WORKING WITH GEODATA

GIS PRINCIPLES

GEODATA

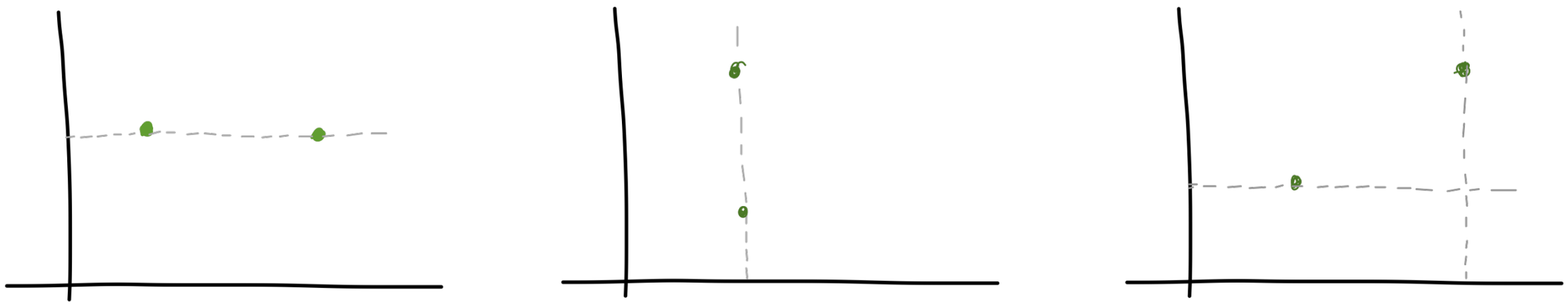
- Spatial information
- Spatial = relating to or occupying space
- E.g. latitude + longitude
- Spatial operations/queries

SPATIAL QUERIES

- Find restaurants closest to this point
- Find villages affected by floods
- Compute areas of industrial buildings in a city
- Find longest cycling route in Bratislava
- ...

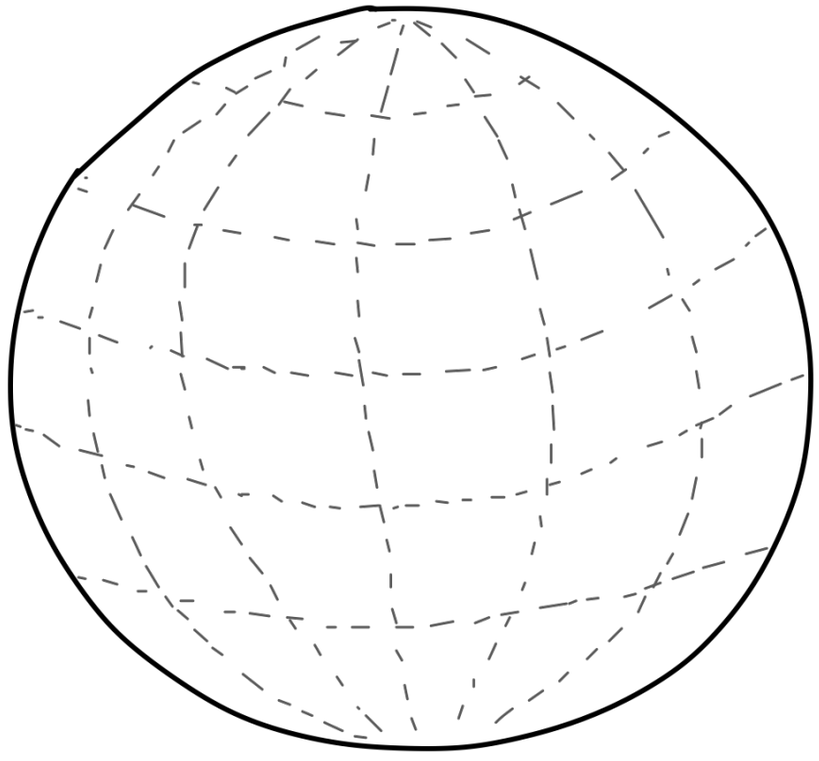
GEOMETRY

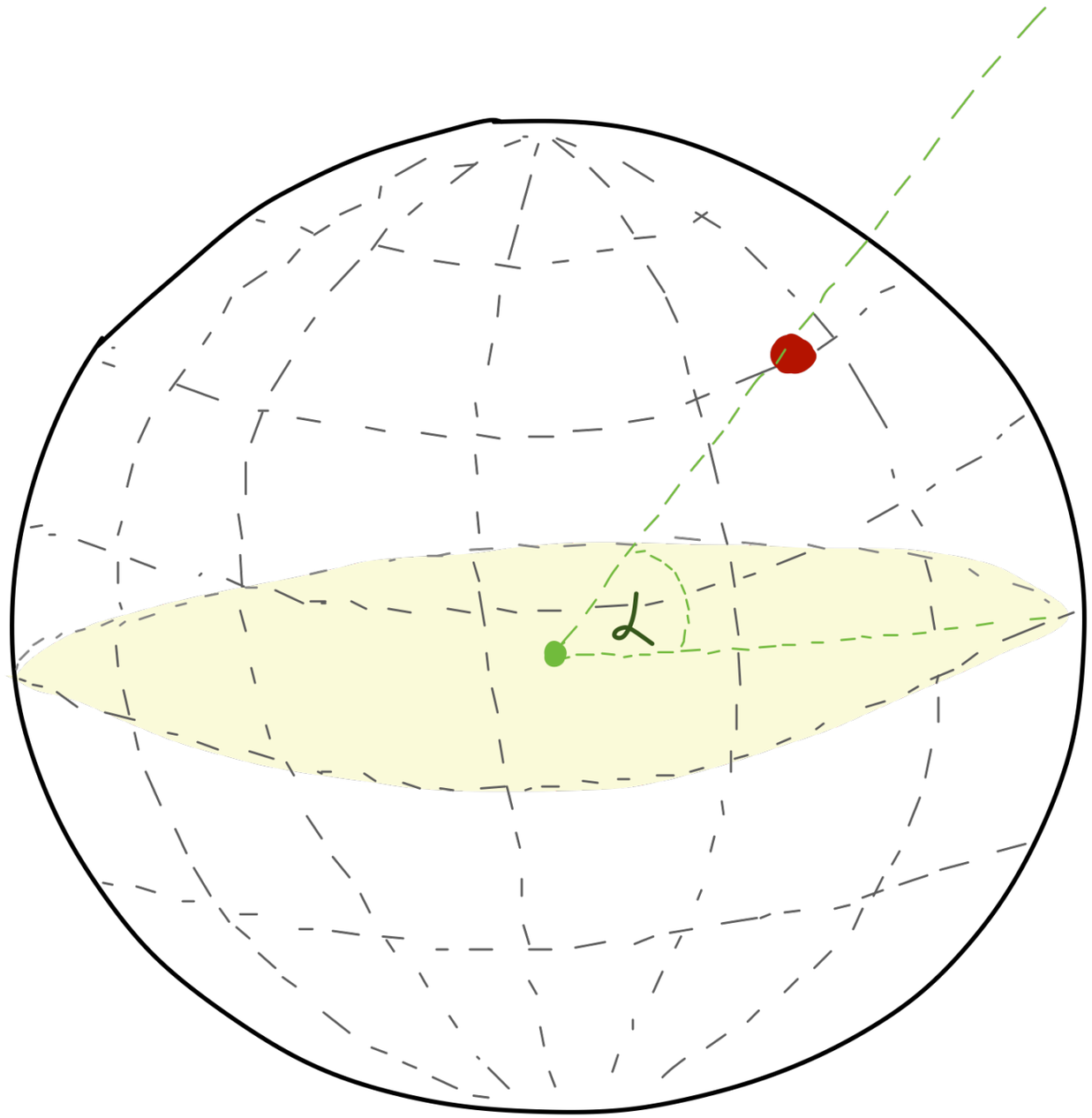
- Spatial operations map to analytical geometry
- E.g. (in 2D)
  - find restaurant closest to point P
  - .. find all restaurants and their points (R)
  - .. compute distance of all R and P
  - .. choose R with the lowest distance

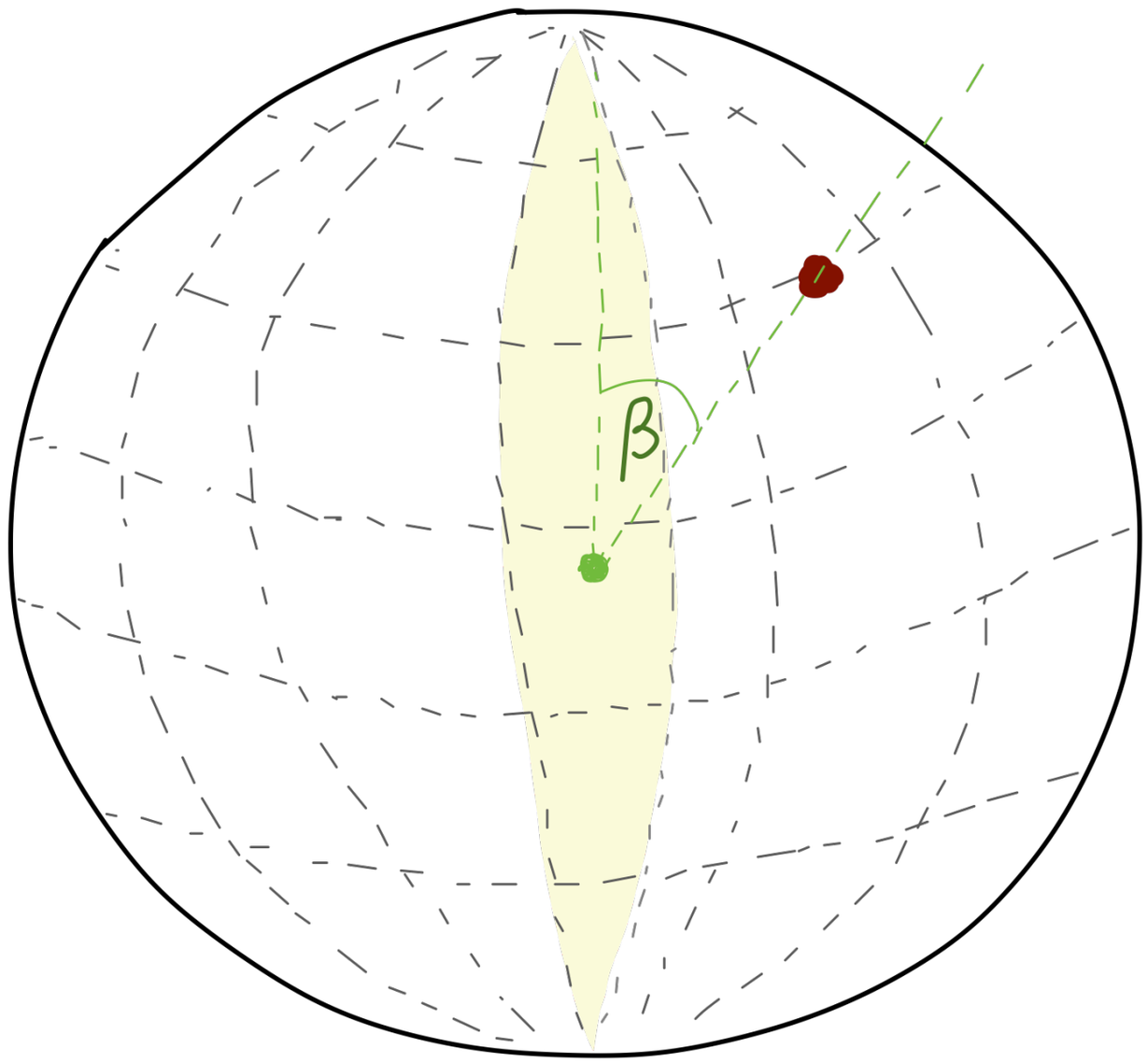


COORDINATE SYSTEM

- Coordinate framework
- Adds meaning to geodata
- E.g.: WGS 84

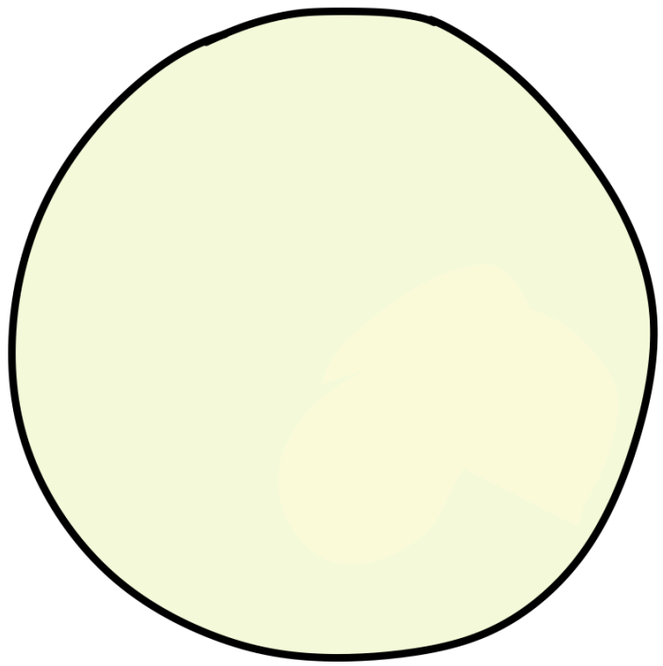



α

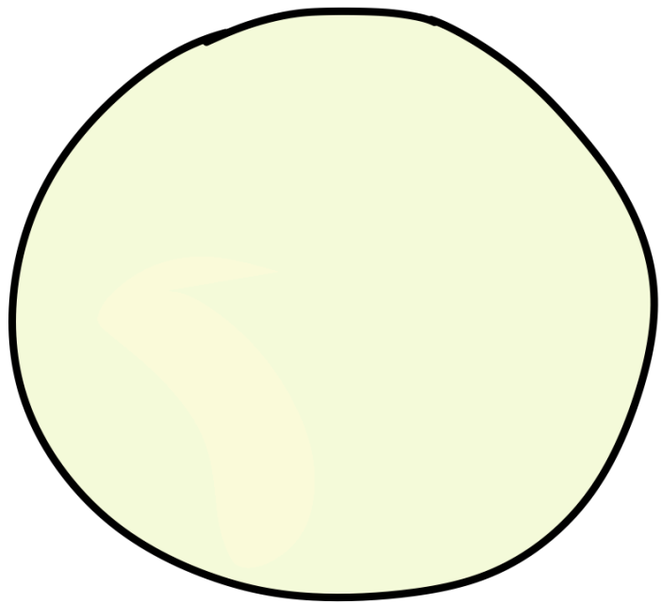

β

COORDINATE SYSTEM

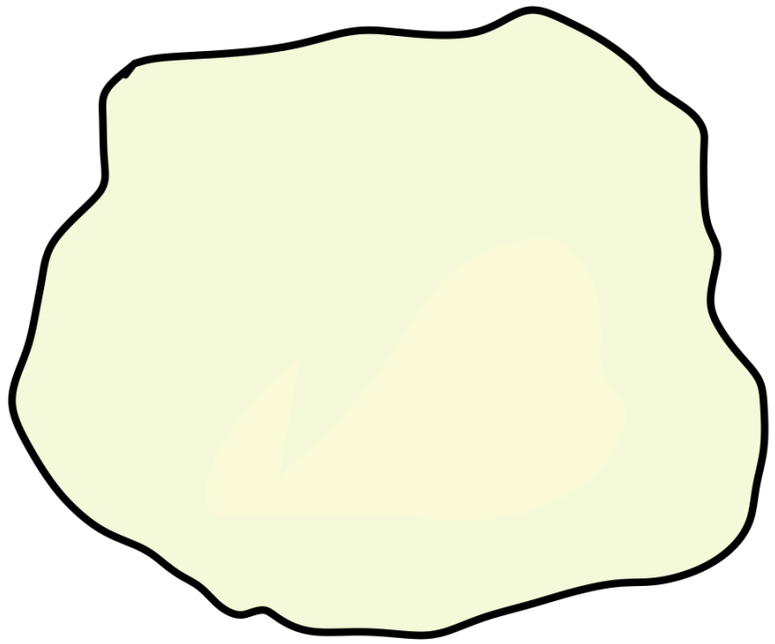
- Measurement framework
  - Geographic (3D)
  - Planimetric (projected) (2D)
- Measurement unit (meters, feed, degrees, ...)
- System properties (reference spheroid, central meridian, ...)



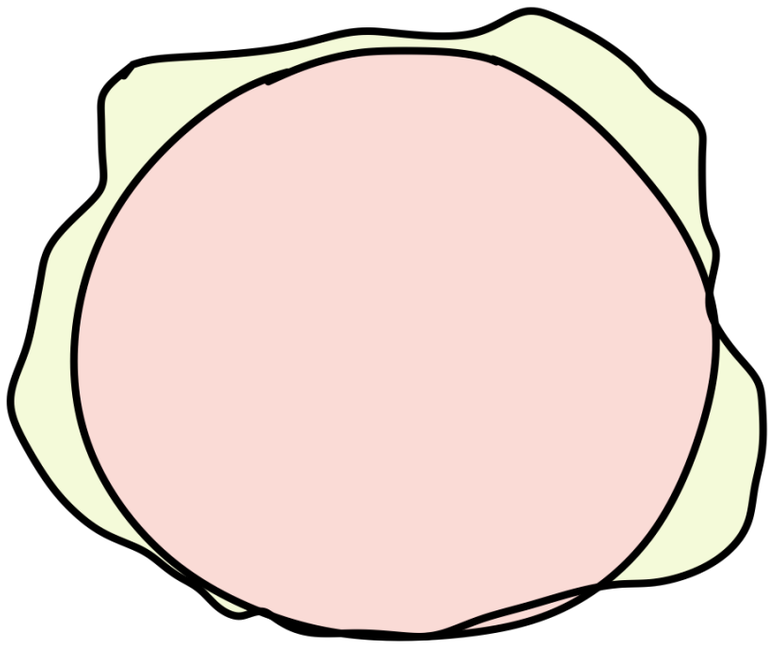
SPHERE

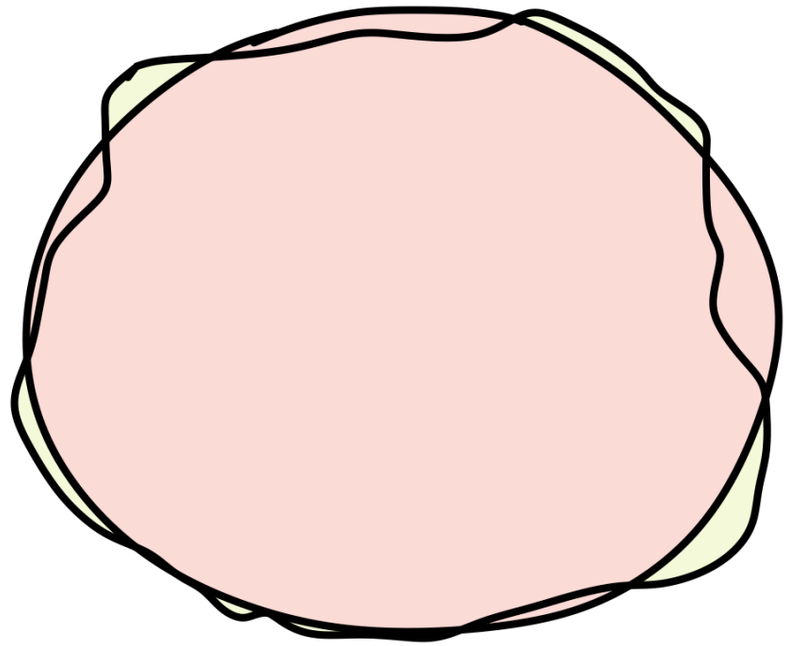


SPHEROID



"REALITY"



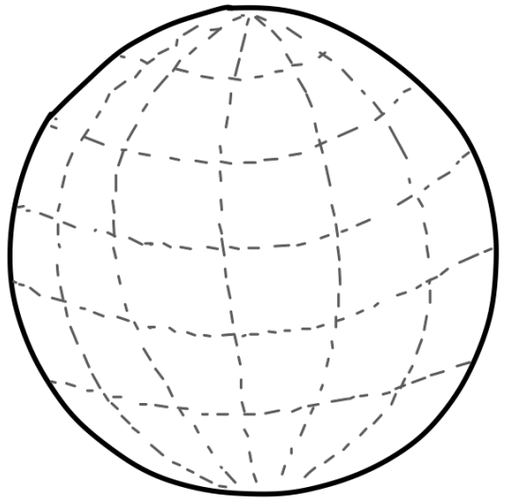


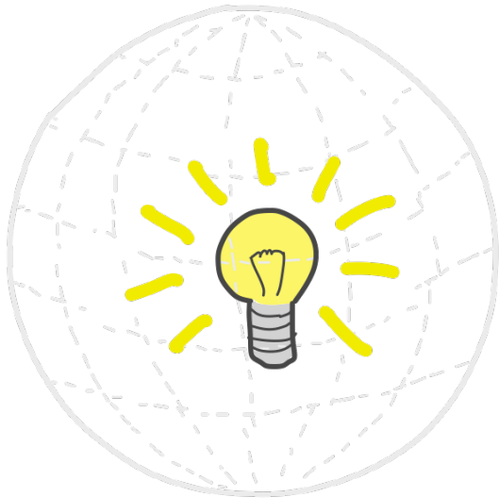
COMBINING COORDINATE SYSTEMS

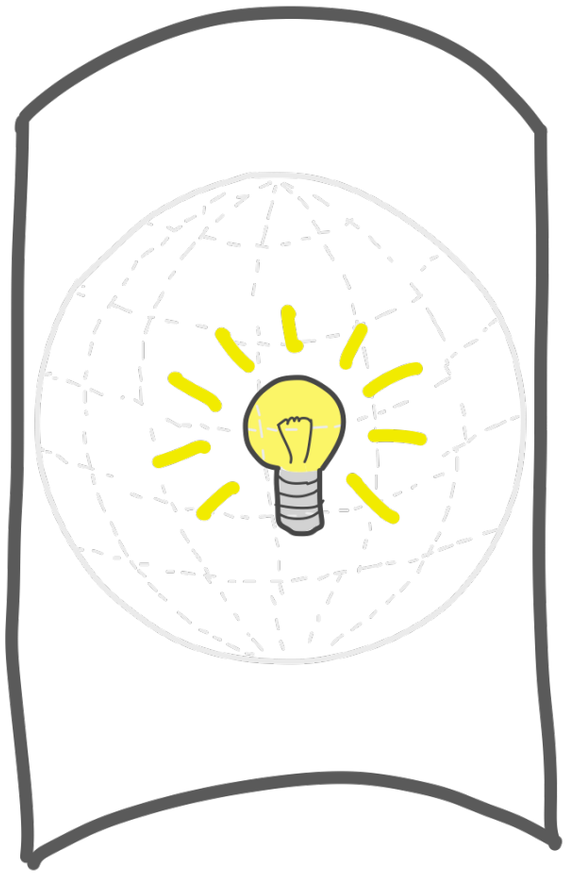
- You don't
- All data must be in the same coordinate system for meaningful result
- Coordinate system transformations

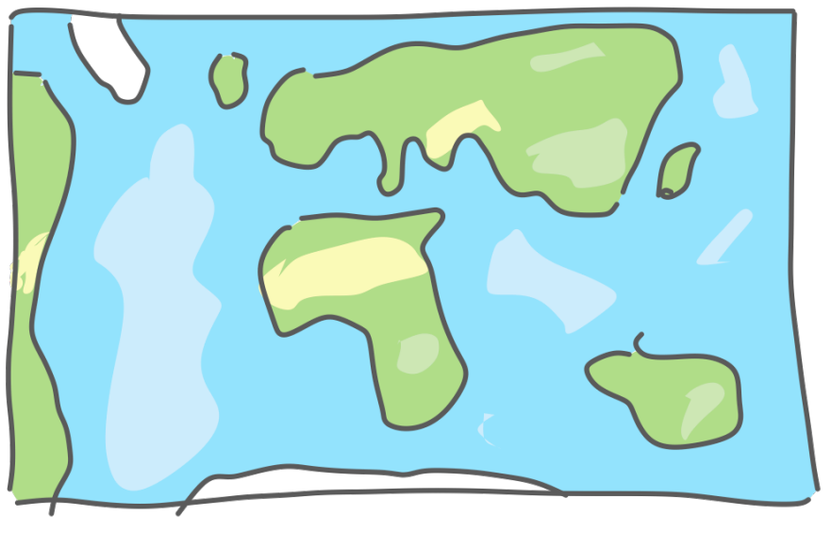
PROJECTIONS

- Transform 3d space into 2d space (a map)
- Mathematical transformations
- 100s of projections
- Best known: Mercator









MERCATOR PROPERTIES

- Distorts distances (play Mercator puzzle - http://hive.sewanee.edu/ldale/maps/10/06-LOCAL.html)
- Preserves shapes (compare to, e.g., Winkel Tripel)

POSTGIS

GEOGRAPHIC INFORMATION SYSTEM (GIS)

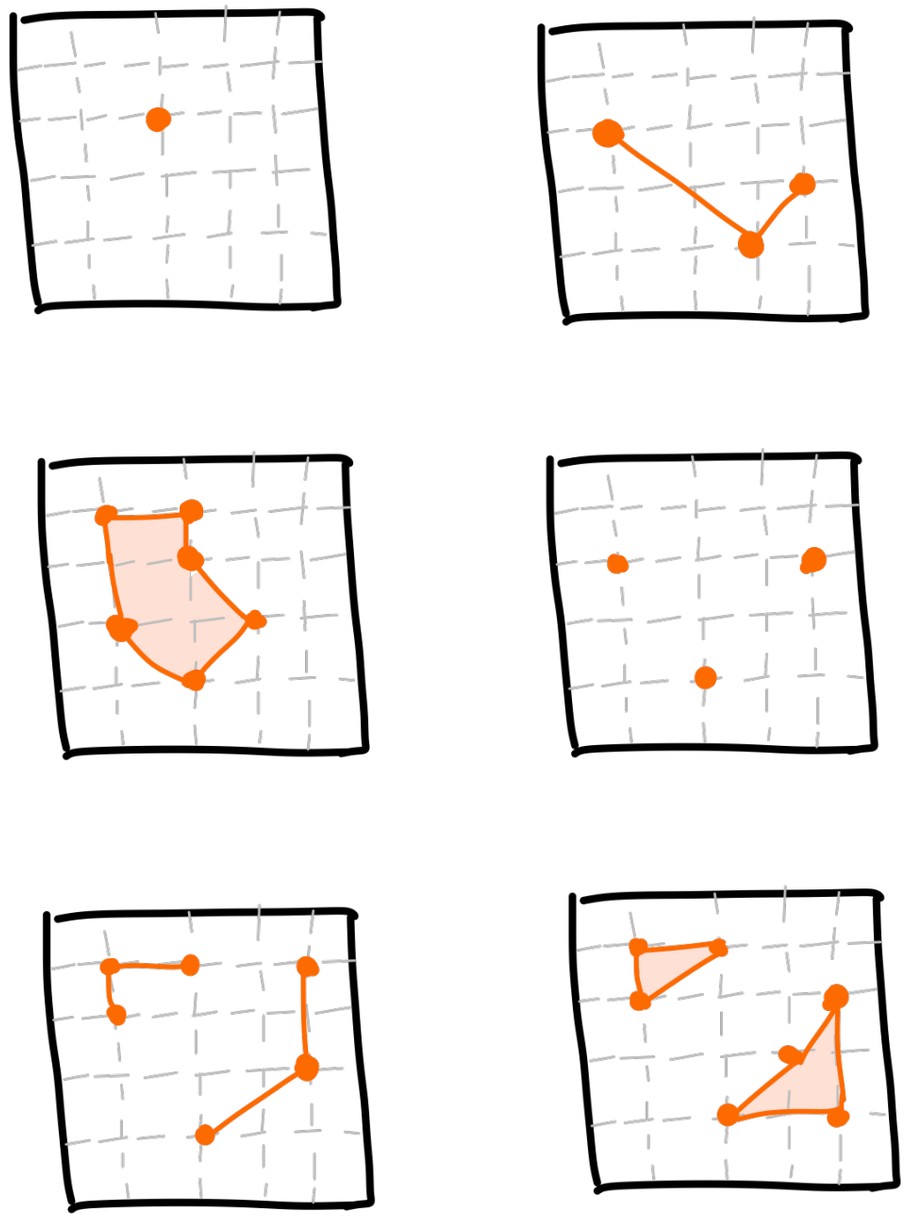
- Provides tools for working with geodata
  - understands coordinate systems
  - provides spatial datatypes
  - provides spatial operations
- Many existing systems
  - ArcGIS, Oracle Spatial, PostGIS

POSTGIS

- Free
- https://postgis.net
- Installation
  - Install PostGIS
  - In the database where you want to use it, run: `create extension postgis;`

BASIC DATATYPES

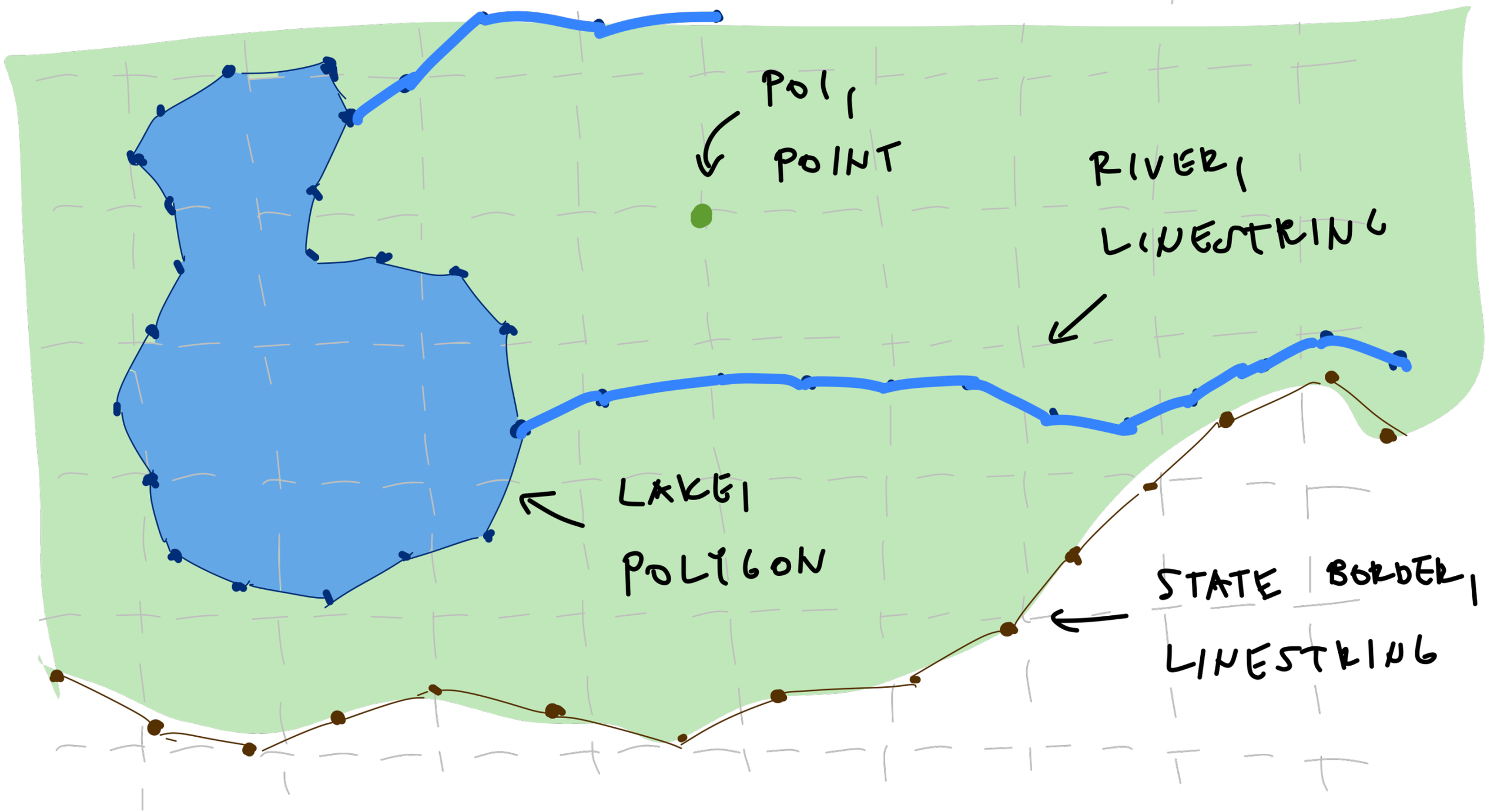
- Point
- LineString
- Polygon
- MultiPoint
- MultiLineString
- MultiPolygon



SPATIAL REFERENCE

- SRID
- https://epsg.io/3857

MAP FEATURES – COMPOSED OF BASIC DATATYPES



DRAWING MAPS

- Map tiles generated by a map server
- Map tile = geodata, rendered and styled with CartoCSS/GL style/…

```
#water {
  line-width: 1;
  fill: #f2d734;
}
```

https://studio.mapbox.com

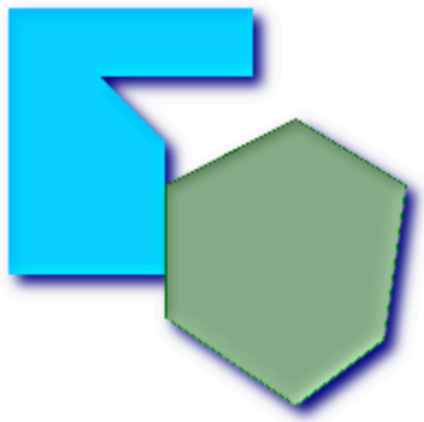
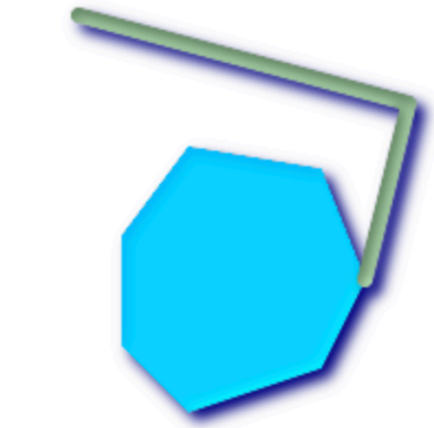
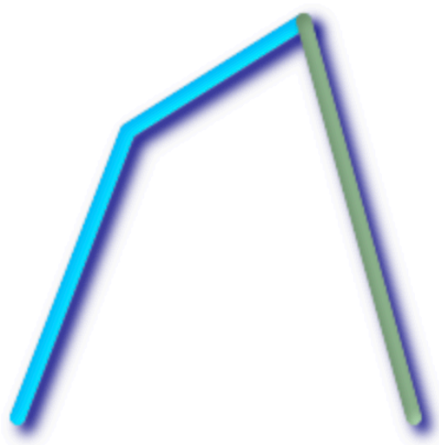
GEO OPERATIONS

- st_touches
- st_intersects
- st_distance
- st_dwithin
- st_contains
- st_area
- st_expand
- st_transform
- ...

GEO OPERATIONS

- Defined for various geo datatypes separately
- Consult the docs
- E.g.

The `ST_Touches` predicate returns **`TRUE`** in all the following illustrations.

		
POLYGON / ***POLYGON***	***POLYGON*** / ***POLYGON***	***POLYGON*** / ***LINESTRING***
		
LINESTRING / ***LINESTRING***	***LINESTRING*** / ***LINESTRING***	***POLYGON*** / ***POINT***

ST_TOUCHES

- Are two geometries touching?
- https://postgis.net/docs/ST_Touches.html
- E.g.: are these 2 districts neighbors?

```
select st_touches(d1.way, d2.way)
  from districts d1
 cross join districst d2
 where d1.name = 'Okres Senec'
   and d2.name = 'Okres Galanta'
```

DEMO:
FIND NEIGHBORING DISTRICS FOR 'KARLOVA VES'

ST_INTERSECTS

- Are two geometries intersecting?
- https://postgis.net/docs/ST_Intersects.html
- E.g.: are these 2 paths crossing?

```
select st_intersects(r.way, b.way)
  from rivers r
 cross join bridges b
 where b.name = 'Lafranconi'
   and r.name = 'Dunaj'
```

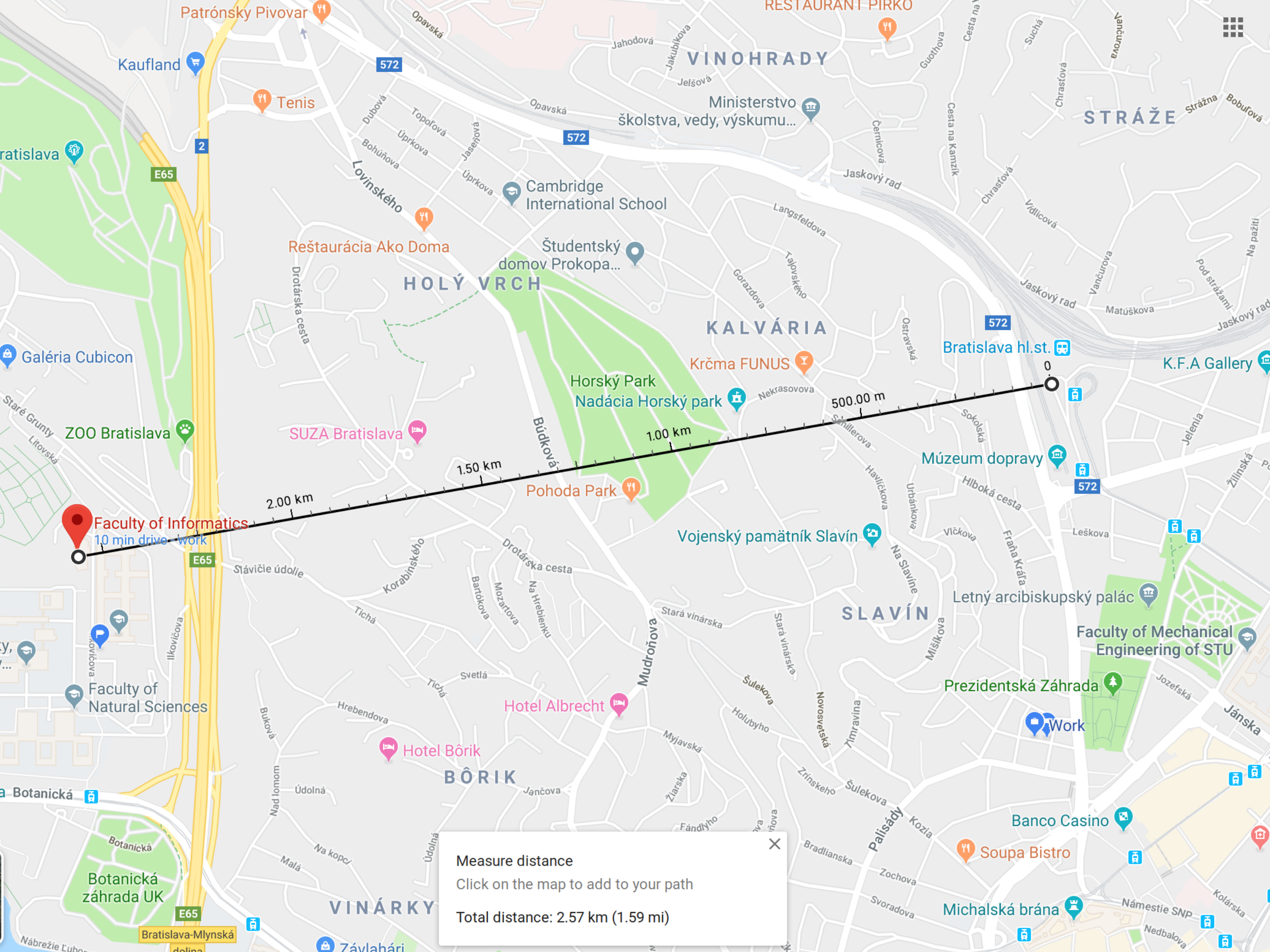
DEMO: FIND BRIDGES OVER DANUBE

ST_DISTANCE

- What is the distance between 2 geometries?
- https://postgis.net/docs/ST_Distance.html
- E.g.: How far away is point A from point B?

```
select st_distance(
  (select p.way from pois p where p.name = 'A'),
  (select p.way from pois p where p.name = 'B')
)
```

DEMO:
FIND DISTANCE BETWEEN FIIT STU AND MAIN TRAIN STATION


Patrónsky Pivovar
Kaufland
Tenis
572
Opavská
Jahodová
Jakubíkova
VINOHRADY
RESTAURANT PIRKO
Guothova
Cesta na Kamzík
Suchá
Vančurova
Chrastová
Ministerstvo školstva, vedy, výskumu...
Jelšová
Černicová
Jaskový rad
STRÁŽE
Strážna
Bobuľová
ratislava
E65
2
Dubová
Topoľová
Úprkova
Jaseňová
Bohúňova
Lovinského
Cambridge International School
Langsfeldova
Chrastová
Vidlicová
Reštaurácia Ako Doma
Študentský domov Prokopa...
HOLÝ VRCH
Drotárska cesta
Gorazdova
Tajovského
Vančurova
Matúškova
Na pažiti
Pod strážami
KALVÁRIA
Ostravská
Galéria Cubicon
Krčma FUNUS
Bratislava hl.st.
0
K.F.A Gallery
Horský Park
Nadácia Horský park
Nekrasovova
500.00 m
1.00 km
1.50 km
2.00 km
Staré Grunty
Litovská
ZOO Bratislava
SUZA Bratislava
Búdková
Schillerova
Sokolská
Múzeum dopravy
Jelenia
Žilinská
Pohoda Park
Havlíčkova
Urbánkova
Hlboká cesta
Vlčkova
Fraňa Kráľa
Leškova
Vojenský pamätník Slavín
Na Slavíne
SLAVÍN
Letný arcibiskupský palác
Faculty of Mechanical Engineering of STU
Faculty of Informatics
10 min drive · work
Slávičie údolie
Korabinského
Drotárska cesta
Bartókova
Mozartova
Na Hrebienku
Tichá
Stará vinárska
Mudroňova
Mišíkova
Prezidentská Záhrada
Jozefská
Jánska
Faculty of Natural Sciences
Ilkovičova
Svetlá
Hotel Albrecht
Šulekova
Novosvetská
Zimná
Work
Hrebendova
Bukova
Hotel Bôrik
Holubyho
Myjavská
Zrínskeho
Banco Casino
Soupa Bistro
Botanická
Nad lomom
Údolná
BÔRIK
Jančova
Žiarska
Fándlyho
Palisády
Kozia
Bradlianska
Zochova
Botanická záhrada UK
Na kopci
Malá
VINÁRKY
Svoradova
Michalská brána
Námestie SNP
Kolárska
Nedbalova
Bratislava-Mlynská dolina
Nábrežie Ľ. Štúra
Measure distance
Click on the map to add to your path
Total distance: 2.57 km (1.59 mi)

ST_DISTANCE UNITS

- Keep in mind the spatial reference unit
- Use geography datatype (cast with ::geography) to calculate distance in spheroid

ST_DWITHIN

- Is the geometry within distance of other geometry?
- https://postgis.net/docs/ST_DWithin.html
- E.g.: Select all points within 1000 meters of point B

```
select r.name
  from buildings b
  join restaurants r on st_dwithin(b.way, r.way,
1000)
 where b.name = 'FIIT STU'
```

DEMO: RESTAURANTS WITHIN 1KM OF FIIT STU

ST_CONTAINS

- Is the geometry contained within other geometry?
- https://postgis.net/docs/ST_Contains.html
- E.g.: Select all bus lines which operate only within the city

```
select b.number
  from bus_lines b
  cross join cities c
 where st_contains(c.way, b.way)
   and c.name = 'Bratislava'
```

DEMO:
FIND ALL STREETS WITHIN DLHÉ DIELY

SUMMARY (WHAT YOU SHOULD KNOW)

- Understand coordinate systems and that you can't combine them (without transformation)
- Understand how projections skew distances
- Write a simple GIS query using the basic GIS functions