On endless ice, searching for clues to our future

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In this July 19, 2011 photo, attached by rope to a waiting helicopter, Arctic researcher Carl Gladish of New York University hammers a steel stake into ice, securing a newly-deployed GPS seismometer, or Geopebble, designed to track glacial movement near the edge of the Greenland ice sheet, atop Jakobshavn Glacier, outside Ilulissat, Greenland. The chief researcher, NYU's David Holland, hopes to eventually deploy scores of the devices to help measure ice loss in Greenland. (AP Photo/Brennan Linsley)

(AP) -- The pilot eased his five-ton helicopter toward the glacier's rumpled surface, aiming for the lightest of setdowns atop one of the fastest-flowing ice streams on Earth.

David Holland's voice suddenly broke in on the intercom.

"Carl doesn't like this!" the scientist shouted. "Carl says it's snow

bridges!" - drifts that can hide a deep crevasse.

The chopper pulled up sharply and veered off over the chaotic icescape of white knobs and pinnacles and bluish glints of meltwater, on to another, safer landing spot where Carl Gladish, Holland's lanky, ponytailed assistant, stepped cautiously off the skid and onto the ice, under the thudding rotor blades, to swiftly carry out his assigned task.

It was one of eight 2-minute touchdowns on which the New York University research team positioned instruments to measure the movement and internal cracking of Jakobshavn Glacier, a risky operation meant to shed light on one more tiny piece of the giant puzzle called Greenland.

Other scientists elsewhere were working on their own pieces, on demanding and often dangerous missions, sometimes in subfreezing temperatures and high winds, sleeping in tents on the ice, isolated for weeks at a time, linked tenuously by satellite phone.

On this same July day, Alun Hubbard was on a solitary trek to the north coast's spectacular, remote Petermann Glacier. Liz Morris was in the first hours of a monthlong research traverse along the hump of Greenland's vast, 3-kilometer-thick (2-mile-thick) ice sheet. Asa Rennermalm and her colleagues, at the ice's western fringe, were in their fourth summer of meticulous, tedious sampling of the meltwater flow from the interior.

Scattered across the world's largest island, as big as Alaska and California combined and 80 percent covered by ice, small bands of specialists tended to GPS sites and automatic weather stations, drilled down into the island's frozen cap, and analyzed the air and clouds overhead, working long hours under the midnight sun to help begin answering a crucial question:

How much of Greenland's ice will melt, and how quickly, in a world growing warmer, and warming fastest in the Arctic?

If all the ice eventually slipped into the ocean, it would be enough to raise global sea levels by 7 meters (23 feet). Even a fraction of that would inundate Bangladesh and south Florida, drown small islands, threaten Shanghai and New York.

But as temperatures rise from greenhouse gases in the atmosphere, the answer isn't coming easily. The challenge - scientific, logistical - appears greater than the resources devoted to it.

This Greenland puzzle, and uncertainty over Antarctica's ice, led the U.N.-sponsored Intergovernmental Panel on Climate Change to essentially disregard the impact on oceans of an accelerating polar melt. In its 2007 global warming report, the IPCC projected a sea-level rise of only 18 to 59 centimeters (7 to 23 inches) this century, mostly from water expanding when warmed.

But researchers have since determined that Greenland lost ice in the 2004-2009 period four times faster than in 1995-2000. This May, the eight-nation Arctic Monitoring and Assessment Program forecast a much higher global sea-level rise - of 90 to 160 centimeters (35 to 63 inches) by 2100.

To those best informed, like Cambridge University's Morris, a polar research veteran, melt is inevitable in a place where temperatures over the ice sheet have risen by 2.2 degrees C (4 degrees F) in just 20 years.

"There's no way that you put greenhouse gases into the atmosphere and it won't warm and the ice won't melt," she said before setting out on her snowmobile expedition. "The uncertainty is when."

The "when" hinges on a web of variables in what Morris called Greenland's "massively complex" ice system.

When and where, for example, are warmer southern waters reaching Greenland's fjords, spreading under their glaciers? How effectively is meltwater percolating from the ice sheet's inland surface to its base, lubricating movement toward the sea? How much does snowfall - water drawn from the oceans - offset the melted ice?

Researchers long focused on southern outlet glaciers like the west coast's Jakobshavn, an awesome iceberg producer 6 kilometers (4 miles) wide, believed to be the Northern Hemisphere's biggest single contributor to ocean rise. The ice where doctoral candidate Gladish did his quick work is streaming toward the sea at a rate of 30 meters (100 feet) a day, twice as fast as in the 1990s.

The big melt is now moving northwest. Last year, U.S. and Danish scientists reported that "crustal uplift," the rising of land as the weight of ice melts away, was detected far up the coast.

"There are big red zones, big thinning rates going on in the far northwest, and that's bizarre because it's meant to be very cold up there," said Hubbard, of Wales' Aberystwyth University.

The ruggedly built British glaciologist spoke with a reporter at Kangerlussuaq, a southern research hub, hours before helicoptering off on a one-man mission to collect GPS and other data from Petermann Glacier, just 1,000 kilometers (600 miles) from the North Pole.

A year ago, a 290-square-kilometer (110-square-mile) piece broke off giant Petermann and into the sea - a chunk of ice three times the size of Manhattan island.

But Hubbard, like others, said intensive research is now most needed deeper in the interior, to learn how the main body of ice is reacting to longer, warmer summers, and particularly whether meltwater pouring down to its base might cause "runaway instability" in the ice sheet.

He said the melt has moved inland up Greenland's icy dome to 1,500 meters (5,000 feet) elevation, some 120 kilometers (75 miles) in from the ice cap's edge.

This summer a U.S.-Swiss team was drilling boreholes into the ice sheet northeast of Jakobshavn Glacier to better understand how ice movement detected by GPS stations relates to the "plumbing," the under-ice meltwater system the boreholes find below.

Far up the slope, at the 3,200-meter-high (10,500-foot-high) frigid heart of the ice sheet, the U.S. National Science Foundation (NSF) maintains its remote Summit Station research site, serviced by big New York Air National Guard LC-130 transport planes equipped with ski landing gear for the ice runway.

In small labs bristling with rooftop sensors, American researchers at Summit upgraded their instruments this summer to better study cloud formation and thickness, precipitation, the reflectivity of the snow and ice, and the presence of "black carbon," falling soot, that would dim that reflectivity and absorb warming sunlight.

Snowfall is key, but "we know so little detail about Greenland," said Summit visitor Erica Key, an Arctic program manager for the NSF, a major funder of Greenland research.

"Most models" - computer climate simulations - "block out Greenland as a black box," she said.

It was in Summit's thin air that 64-year-old Morris, her 155-centimeter (5-foot-1) frame bundled in orange cold-weather gear, set out with assistant John Sweeny on a one-month, two-snowmobile mission to supply her piece of the puzzle: measuring the snow density along a 400-kilometer (250-mile) route, to give the new European Cryosat 2 satellite some "ground truth" data to compare and calibrate with its own remote readings of ice thickness.

Those readings are badly needed. The European Union's first ice-surveying satellite failed on launch in 2005, and NASA's ICESAT orbiter stopped working in 2009, not to be replaced until at least 2015.

Any hard-won data emerging on the ice sheet's dynamics would help refine computer models for a better fix on how a warmer Greenland will produce higher seas. But modelers are short not only on satellite readings, but also on ground observations from a too-thin corps of scientists.

Below its gravelly fringe, near Kangerlussuaq, Rennermalm's team was measuring the volume of meltwater gushing down stream beds from the ice sheet - at up to 2.3 meters (7.5 feet) per second. But this was only one spot on a huge white map.

"I want to understand how much water is coming from the ice sheet," said the Danish researcher, a leader of the Rutgers-UCLA project. "But there are very few measurements like this in Greenland. This is a difficult place to do science, a logistical challenge."

Back up at Summit, two young Dartmouth College engineering graduates put one potential answer on display, testing the tiny, tractor-like "Yeti" autonomous robot over the ice. Like humans, Yeti could deploy ground-penetrating radar, meteorological gear and other research tools, say its designers, who envision hundreds crisscrossing Greenland offering up-to-

the-minute data.

Someday. For now, NYU's Holland has opted for ringed seals, two sea mammals he fitted with instruments for recording temperature and depth in a southeastern fjord of interest - "researchers" whose findings were transmitted by satellite back to his NYU lab.

But two seals against 44,000 kilometers (27,000 miles) of Greenland coastline still come up short.

Solving the problem, said the veteran glaciologist, means accurately forecasting sea-level rise for particular regions over particular time periods. And "we don't have that capability yet."

He sees gaping holes: a need for new technology to comprehensively measure ocean temperatures; a need for an icebreaker dedicated to research in colder seasons.

"We are making a really noble effort," Holland said. "But if you ask me whether we are making adequate progress at an adequate pace, I'd say no."

The authoritative Arctic Monitoring and Assessment Program, in its May report, seemed to agree. Greenland's ice sheet is expected to melt faster and faster, but the impact remains highly uncertain, it said, and only "more robust observational networks" can change that.

"The Fate of Greenland," a new book co-authored by glaciologist Richard Alley and other leading U.S. scientists, offers stunning photos of an extraordinary white world, and dark words of warning.

"Our lack of fundamental understanding of ice-sheet behavior leaves open the possibility that we could be greatly underestimating the rate of

response to warming, with potentially major implications," they write.

The world must pay attention to Greenland, these scientists say, "because in the fate of Greenland lie clues to the fate of the world."