

GEE Workshop – EEID 2024

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Acknowledgments

- **Professor Andrew MacDonald, UCSB**
- **Cloud Based Remote Sensing with GEE:**
<https://www.eefabook.org/>

Saturday Schedule

- **9:00am-9am:15:** Housekeeping
- **9:15am-9:30am:** Introductions
- **9:30am – 10am:** Intro to geospatial data & GEE
- **10:00am -10:30am:** Online Tutorial: Intro to the code editor, basics of JavaScript, The Earth Engine API
- **10:00am-10:45am:** Break
- **10:45am-11:00am:** Intro to Images
- **11:00am-12:00pm:** Online Tutorial: Images

Introductions

- Name
- Position (e.g., first year PhD at University of Washington)
- Study system
- Workshop goals

Intro to Geospatial Data & GEE



Intro to Geographic Information Systems (Science) - GIS

- What is GIS?
- **Geographic:** related to the Earth's surface

Intro to Geographic Information Systems (Science) - GIS

- What is GIS?
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- **Information:** data and metadata (context)

Intro to Geographic Information Systems (Science) - GIS

- What is GIS?
- **G**eographic: related to the Earth's surface
- **I**nformation: data and metadata (context)
- **S**ystem: functional components & connections
- (Burrough and McDonnell, 1998): “a set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world”

Geographic is...

- **Location: where?**
 - x = longitude
 - y = latitude
 - z = elevation



x (longitude)

Geographic is...

- **Location: where?**
 - x = longitude
 - y = latitude
 - z = elevation
- **Resolution: how precise?**
 - Spatial
 - Temporal



High Spatial Resolution



Medium Spatial Resolution

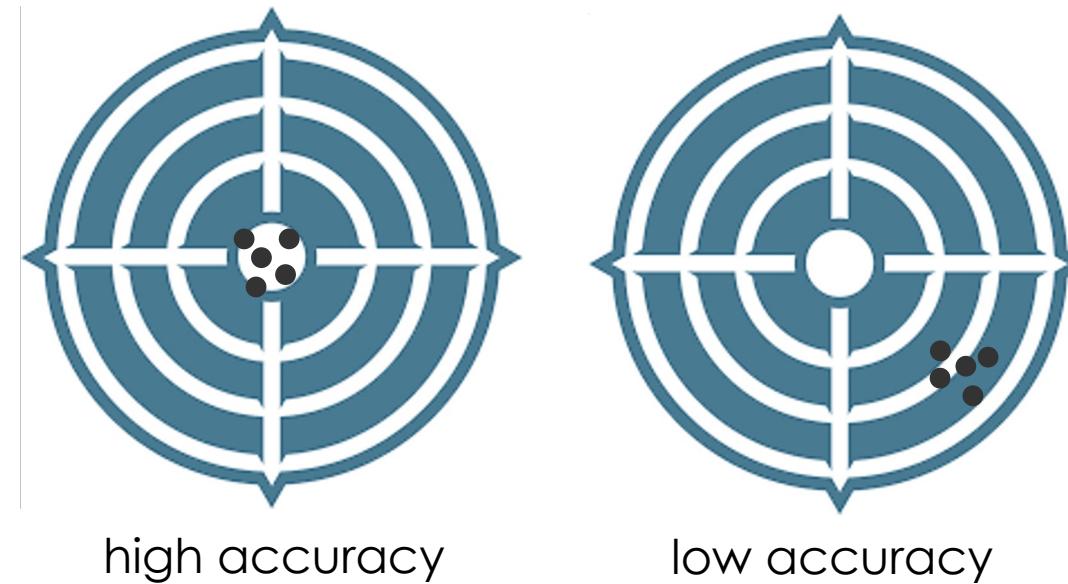


Low Spatial Resolution

hour → day → month → year

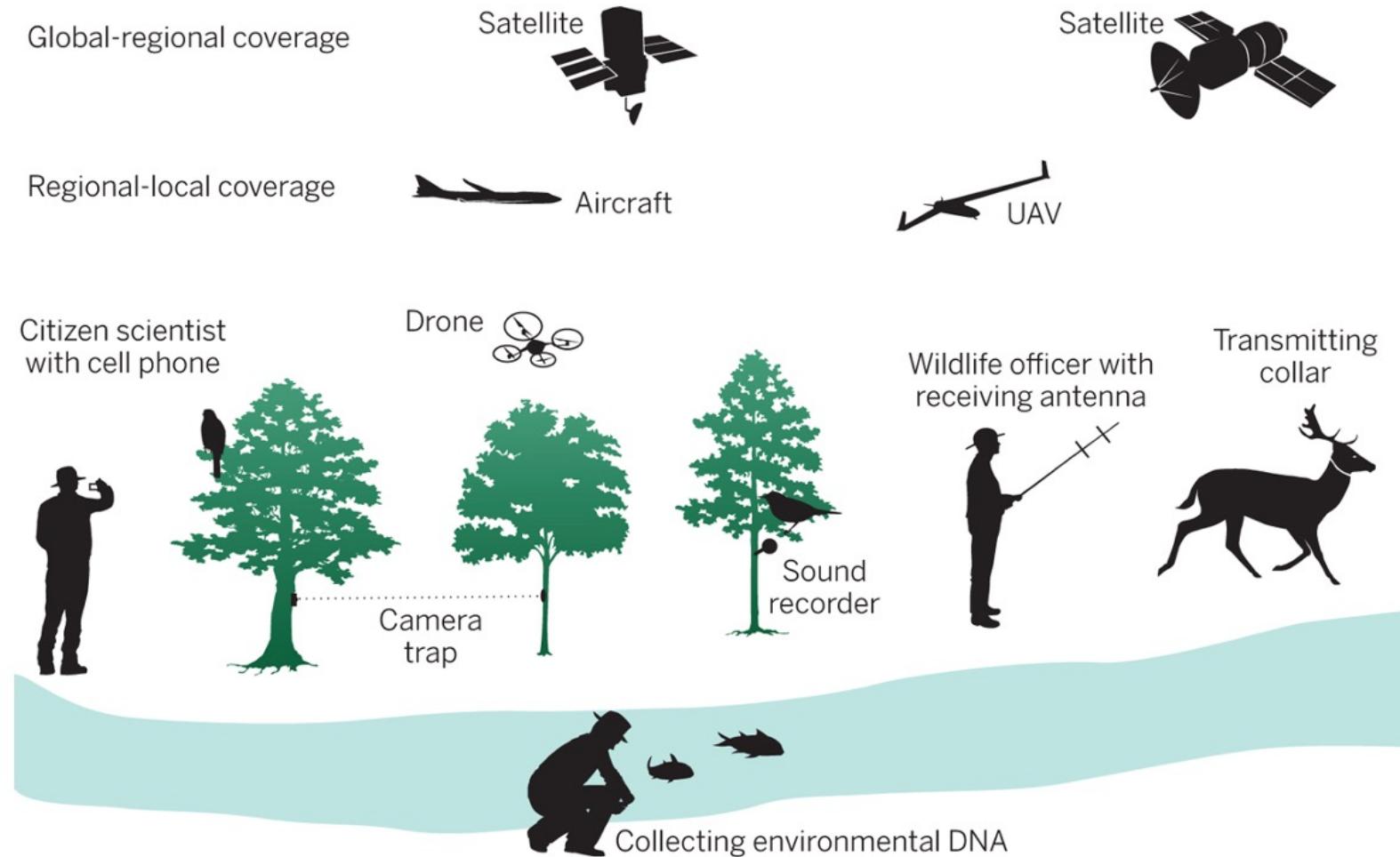
Geographic is...

- **Location:** where?
 - x = longitude
 - y = latitude
 - z = elevation
- **Resolution:** how precise?
 - Spatial
 - Temporal
- **Accuracy:** how reliable?



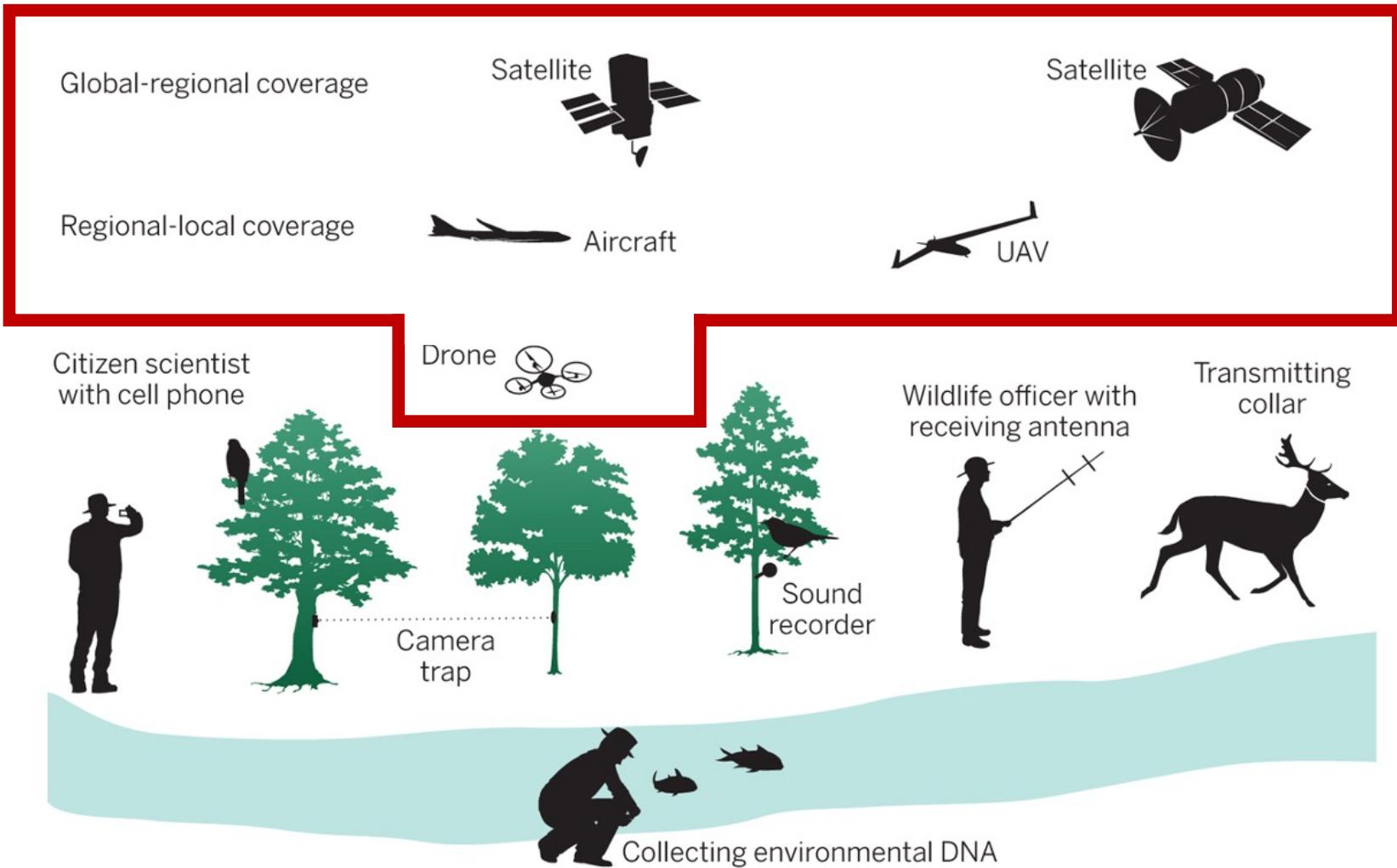
Geographic is...

- **Location:** where?
 - x = longitude
 - y = latitude
 - z = elevation
- **Resolution:** how precise?
 - Spatial
 - Temporal
- **Accuracy:** how reliable?
- **Area:** how big?
- **Distance:** How close?



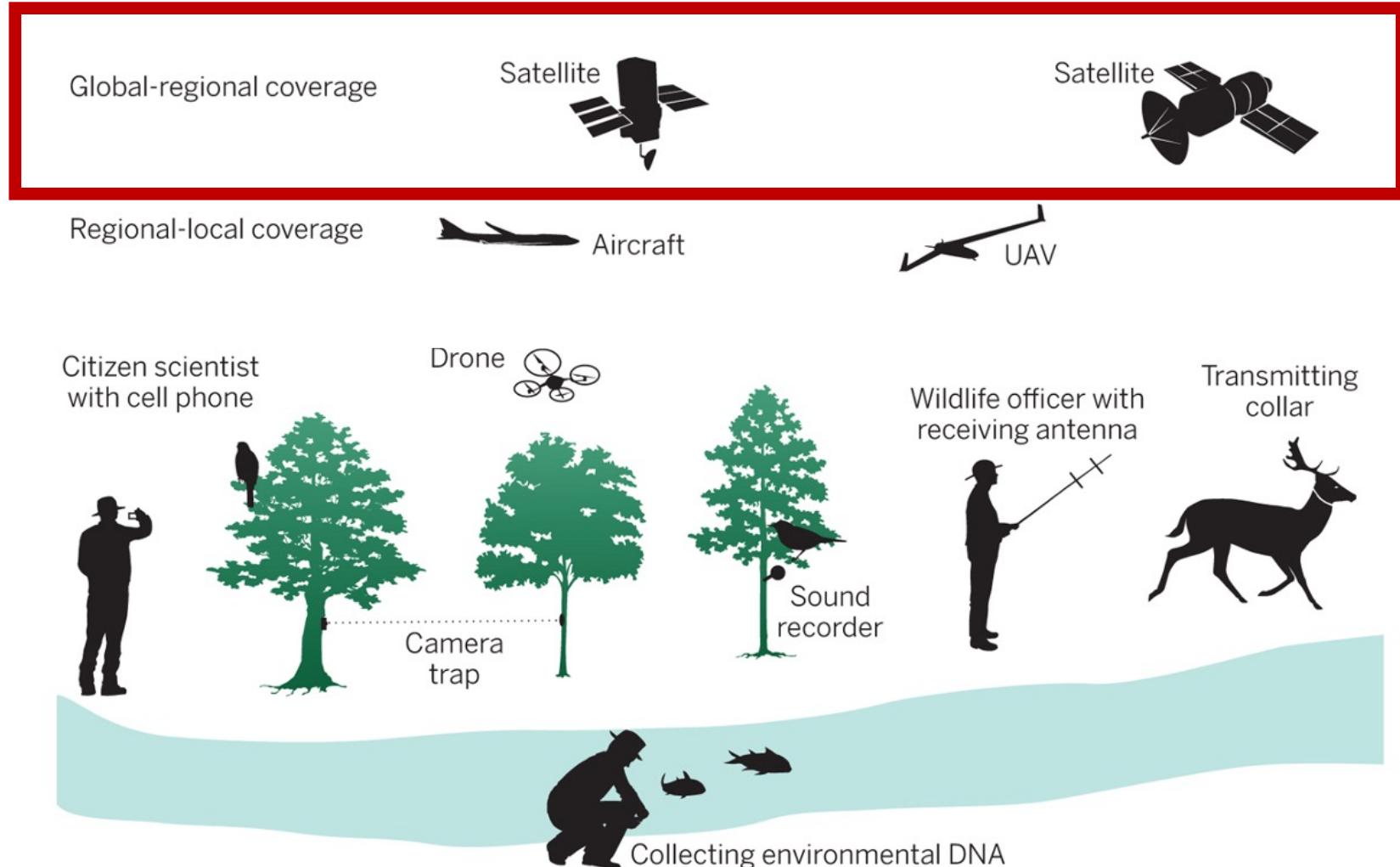
(Science 346:301-302, 10/17/14)

Remote Sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites



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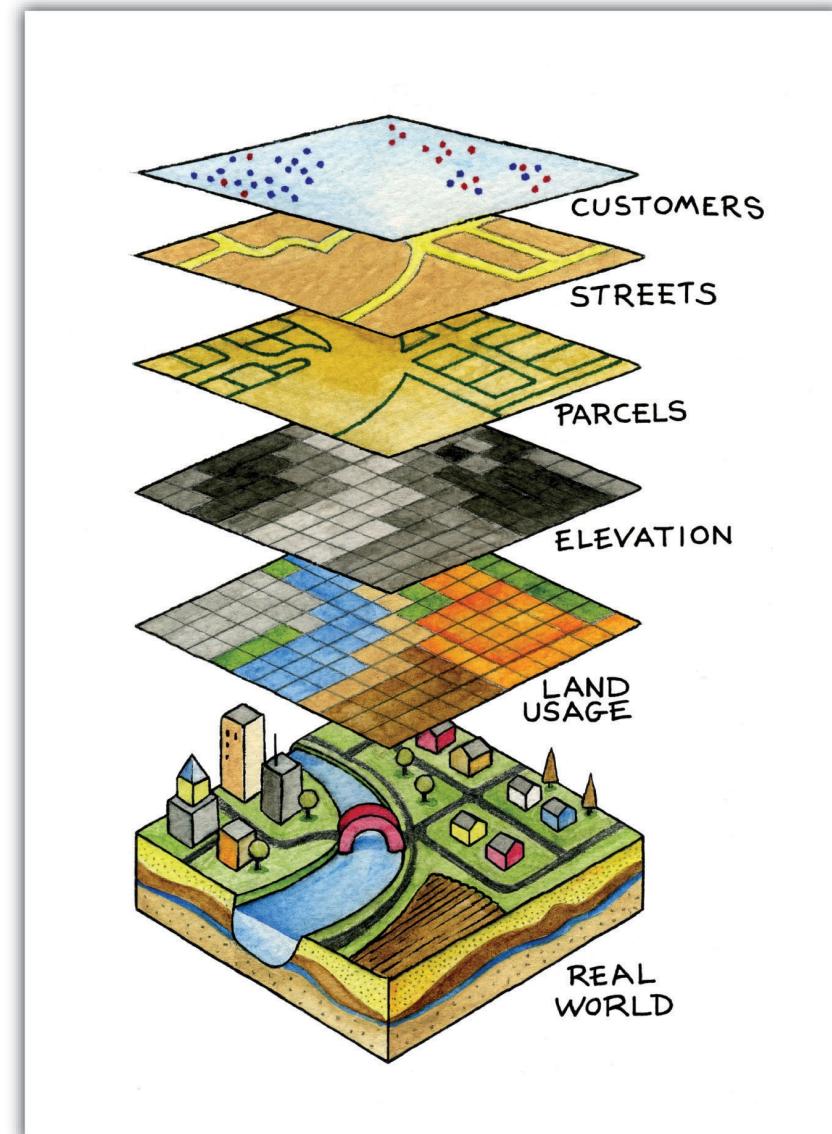


(Science 346:301-302, 10/17/14)

Remote Sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellites

The fundamental Geographic Information Problem

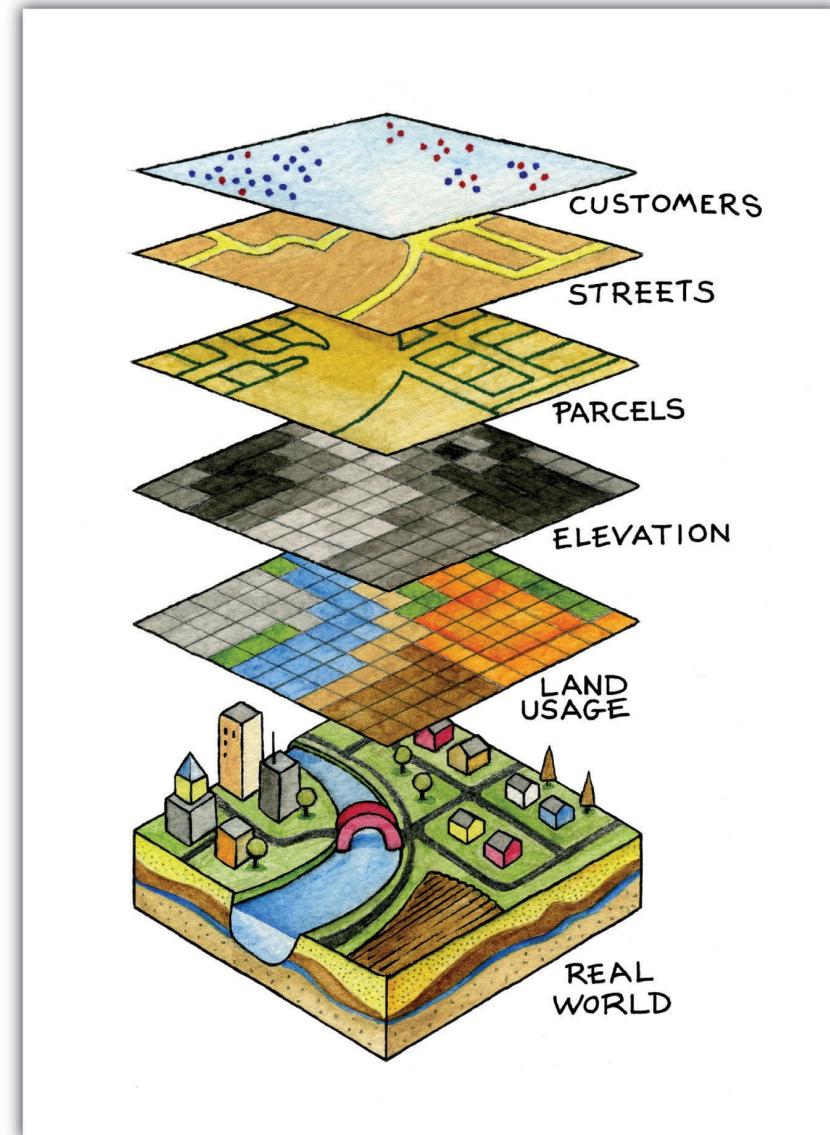
- **Linking:**
 - **Objects:** things located in space and time
 - **Attributes:** physical, social, economic, demographic, environmental...characteristics



Types of data: vector & raster

vector

raster

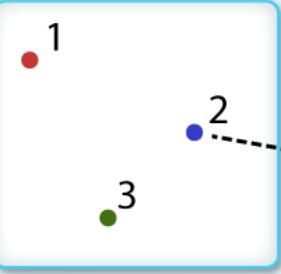


Vector

- Relating objects to attributes, 'features'

Example Attributes for Point Data

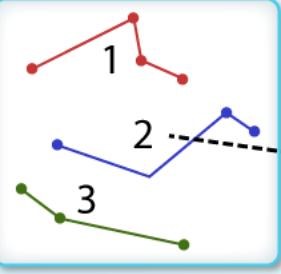
ID	Plot Size	Type	VegClass
1	40	Vegetation	Conifer
2	20	Vegetation	Deciduous
3	40	Vegetation	Conifer



A diagram showing three individual points, each assigned a unique ID (1, 2, or 3). The points are colored red, blue, and green respectively. A dashed arrow points from point 2 to the corresponding row in the attribute table.

Example Attributes for Line Data

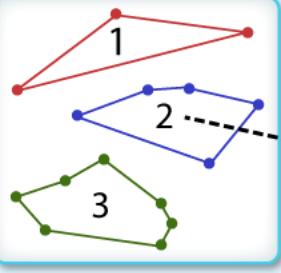
ID	Type	Status	Maintenance
1	Road	Open	Year Round
2	Dirt Trail	Open	Summer
3	Road	Closed	Year Round



A diagram showing three linear features (lines) labeled 1, 2, and 3. Each line consists of multiple points connected by straight segments. A dashed arrow points from line segment 2 to the corresponding row in the attribute table.

Example Attributes for Polygon Data

ID	Type	Class	Status
1	Herbaceous	Grassland	Protected
2	Herbaceous	Pasture	Open
3	Herbaceous / Woody	Grassland	Protected

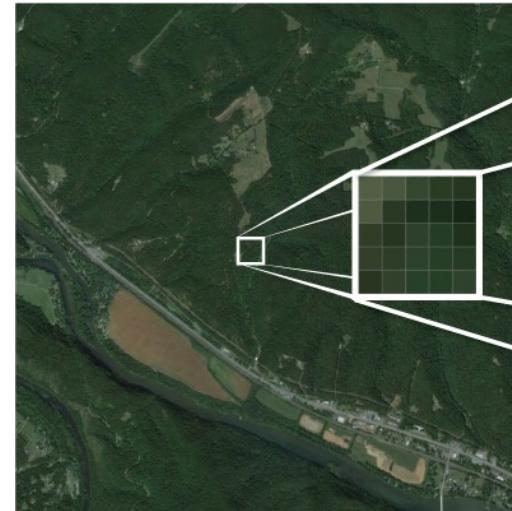


A diagram showing three polygonal regions labeled 1, 2, and 3. Each polygon is defined by a closed set of vertices. A dashed arrow points from polygon 2 to the corresponding row in the attribute table.



Raster

- Gridded data
- Each pixel associated with specific geographic location
- Can be continuous (e.g., temperature) or categorical (e.g., land-use)
- Includes spatial information defining:
 - extent (geographic area covered)
 - cell size (resolution)
 - Coordinate reference system

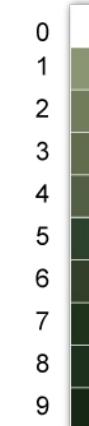


0,0	1	3	9	7	7
1m {	2	8	7	7	8
6	7	3	5	7	
7	6	5	5	6	
8	6	5	6	4	

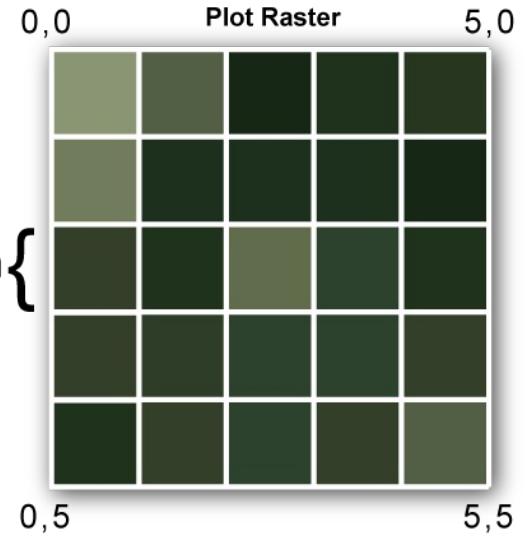
0,5 5,5

Plot Raster

Legend



1m {



0,5

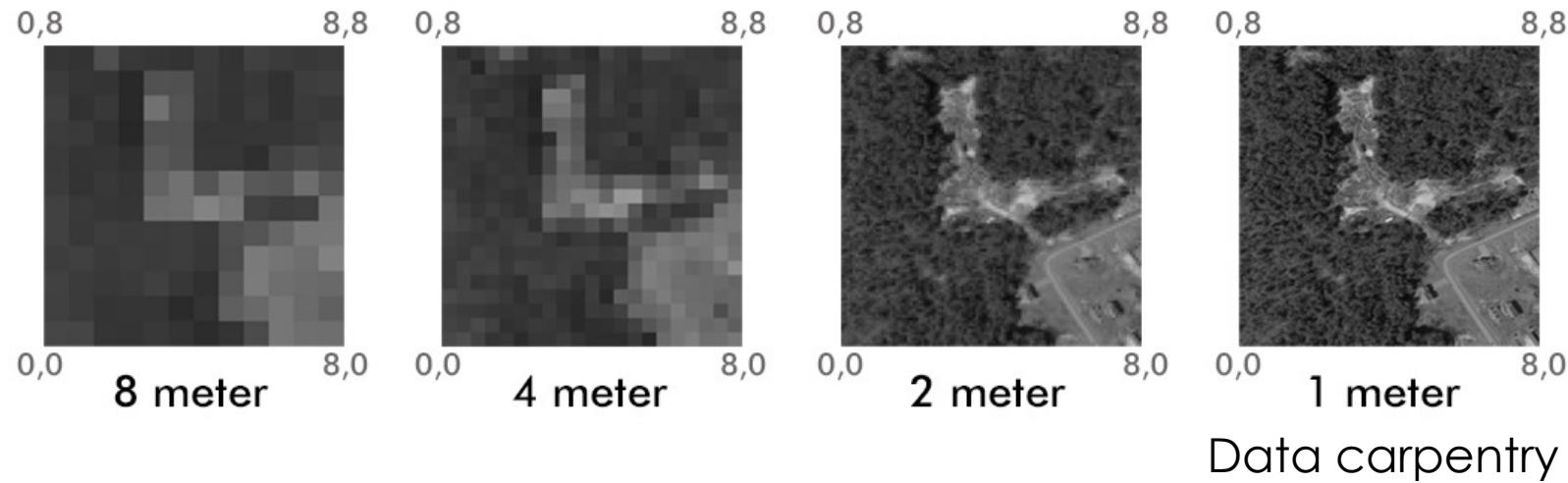
5,5

neon

Data carpentry

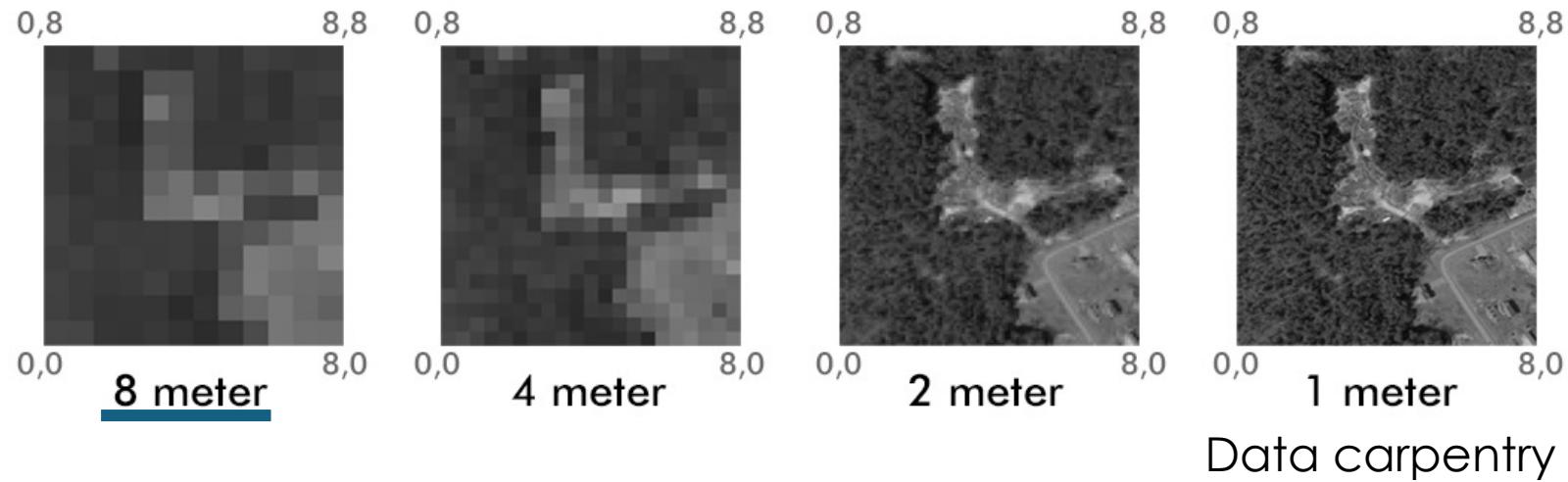
Raster

Raster over the same extent, at 4 different resolutions



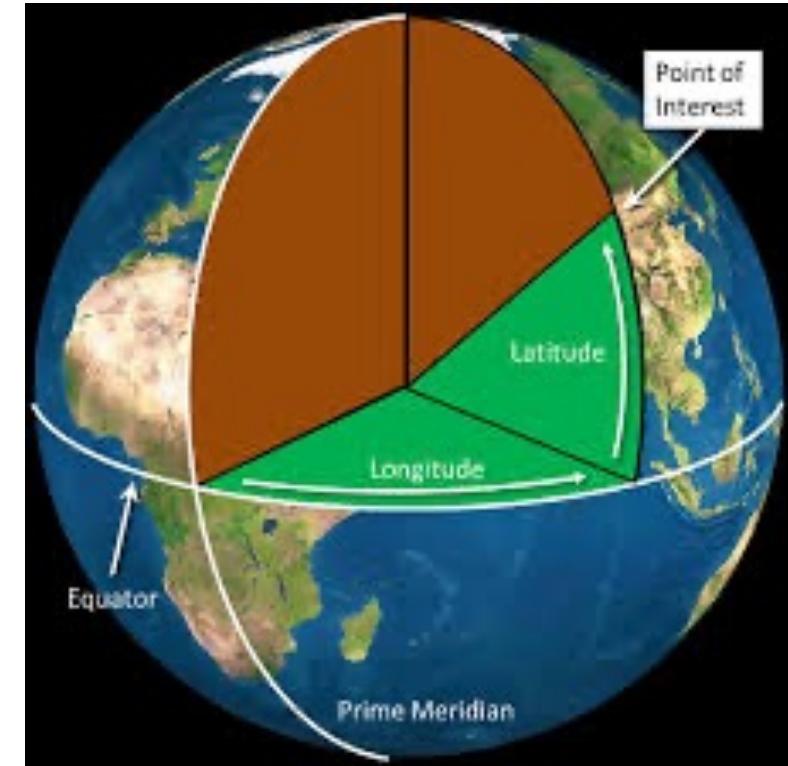
Raster

Raster over the same extent, at 4 different resolutions



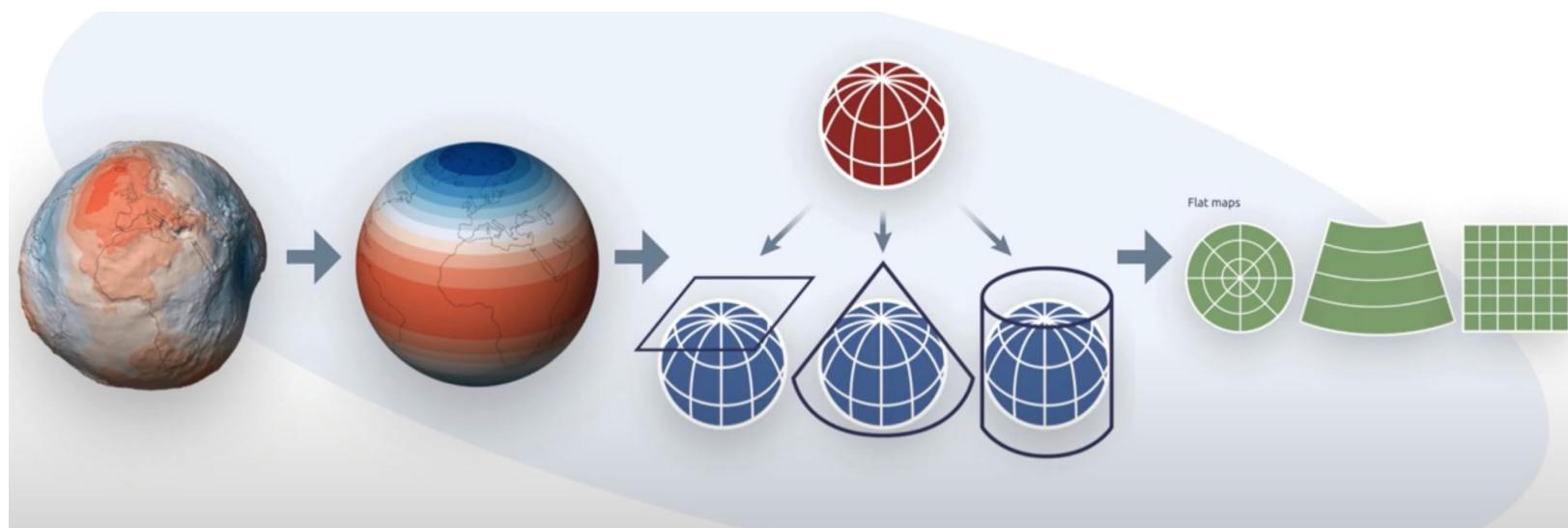
Coordinate Reference System

- Relate locations in projected 2D space to actual locations on earth's surface
- Tells us distance, location, direction
- Geographic CS: lat & long
- Projected CS: transformed to 2D, represented by meters, feet, etc



Projections

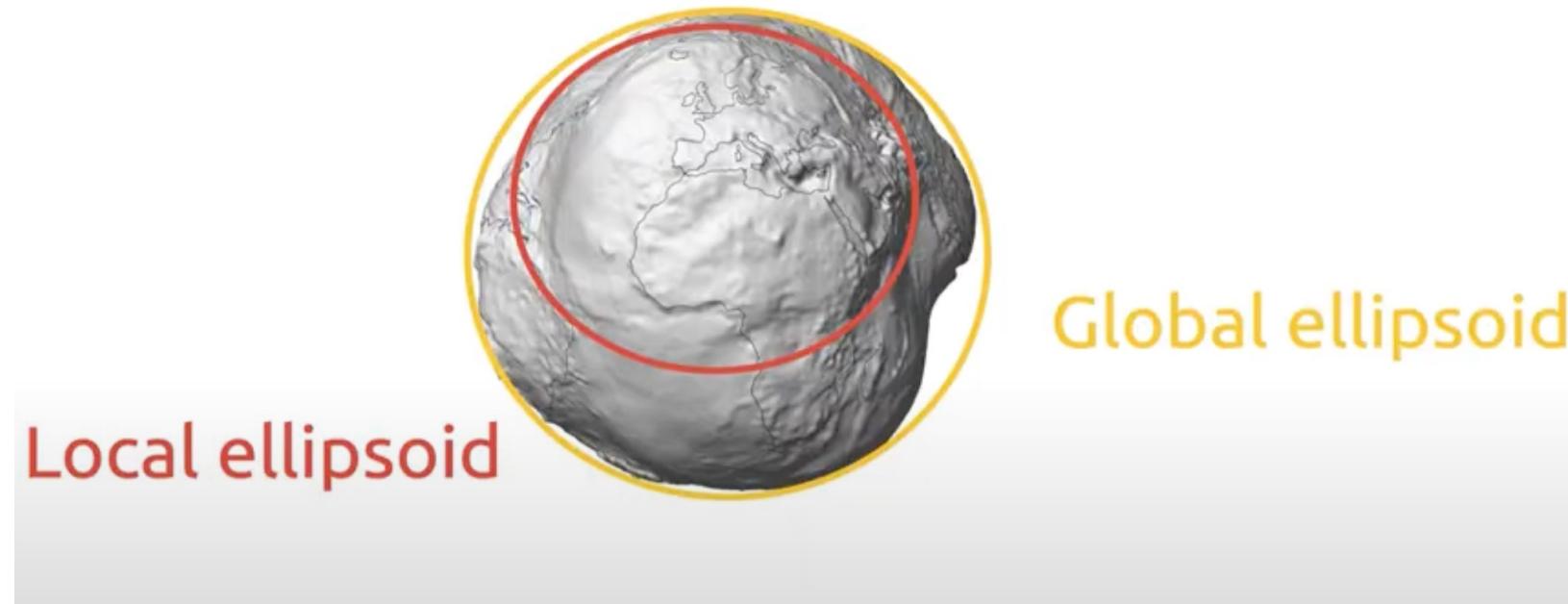
- Shape of Earth impossible to model (~ellipsoid)
- Projections simplify shape so we can map it
- Project shapes in a way that they can be “unrolled” to 2D representations
- All trade off in ability to capture angles, distance, shape, and area



MapTiler

Datum

- a mathematical model of the Earth that serves as the reference point for the geographic coordinate systems
- defines the position of the spheroid relative to the center of the earth
- **critical to making sure geographic data is comparable**



When datum doesn't match



USS LA MOURE COUNTY aground in Caleta Cifuncho Bay, Chile
after navigating with GPS (WGS-84 datum) on a local chart with a local datum.

When datum doesn't match



Google Earth Engine Default; Facilitates combining global data sources

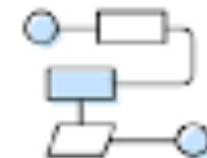
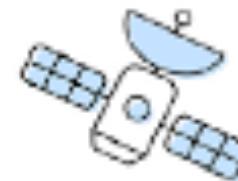
- CRS: EPSG:4326
- Datum: WGS 84 (World Geodetic System 1984)
- No projection when analyzing data, retains spherical relationships (lat, long)
- Projected for image visualization
 - Typically cylindrical projection Web Mercator, corresponding to EPSG:3857

Intro to Google Earth Engine

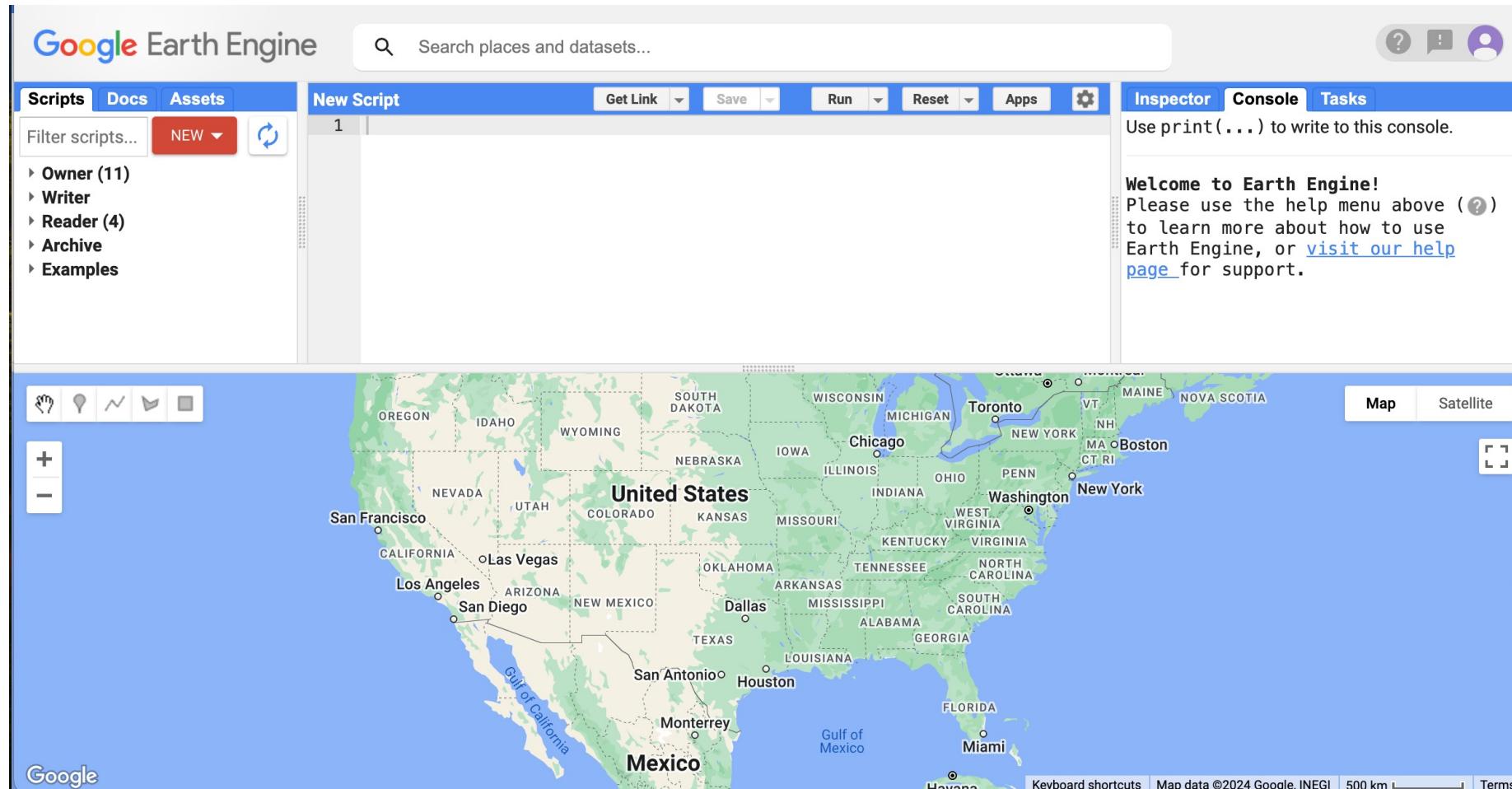
- Cloud based platform for geospatial analyses
 - Enables complex, computationally expensive analyses
 - Stores tons of data



Google Earth Engine



The code editor



The data catalog

Earth Engine Data Catalog

 Search[English](#)[Home](#) [View all datasets](#) [Browse by tags](#) [Landsat](#) [MODIS](#) [Sentinel](#) [Publisher](#) [Community](#) [API Docs](#)

Earth Engine Data Catalog



Earth Engine's public data catalog includes a variety of standard Earth science raster datasets. You can import these datasets into your script environment with a single click. You can also upload your own [raster data](#) or vector data for private use or sharing in your scripts.

Looking for another dataset not in Earth Engine yet? Let us know by [suggesting a dataset](#).

 Filter list of datasets

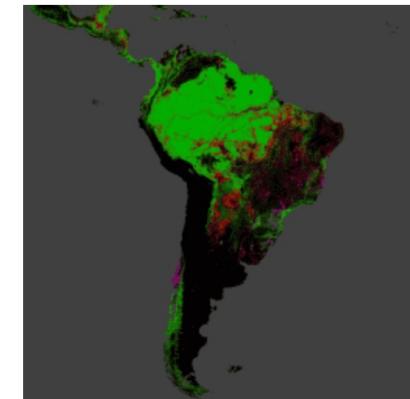
Earth Engine Data Catalog

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 Hansen

Hansen Global Forest Change v1.11
(2000-2023)



Results from time-series analysis of Landsat images in characterizing global forest extent and change. The 'first' and 'last' bands are reference multispectral imagery from the first and last available years for Landsat spectral bands corresponding to red, NIR, SWIR1, and SWIR2. Reference composite imagery represents ...

10:00am - 10:30am:

Online Tutorial: Intro to the code editor, basics of JavaScript, The Earth Engine API

<https://github.com/ckglidden/gee-eeid-wkshp>

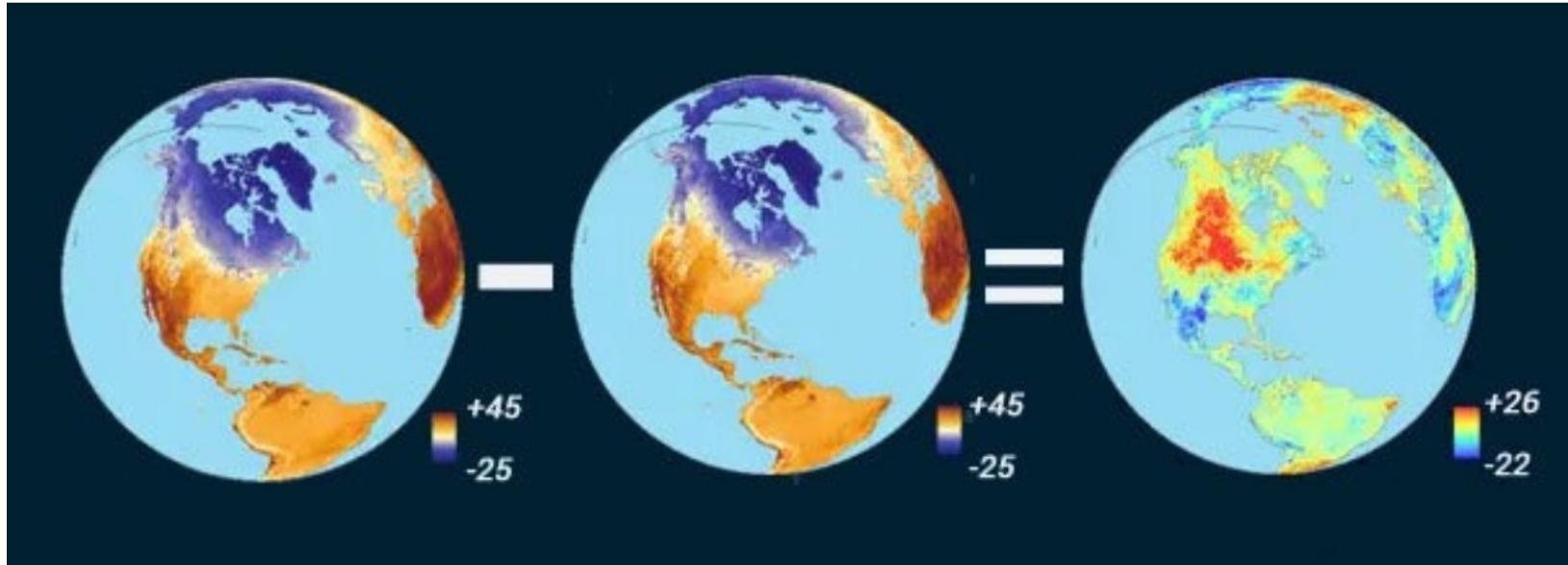


Intro to Images

GEE's strength is processing raster data

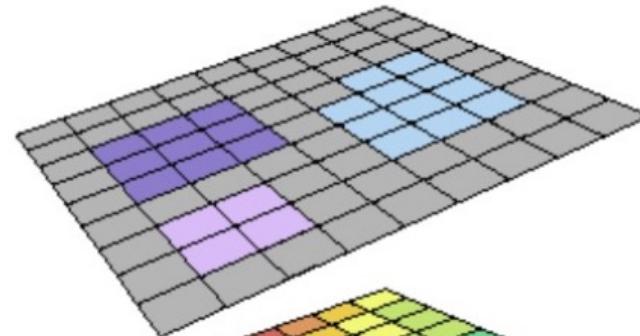
GEE's strength is processing raster data

- Data visualization
- Raster algebra
- Raster clipping & masking

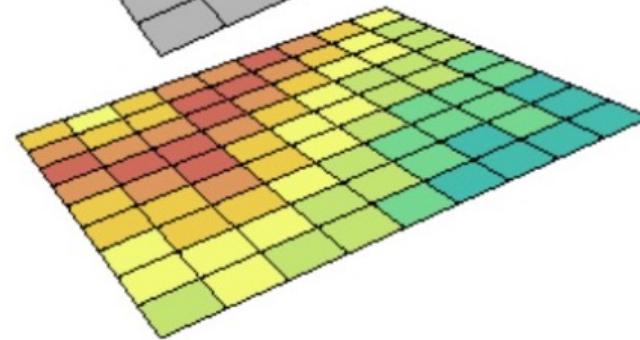


GEE's strength is processing raster data

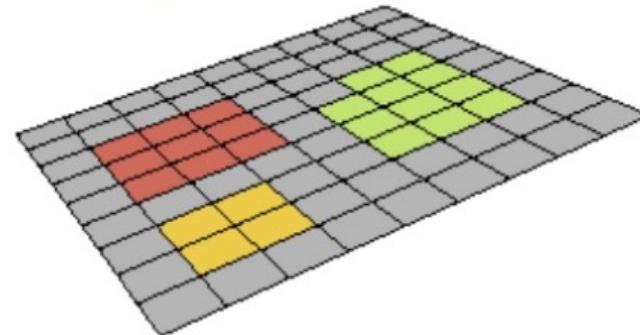
- Data visualization
- Raster algebra
- Raster clipping & masking
- Zonal statistics
 - (Feature Collections)



Zone layer
Defines the zones
(shapes, values and locations)

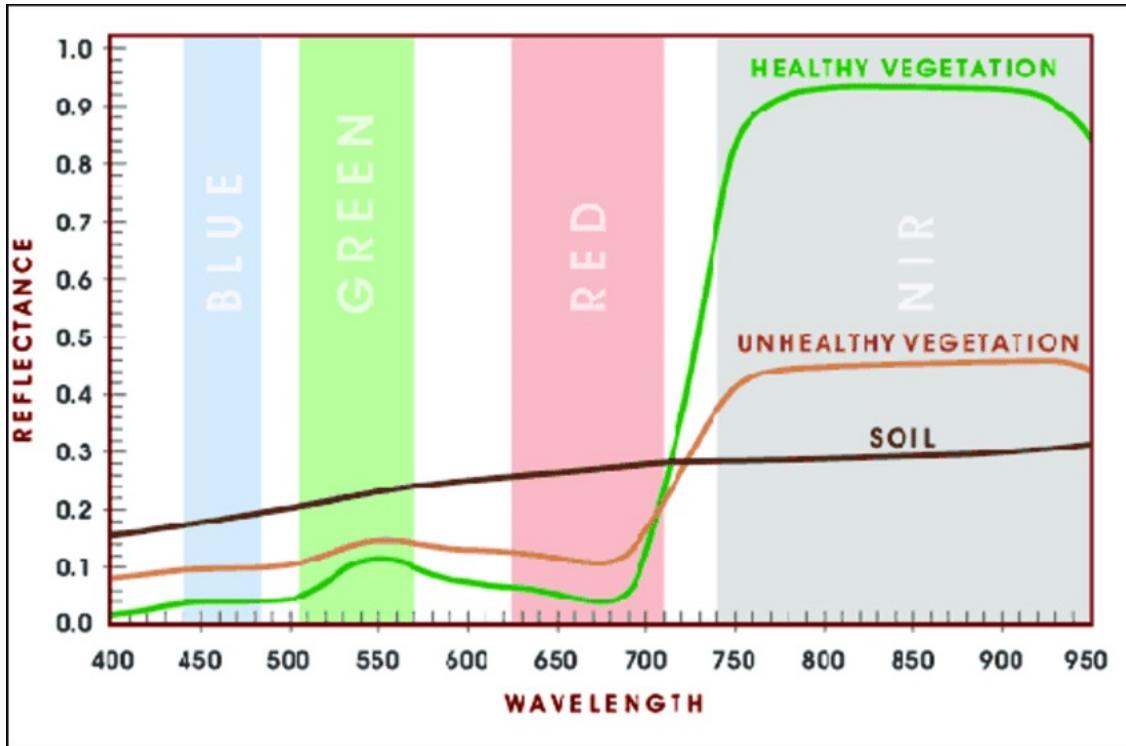


Value layer
Contains the input values
used in calculating the output
for each zone.

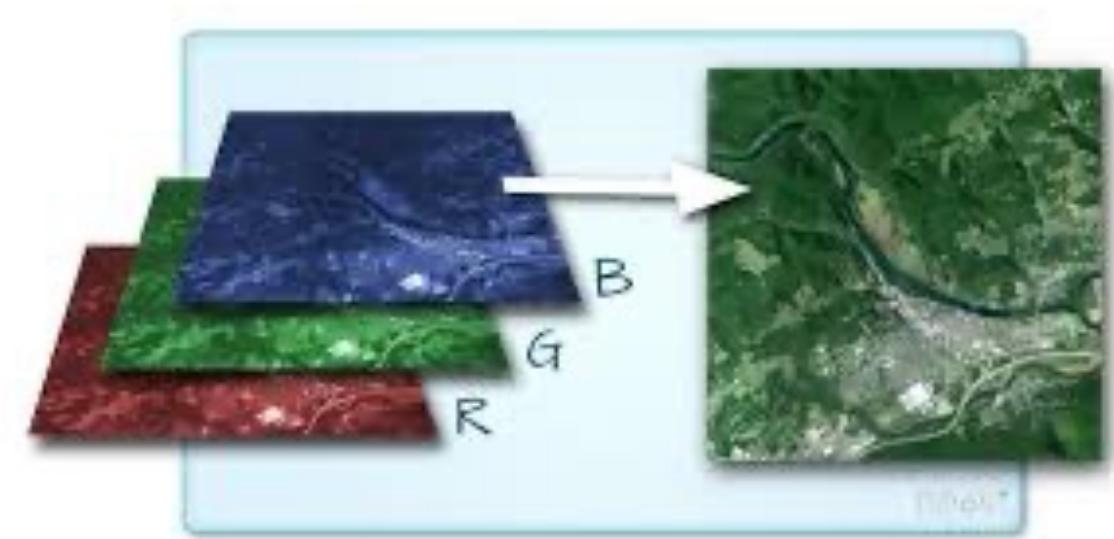


Output
The result of the statistic
applied to the value input
(Maximum in this example).

Images = Raster data

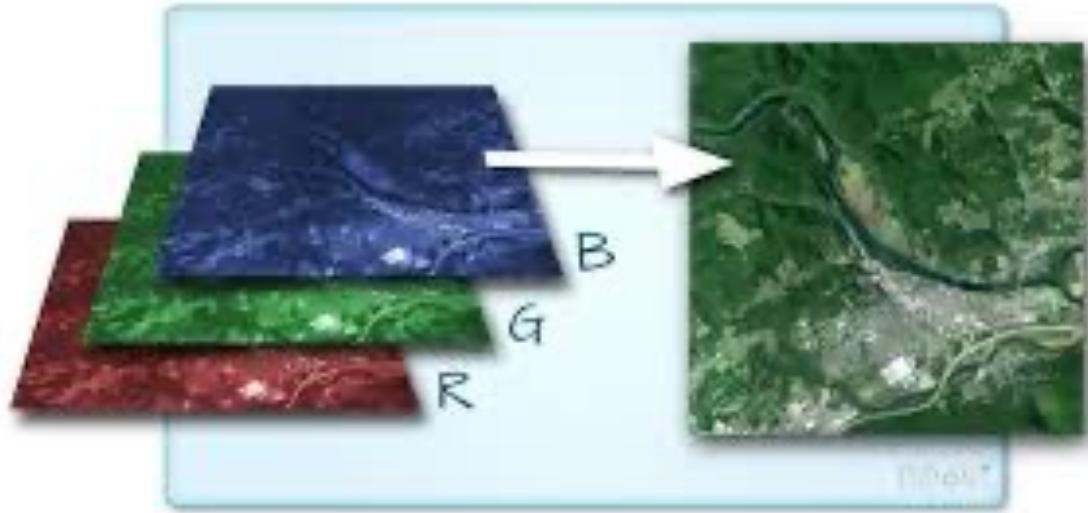


ESRI



Data Carpentry

Images = Raster data



Data Carpentry

```
1 var first_image = ee.Image(  
2   'LANDSAT/LT05/C02/T1_L2/LT05_118038_20000606');  
3
```

```
use print() to write to this console.  
  
▼ Image LANDSAT/LT05/C02/T1_L2/LT05_118038_20000606...  
  type: Image  
  id: LANDSAT/LT05/C02/T1_L2/LT05_118038_20000606  
  version: 1627477178987932  
  ▼ bands: List (19 elements)  
    ▷ 0: "SR_B1", unsigned int16, EPSG:32651, 7891x7  
    ▷ 1: "SR_B2", unsigned int16, EPSG:32651, 7891x7  
    ▷ 2: "SR_B3", unsigned int16, EPSG:32651, 7891x7  
    ▷ 3: "SR_B4", unsigned int16, EPSG:32651, 7891x7  
    ▷ 4: "SR_B5", unsigned int16, EPSG:32651, 7891x7  
    ▷ 5: "SR_B7", unsigned int16, EPSG:32651, 7891x7  
    ▷ 6: "SR_ATMOS_OPACITY", signed int16, EPSG:3265  
    ▷ 7: "SR_CLOUD_QA", unsigned int8, EPSG:32651, 7  
    ▷ 8: "ST_B6", unsigned int16, EPSG:32651, 7891x7  
    ▷ 9: "ST_ATRAN", signed int16, EPSG:32651, 7891x  
    ▷ 10: "ST_CDIST", signed int16, EPSG:32651, 7891  
    ▷ 11: "ST_DRAD", signed int16, EPSG:32651, 7891x  
    ▷ 12: "ST_EMIS", signed int16, EPSG:32651, 7891x  
    ▷ 13: "ST_EMSD", signed int16, EPSG:32651, 7891x  
    ▷ 14: "ST_QA", signed int16, EPSG:32651, 7891x72  
    ▷ 15: "ST_TRAD", signed int16, EPSG:32651, 7891x  
    ▷ 16: "ST_URAD", signed int16, EPSG:32651, 7891x  
    ▷ 17: "QA_PIXEL", unsigned int16, EPSG:32651, 78  
    ▷ 18: "QA_RADSAT", unsigned int16, EPSG:32651, 7
```

11:00am - 12:00pm:

Online Tutorial: Images

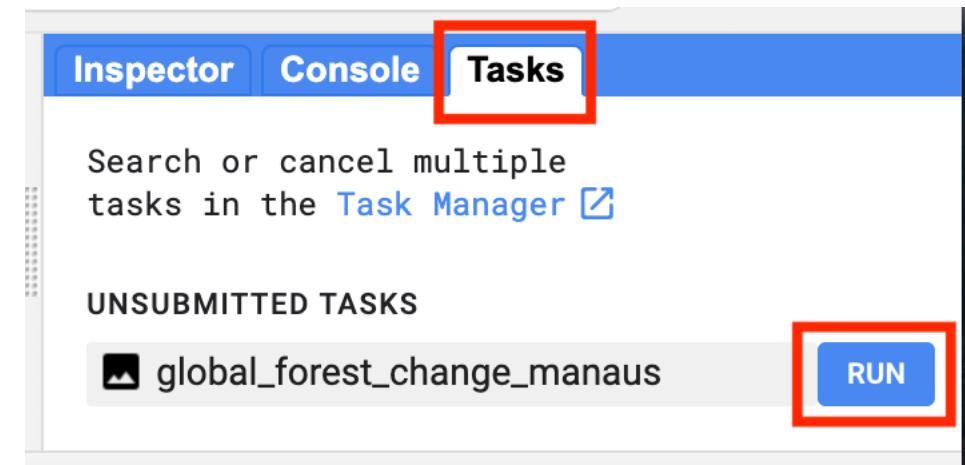
<https://github.com/ckglidden/gee-eid-wkshp>

Sunday Schedule

- **12:30pm-12:40pm:** Intro to Image Collections
- **12:40pm-1:30pm:** Online Tutorial: Image Collections
- **1:30pm-1:45pm:** Intro to Feature
- **1:45pm-2:00pm:** Online Tutorial: Features
- **2:00-2:15pm:** Break
- **2:15-2:30pm:** Intro to Feature Collections
- **2:30-3:30pm:** Online tutorial: Feature Collections
- **3:30pm-4:00pm:** Online Tutorial: Working with data in R
- **4:00pm-4:30pm:** Aly Presentation
- **4:30pm-5:00pm:** Plan individual projects

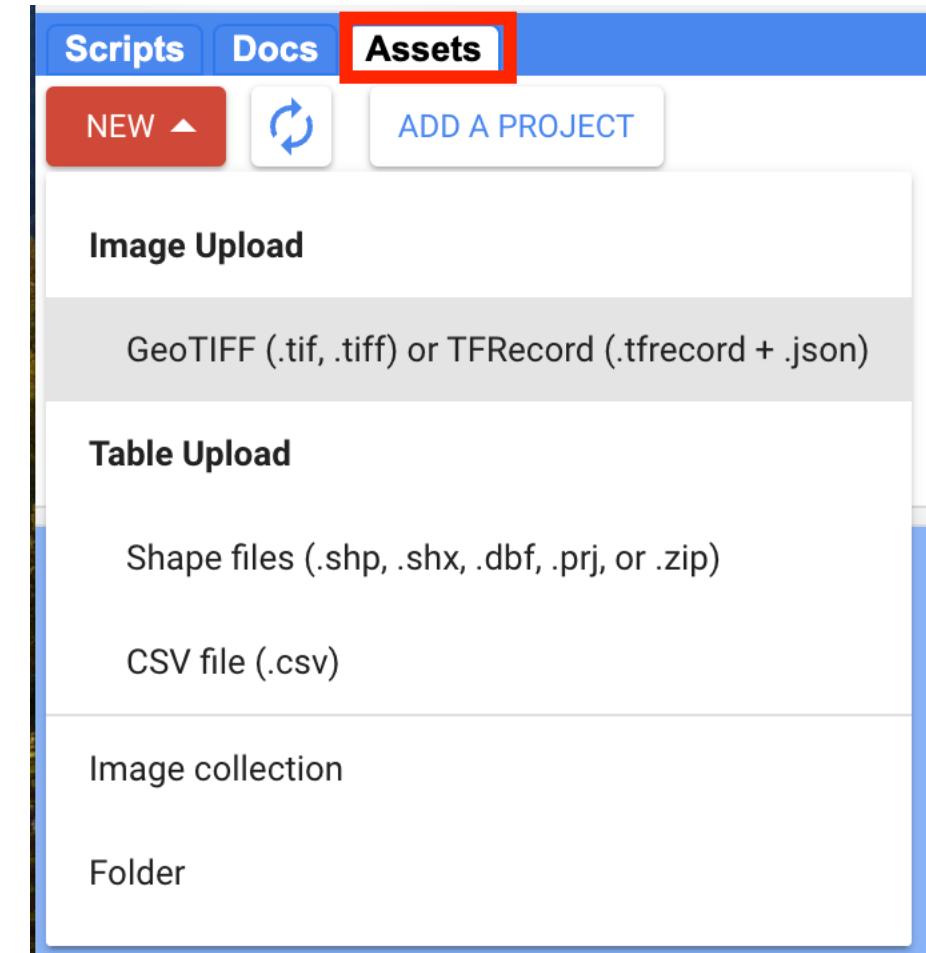
Images recap

- Exporting data/tasks



Images recap

- Exporting data/tasks
- EE Assets
 - Rasters
 - Vectors
 - Model results





Intro to Image Collections

Image collections



Image collections



```
era5 2023 temps          JSON
└─ ImageCollection ECMWF/ERA5_LAND/MONTHLY_AGGR... JSON
    type: ImageCollection
    id: ECMWF/ERA5_LAND/MONTHLY_AGGR
    version: 1715231870071743
    bands: []
    └─ features: List (12 elements)
        └─ 0: Image ECMWF/ERA5_LAND/MONTHLY_AGGR/20230...
            type: Image
            id: ECMWF/ERA5_LAND/MONTHLY_AGGR/202301
            version: 1715231870071743
            bands: List (3 elements)
                └─ 0: "temperature_2m", double, EPSG:4326, ...
                └─ 1: "temperature_2m_min", double, EPSG:4...
                └─ 2: "temperature_2m_max", double, EPSG:4...
            properties: Object (7 properties)
        └─ 1: Image ECMWF/ERA5_LAND/MONTHLY_AGGR/20230...
```

**console can't print > 5k elements

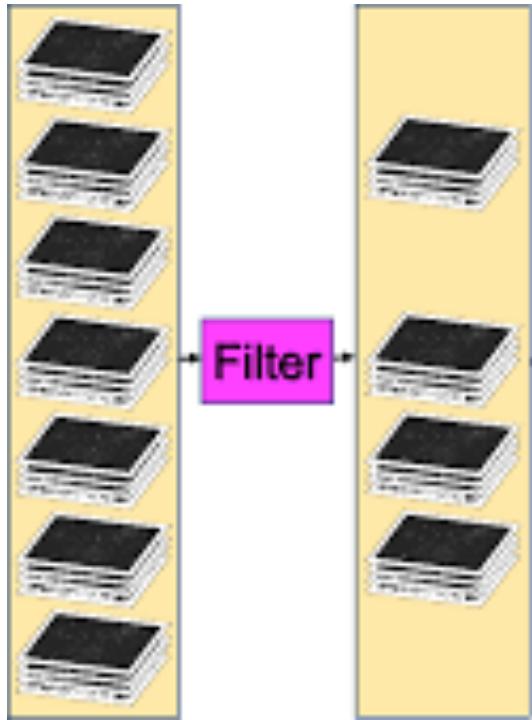
Image collections



```
era5 2023 temps          JSON
└─ ImageCollection ECMWF/ERA5_LAND/MONTHLY_AGGR... JSON
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    bands: []
    └─ features: List (12 elements)
        └─ 0: Image ECMWF/ERA5_LAND/MONTHLY_AGGR/20230...
            type: Image
            id: ECMWF/ERA5_LAND/MONTHLY_AGGR/202301
            version: 1715231870071743
            └─ bands: List (3 elements)
                └─ 0: "temperature_2m", double, EPSG:4326, ...
                └─ 1: "temperature_2m_min", double, EPSG:4...
                └─ 2: "temperature_2m_max", double, EPSG:4...
            └─ properties: Object (7 properties)
            └─ 1: Image ECMWF/ERA5_LAND/MONTHLY_AGGR/20230...
```

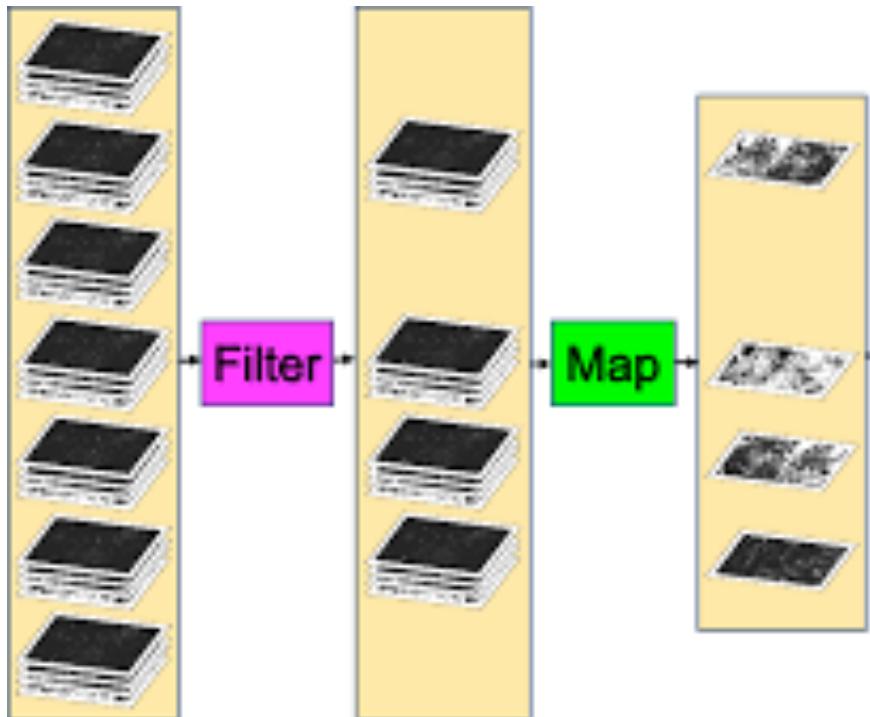
```
// try to print collection - you may get a memory error
print('era5 print attempt', era5); → // print('era5 print attempt', era5);
```

Filter: reduce number of images



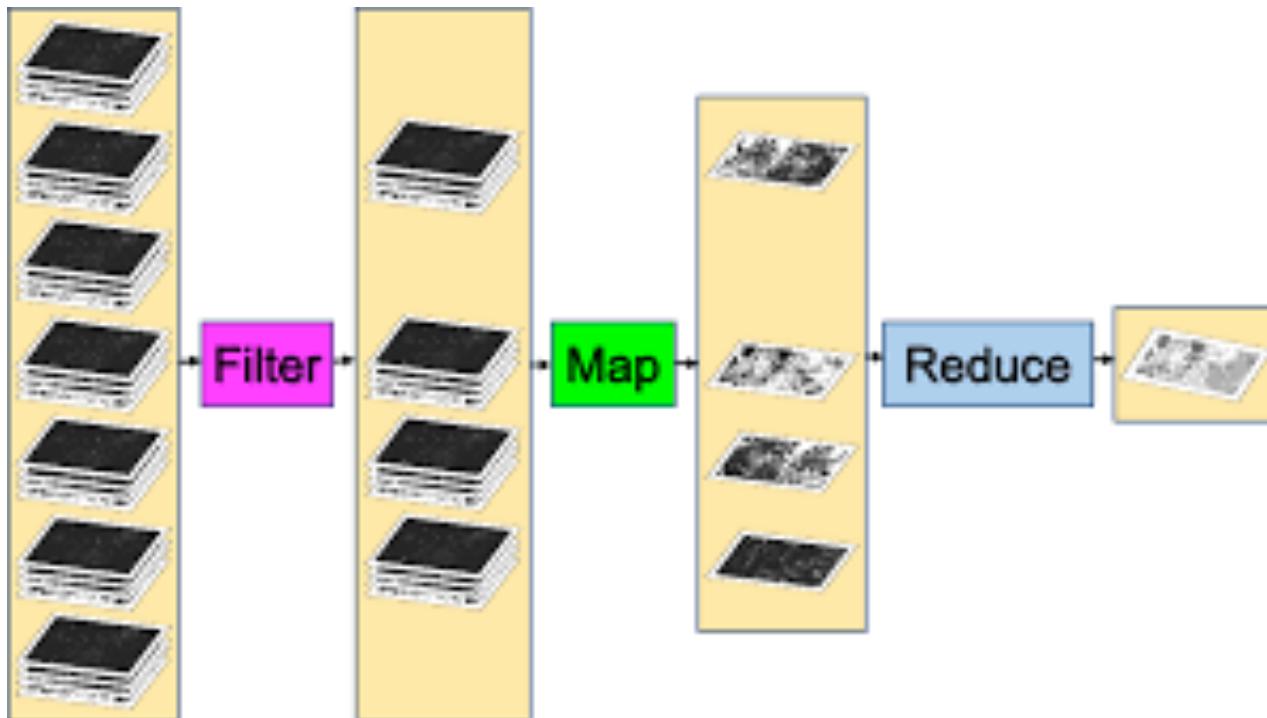
- By date
 - *filterDate(start,end)*
- By properties
 - *filterMetaData()*
- By bounds
 - Selects figures that overlap AOI
 - *filterBounds()*

Map: apply function to each element

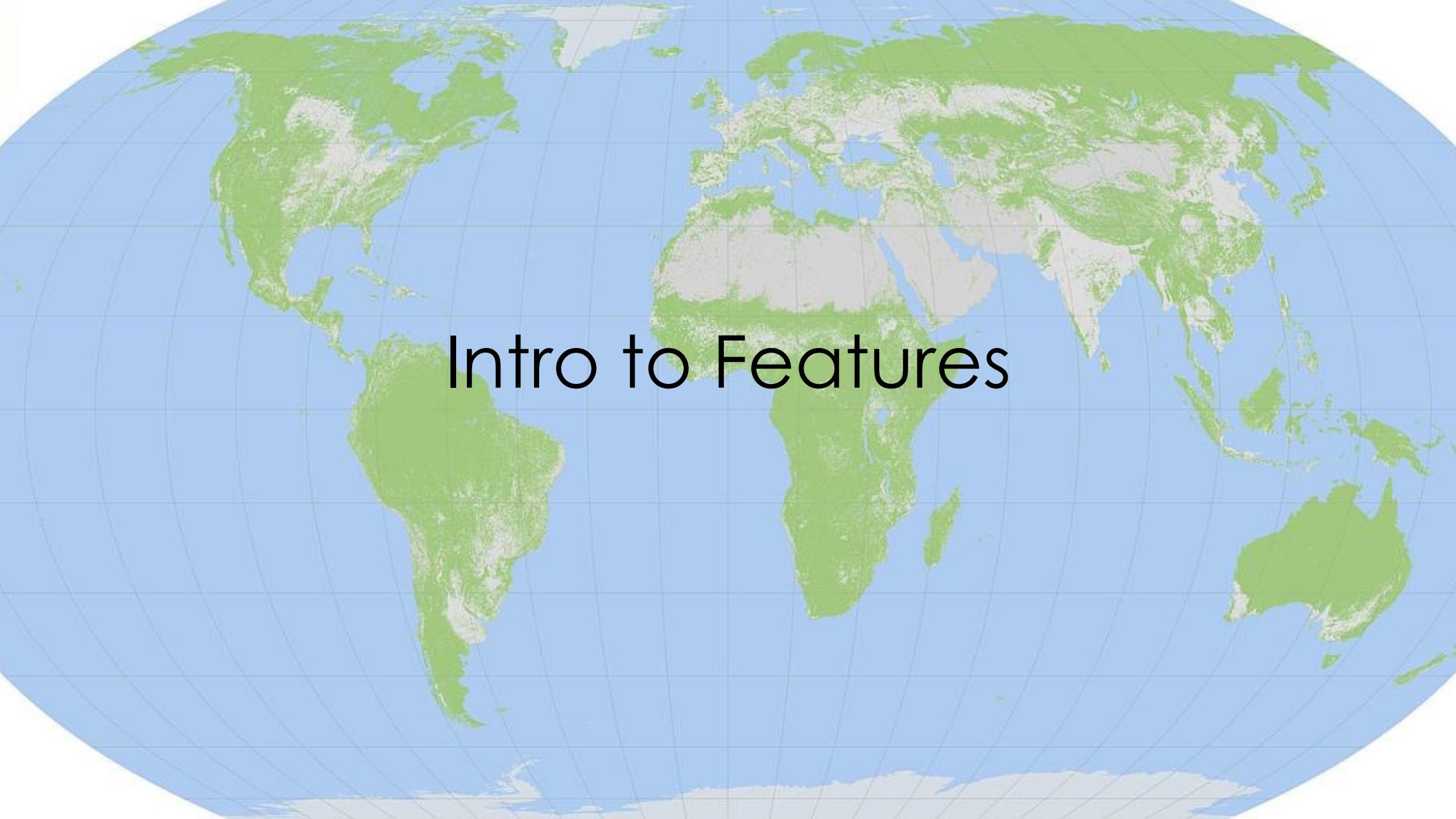


- Applying a function to each image in a collection
 - band in an image, feature in a feature collection...
- E.g., clipping is a function specific to images
- **filter first to apply to less elements

Reduce: summarize image collection



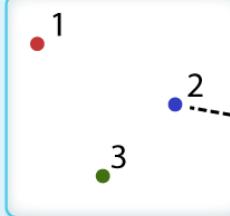
e.g, min, max, mean,
median...monthly
temp in a year



Intro to Features

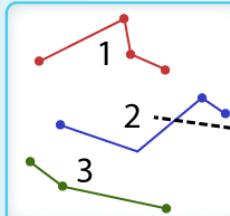
Feature data = vector data

Example Attributes for Point Data



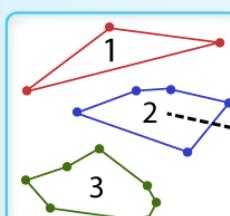
ID	Plot Size	Type	VegClass
1	40	Vegetation	Conifer
2	20	Vegetation	Deciduous
3	40	Vegetation	Conifer

Example Attributes for Line Data



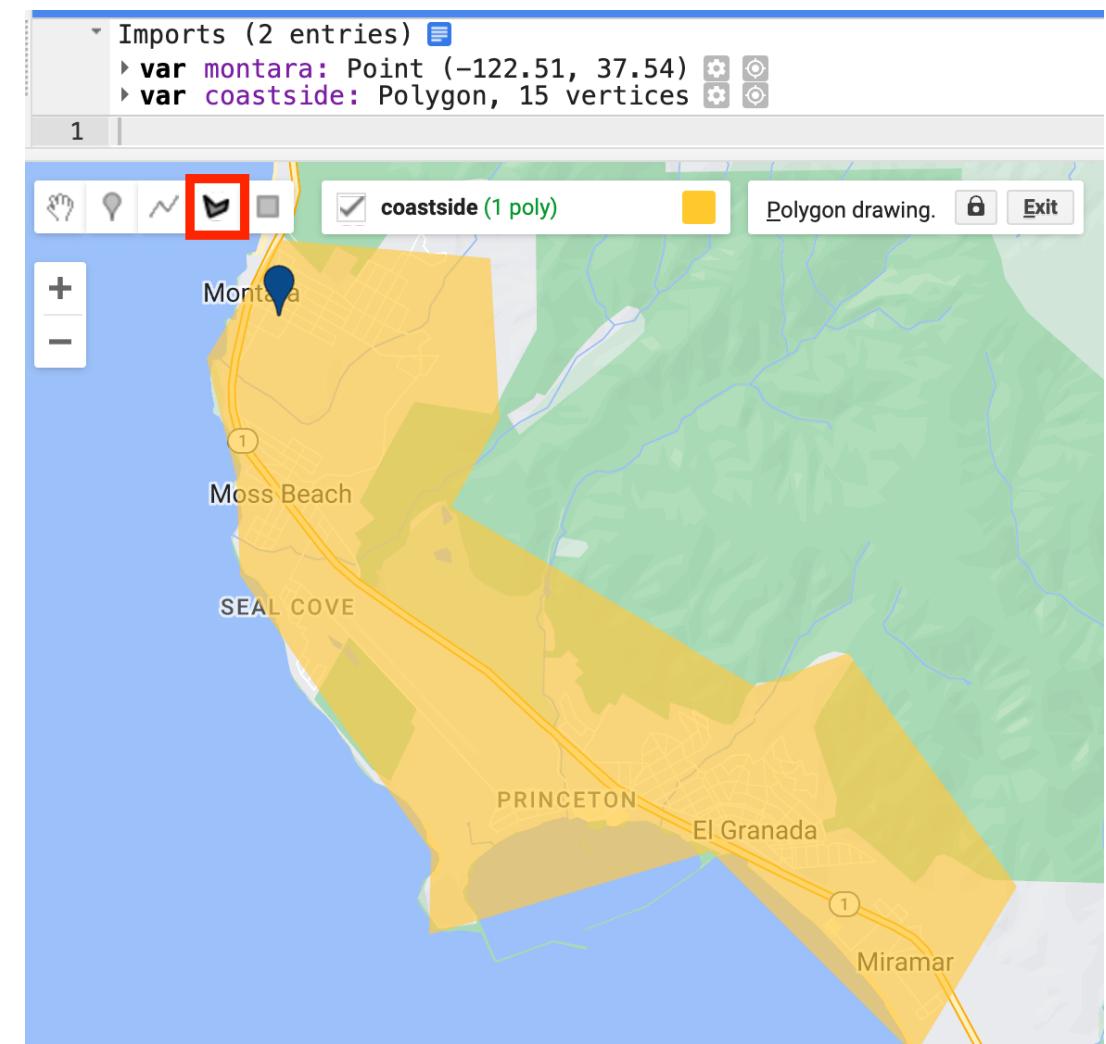
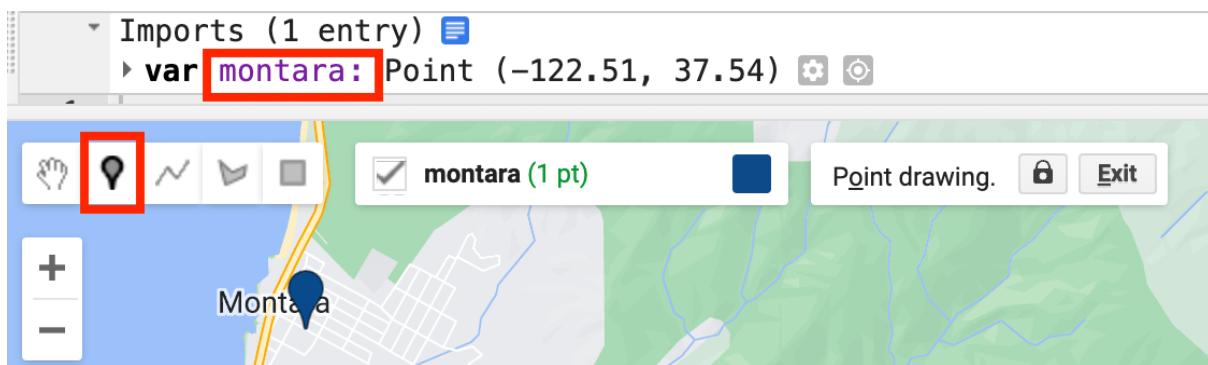
ID	Type	Status	Maintenance
1	Road	Open	Year Round
2	Dirt Trail	Open	Summer
3	Road	Closed	Year Round

Example Attributes for Polygon Data



ID	Type	Class	Status
1	Herbaceous	Grassland	Protected
2	Herbaceous	Pasture	Open
3	Herbaceous / Woody	Grassland	Protected

neon





Intro to Feature Collections

Feature Collections

- collection of features
- each feature has a dictionary of properties
- can filter by geometries and properties

Feature Collections

- collection of features
- each feature has a dictionary of properties
- can filter by geometries and properties

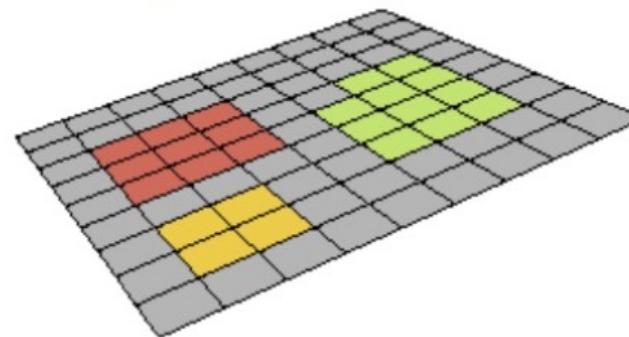
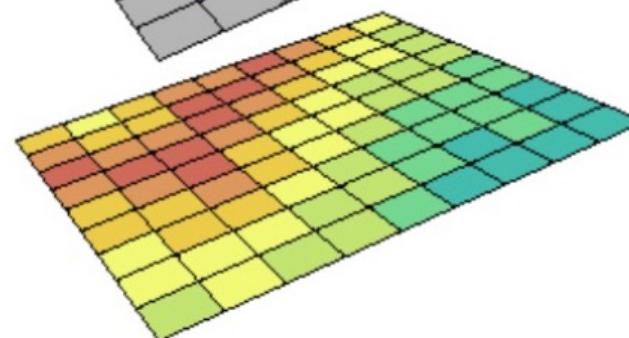
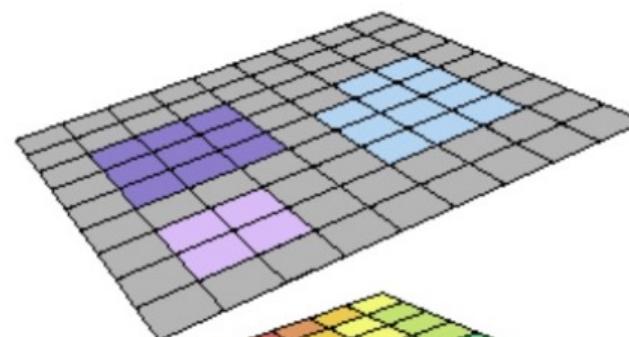
```
Topo zonal stats table
*FeatureCollection (5 elements, 0 columns)
  type: FeatureCollection
  columns: Object (0 properties)
  *features: List (5 elements)
    *0: Feature 0_0 (Polygon, 5 properties)
      type: Feature
      id: 0_0
      geometry: Polygon, 24 vertices
      properties: Object (5 properties)
        datetime: 2000-01-01 00:00:00
        elevation: 2648.076639640231
        plot_id: 1
        slope: 29.730086433282917
        timestamp: 946684800000
```

plot_id	slope	elevation	...
1	29.731	2648.077	...
....

Feature Collection: zonal statistics



Feature Collection: zonal statistics





Working with Data in R

Goals:

- Work on your own research projects
- Share different datasets & methods with broader groups

Monday Schedule

- **9:00am-9:30am:** Andy presentation
- **9:30am-11:30am:** Work analyzing your own data
- **11:30am - 12:00pm:** Group discussion