Remote sensing applications for forest fire management

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SIO236 Spring 2019

Overview

- Remote sensing is used for active forest fire detection and post-fire ecological effects

- Satellite or airborne instruments

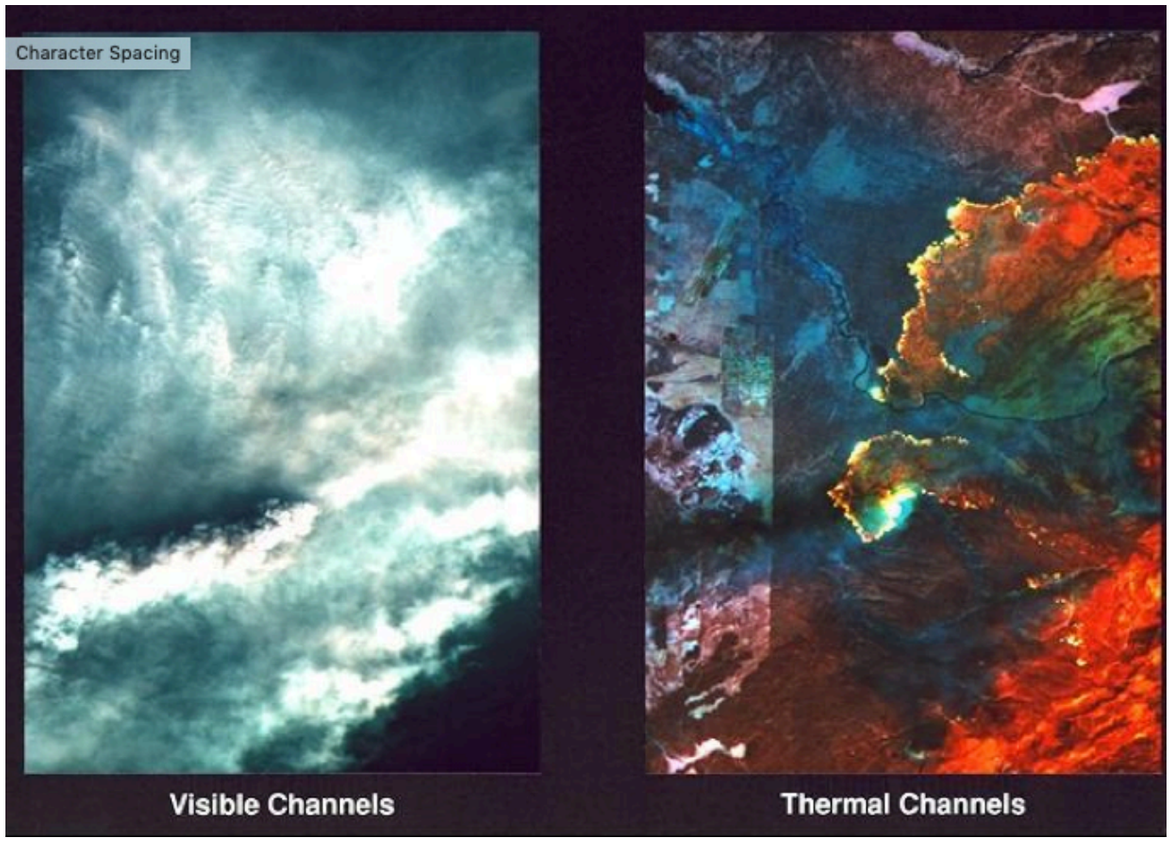
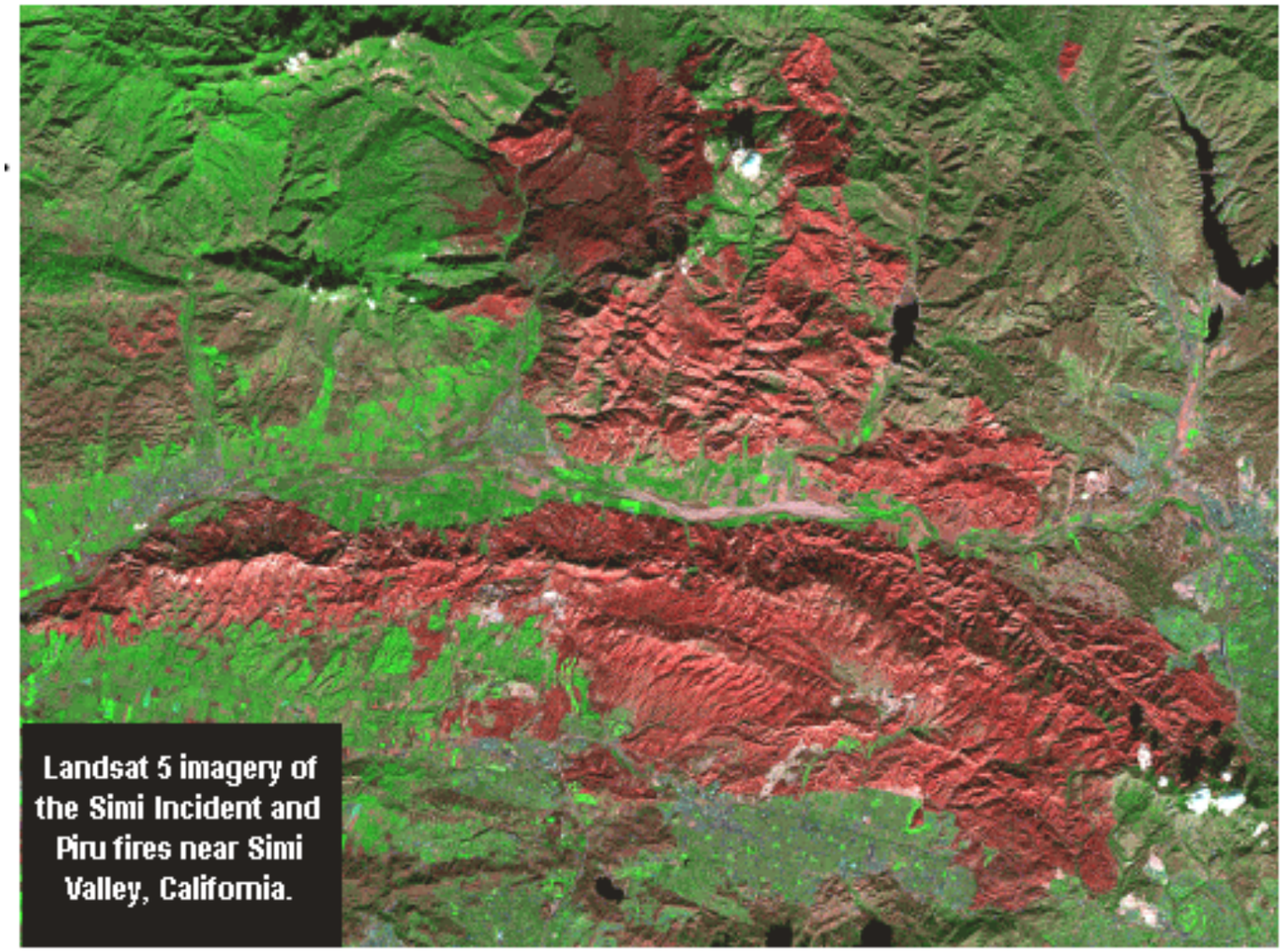


Image courtesy SIO236 slides

- Major fires usually imaged by satellites in IR bands, burn damage analyzed in the visible bands

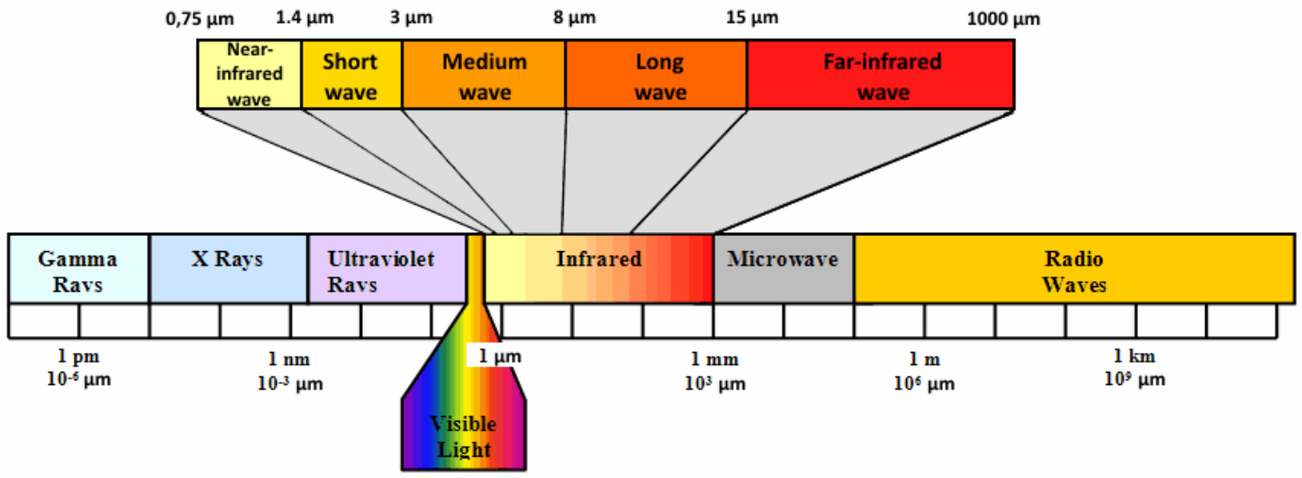
Overview

- Pre-fire conditions and forecasting fire risk
- Modeling of wildfire behavior
- Mapping the fire to plan fire fighting operations
- Modeling smoke propagation
- Analyzing historical fire regimes



Landsat 5 imagery of the Simi Incident and Piru fires near Simi Valley, California.

Fire Detection



Thermal infrared wavelengths

Combining thermal infrared bands cuts through the smoke

- Satellite is easy and inexpensive but airborne can be quicker and higher resolution
- Estimate rate and direction of spreading of a fire
- Also can assess fire potential and help with prevention

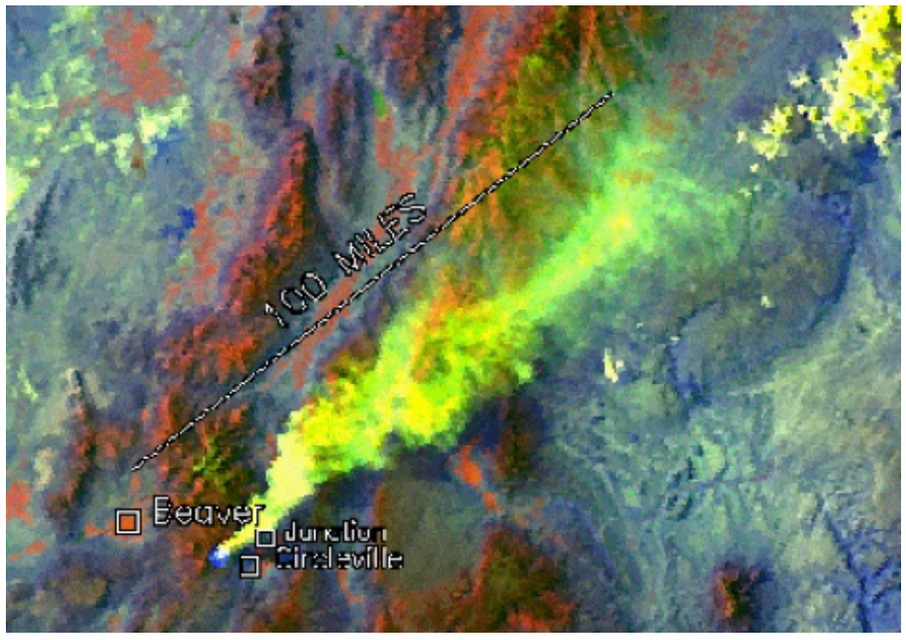
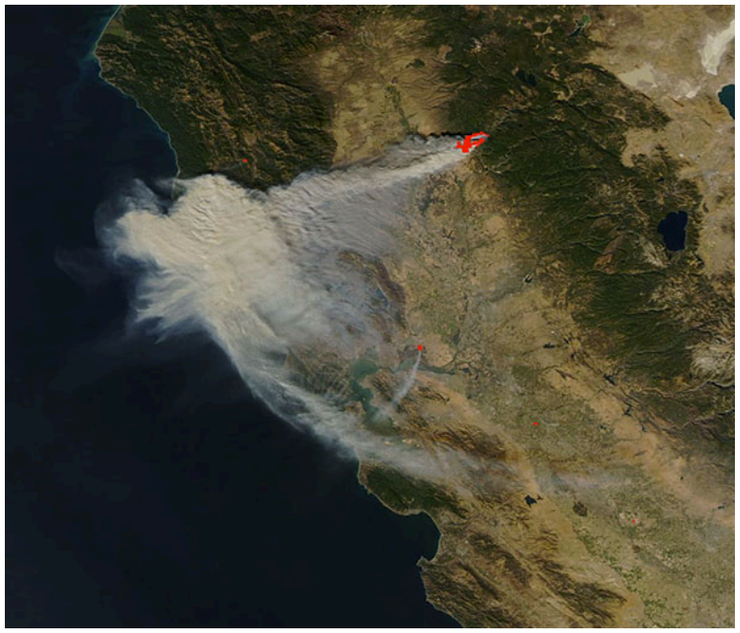


Image courtesy SIO236 slides
Smoke in yellow, fire in blue!



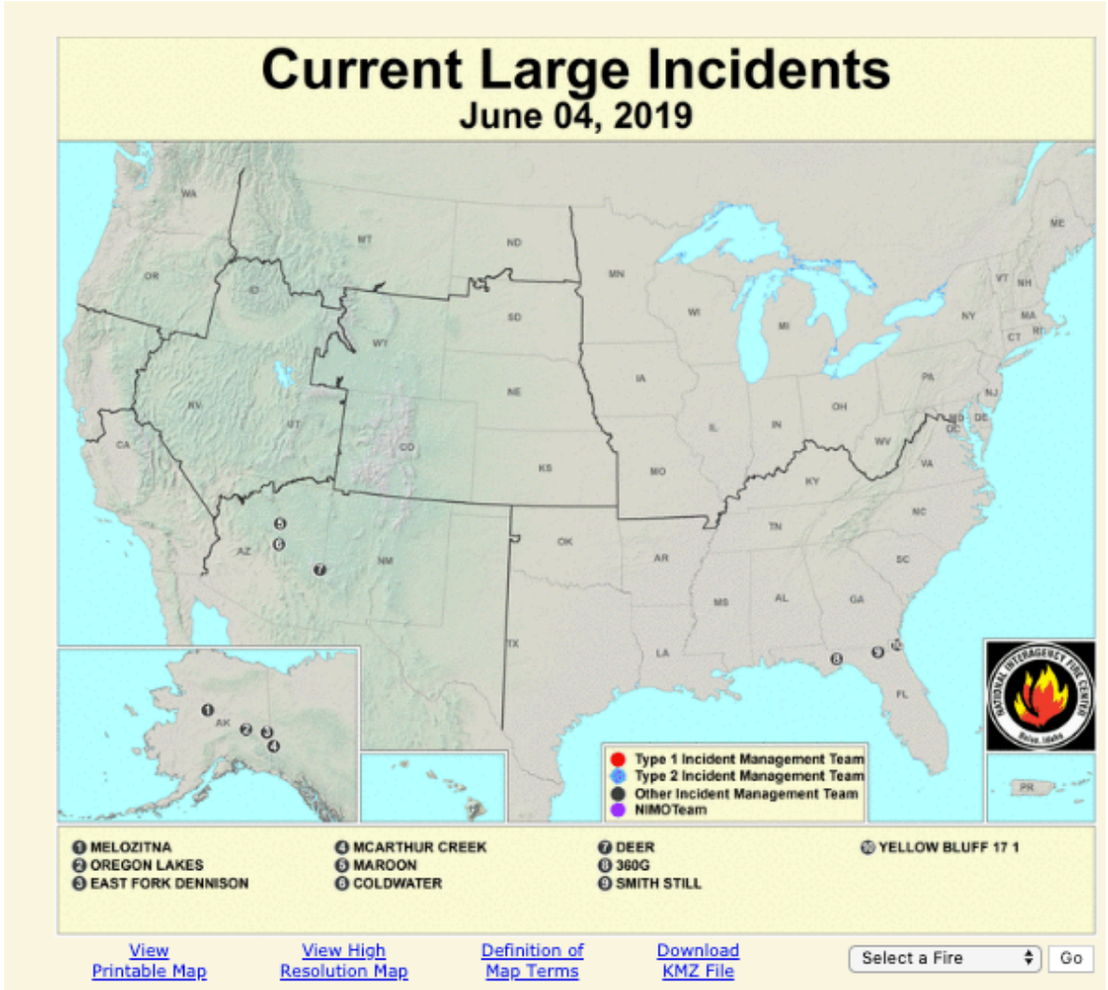
Fire Detection

- Programs such as the USDA Forest Service Active Fire Mapping Program use high temporal imaging data

- Uses MODIS (Moderate Resolution Imaging Spectroradiometer (MODIS) for continuous monitoring of spectral, temporal and structural changes

  - Rapid changes in daily surface reflectance of a time series

  - Better for mapping spatial extent of recent/current fires



Post-Fire Assessment

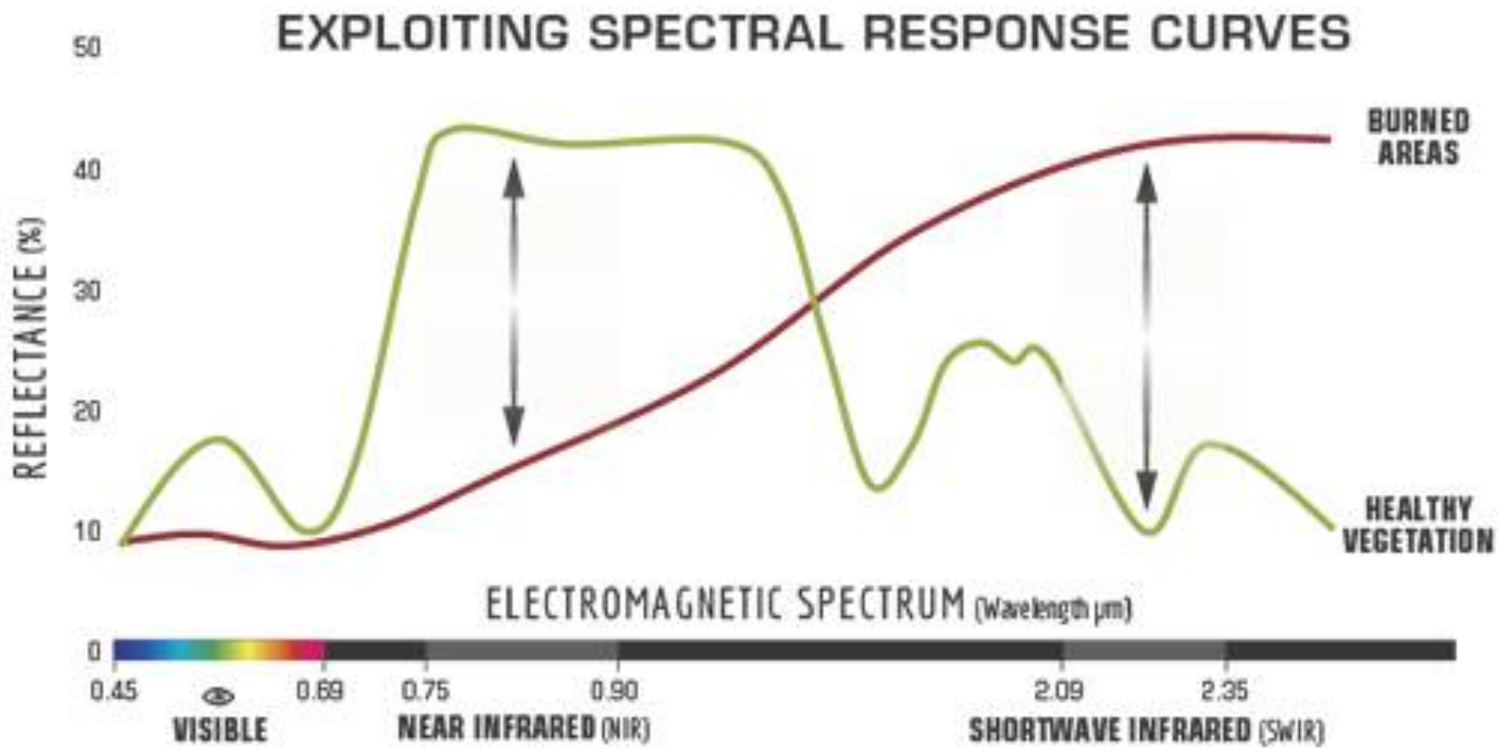
Burn severity and extent

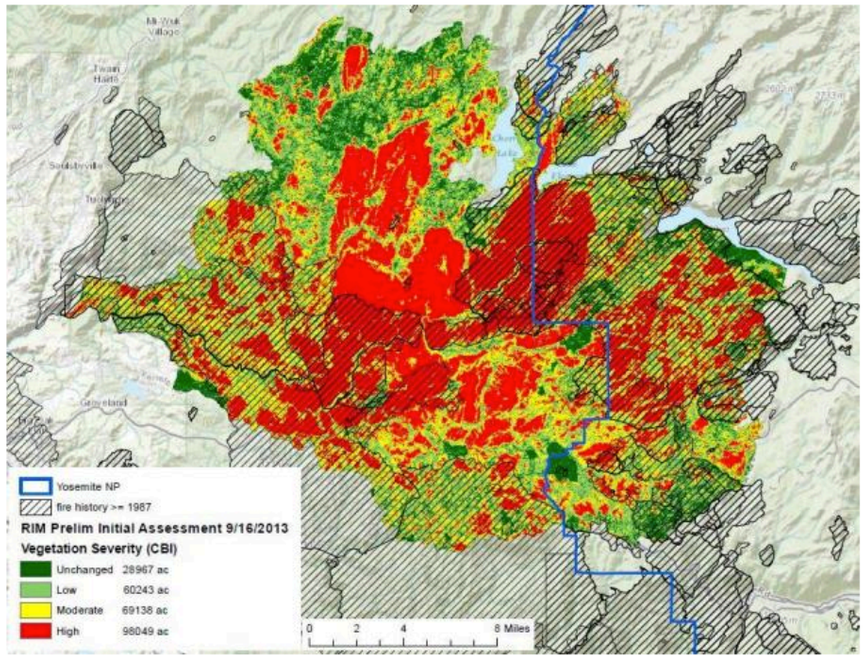
Soil conditions (moisture, etc)

Vegetation and regrowth

dNBR
(differenced Normalized Burn Ratio)

- Index to quantify burnt areas in large fire zones
- Formula combines near IR and shortwave IR wavelengths
- Healthy vegetation has high reflectance in NIR but low in SWIR
- Recently burnt areas are the opposite





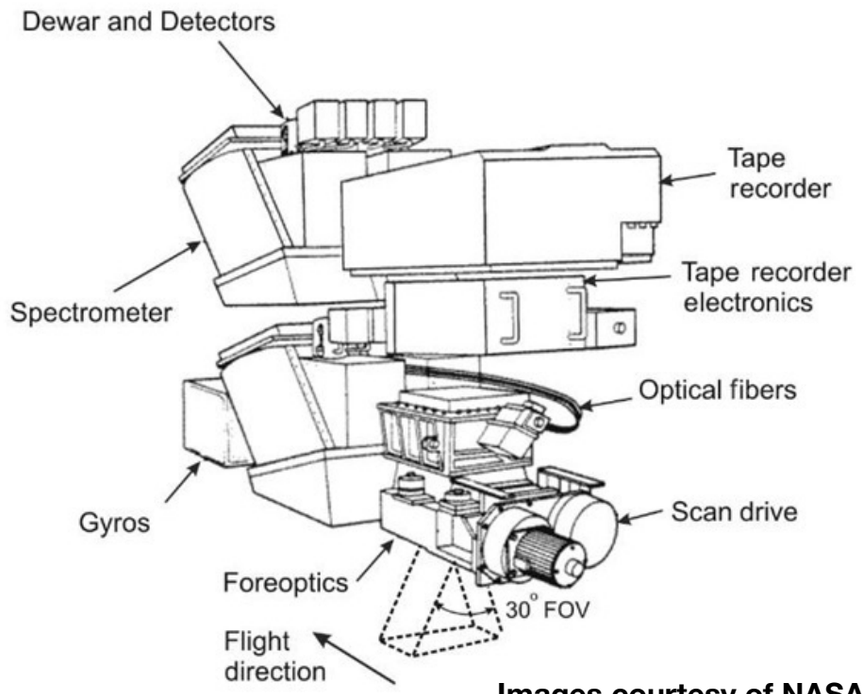
Images courtesy US Forest Service

$$NBR = \frac{NIR - SWIR}{NIR + SWIR}$$

Instruments

AVIRIS

(Airborne Visible/Infrared Imaging Spectrometer)

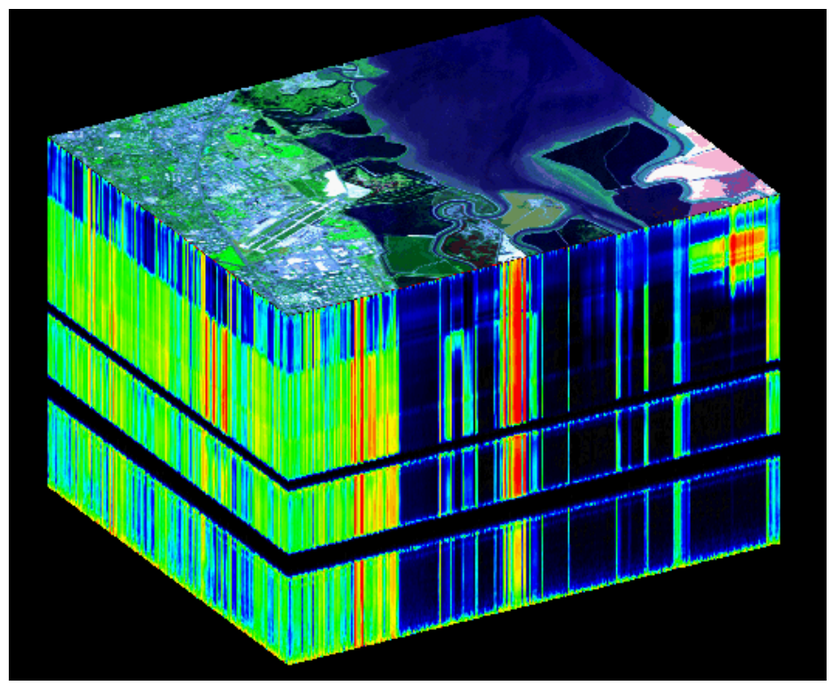


Images courtesy of NASA

- Optical sensor that produces calibrated images of spectral radiance

- Flown on four of NASA's aircrafts anywhere from 4 to 20 kilometers above ground/sea level

- AVIRIS data is predominantly used to map Earth's global processes and climate change



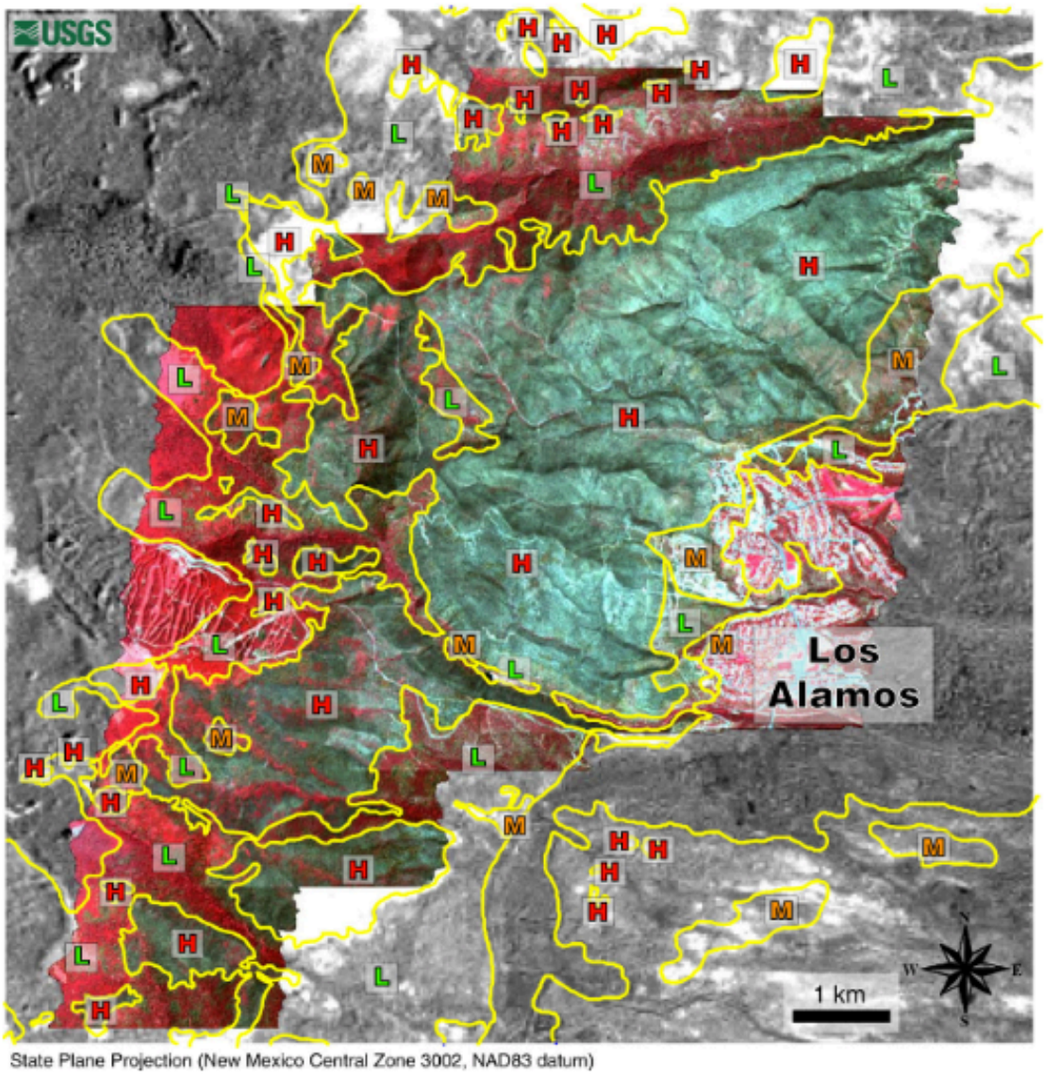
Landsat ETM+

Image courtesy of NASA

- Enhanced Thematic Mapper Plus sensor is flown on Landsat 7
  - Advanced, multispectral scanner (MSS) with improvements made from previous Landsat instruments
    - Higher spatial and radiometric resolution
    - Finer spectral bands
    - 7 bands instead of 4, acquired simultaneously
- Band 6 senses thermal infrared radiation, or heat
  - Only *night* scenes can be acquired in Band 6

Case Studies

Characterization of post-fire surface cover, soils, and burn severity at the Cerro Grande Fire, New Mexico, using hyperspectral and multispectral remote sensing (Kokaly et al., 2007)



- Analyzed high spatial resolution (2.4 meter pixel sizes) AVIRIS data and Landsat ETM+ data

- AVIRIS mapped post-fire surface cover into 10 classes (ash, soils, trees, vegetation, etc.)

- Created a surface cover map using Landsat ETM+

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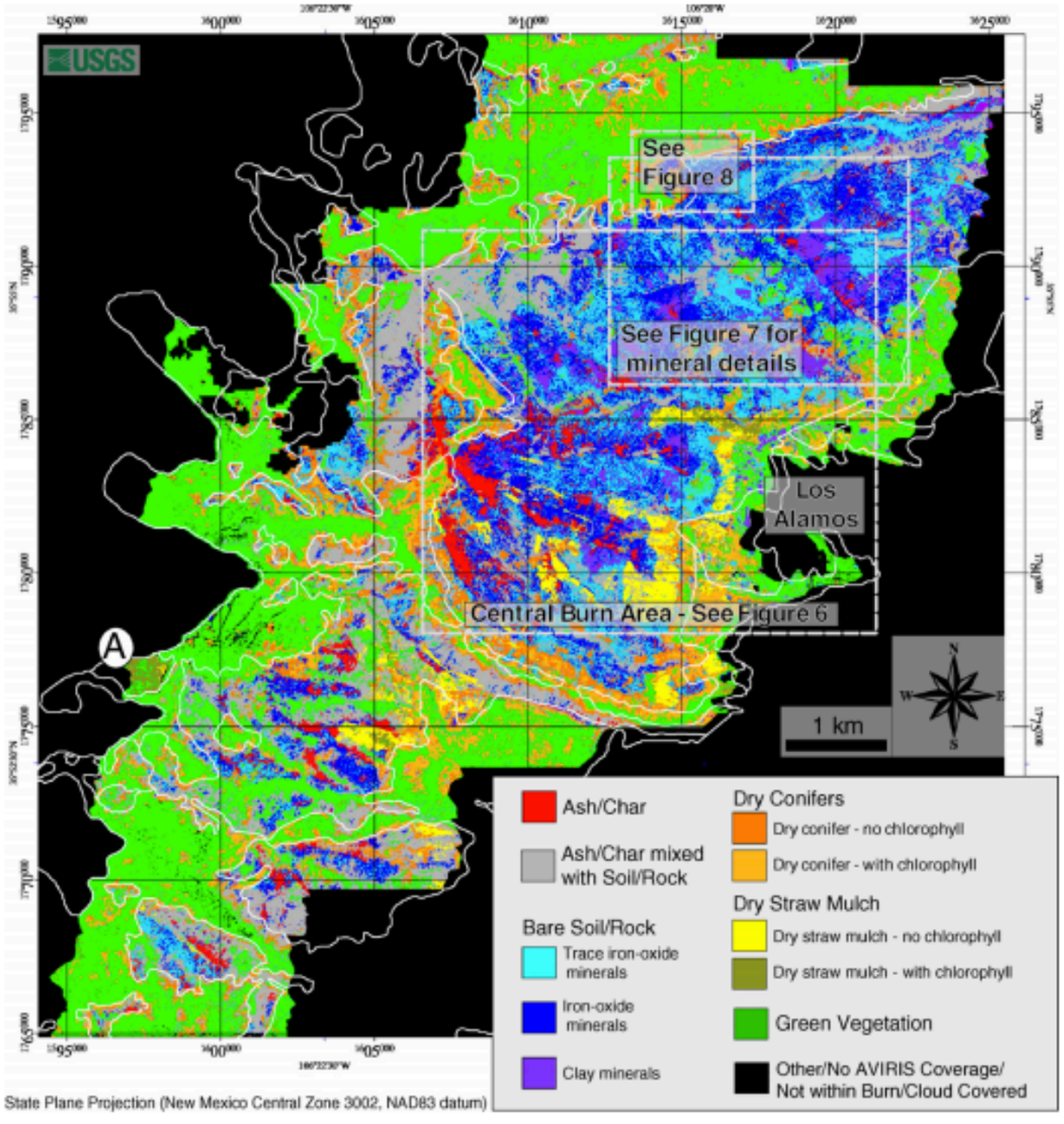
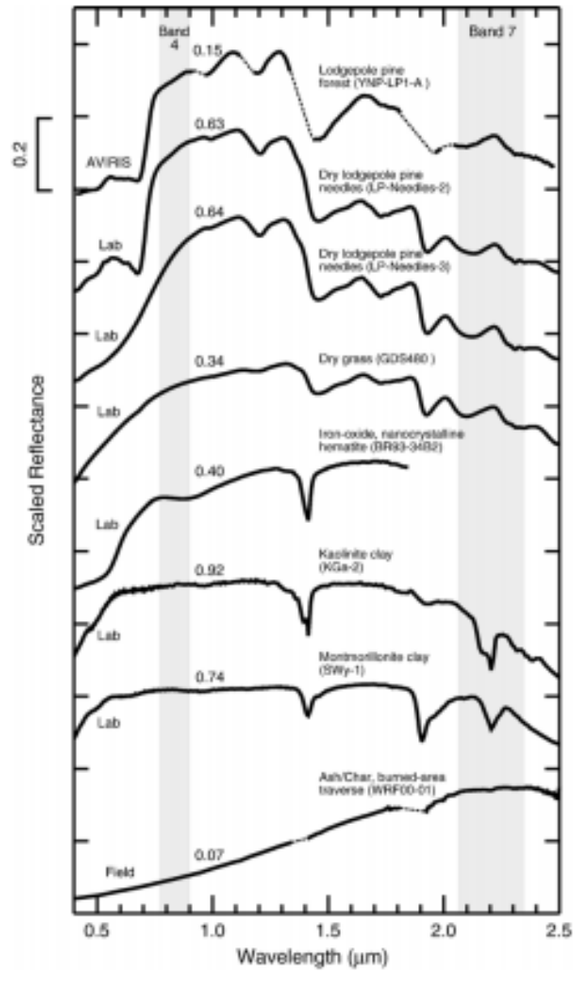


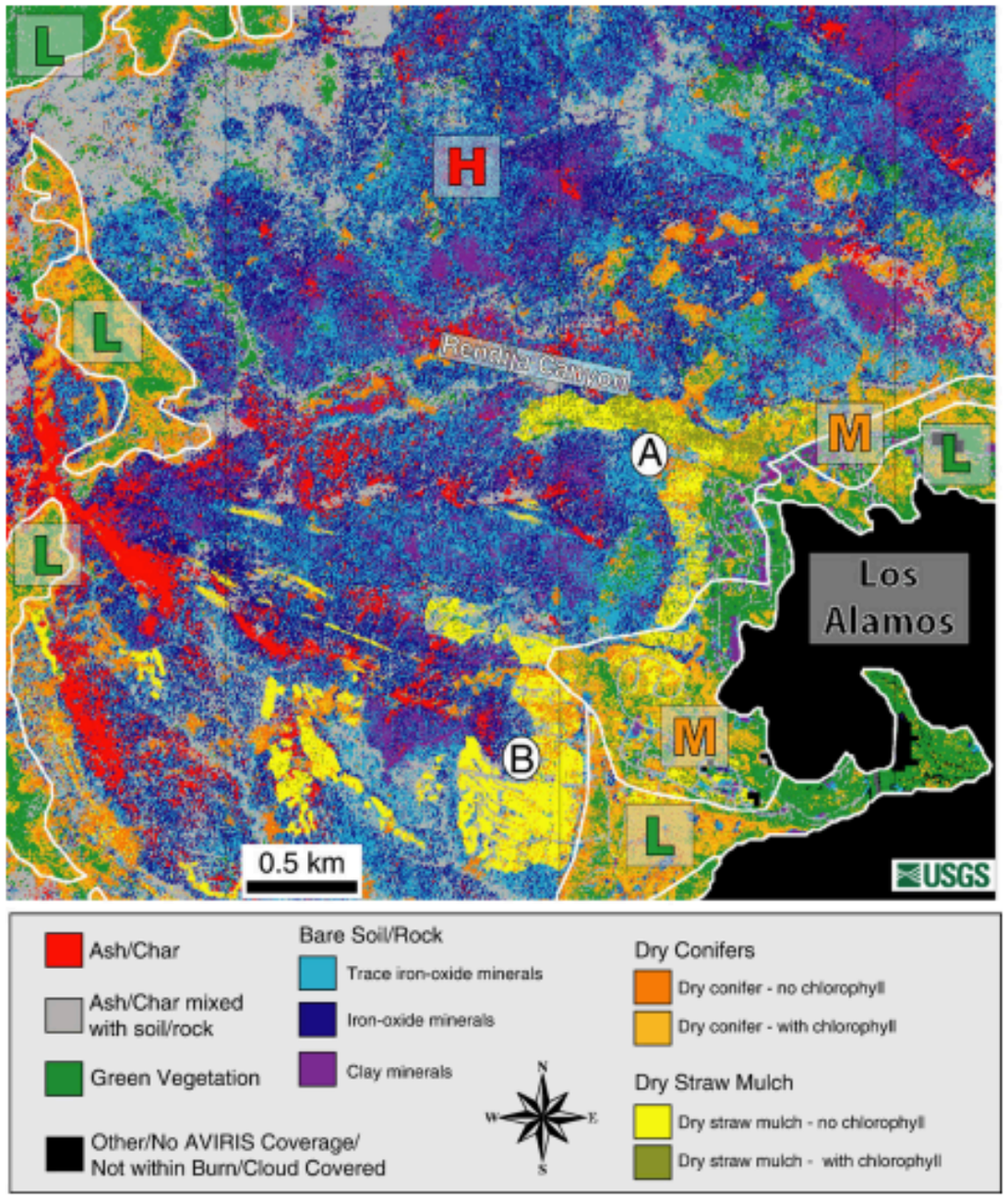
Landsat classification of surface materials

Lab measurements are used for reference



Characterization of post-fire surface cover, soils, and burn severity at the Cerro Grande Fire, New Mexico, using hyperspectral and multispectral remote sensing (Kokaly et al., 2007)

- Found that Landsat overestimated the surface cover of the dry conifer and ash classes and underestimated soil and green vegetation compared to AVIRIS
- The Landsat dNBR maps had low agreement with the AVIRIS class of scorched trees
- Overall the different data types complemented each other well
    - AVIRIS for surface cover, Landsat for burn severity



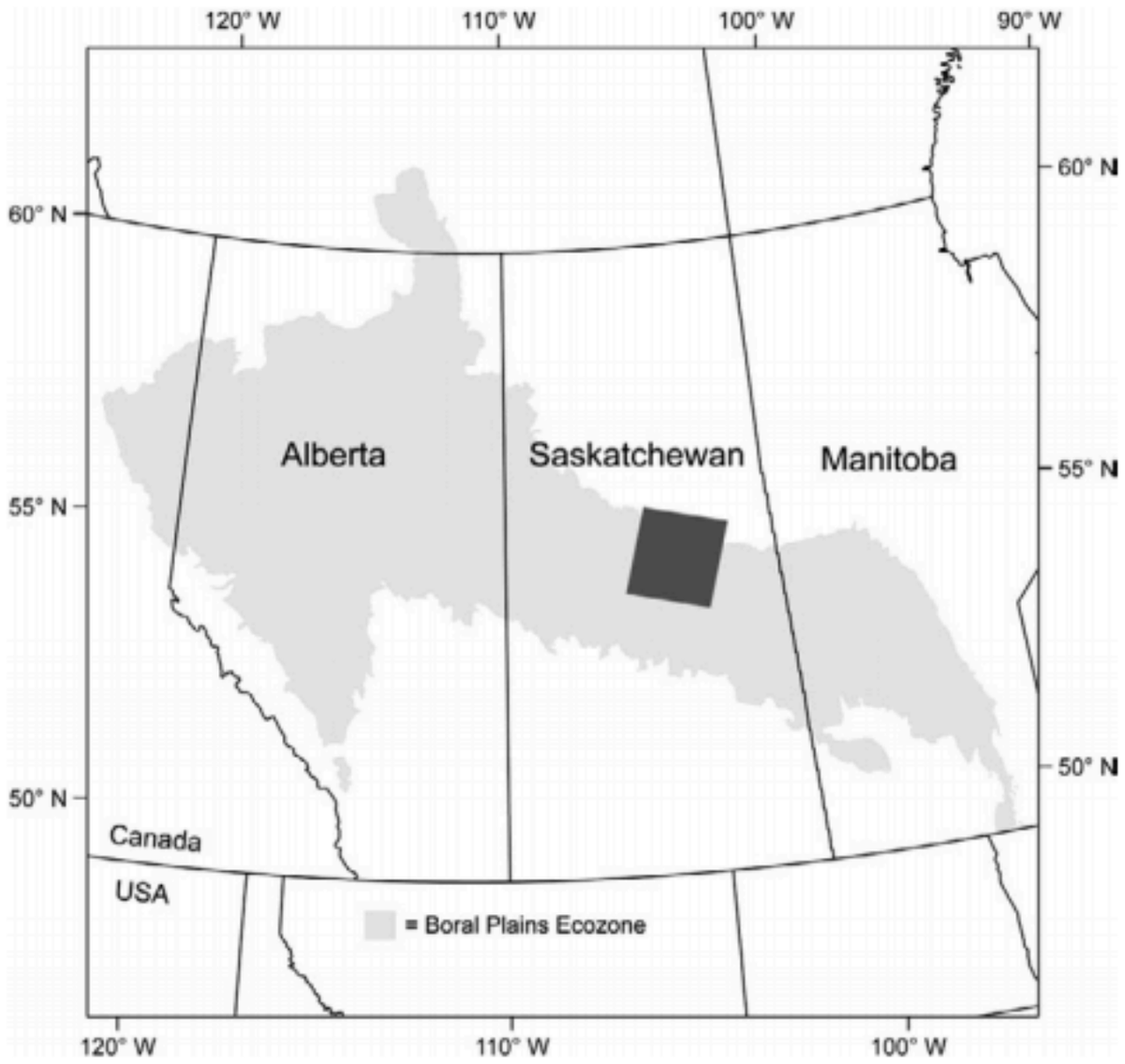
AVIRIS-derived map

Mapping wildfire and clearcut harvest disturbances in boreal forests with Landsat time series data (Schroeder et al., 2011)

- Timing and magnitude of forest disturbance for estimating terrestrial carbon balance following a fire

- Distinguish the type/cause of forest disturbance (wildfire, timber harvesting, etc)

- Aimed to get an improved understanding of the spectral properties of the two types of forest disturbances to better separate the two



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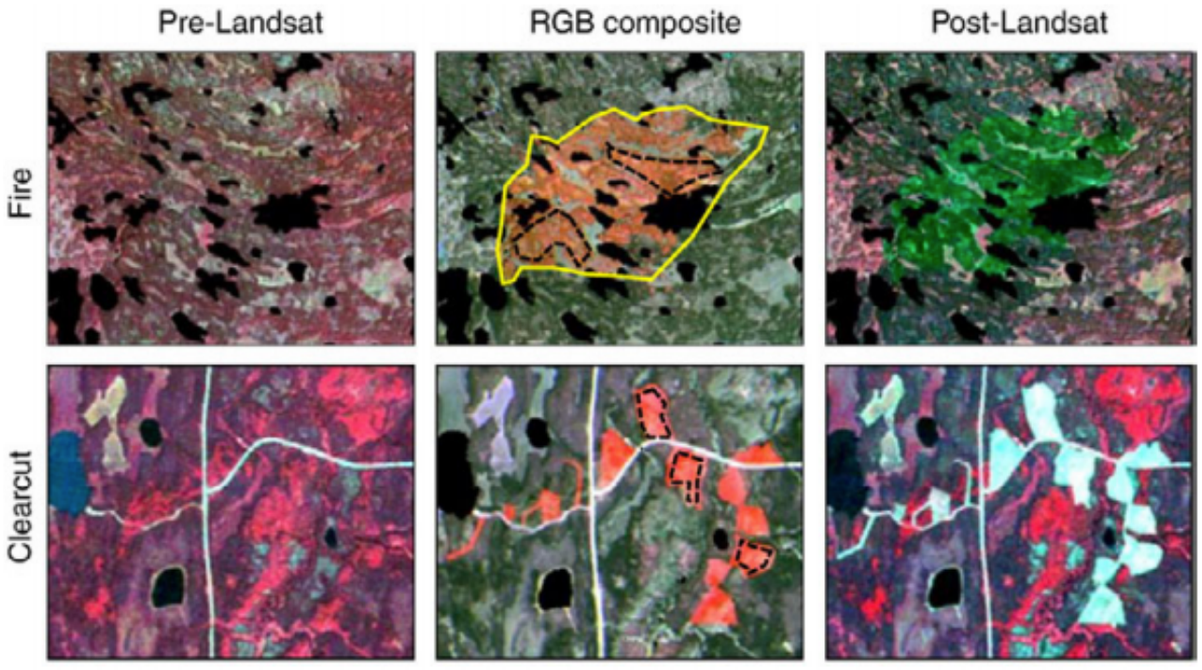
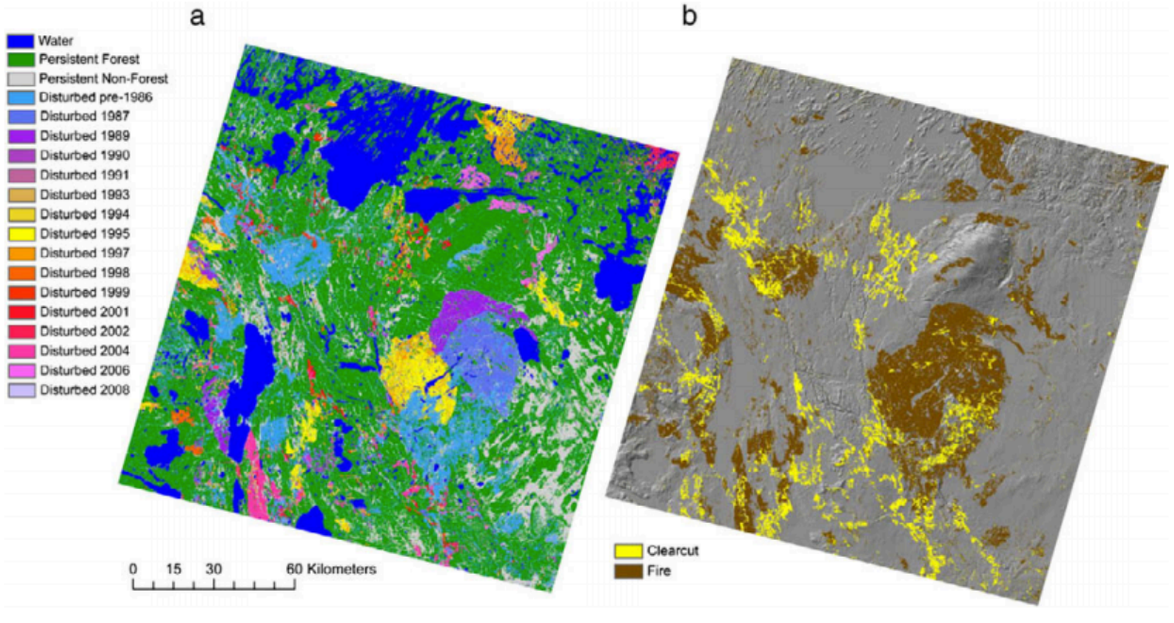




- Six Landsat bands to identify features such as soil content and vegetation cover to distinguish

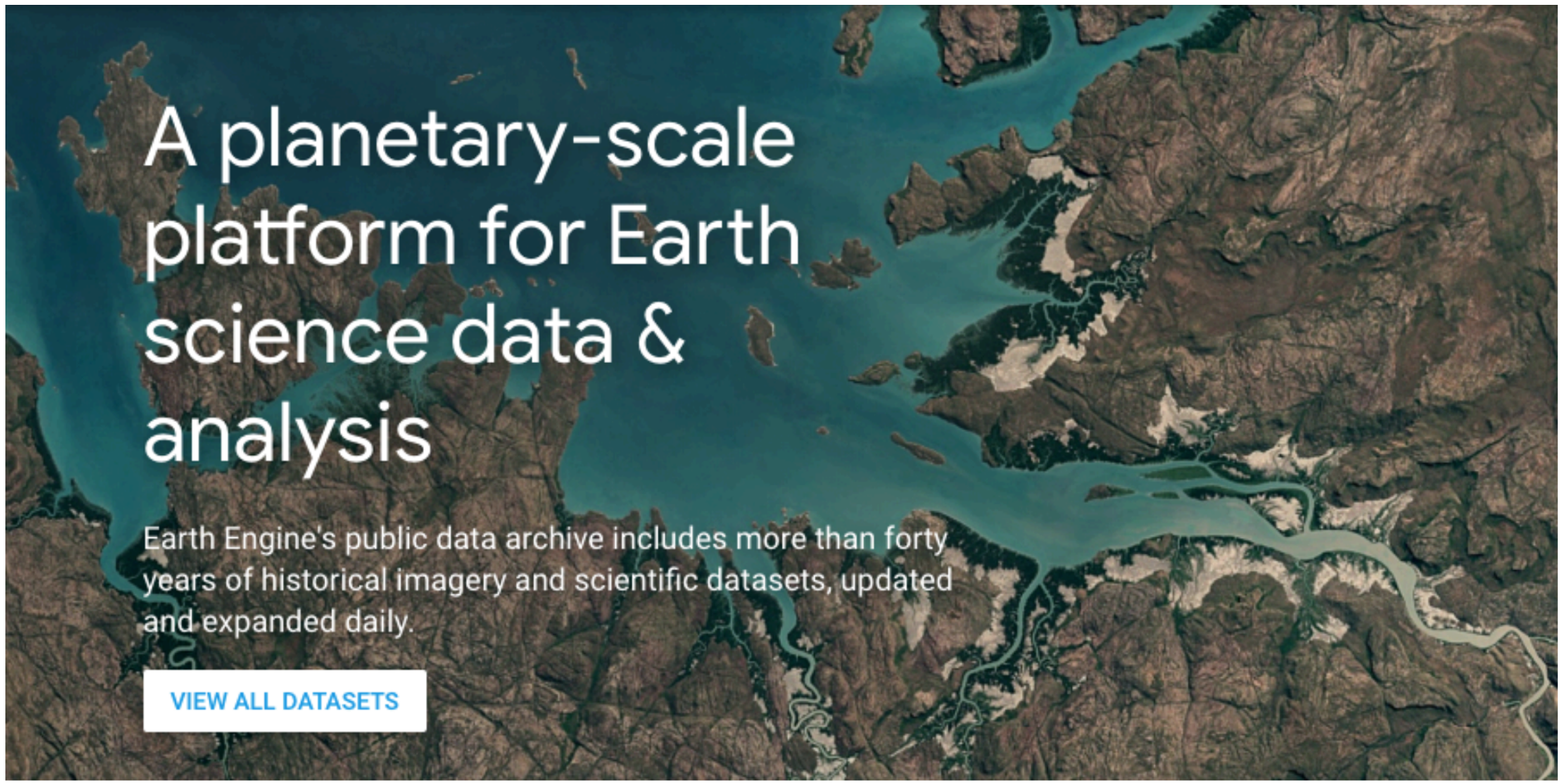
- Used an existing reference map of historical forest disturbances (year and cause) for comparison

- Results shows that the spectral data from short-wave infrared Landsat Band 5 was the most effective → $0.6 - 0.7\mu m$

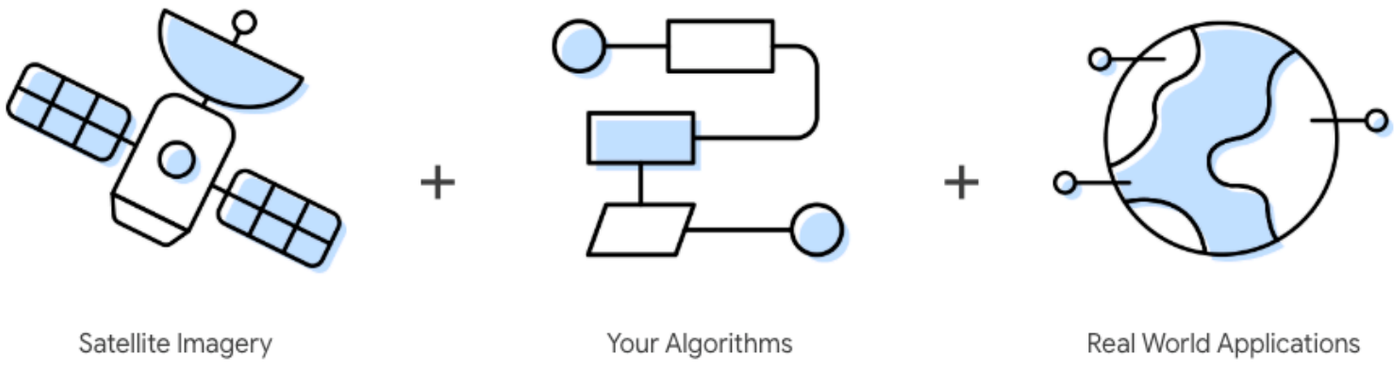
Can be classified up to 3-4 years following the disturbance

Data

Google Earth Engine



Data is instant and free!

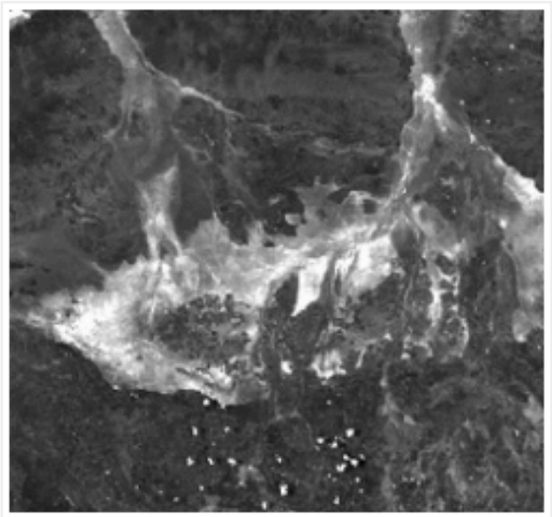


Google Earth Engine

Landsat 7 Collection 1 Tier 1 8-Day BAI Composite

NBRT (Normalized Burn Ratio Thermal)
Generated from NIR, Mid-IR and thermal bands

BAI (Burn Area Index)
Generated from Red and Near-IR bands



Dataset Provider

Google

Earth Engine Snippet

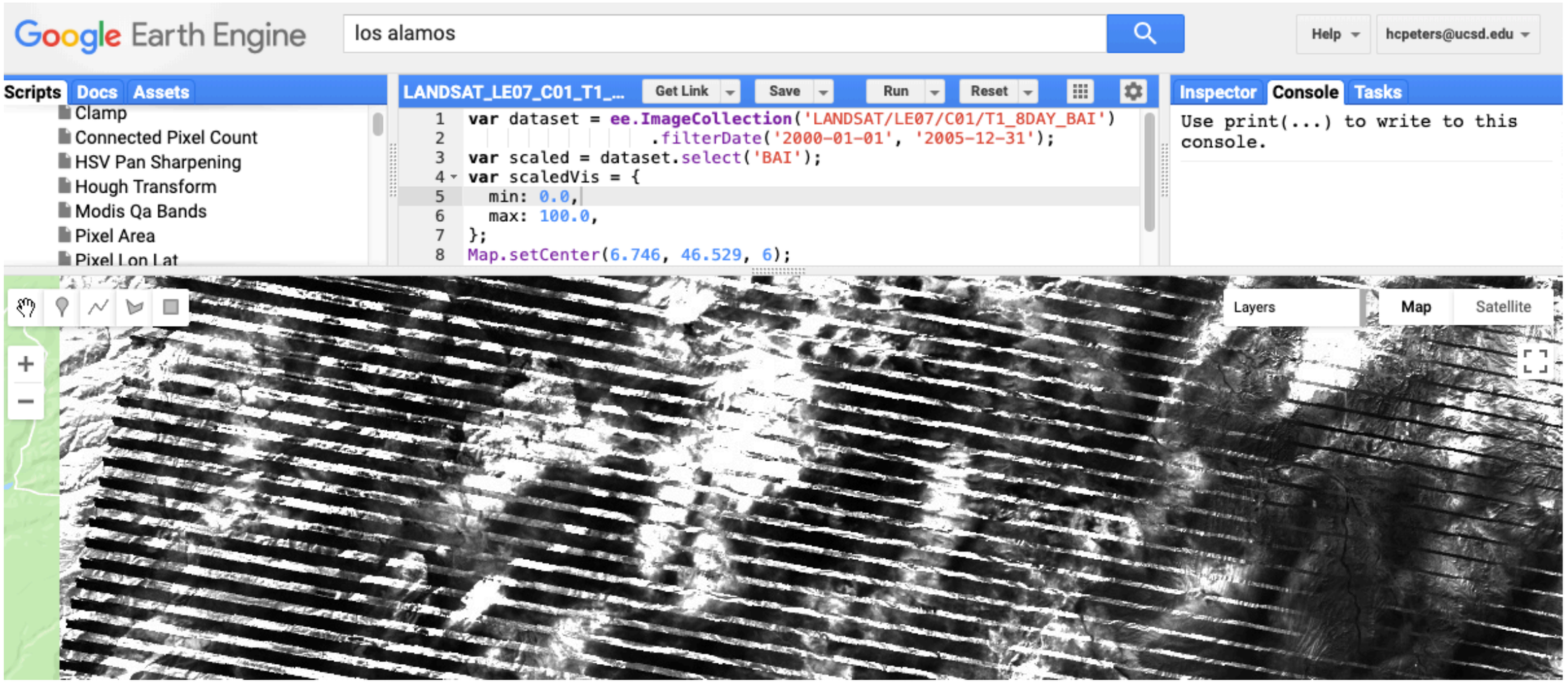
```
ee.ImageCollection("LANDSAT/LE07/C01/T1_8DAY_BAI")
```

Tags

bai

```
var dataset = ee.ImageCollection('LANDSAT/LE07/C01/T1_8DAY_NBRT')
                  .filterDate('1999-01-01', '2002-12-31');
var colorized = dataset.select('NBRT');
var colorizedVis = {
  min: 0.9,
  max: 1.0,
  palette: ['000000', 'FFFFFF'],
};
Map.setCenter(6.746, 46.529, 6);
Map.addLayer(colorized, colorizedVis, 'Colorized');
```

Google Earth Engine



https://earthengine.google.com/

Thank you!