Disappearing Glaciers - Evidence of A Rapidly Warming Earth

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- Lonnie Thompson, Ph.D., Glacial Geologist, Ohio State University -


Qori Kalis glacier in Peru's Quelccaya ice cap, Southern Andes.
Image on **left**, 1978. Image on **right**, 2000, shows new 10 acre lake from ice melt.
Twenty percent decrease in square kilometers of ice, retreating at 1.3 feet per day since 1963.
Photographs by Lonnie Thompson, Ph.D.

March 4, 2001 Columbus, Ohio - At the American Association for the Advancement of Science (AAAS) meeting in San Francisco on February 25, Prof. Lonnie Thompson from Ohio State University's Department of Geological Sciences presented a paper entitled "Disappearing Glaciers - Evidence of A Rapidly Changing Earth." He spoke before a special session of Earth Systems Science: The Quiet Revolution, organized by the International Geosphere/Biosphere program. Dr. Thompson has completed 37 expeditions since 1978 to collect and study perhaps the world's largest archive of glacial ice cored from the Himalayas, Mount Kilimanjaro in Africa, the Andes in South America, the Antarctic and Greenland.

Dr. Thompson reported to AAAS that at least one-third of the massive ice field on top of Tanzania's Mount Kilimanjaro has melted in only the past twelve years. Further, since the first mapping of the mountain's ice in 1912, the ice field has shrunk by 82%. By 2015, there will be no more "snows of Kilimanjaro."

In Peru, the Quelccaya ice cap in the Southern Andes Mountains is at least 20% smaller than it was in 1963. One of the main glaciers there, Qori Kalis, has been melting at the astonishing rate of 1.3 feet per day. Back in 1963, the glacier covered 56 square kilometers. By 2000, it was down to less than 44 square kilometers and now there is a new ten acre lake. It's melt rate has been increasing exponentially and at its current rate will be entirely gone between 2010 and 2015, the same time that Kilimanjaro dries.

In the Himalayas, a recent ice core in fall 2000 from the Dasuopu Glacier at

26,293 feet on top of Mt. Xixabangma on the southern edge of the Tibetan Plateau indicated that the last 50 years have been the warmest for that ice cap in at least 9,000 years. That conclusion is based on oxygen isotope measurements from the Tibetan ice cores that indicate what the original temperatures of the source waters were before freezing.

Interview:

Lonnie Thompson, Ph.D., Professor of Geological Sciences, Ohio State University and Senior Research Scientist, Byrd Polar Research Center, Columbus, Ohio: "We have drilled four sites in Tibet. We have drilled in Russia, Tanzania, Peru, Ecuador and Bolivia in South America. We also have ongoing programs in Greenland and down in Antarctica. So we have drilled on just about every continent.

FROM ALL OF THE ICE CORES, WHAT IS THE CURRENT STORY ABOUT GLOBAL CLIMATE CHANGE?
The earth is getting warmer. There is no doubt about that. You see it whether you are looking at the oxygen isotopes which are one of the parameters that we measure on these ice cores that we collect. Oxygen isotopes are a proxy for temperature in ice. They record a temperature of the source area - the oceans where the water vapor comes from that makes up the snow as well as the temperatures at the area where condensation takes place that forms these glaciers. And from those, you can see the seasonal temperature variations in winter, summer.

So, when you analyze the cores, they are layered very much like a tree and you start with the year you do the drilling and count the layers back in time. And in Tibet, for example, every site - all 4 sites we have drilled - the real consistent story in the records is the enrichment, the warming, that the isotopes show over the last 200 years, starting about 1800 and coming up to the present. So, it's a very consistent signal there, and also very consistent with the meteorological stations from the Tibetan Plateau. There are about 178 stations up there at different elevations.

If you look at the temperature records from those stations, you'll see that temperatures have been warming on average about .16 degree Centigrade per decade. Those records stand from 1955 up through about 1996. And the interesting thing about those station records is that the stations from the highest elevations show the greatest warming. At the highest sites right at the top of the plateau, temperatures have been warming at about .35 degrees C. per decade.

The highest ice cores ever recovered on earth come from the top of the Himalayas at 23,500 feet. There we have the greatest isotopic enrichment occurring in the last 50 years and that enrichment is greater than anything in the last 1000 years for that site. And in fact, greater than since these particular ice fields started to form.

WHICH WOULD BE BACK HOW MANY THOUSAND YEARS?
At least 8,000-9,000 years.

IN THE LAST 9,000 YEARS THERE HAS NEVER BEEN A PERIOD THAT HAS WARMED UP AS RAPIDLY AS IT HAS IN THE LAST FIFTY YEARS?
That's correct.

HOW DO YOU EXPLAIN THAT AT THE HIGHER ELEVATIONS THAT THERE WOULD BE MORE WARMING?
That's a very important question and one that we have been looking into because when you look at the details of the glaciers in Peru, for example, they are not only retreating but the rate of retreat is accelerating. We are trying to figure out

what is driving that and one theory is that what is happening in the Tropics - that's where the energy that drives the climate system comes into the planet. It's also where water vapor is evaporated from the earth's oceans and goes into the climate system.

We think as the earth warms in the Tropics, we are getting greater evaporation at the surface down where most of our instrumental records, meteorological stations, are located. Evaporation is a cooling process, but it's really a transfer of heat from the surface of the ocean and water vapor gets tied up in these deep convective cells that make up the inter-Tropical convergence zone and have very heavy rainfall. And when you have condensation taking place, this heat is released.

Tibet Glacial Retreat

If we start in Tibet - the last glacier we visited in the central part of Tibet. We were the first westerners, the first people to go into that area. Very remote. No roads. But we had a map. The map of the glacier, Puruogangri, was made from aerial photographs that the Chinese took back in 1974. And in the year 2000, all the lobes coming off of that ice cap onto the plateau had retreated 1 to 2 kilometers since that map had been made.

Africa's Mount Kilimanjaro Glacier Melting Rapidly

Mount Kilimanjaro, Tanzania, Africa.
Photograph of disappearing glacier taken in 2000
by Lonnie Thompson, Ph.D., Ohio State University.

If we go to Kilimanjaro where we drilled in the year 2000 also, as part of the project we recovered six cores to the bedrock from the ice fields on top of Kilimanjaro. But on Feb. 16, 2000, we also had aerial photographs taken of the ice fields. And from those, we were able to make a map of the area of ice that's on the mountain in the year 2000. And that turns out to be 2.2 square kilometers.

The first map of the Kilimanjaro ice field was made in 1912 and there have been five maps, including ours, that have been made from 1912 to 2000. In 1912, there was 12.1 square kilometers of ice on the mountain. So, that means that since 1912, 82% of the area of ice has disappeared. The last map that was made before we made ours was in 1989. In 1989, there was 3.3 square kilometers of ice which means that 33% of the area has decreased from 1989 to the year 2000.

You can take all five of those maps, map out the area that existed as you come forward in time, and you get a line that if you project it into the future will show those ice caps disappearing around 2015.

COMPLETELY GONE.
Completely gone in another 14 years. And that is assuming there is no increase in the rates of the warming of the atmosphere.

THE U. N.'S INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE SAYS THAT PLANETARY WARMING WILL KEEP INCREASING.
We believe that's what will happen, yes.

THAT MEANS THAT THE GLACIER ON TOP OF MT. KILIMANJARO COULD BE GONE SOONER THAN 2015?
That's correct. We think that's a conservative estimate. But if it just maintains the rate of retreat that we've seen since the first map was made in 1912, it will be gone by 2015. So it's remarkable when you think about the history of that area, Ernest Hemingway and The Snows of Kilimanjaro and the like. For the people who live there, of course, it has tremendous implications for tourism. Some 20,000 tourists come to Kilimanjaro every year. It's the only mountain in the world that I know that has its own international airport. So, the local hotels and tourist industry are very concerned about what's happening in that area.

But it also has implications for the local towns like Moshe and Arusha because the mountain serves as a water source. A lot of that water comes from the rains that occur on the lower levels of the mountain. But glaciers kind of serve like a natural dam. They accumulate snow in wet periods and when there is an abundance of precipitation and it kind of waste melts when it's drier, so they kind of maintain water flow in the stream in dry periods. So, when the ice caps are gone, we would expect greater variability in water supplies in that area.

Rapid Retreat of South American Glaciers

If you go to South America where we have our longest documented records and that's because it was the first place that we went to drill tropical ice cores. I first went to Peru in 1974 and we went to look at this ice cap called Quelccaya that at that time covered 56 square kilometers. It's probably the only true ice cap in the tropics - very flat body of ice on the basalt flow, some at elevation 18,700 feet. As part of our ice core drilling program there, way back in 1978 we set up a baseline, a line where we measured the distance very carefully where we could take terrestrial photographs of the largest outlet glacier, the Qori Kalis, which flows to the west off of the Quelccaya ice cap. We could take photographs and map that glacier not only at its terminus, but also map the volume changes of ice through time. We did that back in the 1970s when no one was talking about global warming and no one was talking about global change. But we have revisited Quelccaya repeatedly to get a documented record of the change taking place there.

Our first map of this Qori Kalis glacier comes from 1963 aerial photographs and our first terrestrial photographs were in 1978. And if you look at the rate of retreat from 1963 to 1978, it was 4.9 meters per year. We went back and re-photographed the glacier in 1983. Between 1978 and 1983, the rate of retreat had increased to about 8 meters per year. We went back again in 1993 and photographed Qori Kalis, and from 1983 to 1993, the rate of retreat had increased to about 14 meters per year. Then from 1993 to 1995, the next time we measured it, the rate of retreat had increased to 30 meters per year. Then from 1995-1998, it had increased up to 49 meters per year. And from 1998 to August 2000, the last time we mapped it, the rate of retreat had increased to 155 meters per year.

IT'S ALMOST AN EXPONENTIAL MELT RATE.
It *is* an exponential melt rate. It's 32 times faster today in the rate of retreat than it was in that first period from 1963 to 1978. Since 1963, the Qori Kalis glacier in Peru's Quelccaya ice cap in the Southern Andes has shrunk by at least 20%. The rate of retreat has been 509 feet per year, or 1.3 feet per day! You can literally sit there and watch it retreat. And if you assume that the current rate of retreat will continue, this ice cap will disappear some time between 2010 and 2020.

THE SAME TIME PERIOD AS THE DISAPPEARANCE OF MT. KILIMANJARO.
That's correct.

HOW MANY OTHER OF THE WORLD'S GLACIERS THAT YOU HAVE BEEN DEALING WITH WILL ALSO BE GONE BY 2015?
The power company in Peru, Electric Peru, has been monitoring the terminus of glaciers since 1945 on about six other glaciers in northern Peru. Every one of those glaciers show retreat and they show the same acceleration in the rate of retreat that we have just talked about on Qori Kalis and the Quelccaya ice cap in the south. And so, already in Peru, the power company is worried about hydroelectric power production. In the dry season in the Rio Sante River Valley, the plant produces 100% of capacity in the wet season and that drops to 20% capacity in the dry season. In Peru, there is a very strong dry season in June, July and August and the only water comes from the melting of these glaciers. So, once the glaciers are gone, there will be very little water in those valleys.

HOW ARE THEY GOING TO GET POWER?
In cities like Lima, Peru, a city out in the desert, coastal desert, has 9 million people - they've already started to build fuel-burning power plants to make up for the loss of power and the extra need of power because population continues to increase.

BUT THAT CONTRIBUTES MORE CARBON DIOXIDE INTO THE ATMOSPHERE AND ACCELERATES THE WARMING.
That's exactly right. And we believe that in ten to 20 years, a lot of these ice fields - if you want to see and look at tropical ice - you'll have to come to the freezers here at Ohio State where we have an archive. We are storing an archive of these cores frozen at 40 deg. C. because we know that there will be new technologies and advancements in understanding that you won't be able to go out into the natural world in the tropics and recover some of these archives.

BECAUSE ALL THE ICE WILL BE GONE.
Yes.

WHAT IS YOUR OWN PERSPECTIVE ABOUT BOTH THE POLAR MELTS AND WHERE THINGS ARE HEADED AND WHAT COULD HAPPEN IN ANTARCTICA?
We have two big ice sheets on the earth, Greenland up in the Arctic regions and the Antarctic ice fields. These are where most of the fresh water on earth is contained. And for sure, the Arctic sea ice has been thinning and as the temperature of the world continues to warm, I believe that one of the things we need to be concerned about is - We know for example, that 1998 was the warmest year on record. That's the warmest year since we've had instrumental records on the planet. We also know that the decade of the 1990s was the warmest on the planet. We also know from our proxy records - tree rings, ice cores, corals and the like - that the 1990s was probably the warmest decade in the last 1000 years, at least. And we know the glaciers are melting and retreating. But we also know that the glaciers and oceans of the world serve as a buffer. As the temperatures warm, that energy, some of that energy, is going into melting the glaciers and warming of the oceans. But once the glaciers are gone, then you don't have these buffers for future temperature rises. So we have to be concerned about the natural balance that exists on the earth for trying to maintain the ways it maintains its temperature.

IF WE LOSE ALL THE ICE, THEN WHAT HAPPENS?
Then we would expect temperatures to accelerate. You have to always remember that the earth's climate has changed through time. There have been warmer periods. There have been colder periods. Natural variations in climate systems. The difference is as we go into the 21st Century, there has never been 6 billion people on the planet. There has never been a time when we were adding 200,000 people a day to that number. And probably even more telling is the fact that most of these people on the earth are poor. Most of them are striving to have a life style like western cultures and you can't blame them. But to do that, they must increase consumption. To increase consumption means you must produce more product. To produce more products, you must burn more fuels. So, it's not only the fact that the population is increasing and we're at these record levels in the history of the planet, but the fact that is our rate of

consumption is increasing even faster.

We know from the ice core studies that have been done in Antarctica that if you look at the long term history of CO2 in the earth's atmosphere, it varied due to natural changes and during glacial periods it's very low - on the order of 180-200 ppm by volume.

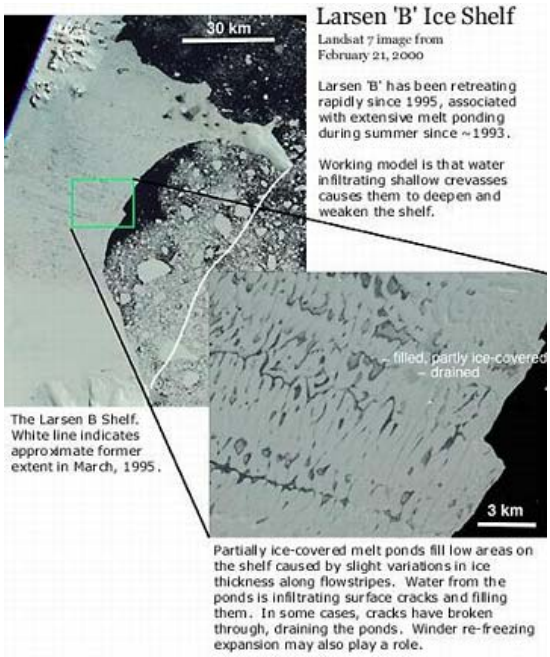
During warm periods, it gets up to 280 ppm by volume. But we crossed 300 ppm by volume in 1900. We're now at 370 ppm by volume. Sixty years out, if we go about business as usual, we'll be at 600 ppm by volume.

So, we've entered what at least in the history that we have good CO2 measurements, a period that there is no analog in the natural system.

NO PRECEDENT EVER?
No. So, we don't know exactly how the system will respond to this. But we do know these gases have long residence time. Again, another argument why - if you don't know how the system is going to respond to something like this, then we should be taking the first steps to reduce those emissions until we better understand how the climate system works.That's why when you do the business as usual projections, you see the CO2 doubling, tripling in the earth's atmosphere.

WITH NO PRECEDENT FOR THAT, AND SCIENTISTS INCREASINGLY SAYING THAT WE ARE HEADED INTO SUCH UNKNOWN TERRITORY WITH SUCH UNPREDICTABLE CONSEQUENCES THAT IF THE PLANET DID WARM ANOTHER 10 DEGREES IN THE NEXT 100 YEARS, THE CONSEQUENCES COULD BE SEVERE.
If that's where we're headed, yes. But any time you look at a model prediction of the future, it's based on what we know today and what we know from the past. But we always have to remember that the earth's climate system has always changed. There have been periods when it has warmed and cooled. If all the evidence we have was only the ice, I wouldn't be so concerned. But it comes from our instrumental records. It comes from tree ring data. It comes from ocean temperatures. From corals. That when you look at the balance of that evidence the earth is getting warmer and there is no reason to believe that it's going to reverse in the near future."

Antarctica Warming



Larsen B Ice Shelf in Antarctica has experienced major retreats
in 1995 and 1998. Satellite image courtesy NASA.

DO YOU THINK AS A PERSON STUDYING ICE CORES THAT THERE IS ANY CHANCE THAT SOME OF THOSE BIG ICE SHELVES THAT ARE ON LAND IN ANTARCTICA COULD SLIDE OFF INTO THE OCEANS IN THE NEXT 100 YEARS?
Certainly in the Antarctic peninsula area, these ice shelves have been breaking up here recently. Unfortunately we don't have a long term history to know if this has happened in the past under natural conditions. But we know that in the area in the peninsula since the first meteorological station was put in there, temperatures have increased 2.5 deg. C. And we have the break up of the ice shelves taking place.

The big ice sheets in the interior - they have a much longer response time to temperature changes. You have to look at Vostok in central east Antarctica. Temperatures there are minus 55 deg. C. So, if you raise the temperature 10 deg. C., or 5 deg. C., it's still cold. And so the response time there is slower.

But I think that we expected to see the first changes taking place in the tropical glaciers because they set right at the snow line, zero isotherm, and therefore, if temperatures of the earth rise, they will respond. They will see it first. I refer to them as the "canary in the coal mine." In the old days they used to take canaries down in a cage and if that canary died, it meant there was methane in the mine and the miners got out. I think the tropical glaciers are in a way the earth's early warning signal of the increasing temperatures of the earth.

WHEN WAS THE LAST TIME THAT ANTARCTICA HAD NO ICE ON THE LAND?
That's debated. But it's on the order of 30 million years ago. You'll find other people who say it was only 3 million years ago, but a long time ago. But certainly a time when we didn't have this human population on the planet. It's a fact that you can look at these glaciers and we have these series of photos we have collected over so many years that is so compelling because glaciers have no political agenda. All they do is respond to their environment. That's what they are doing.

AND THEY ARE MELTING.
And they are melting!"

Websites:

http://www.acs.ohio-state.edu/units/research/archive/glacgone.htm

Credits