

## Week 3

### Using and Modelling Spatial Objects

#### Overview

Welcome to Week 2 of Spatial Analysis.

This week we will cover three topics:

- Spatial objects in the sf package
- Using geographic maps with sp and sf

You will start this week learning about the sf package. Together with sp, it is one of the most popular R packages for handling spatial data. We will discuss several main approaches for creating of objects. You also will learn also how to plot sf objects and convert data between sp and sf packages.

Then, we will discuss several simple strategies to use geographic maps and plot sp and sf objects using these maps.

Finally, you will participate in a workshop, in which you can practise conducting an analysis of real spatial data.

By the end of this week, you will learn:

#### Topic 1: Spatial objects in sf package

- Representing spatial data in the sf package
- Creating sf objects from scratch
- Creating sf objects from coordinate tables
- Plotting sf objects
- Converting between sp and sf formats

#### Topic 2: Using geographic maps with sp and sf

- Using maps in the maps package
- Using maps from the database of Global Administrative Areas
- Plotting sp objects using the world map
- Plotting sf objects using the world map

By completing this module, you will be working towards the following subject-intended learning outcomes:

1. Formulate purposeful questions to explore new statistical ideas and subsequently design valid statistical experiments.
2. Creatively find solutions to real-world problems consistent with those commonly faced by practising statisticians.

## Topic 1: Spatial objects in the sf package

We will begin this week by discussing the main types of spatial data in the sf package. There are seven basic simple geometric feature types:

- Point,
- MultiPoint,
- LineString,
- MultiLineString,
- Polygon,
- MultiPolygon, and
- GeometryCollection.

Then you will learn how to create and work with some of these types. Other types are similar and you can practice with them on your own.

You will read the content, watch videos and complete activities to test your understanding of this topic.

Upon completion of this topic, you will be able to distinguish between different types of spatial data in sf, create corresponding sf objects and work with them.

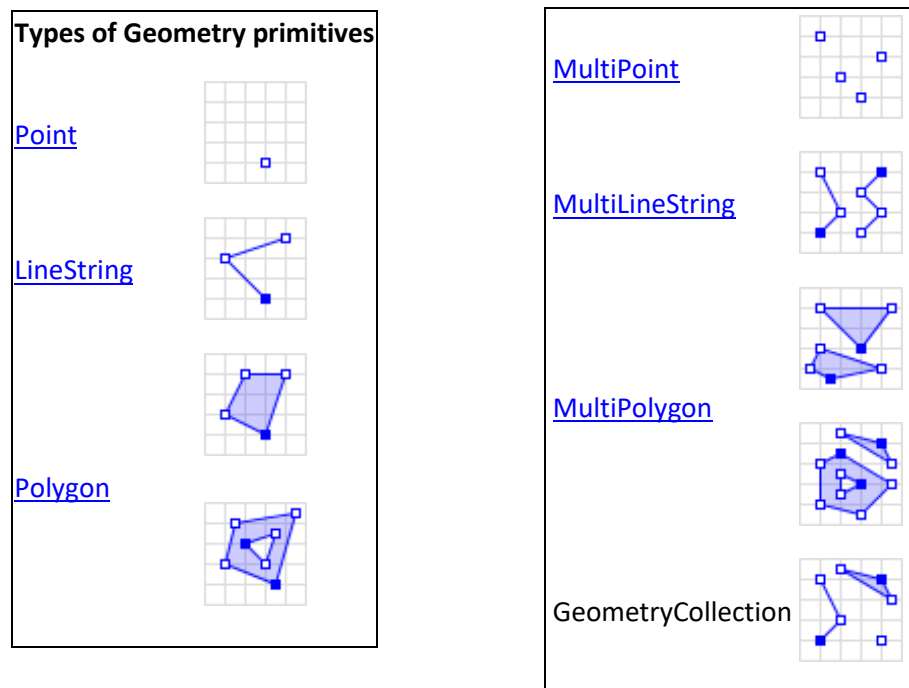
### Examples of spatial objects in the sf package

The sf package stores spatial objects as data frames with a special column that contains information about geometry features. Thus, all methods of subsetting, indexing, transformation, etc. that one usually applies to R data frames are valid for sf objects. To start working with sf objects, one needs to understand what geometries in the special column are and how to create them. Figure 2.1 gives examples of the most important geometries implemented in the sf package. They are very simple and intuitive but can be combined in complex geometric configurations using the GeometryCollection type.

You will consider several examples of how to create sf objects in the first part of our readings.

**Figure 2.1**

## Main geometry features for 2D data



[https://en.wikipedia.org/wiki/Well-known\\_text\\_representation\\_of\\_geometry](https://en.wikipedia.org/wiki/Well-known_text_representation_of_geometry)

### Read

In the reading [Spatial Objects in the sf package](#), you will explore the examples of creating create sf objects of multipoint and polygon types. You will see how an external file with coordinates can be used to create sf objects.

From the folder, open the document titled **Week\_3\_Topic\_1** and read **slides 1–8**.

## Working with sf objects

After these introductory examples, you will learn some basic methods to subset and plot sf objects. You will get your first experience of how to add your sf object to the world geographic map.

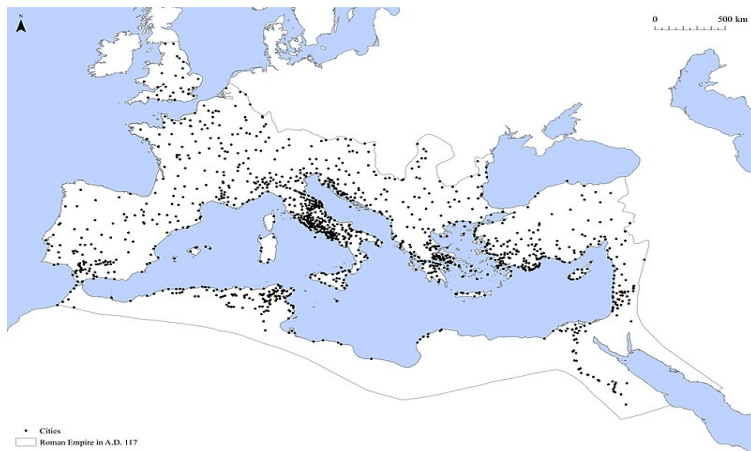
As sf objects are stored as R data frames, you can use the usual way of subsetting, by applying the brackets [...] and logical conditions.

The generic command plot can be used to produce basic plots of sf objects. Changing its standard options (add, col, pch, etc.) you can control the appearance of sf objects in a very similar way to usual R plots.

For the more advanced tasks you can use the package mapview with the same command from it. Changing options of the mapview command you can change how sf objects are represented on the geographic map.

**Figure 2.2**

**The cities of the Roman world in the Imperial period**



[https://commons.wikimedia.org/wiki/File:The\\_cities\\_of\\_the\\_Roman\\_world\\_in\\_the\\_Imperial\\_period.jpg](https://commons.wikimedia.org/wiki/File:The_cities_of_the_Roman_world_in_the_Imperial_period.jpg)

In the following, we will extend these visualisation methods and will be using them for exploratory analysis of spatial data.

**Read**

In the second part of the reading [Spatial Objects in the sf package](#), you will learn about different types of visualising sf objects.

From the folder, open the document titled **Week\_3\_Topic\_1** and read **slides 9–13**.

**Converting between sf and sp formats**

In week 2 we studied the sp package. In this section, you will learn how to convert objects between sp and sf packages. One of the approaches is to use the generic R command `as`. Another way is to employ the sf specific conversion method realised in the function `st_as_sf`.

For examples and plots we will continue using the meuse and CRAN data introduced in previous topics.

**Read**

In the third part of the reading [Spatial Objects in the sf package](#), you will learn about the conversion between the sf and sp spatial data formats.

From the folder, open the document titled **Week\_3\_Topic\_1** and read **slides 14–16**.

## Topic 2: Using geographic maps in R

This topic discusses the basic approaches of using geographic maps in R. You will learn about the maps package and the database of Global Administrative Areas. You will get a basic understanding of visualising sp and sf objects using geographic maps.

### The maps library

In this section, you will learn the maps library in and its basic tools for creating maps of countries and regions of the world.

#### Read

First, in the reading [Geographic maps in R](#), you will learn the maps library.

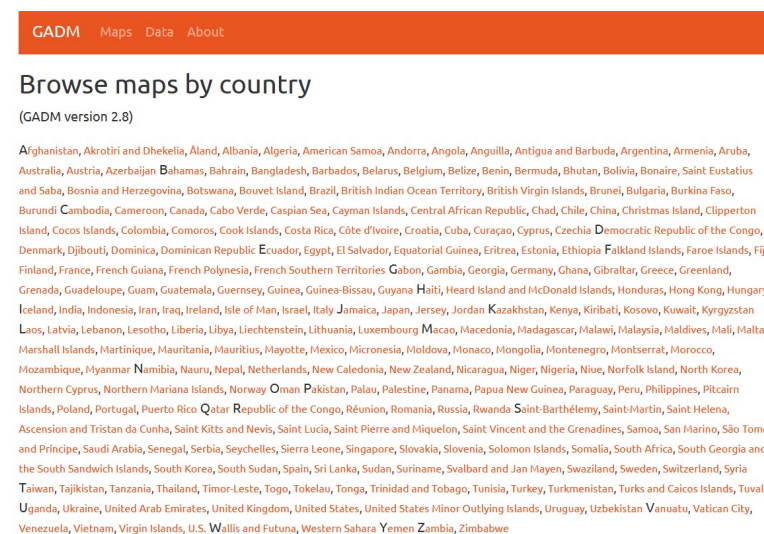
From the folder, open the document titled **Week\_2\_Topic\_2** and read **slides 1–3**.

## Using the database of Global Administrative Areas

In many R packages maps are fairly low-resolution, and political boundaries can be incomplete or out-of-date. Thus, we often use other GIS resources to get maps into R. GADM is a spatial database with an extensive list of the location of the world's administrative areas, see Fig 2.3. It includes countries and their subregions, states, etc. You will learn how to download and plot maps from the GADM webpage. You will use sp and sf packages to visualise them.

Figure 2.3

*List of countries maps in GADM*



<https://gadm.org/maps.html>

## Read

You will read the second part of [Geographic maps in R](#) and will learn how to work with the GADM database.

From the folder, open the document titled **Week\_2\_Topic\_2** and read **slides 3–8**.

## Using geographic maps with sp and sf objects

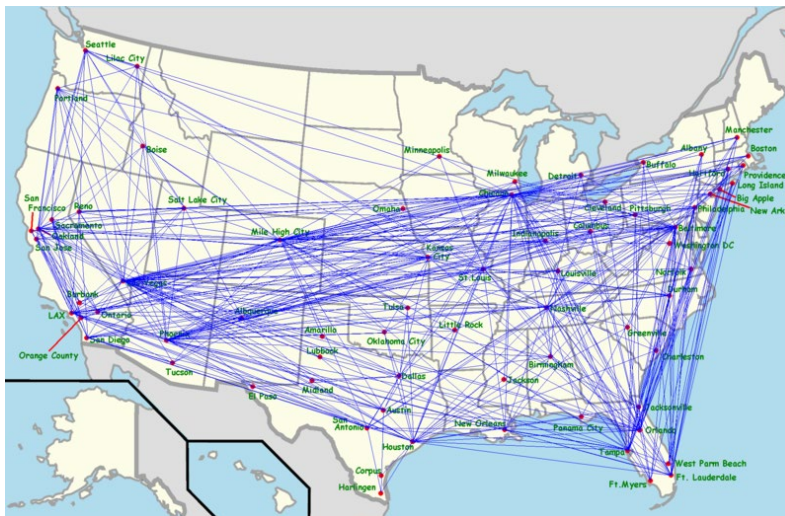
In this section, you will learn how to plot sp and sf objects on geographic maps.

First, we use the dataset with information about locations and population of cities. We select cities which population is greater than 1000000. After preparing an sp object we plot these cities with the largest population on the world map. The map from the package maps will be used.

In the second example, we convert the sp object with the cities to the sf format and use the package mapview to visualise their locations. Then we select the first 6 cities and plot straight lines connecting them. It can be useful for visualising trips or optimizing routes, see Fig 2.4.

**Figure 2.4**

### Southwest Airlines Route



[https://commons.wikimedia.org/wiki/File:Southwest\\_Airlines\\_Route\\_20110327.png](https://commons.wikimedia.org/wiki/File:Southwest_Airlines_Route_20110327.png)

## Read

In the third part of the reading [Geographic maps in R](#), you will learn to use geographic maps with sp and sf objects.

From the folder, open the document titled **Week\_3\_Topic\_2** and read **slides 9–16**.

Revise key R commands used in this week's materials.

### **Read**

In the reading [Key R commands](#), you will revise some of the key R commands that were used in this week's materials.

From the folder, open the document titled **Week\_3\_Topic\_2** and read **slide 17**.

## Workshop 3

### Activity

#### Workshop 3

This activity will be completed in R. Repeat the R programming content covered in Week 3. Modify the code and understand the impact of different R parameters on changes in results.

#### Your task

- Repeat R commands learnt in Week 2 prior to the two-hour workshop session.
- Try to modify the code and understand the impact and meaning of different R function parameters. Interpret the observed changes in plots and analysis results.
- Feel free to discuss questions with other students as you go in the forum, and please also take the time to help others. It is amazing how much we all can learn from each other's questions, and how in helping others we strengthen our own understanding.
- If you can, come along to the two-hour scheduled workshop session and discuss any challenges, seek advice and work through some problems with your peers and facilitator.
- Revisit these problems in later weeks and challenge yourself to get a deeper understanding to build on what you learn later.

#### Guidelines

- This activity is not graded but is an essential part of your learning. It will be held synchronously and facilitated by your instructor.
- You don't need to submit your R code; however, to be successful in this subject it is necessary to work through all R coding materials from this week and understand how to apply the corresponding R commands.
- You should repeat all R commands in this week's materials before the online workshop. This will give you an opportunity to efficiently work with the facilitator during the online workshop and get your questions answered.
- You should spend around two hours on this activity.



## Summary

This week, we looked at representation of spatial data in the package `sf`. You learnt about the main geometric features and R methods to work with them. You also explored basic R methods to use geographic maps.

Next week, we will continue learning about how to use R and random fields for spatial data representation and analysis.

Here's a list of tasks that you should be working on or have completed:

- **Required readings**
- **Workshop**

The following resources provide you with this week's references and additional suggested readings.

## Additional suggested readings and resources

While these readings and resources are not essential, they provide greater insight into the concepts covered in the week and give you the choice to enhance your learning or pursue an area of interest in greater detail.

### Software and data:

- CRAN documentation for the `sf` package: <https://cran.r-project.org/web/packages/sf/index.html>
- Database of Global Administrative Areas: <https://gadm.org/>

### Books:

- Bivand, R. S., Pebesma, E., & Gomez-Rubio, V. (2013). Applied spatial data analysis with R (2nd ed.). Springer. <https://doi.org/10.1007/s12061-014-9118-y> Available on-line in La Trobe EBL ebook Library
- Cressie, N.A.C (1993) Statistics for spatial data. Wiley.  
<https://onlinelibrary.wiley.com/doi/book/10.1002/9781119115151>  
Available on-line in La Trobe EBL ebook Library