Remote sensing with Dr Angela Kross

Extra activities and answers

Find Angela's article and instructions for Activities A and B at: futurumcareers.com/how-can-remote-sensing-make-agriculture-more-sustainable

Watch videos of Angela conducting the Activity A experiments at futurumcareers.com/Angela-Kross-activity-a1-a2-video.mp4 and futurumcareers.com/Angela-Kross-activity-a3-video.mp4

Activity C: Explore how light interacts with sensors

You will need:

- Remote control (e.g., for a TV)
- Camera phone(s)

NEVER point the remote control directly at someone's eyes!

1. Press any button on the remote control. Do you see any light coming from it? DO NOT look into the remote – look from the side.
2. Point the remote control towards your camera phone and press any button while watching the phone screen. Do you see any light coming from the remote control? DO NOT look into the remote – look at the phone screen.
3. Try pointing the remote control at different cameras while pressing any button. Do you see different amounts of light with different cameras?

Watch a video of Angela conducting this experiment at futurumcareers.com/Angela-Kross-activity-c-video.mp4

Questions

1. Why do you see light from the remote control with a camera but not with your eyes?
2. Why do you think the amount of light observed is different for different cameras? (if applicable)
3. What kind of light do you think the remote control uses?

Activity D: Explore how light interacts with plants

In greyscale images of specific wavelength ranges (i.e., colour bands), objects that reflect a lot of that colour will appear white, while objects that absorb a lot of that colour will appear black.

The greyscale images below show two plants that have been imaged in five different colour bands (blue, green, red, near-infrared and red edge).

Band 1 – Blue	Band 2 – Green

Band 3 – Red	Band 4 – Near-infrared

Band 5 – Red edge	
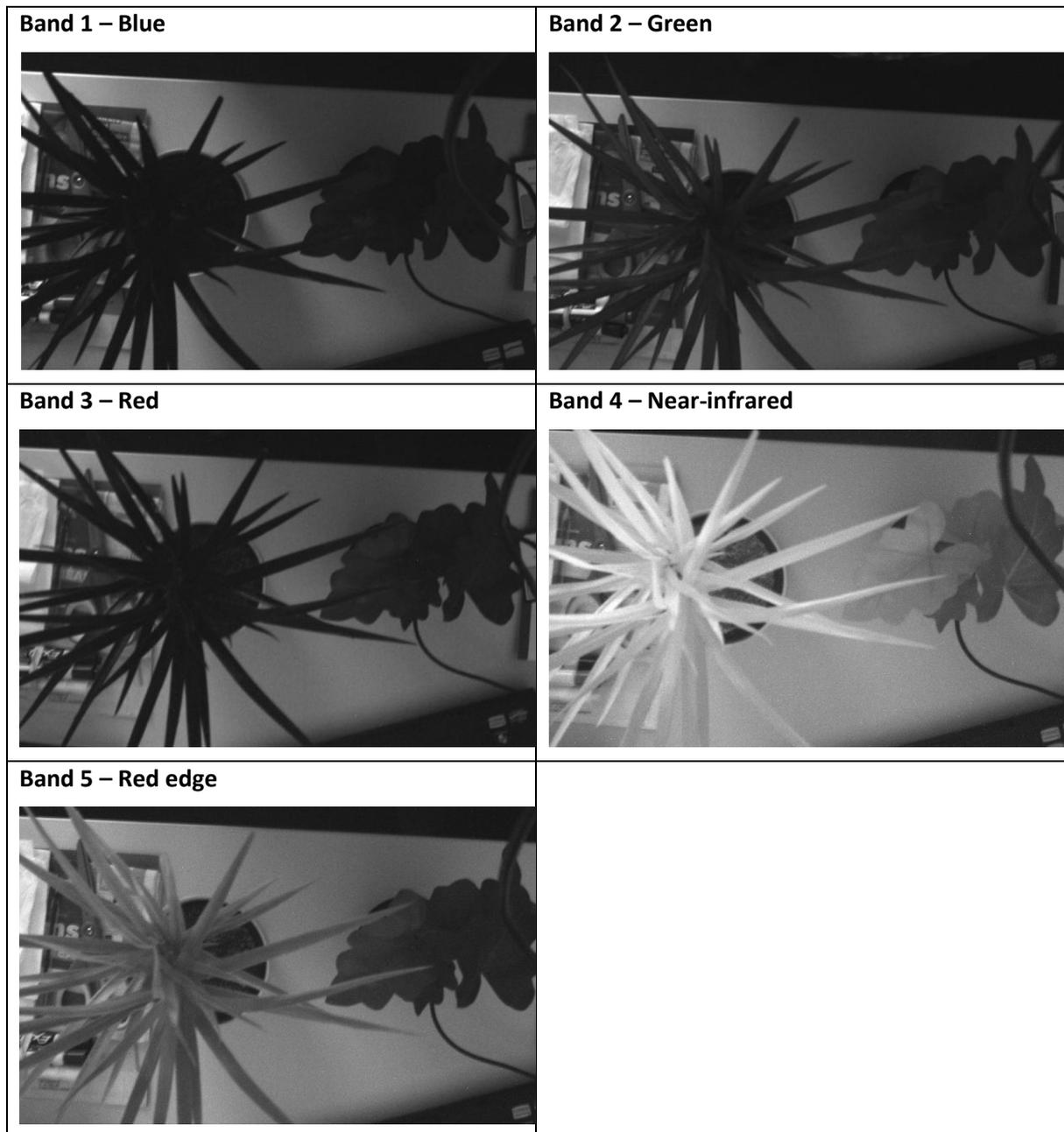
The diagrams below show how plants and different materials reflect different wavelengths of light.

(NIR = near-infrared, SWIR = short-wave infrared, UV = ultraviolet)
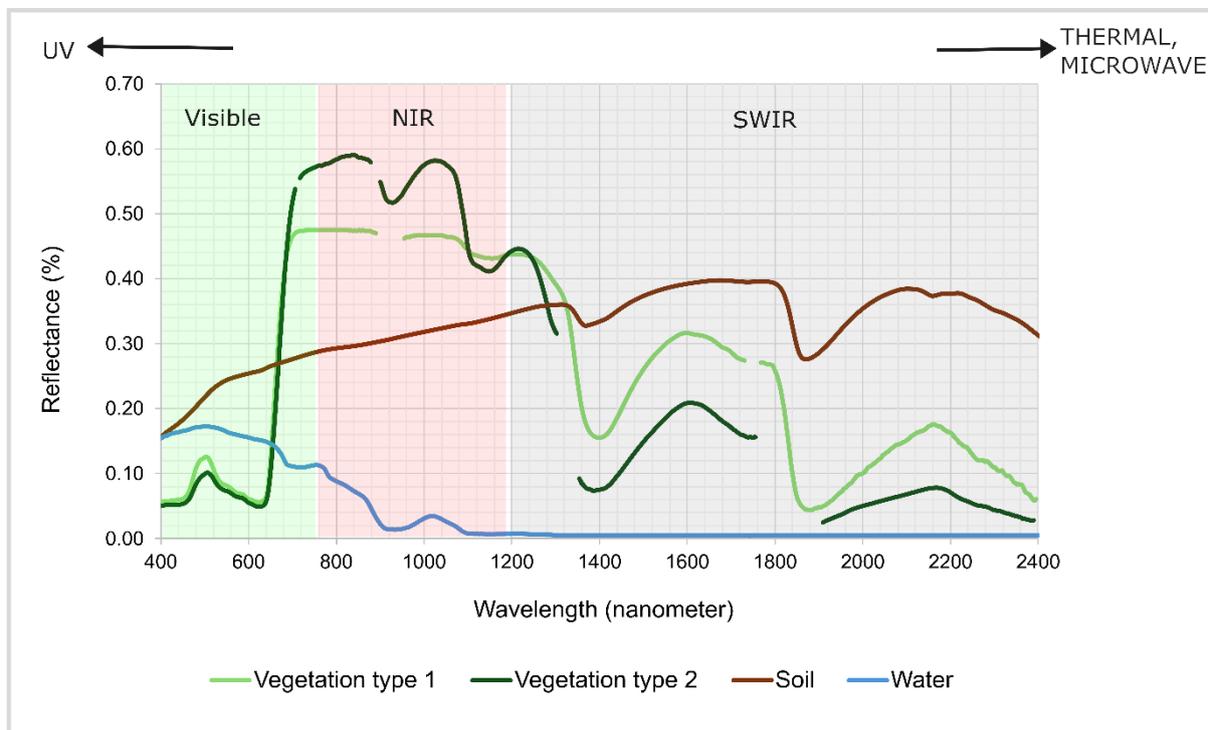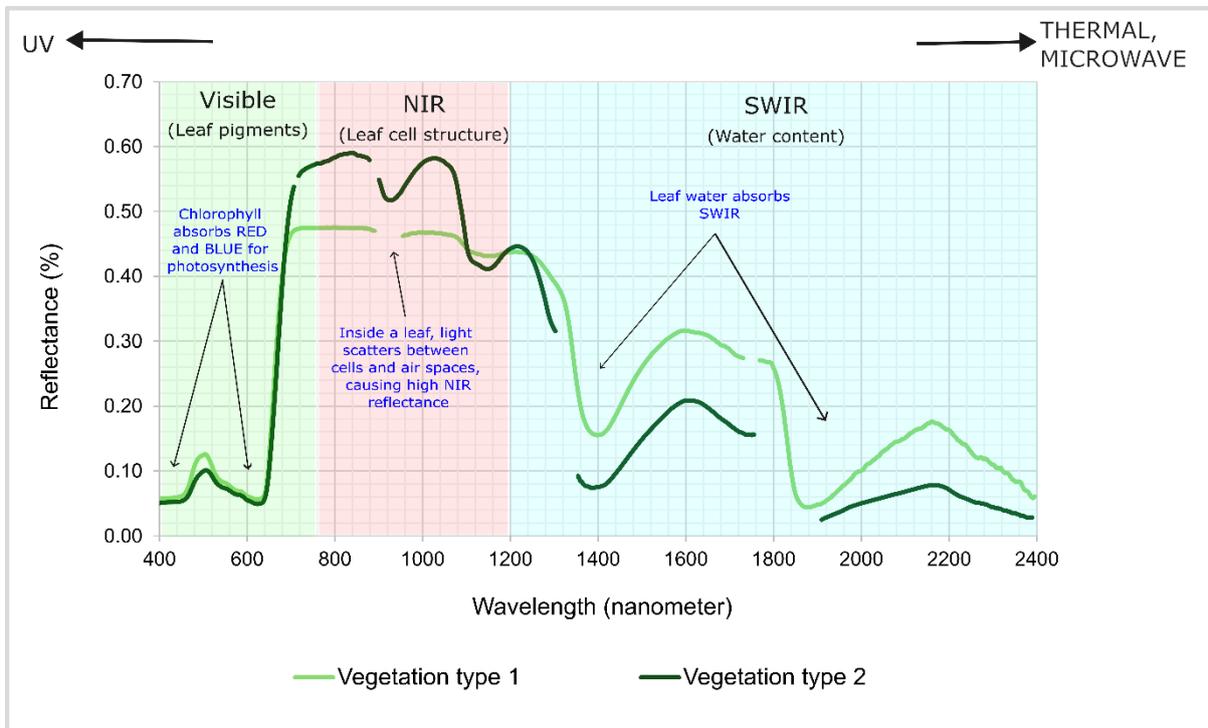
Angela created these spectral signatures in Excel using data from the US Geological Survey. You can download the data yourself from sciencebase.gov/catalog/item/586e8c88e4b0f5ce109fccae and find further information at usgs.gov/labs/spectroscopy-lab/usgs-spectral-library and usgs.gov/media/files/usgs-spectral-library-data-download-information-docx.

Questions

1. In the greyscale images, how does the reflectance of the plants differ in each band? Why does this occur? For example, why is the blue band image so dark and the near-infrared band image so bright?
2. How does the reflectance differ between the two plants? In which band(s) do the plants differ the most? Why might this be?
3. Which band would allow you to differentiate between the two different plants and the soil in the pots?

Activity E: Remote sensing for agricultural monitoring

Imagine you are part of a research team helping farmers use remote sensing to improve irrigation efficiency.

1. What kind of remote sensing data do you think would be most useful for monitoring crop health and detecting water stress in crops. For example, what types of light would you want to measure, and why?
2. What remote sensing platforms (e.g., satellites, drones) would you use to collect your data, and why?

Use information from Angela's article and the following sources to help you:

- Natural Resources Canada: natural-resources.canada.ca/science-data/science-research/geomatics/remote-sensing/tutorial-fundamentals-remote-sensing
- Canada Centre for Remote Sensing: natural-resources.canada.ca/sites/nrcan/files/earthsciences/pdf/resource/tutor/fundam/pdf/fundamentals_e.pdf
- Science Education through Earth Observation for High Schools: seos-project.eu/index-en.html
- Remote sensing for agricultural applications: A meta-review, Weiss et al., 2020: doi.org/10.1016/j.rse.2019.111402
- A geospatial framework for the assessment and monitoring of environmental impacts of agriculture, Kross et al., 2022: doi.org/10.1016/j.eiar.2022.106851

Activity F: Role-play the importance of science communication

In pairs, one person will take on the role of a remote sensing researcher while the other will be a farmer (who manages Field B from Activity B, see futurumcareers.com/how-can-remote-sensing-make-agriculture-more-sustainable). Role-play a conversation in which the researcher explains to the farmer how remote sensing could help improve crop health.

Use information from Angela's Futurum article, your answers to Activities B, D and E, and other sources you find online to contribute to your discussion.

The researcher should explain:

- How remote sensing is used to monitor crop health
- How satellites use different types of light to monitor crop health
- Why near-infrared images are useful for monitoring crop health
- How this information can support better agricultural management decisions (such as irrigation)

The farmer should ask questions to learn more, such as:

- How often can I get remote sensing data of my farm?
- Do I need specialist equipment to get or interpret remote sensing images?
- How will remote sensing images help me save money or water?

Download satellite images and remote sensing data

If you want to download free satellite images and remote sensing data, Angela recommends MODIS or Landsat data from NASA or Sentinel data from ESA, which can be found on the following platforms:

- glovis.usgs.gov
- earthexplorer.usgs.gov
- browser.dataspace.copernicus.eu
- planet.com/explorer

Answers

Activity A: Explore how light interacts with objects

1. When you shine white light on the red and green gummy bears, the light is transmitted through both. The red bear reflects and transmits red light while the green bear reflects and transmits green light.

2. When you shine red light on the red and green gummy bears, the red bear reflects and transmits the red light and so it appears whiter, while the green bear absorbs the red light so appears darker.

3. A colour filter lets only one colour of light pass through it; it absorbs all other colours. So, a red filter will absorb all colours except red. Through a red filter, you will see objects as shades of white-to-pink and red-to-black. Objects that reflect red light (i.e. red objects) will appear white, while objects that absorb a lot of red light (e.g., green objects) will appear black. In this experiment, the red filter only lets red light through. The red gummy bear reflects red light which can pass through the red filter, so the bear appears bright or white when viewed through the filter. In contrast, the green gummy bear absorbs red light. It reflects green light which cannot pass through the red filter, so the bear appears dark or black when viewed through the filter.

Activity B: Case study – remote sensing of crop health

1. Considering that the two fields have the same crop type (corn), the brighter appearance of Field A in the near-infrared indicates healthier vegetation and/or denser vegetation with well-developed leaf structure, whereas the darker appearance of Field B suggests vegetation that is stressed, less dense or less vigorous.

2. The plants in Field B may be experiencing stress (e.g., water stress, nutrient deficiency or disease), which reduces leaf structure and NIR reflectance. Field B may have lower canopy density or leaf area (e.g., later planting date so at earlier growth stage, poor emergence or partial crop damage), allowing more NIR to be absorbed by the soil.

Activity C: Explore how light interacts with sensors

1. You can't see the light with your eyes because the remote control uses a wavelength that is not in the visible light range. Cameras can detect light beyond the visible spectrum and so can detect the light emitted by the remote control.

2. Different cameras will have different sensitivities and may have different filters in them.

3. Most remote controls use infrared light, which is just beyond red light in the visible spectrum.

Activity D: Explore how light interacts with plants

1. The reflectance of each colour band depends on the interaction of an object with that specific band. For plants, this is illustrated in the spectral signature graph. Plants absorb blue light (~435-500 nm), so very little blue light is reflected. This means plants appear dark in a blue band greyscale image. In contrast, plants reflect near-infrared light (~750-1400 nm). This means plants appear bright in a near-infrared band greyscale image.

2. The difference in reflectance between the two plants is most obvious in the near-infrared and red edge bands. This could be due to differences in plant health, stress levels, growth/development stage, leaf colour or species (in this case, the plant on the right is a fake plastic plant).

3. The near-infrared band (band 4) shows the greatest difference between the plants and soil.

Activity E: Remote sensing for agricultural monitoring

1. Multispectral data that measure visible, near-infrared and shortwave infrared (SWIR) light are especially useful for monitoring crop health and water stress. Visible bands provide information on chlorophyll content (visible light is absorbed in the photosynthesis process), near-infrared wavelengths relate to leaf and canopy structure (reflected). SWIR light is absorbed by water in the plants, making that range particularly effective for detecting plant water stress.

2. Satellites are well suited for monitoring large agricultural regions over time as they can provide continuous spatial and temporal data (daily, weekly, monthly, depending on the satellite platform). Drones provide high-resolution data for detailed field-scale assessments.