Letter from the Desk of David Challinor
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Locked up at the two poles is most of the planet's fresh water. Ice up to two miles deep covers much of Greenland; it is up to three miles deep over Antarctica. This ice accounts for about two-thirds of the world's fresh water, and in solid form is so heavy that cores through this mantle show the western part of Greenland to be depressed about ¼ mile below sea level. In the Antarctic there is an equivalent deformation of the substrate. These two polar ice masses have a profound effect on the earth's ocean circulatory system. By studying ice cores, lake and marine sediment cores, variations in sea temperature and long-range atmospheric conditions, scientists can grasp the complicated dynamics of the earth's climate, both past and present. This letter will discuss the ways this information is gained and how it can be applied to the potential problem of global warming.

First a word about the differences in the two polar regions. The North Pole is in the approximate center of the shallow Arctic Ocean. The perpetual salt water ice rotates clockwise around it. Because most of the Arctic Ocean is surrounded by land masses, relatively little of the north polar sea ice moves south. Fresh water icebergs calve from glaciers in Greenland and the Canadian archipelago, but they represent only a small fraction of the total floating ice mass of the northern seas. The south polar seas have no such land barriers and the edge of the sea ice moves seasonally north and south. The melting of sea ice has no measurable effect on the ocean's average level, but should Greenland's fresh water ice cap and that covering the land of the Antarctic continent ever completely melt, the world's oceans would rise by about 20 feet. Such an event is unlikely to occur within centuries or even millennia, but because such a high percentage of the world's population lives on coastlines, even a modest rise of two or three feet could have disastrous consequences.

It is prudent, therefore, to monitor closely the changing condition of the major ice caps. A recent article in SCIENCE (270:286-2088) of 27 March 1998 reported the results of satellite imagery monitoring the thickness of Greenland's ice cap. During the decade 1978-88, its surface elevation increased by only a cm (less than ½") per year. This rate is too small to indicate any significant long-term change in Greenland's glacier due to a warming polar climate. Ordinarily the warmer the air over an ice cap, the more moisture it should hold, thereby increasing snowfall and ultimately glacial ice thickness. This does not seem to be happening in Greenland.

Teasing out information stored in polar ice helps scientists to use the present to understand the past—a process called retrodicting, whereby one gains insight on future climate perturbations. Analysis of deep glacial cores has shown climates can change dramatically in a short time. For example, an 18°F warming occurred in some places in Greenland in only three years. A mere 2°F drop in global temperature in the mid-13th century created the little ice age and wiped out Greenland's thriving European colony. Cores from the Antarctic ice cap are difficult to take and drilling is usually limited to only

40 days/year. Deep cores (a mile or more down) find the ice under such pressure that the cores could shatter if not brought carefully to the surface. Both the retrieval of deep ice cores and their ultimate analysis are a slow process.

From small bubbles locked in the ice scientists study the complicated dynamics controlling the close relationship between climate change and greenhouse gas concentrations in pre-industrial society. The oxygen isotope record from cores shows rapid climate changes before the Holocene era (the interglacial time in which we live). Studies of ice cores are correlated with those of lake and marine bottom sediments to achieve the most comprehensive record possible.

From the evidence available, scientists conclude that during the current warm post-glacial period in which we live, climate has varied over a larger range than our present instruments regularly record. Thus natural variations which cause major changes in lake and river levels happen on a scale that far exceeds the range limits used in typical human planning. The record beyond the present interglacial period shows that our ocean atmosphere-system has been very unstable, with massive changes in ocean circulation patterns causing dramatic climate changes in only a few decades. Once a clear picture emerges of the natural extremes of climate variation in pre-industrial times, we can better understand and predict the effect of greenhouse gases produced by human activity on global warming.

Meanwhile, satellite imagery has recorded an ice field the size of Connecticut that broke off the Larsen Ice Shelf in Antarctica last month. Even larger pieces have detached from the Antarctic ice shelf in the recent past, but the cause of their separation is still not directly attributable to global warming. During the severe drought in California a decade ago, there were plans to tow a giant freshwater ice island to southern California as a potable water source. The proposal died quickly when the drought broke.

Recordings over the past century from tide gages and other instruments have shown an increase of 10 to 20cm (4" to 8") in global sea level. If, as we believe, the Greenland ice cap has remained relatively stable during this period as has the one in Antarctica, then a partial explanation for this rise in sea level may be a significant warming of the oceans themselves, since warm water occupies a greater volume than cold water. Global monitoring of ocean temperatures and refinement of existing radar techniques to measure changes in elevation of ocean surfaces will improve our understanding of ocean dynamics so that scientists will have a more precise explanation for the rise in sea level.

The crucial issue confronting us today is to determine how real is the threat of global warming. The Kyoto summit meeting (1-10 December 1997) concluded that the threat was real and that altering human activity and lifestyle by reducing CO_2 emissions could slow the process. Such behavioral changes as curbs on driving are politically unpopular, especially when the consequences of the threat are relatively imprecise and are expected to occur far in the future.

The world economy is currently gambling on global warming predictions. Those nations that believe the threat is real are prepared to act now. A minority group in the U.S., however, led by Frederick Seitz, former President of the National Academy of Science, claims there is yet no hard evidence of global warming and the U.S. should not sign the Kyoto Convention. This view is strongly endorsed by automobile manufacturers and other petroleum product users who are reluctant to invest in costly projects that would reduce ozone-damaging particulate emissions. Nitrogen and sulphur compounds released in the exhaust of internal combustion engines end up in the atmosphere where they exacerbate the greenhouse effect, the principal cause of global warming. A significant majority of concerned scientists accept the warming threat, pointing to the recent fulfillment of their prediction of a few years ago that the frequency of storm systems would remain unchanged, but the violence of those that occurred would be greater than normal; note the two major hurricanes this decade.

The damage caused by hurricane Andrew in Florida in 1992 cost $16.5 billion to repair; Opal in 1995 caused an expenditure of $2.1 billion in the southern U.S. Such staggering losses have attracted the attention of one of the largest segments of the world's equity markets—global insurance and re-insurance companies. The publicity attendant on the corporate damage suffered by Lloyds of London as a result of hurricane Andrew and other insured losses alerted the industry that weather risks to property seem to be increasing as scientists predicted. Global insurance companies now have such large investment portfolios (insurers and re-insurers have assets equivalent to half of the world's equity investment) that they could pressure publicly listed companies to act quickly to reduce the threat of global warming.

Insurers have good reason to be worried. Analysts report that about half of the total number of catastrophe-related insurance claims of the past 50 years has been filed in this decade alone. The number of major natural catastrophic events has quadrupled since the 1960's, with economic losses increasing by a factor of eight. Risk reduction is becoming a critical business factor. Insurers encourage risk reduction through lower rates for new construction designed to withstand earthquakes and fire; they also seek limitations on coastal development exposed to hurricanes.

As the world becomes more crowded, increasing risks will be inevitable. Studies of polar ice caps may seem remote from human problems, yet the earth's poles serve as an extraordinary storehouse of our past climate records for hundreds of thousands of years. Changing patterns of ice cover and movement provide invaluable early notice of climate trends. These changes are generally so gradual in terms of human life spans that the predictions are often ignored politically, but with the increasing sophistication of current monitoring techniques, we will do so at our peril. The rejection of the idea of the growing risk of global warming from human-induced causes may be primarily attributable to generational attitudes. Young people strike me as more concerned than their elders about global warming, therefore, I am optimistic about the future.