

An introduction to the geospatial world

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[\(napo@fbk.eu\)](mailto:(napo@fbk.eu))

Agenda

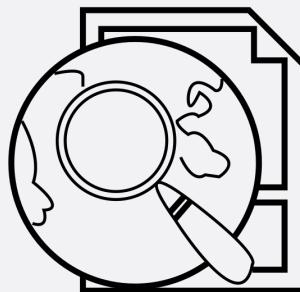
The GIS Cookbook
Geocoding Love&Hate
The OpenStreetMap Ecosystem
Geospatial & Python

the GIS cookbook



Projections

Data Model



Distribution protocols

Spatial Analysis



Rendering

special guest: geocoding

Flat earth?



The
FLAT EARTH
SOCIETY

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@FlatEarthOrg

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 tfes.org

 Iscritto a dicembre 2013

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 [Messaggio](#)

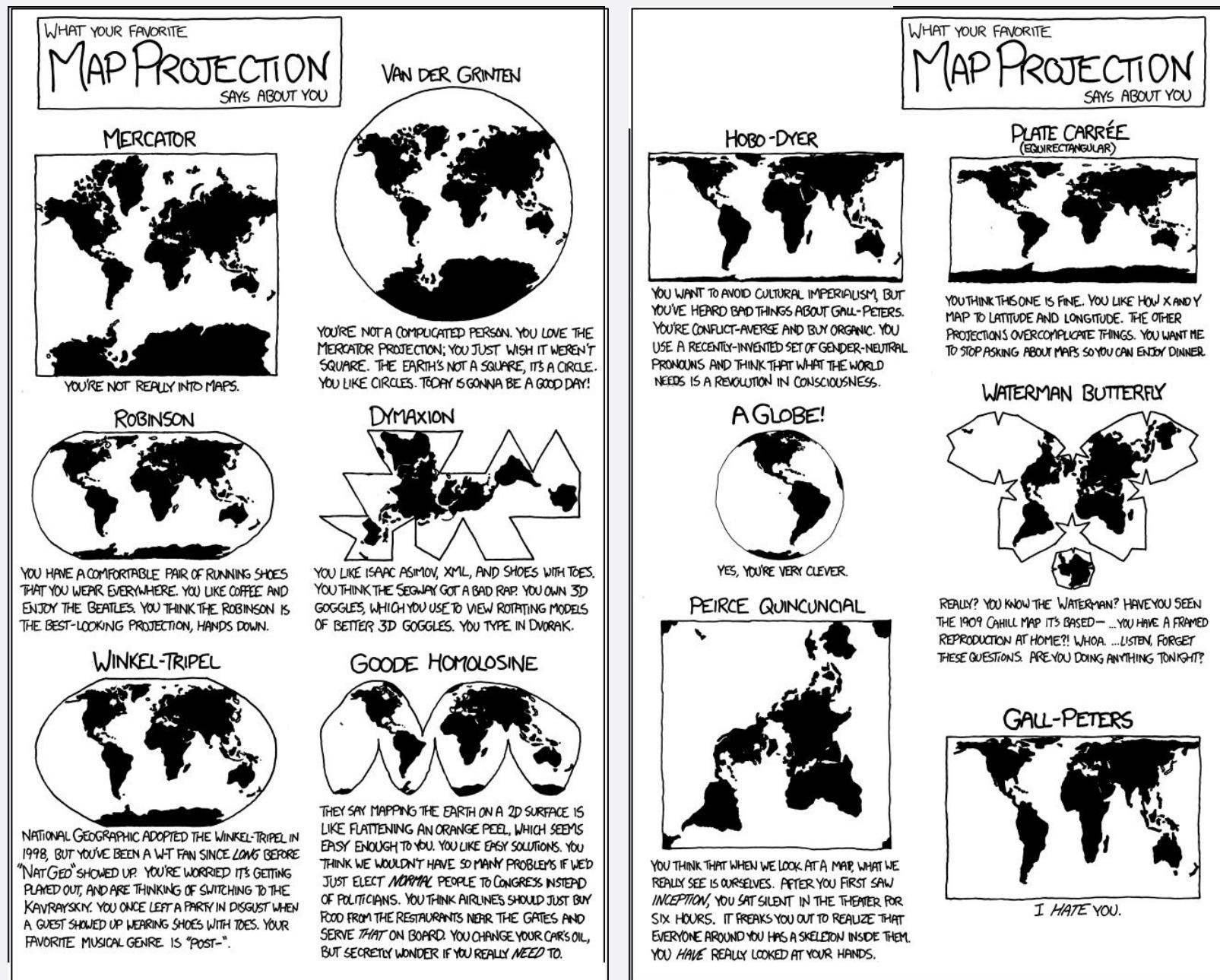
 352 foto e video

Tweet	Tweet e risposte	Contenuti
 Tweet fissato Flat Earth Society  @FlatEarthOrg - 1 giu In risposta a @NewYorker One has to wonder about the state of our mainstream media when staunch empiricism is described as "post-truth" by major outlets.  Traduci il Tweet  146  19  71 		
 Flat Earth Society  @FlatEarthOrg - 5 h facebook.com/FlatSoc tfes.org		

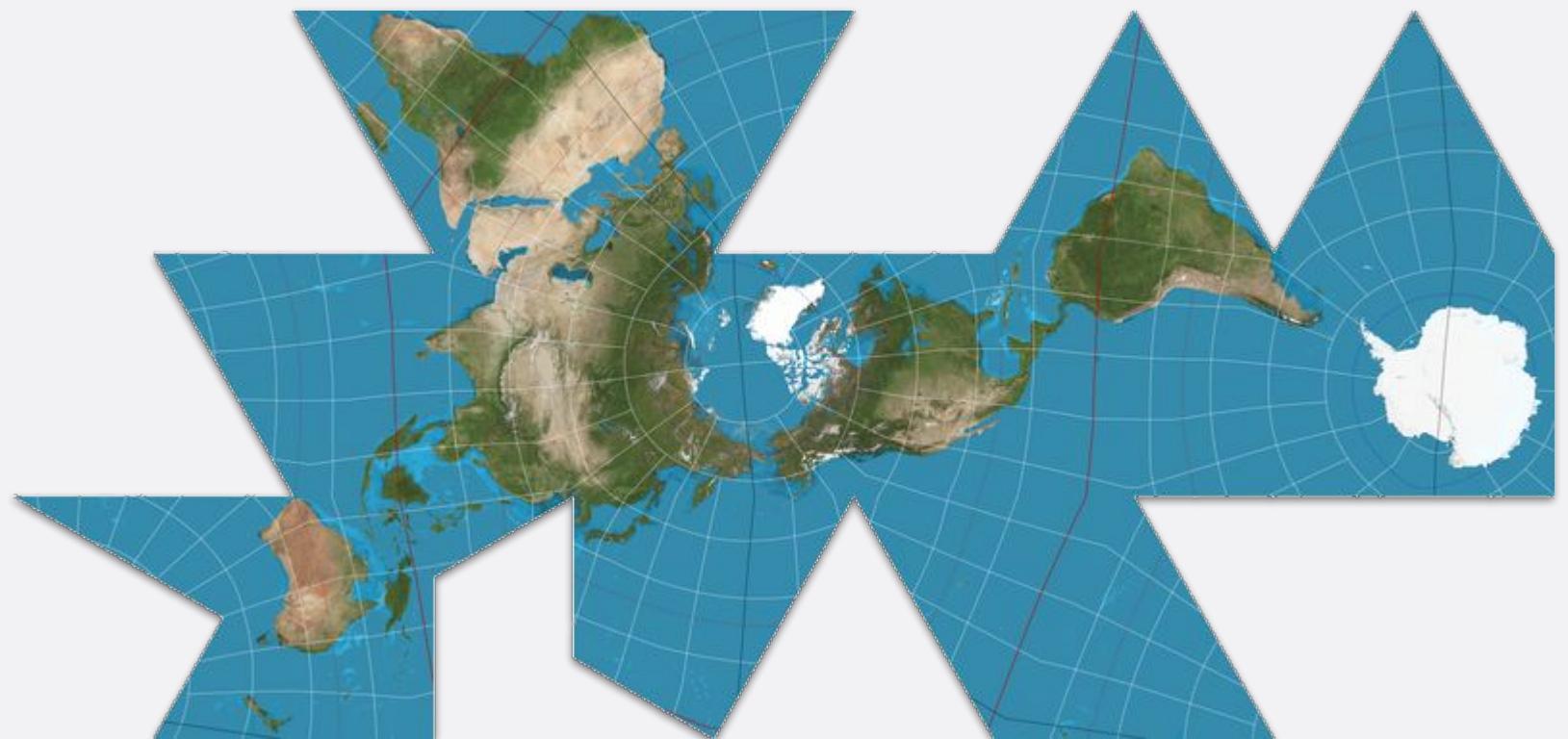
 @napo



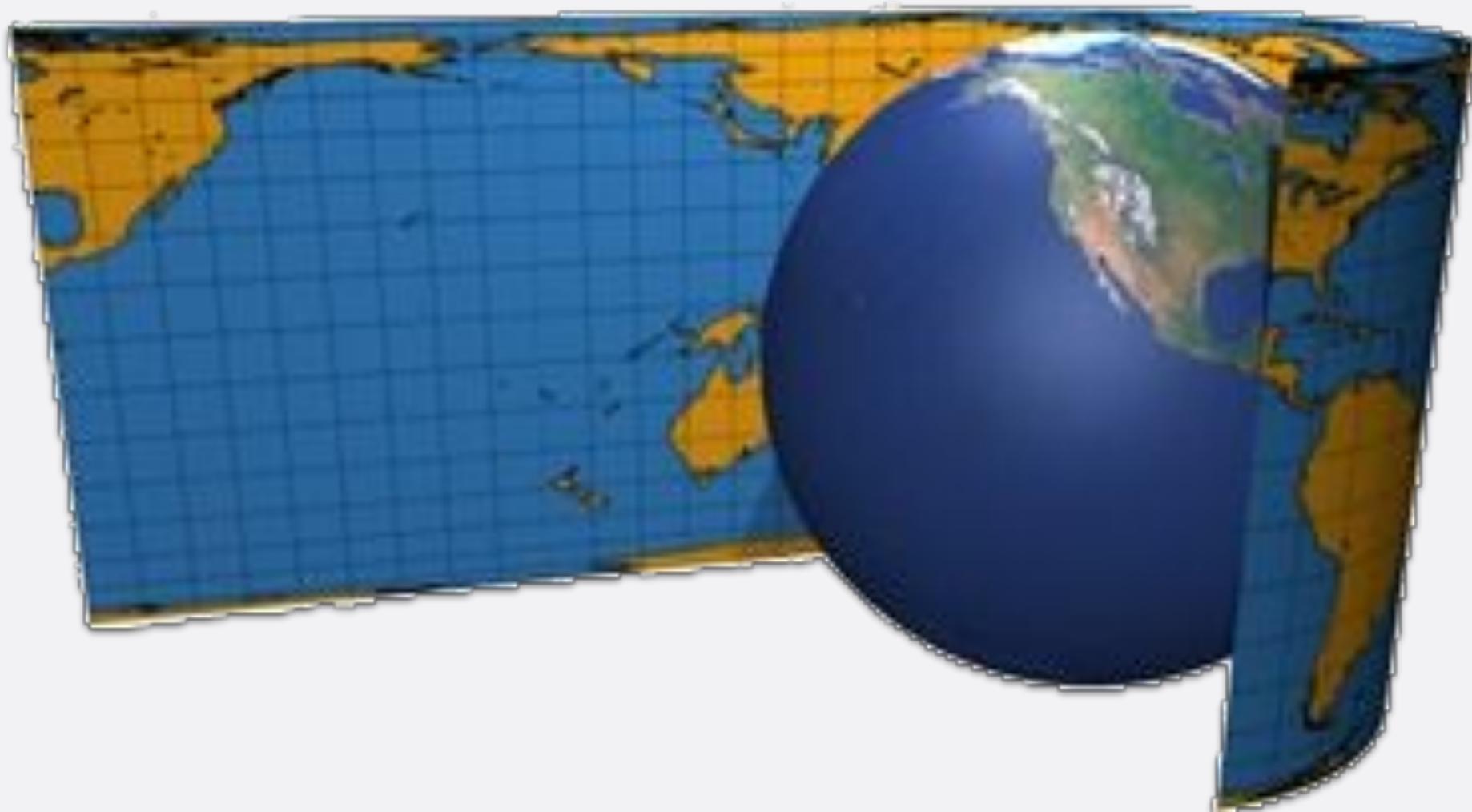
Projections



Dymaxion

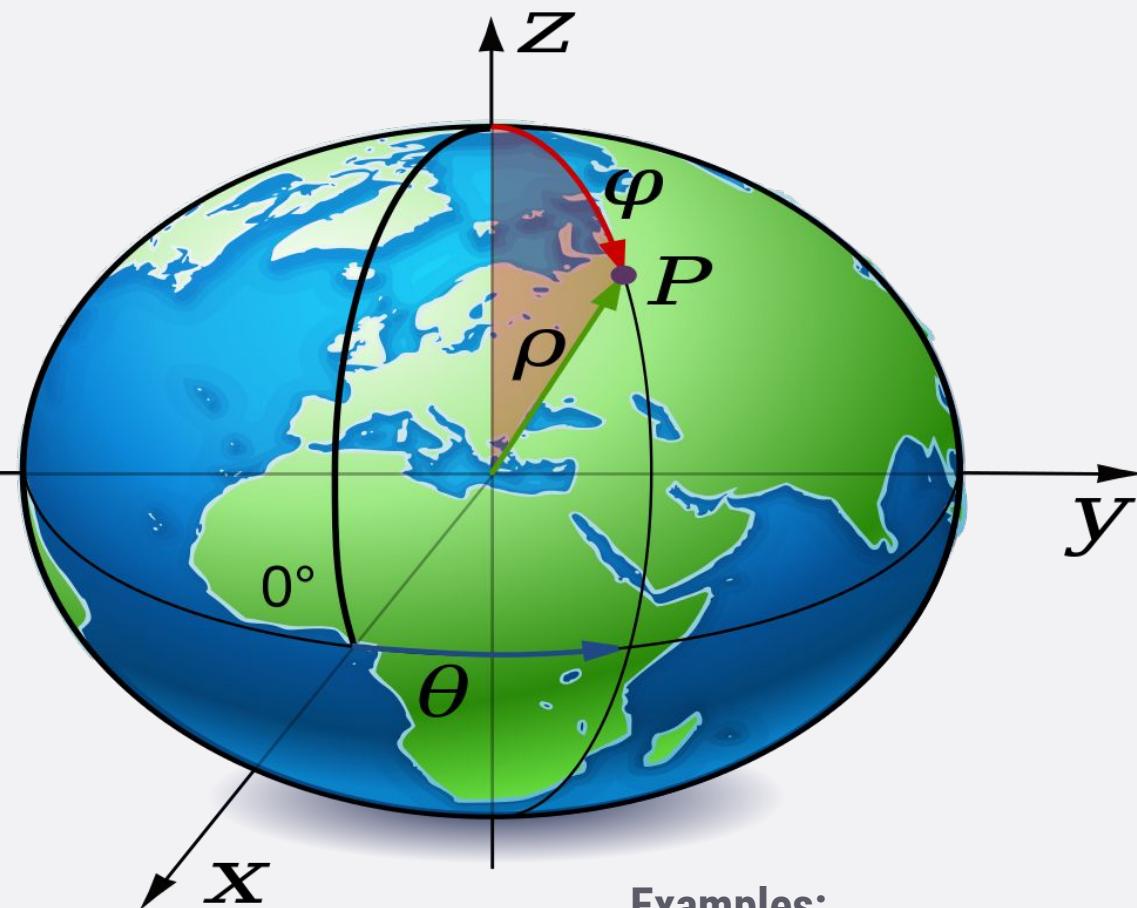


Cylindrical projection

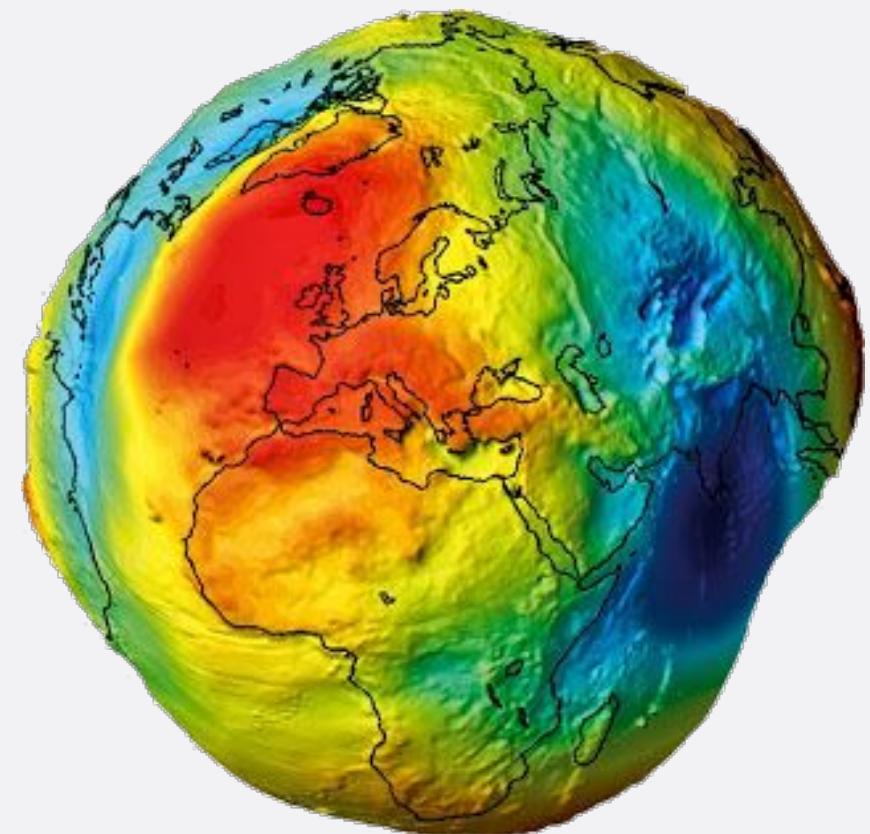


Datum

oblate spheroid



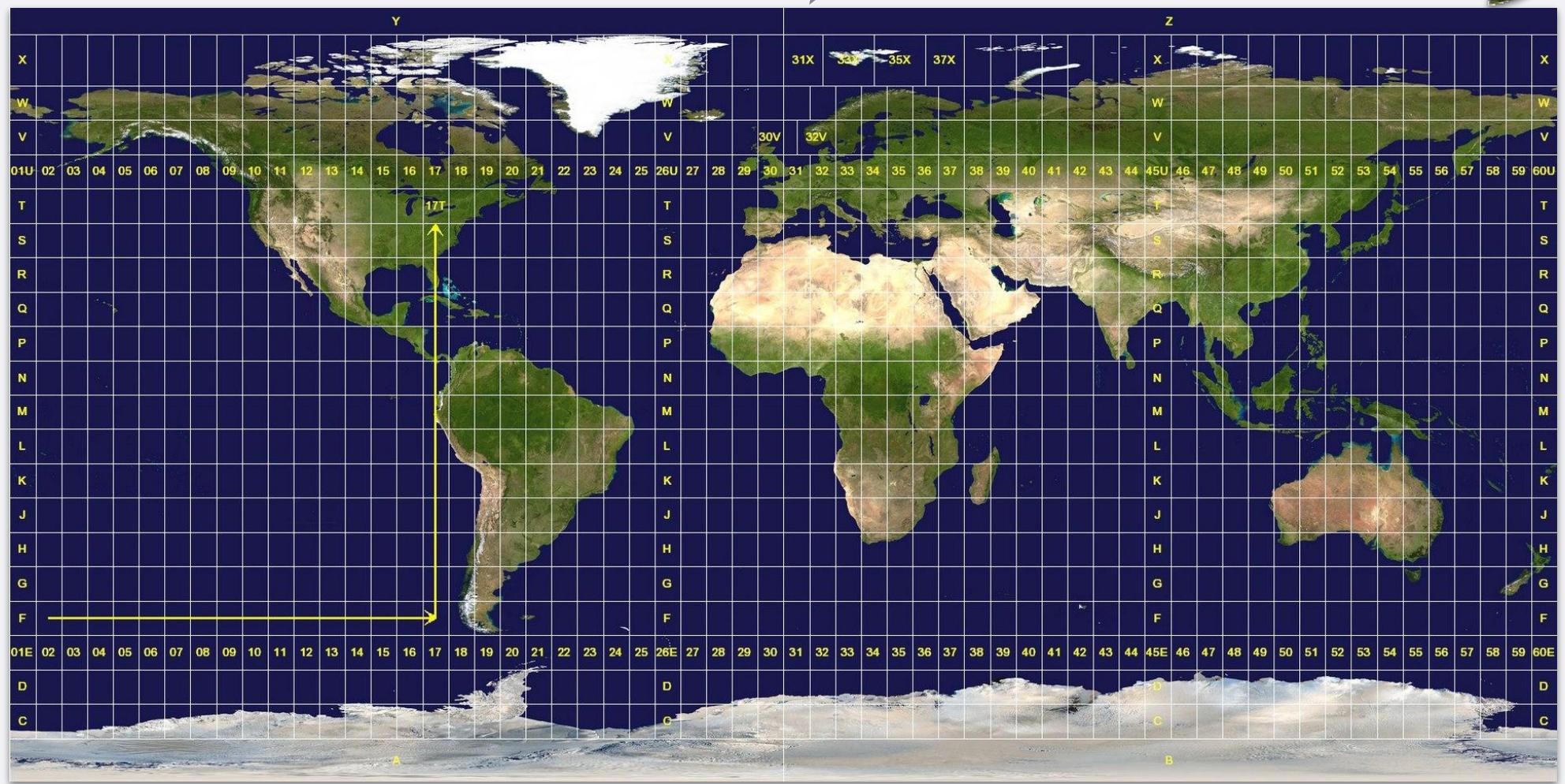
geoid



Examples:

- **Rome 40**
- **European Datum 1950**
- **European Terrestrial Reference System 1989**
- **World Geodetic System 1984**

Universal Transverse Mercator



The most used for the web

EPSG:4326 - WGS84

- Degree (lat/long)
- WGS84

EPSG: 3857 - Web Mercator

- Meters
- WGS84
- World without polos

former EPSG: 900913 Google
Mercator
(digit version of the word Google)

EPSG???



International
Association
of Oil & Gas
Producers

former
European Petroleum Survey Group

<http://www.epsg.org/>



<http://spatialreference.org/>



<http://epsg.io/>

DATA MODELS

Discrete Data

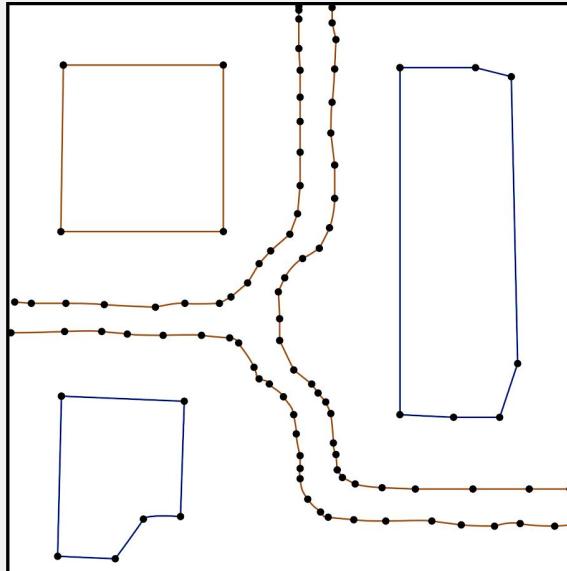
Vectors with attributes

Eg.

Points

Lines

Polygons



Continuous Data

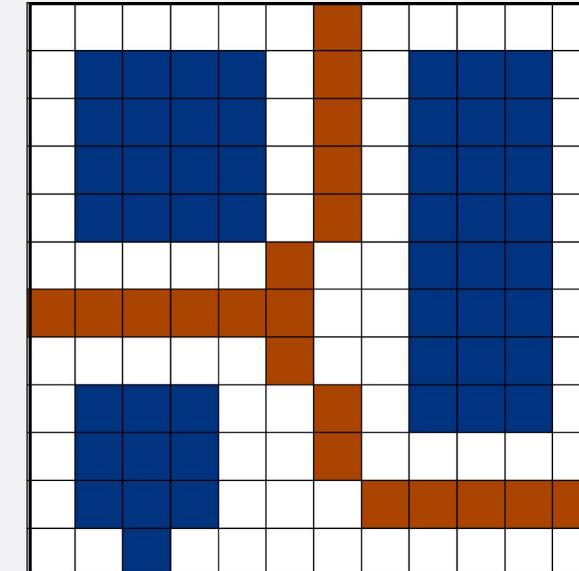
Matrix

Eg.

Digital Elevation Models

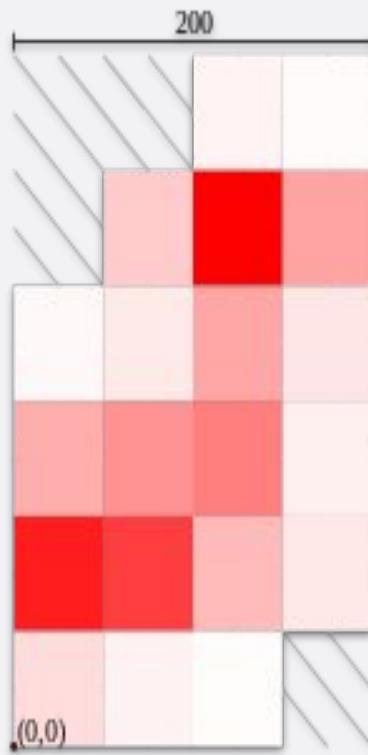
Solar Power Cells

Orthophotos



Example RASTER

GRID IMAGE



VALUES

	25	75	125	175
275	NA	NA	5	2
225	NA	20	100	36
175	3	8	35	10
125	32	42	50	6
75	88	75	27	9
25	13	5	1	NA

ASCII Grid Format

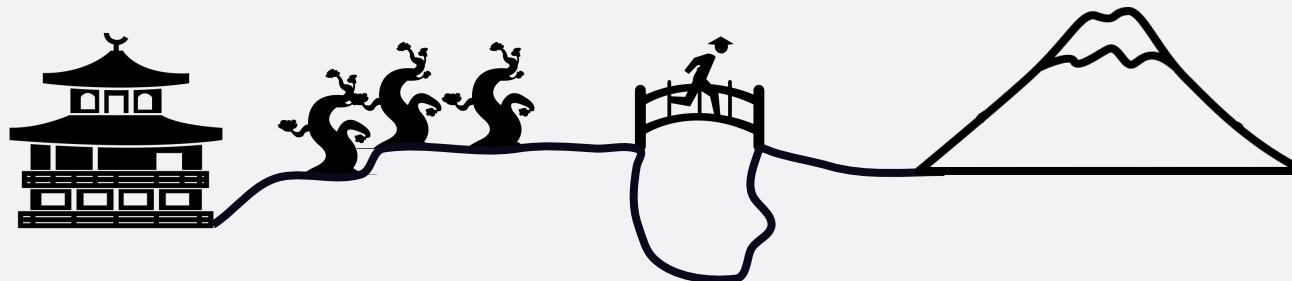
```
ncols          4
nrows          6
xllcorner     0.0
yllcorner     0.0
cellsize       50.0
NODATA_value -9999
-9999 -9999 5 2
-9999 20 100 36
3 8 35 10
32 42 50 6
88 75 27 9
13 5 1 -9999
```

https://en.wikipedia.org/wiki/Esri_grid

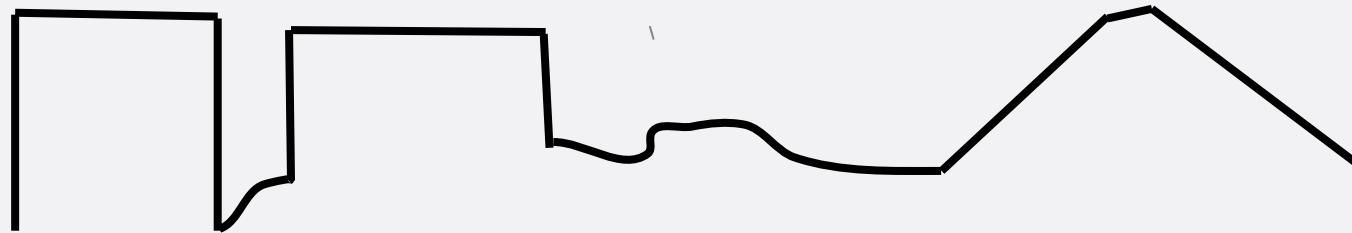
DSM vs DTM

DEM is often used as a generic term for DSMs and DTMs

Real World



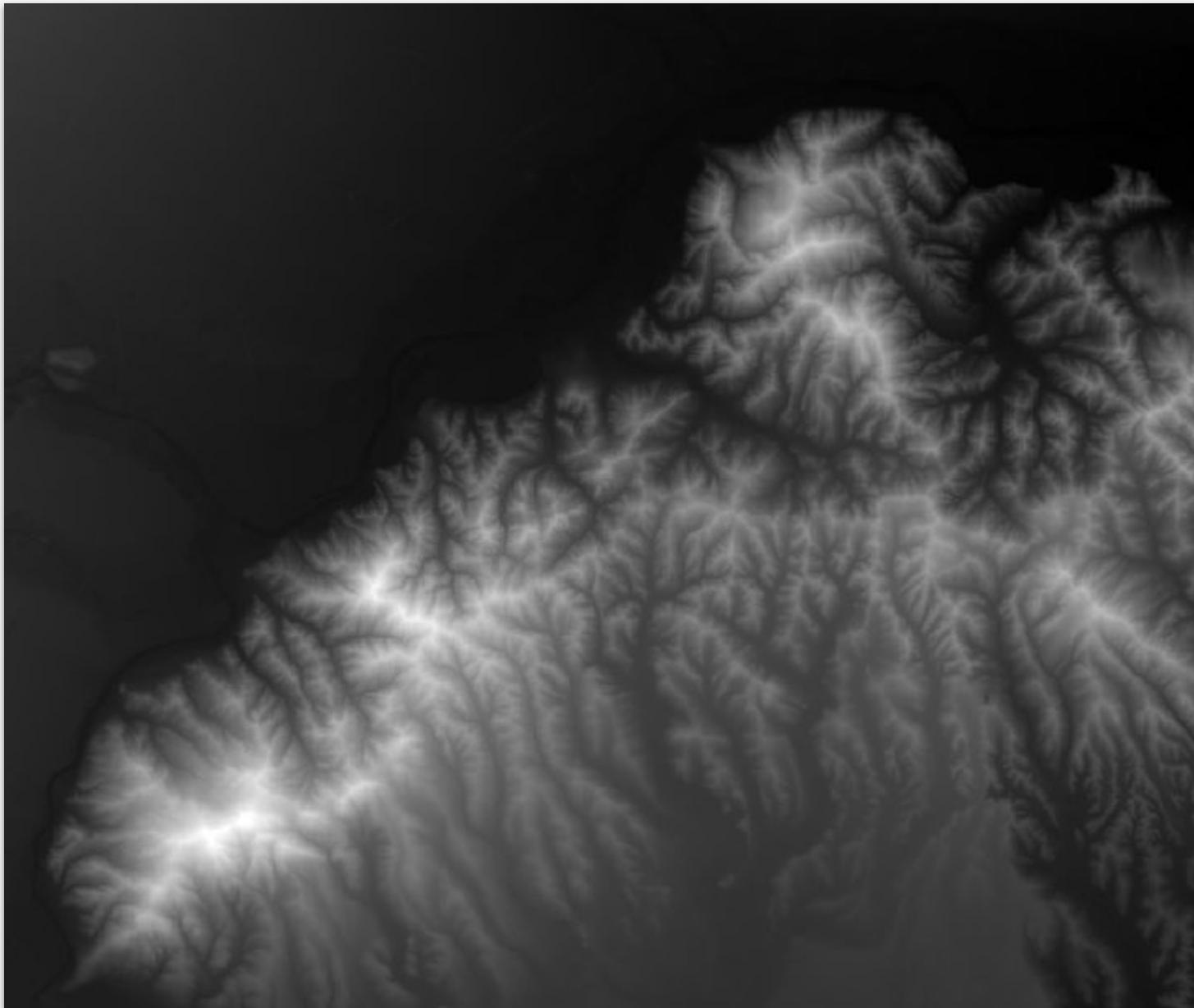
Digital Surface Model (DSM)



Digital Terrain Model (DTM)



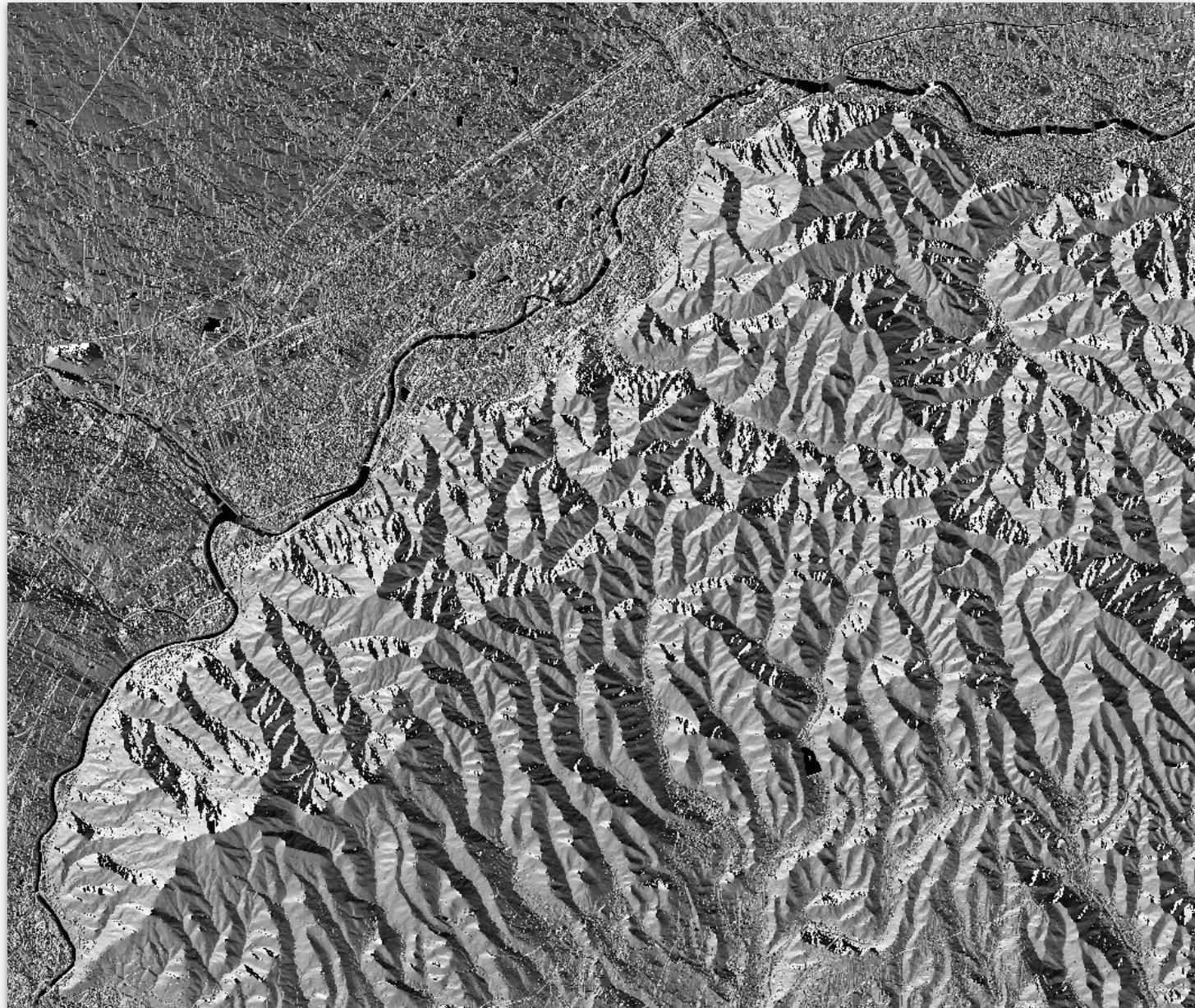
DTM - shades of gray



DTM - slope

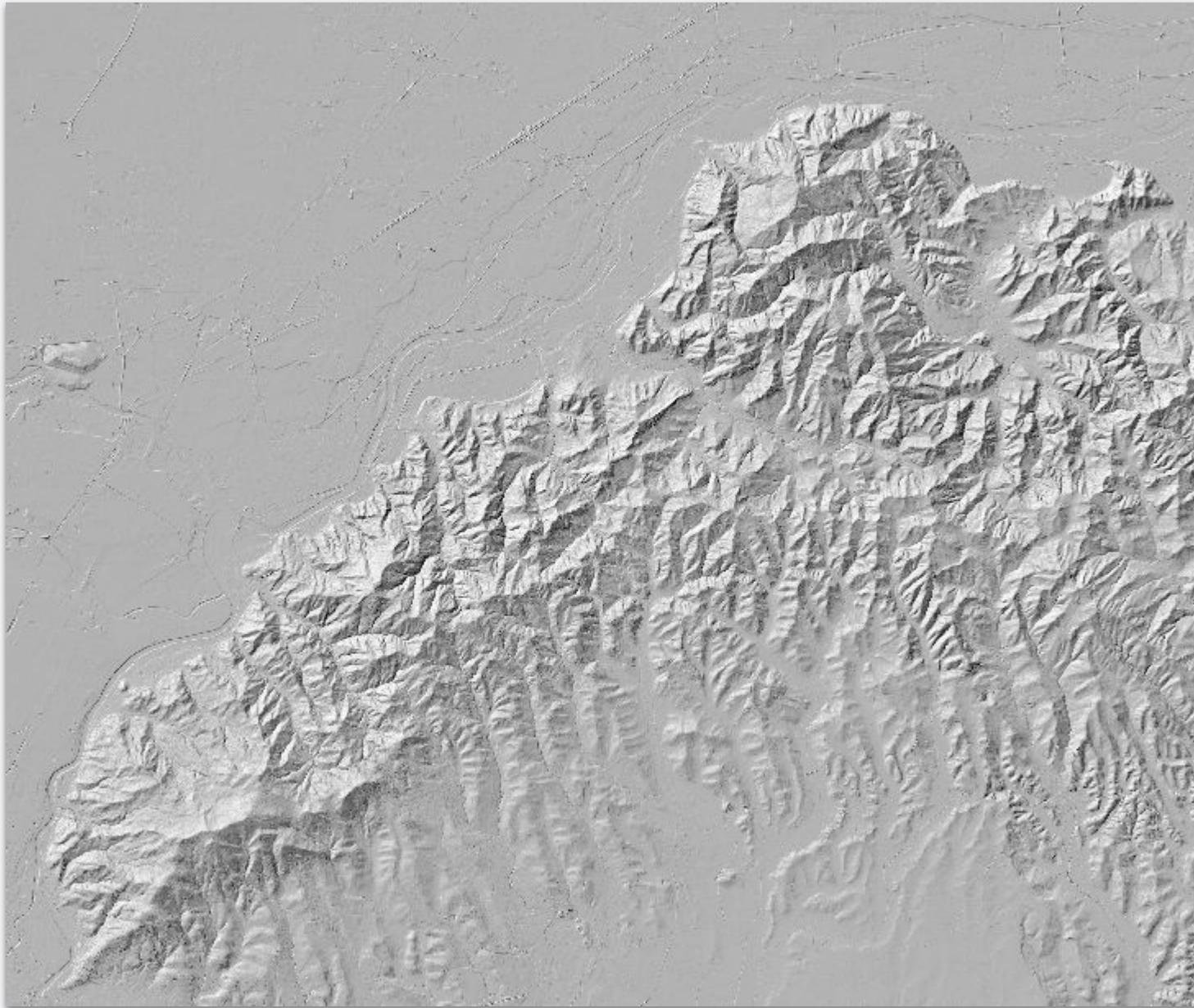


DTM aspect



aspect is the compass direction that a slope faces

DTM Hillshade



simulation of lighting intensity with a shading effect from an azimuth and altitude of light
it can be used to produce the impression of the terrain relief.

Example Vector

```
{  
  "type": "FeatureCollection",  
  "features": [  
    {  
      "type": "Feature",  
      "geometry": {  
        "type": "Point",  
        "coordinates": [  
          11.1215698,  
          46.0677293  
        ]  
      },  
      "properties": {  
        "name": "Fontana dell'Aquila",  
        "amenity": "drinking-water"  
      }  
    }  
  ]  
}
```

Points



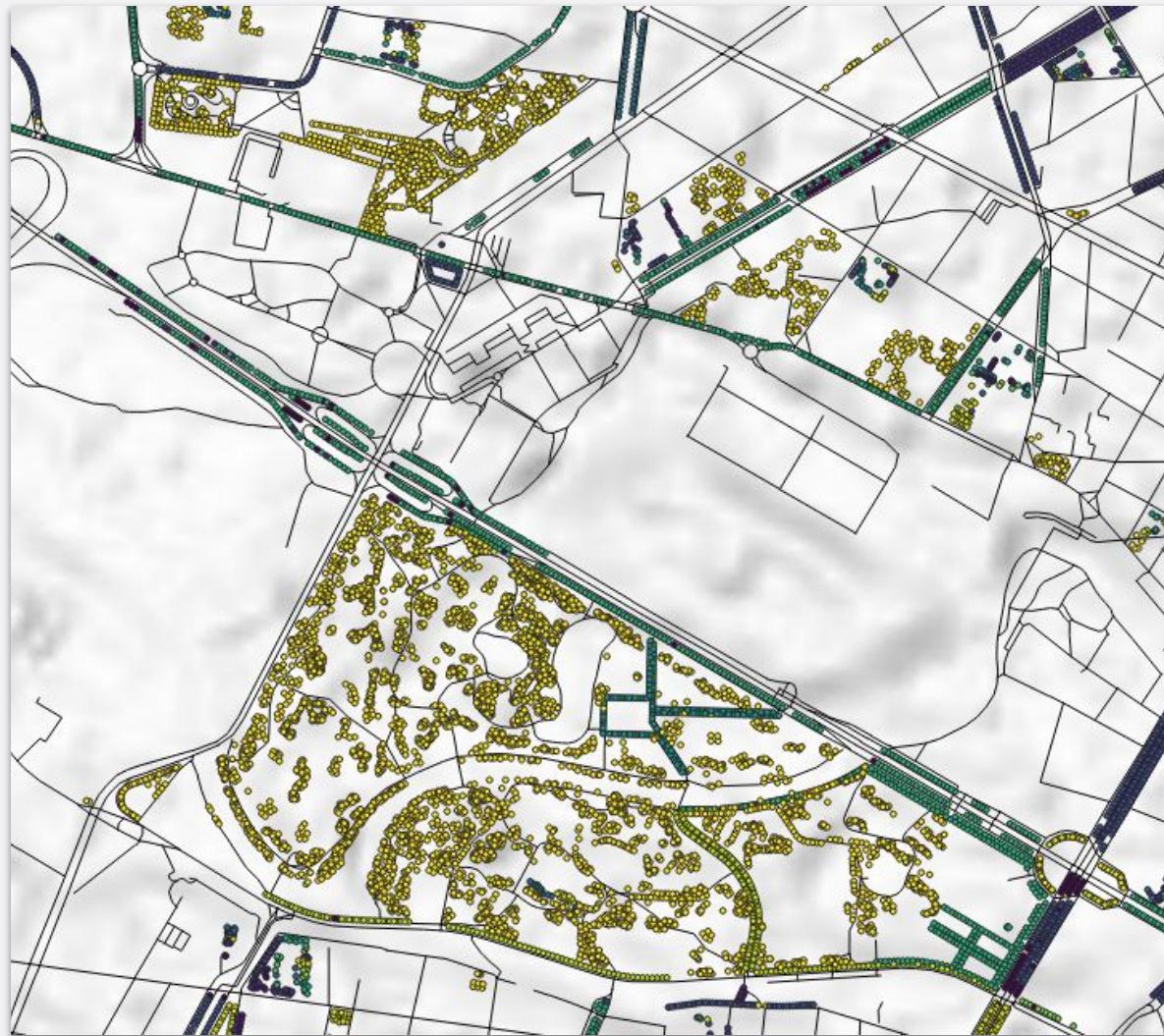
Lines



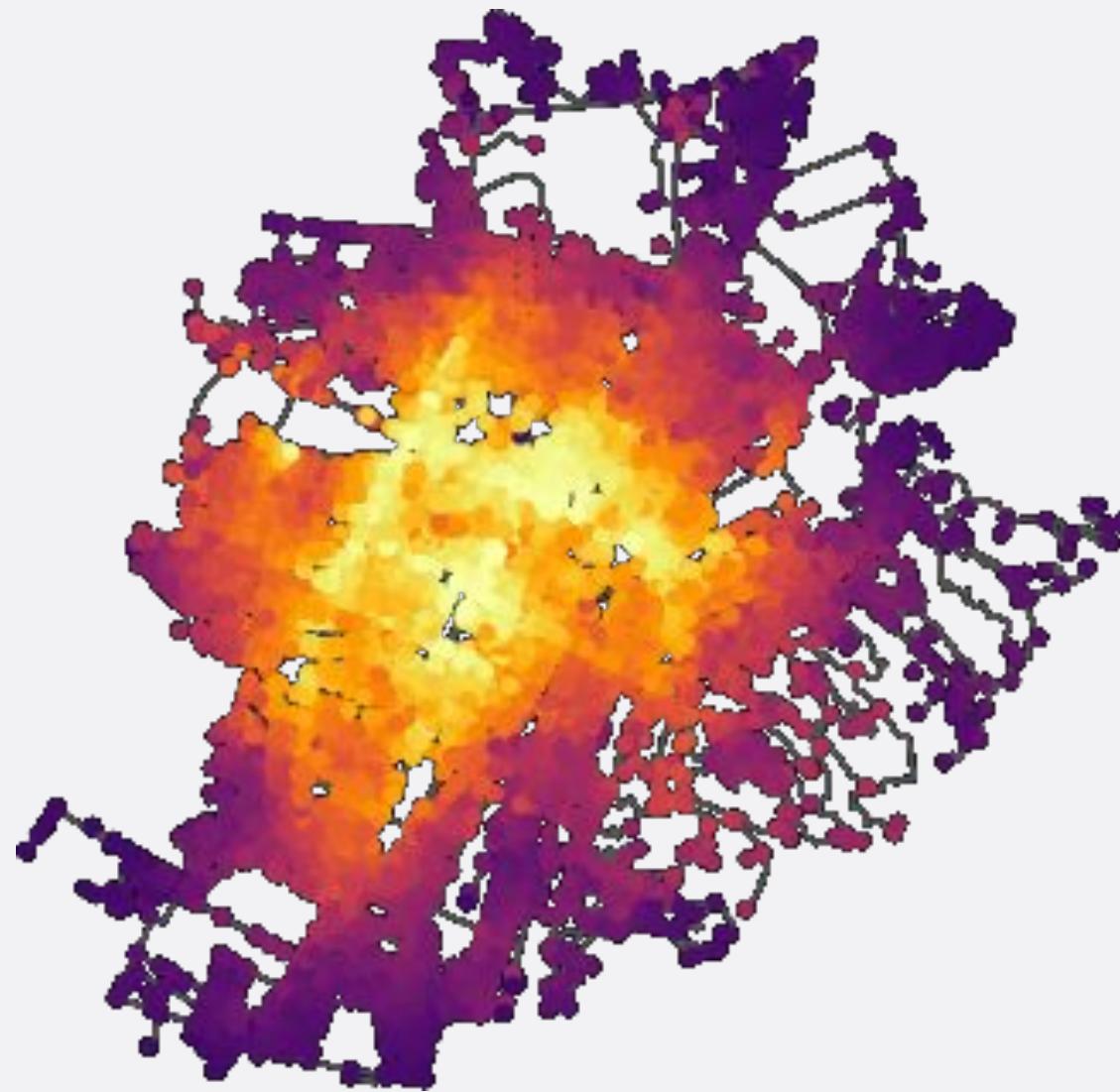
Overlay



Queries



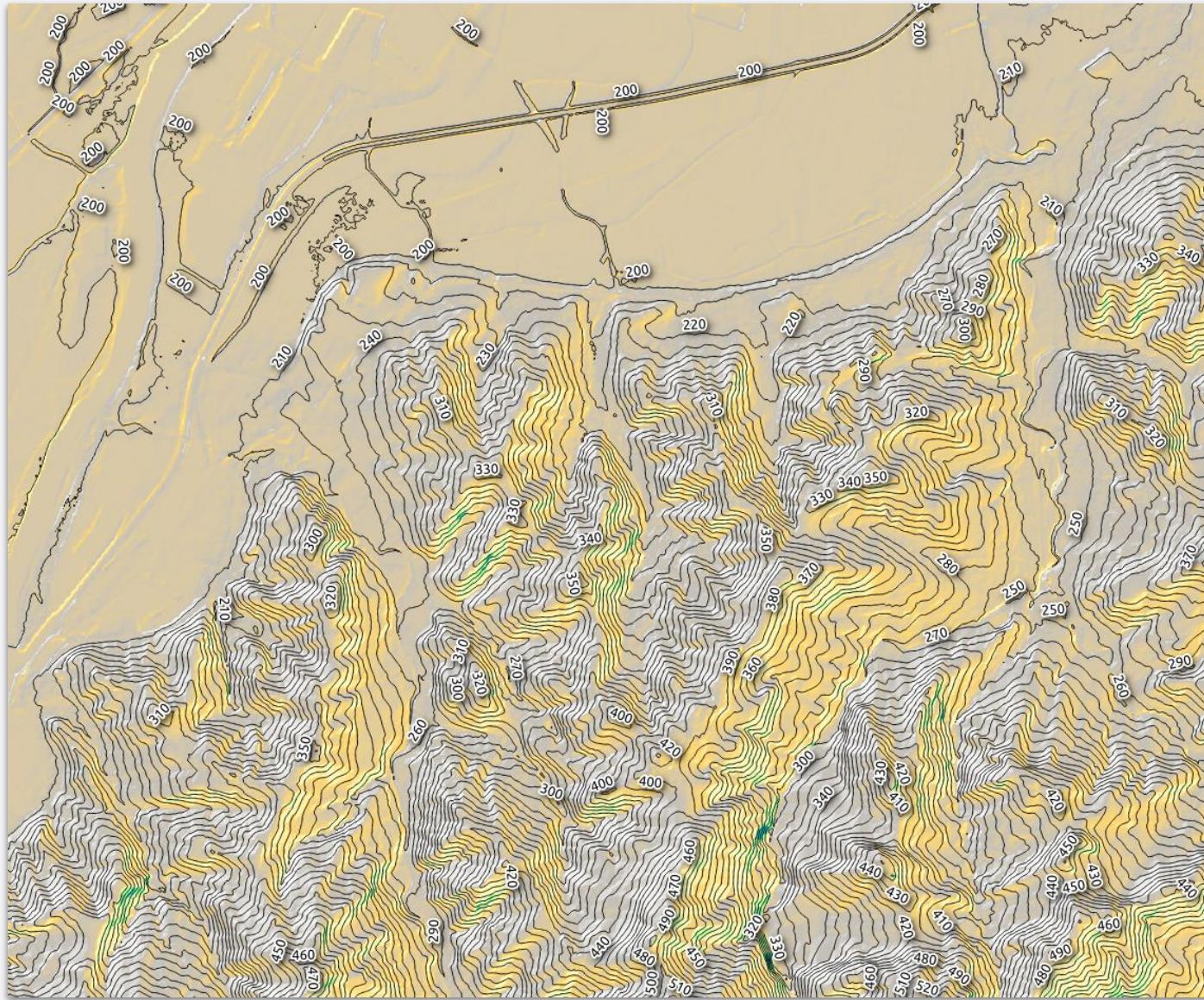
Network Analysis



Isochrones



Raster to Vector



the dark lines are created from the DTM values where the altitude is the same (**isopleths**)

Formats

Vectors

- ESRI Shapefile
- WKT
- GeoJSON
- KML
- ...

Raster

- Ascii Grid
- GeoTiff
- MBtiles

...



<http://www.gdal.org/>

ESRI Shapefile

Standard de facto

from 3 to 7 files with the same name and different extension

filename.shp →
filename.shx →
filename.dbf →
filename.prj →

geometry
index
table
projection

The future is in GeoPackage



GeoPackage



An Open Format for Geospatial Information

GeoPackage is an open, standards-based, platform-independent, portable, self-describing, compact format for transferring geospatial information.

The GeoPackage Encoding Standard describes a set of conventions for storing the following within an SQLite database:

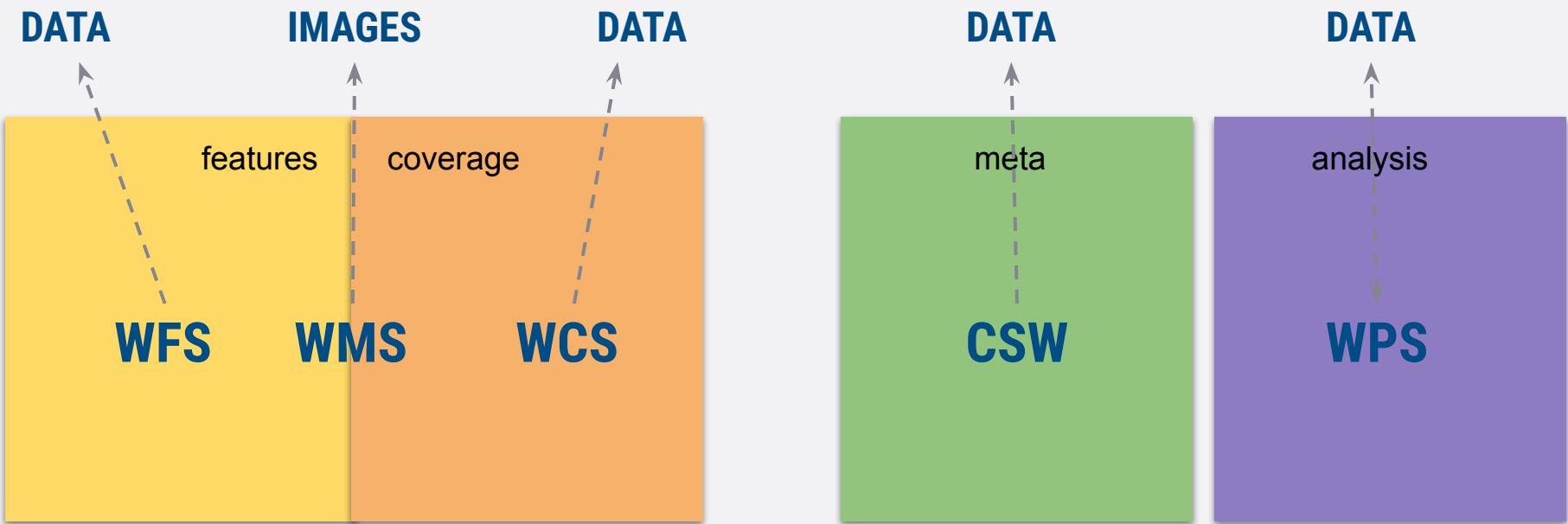
- vector features
- tile matrix sets of imagery and raster maps at various scales
- attributes (non-spatial data)
- extensions

To be clear, a GeoPackage is the SQLite container and the GeoPackage Encoding Standard governs the rules and requirements of content stored in a GeoPackage container. The GeoPackage standard defines the schema for a GeoPackage, including table definitions, integrity assertions, format limitations, and content constraints. The required and supported content of a GeoPackage is entirely defined in the standard. These capabilities are built on a common base and the extension mechanism provides implementors a way to include additional functionality in their GeoPackages.

Since a GeoPackage is a database container, it supports direct use. This means that the data in a GeoPackage can be accessed and updated in a "native" storage format without intermediate format translations. GeoPackages that comply with the requirements in the standard and do not implement vendor-specific extensions are interoperable across all enterprise and personal computing environments. GeoPackages are particularly useful on mobile devices such as cell phones and tablets in communications environments where there is limited connectivity and bandwidth.

<http://www.geopackage.org/>

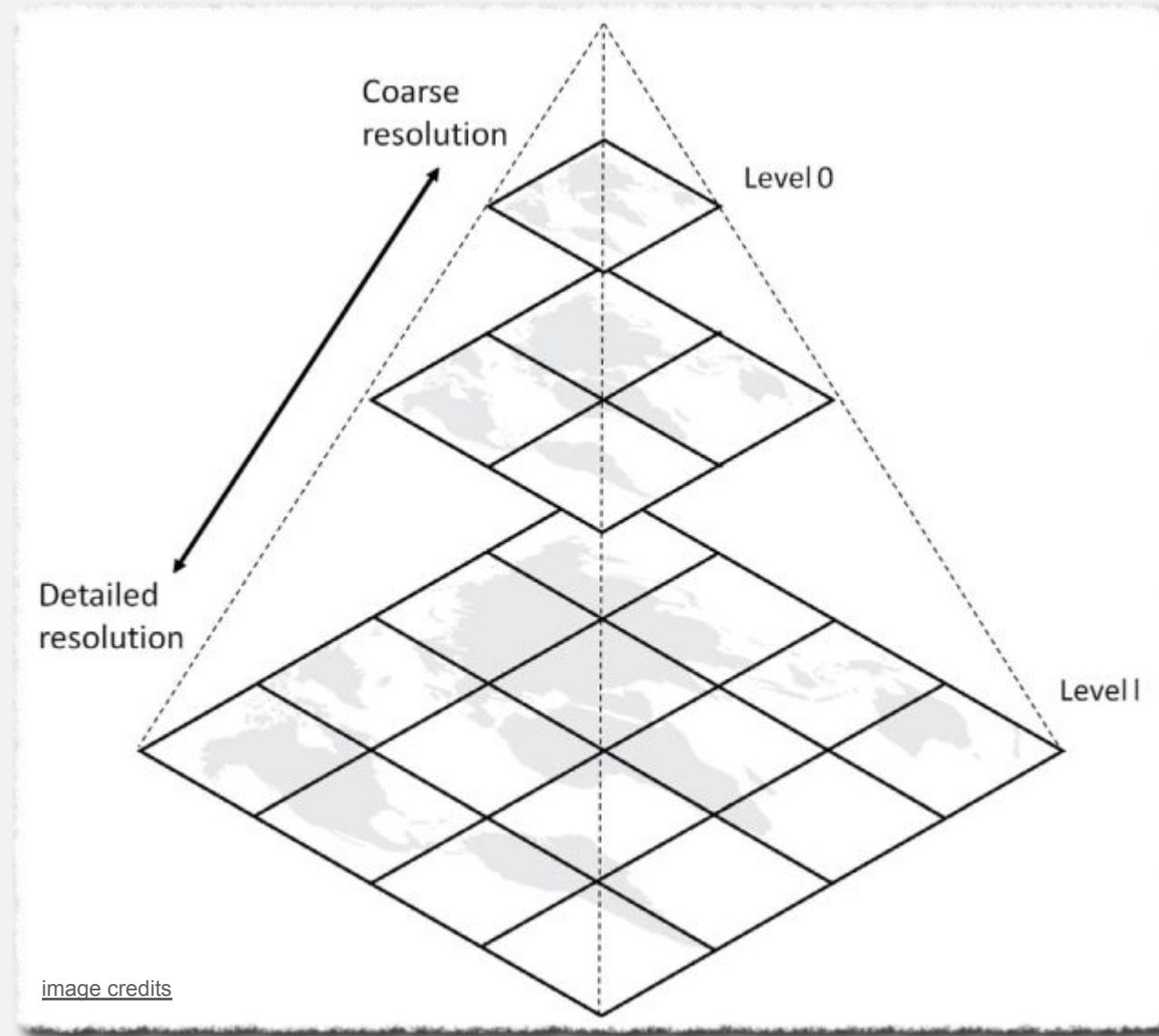
OGC Protocols



- | | | |
|------------|---|-----------------------------|
| WMS | - | Web Map Service |
| WFS | - | Web Feature Service |
| WCS | - | Web Coverage Service |
| WPS | - | Web Processing Service |
| CSW | - | Catalog Service for the Web |



TMS



Tile Map Service

Geocoding Suggestions

How it works

- name of a location in input
- matching algorithm (place, region, country)
- output a geometry (in most of the cases a point) expressed in wgs84

notes

human vs computer

a query mediated by a human with a geocoder works better as an automate script

enrich the query

better you write your location in input and better the geocoder can guess the name

Eg. you are looking for *TOP-IX, Via M. Vittoria, Torino*

Suggestions:

- write the complete name of the street: Via Maria Vittoria
- add the civic number: 38
- add the zipcode: 10123
- add the name of the city: Torino
- add the acronym of the province: TO
- add the name of the State: Italy

the new query is: *Top-ix, Via Maria Vittoria, 38, 10123 Torino TO, Italy*

use all the feedbacks of the geocoder service

a good geocoder give you back an indicator of ranking of the result

Geocoders: love and hate

getlon.lat Help! I need a geocoder.

Geocoding service APIs from dozens of different providers analysed to help you choose. [More information.](#)

I use about

5000

geocodes per month

100

geocodes on busy days

1

geocodes per second

My app is:

Accessible to the public

Free of charge

I need to:

Store geocodes permanently

Carry out bulk jobs not triggered by users

ArcGIS

Geosearch, Not Stored

\$0 for 1,000,000 /mo.

- Must not store geocodes.
- Must not combine with third-party basemaps
- [Terms and conditions](#)

API

- Auto-complete [i](#)
- Reverse-geocode [i](#)

OpenCage

Free Trial

\$0 for 2,500 /day

(76,000 /mo.)
Rate limit: 1 per sec

- Based on open data
- Storing geocodes ok
- Third-party basemaps ok
- AU: ★★★ GNAF, elsewhere: ★★☆ OSM + other open data sources

API

\$0/yr

Geocode.xyz

Throttled API

\$0 for **unlimited** /mo.

86,400 requests per day max.

Rate limit: 1 per sec

- Based on open data
- Storing geocodes ok
- Third-party basemaps ok

API

- No auto-complete

\$0/yr

Mapquest

Free

\$0 for 15,000 /mo.

- Must not store geocodes.
- Must not combine with third-party basemaps
- No scripted queries
- AU: ★★☆ Unit-level
- [Terms and conditions](#)

API

\$0/yr

Built by [Steve Bennett](#). Github: [Stevage](#). Twitter: [@steverage1](#). Disclaimer: Geocoder plans change all the time. Obviously. Use at your own risk.

<http://getlon.lat/>

Open Geo Data Turin

Region Piedmont - OGC Services

<http://www.geoportale.piemonte.it/cms/bdtre/modalita-di-pubblicazione-e-fruizione>

WMS ortofoto - AGEA 2015

http://geomap.reteunitaria.piemonte.it/WEBCAT/CAPABILITIES/wmts_regp_ortofoto_ice_nir_2010.xml

wms http://geomap.reteunitaria.piemonte.it/ws/taims/rp-01/taimsortoregp/wms_ortoregp2010

wmts http://geomap.reteunitaria.piemonte.it/WEBCAT/CAPABILITIES/wmts_rp_ortofoto_2010.xml

3) DTM 2010 5x5 m2

http://www.datigeo-piem-download.it/static/regp01/DTM5_ICE/RIPRESA_AEREA_ICE_2009_2011_DTM-SDO_CTR_FOGLI50-155-EPSG32632-TIF.zip

http://www.datigeo-piem-download.it/static/regp01/DTM5_ICE/RIPRESA_AEREA_ICE_2009_2011_DTM-SDO_CTR_FOGLI50-156-EPSG32632-TIF.zip

4) City of Turin

<http://geoportale.comune.torino.it/web/cartografia/catalogo-dei-metadati>

The OpenStreetMap Ecosystem

What is OpenStreetMap?



© OpenStreetMap contributors

OpenStreetMap powers map data on thousands of web sites, mobile apps, and hardware devices



Local Knowledge



Community Driven

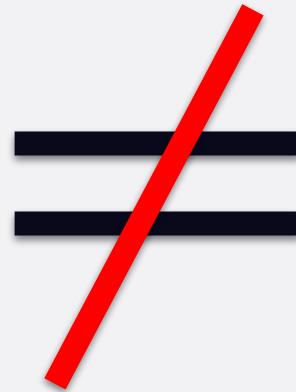


Open Data

OpenStreetMap is built by a community of mappers that contribute and maintain data about roads, trails, cafés, railway stations, and much more, all over the world.

<http://www.openstreetmap.org/about>

OpenStreetMap is NOT an alternative to Google Maps





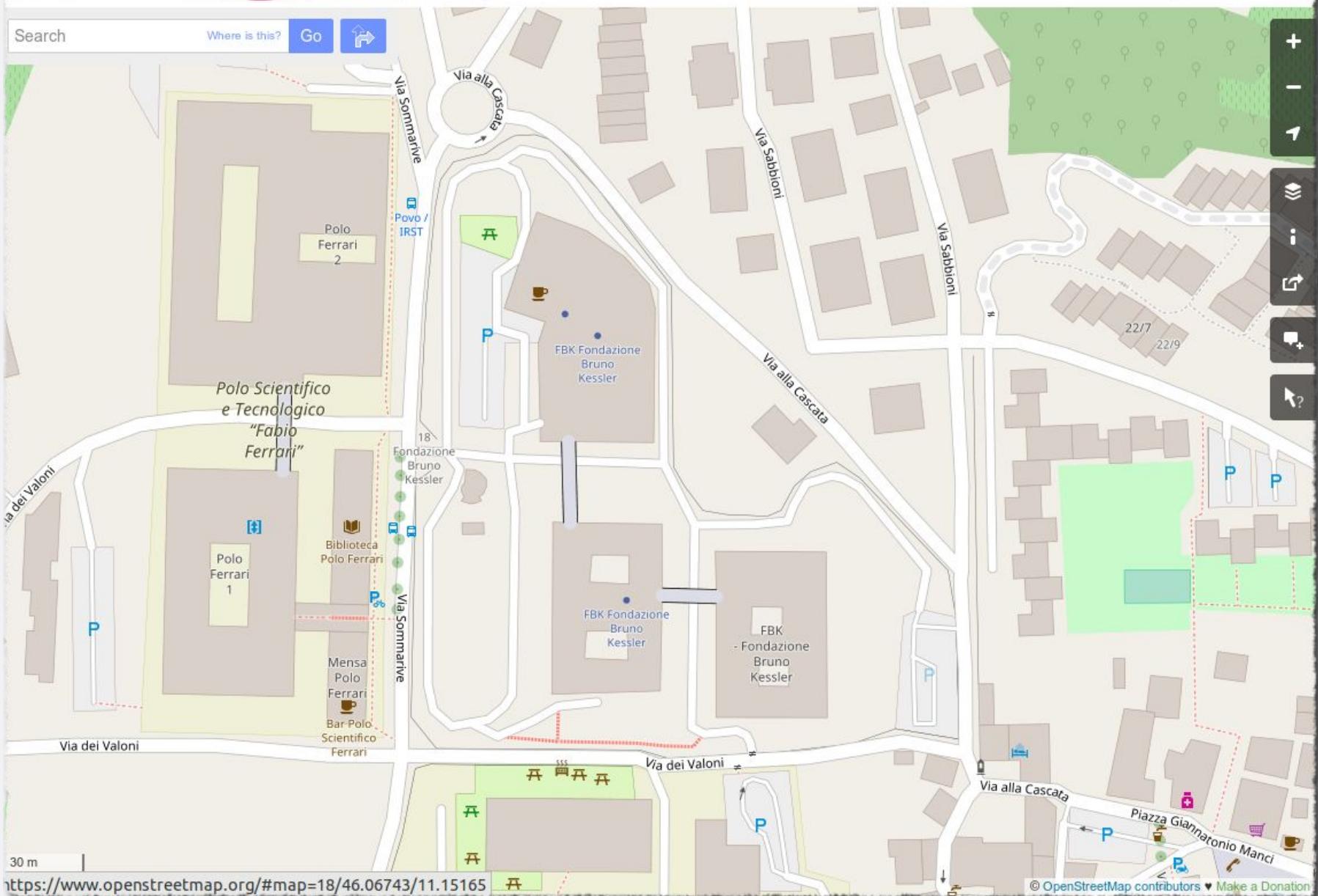
OPEN DATA

IS A COMMONS

OpenStreetMap [Edit](#) History Export

GPS Traces User Diaries Copyright Help About napo

Search Where is this? Go



This OpenStreetMap map shows the FBK Fondazione Bruno Kessler campus in Trento, Italy. The map includes several buildings and facilities:

- Polo Ferrari 2 (large yellow building)
- Polo Scientifico e Tecnologico "Fabio Ferrari"
- Polo Ferrari 1 (large grey building)
- Fondazione Bruno Kessler (multiple locations)
- Biblioteca Polo Ferrari
- Mensa Polo Ferrari
- Bar Polo Scientifico Ferrari
- Via Sommarive
- Via alla Cascata
- Via dei Valoni
- Via Sabbioni
- Via Giannantonio Manci

The map also features green areas representing parks and a river. A legend in the bottom right corner identifies symbols for buildings, roads, and other geographical features.

30 m

<https://www.openstreetmap.org/#map=18/46.06743/11.15165>

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What's happening now



<http://osmlab.github.io/show-me-the-wav/>



TOP-IX Consortium

TOP-IX Consortium [@topixconsortium](#)

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Recensioni
4,0 ★★★★☆ 8 recensioni

Comunica alle persone cosa pensi

[Mostra tutte](#)

Foto

Azienda nel settore delle tecnologie a Torino
4,0 ★★★★☆

Community [Mostra tutti](#)

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[Piace a 1247 persone](#)

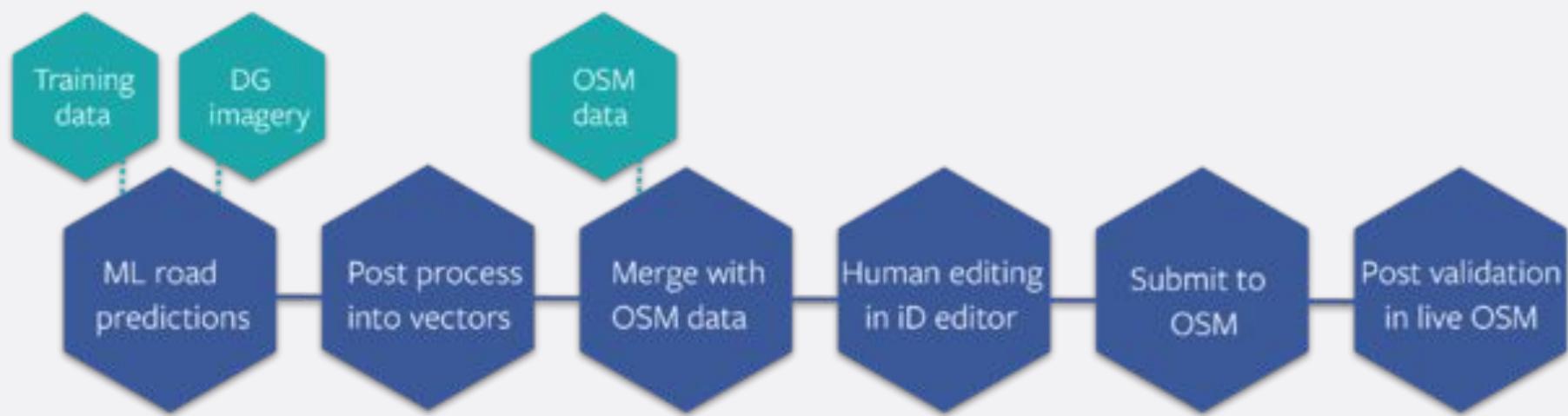
[Seguito da 1240 persone](#)

[Valentina Chapelli e altri 101 amici hanno messo "Mi piace" a questo luogo oppure hanno effettuato la registrazione qui](#)

Informazioni [Mostra tutto](#)

Via Maria Vittoria, 38 (0,02 km)

facebook



https://wiki.openstreetmap.org/wiki/AI-Assisted_Road_Tracing



Atlas

build passing

The [Atlas](#) is a way to efficiently represent OpenStreetMap data in memory. A subset of the data is in a "navigable network" form, meaning anything that is assumed to be navigable will be in a form of `Node`s and `Edge`s in a way a routing algorithm could traverse it. It also provides easy to use APIs to access geographical data. On top of it all, it is easy to shard and re-stitch, making it perfect for distributed processing!

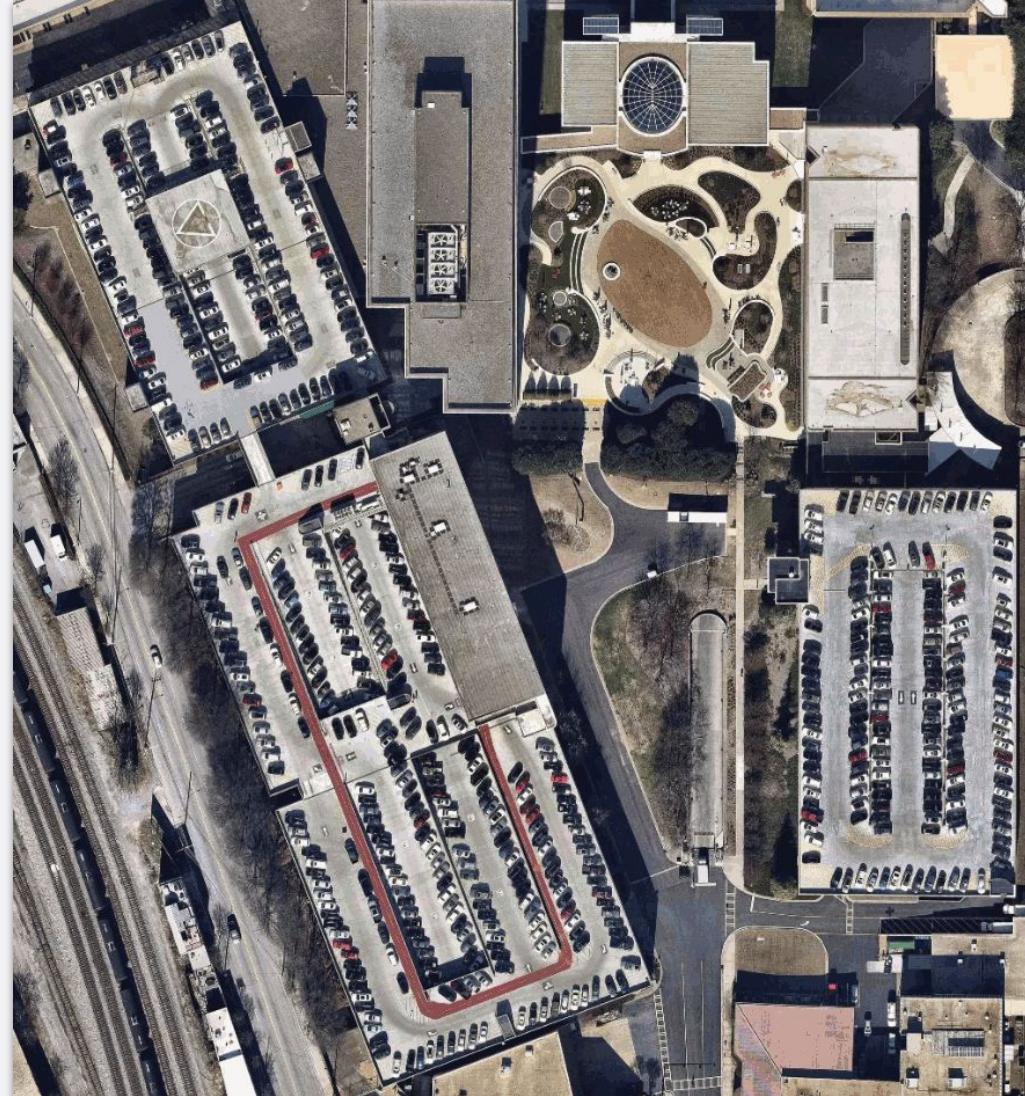
Projects using Atlas:

- [atlas-generator](#): A Spark job to distribute Atlas shards generation
- [atlas-checks](#): A suite of tools to check OSM data integrity using Atlas, and Spark.
- [josm-atlas](#): A JOSM plugin to visualize Atlas data.

<https://github.com/osmlab/atlas>

27 lines (21 sloc) | 1.52 KB

```
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24 WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE)
25 ARISING IN ANY WAY OUT OF THE USE OF THIS SOFTWARE, EVEN IF ADVISED OF THE
26 POSSIBILITY OF SUCH DAMAGE.
```



<https://github.com/mapbox/robosat>

The ODbL license by examples

```
<?xml version='1.0' encoding='UTF-8'?>
<osm version="0.6" generator="osmconvert 0.7m" timestamp="2014-09-29T20:21:02Z">
  <bounds minlat="45.9775306" minlon="11.0224735" maxlat="46.1530112" maxlon="11.1948226"/>
  <node id="9191867" lat="46.104119" lon="11.0899633" version="4" timestamp="2010-09-01T22:36:26Z" changeset="5658159" uid="330007" user="pikappa79"/>
  <node id="9191982" lat="46.0499659" lon="11.1169915" version="6" timestamp="2011-08-06T16:07Z" changeset="8939495" uid="330007" user="pikappa79"/>
  <node id="9192136" lat="46.054435" lon="11.1180986" version="6" timestamp="2012-12-14T22:11:48Z" changeset="14276412" uid="330007" user="pikappa79"/>
  <node id="9192343" lat="46.1140579" lon="11.0871511" version="6" timestamp="2010-09-01T22:36:35Z" changeset="5658159" uid="330007" user="pikappa79"/>
  <node id="9192428" lat="46.076984" lon="11.112499" version="2" timestamp="2011-01-19T18:32:46Z" changeset="7023211" uid="76312" user="scratara"/>
  <node id="9192494" lat="45.977028" lon="11.114043" version="1" timestamp="2006-06-30T11:53:08Z" changeset="48807" uid="573" user="Jörg Ostertag">
    <tag k="created_by" v="JOSM"/>
  </node>
  <node id="9192593" lat="46.0521296" lon="11.1170876" version="9" timestamp="2011-08-06T16:15:07Z" changeset="8939495" uid="330007" user="pikappa79"/>
  <node id="9192771" lat="46.0181248" lon="11.1274916" version="4" timestamp="2011-02-16T13:31:43Z" changeset="7303863" uid="330007" user="pikappa79"/>
  <node id="9193403" lat="45.9945344" lon="11.1215165" version="2" timestamp="2009-07-06T23:57:51Z" changeset="1757920" uid="136835" user="user_136835">
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  </node>
  <node id="9193405" lat="46.0313027" lon="11.1277415" version="5" timestamp="2011-02-16T13:31:31Z" changeset="7303863" uid="330007" user="pikappa79"/>
  <node id="9193447" lat="45.9697045" lon="11.1130485" version="4" timestamp="2008-08-04T17:14:50Z" changeset="57846" uid="20610" user="napo">
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  </node>
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  <node id="9193589" lat="46.0098562" lon="11.1251955" version="3" timestamp="2013-07-07T06:28:42Z" changeset="16856691" uid="530691" user="Peterfritz"/>
  <node id="9193607" lat="46.054411" lon="11.1295695" version="6" timestamp="2011-11-28T21:45:33Z" changeset="9982706" uid="330007" user="pikappa79"/>
  <node id="9193619" lat="46.0744894" lon="11.1124451" version="9" timestamp="2013-04-21T11:37:25Z" changeset="15809662" uid="330007" user="pikappa79"/>
  <node id="9193812" lat="46.0514793" lon="11.1157438" version="5" timestamp="2010-08-09T13:10:36Z" changeset="5443649" uid="24966" user="alesstoz"/>
  <node id="9193846" lat="46.1201572" lon="11.0860899" version="6" timestamp="2011-02-02T16:18:24Z" changeset="7217702" uid="330007" user="pikappa79"/>
  <node id="9193873" lat="46.0869729" lon="11.104303" version="5" timestamp="2010-09-01T22:35:55Z" changeset="5658159" uid="330007" user="pikappa79"/>
  <node id="9193877" lat="46.0521785" lon="11.1175845" version="11" timestamp="2011-08-06T16:15:07Z" changeset="8939495" uid="330007" user="pikappa79"/>
  <node id="9193996" lat="46.0534124" lon="11.1185143" version="9" timestamp="2013-05-21T19:07:54Z" changeset="16228624" uid="330007" user="pikappa79"/>
  <node id="9194295" lat="46.0533991" lon="11.1278855" version="8" timestamp="2011-05-07T00:08:51Z" changeset="5452578" uid="nfranz" user="nfranz"/>
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```



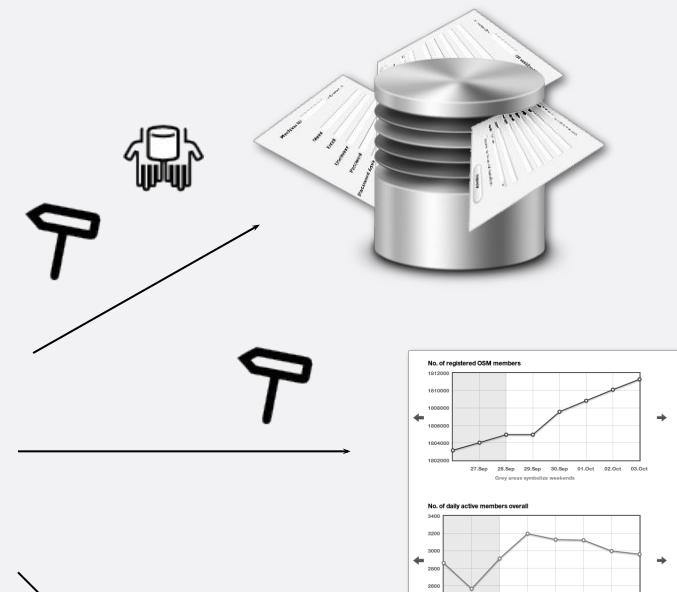
Graphhopper maps

Powered by Graphhopper API

Search Bar: Matera

Search Results:

- City Boundary Matera, MT, BAS, Italy
- Hamlet Matera, AP, MAR, Italy
- Locality La Matera, San Esteban de Gormaz, Provincia de Soria, Castile and León, Spain
- County Boundary MT, BAS, Italy
- Archaeological Site Matera, Vista Filiars, Northwood, Irvine, Orange, California, 92620, United States of America



OpenStreetMap

Search Bar: Matera

Search Results:

- Results from OpenStreetMap Nominatim
 - City Boundary Matera, MT, BAS, Italy
 - Hamlet Matera, AP, MAR, Italy
 - Locality La Matera, San Esteban de Gormaz, Provincia de Soria, Castile and León, Spain
 - County Boundary MT, BAS, Italy
 - Archaeological Site Matera, Vista Filiars, Northwood, Irvine, Orange, California, 92620, United States of America

More results



Licence/Community Guidelines/Geocoding - Guideline

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Status: Endorsed by the OSMF board 2017-08-24

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- [5.1 Why did the LWG decide to take up work on a geocoding guideline?](#)

Tech Corner: how obtain the data

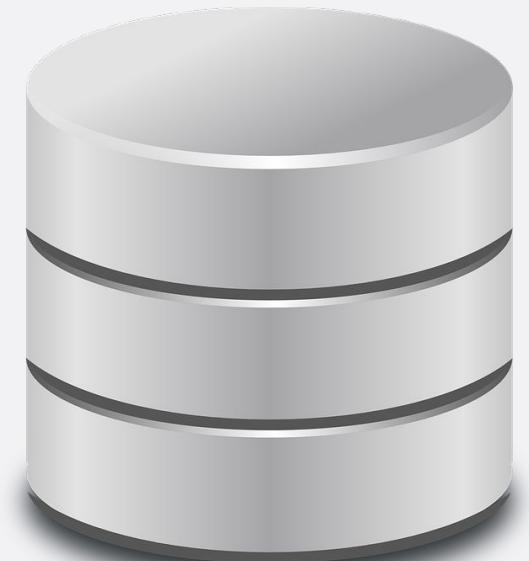
Talk with OSM

API for special queries

<http://overpass-api.de>

Overpass Turbo

<http://overpass-turbo.eu>



Areas in different formats

<http://https://osmaxx.hsr.ch/>

<https://export.hotosm.org/en/v3/>

<http://download.geofabrik.org>

Routing services

<http://project-osrm.org/>

<http://vroom-project.org/>

<http://www.opentripplanner.org/>

<https://www.graphhopper.com/>

<https://openrouteservice.org/>

<http://vroom-project.org>

Python GIS



Python libraries :)

Projections

pyproj

Vector Data

geopandas
shapely
osmnx

Raster Data

rasterio

Analysis

osmnx
shapely
geopandas
pysal

Geocoding

geopy
geocoder

Visualization

matplotlib
seaborn
folium
bouquet



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dffeeded on May 7

1 contributor

656 lines (655 sloc) | 17.6 KB

[Code](#) [Raw](#) [Blame](#) [History](#) [Edit](#) [Delete](#)

Introduction to geospatial vector data in Python

```
In [ ]: %matplotlib inline  
  
import pandas as pd  
import geopandas  
  
pd.options.display.max_rows = 10
```

Importing geospatial data

Geospatial data is often available from specific GIS file formats or data stores, like ESRI shapefiles, GeoJSON files, geopackage files, PostGIS (PostgreSQL) database, ...

We can use the GeoPandas library to read many of those GIS file formats (relying on the fiona library under the hood, which is an interface to GDAL/OGR), using the `geopandas.read_file` function.

<https://github.com/jorisvandenbossche/geopandas-tutorial>

resources



Python

http://darribas.org/qds15/labs/Lab_08.html
<https://github.com/puntofisso/SpikesMap>
<https://geohackweek.github.io/schedule.html>
<https://automating-gis-processes.github.io>
<http://geopandas.org>
<https://shapely.readthedocs.io/en/latest/>
<https://rasterio.readthedocs.io/en/latest/>
<http://pysal.readthedocs.io/en/latest/>
<https://geohackweek.github.io/vector/04-geopandas-intro/>

GIS

<https://volaya.github.io/gis-book/en/index.html>
<http://qgis.org>
<http://www.qgistutorials.com/en/>
<http://grass.osgeo.org>
<http://postgis.org>
https://postgis.net/docs/manual-2.4/using_postgis_dbmanagement.html#RefObject
<https://blog.gvsig.org/2017/07/12/learning-gis-with-game-of-thrones-free-book/>

OpenStreetMap

<https://overpass-turbo.eu>
<https://export.hotosm.org/en/v3/>
<https://planet.openstreetmap.org>
<https://openrouteservice.org/example-apartment-search-with-ors/>

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images - wikipedia, openstreetmap