Using Remote Sensing Data to Evaluate Water Resources in North Carolina

Overview

This lesson uses Landsat imagery to introduce students to remote sensing as a tool that is used by water resource managers to understand land use and hydrologic changes. Students will investigate the water budget for Falls Lake, NC from 2007-2009 by analyzing satellite imagery and hydrologic data from the US Army Corp of Engineers and will learn about the interrelationship between hydrologic and human systems.

Alignment to NC Essential Standards for Science

8th Grade Science
8.E.1 Understand the hydrosphere and the impact of humans on local systems and the effects of the hydrosphere on humans.

Earth and Environmental Science
EEn.2.3 Explain the structure and processes within the hydrosphere.
EEn.2.4 Evaluate how humans use water.

Learning objectives

- Students will describe the difference between aerial photographs and satellite images.
- Students will analyze hydrologic data.
- Students will use remote sensing images to analyze hydrologic changes in Falls Lake, NC.
- Students will describe the water budget for Falls Lake, a source of municipal drinking water.
- Students will describe the interrelationship between hydrologic and human systems.

Time required

90 - 120 minutes

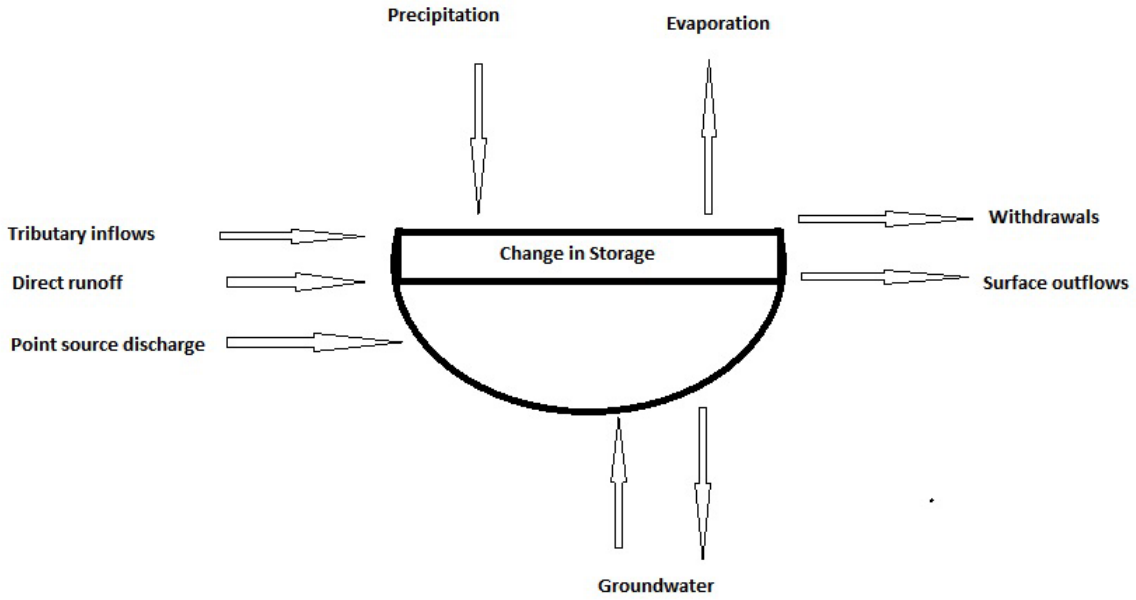
Materials needed

- *Landsat Compositor: How Satellite images are different from Photograph (See Resources)*
- *Landsat: A Global Land-Imaging Mission (See Resources for link or print pdf version)*
- Landsat Imagery of Falls Lake (2007-2009), laminated (1 set for each student pair)
- *Falls Lake Data Sheet*, one copy per student
- Worksheet 1: Remote Sensing , one copy per student
- Worksheet 2: Using the Data, one copy per student
- *Student Instructions for using the USGS LandsatLook Viewer*, one copy per student
- Computer with Internet

Procedure

Engage

1. Show students a photo of Falls Lake and show the location of this lake on a map of North Carolina. Tell students that Falls Lake is the main source of water for customers on Raleigh's water system and for this reason an important water resource for the region.
2. Introduce students to the concept of water resource management and tell them that there are people whose job it is to plan, develop, distribute and manage the optimum use of water resources (*Wikipedia*). These individuals have to be knowledgeable about a lake's water budget to manage this resource wisely.
3. Ask students what they think is meant by the phrase "water budget" and then on the whiteboard draw simple cross-section of a lake and ask them to list aloud the inflows and outflows they can think of, using arrows to denote the direction of water movement (a complete water budget diagram is included below for teacher reference). **Do not reveal the answers; the intent of the exercise in the Explore section below will be to help them discover the inputs and outputs on their own**. *Note: Students could also be asked to do this individually on paper, thus serving as a pre-assessment.*



4. Ask students how satellite images might be useful to water resource managers? How might satellite images enhance our knowledge Falls Lake and its water budget?

Explore

4. Ask the students to read *How Satellite images are different from Photographs,* and *Landsat: A Global Land-Imaging Mission* and supplement information with their own research. Ask them to complete worksheet 1 either individually or with a partner. Alternatively, this step could also be completed as homework.
5. Provide each pair of students with the *Falls Lake Data Sheet* and ask them to answer the questions on the first page of worksheet 2.

6. Once the students have answered the questions, provide each pair of students with laminated, color

satellite image of Falls Lake for the years 2007, 2008 and 2009. Ask them to complete the second page of worksheet 2.

Explain

7. As a class, ask students to summarize their observations from the exploration either orally or in writing and then use the following questions to prompt a class discussion:
    - Would it have helped to have had the Landsat images before examining the *Falls Lake Data Sheet*?
    - How did the Landsat images help you understand the data table better?
    - What other information can be assessed from the Landsat images to help understand development patterns around the lake?

Elaborate

8. Using the *Student Instructions for using the USGS LandsatLook Viewer* zoom in to Falls Lake. Following the instructions, find the oldest image of Falls Lake from November 1982. Ask students to observe this image and then compare to the next available image from 1984. Ask them to reflect on what has changed? Why? *Hint: the dam was completed in 1981*.
9. What additional data would be useful for predicting and preparing for future inflows and outflows of Falls Lake?

Evaluate

10. Ask students to draw a water budget diagram for Falls Lake using the data - what are the inflows and outflows for this lake? (This can be compared to student pre-assessment).
11. Then, as a journaling activity or writing assignment, ask students to describe the interrelationship between hydrologic and human systems by considering how people impact the water budget of a lake such as Falls Lake and how these impacts might shift depending on seasons, drought conditions, and growth in population.
12. (*optional)* Using the *Student Instructions for using the USGS LandsatLook Viewer,* ask students to examine another North Carolina Lake over time, such as Kerr Scott or Jordan Lake and reflect on changes observed and identify connections to the water budget. Data for these lakes can be found at http://epec.saw.usace.army.mil/

Resources

Landsat Compositor: How Satellite images are different from Photographs
http://landsat.gsfc.nasa.gov/education/compositor/pdfs/Landsat_7_Compositor.pdf

Landsat: A Global Land-Imaging Mission
http://pubs.usgs.gov/fs/2012/3072/fs2012-3072.pdf

USGS LandsatLook Viewer
http://landsatlook.usgs.gov/

About Landsat
http://landsat.gsfc.nasa.gov/

Acknowledgements

This lesson was written by:
Michele Drostin and Dana Haine, Institute for the Environment, University of North Carolina at Chapel Hill.

Reviewed by:
Tamlin Pavelsky, Ph.D., Department of Geological Sciences, University of North Carolina at Chapel Hill
DeeDee Whitaker, MAT, NBCT, Chemistry and Environmental Science, Southwest Guilford High School

Funded by the NASA New Investigator Program under grant #NNX11AP63G

Worksheet 1: Remote Sensing

Student Name _____

Use the handouts *How are Satellite images different from photographs* and *Landsat: A Global Land-Imaging Mission* to answer the following questions.

1. What is a true color image?

2. What is a false color image?

3. What is the electromagnetic spectrum?

4. How many images does the Landsat 7 Satellite collect?

5. Do different objects on earth reflect different wavelengths of light? What wavelengths can humans see?

6. Why do we call color satellite images false color images?

7. Based on what you just read, describe the difference between a photograph and a satellite image.

8. What is remote sensing?

Worksheet 2: Using the Data

Student name: _____

Using the data provided for Falls Lake answer the following questions.

1. The Corps of Engineers uses a 251.5 feet surface elevation as their target level for Falls Lake. If the elevation is above 251.5, the lake is being used to store extra water to prevent flooding downstream. If it drops below that number, water release (outflow and water supply) must be managed. Using the surface elevation data along with the other data and the precipitation graph tell a story of what happened to the lake between May of 2007 and April of 2008.

2. Look at the column on the Falls Lake, NC data sheet that says inflow. The Corps of Engineers uses an equation to estimate the inflow because they cannot get exact measurements. Using the lake water budget diagram provided on the back of the Falls Lake data sheet, consider which factors should be included in an inflow calculation and list them here. Why do you think some of these factors would be difficult to measure?

Your teacher will provide you with 3 Landsat images of Falls Lake for 2007, 2008 and 2009, each taken in the month of February. Please answer the following questions.

1. Compare and contrast the images. What differences do you observe? What might account for any differences you observe?

2. Are the images consistent with the data presented on the Falls Lake data sheet? Why or why not?

3. Would it have been easier to understand the tabular data if you had seen the images first?

4. What information could you collect using remote sensing images such as these? How might these data be useful?

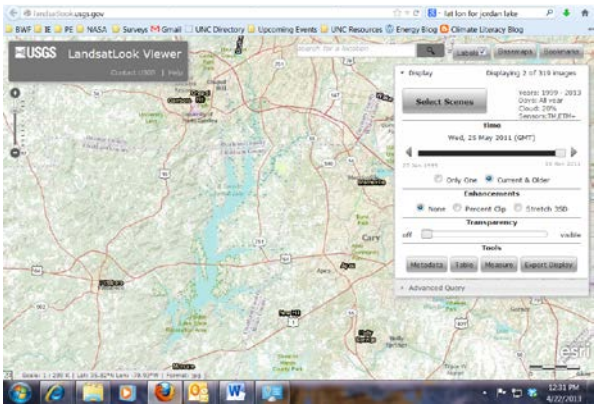
Student Instructions for using the USGS LandsatLook Viewer

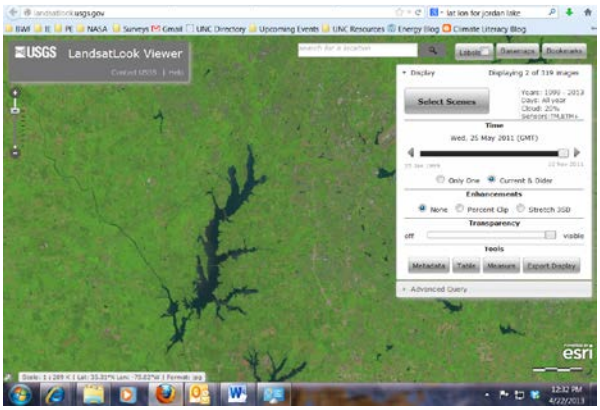
http://landsatlook.usgs.gov/

Instructions for generating land cover images from 1972 to present.

1. Zoom into map to select region of interest.
2. Once you have narrowed in on your area of interest, click on “select scenes.”
3. Images from 1999- present that correspond to this region will be downloaded.
   For example, for the Jordan lake area, the search returned 319 images dating back to January 1999.
   **Note: You can choose to go back further than 1999 if you click on "Advanced Query" and adjust the dates.*
4. A slider bar can be used to view past images.
5. Selecting “labels” will show town/cities and county/state lines.
6. The Advanced Query option will enable you to set what % cloud cover is acceptable and the Landsat sensors used. The TM and ETM+ sensors (default setting) are recommended for use by educators.
7. Under transparency, the slider bar can be used to transition between a satellite view and a map view, reveal highways and labeled bodies of water.
8. A measurement tool enables one to calculate area and distance as well as show the latitude/longitude coordinates for a specific location.
9. Images can be exported as .jpg files.
10. By clicking on "Table," you can actually order the underlying data.

Map View **Satellite View**





Falls Lake, NC Data Sheet

The US Army Corp of Engineers records information about Falls Lake daily, these data have been compiled into monthly averages in the table below. Data can be obtained from the year 2000 to present at this link: http://epec.saw.usace.army.mil/fall00pr.txt

Red text correspond to the dates of the accompanying Landsat Images

Year	Month	Avg Surface Elevation (ft)	Total Content (acre ft)	Outflow (cfs)	Water Supply (cfs)	Inflow (cfs)	Precipitation Data (mm)
2007	Feb	251.82	127,429	481	68	586	42.6
	March	252.21		945	73	1023	96
	April	252.42		974	76	1060	116.1
	May	251.57		188	90	137	45.8
	June	250.79		135	93	47	95.1
	July	249.42		137	93	-25	92.7
	Aug	247.71		171	98	-46	33.1
	Sept	245.52		133	84	-44	81
	Oct	243.58		118	75	93	107.4
	Nov	242.82		72	64	8	17.6
	Dec	241.86		55	62	185	117.5
2008	Jan	243		56	63	101	38.7
	Feb	243.35	49,587	54	61	221	64.7
	March	248.07		30	58	887	126.5
	April	251.79		337	61	1114	107.9
	May	252.19		415	66	223	60.9
	June	251.28		118	82	81	79
	July	251.49		102	78	174	110
	Aug	250.52		156	83	252	156.1
	Sept	254.36		1328	74	1930	239.7
	Oct	251.98		477	74	66	35.4
	Nov	251.43		97	67	230	89.7
	Dec	252.55		851	63	990	128
2009	Jan	252.1		672	64	736	64.7
	Feb	252.29	132,932	143	65	298	25

Average Surface Elevation (feet): This is the elevation of the lake above sea level. The deepest part of the lake is considered to be at 200 feet of elevation.

Total Content (acre feet): This is the amount of water, or volume of water in the lake determined by calculations made by the Corps of Engineers.

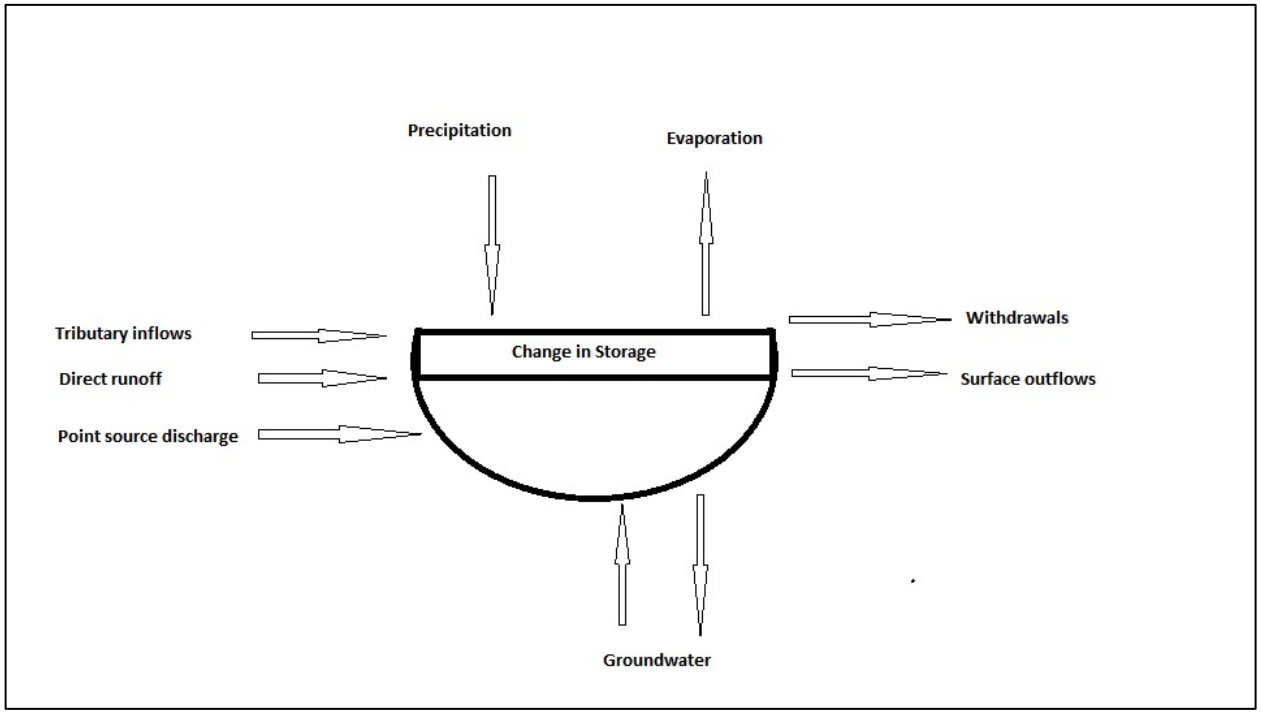
Outflow (cubic feet/second): The amount of water release at the dam.

Water Supply (cubic feet/second): The amount of water taken directly from the lake for Raleigh water supply.

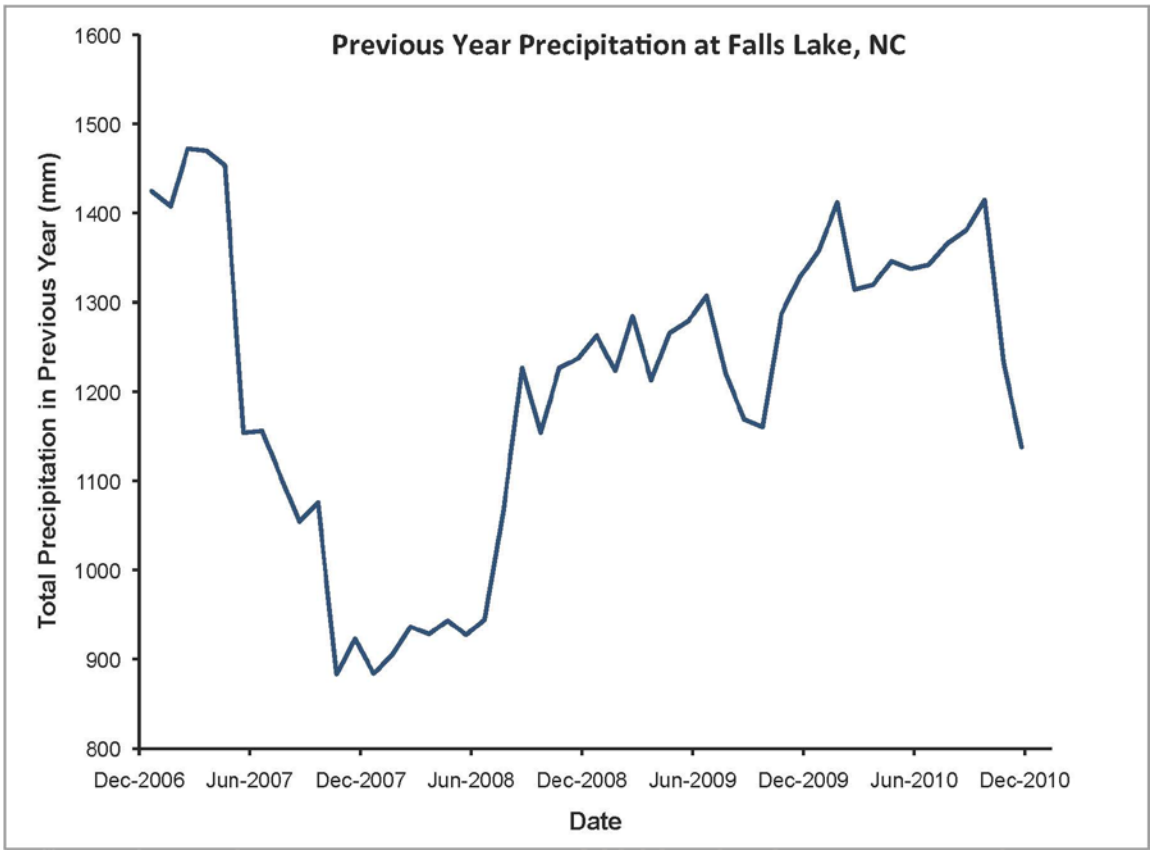
Inflow (cubic feet/second): Inflow is calculated by the Corp of Engineers using measurable factors such as surface elevation and outflow to estimate inflow. Reasons for negative calculations can be evaporation or wind affecting the elevation measurements.

Precipitation (millimeters): Monthly precipitation.

Schematic of a water budget for a lake



Graph of Total Precipitation at Falls Lake, NC from December 2006 to December 2010



Falls Lake, Feb 2007: inundated area = 46.3 sq km or 11,440 acres

Falls Lake, Feb 2008: inundated area = 24.5 sq km or 6,054 acres

Falls Lake, Feb 2009: inundated area = 43.3 sq km or 11,440 acres