Topic 2d - Albedo feedback and validating albedo measurement

It's interesting to note that the summer temperature here, three months, June, July, August, started around -4, -3 degrees. And now it's definitely above zero degrees, that we have continuous melts in the summer months. But how does it affect actually the surface of the Greenland Ice Sheet? This is shown in the next few graphs here.

What I've plotted for the time period 1993 to present is how much of the surface is reflected on a monthly mean? What does it mean? The amount of solar energy that falls upon the snow surface divided by the amount that is reflected. If it's a completely white surface, very white-- as you know, when you go skiing you have sunglasses-- then the albedo is around one. Up here. If the surface gets dark, it goes to 0.4.

What it means-- when the snow is very new, here in the winter months, in the spring months-- albedo is in the order of 80%. If you start to melt the snow, the snow gets wet, the albedo drops to 70 or even 50. If you start to lose all the snow and you only have bare ice, the albedo goes down to 60.6%, 60%. If the albedo drops beyond 0.6, you have bare ice and actually standing water.

And we see these bull eyes here, that is what we call the albedo feedback. Once you have a dark surface more energy is absorbed by the sun and that increases the melt. And that is the time period where we have the big ice losses, where we actually lost like two meters of ice. This is the time period we can do fieldwork in the Arctic without using our arctic gear, because the temperatures are a comfortable two, three, four degrees and it feels like a summer in the Arctic.

Now what is happening? What we did here, we have a plot for the year 1995 to 2028. So we look into the future. But we actually illustrated with all our measurements-- that is the important part, we do a lot of our surface measurements to understand processes and then we take our understanding and project it into the future. How does it look like in 2020, in 2030 if the trend of the current warming continues as we know it from today? And knowing the cause of the warming, the feedback from the greenhouse gases, the assumption is correct, it will continue to warm along that path.

What we put here is actually the elevation and the place where we had the ELA-- equilibrium line altitude, or in this case, where we had zero degrees. Zero degrees was where, the Greenland Ice Sheet started to melt during that summer. And it's quite obvious, you can see, this has changed over the years. From around 2,000 meters, all the way up to close to 3,000.

But let's look at this graph that's more important. This is the ELA, equilibrium line altitude, where we have that balance between the incoming snow and melting in the summer. And we remember that Swiss Camp was around 1,100. That's the elevation, that's where we have the ELA up to about 2,000. And in the following years-- you see these dots-- this is actually our

measured ELA. So the ELA has moved up from 1,100 meters to about 1,800 meters. This is a station we call Crawford Point, we have another instrument there.

So when we look into the future, we can actually predict that the ELA will move in this band, according to our understanding standing today. Because we know the current warming of the climate, we know the cause of the warming, which is the greenhouse gas, and that concentration will remain or is currently even increasing-- 400 PPMs and more-- so if we go in this trajectory, we actually can predict that the ELA will be, around 2024, at 2,500 meters.

And if you project even further, the height of the ice sheet is slightly above 3,000, 3,300. So by making this step forward, assuming the same assumption we know, by 2050 the Greenland sheet will be melting every year to the very top. That also means we are losing the Greenland Ice Sheet from that year on because melting to the very top will reduce Greenland to an ablation area. We cannot accumulate any snow during the summer, it's melting away. And then over thousands of years, Greenland will disappear. It's not disappearing within a few decades or even a hundred years. According to our model calculation, this takes 1, 2,000 years, but we have to remember there is about six meters sea level stored in the Greenland Ice Sheet. And that would change the entire landscape on this earth simply from the Greenland Ice Sheet, by about six meters once this ice sheet is gone.

Satellites also measure how much light the surface reflects. But it's quite complicated to calculate from the light that the satellite receives to measure the physical property, what we call albedo. And with these measurements, we help to develop better algorithms to calculate the albedo. It's quite nice because it starts freezing, see look, the grains are quite coarse. And what does that mean? That means that the reflectivity, the albedo, is getting smaller. And what does that mean? A smaller albedo means the snow pack takes up more sun solar energy. So it heats up more. And this process of getting from small grains to coarse grains, is very important for the energy balance. Because it's very simple, the more energy the snow pack takes, the faster it melts. And the ice cube you see out there is a relatively easy instrument to measure these sorts of property.

This instrument is for measurement of the snow reflectivity, so how the sun radiation is reflected to the atmosphere. And this varies with the snow type. So the size of the snow grain and the snow impurity and all this stuff. So yeah, this is basically, there is a laser which points to the snow sample, and the snow sample will reflect and then there is a gap there which measures how much it reflects.

And first of-- before to do the measurement, we have this target and so-- from very dark to very bright. And basically this is to calibrate the instrument, because we know exactly what are the reflectance of this target so we use it for calibration. Here we do in situ measurement around this area. And this is to compare with satellite data. So they can also do a bigger area. The snow, albedos of the snow reflectance, and this is to confirm and validate the data.

So now we start the measurement with the snow. So we basically, to do a statistic, to have an average value, we will need 25 measurements from snow. And we do random sampling around this point.

We do the same measurements like yesterday, with the reflectivity, so with the ice cube. And we try to sample the surface randomly. And now we make our parameter and we flow around the parameter before we do the measurements. And we will do it afterwards and then we will see how randomly our measurements are. And, as I took more pictures from different angles, we can then also do a 3D model of the study site afterwards.