

Winter Camp: A Blog from the Greenland Summit

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*When temperatures turn cold, some people travel to a tropical destination to stay warm. Instead, Lora Koenig—a remote-sensing glaciologist at NASA's Goddard Space Flight Center—donned layer upon layer of extra clothes to brave the harsh Arctic at the National Science Foundation's (NSF) Greenland Summit Camp. Koenig lived and worked at the research station from November 2008–February 2009, making ground-truth measurements of the Greenland Ice Sheet to validate data collected by NASA's Aqua, Terra, and Ice, Clouds, and land Elevation Satellite (ICESat) satellites. Koenig described her experience at Summit in a weekly blog, with excerpts from the first seven weeks of her stay presented here. Look for Part II of the story of Koenig's "Journey to Greenland's Frozen Summit" in the May–June 2009 issue of *The Earth Observer*. The complete blog with color photos, along with a question & answer by Koenig, is available at: earthobservatory.nasa.gov/Features/GreenlandBlogKoenig/.*

Week One

November 3, 2008

Introduction

Hello! I'm a remote sensing glaciologist in the Cryospheric Sciences Branch at the NASA Goddard Space Flight Center (GSFC). My research uses satellites to monitor ice sheets and compares measurements from space to those taken on the ground.

These interests have led me to spend this winter at Summit, Greenland (Latitude 72.5°N, Longitude 38.5°W). Over the course of this weekly blog, I will tell you about my life and science, in the middle of the Greenland Ice Sheet, in the middle of the winter. First, a quick introduction:



The winter-over team from left to right: Lora Koenig, Bill McCormick, Kat Huybers, and Brad Whelchel.

In June of 2008, I finished my PhD in Geophysics at the University of Washington. My dissertation focused on passive microwave remote sensing of *firn*—snow on ice sheets that has persisted through one melt season or year old snow. For my

dissertation, I took many field measurements during summer trips to both Greenland and Antarctica, but I still had some questions about how these measurements would change if they were taken in the winter. When I was given an opportunity to spend November 2008–February 2009 at Summit, Greenland I took it.

Three other people are staffing the camp with me are: Bill McCormick—Polar Field Services, our camp manager who has spent many seasons working in Antarctica; Brad Whelchel—Polar Field Services, our mechanic new to working on “the ice”; and Kat Huybers—National Oceanic and Atmospheric Administration (NOAA). Kat and I are the science techs maintaining the year round science at camp during the winter.

Summit is quite a different place in the winter when there are only four people staffing the camp. In the summer, when most scientists come to Summit, there can be up to 40 people in camp. Go to www.summitcamp.org to see a live webcam of the camp and to learn more about the weather and ongoing science here.

Week Two
November 16, 2008

Temperature:
 -27°C/-16.6°F

After using its skis to land at Summit, the *Twin Otter* is unloaded on the ice sheet.

Getting to Summit and Goodbye Sun

I left Washington D.C. and flew to Copenhagen, Denmark on October 30, 2008. From Copenhagen, I took an *Air Greenland* flight to Kangerlussaq—once an American military base and now the host of Greenland's international airport. From Kangerlussaq, we all piled into a chartered *Air Greenland Twin Otter* airplane with skis attached and took the approximately three hour flight to Summit.

During the flight I sat next to Brad. It's his first time on an ice sheet and I enjoyed sharing in his excitement. When instruments in the cockpit read 20 minutes left in the flight, we all watched out the window for the first sight of camp. Fifteen minutes later, we were squealing with the first sight of the Big House, our kitchen area, and the Swiss Tower, a tower housing atmospheric sampling equipment. Upon landing, the



current four-person staff greeted us. The air was cold, about -40°C/-40°F, and the wind was blowing mildly.

We spent last week doing *turnover*—a training period where the four people who

were staffing camp train the new crew. This training ensures that all science experiments are conducted in a consistent manner. As this blog continues, I will highlight different science projects in more detail.

The biggest news of the past week was that on November 13, 2008 we no longer had an official sunrise. This doesn't mean we don't have light—from about 9:00 am to 1:00 pm local Greenland time there is light on the horizon, but the sun never actually rises. This is called *civilian twilight*. As we get deeper into the winter we will have less twilight.

Week Three
November 23, 2008

Hello from the Summit

There are two areas on an ice sheet, the *ablation area* and the *accumulation area*. The *ablation area*—near the edge of the ice sheet—is where snow and ice are lost from melting and calving. The *accumulation area*—near the center of the ice sheet—is where snow falls and ice accumulates. NASA scientists monitor the accumulation and ablation areas of Greenland and Antarctica using measurements from the ICESat satellite (icesat.gsfc.nasa.gov/). The mass balance of the ice sheet, determined from accumulation and ablation measurements, is used to estimate changes in sea level.

Summit, located in the *accumulation area* of the Greenland Ice Sheet, is amassing about 65 cm of snow per year. This means that the height of the ice sheet rises about 65 cm a year and the buildings are buried by 65 cm of snow per year. The buildings must be raised every few years to stay on the surface of the ice sheet.

There are three main buildings: the Big House, the Green House, and the Shop. The Big House is where we cook, eat, exercise, and entertain ourselves. It has a TV, DVD player, library, a huge kitchen, and exercise equipment. It's elevated on stilts to stay above the accumulating snow. The Green House has science labs, computers, a small kitchen, and the berthing module, where our rooms are. They have desks, beds,

The Big House rests above the snow surface with stilts.



shelves, and lots of coat hooks! The Green House is starting to get buried by snow accumulation and drifts. It's scheduled to be raised soon but for now we get in and out using a tunnel

that Brad and Bill built. The Shop contains a large generator that provides the camp's power. It also has a snow melter, two snowmobiles, a Caterpillar, and other tools necessary to fix any problem that may arise in camp.

A few small buildings around camp house science equipment. The Temporary Atmospheric Watch Observatory (TAWO) building houses NOAA instruments that measure temperature and wind speed. Beside the TAWO are towers that hold the meteorological (met) instruments.

Week Four **November 30, 2008**

Temperature:
-46°C/-50°F

What can you eat at the Summit?

We had a festive and busy week here at Summit. Kat and I planned our Thanksgiving menu in advance. We have a spreadsheet of all the food that is on station on the computer. Everything at Summit is inventoried so we know exactly what we have and what we need to order. Since we only get flights every three months in the winter, it's important not to forget to order the things we need. (Imagine if you could only go to the grocery store every three months!) Most of our food here is frozen and must be defrosted. It's stored in large snow caves underneath the Green House and beside the Big House for the winter season.

This week wasn't all about food; there was quite a bit of science as well. Each day, Kat and I go through a routine of daily science tasks, checking machines to make sure they are running and gathering data. Data from the instruments on the TAWO tower are used to validate surface temperature measurements taken from satellites.

Lora cleaning *rime* off the TAWO tower. The tower and cable have lots of *rime* but the wind bird (top) and the temperature sensor enclosure (middle), are *rime* free and gathering good data. Photo by Brad Whelchel.



Met instruments on ice sheets are constantly being attacked by *rime*—an icy build-up formed when a supercooled droplet of water in the air freezes. When *rime* accumulates on temperature sensors, it can insulate the sensors and cause incorrect air temperatures to be recorded. On wind sensors, *rime* slows the rate of instrument spin and gives an incorrect wind speed.

Kat and I climb the TAWO tower daily to brush the *rime* off the instruments. It's difficult to move in all the clothes we wear and it's hard to grip the tower wearing large mittens. (Next time you are near a set of monkey bars, try crossing them wearing the biggest mittens you have!)

Week Five
December 7, 2008

Temperature:
-38°C/-36°F

A snow pit used to analyze the top two meters of firn. If you look closely, you can see the different snow layers in the pit wall deposited by different snow storms. This picture was taken at Summit in Summer of 2007, hence the sun and sunglasses.

Are you cold?

One question I get when doing field work in Greenland is: *Are you cold?* Most of the time, no, but my fingers often get very cold. When Kat and I head out to clean the towers, collect snow samples, measure accumulation stakes, and launch weather balloons, we will spend 2–3 hours outdoors. A normal day's outfit includes one thin pair of thermal underwear pants, one thick layer of thermal underwear pants, two thermal underwear tops, one thin insulated jacket, a pair of insulated bibs, a down parka, two pairs of socks with toe warmers, a pair of big snow boots, one pair of glove liners, one pair of mittens with hand warmers, a face mask, and a hat.



This week we took monthly snow samples of the top meter of firn in a snow pit. Usually snow pits are between one and two meters deep. One face of the pit is smoothed to study and sample the snow. This face makes it easy to see the different layers of snow or firn deposited from either snowfall or blowing snow. Each layer of snow/firn has unique characteristics—temperature, the size

and shape of snow crystals, the density, the degree of bonding or hardness, and chemical composition. If you were to take the different layers of snow into a lab you would realize that each layer has different chemical properties dependent upon the chemistry in the atmosphere when the snow was deposited. What is learned today about how the atmosphere interacts with the snow surface helps scientists interpret the chemical signals in ice cores like the Greenland Ice Sheet Project (GISP) II ice core drilled here at Summit that goes back over 100,000 years.

Week Six
December 14, 2008

Temperature:
-37°C/-35°F

Kat and Lora following the flag line to the Big House on a very stormy day. Photo by Brad Whelchel.

Drifting

It was another stormy week with winds upward of 20 kts (23 mph) for 4 days. We recorded the highest winds since we have been here at upwards of 55 kts (63 mph). This week's storms were different than previous storms; the winds were coming from the East (usually winds are from the South). The East winds caused very large drifts to form near the garage doors of the shop and on the tunnel entrance to the Green House. The garage doors to the shop had drifts almost as high as the roof and drifts had buried the tunnel entrance to the Green House with a foot of snow.



The drifts sent Brad and Bill outside to shovel. They spent a day digging out the garage doors and hours digging out the tunnel. Bill raised the tunnel entrance hatch above the height of the Green House roof so it wouldn't be buried by drifts.

The storms also made visibility difficult. When

everything around you is snowy and in polar darkness, it is quite easy to lose your way. On ice sheets we use *flag line*—lines of poles about 15 feet apart—to mark the routes between buildings. We had to use the flag lines a lot this week because we couldn't always see the other buildings in the blowing snow.

The other big news at camp is that with all the indoor time we started decorating for the holidays. We found four strands of fir bow garland in a few boxes of holiday decorations left here at Summit. They are the beginnings of my project to make a Christmas Tree.

Week Seven December 21, 2008

Temperature:
-48°C/-56°F

Solstice Celebrations and a Temperature Experiment

Happy Solstice! We celebrated our shortest, darkest day with a mile fun run. A mile may not seem like far under normal circumstances, but we are at a pressure altitude of 11,500 ft (3,500 m). We were all breathing very hard by the end!

One of my science experiments here at Summit is to monitor temperature. If Greenland continues to warm, additional melting will cause sea level to rise. There are a very limited number of weather stations across Greenland due to the extremely harsh conditions and difficulty in keeping ground-based stations operating year-round. Temperatures over Greenland are most easily monitored by satellites.

Thermal infrared channels on satellite sensors are used to record direct measurements of surface temperatures over Greenland on cloud-free days. Infrared wavelengths cannot penetrate clouds, so on cloudy days, the satellite temperatures are masked, or removed, from the surface temperature datasets. The Moderate Resolution Imag-



Three Thermocron ibuttons placed on the snow surface to monitor the surface temperature and compare to the 2-m air temperature.

ing Spectroradiometer (MODIS) sensor (modis.gsfc.nasa.gov) on board both the Terra (terra.nasa.gov) and Aqua (aqua.nasa.gov) satellites is a NASA sensor used to monitor surface temperatures.

As MODIS travels over Greenland, the sensor measures and records the *irradiance*, or temperature, of the very top surface

layer of snow. Most weather stations only measure the air temperature at 2-m off of the snow surface. In general, the 2-m air temperature compares well with the surface snow temperature but there are limited measurements.

I am investigating the use of small, inexpensive temperature sensors—called *Thermocron ibuttons*—to measure the 2-m air temperature and the snow surface temperature. I am testing these sensors to see if they can withstand cold temperatures, rest on the surface of the ice sheet, and record accurate temperatures when compared to the more expensive temperature sensors.

I check the sensors everyday to make sure they stay right at the surface, measuring the same temperature as the infrared satellite sensors. Even with the heavy drifting snow last week, the ibutton sensors stayed at the snow surface. With their low cost and ease of use, we hope that the ibuttons can be used more extensively on Greenland to help validate satellites.

Stay tuned to the May-June 2009 issue of *The Earth Observer* for the second half of Koenig's story. ■