Introdução ao uso de dados geoespaciais no R

7 Estrutura e manipulação de dados vetoriais

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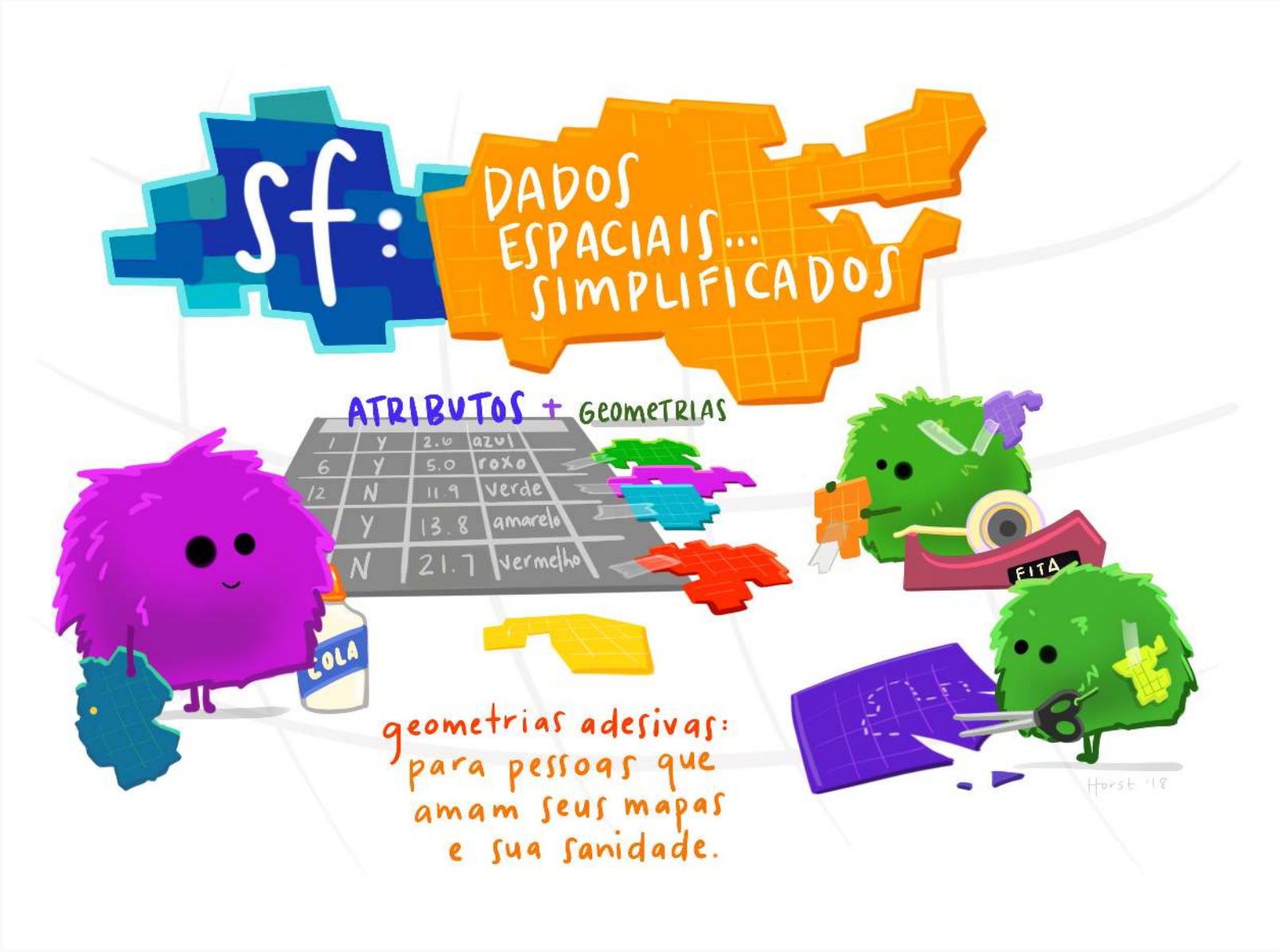
25/10/2021-05/11/2021

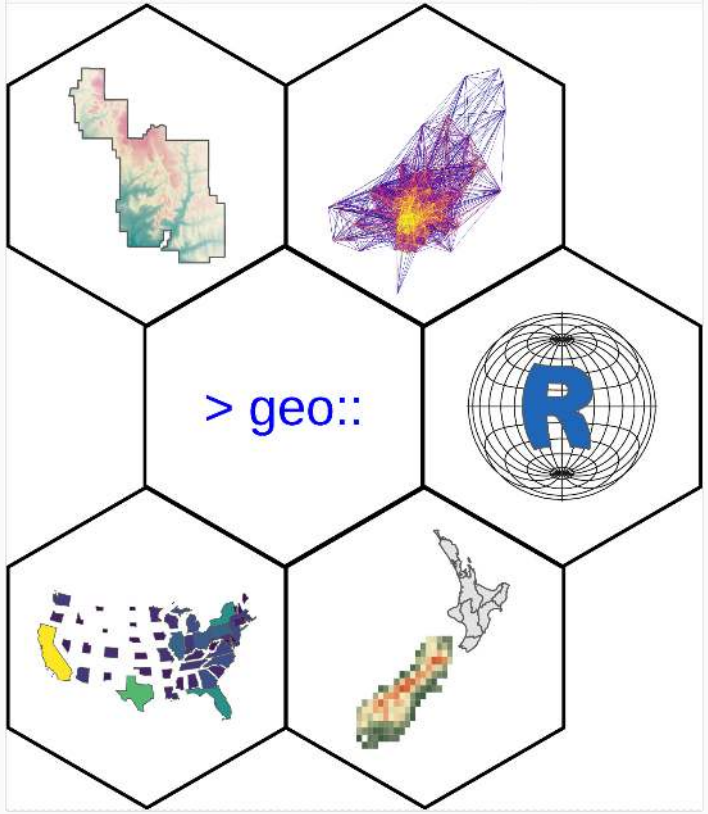


@allison_horst

7 Estrutura e manipulação de vetores

Tópicos

1. Principais pacotes
2. Geometrias sf
3. Classes sf
4. Importar dados vetoriais
5. Descrição de objetos sf
6. Converter objetos para sf
7. Converter CRS de objetos sf
8. Operações de objetos sf
9. Exportar objetos sf



Lovelace et al. (2020)

7´ Estrutura e manipulação de vetores

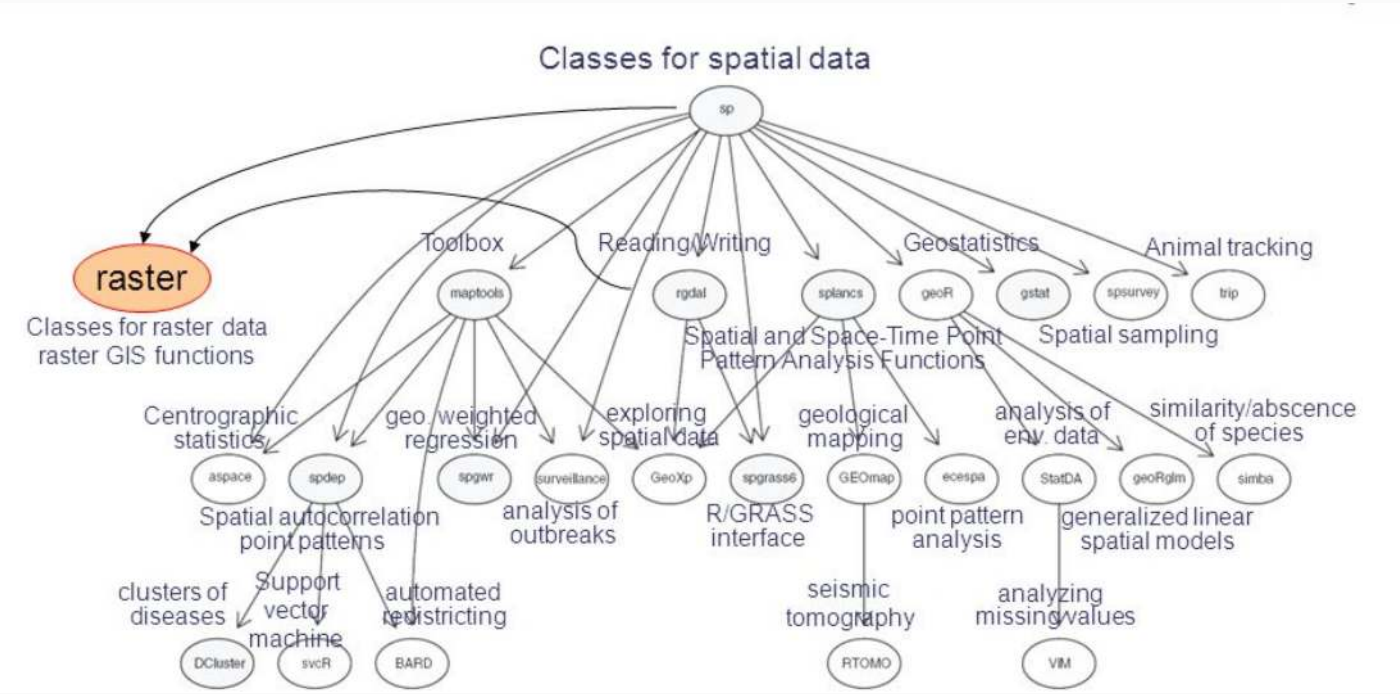
Script

`07_script_intro_geoespacial_r.R`

1. Principais pacotes

Pacote sp

```
# sp
install.packages("sp")
library(sp)
```



sp

1. Principais pacotes

Pacote sf

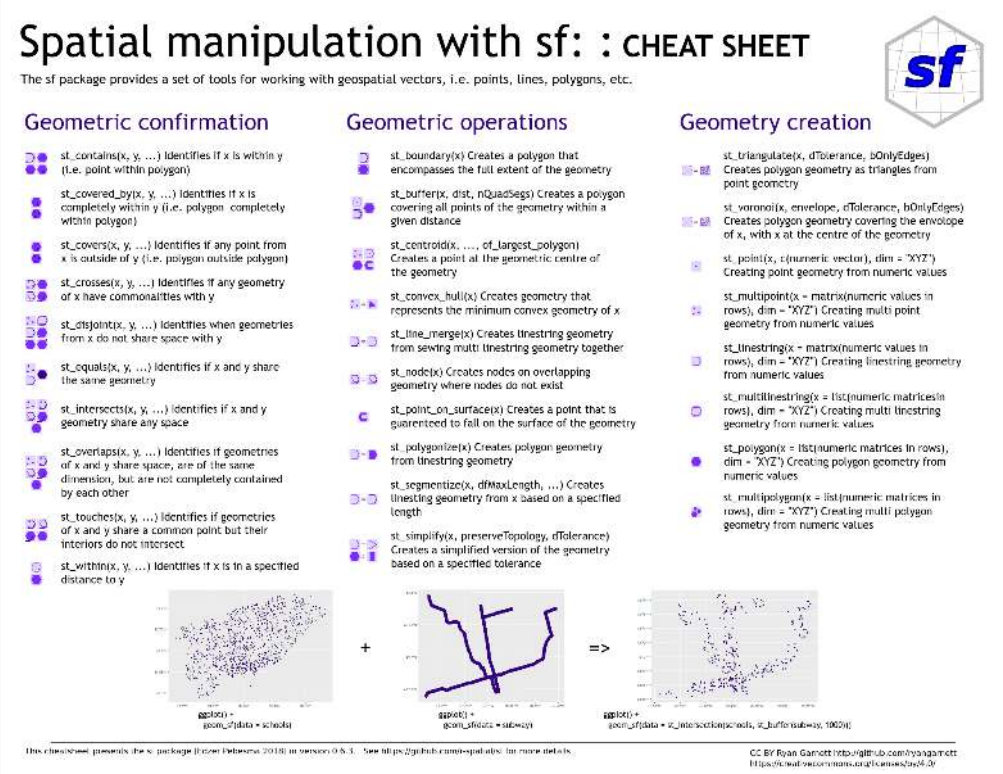
```
# sf
install.packages("sf")
library(sf)
```

sf

1. Principais pacotes

Pacote sf

Spatial manipulation with sf cheat sheets



Spatial manipulation with sf: : CHEAT SHEET

The sf package provides a set of tools for working with geospatial vectors, i.e. points, lines, polygons, etc.

Geometric confirmation

- st_contains(x, y, ...) Identifies if x is within y (i.e. point within polygon)
- st_covered_by(x, y, ...) Identifies if x is completely within y (i.e. polygon completely within polygon)
- st_covers(x, y, ...) Identifies if any point from x is outside of y (i.e. polygon outside polygon)
- st_crosses(x, y, ...) Identifies if any geometry of x have commonalities with y
- st_disjoint(x, y, ...) Identifies when geometries from x do not share space with y
- st_equals(x, y, ...) Identifies if x and y share the same geometry
- st_intersects(x, y, ...) Identifies if x and y geometry share any space
- st_overlaps(x, y, ...) Identifies if geometries of x and y share space, are of the same dimension, but are not completely contained by each other
- st_touches(x, y, ...) Identifies if geometries of x and y share a common point but their interiors do not intersect
- st_within(x, y, ...) Identifies if x is in a specified distance to y

Geometric operations

- st_boundary(x) Creates a polygon that encompasses the full extent of the geometry
- st_buffer(x, dist, nQuadSegs) Creates a polygon covering all points of the geometry within a given distance
- st_centroid(x, ..., of_largest_polygon) Creates a point at the geometric centre of the geometry
- st_convex_hull(x) Creates geometry that represents the minimum convex geometry of x
- st_line_merge(x) Creates linestring geometry from sewing multi linestring geometry together
- st_node(x) Creates nodes on overlapping geometry where nodes do not exist
- st_point_on_surface(x) Creates a point that is guaranteed to fall on the surface of the geometry
- st_polygonize(x) Creates polygon geometry from linestring geometry
- st_segmentize(x, dfMaxLength, ...) Creates linestring geometry from x based on a specified length
- st_simplify(x, preserveTopology, dTolerance) Creates a simplified version of the geometry based on a specified tolerance

Geometry creation

- st_triangulate(x, dTolerance, bOnlyEdges) Creates polygon geometry as triangles from point geometry
- st_voronoi(x, envelope, dTolerance, bOnlyEdges) Creates polygon geometry covering the envelope of x, with x at the centre of the geometry
- st_point(x, c(numeric vector), dim = "XYZ") Creating point geometry from numeric values
- st_multipoint(x = matrix(numeric values in rows), dim = "XYZ") Creating multi point geometry from numeric values
- st_linestring(x = matrix(numeric values in rows), dim = "XYZ") Creating linestring geometry from numeric values
- st_multilinestring(x = list(numeric matrices in rows), dim = "XYZ") Creating multi linestring geometry from numeric values
- st_polygon(x = list(numeric matrices in rows), dim = "XYZ") Creating polygon geometry from numeric values
- st_multipolygon(x = list(numeric matrices in rows), dim = "XYZ") Creating multi polygon geometry from numeric values

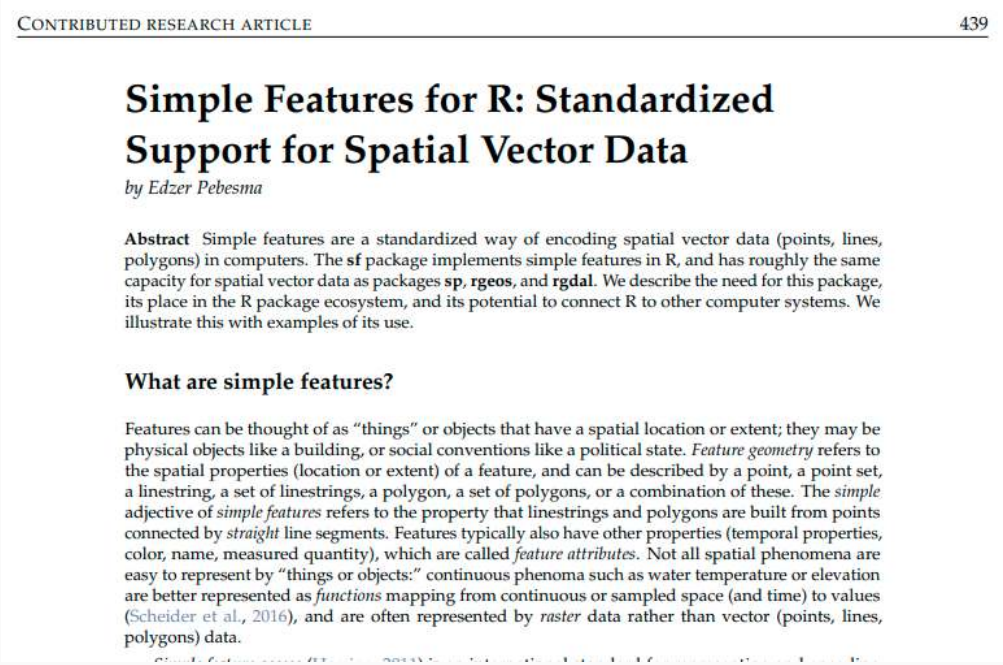
[Spatial manipulation with sf]

1. Principais pacotes

Pacote sf

Artigo

> - Pebesma, Edzer. "Simple Features for R: Standardized Support for Spatial Vector Data." The R Journal 10.01 (2018): 439-446.



CONTRIBUTED RESEARCH ARTICLE 439

Simple Features for R: Standardized Support for Spatial Vector Data

by Edzer Pebesma

Abstract Simple features are a standardized way of encoding spatial vector data (points, lines, polygons) in computers. The **sf** package implements simple features in R, and has roughly the same capacity for spatial vector data as packages **sp**, **rgeos**, and **rgdal**. We describe the need for this package, its place in the R package ecosystem, and its potential to connect R to other computer systems. We illustrate this with examples of its use.

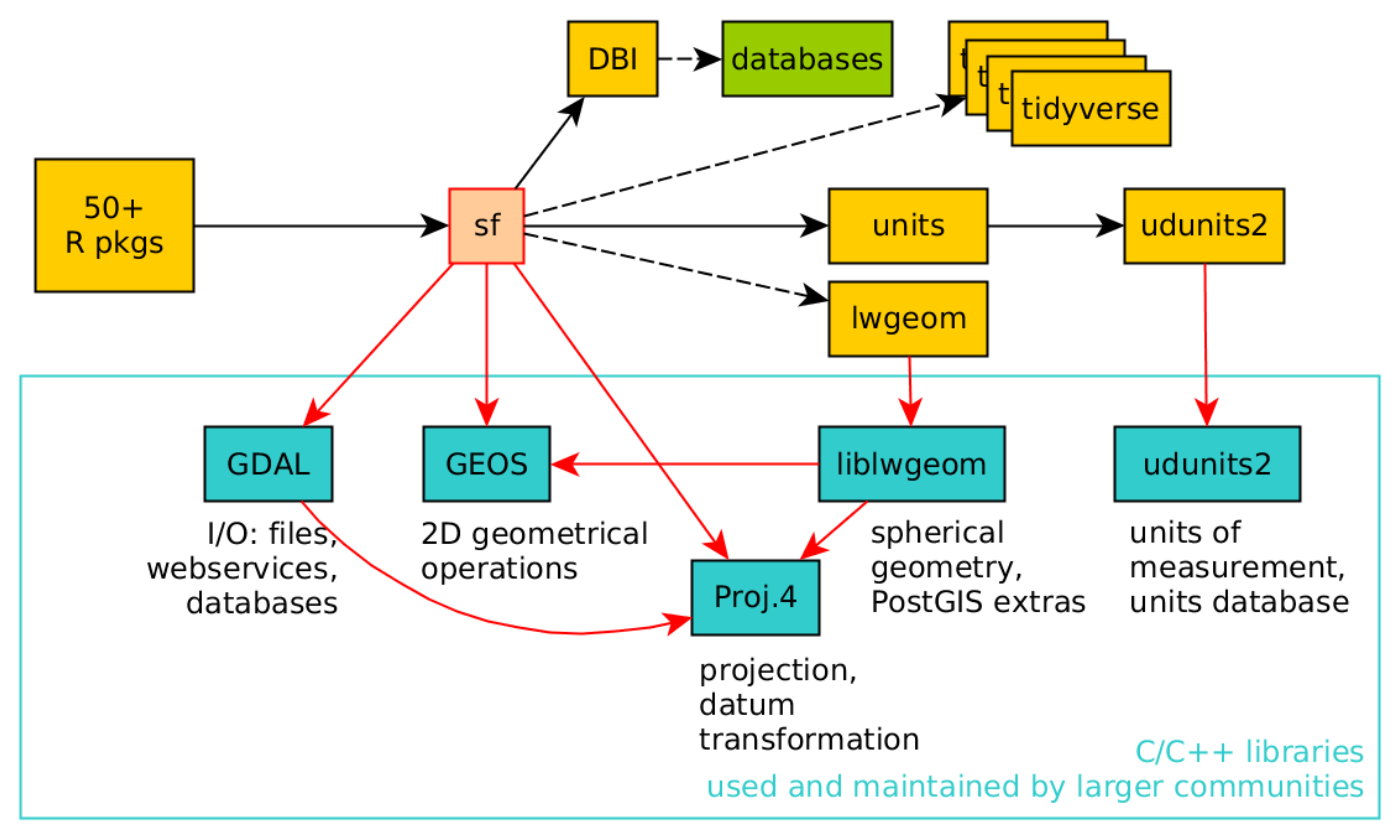
What are simple features?

Features can be thought of as "things" or objects that have a spatial location or extent; they may be physical objects like a building, or social conventions like a political state. *Feature geometry* refers to the spatial properties (location or extent) of a feature, and can be described by a point, a point set, a linestring, a set of linestrings, a polygon, a set of polygons, or a combination of these. The *simple* adjective of *simple features* refers to the property that linestrings and polygons are built from points connected by *straight* line segments. Features typically also have other properties (temporal properties, color, name, measured quantity), which are called *feature attributes*. Not all spatial phenomena are easy to represent by "things or objects:" continuous phenoma such as water temperature or elevation are better represented as *functions* mapping from continuous or sampled space (and time) to values (Scheider et al., 2016), and are often represented by *raster* data rather than vector (points, lines, polygons) data.

1. Principais pacotes

Pacote sf

Dependências de outros pacotes



1. Principais pacotes

Pacote sf

Métodos

class	methods
`sfg`	as.matrix, c, coerce, format, head, Ops, plot, print, st_as_binary, st_as_grob, st_as_text, st_transform, st_coordinates, st_geometry, st_boundary, st_buffer, st_centroid, st_convex_hull, st_difference, st_intersection, st_line_merge, st_make_valid, st_node, st_point_on_surface, st_polygonize, st_segmentize, st_simplify, st_split, st_sym_difference, st_triangulate, st_union, st_voronoi, st_cast, st_collection_extract, st_is, st_zm
`sfc`	[, [<-, as.data.frame, c, coerce, format, Ops, print, rep, st_as_binary, st_as_text, st_bbox, st_coordinates, st_crs, st_crs<-, st_geometry, st_precision, st_set_precision, str, summary, st_boundary, st_buffer, st_centroid, st_convex_hull, st_difference, st_intersection, st_line_merge, st_make_valid, st_node, st_point_on_surface, st_polygonize, st_segmentize, st_simplify, st_split, st_sym_difference, st_transform, st_triangulate, st_union, st_voronoi, st_cast, st_collection_extract, st_is, st_zm, obj_sum, type_sum
`sf`	[, [[<-, $<-, aggregate, cbind, coerce, merge, plot, print, rbind, st_agr, st_agr<-, st_bbox, st_coordinates, st_crs, st_crs<-, st_geometry, st_geometry<-, st_precision, st_set_precision, st_transform, st_boundary, st_buffer, st_centroid, st_convex_hull, st_difference, st_intersection, st_line_merge, st_make_valid, st_node, st_point_on_surface, st_polygonize, st_segmentize, st_simplify, st_split, st_sym_difference, st_triangulate, st_union, st_voronoi, st_cast, st_collection_extract, st_is, st_zm, anti_join, arrange, distinct, filter, full_join, gather, group_by, inner_join, left_join, nest, mutate, rename, right_join, sample_frac, sample_n, select, semi_join, separate, slice, spread, summarise, transmute, ungroup, unite
`crs`	$, is.na, Ops, print, st_as_text, st_crs

1. Principais pacotes

Pacote sf

Funções

category	functions
binary predicates	st_contains, st_contains_properly, st_covered_by, st_covers, st_crosses, st_disjoint, st_equals, st_equals_exact st_intersects, st_is_within_distance, st_within, st_touches, st_overlaps
binary operations	st_relate, st_distance
unary operations	st_dimension, st_area, st_length, st_is_longlat, st_is_simple, st_is_valid, st_jitter, st_geohash, st_geometry_type
miscellaneous	st_sample, st_line_sample, st_join, st_interpolate_aw, st_make_grid, st_graticule, sf_extSoftVersion, rawToHex, st_proj_info
setters	st_set_agr, st_set_crs
constructors	st_sfc, st_sf, st_as_sf, st_as_sfc, st_point, st_multipoint, st_linestring, st_multilinestring, st_polygon, st_multipolygon, st_geometrycollection, st_combine, st_bind_cols
in- & output	st_read, st_read_db, st_write, st_write_db, read_sf, write_sf, st_drivers, st_layers
plotting	st_viewport, st_wrap_dateline, sf.colors

1. Principais pacotes

Pacote sf - Descrição

Rápida importação e exportação de dados

Desempenho aprimorado de mapas e gráficos

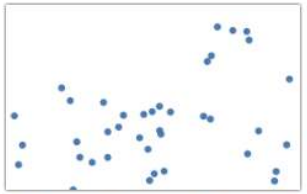
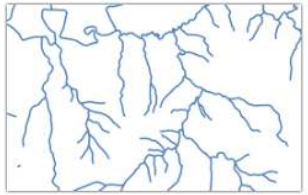
Objetos `sf` podem ser tratados como `data frames` (`tibbles`) na maioria das **operações de manipulação**

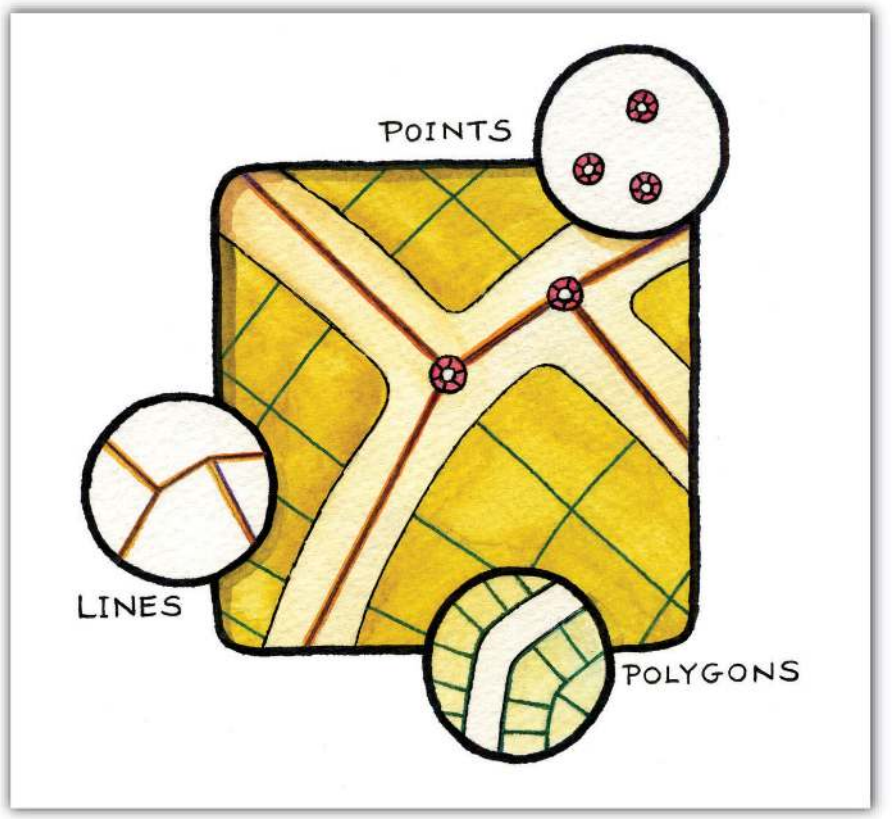
As funções `sf` **podem ser combinadas** usando o operador `%>%` e funcionam bem com `tidyverse`

Os nomes das funções sf são relativamente **consistentes e intuitivos** (todos começam com `sf::st_`)

2. Tipos de geometrias sf

Tipos de dados geoespaciais vetoriais

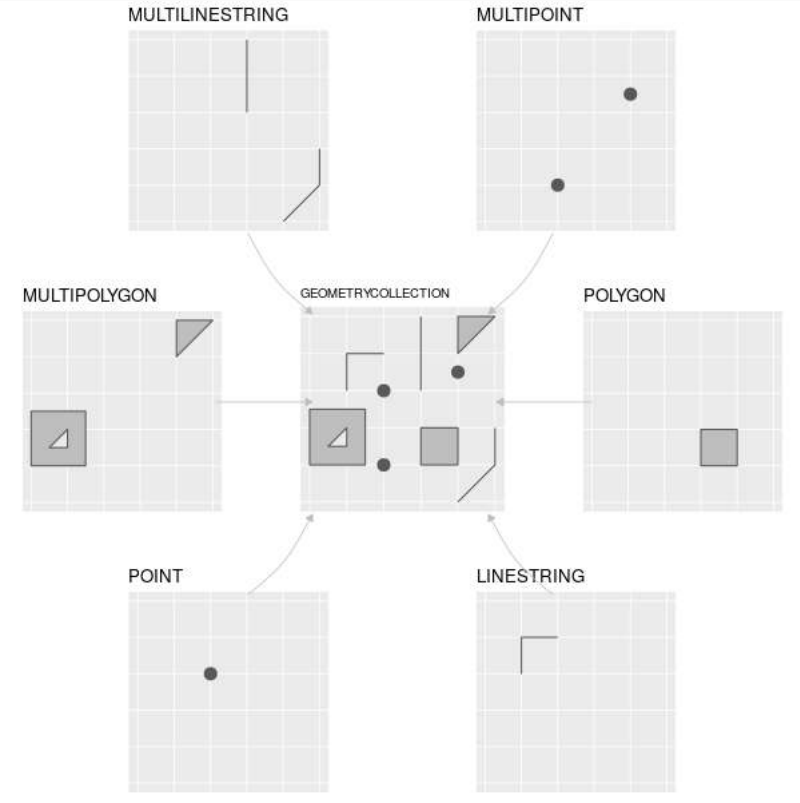
Geometrias	Entidade espacial	Representação	Atributos
Pontos			FID | Município | Hidrografia | Vazão 1 | Rio Claro | Nascente | 0,2 2 | Rio Claro | Nascente | 0,8 3 | Rio Claro | Nascente | 1,1 ... | ... | ... | ...
Linhas			FID | Município | Hidrografia | Vazão 1 | Rio Claro | Rios | 2,4 2 | Rio Claro | Rios | 3,1 3 | Rio Claro | Rios | 7,7 ... | ... | ... | ...
Polígonos			FID | Município | Uso | Área 1 | Rio Claro | Floresta | 10,1 2 | Rio Claro | Floresta | 19,8 3 | Rio Claro | Floresta | 50,2 ... | ... | ... | ...

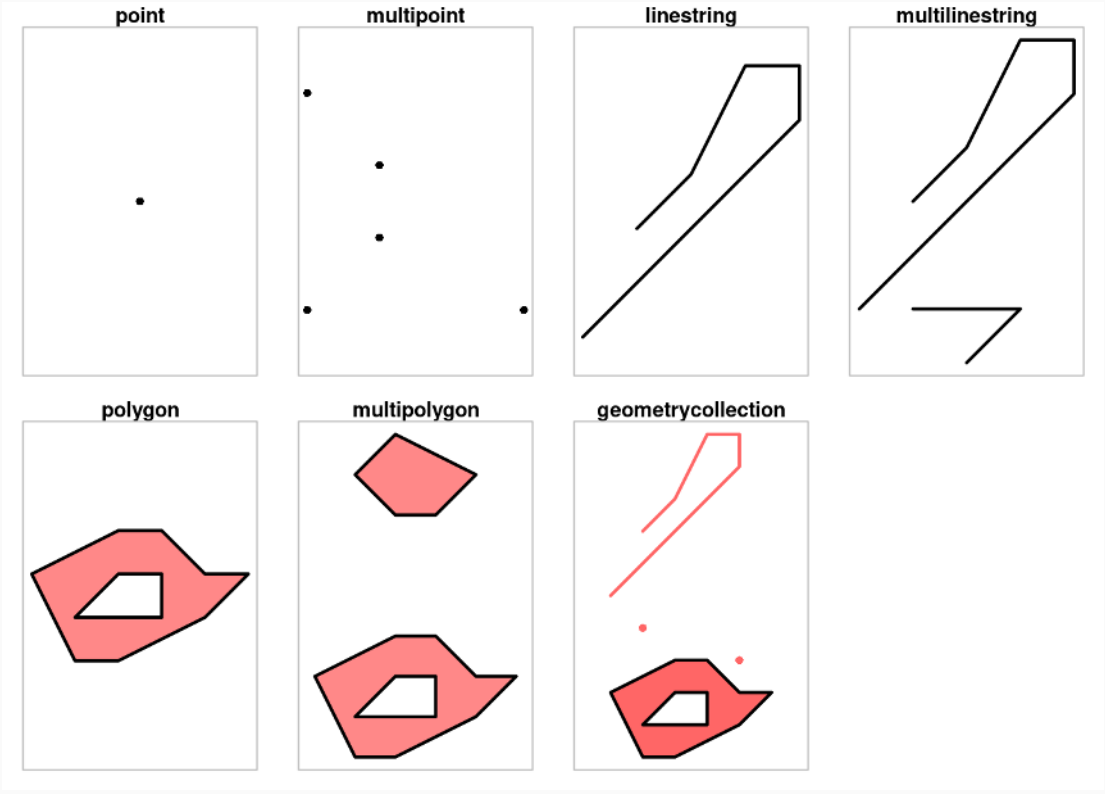


Shin et al. (2017), Silva et al. (in prep.)

2. Tipos de geometrias sf

Tipos de geometrias





Lovelace et al. (2020)

3. Classes sf

O pacote sf define um sistema de três classes hierárquicas

Classes	Hierarquia	Informação
1. Simple feature geometries (**g**)	Geometria	Tipo de geometria e coordenadas
2. Simple feature columns (**c**)	Coluna de geometria	Conjunto de **g** + CRS
3. Simple feature ()	Camada	Conjunto de **c** + atributos

- 1. Classe `sfg` - uma geometria única
- 1. Classe `sfc` - uma coluna de geometria, que é um conjunto de geometrias `sfg` e informações Sistema de Referência de Coordenadas (do inglês *Coordinate Reference Systems - CRS*)
- 1. Classe `sf` - uma camada, que é uma coluna de geometria `sfc` dentro de um data frame com atributos não espaciais (tabela de atributos)

3. Classes sf

1. Simple feature geometries (`sfg`)

A classe `sfg` representa os **diferentes tipos de geometrias** no R: ponto, linha, polígono (e seus equivalentes 'multi') ou coleção de geometrias

Funções para criar geometrias da classe `sfg`:

```
# simple
sf::st_point()
sf::st_linestring()
sf::st_polygon()

# multi
sf::st_multipoint()
sf::st_multilinestring()
sf::st_multipolygon()

# collections
sf::st_geometrycollection()
```

3. Classes sf

1. Simple feature geometries (`sfg`)

Os objetos `sfg` podem ser **criados** a partir de **três tipos de dados R base**:

1. **vetor numérico**: um único ponto

2. **matriz**: um conjunto de pontos, onde cada linha representa um ponto, um multiponto ou uma linha

3. **lista**: uma coleção de objetos como matrizes, cadeias multilinha ou coleções de geometrias

3. Classes sf

1. Simple feature geometries (`sfg`)

```
# vector - point
vec ← c(5, 2)
po ← sf::st_point(vec)
po
```

```
# plot
plot(po, pch = 20, cex = 4, axes = TRUE, graticule = TRUE)
```

3. Classes sf

1. Simple feature geometries (`sfg`)

```
# matrix - multipoint
multipoint_matrix ← rbind(c(5, 2), c(1, 3), c(3, 4), c(3, 2))
po_mul ← sf::st_multipoint(multipoint_matrix)
po_mul
```

```
# plot
plot(po_mul, pch = 20, cex = 4, axes = TRUE, graticule = TRUE)
```

3. Classes sf

1. Simple feature geometries (`sfg`)

```
# matrix - linestring
multipoint_matrix ← rbind(c(5, 2), c(1, 3), c(3, 4), c(3, 2))
lin ← sf::st_linestring(multipoint_matrix)
lin
```

```
# plot
plot(lin, lwd = 2, axes = TRUE, graticule = TRUE)
```

3. Classes sf

1. Simple feature geometries (`sfg`)

```
# list - polygon
polygon_list ← list(rbind(c(1, 5), c(2, 2), c(4, 1), c(4, 4), c(1, 5)))
pol ← sf::st_polygon(polygon_list)
pol
```

```
# plot
plot(pol, col = "gray", axes = TRUE, graticule = TRUE)
```

3. Classes sf

2. Simple feature columns (`sfc`)

Uma **lista de objetos** `sfg` que possui o **mesmo CSR** (*Coordinate Reference System*)

Pode conter objetos da **mesma geometria** ou de **geometrias diferentes**

Funções para **criar** a classe `sfc` e verificar o **tipo da geometria e CRS**:

```
sf::st_sfc()
sf::st_geometry_type()
sf::st_crs()
```

3. Classes sf

2. Simple feature columns (`sfc`)

```
# sfc point
point1 ← sf::st_point(c(5, 2))
point2 ← sf::st_point(c(1, 3))
points_sfc ← sf::st_sfc(point1, point2)
points_sfc
```

```
## Geometry set for 2 features
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 1 ymin: 2 xmax: 5 ymax: 3
## CRS:           NA
```

```
sf::st_geometry_type(points_sfc)
```

```
## [1] POINT POINT
## 18 Levels: GEOMETRY POINT LINESTRING POLYGON MULTIPOINT MULTILINESTRING MULTIPOLYGON GEOMETRYCOLLECTION CIRCULARST
```

2. Simple feature columns (`sfc`)

```
# plot
plot(points_sfc, pch = 20, cex = 4, axes = TRUE, graticule = TRUE)
```

2. Simple feature columns (`sfc`)

```
# sfc geometry
po_pol_sfc ← sf::st_sfc(po, pol)
po_pol_sfc
```

```
## Geometry set for 2 features
## Geometry type: GEOMETRY
## Dimension:     XY
## Bounding box:  xmin: 1 ymin: 1 xmax: 5 ymax: 5
## CRS:           NA
```

```
sf::st_geometry_type(po_pol_sfc)
```

```
## [1] POINT   POLYGON
## 18 Levels: GEOMETRY POINT LINESTRING POLYGON MULTIPOINT MULTILINESTRING MULTIPOLYGON GEOMETRYCOLLECTION CIRCULARST
```

2. Simple feature columns (`sfc`)

```
# plot
plot(po_pol_sfc, pch = 20, cex = 4, lwd = 2, col = "gray", axes = TRUE, graticule = TRUE)
```

2. Simple feature columns (`sfc`)

Coordinate Reference Systems (CRS) - EPSG

```
# epsg definition
points_sfc_wgs ← sf::st_sfc(point1, point2, crs = 4326)
sf::st_crs(points_sfc_wgs)
```

```
## Coordinate Reference System:
##   User input: EPSG:4326
##   wkt:
## GEOGCRS["WGS 84",
##     DATUM["World Geodetic System 1984",
##         ELLIPSOID["WGS 84",6378137,298.257223563,
##             LENGTHUNIT["metre",1]]],
##     PRIMEM["Greenwich",0,
##         ANGLEUNIT["degree",0.0174532925199433]],
##     CS[ellipsoidal,2],
##         AXIS["geodetic latitude (Lat)",north,
##             ORDER[1],
##             ANGLEUNIT["degree",0.0174532925199433]],
##         AXIS["geodetic longitude (Lon)",east,
```

2. Simple feature columns (`sfc`)

Coordinate Reference Systems (CRS) - proj4string

```
# proj4string definition
points_sfc_wgs ← sf::st_sfc(point1, point2, crs = "+proj=longlat +datum=WGS84 +no_defs")
sf::st_crs(points_sfc_wgs)
```

```
## Coordinate Reference System:
##   User input: +proj=longlat +datum=WGS84 +no_defs
##   wkt:
## GEOGCRS["unknown",
##     DATUM["World Geodetic System 1984",
##         ELLIPSOID["WGS 84",6378137,298.257223563,
##             LENGTHUNIT["metre",1]],
##         ID["EPSG",6326]],
##     PRIMEM["Greenwich",0,
##         ANGLEUNIT["degree",0.0174532925199433],
##         ID["EPSG",8901]],
##     CS[ellipsoidal,2],
##         AXIS["longitude",east,
##             ORDER[1],
```

2. Simple feature columns (`sfc`)

```
# plot
plot(points_sfc_wgs, pch = 20, cex = 4, axes = TRUE, graticule = TRUE)
```

3. Simple feature (`sf`)

A classe sf (simple features) são *data frames* com **atributos espaciais** armazenados em uma coluna, geralmente chamada de **geometry**

Essa **dualidade** é central para o conceito de **simple features**: na maioria das vezes, um sf pode **ser tratado e se comporta** como um *data frame*

Simple features são, em essência, *data frames* com uma **extensão espacial**

3. Simple feature (`sf`)

Criar um objeto sf

```
rc_point ← sf::st_point(c(-47.57, -22.39))          # `sfg` object
rc_geom ← sf::st_sfc(rc_point, crs = 4326)         # `sfc` object
rc_attrib ← data.frame(                           # data frame object
  name = "Rio Claro",
  temperature = 19,
  date = as.Date("2020-10-13")
)
rc_sf ← sf::st_sf(rc_attrib, geometry = rc_geom)  # sf object
```

3. Simple feature (`sf`)

A estrutura de um objeto sf

```
rc_sf
```

```
## Simple feature collection with 1 feature and 3 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -47.57 ymin: -22.39 xmax: -47.57 ymax: -22.39
## Geodetic CRS:  WGS 84
##        name temperature       date              geometry
## 1 Rio Claro          19 2020-10-13 POINT (-47.57 -22.39)
```

As duas classes do objeto sf

```
class(rc_sf)
```

```
## [1] "sf"         "data.frame"
```

3. Simple feature (`sf`)

```
# plot
plot(rc_sf[1], pch = 20, cex = 4, axes = TRUE, graticule = TRUE) # rc_sf[1] - plotar a primeira coluna
```

3. Simple feature (`sf`)

```
# plot
plot(rc_sf[2], pch = 20, cex = 4, axes = TRUE, graticule = TRUE) # rc_sf[2] - plotar a segunda coluna
```

3. Simple feature (`sf`)

```
# plot
plot(rc_sf$geometry, pch = 20, cex = 4, axes = TRUE, graticule = TRUE) # rc_sf$geometry - plotar apenas a geomet
```

4. Importar dados vetoriais

Fundação Brasileira Desenvolvimento Sustentável (FBDS)

Em 2015, a FBDS deu início ao *Projeto de Mapeamento em Alta Resolução dos Biomas Brasileiros*:

- Cobertura da terra
- Hidrografia (nascentes, rios e lagos)
- Áreas de Preservação Permanente (APP)

O mapeamento foi concluído para os municípios dos biomas *Mata Atlântica e Cerrado*

Site: https://www.fbds.org.br/
Repositório: http://geo.fbds.org.br/

4. Importar dados vetoriais

Download

Criar um diretório

```
# create directory
dir.create(here::here("03_dados", "vetor"))
```

Download de **pontos de nascentes** para Rio Claro/SP

```
# increase time to download
options(timeout = 600)

# download points
for(i in c(".dbf", ".prj", ".shp", ".shx")){
  download.file(url = paste0("http://geo.fbds.org.br/SP/RIO_CLARO/HIDROGRAFIA/SP_3543907_NASCENTES", i),
                destfile = here::here("03_dados", "vetor", paste0("SP_3543907_NASCENTES", i)), mode = "wb")
}
```

4. Importar dados vetoriais

Download

Download de **linhas da hidrografia** para Rio Claro/SP

```
# download lines
for(i in c(".dbf", ".prj", ".shp", ".shx")){
  download.file(url = paste0("http://geo.fbds.org.br/SP/RIO_CLARO/HIDROGRAFIA/SP_3543907_RIOS_SIMPLES", i),
                destfile = here::here("03_dados", "vetor", paste0("SP_3543907_RIOS_SIMPLES", i)), mode = "wb")
}
```

Download de **polígonos de cobertura da terra** para Rio Claro/SP

```
# download polygon
for(i in c(".dbf", ".prj", ".shp", ".shx")){
  download.file(url = paste0("http://geo.fbds.org.br/SP/RIO_CLARO/USO/SP_3543907_USO", i),
                destfile = here::here("03_dados", "vetor", paste0("SP_3543907_USO", i)), mode = "wb")
}
```

4. Importar dados vetoriais

Dados preexistentes

```
# importar pontos
rc_nas ← sf::st_read(here::here("03_dados", "vetor", "SP_3543907_NASCENTES.shp"), quiet = TRUE)
rc_nas
```

```
## Simple feature collection with 1220 features and 5 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 217622.9 ymin: 7504132 xmax: 246367.4 ymax: 7537855
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##    GEOCODIGO MUNICIPIO UF CD_UF    HIDRO                  geometry
## 1    3543907 RIO CLARO SP    35 nascente POINT (217622.9 7528315)
## 2    3543907 RIO CLARO SP    35 nascente POINT (217836.5 7528103)
## 3    3543907 RIO CLARO SP    35 nascente POINT (217988.9 7528203)
## 4    3543907 RIO CLARO SP    35 nascente POINT (218288.9 7528237)
## 5    3543907 RIO CLARO SP    35 nascente POINT (218346.6 7530583)
## 6    3543907 RIO CLARO SP    35 nascente POINT (218393.1 7528031)
## 7    3543907 RIO CLARO SP    35 nascente POINT (218508.3 7528470)
## 8    3543907 RIO CLARO SP    35 nascente POINT (218535.4 7530642)
## 9    3543907 RIO CLARO SP    35 nascente POINT (218583.5 7528215)
```

4. Importar dados vetoriais

Dados preexistentes

```
# plot
plot(rc_nas$geometry, pch = 20, col = "blue", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados preexistentes

```
# importar linhas
rc_hid ← sf::st_read(here::here("03_dados", "vetor", "SP_3543907_RIOS_SIMPLES.shp"), quiet = TRUE)
rc_hid
```

```
## Simple feature collection with 1 feature and 6 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: 215155.3 ymin: 7504132 xmax: 246367.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF                  HIDRO COMP_KM                          geometry
## 1   3543907 RIO CLARO SP    35 curso d'água (0 - 10m) 1142.98 MULTILINESTRING ((231815.7 ...
```

4. Importar dados vetoriais

Dados preexistentes

```
# plot
plot(rc_hid$geometry, col = "steelblue", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados preexistentes

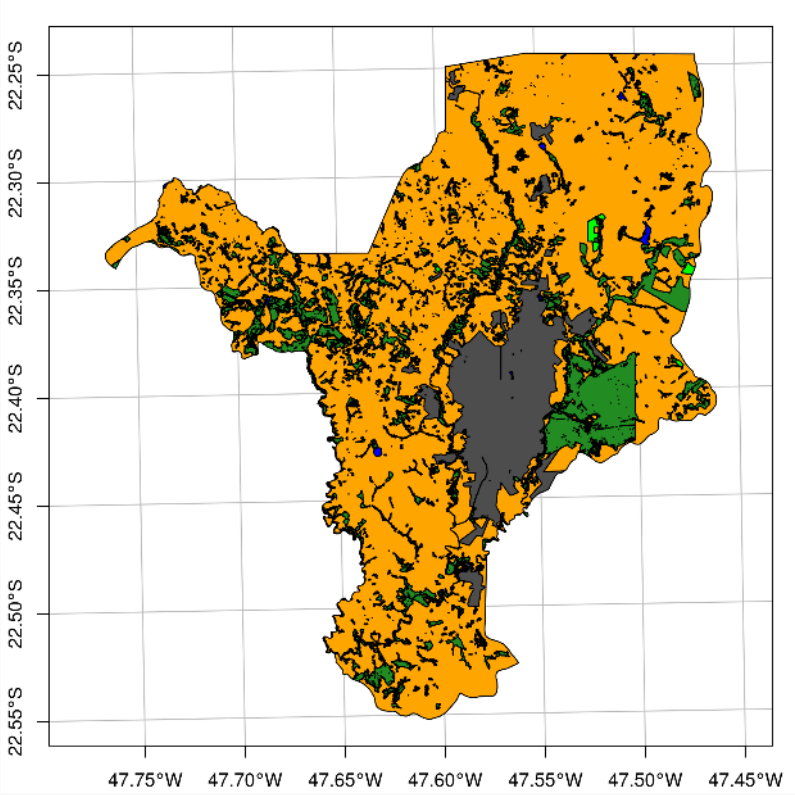
```
# importar poligonos
rc_cob ← sf::st_read(here::here("03_dados", "vetor", "SP_3543907_USO.shp"), quiet = TRUE)
rc_cob
```

```
## Simple feature collection with 5 features and 6 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 215151.7 ymin: 7503723 xmax: 246582.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF         CLASSE_USO   AREA_HA                       geometry
## 1   3543907 RIO CLARO SP    35              água   357.027 MULTIPOLYGON (((235487.6 75 ...
## 2   3543907 RIO CLARO SP    35   área antropizada 37297.800 MULTIPOLYGON (((232275 7504 ...
## 3   3543907 RIO CLARO SP    35     área edificada  5078.330 MULTIPOLYGON (((233123.6 75 ...
## 4   3543907 RIO CLARO SP    35 formação florestal  7017.990 MULTIPOLYGON (((232355 7504 ...
## 5   3543907 RIO CLARO SP    35       silvicultura   138.173 MULTIPOLYGON (((243052.1 75 ...
```

4. Importar dados vetoriais

Dados preexistentes

```
# plot
plot(rc_cob[5], col = c("blue", "orange", "gray30", "forestgreen", "green"), main = NA, axes = TRUE, graticule =
```



4. Importar dados vetoriais

Dados de GPS (.gpx)

```
# importar dados de gps
gps_gpx ← sf::st_read(here::here("03_dados", "vetor", "waypoints.gpx"), layer = "waypoints", quiet = TRUE)
gps_gpx
```

```
## Simple feature collection with 11 features and 23 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -47.54245 ymin: -22.39524 xmax: -47.53969 ymax: -22.39209
## Geodetic CRS:  WGS 84
## First 10 features:
##         ele                time magvar geoidheight name cmt desc  src link1_href link1_text link1_type link2_href
## 1  603.0454 2020-08-20 10:13:35     NA          NA  102  33 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 2  595.2947 2020-08-20 10:22:52     NA          NA  103  71 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 3  581.9885 2020-08-20 10:32:30     NA          NA  104  11 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 4  587.4568 2020-08-20 10:42:05     NA          NA  105  72 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 5  581.2265 2020-08-20 10:49:32     NA          NA  106  68 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 6  593.6844 2020-08-20 11:06:53     NA          NA  107 121 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 7  591.4097 2020-08-20 11:16:36     NA          NA  108  83 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 8  594.1143 2020-08-20 11:27:59     NA          NA  109 162 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
## 9  594.4582 2020-08-20 11:43:04     NA          NA  110 103 <NA> <NA>       <NA>       <NA>       <NA>       <NA>
```

4. Importar dados vetoriais

Dados de GPS (.gpx)

```
# plot
plot(gps_gpx$geometry, cex = 4, pch = 20, col = "red", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de GPS (.kml)

```
# importar dados de gps
gps_kml ← sf::st_read(here::here("03_dados", "vetor", "waypoints.kml"), quiet = TRUE)
gps_kml
```

```
## Simple feature collection with 11 features and 16 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -47.54245 ymin: -22.39524 xmax: -47.53969 ymax: -22.39209
## Geodetic CRS:  WGS 84
## First 10 features:
##    Name description timestamp begin  end altitudeMode tessellate extrude visibility drawOrder icon elevation comme
## 1   102        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  603.0454
## 2   103        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  595.2947
## 3   104        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  581.9885
## 4   105        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  587.4568
## 5   106        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  581.2265
## 6   107        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  593.6844     1
## 7   108        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  591.4097
## 8   109        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  594.1143     1
## 9   110        <NA>      <NA>  <NA> <NA>         <NA>         -1       0         -1        NA <NA>  594.4582     1
```

4. Importar dados vetoriais

Dados de GPS (.kml)

```
# plot
plot(gps_kml$geometry, cex = 4, pch = 20, col = "blue", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de uma tabela de coordenadas

```
# importar tabela
si ← readr::read_csv(
  here::here("03_dados", "tabelas", "ATLANTIC_AMPHIBIANS_sites.csv"))
si
```

```
## ¤[90m# A tibble: 1,163 × 25¤[39m
##    id      reference_number species_number record sampled_habitat active_methods passive_methods complementary_me…
##    ¤[3m¤[90m<chr>¤[39m¤[23m              ¤[3m¤[90m<dbl>¤[39m¤[23m          ¤[3m¤[90m<dbl>¤[39m¤[23m ¤[3m¤[90m<c
## ¤[90m 1¤[39m amp1001             ¤[4m1¤[24m001             19 ab     fo,ll            as              pt
## ¤[90m 2¤[39m amp1002             ¤[4m1¤[24m002             16 co     fo,la,ll         as              pt
## ¤[90m 3¤[39m amp1003             ¤[4m1¤[24m002             14 co     fo,la,ll         as              pt
## ¤[90m 4¤[39m amp1004             ¤[4m1¤[24m002             13 co     fo,la,ll         as              pt
## ¤[90m 5¤[39m amp1005             ¤[4m1¤[24m003             30 co     fo,ll,br         as              ¤[31mNA¤[39m
## ¤[90m 6¤[39m amp1006             ¤[4m1¤[24m004             42 co     tp,pp,la,ll,is   ¤[31mNA¤[39m            ¤[3
## ¤[90m 7¤[39m amp1007             ¤[4m1¤[24m005             23 co     sp               as              ¤[31mNA¤[39m
## ¤[90m 8¤[39m amp1008             ¤[4m1¤[24m005             19 co     sp,la,sw         as,sb,tr        ¤[31mNA¤[39m
## ¤[90m 9¤[39m amp1009             ¤[4m1¤[24m005             13 ab     fo               ¤[31mNA¤[39m            pt
## ¤[90m10¤[39m amp1010             ¤[4m1¤[24m006              1 ab     fo               ¤[31mNA¤[39m            pt
## ¤[90m# … with 1,153 more rows, and 14 more variables: month_finish <dbl>, year_finish <dbl>, effort_months <dbl>,
## ¤[90m#   state_abbreviation <chr>, municipality <chr>, site <chr>, latitude <dbl>, longitude <dbl>, coordinate_pre
```

4. Importar dados vetoriais

Dados de uma tabela de coordenadas (.csv | .xlsx)

```
# converter para sf
si_ve ← si %>%
  sf::st_as_sf(coords = c("longitude", "latitude"), crs = 4326)
si_ve
```

```
## Simple feature collection with 1163 features and 23 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: -56.74194 ymin: -33.51083 xmax: -34.79667 ymax: -3.51525
## Geodetic CRS:  WGS 84
## ¤[90m# A tibble: 1,163 × 24¤[39m
##    id      reference_number species_number record sampled_habitat active_methods passive_methods complementary_me…
##  ¤[90m*¤[39m ¤[3m¤[90m<chr>¤[39m¤[23m              ¤[3m¤[90m<dbl>¤[39m¤[23m          ¤[3m¤[90m<dbl>¤[39m¤[23m ¤
## ¤[90m 1¤[39m amp1001            ¤[4m1¤[24m001              19 ab     fo,ll           as              pt
## ¤[90m 2¤[39m amp1002            ¤[4m1¤[24m002              16 co     fo,la,ll        as              pt
## ¤[90m 3¤[39m amp1003            ¤[4m1¤[24m002              14 co     fo,la,ll        as              pt
## ¤[90m 4¤[39m amp1004            ¤[4m1¤[24m002              13 co     fo,la,ll        as              pt
## ¤[90m 5¤[39m amp1005            ¤[4m1¤[24m003              30 co     fo,ll,br        as              ¤[31mNA¤[39m
## ¤[90m 6¤[39m amp1006            ¤[4m1¤[24m004              42 co     tp,pp,la,ll,is  ¤[31mNA¤[39m            ¤[3
## ¤[90m 7¤[39m amp1007            ¤[4m1¤[24m005              23 co     sp              as              ¤[31mNA¤[39m
```

4. Importar dados vetoriais

Dados de uma tabela de coordenadas (.csv | .xlsx)

```
# plot
plot(si_ve$geometry, pch = 20, main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
install.packages("geobr")
library(geobr)
```

geobr

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# brasil 2019
br_2019 ← geobr::read_country(year = 2019, showProgress = FALSE)
br_2019
```

```
## Simple feature collection with 27 features and 5 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84784 ymax: 5.271841
## Geodetic CRS:  SIRGAS 2000
## First 10 features:
##    code_state abbrev_state name_state code_region name_region                       geom
## 1          11           RO   Rondônia           1       Norte MULTIPOLYGON (((-65.3815 -1...
## 2          12           AC       Acre           1       Norte MULTIPOLYGON (((-71.07772 -...
## 3          13           AM   Amazônas           1       Norte MULTIPOLYGON (((-69.83766 -...
## 4          14           RR    Roraima           1       Norte MULTIPOLYGON (((-63.96008 2...
## 5          15           PA       Pará           1       Norte MULTIPOLYGON (((-51.43248 -...
## 6          16           AP      Amapá           1       Norte MULTIPOLYGON (((-53.27918 2...
## 7          17           TO  Tocantins           1       Norte MULTIPOLYGON (((-48.23163 -...
## 8          21           MA   Maranhão           2    Nordeste MULTIPOLYGON (((-46.16128 -...
## 9          22           PI      Piauí           2    Nordeste MULTIPOLYGON (((-42.91539 -...
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# plot
plot(br_2019$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# brasil 1872
br_1872 ← geobr::read_country(year = 1872, showProgress = FALSE)
br_1872
```

```
## Simple feature collection with 1 feature and 0 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -73.80132 ymin: -33.74912 xmax: -34.79313 ymax: 5.271891
## Geodetic CRS:  SIRGAS 2000
##                                geom
## 1 MULTIPOLYGON (((-48.40975 - ...
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# plot
plot(br_1872$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# sao paulo municipios
sp_mun_2019 ← geobr::read_municipality(code_muni = "SP", year = 2019, showProgress = FALSE)
sp_mun_2019
```

```
## Simple feature collection with 645 features and 7 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -53.10986 ymin: -25.35794 xmax: -44.16137 ymax: -19.77966
## Geodetic CRS:  SIRGAS 2000
## First 10 features:
##    code_muni               name_muni code_state abbrev_state name_state code_region name_region
## 1    3500105             Adamantina         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-51
## 2    3500204                 Adolfo         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-49
## 3    3500303                  Aguaí         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-47
## 4    3500402          Águas Da Prata         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-46
## 5    3500501        Águas De Lindóia         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-46
## 6    3500550 Águas De Santa Bárbara         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-49
## 7    3500600      Águas De São Pedro         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-47
## 8    3500709                  Agudos         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-49
## 9    3500758                Alambari         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-47
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# plot
plot(sp_mun_2019$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# rio claro
rc_2020 ← geobr::read_municipality(code_muni = 3543907, year = 2020, showProgress = FALSE)
rc_2020
```

```
## Simple feature collection with 1 feature and 7 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -47.76521 ymin: -22.55203 xmax: -47.46188 ymax: -22.24368
## Geodetic CRS:  SIRGAS 2000
##     code_muni name_muni code_state abbrev_state name_state code_region name_region                          geom
## 493   3543907 Rio Claro         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-47.46875 - ...
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# plot
plot(rc_2020$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# biomas
bi_2019 ← geobr::read_biomes(year = 2019, showProgress = FALSE)
bi_2019
```

```
## Simple feature collection with 7 features and 3 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -73.98304 ymin: -34.95942 xmax: -28.84785 ymax: 7.053767
## Geodetic CRS:  SIRGAS 2000
##         name_biome code_biome year                           geom
## 1         Amazônia          1 2019 MULTIPOLYGON (((-44.08515 - ...
## 2         Caatinga          2 2019 MULTIPOLYGON (((-41.7408 -2 ...
## 3          Cerrado          3 2019 MULTIPOLYGON (((-43.39009 - ...
## 4   Mata Atlântica          4 2019 MULTIPOLYGON (((-48.70814 - ...
## 5            Pampa          5 2019 MULTIPOLYGON (((-52.82472 - ...
## 6         Pantanal          6 2019 MULTIPOLYGON (((-57.75946 - ...
## 7 Sistema Costeiro         NA 2019 MULTIPOLYGON (((-44.64799 - ...
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# plot
plot(bi_2019$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
```

4. Importar dados vetoriais

Dados de pacotes: *geobr*

Function	Geographies available	Years available	Source
`read_country()`	Country	1872, 1900, 1911, 1920, 1933, 1940, 1950, 1960, 1970, 1980, 1991, 2000, 2001, 2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019	IBGE
`read_state()`	States	1872, 1900, 1911, 1920, 1933, 1940, 1950, 1960, 1970, 1980, 1991, 2000, 2001, 2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019	IBGE
`read_municipality()`	Municipality	1872, 1900, 1911, 1920, 1933, 1940, 1950, 1960, 1970, 1980, 1991, 2000, 2001, 2005, 2007, 2010, 2013, 2014, 2015, 2016, 2017, 2018, 2019	IBGE
`read_biomes()`	Biomes	2004, 2019	IBGE

4. Importar dados vetoriais

Dados de pacotes: *geobr*

```
# list all datasets available in the geobr package
geobr::list_geobr()
```

```
## ¤[90m# A tibble: 27 × 4¤[39m
##    `function`                 geography                                    years
##    ¤[3m¤[90m<chr>¤[39m¤[23m                   ¤[3m¤[90m<chr>¤[39m¤[23m                                ¤
## ¤[90m 1¤[39m `read_country`            Country                                      1872, 1900, 1911, 1920, 1933, 1
## ¤[90m 2¤[39m `read_region`             Region                                       2000, 2001, 2010, 2013, 2014, 2
## ¤[90m 3¤[39m `read_state`              States                                       1872, 1900, 1911, 1920, 1933, 1
## ¤[90m 4¤[39m `read_meso_region`        Meso region                                  2000, 2001, 2010, 2013, 2014, 2
## ¤[90m 5¤[39m `read_micro_region`       Micro region                                 2000, 2001, 2010, 2013, 2014, 2
## ¤[90m 6¤[39m `read_intermediate_region` Intermediate region                         2017, 2019, 2020
## ¤[90m 7¤[39m `read_immediate_region`   Immediate region                             2017, 2019, 2020
## ¤[90m 8¤[39m `read_municipality`       Municipality                                 1872, 1900, 1911, 1920, 1933, 1
## ¤[90m 9¤[39m `read_municipal_seat`     Municipality seats (sedes municipais)        1872, 1900, 1911, 1920, 1933, 1
## ¤[90m10¤[39m `read_weighting_area`     Census weighting area (área de ponderação) 2010
## ¤[90m# … with 17 more rows¤[39m
```

4. Importar dados vetoriais

Dados de pacotes: *rnaturalearth*

```
# package
install.packages("rnaturalearth")
library(rnaturalearth)
```

naturalearthdata, rnaturalearth

4. Importar dados vetoriais

Dados de pacotes: *rnaturalearth*

```
# south america
sa ← rnaturalearth::ne_countries(scale = "small", continent = "South America", returnclass = "sf")
sa
```

```
## Simple feature collection with 13 features and 63 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -81.41094 ymin: -55.61183 xmax: -34.72999 ymax: 12.4373
## CRS:           +proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0
## First 10 features:
##     scalerank      featurecla labelrank     sovereignt sov_a3 adm0_dif level              type            admin ad
## 4           1 Admin-0 country         2      Argentina    ARG        0     2 Sovereign country        Argentina
## 21          1 Admin-0 country         3        Bolivia    BOL        0     2 Sovereign country          Bolivia
## 22          1 Admin-0 country         2         Brazil    BRA        0     2 Sovereign country           Brazil
## 29          1 Admin-0 country         2          Chile    CHL        0     2 Sovereign country            Chile
## 35          1 Admin-0 country         2       Colombia    COL        0     2 Sovereign country         Colombia
## 46          1 Admin-0 country         3        Ecuador    ECU        0     2 Sovereign country          Ecuador
## 54          1 Admin-0 country         5 United Kingdom    GB1        1     2        Dependency Falkland Islands
## 67          1 Admin-0 country         4         Guyana    GUY        0     2 Sovereign country           Guyana
## 124         1 Admin-0 country         2           Peru    PER        0     2 Sovereign country             Peru
```

4. Importar dados vetoriais

Dados de pacotes: *rnaturalearth*

```
# plot
plot(sa$geometry, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
```

5. Descrição de objetos sf

Informações geográficas e tabela de atributos

```
# rio claro
rc_2020
```

```
## Simple feature collection with 1 feature and 7 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -47.76521 ymin: -22.55203 xmax: -47.46188 ymax: -22.24368
## Geodetic CRS:  SIRGAS 2000
##     code_muni name_muni code_state abbrev_state name_state code_region name_region                              geom
## 493   3543907 Rio Claro         35           SP  São Paulo           3     Sudeste MULTIPOLYGON (((-47.46875 - ...
```

5. Descrição de objetos sf

Informações

- *resumo do vetor*: indica o número de feições (linhas) e campos (colunas)
- *tipo da geometria*: umas das sete classes listadas anteriormente
- *dimensão*: número de dimensões, geralmente duas (XY)
- *bbox (bordas)*: coordenadas mínimas e máximas da longitude e latitude
- *informação do CRS*: `epsg` ou `proj4string` indicando o CRS
- *tibble*: tabela de atributos, com destaque para a coluna `geom` ou `geometry` que representa cada feição ou geometria

```
## Simple feature collection with 100 features and 6 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
## epsg (SRID):    4267
## proj4string:    +proj=longlat +datum=NAD27 +no_defs
## precision:      double (default; no precision model)
## First 3 features:
##   BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79                           geom
## 1  1091     1      10  1364     0      19 MULTIPOLYGON(((-81.47275543...
## 2   487     0      10   542     3      12 MULTIPOLYGON(((-81.23989105...
## 3  3188     5     208  3616     6     260 MULTIPOLYGON(((-80.45634460...
```

Simple feature

Simple feature geometry list-colum (sfc)

Simple feature geometry (sfg)

5. Descrição de objetos sf

Informações geográficas

Geometry type

```
# tipo de geometria
sf::st_geometry_type(rc_2020)
```

```
## [1] MULTIPOLYGON
## 18 Levels: GEOMETRY POINT LINESTRING POLYGON MULTIPOINT MULTILINESTRING MULTIPOLYGON GEOMETRYCOLLECTION CIRCULARST
```

Bounding box

```
# extensao
sf::st_bbox(rc_2020)
```

```
##      xmin      ymin      xmax      ymax
## -47.76521 -22.55203 -47.46188 -22.24368
```

5. Descrição de objetos sf

Informações geográficas

Coordinate Reference System (CRS)

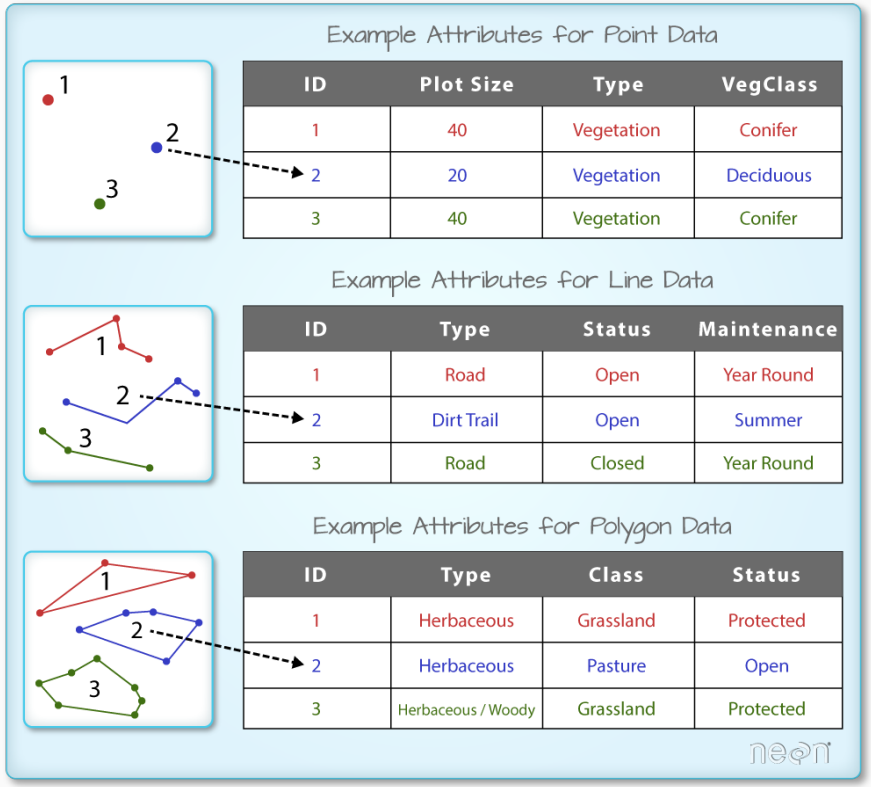
```
# crs
sf::st_crs(rc_2020)
```

```
## Coordinate Reference System:
##   User input: SIRGAS 2000
##   wkt:
## GEOGCRS["SIRGAS 2000",
##     DATUM["Sistema de Referencia Geocentrico para las AmericaS 2000",
##         ELLIPSOID["GRS 1980",6378137,298.257222101,
##             LENGTHUNIT["metre",1]]],
##     PRIMEM["Greenwich",0,
##         ANGLEUNIT["degree",0.0174532925199433]],
##     CS[ellipsoidal,2],
##         AXIS["geodetic latitude (Lat)",north,
##             ORDER[1],
##             ANGLEUNIT["degree",0.0174532925199433]],
##         AXIS["geodetic longitude (Lon)",east,
##             ORDER[2],
```

5. Descrição de objetos sf

Tabela de atributos

Relação entre a geometria e suas características



Example Attributes for Point Data

ID	Plot Size	Type	VegClass
1	40	Vegetation	Conifer
2	20	Vegetation	Deciduous
3	40	Vegetation	Conifer

Example Attributes for Line Data

ID	Type	Status	Maintenance
1	Road	Open	Year Round
2	Dirt Trail	Open	Summer
3	Road	Closed	Year Round

Example Attributes for Polygon Data

ID	Type	Class	Status
1	Herbaceous	Grassland	Protected
2	Herbaceous	Pasture	Open
3	Herbaceous / Woody	Grassland	Protected

5. Descrição de objetos sf

Tabela de atributos

Acessar a tabela de atributos de um `sf`

```
# acessar a tabela de atributos
rc_2020_tab ← sf::st_drop_geometry(rc_2020)
rc_2020_tab
```

```
##     code_muni name_muni code_state abbrev_state name_state code_region name_region
## 493   3543907 Rio Claro         35           SP  São Paulo           3     Sudeste
```

```
# classe
class(rc_2020_tab)
```

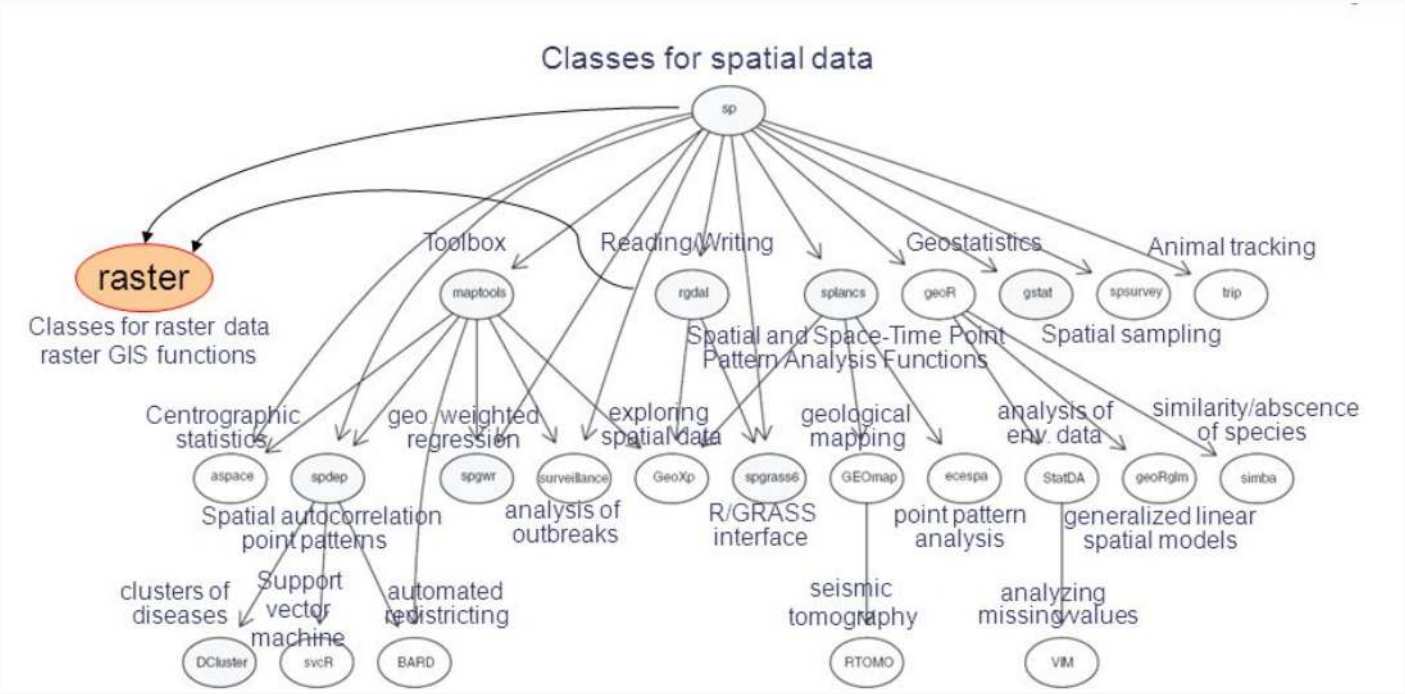
```
## [1] "data.frame"
```

6. Converter objetos para sf

Tipos de objetos `sp`

- SpatialPoints
- SpatialLines
- SpatialPolygons
- SpatialPointsdata frame
- SpatialLinesdata frame
- SpatialPolygonsdata frame

R package	Class
maps [8]	map
sp [10]	SpatialPoints
	SpatialPointsDataFrame
	Line
	Lines
	SpatialLines
	SpatialLinesDataFrame
	Polygon
	Polygons
	SpatialPolygons
	SpatialPolygonsDataFrame



6. Converter objetos para sf

Dados `sp`

```
# paises sp
co110_sp ← rnaturalearth::countries110
co110_sp
```

```
## class       : SpatialPolygonsDataFrame
## features    : 177
## extent      : -180, 180, -90, 83.64513  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0
## variables   : 63
## names       : scalerank,      featurecla, labelrank,  sovereignt, sov_a3, adm0_dif, level,              type,
## min values  :         1, Admin-0 country,         2, Afghanistan,    AFG,        0,     2,           Country, Afgh
## max values  :         3, Admin-0 country,         7,    Zimbabwe,    ZWE,        1,     2, Sovereign country,    Z
```

6. Converter objetos para sf

Converter `sp` para `sf`

```
# paises sf
co110_sf ← sf::st_as_sf(co110_sp)
co110_sf
```

```
## Simple feature collection with 177 features and 63 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -180 ymin: -90 xmax: 180 ymax: 83.64513
## CRS:           +proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0
## First 10 features:
##   scalerank      featurecla labelrank           sovereignt sov_a3 adm0_dif level              type
## 0         1 Admin-0 country         3          Afghanistan    AFG        0     2 Sovereign country
## 1         1 Admin-0 country         3               Angola    AGO        0     2 Sovereign country
## 2         1 Admin-0 country         6              Albania    ALB        0     2 Sovereign country
## 3         1 Admin-0 country         4 United Arab Emirates    ARE        0     2 Sovereign country
## 4         1 Admin-0 country         2            Argentina    ARG        0     2 Sovereign country
## 5         1 Admin-0 country         6              Armenia    ARM        0     2 Sovereign country
## 6         1 Admin-0 country         4           Antarctica    ATA        0     2     Indeterminate
## 7         3 Admin-0 country         6               France    FR1        1     2        Dependency French Southern
## 8         1 Admin-0 country         2            Australia    AU1        1     2           Country
```

6. Converter objetos para sf

Converter `sf` para `sp`

```
# plot
plot(co110_sf$geometry, col = "gray", main = NA, graticule = TRUE)
```

6. Converter objetos para sf

Converter `sf` para `sp`

```
# paises sp
co110_sp ← sf::as_Spatial(co110_sf)
co110_sp
```

```
## class       : SpatialPolygonsDataFrame
## features    : 177
## extent      : -180, 180, -90, 83.64513  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +ellps=WGS84 +towgs84=0,0,0,0,0,0,0 +no_defs
## variables   : 63
## names       : scalerank,      featurecla, labelrank,  sovereignt, sov_a3, adm0_dif, level,              type,
## min values  :         1, Admin-0 country,         2, Afghanistan,    AFG,        0,     2,           Country, Afgh
## max values  :         3, Admin-0 country,         7,    Zimbabwe,    ZWE,        1,     2, Sovereign country,    Z
```

7. Converter CRS de objetos sf

Os principais CRSs

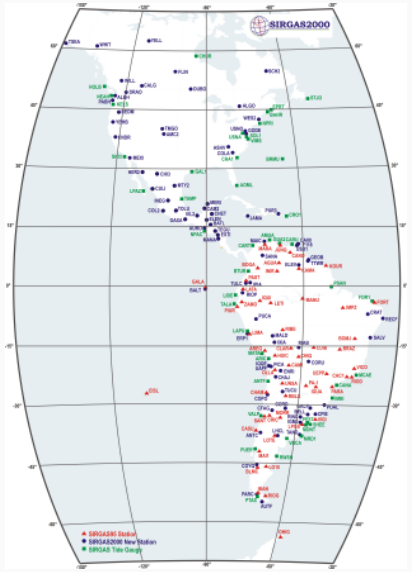
CRS	Tipo de CRS	Descrição	epsg.io	spatialreference.org
WGS84	Geográfico	CRS geográfico mais comum para o mundo	[EPSG:4326] (http://epsg.io/4326)	[EPSG:4326] (https://spatialreference.org/ref/epsg/4326/)
SIRGAS 2000	Geográfico	CRS geográfico oficial para o Brasil	[EPSG:4674] (http://epsg.io/4674)	[EPSG:4674] (https://spatialreference.org/ref/epsg/4674/)
Projeção de Mollweide	Projetado	CRS projetado que preserva as relações de área	[ESRI:54009] (https://epsg.io/54009)	[SR-ORG:7099] (https://spatialreference.org/ref/sr-org/7099/)
Projeção de Winkel Tripel	Projetado	CRS projetado que preserva a área e com meridianos elípticos	[EPSG:54012] (https://epsg.io/54012)	[ESRI:54012] (https://spatialreference.org/ref/esri/54012/)

7. Converter CRS de objetos sf

Converter CRS local

SIRGAS2000/GCS -> SIRGAS2000/UTM23S

```
# converter sistema de coordenadas
rc_2020_sirgas2000_utm23s ← sf::st_transform(rc_2020, crs = 31983)
```

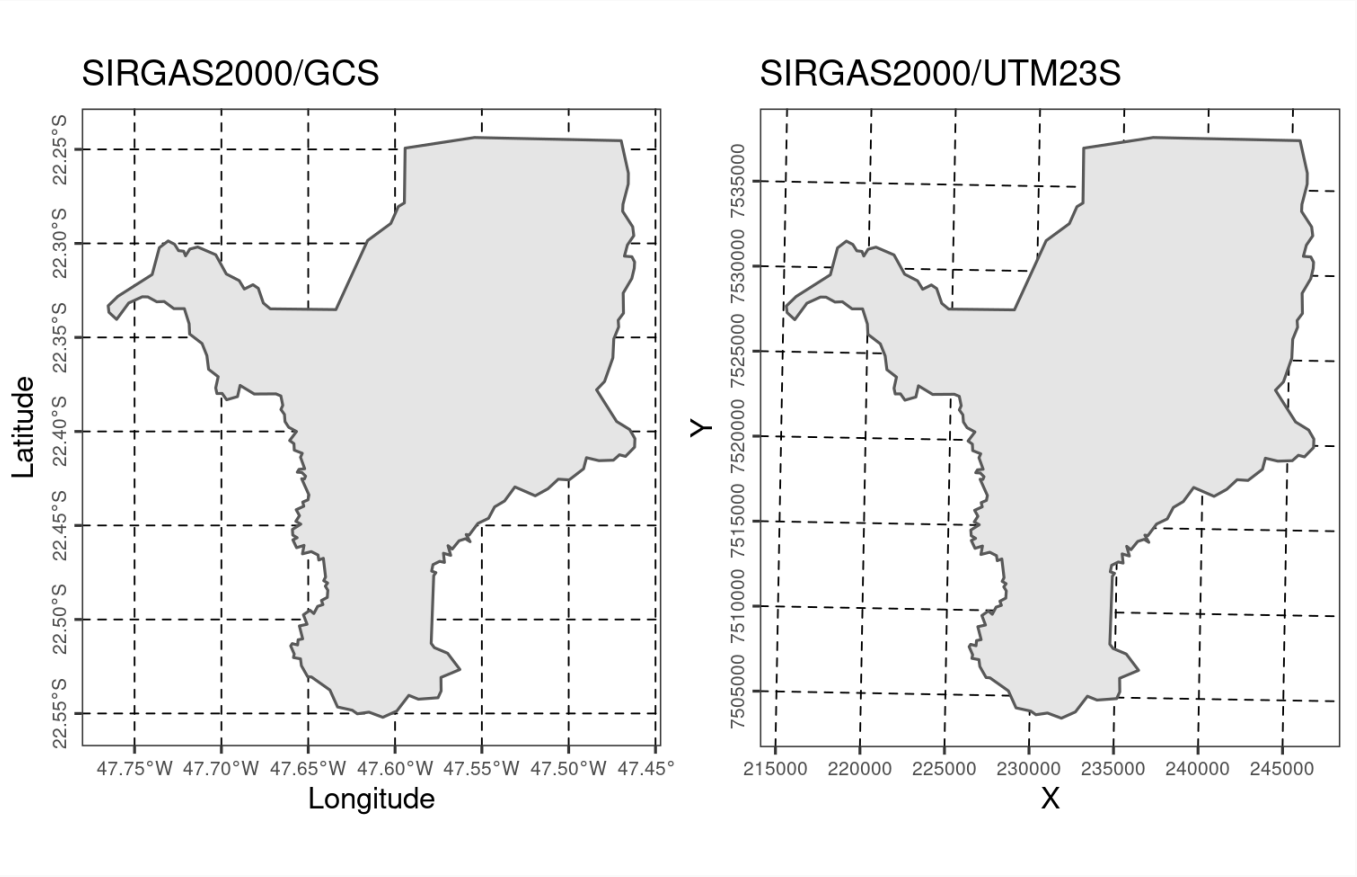


EPSG: 31983 SIRGAS2000

7. Converter CRS de objetos sf

Converter CRS local

SIRGAS2000/GCS -> SIRGAS2000/UTM23S

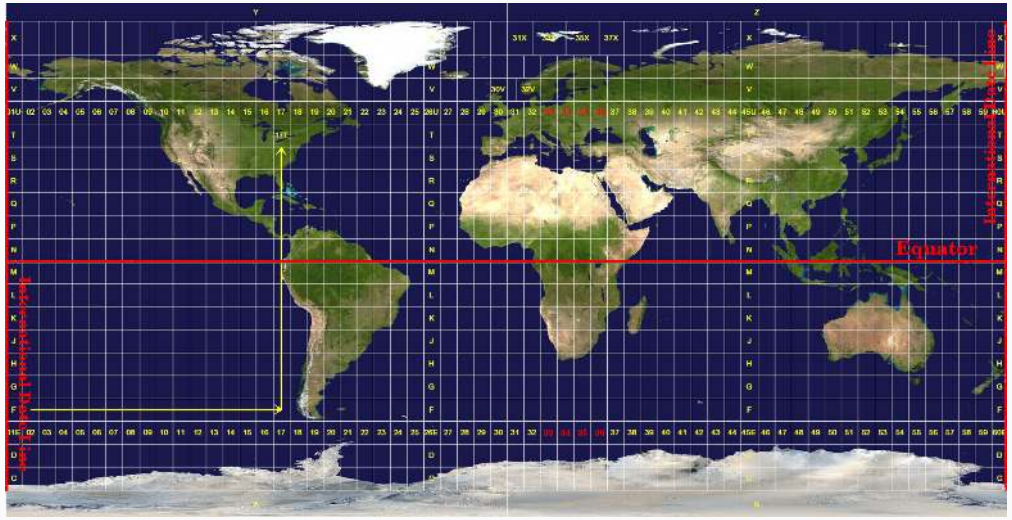


7. Converter CRS de objetos sf

Converter CRS local

SIRGAS2000/GCS -> WGS84/UTM23S

```
# converter sistema de coordenadas e datum
rc_2020_wgs84_utm23s ← sf::st_transform(rc_2020, crs = 32723)
```



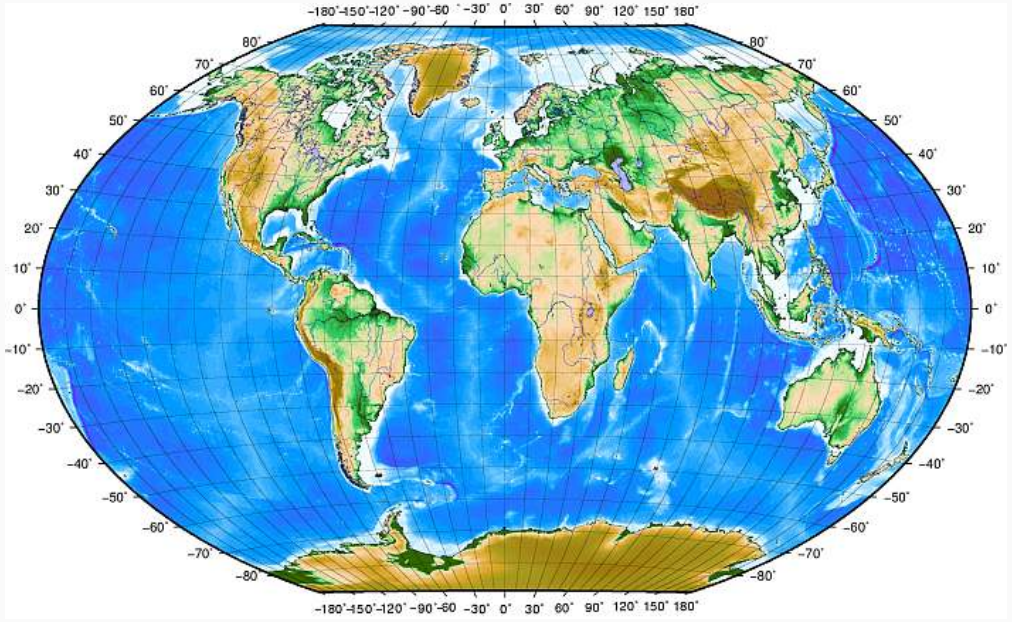
EPSG: 32723 ESRI (2021)

7. Converter CRS de objetos sf

Converter CRS local

SIRGAS2000/GCS -> WGS84/GCS

```
# converter datum
rc_2020_wgs84_gcs ← sf::st_transform(rc_2020, crs = 4326)
```



EPSG: 4326

7. Converter CRS de objetos sf

Converter CRS global

```
# paises - WGS84/GCS
co110_sf
```

```
## Simple feature collection with 177 features and 63 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: -180 ymin: -90 xmax: 180 ymax: 83.64513
## CRS:           +proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0
## First 10 features:
##   scalerank      featurecla labelrank           sovereignt sov_a3 adm0_dif level              type
## 0         1 Admin-0 country         3          Afghanistan    AFG        0     2 Sovereign country
## 1         1 Admin-0 country         3               Angola    AGO        0     2 Sovereign country
## 2         1 Admin-0 country         6              Albania    ALB        0     2 Sovereign country
## 3         1 Admin-0 country         4 United Arab Emirates    ARE        0     2 Sovereign country
## 4         1 Admin-0 country         2            Argentina    ARG        0     2 Sovereign country
## 5         1 Admin-0 country         6              Armenia    ARM        0     2 Sovereign country
## 6         1 Admin-0 country         4           Antarctica    ATA        0     2     Indeterminate
## 7         3 Admin-0 country         6               France    FR1        1     2        Dependency French Southern
## 8         1 Admin-0 country         2            Australia    AU1        1     2           Country
## 9         1 Admin-0 country         4              Austria    AUT        0     2 Sovereign country
```

7. Converter CRS de objetos sf

Converter CRS global

```
# plot
plot(co110_sf$geometry, col = "gray", graticule = TRUE)
```

7. Converter CRS de objetos sf

Converter CRS global

Projeção de Mollweide: preserva as relações de área

```
# projecao mollweide
co110_sf_moll ← sf::st_transform(co110_sf, crs = "+proj=moll")
```

EPSG: 54009 ESRI (2021)

7. Converter CRS de objetos sf

Converter CRS global

Projeção de Mollweide

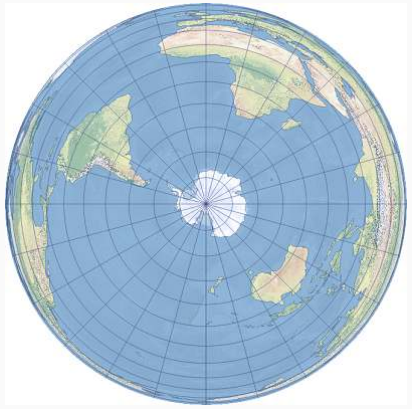
```
# plot
plot(co110_sf_moll$geometry, col = "gray", graticule = TRUE)
```

7. Converter CRS de objetos sf

Converter CRS global

Projeção azimutal de Lambert: preserva os tamanhos relativos e senso de direção a partir do centro

```
# projecao lambert
co110_sf_laea ← sf::st_transform(co110_sf, crs = "+proj=laea +x_0=0 +y_0=0 +lon_0=0 +lat_0=0")
```



ESRI(2021)

7. Converter CRS de objetos sf

Converter CRS global

Projeção azimutal de Lambert

```
# plot
plot(co110_sf_laea$geometry, col = "gray", graticule = TRUE)
```

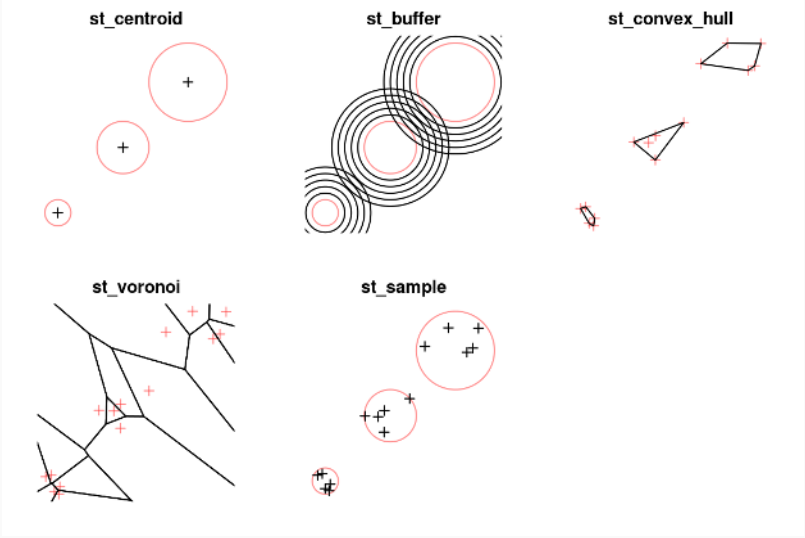
8. Operações com objetos sf

As operações podem ser separadas em três tipos

1. **Operações de atributos** (informações não espaciais, como tabela de atributos)

2. **Operações espaciais** (informações espaciais, como localização e formato)

3. **Operações geométricas** (informações geométricas, como mudanças geométricas unárias e binárias)



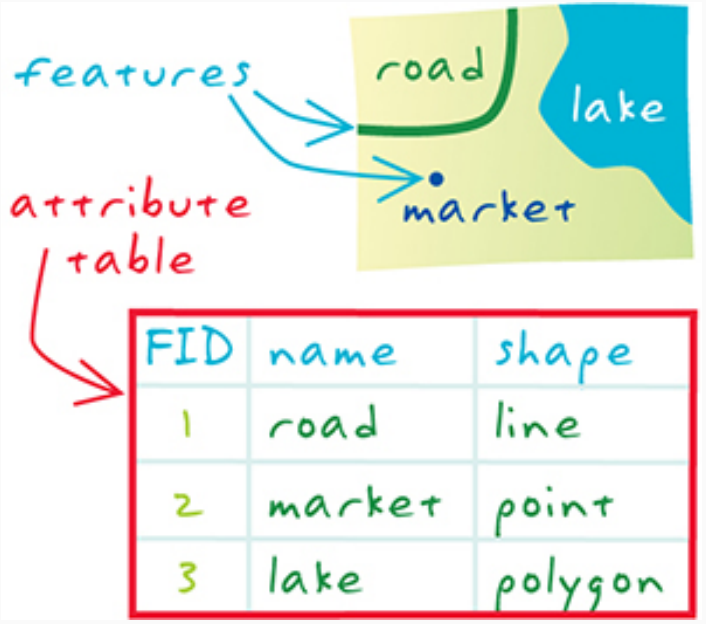
8. Operações com objetos sf

1. Operações de atributos

Modificação de objetos espaciais baseado em **informações não espaciais** associadas a objetos sf

Operações

1. Filtro
2. Junção
3. Agregação
4. Manipulação da tabela de atributos



8. Operações com objetos sf

1. Operações de atributos

1.1 Filtro

```
# filtro
rc_cob_floresta ← rc_cob %>%
  dplyr::filter(CLASSE_USO == "formação florestal")
rc_cob_floresta
```

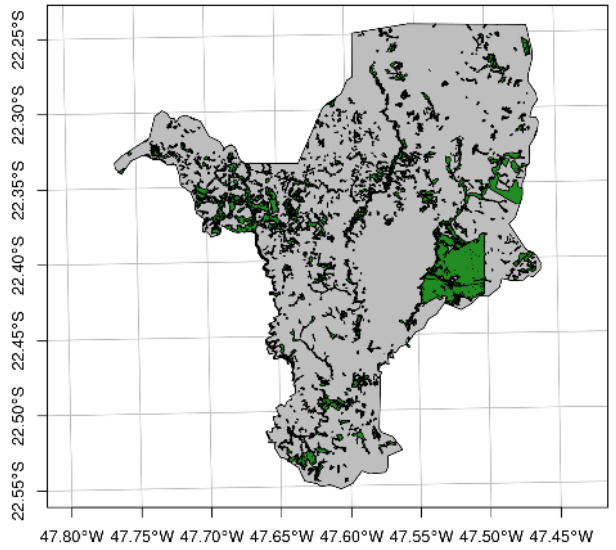
```
## Simple feature collection with 1 feature and 6 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 215442.4 ymin: 7504235 xmax: 246282.3 ymax: 7537969
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF         CLASSE_USO AREA_HA                       geometry
## 1   3543907 RIO CLARO SP    35 formação florestal 7017.99 MULTIPOLYGON (((232355 7504 ...
```

8. Operações com objetos sf

1. Operações de atributos

1.1 Filtro

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_cob_floresta$geometry, col = "forestgreen", add = TRUE)
```



8. Operações com objetos sf

1. Operações de atributos

1.2 Junção

```
# dados
da_classes ← tibble::tibble(CLASSE_USO = rc_cob$CLASSE_USO,
                            classe = c("agua", "antropico", "edificado", "floresta", "silvicultura"))
da_classes
```

```
## ¤[90m# A tibble: 5 × 2¤[39m
##   CLASSE_USO         classe
##   ¤[3m¤[90m<chr>¤[39m¤[23m              ¤[3m¤[90m<chr>¤[39m¤[23m
## ¤[90m1¤[39m água               agua
## ¤[90m2¤[39m área antropizada   antropico
## ¤[90m3¤[39m área edificada     edificado
## ¤[90m4¤[39m formação florestal floresta
## ¤[90m5¤[39m silvicultura       silvicultura
```

8. Operações com objetos sf

1. Operações de atributos

1.2 Junção

```
# juncao
rc_cob_classes ← dplyr::left_join(rc_cob, da_classes, by = "CLASSE_USO") %>%
  sf::st_drop_geometry()
rc_cob_classes
```

```
##   GEOCODIGO MUNICIPIO UF CD_UF         CLASSE_USO   AREA_HA       classe
## 1   3543907 RIO CLARO SP    35              água   357.027         agua
## 2   3543907 RIO CLARO SP    35   área antropizada 37297.800    antropico
## 3   3543907 RIO CLARO SP    35     área edificada  5078.330    edificado
## 4   3543907 RIO CLARO SP    35 formação florestal  7017.990     floresta
## 5   3543907 RIO CLARO SP    35       silvicultura   138.173 silvicultura
```

8. Operações com objetos sf

1. Operações de atributos

1.3 Agregação

```
# agregar
rc_nas_n ← rc_nas %>%
  dplyr::group_by(MUNICIPIO, HIDRO) %>%
  dplyr::summarise(n = n())
rc_nas_n
```

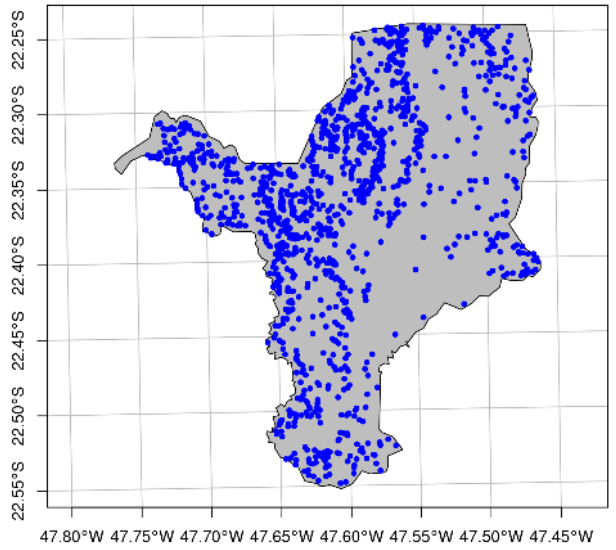
```
## Simple feature collection with 1 feature and 3 fields
## Geometry type: MULTIPOINT
## Dimension:     XY
## Bounding box:  xmin: 217622.9 ymin: 7504132 xmax: 246367.4 ymax: 7537855
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## ¤[90m# A tibble: 1 × 4¤[39m
## ¤[90m# Groups:   MUNICIPIO [1]¤[39m
##   MUNICIPIO HIDRO        n                                                                                geomet
##   ¤[3m¤[90m<chr>¤[39m¤[23m     ¤[3m¤[90m<chr>¤[39m¤[23m    ¤[3m¤[90m<int>¤[39m¤[23m
## ¤[90m1¤[39m RIO CLARO nascente  ¤[4m1¤[24m220 ((217622.9 7528315), (217836.5 7528103), (217988.9 7528203), (21828
```

8. Operações com objetos sf

1. Operações de atributos

1.3 Agregação

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_nas_n$geometry, pch = 20, col = "blue", add = TRUE)
```



8. Operações com objetos sf

1. Operações de atributos

1.4 Manipulação da tabela de atributos

```
# criar coluna
rc_cob_cob_col_area ← rc_cob %>%
  dplyr::mutate(classe_area = paste0(CLASSE_USO, " (", AREA_HA, " ha)")) %>%
  sf::st_drop_geometry()
rc_cob_cob_col_area
```

```
##   GEOCODIGO MUNICIPIO UF CD_UF         CLASSE_USO   AREA_HA                    classe_area
## 1   3543907 RIO CLARO SP    35              água   357.027              água (357.027 ha)
## 2   3543907 RIO CLARO SP    35   área antropizada 37297.800   área antropizada (37297.8 ha)
## 3   3543907 RIO CLARO SP    35     área edificada  5078.330     área edificada (5078.33 ha)
## 4   3543907 RIO CLARO SP    35 formação florestal  7017.990 formação florestal (7017.99 ha)
## 5   3543907 RIO CLARO SP    35       silvicultura   138.173       silvicultura (138.173 ha)
```

8. Operações com objetos sf

1. Operações de atributos

1.4 Manipulação da tabela de atributos

```
# comprimento das linhas
rc_hid_comp ← rc_hid %>%
  dplyr::mutate(comprimento = sf::st_length(.))
rc_hid_comp
```

```
## Simple feature collection with 1 feature and 7 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: 215155.3 ymin: 7504132 xmax: 246367.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF                  HIDRO COMP_KM                       geometry comprimento
## 1   3543907 RIO CLARO SP    35 curso d'água (0 - 10m) 1142.98 MULTILINESTRING ((231815.7 ...  1142981 [m]
```

8. Operações com objetos sf

1. Operações de atributos

1.4 Manipulação da tabela de atributos

```
# area das poligonos
rc_cob_area ← rc_cob %>%
  dplyr::mutate(area_m2 = sf::st_area(.))
rc_cob_area
```

```
## Simple feature collection with 5 features and 7 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 215151.7 ymin: 7503723 xmax: 246582.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF         CLASSE_USO   AREA_HA                       geometry         area_m2
## 1   3543907 RIO CLARO SP    35              água   357.027 MULTIPOLYGON (((235487.6 75 ...    3570267 [m^2]
## 2   3543907 RIO CLARO SP    35  área antropizada 37297.800 MULTIPOLYGON (((232275 7504 ... 372978415 [m^2]
## 3   3543907 RIO CLARO SP    35    área edificada  5078.330 MULTIPOLYGON (((233123.6 75 ...   50783283 [m^2]
## 4   3543907 RIO CLARO SP    35 formação florestal  7017.990 MULTIPOLYGON (((232355 7504 ...   70179895 [m^2]
## 5   3543907 RIO CLARO SP    35       silvicultura   138.173 MULTIPOLYGON (((243052.1 75 ...    1381726 [m^2]
```

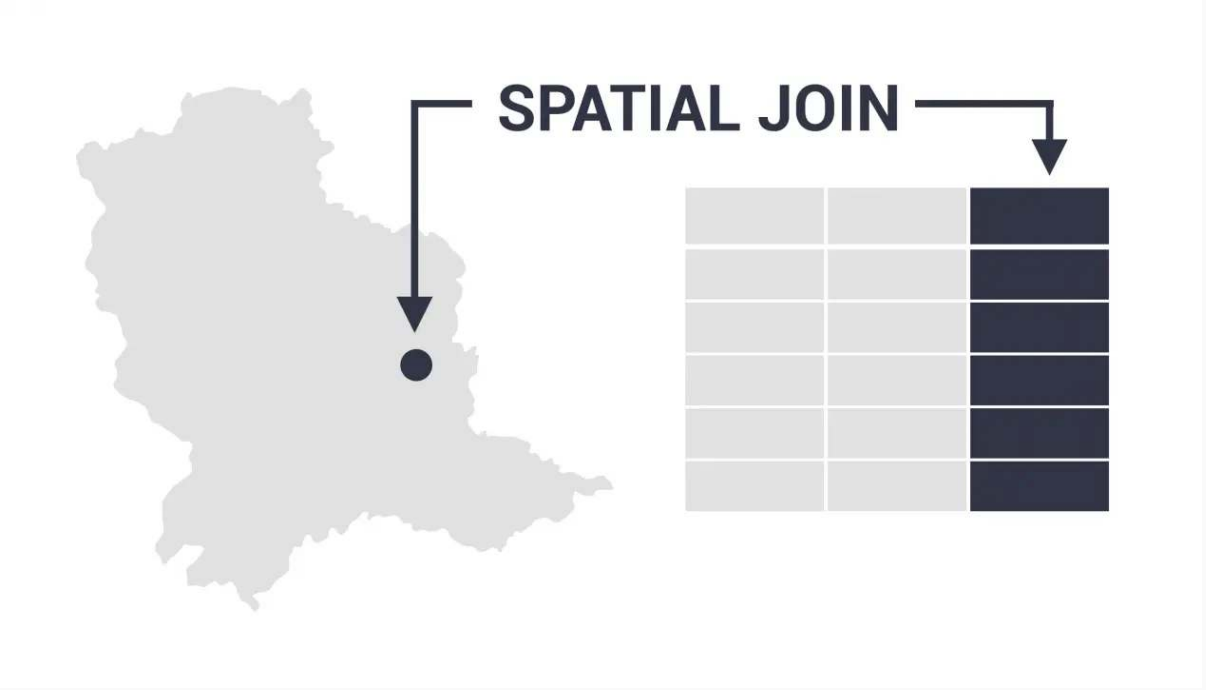
8. Operações com objetos sf

2 Operações espaciais

Modificação de objetos espaciais baseado na sua **localização e formato**

Operações

1. Filtro espacial
2. Junção espacial
3. Agregação espacial
4. Distância espacial



8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial

```
# filtro espacial
sf::st_intersects(x = rc_nas, y = rc_cob_floresta)
```

```
## Sparse geometry binary predicate list of length 1220, where the predicate was `intersects'
## first 10 elements:
##  1: 1
##  2: 1
##  3: (empty)
##  4: 1
##  5: (empty)
##  6: (empty)
##  7: (empty)
##  8: (empty)
##  9: 1
##  10: (empty)
```

8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial - interno

```
# filtro espacial - interno
rc_nas_floresta_int ← rc_nas %>%
  dplyr::filter(sf::st_intersects(x = ., y = rc_cob_floresta, sparse = FALSE))
rc_nas_floresta_int
```

```
## Simple feature collection with 169 features and 5 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 217622.9 ymin: 7505568 xmax: 246181.4 ymax: 7537185
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##    GEOCODIGO MUNICIPIO UF CD_UF    HIDRO                  geometry
## 1    3543907 RIO CLARO SP    35 nascente POINT (217622.9 7528315)
## 2    3543907 RIO CLARO SP    35 nascente POINT (217836.5 7528103)
## 3    3543907 RIO CLARO SP    35 nascente POINT (218288.9 7528237)
## 4    3543907 RIO CLARO SP    35 nascente POINT (218583.5 7528215)
## 5    3543907 RIO CLARO SP    35 nascente POINT (219062.2 7528499)
## 6    3543907 RIO CLARO SP    35 nascente POINT (219246.2 7529011)
```

8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial [] - interno

```
# filtro espacial com [] - interno
rc_nas_floresta_int ← rc_nas[rc_cob_floresta, ]
rc_nas_floresta_int
```

```
## Simple feature collection with 169 features and 5 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 217622.9 ymin: 7505568 xmax: 246181.4 ymax: 7537185
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##    GEOCODIGO MUNICIPIO UF CD_UF    HIDRO                 geometry
## 1    3543907 RIO CLARO SP    35 nascente POINT (217622.9 7528315)
## 2    3543907 RIO CLARO SP    35 nascente POINT (217836.5 7528103)
## 4    3543907 RIO CLARO SP    35 nascente POINT (218288.9 7528237)
## 9    3543907 RIO CLARO SP    35 nascente POINT (218583.5 7528215)
## 15   3543907 RIO CLARO SP    35 nascente POINT (219062.2 7528499)
## 19   3543907 RIO CLARO SP    35 nascente POINT (219246.2 7529011)
## 23   3543907 RIO CLARO SP    35 nascente POINT (219554.5 7528573)
```

8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial [] - interno

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_cob_floresta$geometry, col = "forestgreen", add = TRUE)
plot(rc_nas_floresta_int$geometry, col = "blue", pch = 20, cex = 1, add = TRUE)
```

8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial - externo

```
# filtro espacial - externo
rc_nas_floresta_ext ← rc_nas %>%
  dplyr::filter(sf::st_disjoint(x = ., y = rc_cob_floresta, sparse = FALSE))
rc_nas_floresta_ext
```

```
## Simple feature collection with 1051 features and 5 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 217988.9 ymin: 7504132 xmax: 246367.4 ymax: 7537855
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##    GEOCODIGO MUNICIPIO UF CD_UF    HIDRO                  geometry
## 1    3543907 RIO CLARO SP    35 nascente POINT (217988.9 7528203)
## 2    3543907 RIO CLARO SP    35 nascente POINT (218346.6 7530583)
## 3    3543907 RIO CLARO SP    35 nascente POINT (218393.1 7528031)
## 4    3543907 RIO CLARO SP    35 nascente POINT (218508.3 7528470)
## 5    3543907 RIO CLARO SP    35 nascente POINT (218535.4 7530642)
## 6    3543907 RIO CLARO SP    35 nascente POINT (218760.1 7530258)
```

8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial [] - externo

```
# filtro espacial com [] - externo
rc_nas_floresta_ext ← rc_nas[rc_cob_floresta, , op = st_disjoint]
rc_nas_floresta_ext
```

```
## Simple feature collection with 1051 features and 5 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 217988.9 ymin: 7504132 xmax: 246367.4 ymax: 7537855
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##    GEOCODIGO MUNICIPIO UF CD_UF    HIDRO                 geometry
## 3    3543907 RIO CLARO SP    35 nascente POINT (217988.9 7528203)
## 5    3543907 RIO CLARO SP    35 nascente POINT (218346.6 7530583)
## 6    3543907 RIO CLARO SP    35 nascente POINT (218393.1 7528031)
## 7    3543907 RIO CLARO SP    35 nascente POINT (218508.3 7528470)
## 8    3543907 RIO CLARO SP    35 nascente POINT (218535.4 7530642)
## 10   3543907 RIO CLARO SP    35 nascente POINT (218760.1 7530258)
## 11   3543907 RIO CLARO SP    35 nascente POINT (218821.1 7529750)
```

8. Operações com objetos sf

2 Operações espaciais

2.1 Filtro espacial

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_cob_floresta$geometry, col = "forestgreen", add = TRUE)
plot(rc_nas_floresta_ext$geometry, col = "steelblue", pch = 20, cex = 1, add = TRUE)
```

8. Operações com objetos sf

2 Operações espaciais

2.2 Junção espacial

```
# juncao espacial
rc_nas_cob_jun ← rc_nas %>%
  sf::st_join(x = ., y = rc_cob) %>%
  dplyr::group_by(CLASSE_USO) %>%
  dplyr::summarise(n = n())
rc_nas_cob_jun
```

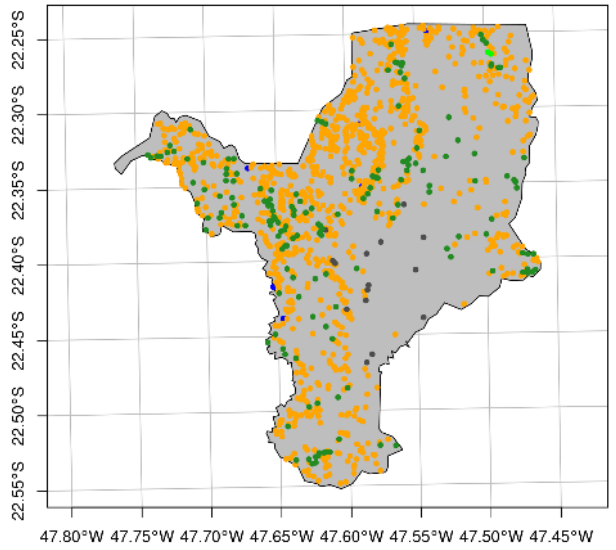
```
## Simple feature collection with 5 features and 2 fields
## Geometry type: MULTIPOINT
## Dimension:     XY
## Bounding box:  xmin: 217622.9 ymin: 7504132 xmax: 246367.4 ymax: 7537855
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## ¤[90m# A tibble: 5 × 3¤[39m
##   CLASSE_USO             n                                                                                                geomet
##   ¤[3m¤[90m<chr>¤[39m¤[23m              ¤[3m¤[90m<int>¤[39m¤[23m
## ¤[90m1¤[39m água                     7 ((224989.9 7527331), (226855.6 7518588), (226859.8 7518617), (227604.7 751627
## ¤[90m2¤[39m área antropizada    ¤[4m1¤[24m027 ((217988.9 7528203), (218346.6 7530583), (218393.1 7528031), (21850
## ¤[90m3¤[39m área edificada         15 ((230717 7522791), (231255.1 7520519), (231420.5 7520332), (232278.7 7516953)
```

8. Operações com objetos sf

2 Operações espaciais

2.2 Junção espacial

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_nas_cob_jun[1], col = c("blue", "orange", "gray30", "forestgreen", "green"), pch = 20, add = TRUE)
```



2 Operações espaciais

2.3 Agregação espacial

```
# agregacao espacial
rc_cob_nas_agre ← rc_nas %>%
  aggregate(x = ., by = rc_cob, FUN = length)
rc_cob_nas_agre
```

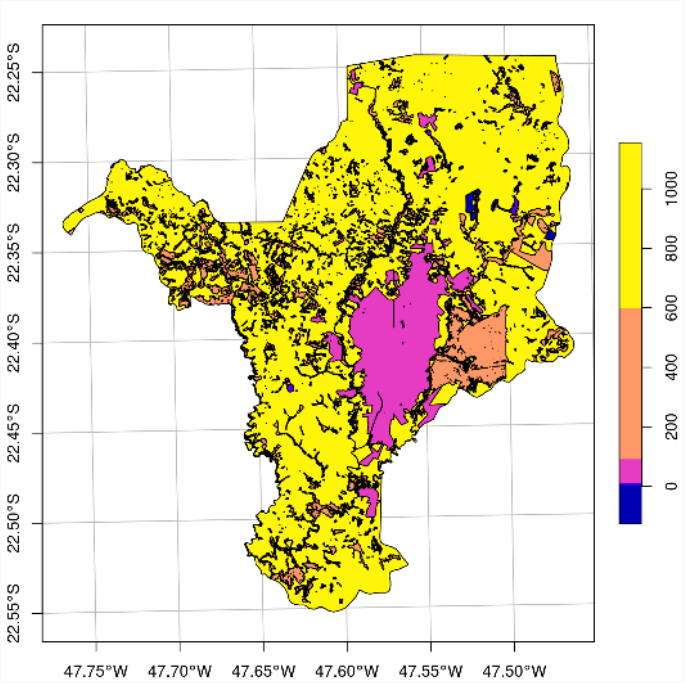
```
## Simple feature collection with 5 features and 5 fields
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 215151.7 ymin: 7503723 xmax: 246582.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO   UF CD_UF HIDRO                       geometry
## 1         7         7    7     7     7 MULTIPOLYGON (((235487.6 75 ...
## 2      1027      1027 1027  1027  1027 MULTIPOLYGON (((232275 7504 ...
## 3        15        15   15    15    15 MULTIPOLYGON (((233123.6 75 ...
## 4       169       169  169   169   169 MULTIPOLYGON (((232355 7504 ...
## 5         2         2    2     2     2 MULTIPOLYGON (((243052.1 75 ...
```

8. Operações com objetos sf

2 Operações espaciais

2.3 Agregação espacial

```
# plot
plot(rc_cob_nas_agre[1], axes = TRUE, graticule = TRUE, main = NA)
```



8. Operações com objetos sf

2 Operações espaciais

2.4 Distância espacial

```
# distancia
rc_nas_dist_flo ← rc_nas %>%
  dplyr::mutate(dist_flo = sf::st_distance(rc_nas, rc_cob_floresta))
rc_nas_dist_flo
```

```
## Simple feature collection with 1220 features and 6 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 217622.9 ymin: 7504132 xmax: 246367.4 ymax: 7537855
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##    GEOCODIGO MUNICIPIO UF CD_UF    HIDRO                  geometry      dist_flo
## 1    3543907 RIO CLARO SP    35 nascente POINT (217622.9 7528315)   0.00000 [m]
## 2    3543907 RIO CLARO SP    35 nascente POINT (217836.5 7528103)   0.00000 [m]
## 3    3543907 RIO CLARO SP    35 nascente POINT (217988.9 7528203)  37.41369 [m]
## 4    3543907 RIO CLARO SP    35 nascente POINT (218288.9 7528237)   0.00000 [m]
## 5    3543907 RIO CLARO SP    35 nascente POINT (218346.6 7530583) 714.91131 [m]
## 6    3543907 RIO CLARO SP    35 nascente POINT (218393.1 7528031)  21.87610 [m]
```

2 Operações espaciais

2.4 Distância espacial

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_cob_floresta$geometry, col = "forestgreen", add = TRUE)
plot(rc_nas_dist_flo[7], pch = 20, add = TRUE)
```

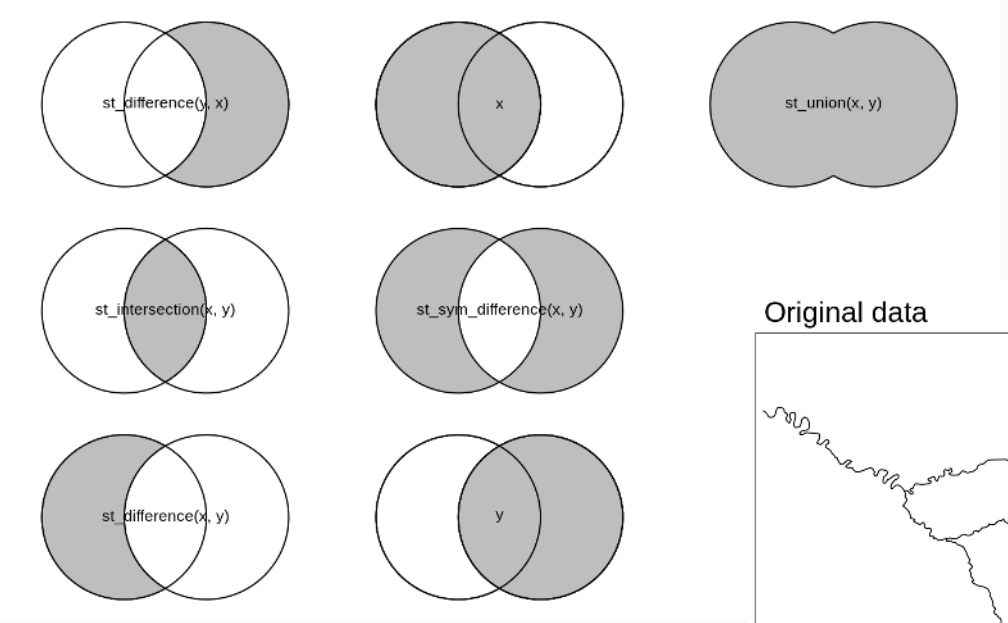
8. Operações com objetos sf

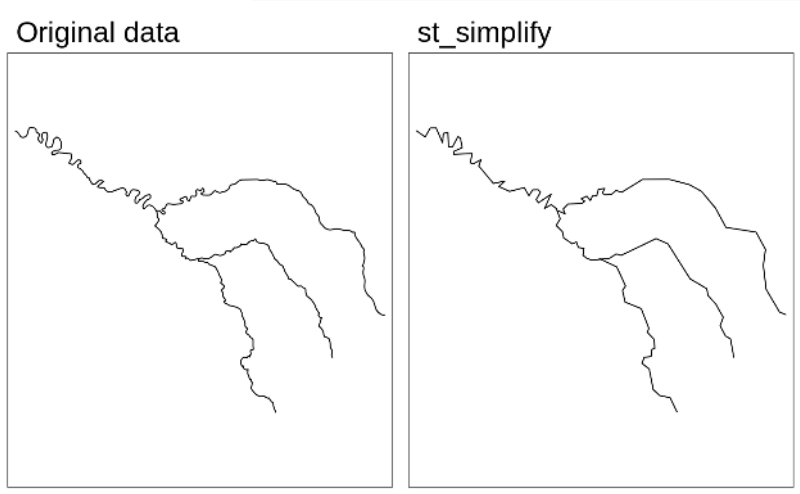
3 Operações geométricas

Modificação de objetos espaciais baseado em operações que mudam a **geometria do vetor**

Operações

1. Simplificação
2. Centroides
3. Pontos aleatórios
4. Buffers
5. Polígono convexo
6. Polígonos de Voronoi
7. Quadrículas e hexágonos
8. União ("dissolver")
9. Recorte ("clipar")
10. Transformações de tipo





3 Operações geométricas

3.1 Simplificação

```
# simplificacao
rc_hid_simplificado ← sf::st_simplify(x = rc_hid, dTolerance = 1000)
rc_hid_simplificado
```

```
## Simple feature collection with 1 feature and 6 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: 215155.3 ymin: 7504132 xmax: 246367.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF                  HIDRO COMP_KM                       geometry
## 1   3543907 RIO CLARO SP    35 curso d'água (0 - 10m) 1142.98 MULTILINESTRING ((231815.7 ...
```

3 Operações geométricas

3.1 Simplificação

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_hid$geometry, col = "steelblue", lwd = 2, add = TRUE)
plot(rc_hid_simplificado$geometry, col = adjustcolor("black", .7), add = TRUE)
```

8. Operações com objetos sf

3 Operações geométricas

3.2 Centroides

```
# centroides
rc_2020_sirgas2000_utm23s_cent ← sf::st_centroid(rc_2020_sirgas2000_utm23s)
rc_2020_sirgas2000_utm23s_cent
```

```
## Simple feature collection with 1 feature and 7 fields
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 234338.3 ymin: 7523516 xmax: 234338.3 ymax: 7523516
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##     code_muni name_muni code_state abbrev_state name_state code_region name_region                    geom
## 493   3543907 Rio Claro         35           SP  São Paulo           3     Sudeste POINT (234338.3 7523516)
```

8. Operações com objetos sf

3 Operações geométricas

3.2 Centroides

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_cent$geom, cex = 3, pch = 20, add = TRUE)
```

3 Operações geométricas

3.3 Pontos aleatórios

```
# fixar amostragem
set.seed(42)

# pontos aleatorios
rc_2020_sirgas2000_utm23s_pontos_aleatorios ← sf::st_sample(rc_2020_sirgas2000_utm23s, size = 30)
rc_2020_sirgas2000_utm23s_pontos_aleatorios
```

```
## Geometry set for 30 features
## Geometry type: POINT
## Dimension:     XY
## Bounding box:  xmin: 223360.4 ymin: 7505201 xmax: 243540.8 ymax: 7536696
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 5 geometries:
```

3 Operações geométricas

3.3 Pontos aleatórios

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios, pch = 20, add = TRUE)
```

8. Operações com objetos sf

3 Operações geométricas

3.4 Buffer

```
# buffer
rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer ← sf::st_buffer(x = rc_2020_sirgas2000_utm23s_pontos_aleator
rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer
```

```
## Geometry set for 30 features
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 222360.4 ymin: 7504201 xmax: 244540.8 ymax: 7537696
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 5 geometries:
```

3 Operações geométricas

3.4 Buffer

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer, col = NA, lwd = 2, border = "red", add = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios, pch = 20, cex = 1, add = TRUE)
```

3 Operações geométricas

3.5 Polígono convexo

```
# poligono convexo
rc_2020_sirgas2000_utm23s_convexo ← rc_2020_sirgas2000_utm23s_pontos_aleatorios %>%
  sf::st_union() %>%
  sf::st_convex_hull()
rc_2020_sirgas2000_utm23s_convexo
```

```
## Geometry set for 1 feature
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 223360.4 ymin: 7505201 xmax: 243540.8 ymax: 7536696
## Projected CRS: SIRGAS 2000 / UTM zone 23S
```

3 Operações geométricas

3.5 Polígono convexo

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_convexo, col = NA, lwd = 2, border = "red", add = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios, pch = 20, cex = 1, add = TRUE)
```

3 Operações geométricas

3.6 Polígonos de Voronoi

```
# poligono de voronoi
rc_2020_sirgas2000_utm23s_voronoi ← rc_2020_sirgas2000_utm23s_pontos_aleatorios %>%
  sf::st_union() %>%
  sf::st_voronoi()
rc_2020_sirgas2000_utm23s_voronoi
```

```
## Geometry set for 1 feature
## Geometry type: GEOMETRYCOLLECTION
## Dimension:     XY
## Bounding box:  xmin: 191865.2 ymin: 7473706 xmax: 275036.1 ymax: 7568192
## Projected CRS: SIRGAS 2000 / UTM zone 23S
```

3 Operações geométricas

3.6 Polígonos de Voronoi

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_voronoi, col = NA, lwd = 2, border = "red", add = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios, pch = 20, cex = 1, add = TRUE)
```

8. Operações com objetos sf

3 Operações geométricas

3.7 Quadrículas e hexágonos

```
# quadriculas
rc_2020_sirgas2000_utm23s_grid ← sf::st_make_grid(x = rc_2020_sirgas2000_utm23s, cellsize = 2000, what = "polyg
  sf::st_as_sf() %>%
  dplyr::filter(sf::st_intersects(x = ., y = rc_2020_sirgas2000_utm23s, sparse = FALSE))

# centroides das quadriculas
rc_2020_sirgas2000_utm23s_grid_cent ← rc_2020_sirgas2000_utm23s %>%
  sf::st_make_grid(cellsize = 2000, what = "centers") %>%
  sf::st_as_sf() %>%
  dplyr::filter(sf::st_intersects(x = ., y = sf::st_union(rc_2020_sirgas2000_utm23s_grid), sparse = FALSE))
```

3 Operações geométricas

3.7 Quadrículas e hexágonos

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_grid, col = NA, border = "red", lwd = 2, add = TRUE)
plot(rc_2020_sirgas2000_utm23s_grid_cent, pch = 20, add = TRUE)
```

3 Operações geométricas

3.7 Quadrículas e hexágonos

```
# hexagonos
rc_2020_sirgas2000_utm23s_hex ← rc_2020_sirgas2000_utm23s %>%
  sf::st_make_grid(cellsize = 2000, square = FALSE) %>%
  sf::st_as_sf() %>%
  dplyr::filter(sf::st_intersects(x = ., y = rc_2020_sirgas2000_utm23s, sparse = FALSE))

# centroides de hexagonos
rc_2020_sirgas2000_utm23s_hex_cent ← rc_2020_sirgas2000_utm23s %>%
  sf::st_make_grid(cellsize = 2000, square = FALSE, what = "centers") %>%
  sf::st_as_sf() %>%
  dplyr::filter(sf::st_intersects(x = ., y = sf::st_union(rc_2020_sirgas2000_utm23s_hex), sparse = FALSE))
```

8. Operações com objetos sf

3 Operações geométricas

3.7 Quadrículas e hexágonos

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_hex, col = NA, border = "red", lwd = 2, add = TRUE)
plot(rc_2020_sirgas2000_utm23s_hex_cent, pch = 20, add = TRUE)
```

3 Operações geométricas

3.8 União ("dissolver")

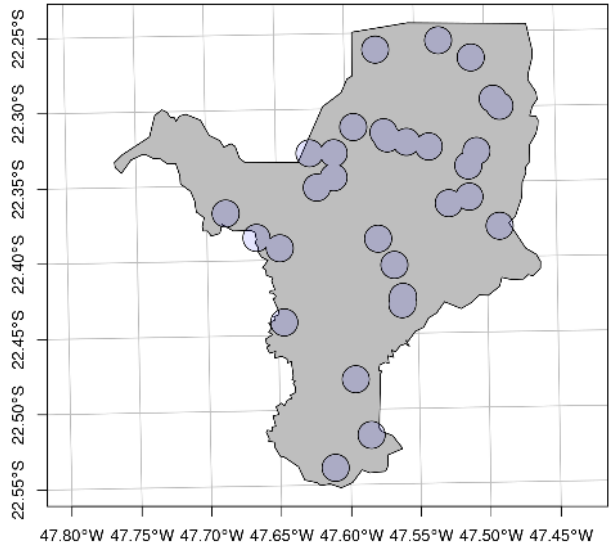
```
# uniao
rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uniao ← sf::st_union(rc_2020_sirgas2000_utm23s_pontos_aleato
rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uniao
```

```
## Geometry set for 1 feature
## Geometry type: MULTIPOLYGON
## Dimension:     XY
## Bounding box:  xmin: 222360.4 ymin: 7504201 xmax: 244540.8 ymax: 7537696
## Projected CRS: SIRGAS 2000 / UTM zone 23S
```

3 Operações geométricas

3.8 União ("dissolver")

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uniao, col = adjustcolor("blue", .1), add = TRUE)
```



3 Operações geométricas

3.9 Recorte ("clipar")

```
# recorte - interseccao
rc_hid_interseccao ← sf::st_intersection(x = rc_hid, y = rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uni
rc_hid_interseccao
```

```
## Simple feature collection with 1 feature and 6 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: 222421.9 ymin: 7504269 xmax: 244527.4 ymax: 7537655
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF                   HIDRO COMP_KM                          geometry
## 1   3543907 RIO CLARO SP    35 curso d'água (0 - 10m) 1142.98 MULTILINESTRING ((231820 75 ...
```

3 Operações geométricas

3.9 Recorte ("clipar")

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uniao, col = adjustcolor("blue", .1), add = TRUE)
plot(rc_hid_interseccao$geometry, col = "blue", add = TRUE)
```

3 Operações geométricas

3.9 Recorte ("clipar") - diferença

```
# recorte - diferenca
rc_hid_diferenca ← sf::st_difference(x = rc_hid, y = rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uniao)
rc_hid_diferenca
```

```
## Simple feature collection with 1 feature and 6 fields
## Geometry type: MULTILINESTRING
## Dimension:     XY
## Bounding box:  xmin: 215155.3 ymin: 7504132 xmax: 246367.4 ymax: 7537978
## Projected CRS: SIRGAS 2000 / UTM zone 23S
##   GEOCODIGO MUNICIPIO UF CD_UF                  HIDRO COMP_KM                          geometry
## 1   3543907 RIO CLARO SP    35 curso d'água (0 - 10m) 1142.98 MULTILINESTRING ((231815.7 ...
```

8. Operações com objetos sf

3 Operações geométricas

3.9 Recorte ("clipar") - diferença

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_2020_sirgas2000_utm23s_pontos_aleatorios_buffer_uniao, col = adjustcolor("blue", .1), add = TRUE)
plot(rc_hid_diferenca$geometry, col = "blue", add = TRUE)
```

3 Operações geométricas

3.10 Transformações de tipo

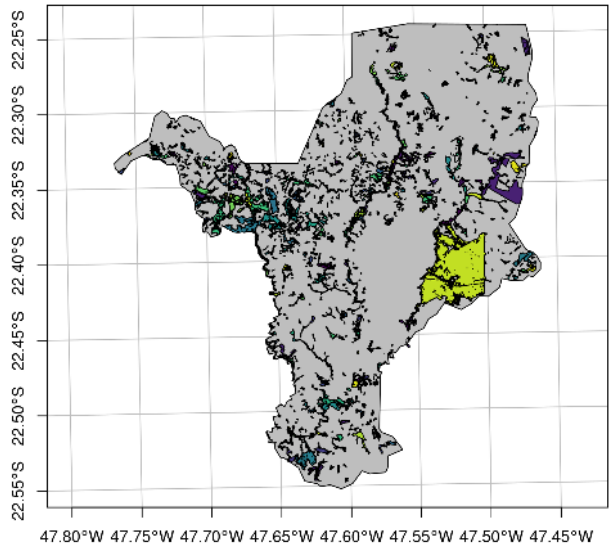
```
# transformacao de tipo
rc_cob_floresta_polygon ← rc_cob_floresta %>%
  sf::st_cast("POLYGON") %>%
  dplyr::mutate(area_ha = sf::st_area(.)/1e4 %>% round(2))
rc_cob_floresta_polygon
```

```
## Simple feature collection with 1732 features and 7 fields
## Geometry type: POLYGON
## Dimension:     XY
## Bounding box:  xmin: 215442.4 ymin: 7504235 xmax: 246282.3 ymax: 7537969
## Projected CRS: SIRGAS 2000 / UTM zone 23S
## First 10 features:
##     GEOCODIGO MUNICIPIO UF CD_UF         CLASSE_USO AREA_HA                       geometry            area_ha
## 1     3543907 RIO CLARO SP    35 formação florestal 7017.99 POLYGON ((232355 7504440, 2 ... 3.232500e+00 [m^2]
## 1.1   3543907 RIO CLARO SP    35 formação florestal 7017.99 POLYGON ((229470 7505200, 2 ... 7.015000e+00 [m^2]
## 1.2   3543907 RIO CLARO SP    35 formação florestal 7017.99 POLYGON ((231185 7505305, 2 ... 2.992500e+00 [m^2]
## 1.3   3543907 RIO CLARO SP    35 formação florestal 7017.99 POLYGON ((232175 7505460, 2 ... 3.750002e-01 [m^2]
## 1.4   3543907 RIO CLARO SP    35 formação florestal 7017.99 POLYGON ((231720 7505435, 2 ... 5.017500e+00 [m^2]
```

3 Operações geométricas

3.10 Transformações de tipo

```
# plot
plot(rc_2020_sirgas2000_utm23s$geom, col = "gray", main = NA, axes = TRUE, graticule = TRUE)
plot(rc_cob_floresta_polygon["area_ha"], col = viridis::viridis(100),  add = TRUE)
```



9. Exportar objetos sf

Exportar como shapefile

```
# exportar o vetor de floresta na extensão esri shapefile
sf::st_write(obj = rc_cob_floresta_polygon, dsn = here::here("03_dados", "vetor", "rc_cob_floresta_polygon.shp")
```

9. Exportar objetos sf

Exportar como geopackage

```
# exportar o vetor de floresta na extensão geopackage
sf::st_write(obj = rc_cob_floresta_polygon, dsn = here::here("03_dados", "vetor", "vetores.gpkg"), layer = "rc_c
```

Switch from Shapefile, Using the Geopackage Format with R

9. Exportar objetos sf

Exportar como geopackage

```
# exportar o vetor da america do sul na extensão geopackage
sf::st_write(obj = sa, dsn = here::here("03_dados", "vetor", "vetores.gpkg"), layer = "south_america")
```

Switch from Shapefile, Using the Geopackage Format with R

Dúvidas?

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Slides criados via pacote xaringan e tema Metropolis. Animação dos sapos por @probzz.