Geoestatística com R

Disciplina do PPGME/UFPA

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Contents

Sobre

Nós idealizamos este material como uma contribuição dos pesquisadores do Laboratório de Modelamento Estatístico-Matemático - LAMEM/UFPA para auxiliar os estudos na disciplina de Geoestatística nas turmas do Programa de Pós-Graduação em Matemática e Estatística - PPGME, Instituto de Ciências Exatas e Naturais - ICEN, da Universidade Federal do Pará - UFPA. Esta disciplina é anualmente ministrada pelo Prof. Dr. João Marcelo Protázio neste programa.

Esperamos que vocês aproveitem este livro. Ele é uma pequena contribuição elaborado com todo cuidado para colaborar com a comunidade dos usuários do `R`. Consiste numa retribuição a quem muito nos tem ajudado ao longo destes anos de estudos.

Agradecemos qualquer tipo de *feedback*. Eles sempre nos guiarão na melhoria deste livro. Os *e-mails* dos autores estão disponibilizados aqui para contato.

0.1 Usage

Each **bookdown** chapter is an .Rmd file, and each .Rmd file can contain one (and only one) chapter. A chapter *must* start with a first-level heading: `# A good chapter`, and can contain one (and only one) first-level heading.

Use second-level and higher headings within chapters like: `## A short section` or `### An even shorter section`.

The `index.Rmd` file is required, and is also your first book chapter. It will be the homepage when you render the book.

0.2 Render book

You can render the HTML version of this example book without changing anything:

1. Find the **Build** pane in the RStudio IDE, and

2. Click on **Build Book**, then select your output format, or select "All formats" if you'd like to use multiple formats from the same book source files.

Or build the book from the R console:

```
bookdown::render_book()
```

To render this example to PDF as a `bookdown::pdf_book`, you'll need to install XeLaTeX. You are recommended to install TinyTeX (which includes XeLaTeX): https://yihui.org/tinytex/.

0.3 Preview book

As you work, you may start a local server to live preview this HTML book. This preview will update as you edit the book when you save individual .Rmd files. You can start the server in a work session by using the RStudio add-in "Preview book", or from the R console:

```
bookdown::serve_book()
```

```
# automatically create a bib database for R packages
knitr::write_bib(c(
  .packages(), 'bookdown', 'knitr', 'rmarkdown'
), 'packages.bib')
```

Chapter 1

Introdução

Neste curso, seguiremos o roteiro apresentado por ...., nos *slides* disponíveis em: . E o nosso texto-base é o livro de *A Practical Guide to Geostatistical Mapping* de *Tomislav Hengl* disponível gratuitamente no *link* https://spatial-analyst.net/book/.

1.1 Definições

Modelo Universal de Variação

$$Z(\mathbf{s}) = Z^*(\mathbf{s}) + \varepsilon'(\mathbf{s}) + \varepsilon''$$

Inverso da distância

$$\hat{z}(s_0) = \sum_{i=1}^{n} \lambda_i(s_0)\, z(s_i)$$

Variograma

Semi-variograma

Chapter 2

Código

2.1 Cabeçalho

No início de todo código aconselhamos a organização tal como declarando o autor do código e a disciplina na qual ele foi elaborado.

```
## --------------------------
## Prof. Dr. Marcelo Protazio
## Geostatistica PPGME
## --------------------------
```

2.2 Pacotes

A seguir, os pacotes utilizados.

```
## ------------
## ------------
## [1] Packages
## ------------
## ------------

library(gstat)
library(sp)
library(MASS)
if(!require(spatstat)){install.packages("spatstat")};library(spatstat)
```

```
## Carregando pacotes exigidos: spatstat
```

```
## Carregando pacotes exigidos: spatstat.data

## Carregando pacotes exigidos: spatstat.geom

## spatstat.geom 2.4-0

##
## Attaching package: 'spatstat.geom'

## The following object is masked from 'package:MASS':
##
##     area

## Carregando pacotes exigidos: spatstat.random

## spatstat.random 2.2-0

## Carregando pacotes exigidos: spatstat.core

## Carregando pacotes exigidos: nlme

## Carregando pacotes exigidos: rpart

## spatstat.core 2.4-4

##
## Attaching package: 'spatstat.core'

## The following object is masked from 'package:gstat':
##
##     idw

## Carregando pacotes exigidos: spatstat.linnet

## spatstat.linnet 2.3-2

##
## spatstat 2.3-4       (nickname: 'Watch this space')
## For an introduction to spatstat, type 'beginner'
```

Caso algum pacote não esteja instalado, execute o código

2.3 Leitura dos dados

Aqui, o carregamento dos dados.

```
## -------------
## -------------
## [2] Read Data
## -------------
## -------------

data(jura)
data = rbind(jura.pred,jura.val)
borda = read.csv('border.csv')
```

2.4 Organização dos dados

```
## ---------------------
## ---------------------
## [3] Data Organization
## ---------------------
## ---------------------

data = data[,c(1,2,5:13)]
names(data)[1:2] = c('x','y')
rx = range(borda[,1])
ry = range(borda[,2])
```

2.5 Experimento com uma variável

Vamos selecionar o Cádmio (Cd) como variável.

2.5.1 Transformação dos dados

```
## -------------------------
## -------------------------
## [4] Univariate Experiment
## -------------------------
## -------------------------
```

```
## -------------------------
## [4.1] Data Transformation
## -------------------------

id = 5
d1 = d2 = data[,c(1,2,id)]
s1 = shapiro.test(d1$Cd)
l = boxcox(d1$Cd~1,plotit=F)
l = l$x[which.max(l$y)]
d2$Cd = (d1$Cd^l-1)/l
s2 = shapiro.test(d2$Cd)
```

Gráficos de pressupostos do modelo

```
pdf('zt.pdf',width=6,height=5)
par(mfrow=c(2,2))
hist(d1$Cd,col='gray',xlab=expression(z),main=NULL)
qqnorm(d1$Cd, pch = 19, main=NULL)
qqline(d1$Cd)
hist(d2$Cd,col='gray',xlab=expression(z[t]),main=NULL)
qqnorm(d2$Cd, pch = 19, main=NULL)
qqline(d2$Cd)
dev.off()
```

O código acima deverá gerar os seguintes gráficos.

2.6 Visualização dos dados

```
## ------------------------
## [4.2] Data Visualization
## ------------------------

pdf('mapa.pdf')
plot(borda,lty=1,lwd=2,type='l',col='gray')
points(d1$x,d1$y,pch=19,cex=d2$Cd)
dev.off()
```

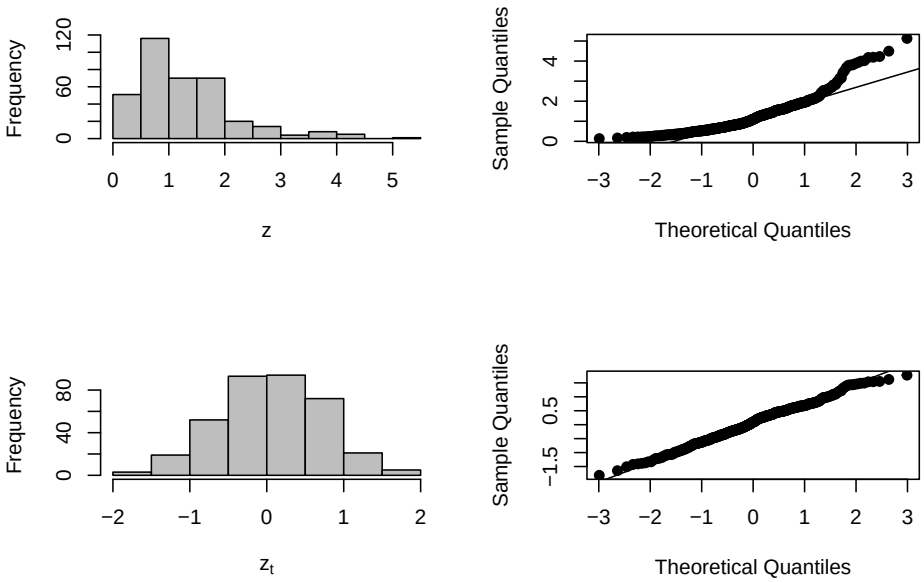
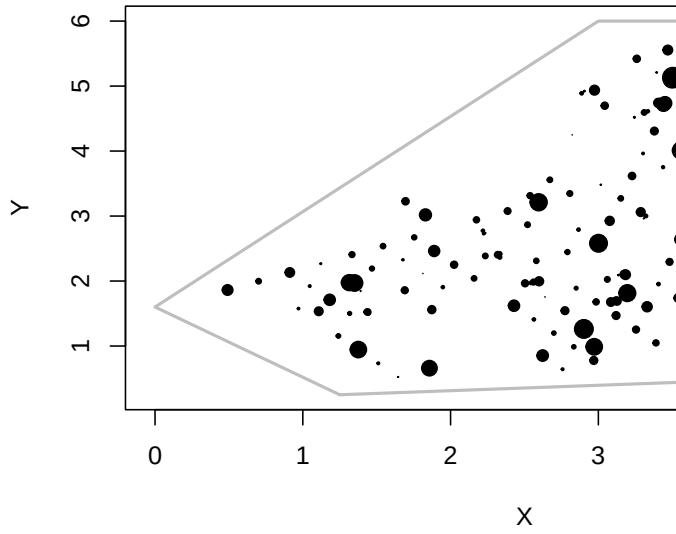


Figure 2.1: Histogramas e *qqplots* da variável original na primeiro linha e da variável transformada na segunda linha.



Se o código acima funcionar, você terá o seguinte resultado.

2.7 Estimação espacial

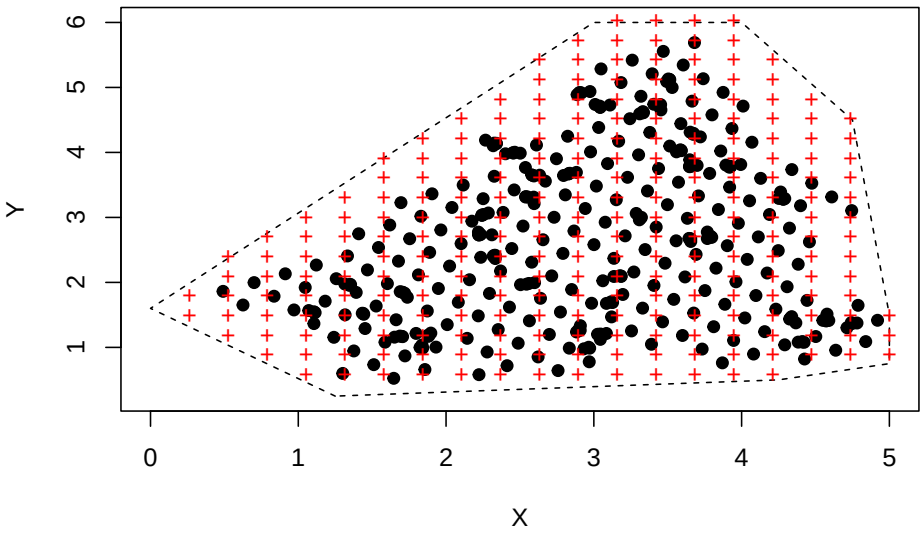
```
## ------------------------
## [4.3] Spatial Estimation
## ------------------------

nd = 20
coordinates(d1) = ~x+y
coordinates(d2) = ~x+y
xd = seq(rx[1],rx[2],l=nd)
yd = seq(ry[1],ry[2],l=nd)
grid = expand.grid(xd,yd)
ind = which(point.in.polygon(grid[,1],grid[,2],borda[,1],borda[,2])>0)
grid = grid[ind,]
```

2.8 Visualização do *grid*

```
## ------------------------
## [4.4] Grid Visualization
## ------------------------

pdf('grid.pdf')
plot(borda,lty=2,type='l')
points(d1,pch=19)
points(grid,pch='+',col='red')
dev.off()
```



Cross-references make it easier for your readers to find and link to elements in your book.

2.9 Chapters and sub-chapters

There are two steps to cross-reference any heading:

1. Label the heading: `# Hello world {#nice-label}`.
    - Leave the label off if you like the automated heading generated based on your heading title: for example, `# Hello world` = `# Hello world {#hello-world}`.
    - To label an un-numbered heading, use: `# Hello world {-#nice-label}` or `{# Hello world .unnumbered}`.
2. Next, reference the labeled heading anywhere in the text using `\@ref(nice-label)`; for example, please see Chapter 2.
    - If you prefer text as the link instead of a numbered reference use: any text you want can go here.

2.10 Captioned figures and tables

Figures and tables *with captions* can also be cross-referenced from elsewhere in your book using `\@ref(fig:chunk-label)` and `\@ref(tab:chunk-label)`, respectively.

See Figure 2.2.

```
par(mar = c(4, 4, .1, .1))
plot(pressure, type = 'b', pch = 19)
```

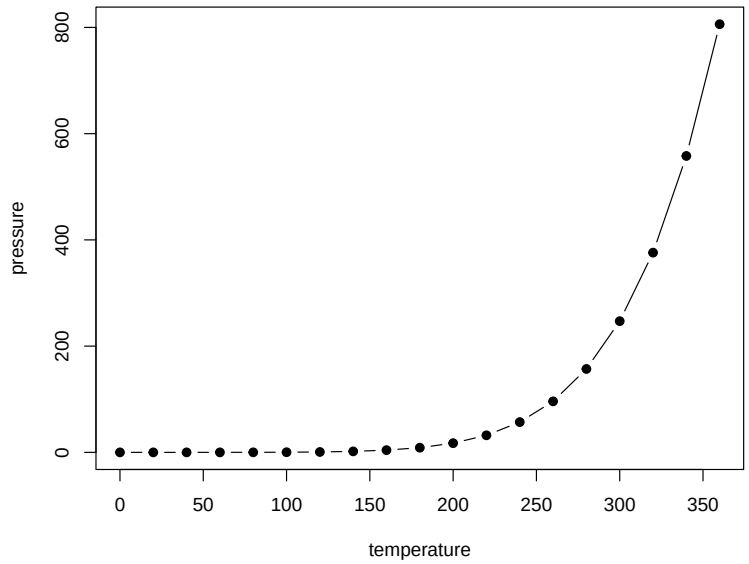


Figure 2.2: Here is a nice figure!

Don't miss Table 2.1.

```
knitr::kable(
  head(pressure, 10), caption = 'Here is a nice table!',
  booktabs = TRUE
)
```

Table 2.1: Here is a nice table!

temperature	pressure
0	0.0002
20	0.0012
40	0.0060
60	0.0300
80	0.0900
100	0.2700
120	0.7500
140	1.8500
160	4.2000
180	8.8000

Chapter 3

Parts

You can add parts to organize one or more book chapters together. Parts can be inserted at the top of an .Rmd file, before the first-level chapter heading in that same file.

Add a numbered part: `# (PART) Act one {-}` (followed by `# A chapter`)

Add an unnumbered part: `# (PART\*) Act one {-}` (followed by `# A chapter`)

Add an appendix as a special kind of un-numbered part: `# (APPENDIX) Other stuff {-}` (followed by `# A chapter`). Chapters in an appendix are prepended with letters instead of numbers.

Chapter 4

Footnotes and citations

4.1 Footnotes

Footnotes are put inside the square brackets after a caret `^[]`. Like this one [1].

4.2 Citations

Reference items in your bibliography file(s) using `@key`.

For example, we are using the **bookdown** package [Xie, 2022] (check out the last code chunk in index.Rmd to see how this citation key was added) in this sample book, which was built on top of R Markdown and **knitr** [Xie, 2015] (this citation was added manually in an external file book.bib). Note that the `.bib` files need to be listed in the index.Rmd with the YAML `bibliography` key.

The RStudio Visual Markdown Editor can also make it easier to insert citations: https://rstudio.github.io/visual-markdown-editing/#/citations

[1] This is a footnote.

Chapter 5

Blocks

5.1 Equations

Here is an equation.

$$f(k) = \binom{n}{k} p^k (1-p)^{n-k} \tag{5.1}$$

You may refer to using `\@ref(eq:binom)`, like see Equation (5.1).

5.2 Theorems and proofs

Labeled theorems can be referenced in text using `\@ref(thm:tri)`, for example, check out this smart theorem 5.1.

Theorem 5.1. *For a right triangle, if c denotes the* length *of the hypotenuse and a and b denote the lengths of the* ***other*** *two sides, we have*

$$a^2 + b^2 = c^2$$

Read more here https://bookdown.org/yihui/bookdown/markdown-extensions-by-bookdown.html.

5.3 Callout blocks

The R Markdown Cookbook provides more help on how to use custom blocks to design your own callouts: https://bookdown.org/yihui/rmarkdown-cookbook/custom-blocks.html

Chapter 6

Sharing your book

6.1 Publishing

HTML books can be published online, see: https://bookdown.org/yihui/bookdown/publishing.html

6.2 404 pages

By default, users will be directed to a 404 page if they try to access a webpage that cannot be found. If you'd like to customize your 404 page instead of using the default, you may add either a `_404.Rmd` or `_404.md` file to your project root and use code and/or Markdown syntax.

6.3 Metadata for sharing

Bookdown HTML books will provide HTML metadata for social sharing on platforms like Twitter, Facebook, and LinkedIn, using information you provide in the `index.Rmd` YAML. To setup, set the `url` for your book and the path to your `cover-image` file. Your book's `title` and `description` are also used.

This `gitbook` uses the same social sharing data across all chapters in your book- all links shared will look the same.

Specify your book's source repository on GitHub using the `edit` key under the configuration options in the `_output.yml` file, which allows users to suggest an edit by linking to a chapter's source file.

Read more about the features of this output format here:

https://pkgs.rstudio.com/bookdown/reference/gitbook.html

Or use:

```
?bookdown::gitbook
```

Bibliography

Yihui Xie. *Dynamic Documents with R and knitr*. Chapman and Hall/CRC, Boca Raton, Florida, 2nd edition, 2015. URL http://yihui.org/knitr/. ISBN 978-1498716963.

Yihui Xie. *bookdown: Authoring Books and Technical Documents with R Markdown*, 2022. URL https://CRAN.R-project.org/package=bookdown. R package version 0.26.