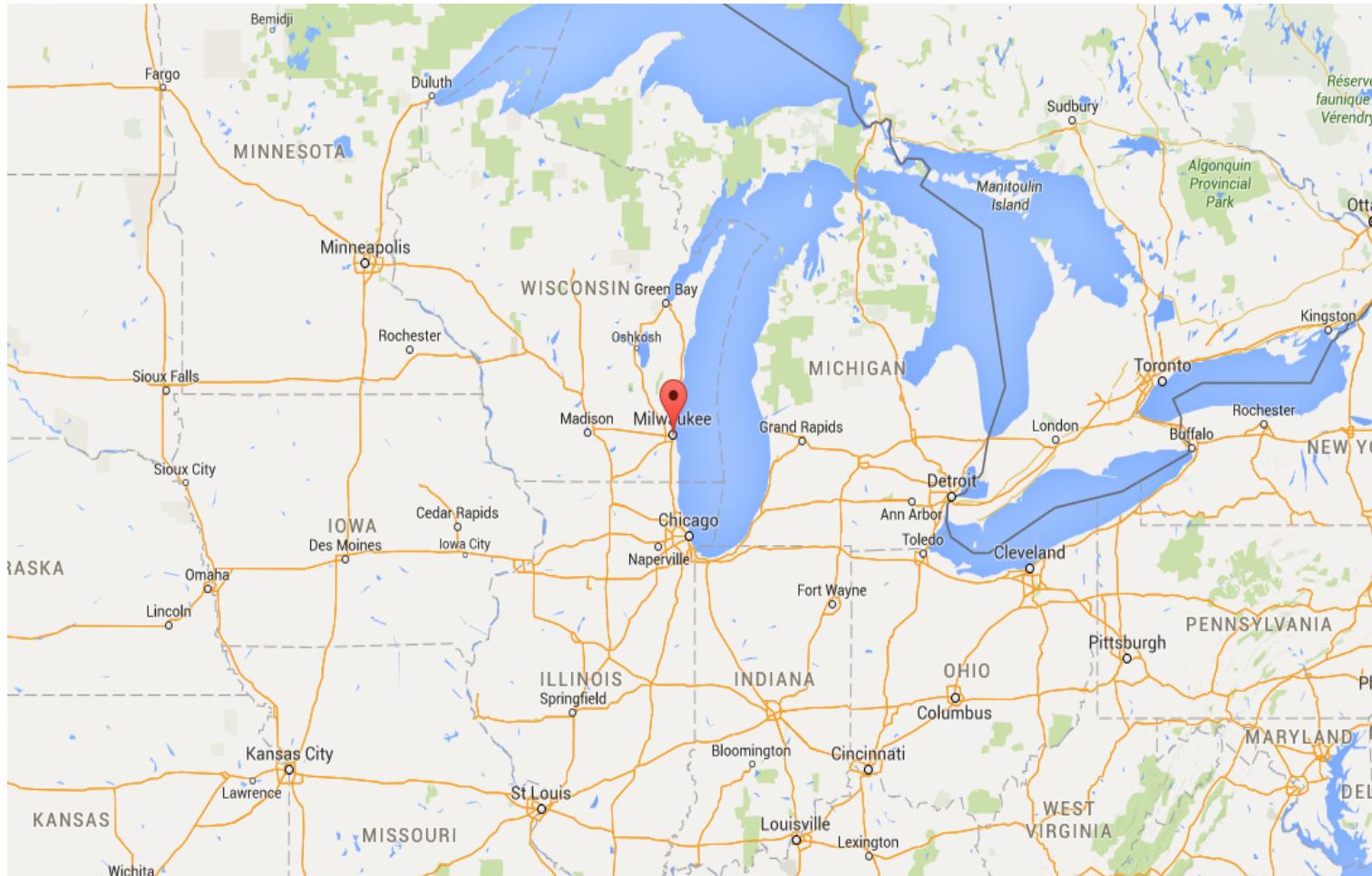


Spatial Analytics from a Computer Science perspective

Satish Puri,
Assistant Professor,
Department of **Computer Science**,
College of Arts and Science
Marquette University

My location



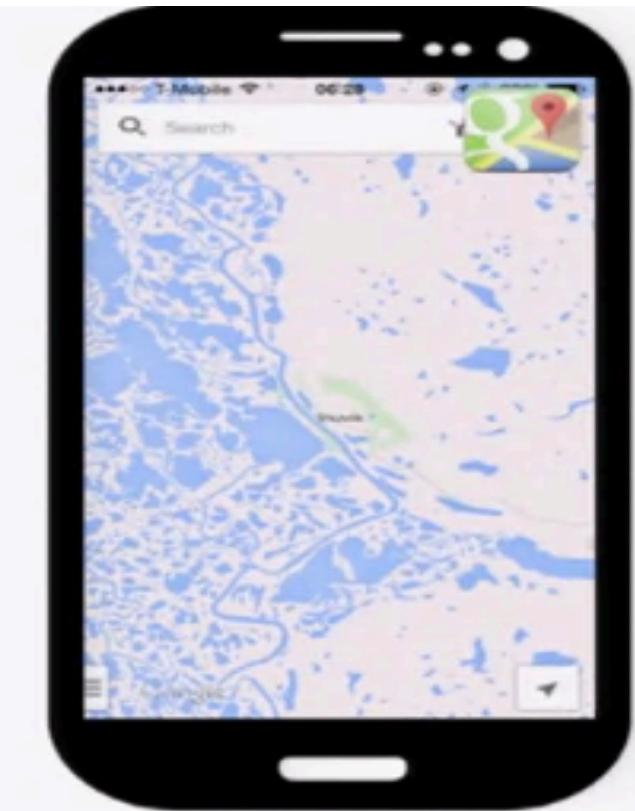
Agenda

- Algorithms & Data Structure used in GIS
- Spatial Databases
 - Structured Query Language (SQL)
- Spatial Data Mining

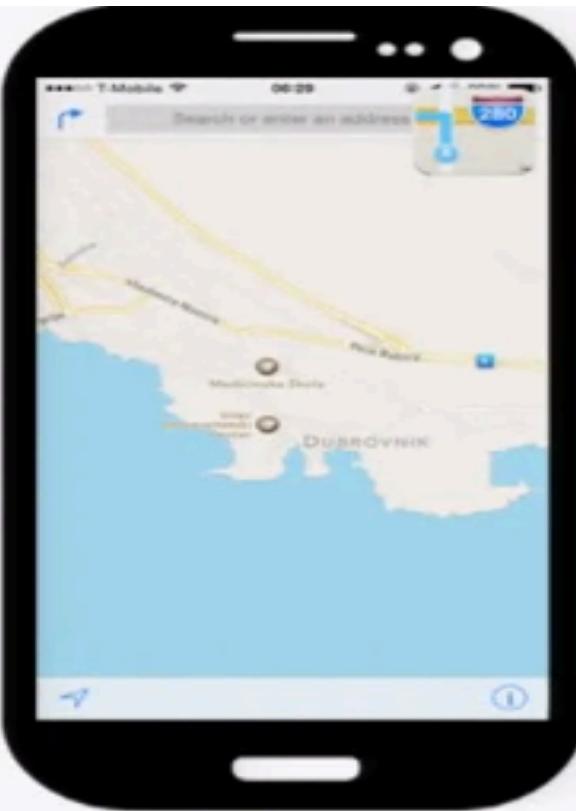
Show me pizza places nearby



Well known mobile apps



Google Maps app



Apple Maps app



Waze



Nokia HERE Maps

10 most popular apps in US

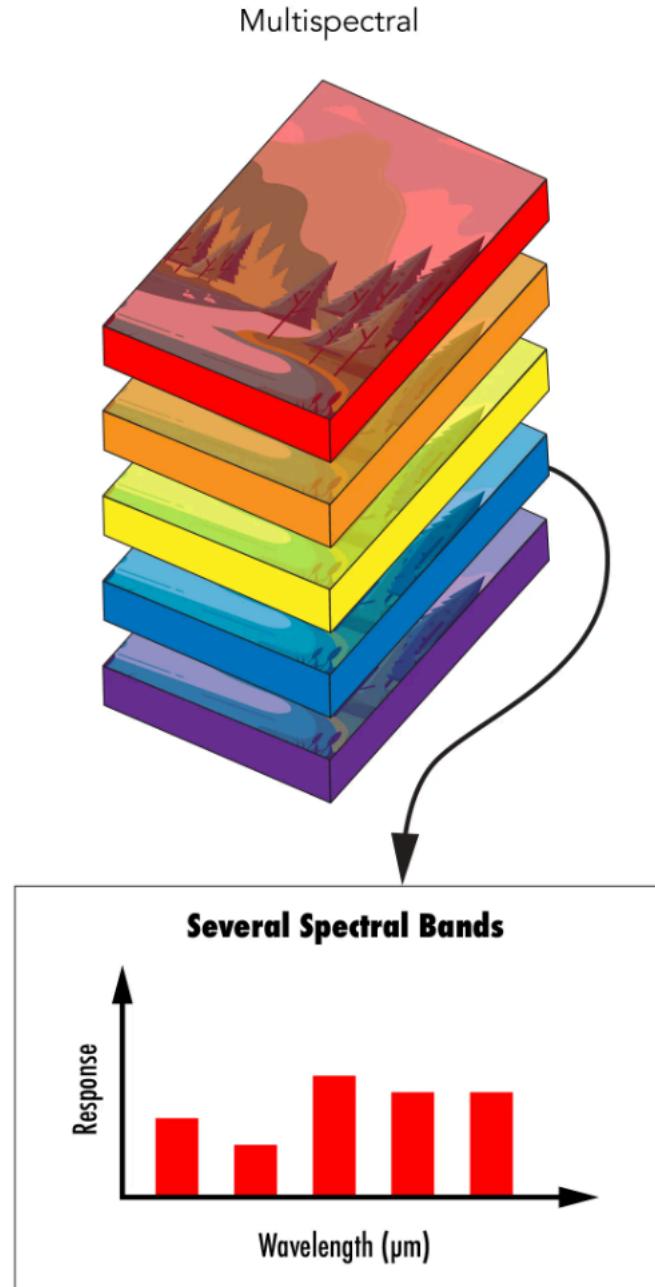


Spatial Data Types

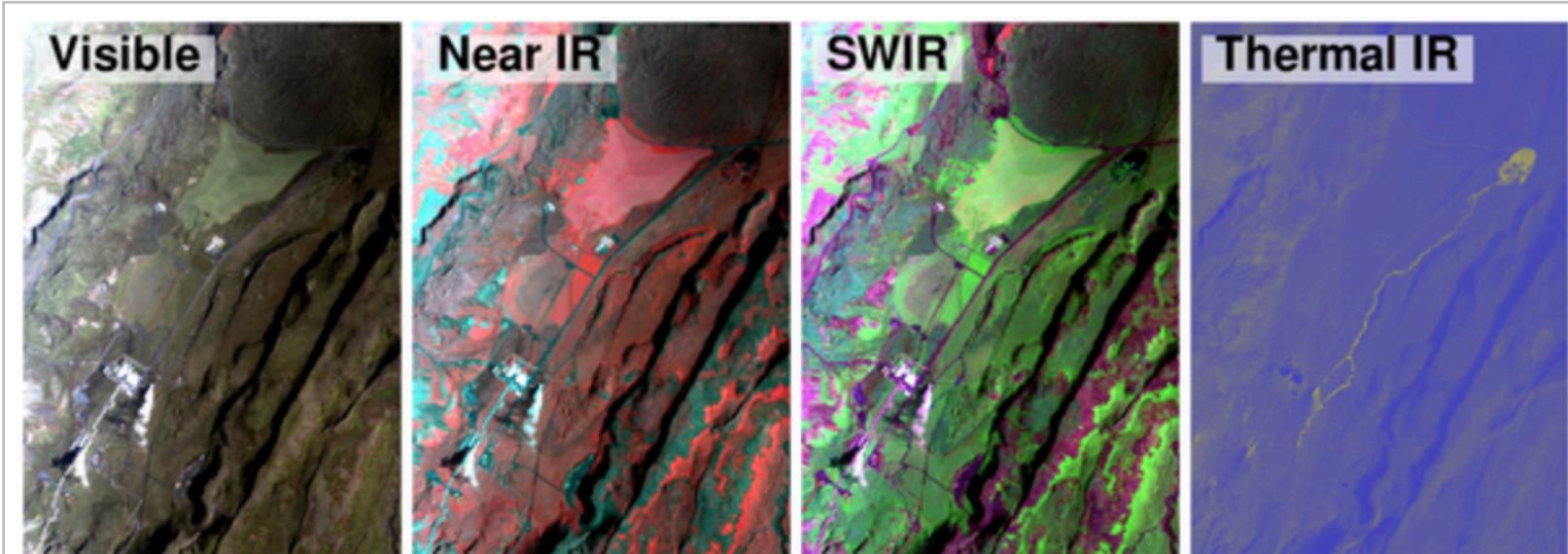
- Raster – images
- Vector
 - coordinates of vertices: (1,2), (2,3), ..
- Point clouds (elevation)

Raster data

- multi-spectral images
 - many bands
 - matrix format



Raster image with multiple bands



Multispectral infrared data channels combined in GRASS to highlight different landscape/vegetation features. If you have visited Iceland, you may recognise the Nesjavellir geothermal plant, with its steam and warm river. Click the image to enlarge.

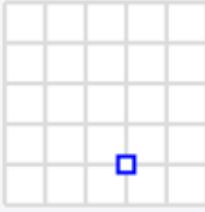
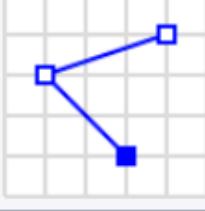
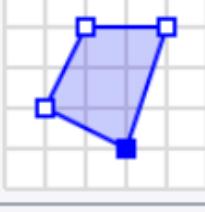
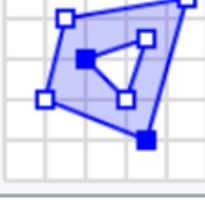
Examples

- Remote sensing
Deforestation (leaf color)

Parking area with cars comparison

Vector data examples

Geometry primitives (2D)

Type	Examples
Point	 POINT (30 10)
LineString	 LINESTRING (30 10, 10 30, 40 40)
Polygon	 POLYGON ((30 10, 40 40, 20 40, 10 20, 30 10))
	 POLYGON ((35 10, 45 45, 15 40, 10 20, 35 10), (20 30, 35 35, 30 20, 20 30))

Vector formats

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
<Document>
<Placemark>
  <name>New York City</name>
  <description>New York City</description>
  <Point>
    <coordinates>-74.006393,40.714172,0</coordinates>
  </Point>
</Placemark>
</Document>
</kml>
```

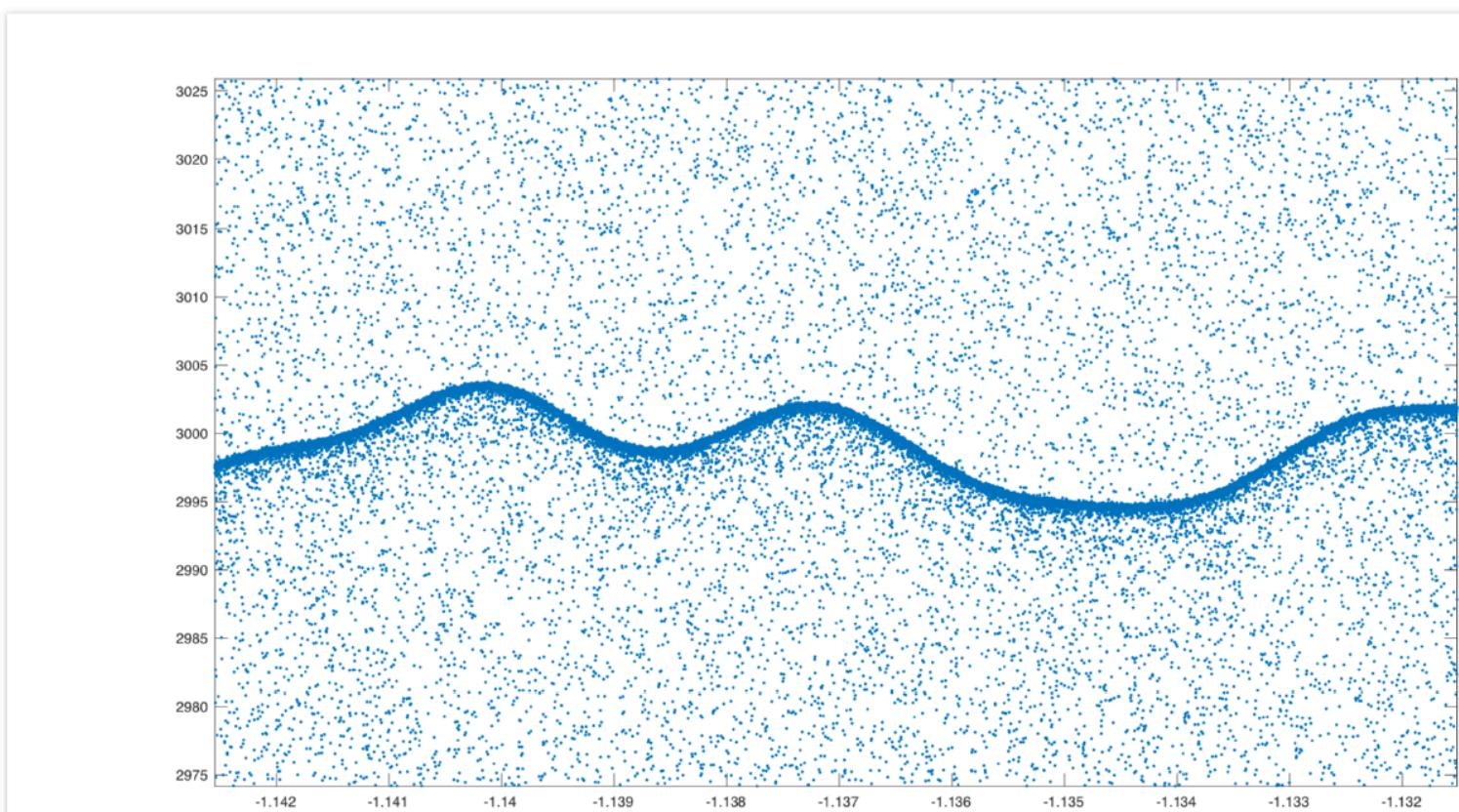
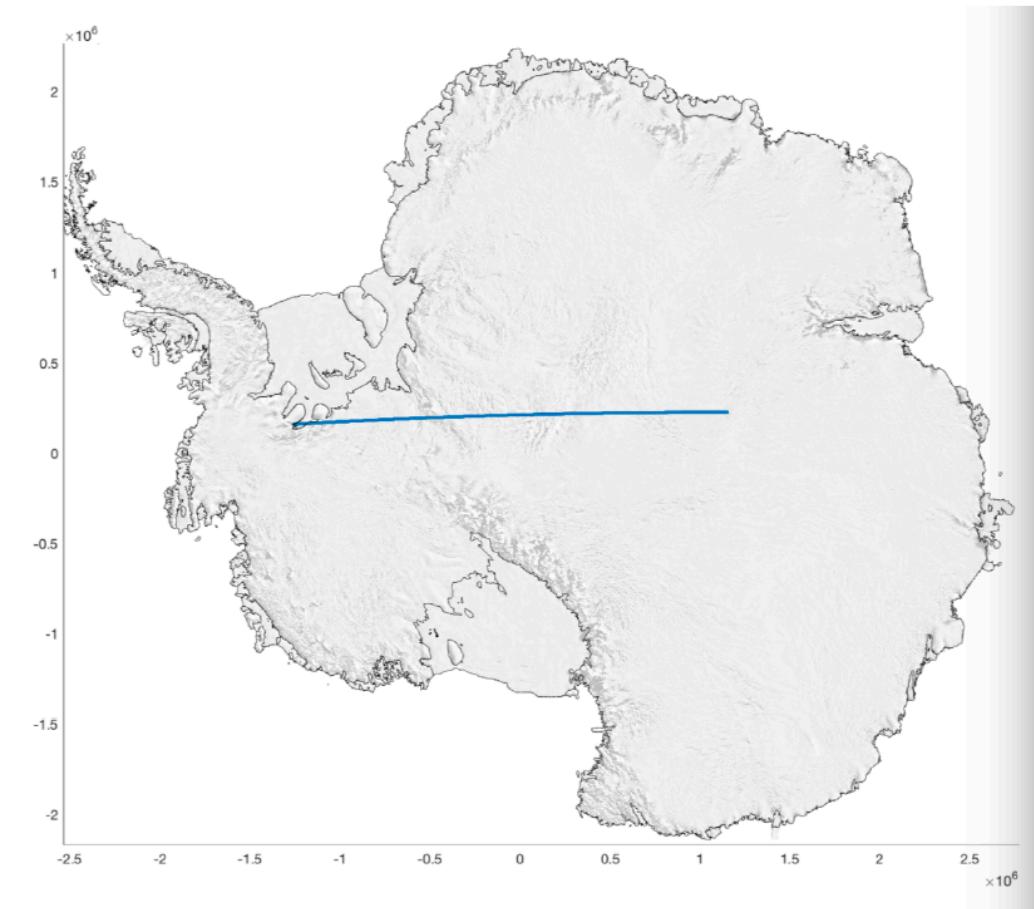
KML: Keyhole Markup Language.
Used in google maps. Shows longitude, latitude coordinates.

Vector formats with Coordinates

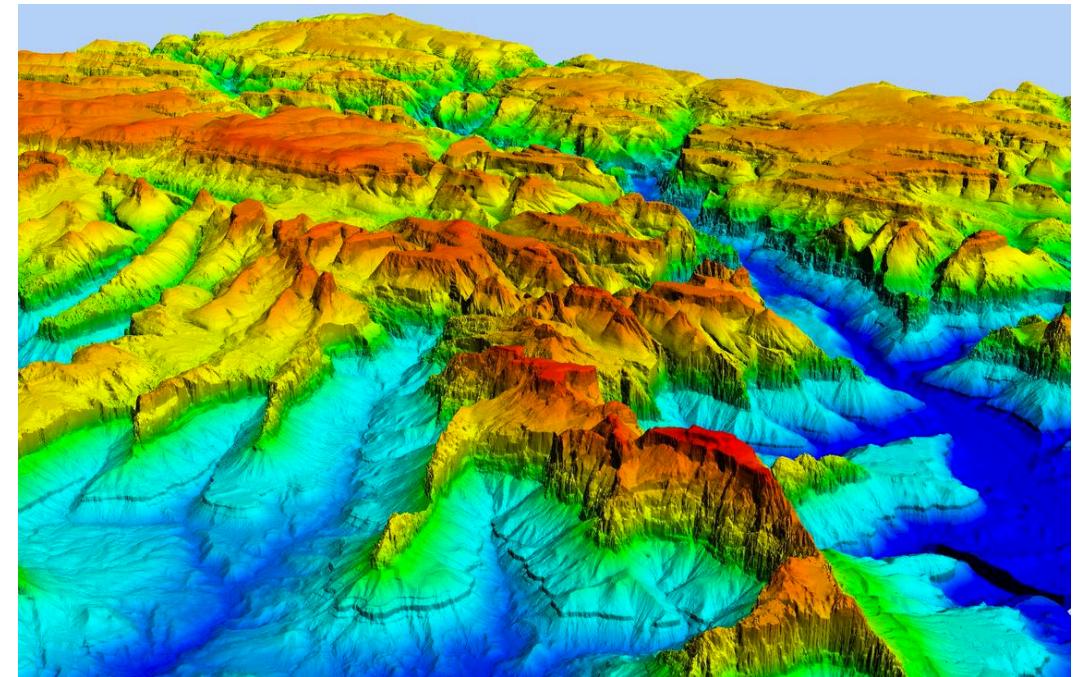
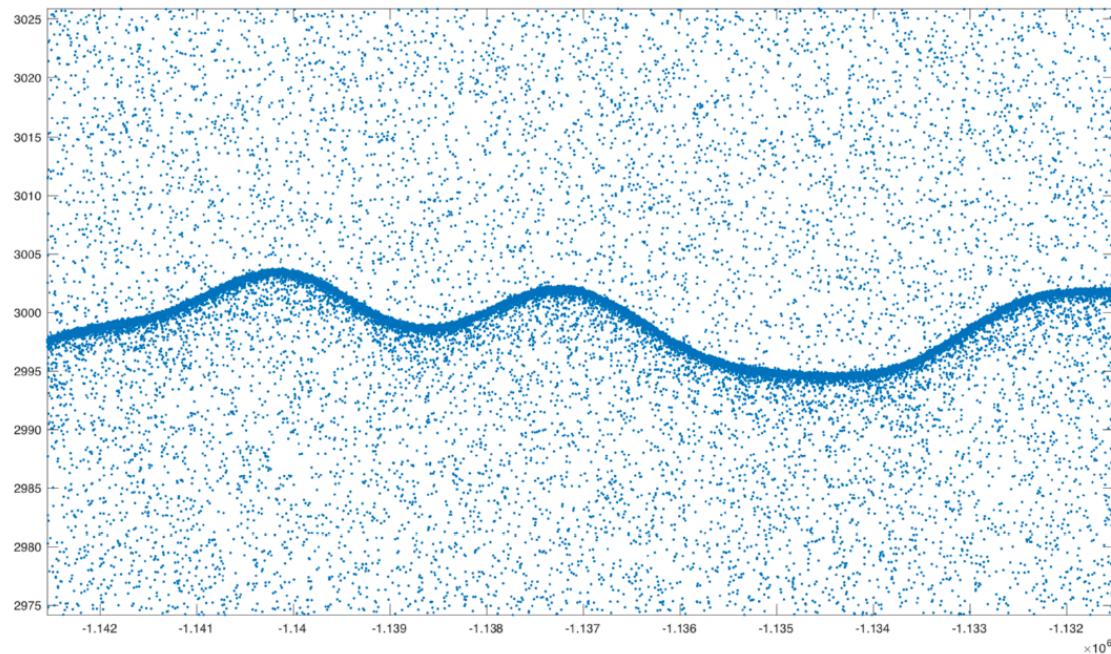
KML: Keyhole Markup Language.
Used in google maps. Shows longitude, latitude coordinates.

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
  <Placemark>
    <name>The Pentagon</name>
    <Polygon>
      <extrude>1</extrude>
      <altitudeMode>relativeToGround</altitudeMode>
      <outerBoundaryIs>
        <LinearRing>
          <coordinates>
            -77.05788457660967,38.87253259892824,100
            -77.05465973756702,38.87291016281703,100
            -77.05315536854791,38.87053267794386,100
            -77.05552622493516,38.868757801256,100
            -77.05844056290393,38.86996206506943,100
            -77.05788457660967,38.87253259892824,100
          </coordinates>
        </LinearRing>
      </outerBoundaryIs>
      <innerBoundaryIs>
        <LinearRing>
          <coordinates>
            -77.05668055019126,38.87154239798456,100
            -77.05542625960818,38.87167890344077,100
            -77.05485125901024,38.87076535397792,100
            -77.05577677433152,38.87008686581446,100
            -77.05691162017543,38.87054446963351,100
            -77.05668055019126,38.87154239798456,100
          </coordinates>
        </LinearRing>
      </innerBoundaryIs>
    </Polygon>
  </Placemark>
```

Point cloud for elevation measurement



Point cloud



Volume of Spatial data

- NASA satellite data archives – 500 TB.
- OpenStreetMap - Terabyte

<https://www.openstreetmap.org>



Space telescopes



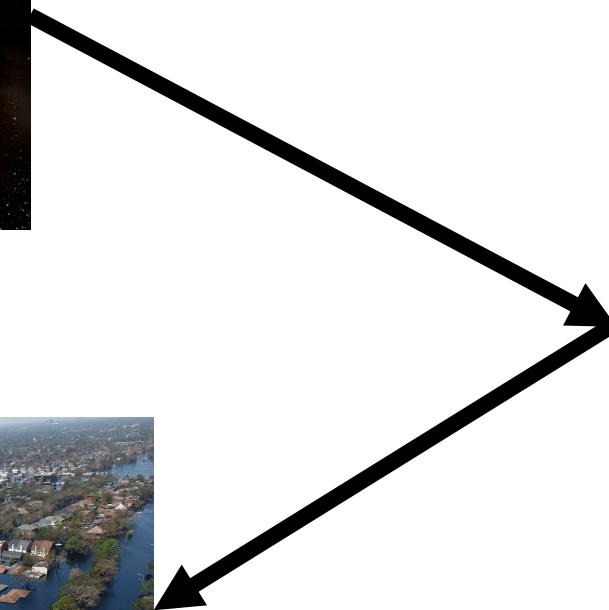
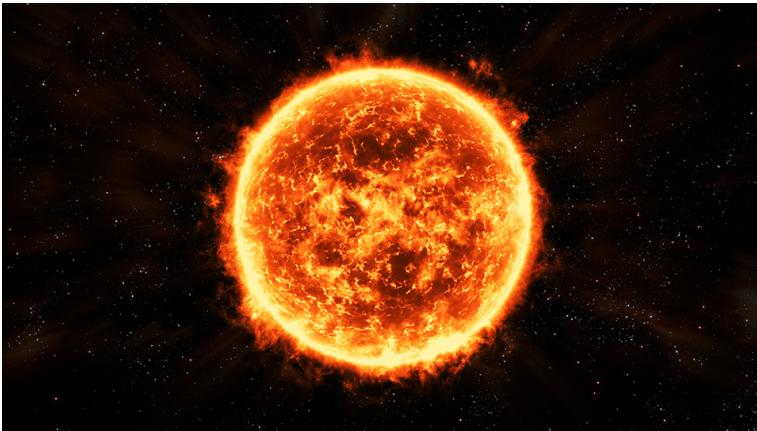
Medical data

Remote sensing



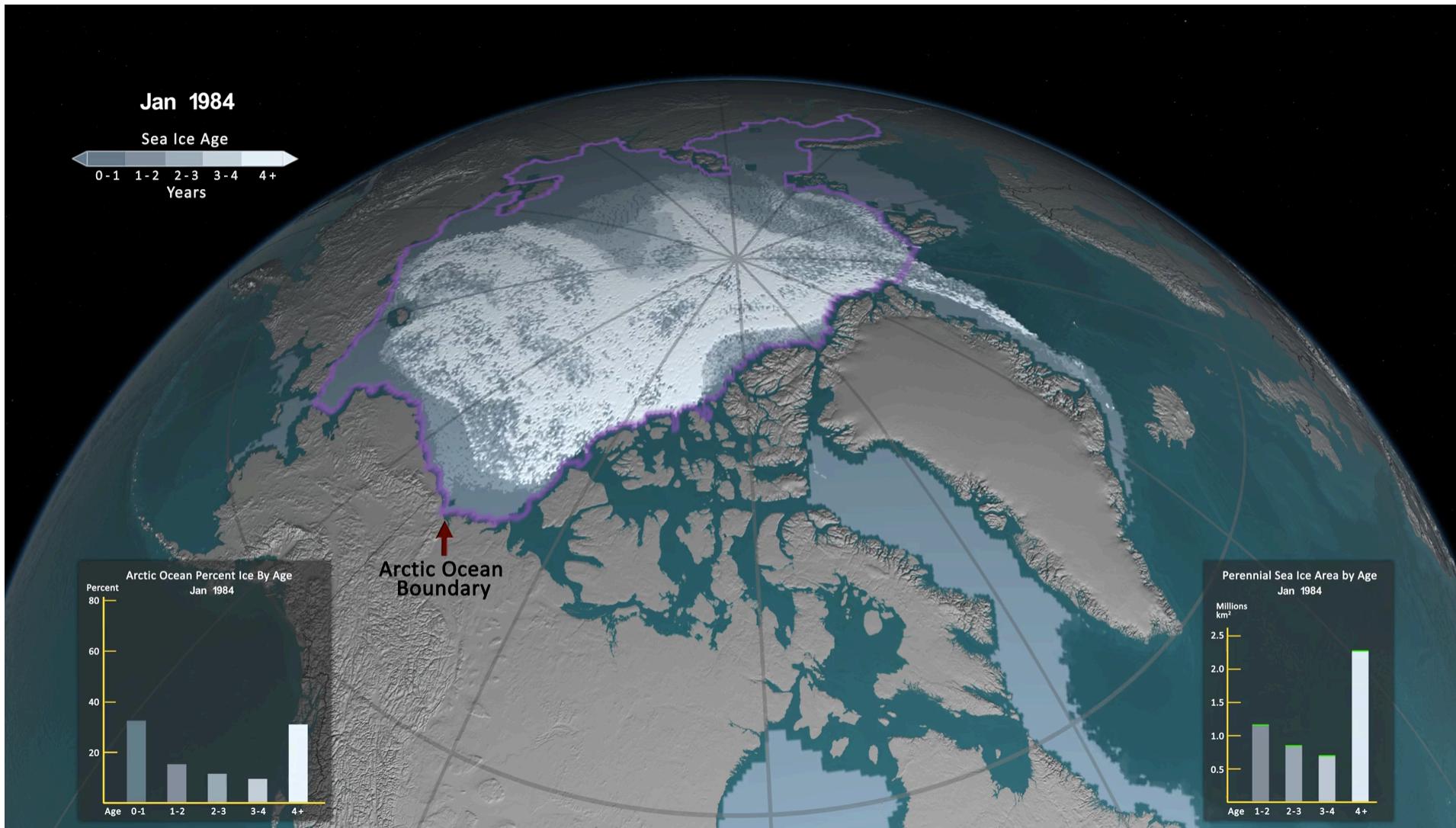
Motivations

Global Warming



Arctic Sea Ice Trend

Visualization: NASA



Remote sensing

Overlay, satellites

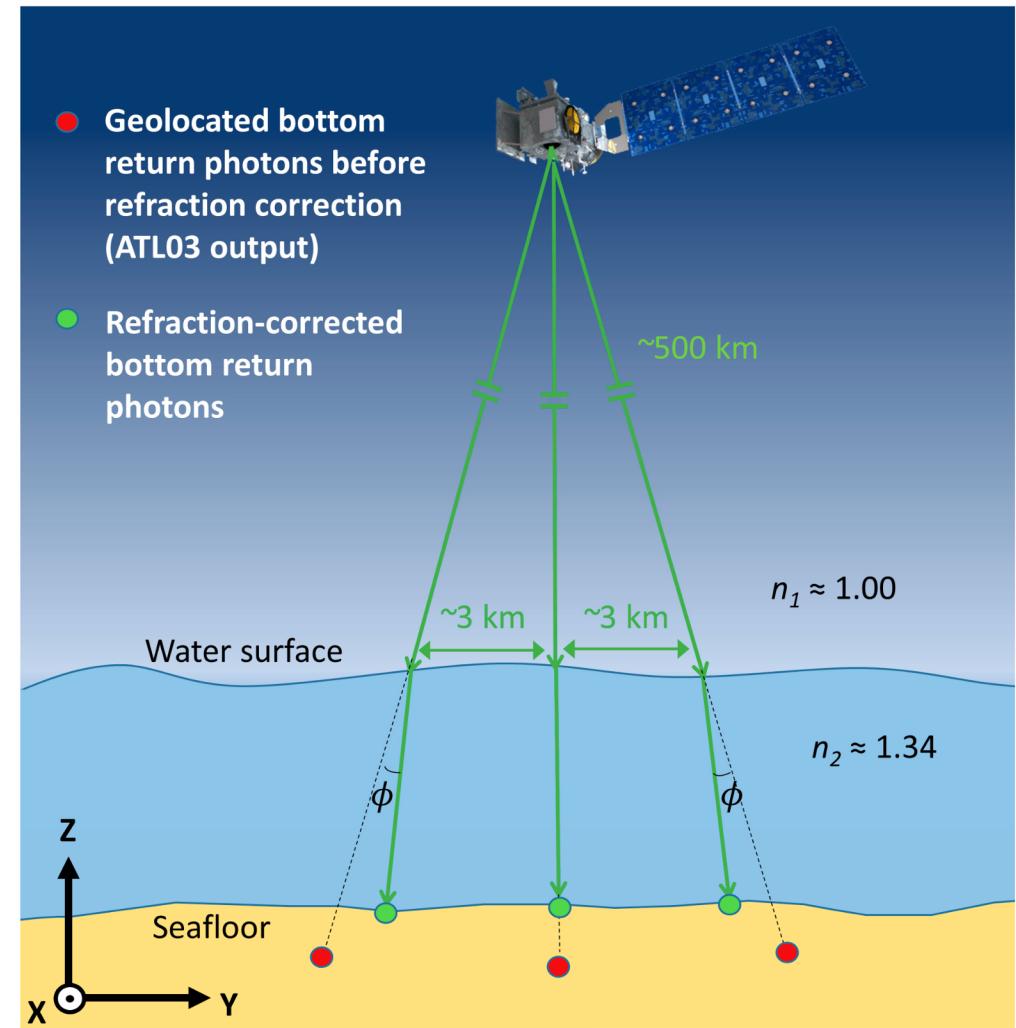
<https://www.planet.com/> (shorter)

Planet at a Glance

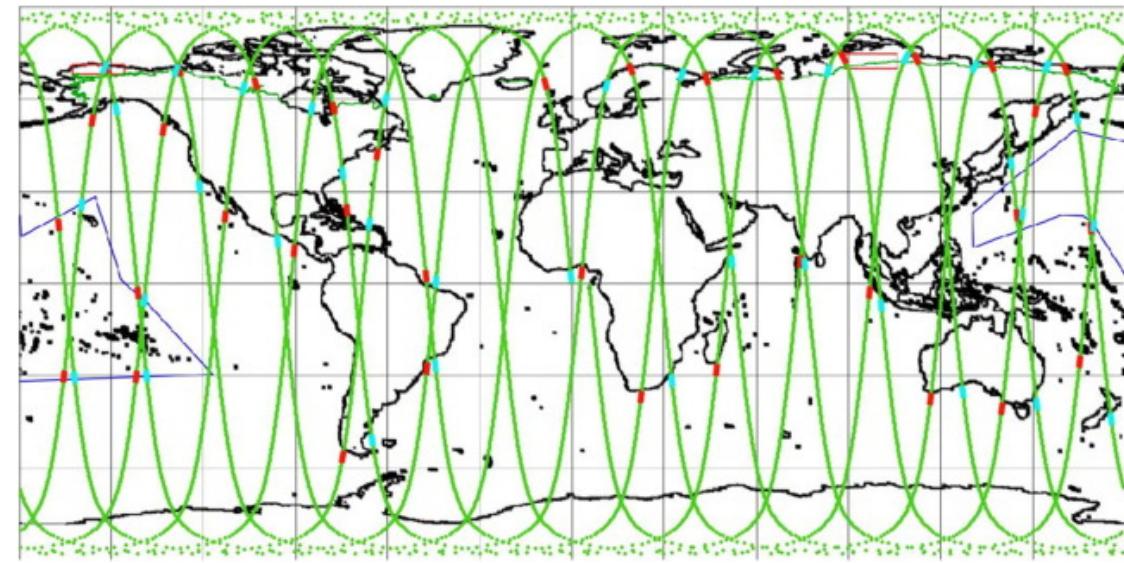
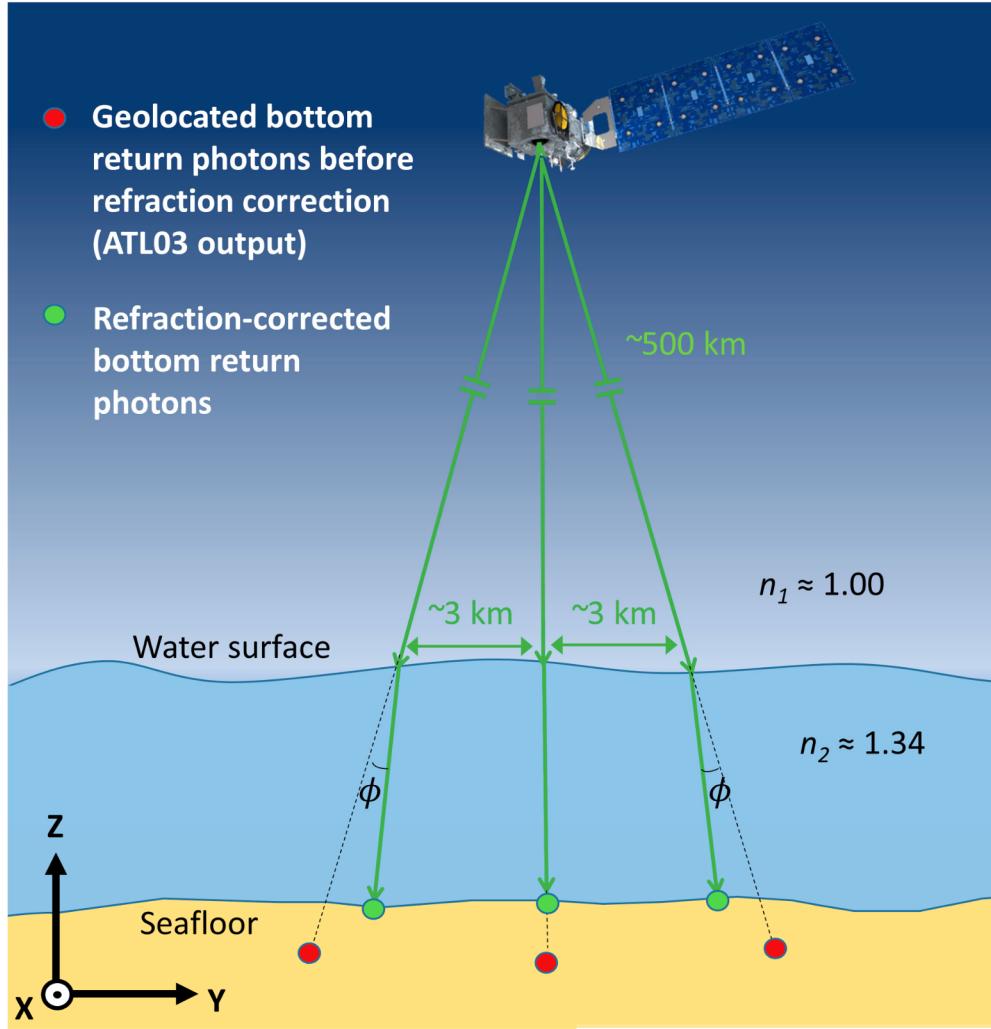
https://www.youtube.com/watch?time_continue=173&v=UL1aAwGW7VQ

Elevation data from satellites

- September 2018, NASA launched ICESat-2 laser altimeter
 - has 6 beams, consisting of 3 pairs of a strong beam and a weak beam
- Pulses of trillions of photons are sent down from the satellite and a small percentage are returned back up by satellite to accurately measure surface elevation

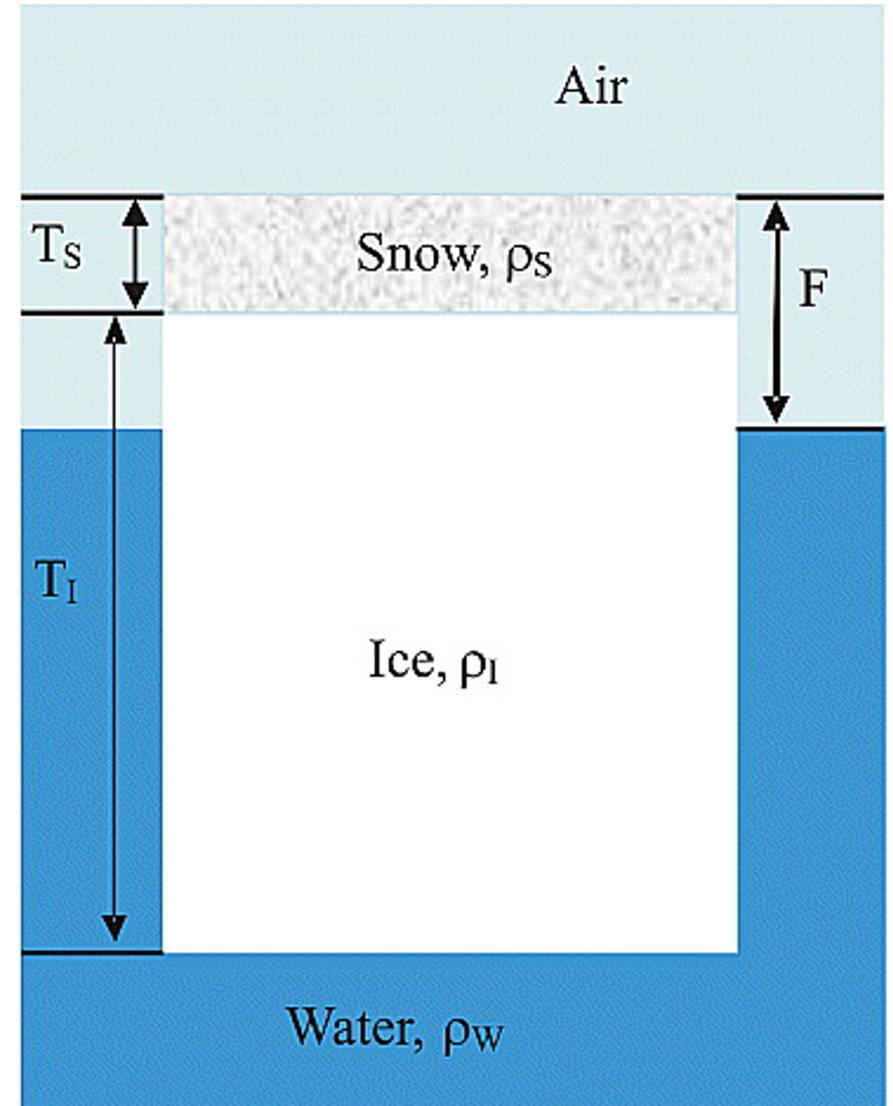


Satellite collecting elevation data



Sea Ice and leads

- The Archimedes principle is used in estimating sea ice thickness
 - Explains that the upward force is equal to the weight of the water it displaces
- Estimating sea ice thickness is a function of freeboard, determined by altimetry and other parameters. A recent study uses the following equation to estimate thickness (Quatly et al)



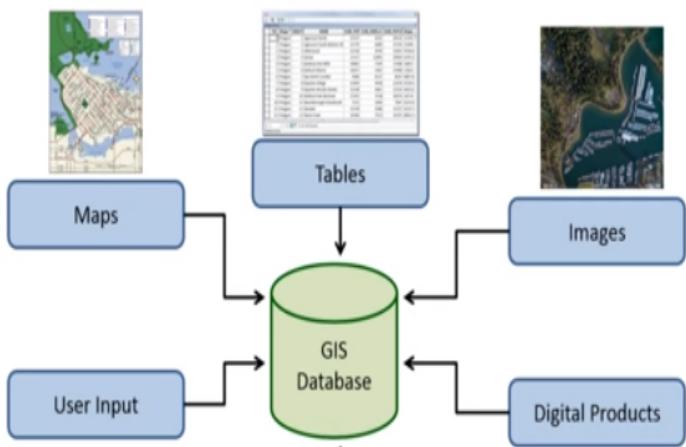
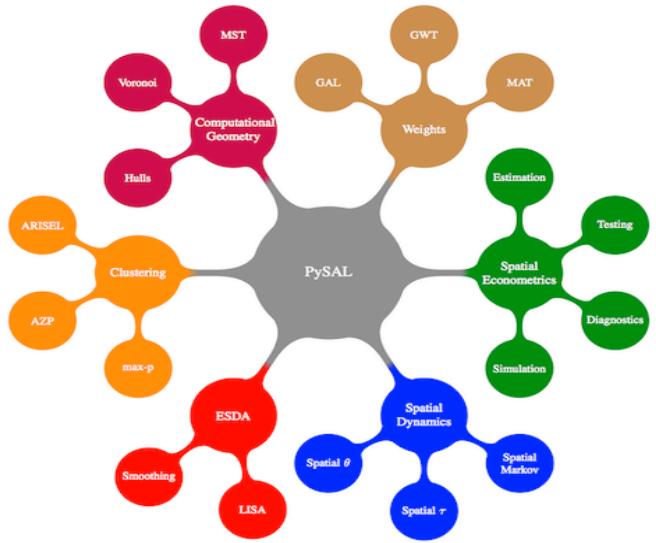
Hands on activity

- Visualizing wkt polygons

<https://github.com/satishphd/spatial-data-analytics>

- UCR star repository

Spatial Software



JTS Topology Suite



Geographic Information System (GIS) Application

- Map of population distribution
- Map of a region affected by hurricane Sandy

Where are the safe rescue shelters?



Spatial is Special

- Adding location to data adds value,
but harder to process and analyze.
- Spatial Routing:
Shortest path vs path with minimum left turns
- Cholera outbreak by hotspots

Spatial is Special

- Why all world maps are wrong ?

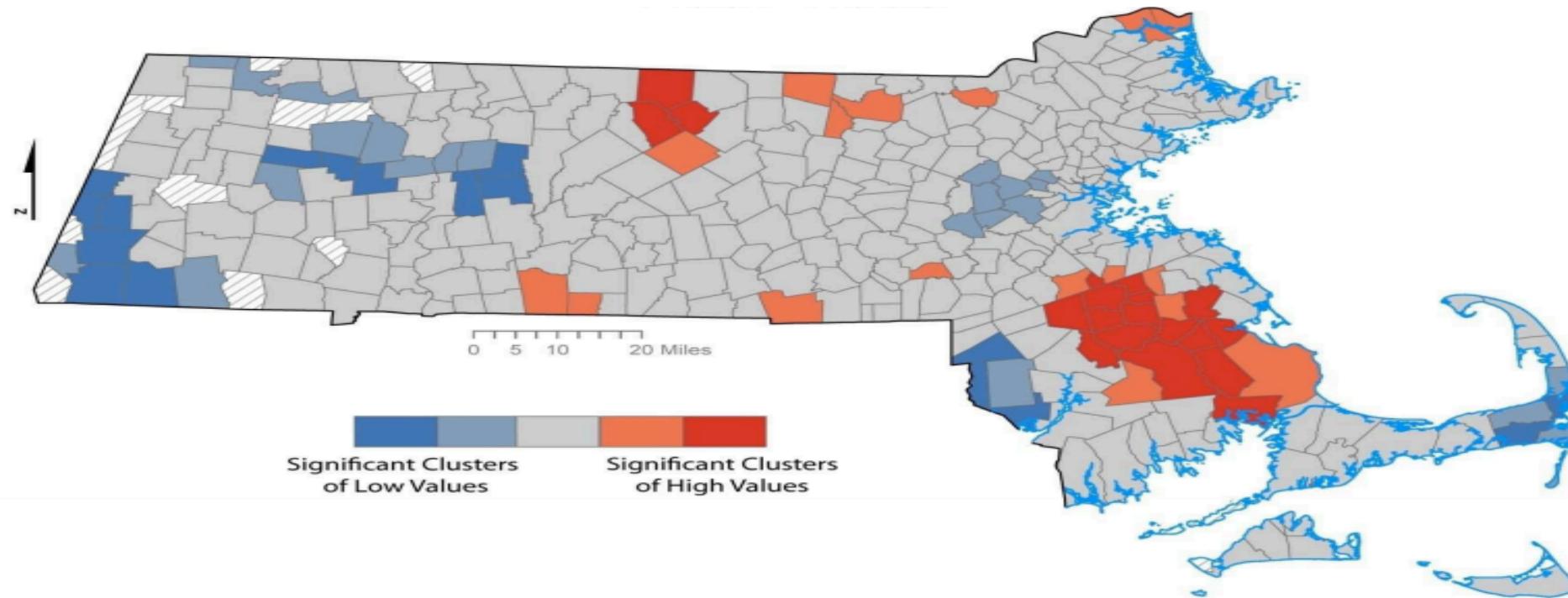
<https://www.youtube.com/watch?v=kIID5FDi2JQ>

- Why UPS trucks (almost) never turn left ?

<http://www.cnn.com/2017/02/16/world/ups-trucks-no-left-turns/index.html>

Spatial Statistics

- Hot Spot Analysis



Spatial Statistics

