

Land Cover Change Detection Protocol



Purpose

Using MultiSpec software, evaluate and investigate changes that have occurred in the major land cover types of your GLOBE Study Site by examining the digital files of two Landsat satellite images that were acquired a few years apart.

Overview

Using MultiSpec software, students compare two registered images, acquired several years apart, of a GLOBE Study Site and identify changes in land cover.

Student Outcomes

Science Concepts

Life Science

- Organisms can change the environment in which they live.
- Earth has many different environments that support different combinations of organisms.
- All organisms must be able to obtain and use resources while living in a constantly changing environment.
- All populations living together and the physical factors with which they interact constitute an ecosystem.
- Humans can change ecosystem balance.

Geography

- How to use maps (real and imaginary)
- The physical characteristics of place
- The characteristics and spatial distribution of ecosystems
- How humans modify the environment

Scientific Inquiry Abilities

- Use land cover data and appropriate tools and technology to interpret change.
- Gathering spatial data and historical data to determine validity of change hypotheses.
- Identify answerable questions.
- Design and conduct scientific investigations.
- Develop descriptions and predictions using evidence.
- Recognize and analyze alternative explanations.

Communicate procedures, descriptions, and predictions.

Level

Middle and secondary

Time

Two or three class periods

Frequency

One time, but may be an iterative process as you progressively investigate more areas within your GLOBE Study Site

Materials and Tools

- Computer
- MultiSpec computer software (provided by GLOBE or downloaded from the Web)
- 2 - Landsat TM registered image datasets of the 15 km x 15 km GLOBE Study Site (disks provided by GLOBE), one recent, one a few years old, acquired at approximately the same time of year
- Printed Landsat TM images of the 15 km x 15 km GLOBE Study Site from the datasets
- Student land cover type map(s) of the GLOBE Study Site
- Topographic maps of your area (if available)
- Aerial photos of your area (if available)
- Introduction to the MultiSpec Program* and *Change Detection Tutorial*
- MUC data from previous land cover type map classifications

Preparation

- Install the MultiSpec software on the computers students will be using.
- Install the images on the computers the students will be using.
- Familiarize yourself with MultiSpec and the *Change Detection Tutorial*.

Prerequisites

Review and practice the *Introduction to the MultiSpec Program* and the *Change Detection Tutorial*.



Land Cover Change Detection Protocol – Introduction

Compare the two satellite images of your GLOBE Study Site. One was acquired before the other. However, the images have been *registered*. Registration is when the images are lined up so that every point on one image can be placed on top and matched with the same point on the other image. What has changed between the images? Can you see changes in your community's size, shape or dominant land cover? Is your school still surrounded by the same land cover classes? Can you see more vegetated areas in an image? Has there been a big event, such as a flood, earthquake, drought, hurricane, tornado, etc., which has changed your landscape? Has the type or size of natural areas changed? Are there more houses on your way to school? Can you see evidence of these changes in your satellite images?

Work on your own or with a partner. Make a list of questions about what you see in the images. Is there anything that you would like to know about these images regarding the change you may see? Some changes may not be easy to see but they are there.

Narrow your list down to one question. Once you have a question, come up with a plan to answer your question. You will need to use the Field Guide for *Land Cover Change Detection Protocol* and/or some of the other *Land Cover Field Guides*. In the *Land Cover Change Detection Protocol*, you *composite* the two satellite images. Compositing is combining two registered images into one. After that, you use the MultiSpec software to look for change.

Scientists use the same process to answer their questions about changes in satellite imagery. First they look at different images. Then they come up with questions they have about the images. Once they have decided on one question, they use scientific protocols or field techniques to answer it. Scientists may have to add new protocols or use ones that have already been used. You can do the same thing in GLOBE with the *Land Cover/Biology Protocols*.

Land cover change maps are a major product created from remotely sensed data. Keeping track of change is important to our understanding of the earth as a system. Knowing about these changes is the first step towards understanding why and where they happen. Change data can be used to update maps. It can also be used to estimate the rates of change in certain areas.



Teacher Support

The Measurement

The *Land Cover Change Detection Protocol* is the culmination of the *Land Cover/Biology Investigation*. In order to get to this point, students will have had to use the *Land Cover Sample Site* and *Biometry Protocols* to collect MUC data, and then used these data to create maps from their satellite image. In terms of understanding land cover, your students should be sophisticated and ready to be motivated to learn about the changes in their GLOBE Study Site that have taken place over time. They should be interested in tracking how future changes might influence the landscape. This protocol is the application of the protocols that have come before it and a point where there is room to incorporate other Investigations, if you have not already done so. The land cover of your GLOBE Study Site can influence temperature and in some cases, precipitation in your area. The history of the land cover can also influence the soil and the water bodies that are close to it. For example, heavily farmed areas that are now forest may have soil properties that indicate this. Currently farmed areas with high nitrogen levels in the soil can influence nitrogen values in a water body close to the field. It goes without saying that temperature, precipitation, soil and hydrology can also influence the types of land cover in an area. For instance, a drought can cause a field of herbaceous vegetation to die off. Tundra is not found near the equator. There are other relationships that you and your students may want to explore. The *Land Cover Change Detection Protocol* can be the starting point for exploring questions about such relationships. The student introduction can hopefully start your students thinking along those lines but they may also bring their own questions, such as how a new residential development in their neighborhood may influence their water supply or a neighboring wetland. Although the protocol directions themselves are simple, the true meaning of the protocol is in using it to identify and explore your students' questions about their changing landscape.

Obtaining Landsat Data

Your school may have already received more than one Landsat image; however, this protocol requires that the two scenes being compared be registered to one another and acquired at the same time of year. You may request scene pairs from GLOBE by contacting your Country Coordinator, US Partner, or the GLOBE Help Desk. Before making this request, your school must complete the *Computer-aided Land Cover Mapping Protocol* and have reported measurements for at least 10 Land Cover Sample Sites to GLOBE.

Teacher Follow-Up: For each band combination that you use to investigate change, use the **File** menu to save the image onto a disk as a TIFF file. If you have a color printer, print copies for comparison to your student-produced land cover maps. Students should prepare a summary on the nature of the changes they have discovered. Send copies of your land cover maps, change images, and student summary to the GLOBE Student Data Archive by following the directions given in the *How to Submit Photos and Maps* section of the *Implementation Guide*.

Supporting Measurements

All the *Land Cover/Biology Protocols*

Student Preparation

Have an understanding of MUC

Implementation of the *Land Cover Sample Site Protocol* at least 10 times

Completion and understanding of the *Computer-aided Land Cover Mapping Protocol*

Review and practice the *Introduction to the MultiSpec Program* and the *Change Detection Tutorial*



Helpful Hints

- When your students look at the two images, they might not see any major areas of change between them. This does not mean that change has not occurred, only that the changes are relatively small.
- Comparing a single Landsat channel between two years is helpful for looking at changes for different land cover types. Each channel has specific applications based on the spectral signatures of the different land cover types.
- If a pixel in the **newer** image is brighter than in the **older image**, that pixel will show **green**. This means an **increase** in the property being measured.
- If a pixel in the **older** image has a higher reflectance, the red and blue will produce **magenta**, indicating a **decrease** in the measured quantity in the newer image.
- Since strong visible reflectance is often associated with exposed mineral materials (urban development, rocks, bare ground) we might infer that in a (1, 6, 1) combination, green areas have undergone an increase in urban development. Landsat channel 1 (blue) is useful for human-made features.
- It is important to consider the time of year each satellite image was acquired. Most of the time, your images will be at the same time of year but there may be a few crucial weeks of difference between them. For example, in one image, the leaf foliage may not be completely out or certain crops may not have been planted in agricultural fields. In a (4,9,4) combination, when green areas in two different images taken at different times of the year are evident, we are faced with the problem of deciding how much of the change is due to a real increase in vegetated area, and how much is due to seasonal variations. (See the example in the Durham, NH, images in the *Change Detection Tutorial*.)
- If we can find locations that appear to show an increase in vegetation in the newer image, we might infer more strongly

that these represent areas of real vegetation increase. Conversely, areas of magenta in the newer image that appear green in the older image could represent areas of vegetative decrease. Landsat channel 4 (near infrared) is useful for vegetated areas.

- Have your students fill in the names of the files they will be using on their *Field Guide*.

Questions for Further Investigation

- Which land cover type (MUC class) changed the most? What are some causes of this change?
- Generally, was there an increase or decrease in vegetation?
- Look at other areas of change. Try to explain why these changes occurred. Are these changes because your satellite images are from different time periods (i.e. summer vs. winter, drought vs. rainy season), or was there human influence, or a major environmental event (i.e. fire, flood, etc.)?
- How can you use this change information to help your community?
- How would your satellite image change if you compared different seasons? How would the composite image appear?
- What is the effect of temperature and precipitation in the time immediately preceding the images? Students will have to research this question.
- If you live in a coastal region, what is the effect of the position of the tides? You will have to research the times of high and low tides on the dates of your images. Remember that Landsat images are acquired in the morning.

Change Detection Protocol

Field Guide

Task

Use MultiSpec to combine the digital data for two images of your GLOBE Study Site (acquired a few years apart) into one composite image and analyze the composite to learn about the land cover type changes that have occurred.

What You Need

- Introduction to the MultiSpec Program and the Change Detection Tutorial*
- MultiSpec computer software
- MUC data from previous land cover type map classifications
- 2 - 512 x 512 pixel Landsat TM registered image data of the 15 km x 15 km GLOBE Study Site (disks provided by GLOBE), one recent, one a few years old
- Computer

What To Do

1. Compare the hard copies of the Landsat TM images from the two different dates. What are the differences that you see between them?
2. Start the MultiSpec program on the computer.
3. From the **File** menu, select **Open Image**.
4. Select and open the older image of your GLOBE Study Site. It is labeled _____. Follow the defaults in the *Change Detection Tutorial*.
5. Select and open the newer image of your GLOBE Study Site. It is labeled _____. Check the **Link to Active File** box.
6. Reformat, name and save the new image (called _____) using the directions in the *Change Detection Tutorial*.
7. Open the new image and follow the directions in the *Change Detection Tutorial* for saving the statistics.
8. Examine the image for change by following the defaults in the *Change Detection Tutorial*.
9. Save the developed land cover image (1, 6, 1) and the vegetative image (4, 9, 4) used for comparison as TIFF files. See you teacher for further instructions on submitting them to GLOBE.



Looking at the Data

Are the data reasonable?

After you have completed the production of your Land Cover Change Image, you will have drawn some conclusions about which land cover types have shown increases or decreases in the time between your two images. Land cover changes in both space and time. Some of these changes, such as the process of succession in a wooded area, are natural. Others are “anthropogenic,” that is, produced by human beings. To determine whether these apparent changes are reasonable, use the substantial amount of data collected with the *Land Cover Sample Site Protocol*. The Land Cover Sample Sites that you visited will help to determine the accuracy of your land cover maps. If you find that you need more data than you have, simply use the protocol to collect more.

For example, if your change image appears to show large increases in urban areas within your GLOBE Study Site, you will need to visit these areas to determine if this is really the case. Remember that some kinds of features appear very similar in Landsat images. Clouds, beach sand, and highly developed urban areas all appear similar, and may not be well distinguished. Since you are the experts for your GLOBE Study Site, you can use your own familiarity with the area to help you determine if the changes shown are reasonable.

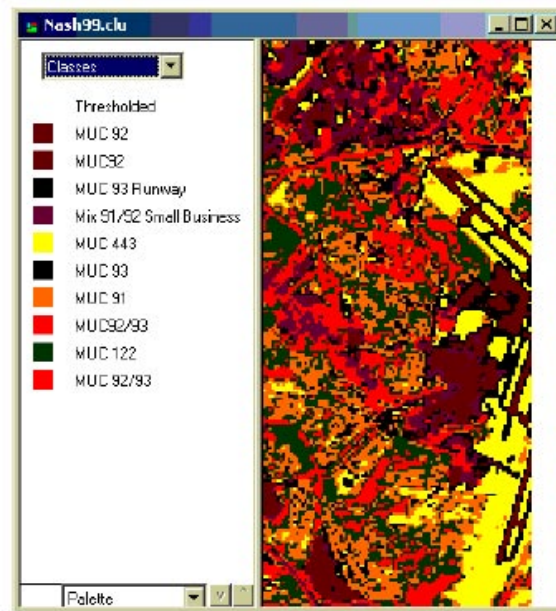


What do scientists look for in these data?

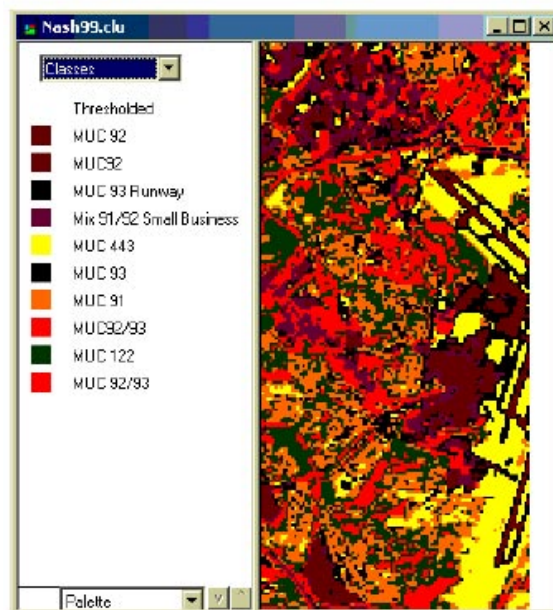
Environmental scientists use land cover data to help develop computer models for everything from atmospheric circulation to the uptake of Carbon by different parts of the environment. Often, remotely sensed images are used to determine land cover. If the images used are not up-to-date, they do not provide accurate input to the models. Also, scientists must often estimate land cover types without visiting the area in question. Your data on land cover change can help scientists fine tune their models. These data are also very valuable to local community planners who are not always able to see change over as large a scale as you can. To adequately understand what has happened, and to help predict what may yet occur, scientists need to know what changes have occurred, and how much time was needed for those changes. From these data, rates of change can be calculated. It is rates and directions of change that help us to predict what may happen next.

An Example of Student Inquiry

Students in the Nashville, Tennessee, area were investigating change over time around the Nashville International Airport. They knew that during the time between their Landsat 5 and 7 images, the runways at the airport had been lengthened. This group created a computer-assisted land cover map of a portion of their 1992 image that included the airport.

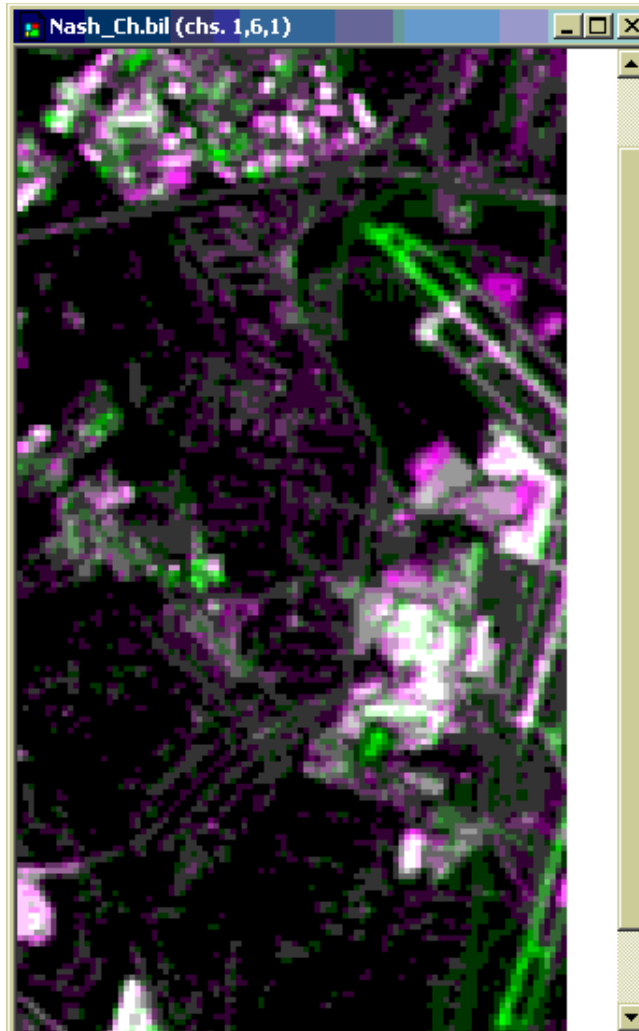


The group then created a map for their 1999 image of the same area.





Examining these maps, they were certain that significant growth had occurred in the airport area over the time between the images. They used the *Change Detection Tutorial* to produce a change image.



The group found that the change image indicated development at the airport. They could see the change represented as the green areas at the ends of the runways. They were also interested to see that there were other areas of green, or change. They thought that this might indicate places where there was urban-type development. They knew that magenta (purple) areas suggest places in which there may have been a decrease in developed-type land covers. The MUC 91 areas (residential) showed this. The group wondered if that was due to the growth of trees around homes. They decided that they should visit these places to explore their ideas further.