National Aeronautics and Space Administration

NASA Satellite Observations and Tools for Fire and Smoke Monitoring

Fire Detections, Using NASA FIRMS, & A Case Study

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Learning Objectives

By the end of this training, you will be able to:

- Understand how active fire detections are made

- Understand the difference in types of satellites that detect active fires

- Evaluate active fire detection data sources using FIRMS to build a wildfire narrative

- Apply strategies using FIRMS to identify factors that can impact satellite-based wildfire detection, resulting in a 'missed' wildfire, and plan for when data may become available

- Use FIRMS to monitor a particular area of interest by accessing active fire data from the archive of available data

- Shown where on FIRMS …

  - Web services are to create an email alert for the area

  - Ingesting the resulting fire alerts into a GIS platform to enable evaluation

- Case study of a recent wildland fire

How to Ask Questions

- Please hold your questions to the end of the section
  - I will answer those when I change direction
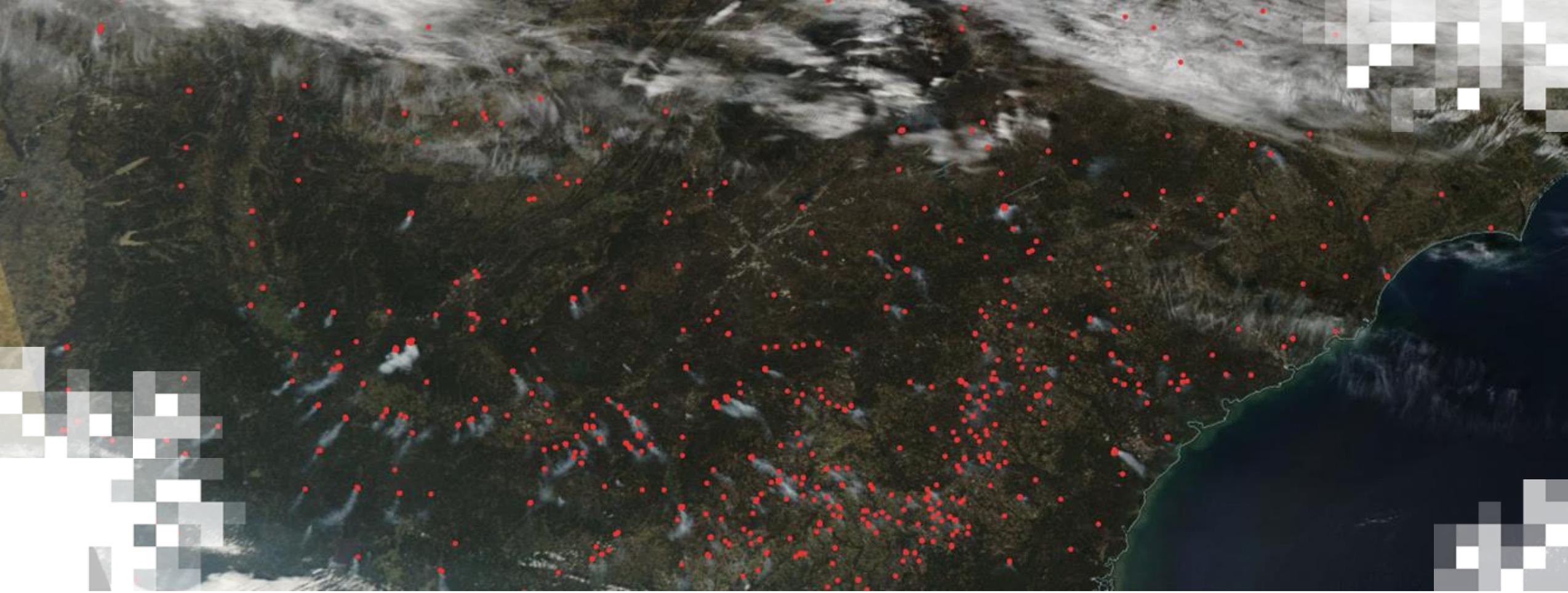
NASA Satellite Observations and Tools for Fire and Smoke Monitoring
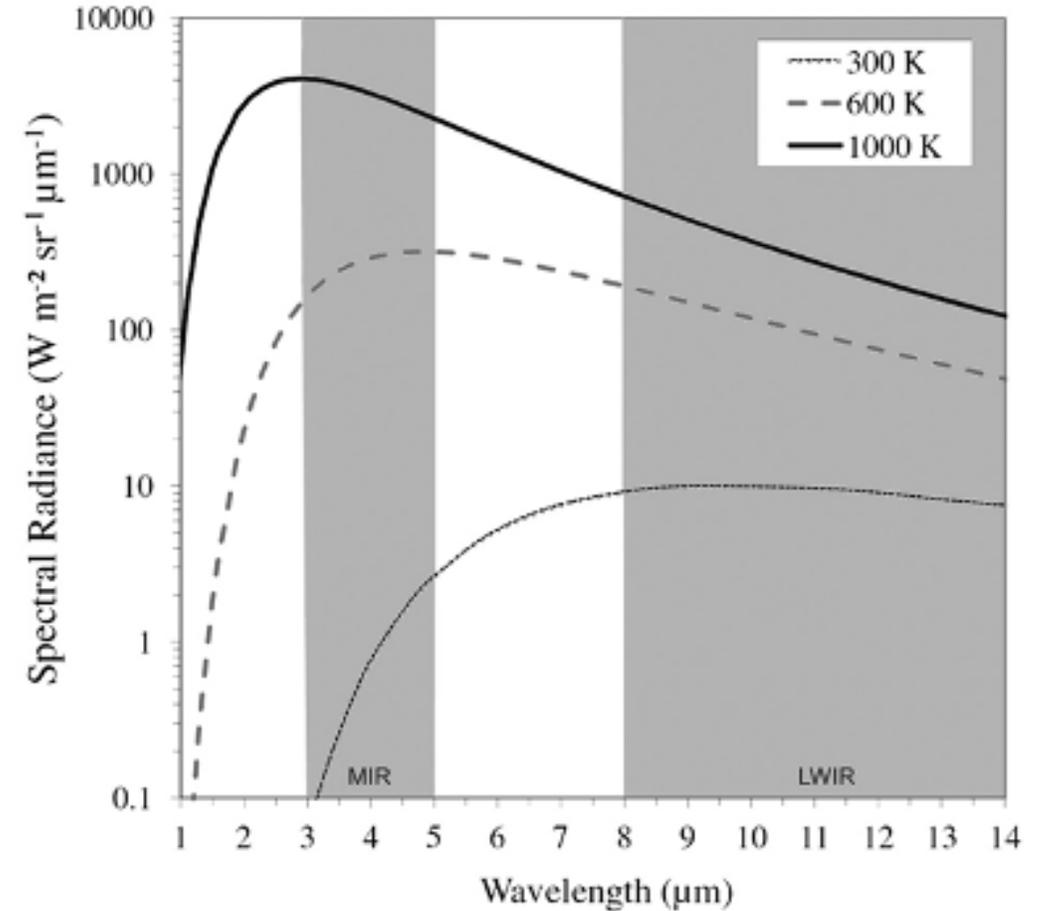**Overview of Fire Detections**
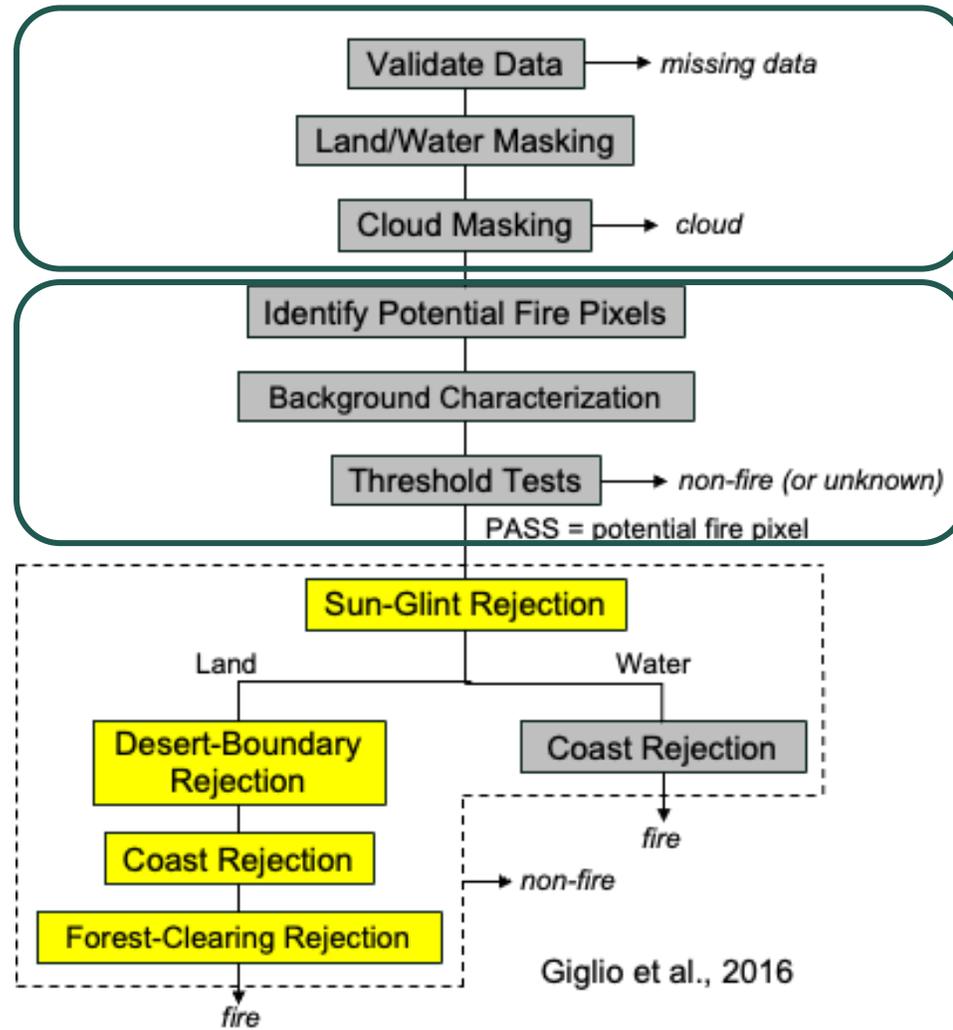
Observing Fires from Space

How is a fire detected by satellite?

- Satellites detect fires at the time of observation or overpass.
- Typical Temperatures:
  - Earth's Surface: ~300K
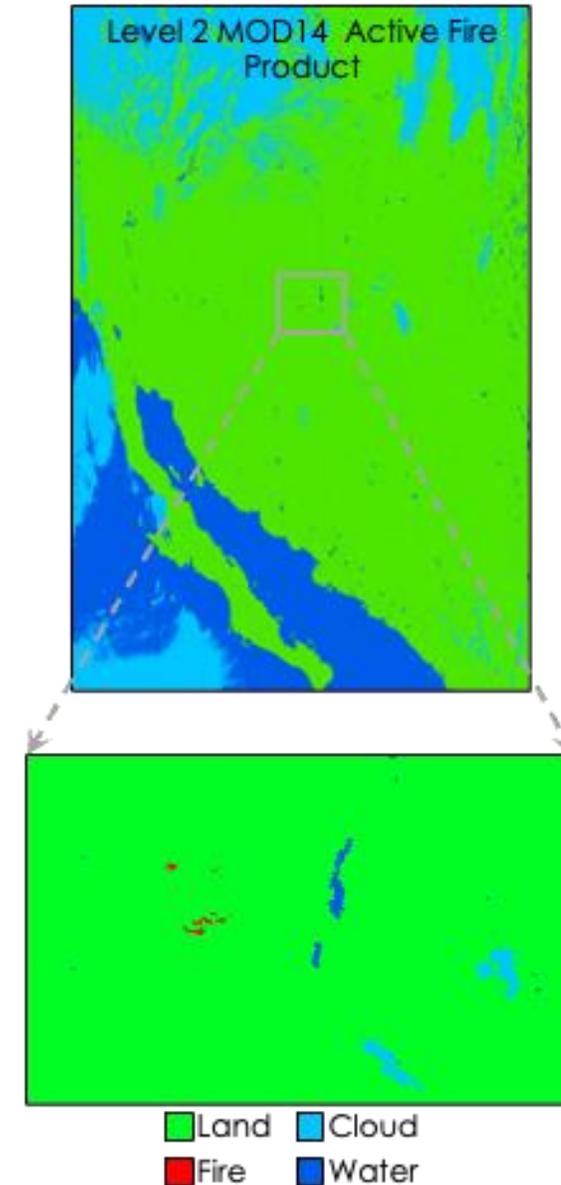 - Smoldering Fires: 600K to 800K
  - Flaming Fires: ~1000K and Higher

Wooster et al., 2021

How is a fire detected by satellite?

Validate Data → missing data

Land/Water Masking

Cloud Masking → cloud

Identify Potential Fire Pixels

Background Characterization

Threshold Tests → non-fire (or unknown)

PASS = potential fire pixel

Sun-Glint Rejection

Land / Water

Desert-Boundary Rejection

Coast Rejection

Coast Rejection → fire

Forest-Clearing Rejection → non-fire

fire

Giglio et al., 2016

Level 2 MOD14 Active Fire Product

Land   Cloud
Fire   Water

What does a detection mean on the ground?

- Driven by the characteristics of the fire.
- Detected fire activity is often less than the pixel size.
  - Small or large, intense fire(s)
  - Less intense fire burning over a broader area
- Pixel size for fire detection data is determined by sensor spatial resolution.
- Detection coordinates are the center of a pixel containing fire activity.
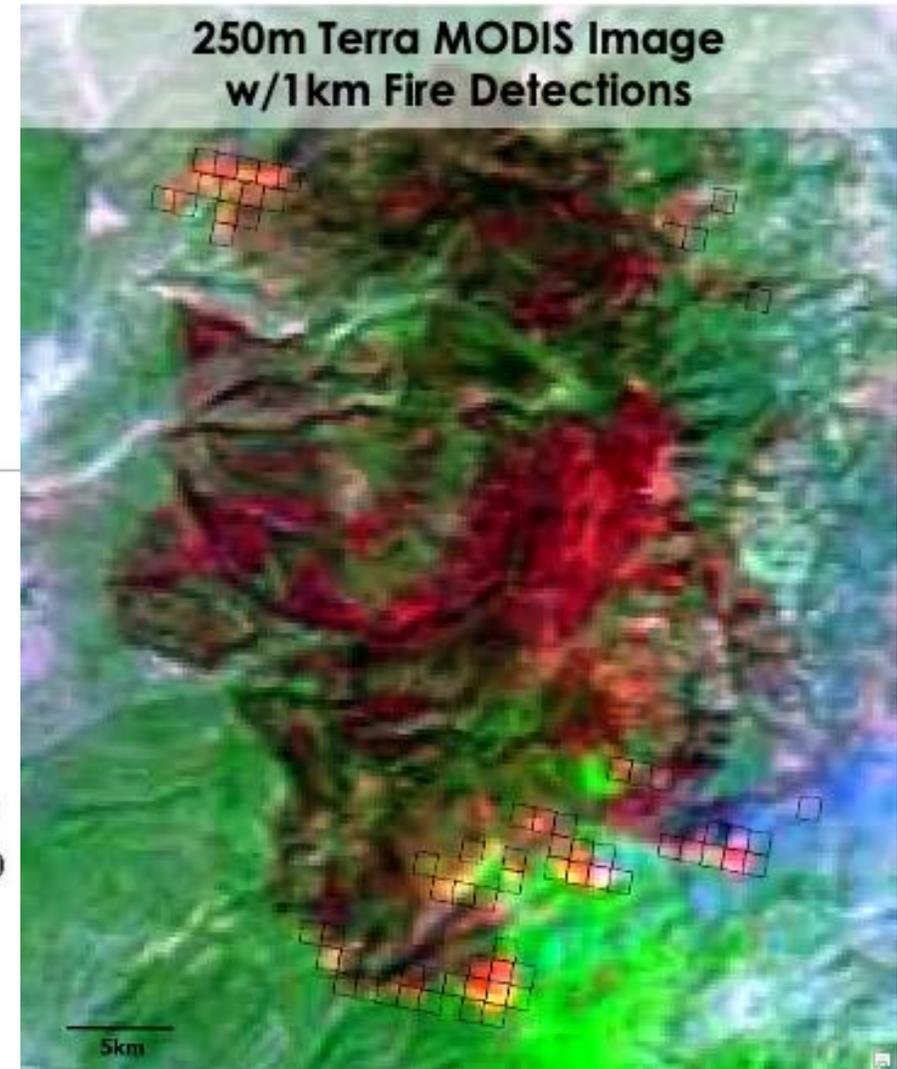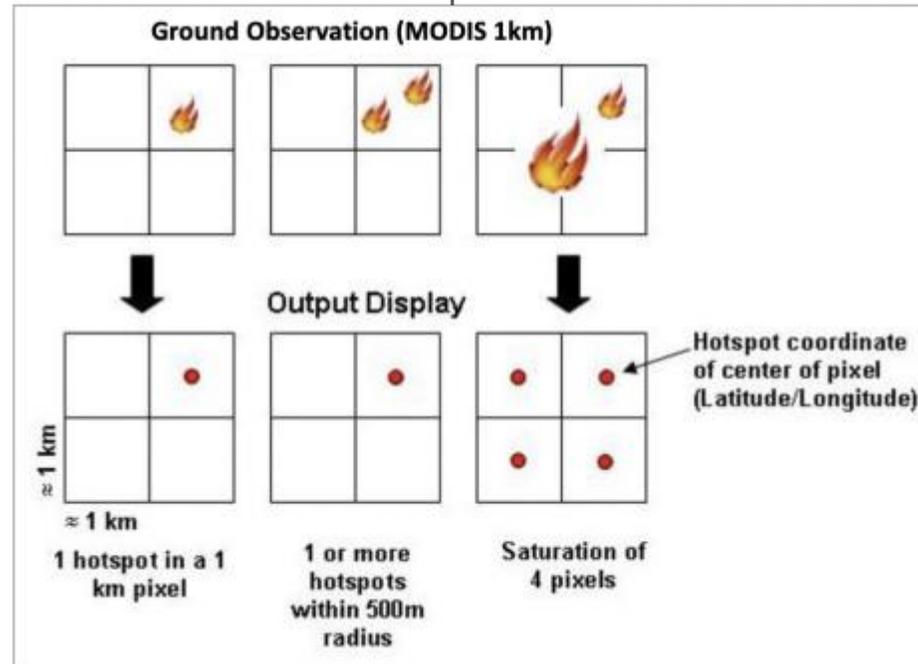
What does a detection mean on the ground?

- Sensor altitude, view angle affects ground footprint covered by a pixel
- Time of sensor observation or overpass relative to fire activity

- Other factors affecting detection ability:
  - Fire Size and Intensity
  - Cloud Cover
  - Smoke
  - Canopy Cover
  - Terrain
  - Land Cover Heterogeneity
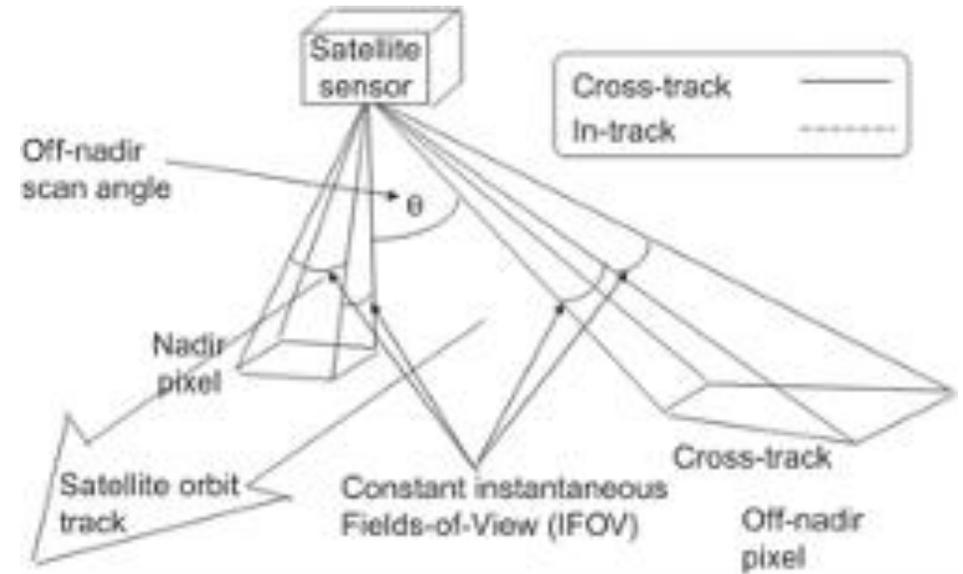
Schueler and Barnes, 1998
Schueler et al., 2013

What sizes/types of fires can be detected by satellite?

MODIS (1000m)

    ~1,000m^2 smoldering to flaming fires in good conditions (day)

    ~100m^2 flaming fire in good conditions (day)

VIIRS I-Band (375m)

    ~100m^2 smoldering to flaming fires in good conditions (day)

    ~20m^2 flaming fire in good conditions (day)

    ~2m^2 flaming fire in good conditions (night)

Landsat OLI (30m)

    ~10-20m^2 smoldering to flaming fires in good conditions (day)

    ~4m^2 flaming fire in good conditions (day)

    ~1m^2 flaming fire in good conditions (night)

Algorithms and products are not perfect!

Landsat (30m)	Schroeder et al., 2016
VIIRS (375m)	Schroeder et al., 2014
MODIS (1km)	Schroeder & Giglio, 2017

Satellite Orbits

- Polar-Orbiting Satellite Orbits
  - Orbit from pole to pole while Earth rotates beneath
  - Sun-synchronous; collect on both daytime and nighttime sides
  - Low orbit (<1,000km)
  - 1-2 observations daily (more in higher latitudes)
  - Sensors cover a defined swath width
  - Relatively higher spatial resolution
- Geostationary Satellite Orbits
  - Locked on fixed point while Earth rotates
  - High orbit (35,000km)
  - Sensors observe full-disk of Earth's hemisphere
  - Multiple observations per hour
  - Relatively coarser spatial resolution
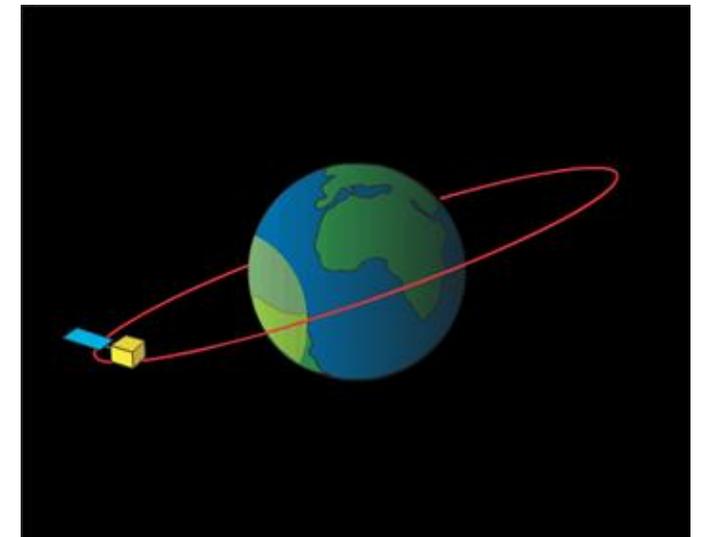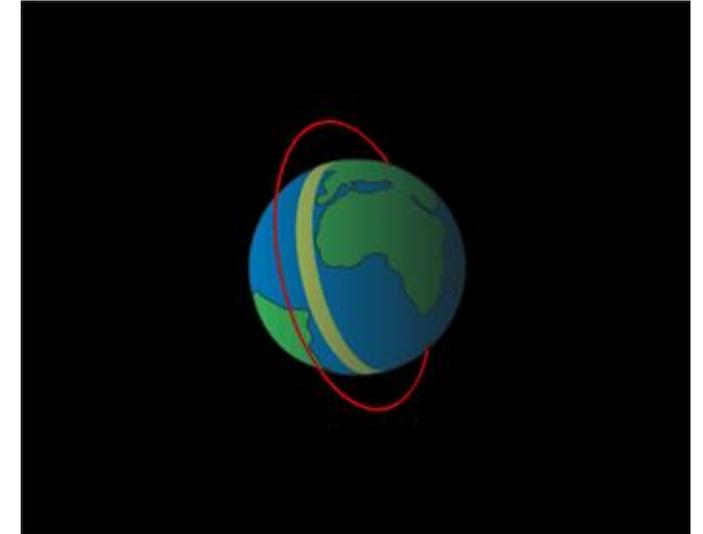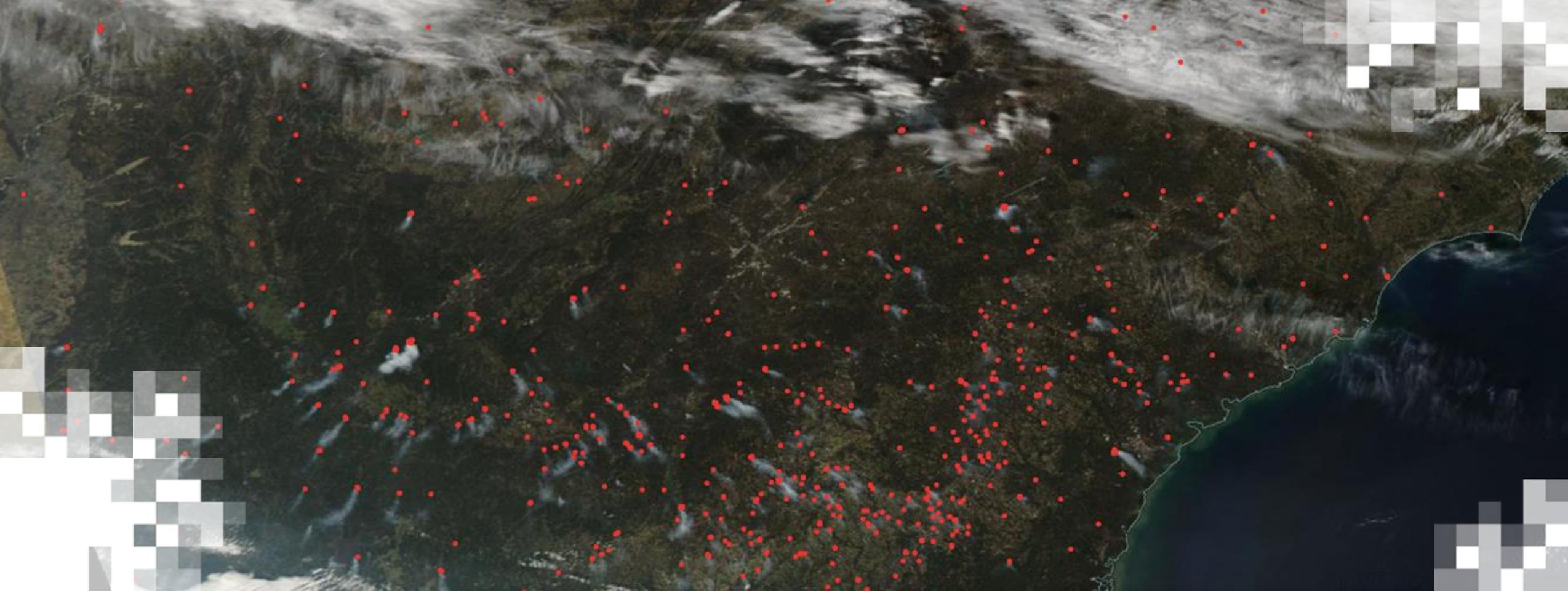
Source: https://spaceplace.nasa.gov/orbits/en/
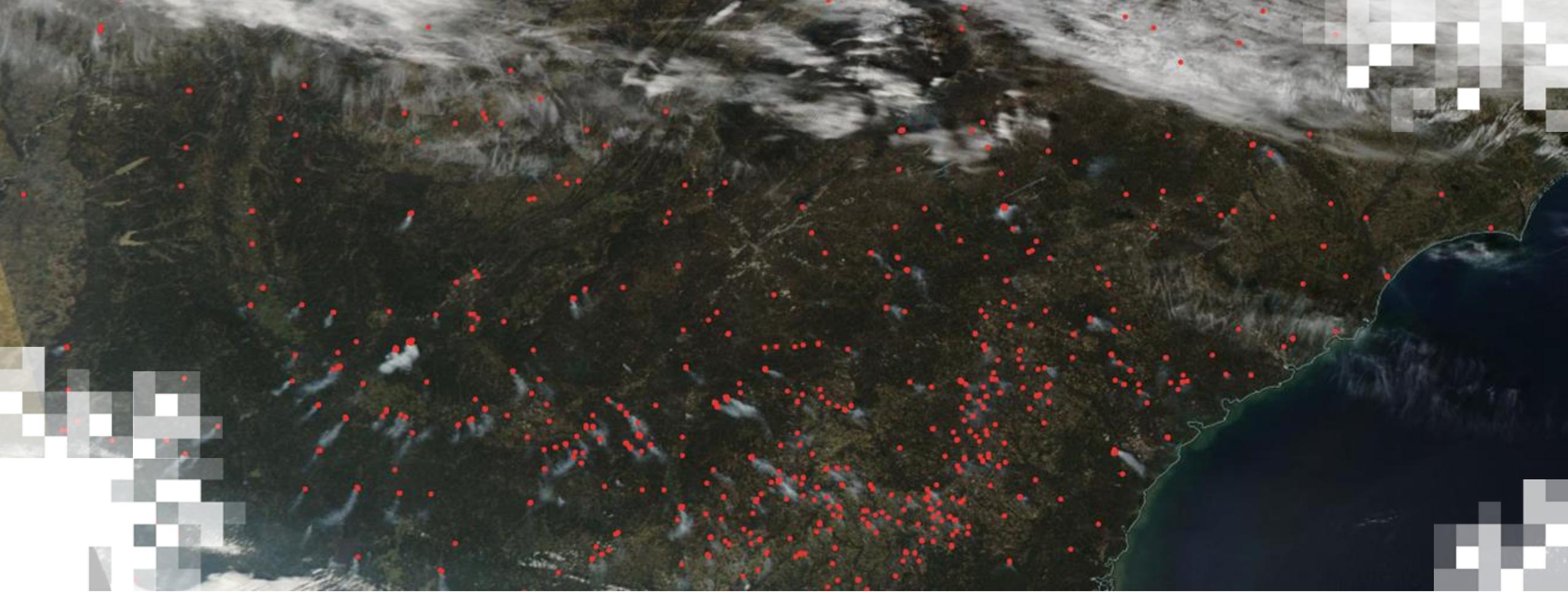
NASA Satellite Observations and Tools for Fire and Smoke Monitoring
NASA Fire Information for Resource Management System (FIRMS)

Fire Information for Resource Management System (FIRMS)

- Provides multiple sources of time sensitive derived active fire detection data products and satellite imagery
- Objectives:
  - Enable access to global, NRT satellite imagery, active fire/hotspots and related products from multiple satellite missions
  - Detect and monitor the location, extent and intensity/severity of fire activity, its effects on the environment, and to support event response
  - Inform science-based decision making through standardized, readily interpretable interfaces and services to support operational users, researchers, and other stakeholders

FIRMS - Global & US/Canada

FIRMS Website: earthdata.nasa.gov/data/tools/firms
- Enables access to global near real-time satellite imagery, active fire detections and other data from multiple satellites
- Developed by University of Maryland in early 2000s and used data from MODIS
- Transitioned to NASA's **L**and, **A**tmosphere **N**ear real-time **C**apability for **E**arth observation (**LANCE**) in 2012
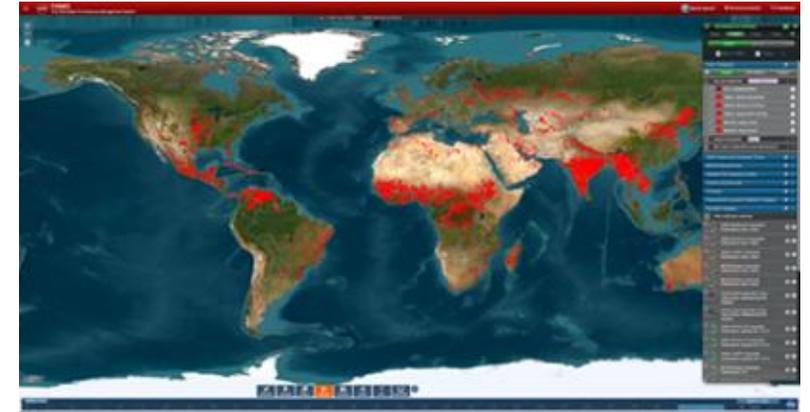
FIRMS US/Canada Website: firms.modaps.eosdis.nasa.gov/usfs
- Near real-time, real-time imagery and active fire detection products for the US & Canada
- Developed in partnership with USDA Forest Service
- Integrated with FIRMS Global within NASA LANCE in 2021

Earth Observation Satellites and Sensors Used in FIRMS

- 15 Satellites
  - 10 Polar-Orbiting
  - 5 Geostationary

- 16 Sensors

- 5 Space Agencies
  - NASA
  - NOAA
  - ESA
  - EUMETSAT
  - JAXA
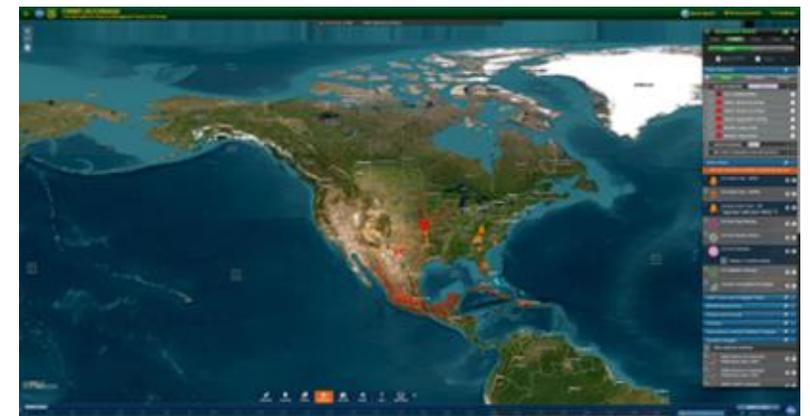
Summary of Satellite Data Product Availability in FIRMS

Satellite - Sensor	Active Fire	True Color Composite Imagery	False Color Composite Imagery	DNB Imagery	DNB/IR Composite Imagery	Burned Area	Vegetation Indices	Aerosol Indices	Snow Cover
GOES-18 ABI	Available – Provided	Available – Provided	Available – Not Provided	Not Available	Not Available	Not Available	Available – Not Provided	Available – Not Planned	Available – Not Planned
GOES-19 ABI	Available – Provided	Available – Provided	Available – Not Provided	Not Available	Not Available	Not Available	Available – Not Provided	Available – Not Planned	Available – Not Planned
Meteosat-9 SEVIRI	Available – Provided	Available – Planned	Available – Not Provided	Not Available	Not Available	Not Available	Available – Not Provided	Available – Not Planned	Available – Not Planned
Meteosat-10 SEVIRI	Available – Provided	Available – Planned	Available – Not Provided	Not Available	Not Available	Not Available	Available – Not Provided	Available – Not Planned	Available – Not Planned
Himawari-9 AHI	Available – Provided	Available – Planned	Available – Not Provided	Not Available	Not Available	Not Available	Available – Not Provided	Available – Not Planned	Not Available
Terra MODIS	Available – Provided	Available – Provided	Available – Provided	Not Available	Not Available	Available – Provided	Available – Not Provided	Available – Not Planned	Available – Not Planned
Aqua MODIS	Available – Provided	Available – Provided	Available – Provided	Not Available	Not Available	Available – Provided	Available – Not Provided	Available – Not Planned	Available – Not Planned
S-NPP VIIRS	Available – Provided	Available – Provided	Available – Provided	Available – Provided	Available – Provided	Available – Provided	Available – Not Provided	Available – Provided	Available – Not Planned
NOAA-20 VIIRS	Available – Provided	Available – Provided	Available – Provided	Available – Provided	Available – Provided	Not Available	Available – Not Provided	Available – Provided	Available – Provided
NOAA-21 VIIRS	Available – Provided	Available – Provided	Available – Provided	Available – Planned	Available – Planned	Not Available	Available – Not Provided	Available – Planned	Available – Not Planned
Sentinel-3A SLSTR	Available – Planned	Available – Planned	Available – Planned	Not Available	Not Available	Available – Not Provided	Available – Not Provided	Available – Not Planned	Available – Not Planned
Sentinel-3B SLSTR	Available – Planned	Available – Planned	Available – Planned	Not Available	Not Available	Available – Not Provided	Available – Not Provided	Available – Not Planned	Available – Not Planned
Landsat 8 OLI	Available – Provided	Available – Provided	Available – Provided	Available – Not Provided	Not Available	Available – Not Provided	Available – Provided	Not Available	Available – Not Planned
Landsat 9 OLI	Available – Provided	Available – Provided	Available – Provided	Available – Not Provided	Not Available	Available – Not Provided	Available – Provided	Not Available	Available – Not Planned
Sentinel 2A MSI	Not Available	Available – Provided	Available – Provided	Not Available	Not Available	Not Available	Available – Provided	Not Available	Available – Not Planned
Sentinel 2B MSI	Not Available	Available – Provided	Available – Provided	Not Available	Not Available	Not Available	Available – Provided	Not Available	Available – Not Planned

Legend:
- Available – Provided in FIRMS (green)
- Available – Planned to Include in FIRMS (blue)
- Available – Not Planned to Include in FIRMS (yellow)
- Available – Not Provided in FIRMS (red)
- Not Available (gray)
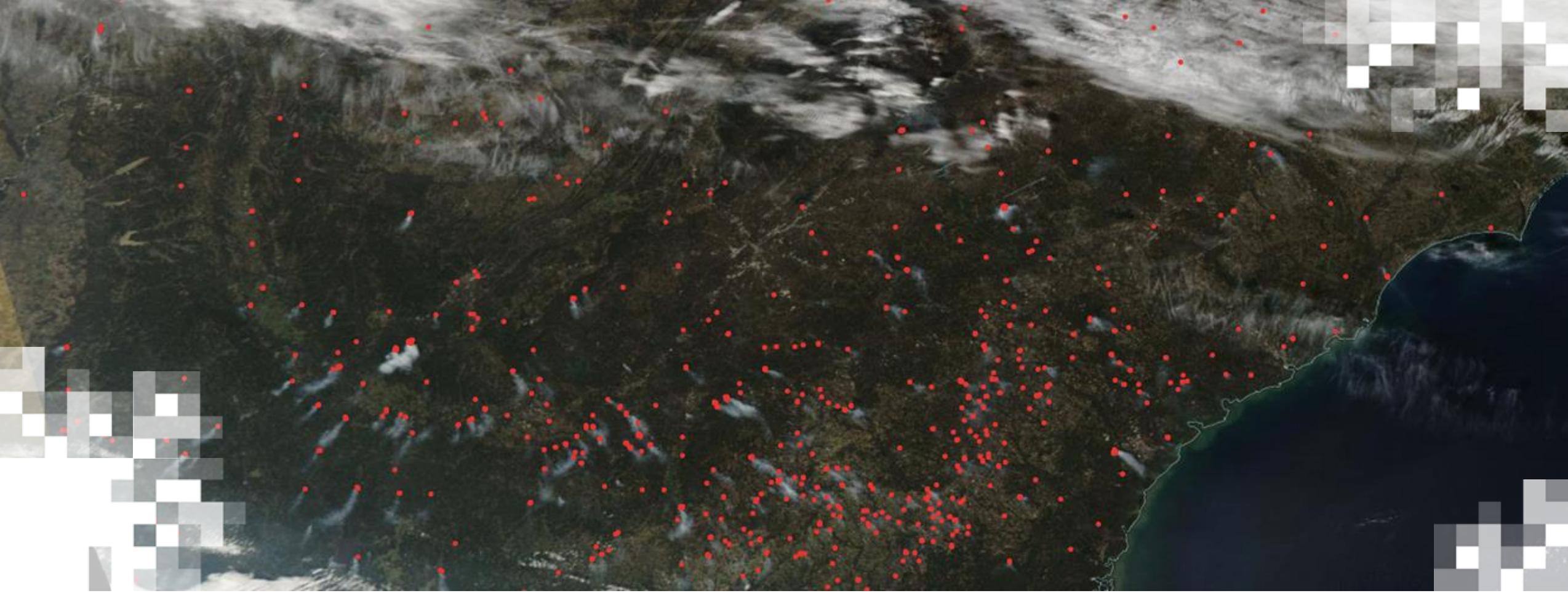
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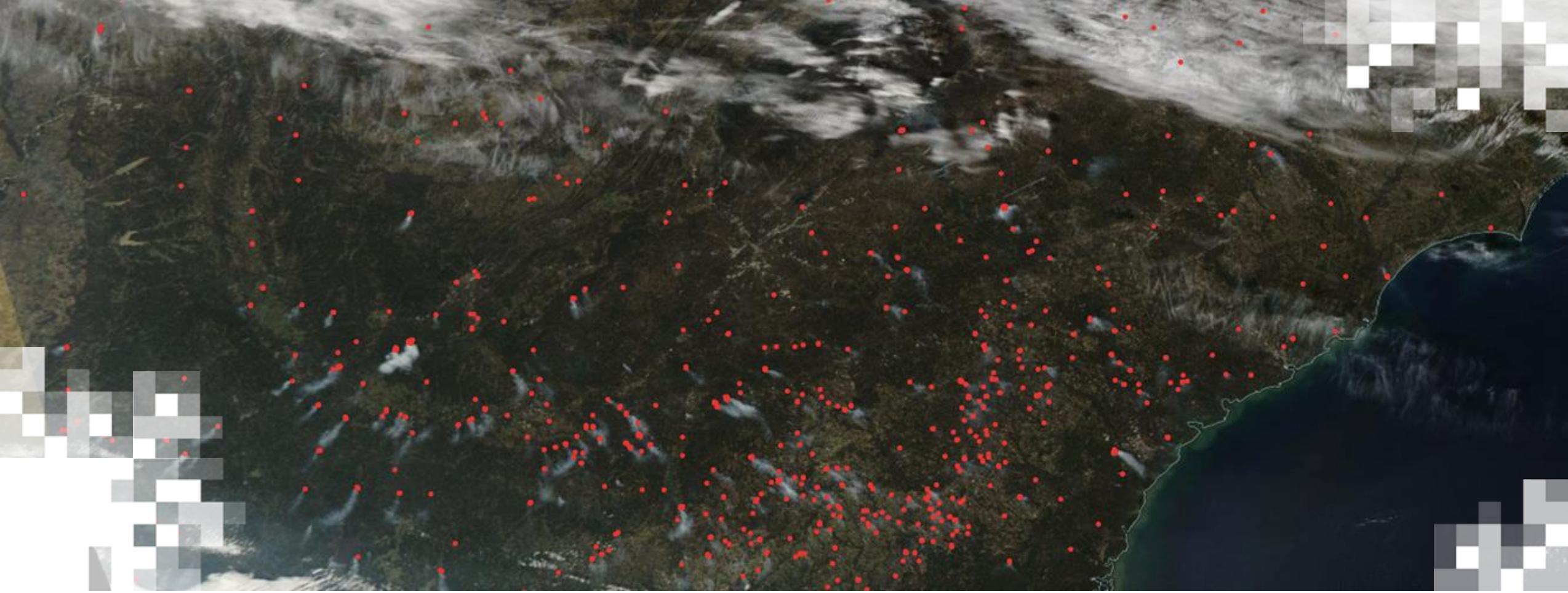
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Launch US/Canada FIRMS Map

Turn Off Pre-Selected Layers

Change the Mode to Advanced

Use the Location Tool to Select Beaver, OK

Close the Location Tool, Zoom Out, & Scroll to Dynamic Imagery

Change the Date to February 17, 2026

Flip Through Various True Color Imagery is the Clearest

Flip Through Various True Color Imagery is the Clearest

Turn on the Active Fire Detections for all Polar Orbiting Satellites

Pan to the Left to See More Smoke in the Imagery, Click for Metadata

Open Smoke & Aerosols Layer List, Turn on Aerosol Index
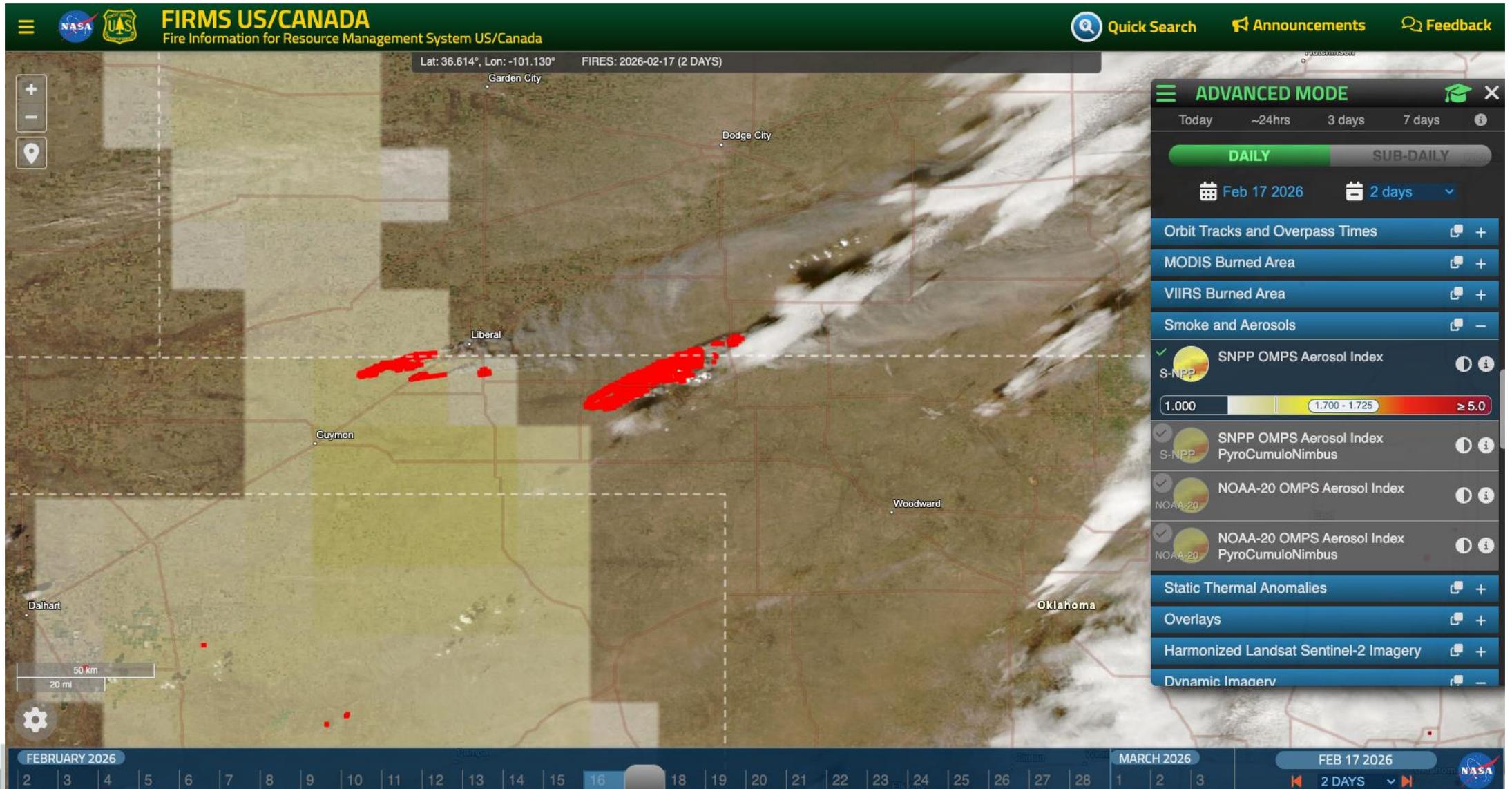
Click on the Legend, Decrease Threshold
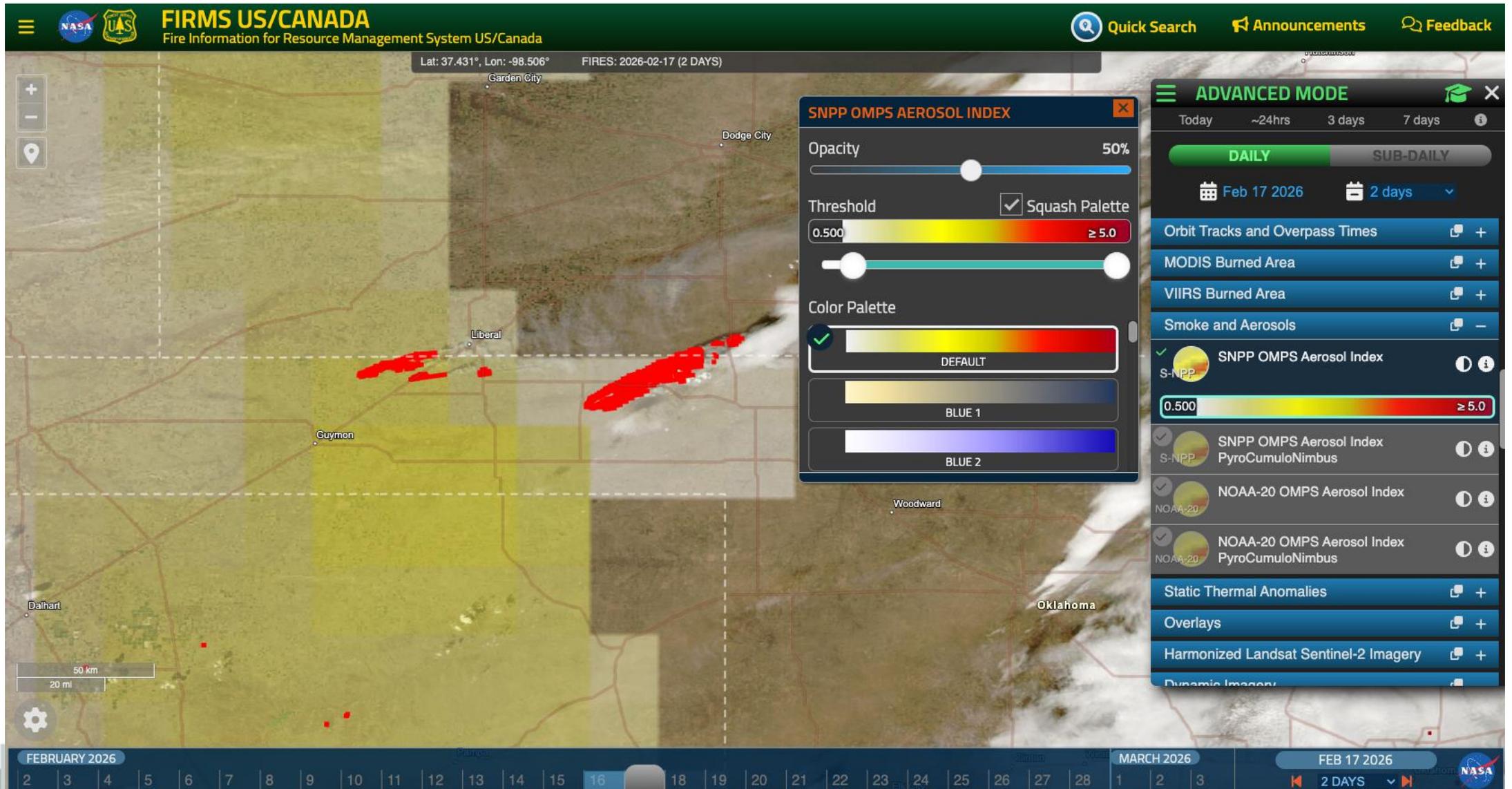
Drag to the Right to Expand the Timeline for Detections
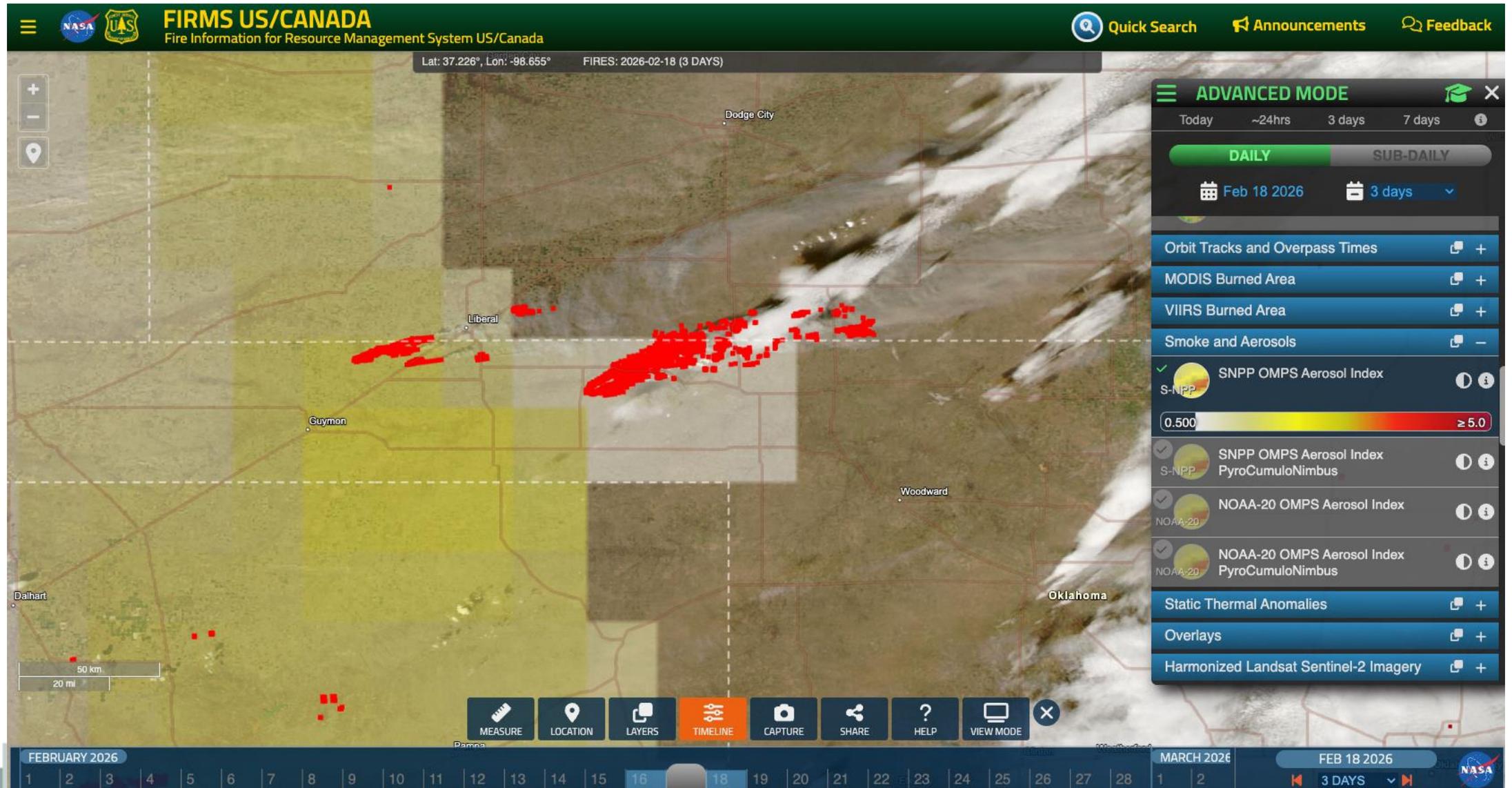
Drag to the Right to Expand the Timeline until the 24th
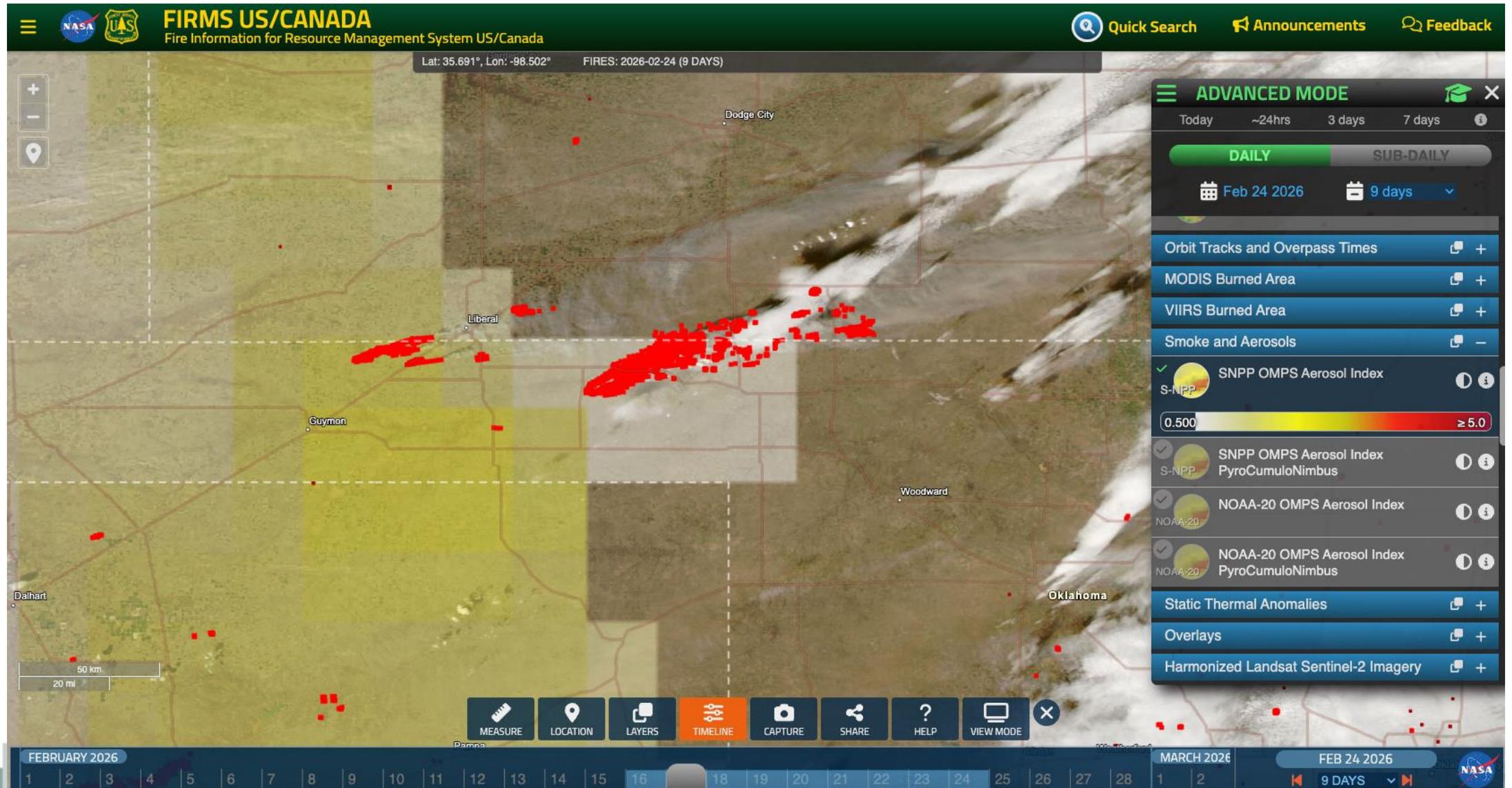
Step Through the Various Days to See Imagery Difference
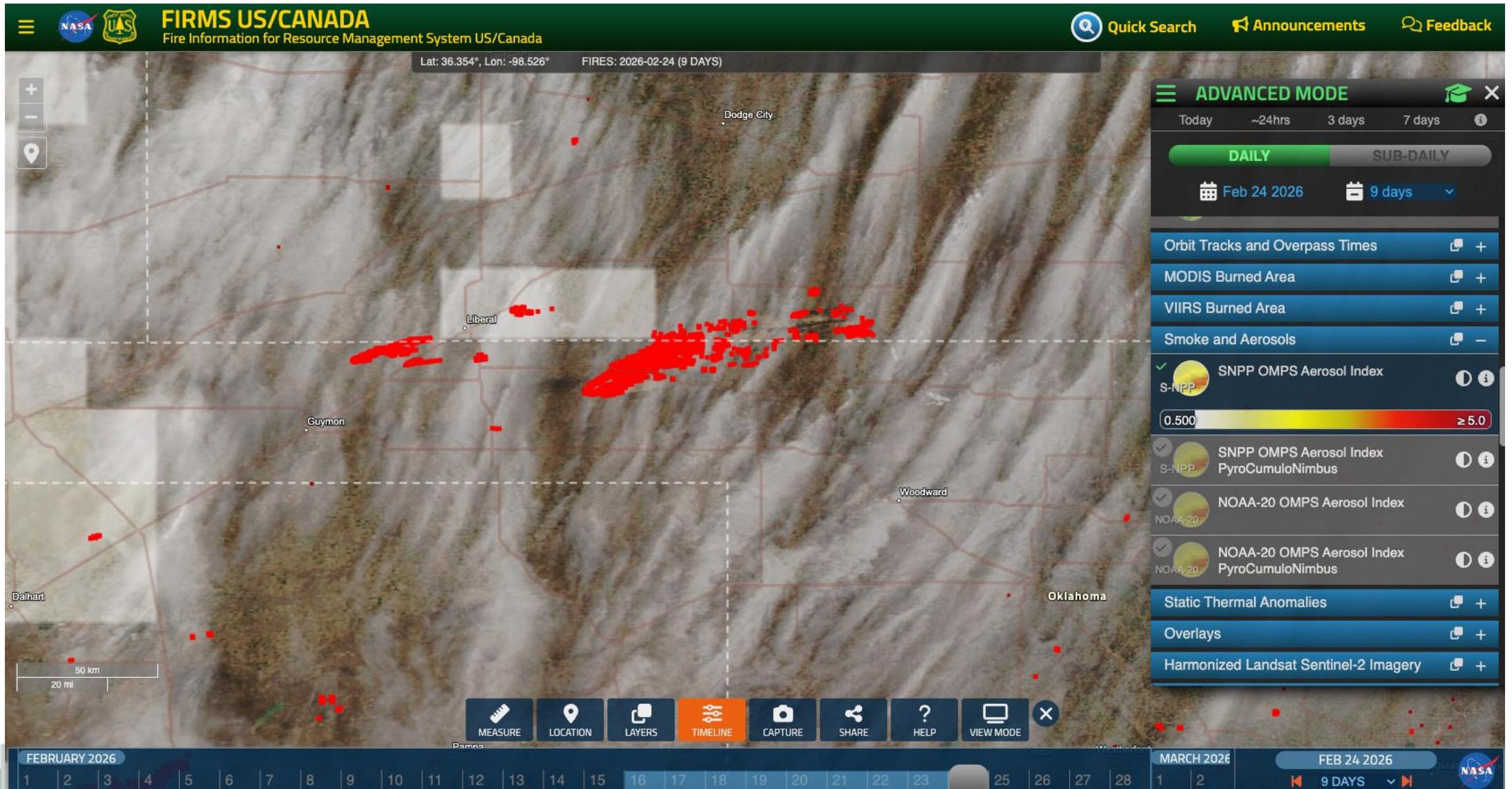
Turn Off the Imagery and Aerosol Index

Turn On HLS Adjusted Reflectance BRDF
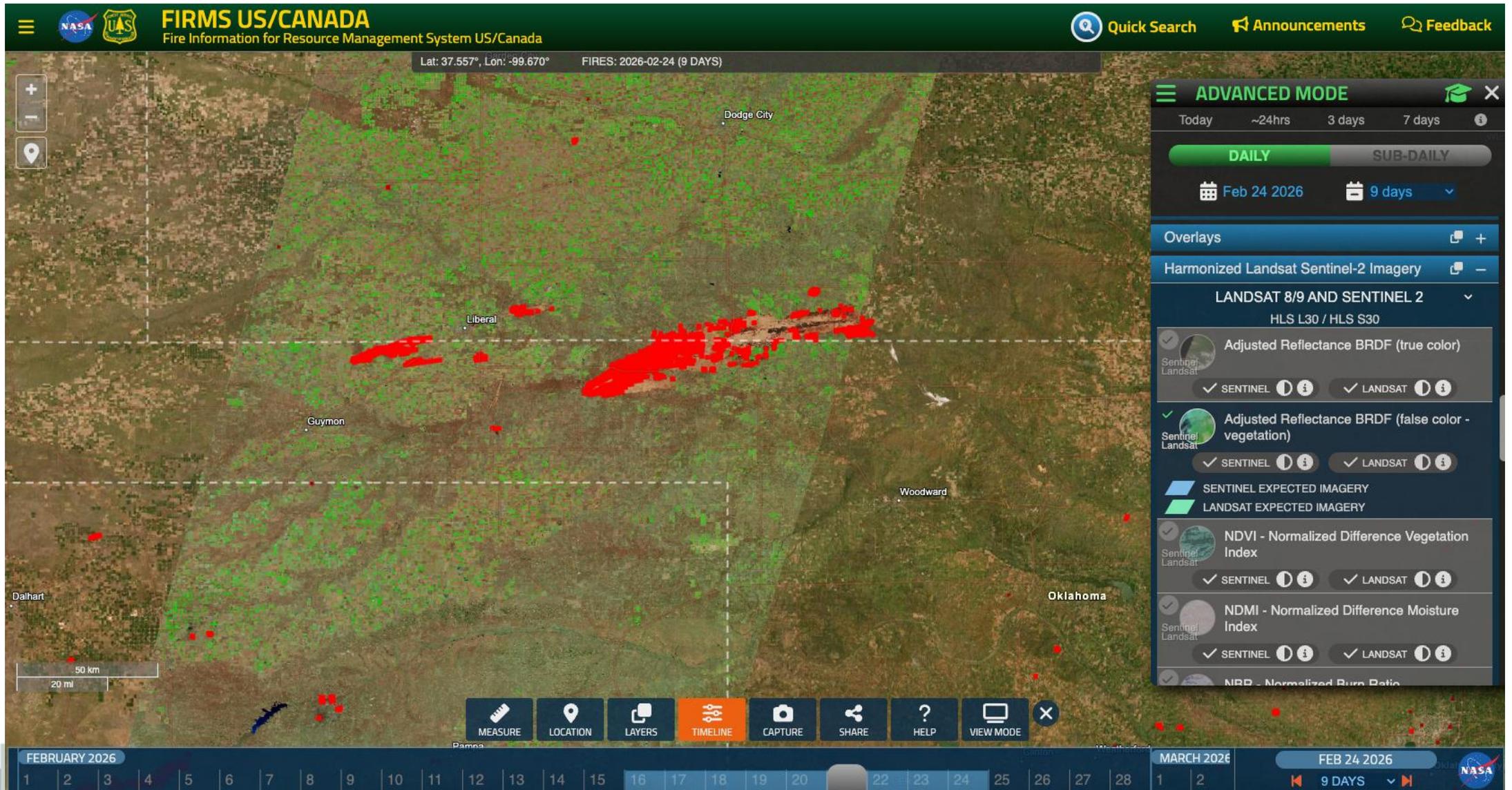
Turn Off Fire Detections

Change the Date to See the Other Half of the Burned Area

Summary

You should generally understand

- How fires on the ground translate into active fire detections
- Which satellites to use to see a general area of interest
- What caveats there may be to what is seen on the FIRMS map
- How FIRMS is set up
- How to build a display on FIRMS for a fire or smoke event of interest

Thank You!