotemporal features

Description

Extract pixel values of a data cube from a set of spatial or spatiotemporal features. Applications include the extraction of full time series at irregular points, extraction from spatiotemporal points, extraction of pixel values in polygons, and computing summary statistics over polygons.

Usage

extract_geom(
  cube,
  sf,
  datetime = NULL,
  time_column = NULL,
  FUN = NULL,
  ...
)

Arguments

cube  source data cube to extract values from
sf  object of class sf, see sf package
datetime  Date, POSIXt, or character vector containing per feature time information; length must be identical to the number of features in sf
time_column  name of the column in sf containing per feature time information
FUN  optional function to compute per feature summary statistics
...  additional arguments passed to FUN
reduce_time  logical; if TRUE, time is ignored when FUN is applied
Details

The geometry in \textit{sf} can be of any simple feature type supported by GDAL, including POINTS, LINES, POLYGONS, MULTI*, and more. If no time information is provided in one of the arguments \textit{datetime} or \textit{time_column}, the full time series of pixels with regard to the features are returned.

Pixels with missing values are automatically dropped from the result. It is hence not guaranteed that the result will contain rows for all input features.

Features are automatically reprojected if the coordinate reference system differs from the data cube.

Extracted values can be aggregated by features by providing a summary function. If \textit{reduce\_time} is FALSE (the default), the values are grouped by feature and time, i.e., the result will contain unique combinations of FID and time. To ignore time and produce a single value per feature, \textit{reduce\_time} can be set to TRUE.

Value

A \texttt{data.frame} with columns FID, time, and data cube bands / variables

Examples

```r
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(srs="EPSG:32618", dy=1000, dx=1000, dt="P1M",
              aggregation = "median", resampling = "bilinear",
              extent=list(left=388941.2, right=766552.4,
                           bottom=4345299, top=4744931,
                           t0="2018-01-01", t1="2018-04-30"))

L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
L8.ndvi = apply_pixel(L8.cube, 
                      (B05-B04)/(B05+B04), "NDVI")
L8.ndvi

if (gdalcubes_gdal_has_geos()) {
  if (requireNamespace("sf", quietly = TRUE)) {
    x = runif(20, v$space$left, v$space$right)
    y = runif(20, v$space$bottom, v$space$top)
    t = sample(seq(as.Date("2018-01-01"), as.Date("2018-04-30"), by = 1), 20, replace = TRUE)
    df = sf::st_as_sf(data.frame(x = x, y = y), coords = c("x", "y"), crs = v$space$srs)

    # spatiotemporal points
    extract_geom(L8.ndvi, df, datetime = t)

    # time series at spatial points
    extract_geom(L8.ndvi, df)
  }
}
```
# summary statistics over polygons
x = sf::st_read(system.file("nycd.gpkg", package = "gdalcubes"))
zstats = extract_geom(L8.ndvi, x, FUN=median, reduce_time = TRUE)
zstats

# combine with original sf object
x$FID = rownames(x)
x = merge(x, zstats, by = "FID")
x
# plot(x["NDVI"])
}
}

---

**fill_time**  
*Fill NA data cube pixels by simple time series interpolation*

**Description**
Create a proxy data cube, which fills NA pixels of a data cube by nearest neighbor or linear time series interpolation.

**Usage**

```r
fill_time(cube, method = "near")
```

**Arguments**

- `cube`: source data cube
- `method`: interpolation method, can be "near" (nearest neighbor), "linear" (linear interpolation), "locf" (last observation carried forward), or "nocb" (next observation carried backward)

**Details**
Please notice that completely empty (NA) time series will not be filled, i.e. the result cube might still contain NA values.

**Value**
a proxy data cube object

**Note**
This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.
Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
  srs="EPSG:32618", nx = 497, ny=526, dt="P3M", aggregation = "median")
L8.cube = raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.filled = fill_time(L8.rgb, "linear")
L8.filled

plot(L8.filled, rgb=3:1, zlim=c(5000,12000))

filter_geom

Filter data cube pixels by a polygon

Description

Create a proxy data cube, which filters pixels by a spatial (multi)polygon For all pixels whose center is within the polygon, the original

Usage

filter_geom(cube, geom, srs = NULL)

Arguments

cube source data cube
geom either a WKT string, or an sfc or sfg object (sf package)
srs string identifier of the polygon’s coordinate reference system understandable for GDAL

Details

The resulting data cube will not be cropped but pixels outside of the polygon will be set to NAN.
If geom is provided as an sfc object with length > 1, geometries will be combined with sf::st_combine() before.
The geometry is automatically transformed to the data cube’s spatial reference system if needed.
**filter_pixel**

Filter data cube pixels by a user-defined predicate on band values

<table>
<thead>
<tr>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a proxy data cube object</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td># create image collection from example Landsat data only</td>
</tr>
<tr>
<td># if not already done in other examples</td>
</tr>
<tr>
<td>if (!file.exists(file.path(tempdir(), &quot;L8.db&quot;))) {</td>
</tr>
<tr>
<td>L8_files &lt;- list.files(system.file(&quot;L8NY18&quot;, package = &quot;gdalcubes&quot;),</td>
</tr>
<tr>
<td>&quot;TIF&quot;, recursive = TRUE, full.names = TRUE)</td>
</tr>
<tr>
<td>create_image_collection(L8_files, &quot;L8_L1TP&quot;, file.path(tempdir(), &quot;L8.db&quot;))</td>
</tr>
<tr>
<td>}</td>
</tr>
<tr>
<td>L8.col = image_collection(file.path(tempdir(), &quot;L8.db&quot;))</td>
</tr>
<tr>
<td>v = cube_view(extent=list(left=388941.2, right=766552.4,</td>
</tr>
<tr>
<td>bottom=4345299, top=4744931, t0=&quot;2018-01&quot;, t1=&quot;2018-06&quot;),</td>
</tr>
<tr>
<td>srs=&quot;EPSG:32618&quot;, nx = 497, ny=526, dt=&quot;P1M&quot;)</td>
</tr>
<tr>
<td>L8.cube = raster_cube(L8.col, v)</td>
</tr>
<tr>
<td>L8.ndvi = apply_pixel(L8.cube, &quot;(B05-B04)/(B05+B04)&quot;, &quot;NDVI&quot;)</td>
</tr>
<tr>
<td>WKT = gsub(pattern=&quot;/quotesingle.Var\n/quotesingle.Var&quot;,replacement=&quot;&quot;,x =</td>
</tr>
<tr>
<td>&quot;Polygon ((-74.3541 40.9254,</td>
</tr>
<tr>
<td>-73.9813 41.2467,</td>
</tr>
<tr>
<td>-73.9997 41.4400,</td>
</tr>
<tr>
<td>-74.5362 41.1795,</td>
</tr>
<tr>
<td>-74.6286 40.9137,</td>
</tr>
<tr>
<td>-74.3541 40.9254))&quot;)</td>
</tr>
<tr>
<td>L8.ndvi.filtered = filter_geom(L8.ndvi, WKT, &quot;EPSG:4326&quot;)</td>
</tr>
<tr>
<td>L8.ndvi.filtered</td>
</tr>
<tr>
<td>plot(L8.ndvi.filtered)</td>
</tr>
</tbody>
</table>

---

**Description**

Create a proxy data cube, which evaluates a predicate over all pixels of a data cube. For all pixels that fulfill the predicate, the original band values are returned. Other pixels are simply filled with NANS. The predicate may access band values by name.

**Usage**

`filter_pixel(cube, pred)`
Arguments

cube source data cube
pred predicate to be evaluated over all pixels

Details

gdalubes uses and extends the tinyexpr library to evaluate expressions in C / C++, you can look at the library documentation to see what kind of expressions you can execute. Pixel band values can be accessed by name.

Value

a proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                          bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"), 
                          srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
L8.ndvi = apply_pixel(L8.cube, "(B05-B04)/(B05+B04)", "NDVI")
L8.ndvi.filtered = filter_pixel(L8.ndvi, "NDVI > 0.5")
L8.ndvi.filtered

plot(L8.ndvi.filtered)
Description

Processing collections of Earth observation images as on-demand multispectral, multitemporal raster data cubes. Users define cubes by spatiotemporal extent, resolution, and spatial reference system and let ‘gdalcubes’ automatically apply cropping, reprojection, and resampling using the 'Geospatial Data Abstraction Library' ('GDAL'). Implemented functions on data cubes include reduction over space and time, applying arithmetic expressions on pixel band values, moving window aggregates over time, filtering by space, time, bands, and predicates on pixel values, exporting data cubes as ‘netCDF’ or ‘GeoTIFF’ files, plotting, and extraction from spatial and or spatiotemporal features. All computational parts are implemented in C++, linking to the 'GDAL', 'netCDF', 'CURL', and 'SQLite' libraries. See Appel and Pebesma (2019) <doi:10.3390/data4030092> for further details.

---

gdalcubes_gdalformats  Get available GDAL drivers

Description

Get available GDAL drivers

Usage

gdalcubes_gdalformats()

Examples

gdalcubes_gdalformats()

---

gdalcubes_gdalversion  Get the GDAL version used by gdalcubes

Description

Get the GDAL version used by gdalcubes

Usage

gdalcubes_gdalversion()

Examples

gdalcubes_gdalversion()
gdalcubes_gdal_has_geos

*Check if GDAL was built with GEOS*

**Description**
Check if GDAL was built with GEOS

**Usage**
```r
gdalcubes_gdal_has_geos()
```

**Examples**
```r
gdalcubes_gdal_has_geos()
```

gdalcubes_options

*Set or read global options of the gdalcubes package*

**Description**
Set global package options to change the default behavior of gdalcubes. These include how many parallel processes are used to process data cubes, how created netCDF files are compressed, and whether or not debug messages should be printed.

**Usage**
```r
gdalcubes_options(
  ..., 
  parallel,
  ncdf_compression_level,
  debug,
  cache,
  ncdf_write_bounds,
  use_overview_images,
  show_progress,
  default_chunksize,
  streaming_dir,
  log_file,
  threads
)
```
Arguments

... not used
parallel number of parallel workers used to process data cubes or TRUE to use the number of available cores automatically
ncdf_compression_level integer; compression level for created netCDF files, 0=no compression, 1=fast compression, 9=small compression
debug logical; print debug messages
cache logical; TRUE if temporary data cubes should be cached to support fast reprocessing of the same cubes
ncdf_write_bounds logical; write dimension bounds as additional variables in netCDF files
use_overview_images logical; if FALSE, all images are read on original resolution and existing overviews will be ignored
show_progress logical; if TRUE, a progress bar will be shown for actual computations
default_chunksize length-three vector with chunk size in t, y, x directions or a function taking a data cube size and returning a suggested chunk size
streaming_dir directory where temporary binary files for process streaming will be written to
log_file character, if empty string or NULL, diagnostic messages will be printed to the console, otherwise to the provided file
threads number of threads used to process data cubes (deprecated)

Details

Data cubes can be processed in parallel where the number of chunks in a cube is distributed among parallel worker processes. The actual number of used workers can be lower if a data cube as less chunks. If parallel is TRUE, the number of available cores is used. Setting parallel = FALSE can be used to disable parallel processing. Notice that since version 0.6.0, separate processes are being used instead of parallel threads to avoid possible R session crashes due to some multithreading issues.

Caching has no effect on disk or memory consumption, it simply tries to reuse existing temporary files where possible. For example, changing only parameters to plot will void reprocessing the same data cube if cache is TRUE.

The streaming directory can be used to control the performance of user-defined functions, if disk IO is a bottleneck. Ideally, this can be set to a directory on a shared memory device.

Passing no arguments will return the current options as a list.

Examples

gdalcubes_options(parallel=4) # set the number
gdalcubes_options() # print current options
gdalcubes_options(parallel=FALSE) # reset
gdalcubes_selection  

Select a data cube band by name

Description
Select a data cube band by name
Extract a subset of a data cube

Usage

```r
## S3 method for class 'cube'
x$name

## S3 method for class 'cube'
cube[ib = TRUE, it = TRUE, iy = TRUE, ix = TRUE, ...]
```

Arguments

- `x` source data cube
- `name` character; name of selected band
- `cube` source data cube
- `ib` first selector (optional), object of type character, list, Date, POSIXt, numeric, `st_bbox`), or `st_sfc`), see Details and examples
- `it` second selector (optional), see `ib`
- `iy` third selector (optional), see `ib`
- `ix` fourth selector (optional), see `ib`
- `...` further arguments, not used

Details
The `[` operator allows for flexible subsetting of data cubes by date, datetime, bounding box, spatial points, and band names. Depending on the arguments, it supports slicing (selecting one element of a dimension) and cropping (selecting a subinterval of a dimension) and combinations thereof (e.g., selecting a spatial window and a temporal slice). Dimension subsets can be specified by integer indexes or coordinates / datetime values. Arguments are matched by type and order. For example, if the first argument is a length-two vector of type Date, the function will realize that this is for subsetting the time dimension. If needed, arguments are treated in the order band, time, y, x.

Note
This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.
This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.
Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                        bottom=4345299, top=4744931, t0="2018-01-01", t1="2018-12-31"),
srs="EPSG:32618", nx = 497, ny=526, dt="P1D", aggregation = "median")
L8.cube = raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.red = L8.cube$B04

plot(L8.red)

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                        bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
srs="EPSG:32618", nx = 497, ny=526, dt="P3M", aggregation = "median")
L8.cube = raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.cube[c("B05","B04")]
L8.cube[as.Date(c("2018-01-10", "2018-01-20"))] # crop by time
L8.cube[as.Date("2018-01-10")]
L8.cube["B05", "2018-01-10"]
L8.cube["B05", c("2018-01-10","2018-01-17")]
L8.cube[, c("2018-01-10","2018-01-17")]
L8.cube[,,c(1,100), c(1,100)]
L8.cube[,c(1,2),,] # crop by time (integer indexes)
L8.cube[as.Date(c("2018-01-10", "2018-01-20"))] # slice by time
L8.cube["B05", c("2018-01-10","2018-01-17")]
L8.cube[, c("2018-01-10","2018-01-17")]
L8.cube[,,c(1,100), c(1,100)]

L8.cube[as.Date(c("2018-01-10", "2018-01-20"))] # slice by time
L8.cube[as.Date("2018-01-10")]
L8.cube[,,c(1,100), c(1,100)]
L8.cube[,c(1,2),,] # crop by time (integer indexes)
L8.cube[as.Date(c("2018-01-10", "2018-01-20"))] # slice by time
L8.cube[as.Date("2018-01-10")]
L8.cube[,,c(1,100), c(1,100)]
L8.cube[,c(1,2),,] # crop by time (integer indexes)

# select by spatial point or bounding box
if (requireNamespace("sf", quietly = TRUE)) {
  s = sf::st_sfc(sf::st_point(c(500000, 4500000)), crs = "EPSG:32618")
  L8.cube[s]

  bbox = sf::st_bbox(c(xmin = 388941.2 + 1e5, xmax = 766552.4 - 1e5,
                     ymin = 4744931 - 1e5, ymax = 4345299 + 1e5), crs = sf::st_crs(32618))
  L8.cube[bbox]
}
gdalcubes_set_gdal_config

Set GDAL config options

Description

Set GDAL config options

Usage

gdalcubes_set_gdal_config(key, value)

Arguments

<table>
<thead>
<tr>
<th>key</th>
<th>name of a GDAL config option to be set</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>value</td>
</tr>
</tbody>
</table>

Details

Details and a list of possible options can be found at https://gdal.org/user/configoptions.html.

Examples

gdalcubes_set_gdal_config("GDAL_NUM_THREADS", "ALL_CPUS")

---

gdalcubes_version

Query gdalcubes version information

Description

Query gdalcubes version information

Usage

gdalcubes_version()

Value

List with gdalcubes library version information

Examples

gdalcubes_version()
**image_collection**

*Load an existing image collection from a file*

**Description**

This function will load an image collection from an SQLite file. Image collection files index and reference existing imagery. To create a collection from files on disk, use `create_image_collection`.

**Usage**

``` r
image_collection(path)
```

**Arguments**

- **path**
  - path to an existing image collection file

**Value**

an image collection proxy object, which can be used to create a data cube using `raster_cube`

**Examples**

``` r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
L8.col
```

---

**image_mask**

*Create a mask for images in a raster data cube*

**Description**

Create an image mask based on a band and provided values to filter pixels of images read by `raster_cube`
Usage

```r
image_mask(
  band,
  min = NULL,
  max = NULL,
  values = NULL,
  bits = NULL,
  invert = FALSE
)
```

Arguments

- **band**: name of the mask band
- **min**: minimum value, values between min and max will be masked
- **max**: maximum value, values between min and max will be masked
- **values**: numeric vector; specific values that will be masked.
- **bits**: for bitmasks, extract the given bits (integer vector) with a bitwise AND before filtering the mask values, bit indexes are zero-based
- **invert**: logical; invert mask

Details

Values of the selected mask band can be based on a range (by passing min and max) or on a set of values (by passing values). By default pixels with mask values contained in the range or in the values are masked out, i.e. set to NA. Setting invert = TRUE will invert the masking behavior. Passing values will override min and max.

Note

Notice that masks are applied per image while reading images as a raster cube. They can be useful to eliminate e.g. cloudy pixels before applying the temporal aggregation to merge multiple values for the same data cube pixel.

Examples

```r
image_mask("SCL", values = c(3,8,9)) # Sentinel 2 L2A: mask cloud and cloud shadows
image_mask("BQA", bits=4, values=16) # Landsat 8: mask clouds
image_mask("B10", min = 8000, max=65000)
```
join_bands

Join bands of two identically shaped data cubes

Description

Create a proxy data cube, which joins the bands of two identically shaped data cubes. The resulting cube will have bands from both input cubes.

Usage

join_bands(cube_list, cube_names = NULL)

Arguments

cube_list a list with two or more source data cubes
cube_names list or character vector with optional name prefixes for bands in the output data cube (see Details)

Details

The number of provided cube_names must match the number of provided input cubes. If no cube_names are provided, bands of the output cube will adopt original names from the input cubes (without any prefix). If any two of the input bands have identical names, prefixes default prefixes ("X1", "X2", ...) will be used.

Value

proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-05"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.cube.b04 = select_bands(raster_cube(L8.col, v), c("B04"))
L8.cube.b05 = select_bands(raster_cube(L8.col, v), c("B05"))
join_bands(list(L8.cube.b04, L8.cube.b05))

plot(join_bands(list(L8.cube.b04, L8.cube.b05)))

---

**json_cube**

Read a data cube from a json description file

**Description**

Read a data cube from a json description file

**Usage**

`json_cube(json, path = NULL)`

**Arguments**

- `json` length-one character vector with a valid json data cube description
- `path` source data cube proxy object

**Details**

Data cubes can be stored as JSON description files. These files do not store any data but the recipe how a data cube is constructed, i.e., the chain (or graph) of processes involved.

Since data cube objects (as returned from `raster_cube`) cannot be saved with normal R methods, the combination of `as_json` and `json_cube` provides a cheap way to save data cube objects across several R sessions, as in the examples.

**Value**

data cube proxy object

**Examples**

```r
{
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        "TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
```
memsize

botom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
cube = raster_cube(L8.col, v)
#
fname = tempfile()
writeLines(as_json(cube), fname)
#
# load
json_cube(path = fname)

memsize

---

**Query data cube properties**

**Description**
Query data cube properties

**Usage**
memsize(obj, unit = "MiB")

**Arguments**
- **obj**: a data cube proxy object (class cube)
- **unit**: Unit of data size, can be "B", "KB", "KiB", "MB", "MiB", "GB", "GiB", "TB", "TiB", "PB", "PiB"

**Value**
Total data size of data cube values expressed in the given unit

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
memsize(raster_cube(L8.col, v))
```
names.cube  Query data cube properties

Description
Query data cube properties

Usage
## S3 method for class 'cube'
names(x)

Arguments
x  a data cube proxy object (class cube)

Value
Band names as character vector

Examples
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                        bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
                        srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
names(raster_cube(L8.col, v))

nbands  Query data cube properties

Description
Query data cube properties

Usage
nbands(obj)
ncdf_cube

Arguments

obj a data cube proxy object (class cube)

Value

Number of bands

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
    L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                           ".TIF", recursive = TRUE, full.names = TRUE)
    create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                           bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

nbands(raster_cube(L8.col, v))

ncdf_cube Read a data cube from an existing netCDF file

Description

Create a proxy data cube from a netCDF file that has been created using write_ncdf. This function
does not read cubes from arbitrary netCDF files and can be used e.g., to load intermediate results
and/or plotting existing netCDF cubes on disk without doing the data cube creation from image
collections.

Usage

ncdf_cube(path, chunking = NULL, auto_unpack = TRUE)

Arguments

path path to an existing netCDF file
chunking custom chunk sizes to read form the netCDF file; defaults to using chunk sizes
        from the netCDF file
auto_unpack logical; automatically apply offset and scale when reading data values

Value

a proxy data cube object
Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                         bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"), 
                         srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

ncfile = write_ncdf(select_bands(raster_cube(L8.col, v), c("B02", "B03", "B04")))
ncdf_cube(ncfile)
```

---

### Description

Query data cube properties

### Usage

```r
nt(obj)
```

### Arguments

- **obj**
  a data cube proxy object (class cube)

### Value

Number of pixels in the time dimension
Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
    L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                          ".TIF", recursive = TRUE, full.names = TRUE)
    create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

nt(raster_cube(L8.col, v))

---

nx  Query data cube properties

Description

Query data cube properties

Usage

nx(obj)

Arguments

obj  a data cube proxy object (class cube)

Value

Number of pixels in the x dimension

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
    L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                          ".TIF", recursive = TRUE, full.names = TRUE)
    create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

nx(raster_cube(L8.col, v))
### ny

**Query data cube properties**

**Description**

Query data cube properties

**Usage**

`ny(obj)`

**Arguments**

- **obj**
  
a data cube proxy object (class cube)

**Value**

Number of pixels in the y dimension

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
ny(raster_cube(L8.col, v))
```

### pack_minmax

**Helper function to define packed data exports by min / max values**

**Description**

This function can be used to define packed exports in `write_ncdf` and `write_tif`. It will generate scale and offset values with maximum precision (unless `simplify=TRUE`).

**Usage**

`pack_minmax(type = "int16", min, max, simplify = FALSE)`
Arguments

- **type**: target data type of packed values (one of "uint8", "uint16", "uint32", "int16", or "int32")
- **min**: numeric; minimum value(s) of original values, will be packed to the 2nd lowest value of the target data type
- **max**: numeric; maximum value(s) in original scale, will be packed to the highest value of the target data type
- **simplify**: logical; round resulting scale and offset to power of 10 values

Details

Nodata values will be mapped to the lowest value of the target data type.

Arguments min and max must have length 1 or length equal to the number of bands of the data cube to be exported. In the former case, the same values are used for all bands of the exported target cube, whereas the latter case allows to use different ranges for different bands.

Note

Using simplify=TRUE will round scale values to the next smaller power of 10.

Examples

```r
dvi_packing = pack_minmax(type="int16", min=-1, max=1)
dvi_packing
```

plot.cube  

Plot a gdalcubes data cube

Description

Plot a gdalcubes data cube

Usage

```r
## S3 method for class 'cube'
plot(
  x,
  y,
  ...,
  nb breaks = 11,
  breaks = NULL,
  col = grey(1:(nb breaks - 1)/nb breaks),
  key.pos = NULL,
  bands = NULL,
  t = NULL,
```
rgb = NULL,
zlim = NULL,
periods.in.title = TRUE,
join.timeseries = FALSE,
axes = TRUE,
ncol = NULL,
nrow = NULL,
na.color = "#AAAAAA"
)

Arguments

x a data cube proxy object (class cube)
y __not used__
... further arguments passed to image.default
nbbreaks number of breaks, should be one more than the number of colors given
breaks actual breaks used to assign colors to values; if missing, the function subsamples values and uses equally sized intervals between min and max or zlim[0] and zlim[1] if defined
col color definition, can be a character vector with nbbreaks - 1 elements or a function such as heat.colors
key.pos position for the legend, 1 (bottom), 2 (left), 3 (top), or 4 (right). If NULL (the default), do not plot a legend.
bands integer vector with band numbers to plot (this must be band numbers, not band names)
t integer vector with time indexes to plot (this must be time indexes, not date / time)
rgb bands used to assign RGB color channels, vector of length 3 (this must be band numbers, not band names)
zlim vector of length 2, defining the minimum and maximum values to either derive breaks, or define black and white values in RGB plots
periods.in.title logical value, if TRUE, the title of plots includes the datetime period length as ISO 8601 string
join.timeseries logical, for pure time-series plots, shall time series of multiple bands be plotted in a single plot (with different colors)?
axes logical, if TRUE, plots include axes
ncol number of columns for arranging plots with `layout()`, see Details
nrow number of rows for arranging plots with `layout()`, see Details
na.color color used to plot NA pixels
print.cube

Details

The style of the plot depends on provided parameters and on the shape of the cube, i.e., whether it is a pure time series and whether it contains multiple bands or not. Multi-band, multi-temporal images will be arranged with `layout()` such that bands are represented by the x axis and time is represented by the y axis. Time series plots can be combined to a single plot by setting `join.timeseries = TRUE`. For other cases, a default arrangement of the plots is derived, trying to reach a square overall plot. The layout can be controlled with `ncol` and `nrow`, which define the number of rows and columns in the plot layout. Typically, only one of `ncol` and `nrow` is provided. For multi-band, multi-temporal plots, the actual number of rows or columns can be less if the input cube has less bands or time slices.

Note

If caching is enabled for the package (see `gdalcubes_options`), repeated calls of `plot` for the same data cube will not reevaluate the cube. Instead, the temporary result file will be reused, if possible.

Some parts of the function have been copied from the stars package (c) Edzer Pebesma

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                        bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
plot(select_bands(raster_cube(L8.col, v), c("B02", "B03", "B04")), rgb=3:1)
L8.cube = select_bands(raster_cube(L8.col, v), c("B04", "B05"))
L8.ndvi = apply_pixel(L8.cube, "(B05-B04)/(B05+B04)", "NDVI")
plot(reduce_time(L8.ndvi, "median(NDVI)"), key.pos=1, zlim=c(0,1))
```

print.cube: Print data cube information

Description

Prints information about the dimensions and bands of a data cube.
print.cube_view

Usage

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

Arguments

x Object of class "cube"
...

Further arguments passed to the generic print function

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
    ",.TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
print(raster_cube(L8.col, v))

print.cube_view

Print data cube view information

Description

Prints information about a data cube view, including its dimensions, spatial reference, aggregation method, and resampling method.

Usage

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

Arguments

x Object of class "cube_view"
...

Further arguments passed to the generic print function

Examples

v = cube_view(extent=list(left=388941.2, right=766552.4,
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
print(v)
print.image_collection

Print image collection information

Description

Prints information about images in an image collection.

Usage

```r
## S3 method for class 'image_collection'
print(x, ..., n = 6)
```

Arguments

- `x` Object of class "image_collection"
- `...` Further arguments passed to the generic print function
- `n` Number of images for which details are printed

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
print(L8.col)
```

proj4

Query data cube properties

Description

Query data cube properties

Usage

```r
proj4(obj)
```

Arguments

- `obj` a data cube proxy object (class cube)
raster_cube

Create a data cube from an image collection

Description

Create a proxy data cube, which loads data from a given image collection according to a data cube view.

Usage

raster_cube(
  image_collection,
  view,
  mask = NULL,
  chunking = .pkgenv$default_chunksize
)

Arguments

image_collection
  Source image collection as from image_collection or create_image_collection

view
  A data cube view defining the shape (spatiotemporal extent, resolution, and spatial reference), if missing, a default overview is used

mask
  mask pixels of images based on band values, see image_mask

chunking
  length-3 vector or a function returning a vector of length 3, defining the size of data cube chunks in the order time, y, x.
read_chunk_as_array

Details

The following steps will be performed when the data cube is requested to read data of a chunk:
1. Find images from the input collection that intersect with the spatiotemporal extent of the chunk.
2. For all resulting images, apply gdalwarp to reproject, resize, and resample to an in-memory GDAL dataset.
3. Read the resulting data to the chunk buffer and optionally apply a mask on the result.
4. Update pixel-wise aggregator (as defined in the data cube view) to combine values of multiple images within the same data cube pixels.

If chunking is provided as a function, it must accept exactly three arguments for the total size of the cube in t, y, and x axes (in this order).

Value

A proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
raster_cube(L8.col, v)

# using a mask on the Landsat quality bit band to filter out clouds
raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
```

Description

This function can be used within function passed to `chunk_apply` in order to read a data cube chunk as a four-dimensional R array. It works only for R processes, which have been started from the gdalcubes C++ library. The resulting array has dimensions band, time, y, x (in this order).
Usage

read_chunk_as_array(with.dimnames = TRUE)

Arguments

with.dimnames if TRUE, the resulting array will contain dimnames with coordinates, datetime, and band names

Value

four-dimensional array

Note

Call this function ONLY from a function passed to chunk_apply.

This function only works in R sessions started from gdalcubes streaming.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
f <- function() {
  x <- read_chunk_as_array()
  out <- reduce_time(x, function(x) {
    cor(x[1,], x[2,], use="na.or.complete", method = "kendall")
  })
  write_chunk_from_array(out)
}
L8.cor = chunk_apply(L8.cube, f)
plot(L8.cor, zlim=c(0,1), key.pos=1)
Reduce multidimensional data over space

Description

This generic function applies a reducer function over a data cube, an R array, or other classes if implemented.

Usage

reduce_space(x, ...)

Arguments

x          object to be reduced
...        further arguments passed to specific implementations

Value

return value and type depend on the class of x

See Also

reduce_space.cube
reduce_space.array

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                        bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
reduce_space(raster_cube(L8.col, v), "median(B02)"

d <- c(4,16,32,32)
x <- array(rnorm(prod(d)), d)
y <- reduce_space(x, function(v) {
  apply(v, 1, mean)
})
reduce_space.array

Apply a function over space and bands in a four-dimensional (band, time, y, x) array and reduce spatial dimensions

Description

Apply a function over space and bands in a four-dimensional (band, time, y, x) array and reduce spatial dimensions

Usage

## S3 method for class 'array'
reduce_space(x, FUN, ...)

Arguments

x four-dimensional input array with dimensions band, time, y, x (in this order)
FUN function which receives one spatial slice in a three-dimensional array with dimensions bands, y, x as input
... further arguments passed to FUN

Details

FUN is expected to produce a numeric vector (or scalar) where elements are interpreted as new bands in the result.

Note

This is a helper function that uses the same dimension ordering as gdalcubes streaming. It can be used to simplify the application of R functions e.g. over spatial slices in a data cube.

Examples

d <- c(4,16,32,32)
x <- array(rnorm(prod(d)), d)
# reduce individual bands over spatial slices
y <- reduce_space(x, function(v) {
    apply(v, 1, mean)
})
dim(y)
reduce_space.cube

Reduce a data cube over spatial (x,y or lat,lon) dimensions

Description

Create a proxy data cube, which applies one or more reducer functions to selected bands over spatial slices of a data cube.

Usage

## S3 method for class 'cube'
reduce_space(x, expr, ..., FUN, names = NULL)

Arguments

- **x**: source data cube
- **expr**: either a single string, or a vector of strings defining which reducers will be applied over which bands of the input cube
- **...**: optional additional expressions (if expr is not a vector)
- **FUN**: a user-defined R function applied over pixel time series (see Details)
- **names**: character vector; if FUN is provided, names can be used to define the number and name of output bands

Details

Notice that expressions have a very simple format: the reducer is followed by the name of a band in parantheses. You cannot add more complex functions or arguments.

Possible reducers currently are "min", "max", "sum", "prod", "count", "mean", "median", "var", "sd".

Value

proxy data cube object

Note

Implemented reducers will ignore any NAN values (as na.rm=TRUE does).

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.
Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
    L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                           
    create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4, 
                         bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

L8.cube = raster_cube(L8.col, v)
L8.b02 = select_bands(L8.cube, c("B02"))
L8.b02.median = reduce_space(L8.b02, "median(B02)"
L8.b02.median

plot(L8.b02.median, key.pos=1)

---

reduce_time

Reduce multidimensional data over time

Description

This generic function applies a reducer function over a data cube, an R array, or other classes if implemented.

Usage

reduce_time(x, ...)

Arguments

x

object to be reduced

...

further arguments passed to specific implementations

Value

return value and type depend on the class of x

See Also

reduce_time.cube
reduce_time.array
reduce_time.array

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
      ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(
  extent = list(left=388941.2, right=766552.4,
                 bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"),
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
reduce_time(raster_cube(L8.col, v), "median(B02)", "median(B03)", "median(B04")


d <- c(4,16,32,32)
x <- array(rnorm(prod(d)), d)
y <- reduce_time(x, function(v) {
      apply(v, 1, mean)
    })

reduce_time.array

Apply a function over time and bands in a four-dimensional (band, time, y, x) array and reduce time dimension

Description

Apply a function over time and bands in a four-dimensional (band, time, y, x) array and reduce time dimension

Usage

## S3 method for class 'array'
reduce_time(x, FUN, ...)

Arguments

x four-dimensional input array with dimensions band, time, y, x (in this order)
FUN function which receives one time series in a two-dimensional array with dimensions bands, time as input
... further arguments passed to FUN

Details

FUN is expected to produce a numeric vector (or scalar) where elements are interpreted as new bands in the result.
Note

This is a helper function that uses the same dimension ordering as gdalcubes streaming. It can be used to simplify the application of R functions e.g. over time series in a data cube.

Examples

d <- c(4,16,32,32)
x <- array(rnorm(prod(d)), d)
# reduce individual bands over pixel time series
y <- reduce_time(x, function(v) {
    apply(v, 1, mean)
})
dim(y)

reduce_time.cube  Reduce a data cube over the time dimension

Description

Create a proxy data cube, which applies one or more reducer functions to selected bands over pixel time series of a data cube

Usage

## S3 method for class 'cube'
reduce_time(x, expr, ..., FUN, names = NULL)

Arguments

x  source data cube
expr either a single string, or a vector of strings defining which reducers will be applied over which bands of the input cube
... optional additional expressions (if expr is not a vector)
FUN  a user-defined R function applied over pixel time series (see Details)
names  character vector; if FUN is provided, names can be used to define the number and name of output bands

Details

The function can either apply a built-in reducer if expr is given, or apply a custom R reducer function if FUN is provided.

In the former case, notice that expressions have a very simple format: the reducer is followed by the name of a band in parantheses. You cannot add more complex functions or arguments. Possible reducers currently are "min", "max", "sum", "prod", "count", "mean", "median", "var", "sd", "which_min", and "which_max".
User-defined R reducer functions receive a two-dimensional array as input where rows correspond to the band and columns represent the time dimension. For example, one row is the time series of a specific band. FUN should always return a numeric vector with the same number of elements, which will be interpreted as bands in the result cube. Notice that it is recommended to specify the names of the output bands as a character vector. If names are missing, the number and names of output bands is tried to be derived automatically, which may fail in some cases.

Value

proxy data cube object

Note

Implemented reducers will ignore any NAN values (as na.rm=TRUE does)

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                           bottom=4345299, top=4744931, t0="2018-01", t1="2018-06"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

L8.cube = raster_cube(L8.col, v)
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.rgb.median = reduce_time(L8.rgb, "median(B02)", "median(B03)", "median(B04)"
L8.rgb.median

plot(L8.rgb.median, rgb=3:1)

# user defined reducer calculating interquartile ranges
L8.rgb.iqr = reduce_time(L8.rgb, names=c("iqr_R", "iqr_G","iqr_B"), FUN = function(x) {
  c(diff(quantile(x["B04"],c(0.25,0.75), na.rm=TRUE)),
      diff(quantile(x["B03"],c(0.25,0.75), na.rm=TRUE)),
      diff(quantile(x["B02"],c(0.25,0.75), na.rm=TRUE)))
})
L8.rgb.iqr

plot(L8.rgb.iqr, key.pos=1)
rename_bands

Rename bands of a data cube

Description
Create a proxy data cube, which renames specific bands of a data cube.

Usage
rename_bands(cube, ...)

Arguments
cube source data cube
... named arguments with bands that will be renamed, see Details

Details
The result data cube always contains the same number of bands. No subsetting is done if only names for some of the bands are provided. In this case, only provided bands are renamed whereas other bands keep their original name. Variable arguments must be named by the old band name and the new names must be provided as simple character values (see example).

Value
proxy data cube object

Note
This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-07"),
               srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.rgb
select_bands

L8.rgb = rename_bands(L8.cube, B02 = "blue", B03 = "green", B04 = "red")
L8.rgb

select_bands

Select bands of a data cube

Description

Create a proxy data cube, which selects specific bands of a data cube. The resulting cube will drop any other bands.

Usage

select_bands(cube, bands)

Arguments

cube source data cube

bands character vector with band names

Value

proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

For performance reasons, select_bands should always be called directly on a cube created with raster_cube and drop all unneded bands. This allows to reduce RasterIO and warp operations in GDAL.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-04", t1="2018-07"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
```r
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.rgb

plot(L8.rgb, rgb=3:1)
```

---

**select_time**  
*Select time slices of a data cube*

**Description**
Create a proxy data cube, which selects specific time slices of a data cube. The time dimension of the resulting cube will be irregular/labeled.

**Usage**

```r
select_time(cube, t)
```

**Arguments**
- `cube` source data cube
- `t` character vector with date/time

**Value**
proxy data cube object

**Note**
This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         
".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
bottom=4345299, top=4744931, t0="2018-04", t1="2018-07"), 
srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
```
L8.rgb = select_time(L8.rgb, c("2018-04", "2018-07"))
L8.rgb

plot(L8.rgb, rgb=3:1)

---

**size**

*Query data cube properties*

**Description**

Query data cube properties

**Usage**

```r
size(obj)
```

**Arguments**

- `obj` a data cube proxy object (class `cube`)

**Value**

Size of a data cube (number of cells) as integer vector in the order t, y, x

**See Also**

- `dim.cube`

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                        ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"), 
srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
size(raster_cube(L8.col, v))
```
slice_space

Extract a single time series (spatial slice) from a data cube

Description

Create a proxy data cube, which extracts a time series from a data cube defined by spatial coordinates or integer x and y indexes.

Usage

slice_space(cube, loc = NULL, i = NULL)

Arguments

cube
  source data cube

loc
  numeric length-two vector; spatial coordinates (x, y) of the time series, expressed in the coordinate reference system of the source data cube

i
  integer length-2 vector; indexes (x,y) of the time slice (zero-based)

Details

Either loc or i must be non-NULL. If both arguments are provided, integer indexes i are ignored.

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                         bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
                         srs="EPSG:32618", nx = 497, ny=526, dt="P3M", aggregation = "median")
L8.cube = raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.ts = slice_space(L8.rgb, loc = c(5e05, 4400000))
L8.ts

plot(L8.ts, join.timeseries = TRUE)
slice_time  

Extract a single time slice from a data cube

Description

Create a proxy data cube, which extracts a time slice from a data cube defined by label (datetime string) or integer index.

Usage

slice_time(cube, datetime = NULL, it = NULL)

Arguments

cube  
source data cube

datetime  
character; datetime string of the time slice

it  
integer; index of the time slice (zero-based)

Details

Either datetime or it must be non-NULL. If both arguments are provided, the integer index it is ignored.

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
    
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4, 
  bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"), 
  srs="EPSG:32618", nx = 497, ny=526, dt="P1M", aggregation = "median")
L8.cube = raster_cube(L8.col, v, mask=image_mask("BQA", bits=4, values=16))
L8.rgb = select_bands(L8.cube, c("B02", "B03", "B04"))
L8.slice = slice_time(L8.rgb, "2018-03")
L8.slice
plot(L8.slice, rgb=3:1, zlim=c(5000,12000))

---

Query data cube properties

**Description**

Query data cube properties

**Usage**

`srs(obj)`

**Arguments**

- `obj`: a data cube proxy object (class `cube`)

**Value**

The spatial reference system expressed as a string readable by GDAL

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                          bottom=4345299, top=4744931, t0="2018-04", t1="2018-06"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
srs(raster_cube(L8.col, v))
```
Create a data cube from a set of images with the same spatial extent and spatial reference system

Description

Create a spatiotemporal data cube directly from images with identical spatial extent and spatial reference system, similar to a raster stack with an additional dimension supporting both, time and multiple bands / variables.

Usage

```r
stack_cube(
  x,
  datetime_values,
  bands = NULL,
  band_names = NULL,
  chunking = c(1, 256, 256),
  dx = NULL,
  dy = NULL
)
```

Arguments

- `x` character vector where items point to image files
- `datetime_values` vector of type character, Date, or POSIXct with recording date of images
- `bands` optional character vector defining the band or spectral band of each item in `x`, if files relate to different spectral bands or variables
- `band_names` name of bands, only used if bands is NULL, i.e., if all files contain the same spectral band(s) / variable(s)
- `chunking` vector of length 3 defining the size of data cube chunks in the order time, y, x.
- `dx` optional target pixel size in x direction, by default (NULL) the original or highest resolution of images is used
- `dy` optional target pixel size in y direction, by default (NULL) the original or highest resolution of images is used

Details

This function creates a four-dimensional (space, time, bands / variables) raster data cube from a set of provided files without the need to create an image collection before. This is possible if all images have the same spatial extent and spatial reference system and can be used for two different file organizations:

1. If all image files share the same bands / variables, the bands argument can be ignored (default NULL) and names of the bands can be specified using the band_names argument.
2. If image files represent different band / variable (e.g. individual files for red, green, and blue channels), the bands argument must be used to define the corresponding band / variable. Notice that in this case all files are expected to represent exactly one variable / band at one point in datetime. It is not possible to combine files with different numbers of variables / bands. If image files for different bands have different pixel sizes, the smallest size is used by default.

Notice that to avoid opening all image files in advance, no automatic check whether all images share the spatial extent and spatial reference system is performed.

Value

A proxy data cube object

Note

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.

Examples

```r
# toy example, repeating the same image as a daily time series
L8_file_nir <-
  system.file("L8NY18/LC08_L1TP_014032_20181122_20181129_01_T1/LC08_L1TP_014032_20181122_B5.TIF",
    package = "gdalcubes")
files = rep(L8_file_nir, 10)
datetime = as.Date("2018-11-22") + 1:10
stack_cube(files, datetime, band_names = "B05")

# using a second band from different files
L8_file_red <-
  system.file("L8NY18/LC08_L1TP_014032_20181122_20181129_01_T1/LC08_L1TP_014032_20181122_B4.TIF",
    package = "gdalcubes")
files = rep(c(L8_file_nir, L8_file_red), each = 10)
datetime = rep(as.Date("2018-11-22") + 1:10, 2)
bands = rep(c("B5", "B4"), each = 10)
stack_cube(files, datetime, bands = bands)
```

---

**stac_image_collection**  
Create an image collection from a STAC feature collection

**Description**

This function creates an image collection from a STAC API collection response. It does not need to read any image data. Additionally, bands can be filtered and asset links can be transformed to make them readable for GDAL.
Usage

```r
stac_image_collection(
  s,
  out_file = tempfile(fileext = ".sqlite"),
  asset_names = NULL,
  asset_regex = NULL,
  url_fun = function(x) { paste0("/vsicurl/", x) },
  property_filter = NULL,
  skip_image_metadata = FALSE
)
```

Arguments

- `s`: STAC feature collection
- `out_file`: optional name of the output SQLite database file, defaults to a temporary file
- `asset_names`: character vector with names of assets (e.g., bands) to be used, other assets will be ignored. By default (NULL), all asset names with "eo:bands" attributes will be used
- `asset_regex`: length 1 character defining a regular expression asset names must match to be considered
- `url_fun`: optional function to modify URLs of assets, e.g., to add /vsicurl/ to URLs (the default)
- `property_filter`: optional function to filter STAC items (images) by their properties; see Details
- `skip_image_metadata`: logical, if TRUE per-image metadata (STAC item properties) will not be added to the image collection

Details

The `property_filter` argument can be used to filter images by metadata such as cloud coverage. The function receives all properties of a STAC item (image) as input list and is expected to produce a single logical value, where an image will be ignored if the function returns FALSE.

Note

Currently, bbox results are expected to be WGS84 coordinates, even if bbox-crs is given in the STAC response.

This function is experimental.
st_as_stars.cube
Coerce gdalcubes object into a stars object

Description

The function materializes a data cube as a temporary netCDF file and loads the file with the stars package.

Usage

st_as_stars.cube(.x, ...)

Arguments

.x         data cube object to coerce
...        not used

Value

stars object

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                       ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}
L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
              bottom=4345299, top=4744931, t0="2018-04", t1="2018-04"),
              srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
if(require("stars"))
st_as_stars(select_bands(raster_cube(L8.col, v), c("B04", "B05")))
**window_time**

Apply a moving window operation over time

**Description**

This generic function applies a reducer function over a moving window over the time dimension of a data cube, an R array, or other classes if implemented.

**Usage**

`window_time(x, ...)`

**Arguments**

- `x` object to be reduced
- `...` further arguments passed to specific implementations

**Value**

value and type depend on the class of `x`

**See Also**

- `window_time.cube`

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4, 
                        bottom=4345299, top=4744931, t0="2018-01", t1="2018-07"), 
               srs="EPSG:32618", nx = 400, dt="P1M")
L8.cube = raster_cube(L8.col, v)
L8.nir = select_bands(L8.cube, c("B05"))
window_time(L8.nir, window = c(2,2), "min(B05)"
window_time(L8.nir, kernel=c(-1,1), window=c(1,0))

plot(window_time(L8.nir, kernel=c(-1,1), window=c(1,0)), key.pos=1)
```
Description

Create a proxy data cube, which applies one or more moving window functions to selected bands over pixel time series of a data cube. The function can either use a predefined aggregation function or apply a custom convolution kernel.

Usage

```r
## S3 method for class 'cube'
window_time(x, expr, ..., kernel, window)
```

Arguments

- `x`: source data cube
- `expr`: either a single string, or a vector of strings defining which reducers will be applied over which bands of the input cube
- `...`: optional additional expressions (if `expr` is not a vector)
- `kernel`: numeric vector with elements of the kernel
- `window`: integer vector with two elements defining the size of the window before and after a cell, the total size of the window is `window[1] + 1 + window[2]`

Details

The function either applies a kernel convolution (if the `kernel` argument is provided) or a general reducer function over moving temporal windows. In the former case, the kernel convolution will be applied over all bands of the input cube, i.e., the output cube will have the same number of bands as the input cubes. If a kernel is given and the `window` argument is missing, the window will be symmetric to the center pixel with the size of the provided kernel. For general reducer functions, the `window` argument must be provided and several expressions can be used to create multiple bands in the output cube.

Notice that expressions have a very simple format: the reducer is followed by the name of a band in parentheses. You cannot add more complex functions or arguments.

Possible reducers currently are "min", "max", "sum", "prod", "count", "mean", "median".

Value

proxy data cube object

Note

Implemented reducers will ignore any NAN values (as `na.rm=TRUE` does).

This function returns a proxy object, i.e., it will not start any computations besides deriving the shape of the result.
### Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                         bottom=4345299, top=4744931, t0="2018-01", t1="2018-07"),
               srs="EPSG:32618", nx = 400, dt="P1M")

L8.cube = raster_cube(L8.col, v)
L8.nir = select_bands(L8.cube, c("B05"))
L8.nir.min = window_time(L8.nir, window = c(2,2), "min(B05")
L8.nir.min

L8.nir.kernel = window_time(L8.nir, kernel=c(-1,1), window=c(1,0))
L8.nir.kernel
```

---

**write_chunk_from_array**

Write chunk data of a cube to stdout or a file

### Description

This function can be used within function passed to `chunk_apply` in order to pass four-dimensional R arrays as a data cube chunk to the gdalcubes C++ library. It works only for R processes, which have been started from the gdalcubes C++ library. The input array must have dimensions band, time, y, x (in this order).

### Usage

```r
write_chunk_from_array(v)
```

### Arguments

- **v**
  - four-dimensional array with dimensions band, time, y, and x

### Note

Call this function ONLY from a function passed to `chunk_apply`.

This function only works in R sessions started from gdalcubes streaming.
## Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
                         ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
                        bottom=4345299, top=4744931, t0="2018-01", t1="2018-12"),
                        srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

L8.cube = raster_cube(L8.col, v)
L8.cube = select_bands(L8.cube, c("B04", "B05"))
f <- function() {
  x <- read_chunk_as_array()
  out <- reduce_time(x, function(x) {
    cor(x[1,], x[2,], use="na.or.complete", method = "kendall")
  })
  write_chunk_from_array(out)
}
L8.cor = chunk_apply(L8.cube, f)
plot(L8.cor, zlim=c(0,1), key.pos=1)
```

## write_ncdf

### Export a data cube as netCDF file(s)

This function will read chunks of a data cube and write them to a single (the default) or multiple (if `chunked = TRUE`) netCDF file(s). The resulting file(s) uses the enhanced netCDF-4 format, supporting chunking and compression.

### Usage

```r
write_ncdf(
  x,
  fname = tempfile(pattern = "gdalcubes", fileext = ".nc"),
  overwrite = FALSE,
  write_json_descr = FALSE,
  with_VRT = FALSE,
  pack = NULL,
  chunked = FALSE
)
```
write_ncdf

Arguments

- **x**: a data cube proxy object (class cube)
- **fname**: output file name
- **overwrite**: logical; overwrite output file if it already exists
- **write_json_descr**: logical; write a JSON description of x as additional file
- **with_VRT**: logical; write additional VRT datasets (one per time slice)
- **pack**: reduce output file size by packing values (see Details), defaults to no packing
- **chunked**: logical; if TRUE, write one netCDF file per chunk; defaults to FALSE

Details

The resulting netCDF file(s) contain three dimensions (t, y, x) and bands as variables.

If **write_json_descr** is TRUE, the function will write an addition file with the same name as the NetCDF file but "json" suffix. This file includes a serialized description of the input data cube, including all chained data cube operations.

To reduce the size of created files, values can be packed by applying a scale factor and an offset value and using a smaller integer data type for storage (only supported if chunked = TRUE). The pack argument can be either NULL (the default), or a list with elements type, scale, offset, and nodata. type can be any of "uint8", "uint16", "uint32", "int16", or "int32". scale, offset, and nodata must be numeric vectors with length one or length equal to the number of data cube bands (to use different values for different bands). The helper function *pack_minmax* can be used to derive offset and scale values with maximum precision from minimum and maximum data values on original scale.

If chunked = TRUE, names of the produced files will start with name (with removed extension), followed by an underscore and the internal integer chunk number.

Value

returns (invisibly) the path of the created netCDF file(s)

Note

Packing is currently ignored if chunked = TRUE

See Also

- *gdalcubes_options*
- *pack_minmax*

Examples

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
```

---

**write_ncdf**  

**Arguments**

- **x**: a data cube proxy object (class cube)
- **fname**: output file name
- **overwrite**: logical; overwrite output file if it already exists
- **write_json_descr**: logical; write a JSON description of x as additional file
- **with_VRT**: logical; write additional VRT datasets (one per time slice)
- **pack**: reduce output file size by packing values (see Details), defaults to no packing
- **chunked**: logical; if TRUE, write one netCDF file per chunk; defaults to FALSE

**Details**

The resulting netCDF file(s) contain three dimensions (t, y, x) and bands as variables.

If **write_json_descr** is TRUE, the function will write an addition file with the same name as the NetCDF file but "json" suffix. This file includes a serialized description of the input data cube, including all chained data cube operations.

To reduce the size of created files, values can be packed by applying a scale factor and an offset value and using a smaller integer data type for storage (only supported if chunked = TRUE). The pack argument can be either NULL (the default), or a list with elements type, scale, offset, and nodata. type can be any of "uint8", "uint16", "uint32", "int16", or "int32". scale, offset, and nodata must be numeric vectors with length one or length equal to the number of data cube bands (to use different values for different bands). The helper function *pack_minmax* can be used to derive offset and scale values with maximum precision from minimum and maximum data values on original scale.

If chunked = TRUE, names of the produced files will start with name (with removed extension), followed by an underscore and the internal integer chunk number.

**Value**

returns (invisibly) the path of the created netCDF file(s)

**Note**

Packing is currently ignored if chunked = TRUE

**See Also**

- *gdalcubes_options*
- *pack_minmax*

**Examples**

```r
# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"),
```
`.TIF`, recursive = TRUE, full.names = TRUE)
create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))
v = cube_view(extent=list(left=388941.2, right=766552.4,
bottom=4345299, top=4744931, t0="2018-04", t1="2018-04"),
srs="EPSG:32618", nx = 497, ny=526, dt="P1M")
write_ncdf(select_bands(raster_cube(L8.col, v), c("B04", "B05")), fname=tempfile(fileext = ".nc"))

---

**write_tif**

*Export a data cube as a collection of GeoTIFF files*

**Description**

This function will time slices of a data cube as GeoTIFF files in a given directory.

**Usage**

```r
write_tif(
  x,
  dir = tempfile(pattern = ""),
  prefix = basename(tempfile(pattern = "cube_")),
  overviews = FALSE,
  COG = FALSE,
  rsmpl_overview = "nearest",
  creation_options = NULL,
  write_json_descr = FALSE,
  pack = NULL
)
```

**Arguments**

- **x**
  - a data cube proxy object (class cube)
- **dir**
  - destination directory
- **prefix**
  - output file name
- **overviews**
  - logical; generate overview images
- **COG**
  - logical; create cloud-optimized GeoTIFF files (forces overviews=TRUE)
- **rsmpl_overview**
  - resampling method for overviews (image pyramid) generation (see [https://gdal.org/programs/gdaladdo.html](https://gdal.org/programs/gdaladdo.html) for available methods)
- **creation_options**
  - additional creation options for resulting GeoTIFF files, e.g. to define compression (see [https://gdal.org/drivers/raster/gtiff.html#creation-options](https://gdal.org/drivers/raster/gtiff.html#creation-options))
- **write_json_descr**
  - logical; write a JSON description of x as additional file
- **pack**
  - reduce output file size by packing values (see Details), defaults to no packing
Details

If write_json_descr is TRUE, the function will write an additional file with name according to prefix (if not missing) or simply cube.json This file includes a serialized description of the input data cube, including all chained data cube operations.

Additional GDAL creation options for resulting GeoTIFF files must be passed as a named list of simple strings, where element names refer to the key. For example, creation_options = list("COMPRESS" = "DEFLATE","ZLEVEL" = "5") would enable deflate compression at level 5.

To reduce the size of created files, values can be packed by applying a scale factor and an offset value and using a smaller integer data type for storage. The pack argument can be either NULL (the default), or a list with elements type, scale, offset, and nodata. type can be any of "uint8", "uint16", "uint32", "int16", or "int32". scale, offset, and nodata must be numeric vectors with length one or length equal to the number of data cube bands (to use different values for different bands). The helper function pack_minmax can be used to derive offset and scale values with maximum precision from minimum and maximum data values on original scale.

If overviews=TRUE, the numbers of pixels are halved until the longer spatial dimensions counts less than 256 pixels. Setting COG=TRUE automatically sets overviews=TRUE.

Value

returns (invisibly) a vector of paths pointing to the created GeoTIFF files

See Also

pack_minmax

Examples

# create image collection from example Landsat data only
# if not already done in other examples
if (!file.exists(file.path(tempdir(), "L8.db"))) {
  L8_files <- list.files(system.file("L8NY18", package = "gdalcubes"), 
    ".TIF", recursive = TRUE, full.names = TRUE)
  create_image_collection(L8_files, "L8_L1TP", file.path(tempdir(), "L8.db"))
}

L8.col = image_collection(file.path(tempdir(), "L8.db"))

v = cube_view(extent=list(left=388941.2, right=766552.4,
                bottom=4345299, top=4744931, t0="2018-04", t1="2018-04"),
                srs="EPSG:32618", nx = 497, ny=526, dt="P1M")

cube_view

write_tif(select_bands(raster_cube(L8.col, v), c("B04", "B05")), dir=tempdir())
Index

.copy_cube, 4
[.cube (gdalcubes_selection), 38
$.cube (gdalcubes_selection), 38

add_collection_format, 4
add_images, 5
aggregate_time, 6
animate, 7
apply_pixel, 8
apply_pixel.array, 9, 9
apply_pixel.cube, 9, 10
apply_time, 12
apply_time.array, 12, 13
apply_time.cube, 12, 14
as_array, 15
as_json, 16, 44

bands, 17
chunk_apply, 18, 57, 58, 79
collection_formats, 19, 20
create_image_collection, 20, 41
crop, 21
cube_view, 23
dim.cube, 25, 69
dimension_bounds, 27
dimension_values, 27
dimensions, 26
dimension_values, 27
dimensions, 26
extent, 23, 24, 28
extract_geom, 29

fill_time, 31
filter_geom, 32
filter_pixel, 33
gdalcubes, 34
gdalcubes_gdal_has_geos, 36
gdalcubes_gdalformats, 35
gdalcubes_gdalversion, 35
gdalcubes_options, 36, 53, 81
gdalcubes_selection, 38
gdalcubes_set_gdal_config, 40
gdalcubes_version, 40

image_collection, 41
image_mask, 41, 56
join_bands, 43
json_cube, 44, 44

memsize, 45
names.cube, 46
nbands, 46
ncdf_cube, 47
nt, 48
nx, 49
ny, 50

pack_minmax, 50, 81, 83
plot.cube, 8, 51
print.cube, 53
print.cube_view, 54
print.image_collection, 55
proj4, 55

raster_cube, 5, 18, 21, 41, 44, 56, 67
read_chunk_as_array, 57
reduce_space, 59
reduce_space.array, 59, 60
reduce_space.cube, 59, 61
reduce_time, 14, 62
reduce_time.array, 62, 63
reduce_time.cube, 62, 64
rename_bands, 66

select_bands, 67
select_time, 68
sf package, 29
size, 25, 69
slice_space, 70
slice_time, 71
srs, 72
st_as_stars.cube, 76
st_bbox, 38
st_sfc, 38
stac_image_collection, 74
stack_cube, 73

window_time, 77
window_time.cube, 77, 78
write_chunk_from_array, 79
write_ncdf, 47, 50, 80
write_tif, 50, 82