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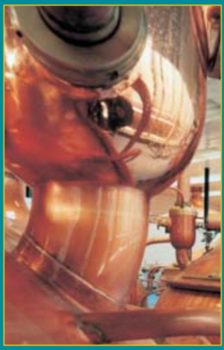

Heineken Lecture

Lonnie Thompson

hoogleraar aan het Byrd Polar Research Center,
Ohio State University
winnaar van de Dr. A.H. Heinekenprijs
voor de Milieuwetenschappen 2002

Rapid Climate Change in the Earth System: Past, Present, Future

over ijskappen als bron van informatie over klimaatveranderingen

maandag 23 september 2002, 16.00 uur
Universiteitscentrum De Uithof, Faculteitsgebouw
Aardwetenschappen, Grote collegezaal,
Budapestlaan 4, Utrecht

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Rapid Climate Change in the Earth System: Past, Present, Future

DR A.H. HEINEKEN PRIZE FOR ENVIRONMENTAL SCIENCES

LONNIE THOMPSON

Professor Lonnie G. Thompson received the Dr A.H. Heineken Prize for Environmental Sciences 2002 for his pioneering work in research into ice cores in the polar regions and the tropics.

Over the last 25 years our principal objective has been the acquisition of a global array of ice cores that can provide high-resolution climatic and environmental histories that will contribute to our understanding of the complex interactions within the Earth's coupled climatic system. Ice core histories from Africa, Antarctica, Bolivia, China, Greenland, Russia and the United States make it possible to study processes linking the polar regions to the lower latitudes where human activities are concentrated. These ice-core records contribute prominently to the Earth's paleoclimate record, the ultimate yardstick against which the significance of present and projected anthropogenic effects will be assessed.

The histories contained within the Earth's ice caps, glaciers and ice sheets provide a wealth of information that contributes to a spectrum of critical scientific questions. These issues range from the role of anthropogenic activities in 20th century climate change and the reconstruction of high-resolution climate histories to help explore the oscillatory nature of the climate system, to the role of climate variability in the rise and fall of past civilizations. We use an ever-expanding ice core-derived database of multiple proxy information (e.g. dust, stable isotopes, major and minor element chemistry, precipitation, microorganisms, pollen etc.) that is global in scope and of the highest possible temporal resolution. These data have and will continue to inform and challenge our basic constructs of how the climate system operates now as well as in the past.

Unprecedented global and regional-scale climatic, environmental and social changes during the 20th century have heightened our awareness of human vulnerability to the continuation and acceleration of such changes in the coming centuries. One-half of the Earth's surface area lies between 30°N and 30°S and supports roughly 70% of the global population. Thus, temporal and spatial variations in the occurrence and intensity of El Niño and the Monsoons are of global-scale significance, but observational records of such phenomena are scare and of short duration. Fortunately, ice core records are available from the large polar ice sheets, as well as selected high altitude, low-latitude ice caps, and when coupled with high-resolution proxy histories such as those from tree rings, sediment cores, corals, etc., provide an unprecedented view of Earth's climate history. This lecture provides an overview of these unique archives of past

climate and environmental change, examines the magnitude and rates of change, reviews the recent retreat of glaciers on a global scale under present climate conditions and begins to place the significance of this retreat into a longer term perspective which can only be provided by the paleoclimate records.

The Ice Core Paleoclimate Research Group has a 25-year history of achieving its scientific objectives by pushing ice-core research out of the polar regions to the highest tropical and subtropical mountains. This is particularly important, since much of the climatic activity of significance to humanity, such as variations in the occurrence and intensity of the El Niño-Southern Oscillation and Monsoons, is most strongly expressed in the tropics and subtropics. State of the art, one of a kind, light-weight drilling equipment has been developed which is necessary to acquire ice cores from remote, logistically challenging ice fields.

For the past two decades we have targeted ice cores for reconstructing the climate history of remote areas where meteorological and proxy records are scarce or absent. These records contribute to understanding climate variability and change over decadal-to-centennial time scales and provide insights that have modified conventional wisdom regarding tropical climate variability and its role in forcing the global climate system. More specifically, these ice core records have revealed the nature of climate variability over both glacial and interglacial time scales, with emphasis on the Late Glacial Maximum (20 thousand years before present) to the present. Records from the South American Andes have confirmed:

- much cooler conditions during the last glacial stage than previously thought;
- large spatial differences in precipitation minus evaporation (P-E) along the axis of the Andes during the last glacial state;
- warmer conditions in the Early Holocene followed by a mid-Holocene cooling that culminated in a strong neoglacial cooling (i.e., the Little Ice Age); and
- marked 20th century warming in the Peruvian Andes.

Information from the Qinghai-Tibetan Plateau show us that:

- the ice fields along the northern margin have existed throughout the last glacial stage;
- stadial and interstadial climate variability during the last glacial stage was likely forced by the tropical hydrological cycle;
- the ice fields along the southern margin and in the center of the Qinghai-Tibetan Plateau, which appear to have accumulated over the last 10,000 years, record the variability (strength and timing) of the South Asian Monsoon; and
- 20th century warming on the Qinghai-Tibetan Plateau is amplified and is accelerating with increased elevation.

Cores collected from Kilimanjaro in 2000 reveal that those ice fields are Holocene in age and contain a detailed 10,000-year history of the hydrology of tropical East Africa (scheduled to appear in *Science*, October 4th, 2002). In the summer of 2002 we used our portable, lightweight electromechanical and thermal alcohol drill systems to recover a 460-meter core to bedrock on the Bona-Churchill col in the Wrangell Mountains of Alaska.

The mechanisms responsible for the current global warming remain a topic of much debate, but the scientific evidence verifies that the Earth's globally averaged surface temperature is indeed increasing. At the same time, global water resources are at risk, and mountain glaciers and their unique climate histories are disappearing at an ever-increasing rate. In order to preserve these records that are essential for examining how the climate has changed in the past and to predict future changes, we must accelerate the rate at which ice cores are being recovered and focus on those ice fields that are at the greatest risk.

Meteorological data from across the world suggest that the Earth's globally averaged temperature has increased 0.6°C since 1950. Globally averaged temperatures were the warmest on record in 1998 (an El Niño year) while 2001 (a La Niña year) was the second warmest and 2002 (a La Niña year) is on track of becoming the warmest year on record. Permanent ice fields, or glaciers, are built by successive layers of snowfall that densify into ice that contains a preserved record of the chemical and physical characteristics of the atmosphere at the time of deposition. The record warmth of the last two decades has contributed to the widespread melting of these glaciers throughout the tropics and mid-latitudes. During this time, the Ice Core Paleoclimate Research Group at The Ohio State University has been monitoring the accelerating retreat of these ice caps and glaciers in parallel with its global ice core drilling and climate reconstruction program. We are literally watching these unique archives of the Earth's climate history melt away at an astonishing rate. The OSU group has collected a suite of globally distributed ice core records that reveal that the last decade was the warmest in at least the last 1000 years at most coring sites. In fact, a composite of the decadally averaged oxygen isotopic records from three Andean and three Tibetan ice cores over the last millennium shows a 20th Century isotopic enrichment that suggest that large scale warming is underway in the low latitudes. In concert with this apparent warming, *in situ* observations reveal that tropical glaciers are currently disappearing. For example, the Qori Kalis Glacier in Peru now retreats 205 meters per year, which is about 44 times faster than it did in 1978. Similarly, the ice on Mount Kilimanjaro, Africa covered 12.1 km^2 in 1912, but only 2.6 km^2 remain today. If the current rate of retreat continues, the perennial ice on Kilimanjaro will disappear within the next 20 years.

The clearest evidence for major climate warming underway today comes from the tropical glaciers, recorded in both the ice core records and in the drastic and accelerating retreats of both total area and total ice volume. The rapid retreat of these glaciers causes grave concern for two reasons. First, these glaciers are the world's 'water towers', and their loss threatens water resources necessary for hydroelectric production, crop irrigation, and municipal water supplies for many nations of the world. The ice fields constitute a 'bank account' that is drawn upon during dry times to feed and energize the people downstream. The current melting is cashing in on that bank account that was built over thousands of years, but is not currently being replenished. Second, these ice fields contain paleoclimate histories that are unattainable elsewhere and, as the ice fields melt, the records preserved therein are lost forever. These records are needed to discern how climate has changed in the past in these regions and to assist in predicting future change.