NRI Annual Summary Report (November 2014)
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Dynamics and Change of the Devon Ice Cap

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Dates in the field: 3 May – 24 May, 2014.

This research program aims to describe and explain ongoing changes in the area, mass, and flow of the Devon Island ice cap so that we can estimate its recent, current, and future contribution to changes in global sea level. We are interested in how climate warming may cause faster flow of glaciers that end in the ocean, and how faster flow may lead to more mass loss by iceberg calving. Our work combines field studies with satellite and airborne remote sensing, and with modelling of ice cap flow and the interactions between ice and the atmosphere. Our fieldwork involves calibrating and validating measurements made by remote sensing instruments, and measuring changes in ice thickness, snow properties, glacier flow, meltwater production and runoff, and rates of iceberg calving.

Recent Progress

Changes in the mass balance of Canada's Arctic ice caps in the 21st century are bigger than any seen previously in the 55-year period of observations. These recent changes are mainly due to warming of the summer climate and increased surface melting. The decade of the 2000s had the warmest summer temperatures in the last 60 years, and 2005-2009 was the warmest 5-year period. Across the Queen Elizabeth Islands, glacier lost mass about 3.8 times faster after 2005 than over the previous 50 years. Both modeling and satellite measurements show that, from 2007-2009, ice caps in the Canadian Arctic contributed more to global sea level rise than any other source apart from the ice sheets in

Greenland and Antarctica. Our surveys of the Devon Ice Cap show that there has been a huge change since 2005 in how quickly snow is turned into glacier ice. Even at the highest elevations on the ice cap where, until the 2000s, surface melt occurred only once or twice a decade, surface meltwater is penetrating deep into snow and firn near the glacier surface and refreezing to form ice. The last time this happened was around 4200 years ago. This is reducing the amount of water that can be stored in the ice cap, and increasing the fraction of each year's melt that runs off to the ocean.

<u>2014 Field Season:</u>

This year our fieldwork focused on three areas i) investigating the calving process in an effort to determine how tidewater glaciers respond to climate change and contribute to the mass loss of ice caps, ii) a study of how the biogeochemistry of basal ice differs between warm-based and cold-based ice, and iii) a pilot project to establish continuously recording GPS units on bedrock. We also repeated measurements required to update our ongoing records of the Devon Ice Cap's mass change.

1) CryoSat/Summit: ongoing maintenance to record Devon Ice Cap mass change

Since 2004 we have taken routine measurements of the amount of ice and firn, and the temperature of the air and firn along a 40-km long transect which runs from the ice cap summit to its southern margin. This year (May 2014) only the minimum measurements required to maintain our observational record were taken. Specifically, data from 15 temperature and humidity sensors were collected and the height of the 2013 summer surface, which is used to estimate the amount of mass gained or lost over the last year, was measured at 22 permanent mass balance stakes. Three existing automatic weather stations were downloaded (and two were removed), and one new automatic weather station was installed.

2) Belcher Glacier

On Belcher Glacier, we made a kinematic GPS survey of a 35 km long centerline transect that we have surveyed annually since 2007 to monitor surface height changes along the glacier. An existing automatic weather station (AWS), located approximately 25 km from the glacier terminus at

900m elevation, was dismantled and replaced with a new AWS system at the same location. The AWS data help us track the relationship between summer melt events and glacier motion.

This year much of our work on the Belcher Glacier focused on the terminus region. Five existing continuously running differential GPS units that measure how fast the glacier is flowing were serviced (data downloaded, instruments reset) and re-positioned if necessary. Three new dGPS units were installed bringing the total number of continuously running dGPS units in the terminus region to eight. Time-lapse cameras are used to record iceberg calving from the glacier terminus. One existing camera was serviced and four new time-lapse cameras were installed on cliffs overlooking the terminus region.

3) Basal Ice Sampling

Approximately 50 lbs of basal ice samples were collected from several locations on the Sverdrup Glacier and the Western Margin of the ice cap. These samples have been transported back to the laboratory and are being analyzed for their physical, biogeochemical, and microbial characteristics to explore how these properties differ between warm-based ice (Sverdrup Glacier), which represents fast flowing glaciers with active subglacial drainage systems, and cold-based ice (Western Margin), which represent slow flowing/stationary glaciers with no meltwater at the bed.

4) Bedrock GPS

We have initiated a pilot project to evaluate a geodetic method of monitoring glacier mass change. This method uses continuously recording GPS stations installed on bedrock near a glacier to measure the vertical motion of the earth's crust as it responds elastically to unloading as glacier mass is removed. We expect that long term records of these measurements derived from ice marginal sites will be affected by fluctuations in snow accumulation, summer melt, and/or mass loss by iceberg calving/marine melting, while measurements from sites on bedrock outcrops in ice cap interiors will be more strongly affected by variability in snow accumulation.

We have been operating one GPS station on a bedrock outcrop near the Belcher Glacier since 2007, and this station was serviced in May 2014. A second GPS station was installed on a rock outcrop near the Sverdrup

Glacier.

NRI-ᑯᓐᓄᑦ ᐊᕿᒍᑕᒫᖅᓯᐅᑎ ᐅᓂᒃᑳᖅ (ᓄᕕᐱᕆ 2014)
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ᖃᓄᐃᓕᖓᓕᕐᓂᖓ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᓂᖓᓄ ᑕᓪᓗᕈᑎᒥ ᓯᕐᒥᐊᓗᒃ

**ᒪᑎᓐ ᓵᑉ, ᓄᓇᒥᐅᑕᓕᕆᔩᒃᑯᑦ ᓯᓚᓐᓂᐊᖅᑎᒃᑯᓪᓗ ᓯᓚᕐᑐᒃᓴᐅᑎᖏᑦ,
ᐃᐊᓪᔫᑕᒥᐅᑦ ᓯᓚᕐᑐᒃᓴᕐᕕᔪᐊᖓᓂ**

ᑕᐅᕗᖓᖅᓯᒪᔪᑦ ᐃᖅᑲᓇᐃᔭᖅᑏᑦ 2014-ᒥ: ᒪ. ᓵᑉ, ᓯ.ᑖᑎᒧ, ᐊ. ᑕᑉᓂᒃ, ᑕ. ᓯᓕᓐᔫᒍ

ᐅᓪᓗᐃᑦ ᑖᕙᓂᓐᓂᐊᖅᑕᖏᑦ: 3 ᒪᐃ – 24 ᒪᐃ, 2014.

ᖃᐅᔨᓴᕈᑕᐅᔪᑦ ᑐᕿᖓᕐᑲᕐᒪᑕ ᓇᓗᓇᐃᔭᐃᔪᒪᓪᓗᑎᒃ ᐅᓂᒃᑲᐅᑎᒋᑦᑎᐊᕐᓗᒋᑦ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᓂᖏᑦ ᑕᒪᑐᒪ ᐊᕙᑎᖓᓂ, ᐊᒃᑎᒋᓂᖏᓪᓗ, ᖃᓄᑎᒋᓗ ᓯᒡᔭᒧᑦ ᑰᒃᐸᓪᓕᐊᓂᖏᑦ ᑕᓪᓗᕈᑎᐅᑉ ᕿᑭᖅᑕᖓᓂ ᓯᕐᒥᐅᓗᐃᑦ ᑕᐃᒪᓐᓇ ᓇᓚᐅᑦᑖᕈᓐᓇᖅᓯᓂᐊᕐᑕ ᖃᓄᑎᒋ ᐃᒃᐱᖕᓇᕐᓂᖅᑲᕐᓂᐊᕐᒪᖔᑕ ᓄᓇᕐᔪᐊᒥ ᓯᒡᔭᐃᑦ ᕐᑯᑎᖕᓂᖏᓐᓄᑦ. ᖃᐅᔨᓇᓱᐊᕐᑕ ᖃᓄᑎᒋ ᓯᓚ ᐅᖅᑰᓯᕙᓪᓕᐊᓂᖓ ᒪᓕᒃᓱᒍ ᓱᒃᑲᓕᓂᖅᓴᒥᒃ ᐊᐅᒃᐸᓪᓕᐊᓕᕐᒪᖔᑕ ᑕᐅᓄᖓ ᓯᒡᔭᒧᑦ ᐱᕐᑲᓗᔭᖕᒍᖅᐸᓪᓕᐊᓂᖏᑦ ᐃᑭᕐᒧᑦ ᑲᑕᖕᓂᕐᓗᑯᖏᑦ, ᐊᒻᒪᓗ ᖃᓄᑎᒋ ᓱᒃᑲᓕᑎᒋᖕᒪᖔᑕ ᑕᐅᓄᖓ ᓯᒡᔭᒧᑦ ᑰᒃᐸᓪᓕᐊᓂᖏᑦ ᓄᖑᔪᖅᐸᓪᓕᐊᓂᖏᓪᓗ ᐱᕐᑲᓗᔭᖕᒍᖅᑲᑦᑕᖅᓱᑎᒃ. ᑕᒪᓐᓇ ᐃᖅᑲᓇᐃᔮᓇᒐᑦᑎᒍ ᖃᐅᔨᓴᖅᑎᐅᓪᓗᑕ ᖃᓇᑕᐅᔭᑎᒎᑦ ᓯᓚᒎᓪᓗ ᖁᕝᕙᖅᑎᑕᐅᓯᒪᔪᒃᑯᑦ ᐅᔾᔨᖅᓱᖅᑲᑦᑕᖅᓱᒋᑦ ᐊᒻᒪᓗ ᖃᖓᑕᓲᒃᑯᑦ ᑕᒪᐅᖓᖅᓱᑕ ᕿᒥᕈᔭᐅᕙᒃᓱᑦ ᖃᓄᑎᒋ ᓯᓚᒧᑦ ᐊᕙᑎᑦᑎᓐᓄᓪᓗ ᓱᕙᓪᓕᐊᑎᑕᐅᓂᖓ ᐅᔾᔨᖅᓱᕐᓂᐊᕐᑎᒍ ᑖᓐᓇ ᓯᕐᒥᐊᓗᒃ. ᑕᐃᑲᓃᒋᐊᖅᑐᕐᓂᐊᖅᑐᒍᑦ ᐆᒃᑐᕋᕆᐊᖅᑐᕐᓗᑕ ᓯᕐᒥᐊᓘᑉ ᐃᔾᔪᓂᖓᓂᒃ, ᐊᐳᑎᕐᑲᐅᕐᓂᖏᓐᓂ, ᓯᕐᒥᐊᓗᒃ ᑕᐅᓄᖓ ᑯᕕᕙᓪᓕᐊᓂᖓ, ᐊᐅᑉᐸᓪᓕᐊᓂᖓᓄ ᑰᒃᐸᓪᓕᐊᓂᖓᓄ, ᐊᒻᒪᓗ ᖃᓄᑎᒋ ᐊᑯᓚᐃᑎᒋᔪᒥᒃ ᐱᕐᑲᓗᔭᕐᑲᑦᑕᕐᒪᖔᑕ.

ᒫᓐᓇᕿᑖᑦᑎᐊᖅ ᓱᕖᓪᓕᕐᓂᖏᑦ

ᐊᓯᔾᔨᖅᐸᓪᓕᐊᓂᖏᑦ ᐊᒃᑎᒋᓂᖏᓪᓗ ᐊᒃᓯᐊᓗᒃ ᓱᒃᑲᓕᓂᖅᓴᒥᒃ ᐱᓕᕐᒪᑕ ᑲᓇᑕᒥ ᐅᑭᐅᖅᑕᖅᑐᖓᓂ ᓯᕐᒥᐊᓗᐃᑦ ᑕᒪᑐᒪᓂ ᐅᑭᐅᖑᕿᑖᖅᑐᓂ 100-ᓂ ᐊᖏᓂᖅᓴᒻᒪᕆᐅᓕᕐᒪᑕ ᐲᔭᖅᐸᓪᓕᐊᔪᑦ ᑕᐃᓱᒪᖓᓂᓂ 55-ᓂᒃ ᐅᑭᐅᓂᒃ ᑕᒪᐅᖓᕐᑲᑦᑕᓕᖅᑎᑦᓗᑕ. ᑕᐃᒫᑎᒋ ᐊᐅᒃᐸᓪᓕᐊᑎᒋᓕᕐᒪᑦ ᐊᐅᔭᒃᑯᑦ ᓯᓚ ᐅᖅᑰᓂᖅᓴᐅᕐᑲᑦᑕᓕᕐᒪᑦ ᓱᒃᑲᓕᓂᖅᓴᒥᒃ ᐊᐅᒃᐸᓪᓕᐊᓂᖅᓴᐅᓕᖅᑐᑦ. ᐅᑭᐅᓂ ᕐᑯᓕᓂ 2000-ᒥ ᐱᒋᐊᖅᓱᑎᒃ ᐊᐅᔭᖏᑦ ᑕᐃᓱᒪᖓᓂᑦ ᐅᖅᑰᓂᖅᐹᖑᕐᑲᑦᑕᖅᓯᒪᖕᒪᑕ ᑕᒪᑐᒪᓂ ᐅᑭᐅᖑᕿᑖᖅᑐᓂ 60-ᓂ, ᐊᒻᒪᓗ 2005-ᒥᓂᑦ 2009-ᒧᑦ ᐅᖅᑰᓂᖅᐹᖏᓪᓗᑎᒃ ᐅᑭᐅᓂ ᑕᓪᓕᒪᓂ. ᑕᒪᑐᒪᓂ ᖃᐅᔪᐃᑦᑑᑉ ᕿᑭᖅᑕᖏᓐᓂ, ᓯᕐᒥᐊᓗᐃᑦ ᐊᐅᒃᐸᓪᓕᐊᓂᕐᑲᖅᑐᑦ 3.8-ᖏᖅᓱᖅᓱᑎᒃ ᓱᒃᑲᓕᓂᖅᓴᐅᓪᓗᑎᒃ ᑭᖑᓂᖓᓂ 2005 ᐅᑭᐅᓂ 50-ᓂ. ᑕᒪᐃᑕ

ᐆᒃᑐᕋᐅᑎᕗᑦ ᓯᓚᒧᑦ ᖁᕝᕙᖅᑎᑕᐅᓯᒪᔪᒃᑯᑦ ᑕᑯᓪᓗᒋᑦ 2007-ᒥᑦ 2009-ᒧᑦ, ᓯᕐᒥᐊᓗᐃᑦ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖕᒐᓂ ᐊᐅᒃᐸᓪᓕᐊᓂᖕᒋᓐᓄᑦ ᓄᓇᕐᔪᐊᒥ ᓯᒡᔭᖕᒋᑦ ᖁᕝᕙᖅᐹᓪᓕᖅᓯᒪᖕᒪᑕ ᐃᓱᒪᒋᖕᒋᓱᒋᑦ ᓯᕐᒥᐊᓗᐃᑦ ᓯᑯᐃᓪᓗ ᐊᑯᑭᑦᑐᒥᐅᑦ ᕿᑭᖅᑕᖕᒐᓂ ᓄᓇᕐᔪᐊᓪᓗ ᐊᑖᓂᒥᐅᓂ. ᑕᑯᔭᖅᑐᖅᑕᐅᓯᒪᑎᓪᓗᒍ ᖃᐅᔨᓚᐅᖅᑐᒍᑦ ᑖᓪᓗᕈᑎᐅᑉ ᓯᕐᒥᐊᓗᐊ ᐊᒃᓱᕐᑲᓪᓚᒃ ᓱᕐᕋᖅᓯᒪᓕᕐᒪᑦ 2005-ᒥᑦ ᐊᒻᒪᓗ ᕿᓚᒥᕈᓘᓂᖅᓴᖅ ᐊᐳᑎ ᓯᑯᖕᒍᕐᑲᑦᑕᓕᖅᓱᓂ ᖃᖕᒐᓂ. ᖁᑦᑎᖕᓂᖅᐹᓂᓘᓐᓃᑦ ᑭᓐᖕᒑᓗᐊᓂ ᓯᕐᒥᐊᓘᑉ ᖃᖕᒐᓂ, ᐊᐅᔭᒃᑯᑦ ᐊᐅᒐᔪᓗᐊᖅᐸᔪᖕᒋᑦᑐᑦ 2000-ᓂ ᒪᕐᕈᐊᖅᑎᖅᓱᑎᒃ ᐊᐅᕐᑲᑦᑕᖅᓯᒪᓕᕐᒪᑕ ᐅᑭᐅᓂ ᖁᓕᓂ, ᐊᐳᑎ ᓯᕐᒥᐊᓘᑉ ᖄᖕᒐᓃᕐᑲᑦᑕᖅᑐᖅ ᐊᐅᒃᑳᖕᒐᑦ ᑰᓕᕐᑲᑦᑕᕐᒪᑕ ᓯᕐᒥᐊᓘᑉ ᐃᓗᐊᓄᑦ ᖄᖕᒐᓃᑦᑐᕐᓗ ᖁᐊᒃᑲᓐᓂᕐᑲᑦᑕᖅᓱᓂ. ᑕᐃᓱᒪᓂᐊᓗᒃ ᑕᐃᓛᑎᒋ ᐊᐅᓚᐅᖅᓯᒪᖕᒪᑦ ᐅᑭᐅᓂ 4200-ᓂ. ᐃᒪᑦᑎᐊᕙᒃ ᓯᕐᒥᐊᓘᑉ ᖄᖕᒐᓂ ᐊᐅᒃᐸᓪᓕᐊᓵᓕᓂᖅᓴᐅᕐᑲᑦᑕᓕᖅᑐᖅ, ᑕᐃᒪᓐᓇ ᓄᖕᒍᓴᕋᐃᓐᓂᖅᓴᐅᓂᐊᖅᑐᖅ ᖁᓖᓂ ᐊᑖᓂᓗ ᐊᕐᕆᒍᑕᓖᑦ ᐱᕐᑲᓗᔭᖕᒍᖅᐸᓪᓕᐊᓗᑎᒃ ᓯᒡᔭᖕᒐᓂ ᐃᑭᕐᒧᑦ ᑲᑕᖕᓂᕐᓗᑯᐃᑦ.

2014-ᒥ ᑕᒪᐅᖕᒐᖅᓯᒪᑎᓪᓗᑕ:

ᑕᒪᑐᒪᓂ ᐅᑭᐅᑦᑎᓐᓂ ᑕᒪᐅᖕᒐᖅᓯᒪᓚᐅᕐᒥᔪᒍᑦ ᐱᖕᒐᓱᓄᑦ ᓄᓇᓄᑦ ᓂᕈᐊᖅᓯᒪᔭᑦᑎᓐᓄᑦ i) ᖃᐅᔨᓴᕆᐊᖅᑐᖅᓱᒋᑦ ᓯᒡᔭᖕᒐᓂ ᐱᕐᑲᓗᔭᖕᒍᖅᐸᓪᓕᐊᔪᑦ ᓯᕐᒥᐊᓗᖕᒥᑦ ᓯᓚ ᒪᓕᒃᓱᒍ ᖃᓄᑎᒋ ᓯᑯᐃᔭᕐᑲᑦᑕᕐᒪᖕᒎᑕ ᓯᕐᒥᐊᓗᐃᑦ, ii) ᖃᐅᔨᓴᖅᑕᐅᓪᓗᑎᒃ ᐅᐊᕈᑎᓯᒪᔪᑦ ᐃᒪᖕᒐᓂ ᓯᑯᖕᒐᓂᓗ ᑲᑕᖕᓂᕐᓗᑯᐃᑦ ᐊᕙᑎᖕᒐᓂᑦ ᖃᓄᐃᓕᕚᓪᓕᕐᑲᑦᑕᕐᒪᖕᒎᑕ ᐃᒃᐲᖕᒍᑎᓪᓗᒍ ᐊᒻᒪᓗ ᐊᐅᔭᒃᑯᑦ ᐅᖅᑰᓕᖅᑎᓪᓗᒍ, ᐊᒻᒪᓗ iii) ᓯᕗᓪᓕᖅᐹᒥ ᐆᒃᑐᕋᐅᑎᒋᓪᓗᒍ ᐱᓕᕆᐊᕐᑲᖅᓱᑎᒃ ᐃᓕᐅᖅᑲᐃᓪᓗᑎᒃ ᐆᒃᑐᕋᐅᑎᓂᒃ ᒪᓂᕋᖕᒐᓂ ᓯᕐᒥᐊᓘᑉ ᐊᔅᓱᐆᖕᒋᑦᑐᓂ ᐊᐅᒃᓯᒪᓂᕐᑲᕐᕚᐅᔪᓂ ᒪᓂᕋᖕᒐᓄᑦ GPS-ᓂᒃ ᐃᓕᐅᖅᑲᐃᓚᐅᖅᑐᑦ. ᑕᐃᒪᖕᒐᓂ ᐆᒃᑐᕋᖅᑕᐅᖕᒋᓇᕐᓂᐊᕐᒪᑦ ᓴᓇᖅᑯᑎᓂᒃ ᐃᓕᐅᖅᑲᐃᕐᑲᑦᑕᖅᑐᑦ ᐊᒻᒪᓗ ᑕᐃᒪᖕᒐᓄᑦ ᕿᒥᕈᔭᐅᕆᐊᖅᑐᕐᑲᑦᑕᖅᓱᑎᒃ ᐃᓱᓕᒃᑳᖕᒐᑕ ᐊᓯᖕᒎᖕᒋᓐᓂᒃ ᐃᓕᓯᕝᕕᐅᕙᒃᓱᑎᒃ ᑕᒪᓂ ᑖᓪᓗᕈᑎᐅᑉ ᓯᕐᒥᐊᓗᐊᓂ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᓂᖕᒐᓂ ᐆᒃᑐᕋᐅᑏᑦ.

1) <u>ᓯᑯᓐᓂᐊᖅᑕᐅᓂᖕᒐ/ᓯᕐᒥᐊᓘᑉ ᖄᖕᒐᓂ: ᑕᐃᒪᖕᒐᓂ ᐆᒃᑐᕋᐅᑏᑦ ᐋᕐᑭᐅᒪᑎᑕᐅᔪᑦ ᑖᓪᓗᕈᑎᐅᑉ ᓯᕐᒥᐊᓗᐊᑕ ᖄᖕᒐᓂ ᐊᓯᔾᔨᖅᐹᓪᓕᐊᓂᖕᒐᓂᒃ ᐆᒃᑐᕋᐅᑕᐅᓪᓗᑎᒃ</u>

ᑕᐃᒪᖕᒐᓂᑦ 2004-ᒥᑦ ᐆᒃᑐᕋᖅᑕᐅᕐᑲᑦᑕᐃᓐᓇᓕᓚᐅᕐᒪᑕ ᓯᑯᖕᒎᖅᐸᓪᓕᐊᓂᖕᒋᑦ ᐊᐳᑏᑦ ᖄᖕᒐᓂ, ᖃᓄᑎᒋᓗ ᐃᒃᐲᖕᒍᓕᖅᑕᕐᓂᖕᒐ ᓯᓚᖕᒐᑕ ᐆᒃᑐᕋᖅᑕᐅᖕᒋᓇᖅᓱᓂ ᑕᒪᑐᒪᓂ 40-ᑭᓚᒥᑐᒥᒃ ᑕᑭᓂᖅᑲᖅᑐᒥᒃ ᐃᑳᖅᓯᓪᓗᑎᒃ ᓯᕐᒥᐊᓗᖕᒥᒃ ᖄᖕᒐᓂᑦ ᑕᐅᓄᖕᒐ ᓯᐅᔭᖕᒐᓄᑦ. ᐅᑭᐅᑦᑎᓐᓂ (ᒪᐃ 2014-ᒥ) ᕿᓚᒥᐅᓂᖅᐹᒥᒃ ᑕᓖᓃᓚᐅᖅᑐᑦ ᐃᓕᔭᐅᓯᒪᔪᑦ ᑕᑯᔭᖅᑐᖅᑲᑦᑕᑐᐃᓐᓇᖅᓱᒋᑦ. ᐱᓗᐊᖕᒍᐊᖅᑐᒥᒃ, ᓈᓴᐅᑎᖕᒋᑦ 15-ᓂ ᐃᓕᔭᐅᓯᒪᔪᓂ ᓯᓚᓐᓂᐊᕐᕕᓂ ᐃᒃᐲᖕᒍᖅᑕᕐᓂᖕᒐᓂᒃ ᑎᑎᕋᖅᐸᓪᓕᐊᔪᑦ ᖃᑎᖅᓱᖅᑕᐅᓚᐅᖅᑐ ᐊᒻᒪᓗ ᐆᒃᑐᕋᖅᑕᐅᓪᓗᓂ ᖃᓄᑎᒋ ᐳᖅᑐᓂᕐᑲᕐᒪᖕᒎᑦ ᐊᐅᔭᒃᑯᑦ 2013-ᒥ ᒪᓂᕋᖕᒐᓂᑦ ᐱᒋᐊᖅᓱᒍ. ᐆᒃᑐᕋᐃᓪᓗᑎᒃ ᖃᓄᑎᒋ ᐊᓯᐅᔭᓚᐅᕐᒪᖕᒎᑕ ᐊᐅᒃᐸᓪᓕᐊᓂᖕᒎᓄᑦ ᐊᒻᒪᓗ ᖃᓄᑎᒋ ᐃᓚᕙᓪᓕᐊᓂᖕᒐ ᖁᓖᓂᑦ ᐅᑭᐅᒃᑯᑦ ᐆᒃᑐᕋᓂᐊᕐᒪᑕ ᐃᓕᐅᖅᑲᐃᓚᐅᖅᑐᑦ ᓇᑉᐸᖅᑕᒐᓂᒃ ᐃᑎᓂᖕᒋᓐᓂᒃ ᓈᓴᐅᑎᓕᖅᓱᖅᓯᒪᐅᖅᑐᓂᒃ. ᐱᖕᒐᓱᓂᒃ ᓯᓚᓐᓂᐊᕈᑎᓂᒃ

ᐃᓕᐅᖅᑲᖅᓯᒪᔭᑦᑎᓐᓂᒃ ᐲᖅᓯᓪᓗᑕ ᑎᑎᕋᖅᑕᕐᑎᓐᓂᒃ (ᐊᒻᒪᓗ ᒪᕐᕚᓐᓂᒃ ᐲᖅᓯᓪᓗᑕ), ᐊᒻᒪᓗ ᓄᑖᒥᒃ ᐃᓕᓯᓪᓗᑕ ᓯᓚᓐᓂᐊᕈᑎᒥᒃ ᑕᒪᓂ.

2) **ᐱᐊᓪᓯ ᓯᕐᒥᐊᓗᐊᓂ**

ᐱᐊᓪᓯ ᓯᕐᒥᐊᓗᐊᓂᓂ (Belcher Glacier), ᒪᓂᕋᖓᑕ ᖃᖓᓂ ᐆᒃᑐᕋᐅᑎᓕᐅᓚᐅᕐᒥᔪᑦ GPS-ᑯᑎᒍᑦ ᑕᑭᓂᖃᖅᑐᒥ 35-ᑭᓛᒥᑐᒥᒃ ᕿᑎᖓᓂᑦ ᑕᐅᓄᖓ ᐆᒃᑐᕋᐅᑎᓕᐅᖅᑕᐅᓪᓗᓂ ᐊᕐᕋᒍᑕᒫᑦ ᑕᑯᔭᖅᑐᖅᑕᐅᖃᑦᑕᓕᖅᑐᓂ 2007-ᒥᓂᑦ ᐅᔾᔨᖅᓱᕈᑕᐅᓪᓗᓂ ᐳᖅᑐᓂᖓᑕ ᐊᓱᔾᔨᖅᐸᓪᓕᐊᓂᖓᓂᒃ ᓯᕐᒥᐊᓘᑉ. ᑕᒫᓃᖏᓐᓇᐅᔭᖅᑐᖅ ᑕᐃᒪᖓᓂᑦ ᓯᓚᓐᓂᐊᕈᑕᐅᔪᖅ (AWS) ᐃᓕᔭᐅᓚᐅᕐᒥᔪᖅ, ᐃᒻᒪᖃ 25-ᑭᓚᒥᓱᒥᒃ ᐅᖓᓯᖕᓂᖅᑲᖅᑐᖅ ᓯᒃᔭᖓᓂᑦ ᓯᕐᒥᐊᓗᐊᑕ ᖁᖅᑎᖕᓂᖅᑲᖅᑐᒥ 900-ᒦᑐᒥᒃ, ᐲᔭᖅᑕᐅᓚᕐᒪᑦ ᐊᒻᒪᓗ ᐃᓕᓯᒃᑲᓐᓂᖅᓱᑎᒃ ᓄᑖᒥᒃ AWS-ᖃᓱᐅᑎᒥᒃ ᑕᙯᓂᓴᐃᓐᓇᖅ. AWS ᑎᑎᕋᖅᐸᓪᓕᐊᖃᑦᑕᕐᒪᑕ ᐊᐅᔭᒃᑯᑦ ᐊᐅᒃᐸᓪᓕᐊᓂᖓᓂᒃ ᐊᒻᒪᓗ ᐃᖏᕋᕙᓪᓕᐊᓂᖓᓂᒃ ᑯᐸᓪᓕᐊᓂᖓᓂᓗ ᓯᑳᔾᒧᑦ.

ᑕᒪᑐᒪᓂ ᐅᑭᐅᑦᑎᓐᓂ ᐱᓕᕆᓂᖅᓴᐅᓚᐅᕋᑦᑕ ᐱᐊᓪᓯ ᓯᕐᒥᐊᑕ ᐊᑖᓂ. ᑕᓪᓕᒪᓂᒃ ᑕᐃᒪᖓᓂ ᐆᒃᑐᕋᐃᓐᓇᖅᑐᓂᒃ GPS-ᓂᒃ ᐃᓕᐅᖅᑲᐃᓚᐅᖅᑐᒍᑦ ᐆᒃᑐᕋᖃᑦᑕᕐᓂᐊᖅᑐᓂᒃ ᓱᒃᑲᓕᓂᖓᓂᒃ ᐃᖏᕋᓂᖓᑕ ᑕᐅᓄᖓ ᓯᑳᔾᒧᑦ ᓄᑖᓂᒃ ᐊᔾᔨᓕᐅᕈᓯᖅᓱᒋᑦ (ᐊᕐᕌᓂᓂᑕᐃᑦ ᐃᓱᓕᓯᒪᔪᓪᓗ ᐲᖅᑕᐅᓪᓗᑎᒃ, ᐆᒃᑐᕋᐅᑎᖏᓪᓗ ᐱᒋᐊᕐᕕᐊᓅᖅᓱᒋᑦ) ᐊᒻᒪᓗ ᐅᕐᕈᓕᖅᑐᕕᓃᑦ ᐋᕿᒋᐊᖅᑕᐅᓪᓗᑎᒃ. ᓄᑖᓃᑕᐅᖅ ᐱᖓᓱᓂᒃ dGPS-ᓂᒃ ᐃᓕᓯᒋᓪᓗᑎᒃ ᑲᑎᓱᒋᑦ ᑕᐃᒪᖓᓂᑦ dGPS-ᓂᒃ ᐆᒃᑐᕋᐅᑎᖃᓕᖅᑐᑦ ᐊᒻᒪᓗ ᐃᓱᓕᕝᕕᐊᓂ 8-ᓂᒃ. ᐊᑕᐅᓯᕐᒥᒃ ᐊᔾᔨᓕᐅᕈᑎᖃᖅᓱᑎᒃ ᐊᔾᔨᒃᓴᓕᖅᑕᐅᒃᑲᓐᓂᕆᓪᓗᓂ ᐊᒻᒪᓗ ᓯᑕᒪᓂ ᓄᑖᓂᒃ ᑕᐃᒪᖓᓂᒃ ᐊᔾᔨᓕᐅᕆᙵᓕᐊᕙᓂᒃ ᐱᑕᖃᓕᕐᒥᔪᖅ ᑭᓐᖓᓂ ᓴᓂᑦᑎᐊᖓᓂ ᓯᕐᒥᐊᓘᑉ ᐃᓱᐊᑕ

3) ᐃᓗᐊᓂ ᓯᑯᐊ ᖃᐅᔨᓴᖅᑕᐅᔪᖅ

ᐃᒻᒪᖃ 50-ᐸᐅᓐᓗᐊᓂᒃ ᐃᑯᑖᕐᓂᑯᓂᒃ ᓯᑯᓂᒃ ᑲᑎᖅᓯᐃᓚᐅᖅᑐᒍᑦ ᐊᔾᔨᕐᖏᑦᑐᓂ ᒪᓂᕋᓂ ᓯᕙᓐᑐᕋᑉ ᓯᕐᒥᐊᓗᐊᓂᑦ ᐊᒻᒪᓗ ᐅᐊᓕᓂᖕᖠᖕᖠᓂᑦ ᓯᕐᒥᐊᓗᐊᑕ ᑕᕐᕋᖕᖠᖕᖓᓂ ᖃᖓᓂᑦ. ᑖᒃᑯᐊ ᑲᑎᖅᓱᖅᑕᐅᔪᑦ ᐅᑎᕐᖅᑎᓪᓗᒋᑦ ᓇᒃᓴᖅᑕᐅᓚᐅᕐᒪᑕ ᑕᐅᓇᓂ ᐃᓗᓕᖕᒋᑦ ᐆᒃᑐᕋᖅᑕᐅᓂᐊᕐᒪᑕ ᖃᐅᔨᓴᕐᕕᖕᒥ ᐃᒪᓐᓂᐊᖅᑕᐅᓂᐊᕐᒪᑕ ᐃᓗᓕᖕᒋᑦ, ᐅᐊᕈᑎᓯᒪᔪᓪᓗ ᓯᑯᒥ, ᐊᒻᒪᓗ ᕿᐱᕈᑯᓗᐃᑦ ᐱᕈᕐᓂᑯᐃᑦ ᓯᑯᒥ ᖃᓄᐃᑦᑑᖕᒪᖕᖠᑕ ᐃᓗᓕᙵᔾᔨᖕᒋᑦ ᓇᓗᓇᐃᔭᖅᑕᐅᓗᑎᒃ ᐊᐅᔭᒃᑯᑦ ᐅᖅᑯᑎᓪᓗᒍ ᓯᕕᓐᑐᕋᑉ ᓯᕐᒥᐊᓗᐊᓂ ᐊᒻᒪᓗ ᓂᓪᓕᓇᕐᓂᖅᓴᒥ ᑕᕐᕋᖕᖠᖕᖠᓂ ᓯᕐᒥᐊᓘᑉ ᓯᕐᑭᓐᓂᖅᑕᐅᖃᖅᑕᖕᒋᖅᑐᒥ, ᐃᖏᕋᖕᒋᓐᓂᖅᓴᐅᖕᒪᑦ ᓯᕐᒥᐅᓗᒃ ᑰᖃᐅᖕᒋᓐᓂᖅᓴᐅᓪᓗᓂ ᐊᐅᒃᐸᓪᓕᐊᔪᓂᒃ ᒪᓂᕋᖓᓄᑦ.

4) **ᒪᓂᕋᖓᓂ ᐅᔭᕋᒥ dGPS**

ᐱᒋᐊᖅᑎᑦᑎᓚᐅᕐᒥᔪᒍᑦ ᐆᒃᑐᕋᐅᑎᓕᐅᖅᑲᐃᓪᓗᑕ ᓯᕐᒥᐊᓘᑉ ᐃᓗᐊᓂ ᐳᖅᑐᓂᕐᓂ ᐊᓱᔾᔨᖅᐸᓪᓕᐊᓂᖓᓂᒃ ᐆᒃᑐᕋᐅᑎᒥᒃ. ᑕᐃᒪᖓᓂᑦ ᐆᒃᑐᕋᖅᐸᓪᓕᐊᓂᐊᕐᒪᑦ ᒪᓂᕋᖓᑕ ᖁᑦᑎᓕᖅᑕᕐᓂᖓᓂᒃ ᑲᑦᑕᕐᓂᖓᓂᓗ ᓄᓇᕐᔪᐊᑉ ᖃᓕᐸᖓᓂᒃ ᐅᔭᕋᒥᒃ

ᐆᒃᑐᕋᖅᐸᓪᓕᐊᔪᒥᒃ ᑕᒪᑐᒪᓂ ᓯᕐᒥᐊᓘᑉ ᐃᓂᕓᓂᐊᓂ ᐊᐅᒃᐸᓪᓕᐊᑎᓪᓗᑦᑦ ᖃᓄᑎᒋ ᒪᓂᕋᖅ ᖁᕝᕚᖅᐸᓪᓕᖅᑕᑦᑕᕐᒪᖕᒋᑦ ᓯᒥᐊᓗᒃ ᖄᖓᓃᑦᑐᕙᓂᖅ ᐊᐅᒃᑳᖕᒐᑦ. ᕿᓚᓈᕋᑦᑕ ᑕᐃᒪᖕᒐᓂ ᓯᕙᑐᔪᒧᑦ ᐆᒃᑐᕋᖅᑕᐅᖃᑦᑕᖅᑐᑦ ᓱᑉᐲᓪᓕᖅᐸᓪᓕᐊᓂᖕᒐᓂᒃ ᑕᑯᑕᐅᔫᓇᕐᓂᐊᕐᒪᑕ ᒪᓂᕋᐅᑉ ᖃᖕᒐᓂ ᓯᕐᒥᐊᓗᖃᖅᑎᓪᓗᒍ ᐊᐱᓯᒪᓕᖅᑎᓪᓗᒍᓗ ᐅᑭᐅᒃᑯᑦ, ᐊᐅᒃᑳᖕᒐᓪᓗ ᐊᐅᔮᒃᑯᑦ, ᐊᒻᒪᓗ/ᐅᕝᕙᓘᓐᓃᑦ ᐱᖃᓗᔮᖑᖅᐸᓪᓕᐊᔪᓄᑦ/ᓯᒃᔭᖕᒐᓂᓗ ᓯᑯ ᐊᐅᒃᑳᖕᒐᑦ, ᑕᒪᑐᒪᓂᓴᐃᓐᓇᖅ ᓯᕐᒥᐊᓘᑉ ᓄᓇᖕᒐᑕ ᖃᖕᒐᓂ ᐅᔭᕋᓯᔪᓂᓗ ᑕᑯᓴᐅᔪᓂ ᐃᓕᓯᖕᒥᔪᑦ ᒪᓂᕋᖕᒐᓂ ᐊᒃᑐᐊᔭᐅᖕᒥᖕᒪᑕ ᐊᐱᖃᑦᑕᕐᓂᖕᒋᓐᓄᑦ.

ᐃᓕᐅᖅᑲᐃᓯᒪᓕᖅᑐᒍᑦ ᐊᑯᓂ ᐆᒃᑐᕋᐅᑎᓂᒃ ᒪᓂᕋᖕᒐᓂ ᐱᐊᓪᓯ ᓯᕐᒥᐊᓗᖕᒐᓂ ᑕᐃᒪᖕᒐᓂᑦ 2007-ᒥᑦ, ᐊᒻᒪᓗ ᑕᑯᔭᖅᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᒪᐃ 2014-ᒥ. ᑐᖕᒐᓂᖕᒐᓂ ᑕᐃᒪᐃᑦᑐᓴᐃᓐᓇᒥᒃ ᐃᓕᓯᒃᑲᓐᓂᖅᓯᑎᒃ dGPS-ᒥᒃ ᒪᓂᕋᖕᒐᓂ ᐅᔭᕋᓯᔪᒥ ᑕᑯᒃᓴᐅᔪᒥ ᓯᕐᒥᐊᓗᖕᒐᓂ ᓯᕙᓐᑐᕌᑉ ᓯᕐᒥᐊᓗᐊᓂ.