NIR Plant Stress Test:
Investigating the Impact of Light and Water on Plants

Objective:

The primary objective of this classroom experiment is to deepen students' understanding of how different wavelengths of the electromagnetic spectrum, particularly Near Infrared (NIR), can be used to assess plant health. By conducting a hands-on experiment with plants, students will explore how the NIR reflectance changes over time in response to variations in light and water conditions.

Materials:

- STELLA spectrometer
- Computer with appropriate USB cable
- Leafy green plants
- Water
- Plant tray
- Sheet of Polystyrene Foam
- Full spectrum grow light (if indoors) or sunshine
- Excel software for data analysis

Setup:

1. Place the plants on a tray, positioning them in full sunlight or under full spectrum grow lights.
2. Divide the plants into two groups and arrange them close together, with the leaves leaving little to no gaps when viewed from above.

Activity Steps

Introduction (15 minutes):

- Discuss the importance of understanding plant health and the role of different wavelengths, especially NIR, in assessing vegetation.
- Explain the experimental setup and the variables being tested: water availability and light exposure.

Setup and Initial Measurements (10 minutes):

- Take initial measurements from both groups of plants

Daily Measurements (15 days):

- Perform calibration measurements each day before taking plant measurements.
- Take measurements of calibration medium (polystyrene foam) and plants from same measured height and angle.
- Water one group of plants regularly while withholding water and/or sunlight/grow light from the other group.
- Use the STELLA spectrometer to take daily measurements from both groups, controlling for variables such as angle and distance.

Data Analysis (60 minutes):

- At the end of 15 days, gather all the measurements.
- Convert measurements to reflectance before comparing.
- Use Excel to create graphs mapping out curves of reflectance for each day.

Discussion (20 minutes):

- Lead a class discussion on the observed trends in NIR reflectance over the 15-day period.
- Encourage students to analyze and interpret the data, considering the differences between the groups.

Conclusion and Reflection (10 minutes):

- Summarize key findings from the experiment.
- Discuss the implications of the results for understanding plant stress and health.
- Encourage students to reflect on the broader applications of using NIR spectroscopy in agriculture and environmental monitoring.

This classroom experiment engages students in a long-term investigation, allowing them to observe and analyze the effects of water availability and light exposure on plant health through NIR reflectance. The use of real-time measurements and data analysis in Excel enhances students' scientific inquiry skills and critical thinking.

Calibration Procedure and Formula:

- keep foam board as clean as possible
- keep STELLA as still as possible when taking calibration measurements
- take measurements from same angle (nadir being ideal)
- measure and maintain distance from calibration medium (foam board)
- avoid any shadows
- take at least 20 measurements (green: sample and average mode)
- during times of heightened atmospherics (more clouds) take frequent calibration batches as close to other measurements as possible

STELLA Reflectance Formula:

STELLA spectral sensor data are reported in irradiance units (uW/cm^2) and need to be converted to reflectance units which makes knowing the height from the medium crucial.

Use the formula below to convert from irradiance to reflectance:
Radiance from Irradiance: Radiance = irradiance * distance²/Area

Further Information, Videos and Visuals:

Tour of the Electromagnetic Spectrum – visuals
A pdf to learn how we use the EM spectrum in our daily lives and for science, containing visuals.
https://smd-cms.nasa.gov/wp-content/uploads/2023/08/tour-of-the-ems-tagged-v7-0.pdf

- **Tour of the Electromagnetic Spectrum** – companion video playlist: https://www.youtube.com/playlist?list=PL09E558656CA5DF76

Reflected Near-Infrared Waves – video, visuals
Contains valuable information, a video and visuals about near infrared and using it to detect plant health.
https://science.nasa.gov/ems/08_nearinfraredwaves/

Seeing Photosynthesis from Space: NASA Scientists Use Satellites to Measure Plant Health - video, visual
Contains valuable information, a video and a visual about detecting plant health from space.
https://www.nasa.gov/earth-and-climate/seeing-photosynthesis-from-space-nasa-scientists-use-satellites-to-measure-plant-health/

Food Documentary Explores Satellites and the Future of Farming - video
Contains valuable information and a video about programs using satellite data to monitor global agriculture.
https://landsat.gsfc.nasa.gov/article/food-documentary-explores-satellites-and-the-future-of-farming/

Meet Dr. David Lagomasino
Contains valuable information about Dr. Lagomasino who is a Research Scientist and Assistant Professor of Coastal Studies at East Carolina University in North Carolina. He uses a combination of field data, environmental data, and remotely-sensed observations to study the impacts of human and natural disturbances on coastal ecosystems and the responses of the coastal landscape.
https://landsat.gsfc.nasa.gov/article/meet-dr-david-lagomasino/

More on STELLA:

STELLA (Science and Technology Education for Land/Life Assessment) project. STELLA instruments are portable low-cost do-it-yourself (DIY) instruments that support science education, and outreach through scientific engagement, inquiry, and discovery while helping you understand Landsat better.

https://landsat.gsfc.nasa.gov/stella/

Have any good ideas, suggestions or questions? Please post them on our open-source forum:
https://github.com/STELLA-Landsat/STELLA/discussions

More STELLA activities:
https://landsat.gsfc.nasa.gov/stella/stella-activities/
https://github.com/STELLA-Landsat/STELLA/discussions/categories/for-educators