Welcome to Virtual Fieldwork in Greenland!

This tool was designed for inquiry-based science instruction for middle and high school students. It highlights the research of Dr. Jasmine Saros of the University of Maine Climate Change Institute. Students gain an exclusive look into cutting edge climate change research and are given the opportunity to access current data from the Arctic. This Virtual Fieldwork Experience (VFE) introduces students to concepts from biology, lake ecology, water science, and climate change research. The design of this tool was informed by current best practices for engaging diverse learners (including English Language Learners) and provides a video introduction allowing students to see and hear key terms prior to engaging with data. It can be used to meet components of the following Next Generation Science Standards (NGSS) disciplinary core ideas. To access the NGSS webpage click here.

Middle School
- MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
- MS-ESS2 Earth's Systems

High School
- HS-LS2 Ecosystems: Interactions, Energy, and Dynamics
- HS-LS4 Biological Evolution: Unity and Diversity
- HS-ESS2 Earth's Systems

What is Virtual Fieldwork?

A Virtual Fieldwork Experience (VFE) is an inquiry-based teaching tool that lets you bring a field site to the classroom. Originating in Earth Sciences education, virtual fieldwork is meant to simulate the experiences of doing research outside of a laboratory (Granshaw & Duggan-Haas, 2012). VFEs fit the Next Generation Science Standards goals of teaching the practices of research and provide ample evidence for the construction of scientific arguments based on data. VFEs use technology to simulate outdoor research so that students can engage in the creative and question-based process of scientific inquiry, when travel to the location is not an option (Ross, McRoberts, & Duggan-Haas, 2007).

How to Use this Tool

This VFE has multiple components that you can choose to use.

1) **Prezi Presentation:**

The primary component is the online Prezi presentation that can be accessed online by clicking here. Ideally your students will be able to access the Prezi in small groups or on individual computers so that they can explore the lakes and access data themselves. (If this is not possible it will also work to put the Prezi on a projector and navigate to the data as a class.) Once you have opened the Prezi presentation (or made it available to your students on their computers), use the allow buttons to progress forward or double click on areas that you would like to zoom in on. The video introduction is the recommended place to start. It is hosted on YouTube and will begin when the play button is pressed. It is just under 8 minutes long and introduces the research of Dr. Jasmine Saros of the University of Maine. It is also available separately on YouTube here.

After watching the video, your students can navigate to the circles by the microscope – these are the representations of each lake – and collect data to compare/contrast. Additional data about the area and a narrative description of the research is available in the Field Notebook. You can provide worksheets or guiding questions for individual concepts that you would like students to focus on – or you can let your students explore and ask them to generate questions or explanations based on the data. For help getting started read the Analysis and Potential Activities section below. The NGSS encourage teachers to help students analyze data, construct explanations/questions based on evidence, and communicate scientific arguments – this VFE is designed to allow you flexibility in how you let your students engage with the data.

If you would like to provide more information or guidance to your students on water quality measurements, the U.S. Geological Service Water Science School linked here provides helpful basic information. Further information about Climate Change Research can be found on The University of Maine Climate Change Institute webpage and Dr. Jasmine Saros' research webpage.

2) **Google Earth Layer**

The use of Geographic Information Systems (GIS) in science education has been found to improve outcomes for students – especially English Language Learners (Goldstein & Alibrandi, 2013). Therefore, a Google Earth layer accompanies this VFE to allow students to see these lakes in their relative position to other landmarks (UMaine, Greenland, Kangerlussuaq, the inland ice sheet, etc.). To use this with students you will need to have an internet connection in your classroom. You can allow students to access this on individual computers or you can use a projector and show them around yourself.

1. If you do not already have Google Earth installed on your computer you can download a free copy here.
2. Install the program and open it.
3. Download the .kmz file from the VFE page linked here.

4. Open the .kmz file in Google Earth. More specifically: In Google Earth choose "Open" from under the file menu. Select the .kmz file (it will be in your download folder unless you specifically saved it somewhere else). Google Earth will open the file and you will be able to see the place marks. You can turn on or off other layers (like photos of the area) by selecting the check box next to the layer.
5. Explore the research sites in relation to each other. Partner this information with the data provided in the Prezi presentation.

3) Narrative Field Log

A Taste of the Arctic is also available for you to use and share with your students. It is the first person account of graduate student Emily J. Rice on a trip to conduct research and collect footage for this VFE. It provides narrative descriptions of the trip, research and general life north of the Arctic Circle. It is a glimpse into the world of field research and contains photos that do not appear elsewhere in the VFE. To access this field log download the pdf file here.

Guide for Analysis and Potential Activities

Virtual Fieldwork Experiences, by design, are flexible and can be approached in many ways. They provide data about a field site and allow students to explore and engage without a pre-described path. Using this sort of lesson plan can be disconcerting. The following analysis of the data is provided to help guide your understanding of the data (prior to letting your students engage with it). It is followed by potential activities/assignments to help you think through how you could use this tool in your classroom.

What These Data Tell Us:

From the Field Notebook graphs we can analyze regional patterns:

- The graph of rainfall shows a gradual decrease in the amount of precipitation per year. This suggests that the region of Kangerlussuaq, Greenland is currently becoming drier.
- The graph of average temperature shows that most summers for the past 20 years have been warmer than the past. This suggests that the area is experiencing a trend of rising temperatures.
- Taken together these data suggest that the area is becoming warmer and drier.

From the lake tables and the graph of species we can make comparative descriptions of the lakes:

- Lake 1 is 50,000 m^2 which is about the same size as Lake 3. Both of these lakes are quite a bit smaller than Lake 2 (70,000 m^2). Lake 1 is relatively warm as told by the surface temperature of 12.8^oC (which converts to 55^oF). This is not as warm as Lake 2 but quite a bit warmer than Lake 3 (49°F). The lake has the lowest pH of the three lakes with a measurement of 8.5. This means that the lake's water is basic but not as basic as the water in the other two lakes. [Remember that pH is a scale. A pH of 7 is neutral. Anything below 7 is acidic. Anything above 7 is basic.] Lake 1 had the lowest conductivity – this means that it was the least salty of the lakes. [Conductivity increases with the salinity of the water- deionized water has a conductivity of about 5.5 uS/cm while sea water has a conductivity a million times higher at 5 S/m]. Lake 1 has lots of light and is not very deep (8m). The water is Lake 1 is well mixed and does not stratify. This means that the water on the bottom of the lake is not significantly colder than the water at the top of the lake. In this lake the diatom species C*yclotella stelligera* makes up 12% of all diatoms in the lake. The species *Cyclotella bodanica* makes up 6% of all diatoms and C*yclotella radiosa* accounts for less than 1% of all diatoms in lake. [These are species of interest in Dr. Saros' research. Other species of diatoms live in the lakes but are not studied here.]

- Lake 2 is the largest of the three lakes with a surface area of 70,000 m^2. It is also the warmest of the lakes with a surface temperature of 14.4°C (which converts to 58°F). The lake has a pH of 9.1 which makes it more basic than Lake 1 but less basic than Lake 3. Lake 2 is the saltiest of the lakes with a conductivity of 370 uS/cm, this is much saltier than Lake 1 (111 uS/cm). Lake 2 is also the deepest of the lakes. It is twice as deep as Lake 1 and unlike the other lakes this lake stratifies. This means that the water at the bottom of the lake is much colder than the water on the top. This also means that the deep water will not mix well with the top water. Also, since the light stops at 10m and the lake is 16m deep, the deepest waters get no light. In this lake the diatom species *Cyclotella radiosa* makes up 7% of all diatoms in the lake and the species C*yclotella stelligera* accounts for 13% of all diatoms in lake. The species C*yclotella bodanica* is not found in this lake.

- Lake 3 is about the same size as Lake 1. It is the coldest of the lakes with a surface temperature of 9.5°C (49°F). It is also the most basic of the lakes with a pH of 9.3. Of all the lakes, Lake 3 has the least amount of nutrients available for diatoms (13 ug/L of Nitrogen and 2 ug/L of Phosphorus). It has lots of light available and has a conductivity of 348 uS/cm. This means that it is saltier than Lake 1 (by quite a bit) and only a little less salty than Lake 2. It has a maximum depth of 13m, which makes it deeper than Lake 1 but not as deep as Lake 2. Lake 3 does not stratify so the water at the surface is not significantly warmer than the water at the greatest depths. This also suggests that the water in this lake will mix better than the water in Lake 2. The species *Cyclotella bodanica* makes up about 7% of diatoms in this lake. The species C*yclotella stelligera* and *Cyclotella radiosa* are not found in Lake 3.

From our comparisons we can make educated guesses about the environmental requirements/ecological interactions of the three diatom species:

- ***Cyclotella bodanica*:** Since this species is the only species found in Lake 3, it is perhaps the easiest to start with. We see that Lake 3 has the coldest temperatures of the three lakes. It is the most basic and has the least number of nutrients. From these observations we might hypothesize that *C. bodanica* is able to cope with harsher (colder, more basic, less 'food') conditions than the other two species. Additionally, it is found in Lake 1. Both Lake 1 and Lake 3 are well mixed and don't stratify. Lake 2 on the other hand is the warmest of the Lakes, stratifies, and does not have light all the way through it. This suggests that *C. bodanica* may not be able to survive in stratified lakes or in warmer and saltier lakes. An alternative explanation could be that *C. bodanica* may be able to survive in harsher conditions than the other species, but in more favorable conditions the other species may out-compete *C. bodanica* for light and nutrient resources. Based on these data alone – either argument could be made.

- ***Cyclotella radiosa*:** This species is found primarily in Lake 2. It has a small (<1% of lake diatoms) population in Lake 1 as well. Lake 2 is different from the other lakes in a few key ways. First, Lake 2 has the warmest surface waters and it stratifies. Lake 2 is also the saltiest lake and is much deeper than the other lakes. It is quite basic – although not as basic as Lake 3. *C. radiosa* lives in both Lake 1 (where it shares its habitat with *C. bodanica* and *C. stelligera*) and in Lake 2 (sharing with only *C. stelligera*). It could be argued that an ecological relationship between *C. radiosa* and *C. bodanica* is a key factor in these species distributions. Lake 1 has the most favorable habitat conditions (warm but nonstratified, highest nutrients, lowest pH, etc.) but it contains *C. bodanica*. If *C. bodanica* is able to out-compete *C. radiosa* for resources than this would explain the low population of *C. radiosa* in Lake 1. However, if *C. bodanica* is unable to live in the warmest, deepest and stratified lake – that would remove the competive pressure on *C. radiosa* and allow the species to have a larger population in an otherwise less favorable lake. An alternative simpler argument could be made that *C. radiosa* prefers stratified lakes. With the information provided both of these arguments could be supported.

- ***Cyclotella stelligera*:** This species has the largest populations of all the diatom species in the study. In both Lakes 1 and 2 it has double the abundance of the other species. It is missing from Lake 3. The environmental requirements of this species are likely to be warmer temperatures (whether the lake is stratified or not), lower pH, high nutrients, and lots of light. Salinity does not appear to be a large factor for this species as it has high abundance in both the saltiest and least salty of the study lakes. It appears to do well and out-compete both of the other species when in the same lake ecosystem.

Understanding Ecology helps us Understand Fossil Records and Climate Changes

- Each diatom has a glass-like cell wall that allows us to identify it by species. While they are alive, diatoms float around in the lake water. They absorb sunlight for photosynthesis and they 'eat' nutrients like Nitrogen and Phosphorus. When they die, they fall to the mud on the bottom of the lake. Eventually, as mud and muck pile up on top of them, the dead diatoms get buried. While the cell of the diatom decays, the glass-like cell wall stays intact for thousands of years. When we go to the lakes and take samples of the mud – we can date how old the mud is and use the glass-like fossils to see which species of diatoms were living in the lakes at different times. Because each species has different environmental needs (and because they are extremely sensitive to environmental changes) we can determine what the lakes (and the climate around them) were like in the past. When we know more about what the climate used to be like – and how it has changed overtime – we can use this knowledge to help us understand and adapt to climate changes both now and in the future.

Potential Activities:

1. **Helping Students Analyze the Data**
   Following the above pattern of analysis, you can help students analyze the trends in the area (rainfall and temperature), compare the lakes for similarities and differences, interpret the water quality data into descriptions that make sense to them, and compare diatom species abundance along with lake conditions to formulate hypotheses about the environmental needs for each species. Help students connect this understanding of ecology with fossil record analysis and studies of climate variation. You can guide them by creating worksheets that highlight the information you would like them to focus on – or ask students to organize the data on their own. Worksheets may make the analysis easier for students.

2. **Debating Cause - Short Activity**
   Introduce the students to the VFE and divide up the class into small teams. Allow the students to explore the 3 lakes. Ask them to collect data on why the lake diatom populations look the way they do. Ask teams to come up with explanations using their observations. Give each team a chance to present/defend their conclusions. Lead a discussion or debate about the conclusions. Emphasize that these are the same questions the UMaine researchers are trying to answer. We have no correct answers at this point. So the best answers will be supported by evidence from the data. For grading purposes this activity could be paired with worksheets or with an essay assignment. For further potential topics see the example areas of focus.

3. **Scientific Conference Unit - Extended Study**
   Introduce the students to the VFE and divide up the class into small teams. Assign each group a topic and give them questions to help them get started. (See the list of example areas of focus.) Allow the students to explore the VFE as a starting place for their research. Beyond the VFE have students conduct internet or library research on their topic area. Tell the students that they will be creating a poster or demonstration to communicate what they have learned about their topic. Hold a "Scientific Conference"

event/day where the students present what they have learned to parents, teachers, or their classmates. This event could happen in your classroom - or in a gymnasium depending on the logistical situation at your school.

Example Areas of Focus:
a) Geology- Why does the land look the way it does? How did this landscape get this way? Is it changing? What might it look like in the future?
b) Biology- What plants and animals live here? How do they live here?
c) Ecology- How do plants and animals live together with the landscape? What relationships exist? Who eats whom?
d) Lakes- What types of lakes are these? How can you tell? What are the differences between the 3 lakes? What is the same? Why do you think they are different?
f) Glaciers- What is a glacier? How do they form? How have they shaped the land? Are they changing? How? What happens to the water when the ice melts? Where does the water go?
g) Microbiology- What lives in the lakes? What do these creatures teach us about the lakes? What do they eat? How can we tell them apart? Have they changed overtime? How can we tell? What does this tell us about the lakes - or about the climate?
h) Earth Sciences- Why does what happens in Greenland matter? How does material travel to and from Greenland? It seems isolated, is it? How has temperature and rainfall changed in Kangerlussuaq? What might these changes indicate? What implications are there for life in lakes?
i) Fieldwork and the Practices of Scientists- What is it like to do fieldwork in Greenland? Who gets to do this type of work? What would be good about it? What would be challenging? What tools are used by researchers?

Further Reading

Goldstein, D., & Alibrandi, M. (2013). Integrating GIS in the Middle School Curriculum: Impacts on Diverse Students' Standardized Test Scores. *Journal of Geography, 112*(2), 68-74.

Granshaw, F. D., & Duggan-Haas, D. (2012). Virtual fieldwork in geoscience teacher education; issues, techniques, and models. *Special Paper - Geological Society of America, 492,* 285-303. doi: 10.1130/2012.2492(20)

Ross, R. M., McRoberts, C. A., & Duggan-Haas, D. (2007). Creating a virtual fieldwork experience at a fossil-rich quarry. *Guidebook - New York State Geological Association, Meeting, 79*, 177-187.

Acknowledgements

This work was supported by the National Science Foundation's Arctic System Science program (Grant 1203434 to J.E. Saros), the U.S. Department of Education award T365Z110040 at the University of Maine and the National Science Foundation award EPS-0904155 to Maine EPSCoR Sustainability Solutions Initiative. This work contributes to Project Reach at the University of Maine. Virtual Fieldwork in Greenland was designed and produced by Emily J. Rice as a Communication and Journalism graduate student with the support of her adviser Dr. Laura A. Lindenfeld and Project Reach. It features Dr. Jasmine Saros, Associate Director and Professor from the University of Maine Climate Change Institute and the School of Biology and Ecology. Photography and cinematography by Benjamin Burpee and Emily J. Rice. Special thanks to: Robert Northington PhD, Steve Juggins PhD, Daniel Capps PhD, and Don Duggan-Haas PhD.