Spatio temporal analysis of extreme wind velocities for infrastructure desing. Case study Colombia

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A Thesis
Presented to
The Division of Instituto for Geoinformatics - IFGI
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Master of Science in Geospatial Technologies

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()

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I want to thank a few people.

Preface

This is an example of a thesis setup to use the reed thesis document class (for LaTeX) and the R bookdown package, in general.

Table of Contents

List of Tables

List of Figures

Abstract

The preface pretty much says it all.

Second paragraph of abstract starts here.

Dedication

You can have a dedication here if you wish.

Chapter 1

If you have more two advisors, un-silence line 7

Placeholder

```
# List of packages required for this analysis
pkg <- c("dplyr", "ggplot2", "knitr", "bookdown", "devtools")
# Check if packages are not installed and assign the
# names of the packages not installed to the variable new.pkg
new.pkg <- pkg[!(pkg %in% installed.packages())]
# If there are any packages in the list that aren't installed,
# install them
if (length(new.pkg))
  install.packages(new.pkg, repos = "http://cran.rstudio.com")
# Load packages (thesisdown will load all of the packages as well)
library(thesisdown)
```

Chapter 2

Data

Input data is made up of three different sources a) IDEAM - Institute of Hydrology, Meteorology and Environmental Studies of Colombia `http://www.ideam.gov.co`, b) ISD - Integrated Surface Database `https://www.ncdc.noaa.gov/isd`, and c) ERA5 climate reanalysis `https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5`.

Table 2.1: Datasets description

Institution	Dataset	Details
IDEAM	Historical records at weather stations	IDEAM is responsible for the instalation, maintenance and management of all kind of weather stations located everywhere along the country
NOAA	ISD	ISD (Integrated Surface Database. NOAA's National Centers for Environmental Information - NCEI) Lite: A subset from the full ISD dataset containing eight common surface parameters in a fixed-width format free of duplicate values, sub-hourly data, and complicated flags.
ECMWF	ERA5	ERA5 is a reanalysis dataset with hourly estimates of atmospheric variables with horizontal resolution of 0.25^{o} (33 kilómeters), this is equally spaced cells every 0.25 degrees

Table 2.2: Datasets variables

Dataset	Variables	Description
IDEAM	vvmx_aut_60	Hourly wind maximun velocity
ISD	wind speed rate	Maximun hourly wind velocity. The rate of horizontal travel of air past a fixed point.
ERA5	fg10	10 metre wind gust since previous post-processing
	fsr	Forecast Surface Roughness

Table 2.3: Variables units and time

Variable	Units	Time	Stations

vvmx_aut_60	meters per second	Variable from 2001 until today. Irregular time series.	203
Wind speed	meters per second	Variable from 1941 until today. Note: There is too much variability in time (start, end, and time range) for each station. Irregutal time series.	101
fg10	meters per second	1979-Today	3381
fsr	meters per second	1979-Today	3381

Ideal data source to create extreme wind speeds maps should be field observed data from IDEAM, but there are not enough number of stations around the study area to represent all the local wind variability in a huge country with multiple variety of climates and and changing thermal floors, but there are other important motivatios to include different sources trying to improve output results:

- As just mentioned, low quantity of IDEAM stations
- There are uncertanties related to the way IDEAM anemometers are registering data, then comparison with other datasources are needed to be able to do appropriate data standardization, needed as a prerequisite to the analysis.
- There is no time continuity in the registration of IDEAM data. Historical time series are different and variable in each station.

Importance of ISD database for this study is based on the fact that post-procesed ISD database has wind extreme values, and it was used to create extreme wind maps for United States. ISD allows comparison with IDEAM records to take better decitions in order to do needed data standarization.

Despite that ERA5 data are not observed data, but forecast, its main advantage is data availability to assess the local climatic variance every 33 square kilometers.

2.1 IDEAM

R

- Item 1
- Item 2

1. Item 1
2. Item 2
3. Item 1
4. Item 2
5. Item 3
    - Item 3a

- Item 3b

Historical observed wind speeds from 203 in Colombia are managed by the official environmental authority IDEAM. Table 2.4 shows a sample of five IDEAM stations. Figure 2.1 shows a map of IDEAM stations.

Table 2.4: IDEAM Stations sample

Name[Code]	Latitud	Longitud
EMAS - AUT [26155230]	5.09	-75.51
SAN BENITO - AUT [25025380]	9.16	-75.04
AEROPUERTO ALFONSO LOPEZ - [28025502]	10.44	-73.25
TIBAITATA - AUT [21206990]	4.69	-74.21
METROMEDELLIN - AUT [27015310]	6.33	-75.55

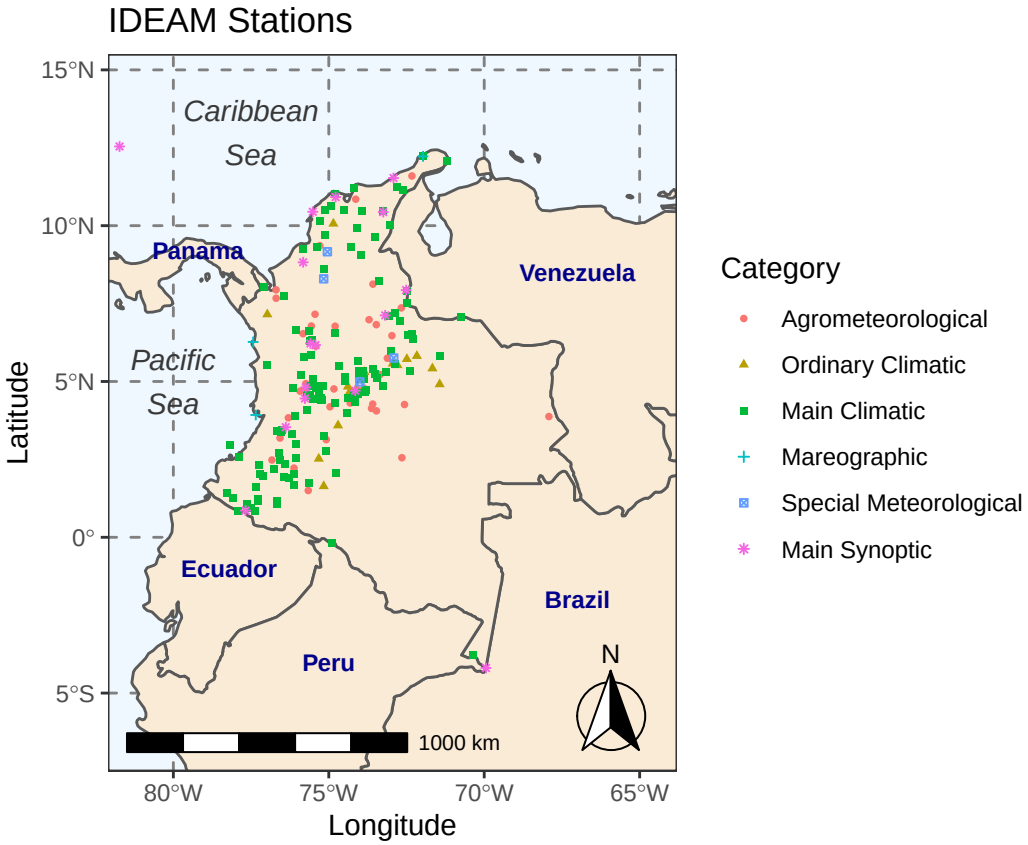

Figure 2.1: IDEAM Stations

2.2 ISD

Now for the correct way: ISD is a database with environmental variables among then extreme wind speeds. ISD has data for the whole planet, and is based on observed data at metereological stations in each country, which means that for Colombia is based on IDEAM data. Main advantage is data availability at neighbor countries and specialized postprocesing made by NOAA's National Centers for Environmental Information - NCEI in United States, which facilitates its use.Table 2.5 shows a sample of five ISD stations. Figure 2.2 shows a map of ISD stations.

Table 2.5: ISD Stations sample

Code	Name	Latitud	Longitud
804400	BARINAS	8.62	-70.22
800810	ALTO CURICHE	7.05	-76.35
801000	BAHIA SOLANO / JOSE MUTIS	6.18	-77.40
802590	ALFONSO BONILLA ARAGON INTL	3.54	-76.38
803150	BENITO SALAS	2.95	-75.29

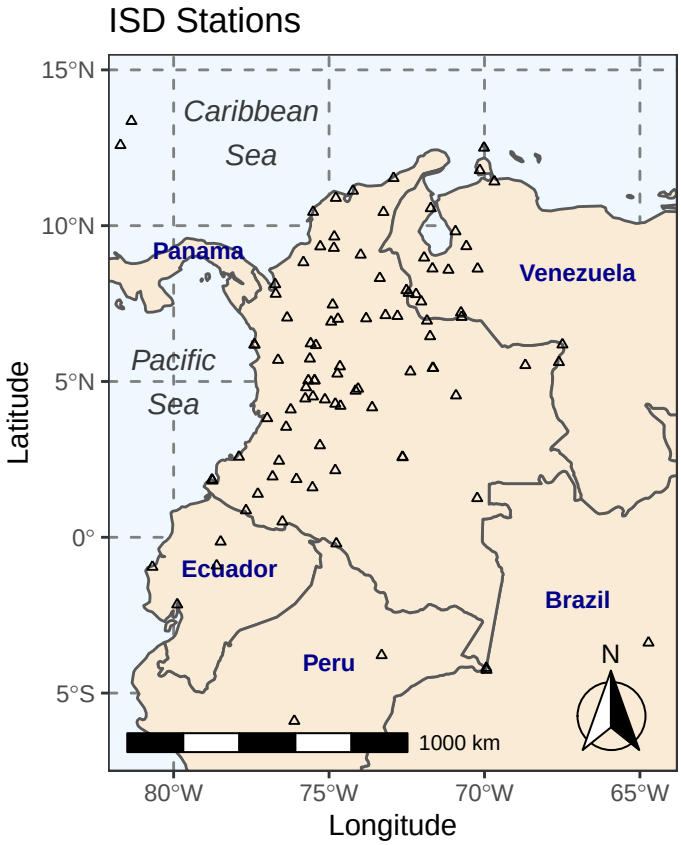

Figure 2.2: ISD Stations

2.3 ERA5

ERA5 is forecast reanalysis data procesed by the *European Centre for Medium-Range Weather Forecasts* - ECMWF with wind speeds time series in square cells *matrix of pixels* of 0.25 degrees (33 km) covering the whole plannet. For the study area was extracted a raster of 69 rows by 49 XXX columns in format NetCDF. Figure 2.3 shows a map of ERA5 stations (cells centers).

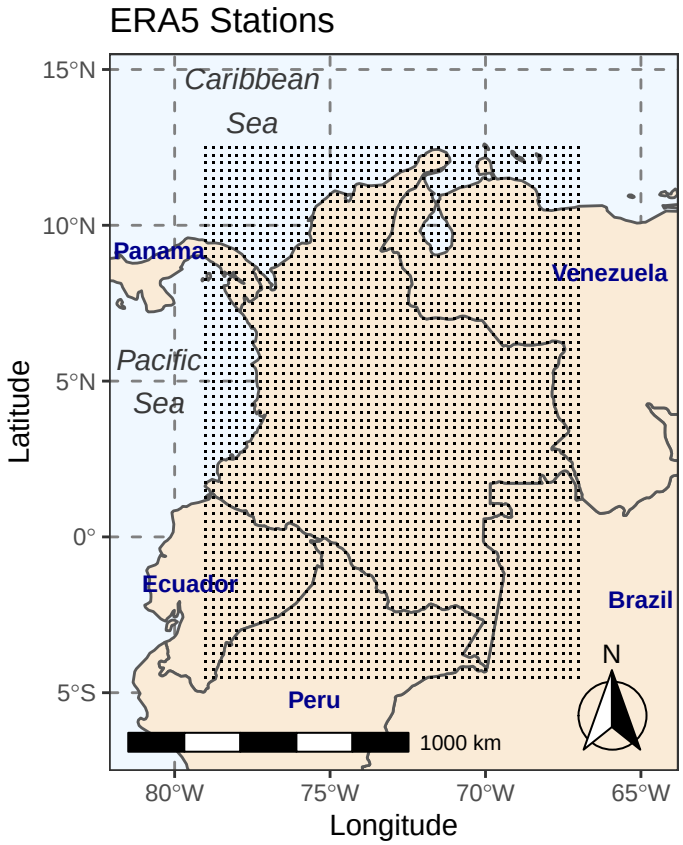

Figure 2.3: ERA5 Stations (cells centers)

2.4

2.5 Data Download and Organization

2.6 Data Standarzation

Analysis of extreme wind speeds requieres data standarizaton as initial step. All input data must be standarized to represent three important conditions: a) anemometer height of 10 meters, b) open space roughness, and c) averaging time of 3-seconds wind gust. Data for analysis must represent 3-s peak wind speeds 10 meters heigh

above the surface, in open terrain. * 10 mts anemometer height * Open space terrain roughness * 3-s gust averagind time

The `cos` of 2π is 1.

The standard deviation of `speed` in `cars` is 5.2876444.

The standard deviation is less than 6.

As you see with `$2 \pi$` above, mathematics can be added by surrounding the mathematical text with dollar signs. More examples of this are in [Mathematics and Science] if you uncomment the code in [Math].

after you have run the **R**

Chapter 3

Theoretical Framework

Placeholder

3.1 Probability Concepts

3.2 Annual Excedance Probability - Pa

3.2.1 Typesetting reactions

3.2.2 Other examples of reactions

3.3 Return Period

3.4 Compound Excedance Probability - Pn

3.5 Extreme Value Analysis Overview

3.5.1 Main Methods

Epochal methods

Peak Over Threshold

GPD

Poisson Process

3.5.2 Commond Distributions for Extreme Values

3.5.3 Methods for parameters estimation

3.5.4 Return Period

3.5.5 Wind Speed at Return Period

Chapter 4

Methodology

Placeholder

4.1 Input Data Selection and Standarization

4.1.1 Data Selection

4.1.2 Data Standarization

Anemometer height - 10 m

Surface Roughness - 0.03 m

Averaging Time - 3-s gust

4.2 Fit data to a POT - Poisson Process

4.2.1 Velocities at Return Periods

4.3 spatial Interpolation

4.4 Footnotes and Endnotes

4.5 Bibliographies

4.6 Anything else?

Conclusion

If we don't want Conclusion to have a chapter number next to it, we can add the `{-}` attribute.

More info

And here's some other random info: the first paragraph after a chapter title or section head *shouldn't be* indented, because indents are to tell the reader that you're starting a new paragraph. Since that's obvious after a chapter or section title, proper typesetting doesn't add an indent there.

Appendix A

The First Appendix

This first appendix includes all of the R chunks of code that were hidden throughout the document (using the `include = FALSE` chunk tag) to help with readibility and/or setup.

In the main Rmd file

In Chapter 4:

Appendix B

The Second Appendix, for Fun

References

Placeholder