Name(s):_____

Using WaterViz to Understand the Water Cycle and Human Impacts

Students will be able to:

- Interpret the variables in the visualization and how they respond to weather events.
- Apply what they have learned from the Waterviz model to answer questions about human and climate interactions with the water cycle.

All around us, humans are altering watersheds through development, forest management, agriculture, and air pollution. In this lesson, students will consider how experience gained from the scientists at Hubbard Brook can help us understand how urbanization and climate change are affecting our earth systems.

Directions:

Form a group of four, with each person focusing on one of the following variables:

- streamflow
- soil water/snowpack
- evapotranspiration
- precipitation

You will need a copy of the water cycle diagram from your teacher. Go to www.Waterviz.org . Looking at the visualization and your water cycle drawing, answer these questions for your individual variable. When you are finished with your section, share your findings with your group and answer the remaining questions about the other variables using information from group members. Another resource is the US Geological Survey interactive diagram entitled, "The Water Cycle for Schools and Students." Keep this window open to help you answer your section below. (see https://water.usgs.gov/edu/watercycle-kids-adv.html.)

Streamflow

Fun Fact: What percentage of the annual precipitation at Hubbard Brook ends up in streamflow? (check your guess below*)

1. Do you think that runoff and streamflow are the same thing? To check and explain, use the USGS interactive water cycle link on the previous page.

2. From where does the water in streamflow originate? Answer using the visualization, the USGS interactive water cycle, and the concept of a watershed.

3. Describe at least three places that water can go from the stream, near-term and long-term.

4. Use Waterviz to examine how streamflow responds to a rain vs. snow storm. For a blizzard, watch Waterviz for March 13, 2018, the date of a 15-inch snow storm. Compare this to the timing and magnitude of how stream flow responded to rain from Tropical Storm Irene. Use your observations from the red stream discharge readings in your answer.

5. Explain what might happen to streamflow if the forest is developed into streets and houses.

6. Explain what might happen to streamflow if the forest were damaged by a storm or the trees were harvested. Hubbard Brook scientists pioneered the small watershed approach to studying ecosystems to answer questions like this.

***Fun Fact Answer:** 65% of rainfall ends up in streamflow at Hubbard Brook.[1]

Soil water/snowpack

Fun Fact: What is the average number of days that the ground is covered by snow at Hubbard Brook? (check your guess below*)

7. Where does the soil water come from?

8. Where does the soil water go?

9. What would happen to soil water if the forest were replaced with pavement? Why?

***10.* How do you think the presence of a snowpack will affect streamflow in February?** How about in April during snowmelt?

Figure 1. Duration of Snowpack at Hubbard Brook Experimental Forest, Woodstock, NH[2]

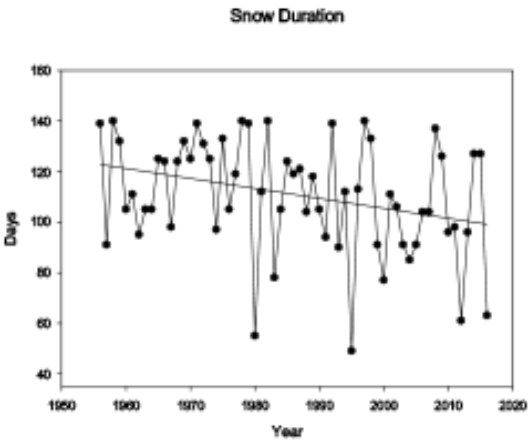


Figure 1. Shows a decline of about 24 days in the duration of snowcover over nearly 60 winters at Hubbard Brook Experimental Forest. How might this shorter snow season affect the timing of snowmelt and streamflow for March and April?

11. On the Waterviz homepage, look below the visualization and click on Current Soil Water Content. What does it mean when the soils are at 100% full capacity? Read more and explain.

12. During Tropical Storm Irene, which lasted for several days, soil water was already high. How would this affect streamflow compared to a storm occurring when soil water starts out low?

**** Fun Fact Answer:*** The average number of days of snow cover at Hubbard Brook 1956-2014 was 111 days. [4]

? DID YOU KNOW | **During Irene, about 7 inches of rain fell in the Hubbard Brook Valley. [3]**

Evapotranspiration

Fun Fact: How much of the water leaving the watershed exits as evapotranspiration? (check your guess below*)

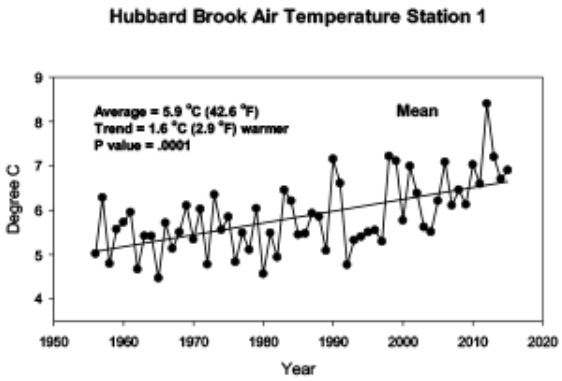
13. What is evapotranspiration and where does the water come from that becomes evapotranspiration?

14. Where does evapotranspiration go?

15. What would happen to evapotranspiration if the forest were cut down and replaced with a city? Why?

16. As you can see in the accompanying graph, the mean annual temperature at Hubbard Brook has increased by 1.4°C (2.52°F) over the period 1956- 2016.[5]

Figure 2. Hubbard Brook Air Temperature Station 1



With increasing temperatures, how might this affect evapotranspiration, and in turn, precipitation? Why?

17. Using Waterviz, go to the summer low flow event. How does evapotranspiration change through a 24-hour period?

18. In what season would you expect evapotranspiration to be the highest? Lowest? Why? Check the visualization using the calendar, what did you find out?

**** Fun Fact Answer:*** About 35% of the precipitation that enters the Hubbard Brook watershed leaves as evapotranspiration, and about 70% of that is transpiration.[6]

Precipitation

Fun Fact: What is the average annual rainfall at Hubbard Brook? What is yours? (check your guess below)

19. On the Waterviz home page, look below the visualization and click on the Water Flux box. What do the inputs to the watershed consist of?

20. What do the outputs from the watershed consist of?

21. What do you notice about the difference between the shapes and values of the input line and the output line? How do the outputs respond to the inputs?

22. How does the amount of precipitation affect the other variables? Watch the first day of the Summer High Flow event in the time stamp window on the Waterviz home page.

i. Relationship between precipitation and streamflow: Can you see the streamflow respond to precipitation? Use streamflow data in your answer.

ii. Relationship between precipitation and evapotranspiration:

23. At Hubbard Brook, mean annual precipitation has increased by 11.8 inches between 1956 and 2014. In addition, the number of heavy precipitation days has increased by 7.4 days per year.[7] Propose two ways that more precipitation and more intense precipitation might affect the ecosystems in the watershed? (To explore the costs of increasing storm intensity, see the #8 reference below.[8])

***Fun Fact Answer:** The average annual rainfall at Hubbard Brook is 55 inches (includes snow converted to rain equivalent). To check yours, search for the National Weather Service's annual climatological report from your nearest big city.

References

1. Holmes, Richard T. and Gene E. Likens. 2016. *Hubbard Brook: The Story of a Forest Ecosystem*. Yale University Press, p. 90.

2. Campbell, John editor. *Online Book: A Synthesis of Scientific Research at Hubbard Brook*. Hubbard Brook Ecosystem Study. Accessed October 11, 2018 at https://hubbardbrook.org/online-book/climate-change Chapter 8. and updated by Amey Bailey, US Forest Service, personal communication September 18, 2018.

3. Green, Mark. *The Hydrology of the Pemigewasset Valley Flood Following Tropical Storm Irene*. Plymouth State University. Accessed October 10, 2018 at: https://campus.plymouth.edu/cfe/wp-content/uploads/sites/127/2012/02/MBG_NH_Water_Conf_2012-GreenHydrology.pdf .

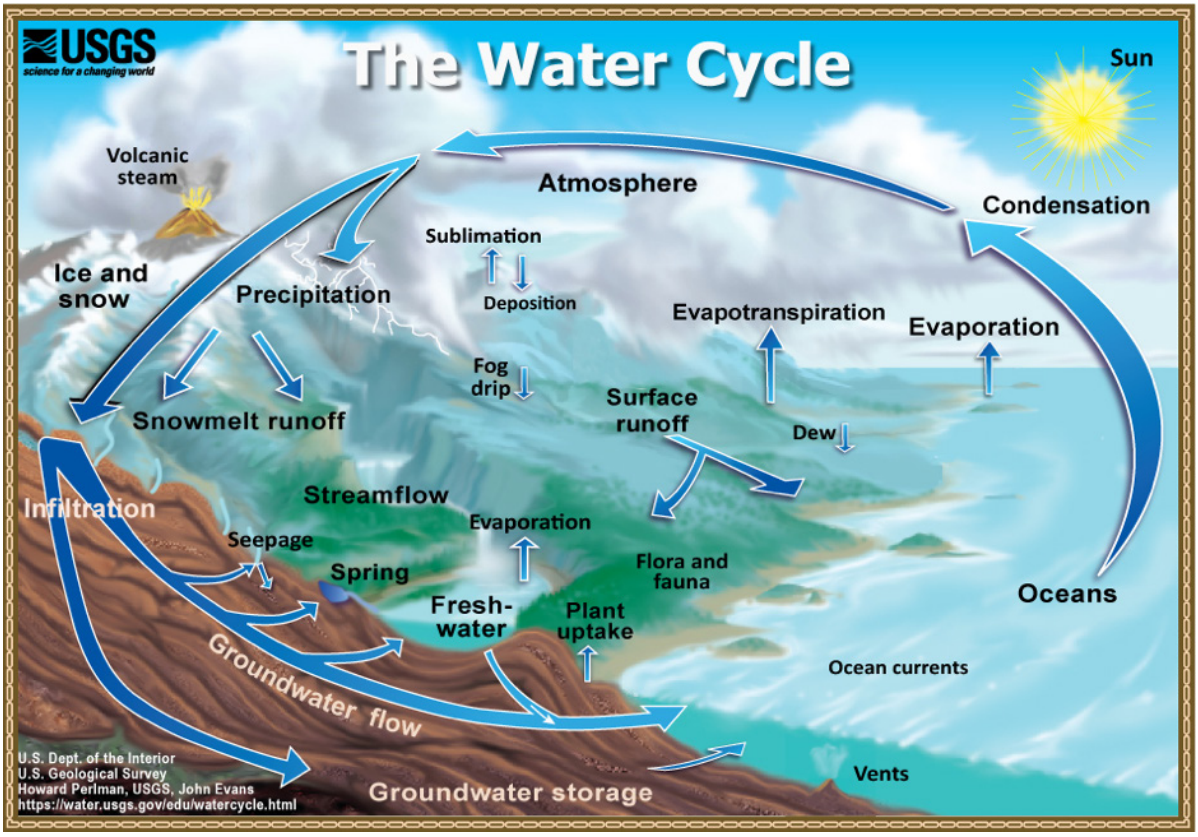
4. Campbell, John editor. *Online Book: A Synthesis of Scientific Research at Hubbard Brook.* Hubbard Brook Ecosystem Study. Accessed October 11, 2018 at https://hubbardbrook.org/online-book/climate-change Chapter 8.

5 . Bailey, Amey, US Forest Service, personal communication, September 18, 2018. See also, Campbell, John et al. *Long-term Trends from Ecosystem Research at the Hubbard Brook Experimental Forest.* USDA Forest Service Northern Forest Research Station, General Technical Report NRS-17, 2007, p. 13.

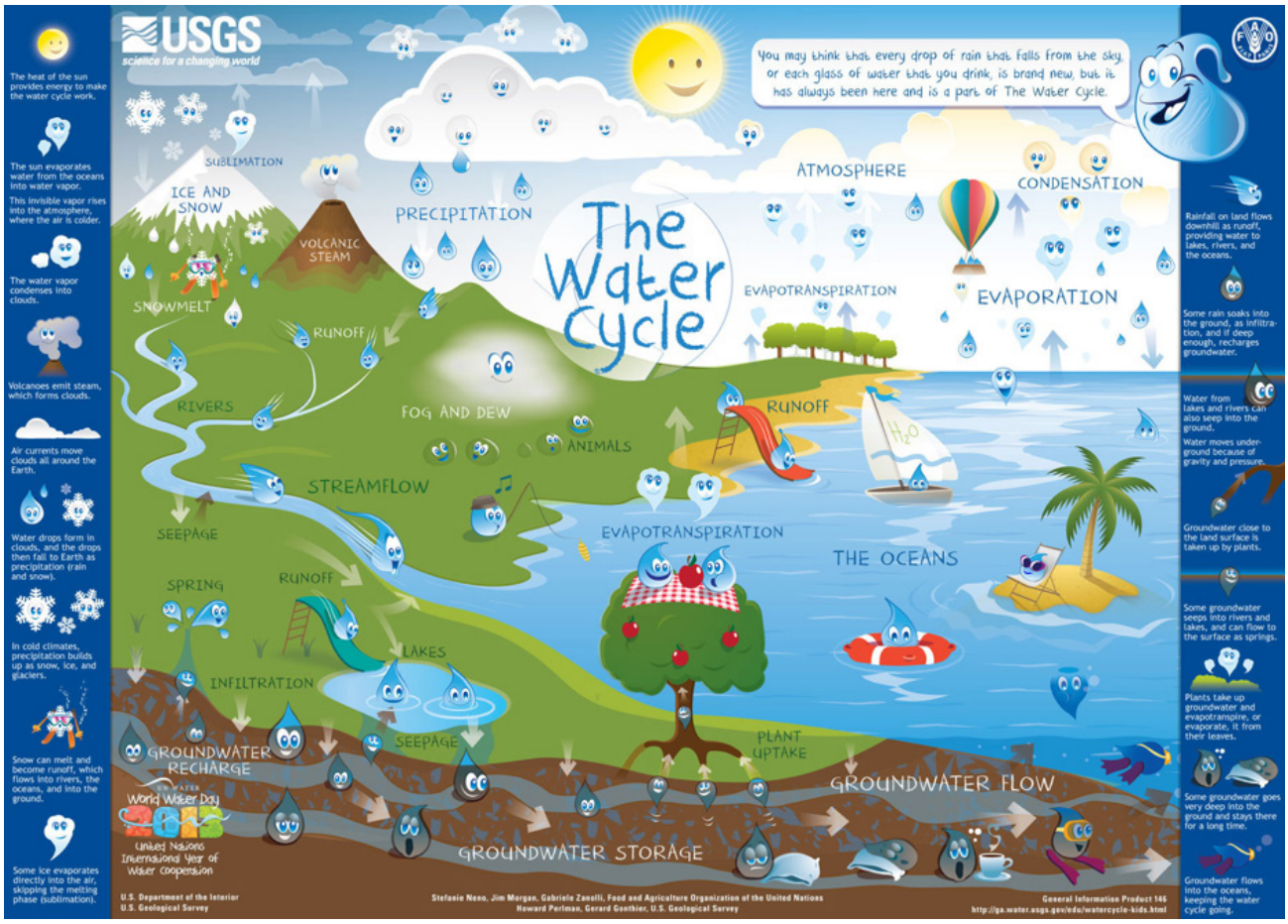
6. Holmes R.T. op cit. pages 90, 94.

7. Campbell, John editor. *Online Book: A Synthesis of Scientific Research at Hubbard Brook.* Hubbard Brook Ecosystem Study. Accessed October 11, 2018 at https://hubbardbrook.org/online-book/climate-change Chapter 8.

8. Pierre-Louis, Kendra, "Five Years after Hurricane Irene, Vermont Still Striving for Resilience." Inside Climate News, 9/1/16. Accessed on October 10, 2018 at https://insideclimatenews.org/news/31082016/five-years-after-hurricane-irene-2011-effects-flooding-vermont-damage-resilience-climate-change.



Source: https://water.usgs.gov/edu/watercycle.html



Source: https://water.usgs.gov/edu/watercycle-kids.html