

Considering space

Objectives

What is Earth's shape?

- Spheroid
- Ellipsoid
- Geoid
- Potato

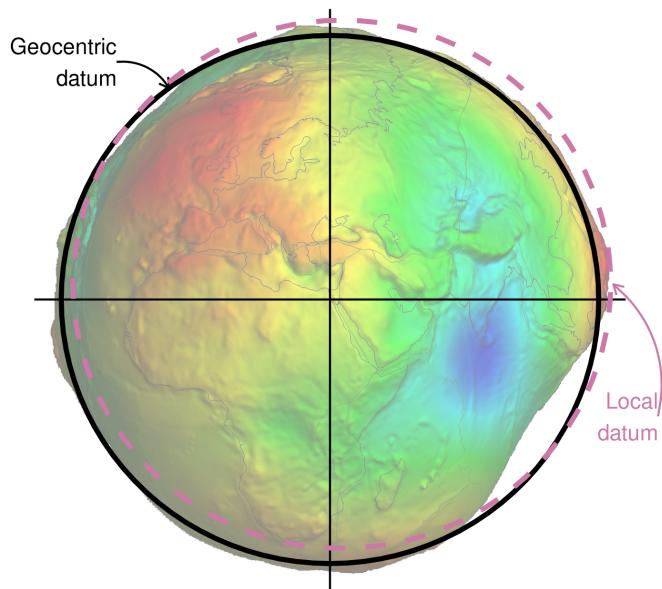
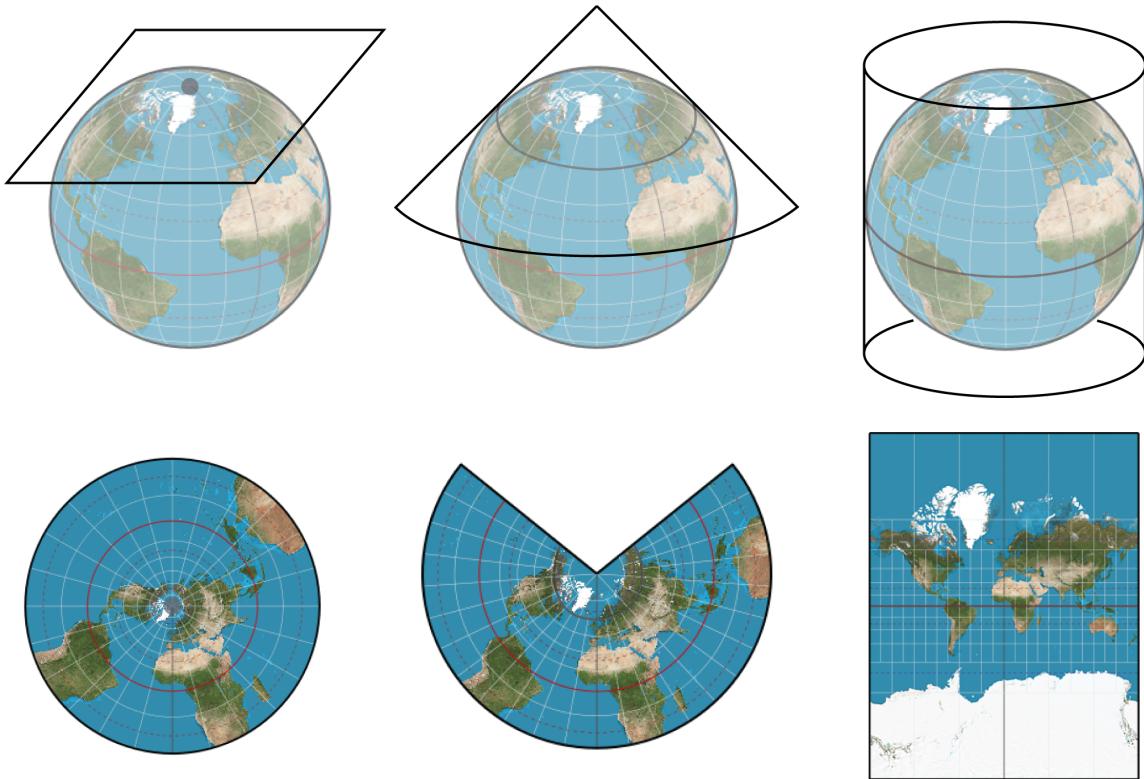


Figure 1: Geocentric and local geodetic datums shown on top of a geoid (in false color and the vertical exaggeration by 10,000 scale factor). From Lovelace, Nowosad, Muenchow: [Geocomputation with R](#)

Projections

How to transform a curved surface of an ellipsoid into a plane?



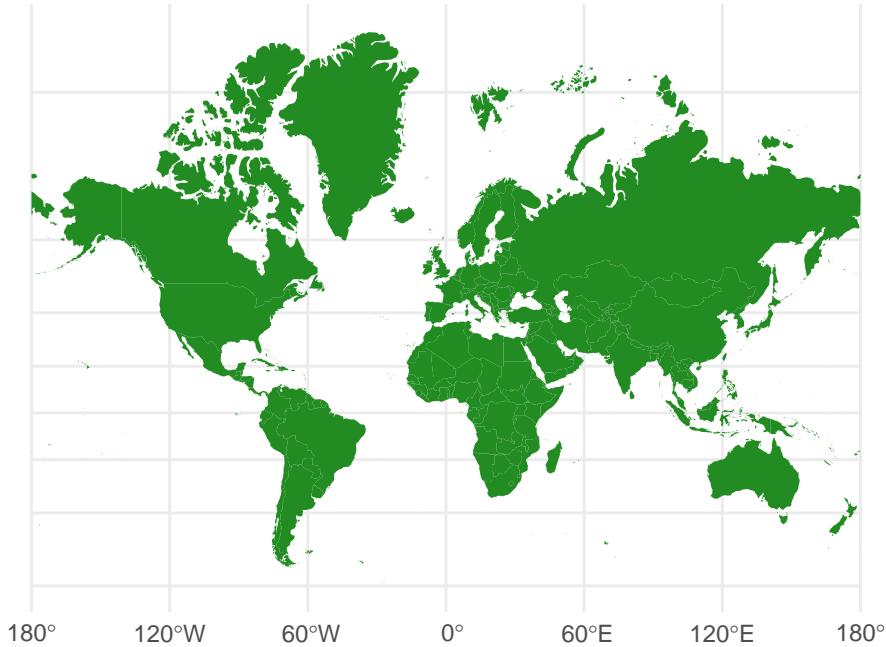


Figure 2: Mercator (1569)

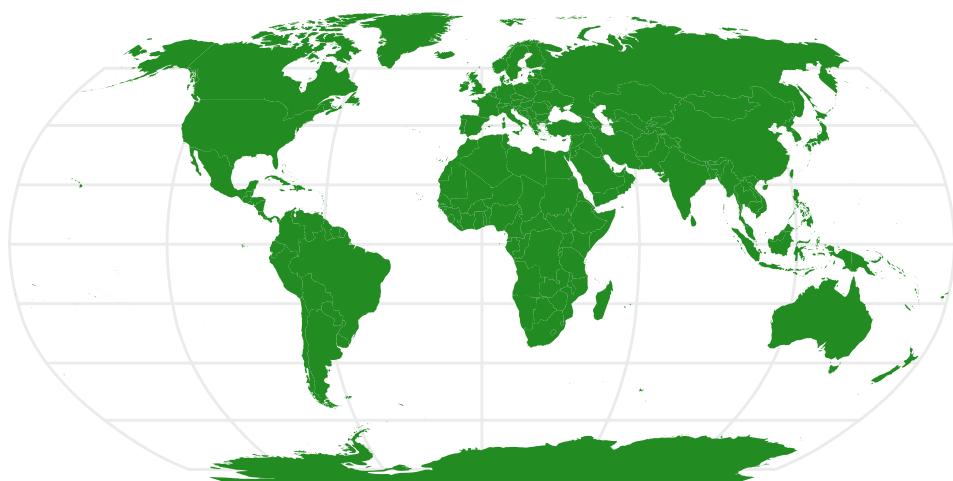


Figure 3: Robinson (1963)

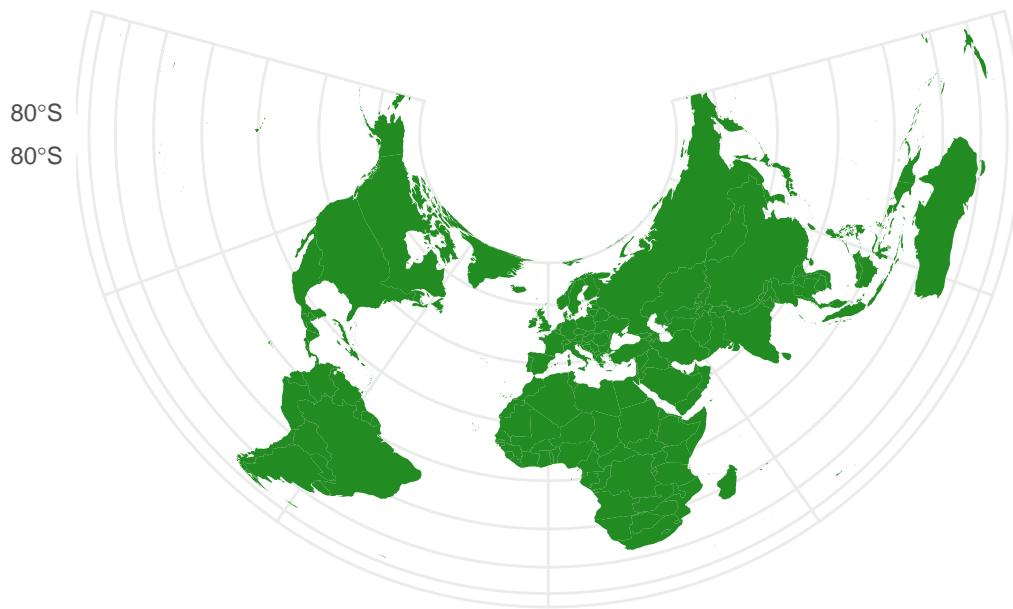


Figure 4: Albers (1805)

Coordinate reference systems

- CRS defines how spatial data relate to the surface of the Earth.

Geographic

WGS 84

- EPSG: 4326
- latitude: N/S, 0° (equator) – 90° (poles)
- longitude: E/W, 0° (prime meridian) – 180° (*antimeridian*)
- in degrees, minutes:
 $N\ 49^{\circ}44.62543'$, $E\ 15^{\circ}20.31830'$
- in decimal degrees:
 $49.7437572N$, $15.3386383E$
- [Package parzer](#) helps to parse coordinates in weird formats.

Projected

- Many operations can be done only with projected coordinates!

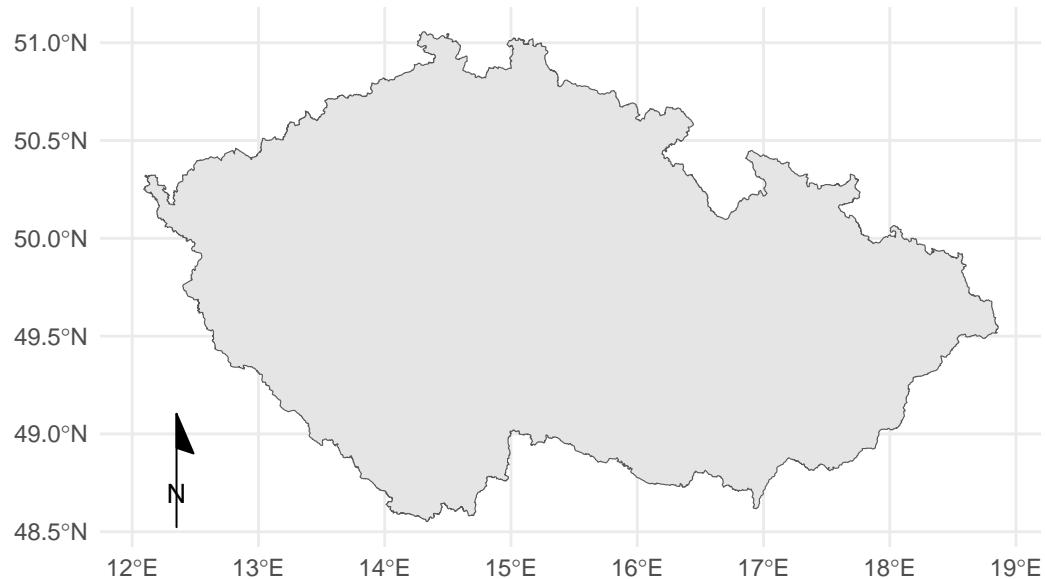
S-JTSK / Křovák East North

- EPSG: 5514
- Czech Republic and Slovakia
- in meters, in negative numbers:
-682473.3, -1089493

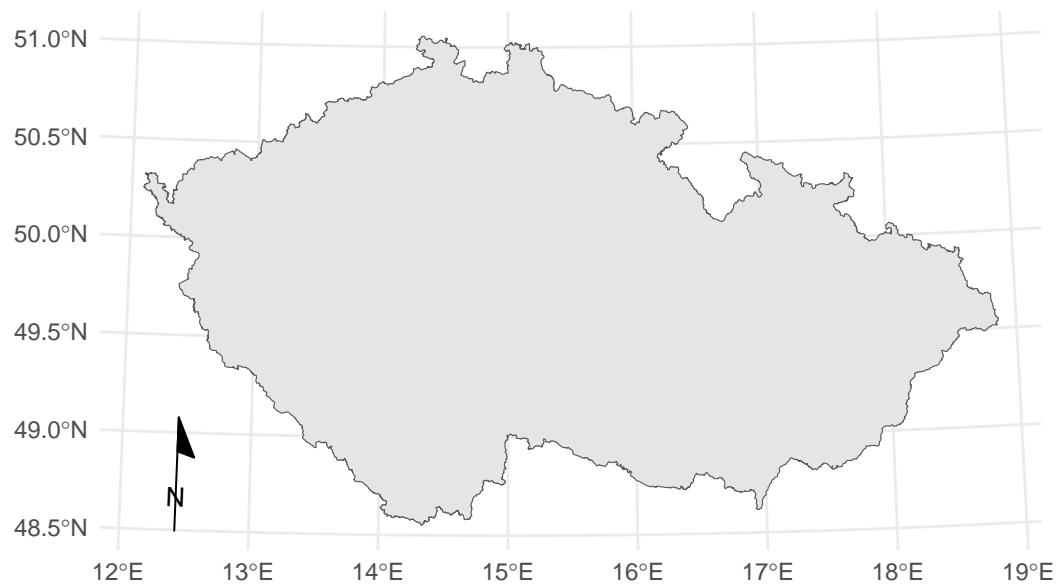
WGS 84 / UTM

- EPSG for zone 33N: 32633
- Czech Republic is in zone UTM 33N

Czech Republic in WGS 84



Czech Republic in WGS 84 / UTM



Czech Republic in S-JTSK / Krovak East North



Raster and vector data

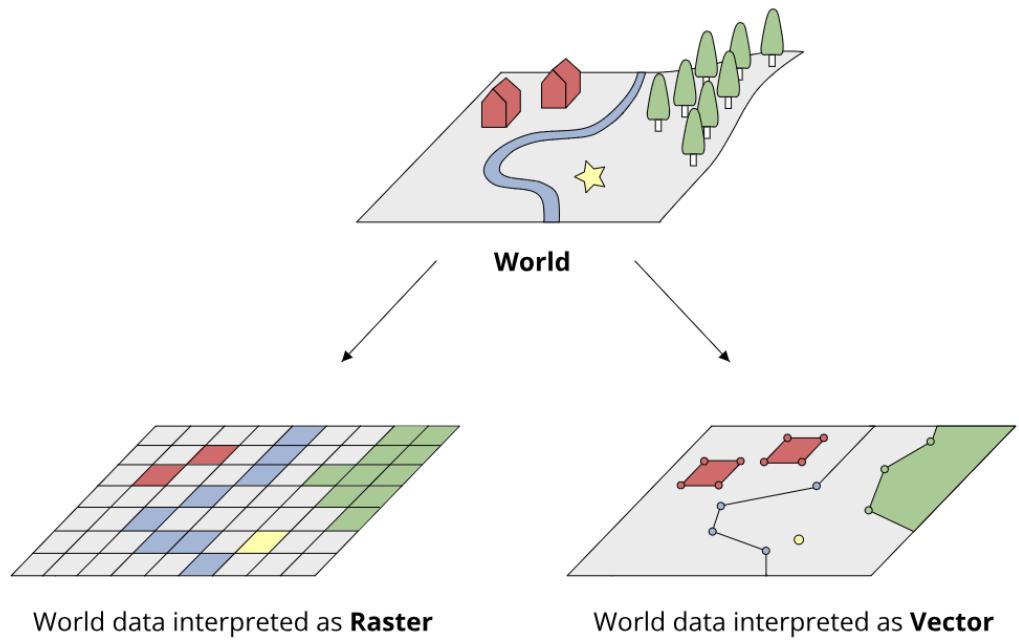


Figure 5: From <https://urstudio.sec.sg/wp-content/uploads/2022/03/featured-3.png>

Vector data



Points, lines, polygons...

Packages

`sf` package

- Vector data, *simple features*
- <https://r-spatial.github.io/sf/>
- [Cheatsheet](#)



Raster data

- [terra package](#) and its predecessor, [raster](#)
- [stars package](#) – spatiotemporal arrays, raster and vector data cubes

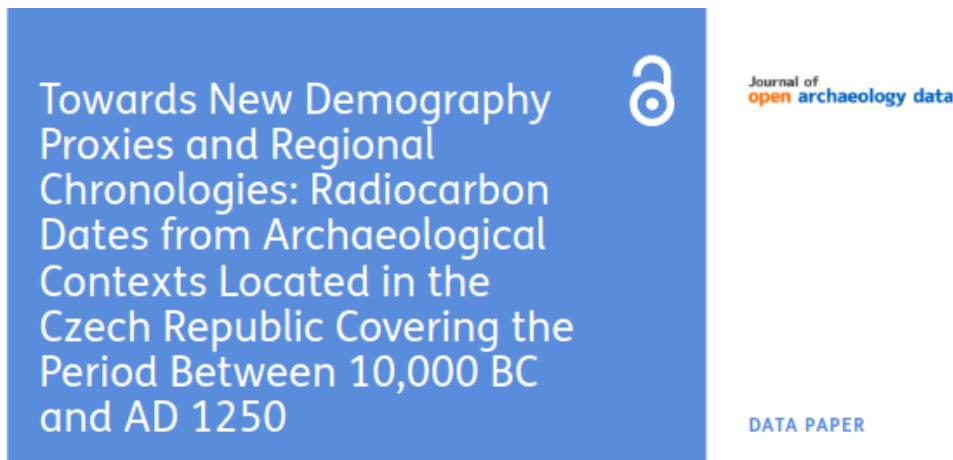
Spatial statistics

- [spatstat package](#)

Making maps

- [ggplot2](#)
- [tmap package](#) – thematic maps
- [leaflet package](#) – interactive maps

Dataset



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]u[ubiquity press

ABSTRACT

The dataset described in this paper represents the largest and most comprehensive collection of radiocarbon dates from the Czech Republic to date. The dataset offers 1579 samples from 357 archaeological sites dating from the Early Mesolithic (10,000 BC) to AD 1250. Published in a simple spreadsheet format, it offers researchers a quick tool for further analyses.

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Data*, 9: 9, pp. 1–14. DOI:
<https://doi.org/10.5334/joad.85>

- Dataset from *Journal of Open Archaeology Data* paper
- Article DOI: [10.5334/joad.85](https://doi.org/10.5334/joad.85)
- Data DOI: [10.5281/zenodo.5728242](https://doi.org/10.5281/zenodo.5728242)
- Table [LASOLES_14C_database.csv](#)

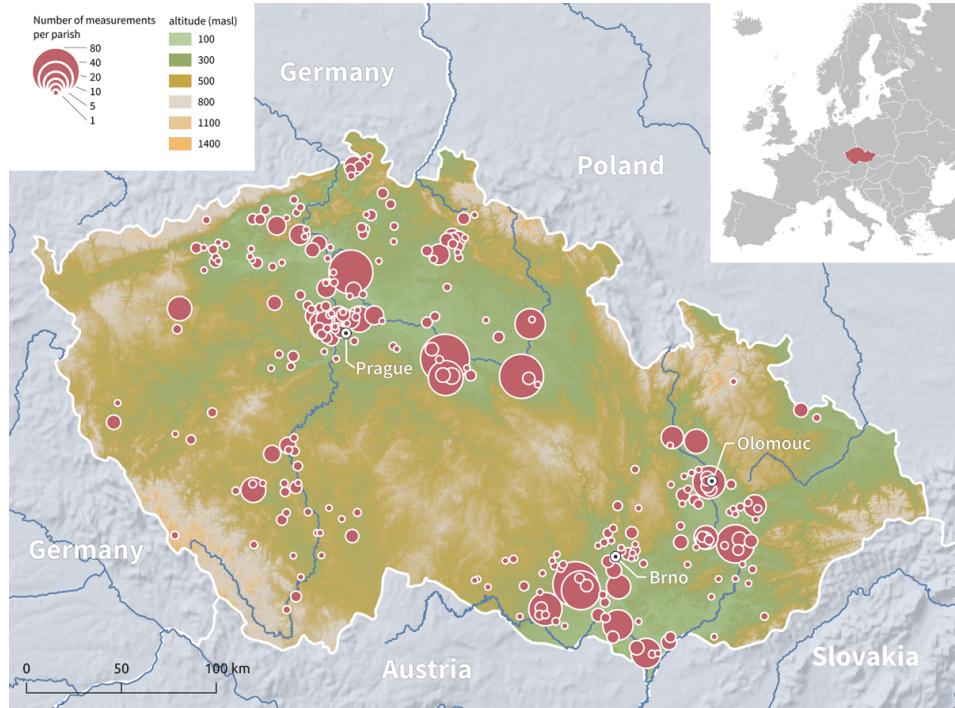


Figure 6: (Tkáč, Kolář 2021)

Reading the data

- Data is in CSV format, separated by semicolon (;)
- Columns `Latitude_WGS84` and `Longitude_WGS84`
- Coordinate reference system is WGS 84

```
lasoles <- read.csv2("./data/LASOLES_14C_database.csv") %>%
  dplyr::select(ID_Date, Context_type, Contex_dating_AMCR, ends_with("WGS84")) %>%
  tibble()
head(lasoles, 4)

# A tibble: 4 x 5
ID_Date  Context_type          Contex_dating_AMCR Latitude_WGS84 Longitude_WGS84
<chr>    <chr>                <chr>           <chr>           <chr>
```

```

1 CzArch_1 layer           br.st          49.051887  16.629824
2 CzArch_5 layer           bronz         50.052464  14.529859
3 CzArch_6 unspecified feature ne.lin   49.776686  16.950669
4 CzArch_7 unspecified feature ne.lin   49.776686  16.950669

```

```

lasoles_wgs84 <- st_as_sf(lasoles, coords = c(x = "Longitude_WGS84", y = "Latitude_WGS84"),
head(lasoles_wgs84, 4)

```

```

Simple feature collection with 4 features and 3 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: 14.52986 ymin: 49.05189 xmax: 16.95067 ymax: 50.05246
Geodetic CRS:  WGS 84
# A tibble: 4 x 4
  ID_Date Context_type      Contex_dating_AMCR      geometry
  <chr>    <chr>            <chr>                  <POINT [°]>
1 CzArch_1 layer           br.st          (16.62982 49.05189)
2 CzArch_5 layer           bronz         (14.52986 50.05246)
3 CzArch_6 unspecified feature ne.lin   (16.95067 49.77669)
4 CzArch_7 unspecified feature ne.lin   (16.95067 49.77669)

```

Reprojecting CRS

Function `st_transform(x, crs)`

EPSG codes:

- WGS 84: 4326
- S-JTSK East-North: 5514
- UTM 33N: 32633

```

lasoles_sjtsk <- st_transform(lasoles_wgs84,  crs = "EPSG:5514")
head(lasoles_sjtsk, 4)

```

```

Simple feature collection with 4 features and 3 fields
Geometry type: POINT
Dimension:     XY
Bounding box:  xmin: -735634.8 ymin: -1176759 xmax: -566666.7 ymax: -1047924
Projected CRS: S-JTSK / Krovak East North
# A tibble: 4 x 4
  ID_Date Context_type      Contex_dating_AMCR      geometry
  <chr>    <chr>            <chr>                  <POINT [m]>
1 CzArch_1 layer           br.st          (-735634.8,-1176759)
2 CzArch_5 layer           bronz         (-566666.7,-1047924)
3 CzArch_6 unspecified feature ne.lin   (-735634.8,-1176759)
4 CzArch_7 unspecified feature ne.lin   (-566666.7,-1047924)

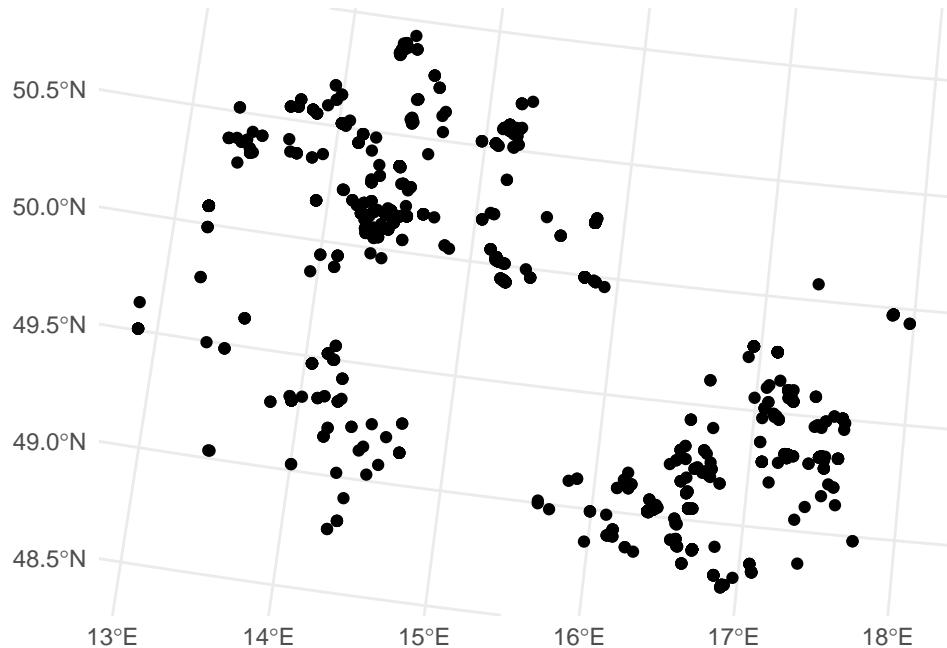
```

<code><chr></code>	<code><chr></code>	<code><chr></code>	<code><POINT [m]></code>
1 CzArch_1 layer		br.st	(-598287.7 -1176759)
2 CzArch_5 layer		bronz	(-735634.8 -1047924)
3 CzArch_6 unspecified feature	ne.lin		(-566666.7 -1099048)
4 CzArch_7 unspecified feature	ne.lin		(-566666.7 -1099048)

Making maps

Geom `geom_sf()`

```
ggplot(lasoles_sjtsk) +
  geom_sf() +
  theme_minimal()
```



Some background data...

Package `RCzechia` has spatial data for the Czech republic...

```
kraje <- RCzechia::kraje()
head(kraje, 4)
```

```

Simple feature collection with 4 features and 3 fields
Geometry type: GEOMETRY
Dimension:     XY
Bounding box:  xmin: 12.40056 ymin: 48.55189 xmax: 15.60422 ymax: 50.61901
Geodetic CRS:  WGS 84
  KOD_KRAJ KOD_CZNUTS3      NAZ_CZNUTS3           geometry
1      3018      CZ010 Hlavní město Praha MULTIPOLYGON (((14.49806 50...
2      3026      CZ020 Středočeský kraj POLYGON ((15.16973 49.61046...
3      3034      CZ031 Jihočeský kraj MULTIPOLYGON (((15.4962 48....
4      3042      CZ032 Plzeňský kraj MULTIPOLYGON (((13.60536 49...

```

```

kraje <- st_transform(kraje, crs = "EPSG:5514")
head(kraje, 4)

```

```

Simple feature collection with 4 features and 3 fields
Geometry type: GEOMETRY
Dimension:     XY
Bounding box:  xmin: -891822.3 ymin: -1211576 xmax: -665628.7 ymax: -989063.4
Projected CRS: S-JTSK / Krovak East North
  KOD_KRAJ KOD_CZNUTS3      NAZ_CZNUTS3           geometry
1      3018      CZ010 Hlavní město Praha MULTIPOLYGON (((-736092 -10...
2      3026      CZ020 Středočeský kraj POLYGON ((-696420.7 -110267...
3      3034      CZ031 Jihočeský kraj MULTIPOLYGON (((-681445.6 -...
4      3042      CZ032 Plzeňský kraj MULTIPOLYGON (((-817386.4 -...

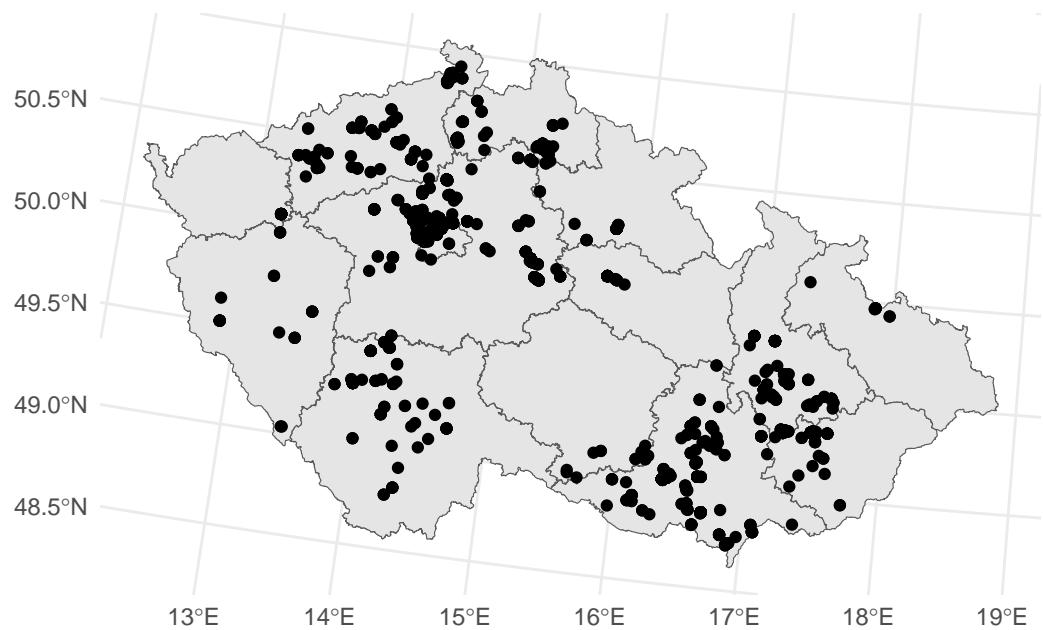
```

Making maps

```

ggplot(lasoles_sjtsk) +
  geom_sf(data = kraje) +
  geom_sf() +
  theme_minimal()

```



Spatial operations

- subsetting
- topological relations

Geometry operations

- centroid
- buffer
- clipping

Where to learn more...

- CRAN Task View: [Analysis of Spatial Data](#)
- Books:

