Topic 1b - The role of the Greenland Ice Sheet in the climate system

Earth's ice is an important part of the climate system. It makes a contribution to global sea level rise. If the ice melts, then sea levels will go up. Or if the ice freezes and more snow falls onto the ice sheets, then sea levels will fall. But it's also a really important barometer of the climate system.

So we can take Earth's temperature, if you like, by looking at how ice changes from season to season, and from year to year in response to environmental change, global warming. This is a sequence showing ice melting and falling off an ice cap in the Russian arctic. It's called Austfonna. It's in Svalbard archipelago, and it's really in the far north of the Barents Sea.

We have been looking at this ice cap with satellite measurements over the past few years. And we found that there are changes happening in this part of Earth. We didn't think that this was exposed to climate change, because it was too far north, and the temperature rises that we'd seen elsewhere on the planet hadn't really factored into what's happening here. But, in fact, what's happened is the sea ice has been retreating around the Barents Sea, progressively.

That's a familiar story to many people over the past few decades. And that's brought with it warm ocean currents into the region. And these warmer ocean currents in turn warm up the atmosphere, and that causes more melting on the surface of the ice. So we now see today these waterfalls, rather beautiful waterfalls falling off the ice and into the ocean. It's a really vivid example of how ice contributes to sea-level rise.

When we looked at these ice sheets with the European Space Agency Sentinel-1 satellite, we spotted that they were flowing more quickly into the ocean, as well. It wasn't just that they're melting at the surface, but the ice was traveling faster than it had been in the past. We could detect it quite easily, because the speed-up-- it was really quite dramatic.

So this particular glacier that you were looking at there in the last sequence, speeded up by a factor 10 or 20 in the time interval that we've had satellite measurements. And you can see some of those satellite measurements now in color scale, showing the pattern of ice flow for Austfonna

So today this very large pink area is flowing into the sea, making a contribution to sea-level rise. And so it's an indirect example of how environmental change can impact on the rest of the planet. It was not related to, directly, the melting of the ice itself, it's related to changes in the ocean around the ice caps.

So as the sea ice retreats in the Northern Hemisphere, it in fact seems to be affecting the ice that's on land as well, which is something that people hadn't thought about. And it's another example of how complicated the climate system is, because we need to be able to simulate all elements of the climate system, not just the oceans and the atmosphere, which traditionally have been the parts of global circulation models.

We've had satellite measurements for the past 30 or 40 years of earth from space, and they've been able to tell us quite a lot about the low-latitude areas of the planet. So we know about the oceans, and we know about the land surfaces, plus or minus 80 degrees or so, because there have been a succession of different satellites monitoring those quite successfully. We haven't had, for very long, measurements of the polar regions, partly because it's difficult to launch satellites into those orbits. But also, partly because 10, 20, 30 years ago, people didn't think that those parts of the planet were changing so much, and didn't merit a large investment of cash into launching satellites to just look at them alone.

It turns out, and we now know for sure, that Earth's cryosphere is changing, and there have been quite dramatic changes in the ice that's in the Northern Hemisphere and then in the Southern Hemisphere. And so more effort has been paid to measuring these changes from space.

We are currently on the Greenland ice sheet, which is actually a remnant of the cold period we had some 10,000 years ago. Greenland, during the last glacial maximum, was extending even further. But it was not the only ice sheet we had in the Northern Hemisphere. We had one in Scandinavia. We had the one in North America. And both the other ice sheets melted away.

Greenland survived because it was that far north, and it lost that high. Greenland is actually a reminder of the past ice ages we had. And if we would create a cold climate again today, Greenland would not grow from its beginning. It has to actually be much colder. So it has survived. But it will survive, as long as the top of the ice sheet remains cold.

And this is the big question today, how much longer can we keep Greenland an ice sheet? That means the water that is locked in Greenland, which is globally 5 to 6 meters sea level. How long can we keep it here in Greenland, on this island, in the form of ice? Or when does it melt, and flows into the ocean, and then actually affects most of the coastline around the globe?

Greenland has been here for at least 100,000 to 200,000 years. We know that because we have climate records. When you drill down into Greenland, it is about 3.3 kilometer thick ice. And today, we can analyze from these ice cores annually the layers of precipitation and temperature. So we do know that the temperature 10,000 years ago, 50,000 years ago, 100,000 years ago-- we know very accurately from this ice core analysis. It does not go back a million years, because the ice is not that old.

This is compared to Antarctica. Antarctica is much older as an ice sheet. We know it's probably 7 million years old. Greenland has survived maybe two ice ages. An ice age is a cycle of about 100,000 years.

What is interesting, when we study Greenland today as a remnant ice sheet from the past, can we infer from a past climate how Greenland changes in the future warming or cooling? And we can, indeed, because from the temperature variability of the past, we know in the last interglacial-- that is, the time of the warm period-- it was about 3 degrees warmer than today-

- 2 and 1/2 degrees. And Greenland was still a large ice sheet, but lost maybe 30% of its volume. That means there was about 1 and 1/2 to 2 meters sea-level rise in the last interglacial.

And we look today. What do we expect the climate to evolve in the next 100, 200 years? We have agreed that the climate should not get warmer than 2 degrees above industrial time period. That was the COP21 agreement in Paris. But that means by 2100, by the end of this century, it will be as warm as it was in the last interglacial time period 120,000 years ago. And, then the sea level was about 2 to 3 meters higher than today.

Do we expect such a big sea-level increase? It's possible that we will have an increase of maybe 1 meter, maybe 1 and 1/2. But within just 85 years, it's almost impossible to release so much fresh water into the ocean purely by melting.

The lesson learned is, in the past, these warming and cooling cycles took much longer. Today, in the Anthropocene-- that is, the climate change through man-- you see the change is much more rapid. And therefore, we are out of balance. We are no longer in the balance of the climate system.

And that is the reason why we are here in Greenland doing research. We are trying to find out, what is the balance of the Greenland ice sheet. We started, in 1990, with this camp here called "Swiss Camp." It was purely run by Swiss researchers. And the emphasis of the research was, how much energy is used to melt the snow that falls throughout the winter? And then, we can actually take this one point and extrapolate for the rest of the Greenland Ice Sheet in our models.

And after two years, it was a very special year, 1992. It was the year without summer, we called it. It was a huge volcanic explosion, Mount Pinatubo in the Philippines. And that volcano put small, reflective material very high into the atmosphere. And the solar radiation no longer penetrated through the atmosphere, all of it. So we got that instant cooling. Within one summer, we had 1.8 degree cooling here in Greenland. And it didn't melt. It accumulated more snow.

We almost lost the station you see in the background, because it got covered by snow. We had to actually put entrance through the roof of our buildings. We had to walk down. We couldn't go like we do today, walk to the station, and then walk up. And I will show you some pictures later that illustrates the change of Swiss Camp over time.