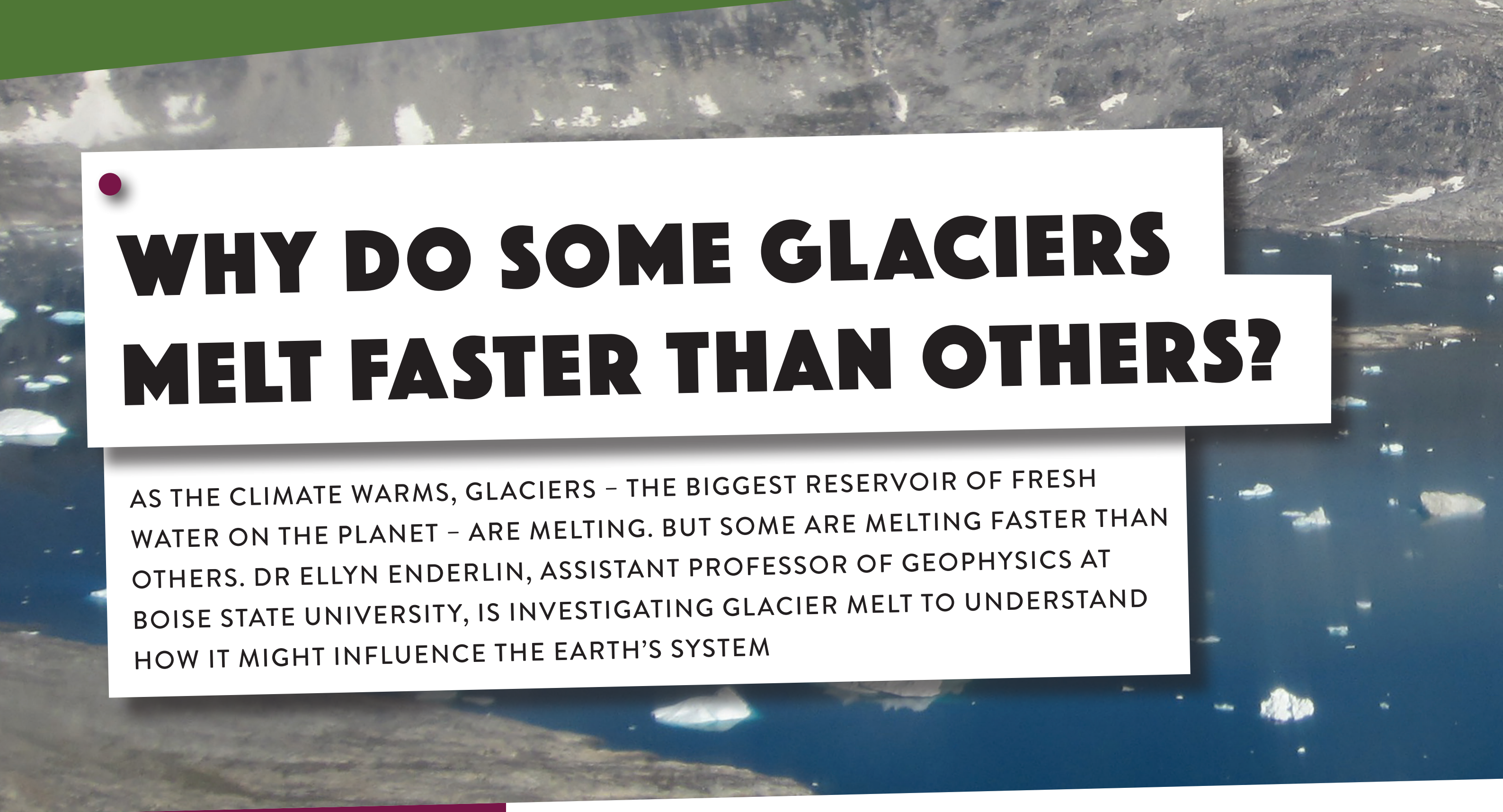


WHY DO SOME GLACIERS MELT FASTER THAN OTHERS?

AS THE CLIMATE WARMS, GLACIERS – THE BIGGEST RESERVOIR OF FRESH WATER ON THE PLANET – ARE MELTING. BUT SOME ARE MELTING FASTER THAN OTHERS. DR ELLYN ENDERLIN, ASSISTANT PROFESSOR OF GEOPHYSICS AT BOISE STATE UNIVERSITY, IS INVESTIGATING GLACIER MELT TO UNDERSTAND HOW IT MIGHT INFLUENCE THE EARTH'S SYSTEM

WHAT WILL HAPPEN IF THE POLAR ICE CAPS MELT?

Melting of the polar ice caps causes:

- Increases in sea level

- Changes to ocean circulation – the addition of cold and fresh glacier melt water influences the flow of ocean water in polar regions, potentially altering global ocean circulation and climate

- Changes to global climate – as the ice sheets melt, the amount of solar radiation reflected by the Earth decreases, leading to more global warming

It's difficult to predict how these changes will progress in the long term, and what effects they will have on our planet.

However, it's likely that these outcomes will have detrimental effects on:

- Ocean ecosystems and their productivity (fisheries)
- Oxygen levels in the ocean
- Carbon dioxide uptake by the ocean
- Climate change

Predicting when, where and why glaciers melt will help to determine the severity of these effects and help us to plan for the future.

Not all glaciers are created equal.

Although all glaciers are sensitive to climate change – on average, approximately 50 billion tonnes of ice from Alaskan glaciers have been lost each year in recent years – the response of individual glaciers to changes in temperature varies a lot.

Understanding why some glaciers are more sensitive than others is important, because it could lead to more accurate predictions of how glaciers will change in the future.

Dr Ellyn Enderlin, Assistant Professor of Geophysics at Boise State University in Idaho, attributes the different responses of glaciers to climate change to variations in their shape. "Their shape influences how a glacier interacts with the underlying land and the ocean," she explains. Her research explores how and why glaciers melt, and what happens to the surrounding environment when glacier melt changes.

WHAT IS A GLACIER?

Glaciers are huge bodies of ice that form from fallen snow over many years. They can form anywhere where there is lots of regular snow, such as Alaska, Greenland and Iceland, and where there isn't much snow but temperatures stay cold year-round, like Antarctica. When enough snow accumulates, its weight causes it to compact until it eventually turns into ice. When they get big enough, the glaciers will flow downhill to areas where the snow and ice will melt.

Some glaciers eventually flow into the oceans, where icebergs form. Icebergs are the huge pieces of ice that break off from glaciers to float freely in the ocean. They can float on the ocean because water is less dense when it is in solid form.

There are many types of glaciers, ranging from small cirque glaciers at high elevations in the mountains to huge ice streams that drain the massive ice sheets covering Antarctica and Greenland. The problem is, they are all shrinking because of climate change.

WHAT HAPPENS WHEN GLACIERS MELT?

When glaciers melt, sea level rises, the temperature and saltiness of polar oceans lower, and the amount of sunlight absorbed by the Earth increases, all of which could threaten the ability of humans and ecosystems to adapt to climate change.

When glaciers rest on land, melt water runs off them and flows to the oceans, contributing to sea level rise. Some of this melt water will also make its way through the glacier to the bottom, underneath the glacier. This water acts as a lubricant on the ground, allowing the glacier to flow faster downhill than if it rested on a dry surface. This means that the glacier flows faster towards the lower, and consequently warmer, elevation regions where it can melt faster. For glaciers that flow into the ocean, an increase in the speed of their flow also contributes to sea level rise because it means more ice is moving from the land to the ocean.

Interestingly, when ice flows over land and into the ocean, it causes the sea level to rise, but

when floating icebergs melt there is no change in sea level. How does this make sense? If you have a glass of water almost full to the top and you add a bunch of ice cubes to it, the glass will overflow because you've added more water to it (in solid form) than it can hold. But if the glass stays perfectly full afterwards and you let the floating ice cubes melt, no more water will overflow because the water displaces the same volume whether it is solid or melted. Although melting icebergs don't influence sea level, the addition of cold and fresh water can change the temperature of the ocean and the air above it, and this can influence ecosystems and climate.

HOW DOES ELLYN MEASURE GLACIER CHANGE?

Scientists like Ellyn measure changes in the size of glaciers and their flow using GPS trackers and satellite images. These two methods have different uses. GPS provides exceptional detail about glaciers' thickness and flow over short time periods. Satellite images are used to measure changes in glaciers' length, thickness and flow over very large areas and long periods of time. Mapping glacier flow using satellite images is known as feature tracking. "It's like watching a boat drift along in a river. You can figure out the flow of the river by measuring how much that boat moves over time," says Ellyn.

Ellyn's lab uses a range of computer programs to analyse the data captured, such as how quickly a glacier moves and where it goes: "I use these data to measure changes in iceberg production over time and explore how the forces that control ice flow respond to changes in temperatures of the air and ocean."

HOW DOES GLACIER MELT WATER AFFECT OCEAN CURRENTS?

The influx of cold, fresh water into the ocean can have a major impact on what is called the "ocean conveyor belt". The ocean currents carry warm water from the tropics towards the poles and when it gets there, heat is released into the atmosphere and the water is cooled. In fact, it cools so much that sea ice begins to form. The salt in the water doesn't freeze with the sea ice, however, which means that it remains in the unfrozen ocean water, making it even saltier.

At the poles, the water is colder and saltier, and therefore denser. This cold, salty water sinks to the bottom of the ocean and works its way south – just like a conveyor belt! "It's this conveyer belt that makes Europe fairly warm despite its high latitude." says Ellyn "If enough melt water from glaciers (and icebergs) is added to the North Atlantic Ocean, this conveyer belt could slow down, leading to colder temperatures in the Northern Hemisphere, in particular, and warmer temperatures near the Equator."

HOW WILL THIS INFORMATION HELP TO PROTECT THE ENVIRONMENT FOR FUTURE GENERATIONS?

Ellyn and her colleagues aim to understand and predict the speed at which glaciers are melting, and the effect this will have on the ocean conveyor belt. Measuring ice flow will help scientists understand how quickly glaciers are melting, why some glaciers are more sensitive to climate change, and the impact that shrinking glaciers have on the ocean and climate.

DR ELLYN ENDERLIN

Boise State University, USA

FIELD OF RESEARCH

Geophysics, Glaciology, Remote Sensing, Climate Change

RESEARCH PROJECT

Ellyn researches glaciers' response to global temperature changes. She also investigates how glacier melting affects the ocean and is predicting their future impact. She hopes more accurate predictions will encourage more action on climate change.

FUNDERS

US National Science Foundation (NSF), US National Aeronautics and Space Administration (NASA)

Ellyn hopes findings like hers will encourage people to take action to curb greenhouse gas emissions. She says uncertainty about how the future will look under climate change decreases individual's motivation to change their behaviour because they don't fully appreciate the long-term risks.

As Ellyn concludes: "Glaciers are sensitive to climate change as a whole, but their responses to climate change differ. We need to know why in order to accurately predict how they'll melt in the future. More accurate predictions of glacier melt and its associated impacts should motivate more action to reduce greenhouse gas emissions."

ABOUT GEOSCIENCE AND GLACIOLOGY

Geoscience is the study of the Earth, its composition and the physical, biological and chemical processes that shape it. It is a big scientific field and can include the study of volcanoes, earthquakes, rivers, oceans, glaciers and more.

The study of glaciers (glaciology) is a field in itself and incorporates geology, geography, maths, physics and chemistry. Geoscientists use lots of different methods to research Earth's interactions, including hands-on field work, analysing samples in the lab, and modelling processes using computers.

Ellyn is passionate about glaciers and geoscience. We ask her why this field makes for an awesome career.

WHY SHOULD YOUNG PEOPLE STUDY GEOSCIENCE?

To me, geoscience is awesome because it incorporates so many other scientific fields to better understand Earth processes. If you're passionate about chemistry, you can study changes in the Earth's atmosphere or investigate the composition of rocks to learn about volcanoes. If you're interested in biology, you can study coral bleaching. Or, if you're a fan of physics, you can measure glacier change (my favourite!), or explore the structure of the Earth beneath our feet. There are so many things that you can do that will advance our understanding of the planet.

APART FROM RESEARCH, WHAT OTHER CAREER OPTIONS ARE AVAILABLE WITH A DEGREE IN GEOSCIENCE?

I know quite a few people that have become environmental consultants, exploring water contamination or wetland management, for example. The increasing use of satellite data has also led to a boom in jobs for people with remote sensing skills. I have students interested in jobs with insurance companies because these companies want to assess the impacts of natural disasters using satellite images. There has also been an increase in scientific writing jobs, with more companies looking for people who have a firm understanding of science and can write well-informed articles.

YOUR RESEARCH USES A LARGE AMOUNT OF COMPUTER MODELLING. IS IT ESSENTIAL TO BE GOOD AT COMPUTING TO STUDY GEOSCIENCES?

I use a lot of different computer programs for my work, many of which require writing code, but I actually have no formal training in computer programming. It would certainly be helpful to have some training in computer programming, but it's not 100% necessary.

OPPORTUNITIES IN GEOSCIENCE

- A degree in a science subject, such as geography or environmental science, is the most common route into geoscience.
- Although some geoscientists have PhDs, it's not absolutely necessary to have a postgraduate degree to work in geoscience. Plenty of people with an undergraduate degree go on to work in industry or as a research assistant, for example.
- The Glacier National Park, Montana, USA runs a glacier internship scheme: https://home.nps.gov/glac/getinvolved/pathways.htm
- The Glacier Society in Coral Springs are on the hunt for interns: http://glaciersociety.org/internship/
- Check out these opportunities for geoscience and geology internships worldwide: https://www.internships.com/geology
- A geophysicist in the US earns around $74,000 on average, but this can increase to $88,000 and above, depending on experience level and place of work. Geophysicists working in industry often earn more than those working in academia, for example.

A small, 1km-wide glacier flows into the ocean in southeast Greenland.

ASK DR ELLYN ENDERLIN

HAVE YOU ALWAYS WANTED TO BE A RESEARCH SCIENTIST?

As a kid I briefly wanted to be a vet because I love animals so much, but I soon realised that this would be too emotionally challenging for me. I have always loved science and when I was about 12, I took part in a fun science fair project. It was then I started to think about getting a job focused on the environment.

WHAT EXACTLY INSPIRED YOU TO STUDY ENVIRONMENTAL AND GEOLOGICAL SCIENCES?

I grew up in a rural area at the base of the Appalachian Mountains and liked playing outdoors. My mom always encouraged me and my siblings to play outside and that led to a real passion for nature in all of us. I was interested in learning more about the environment and, once I got to college, I realised that I could make a career out of studying the environment. I knew that's what I wanted to do.

WHAT SPARKED YOUR INTEREST IN GLACIERS?

I knew very little about glaciers before I went to college, but I knew that I wanted to get a degree that would lead to a job studying the environment. I took a variety of science courses in my first year, including physics, chemistry, anthropology, geology and geographic information systems (GIS). I did really well in GIS, in particular, and that prompted my professor to invite me on a field trip to map glacier landforms in the Andes in Peru. It was an amazing experience. I had never even left the US before and I was struck by the glaciers' beauty, tremendous scale and profound sensitivity to climate change. I was hooked.

WHAT DO YOU LOVE MOST ABOUT YOUR JOB?

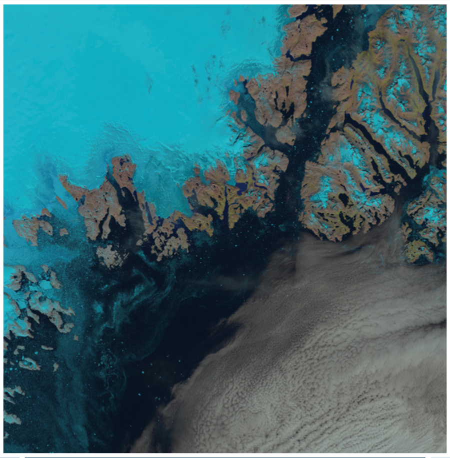
My favourite part of my job is that I get to decide what I'm going to research. If I have a good idea and I can convince my funders that it's worth exploring, that's what I get to do. It's almost like I'm my own boss. A close runner-up is that I have been able to travel to some of the most awesome places in the world. I've been to Greenland, Antarctica, Iceland, Svalbard, Peru, Alaska, and New Zealand for work and numerous places in Europe and the US for conferences.

THERE AREN'T MANY ICEBERGS (OR GLACIERS) IN IDAHO! DO YOU SPEND A LOT OF TIME TRAVELLING TO GREENLAND?

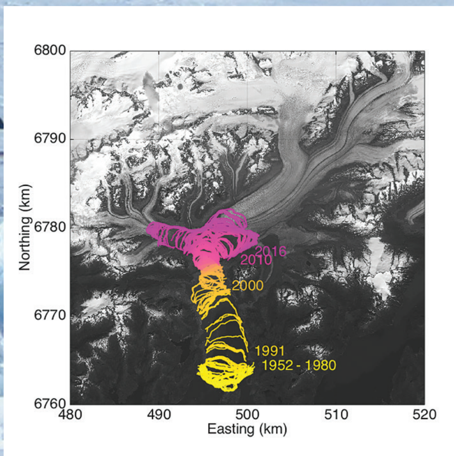
Over the past couple of years, the majority of my work has been done using observations from satellites and aircraft, so I haven't done a lot of field work on glaciers recently. I do miss it, because glaciers are so incredibly beautiful, but it's also nice that I don't have to spend long periods of time away from my husband and son. However, I'm planning on matching more field and satellite observations in the near future. I think field data are absolutely necessary to understanding glaciers, and that everyone should get to see glaciers in person, especially if they are studying them!

ELLYN'S TOP TIP FOR STUDENTS

I recommend taking introductory physics and maths classes early on. A lot of students interested in geoscience are afraid that maths and physics are too hard for them. I actually didn't think I was very good at physics in high school and early in college, but once I started applying physics to the study of glaciers, I realised I just needed to be able to visualise it to understand its application better.



Landsat 8 satellite image of southeast Greenland from July 2014. This is a 'false colour' image. The colours aren't what you would see in the real world but in this image the ocean is black, the clouds over the ocean are the wispy white areas, the land is brown, and the ice is blue. Bright blue is snow on the Greenland Ice Sheet and darker blues are glacier ice.



A black and white Landat 8 satellite image of Columbia Glacier, Alaska, USA. Coloured lines mark changes in glacier length over time. A glacier's geometry strongly influences how it responds to environmental change. While Columbia Glacier's length decreased by ~25km since the 1980s, smaller changes in length have been observed at most other glaciers that flow into the oceans.