C31

VISUALIZAÇÃO DE MAPAS E INFORMAÇÕES ESPACIAIS EM SAÚDE UTILIZANDO R PARA VIGILÂNCIA EPIDEMIOLÓGICA

Programa R e estatística espacial: fundamentos

Elisangela Ap. da Silva Lizzi

Edson Zangiacomi Martinez

24 A 27/11/24 • RIO DE JANEIRO

12°EPI

A Epidemiologia e a complexidade dos desafios sanitários

UTFPR
UNIVERSIDADE TECNOLÓGICA FEDERAL DO PARANÁ

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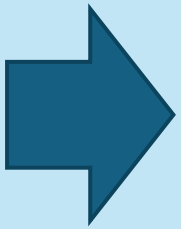
https://www.r-project.org/

- **What is R?**
- R is an open source language and environment for statistical computing and graphics.

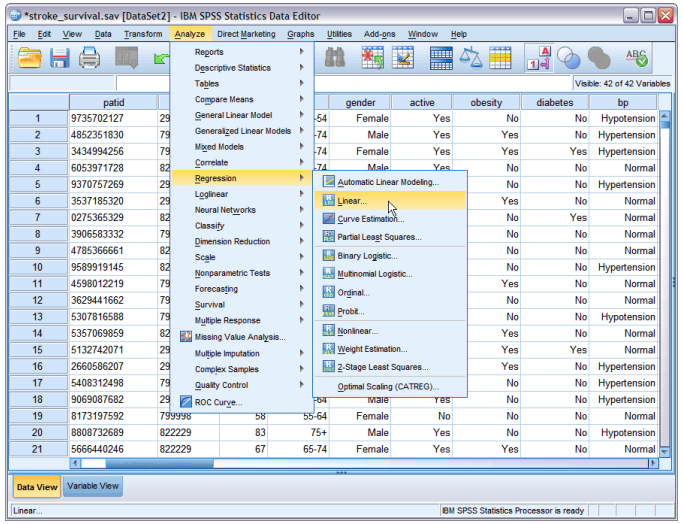
- Many users think of R as a statistics system. We prefer to think of it of an environment within which statistical techniques are implemented. R can be extended (easily) via *packages*.

Learning curve  Difficult at the beginning

Formas em que os usuários podem interagir com dispositivos eletrônicos

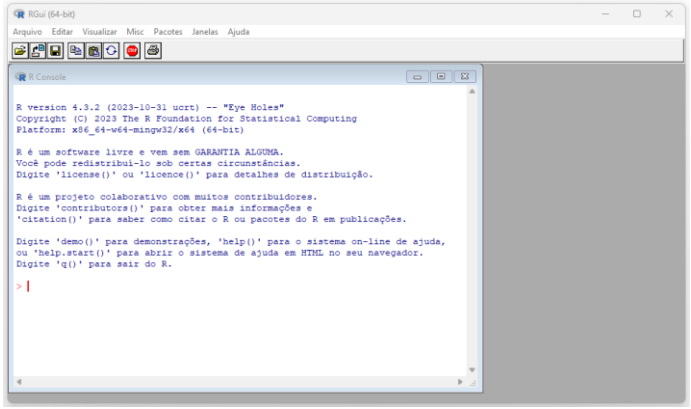
GUI: graphical user interface

- Os usuários clicam em ícones e botões para controlar o software ou os dispositivos
- Os usuários executam tarefas clicando em ícones, selecionando itens de menu e arrastando e soltando arquivos



CLI: command line interface

- Os usuários digitam comandos em um terminal para operar e navegar
- Pode ser intimidadora para iniciantes
- Os comandos devem ser lembrados ou consultados em um manual
- Permitem que o ser humano use habilidades de linguagem em vez de limitar a interação a apontar
- Aumentam a produtividade pois todas as ações têm um nome e uma série de ações pode ser escrita em um *script*
- Tarefas repetitivas podem ser facilmente realizadas com *loops*



Formas em que os usuários podem interagir com dispositivos eletrônicos

GUI: graphical user interface

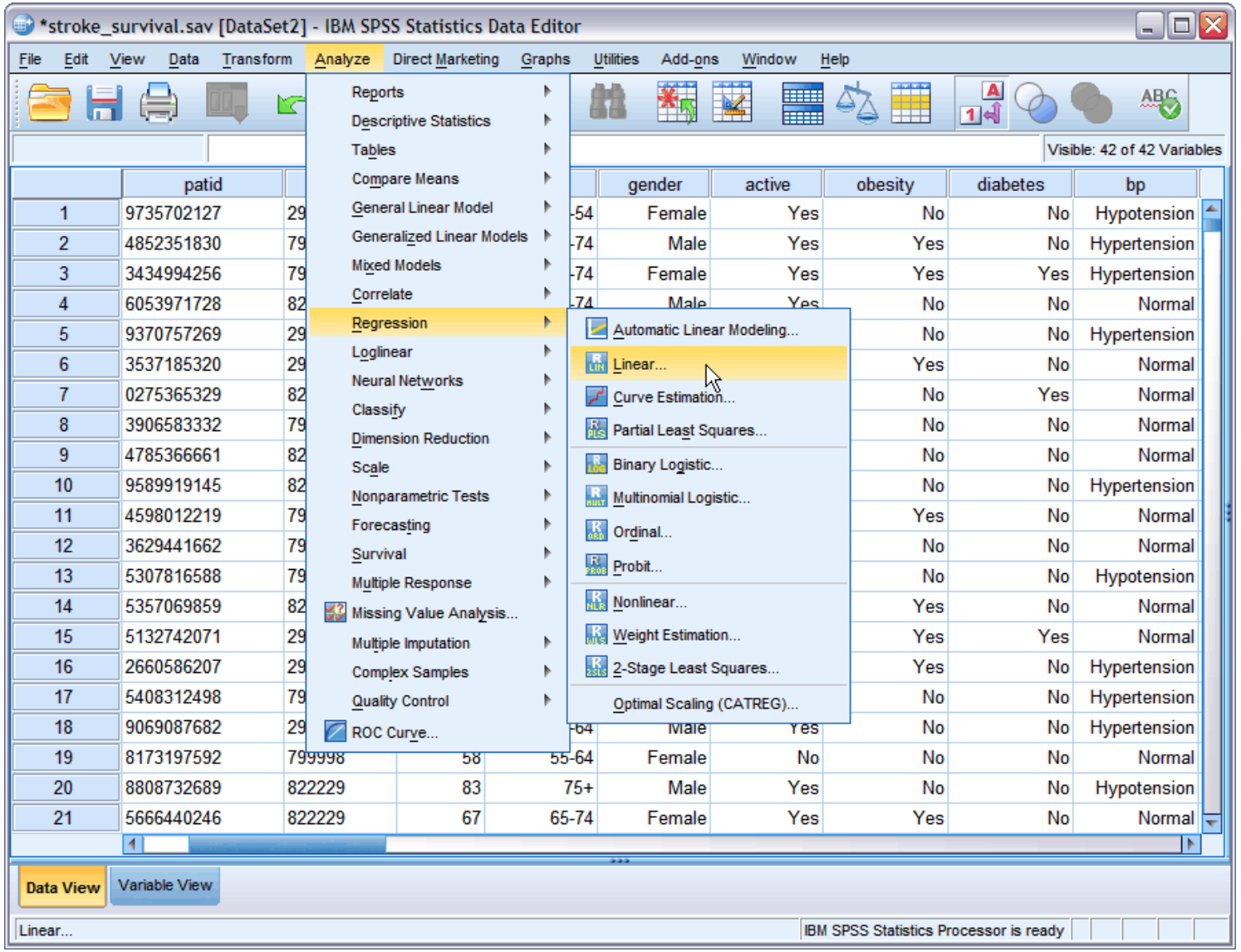
Fácil de aprender

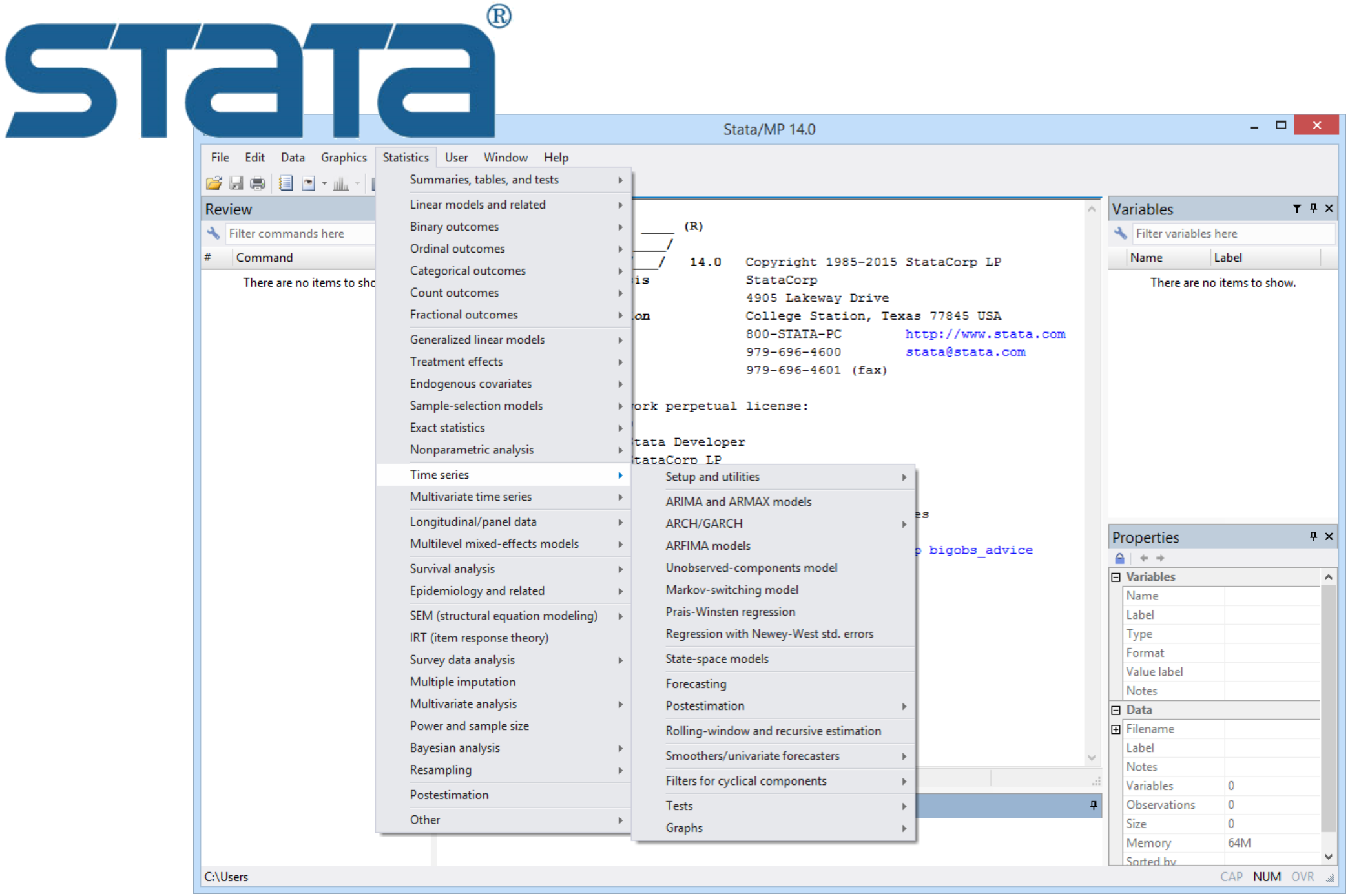
CLI: command line interface

Poderoso quando aprendemos

IBM SPSS

http://www-03.ibm.com/software/products/pt/spss-statistics




Stata/MP 14.0
File Edit Data Graphics Statistics User Window Help
Summaries, tables, and tests
Linear models and related
Binary outcomes
Ordinal outcomes
Categorical outcomes
Count outcomes
Fractional outcomes
Generalized linear models
Treatment effects
Endogenous covariates
Sample-selection models
Exact statistics
Nonparametric analysis
Time series
Multivariate time series
Longitudinal/panel data
Multilevel mixed-effects models
Survival analysis
Epidemiology and related
SEM (structural equation modeling)
IRT (item response theory)
Survey data analysis
Multiple imputation
Multivariate analysis
Power and sample size
Bayesian analysis
Resampling
Postestimation
Other
Setup and utilities
ARIMA and ARMAX models
ARCH/GARCH
ARFIMA models
Unobserved-components model
Markov-switching model
Prais-Winsten regression
Regression with Newey-West std. errors
State-space models
Forecasting
Postestimation
Rolling-window and recursive estimation
Smoothers/univariate forecasters
Filters for cyclical components
Tests
Graphs
Review
Filter commands here
Command
There are no items to sho
Variables
Filter variables here
Name
Label
There are no items to show.
Properties
Variables
Name
Label
Type
Format
Value label
Notes
Data
Filename
Label
Notes
Variables 0
Observations 0
Size 0
Memory 64M
Sorted by
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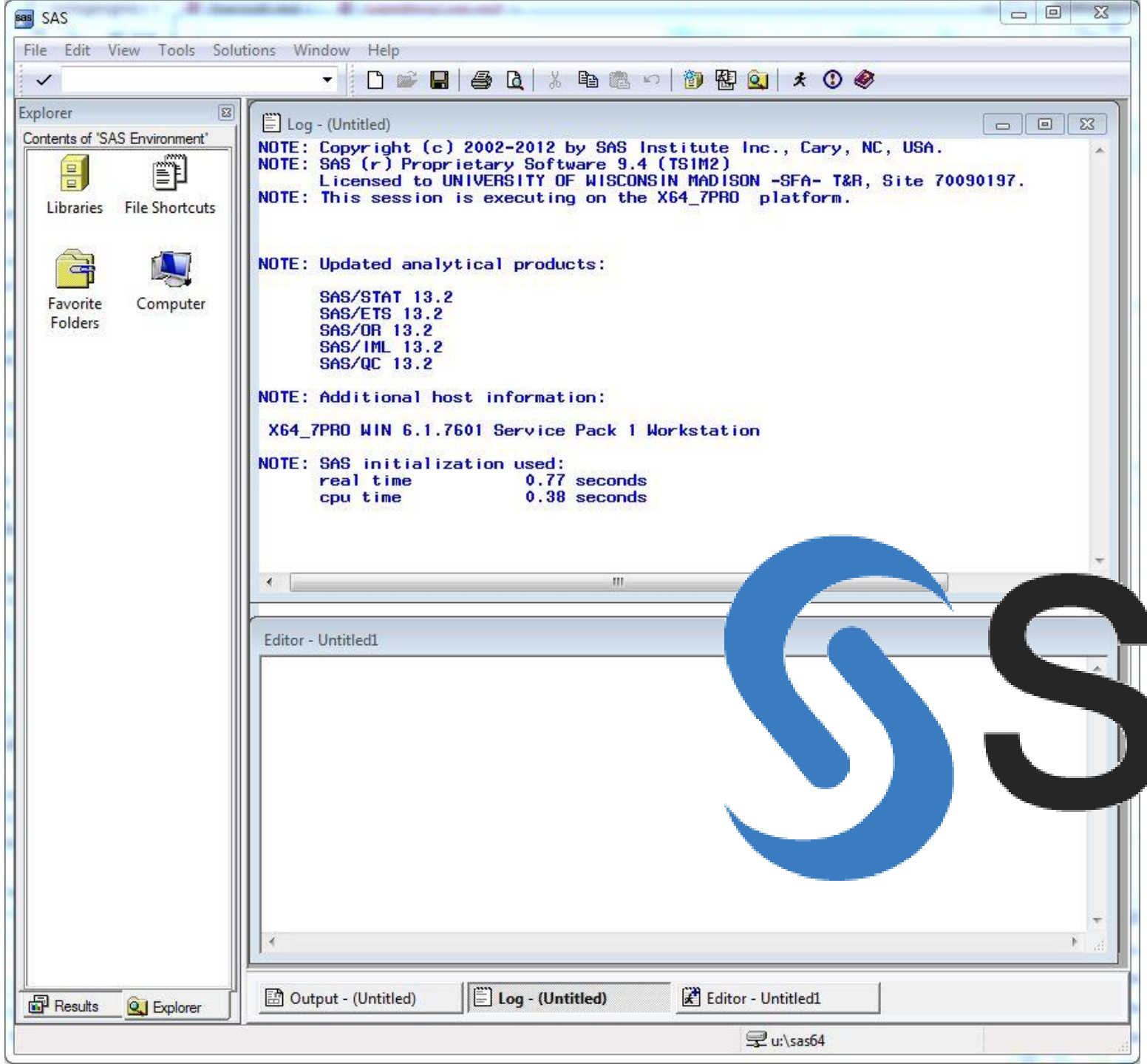
College Station, Texas 77845 USA
800-STATA-PC http://www.stata.com
979-696-4600 stata@stata.com
979-696-4601 (fax)
C:\Users
CAP NUM OVR


SAS
File Edit View Tools Solutions Window Help
Explorer
Contents of 'SAS Environment'
Libraries
File Shortcuts
Favorite Folders
Computer
Results
Explorer
Log - (Untitled)
NOTE: Copyright (c) 2002-2012 by SAS Institute Inc., Cary, NC, USA.
NOTE: SAS (r) Proprietary Software 9.4 (TS1M2)
Licensed to UNIVERSITY OF WISCONSIN MADISON -SFA- T&R, Site 70090197.
NOTE: This session is executing on the X64_7PRO platform.
NOTE: Updated analytical products:
SAS/STAT 13.2
SAS/ETS 13.2
SAS/OR 13.2
SAS/IML 13.2
SAS/QC 13.2
NOTE: Additional host information:
X64_7PRO WIN 6.1.7601 Service Pack 1 Workstation
NOTE: SAS initialization used:
real time 0.77 seconds
cpu time 0.38 seconds
Editor - Untitled1
Output - (Untitled)
Log - (Untitled)
Editor - Untitled1
u:\sas64

IDE (Integrated Development Environment)

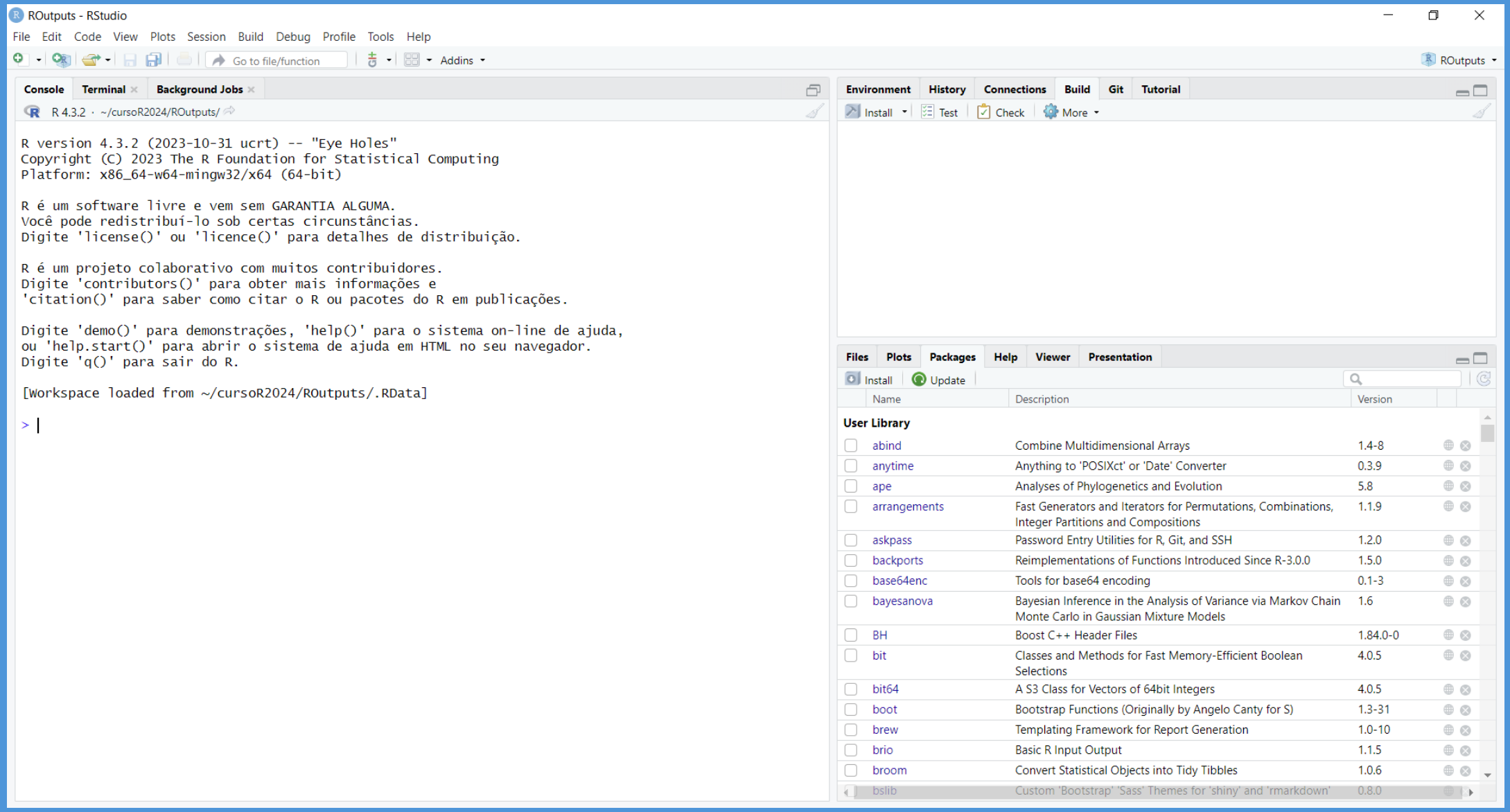
Um ambiente de desenvolvimento integrado (IDE) é um software para criar aplicações que combina ferramentas comuns de desenvolvedor em uma única interface de usuário gráfica (GUI). Um IDE geralmente consiste em:

• **Editor de código-fonte**: é um editor de texto que auxilia na criação de código de software por meio de funcionalidades como destaque da sintaxe com indicadores visuais, recurso de preenchimento automático específico da linguagem e verificação de bugs durante o desenvolvimento.

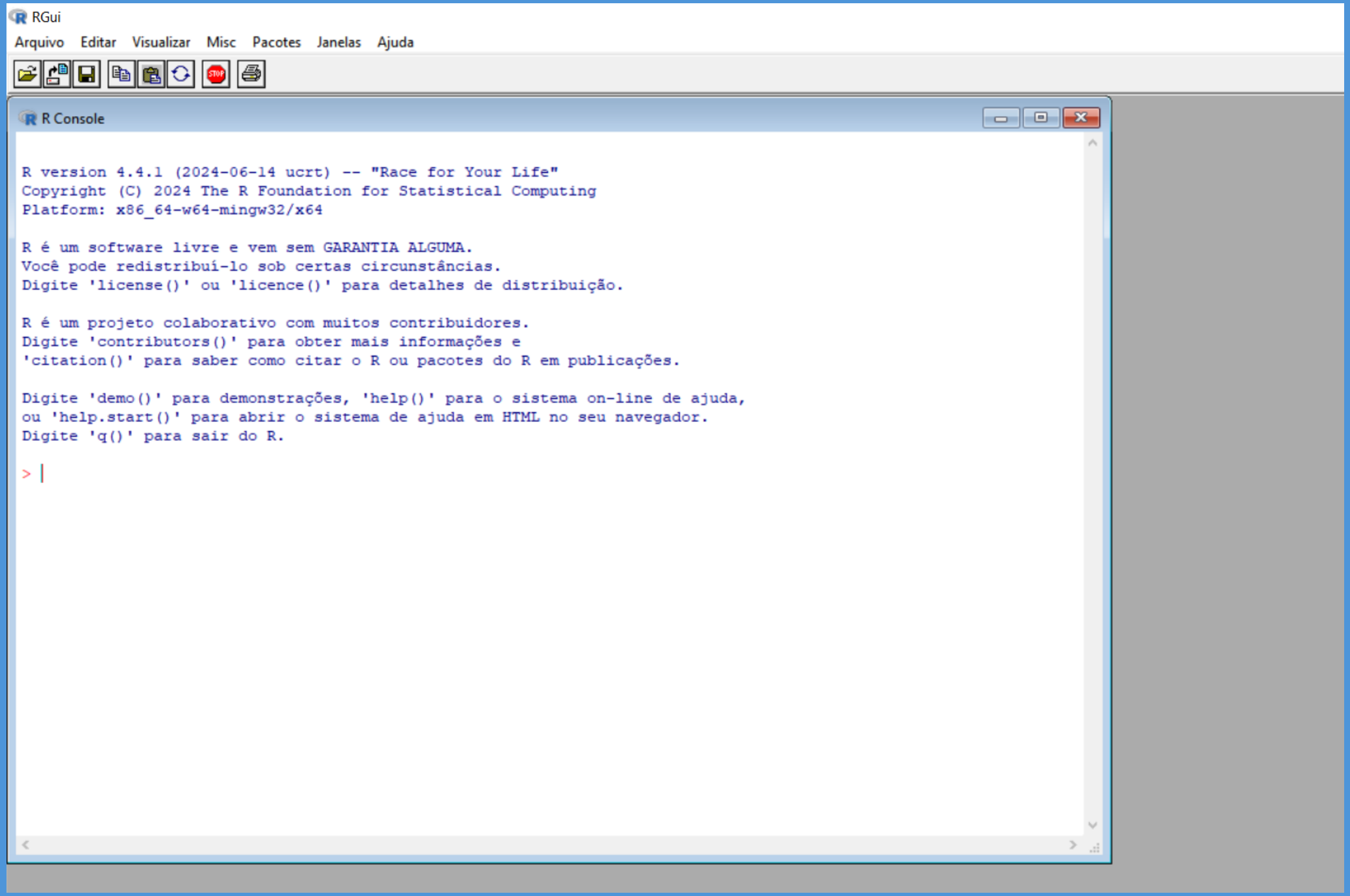
• **Automação de compilação local**: são utilitários que automatizam tarefas simples e repetíveis durante a criação de uma compilação local do software usada pelo desenvolvedor. São tarefas como compilação de código-fonte em código binário, criação de pacotes de código binário e execução de testes automatizados.

• **Debugger**: é um programa usado para testar outros programas e mostrar graficamente a localização do bug no código original.

https://www.redhat.com/pt-br/topics/middleware/what-is-ide



O RStudio é uma IDE

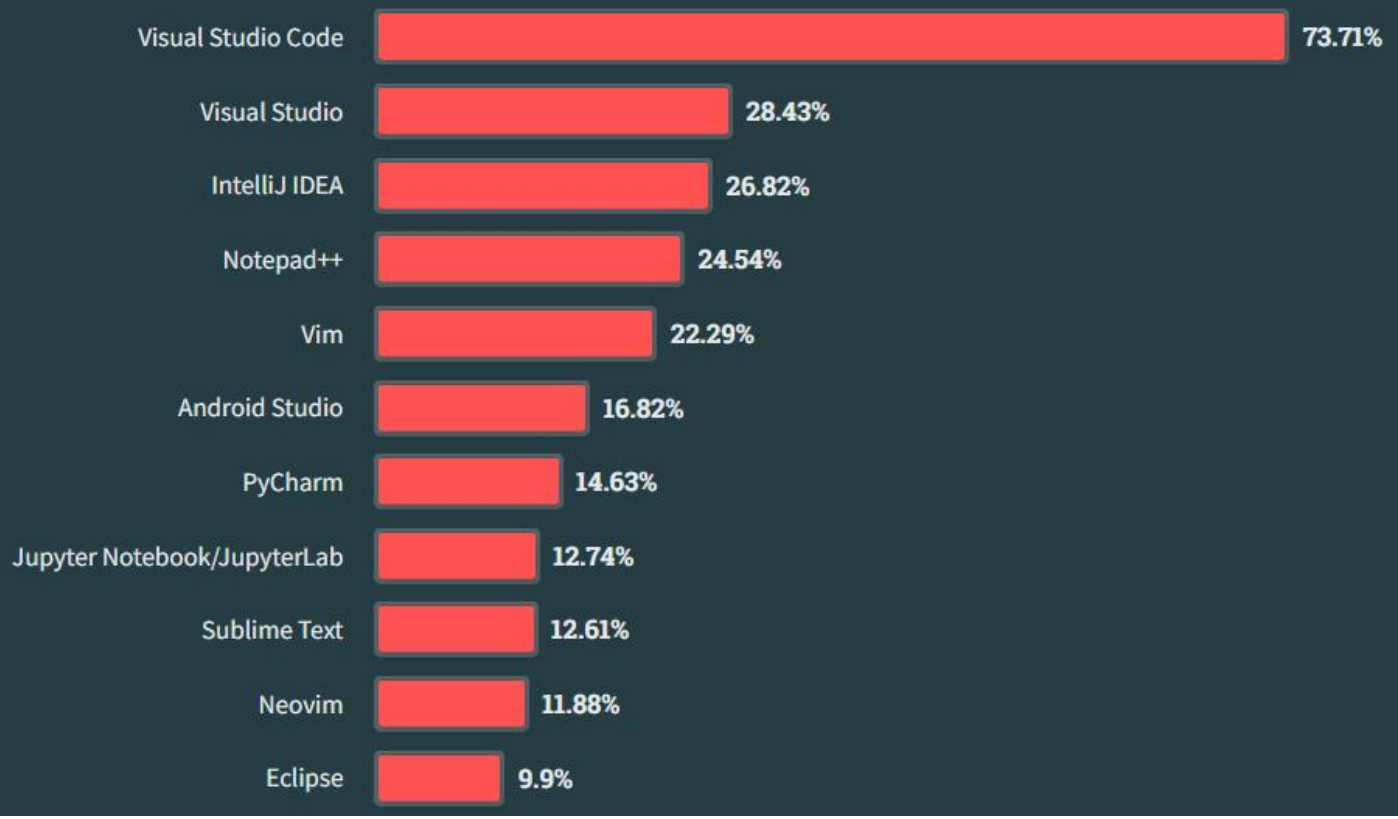

RGui
Arquivo Editar Visualizar Misc Pacotes Janelas Ajuda
R Console
R version 4.4.1 (2024-06-14 ucrt) -- "Race for Your Life"
Copyright (C) 2024 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64
R é um software livre e vem sem GARANTIA ALGUMA.
Você pode redistribuí-lo sob certas circunstâncias.
Digite 'license()' ou 'licence()' para detalhes de distribuição.
R é um projeto colaborativo com muitos contribuidores.
Digite 'contributors()' para obter mais informações e
'citation()' para saber como citar o R ou pacotes do R em publicações.
Digite 'demo()' para demonstrações, 'help()' para o sistema on-line de ajuda,
ou 'help.start()' para abrir o sistema de ajuda em HTML no seu navegador.
Digite 'q()' para sair do R.
>

Integrated development environment

Visual Studio Code remains the preferred IDE across all developers, increasing its use among those learning to code compared to professional developers (78% vs. 74%).

All Respondents | Professional Developers | Learning to Code | Other Coders

86,544 responses



https://survey.stackoverflow.co/2023/#most-popular-technologies-new-collab-tools

Version 1.94 is now available! Read about the new features and fixes from September.

Overview
SETUP
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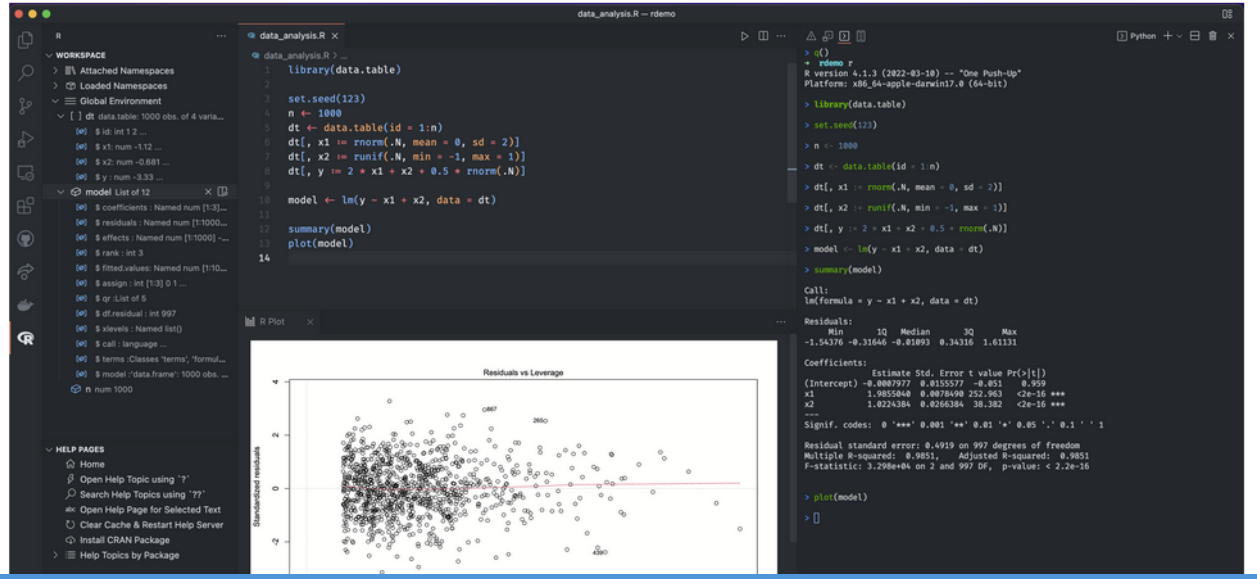
CSS, SCSS and Less
TypeScript
Markdown
PowerShell
C++
Java

R in Visual Studio Code

Edit

The R programming language is a dynamic language built for statistical computing and graphics. R is commonly used in statistical analysis, scientific computing, machine learning, and data visualization.

The R extension for Visual Studio Code supports extended syntax highlighting, code completion, linting, formatting, interacting with R terminals, viewing data, plots, workspace variables, help pages, managing packages and working with R Markdown documents.



IN THIS ARTICLE
Getting started
Running R code
Code completion (IntelliSense)
Linting
Workspace viewer
Debugging
Next steps

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https://code.visualstudio.com/docs/languages/r

Começando...

John M. Chambers diz que há **três princípios fundamentais** para entender o programa R:

1. Tudo que existe no R é um **OBJETO**
2. Tudo que acontece no R é uma **CHAMADA DE FUNÇÃO**
3. Interfaces para outros programas são parte do R

```
a <- sqrt(12)
```

Conjuntos de funções do R

1.R-base: são as funções principais do R, acessíveis quando instalamos o programa.

2.Recommended packages: são pacotes de funções que são instalados junto com o programa R, mas não são carregados quando iniciamos o programa. São exemplos os pacotes survival (usado para análise de sobrevivência), MASS e lattice. Para usarmos as funções do pacote survival, por exemplo, precisamos antes usar a função `library(survival)`.

3.Contributed packages: são pacotes oficiais, que não são instalados junto com o programa R.

Available CRAN Packages By Name

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

A3	Accurate, Adaptable, and Accessible Error Metrics for Predictive Models
AalenJohansen	Conditional Aalen-Johansen Estimation
AATtools	Reliability and Scoring Routines for the Approach-Avoidance Task
ABACUS	Apps Based Activities for Communicating and Understanding Statistics
abasequence	Coding 'ABA' Patterns for Sequence Data
abbreviate	Readable String Abbreviation
abc	Tools for Approximate Bayesian Computation (ABC)
abc.data	Data Only: Tools for Approximate Bayesian Computation (ABC)
ABC.RAP	Array Based CpG Region Analysis Pipeline
ABCanalysis	Computed ABC Analysis
abclass	Angle-Based Large-Margin Classifiers
ABCoptim	Implementation of Artificial Bee Colony (ABC) Optimization
ABCp2	Approximate Bayesian Computational Model for Estimating P2
abcrf	Approximate Bayesian Computation via Random Forests
abcrlda	Asymptotically Bias-Corrected Regularized Linear Discriminant Analysis
abctools	Tools for ABC Analyses
abd	The Analysis of Biological Data
abdiv	Alpha and Beta Diversity Measures
abe	Augmented Backward Elimination
aberrance	Detect Aberrant Behavior in Test Data
abess	Fast Best Subset Selection
abglasso	Adaptive Bayesian Graphical Lasso
ABHgenotypeR	Easy Visualization of ABH Genotypes

Currently, the CRAN package repository features 21694 available packages.

https://cran.r-project.org/web/packages/available_packages_by_name.html

R Console

```
> install.packages("CARBayesdata")
Instalando pacote em 'C:/Users/zenit/AppData/Local/R/win-library/4.4'
(como 'lib' não foi especificado)
instalando as dependências 'wk', 's2', 'units', 'sf' também

tentando a URL 'https://brieger.esalq.usp.br/CRAN/bin/windows/contrib/4.4/wk_0.9.4.zip'
Content type 'application/zip' length 2046426 bytes (2.0 MB)
downloaded 2.0 MB

tentando a URL 'https://brieger.esalq.usp.br/CRAN/bin/windows/contrib/4.4/s2_1.1.7.zip'
Content type 'application/zip' length 4099553 bytes (3.9 MB)
downloaded 3.9 MB

tentando a URL 'https://brieger.esalq.usp.br/CRAN/bin/windows/contrib/4.4/units_0.8-5.zip'
Content type 'application/zip' length 787591 bytes (769 KB)
downloaded 769 KB

tentando a URL 'https://brieger.esalq.usp.br/CRAN/bin/windows/contrib/4.4/sf_1.0-19.zip'
Content type 'application/zip' length 40986608 bytes (39.1 MB)
downloaded 39.1 MB

tentando a URL 'https://brieger.esalq.usp.br/CRAN/bin/windows/contrib/4.4/CARBayesdata_3.0.zip'
Content type 'application/zip' length 358560 bytes (350 KB)
downloaded 350 KB

pacote 'wk' desempacotado com sucesso e somas MD5 verificadas
pacote 's2' desempacotado com sucesso e somas MD5 verificadas
pacote 'units' desempacotado com sucesso e somas MD5 verificadas
pacote 'sf' desempacotado com sucesso e somas MD5 verificadas
pacote 'CARBayesdata' desempacotado com sucesso e somas MD5 verificadas

Os pacotes binários baixados estão em
        C:\Users\zenit\AppData\Local\Temp\Rtmp6vHN8n\downloaded_packages
> 
```

Simple Features for R

A package that provides simple features access for R.

Blogs, links • Cheatsheet • Installing • Contributing • Acknowledgment • How to cite

Package sf:

- represents simple features as records in a `data.frame` or `tibble` with a geometry list-column
- represents natively in R all 17 simple feature types for all dimensions (XY, XYZ, XYM, XYZM)
- interfaces to GEOS for geometrical operations on projected coordinates, and (through R package s2) to s2geometry for geometrical operations on ellipsoidal coordinates
- interfaces to GDAL, supporting all driver options, `Date` and `POSIXct` and list-columns
- interfaces to PRØJ for coordinate reference system conversion and transformation
- uses well-known-binary serialisations written in C++/Rcpp for fast I/O with GDAL and GEOS
- reads from and writes to spatial databases such as PostGIS using DBI
- is extended by
  - lwgeom for selected liblwgeom/PostGIS functions
  - stars for raster data, and raster or vector data cubes (spatial time series)

Links

View on CRAN

Browse source code

Report a bug

License

GPL-2 | MIT + file LICENSE

Citation

Citing sf

Developers

Edzer Pebesma

Author, maintainer

More about authors...

Dev status

mapview

Interactive viewing of spatial data in R

mapview provides functions to very quickly and conveniently create interactive visualisations of spatial data. It's main goal is to fill the gap of quick (not presentation grade) interactive plotting to examine and visually investigate both aspects of spatial data, the geometries and their attributes. It can also be considered a data-driven API for the **leaflet** package as it will automatically render correct map types, depending on the type of the data (points, lines, polygons, raster). In addition, it makes use of some advanced rendering functionality that will enable viewing of much larger data than is possible with **leaflet**. Furthermore, if you're a fan of **mapdeck** (which you should!), you can choose to use it as the rendering platform instead of **leaflet** by setting `mapviewOptions(platform = "mapdeck")` .

The main user relevant functions are:

- `mapview` - view (multiple) spatial objects on a set of background maps
- `viewExtent` - view extent / bounding box of spatial objects
- `viewRGB` - view RGB true- or false-color images of raster objects
- `mapshot` - easily save maps (including leaflet maps) as `html` and/or `png` (or other image formats)

Functions that have been deprecated/deleted recently:

- `addHomeButton` - deprecated, use package leafem instead.
- `addLogo` - deprecated, use package leafem instead.
- `addFeatures` - deprecated, use package leafem instead.
- `addMouseCoordinates` - deprecated, use package leafem instead.

Links

View on CRAN

Browse source code

Report a bug

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Citation

Citing mapview

Developers

Tim Appelhans
Maintainer, author

Florian Detsch
Author

Christoph Reudenbach
Author

Stefan Woellauer
Author

More about authors...

Dev status

tic passing

CRAN NOTE

spdep

R-CMD-check passing CRAN

Spatial Dependence: Weighting Schemes and Statistics

A collection of functions to create spatial weights matrix objects from polygon contiguities, from point patterns by distance and tessellations, for summarizing these objects, and for permitting their use in spatial data analysis, including regional aggregation by minimum spanning tree; a collection of tests for spatial autocorrelation, including global Morans I and Gearys C proposed by Cliff and Ord (1973, ISBN: 0850860369) and (1981, ISBN: 0850860814), Hubert/Mantel general cross product statistic, Empirical Bayes estimates and Assunção/Reis (1999) (https://doi.org/10.1002/(SICI)1097-0258(19990830)18:16%3C2147%3A%3AAID-SIM179%3E3.0.CO%3B2-I) Index, Getis/Ord G (Getis and Ord 1992) (https://doi.org/10.1111/j.1538-4632.1992.tb00261.x) and multicoloured join count statistics, APLE (Li et al.) (https://doi.org/10.1111/j.1538-4632.2007.00708.x), local Morans I (Anselin 1995) (https://doi.org/10.1111/j.1538-4632.1995.tb00338.x) and Getis/Ord G (Ord and Getis 1995) (https://doi.org/10.1111/j.1538-4632.1995.tb00912.x), saddlepoint approximations (Tiefelsdorf 2002) (https://doi.org/10.1111/j.1538-4632.2002.tb01084.x) and exact tests for global and local Morans I (Bivand et al. 2009) (https://doi.org/10.1016/j.csda.2008.07.021) and LOSH local indicators of spatial heteroscedasticity (Ord and Getis) (https://doi.org/10.1007/s00168-011-0492-y), with further extensions in 'Bivand' (2022) doi:10.1111/gean.12319. The implementation of most of the measures is

Links

View on CRAN

Browse source code

Report a bug

License

GPL (>= 2)

Citation

Citing spdep

Developers

Roger Bivand
Maintainer, author

More about authors...

Introduction

1. Application

1.1. editR

1.2. flexdashboard

1.3. htmlwidgets

1.4. listviewer

1.5. miniUI

1.6. shiny

1.7. shinygadgets

1.8. shinyLP

1.9. shinystan

1.10. tooltipsterR

1.11. V8

1.12. xmlview

2. Data Handling

2.1. dplyr

2.2. fuzzyjoin

2.3. janitor

2.4. multidplyr

CARBayes: Spatial Generalised Linear Mixed Models for Areal Unit Data

- CRAN: http://cran.r-project.org/web/packages/CARBayes/index.html
- Vignettes:
  - Vignette for CARBayes package. (PDF)

```
> library(CARBayes)
```

```
Loading required package: MASS
```

```

Attaching package: 'MASS'
```

```
The following object is masked from 'package:dplyr':

    select
```

efg's R Notes: RColorBrewer Package

RNotes

ColorBrewer Palettes

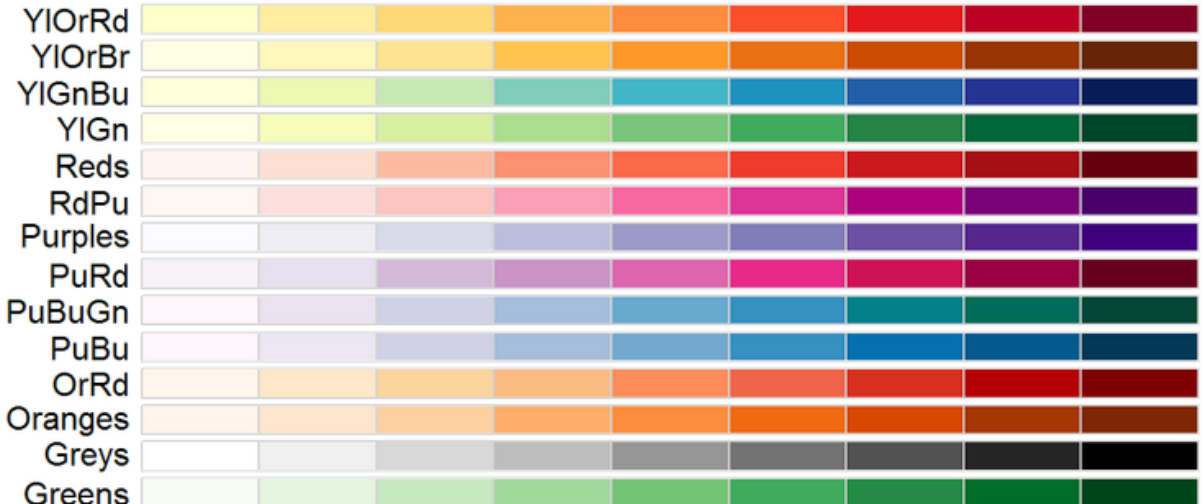
```
library(RColorBrewer)
```

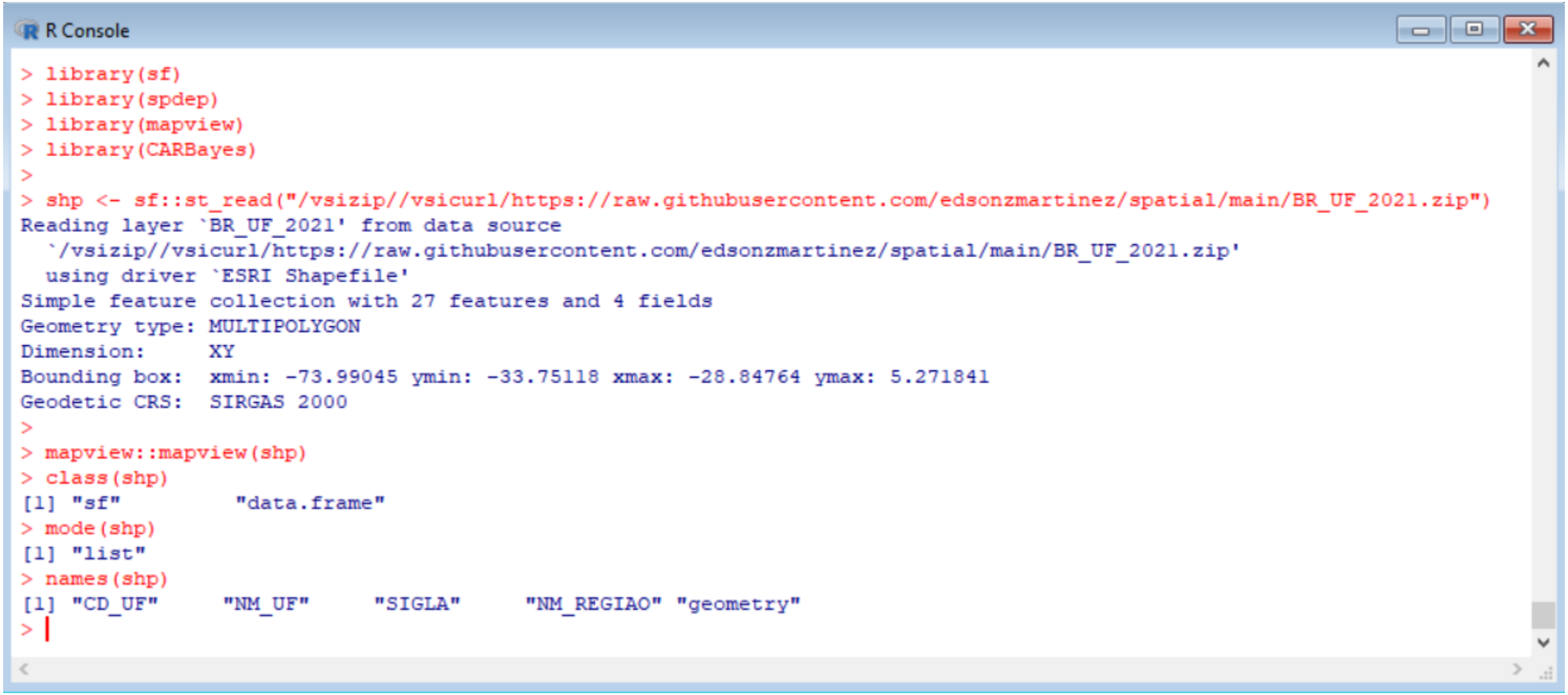
Sequential palettes

Sequential palettes are suited to ordered data that progress from low to high. Lightness steps dominate the look of these schemes, with light colors for low data values to dark colors for high data values.

All the sequential palettes are available in variations from 3 different values up to 9 different values.

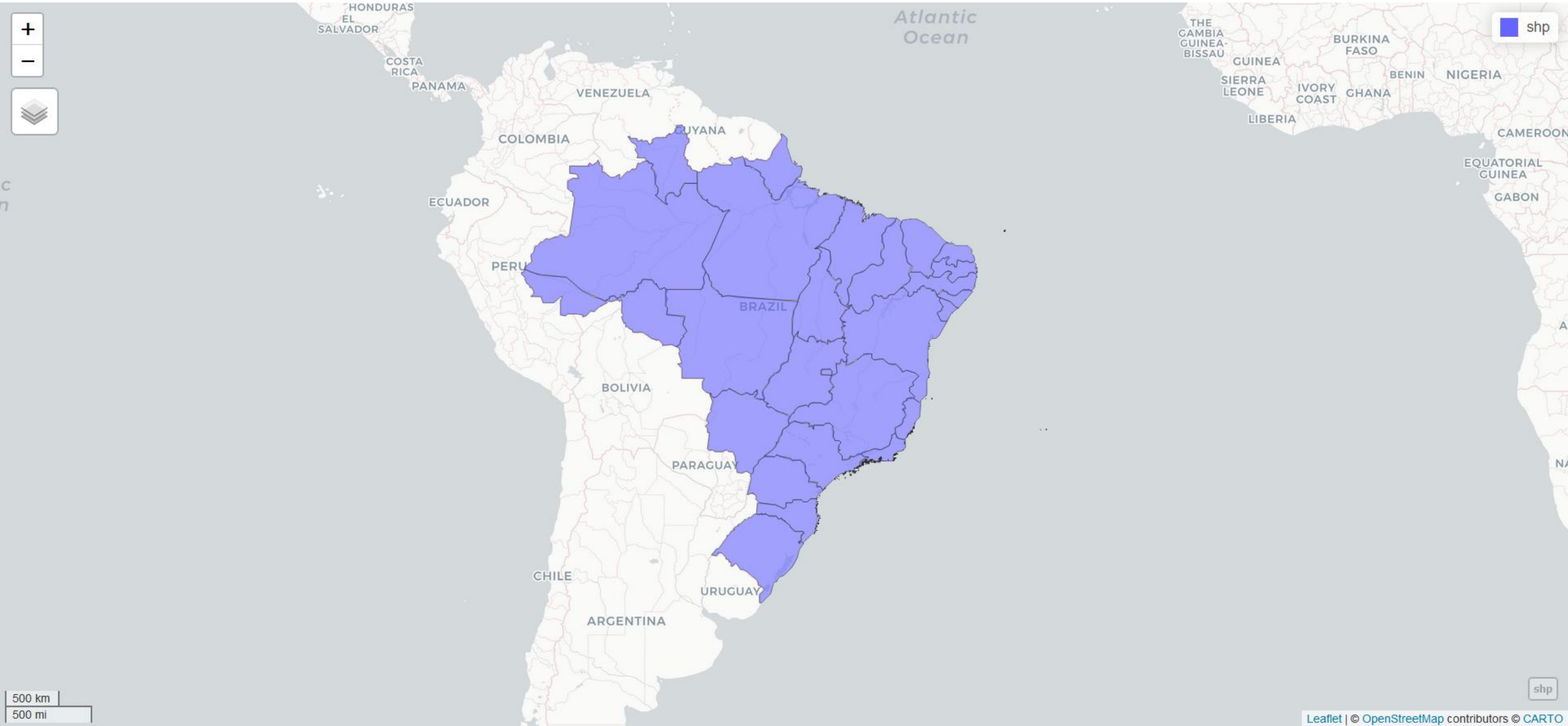
```
par(mar=c(1,5,1,1))
display.brewer.all(type="seq")
```





O /vsizip/ é um manipulador de arquivos que permite a leitura de arquivos ZIP em tempo real, sem descompactá-los previamente

```
library(sf)
library(mapview)
shp <- sf::st_read("/vsizip//vsicurl/https://raw.githubusercontent.com/edsonzmartinez/spatial/main/BR_UF_2021.zip")
mapview::mapview(shp)
```



```
library(sf)
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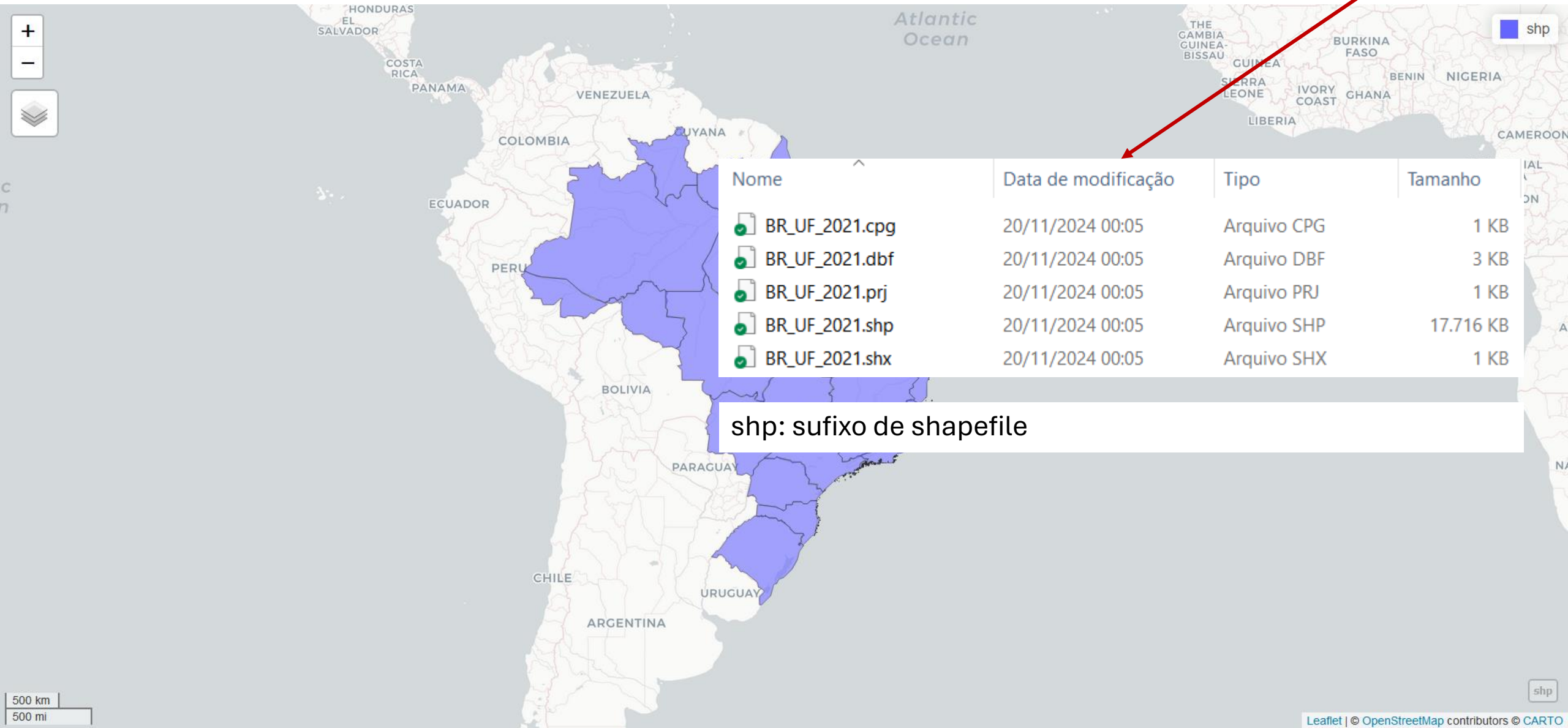
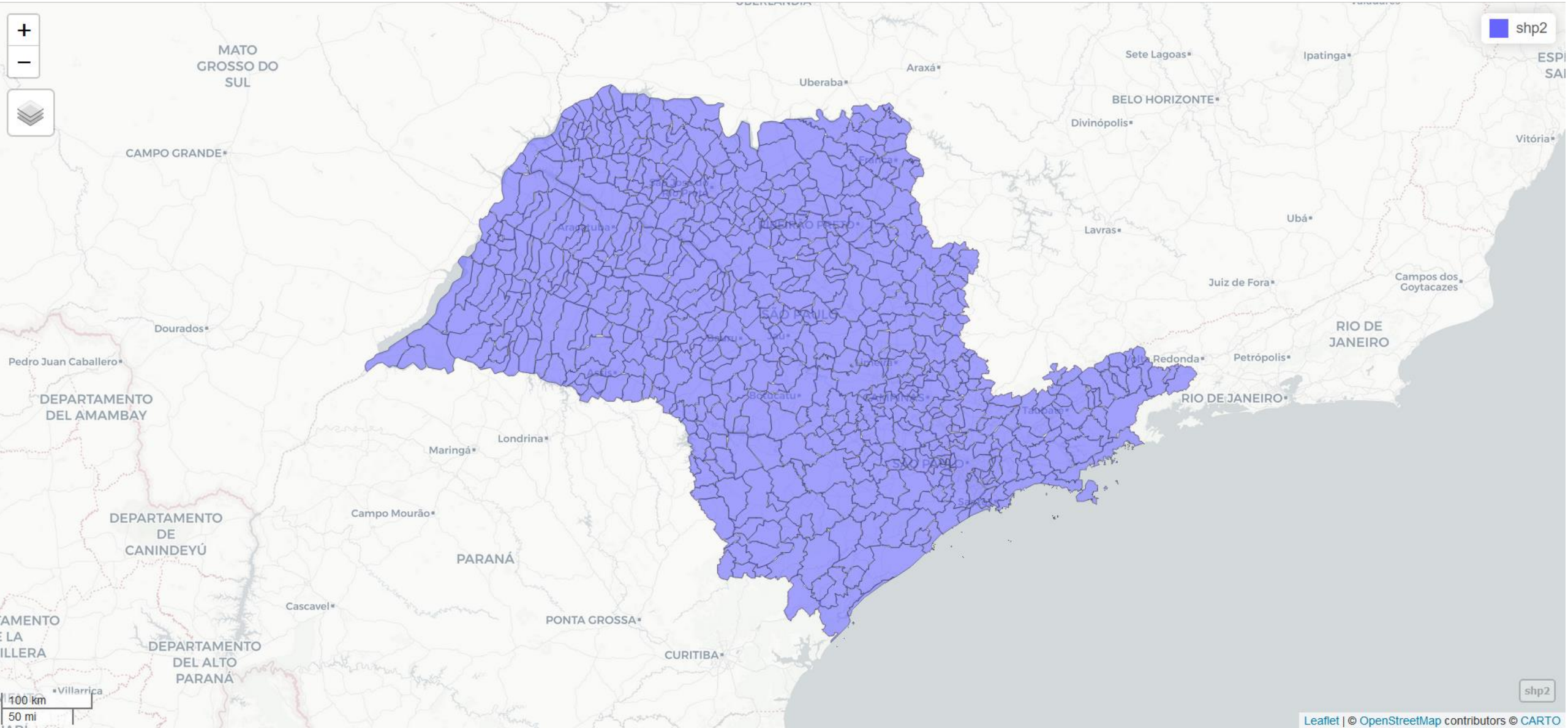


Nome	Data de modificação	Tipo	Tamanho
BR_UF_2021.cpg	20/11/2024 00:05	Arquivo CPG	1 KB
BR_UF_2021.dbf	20/11/2024 00:05	Arquivo DBF	3 KB
BR_UF_2021.prj	20/11/2024 00:05	Arquivo PRJ	1 KB
BR_UF_2021.shp	20/11/2024 00:05	Arquivo SHP	17.716 KB
BR_UF_2021.shx	20/11/2024 00:05	Arquivo SHX	1 KB

shp: sufixo de shapefile

Podemos abrir mapas shapefile diretamente do site do IBGE sem a necessidade de download

```
shp2 <- st_read("/vsizip//vsicurl/https://geoftp.ibge.gov.br/organizacao_do_territorio/malhas_territoriais/malhas_municipais/municipio_2022/UFs/SP/SP_UF_2022.zip")
mapview::mapview(shp2)
```



```
> shp
Simple feature collection with 27 features and 4 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ymax: 5.271841
Geodetic CRS:  SIRGAS 2000
First 10 features:
   CD_UF     NM_UF SIGLA NM_REGIAO                          geometry
1     11  Rondônia    RO     Norte MULTIPOLYGON (((-62.86662 -...
2     12      Acre    AC     Norte MULTIPOLYGON (((-73.1655 -7...
3     13  Amazonas    AM     Norte MULTIPOLYGON (((-67.32609 2...
4     14   Roraima    RR     Norte MULTIPOLYGON (((-60.20051 5...
5     15      Pará    PA     Norte MULTIPOLYGON (((-46.43676 -...
6     16     Amapá    AP     Norte MULTIPOLYGON (((-50.45011 2...
7     17 Tocantins    TO     Norte MULTIPOLYGON (((-48.35878 -...
8     21  Maranhão    MA  Nordeste MULTIPOLYGON (((-44.66115 -...
9     22     Piauí    PI  Nordeste MULTIPOLYGON (((-41.78076 -...
10    23     Ceará    CE  Nordeste MULTIPOLYGON (((-40.49582 -...
> class(shp)
[1] "sf"         "data.frame"
> mode(shp)
[1] "list"
```

```
> shp
Simple feature collection with 27 features and 4 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ymax: 5.271841
Geodetic CRS:  SIRGAS 2000
First 10 features:
   CD_UF     NM_UF SIGLA NM_REGIAO                       geometry
1     11  Rondônia    RO     Norte MULTIPOLYGON (((-62.86662 -...
2     12      Acre    AC     Norte MULTIPOLYGON (((-73.1655 -7...
3     13  Amazonas    AM     Norte MULTIPOLYGON (((-67.32609 2...
4     14   Roraima    RR     Norte MULTIPOLYGON (((-60.20051 5...
5     15      Pará    PA     Norte MULTIPOLYGON (((-46.43676 -...
6     16     Amapá    AP     Norte MULTIPOLYGON (((-50.45011 2...
7     17 Tocantins    TO     Norte MULTIPOLYGON (((-48.35878 -...
8     21  Maranhão    MA  Nordeste MULTIPOLYGON (((-44.66115 -...
9     22     Piauí    PI  Nordeste MULTIPOLYGON (((-41.78076 -...
10    23     Ceará    CE  Nordeste MULTIPOLYGON (((-40.49582 -...
> class(shp)
[1] "sf"         "data.frame"
> mode(shp)
[1] "list"
```

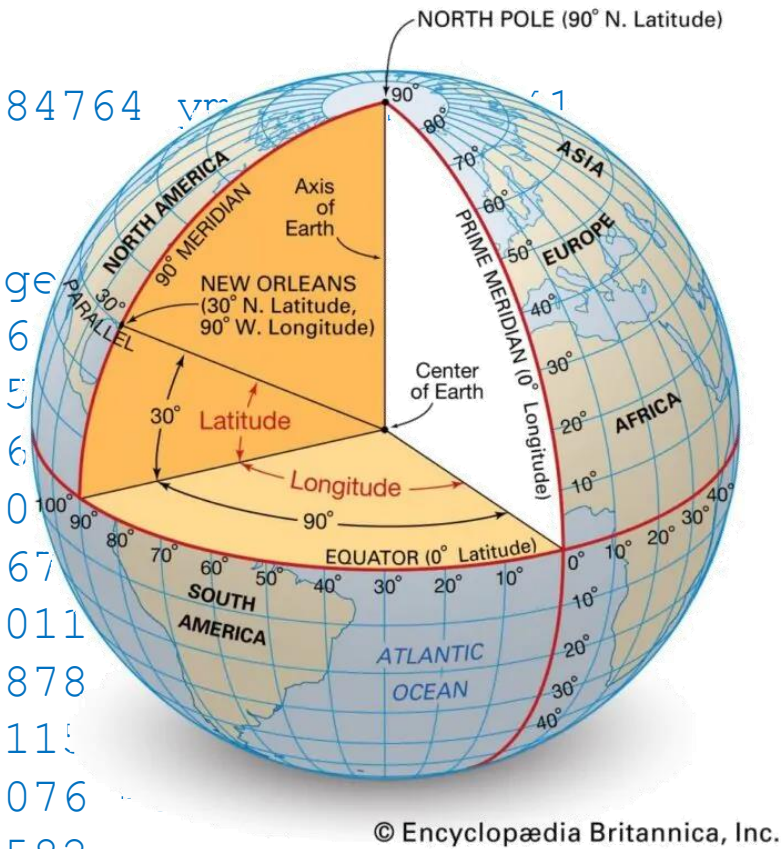
Em sua forma mais básica, um **objeto sf** é uma coleção de características (features) simples que inclui atributos e geometrias na forma de uma base de dados (data frame). Em outras palavras, é uma base de dados com linhas de características, colunas de atributos e uma **coluna de geometria especial que contém os aspectos espaciais das características**.

```
> shp
Simple feature collection with 27 features and 4 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ymax: 5.271841
Geodetic CRS:  SIRGAS 2000
First 10 features:
   CD_UF     NM_UF SIGLA NM_REGIAO                          geometry
1     11  Rondônia    RO     Norte MULTIPOLYGON (((-62.86662 -...
2     12       Acre    AC     Norte MULTIPOLYGON (((-73.1655 -7...
3     13  Amazonas    AM     Norte MULTIPOLYGON (((-67.32609 2...
4     14   Roraima    RR     Norte MULTIPOLYGON (((-60.20051 5...
5     15      Pará    PA     Norte MULTIPOLYGON (((-46.43676 -...
6     16     Amapá    AP     Norte MULTIPOLYGON (((-50.45011 2...
7     17 Tocantins    TO     Norte MULTIPOLYGON (((-48.35878 -...
8     21  Maranhão    MA  Nordeste MULTIPOLYGON (((-44.66115 -...
9     22     Piauí    PI  Nordeste MULTIPOLYGON (((-41.78076 -...
10    23     Ceará    CE  Nordeste MULTIPOLYGON (((-40.49582 -...
> class(shp)
[1] "sf"         "data.frame"
> mode(shp)
[1] "list"
```

Geodetic CRS: Trata-se do Sistema Geodésico de Referência, que permite que se faça a localização espacial de qualquer objeto sobre a superfície terrestre.

SIRGAS2000: sistema geodésico de referência adotado oficialmente no Brasil em 25 de fevereiro de 2005

```
> shp
Simple feature collection with 27 features and 4 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ym
Geodetic CRS:  SIRGAS 2000
First 10 features:
   CD_UF      NM_UF SIGLA NM_REGIAO                                  ge
1     11  Rondônia    RO     Norte MULTIPOLYGON (((-62.866
2     12       Acre    AC     Norte MULTIPOLYGON (((-73.165
3     13  Amazonas    AM     Norte MULTIPOLYGON (((-67.326
4     14   Roraima    RR     Norte MULTIPOLYGON (((-60.200
5     15      Pará    PA     Norte MULTIPOLYGON (((-46.4367
6     16     Amapá    AP     Norte MULTIPOLYGON (((-50.45011
7     17 Tocantins    TO     Norte MULTIPOLYGON (((-48.35878
8     21  Maranhão    MA  Nordeste MULTIPOLYGON (((-44.6611
9     22     Piauí    PI  Nordeste MULTIPOLYGON (((-41.78076
10    23     Ceará    CE  Nordeste MULTIPOLYGON (((-40.49582 -...
> class(shp)
[1] "sf"         "data.frame"
> mode(shp)
[1] "list"
```

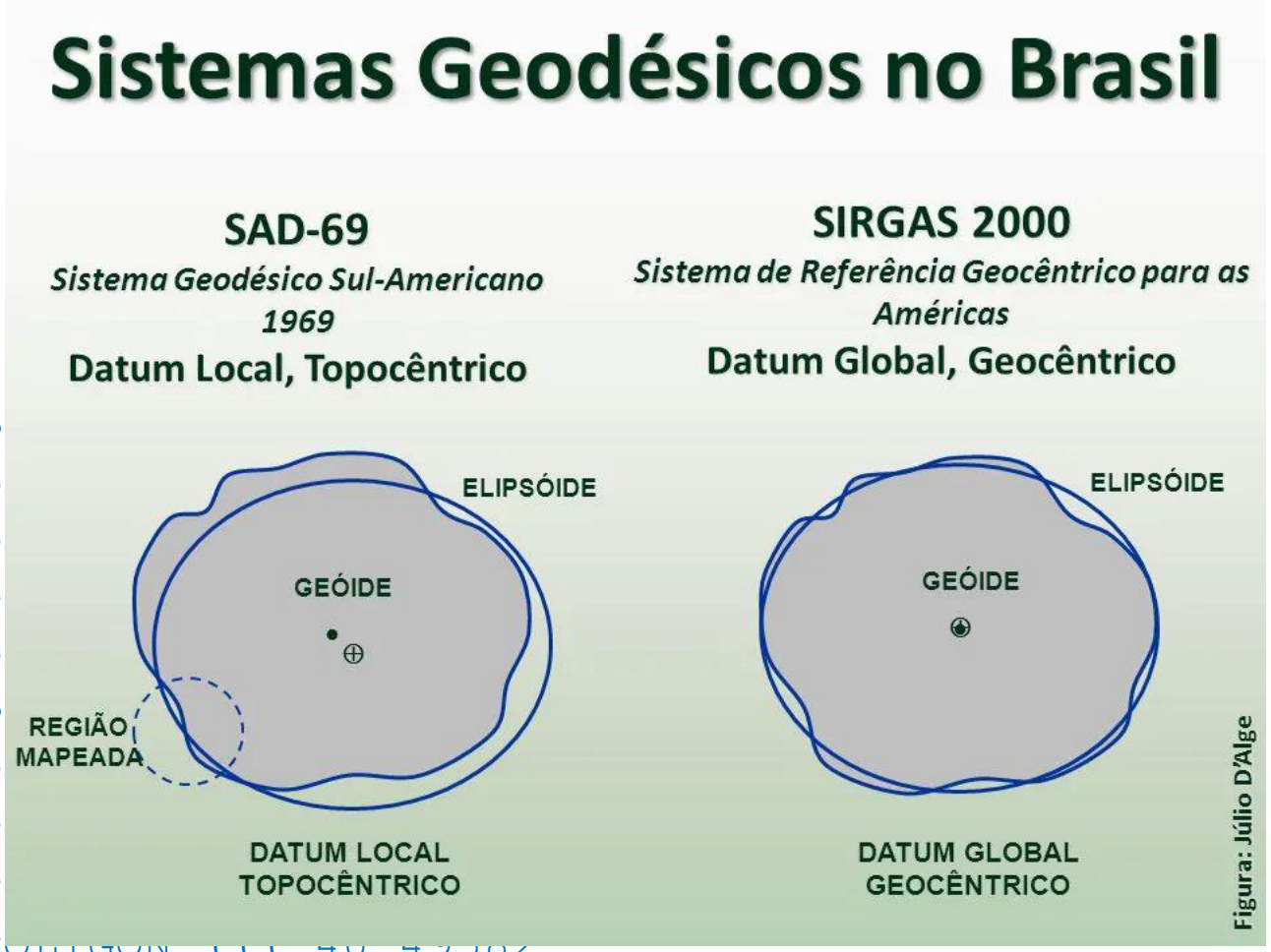


Orientação:

Geocêntrica: Eixo de rotação paralelo ao eixo de rotação da Terra, onde a origem está localizada no centro de massa da Terra.

Topocêntrica: O centro do elipsóide (ou origem dos eixos) não está localizado no centro de massa da Terra, mas sim no ponto de origem (vértice) escolhido.

```
> shp
Simple feature collection with 27 feature
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.
Geodetic CRS:  SIRGAS 2000
First 10 features:
   CD_UF      NM_UF SIGLA NM_REGIAO
1     11  Rondônia    RO     Norte MULTIP
2     12      Acre    AC     Norte MULTIP
3     13  Amazonas    AM     Norte MULTIP
4     14   Roraima    RR     Norte MULTIP
5     15      Pará    PA     Norte MULTIP
6     16     Amapá    AP     Norte MULTIP
7     17 Tocantins    TO     Norte MULTIP
8     21  Maranhão    MA  Nordeste MULTIP
9     22     Piauí    PI  Nordeste MULTIP
10    23     Ceará    CE  Nordeste MULTIPOLIGON ((( -40.49582  ...
> class(shp)
[1] "sf"         "data.frame"
> mode(shp)
[1] "list"
```

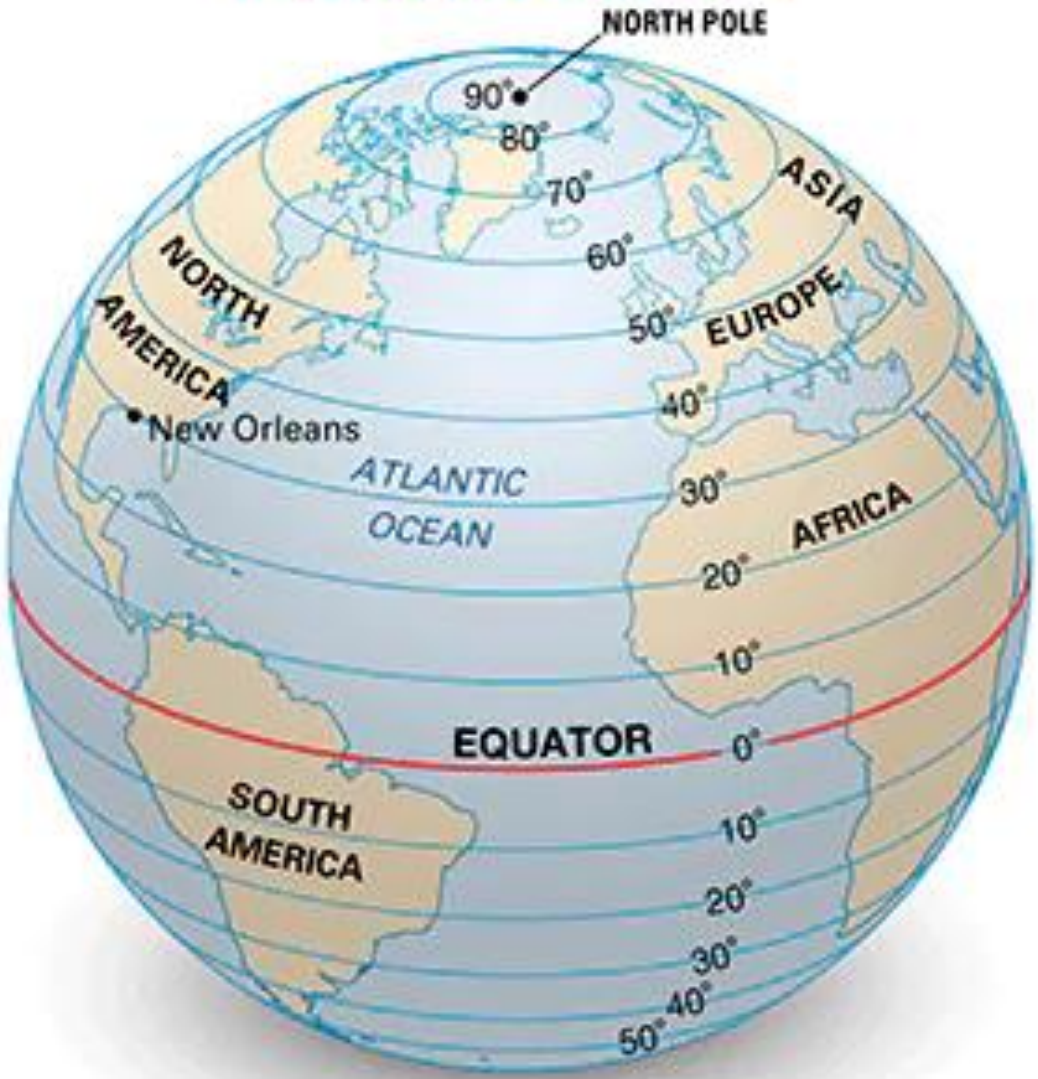


Orientação:

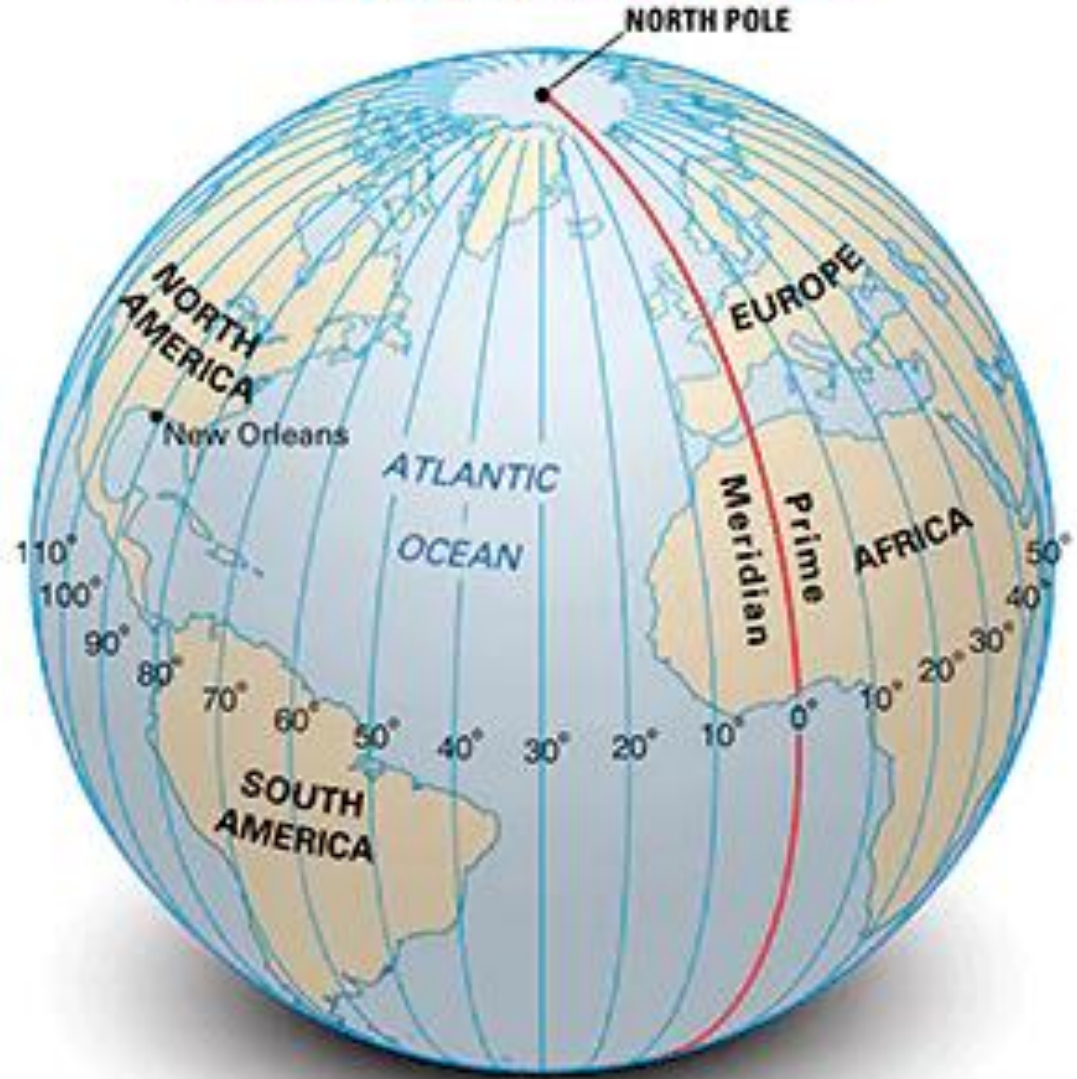
Geocêntrica: Eixo de rotação paralelo ao eixo de rotação da Terra, onde a origem está localizada no centro de massa da Terra.

Topocêntrica: O centro do elipsóide (ou origem dos eixos) não está localizado no centro de massa da Terra, mas sim no ponto de origem (vértice) escolhido.

LATITUDE



LONGITUDE

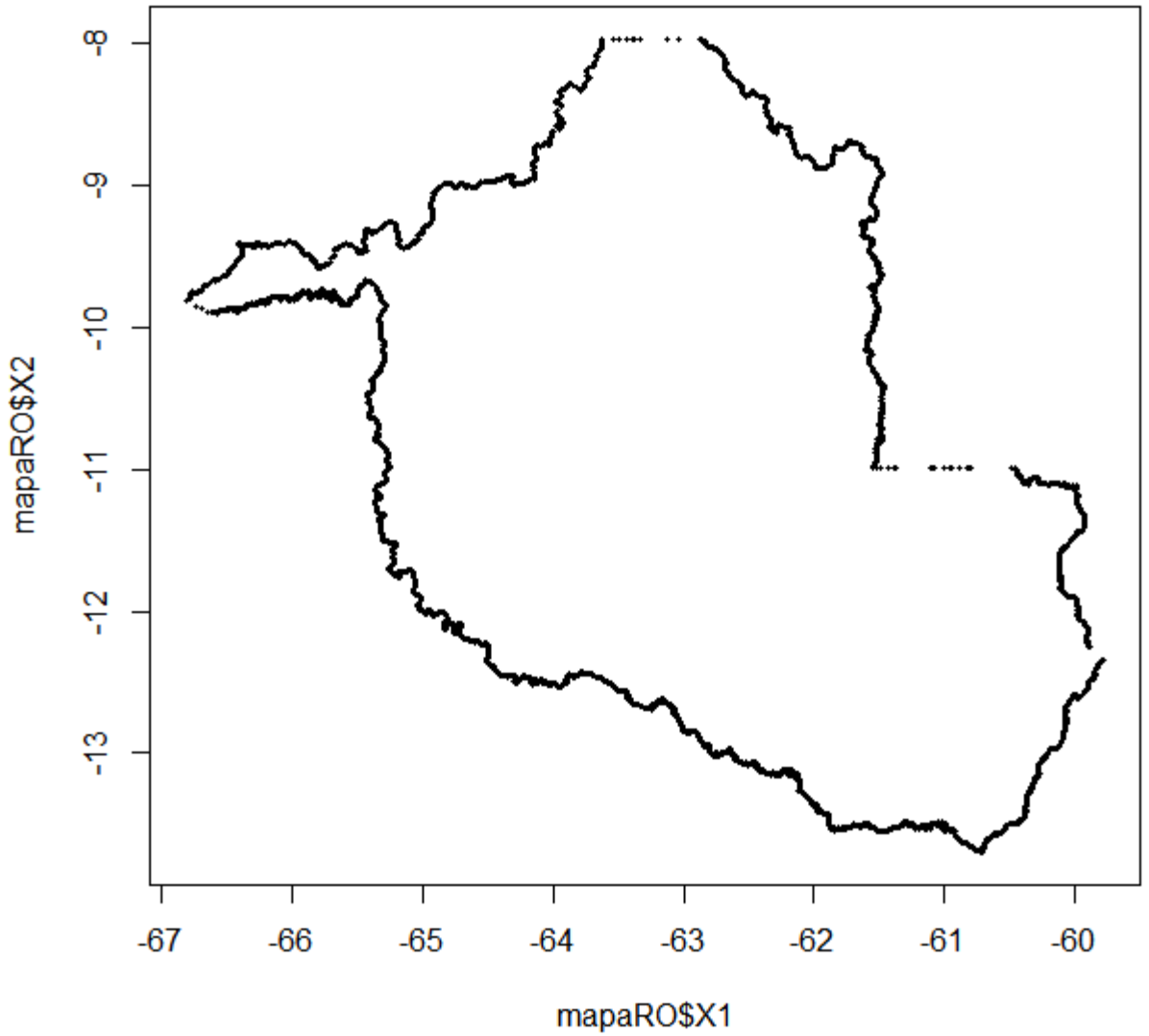


```
> shp
Simple feature collection with 27 features and 4 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ymax: 5.271841
Geodetic CRS:  SIRGAS 2000
First 10 features:
   CD_UF      NM_UF SIGLA NM_REGIAO                       geometry
1     11  Rondônia    RO     Norte MULTIPOLYGON (((-62.86662 -...
2     12       Acre    AC     Norte MULTIPOLYGON (((-73.1655 -7...
3     13   Amazonas    AM     Norte MULTIPOLYGON (((-67.32609 2...
4     14    Roraima    RR     Norte MULTIPOLYGON (((-60.20051 5...
5     15       Pará    PA     Norte MULTIPOLYGON (((-46.43676 -...
6     16      Amapá    AP     Norte MULTIPOLYGON (((-50.45011 2...
7     17 Tocantins    TO     Norte MULTIPOLYGON (((-48.35878 -...
8     21   Maranhão    MA  Nordeste MULTIPOLYGON (((-44.66115 -...
9     22      Piauí    PI  Nordeste MULTIPOLYGON (((-41.78076 -...
10    23      Ceará    CE  Nordeste MULTIPOLYGON (((-40.49582 -...
> class(shp)
[1] "sf"         "data.frame"
> mode(shp)
[1] "list"
```

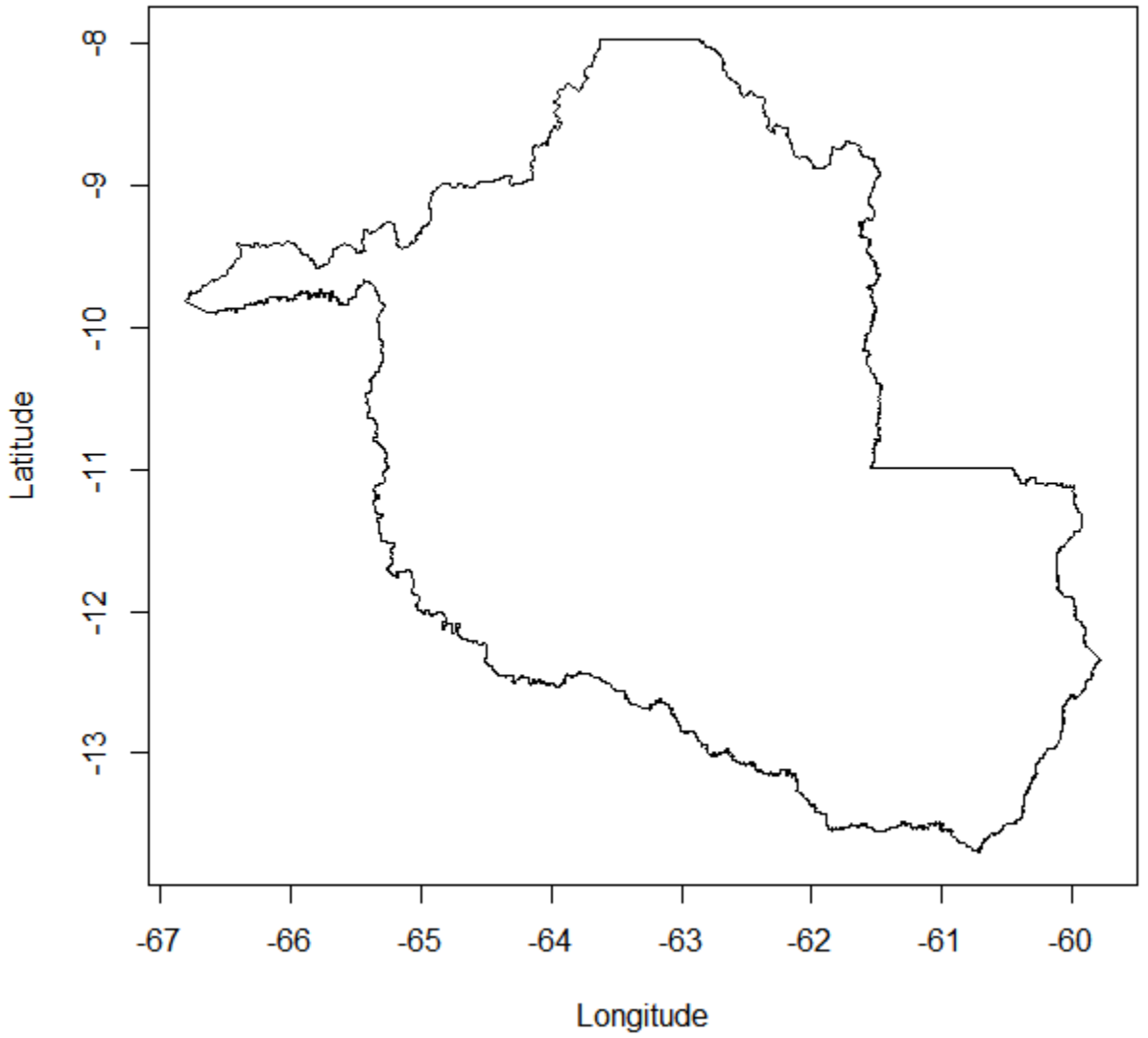
Vamos considerar a primeira “feature” como exemplo

```
> shp$geometry[[1]]
MULTIPOLYGON (((-62.86662 -7.975868, -62.86017 -7.982323, -62.85336 -7.987563, -62.84506 -
7.986531, -62.84161 -7.994973, -62.83283 -7.994372, -62.82572 -8.007521, -62.821 -8.014496, -
62.81434 -8.018363, -62.81 -8.02534, -62.80176 -8.025656, -62.7943 -8.027548, -62.78857 -8.026695,
-62.7862 -8.026343, -62.78218 -8.029451, -62.77984 -8.031259, -62.77219 -8.031494, -62.76528 -
8.036046, -62.75789 -8.038437, -62.7518 -8.043556, -62.74397 -8.045286, -62.73803 -8.050069, -
62.73311 -8.056566, -62.72764 -8.062485, -62.72462 -8.069198, -62.71811 -8.074114, -62.71283 -
8.080583, -62.70642 -8.085313, -62.6995 -8.088366, -62.69228 -8.092908, -62.69056 -8.100904, -
62.68403 -8.104888, -62.67884 -8.111445, -62.67914 -8.111673, -62.6855 -8.116438, -62.6833 -
8.12397, -62.67825 -8.130067, -62.67411 -8.136953, -62.67303 -8.145311, -62.67673 -8.152449, -
62.67917 -8.160776, -62.68525 -8.165718, -62.68666 -8.173774, -62.683 -8.180565, -62.67667 -
8.185398, -62.67352 -8.192735, -62.66694 -8.196721, -62.65989 -8.199634, -62.65103 -8.22203, -
62.655 -8.229056, -62.64995 -8.237026, -62.64195 -8.239343, -62.63628 -8.244598, -62.62897 -
8.248555, -62.6182 -8.25721, -62.61036 -8.2598, -62.60402 -8.265124, -62.60006 -8.272239, -
62.59277 -8.27497, -62.58539 -8.271881, -62.5815 -8.278625, -62.57419 -8.280653, -62.56923 -
8.287279, -62.56192 -8.284007, -62.55731 -8.296261, -62.55626 -8.304282, -62.55594 -8.306759, -
62.56116 -8.313832, -62.55527 -8.319387, -62.55578 -8.327436, -62.54911 -8.342143, -62.54892 -
8.350315, -62.55153 -8.358195, -62.53956 -8.35811, -62.532 -8.371029, -62.52547 -8.375347, -
62.52614 -8.383054, -62.51847 -8.384738, -62.50825 -8.372602, -62.50083 -8.366128, -62.49269 -
8.36436, -62.48695 -8.359212, -62.48275 -8.352751, -62.47892 -8.345673, -62.47297 -8.340753, -
62.46547 -8.33974, -62.45895 -8.343581, -62.45377 -8.349173, -62.44533 -8.362483, -62.43972 -
8.367898, -62.43225 -8.372028, -62.42456 -8.374985, -62.41622 -8.376628, -62.40825 -8.377448, -
62.40002 -8.374803, -62.39236 -8.375321, -62.38403 -8.377556, -62.37055 -8.384659, -62.36508 -
8.391022, -62.3608 -8.398549, -62.35997 -8.406998, -62.36122 -8.42369, -62.36713 -8.43845, -
62.36928 -8.446119, -62.36956 -8.454197, -62.36767 -8.462729, -62.36511 -8.470626, -62.36372 -
8.478227, -62.36402 -8.4859, -62.36605 -8.493562, -62.36008 -8.506364, -62.35398 -8.511701, -
62.34489 -8.513193, -62.33736 -8.516639, -62.33322 -8.527763, -62.33514 -8.537184, -62.33433 -
8.546194, -62.32941 -8.555074, -62.3258 -8.563707, -62.32772 -8.572537, -62.33414 -8.579543
```

```
> # Rondônia
> mapaRO <- data.frame(shp$geometry[[1]][1])
> head(mapaRO,25)
           X1         X2
1  -62.86662 -7.975868
2  -62.86017 -7.982323
3  -62.85336 -7.987563
4  -62.84506 -7.986531
5  -62.84161 -7.994973
6  -62.83283 -7.994372
7  -62.82572 -8.007521
8  -62.82100 -8.014496
9  -62.81434 -8.018363
10 -62.81000 -8.025340
11 -62.80176 -8.025656
12 -62.79430 -8.027548
13 -62.78857 -8.026695
14 -62.78620 -8.026343
15 -62.78218 -8.029451
16 -62.77984 -8.031259
17 -62.77219 -8.031494
18 -62.76528 -8.036046
19 -62.75789 -8.038437
20 -62.75180 -8.043556
21 -62.74397 -8.045286
22 -62.73803 -8.050069
23 -62.73311 -8.056566
24 -62.72764 -8.062485
25 -62.72462 -8.069198
> plot(mapaRO$X1,mapaRO$X2,pch=16,cex=0.4)
```

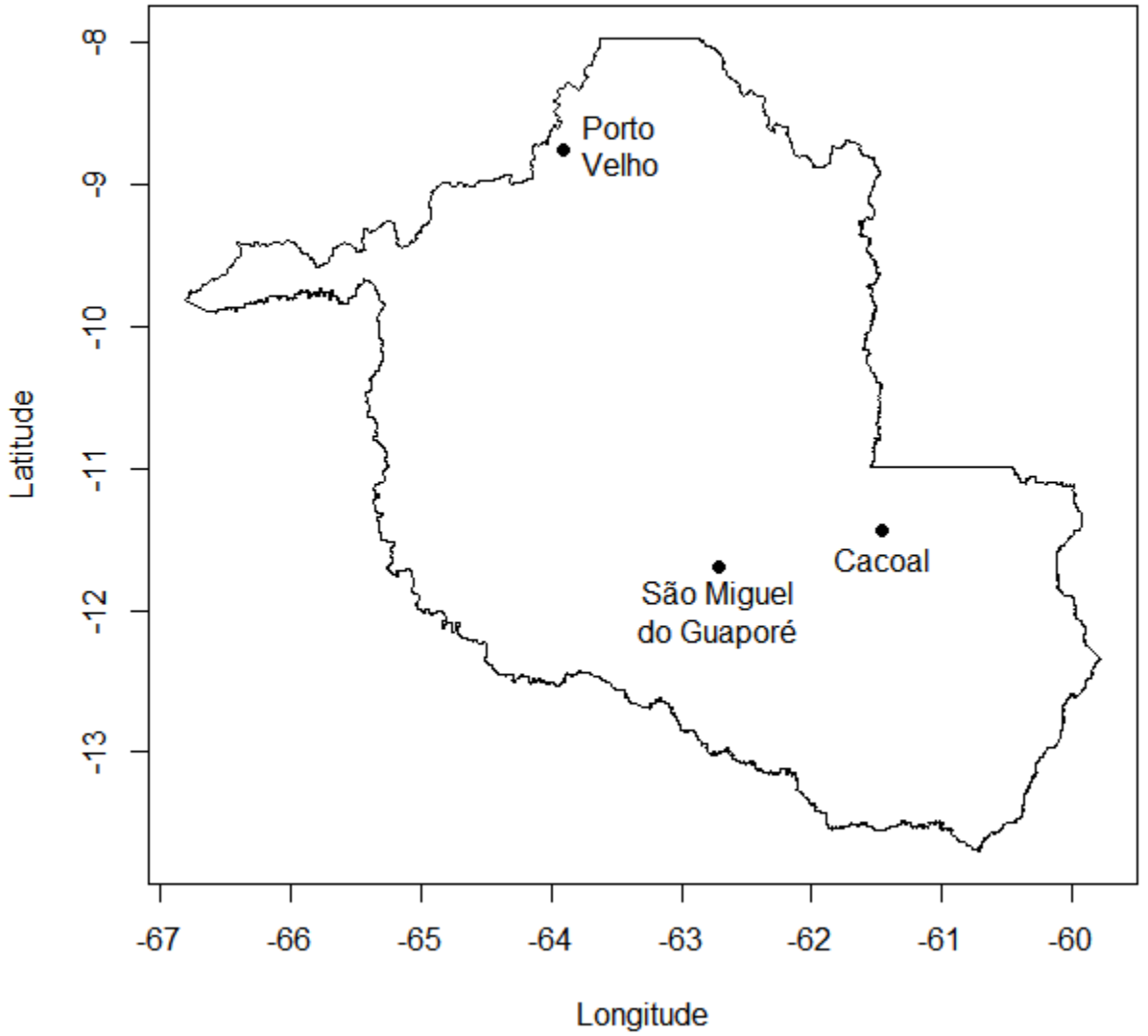


```
> # Rondônia
> mapaRO <- data.frame(shp$geometry[[1]][1])
> head(mapaRO,25)
           X1         X2
1   -62.86662 -7.975868
2   -62.86017 -7.982323
3   -62.85336 -7.987563
4   -62.84506 -7.986531
5   -62.84161 -7.994973
6   -62.83283 -7.994372
7   -62.82572 -8.007521
8   -62.82100 -8.014496
9   -62.81434 -8.018363
10 -62.81000 -8.025340
11 -62.80176 -8.025656
12 -62.79430 -8.027548
13 -62.78857 -8.026695
14 -62.78620 -8.026343
15 -62.78218 -8.029451
16 -62.77984 -8.031259
17 -62.77219 -8.031494
18 -62.76528 -8.036046
19 -62.75789 -8.038437
20 -62.75180 -8.043556
21 -62.74397 -8.045286
22 -62.73803 -8.050069
23 -62.73311 -8.056566
24 -62.72764 -8.062485
25 -62.72462 -8.069198
> plot(mapaRO$X1,mapaRO$X2 ,type="l",xlab="Longitude",ylab="Latitude")
```

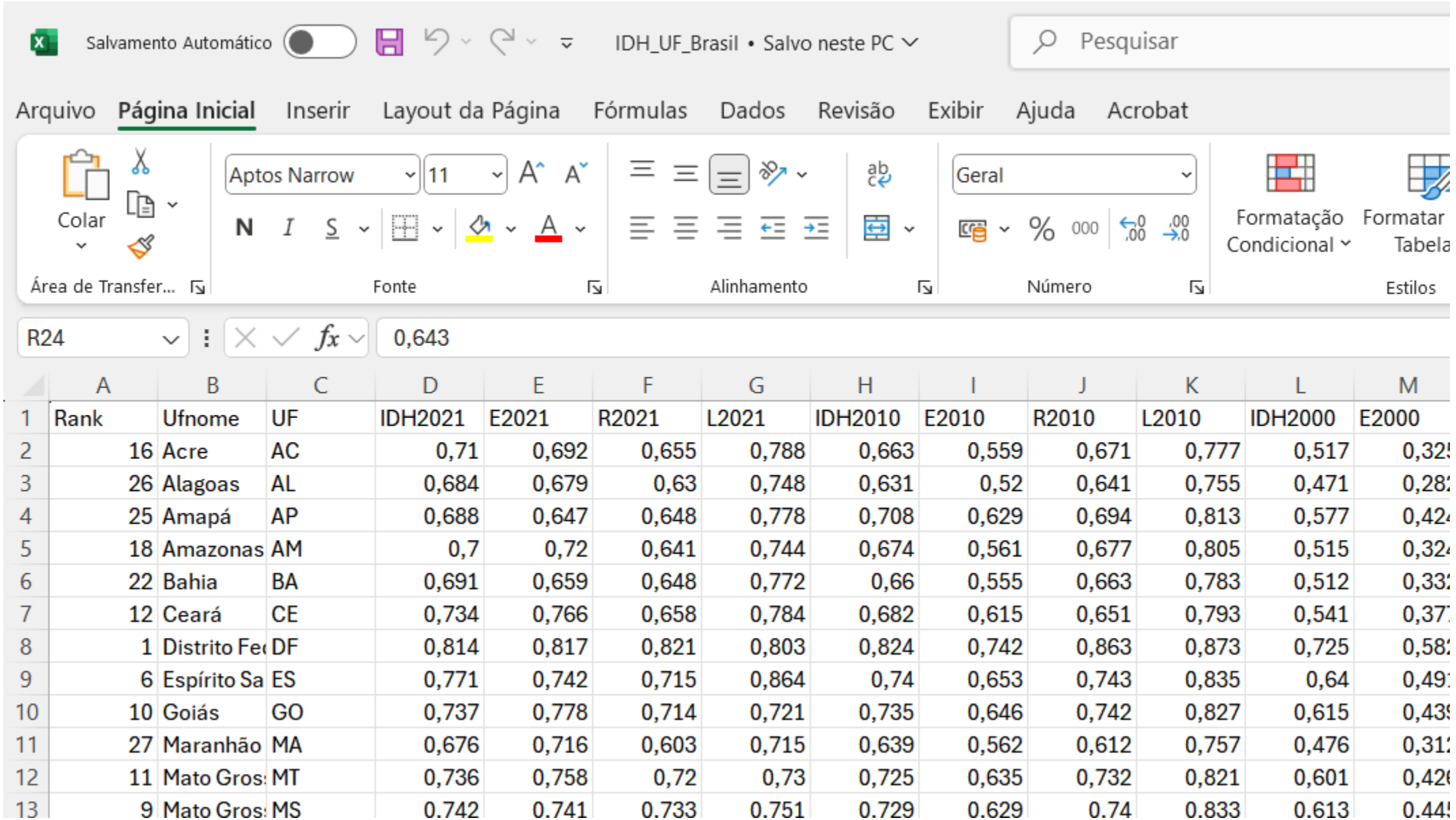


	Latitude	Longitude
Porto Velho	-8.761944	-63.903889
Cacoal	-11.437710	-61.455960
São Miguel do Guaporé	-11.696318	-62.717149

```
> plot(mapaRO$X1,mapaRO$X2,type="l",
       xlab="Longitude",ylab="Latitude")
>
>
> points(-63.903889, -8.761944,pch=19)
> points(-61.455960,-11.437710,pch=19)
> points(-62.717149,-11.696318,pch=19)
>
> text(-63.903889, -8.761944,"Porto\nVelho",pos=4)
> text(-61.455960,-11.437710,"Cacoal",pos=1)
> text(-62.717149,-11.696318,"São Miguel\ndo Guaporé",
    pos=1)
```



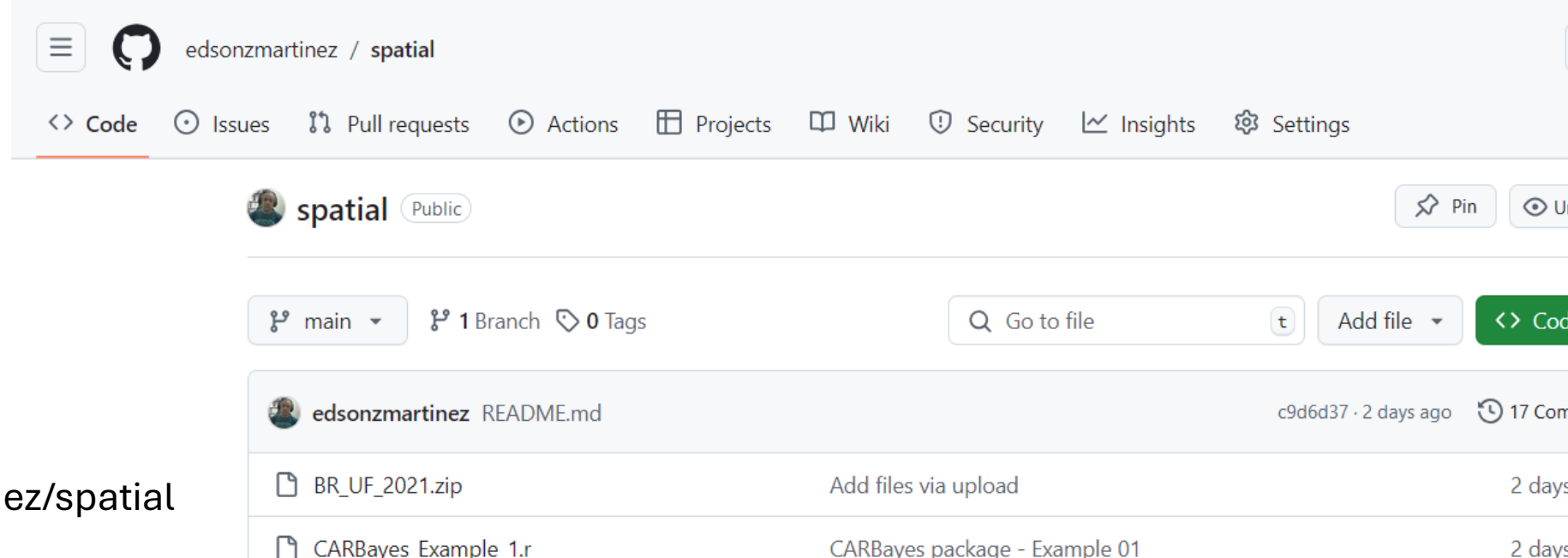
Dados de IDH das UF



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Rank	Ufnome	UF	IDH2021	E2021	R2021	L2021	IDH2010	E2010	R2010	L2010	IDH2000	E2000
2	16	Acre	AC	0,71	0,692	0,655	0,788	0,663	0,559	0,671	0,777	0,517	0,325
3	26	Alagoas	AL	0,684	0,679	0,63	0,748	0,631	0,52	0,641	0,755	0,471	0,282
4	25	Amapá	AP	0,688	0,647	0,648	0,778	0,708	0,629	0,694	0,813	0,577	0,424
5	18	Amazonas	AM	0,7	0,72	0,641	0,744	0,674	0,561	0,677	0,805	0,515	0,324
6	22	Bahia	BA	0,691	0,659	0,648	0,772	0,66	0,555	0,663	0,783	0,512	0,332
7	12	Ceará	CE	0,734	0,766	0,658	0,784	0,682	0,615	0,651	0,793	0,541	0,377
8	1	Distrito Fe	DF	0,814	0,817	0,821	0,803	0,824	0,742	0,863	0,873	0,725	0,582
9	6	Espírito Sa	ES	0,771	0,742	0,715	0,864	0,74	0,653	0,743	0,835	0,64	0,491
10	10	Goiás	GO	0,737	0,778	0,714	0,721	0,735	0,646	0,742	0,827	0,615	0,439
11	27	Maranhão	MA	0,676	0,716	0,603	0,715	0,639	0,562	0,612	0,757	0,476	0,312
12	11	Mato Gros	MT	0,736	0,758	0,72	0,73	0,725	0,635	0,732	0,821	0,601	0,426
13	9	Mato Gros	MS	0,742	0,741	0,733	0,751	0,729	0,629	0,74	0,833	0,613	0,445

Dados de IDH das UF

```
urlfile="https://raw.githubusercontent.com/edsonzmartinez/basesdedados/
main/IDH_UF_Brasil.csv"
w  <- read.csv2(urlfile)
w2 <- data.frame(SIGLA=w$UF, IDH2021=w$IDH2021, E2021=w$E2021,
                                        R2021=w$R2021, L2021=w$L2021)
shp.sf <- merge(x=shp, y=w2, by="SIGLA", all.x=FALSE)
mapview::mapview(shp.sf, zcol = "IDH2021",layer.name="IDH 2021")
```

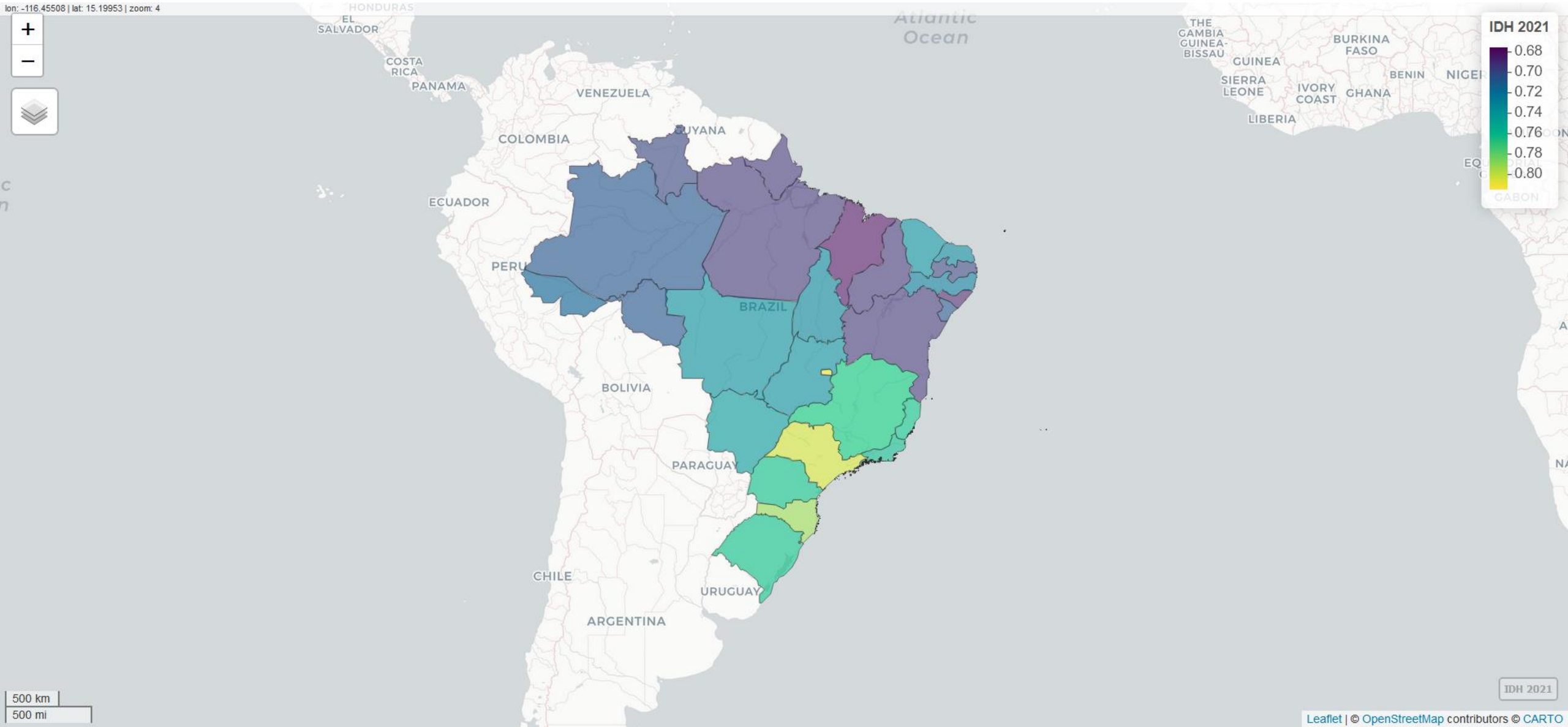


https://github.com/edsonzmartinez/spatial

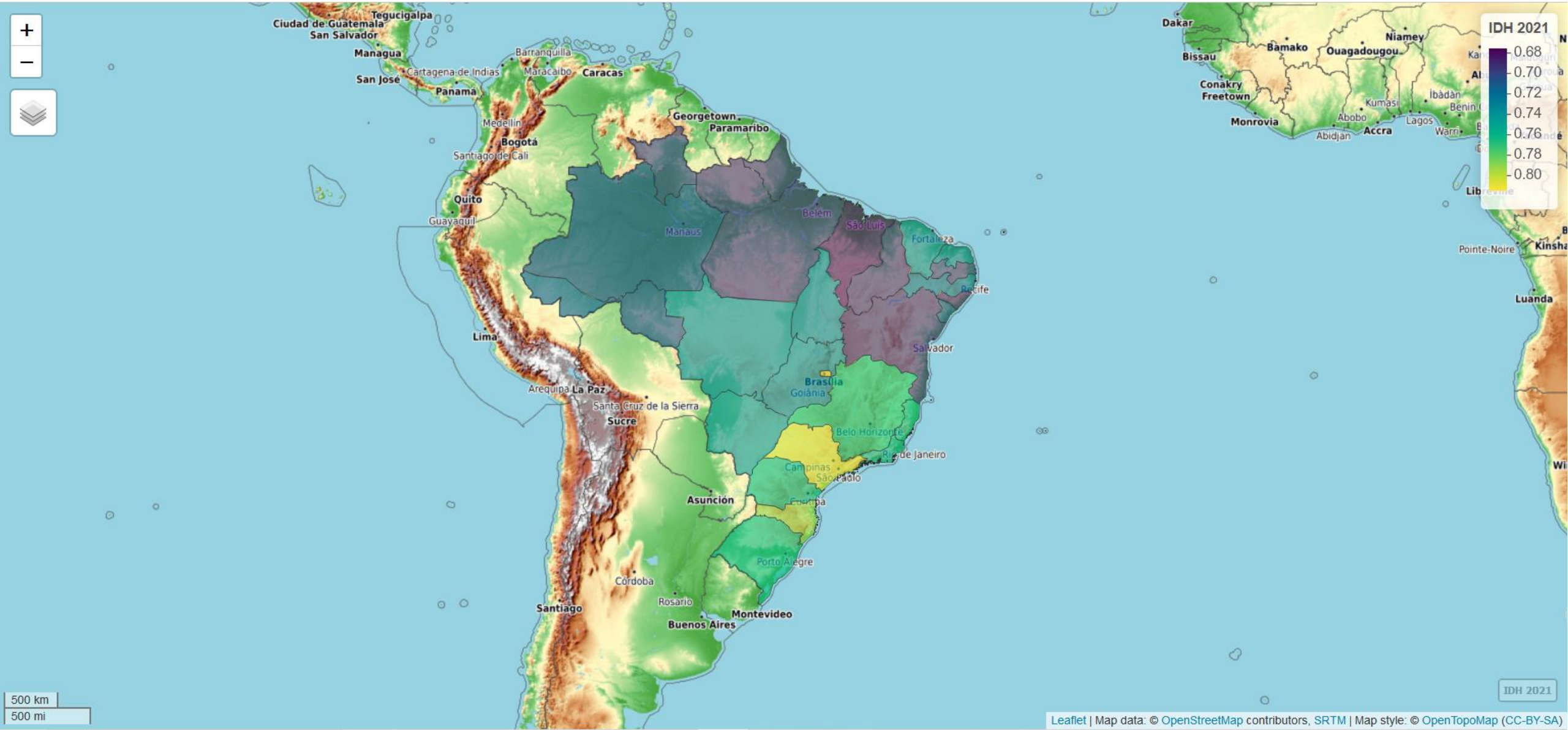
Dados de IDH das UF

```
> shp.sf
Simple feature collection with 27 features and 8 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ymax: 5.271841
Geodetic CRS:  SIRGAS 2000
First 10 features:
   SIGLA CD_UF            NM_UF    NM_REGIAO IDH2021 E2021 R2021 L2021                       geometry
1     AC    12             Acre        Norte   0.710 0.692 0.655 0.788 MULTIPOLYGON (((-73.1655 -7...
2     AL    27          Alagoas     Nordeste   0.684 0.679 0.630 0.748 MULTIPOLYGON (((-35.75791 -...
3     AM    13         Amazonas        Norte   0.700 0.720 0.641 0.744 MULTIPOLYGON (((-67.32609 2...
4     AP    16            Amapá        Norte   0.688 0.647 0.648 0.778 MULTIPOLYGON (((-50.45011 2...
5     BA    29            Bahia     Nordeste   0.691 0.659 0.648 0.772 MULTIPOLYGON (((-38.69616 -...
6     CE    23            Ceará     Nordeste   0.734 0.766 0.658 0.784 MULTIPOLYGON (((-40.49582 -...
7     DF    53 Distrito Federal Centro-oeste   0.814 0.817 0.821 0.803 MULTIPOLYGON (((-47.41734 -...
8     ES    32   Espírito Santo      Sudeste   0.771 0.742 0.715 0.864 MULTIPOLYGON (((-40.8843 -2...
9     GO    52            Goiás Centro-oeste   0.737 0.778 0.714 0.721 MULTIPOLYGON (((-50.15002 -...
10    MA    21         Maranhão     Nordeste   0.676 0.716 0.603 0.715 MULTIPOLYGON (((-44.66115 -...
```

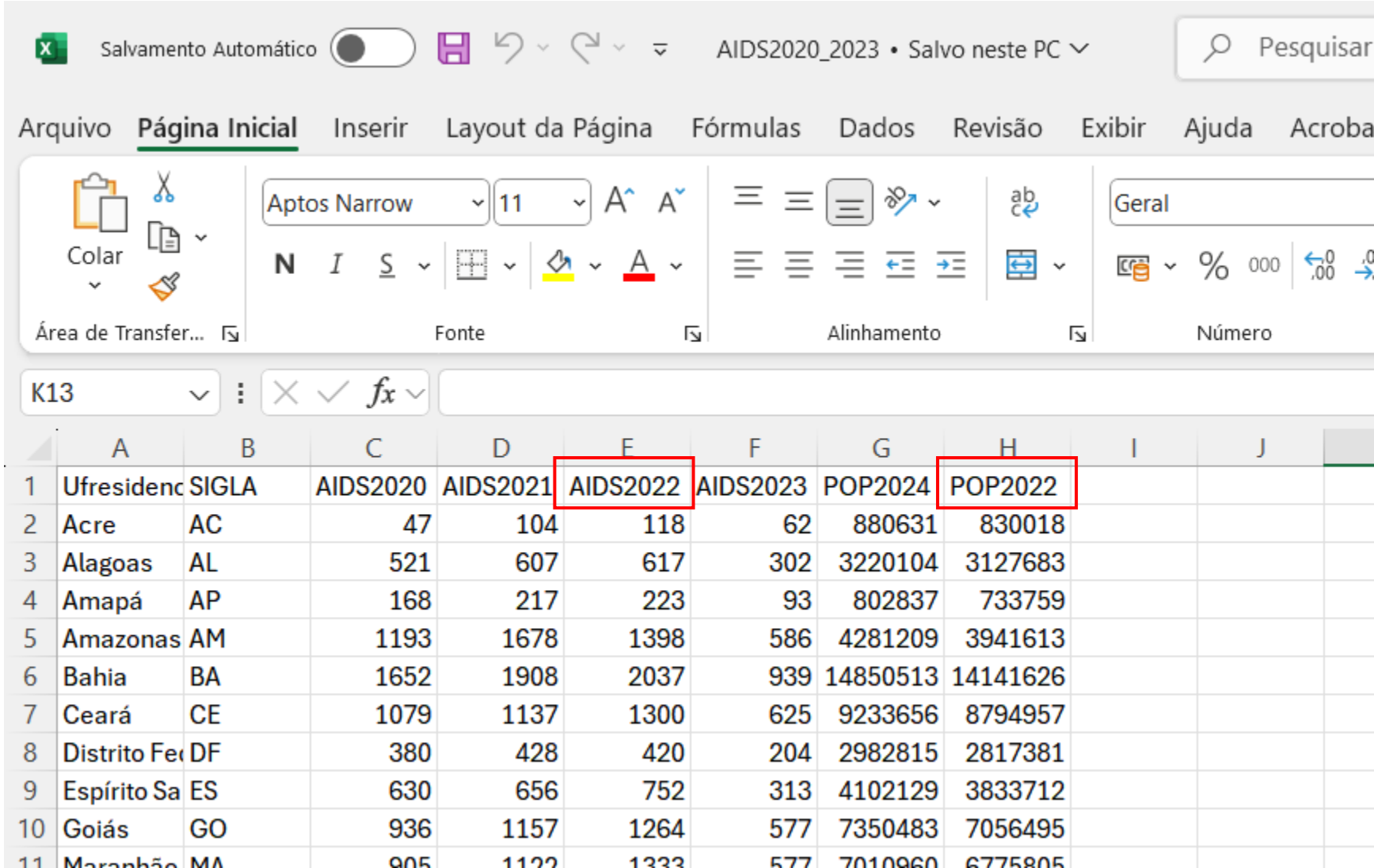
```
mapview::mapview(shp.sf, zcol = "IDH2021",layer.name="IDH 2021")
```



```
mapview::mapview(shp.sf, zcol = "IDH2021",layer.name="IDH 2021")
```



Dados de casos de AIDS, TABNET



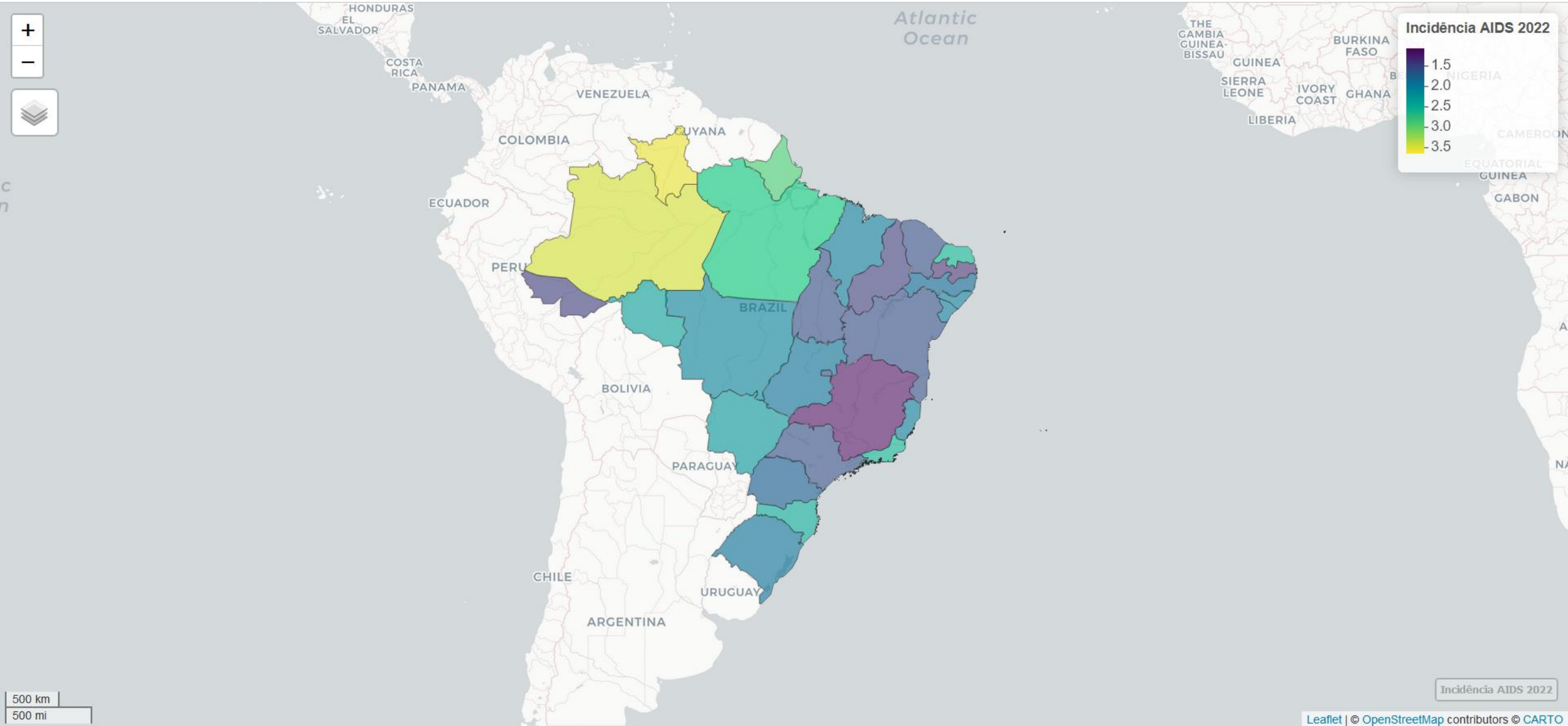
	A	B	C	D	E	F	G	H	I	J
1	Ufresidenc	SIGLA	AIDS2020	AIDS2021	AIDS2022	AIDS2023	POP2024	POP2022		
2	Acre	AC	47	104	118	62	880631	830018		
3	Alagoas	AL	521	607	617	302	3220104	3127683		
4	Amapá	AP	168	217	223	93	802837	733759		
5	Amazonas	AM	1193	1678	1398	586	4281209	3941613		
6	Bahia	BA	1652	1908	2037	939	14850513	14141626		
7	Ceará	CE	1079	1137	1300	625	9233656	8794957		
8	Distrito Fe	DF	380	428	420	204	2982815	2817381		
9	Espírito Sa	ES	630	656	752	313	4102129	3833712		
10	Goiás	GO	936	1157	1264	577	7350483	7056495		
11	Maranhão	MA	905	1122	1333	577	7010960	6775805		

Dados de casos de AIDS, TABNET

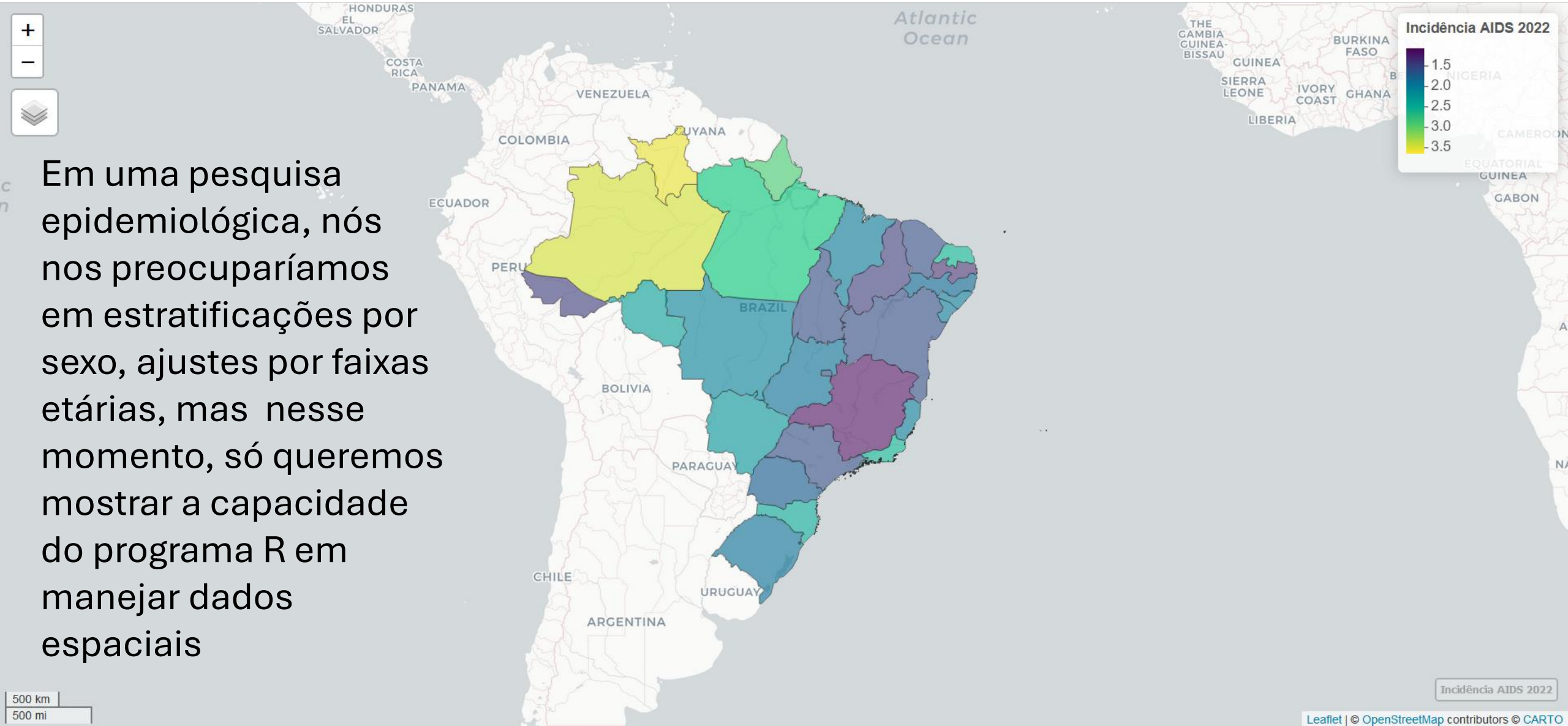
```
# AIDS
urlfile="https://raw.githubusercontent.com/edsonzmartinez/basesdedados/main/AIDS2020_2023.csv"
aids      <- read.csv2(urlfile)
aids$incd <- 10000*aids$AIDS2022/aids$POP2022
aids2     <- data.frame(SIGLA=aids$SIGLA, incd=aids$incd, AIDS2022=aids$AIDS2022,
                        pop2022=aids$POP2022)
shp.sf    <- merge(x=shp.sf, y=aids2, by="SIGLA", all.x=FALSE)
```

```
shp.sf
Simple feature collection with 27 features and 11 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -73.99045 ymin: -33.75118 xmax: -28.84764 ymax: 5.271841
Geodetic CRS:  SIRGAS 2000
First 10 features:
   SIGLA CD_UF           NM_UF    NM_REGIAO IDH2021 E2021 R2021 L2021     incd AIDS2022  pop2022                       geometry
1     AC    12             Acre        Norte   0.710 0.692 0.655 0.788 1.421656      118   830018 MULTIPOLYGON (((-73.1655 -7...
2     AL    27          Alagoas     Nordeste   0.684 0.679 0.630 0.748 1.972706      617  3127683 MULTIPOLYGON (((-35.75791 -...
3     AM    13         Amazonas        Norte   0.700 0.720 0.641 0.744 3.546771     1398  3941613 MULTIPOLYGON (((-67.32609 2...
4     AP    16            Amapá        Norte   0.688 0.647 0.648 0.778 3.039145      223   733759 MULTIPOLYGON (((-50.45011 2...
5     BA    29            Bahia     Nordeste   0.691 0.659 0.648 0.772 1.440428     2037 14141626 MULTIPOLYGON (((-38.69616 -...
6     CE    23            Ceará     Nordeste   0.734 0.766 0.658 0.784 1.478120     1300  8794957 MULTIPOLYGON (((-40.49582 -...
7     DF    53 Distrito Federal Centro-oeste   0.814 0.817 0.821 0.803 1.490746      420  2817381 MULTIPOLYGON (((-47.41734 -...
8     ES    32   Espírito Santo      Sudeste   0.771 0.742 0.715 0.864 1.961545      752  3833712 MULTIPOLYGON (((-40.8843 -2...
9     GO    52            Goiás Centro-oeste   0.737 0.778 0.714 0.721 1.791258     1264  7056495 MULTIPOLYGON (((-50.15002 -...
10    MA    21         Maranhão     Nordeste   0.676 0.716 0.603 0.715 1.967294     1333  6775805 MULTIPOLYGON (((-44.66115 -...
```

```
mapview::mapview(shp.sf, zcol = "incd",layer.name="Incidência AIDS 2022")
```

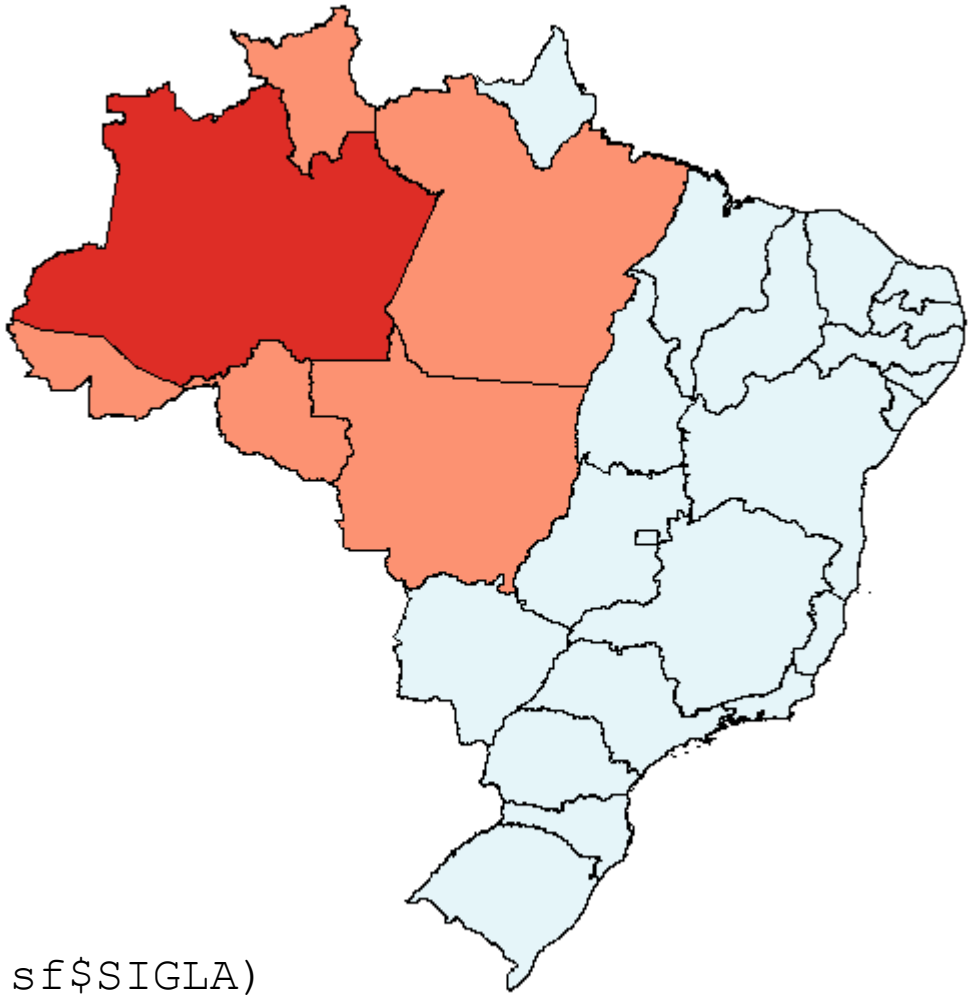


```
mapview::mapview(shp.sf, zcol = "incd",layer.name="Incidência AIDS 2022")
```



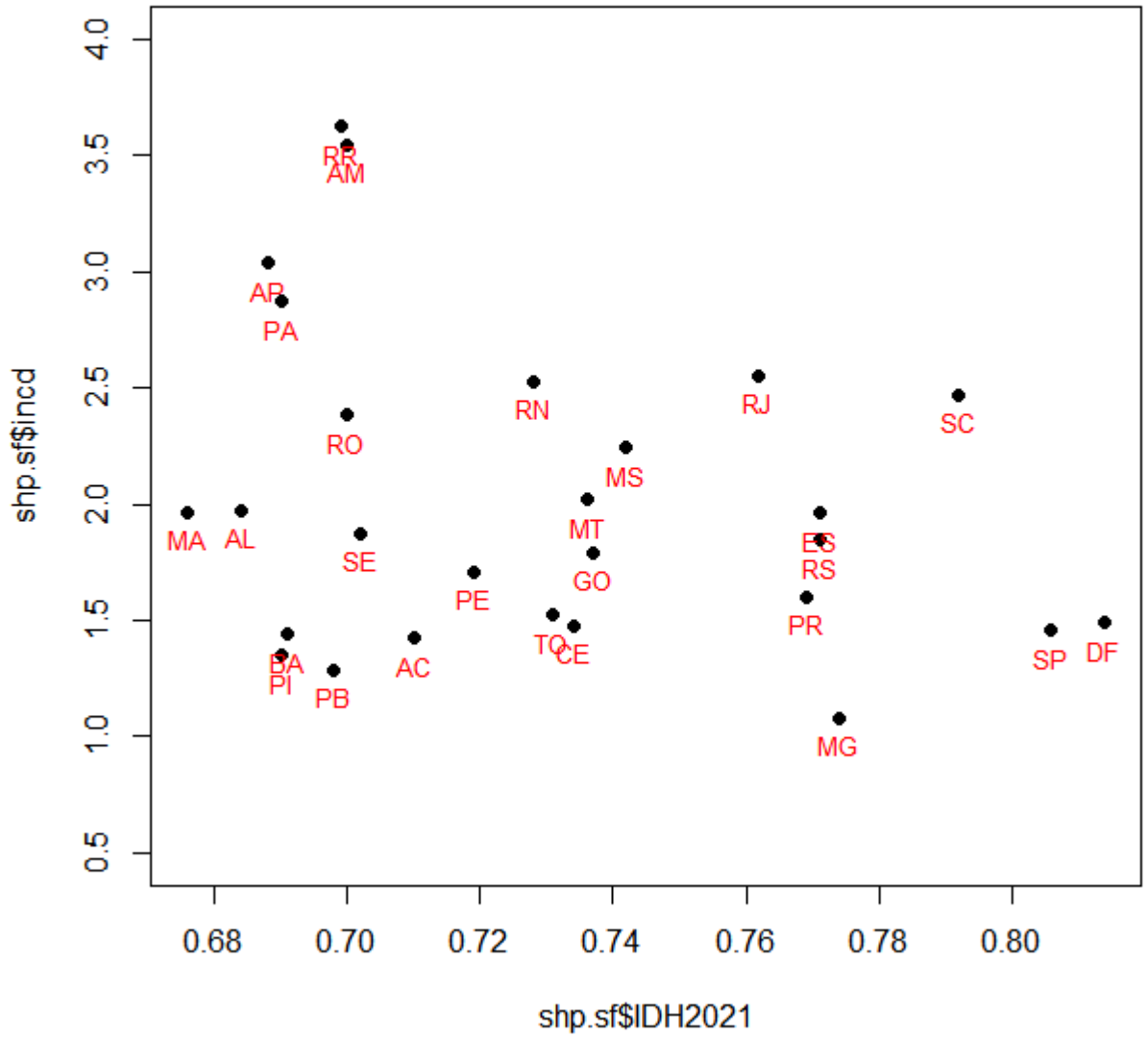
Em uma pesquisa epidemiológica, nós nos preocuparíamos em estratificações por sexo, ajustes por faixas etárias, mas nesse momento, só queremos mostrar a capacidade do programa R em manejar dados espaciais

Vizinhanças



```
# Criando uma matriz de vizinhanças
W.nb   <- spdep::poly2nb(shp.sf, row.names = shp.sf$SIGLA)
W.list <- spdep::nb2listw(W.nb, style="B")
W      <- spdep::nb2mat(W.nb, style="B")
print(matrix(W,ncol=27,dimnames=list(shp.sf$SIGLA,shp.sf$SIGLA)))
```

```
> print(matrix(W,ncol=27,dimnames=list(shp.sf$SIGLA,shp.sf$SIGLA)))
   AC AL AM AP BA CE DF ES GO MA MG MS MT PA PB PE PI PR RJ RN RO RR RS SC SE SP TO
AC  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0
AL  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  1  0  0
AM  1  0  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  0  1  1  0  0  0  0  0
AP  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0
BA  0  1  0  0  0  0  0  1  1  0  1  0  0  0  0  1  1  0  0  0  0  0  0  0  1  0  1
CE  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  1  1  0  0  1  0  0  0  0  0  0  0
DF  0  0  0  0  0  0  0  0  1  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
ES  0  0  0  0  1  0  0  0  0  0  1  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0
GO  0  0  0  0  1  0  1  0  0  0  1  1  1  0  0  0  0  0  0  0  0  0  0  0  0  0  1
MA  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  1  0  0  0  0  0  0  0  0  0  1
MG  0  0  0  0  1  0  1  1  1  0  0  1  0  0  0  0  0  0  1  0  0  0  0  0  0  1  0
MS  0  0  0  0  0  0  0  0  1  0  1  0  1  0  0  0  0  1  0  0  0  0  0  0  0  1  0
MT  0  0  1  0  0  0  0  0  1  0  0  1  0  1  0  0  0  0  0  0  1  0  0  0  0  0  1
PA  0  0  1  1  0  0  0  0  0  1  0  0  1  0  0  0  0  0  0  0  0  1  0  0  0  0  1
PB  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  1  0  0  0  1  0  0  0  0  0  0  0
PE  0  1  0  0  1  1  0  0  0  0  0  0  0  0  1  0  1  0  0  0  0  0  0  0  0  0  0
PI  0  0  0  0  1  1  0  0  0  1  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  1
PR  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  1  0  1  0
RJ  0  0  0  0  0  0  0  1  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0
RN  0  0  0  0  0  1  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0
RO  1  0  1  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0
RR  0  0  1  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0
RS  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0
SC  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  1  0  0  0  0  1  0  0  0  0
SE  0  1  0  0  1  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
SP  0  0  0  0  0  0  0  0  0  0  1  1  0  0  0  0  0  1  1  0  0  0  0  0  0  0  0
TO  0  0  0  0  1  0  0  0  1  1  0  0  1  1  0  0  1  0  0  0  0  0  0  0  0  0  0
```




```
plot(shp.sf$IDH2021,shp.sf$incd,ylim=c(0.5,4),pch=19)
text(shp.sf$IDH2021,shp.sf$incd,shp.sf$SIGLA,pos=1,cex=0.8,col="red")
```

Regressão linear

$$Y_i = \beta_0 + \beta_1 IDH_i + \varepsilon_i$$

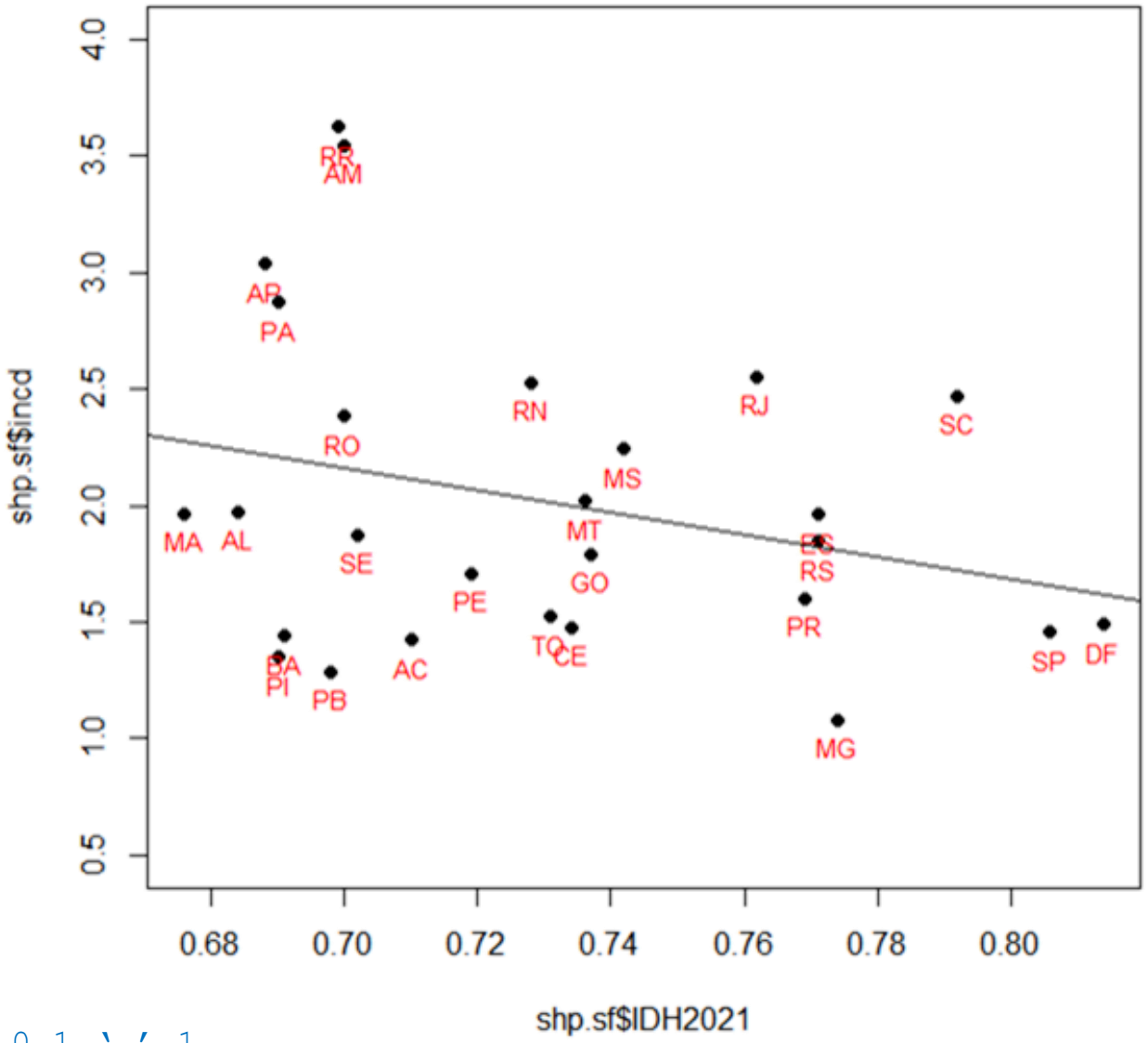
```
> # Modelo de regressão linear
> model <- lm(incd ~ IDH2021, data=shp.sf)
> summary(model)

Call:
lm(formula = incd ~ IDH2021, data = shp.sf)

Residuals:
    Min      1Q  Median      3Q     Max
-0.8856 -0.4284 -0.1954  0.3894  1.4591

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)    5.522      2.357   2.343   0.0274 *
IDH2021       -4.797      3.224  -1.488   0.1492
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6558 on 25 degrees of freedom
Multiple R-squared:  0.08136,   Adjusted R-squared:  0.04462
F-statistic: 2.214 on 1 and 25 DF,  p-value: 0.1492
```

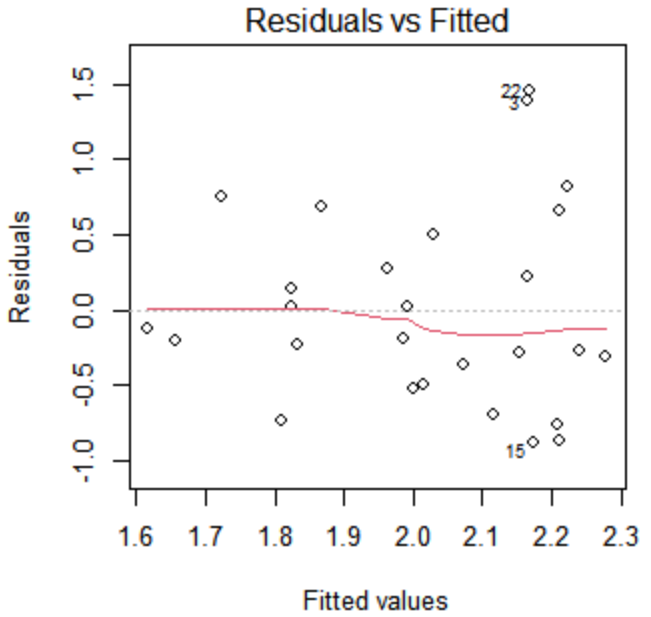


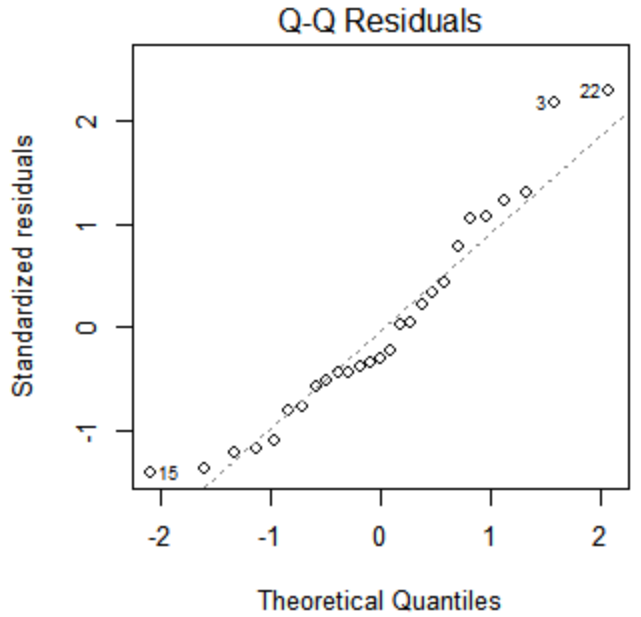
Regressão linear

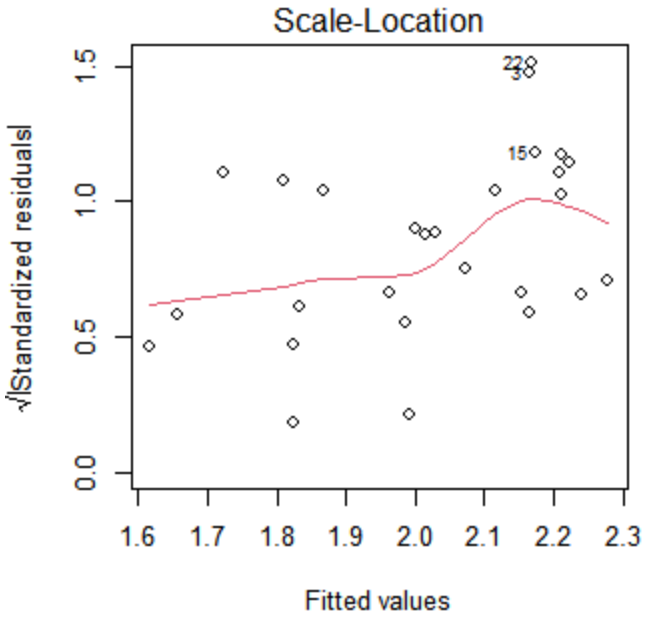
$$Y_i = \beta_0 + \beta_1 IDH_i + \varepsilon_i$$

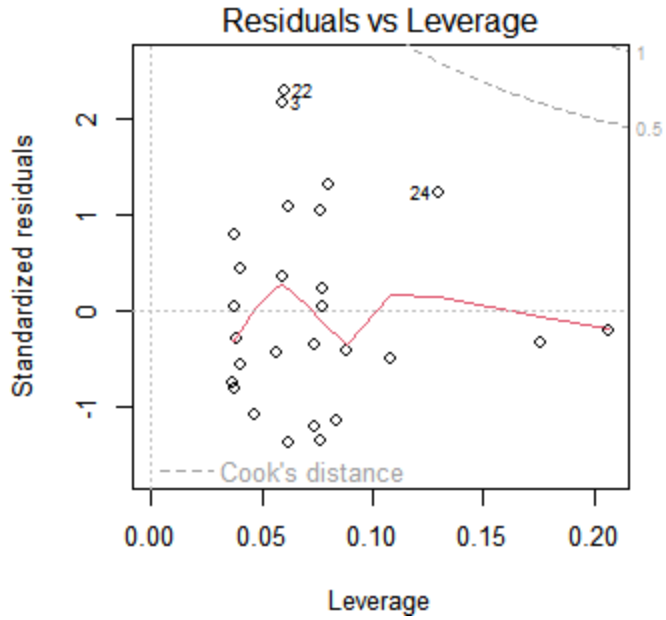
```
> # Diagnósticos de resíduos
> par(mar = c(4, 4, 2, 2), mfrow = c(2, 2))
> plot(model)
```

3: Amazonas
15: Paraíba
22: Roraima





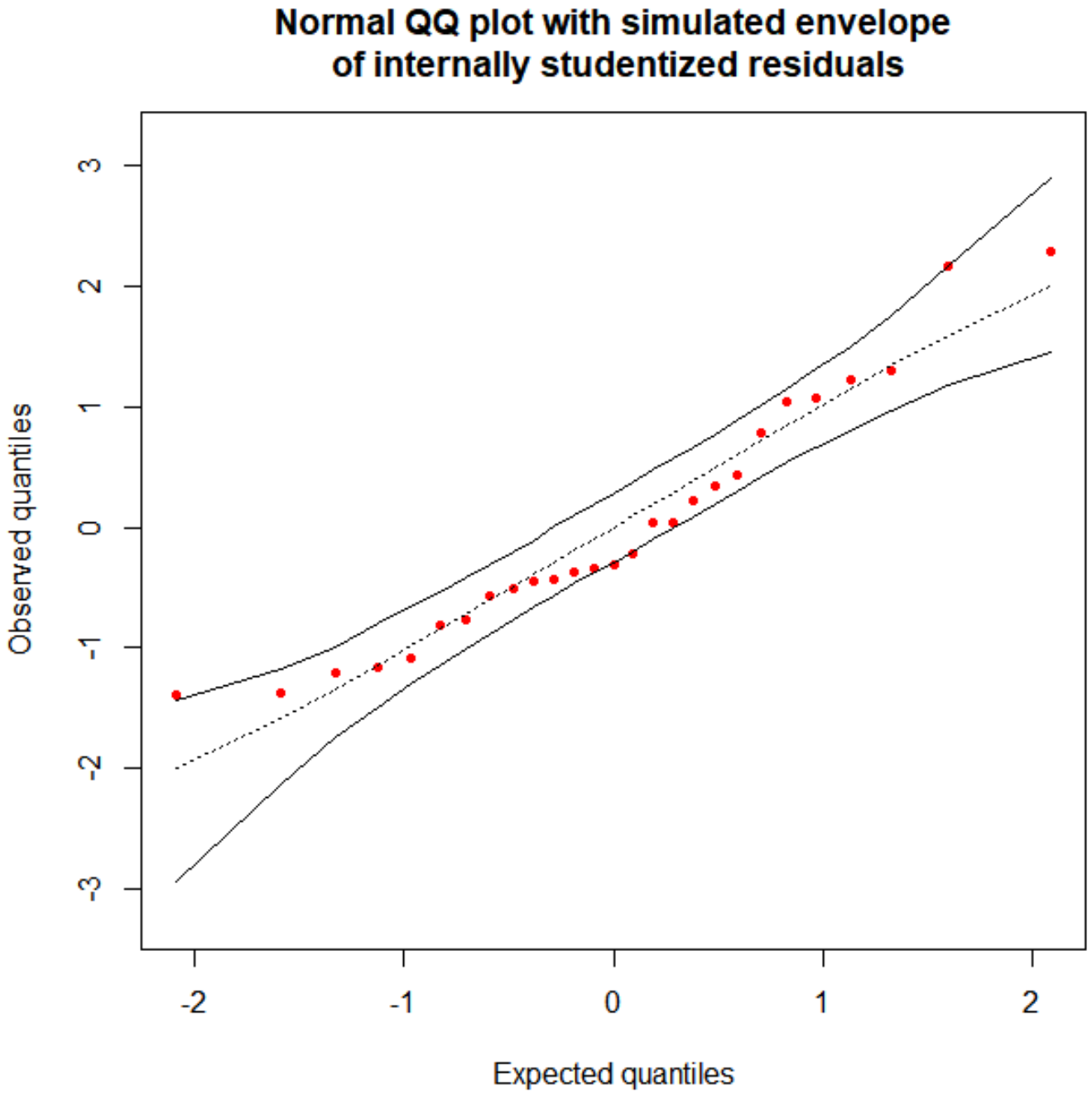




Regressão linear

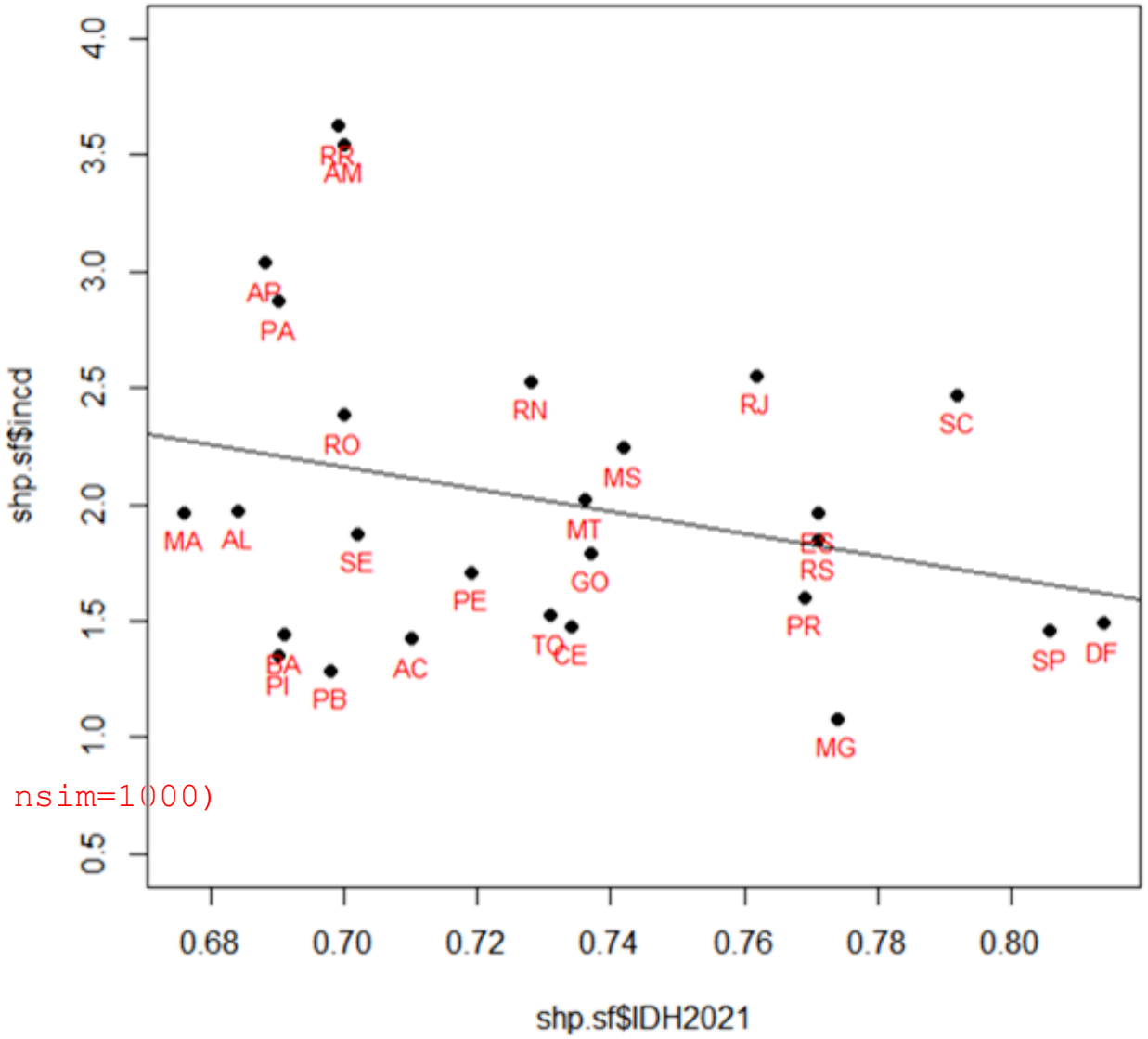
$$Y_i = \beta_0 + \beta_1 IDH_i + \varepsilon_i$$

```
> glmtoolbox::envelope(model, rep=5000,
      col="red", type="internal")
```



Regressão linear

$$Y_i = \beta_0 + \beta_1 IDH_i + \varepsilon_i$$




```
> spdep::moran.mc(x=residuals(model), listw=W.list, nsim=1000)

        Monte-Carlo simulation of Moran I

data:  residuals(model)
weights: W.list
number of simulations + 1: 1001

statistic = 0.34042, observed rank = 995, p-value = 0.005994
alternative hypothesis: greater
```

Regressão de Poisson

$$O_i \sim Poisson(\theta_i \times Pop_i)$$

$$\log \theta_i = \beta_0 + \beta_1 IDH_i$$

```
> # Modelo de Poisson não espacial
> poisson.model <- glm(AIDS2022 ~ IDH2021 + offset(log(pop2022)), data=shp.sf, family = poisson(link = "log"))
> summary(poisson.model)

Call:
glm(formula = AIDS2022 ~ IDH2021 + offset(log(pop2022)), family = poisson(link = "log"),
    data = shp.sf)

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -6.77749    0.08954  -75.69   <2e-16 ***
IDH2021     -2.45624    0.11972  -20.52   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 3423.2  on 26  degrees of freedom
Residual deviance: 3003.5  on 25  degrees of freedom
AIC: 3240.2
```

Regressão de Poisson

$$O_i \sim Poisson(\theta_i \times Pop_i)$$

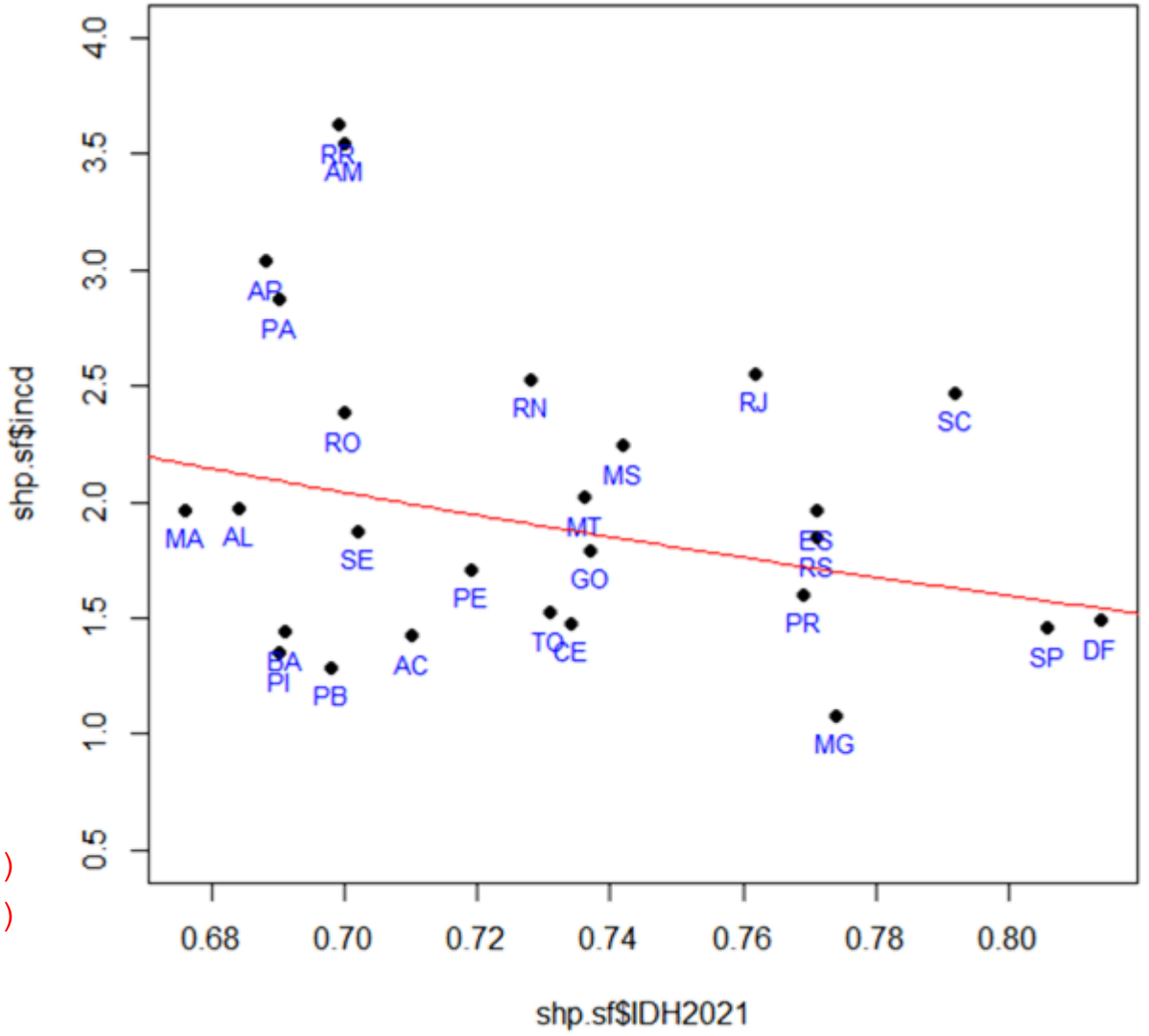
$$\log \theta_i = \beta_0 + \beta_1 IDH_i$$

```
> # Erros padrão robustos (Cameron and Trivedi, 2009)
> # Cameron, A. C. and Trivedi, P. K. 2009. Microeconometrics Using Stata. College Station, TX: Stata Press.
> # Cameron, A. C. and Trivedi, P. K. 1998. Regression Analysis of Count Data. New York: Cambridge Press.
> cov.m1 <- vcovHC(poisson.model, type="HC0")
> std.err <- sqrt(diag(cov.m1))
> r.est <- cbind(Estimate= coef(poisson.model), "Robust SE" = std.err, "Pr(>|z|)" = 2 *
pnorm(abs(coef(poisson.model)/std.err), lower.tail=FALSE),
+ LL = coef(poisson.model) - 1.96 * std.err,
+ UL = coef(poisson.model) + 1.96 * std.err)
> r.est
             Estimate Robust SE     Pr(>|z|)        LL         UL
(Intercept) -6.777492  1.010257 1.963873e-11 -8.757595 -4.7973893
IDH2021     -2.456244  1.349272 6.869488e-02 -5.100818  0.1883298
> Pearson <- sum((shp.sf$AIDS2022 - poisson.model$fitted.values)^2 / poisson.model$fitted.values)
> message("Pearson's goodness-of-fit = ",round(Pearson,3),", p-value ",1 - pchisq(Pearson, df =
poisson.model$df.residual))
Pearson's goodness-of-fit = 3122.855, p-value 0
> message("Estimated dispersion parameter = ",round(Pearson / poisson.model$df.residual,4))
Estimated dispersion parameter = 124.9142
```

Regressão de Poisson

$$O_i \sim Poisson(\theta_i \times Pop_i)$$

$$\log \theta_i = \beta_0 + \beta_1 IDH_i$$




```
> a <- as.numeric(poisson.model$coefficients[1])
> b <- as.numeric(poisson.model$coefficients[2])
> x <- seq(0.5,1,0.001)
> curve <- function(x,a,b,pop) pop*exp(a+b*x)
> plot(shp.sf$IDH2021,shp.sf$incd,ylim=c(0.5,4),pch=19)
> text(shp.sf$IDH2021,shp.sf$incd,shp.sf$SIGLA,pos=1,cex=0.8,col="blue")
> points(x,curve(x,a,b,10000),type="l",col="red")
```

Regressão de Poisson

$$O_i \sim Poisson(\theta_i \times Pop_i)$$

$$\log \theta_i = \beta_0 + \beta_1 IDH_i$$

```
> spdep::moran.mc(x=residuals(poisson.model), listw=W.list, nsim=100000)

        Monte-Carlo simulation of Moran I

data:  residuals(poisson.model)
weights: W.list
number of simulations + 1: 100001

statistic = 0.16536, observed rank = 94302, p-value = 0.05699
alternative hypothesis: greater
```

Regressão Quasi Poisson

```
> # Modelo Quasi Poisson não espacial
> qpoisson.model <- glm(AIDS2022 ~ IDH2021 + offset(log(pop2022)), data=shp.sf, family =
quasipoisson(link = "log"))
> summary(qpoisson.model)

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   -6.777      1.001  -6.773 4.25e-07 ***
IDH2021       -2.456      1.338  -1.836   0.0783 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for quasipoisson family taken to be 124.9143)

    Null deviance: 3423.2  on 26  degrees of freedom
Residual deviance: 3003.5  on 25  degrees of freedom
AIC: NA

Number of Fisher Scoring iterations: 4
```

Regressão Quasi Poisson

```
> spdep::moran.mc(x=residuals(qpoisson.model), listw=W.list, nsim=100000)

        Monte-Carlo simulation of Moran I

data:  residuals(qpoisson.model)
weights: W.list
number of simulations + 1: 100001

statistic = 0.16536, observed rank = 94248, p-value = 0.05753
alternative hypothesis: greater
```

Regressão de Poisson espacial

Besag-York-Mollie (BYM) CAR model

$$O_i \sim Poisson(\theta_i \times Pop_i)$$

$$\log \theta_i = \beta_0 + \beta_1 IDH_i + w_i$$

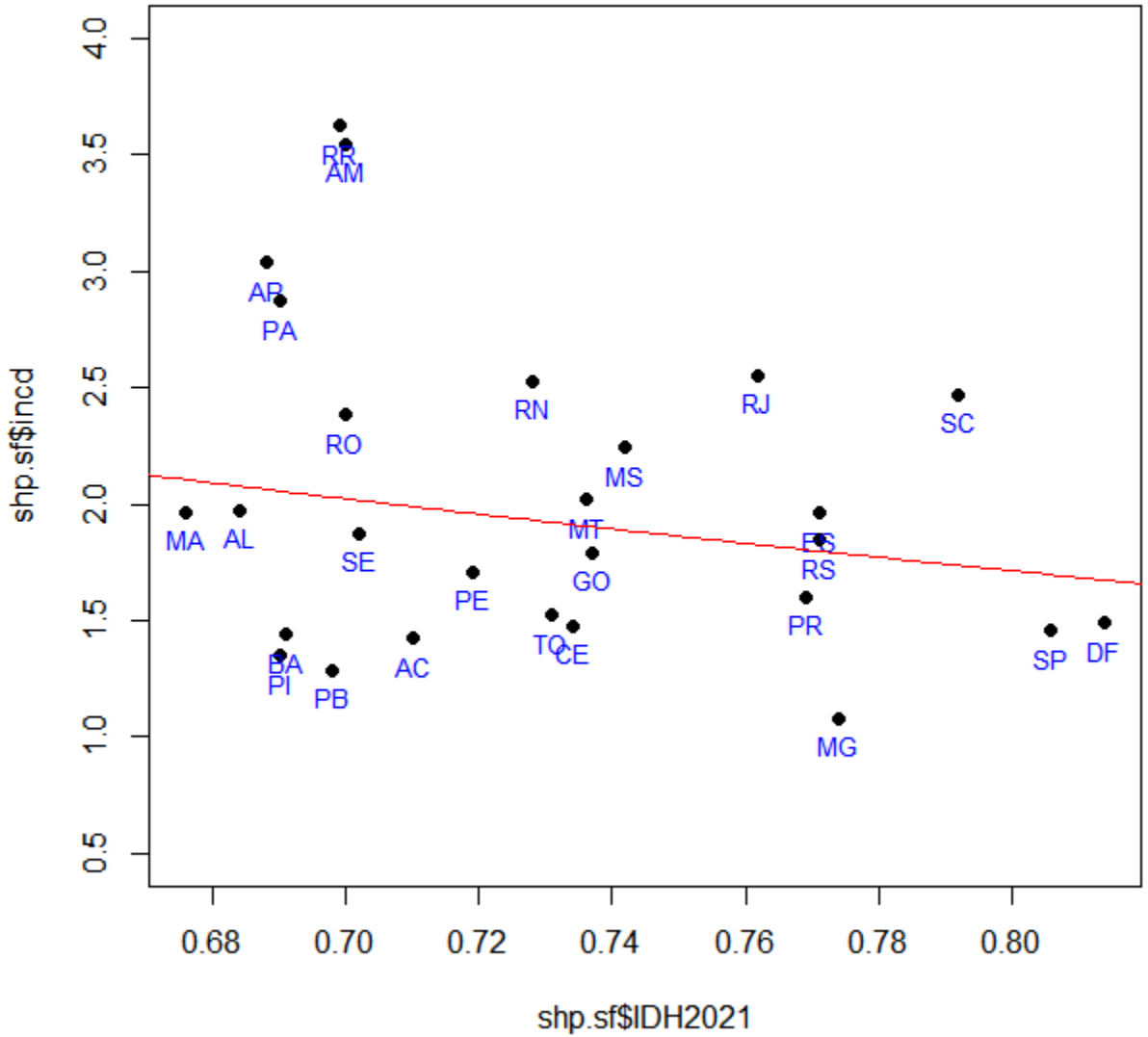
$$w_i = \phi_k + \psi_k$$

$$\psi_i \sim N(0, \sigma^2)$$

$$\phi_i \sim Conditional\ Autoregressive\ (CAR)\ normal\ distribution$$

```
# Modelo de Poisson espacial
form   <- AIDS2022 ~ IDH2021 + offset(log(pop2022))
chain  <- CARBayes::S.CARbym(formula=form, data=shp.sf, family="poisson", W=W,
   burnin=100000, n.sample=300000, thin=100, n.chains=3, n.cores=3)
```

Regressão de Poisson espacial



Regressão de Poisson espacial

```
> summary.beta <- summary(chain$samples$beta, quantiles=c(0.025, 0.975))
>
> summary.beta

Iterations = 1:2000
Thinning interval = 1
Number of chains = 3
Sample size per chain = 2000

1. Empirical mean and standard deviation for each variable,
   plus standard error of the mean:

      Mean    SD Naive SE Time-series SE
[1,] -7.344 1.666  0.02151        0.09665
[2,] -1.659 2.282  0.02947        0.13242

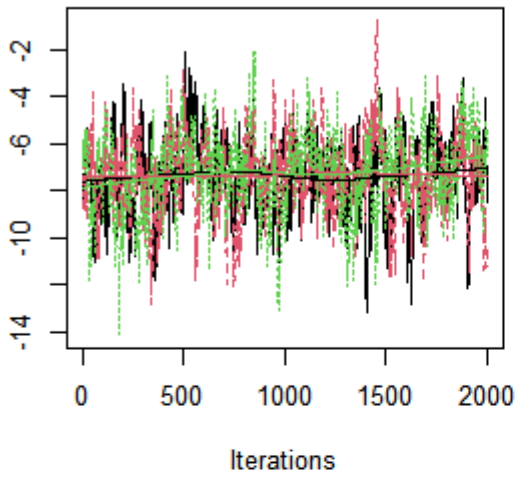
2. Quantiles for each variable:

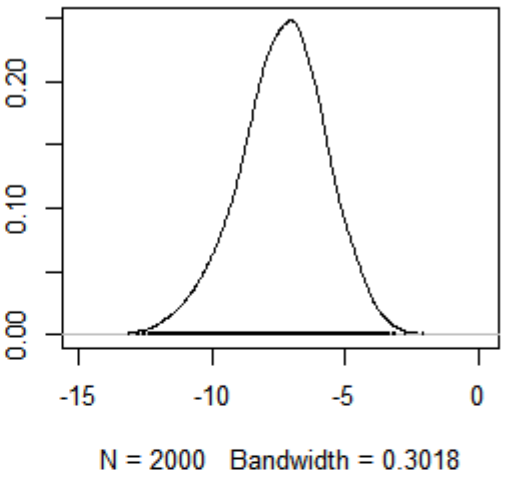
        2.5%  97.5%
[1,] -10.896 -4.273
[2,]  -5.864  3.219
```

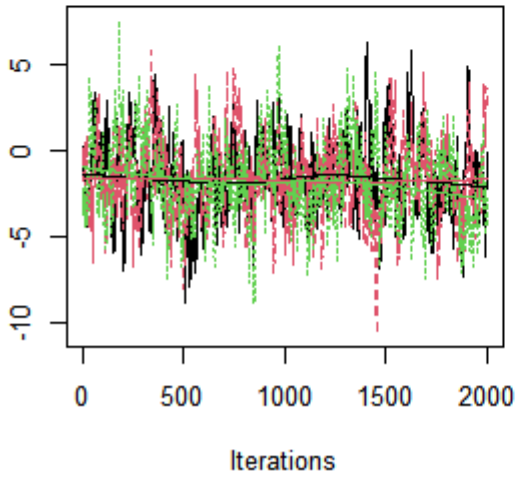
Regressão de Poisson espacial

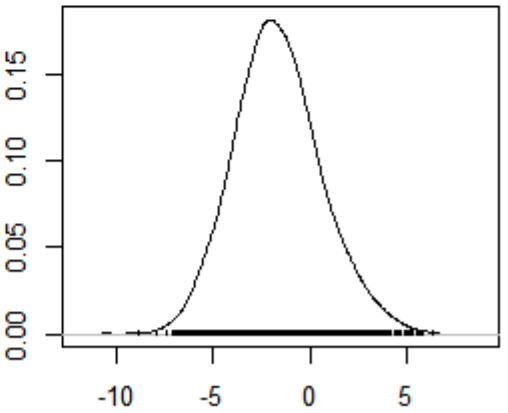
Monte Carlo em Cadeia de Markov (MCMC)

```
# Convergência
plot(chain$samples$beta)
```









Regressão de Poisson espacial

Monte Carlo em Cadeia de Markov (MCMC)

```
> spdep::moran.mc(x=residuals(chain), listw=W.list, nsim=100000)

        Monte-Carlo simulation of Moran I

data:  residuals(chain)
weights: W.list
number of simulations + 1: 100001

statistic = -0.066249, observed rank = 42315, p-value = 0.5769
alternative hypothesis: greater
```

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12º EPI

A Epidemiologia e a complexidade dos desafios sanitários

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