

Plan Title: Is it Getting Greener?

Introduction

The topics in the sequence of lessons include:

1. A review of light and wavelengths; chosen so that students have a basis for understanding the technology being used to monitor vegetation changes.
2. Learning about color filters and why certain color filters are chosen to monitor vegetation.
3. Learning how scientists study vegetation patterns using phenology.
4. Learning how scientists use satellite data to study vegetation patterns.
5. Learn how scientists are using this data to study climate change
 - a. Understand topography changes from tundra to forest as a result of climate change, and in particular because of warming temperatures
 - b. Measure the rate of change from real satellite data
6. Discuss the implications of changing vegetation in the arctic
 - a. Organisms will benefit and why
 - b. Organisms will not benefit and why
 - c. Effect on atmospheric CO₂ levels

The change in vegetation in the arctic was chosen for three reasons. Firstly, I live in an area that is being dramatically affected as the landscape is changing from wetlands and tundra to forested areas as global temperatures increase. The effects can be seen from the plane flights between Kenai and Anchorage as every year there are more areas covered by trees. This topic is relevant to the students here because it affects their lives directly through road and building construction, recreational such as hunting, fishing, snow machining, skiing, and 4 wheeling, and effects the local economy as people participate in these activities.

The second reason this topic was chosen is that the light filters are a low-tech yet powerful tool for observation. It reviews basic physics principals, and since most students have a camera on their phone, they can go out and experiment with colored cellophane filters to see how they work. It gives students a chance to see how the technology they hold in their hands can be used and then how it relates to satellite technology. This lesson could be incorporated into a general science class (which is where I will be using it), into a physics class, or into an integrated

science class. It could be adapted to elementary and middle school level science curriculum as well.

The third reason is that changes in vegetation affect CO₂ levels which in turn affect the global temperature. In most parts of the world, the concern is that deforestation will cause less CO₂ to be absorbed by trees and plants, and thus leaving more in the atmosphere. Also, the albedo of the land changes when forested areas become dirt, concrete, or agricultural areas. This will have an effect on the radiation budget. Here in the arctic, the opposite is happening as far as deforestation: shrubs and trees are “migrating” north! As the temperatures warm, the growing season lengthens, permafrost melts deeper each year and stays melted for longer periods of time, the roots of larger plants can take hold. This is changing the tundra and wetlands in the area. This concept presents a contradiction in “popular media” reports of climate change. It gives the students an opportunity to see another point of view and to draw their own conclusions as to whether climate change is “good” or “bad.”

One note: this was adapted from a section of the curriculum I wrote in October, 2011 when I worked at the Challenger Learning Center of Alaska. Some of the ideas in this lesson were part of the curriculum for a traveling educational display and classroom follow up for a NASA grant called “Eyes on the Arctic.” The curriculum was my own original work, and I want to make sure that no one thinks I am plagiarizing someone else’s work. If you would like more information on the grant and the grant curriculum, I can refer you to the Challenger Learning Center of Alaska for more information.

Define Learners

This unit is written for high school or beginning college level. It can be used in a general or integrated science class, an earth science class, or a physics based class. The activities can be adapted for younger learners with some modifications.

The learners should have some basic knowledge of the principles of light, however, a review is included in the first part of the lesson. The students will also have had an introduction to climate change and some of the principles behind it (see Curriculum Links). The students I work with at the Alaska Christian College have a very basic knowledge of science and most have taken only the minimal requirements for graduation. Some students have English as their second language and struggle with the reading. Visual resources are helpful.

The lessons can be done individually or in small groups. I would encourage the use of small groups (2-3 individuals) as the groups are small enough for all to participate, yet ideas can be

interchanged between members of the group. Groups can compare their observations and data at the conclusion of the lessons.

Standards

Alaska State Science Performance Standards (Grade Level Expectations or GLE's)

<https://www.eed.state.ak.us/akstandards/standards/standards.pdf> (1)

- 9th** **SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating
SA1. 2 hypothesizing, making qualitative and quantitative observations, interpreting data, and using this information to communicate conclusions
SA2.1 formulating conclusions that are logical and supported by evidence
SE2.1 questioning, researching, modeling, simulating, and testing a solution to a problem
- 10th** **SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating
SA1.2 reviewing pertinent literature, hypothesizing, making qualitative observations and using this information to draw conclusions, compare results to others, suggest further experimentation, and apply their conclusions to other problems
SA2.1 examine methodology and conclusions to identify bias and determining if evidence logically supports the conclusions
SE2.1 questioning, researching, modeling, simulating, and testing multiple solutions to a problem
SG3.1 using experimental or observational data to evaluate a hypothesis
- 11th** **SA1.1** asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating
SA1.2 recognizing and analyzing multiple explanations and models, using this information to revise students own explanation or model if necessary
SA2.1 evaluating the credibility of cited sources when conducting the student's own investigation
SC3.2 analyzing the potential impacts of changes (e.g., climate change, habitat loss/gain, cataclysms, human activities) within an ecosystem
SE2.1 questioning, researching, modeling, simulating, and testing multiple solutions to a problem

Topic

The main topic will be exploring the changes in vegetation that are occurring as a result of increased global temperatures. The changes in the Arctic are happening faster and with different consequences than in the rest of the world. The students will explore how scientists collect and use data to monitor changes that are resulting from increased temperatures.

There are two basic science topics involved. The first is a basic physics concept of light, using colored filters to observe vegetation and explore how different colors affect what you see. Students will explore results of satellite data where filters are used to look at specific wavelengths for a vegetation index. The second basic concept is to make measurements on satellite pictures and calculate areas from these data. Students will draw conclusions based on their observations and calculations.

Curriculum Links

This unit fits into the rest of the curriculum as part of an overall section on climate change and the Arctic. In the Introductory Science Class, it will be used to help show how basic science principals are applied in the real world. It will be used as one of the last parts of the climate change section at the end of the semester to help unify other concepts taught in the class.

Prior to this lesson, the students will have had the following units:

- Carbon cycle and atmospheric CO₂ levels
- Albedo – what it is, measuring temperature changes based on color
- Geological record of climate change
- Habitats – in particular Arctic tundra and boreal forest

Following this unit, the students will wrap up on climate change and the many factors that go into change and modeling of change. Then they will study food web and ecosystem interactions by using the Denali Food Web.

Objectives

Students will be able to:

- Describe how scientists use satellite data to monitor vegetation
- Explain how light reflectance can be used to interpret ground based data
- Use satellite data to measure an area of vegetation change in the Arctic
- Infer the consequences of the changing vegetation changes in the Arctic

Materials

- Laptop computer for each student or pair of students
- Smart board or other projection system
- Access to internet and NDVI (Normalized Difference Vegetation Index) data
- Access to a photo processing software such as Photo Shop or other camera software available on laptops
- Pictures of vegetation and landscapes taken through RGB filters (one set per group; cut apart prior to passing them out; these can be laminated and students can use dry erase markers to write on them)
- RGB Filters (frame from file folder with red, green and blue cellophane wrap)
- Digital camera or phone camera with connector for laptops
- Copies of Activity sheets (one per small group)

Time

Each activity is designed to be for one 45-60 minute class session. A 2 hour lab session will be used for Activity One if students are going to take photos with their cameras and analyze them. A 2 hour session can also be used for the measurement and calculations of areas for the “migrating shrubs” activity. This way, students can receive assistance with how to set up a grid and measure the areas on the satellite photos.

Scope and Sequence

Focus Discussion (One class session)

1. Show the NDVI or vegetation data on the Smart Board* or other projection system. Use the website http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD13A2_M_NDVI (2) and download the QuickTime animation of the vegetation data.
2. Show the video. Ask students to make observations about what they see. Discussion questions should include:
 - a. Where is the most vegetation?
 - b. Does the vegetation change with seasons?
 - c. Does the vegetation change over time (years)?
 - d. What do you observe for a, b and c in the northern polar regions?
 - e. Is this different than for the equatorial regions? Why or why not?
3. Ask students for ideas on how scientists obtain this data. They can make a list as a class or in small groups, then share their ideas. These can be written on a white board or large paper to display in the classroom.

4. Explain that in the next few lessons, students are going to learn how satellite imaging is used to track plant growth and location. Discussion questions should include:
 - a. Why is this important?
 - b. What is the connection to the climate change we have been studying?
5. Compare the vegetation animation with the surface temperature representations (on the same website). Show the animation, and have students discuss or record what they observe. Discussion questions can include:
 - a. How are the animations similar?
 - b. How are they different?
 - c. How do they change with seasons?
 - d. What changes do you notice from the first years to the later years?
 - e. What are some ideas about why the seasonal and yearly changes might occur?
Students can make a list of their ideas, then go back and visit those at the end of the unit to see if and how their ideas may have changed.

*This could also be done in pairs or small groups. Direct the students to the website and give them the discussion questions to answer. At the end of the activity, have students share their ideas with other groups.
6. Compare the vegetation animation with the snow cover animation (on the same website). Show the animation, and have students discuss or record what they observe. Use the same discussion questions as listed above.
7. To conclude the investigation, have students write two observations for each map: vegetation, surface temperature and snow cover. Have them write how they compare to each other.

Activity One: What is light? (A review of ROYGBIV) (One class session)

1. Instruct students to use their laptops and go to the Mission Science and NASA Goddard websites on electromagnetic energy. Pass out the Activity One sheet (one per student or one per group).
2. Instruct students to read the introduction at the first website then answer the questions for Activity One: <http://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html> (3)
3. Instruct students to look at the near infrared waves section in the Mission Science website: http://missionscience.nasa.gov/ems/08_nearinfraredwaves.html (4). Have students answer the rest of the questions for Activity One.

This can be done in pairs or in small groups. An option would be to have students write the answers in a science journal or science blog if one is used for the class. Assist the students with completing their observations as needed. Have students discuss and share their answers at the conclusion of the activity.

Activity Two: Seeing Red (or green or blue) (One class session; one lab session or two class sessions if the cell phone camera option is completed)

1. Explain to students that they are going to look at photos of vegetation taken through red, green and blue filters.
2. Students will answer the questions on the activity sheet as they work to compare the visual effects of the filters and try to interpret what they mean. Pass out the Activity Two sheets. This can be done in pairs or small groups.
3. Set aside the “normal” color photos. Pass out one set of filtered photos to each group.
4. Instruct students to look at the photos. Explain that there are questions on the activity sheet to guide them with their observations. They are to make comparisons between the photos and discuss what the real-color photos may look like. Specifically for each color filter:
 - a. Is there green vegetation in the photo? What makes you think that?
 - b. Does the vegetation look the same with the different color filters? How is it the same? How is it different?
 - c. Are there non-green (brown or other color) areas in the photo? What makes you think so?
 - d. How do the areas without green vegetation look with the different color filters? How is it the same? How is it different?
5. Students will answer the questions on the activity sheet as they work to compare the filters and try to interpret what they mean.
6. After all students have completed the activity, pass out the true color photos. Have students complete their analysis of the vegetation by comparing their observations of the color filtered photos to the true color photo of the same area. Discussion questions should include:
 - a. With which color filter was it easier to find vegetation?
 - b. With which color filter was it easier to find non-green (no vegetation) areas?
 - c. Did everyone “see” the same thing? What are some reasons that there are different interpretations of the same photo?

This is a great time to discuss how each person interprets color differently, although we all “agree” on what is red, blue, etc. If there are any color blind students in your class and they don’t mind sharing, ask them how what they see compares with someone who is not color blind.

7. Have students complete their analysis of the vegetation using the activity sheet as a guide.
8. If possible, take the RGB filters and look at vegetation around the school. Indoor plants could also be used. Have students describe how the vegetation or plants look under

each colored filter. Try to find some green plants and some areas that are not green or areas with different color leaves or flowers to compare.

9. Students can use the filters and a cell phone or digital camera to take pictures of vegetation outside or inside the school. Have them take a true color photo, then photos using each of the filters. Students can print them out include photos and write a description of what they observed in their blog or journals online. For each photo, have them include:
 - a. Plant (if they can identify it)
 - b. Location (inside, outside, in the parking lot, etc).
 - c. Time of day taken (ask if this makes a difference and why)
 - d. Filter that was used.

Photos could be displayed in the classroom or on a web or blog site.

Activity Three:

Part 1: What's on the ground? (1/2 class session)

1. On their laptops either individually or in small groups, have students go to the phenology website and read about phenology and what it is.
<http://phenology.cr.usgs.gov/overview.php> (5).

This could also be done as a class discussion. Discussion questions should include:

- a. What is phenology?
 - b. What might it be used for?
 - c. Could it be a useful tool for studying climate change? Why?
2. Next have students go to the information sheet produced by the USGS.
<http://pubs.er.usgs.gov/publication/fs20143052> (6). Have students use the Activity guide to walk through the information then answer the questions.

Part 2: What's up from space or NVDI (1/2 class session)

1. Start with an instructor led class discussion. Explain what NDVI stands for and what it means. Do this by going to the website with a good explanation of NDVI and EVI:
http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php (7). Use the Smart Board or other system to display the website. This could also be done on individual laptops with the instructor guiding students.

Discussion questions should include:

- a. What does NDVI stand for?
- b. What does it measure?

- c. Why is this a useful tool for scientists, and in particular for those studying climate change?
- d. Why is infrared radiation used instead of visible light?
- e. Why is this data useful when collected and analyzed by satellite?

This NOAA website has a brief discussion of satellites if you want to supplement the lesson: <http://www.noaa.gov/satellites.html> (8).

As another supplement, this website has a brief description and graphic of how communication with satellites from the ground works:

<http://www.intelsatgeneral.com/resources/satellite-basics> (9).

2. Explain to student that they are going to look at some real NDVI data. They are going to do a guided exploration of the website. Direct students to the drought website which uses NDVI data <http://maps.wfas.net/> (10). Pass out the Activity Three, Part 2 sheet.
3. Display the website on a Smart Board or other projection system while students have the website on their laptops. Go over the settings with the students and explain what the different settings mean. Pick an example to show:
 - a. Base layer: Blue Marble (this is just the earth)
 - b. WFAF Rasters: use “Depart from Normal” to show a comparison of the year chosen to “normal” (Rasters refers to how the data is displayed on the screen)
 - c. Use Single Image. Students can experiment with compare images if time, however the data is difficult to interpret for this lesson.
 - d. Show how to pick dates to compare. Explain that they will look at a minimum of 2 dates 10 years apart and make comparisons.
 - e. Explain the color scale. For this lesson, the numbers are not important. The red means less than normal, then the scale increases to normal in the middle (around 116 to 125), and the deepest green shade is greater than normal. Explain that the numbers are values that the computer image gives to each pixel on the display. They are a way to show the data so humans can easily interpret it rather than putting a number for reflectance on the map at each point.
4. Have each person or group choose two maps of at least 10 years apart. Answer the questions on the Activity Three, Part two sheet.
5. At the end of the class, have students compare their observations.

Activity Four: Migrating Shrubs (One lab period)

1. On their laptops, direct students to the Earth Picture of the Day with migrating shrubs.

<http://earthobservatory.nasa.gov/IOTD/view.php?id=76962> (11). This can also be displayed on the Smart Board or other projections system. Use the projector to demonstrate how to set up a grid to measure the areas of shrubbery.

2. Have students read the article about the shrubs. Discussion questions should include:
 - a. Where were these photos taken?
 - b. Why are scientists studying changes in shrubs in the Arctic?
 - c. Could or is this change happening where you live?
 - d. What might this tell us about climate change?
3. Print out the images. Give one set to each pair or group of students.
4. Show the students how to make a grid on the maps (use graph paper or copy the images onto graph paper) and using the scale on the map, estimate the area of shrub cover in each image. This can be done on the Smart Board with markers and a ruler.
5. Pass out the sheet for Activity Four. Have students use this as a guide and answer the questions.
6. At the conclusion, students can share their answers. Discussion can include:
 - a. Are all the student's measurements the same?
 - b. Are the student's measurement similar?
 - c. What would cause the measurements to be different?
 - d. How would a scientist deal with the measurements?
 - e. Share and compare your ideas on the consequences of "Migrating Shrubs" in the Arctic.

Activity Five: Wrap Up and Conclusions (One class session)

1. Review with students the NDVI and what it means.
2. Discuss the following questions with the students:
 - a. How can scientists use this data to monitor global warming?
 - b. What changes in vegetation location could be anticipated as a result of global warming?
 - c. What impacts would changes in sea ice as a result of global warming have on vegetation and growth patterns?
3. What other applications might there be for this type of remote sensing? (Monitoring forest health, crop management, etc.)
4. Pass out the Activity Five sheets. Students should answer questions and summarize their observations and conclusions in their science journal or blog if one is used for class.

Supplementary Materials

Name _____

Activity One Reflection (no pun intended) Questions

1. Approximately what percent of the electromagnetic spectrum is visible light that we can see? (Make an estimate from the diagram on the website or look for another source. Please write the website you used.)
2. What two examples are given for infrared electromagnetic radiation?
3. What property of light is used to look at vegetation: absorption or reflection?
4. What difference do you see between the IR and the color photographs of the vegetation?
5. Look at the reflectance graph. Between what wavelengths is the most energy reflected? Where does this fall in the electromagnetic spectrum?
6. Why would near infrared be used by satellites to make images of and to study vegetation?
7. How could this information be used to monitor or study climate change?

Activity Two Reflection Questions

Do I See Green?

Scientists analyze satellite images that are filtered for certain wavelengths of light to determine the presence and health of vegetation. You are going to compare photos of vegetation taken through red, blue and green filters. By looking at the images, you will interpret what the landscape looks like and what kind of vegetation might be present.

1. Compare the three photos.
 - a. How are they different?
 - b. How are they similar?
2. On a separate piece of paper, trace the outlines of the green areas in the photo. Using colored pencils, color the outline in as you think it would look in true color.
3. Compare your interpretation to the real photograph.
 - a. How are they different?
 - b. How are they similar?
4. What kind of information could scientists interpret from this data?

5. What color would give the best information about where there are green plants from space? Why? Remember that these are close up photos, so you can see some shapes that may give you hints. From space, you would not be able to see the individual trees, just as you can't see them on a mountain that is several miles away.
6. Which colored filter do you think is most representative of the filtering used for the NDVI satellite images?

Photos for Activity Two (photos taken by Kathy East)



Newhalen, Alaska



Palmer Creek, Alaska



Clam Gulch Beach, Alaska



Kenai, Alaska

Activity Three Reflection Questions

Part 1

1. What is phenology? What is it used for?
2. Go to the data section (see screenshot below). You are going to download two maps for 2013.
 - a. First, the click on the map for the first row, Beginning of measurable photosynthesis in the vegetation canopy. Choose “Western US” and download the map.
 - b. Go to the third row. Click on the map for End of measurable photosynthesis. Choose “Western US” and download the map.
3. Look at and compare both maps. How are they the same? How are they different?
4. What do the two maps show?
5. Download maps from another year (pick a year between 2000 and 2006). How do these two maps compare?
6. How do the maps from two different years compare?
7. What could the differences tell climatologists about climate change? Why?

Part 2

1. For which two years did you compare maps?
2. How do they compare? Are they similar or different? What changes do you see?
3. How would the scale of the map affect what you observe? In other words, if the maps were bigger, could you see other changes?
4. Look at another year. What trends, if any, do you see?
5. How could this data help climatologists understand climate change?

Activity Four: Migrating Shrubs

1. What is the approximate area of shrub cover in 1996?
2. What is the approximate area of shrub cover in 2009?
3. What is the percent change from 1996 to 2009? Is this an increase or a decrease?
4. Estimate the rate of “migration” in terms of square meters per year. Explain how you did your calculation.
5. If the “migration” continues at the same rate, estimate how long it will take to finish filling in the tundra areas with shrubs (don’t count the lakes).
6. What are the consequences of changes in the tundra on:
 - a. Animals (caribou vs. moose and others)
 - b. Insect populations (for example, spruce bark beetles)
 - c. CO₂ absorption or release (refer to unit on the Carbon Cycle)
 - d. Contribution to overall atmospheric CO₂
 - e. Albedo and the amount of reflected radiation (refer to unit on Albedo)

7. Are these consequences good or bad? Discuss reasons for both points of view. Give at least one “good” example and one “bad” example.

Activity Five: Wrap up

1. How can scientists use remote sensing data to monitor global warming?
2. What changes in vegetation location could be anticipated as a result of global warming?
3. What impacts would changes in sea ice as a result of global warming have on vegetation and growth patterns?
4. What other applications might there be for this type of remote sensing?
5. Thinking about your community, what kinds of changes would you expect to see as global temperature increases? Could you be living in a different biome in the future? Describe what it might look like where you live in 50 to 100 years.

Assessment of Students

Students will be assessed on their participation (25%), their science journal or blog entries (25%) and 50% on completion of the activity sheets. I will give them a more specific rubric including how many points each section is worth when I develop the syllabus at the beginning of the semester.

Evaluation of the Lessons

At the end of the unit, there will be a quiz. The questions will cover the objectives stated at the beginning of the unit. I will also evaluate based on the ease of which student understood the concepts and were able to follow and complete directions. Adjustments in the lessons will be made as needed after the first group of students “test drives” the lessons!

References

Websites are embedded in the lesson plan for convenience. The resources include NASA and USGS websites and data. The following websites are used in the lessons:

1. <https://www.eed.state.ak.us/akstandards/standards/standards.pdf>
2. http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD13A2_M_NDVI

3. <http://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html>
4. http://missionscience.nasa.gov/ems/08_nearinfraredwaves.html
5. <http://phenology.cr.usgs.gov/overview.php>
6. <http://pubs.er.usgs.gov/publication/fs20143052>
7. http://earthobservatory.nasa.gov/Features/MeasuringVegetation/measuring_vegetation_2.php
8. <http://www.noaa.gov/satellites.html>
9. <http://www.intelsatgeneral.com/resources/satellite-basics>
10. <http://maps.wfas.net/>
11. <http://earthobservatory.nasa.gov/IOTD/view.php?id=76962>

Conclusion

This final project incorporates one small part of the information we learned and the driving factors in climate change. I will use this as one piece of the section on climate change – it usually covers approximately one third of my semester introductory science class.

There are several potential challenges. The first is the language barrier as many of my students have English as their second language. Another challenge is the diverse science backgrounds of my students. A few have taken an advanced science class in high school, however, most have taken the minimal requirements for graduation and do not have an interest in science. A challenge is making it understandable and relevant to the students. The idea of climate change and how it impacts students' lives is very real to many here in Alaska. They have seen firsthand things like coastal erosion, changes in vegetation, changes in snow and ice cover, etc. Because of this, it is a little easier for them to see the relevance.

This will fit perfectly into the class I will be teaching fall semester at Alaska Christian College. I already have a section on climate change as described above, but have not incorporated the aspect of vegetation changes. This will be a great addition to the class!