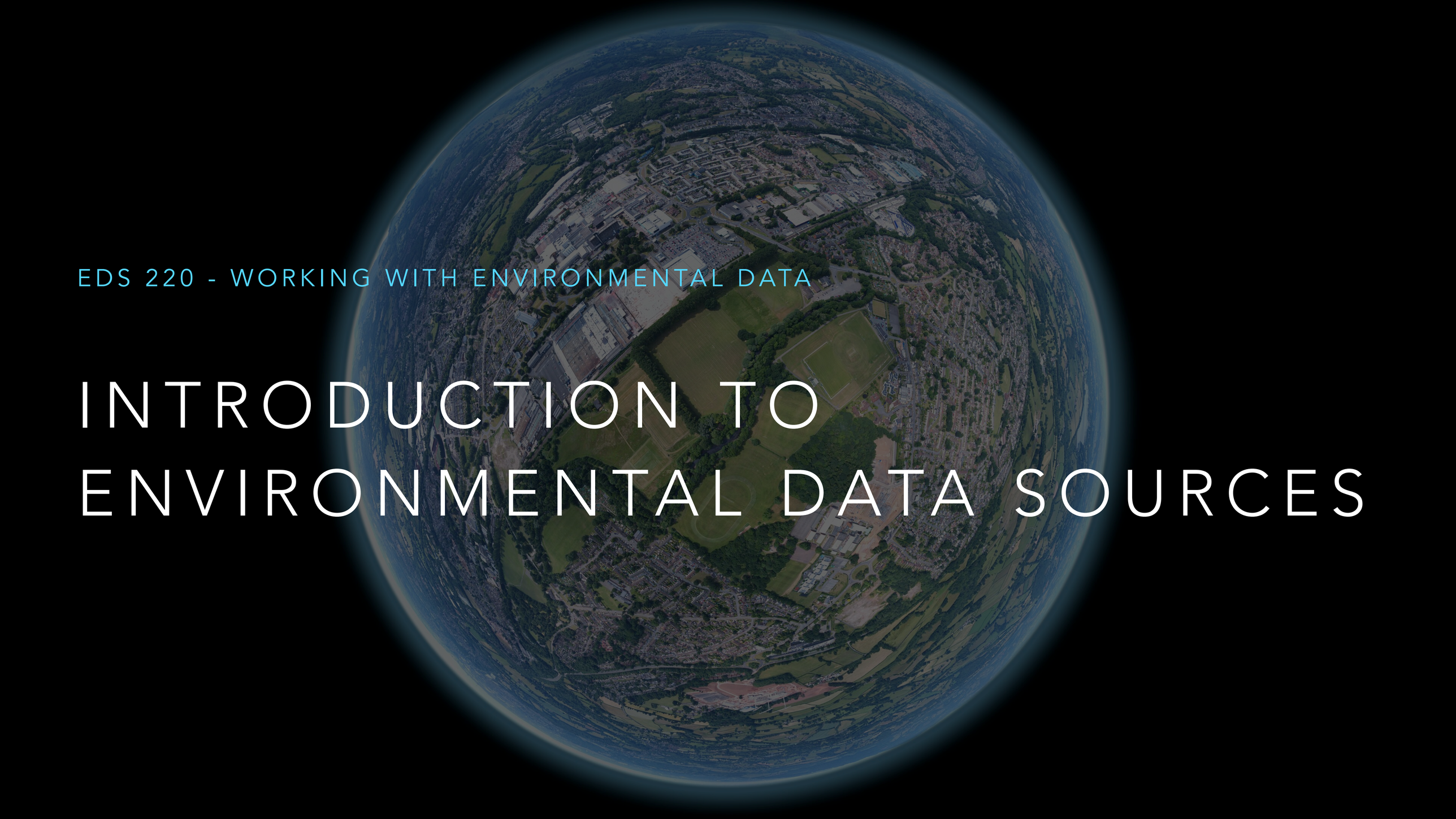

EDS 220 - WORKING WITH ENVIRONMENTAL DATA

INTRODUCTION TO ENVIRONMENTAL DATA SOURCES

FUN FACTS ABOUT YOUR PROFESSOR

New Englander (from CT originally)

Climate scientist: my work focuses on using climate models to study climate variability and change

Adopted “Coloradan”: PhD from CU Boulder, worked at the National Center for Atmospheric Research (also in Boulder)

LOGISTICS/CONTACT INFORMATION

Best way to reach me is by email: sstevenson@ucsb.edu

Office hours: Tuesdays 2-3pm, Bren Hall 3412
(Just contact me for meetings at other times!)

TA: Casey O'Hara (cohara@bren.ucsb.edu)
Casey's office hours: Mondays 2-3pm, NCEAS

COURSE PHILOSOPHY

The Point: Environmental Data is Everywhere!

By the end of this class, my goal is for you to feel comfortable grabbing and working with any new dataset you're interested in!

First half of course: fundamental tools and principles you can apply across a variety of datasets *(with regular quizzes to test learning)*

Second half of course: "deeper dives" into popular environmental data types *(With more in-depth homeworks to provide practice)*

Final project: learn about a dataset you think is cool and teach your classmates about it!

MORE LOGISTICS

No Required Textbooks

Optional (free) resources:

- Rebekah Esmaili "Earth Observation Using Python"
  (log into UCSB network to download)
- Ryan Abernathey "An Introduction to Earth and Environmental Data Science"

MORE LOGISTICS

No Required Textbooks

Optional (free) resources:

- Rebekah Esmaili "Earth Observation Using Python"
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- Ryan Abernathey "An Introduction to Earth and Environmental Data Science"

Class Workflow

BEFORE EVERY LECTURE: slides uploaded to course website
https://samanthastevenson.github.io/EDS220_Fall2022_site/

CLASS GITHUB REPO:
https://github.com/samanthastevenson/EDS220_Fall2022

- Look here for worked example code demonstrating course principles
  you will need this for weekly quizzes, Weeks 1-4!
- Later on: templates for homework assignments and final project posted here

MORE LOGISTICS

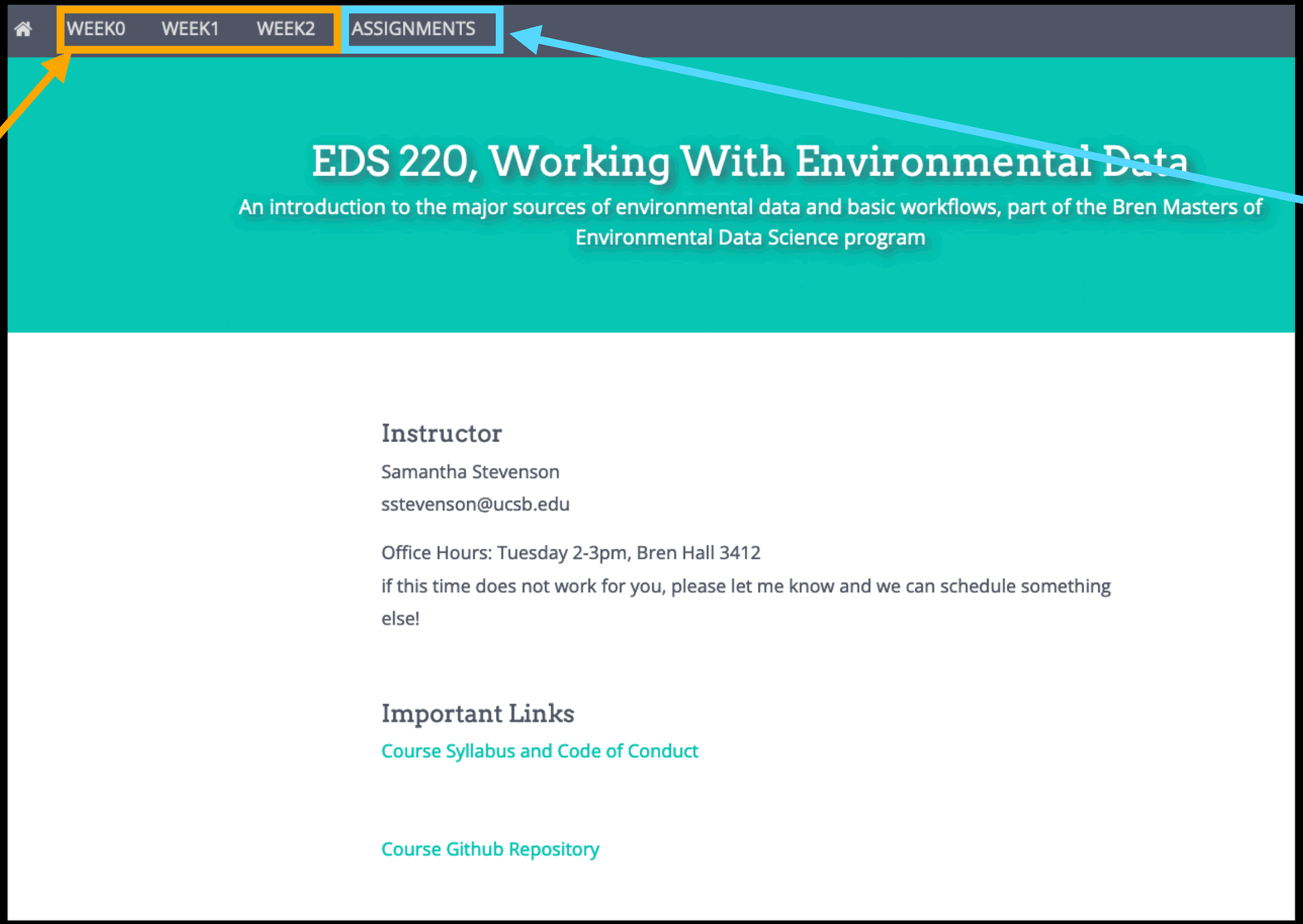
Course Schedule (subject to change)

Week	Topic
1	Overview: Data Types and sources
2	Remote Sensing Basics
3	Mapping Fundamentals
4	Data Quality Control
5	Deeper Dive: Land Cover and Air Quality Data
6	Deeper Dive: Ecological Data
7	Deeper Dive: Snow Remote Sensing
8	Deeper Dive: Other Physical Remote Sensing Data
9	Deeper Dive: Climate Modeling and the IPCC
10	Student Final Presentations

Weeks 1-4: basic skills for working with environmental data

Weeks 5-9: applying these skills to different environmental data types

Week 10: Your Time to Shine!



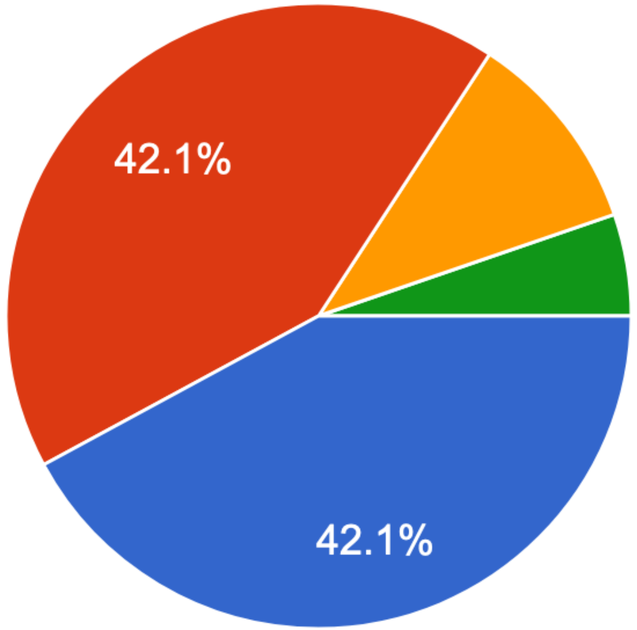
Check here for lecture slides

Check here for assignments

SURVEY RESULTS

What is your approximate level of familiarity with how environmental data are collected?

19 responses



- Novice: little to no experience
- Intermediate: familiar with one or two datasets
- Intermediate: worked with multiple data types and/or strong experience with at least one
- Fluent: very familiar with at least one type of data

SURVEY RESULTS

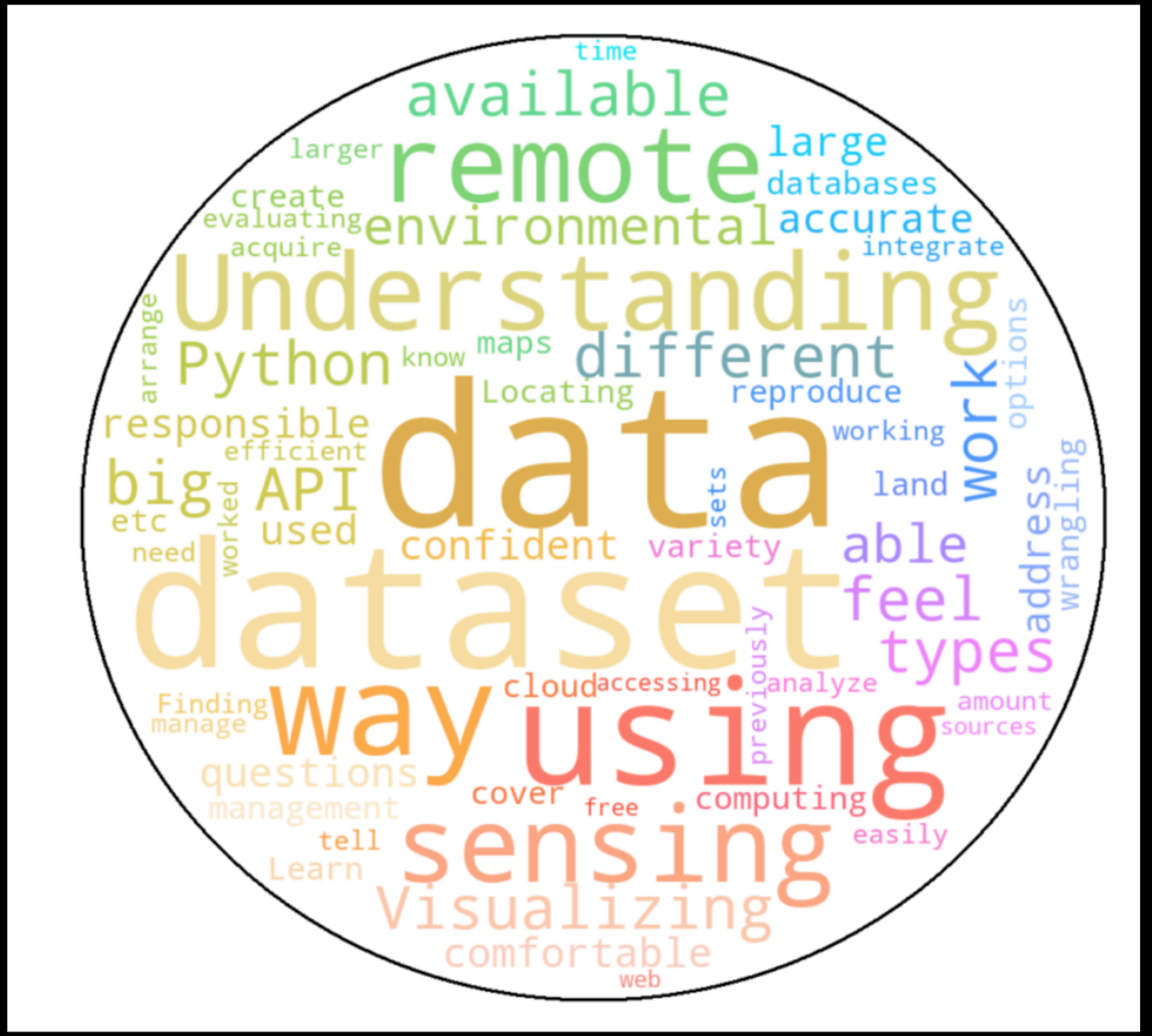
"With respect to EDS 220, what are you most interested in learning about?"

SURVEY RESULTS

"With respect to EDS 220, what are you most worried about?"

SURVEY RESULTS

"At the end of this class, one thing you would like to better at than you are now is:"



LECTURE TOPICS

1. Environmental data: general overview
2. Methods of environmental data collection
3. Environmental data access via APIs

OVERVIEW:
WHAT IS ENVIRONMENTAL DATA?
AND WHY DO WE CARE?

ENVIRONMENTAL DATA: SOME EXAMPLES

- Weather patterns
- Ecological information: species counts, community structure
- Pollutant concentrations
- Ocean conditions: temperature/salinity/currents
- Terrestrial water balance
- *What are some other things we might want to know about??*

CASE STUDY: FLOODING

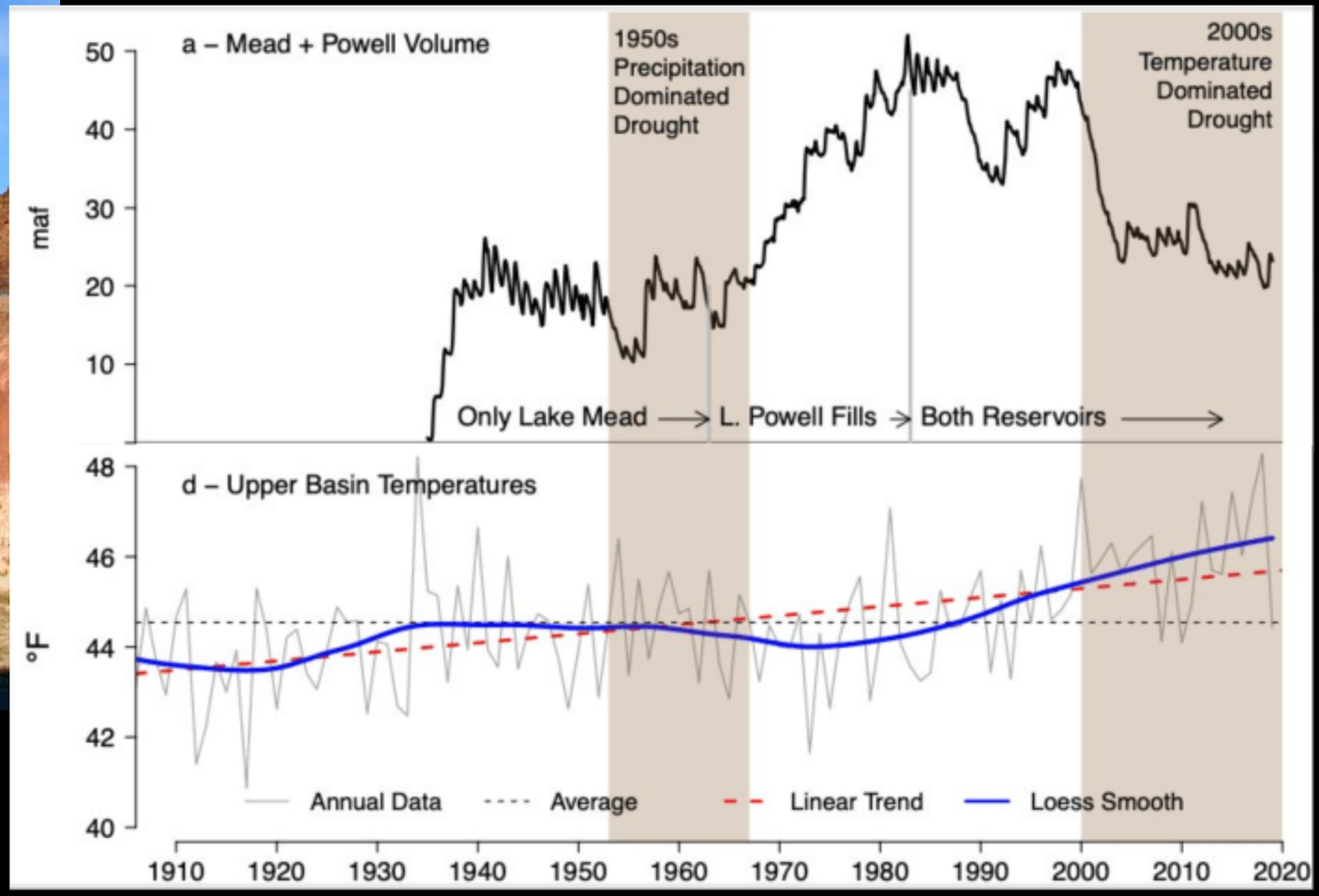
https://www.npr.org/2021/09/01/1033158160/aerial-photos-louisiana-coast-hurricane-ida

Flooding After Hurricane Ida

Sept 2021: widespread flooding in Louisiana. Images captured by Maxar (private satellite company)

CASE STUDY: COLORADO RIVER BASIN

Lake Mead

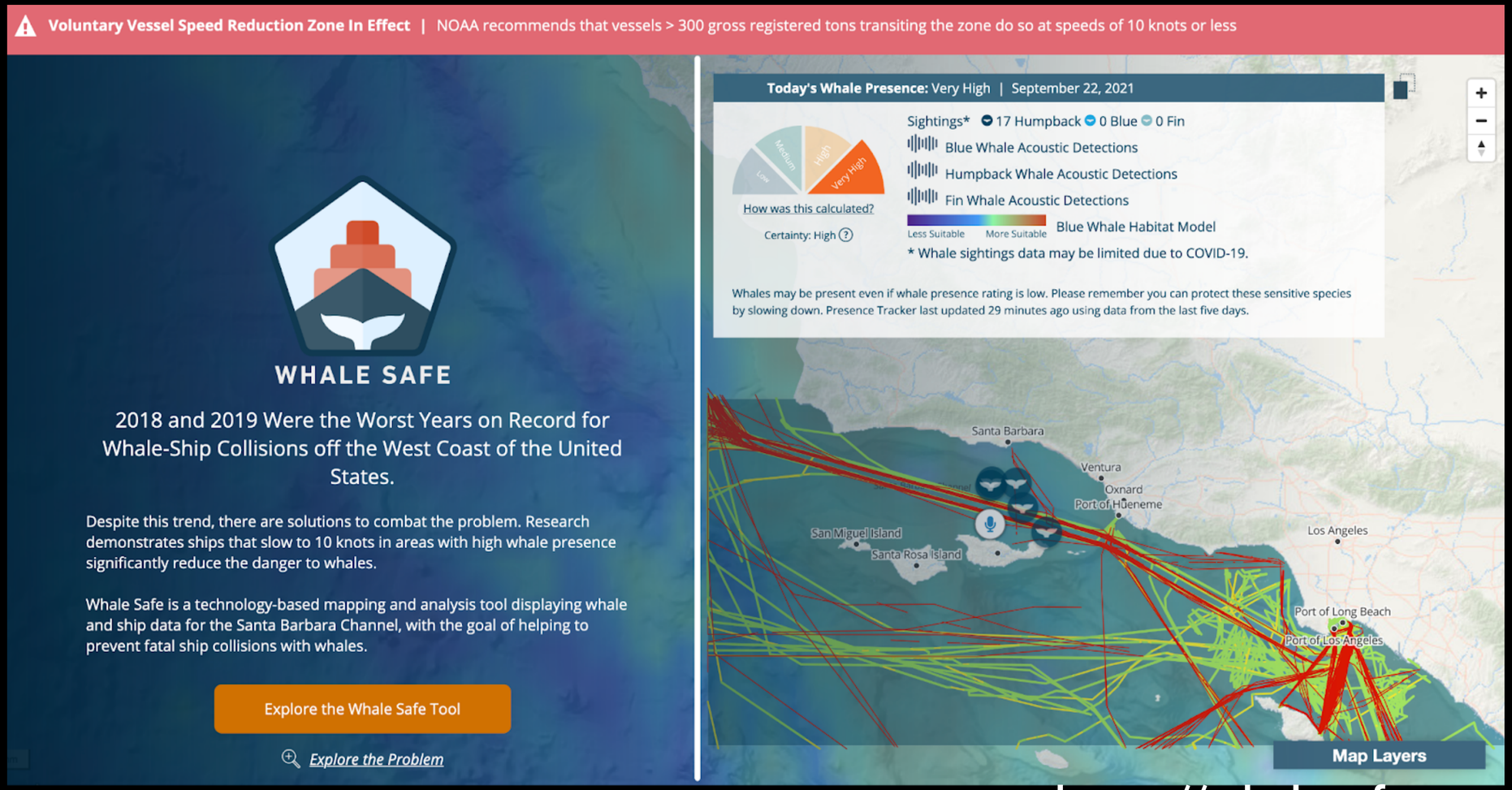


<u>Post-2000s "Hot Drought"</u>

Udall & Overpeck (2017): temperature is the main driver of recent trends toward lower water levels in Lakes Mead and Powell

Data: lake levels from US Bureau of Reclamation, temp/precip from the PRISM model

CASE STUDY: WHALES IN SANTA BARBARA CHANNEL



https://whalesafe.com

Whale Monitoring

Data from: whale sightings reported by tourist/commercial vessels; acoustic measurements; blue whale habitat model including current ocean conditions

WHAT IS ENVIRONMENTAL DATA? AND WHY DO WE CARE?

Environmental Data

Information recorded about the state of our environment:
physical processes, ecological information, health/toxicological impacts

Why Environmental Data Matters

Diverse applications of environmental data exist: natural resource management, public policy, disaster planning, conservation, and many more


ENVIRONMENTAL DATA
COLLECTION METHODS
Weather/Climate/Ocean
Forecasting Models

ENVIRONMENTAL DATA COLLECTION METHODS

- Weather stations
- Ecological observations: manual or automated
- Toxicological measurements
- Marine sensor networks
- Earth-observing satellites
- Other remote sensing techniques: radar, LIDAR
- Numerical modeling (weather and climate)
- *Anything else?*

ENVIRONMENTAL DATA COLLECTION METHODS

General categories of data collection

Details of sensors used to collect environmental data can vary widely!
However, most fall into several broad categories:

- Remote sensing
  - Satellite
  - Earth-based (drones, radar/LIDAR, etc)
- Station-based measurements
- Field surveys
  - Physical
  - Ecological
  - Social

REMOTE SENSING

Definition

Remote sensing = obtaining information from a distance

Most commonly (but not always) through measuring radiation

REMOTE SENSING

Definition

Remote sensing = obtaining information from a distance

Most commonly (but not always) through measuring radiation

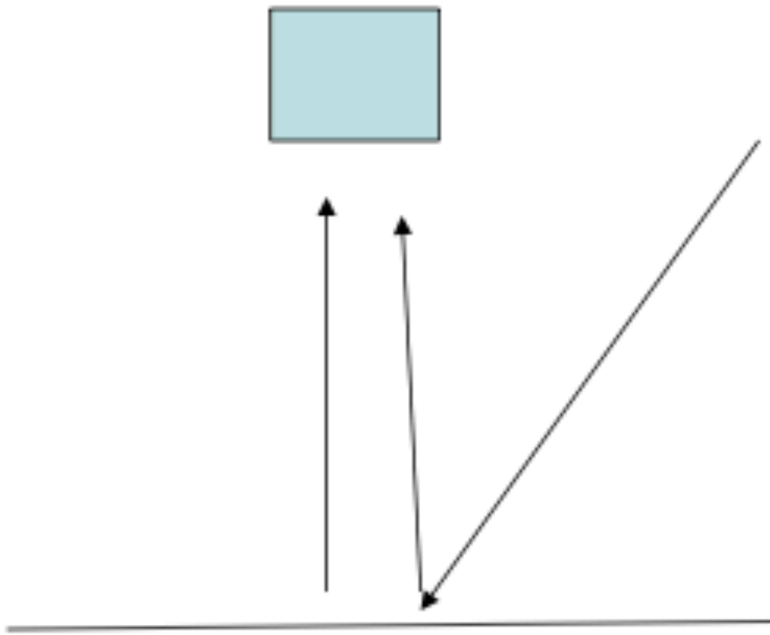
Passive

Relies on radiation already being emitted from target

Active

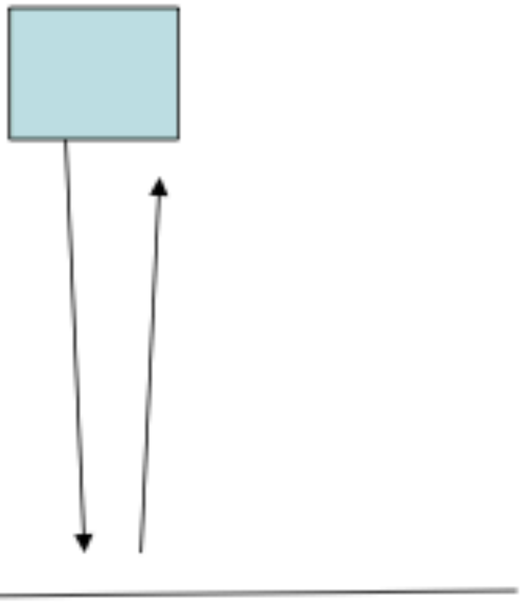
External radiation is generated and aimed at the target to measure amount reflected

Passive Remote Sensing



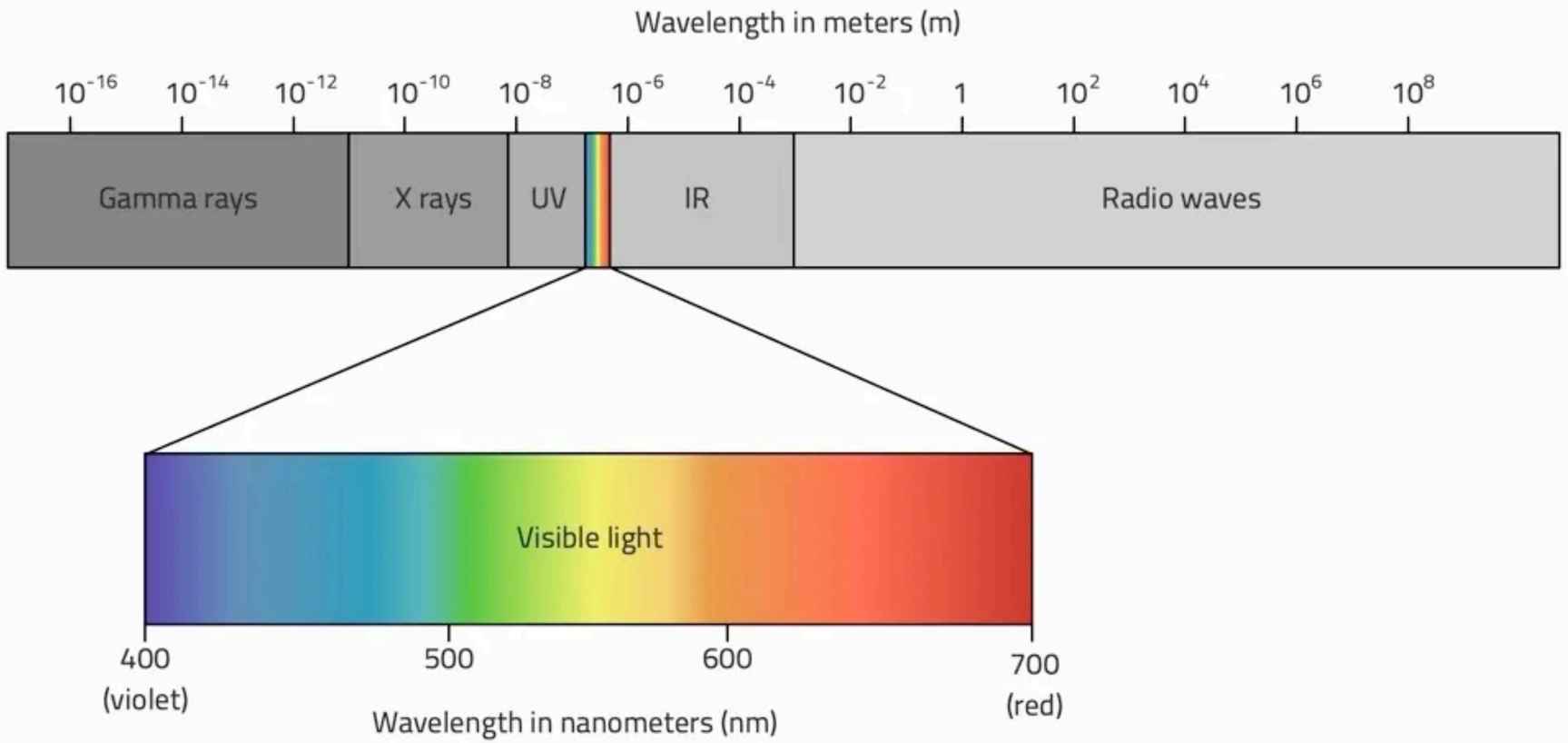
- Natural radiation
- Emitted from earth
- Reflected solar

Active Remote Sensing



- Radar or Lidar
- Emitted from the satellite
- Reflected from earth

REMOTE SENSING

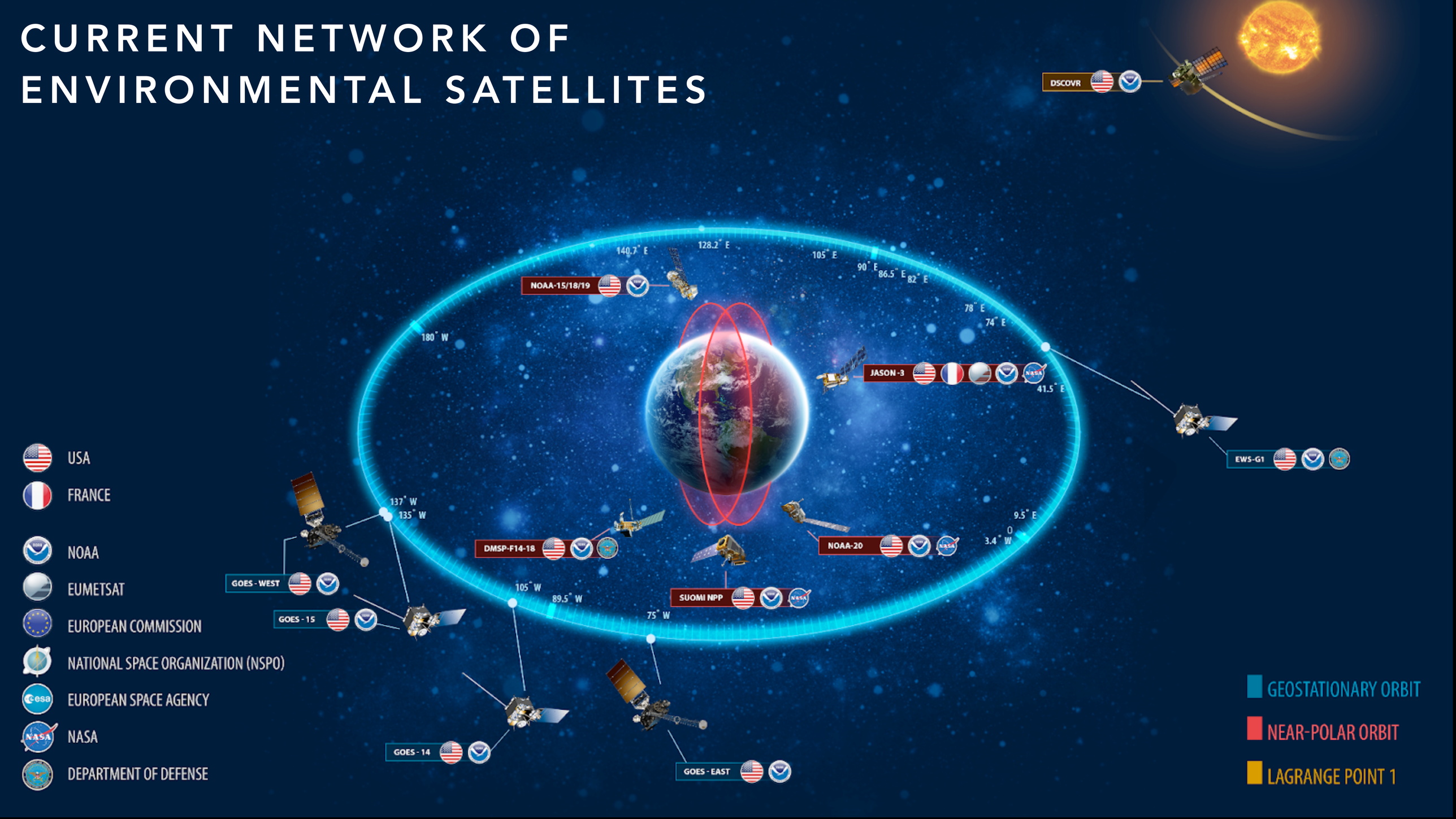


Spectral Bands

Remote sensing instruments detect radiation over a limited range of wavelengths; this is often referred to as a spectral band.

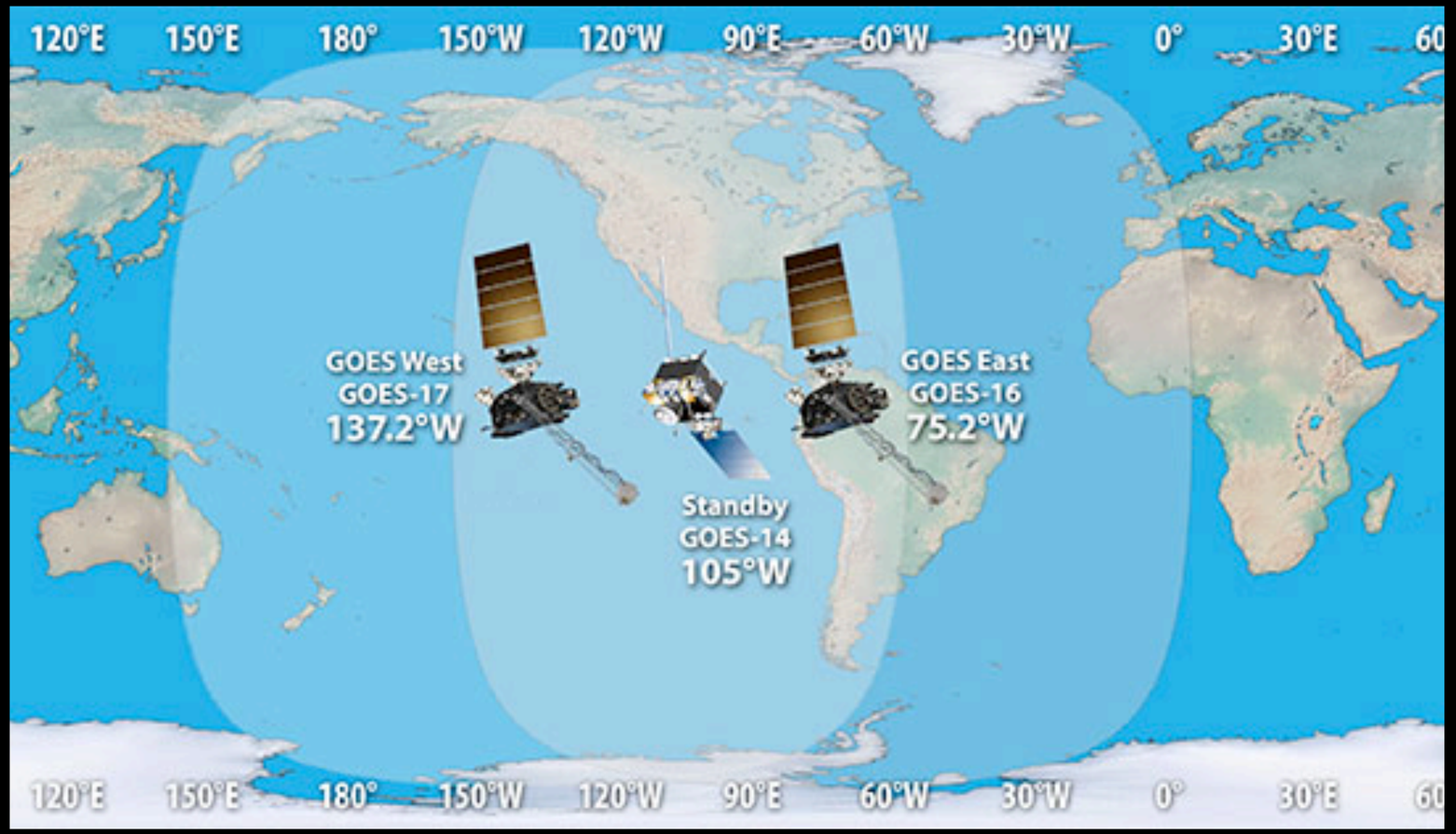
Instruments are not limited to the visible light wavelength range: shortwave and longwave sensors are relatively common as well.

CURRENT NETWORK OF ENVIRONMENTAL SATELLITES



PASSIVE REMOTE SENSING EXAMPLE

NOAA Geostationary Operational Environmental Satellite (GOES)

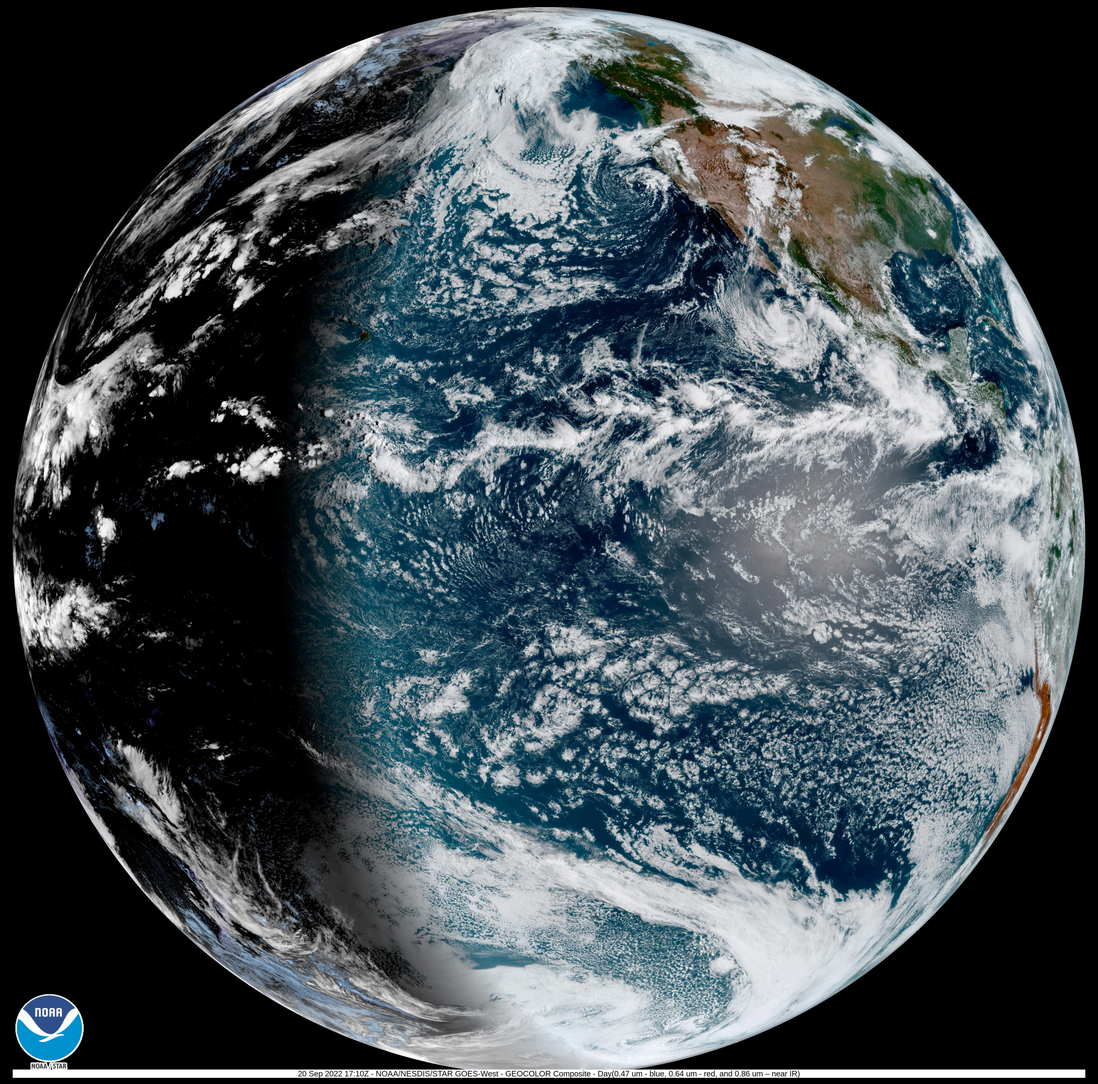


Geostationary orbit: ~22,000 miles above Earth

The GOES satellites hold constant positions, allowing them to continuously observe the entire Western Hemisphere

https://www.goes.noaa.gov/index.html

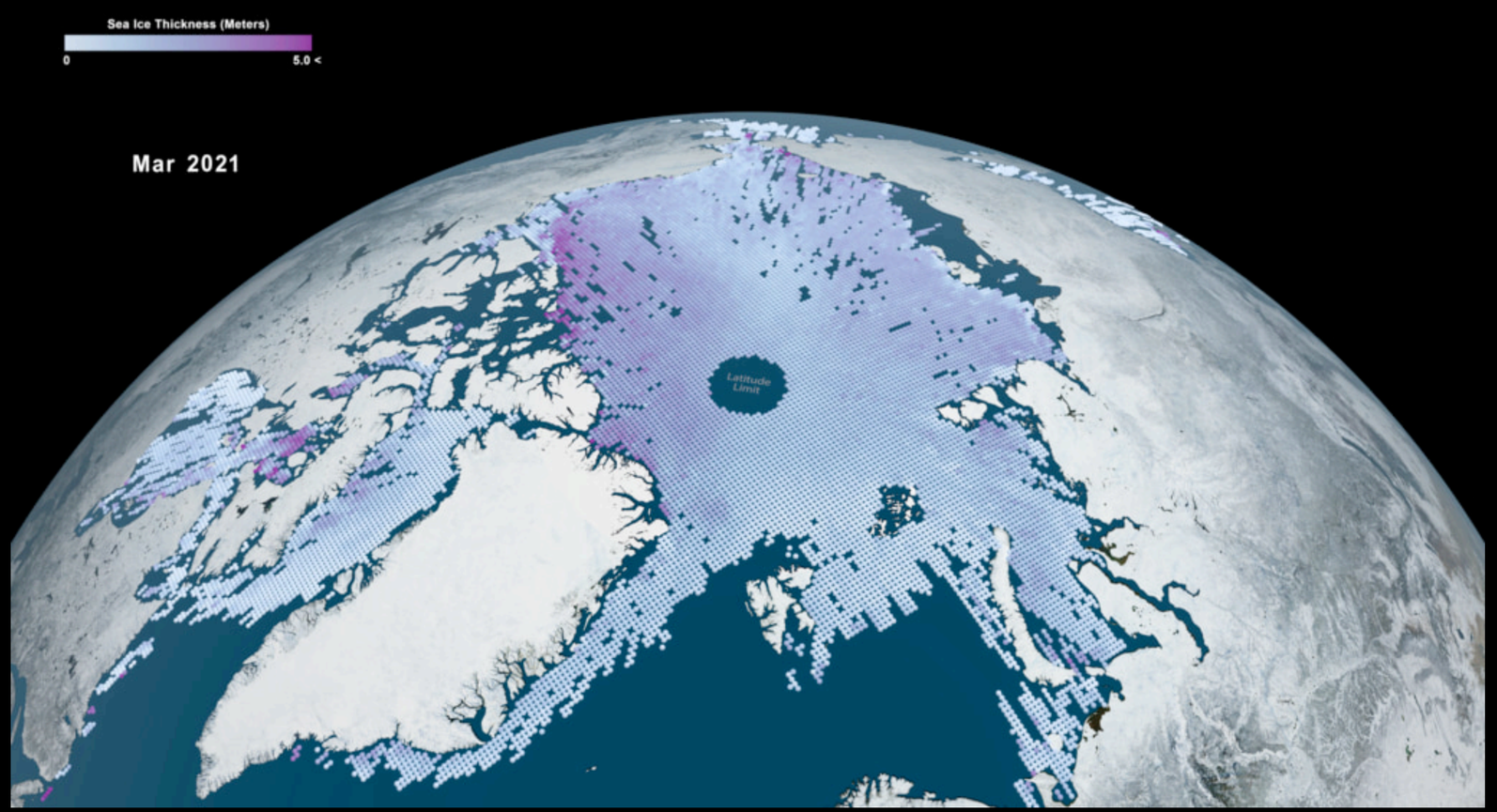
GOES: Real-time Imagery: Sept 20, 2022



https://www.star.nesdis.noaa.gov/GOES/fulldisk.php?sat=G17

ACTIVE REMOTE SENSING: SPACE LASERS!

NASA IceSAT-2

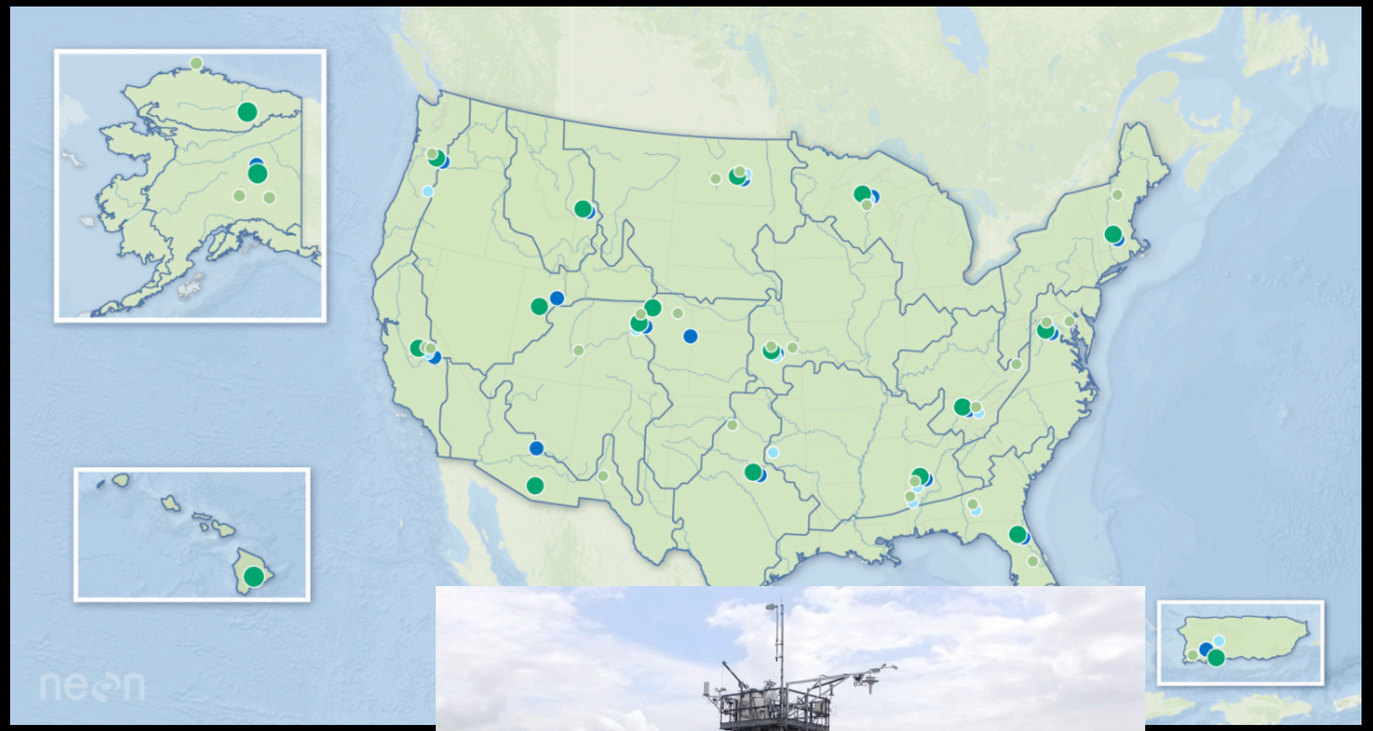


Polar orbit
IceSAT-2 shines a 500nm (green) laser down to the surface: by measuring return time, one can infer the elevation of the surface (and thus thickness of ice)

https://nsidc.org/data/icesat-2

IN SITU SENSOR NETWORKS

National Ecological Observatory Network (NEON)

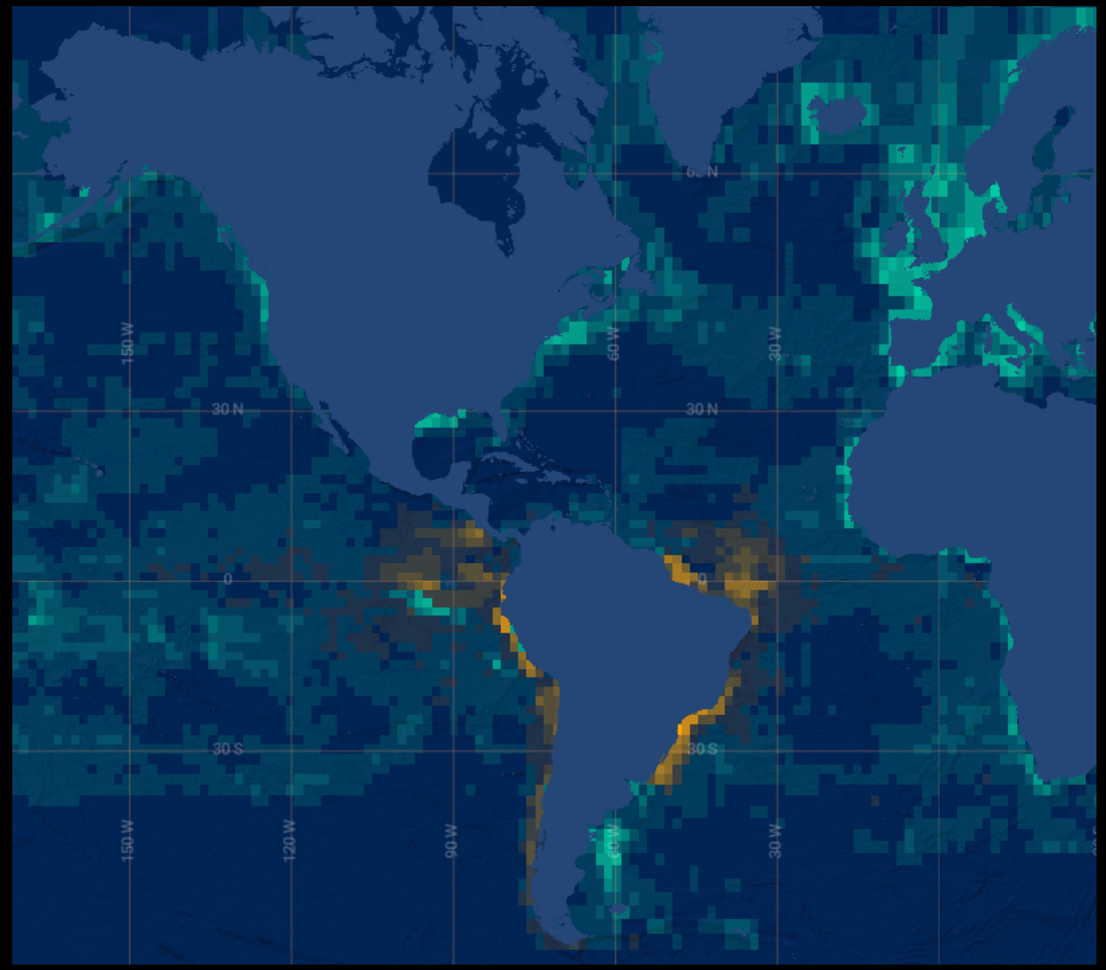


NSF-funded network of field stations across the US
Monitors weather conditions (“flux towers”) along with many other ecological sampling techniques (vegetation and soil sampling, etc)

https://www.neonscience.org/about

IN SITU SENSOR NETWORKS

Global Fishing Watch



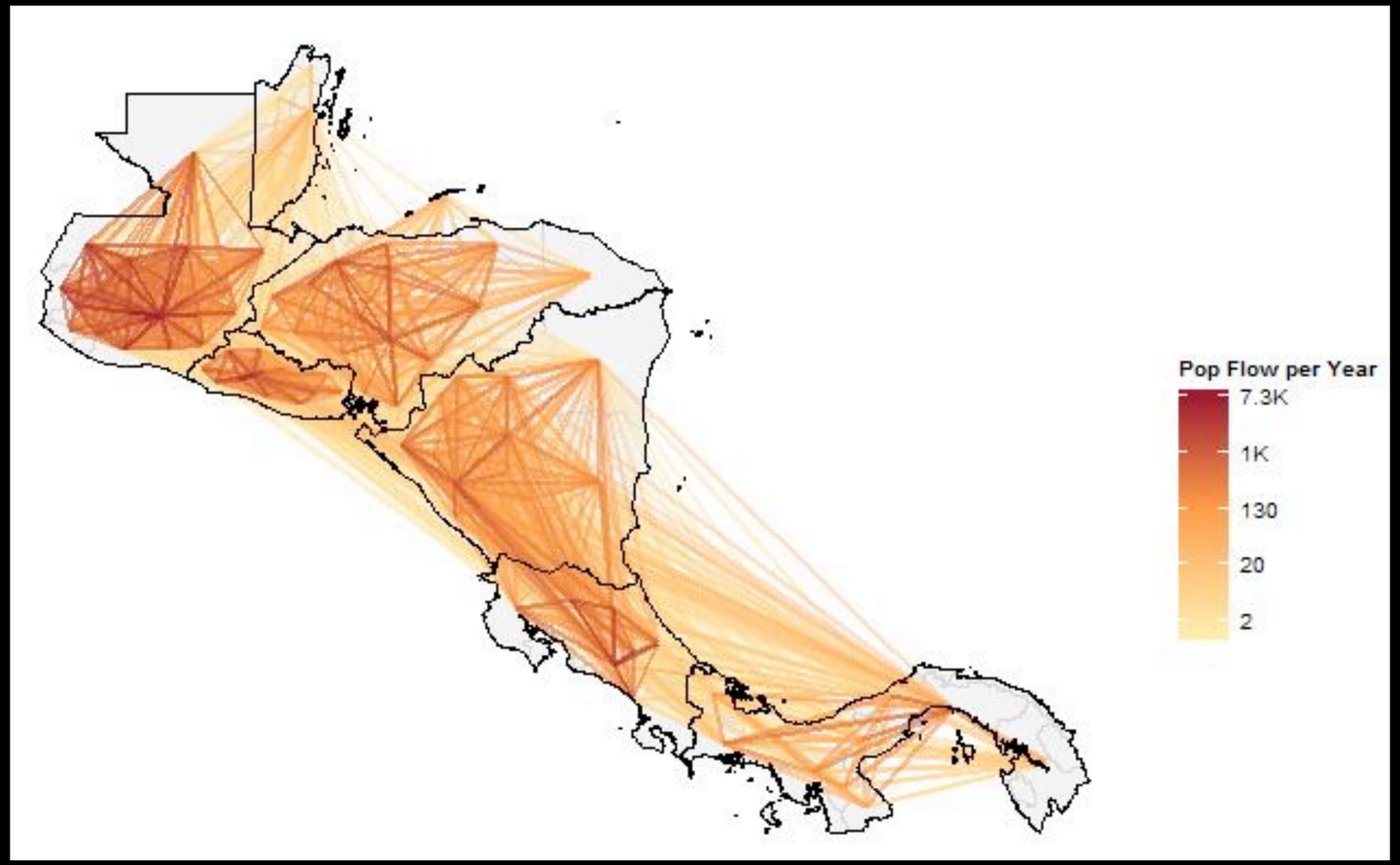
Open-access platform providing real-time information on fishing activity worldwide

https://globalfishingwatch.org/

BLENDED DATASETS: WORLDPOP

World Population Data

Combination of population mapping projects across Africa, Asia, and the Americas
Includes both geospatial imagery and other datasets (census information, surveys, etc.)

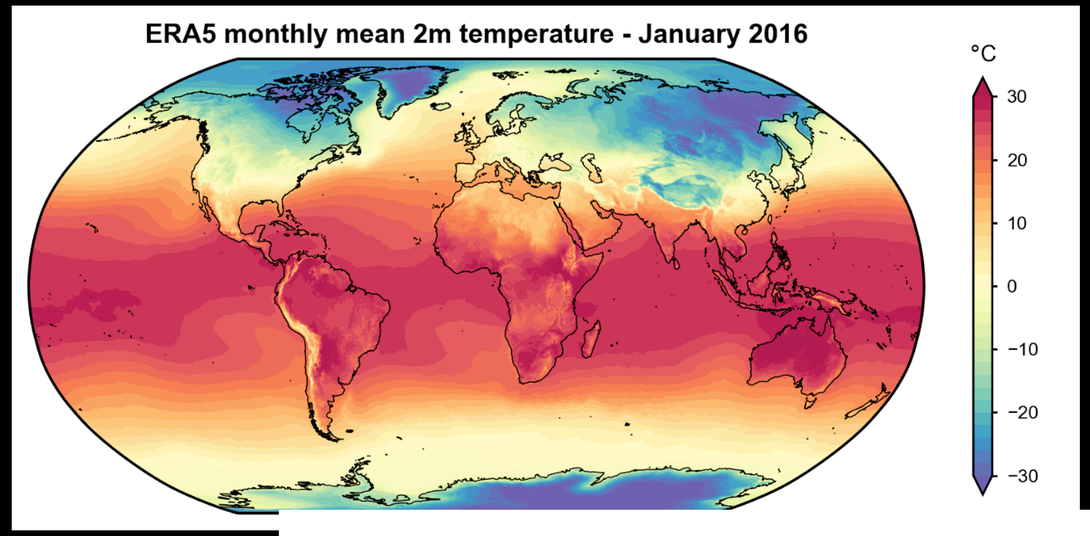


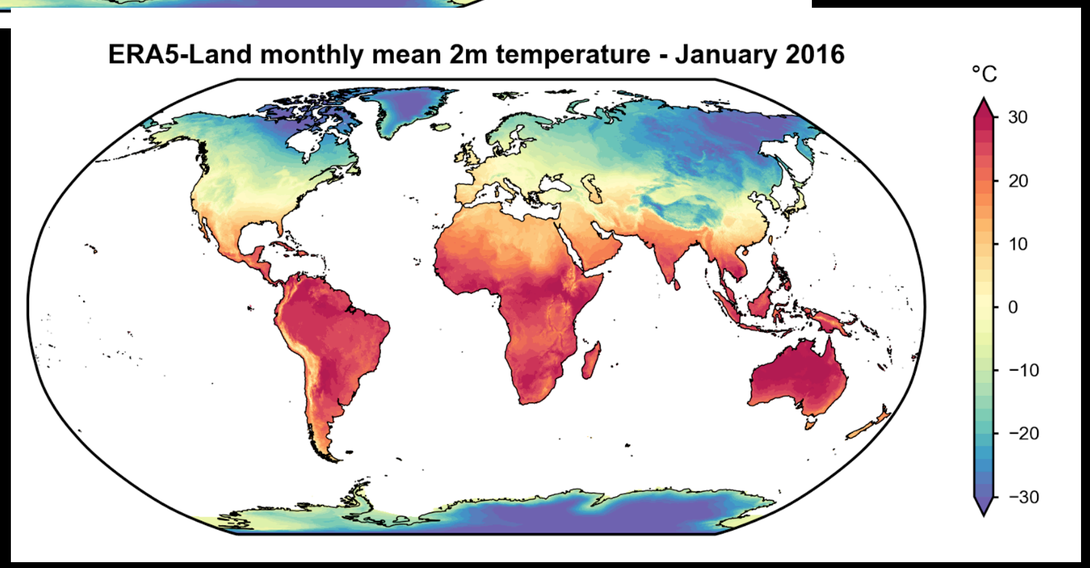
Population flows in Central America, from:
https://www.worldpop.org/focus_areas/population_movements/

https://www.worldpop.org/

NUMERICAL MODELING: REANALYSES

ECMWF Reanalysis version 5 (ERA5)





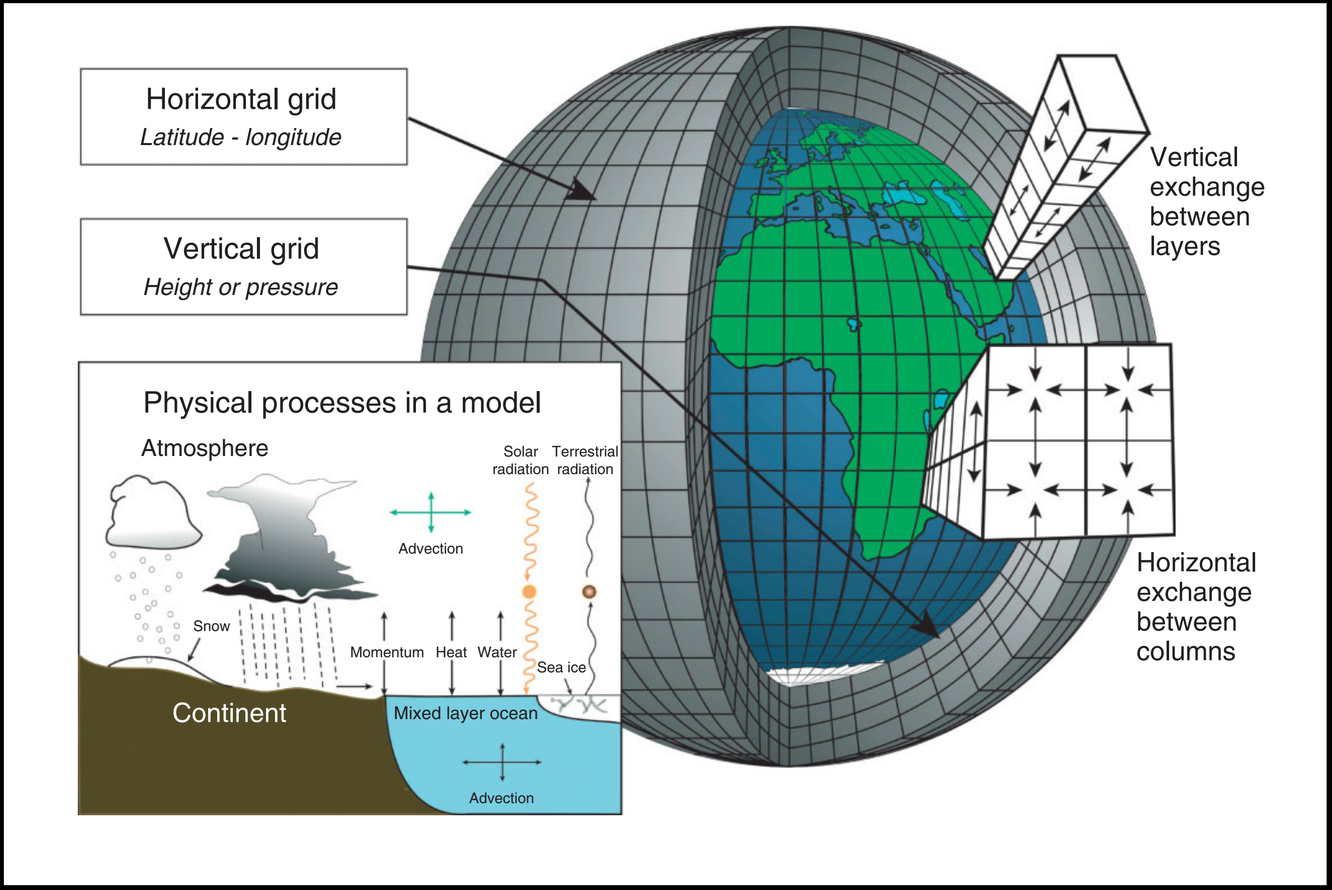
ERA5 is one example of a **reanalysis**: combining a weather model with historical observations of the physical climate using **data assimilation**.

There are many other reanalysis products out there as well!

https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5

NUMERICAL MODELING: CLIMATE MODELS

Coupled Model Intercomparison Project phase 6 (CMIP6)

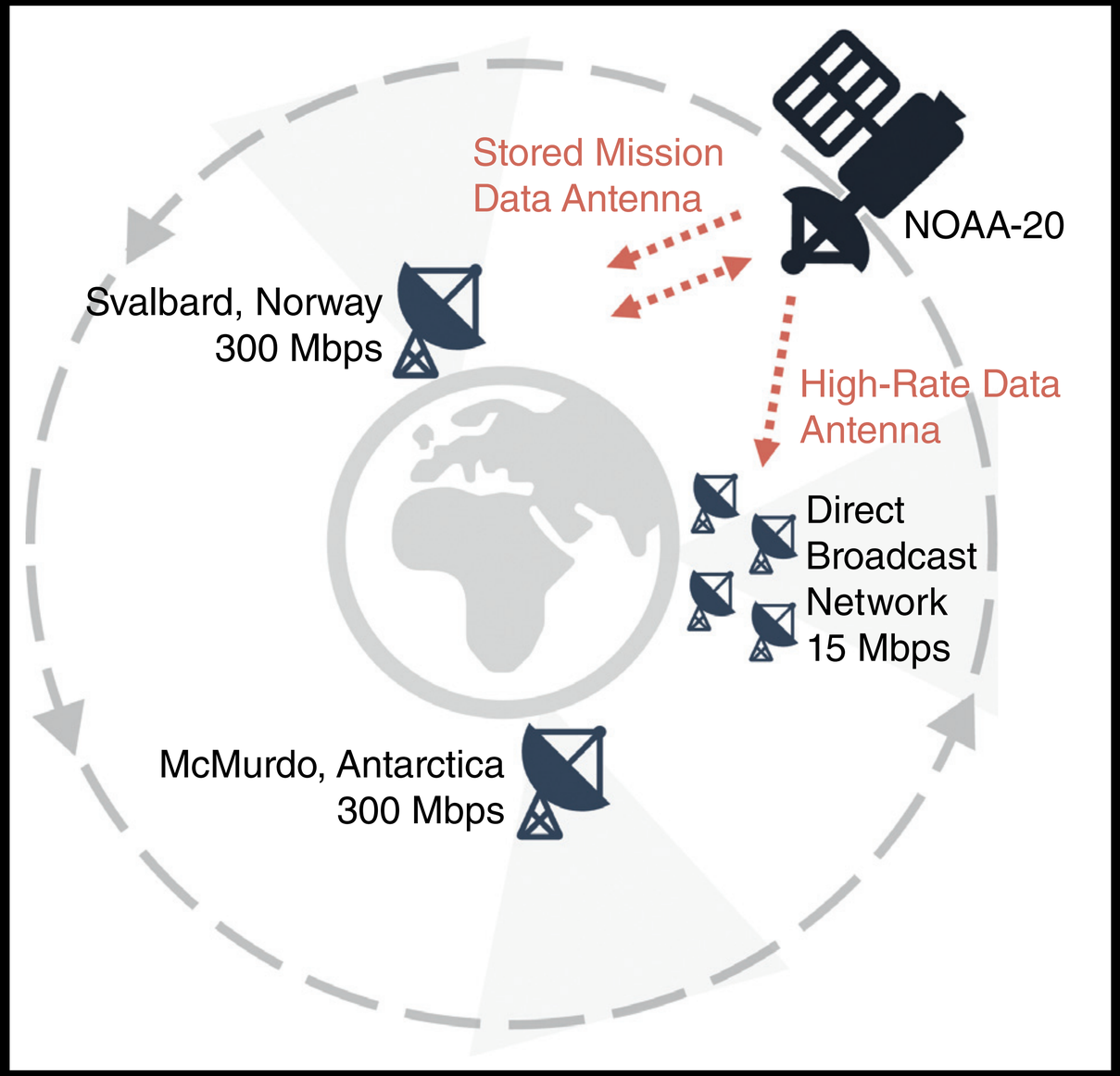


Global climate models: represent all physical processes happening on Earth! (They do NOT directly incorporate observations, which is distinct from how reanalyses work.)
CMIP6 = coordinated projections of climate change with many models, run partly to support the IPCC reports

https://gallery.pangeo.io/repos/pangeo-gallery/cmip6/index.html

ENVIRONMENTAL DATA ACCESS

ENVIRONMENTAL DATA FLOWS



All environmental data must undergo several steps to go from collection to analysis by end users:

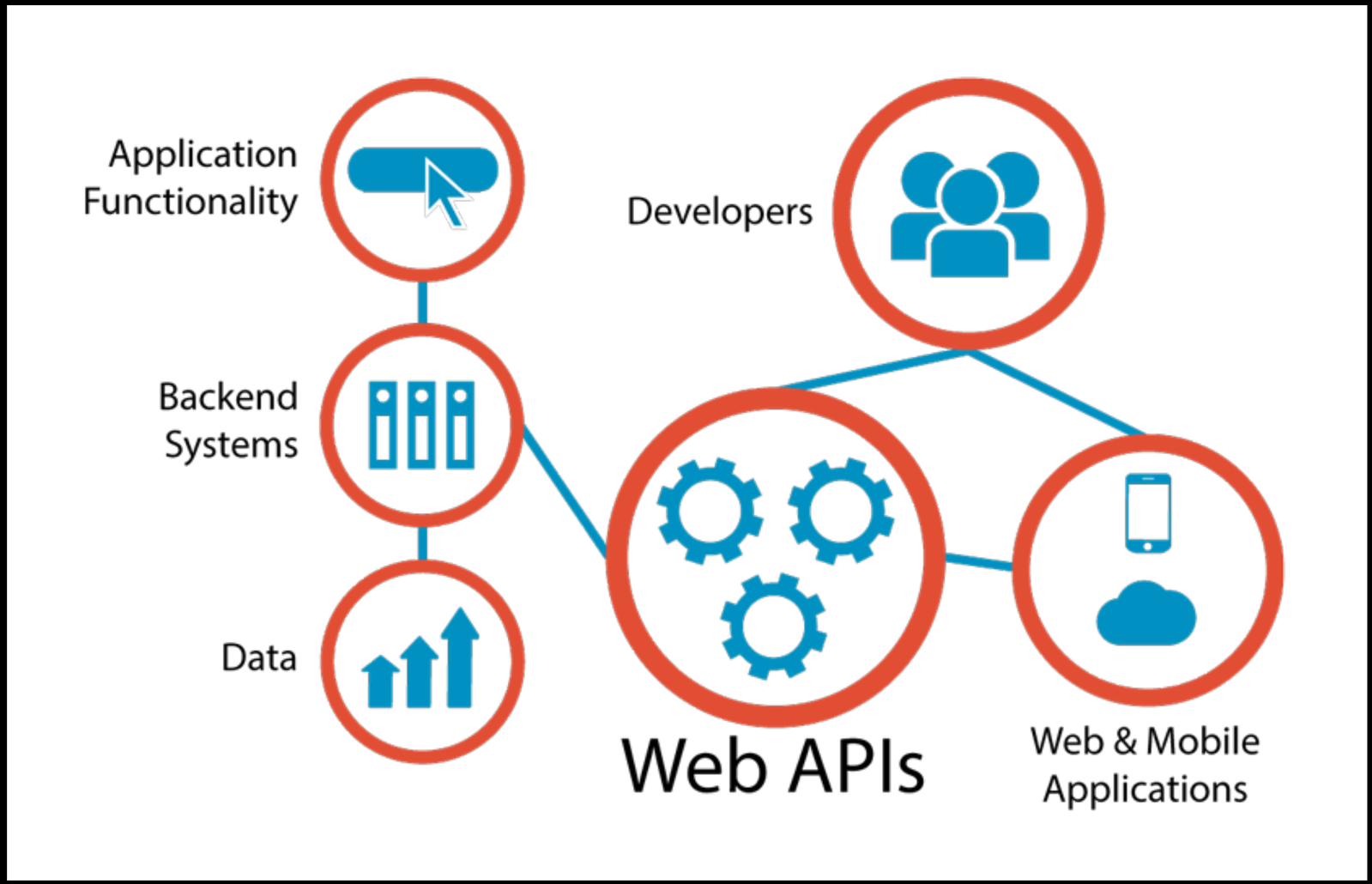
- Transmission to an appropriate server (either by physical transfer or remote broadcast of the signal)
- Post-processing to convert the data into an appropriate format (for remotely sensed data, this often includes the use of retrieval algorithms)
- Serving of the data for access by remote users (most commonly via the Web)

Data flows in satellite downlink from NOAA-20 (Esmaili chapter 1)

API: APPLICATION PROGRAMMING INTERFACE

What is an API?

APIs exist to translate between databases and remote users



REST API

Representational State Transfer (REST) API

The REST format for APIs (sometimes referred to as “RESTful”) is the most common API you’ll encounter in environmental data science.

A REST API transfers a representation of the state of the resource to a remote client when a request is made
- This request is transmitted in standard Web formats (XML, JSON, etc)

REST APIs also must conform to several other criteria involving server-client communication and formatting of the data transmitted between the two:
https://www.redhat.com/en/topics/api/what-is-a-rest-api

EXAMPLES OF API-ENABLED DATA PORTALS

Google Earth Engine

IUCN Red List

PANGEO

FIRST ASSIGNMENT: WORK WITH A REAL API

Quiz 1: will go out by email, evening of Thursday 9/22

Due: next Friday 9/30, 5pm

Jupyter notebook you'll need:
https://github.com/samanthastevenson/EDS220_Fall2022