CEOS Youth Initiative

Webinar outline: Monitoring fire from space

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3/9/26

CEOS in schools

MONITORING FIRE FROM SPACE – Lesson content

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March 2026

CEOS Youth Initiative 2026

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Photo Credit: BC Wildfire Service via Reuters. https://www.ehnewspaper.ca/articles/bc-forest-fire-season-is-sparking

Lesson Plan

1 Lesson aims and expected outcomes

1.1 Lesson aims

This lesson aims to:

- Describe why wildfires are important from the ecological and social perspectives.
- Understand how satellites help us detect active fires, and the vegetation that will burn during a fire.
- Understand the trade-offs between spatial, spectral, and temporal resolutions.
- Apply systems thinking to designing a satellite that monitors vegetation fuels or active fires.

1.2 Lesson outcomes

By the end of the session students should be able to:

- Describe the effects of wildfires on their local environments, and on their communities.
- Describe how satellites detect active fires, and the spectral signatures of drying vegetation.
- Define the spatial, spectral, and temporal resolutions for a satellite to detect active fires, or wildfire risk.

2 Before the lesson

Student links should be sent to the class in advance by the teacher if possible (e.g. via Google Classroom/Teams). Ask the teacher if resources are required to be adapted for students with learning difficulties or disabilities.

Ideally, the students will go through some/most the links before the session.

2.1 Resources needed

Computer or tablet with an internet connection to access the links below.

2.2 Links for students:

2.2.1 Link to YouTube video No. 1:

https://youtu.be/aR15KZu4cVg?si=0C-5whD4qq27x4dY

This video provides background information on wildfires and how we can use satellite remote sensing to keep track of when and where they happen.

2.2.2 Link to YouTube video No. 2:

https://youtu.be/cVXR3BqKPYA?si=j75d9vh4WC8xW4H4

This video provides the students with information about the importance of mapping the vegetation before and during fires. Vegetation is the fuel that burns during fires, so if you know when and where vegetation will burn, you can be better prepared for fires in your area.

2.2.3 Link to The Conversation article:

https://theconversation.com/new-interactive-map-shows-how-flammable-your-part-of-australia-is-right-now-268289

This article describes a new interactive map that tracks how much water there is in the vegetation across Australia. This tool uses machine learning and satellite data to identify dry vegetation, helping fire agencies and Indigenous communities pinpoint high-risk areas before fires ignite. Teachers can use this resource to show students how technology and data science monitor environmental hazards and support bushfire prevention.

2.2.4 Link to the Fuel Moisture Content (FMC) story map:

https://maps.dea.ga.gov.au/story/DEAFuelMoistureContent

This story map shows the students how to access the data, and explains what the data means. Students can then explore the dataset by themselves.

2.2.5 Link to remote sensing learning resource No.1:

https://rscal.maitec.com.au/

Students should complete the following modules and topics before the online session (see images below):

- Module: What is remote sensing?
    - Topics: all
- Module: Spectral signatures
    - Topics: all
- Module: Digital image analysis
    - Topics: 2 and 7 only.

How to use the RSCAL website:

Figure 1: RSCAL landing page. Click on 'enter here'

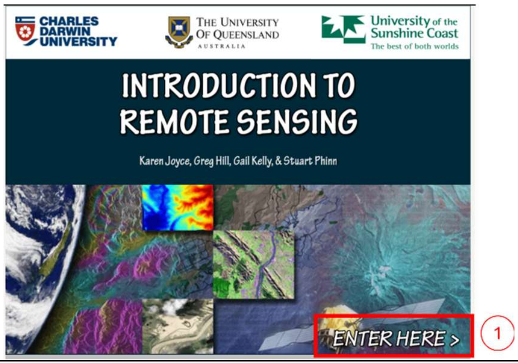


Figure 2: Acknowledgements. Click on the right arrow.

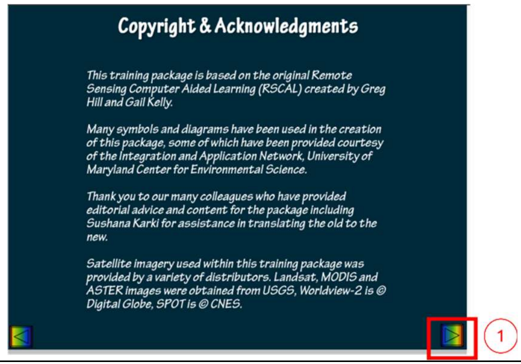


Figure 3: View the introductory video. especially important for Teachers and tutors to solve potential questions about how to navigate the site.

Figure 4: Launch and complete the following modules "What is remote sensing?", and "Spectral signatures". These two modules provide background information about remote sensing and the science of remote sensing.

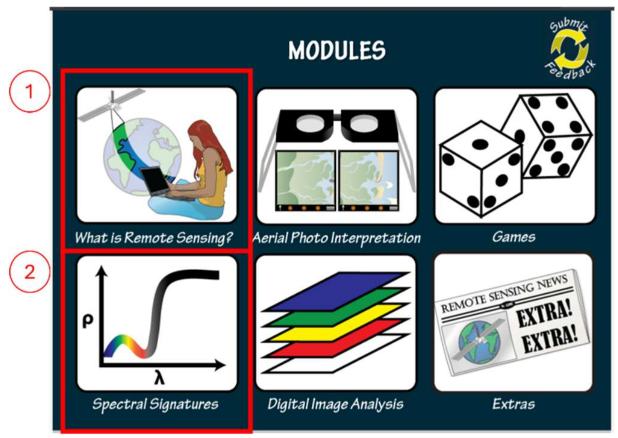


Figure 5: Now go into the "Digital image analysis" module.

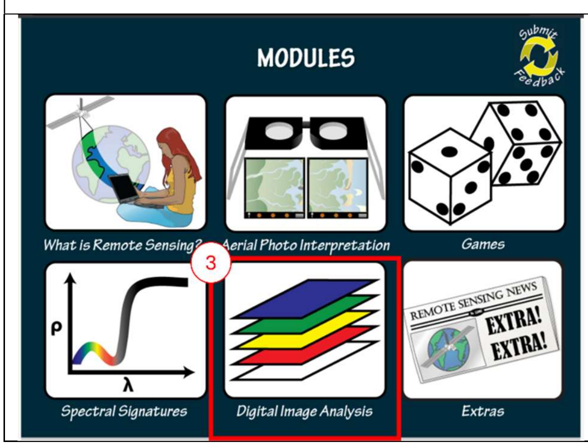
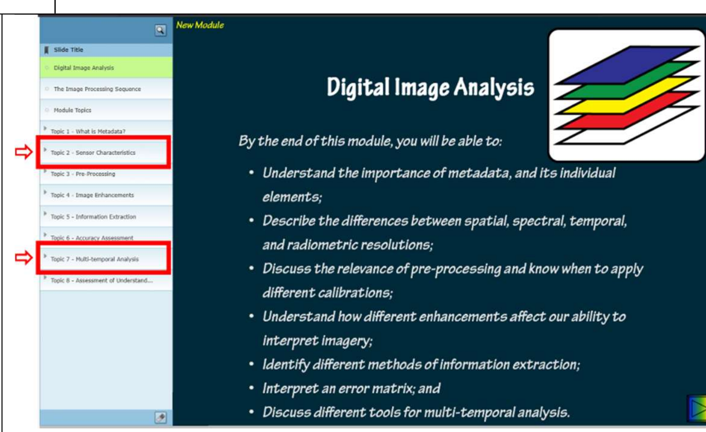


Figure 6: In this module, focus only on Topic 2 and Topic 7, which are related to the activities we'll do during the CEOS meeting.



2.2.6 Link to YouTube video No.3:

https://youtu.be/tqyNoUC5Zvk

this video uses graphs and animations to show the difference between the spatial, spectral, and temporal resolutions of different satellites. This video will be useful to understand the trade-offs between the different resolutions.

2.2.7 Optional - Link to remote sensing learning resource No.2:

https://remotesensinglab.com/

This link provides the students with interactive tools to cement the concepts leaned through RSCAL

2.2.8 Optional - Link to YouTube video No. 4:

https://youtu.be/tLgqBDuSOdU?si=N4WLYRuC2KZWNlQe

This video features a collaboration between scientists and Indigenous communities from Australia and New Zealand. This collaboration aims to understand how Indigenous communities ‘read’ the landscape for clues as to when and where to conduct cultural burns without affecting the environment. In a similar way, researchers use the

This partnership allows schools to explore how blending ancient environmental wisdom with modern technology can protect ecosystems and improve community safe

3 During the lesson (~90 min)

3.1 Resources needed

- Computer or tablet with an internet connection to access the video feed.
- Pens, pencils, colors or similar,
- Sheets of paper, workbook,
- Printed worksheets

3.2 We go through the following:

- why wildfires are important from the ecological and social perspectives.
- how satellites help us detect active fires, and the vegetation that will burn during a fire.
- Understand the trade-offs between spatial, spectral, and temporal resolutions.
- Apply systems thinking to designing a satellite that monitors vegetation fuels or active fires.

3.3 Activity at a glance:

- The aim of this activity is for the students to design a satellite that either (1) detects and monitors active fires, or (2) detects changes in vegetation flammability.
- Teachers, tutors, and facilitators will have a list of questions that can help guide this activity. See **Cheat sheet for facilitators**.
- Students should ideally use their country or region as study area for the activity.

3.4 Presentation content:

Duration	Content	Who
5 min	Introductions (each presenter) Perhaps ask some questions to get students invested - something that is relatable, e.g.: - Have you ever used Google Earth? - Are there wildfires where you live? - Have you ever seen what your town looks like from space?	All presenters
5 min	wildfires - introduction - why wildfires are important from the ecological and social perspectives. - effects on human health, environment, and climate	MY, NYC
10 min	Remote sensing of wildfires - how satellites help us detect active fires, and the vegetation that will burn during a fire. - what do we ‘see’ from space? - different types of vegetation fuels - what makes vegetation fuels more flammable? - Active fires - temperature	MY, NYC
10 min	Satellites - Spatial resolution - Temporal resolution	MY, NYC

	- Spectral resolution Trade-offs What should we aim for, to monitor wildfires?	
10 min	Satellite orbits - LEO - GEO Explain the aim of the activity and break (if time allows)	MY, NYC
25 min	Breakout rooms - group activity (design your own satellite)	All presenters + teachers and facilitators
15 min	Return and present to others	Students
10 min	Wrap up and overview of next workshop	All presenters

3.5 During the workshop:

Worksheet - Design your own satellite!

Use the worksheet below to help design your satellite (use the sheets to draw, sketch, write, describe, create links, etc.). There's no right or wrong way to use the worksheets, so fill each box in whichever way feels natural to you.

By the end of the group activity, each group should have a set of specifications or characteristics for their satellite, including:

- **What will the satellite measure?** Active fires (fires that are already burning), or will the satellite look at the vegetation that is ready to burn but before the fire starts.
- **Spatial resolution →** how many meters per pixel would each pixel in your image represent?
- **Spectral resolution →** how many regions of the electromagnetic spectrum will your satellite capture? The visible range? the near infrared? or thermal? Or all of them?
- **Temporal resolution →** how frequently will your satellite 'see' your region? Every day? 1 or 2 weeks? Every month?
- **Orbit→** how far from Earth will your satellite be? If your satellite is in Geostationary orbit, it will be very, very far away from Remember that the further away, the larger the pixel size will be, and vice versa.
- **Create a list of groups or people who might use the data from your satellite.** Who would be interested in using the data from your satellite? Fire fighters? The council or local government? Researchers? Local businesses?

As a group you will decide on one (1) design for your satellite. That means, one design per group.

What will the spatial resolution be?

Think of this like the pixel size in a digital photo; smaller pixels show sharper details like individual trees, while larger pixels blur whole city blocks together. High-resolution satellites capture small areas with high detail, while low-resolution ones capture vast areas like entire continents but with low detail. Which one is best for this application?

What will the temporal resolution be?

Temporal resolution measures how often a satellite returns to the same spot on Earth. High temporal resolution means a sensor captures images every few hours to track a fire. Low temporal resolution might only provide one update every week or two, which works for monitoring slow changes like forest dryness.

What will the spectral resolution be?

Spectral resolution defines how many specific colors or light wavelengths a sensor can detect. Sensors with high spectral resolution split light into many narrow bands to distinguish between subtle features, such as healthy trees versus dry, flammable scrub. Lower spectral resolution captures broader chunks of the rainbow, which helps identify general land shapes but misses these fine details.

What are the trade-off between the resolutions?

A satellite capturing sharp details like individual trees must stay closer to Earth, and many take weeks to return to that spot. In contrast, satellites that stay far away see whole continents constantly and can provide frequent updates. Which one would work best in this case?

How will this satellite help your community?

What else would your satellite ‘see’?

How will you check that the satellite data is ‘true’?

How will the satellite get power and energy?

Do you see yourself using satellites data in the future? If yes, how could you use it?

Draw a sketch of what your satellite look like

Using the answers from above, draw what the data will look like

3.6 Cheat sheet for facilitators

- **Your role as facilitator is to:**
  - **(1) keep students thinking about the satellite design. The output is not as important as keeping the students engaged and thinking about the problem!**
  - **(2) to keep track of time, and**
  - **(3) to ask for a volunteer to present the design.**
- **There must be one (1) single design from each group, but each student can work independently in their own worksheet.**
- **Please make sure each student has one copy of the worksheet, either digital or printed**
- **Students are allowed to use AI, but we encourage them to talk to other students, not to AI.**

Some questions to help you guide the students.

Questions related to the aim of the satellite, or the 'target'

- Do you want to look for fires that are already burning? Or do you want to see changes if vegetation *before* a fire starts? What do the students think is more important?
- Do you need to see the temperature of the landscape and the fire? Or do you need to see the vegetation dryness? Or both?
- **Guidance for facilitators:**
  - Active fires vs. vegetation change: Monitoring active fires requires high temporal resolution to track fire movement, while vegetation health (pre-fire) focuses on spectral resolution to detect water and heat stress before the fire. Both are vital, but students must prioritize based on whether their mission is "Early Warning" (vegetation) or "Emergency Response" (active fires).
  - Temperature vs. Dryness: Temperature detection (active fires) requires thermal infrared bands to find the heat source, whereas vegetation dryness (pre-fire) is best measured using visible, Near-Infrared (NIR) and Short-Wave Infrared (SWIR) regions of the spectrum to detect vegetation stress.

Questions related to the spectral resolution (How many spectral bands?)

- Which region of the electromagnetic spectrum do you need to use? Visible (red, green, blue), Infrared, or thermal region? The students need to select the one that is more appropriate for their target (active fires, or vegetation)
- **Guidance for facilitators:**
  - Visible light shows smoke, green vegetation, and scorched earth. This region cannot be used to detect temperature.
  - Thermal Infrared is essential for seeing through smoke to find the heat from the fires,
  - Near-Infrared (NIR) and Short-Wave Infrared (SWIR) regions the gold standard for identifying fuel moisture levels.

Questions related to the temporal resolution (How frequently will the satellite 'see' your area?)

- How fast do fires travel over the landscape? In other words, how quickly do you need to capture an image to see your fire, or the vegetation?
- How fast does vegetation dry out and become more flammable?
- How frequently do you want the satellite to 'see' your study area? Every month/week/day/hour. The higher the frequency of observations, the further away the satellite needs to be from Earth, and therefore, the lower the spatial resolution of the images (i.e. larger pixel sizes).
- For reference: Himawari (15 minutes), MODIS or VIIRS (daily), Sentinel-2 (5 days), Landsat (8 days)
- **Guidance for facilitators:**
    - Fire Travel Speed: Wildfires can move at 10-20 km/h (or faster), meaning hourly updates are necessary for firefighting and emergency response.
    - Vegetation Drying Speed: Fuel moisture changes over weeks and months, so a weekly day revisit time may be sufficient for early warning.

Questions related to the spatial resolution (Pixel size, area covered by an image)

- How much area do you want to 'see'? remember that large areas mean low resolution (harder to distinguish features), and small areas can have high resolution (easy to distinguish features).
- What are the trade-offs between the spatial and temporal resolutions of the satellite?
- **Guidance for facilitators:**
    - Area Coverage: Large-area sensors (like MODIS) capture entire states or countries, but they cannot see individual houses or trees. Other satellites capture areas of 200 x 200 km but provide more detail; that is, you can now see roads and neighbourhoods, but not individual houses, trees, or cars.
    - To see a house or a single tree, students need a spatial resolution of 1–10 meters per pixel; to see a large fire, 30–100 meters per pixel is acceptable.
    - Resolution Trade-offs: High spatial resolution usually requires a Low Earth Orbit, which means the satellite only sees a specific spot every few days; low spatial resolution can be in geostationary orbit, which sees whole continents every 15-20 minutes, but the resolution is very low (1-5 km per pixel); you cannot currently have "every tree, every minute" from a single satellite.

Other questions:

Will your satellite be in Low Earth Orbit, or Geostationary orbit? How does the orbit affect the spatial and temporal resolution of the satellite? If you are very far away from Earth (i.e. geostationary orbit) you can see all the continent at once, but your spatial resolution might be very low, and vice versa.

How will your satellite get energy?

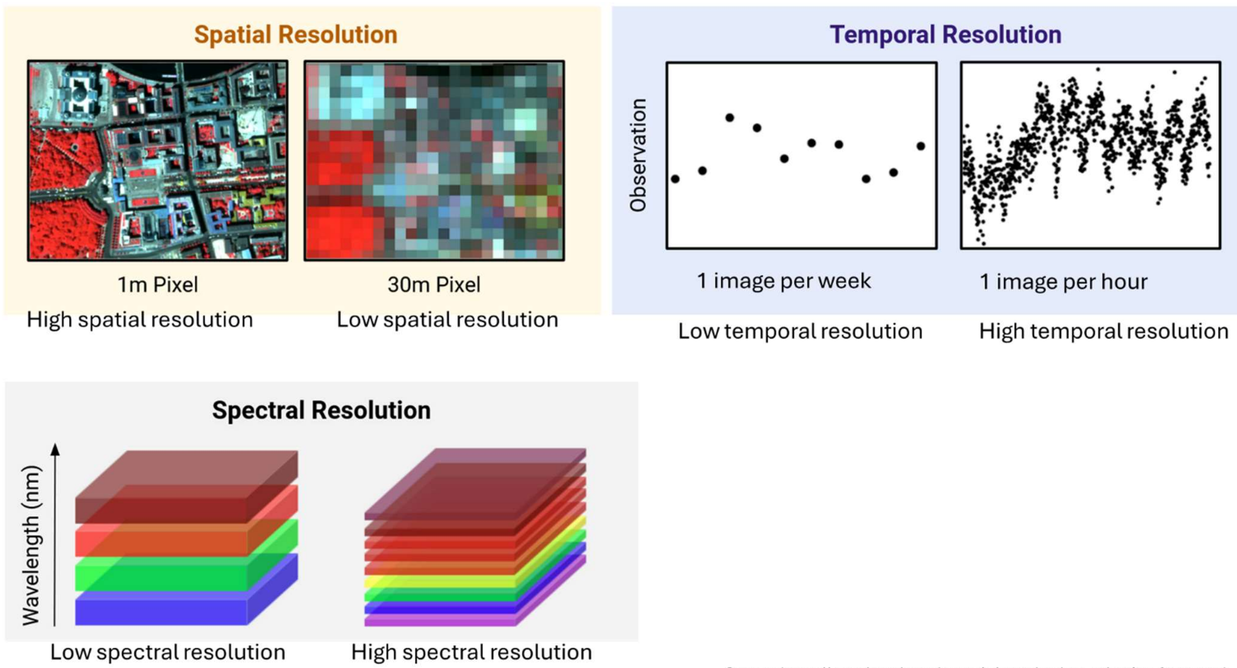
How will the satellite send the data to Earth?

How will you 'steer' or manoeuvre the satellite?

- **Guidance for facilitators:**
    - Orbit Types: Geostationary orbits provide constant "seeing" capability (high temporal) but lower detail, while LEO orbits provide high detail (spatial) but only "snapshot" views every few days or weeks.

- Energy Source: Most satellites have solar panels to charge onboard batteries.
- Data Transmission: Satellites convert sensor images into radio signals, sending the data down to ground stations when they are within the "line of sight."
- Maneuvering: Small thrusters or reaction wheels (spinning discs) allow the satellite to stay in the correct orbit or tilt its camera toward a specific fire.

Here's a visual guide of the resolutions:



Source: https://aetosky.substack.com/p/aetosky-data-selection-framework

And one generated by Google Gemini