

NEWS

Glaciologist Studies Greenland Snow Conditions and Helps Calibrate CryoSat Instrument

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GREENLAND—On a typically frigid mid-July day at Summit Station, almost smack in the middle of Greenland, with the temperature hovering around -10°C , Elizabeth Morris and John Sweeny were bundled up against the cold atop their black Ski-Doo snowmobiles, which Morris described as being similar to motorcycles on ski tracks. They drove the vehicles—without yet attaching three wooden sleds that would be pulled during their summer scientific traverse across part of central Greenland—on a practice spin along the perimeter of Summit's groomed, approximately 4600-meter \times 60-meter snow runway. One of the longest runways in the world, it lies atop 3.2 kilometers of ice, with the horizon stretching in every direction.

Morris, a glaciologist who is a senior associate at the Scott Polar Research Institute at Cambridge University, United Kingdom, and Sweeny, her polar guide, were taking advantage of an unexpected extra day at Summit, a scientific research station sponsored by the U.S. National Science Foundation (NSF), before the traverse began. They hoped that the socked-in visibility just a few hours earlier that morning, 16 July, would not be repeated the following day so that a U.S. Air National Guard 109th Airlift Wing C-130 cargo plane would be cleared to fly to Summit from Kangerlussuaq on Greenland's west coast with needed supplies. Morris and Sweeny would load up each sled with about 270 kilograms of gear.

The pair was eager to begin an approximately 800-kilometer round-trip traverse starting from Summit and going along a portion of the Expédition Glaciologique Internationale au Groenland (EGIG) line across central Greenland established by an earlier expedition. Along the route, Morris will measure the density profile in the snow down to a depth of about 10 meters to help calibrate and validate the synthetic aperture radar interferometric radar altimeter (SIRAL) on the European Space Agency's (ESA) CryoSat-2 satellite. The satellite, which launched in 2010 following the failure of the original CryoSat in 2005, monitors changes in thickness of marine ice in polar oceans and variations in thickness of ice sheets in Greenland and Antarctica, providing information about changes in ice sheet mass and sea level rise.

Morris, 65, is part of the ESA-coordinated CryoSat Calibration, Validation and Retrieval Team. She has participated in

these Greenland field campaigns annually since 2004, usually once but sometimes twice each year. Morris headed up the British Antarctic Survey's (BAS) ice and climate division from 1986 to 1999, and in 1987 she became the first woman allowed to join a BAS field team.

On the snowmobile traverse, the team will stop at 12 sites, roughly every 40–60 kilometers. At each stop, Morris will spend several hours using an approximately 5-centimeter-diameter auger (“like a giant corkscrew,” she said) to drill 10 meters into the snow for a neutron scattering probe to take measurements of the snow every centimeter. As fast neutrons from the probe collide with hydrogen atoms in the snow, the neutrons lose energy and come back as slow neutrons that can be counted, she explained. By counting the slow neutrons, the density of the snow can be determined, she said. With those 10 meters, which represent about 25 years of snow accumulation, combined with data from Morris's years of work in Greenland, she has an approximately 30-year record of snow density.

Morris has been able to track annual snow layering much more easily than actually having to shovel out a snow pit, distinguishing between summer snow, which is fluffy, and winter snow, which is densely packed due to the arms of dendritic ice crystals having been knocked off by the wind, she said. Morris added she hopes to use the 30-year snow record to help with the improvement of climate and meteorological models for Greenland.

Climate Models

Although current climate models are state of the art, they still need to be more accurate, Morris noted. “My view is that there has been so little data around about accumulation over Greenland that everybody's been using the same maps of accumulation and the same data to tune the models,” she said.

Having accurate models “is fairly significant stuff because the only way that you are going to say what happens in the future is by models,” she said. Morris explained that while monitoring is very useful, a concern is that complete results from monitoring may not be known for a while, as climate change continues. “We want to say now what's going to happen in 30 years' time. And that's a question of modeling. So we've got to get those models right.”

She said modelers need to include larger uncertainties in their models. “If the

modelers can actually state what the uncertainty is, then the policy makers know, I suppose, what the range of uncertainty is and the time. I think it's all about time, really; how much time have we got before things get really bad as far as sea level goes and so on?” she said, adding that politicians should know what sort of leeway there is. “It may not help them, because it doesn't really help to say, ‘Well, it could happen in 10 years, or it could happen in 30 years.’ But if that's the truth, then [policy makers] had better have the truth rather than have somebody say it is going to happen in 10 years.”

Rapid changes in Greenland, such as the movement and calving of glaciers, can be seen from satellites and often grab newspaper headlines, Morris noted. “The problem is, we haven't had satellite observations for long enough to know whether this is something that's happened in the past,” she said. Morris added that it is also important to get a balanced view of what is happening on the whole of Greenland, including in the center.

“You've certainly got rapid melting and very obvious melting around the edge of Greenland,” she said, noting that proposed mechanisms for that include meltwater penetrating down to the bed, with ice then sliding more easily over its bed and moving faster, or ocean water getting under the bed. She added that there are mechanisms for having increased snow accumulation in central Greenland in a warmer world. “Whatever is happening to the accumulation in the center is surely critical because it's a much bigger area that we are talking about. And just small changes in accumulation are really equivalent to quite large changes in mass because of the vastness of the ice sheet. It is true that melt has extended quite a long way over the ice sheet over some warm summers recently. But it's also true that there's still a very, very big area which is dry snow and that melt is not happening [there],” she said.

Morris said, though, that there will come a point when the whole of Greenland will be melting. “There's no way out of it. We are probably going to lose the Greenland ice cap.” She said, though, that it will make a big difference whether the change occurs over 15–20 years or over 100 years, which would allow people to adapt and perhaps even take mitigation measures.

The Summer Traverse

Morris said this summer's traverse, which will extend no later than mid-August so the team can catch a plane down from Summit, is her “swan song” with the traverse project, although she hopes another scientist will pick up and continue her efforts. Noting that “it's probably a good thing to try and do new things,” she said she wants to take time to compare her results with various models.

A traverse earlier this spring was called off after just one day because in the -58°C

temperature, Morris's cooking burner wouldn't light and the snowmobiles and instruments wouldn't work, she said. Now, for her last traverse with the project, one sled hauls all of the science gear—including the neutron probe, a generator, winch, augers, electric drills, computers and loggers, everything Morris needs to drill and record data—along with a tent to protect the computer while working. Inside the crates on the other two sleds are a pyramid tent; high-energy foods such as dried beef granules, potato powder, rice, pasta, biscuits, butter, oats, sugar, and chocolate (water will come from melted snow); bedding; Iridium satellite telephones; a 30.6-caliber rifle for protection in the unlikely event that they encounter any menacing polar bears wandering on the middle of the ice sheet; and petrol (with additional petrol having been deposited along the route by a Twin Otter utility airplane earlier this year).

Morris's polar guide, Sweeny, 48, is a lean, 6-foot-tall former British Royal Air Force gunner who worked for five seasons with the BAS—including participating on several traverses, though none happened to be with Morris—before starting his own small forestry business in northern Wales 10 years ago. When Morris—whom he recalled from his time at the BAS as being focused, pleasant, and approachable—e-mailed Sweeny about 7 weeks ago looking for a general assistant on short notice after another assistant was unable to join the traverse, Sweeny took her up on the offer. "Forestry is quite physically hard work, and I'm getting on in years. Now I'm not saying this [traverse] is easy work. But it is easier than wielding a chain saw all day and probably a lot safer," he quipped.

During the traverse, Sweeny, who previously was a member of a mountain rescue team, will fill a number of roles, including navigator, mechanic, tent erector, joint cook, and general help. He rattled off potential dangers including frostbite and hypothermia, burns from cooking fuel spillage, mechanical problems (for which the team has plenty of spare parts), bad weather that could cause poor contrast for traveling, and crevasses. Although the traverse is in an accumulation area with no moving ice, and crevassing generally occurs where ice is on the move, the team is equipped for safe travel near crevasses, he said. Sweeny quoted earlier polar explorer Roald Amundsen: "Victory awaits him who has everything in order."

"Although we've discussed all these things that can go wrong, when things are going to plan, it's a reasonably stress-free existence. We're far removed from the pressures of the normal existence," Sweeny said.

Working in Polar Regions

Morris, who describes herself as "five feet nothing" tall, began her fieldwork in 1987



(Clockwise from top) Elizabeth Morris on her snowmobile during a practice spin around the perimeter of the airfield at Summit Station, Greenland. Polar guide John Sweeny. Glaciologist Elizabeth Morris. Photos by Randy Showstack.

at age 40. Although she initially encountered difficulties in being allowed to do polar fieldwork because of gender restrictions, she said that there should be nothing unusual about women working in polar environments. "It's not a myth that you need to be able to tolerate the cold, and it's not a myth that you need to be able to think clearly if the wind is howling around you, which I always find quite difficult if you have got this incessant wind battering you—you start to lose the capacity to think properly. You've got to do that. But there's nothing fundamental, really, that needs you to be six foot tall, four foot wide. It's more the endurance bit."

Morris also noted that despite being on the Greenland Ice Sheet day after day, year after year, she doesn't get bored by her work or by the environs. "I've had several different field assistants, and after a while they would say, 'Well, oh, God, we're doing

the same thing over and over again.' I've tried to work out why it isn't the same thing over and over again for me."

She said that "two really incompatible things have to go on at the same time" in one's mind during a traverse: a fairly obsessive approach to one's work and also the ability to appreciate Greenland's cold and harsh beauty. She said that one reason it's not the same thing over and over for her is "the science, of course, because with the science, you're always adding something."

"But I think it's partly the landscape, and the landscape is always different," she said. "There's always different weather, there's always different light effects, there's always a different look to the snow, and sometimes you get these amazing days where you get snow crystals out of clear sky so you have this bright blue sky and then little diamonds that are coming down catching

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the light. It's just like a rain of diamonds coming down. And they all pile up on the surface, and you get sparks of light. Very pure color. All the colors in the rainbow are sparkling out from these crystals that are

lying on the surface, and it's utterly magic; it's just unbelievable."

Morris continued, "It happens maybe one or two times per trip, and it's the day that pays for all the misery. You just

have one day which tells you why you're there. It's just so beautiful that it's almost indescribable."

—RANDY SHOWSTACK, Staff Writer

Greenland Elders and High School Students Offer Perspectives on Climate Change and Science

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KANGERLUSSUAQ, GREENLAND—This small town in central western Greenland, which has a population of about 650 and a major airstrip dating from World War II, is a center for scientific research and a starting point for scientists working in the region and on Greenland's ice sheet to study climate change and other issues. The town, just north of the Arctic Circle, sits at the edge of the 190-kilometer-long Kangerlussuaq Fjord and straddles the Qinguata Kuussua River estuary, whose source water is the Russell Glacier, about 20 kilometers to the east. Between Kanger—as some refer to the town—and the glacier, some Eskimo-Kalaallit elders held a traditional gathering last month and also offered their perspectives on climate change during an impromptu 14 July meeting with high school students and other visitors.

The evening before that meeting, Ole Olsvig, Kurt Olsen, Avaruna Mathaussen, and other high schoolers from Greenland were in a makeshift classroom at the back of a renovated former U.S. Army barracks in Kanger, which had served as a U.S. military base. The students, who said they care deeply about their traditional culture and also are very aware of recent changes in climate, were helping to make presentations about their summer science projects. A total of 16 high schoolers from Greenland, 3 from Denmark, and 5 from the United States were there, participating in Joint Science Education Project (JSEP) activities; JSEP is an international collaborative polar science education effort between Greenland, Denmark, and the United States that receives support from the U.S. National Science Foundation (NSF).

The presentations concluded JSEP's week-long Kangerlussuaq Field School section; during a follow-on science education week, some of the students would visit scientific stations on the ice sheet. The student presentation topics included possible atmospheric variations between Arctic microenvironments; locations where musk ox tend to concentrate; and the relationship between water quality and the growth of large *Nostoc* cyanobacteria blooms called sea tomatoes in nearby lakes. JSEP coordinator Laura Lukes said the program has had a positive impact on the students as well as on herself. Lukes, an NSF Albert Einstein Distinguished Educator Fellow, said that she has learned about polar science; has become more motivated to research the impacts that field and research experiences have on students; and also has become more interested in Greenlandic language, culture, and traditions.

The next day, as Lukes guided the students and others across a glacially carved landscape populated with caribou and musk

ox, Olsvig discussed tradition and climate change. The 17-year-old, from a small northwestern village near Upernavik, said he had recently harpooned his first narwhal, a rite of passage. He said older relatives had told him that Greenlandic traditions need to be maintained for the culture to survive. His grandfather also had told him that 30 years ago the sea ice, or siku, in his region would last from September to June but now it comes in December or January and stays until only April or May. Olsvig said this change affects the use of dogsleds, snowmobiles, and boats and makes traditional seal hunting more difficult.

Other students also talked about Greenlandic traditions and environmental changes. Mathaussen said that although climate change may be bad for others, it could allow for more vegetable growing in Greenland. Olsen commented that "the natural cycles of climate have been accelerated because of the CO₂ level."

A Gathering of Elders

Following a stop at what is locally called the sea tomato lake, the group continued by car along a gravel and sand road to meet with elders at Long Lake, near Russell Glacier. There, Angaangaq, a shaman and elder who is Olsen's great-granduncle, was conducting a ceremony on his ancestral land by the shores of what he referred to as Aajuitsup Tasersua, "the lake that hardly ever melts." The nearby Russell Glacier is, as Angaangaq referred to it in the Kalaallisut, or West Greenlandic, language, an inuqgiak of the Sermersuaq, a finger of the Big Ice—the ice sheet—that holds the land in its grip, he said. Angaangaq, who is from a

town near Maniitsoq on Greenland's west coast—though he now travels extensively—welcomed the students and others to the ceremonial circle. While intoning a chant he called "Melting the ice in the heart of man," Angaangaq held up two black qilauts—flat drums that in this case were made with what he referred to as "rain-coated" nylon because bans prevent international travel with sealskins—to the sides of his head and momentarily engulfed each visitor between the elephant ear-sized instruments that he said "are from the Great Sky."

Afterward, the visitors and others at the gathering went inside a large white tent nearby to listen, through a translator, to elders seated in a semicircle discussing climate change. Ole Kreutzmann, 69, from Maniitsoq and known as Ole, stated that the weather used to be more stable. He noted that over the past 2 years, since a similar gathering had been held at the same location, inland ice "has never melted so fast." Joergen Jensen, 73, of Sisimiut and known as Juulut, explained that the sea near where he lives does not freeze as deeply as in the past, which makes travel with sled dogs difficult.

Hansina Lyberth, known as Atsaarsuaq, 83, a great aunt of Angaangaq, said Greenlanders have always adapted to the weather and always knew how to survive the hard winters. "She thinks they were wiser than those professors today who study the weather, because they knew how to live," the translator said. Atsaarsuaq, wearing a black visor and a red-and-black checkered shirt and gesturing with her hands, added that many people first noticed recent changes in climate around the 1980s, when there were warmer summers and more storms.

"She thinks that it is a circle of life. That's the way that the world is, and maybe it has always been like that: that sometimes it



A view of Russell Glacier, in Greenland. Photo by Randy Showstack.

becomes ice and sometimes it melts,” the translator said.

Enos Lyberth, 80—known as Akkaara, who is from Maniitsiq and is Angaangaq’s uncle and a nephew of Atsaarsuaq—said he agrees about the circle of life but that he also strongly believes that climate change has gotten worse because of factories and environmental pollution. He said through an interpreter that the climate has changed throughout his life and people have adapted their lives to these changes. Akkaara said changes have been especially apparent during the past 20 years; some mountains that had always been covered with snow or ice now have neither during summertime.

Concern About the Big Ice

In an interview with *Eos*, Angaangaq, silver-haired and in his 60s, was matter-of-fact about the fate of the Big Ice. He said that some Eskimo-Kalaallit hunters and elders in 1963 noticed the phenomenon of the Big Ice melting. Although Angaangaq has been speaking about the melting of the Big Ice for decades, he bemoaned, “Nobody heard the message.”

“Now the old people say it’s too late; it’s too late to stop the melting of the Big Ice. That’s what they say, that it’s a cycle which goes on which has been going on for millennia. But this time the difference is that it is too late to stop the melting of the ice,” he said. “You and I, our beliefs, our politics, our economy, cannot stop it anymore. It’s simply too late. The world did not react.”

Angaangaq added that another difference this time is the size of the global population. He said that people need to adapt to climate change and also change their attitudes. “Only by melting the ice in the heart of man will man have a chance to change and begin using his knowledge wisely,” he

said, referencing the name of his chant at the gathering.

He said that there are some positive aspects of climate change, including that “the land is now growing up.” He said the mountains in Greenland that have been pressed down by ice for so long now are getting bigger with less ice on top of them. “The other positive sign is that [climate change] is creating a new balance of the world. It’s just that you and I as human beings, we have not learned to live with it,” he said.

In addition, Angaangaq called for science and spirituality to go “hand in hand.” He said, “When we look at the wings of the bird, of the eagle, to the left, closest to the heart, is the spirit. To the right, far away from the heart, is the science. And they have to go hand in hand. If they don’t, it is mere knowledge, and we have so much knowledge, for we have not learned how to use [knowledge] wisely.” The message of his people “is that they think very much like the eagle, that everything has to be in balance,” he said. “They talk about it very often: that no birds can ever lift off with the wings [that] are not equal. Not even a big airplane can do that.”

“It is time that the scientists begin talking to the elders,” he continued, noting that the knowledge of the elders is valuable for science. “If we don’t talk together, the old people’s knowledge will disappear and we will have some new knowledge we don’t know how to use. So it has to go hand in hand. It has to be like the wings of an eagle, where spirit and the science go hand in hand.”

He said that the elders’ message about climate change includes the hope that individuals will change and use knowledge wisely. In addition, Angaangaq said he has hope in the Greenlandic high schoolers. He said he told the students



Angaangaq, an Eskimo-Kalaallit shaman and elder. Photo by Randy Showstack.

at the gathering that “now that they are learning about science, they are now our hope. I told them that ‘I pray that you will be strong enough to be able to carry that responsibility, because through you, the world will realize who we are and the land we live on.’”

For more information, see <http://www.polartrec.com/expeditions/greenland-education-tour-2011> and <http://www.icewisdom.com>. Additional photos can be seen in the online supplement to this *Eos* news article (http://www.agu.org/eos_elec/).

—RANDY SHOWSTACK, Staff Writer