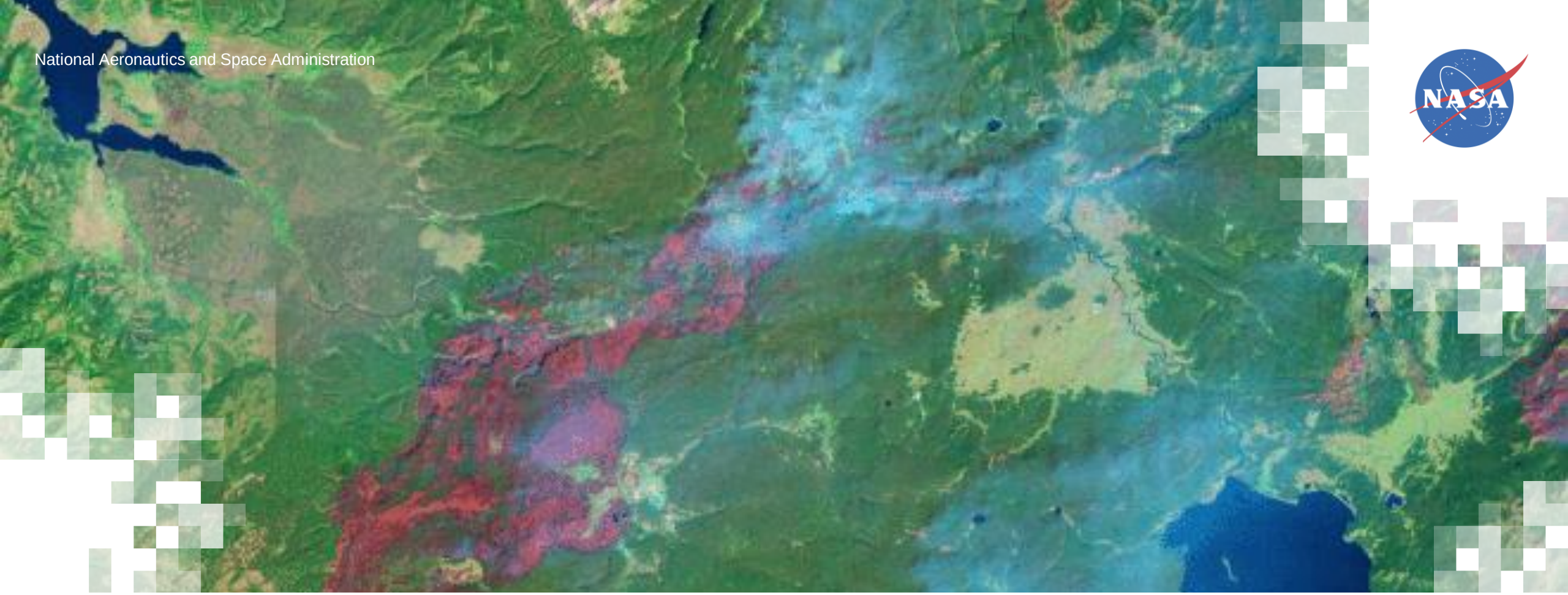


Investigating Time Series of Satellite Imagery

Cindy Schmidt, Amber McCullum

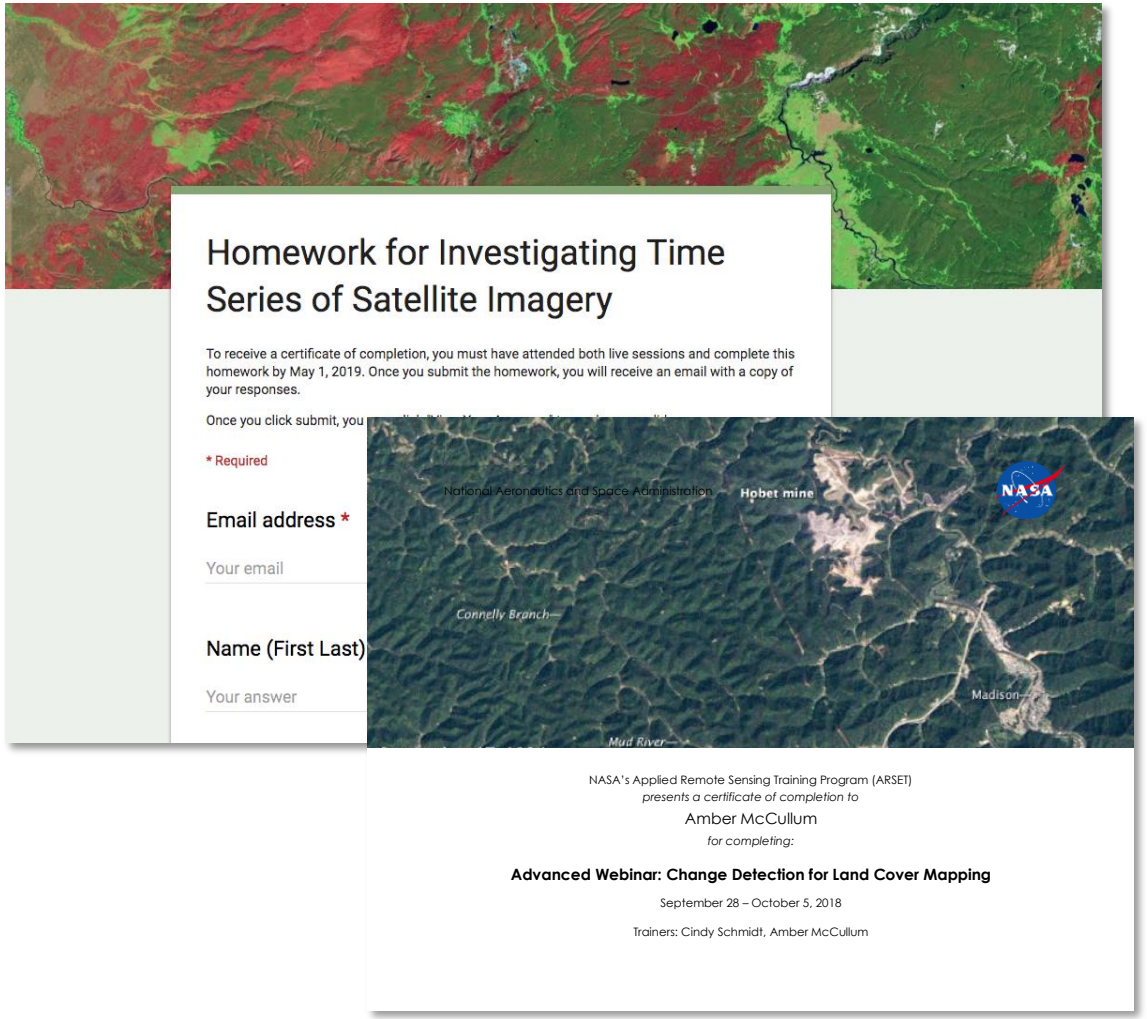
April 15, 2019

Course Structure

- Two, two-hour sessions on April 15 and April 17, 2019
- The same content will be presented at two different times each day:
  - Session A: 10:00-12:00 EST (UTC-4)
  - Session B: 18:00-20:00 EST (UTC-4)
  - **Please only sign up for and attend one session per day**
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - https://arset.gsfc.nasa.gov/land/webinars/time-series-19
- Q&A: Following each lecture and/or by email
    - cynthia.l.schmidt@nasa.gov, or
    - amberjean.mccullum@nasa.gov

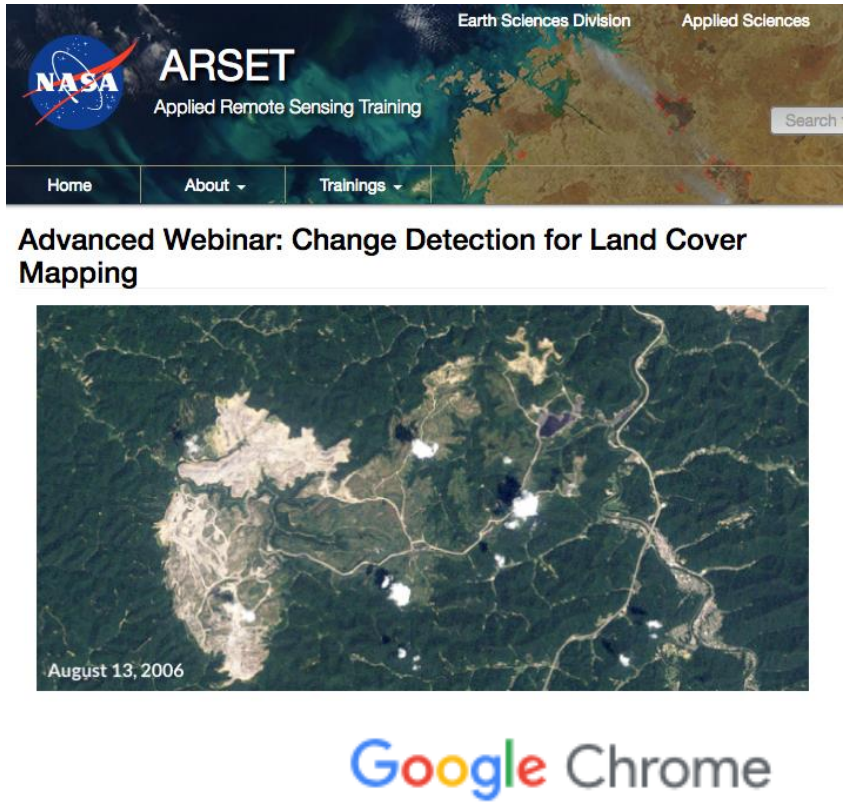
Homework and Certificates

- Homework
  - One homework assignment
  - Answers must be submitted via Google Forms
- Certificate of Completion:
  - Attend both live webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - HW Deadline: Wednesday May 1st
  - You will receive certificates approximately two months after the completion of the course from: marines.martins@ssaihq.com



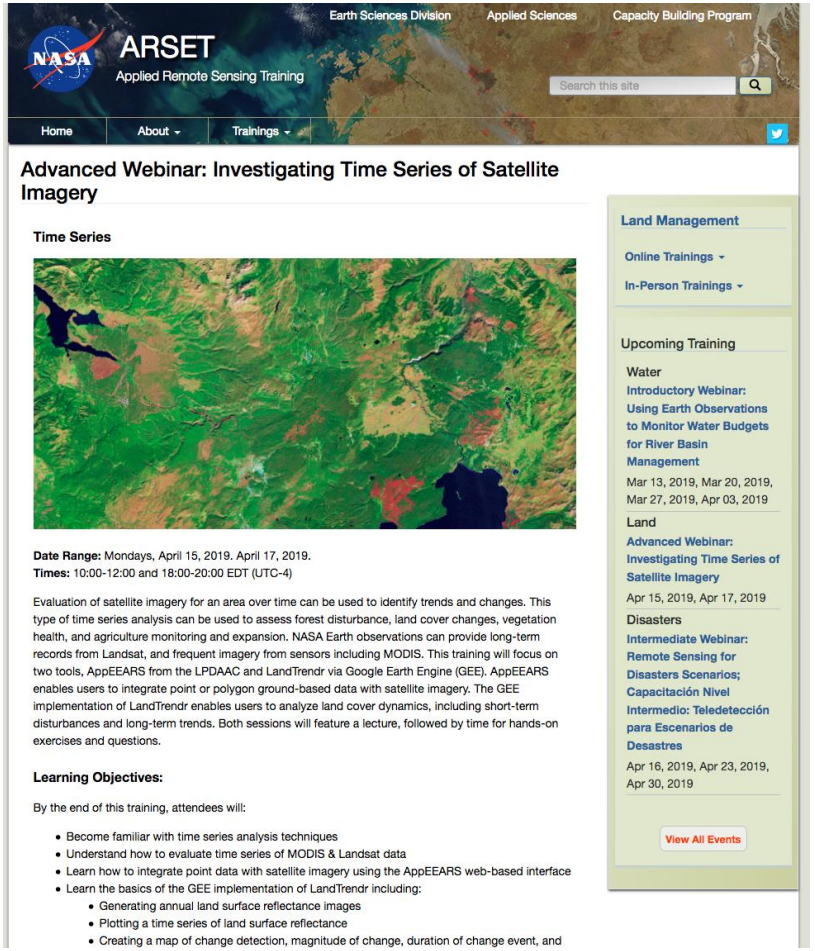
Prerequisites

- ARSET Webinar *Introduction to Remote Sensing* or equivalent knowledge
- Complete the Advanced Webinar: Change Detection for Land Cover Mapping
- Install Google Chrome: https://www.google.com/chrome/
  - For the Google Earth Engine exercise, Chrome should be used to make sure all features work
- Sign up for the Google Earth Engine Code Editor: https://signup.earthengine.google.com/



Accessing Course Materials

https://arset.gsfc.nasa.gov/land/webinars/time-series-19



Prerequisites:

Attendees that do not complete prerequisites may not be adequately prepared for the pace of the course.

- Complete **Sessions 1 & 2A of Fundamentals of Remote Sensing**, or equivalent experience
- Complete the **Advanced Webinar: Change Detection for Land Cover Mapping**
- Install Google Chrome: **https://www.google.com/chrome/**
  - For the Google Earth Engine exercise, Chrome should be used to make sure all features work
- Sign up for the Google Earth Engine Code Editor: **https://signup.earthengine.google.com/**

Audience:

Advanced users of remote sensing data within local, regional, state, federal, and non-governmental organizations involved in land management and conservation efforts. Professional organizations in the public and private sectors engaged in environmental management and monitoring will be given preference over organizations focused primarily on research.

Registration Information:

There is no cost for the webinar, but you must register to attend the sessions. Because we anticipate a high demand for this training, please only sign up for one session. Sessions will only be broadcast in English - Session A will cover the same content as Session B. Professional organizations in the public and private sectors engaged in water resources management and monitoring will be given preference over organizations focused primarily on research.

- **Register for Session A, 10:00-12:00 EDT (UTC-4) »**
- **Register for Session B, 18:00-20:00 EDT (UTC-4) »**

Course Agenda:

Agenda_41.pdf

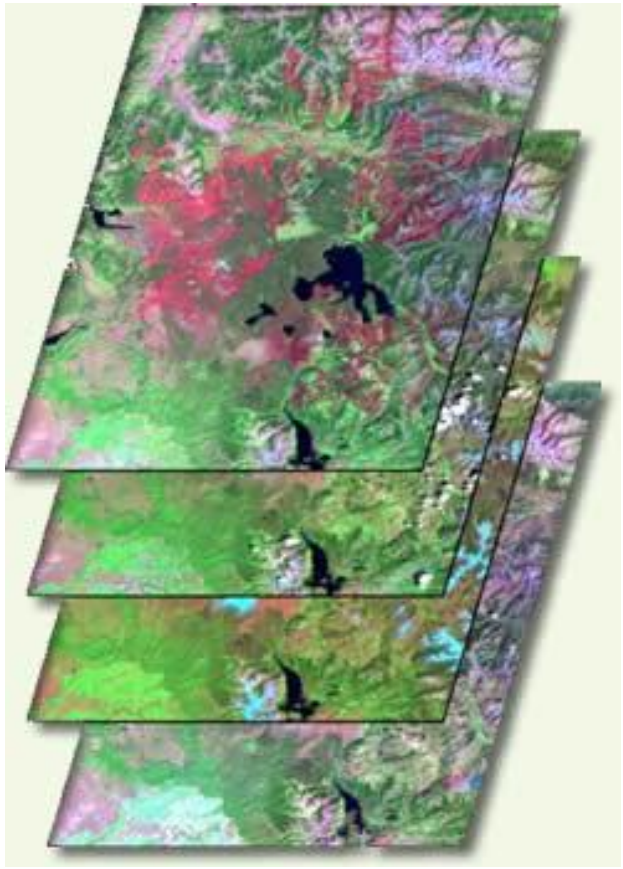
April 15, 2019

This session will include a review of MODIS and Landsat, a review of change detection, an overview of time series analysis methods, and an AppEEARS hands-on exercise.

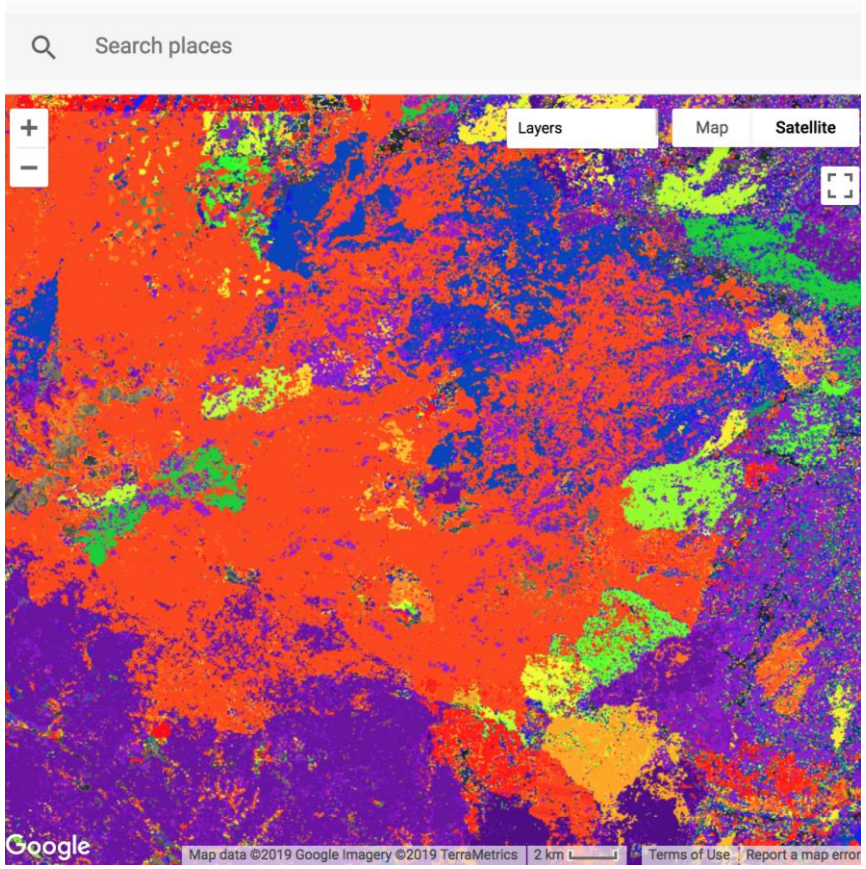
Application Area: Land
Available Languages: English
Instruments/Missions: Terra, Landsat, MODIS, Aqua
Keywords: Ecosystems, Land-Cover and Land-Use Change (LCLUC), Satellite Imagery, Tools

Course Outline

Session 1: Intro to Time Series and AppEEARS

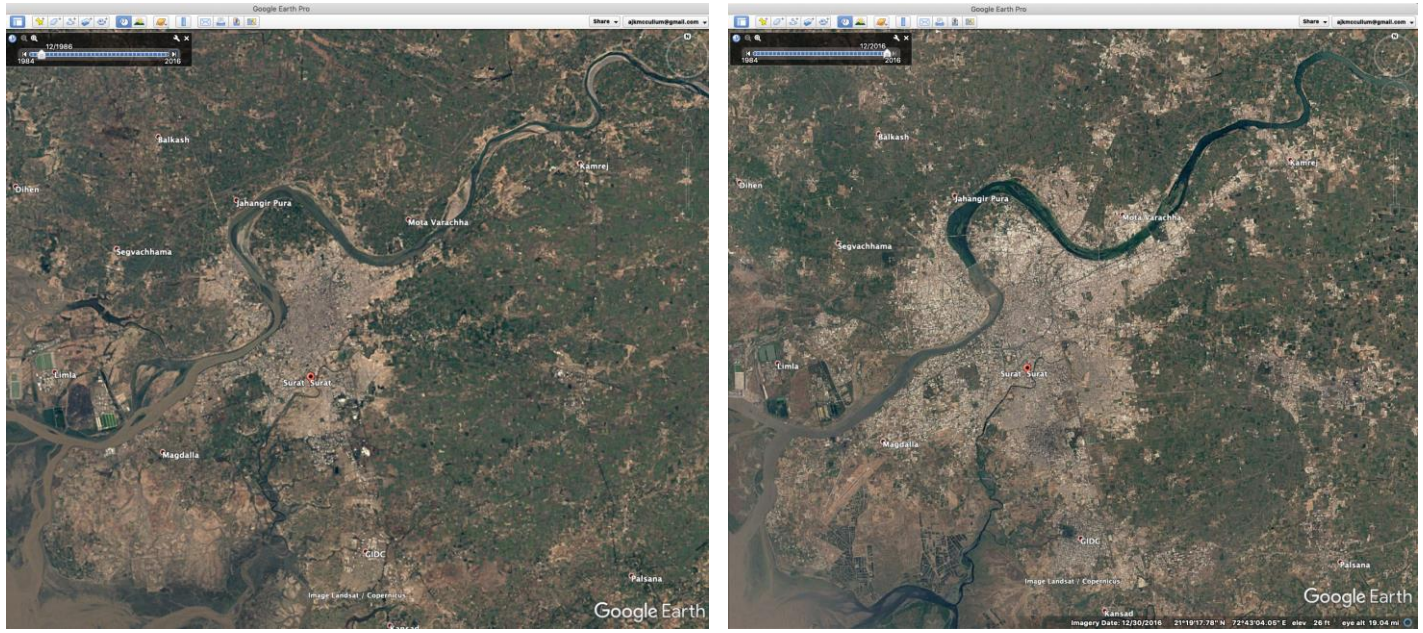


Session 2: LandTrendr Overview and Applications

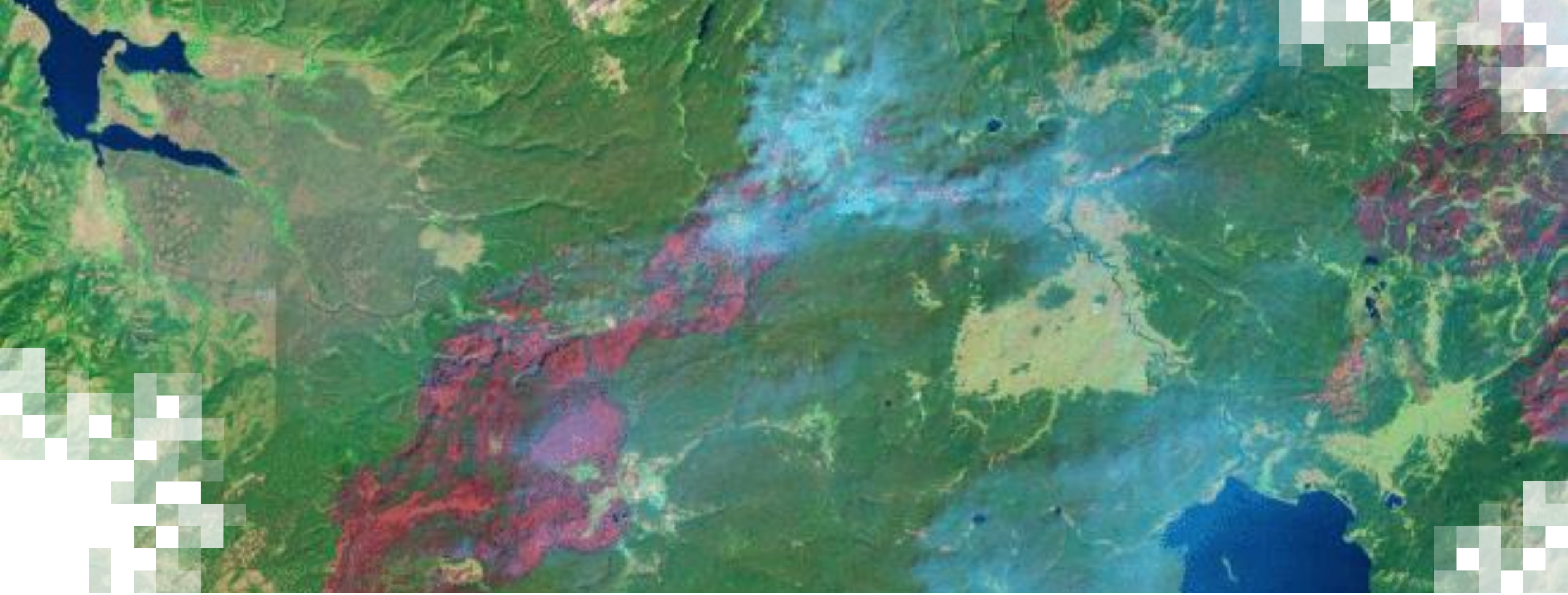


Session 1 Agenda

- Overview of time series satellite imagery
- Types of time series analysis:
  - Annual and Seasonal Trends
  - Anomalies
  - Environmental Descriptors
- Time Series Tools
- Sustainable Development Goals (SDGs)
  - Open Data Cubes
- Overview of AppEEARS



Google Earth Pro (with time slider). Images of Surat, India, one of the fastest growing cities in the world from 1986 (left) and 2016 (right).

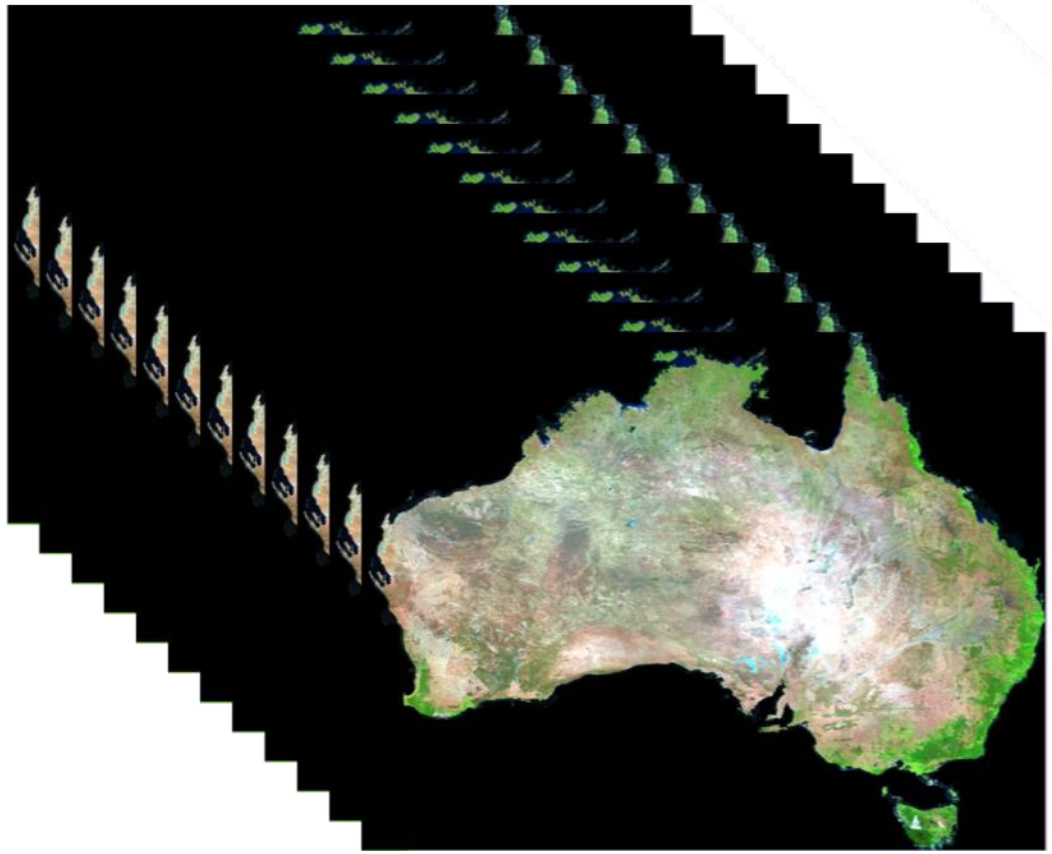


Overview of Time Series Satellite Imagery

Satellite Time Series

Our ability to identify changes over time has changed because:

- The availability of long term satellite data sets
  - Landsat (30+ years)
  - MODIS (18 years)
- Increased computing power and cloud computing
- Improved processing methods

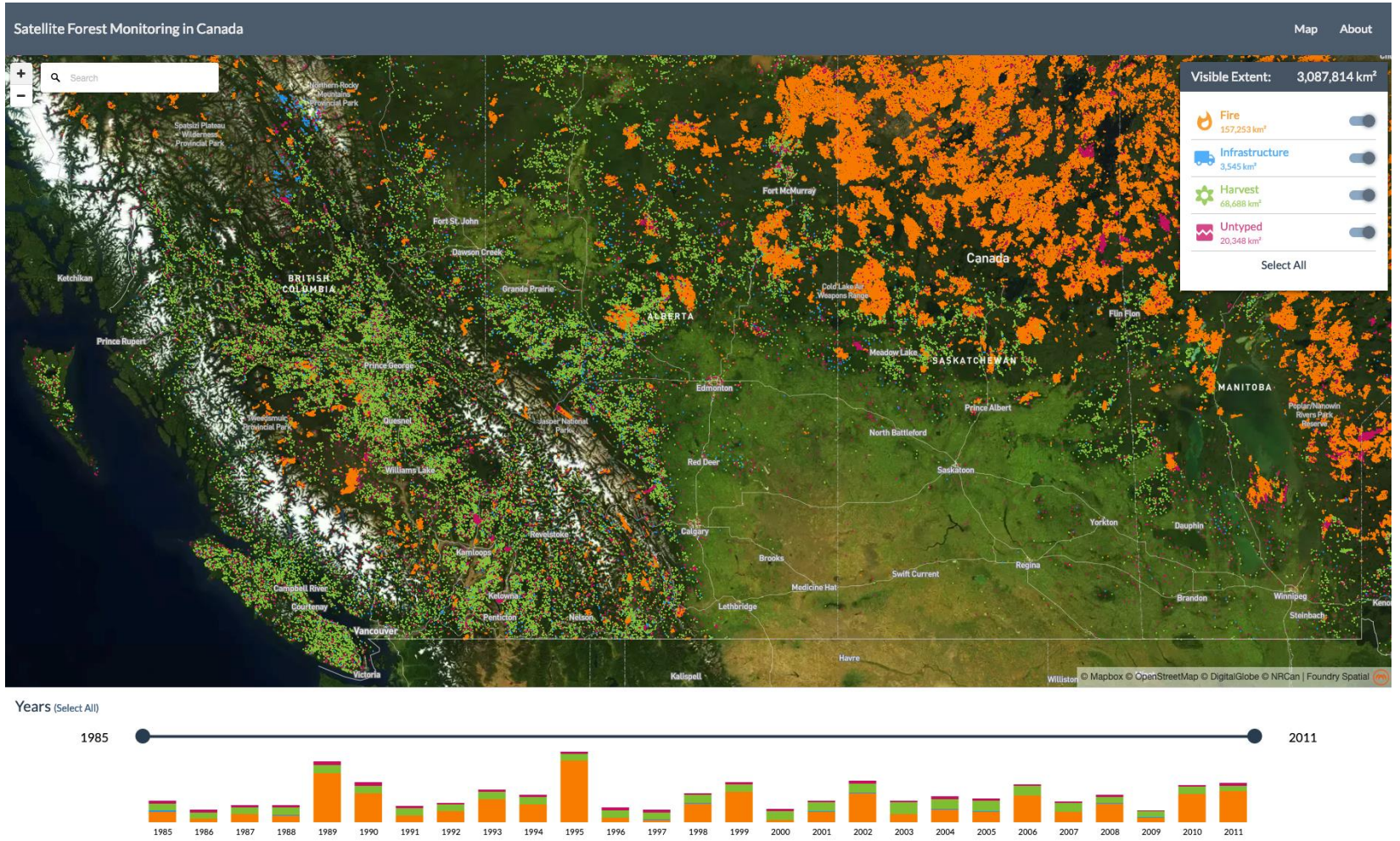


Stack of Landsat images of Australia

Image credit: Data Cube.

Types of Time Series Analysis

- Annual vs. seasonal trends
- Gradual vs. abrupt changes
- Anomalies
- Environmental descriptors



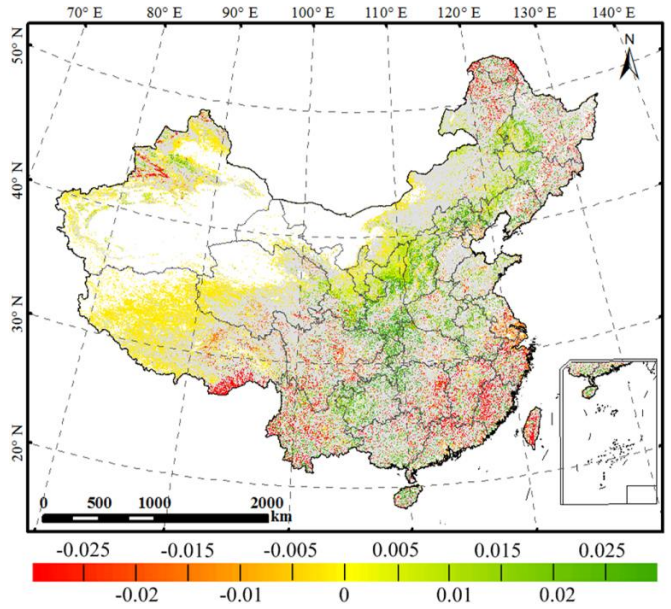
Satellite forest monitoring in Canada. Image credit: Foundry Spatial

Annual vs. Seasonal Trends

- Annual Trends
  - Annual land cover/land use changes over long time periods
  - Ex: Trends in vegetation greenness in China

Annual mean Leaf Area Index (LAI) during 2000-2014 from MODIS

These data were used to analyze the change in evapotranspiration and water yield



- Seasonal Trends
  - Driven by annual temperature and/or precipitation
  - Ex: Snow cover monitoring in the Himalayas

Seasonal snow cover based on MODIS snow cover time series from Mar 2000 to Feb 2008. (Winter, (top), Spring, Summer Autumn (bottom)

The values show the percentage of time that a pixel was snow-covered during the season within the time period

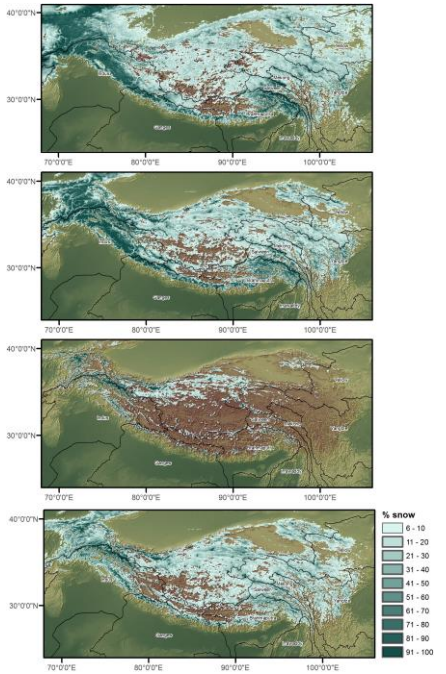


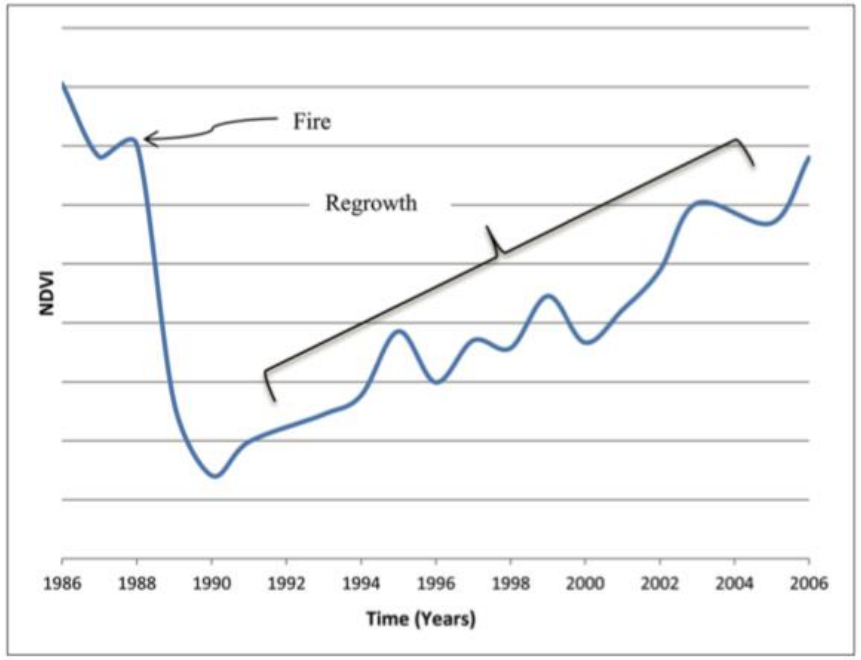
Image Credits: (left) Liu, Y. et al. (2016) Recent trends in vegetation greenness in China significantly altered annual evapotranspiration and water yield, Environmental Research Letters; (right) Immerzeel, W.W. et al. (2009). Large-scale monitoring of snow cover and runoff simulation in Himalayan river basins using remote sensing, Remote Sensing of Environment

Gradual vs. Abrupt Changes

- Gradual changes:
  - Insect infestation in forests
  - Land degradation
  - Forest recovery

- Abrupt changes:
  - Wildfire
  - Deforestation
  - Urban development

- Example: Forest recovery after wildfire in Yellowstone National Park

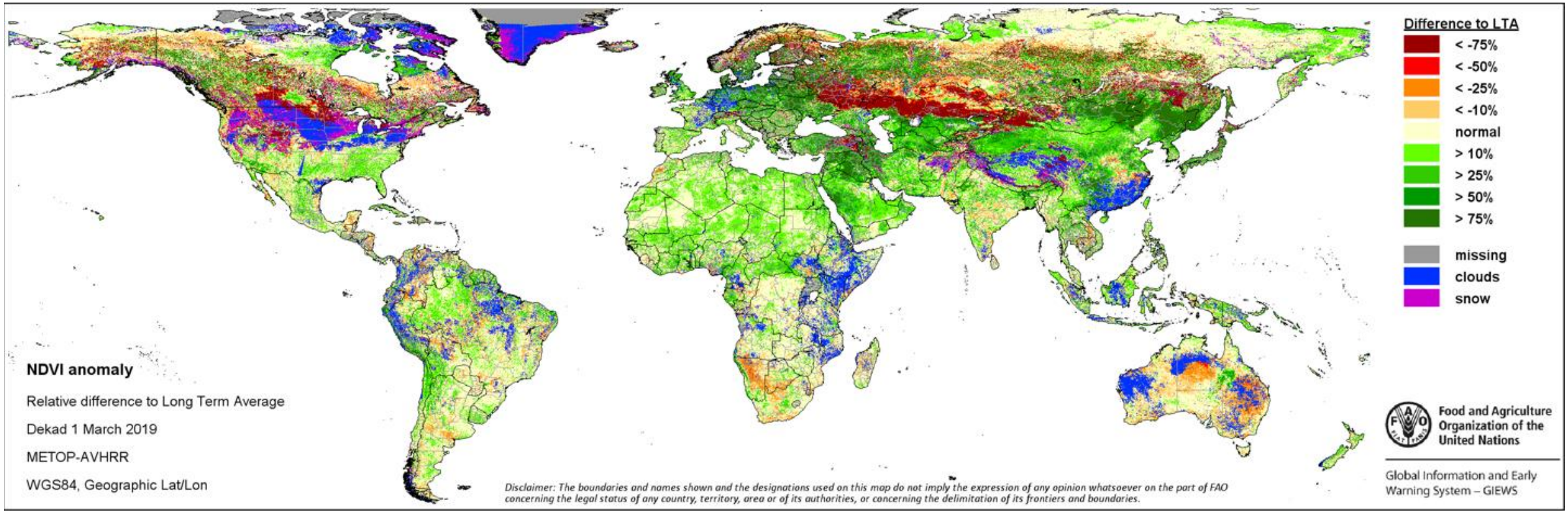


Changes in NDVI values between 1986 and 2006 for one site in Yellowstone National Park

Image Credit: Franks, S. et al. (2013). Monitoring forest regrowth following large scale fire using satellite data- A case study of Yellowstone National Park, USA, European Journal of Remote Sensing

Anomalies

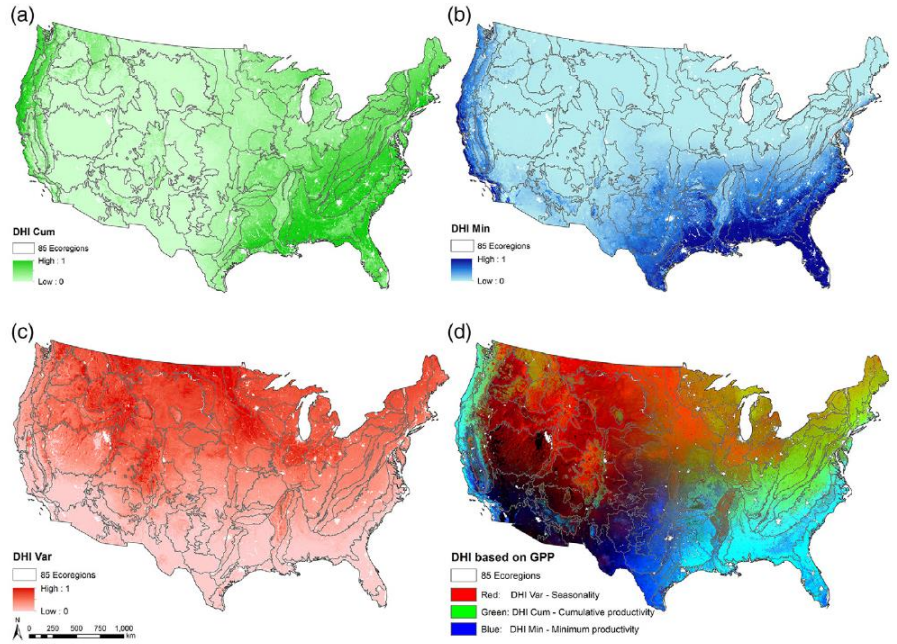
- Relative difference from a long term average
- Example: FAO Global NDVI Anomalies



http://www.fao.org/giews/earthobservation/

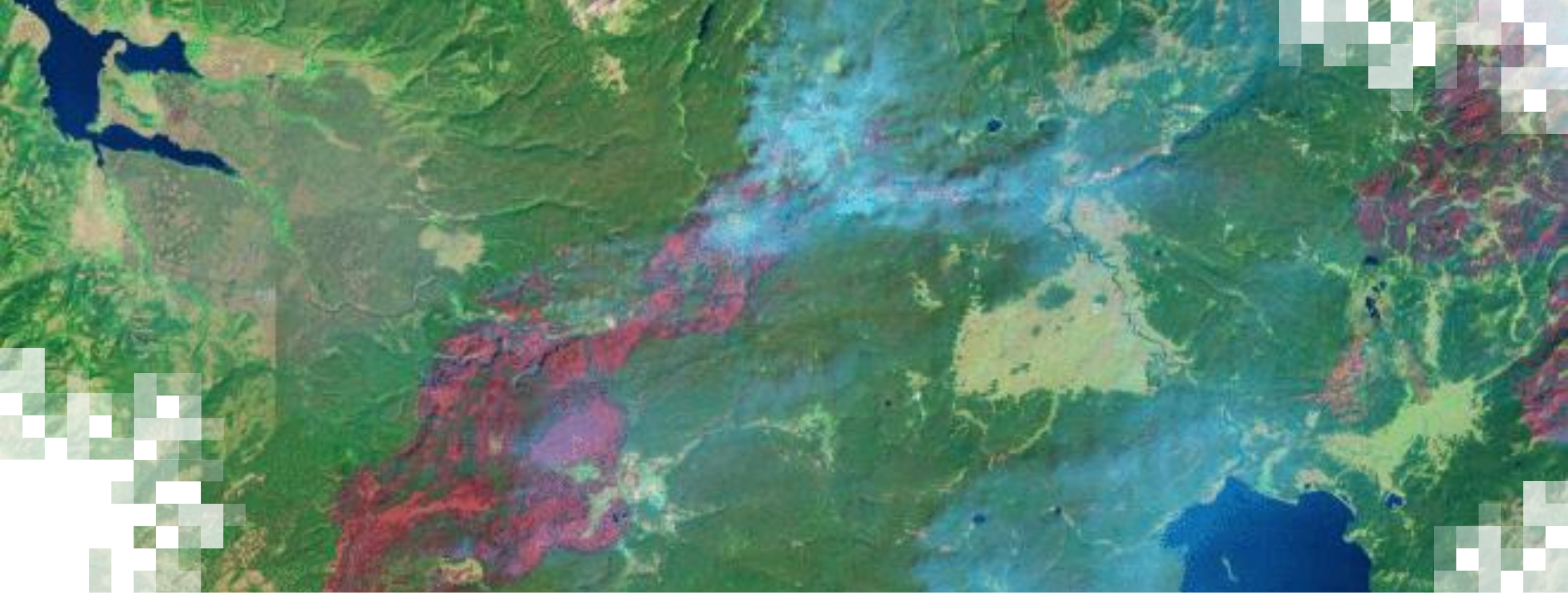
Environmental Descriptors

- Use time series of satellite observations to derive environmental descriptors
- Example: Dynamic Habitat Indices (DHIs) use time series of satellite observations of greenness to describe vegetation dynamics to understand bird species richness
  - DHIs capture seasonal variations in energy that species can utilize in the form of food
  - Vegetation dynamics include: productivity, minimum level of perennial cover, degree of vegetation seasonality



Dynamic Habitat Indices derived from MODIS GPP 2003-2014 data (a)cumulative DHI; (b) minimum DHI; (c) variation DHI; (d) combined DHI

Hobi, M.L. et al. (2017). A comparison of Dynamic Habitat Indices derived from different MODIS products as predictors of avian species richness, Remote Sensing of Environment.



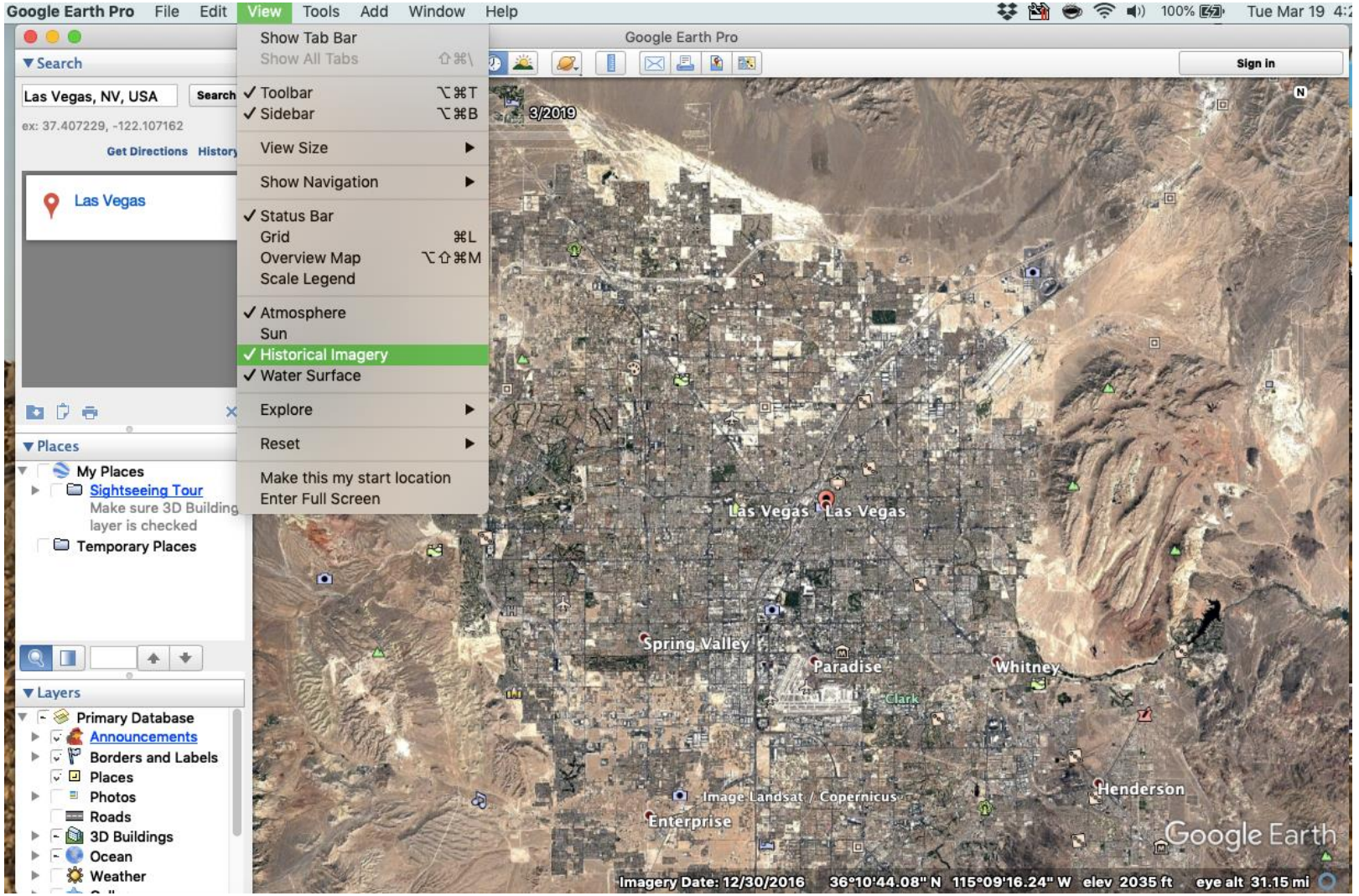
Time Series Tools

Time Series Tools

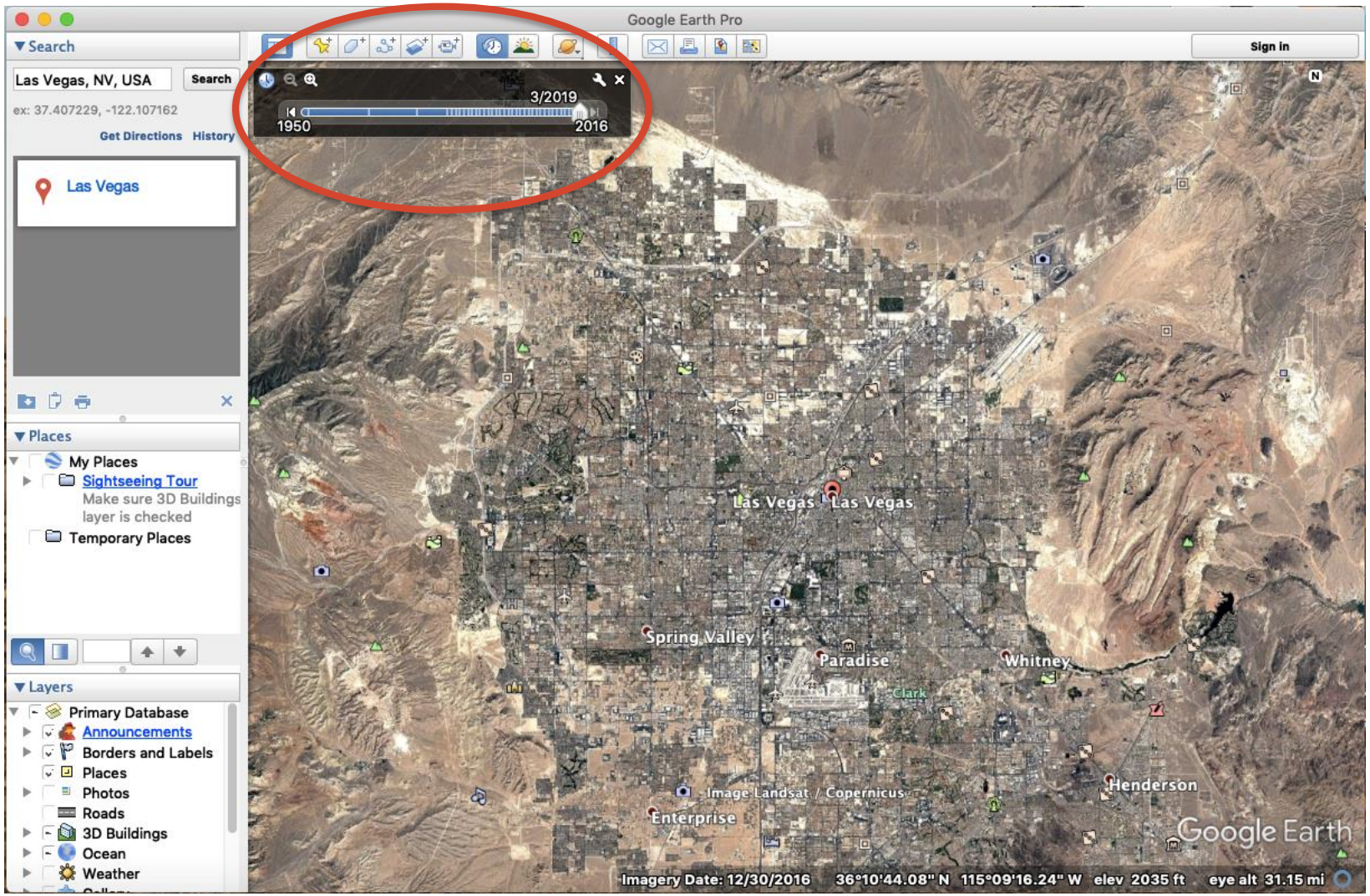
- Visualizing time series
  - Google Earth Engine Time Lapse
  - Google Earth
  - Sentinel Hub EO Browser (European Space Agency)

- Analyzing time series
  - Open Data Cube
  - BFAST
  - AppEEARS (Land Processes DAAC)
  - Landtrendr (next week)

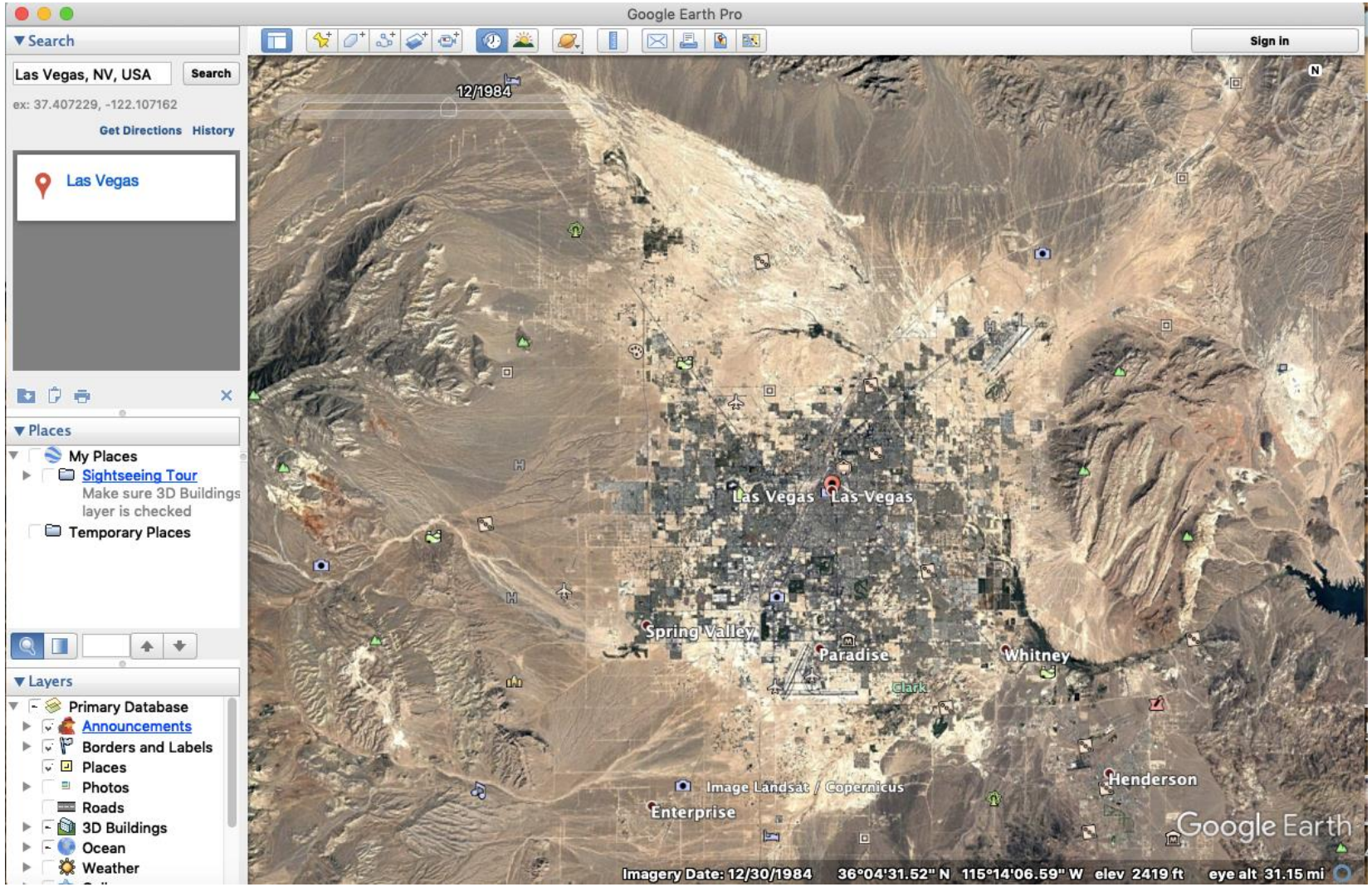
Google Earth: Las Vegas



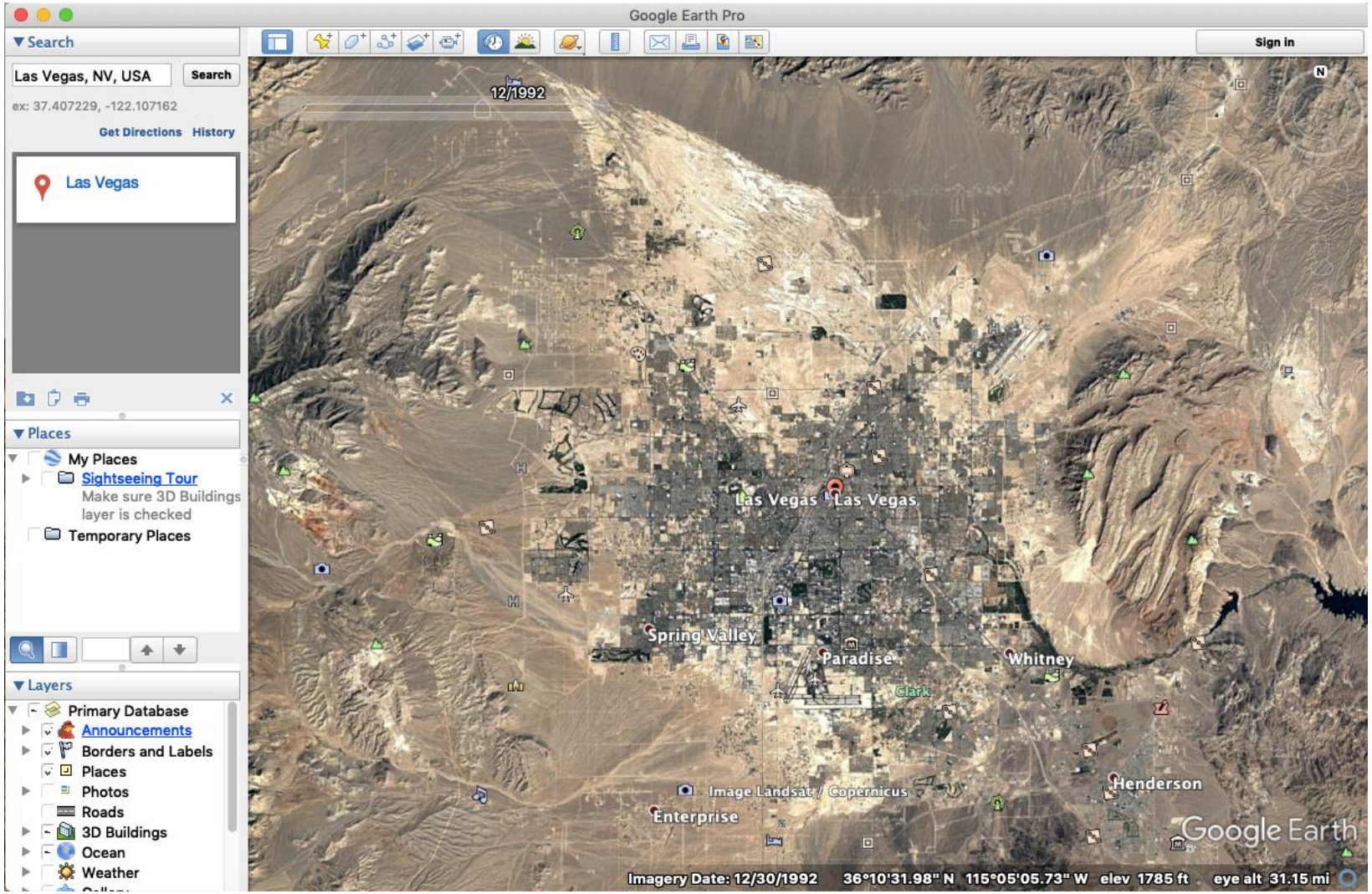
Las Vegas 2016



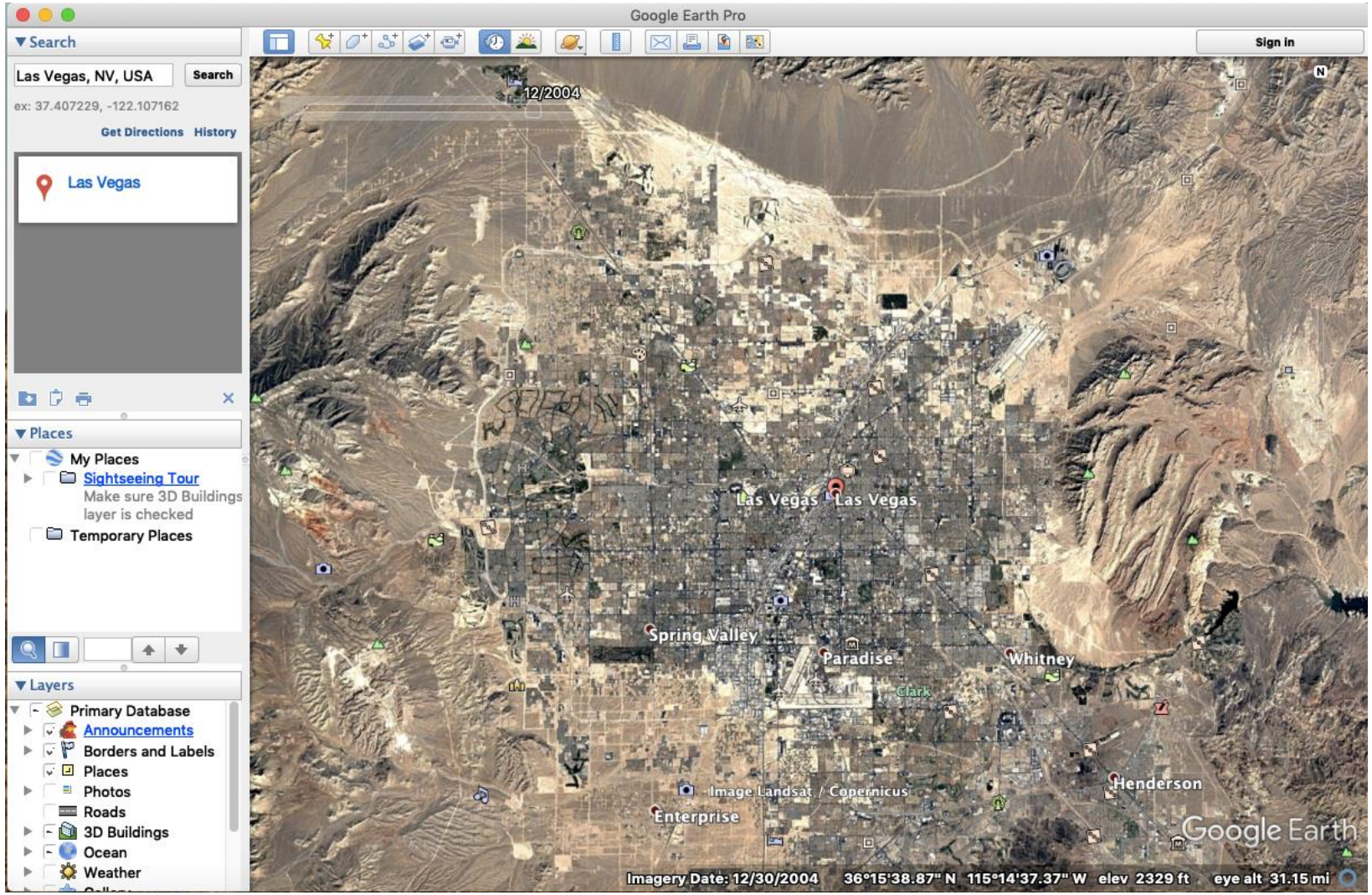
Las Vegas 1984



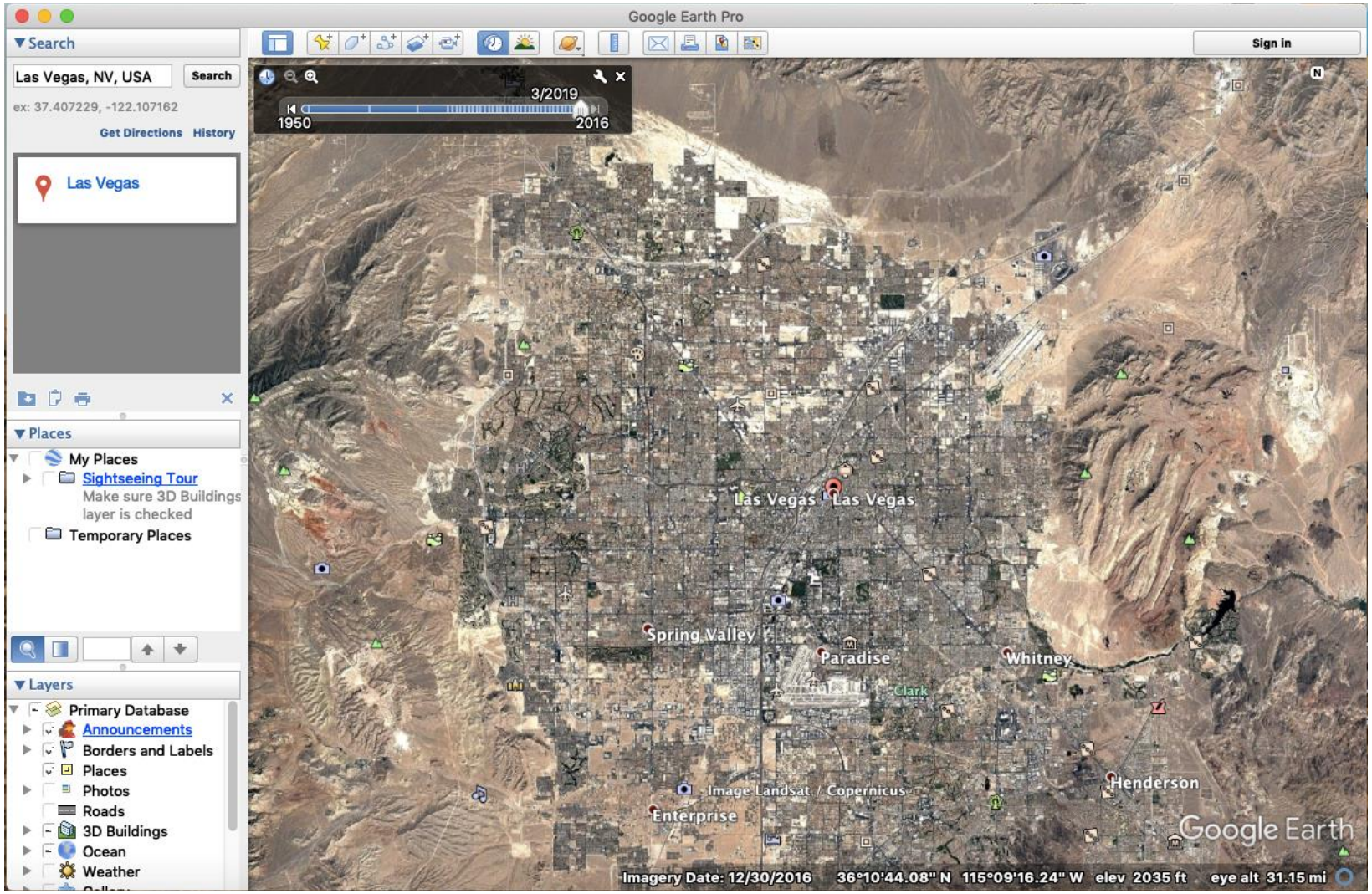
Las Vegas 1992



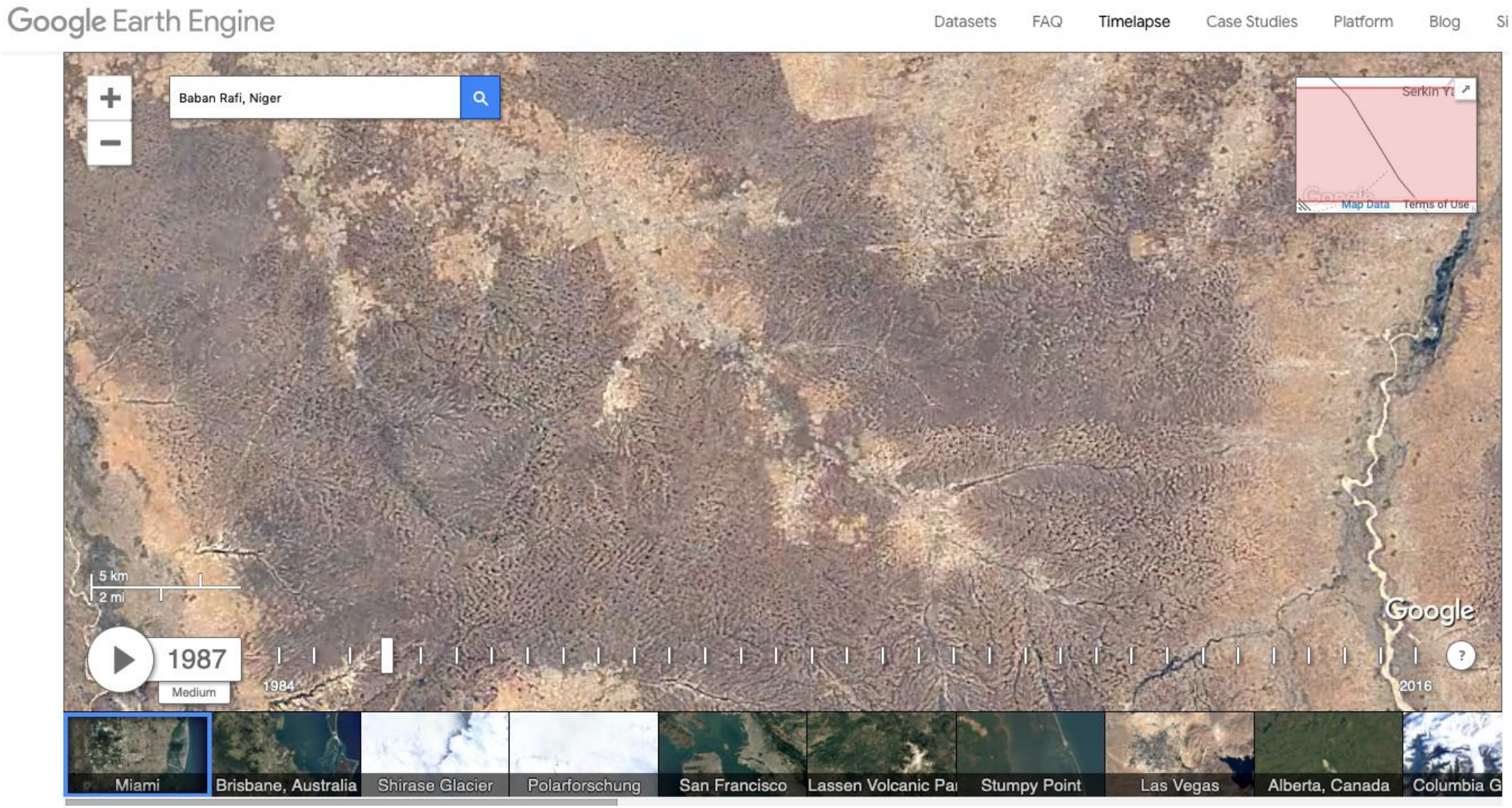
Las Vegas 2004



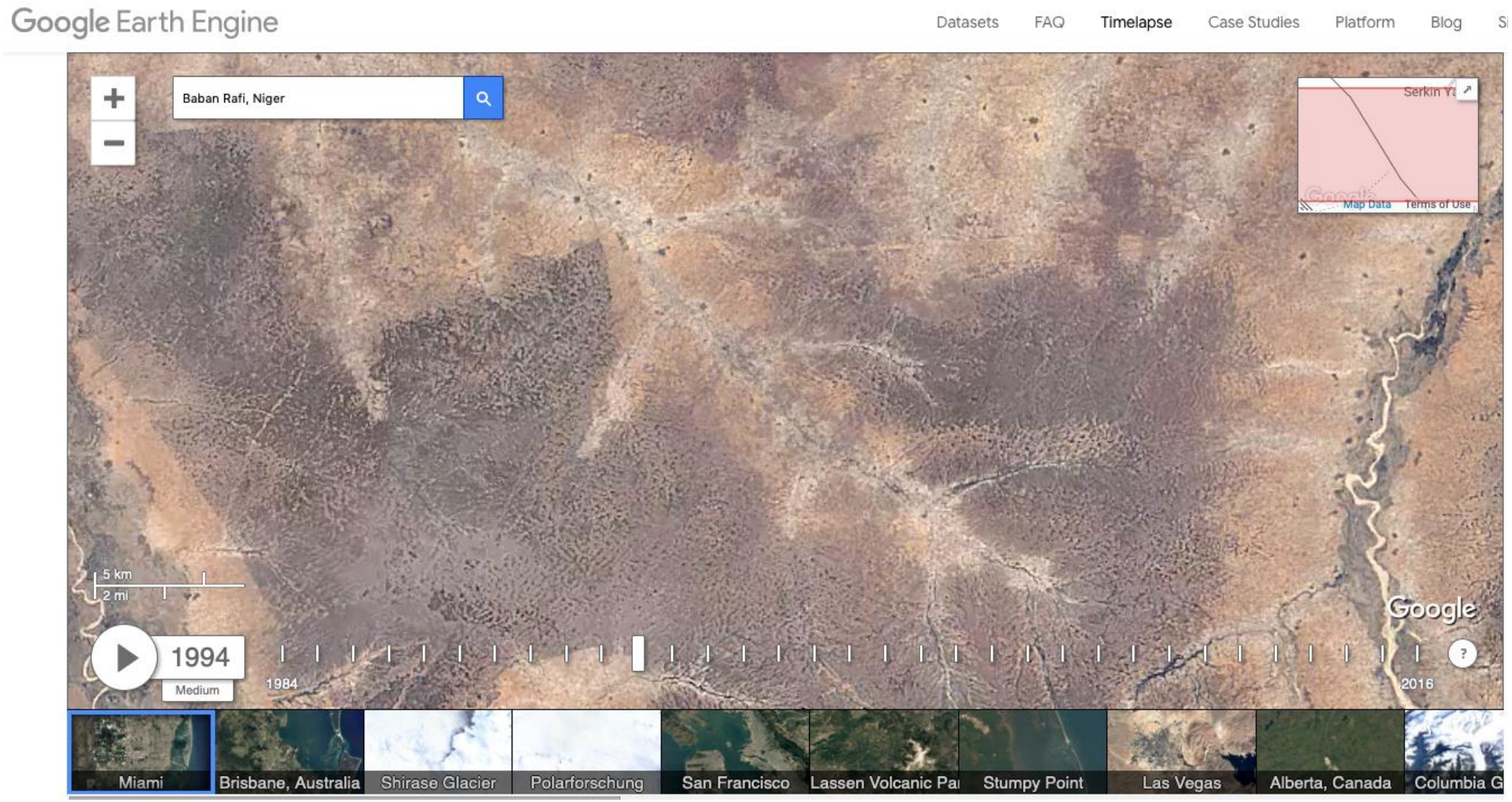
Las Vegas 2016



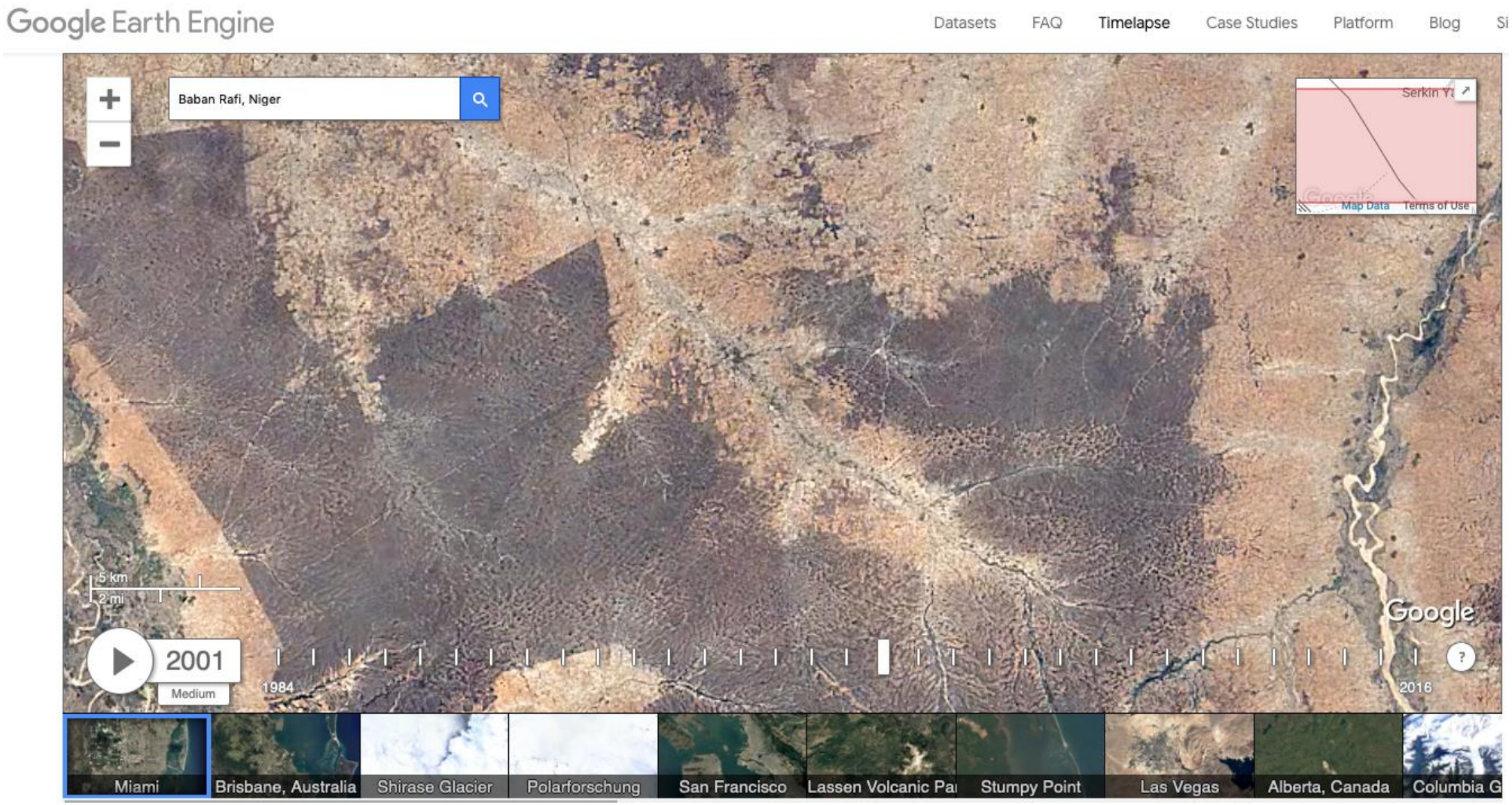
Google Earth Engine Time Lapse: Baban Rafi Forest, Niger



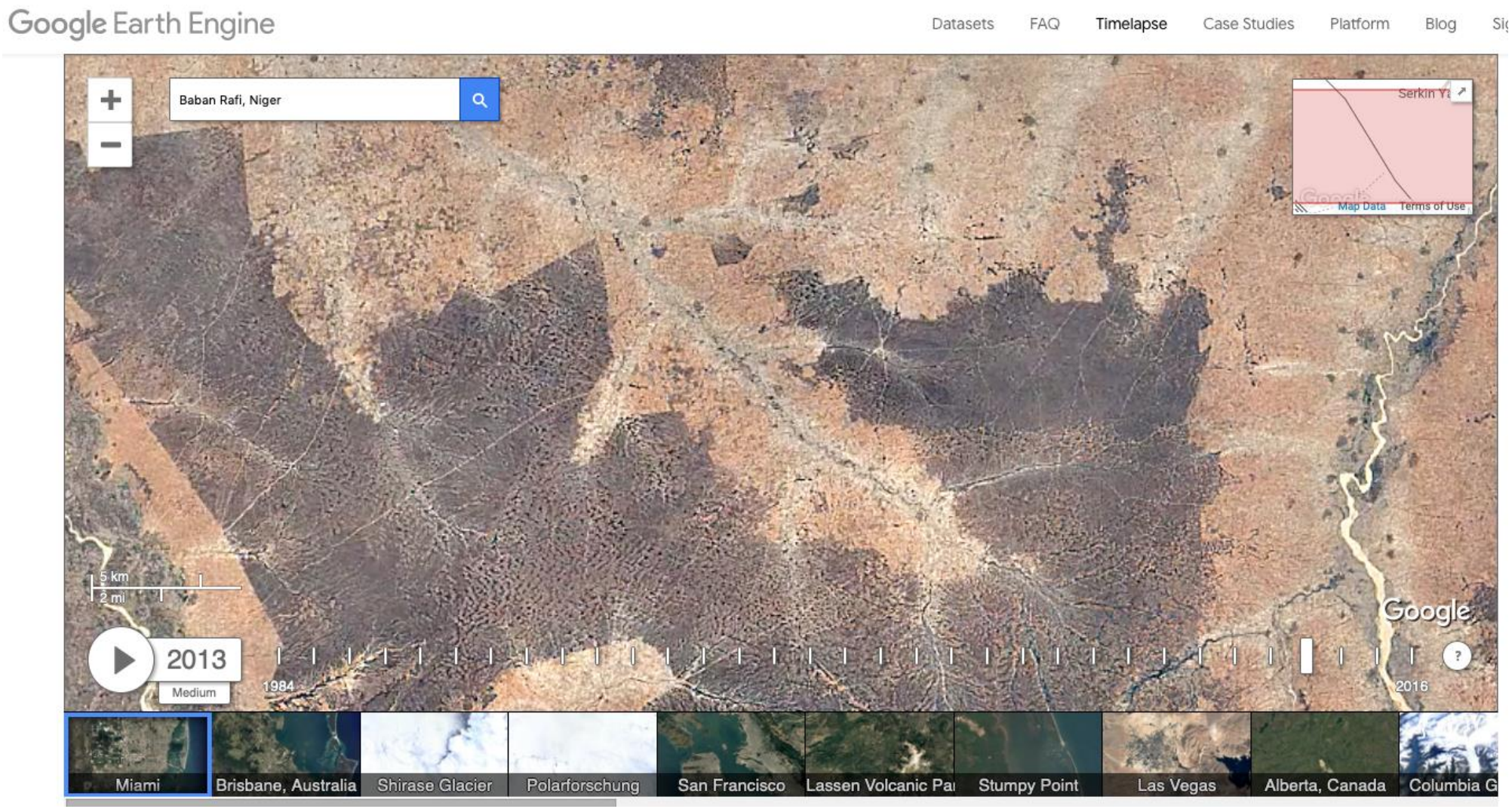
Google Earth Engine Time Lapse: Baban Rafi Forest, Niger



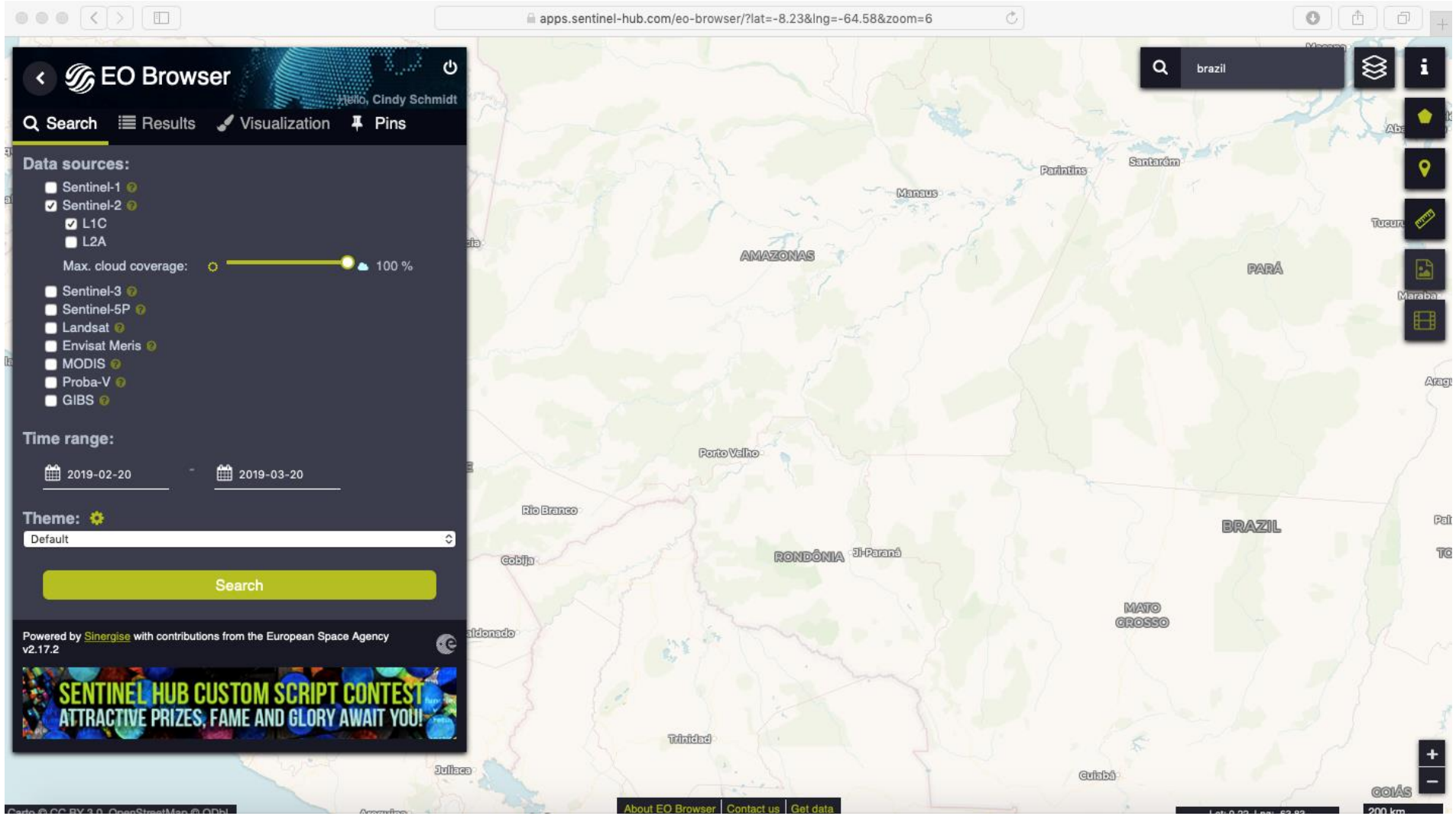
Google Earth Engine Time Lapse: Baban Rafi Forest, Niger



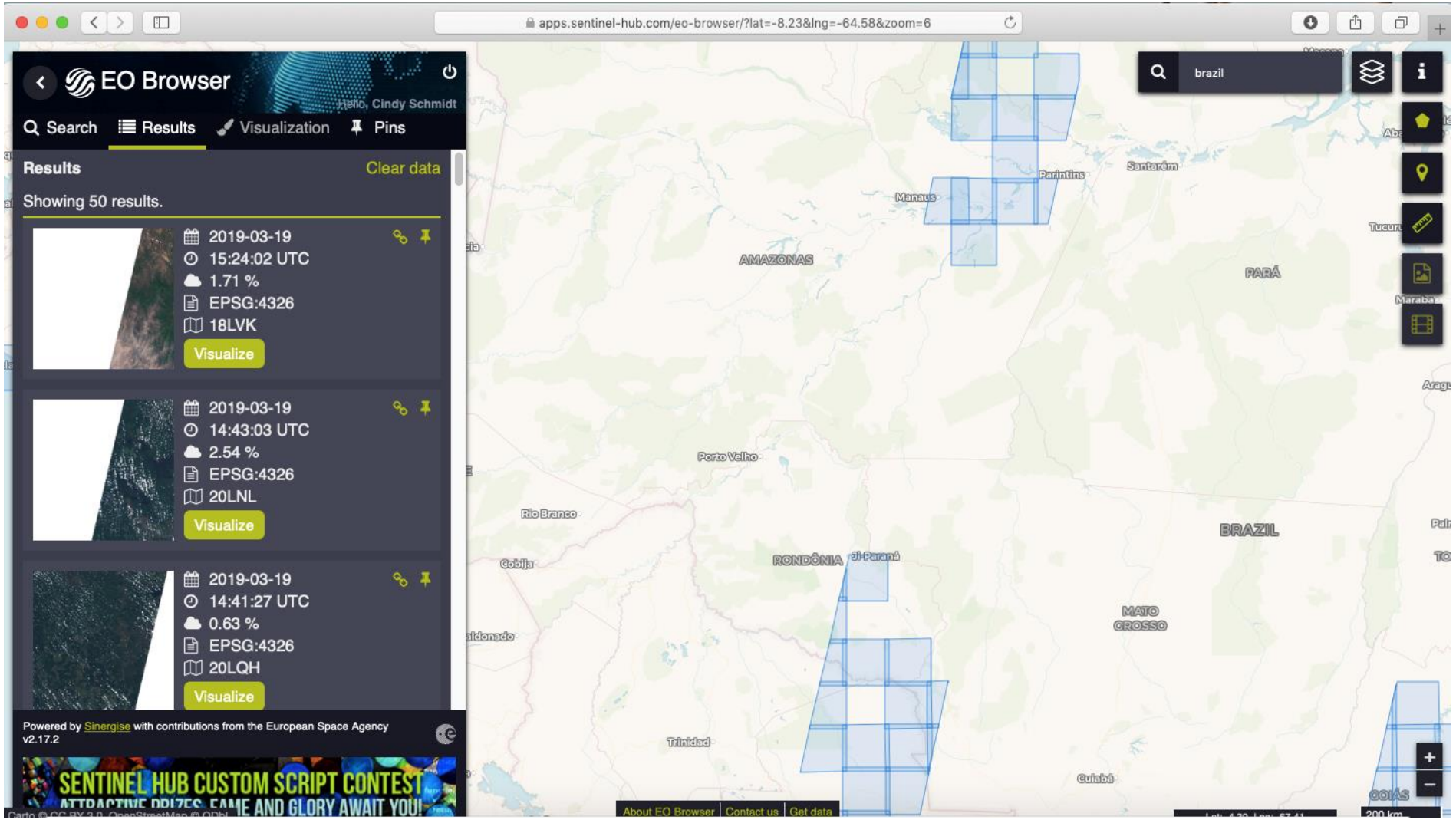
Google Earth Engine Time Lapse: Baban Rafi Forest, Niger



Sentinel Hub EO Browser: Brazil



Sentinel Hub EO Browser: Brazil



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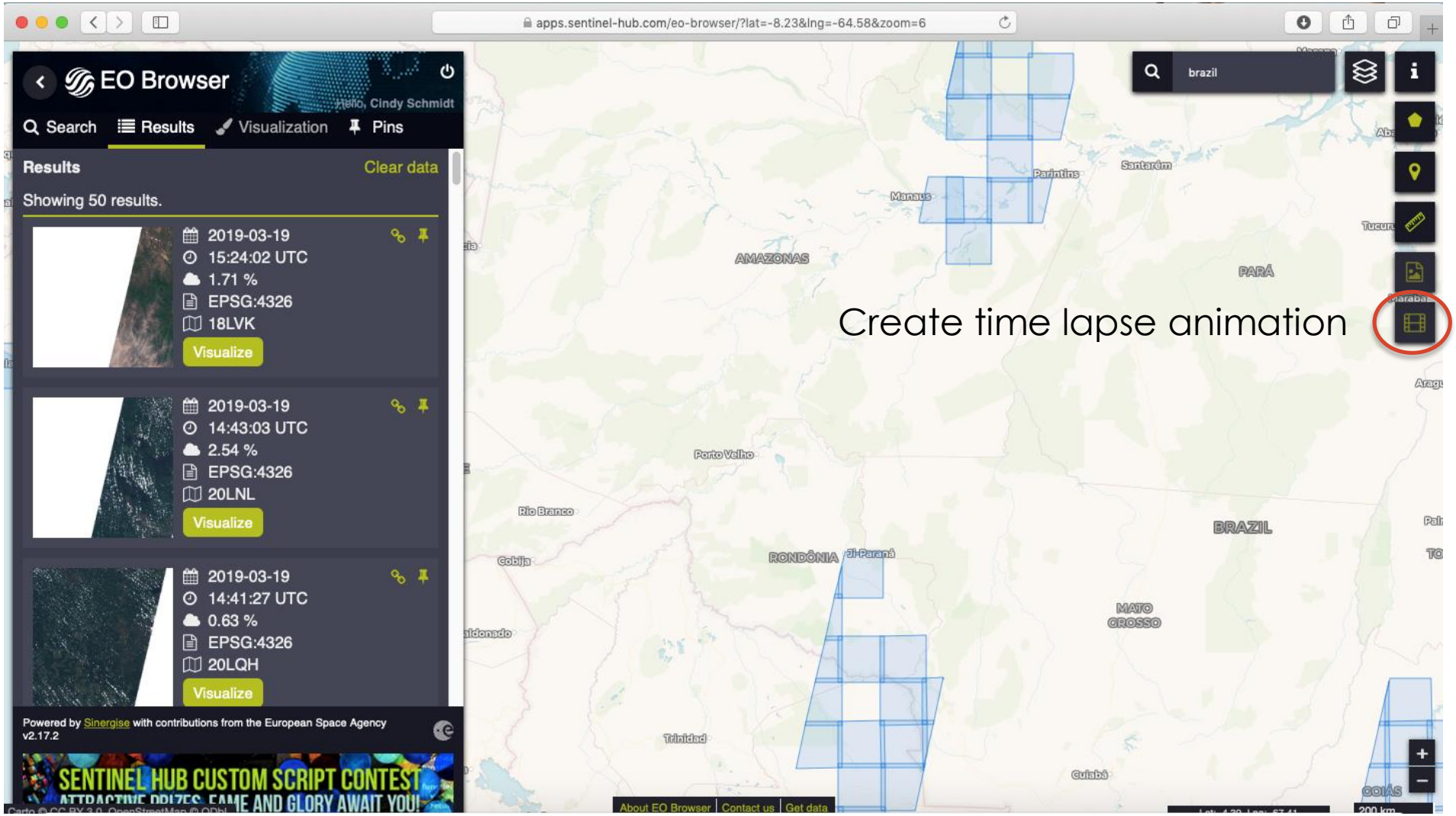
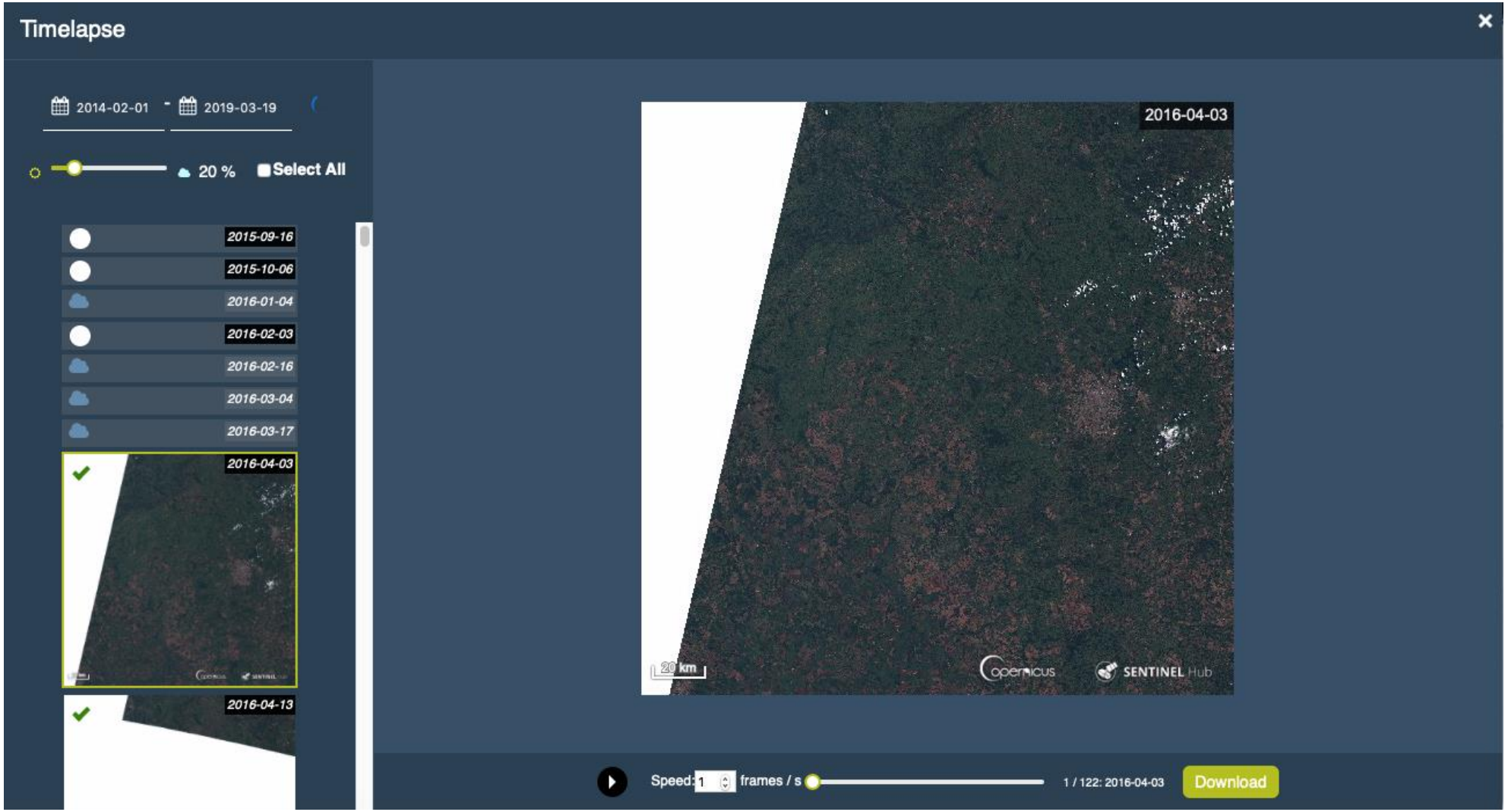
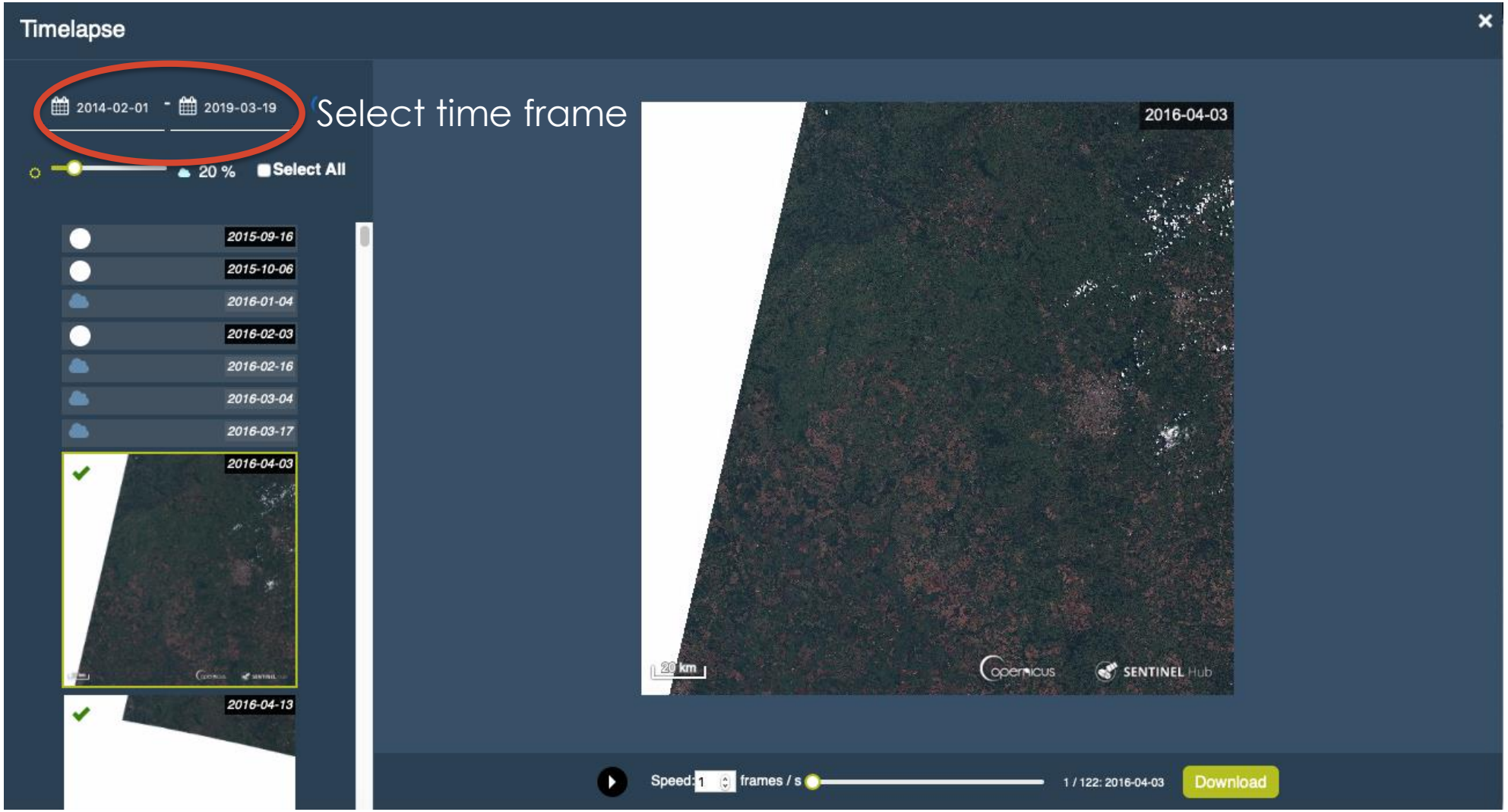


Sentinel Hub EO Browser: Brazil



Sentinel Hub EO Browser: Brazil



Sentinel Hub EO Browser: Brazil

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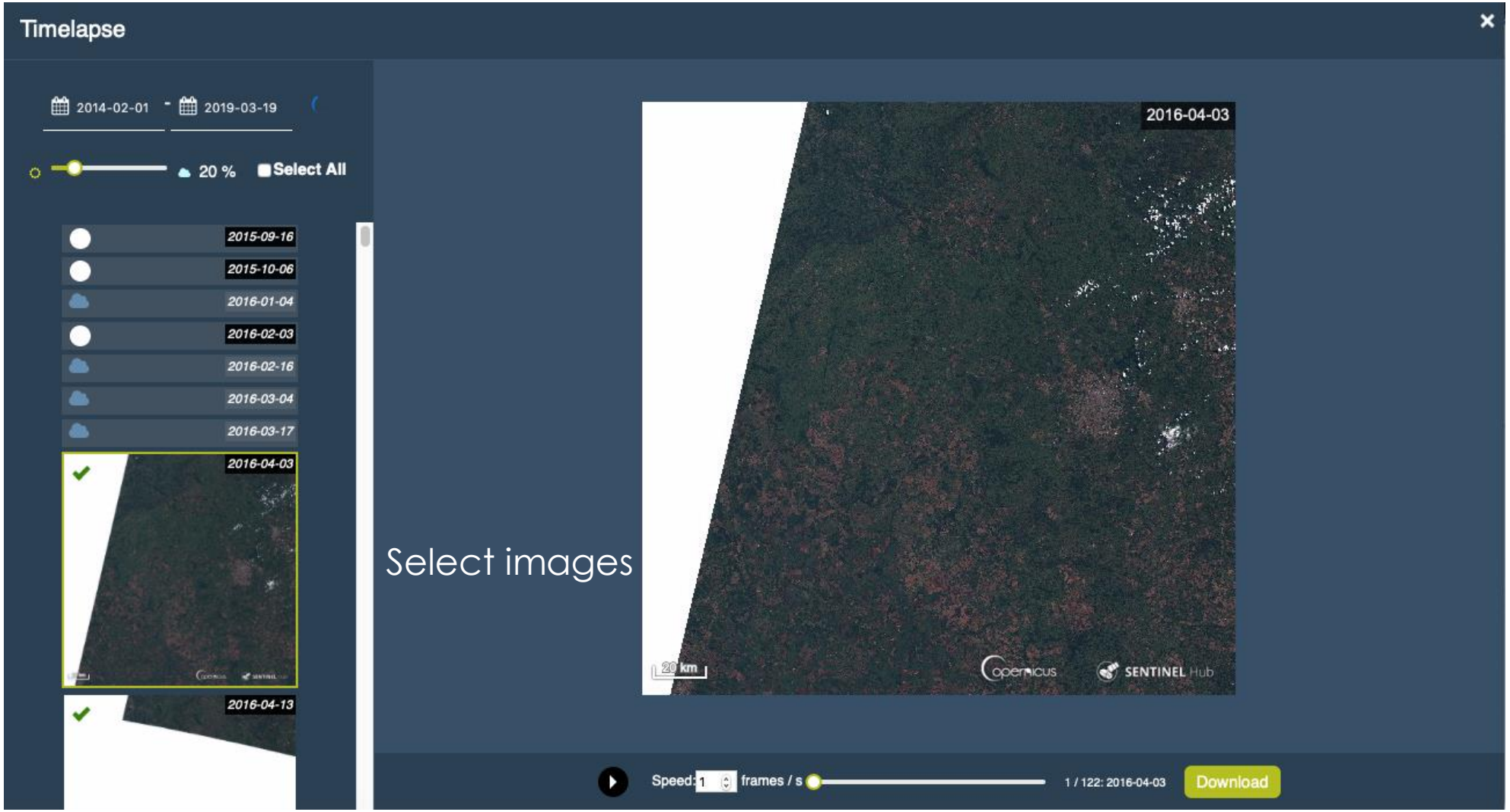
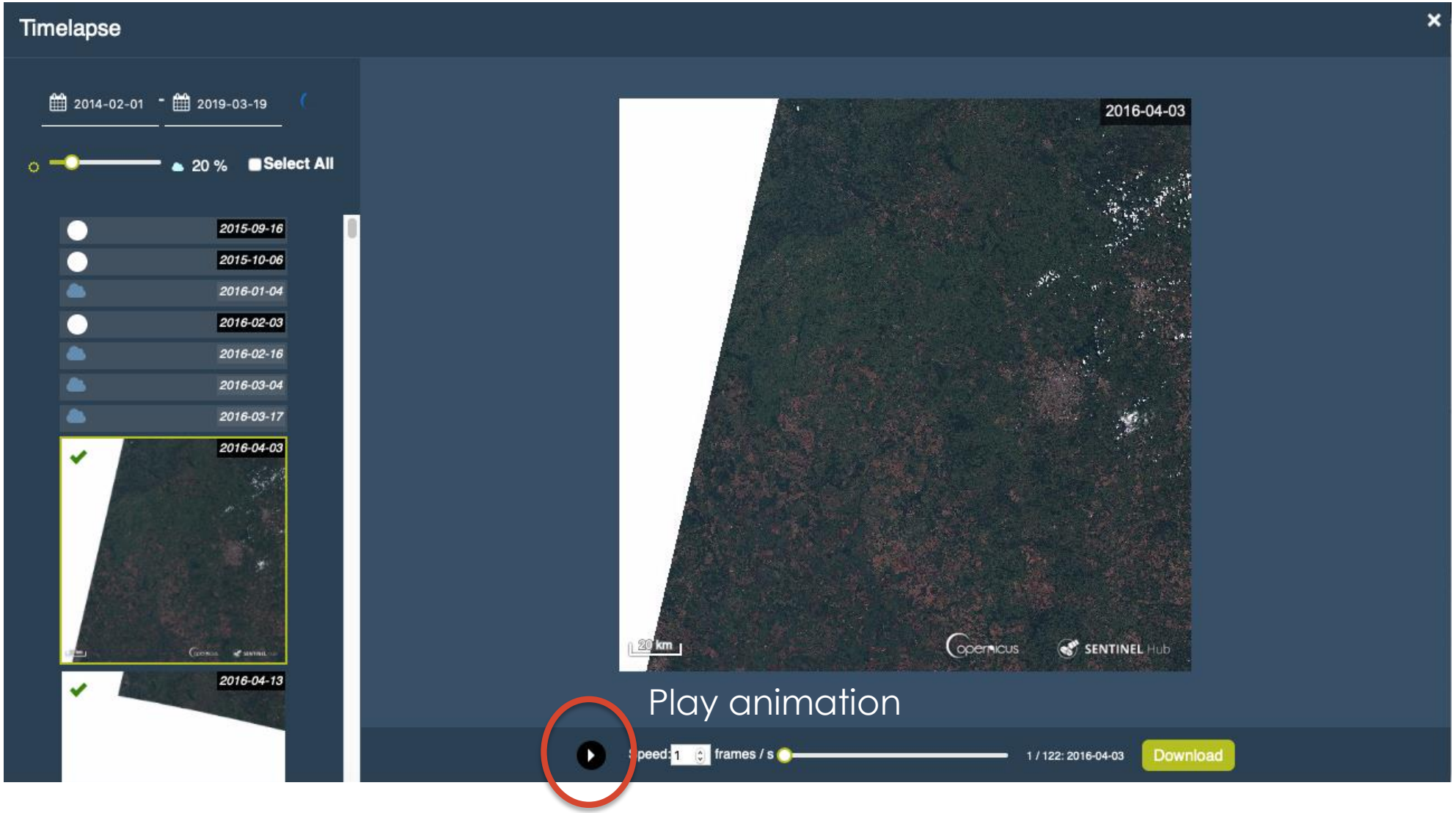
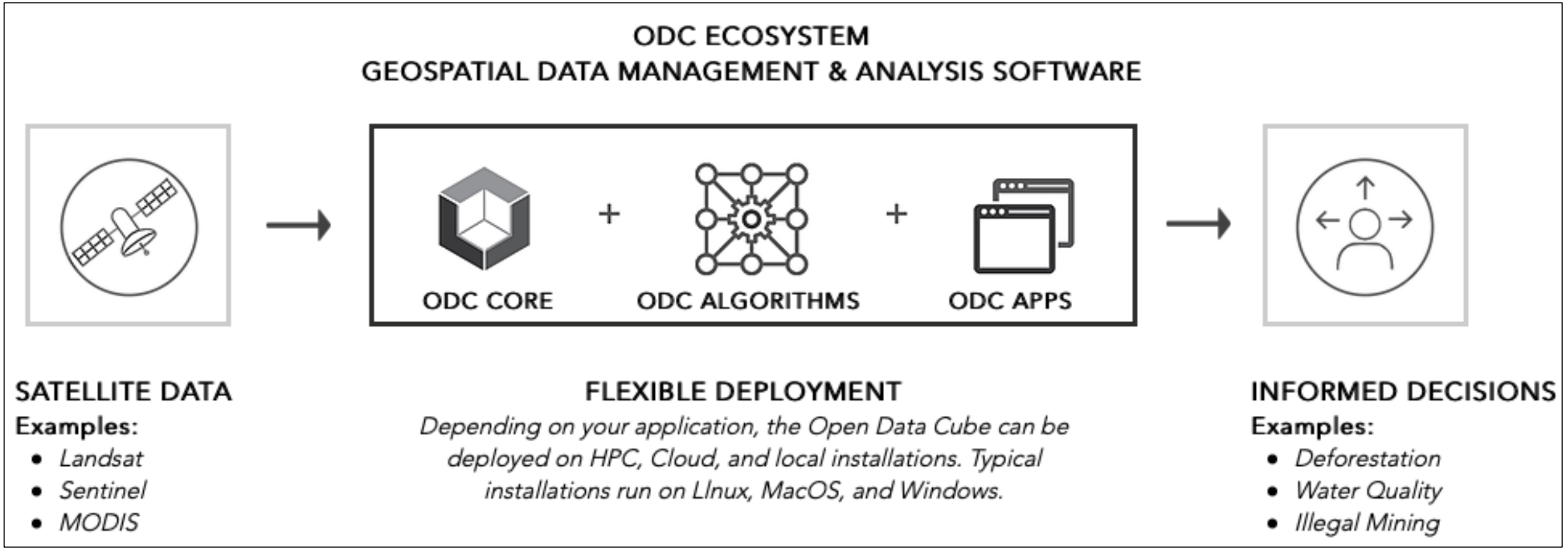


Sentinel Hub EO Browser: Brazil



Open Data Cube

- Open source geospatial data management and analysis software project



https://www.opendatacube.org

Africa Regional Data Cube

- Developed to address Sustainable Development Goals (SDGs)
- Developed by the Committee on Earth Observations Satellite (CEOS) in partnership with the Group on Earth Observations (GEO), Amazon Web Services and Strathmore University in Kenya

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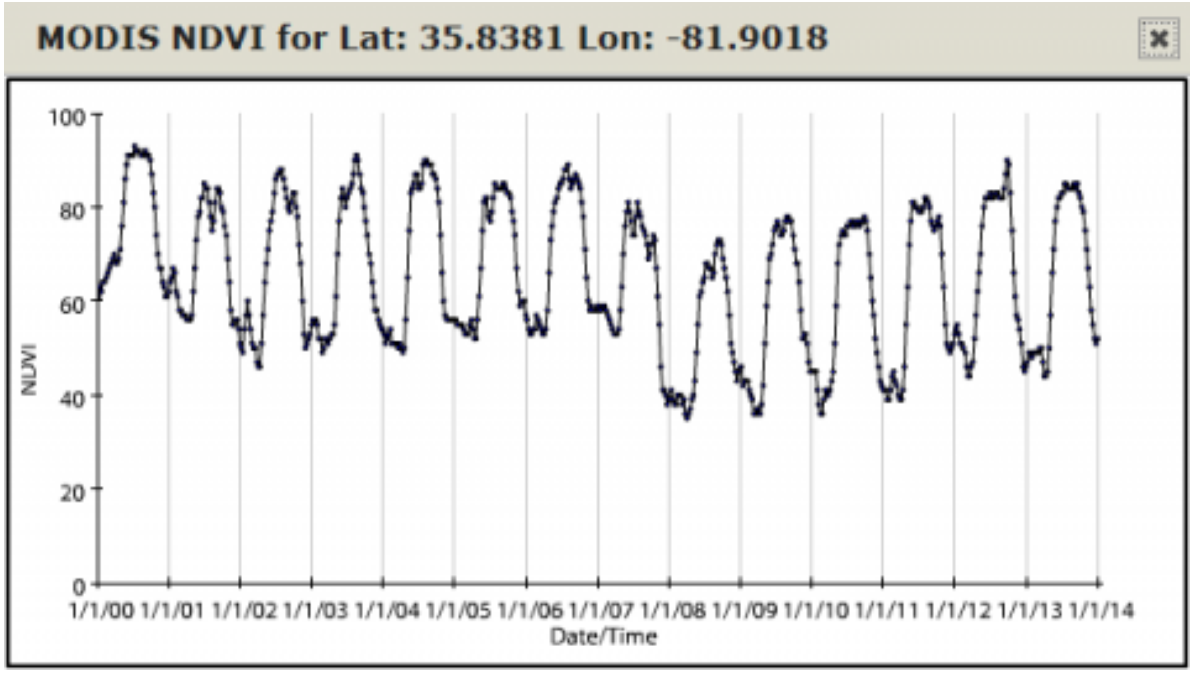
Times Series Graphing

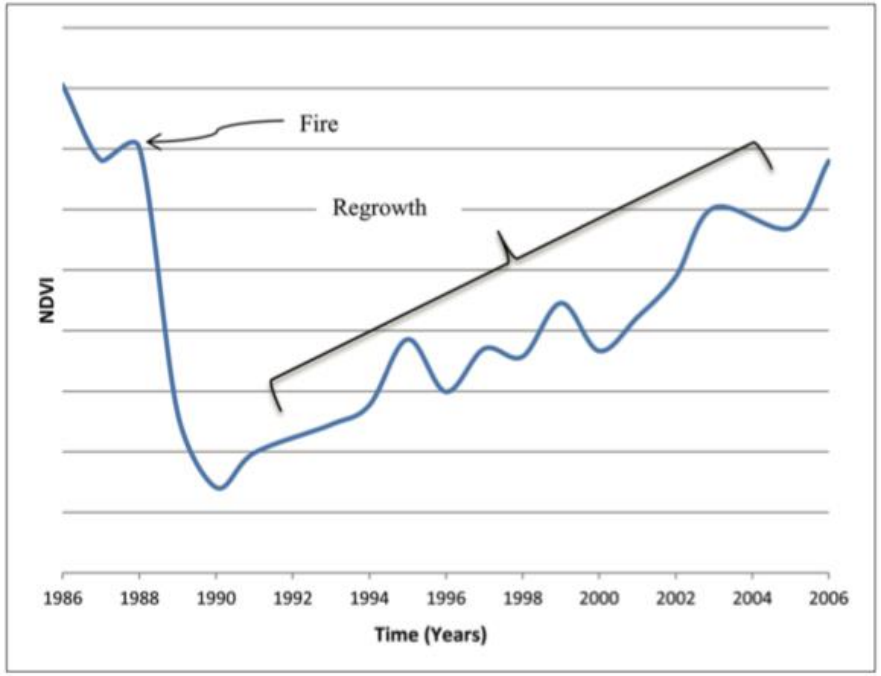
- Phenology: Monthly NDVI



What are the trends?

- Annual max., min., or mean

- Disturbances: Annual trends



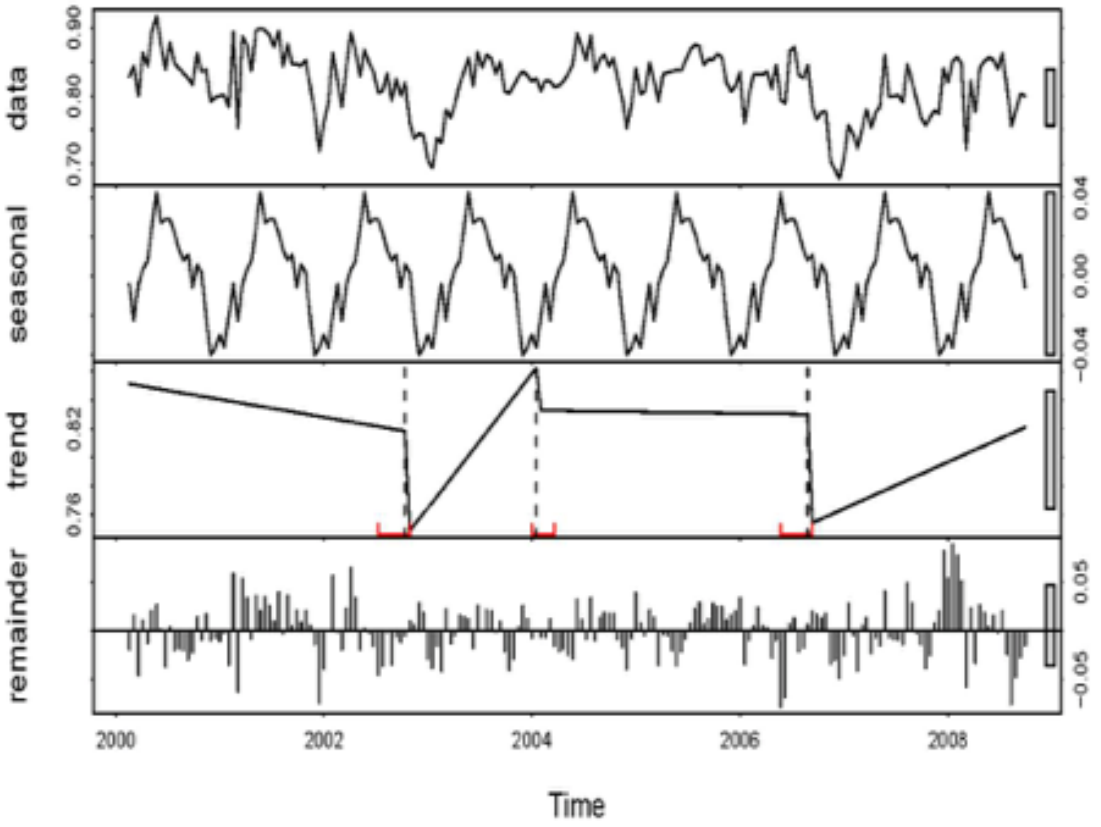
Changes in NDVI values between 1986 and 2006 for one site in Yellowstone National Park

Breaks for Additive Seasonal and Trend Method (BFAST)

- Decomposes time series satellite data into trend, seasonal and remainder components
- Allows you to pinpoint the location and timing of changes
- Available as an R package:

http://bfast.r-forge.r-project.org

NDVI time series of a pine plantation

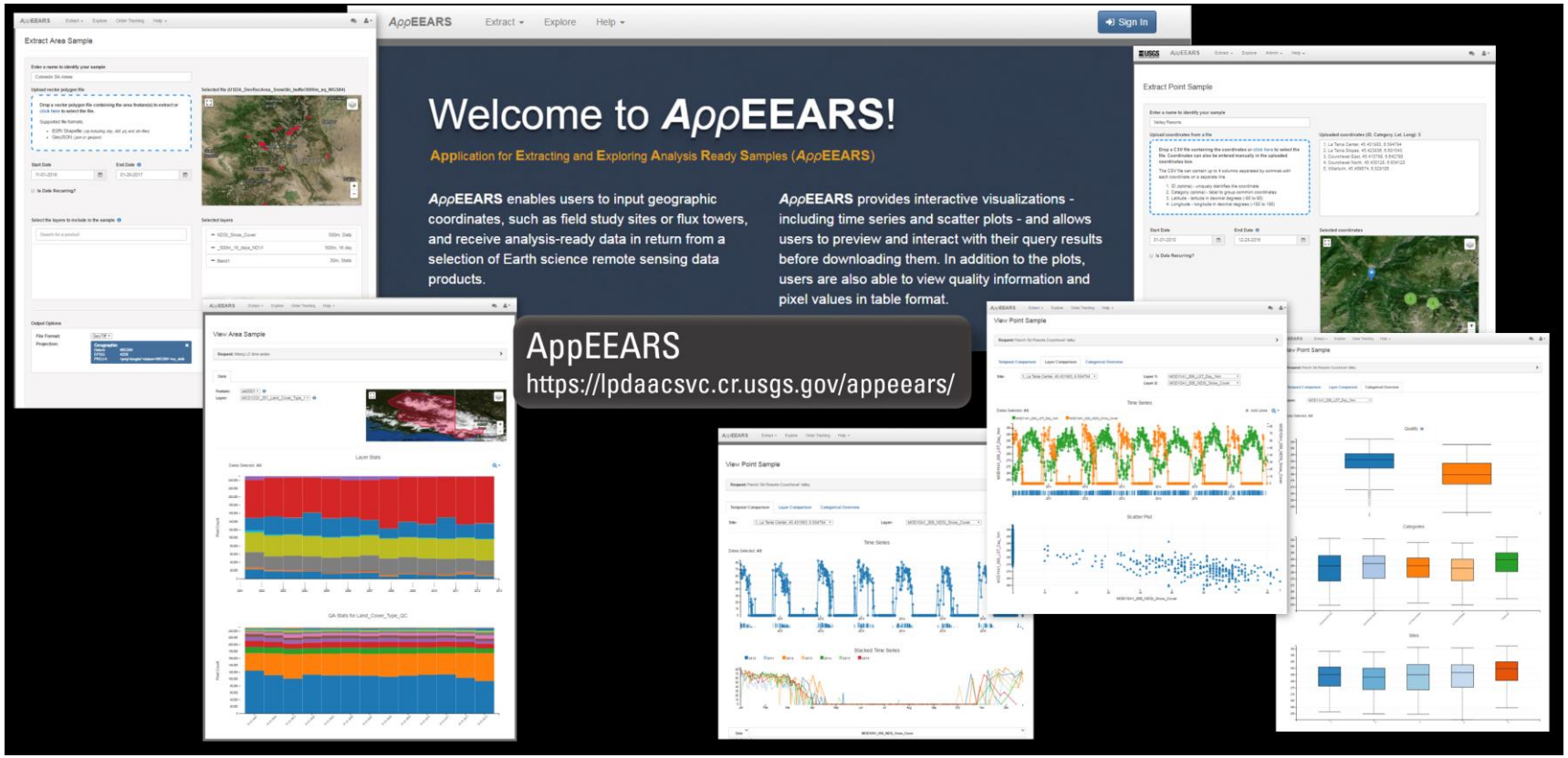


Reference: Verbesselt, J. et al. (2010). Detecting trend and seasonal changes in satellite image time series. Remote Sensing of Environment 114 (1): 106-115

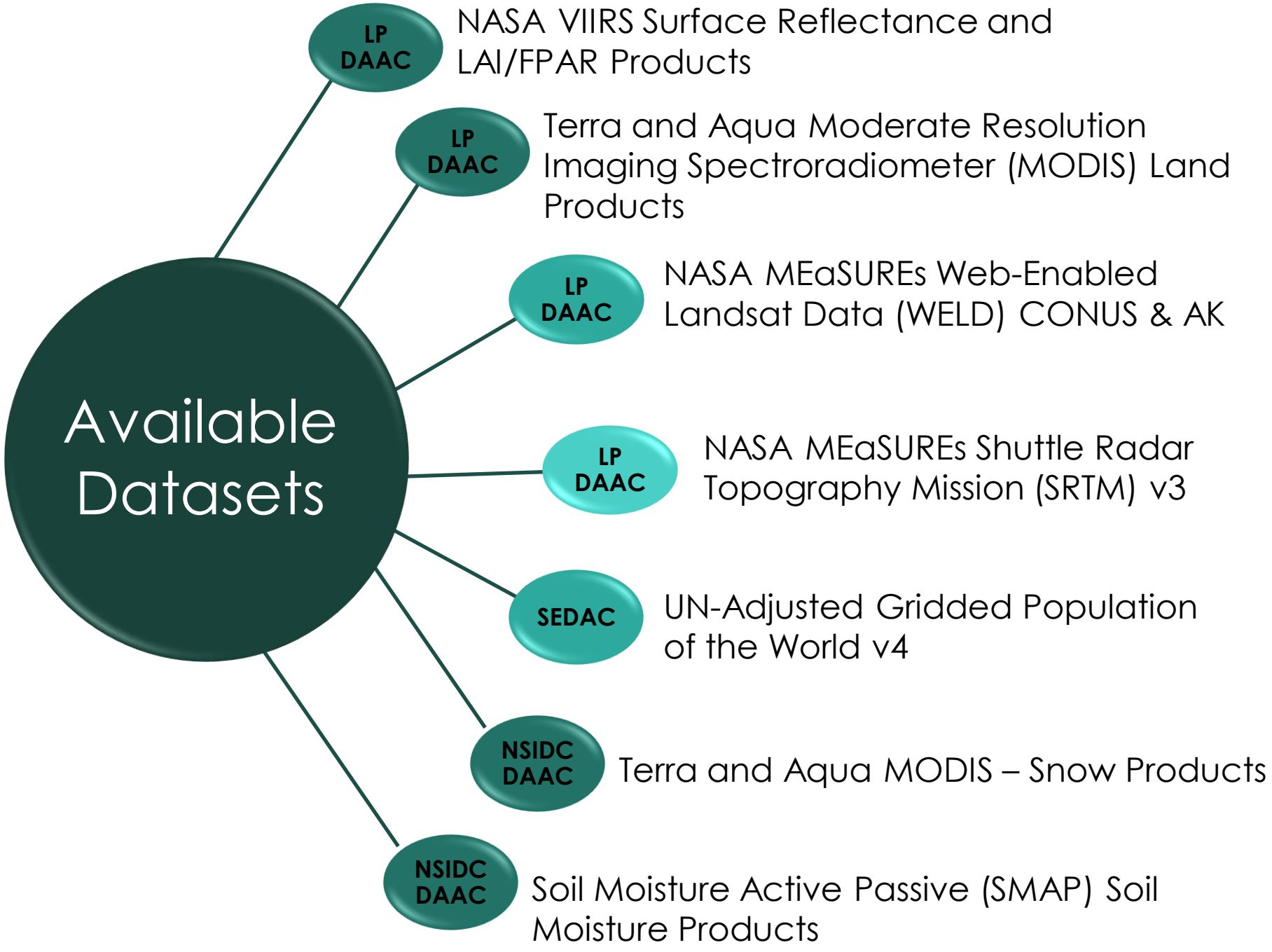
Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)

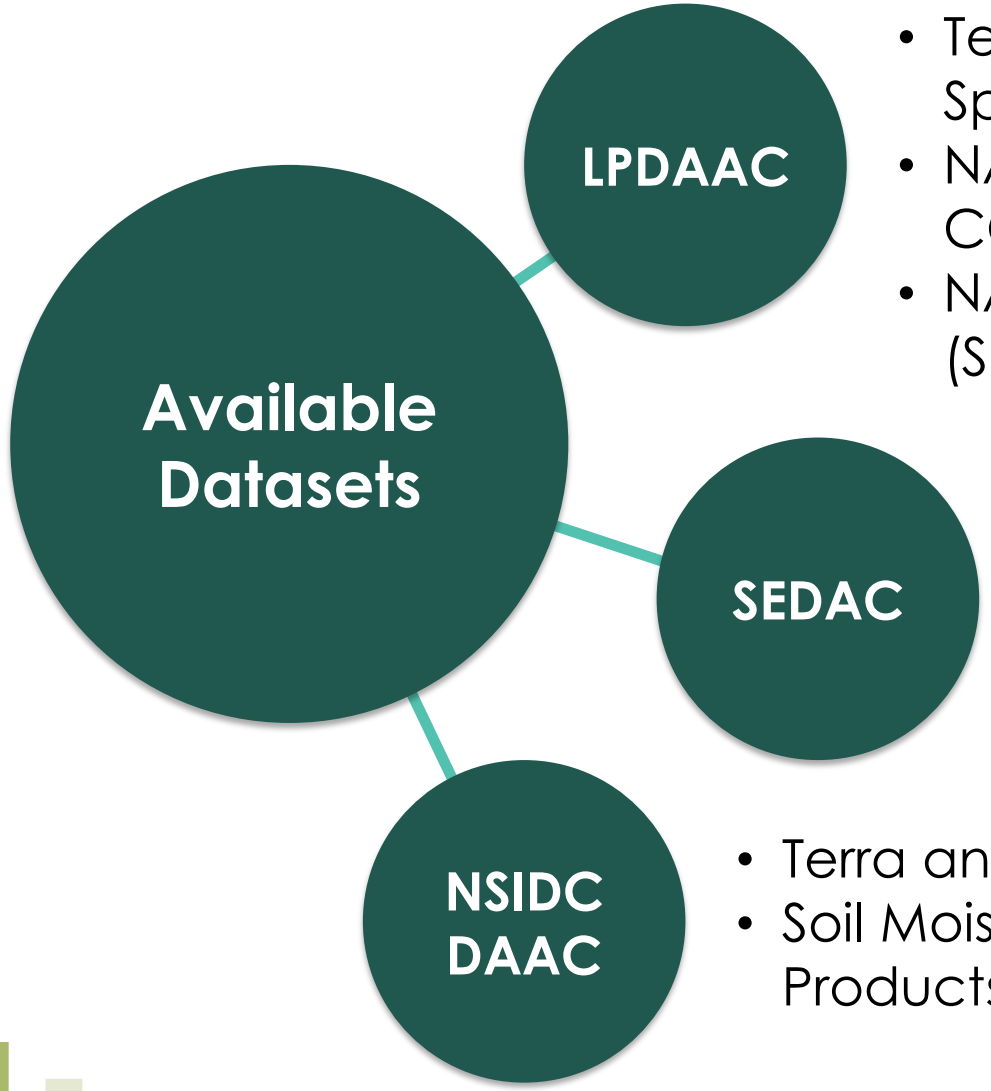
Land Processes Distributed Active Archive Center (LP DAAC)

Web interface for accessing, processing, & visualizing geospatial data products



https://lpdaacsvc.cr.usgs.gov/appeears/

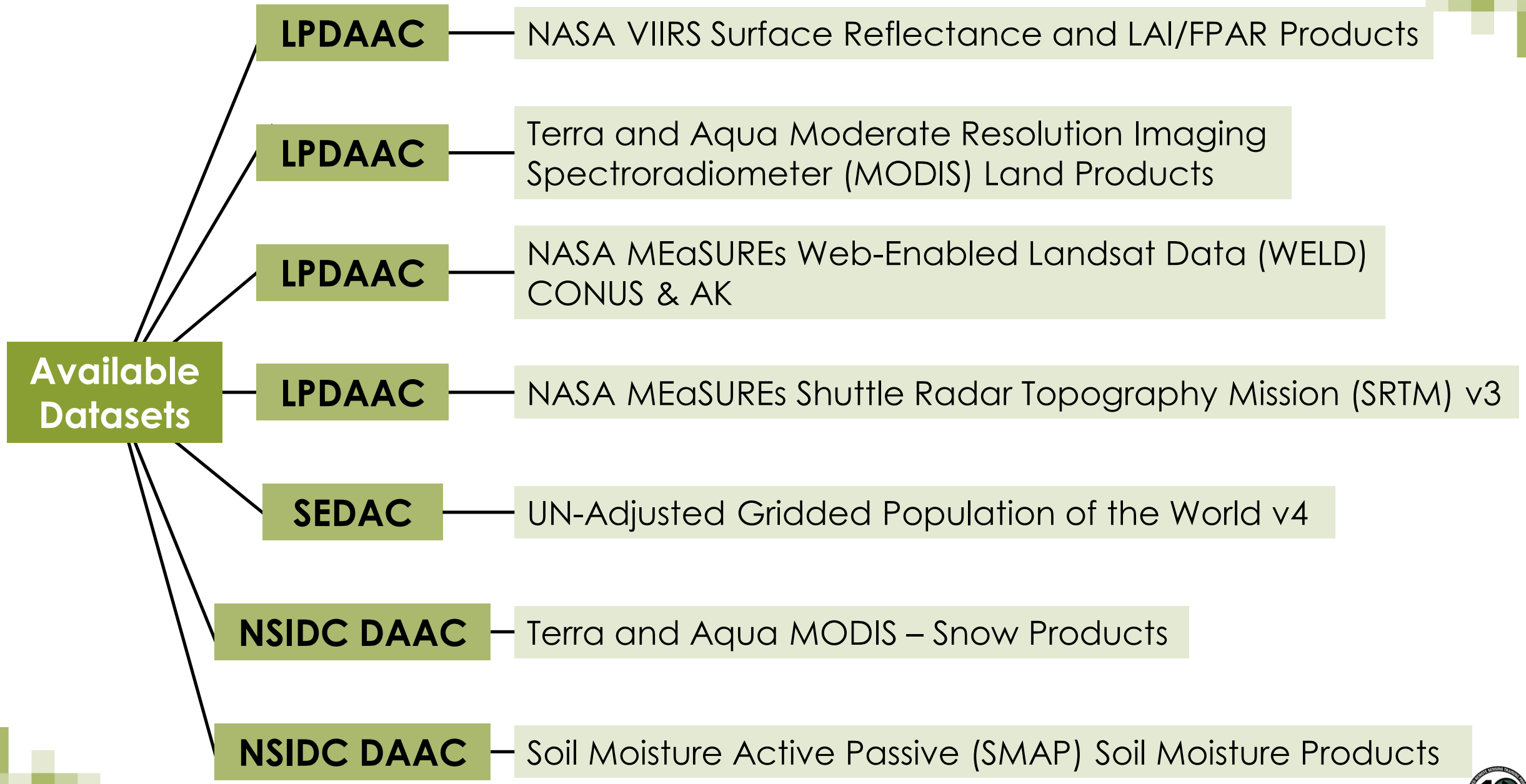

Available Datasets
LP DAAC
NASA VIIRS Surface Reflectance and LAI/FPAR Products
LP DAAC
Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Land Products
LP DAAC
NASA MEaSUREs Web-Enabled Landsat Data (WELD) CONUS & AK
LP DAAC
NASA MEaSUREs Shuttle Radar Topography Mission (SRTM) v3
SEDAC
UN-Adjusted Gridded Population of the World v4
NSIDC DAAC
Terra and Aqua MODIS – Snow Products
NSIDC DAAC
Soil Moisture Active Passive (SMAP) Soil Moisture Products



- NASA VIIRS Surface Reflectance and LAI/FPAR Products
- Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Land Products
- NASA MEaSUREs Web-Enabled Landsat Data (WELD) CONUS & AK
- NASA MEaSUREs Shuttle Radar Topography Mission (SRTM) v3

- UN-Adjusted Gridded Population of the World v4

- Terra and Aqua MODIS – Snow Products
- Soil Moisture Active Passive (SMAP) Soil Moisture Products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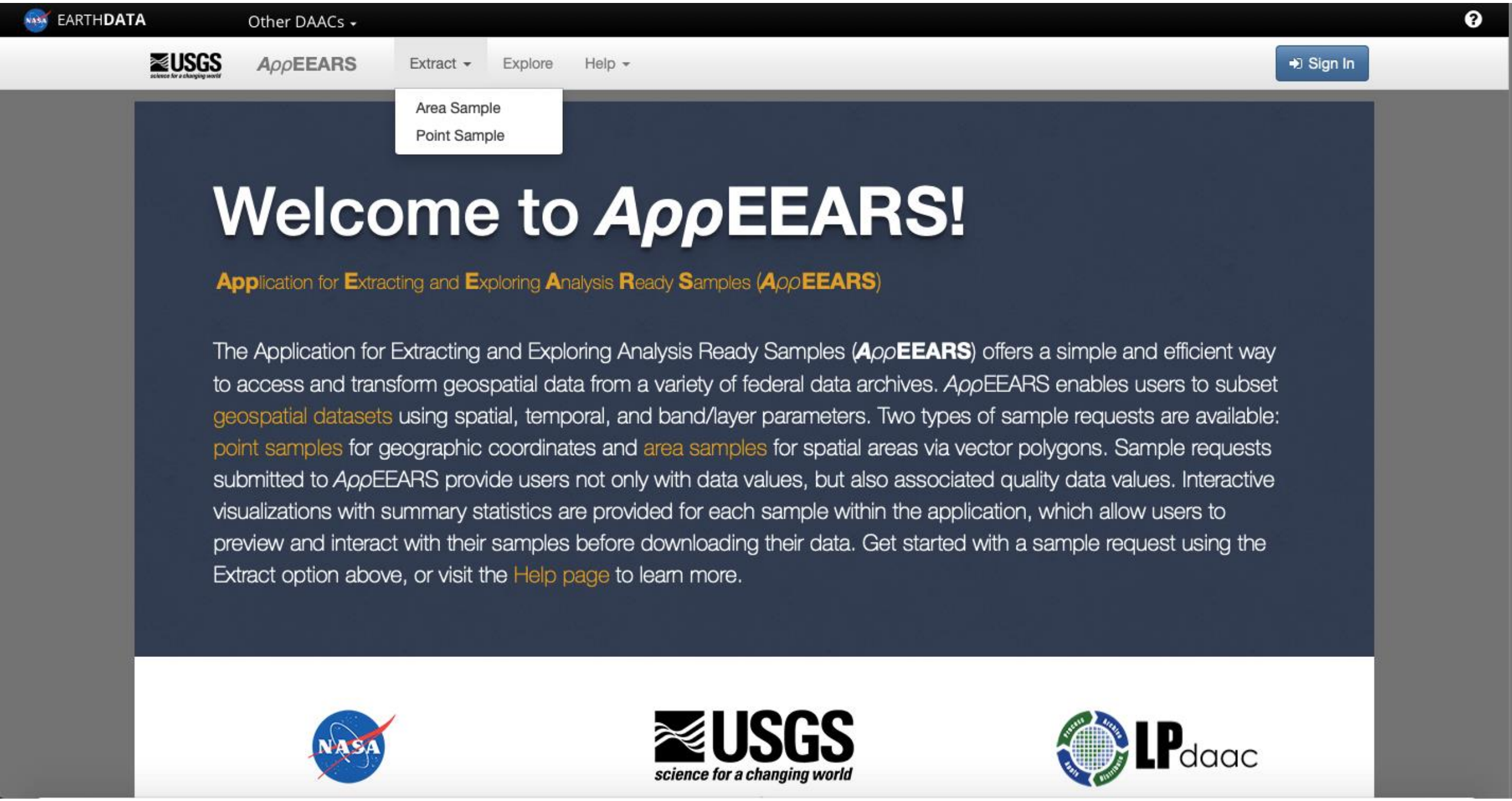
LPDAAC
NASA VIIRS Surface Reflectance and LAI/FPAR Products
LPDAAC
Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) Land Products
LPDAAC
NASA MEaSUREs Web-Enabled Landsat Data (WELD) CONUS & AK
LPDAAC
NASA MEaSUREs Shuttle Radar Topography Mission (SRTM) v3
SEDAC
UN-Adjusted Gridded Population of the World v4
NSIDC DAAC
Terra and Aqua MODIS – Snow Products
NSIDC DAAC
Soil Moisture Active Passive (SMAP) Soil Moisture Products


EARTHDATA
Other DAACs
USGS
AppEEARS
Extract
Explore
Help
Sign In
Area Sample
Point Sample
Welcome to AppEEARS!
Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)
The Application for Extracting and Exploring Analysis Ready Samples (AppEEARS) offers a simple and efficient way to access and transform geospatial data from a variety of federal data archives. AppEEARS enables users to subset geospatial datasets using spatial, temporal, and band/layer parameters. Two types of sample requests are available: point samples for geographic coordinates and area samples for spatial areas via vector polygons. Sample requests submitted to AppEEARS provide users not only with data values, but also associated quality data values. Interactive visualizations with summary statistics are provided for each sample within the application, which allow users to preview and interact with their samples before downloading their data. Get started with a sample request using the Extract option above, or visit the Help page to learn more.
NASA
USGS
science for a changing world
LPdaac

Extract Point Sample

Start a new request

Copy a previous request

- Beetle 3
- Beetle 2
- Beetle1
- point sample july
- Point Example

Upload a request file

Drop a JSON file containing the request to copy or click here to select the file.

JSON request files (*-request.json) are included in the download bundle available from any *App*EEARS requests.

Extract Point Sample

Enter a name to identify your sample

Point Sample name

Upload coordinates from a file

Drop a CSV file containing the coordinates or click here to select the file. Coordinates can also be entered manually in the uploaded coordinates box.

The CSV file can contain up to 4 columns separated by commas with each coordinate on a separate line.

1. ID *(optional)* - uniquely identifies the coordinate
2. Category *(optional)* - label to group common coordinates
3. Latitude - latitude in decimal degrees (-90 to 90)
4. Longitude - longitude in decimal degrees (-180 to 180)

Uploaded coordinates (ID, Category, Lat, Long): 0

Upload or enter the coordinates to include in the sample (e.g. US-Ha1, DBF, 42.5378, -72.1715)

Start Date

MM-DD-YYYY

End Date

MM-DD-YYYY

Is Date Recurring?

Selected coordinates

Add coordinates using the tool. View coordinate details by clicking the markers on the map.

Select the layers to include in the sample

Search for a product

Selected layers

Select the layers to include in the sample

▶ Submit ✖ Cancel

Let’s get started!!!

Contacts

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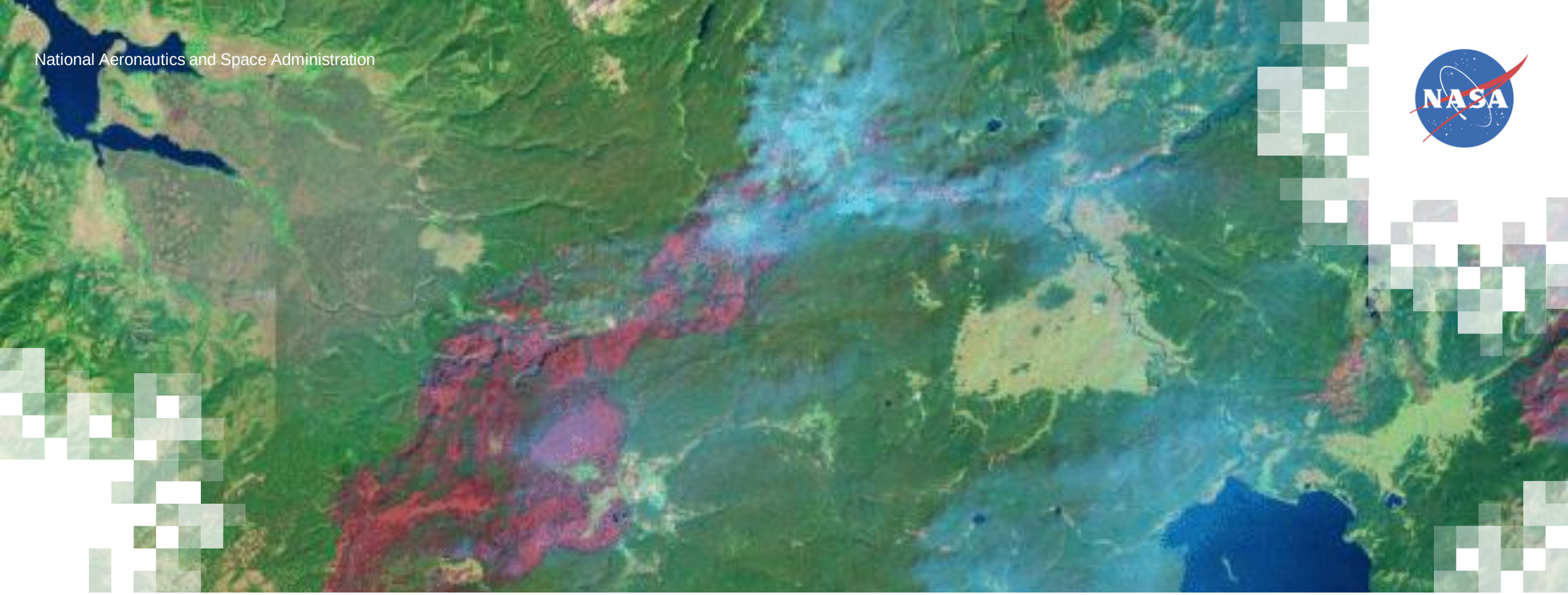
- General ARSET Inquiries
  - Ana Prados: aprados@umbc.edu
- ARSET Website:
  - http://arset.gsfc.nasa.gov



Thank You

Session 2: Thursday April 17th, Time Series Algorithms and LandTrendr

04/15/2019