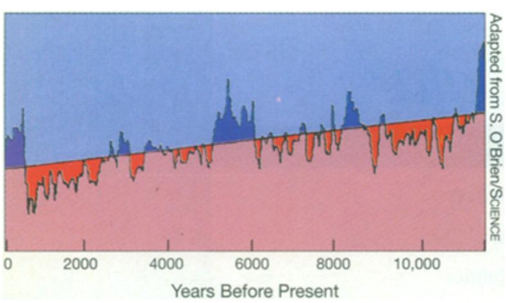
The Case of the Global Jitters

Even in seemingly stable times, climate can take an abrupt turn

By RICHARD MONASTERSKY

Sometime around the year 2200 B.C., residents of northern Mesopotamia noticed a change in the weather. As the once reliable rains disappeared, agricultural communities along tributaries of the Euphrates River withered and died. Refugees from the drought-stricken areas flooded major cities downriver, and the influx ultimately toppled the Akkadian civilization, the world's first empire.

Yale University archaeologist Harvey Weiss proposed this controversial scenario in 1993, after his team found evidence of an abrupt shift toward arid conditions at sites in northeastern Syria. He also hinted that the Akkadians did not suffer alone. Societies from Greece to Pakistan apparently collapsed at about the same time as the Mesopotamian empire, perhaps because of a widespread



The beat goes on: Chemicals in Greenland ice show the climate there swinging between brisker (blue) and balmier (pink) conditions.

change in environmental conditions, the archaeologist contends.

"This was really quite mega. It was probably hemispheric and possibly global," says Weiss.

The problem with this theory is that, according to the geoscience textbooks at least, Earth's climate has remained remarkably stable in the 11,000 years since the last ice age ended. In fact, paleoclimatologists had largely bypassed this apparently uninteresting, modern period, called the Holocene, concentrating instead on the ice ages, with their dramatic global flip-flops.

The Holocene no longer looks so drab, though. Research in different parts of the globe has recently revealed signs that climate has behaved erratically during the last few millennia. Conditions in various regions have shifted abruptly and repeatedly, perhaps even at the time of the Akkadian collapse.

"We're at the stage now where everyone would agree that the Holocene is anything but stable and boring," says Jonathan T. Overpeck, a paleoclimatologist with the National Oceanic and Atmospheric Administration in Boulder, Colo.

Recognition of these relatively recent natural swings has thrown a monkey wrench into the work of scientists trying to forecast future conditions. Not only must researchers work now to understand what is causing these shifts, they must also determine whether this rhythm has played a role in the recent global warming.

Some of the best clues to understanding the Holocene have come from a frozen, windswept plain near the center of the ice sheet that blankets Greenland. From 1989 through 1993, a team of U.S. researchers spent the summer at this site, drilling through the 3-kilometer-thick glacier. A European crew bored a separate hole nearby. The cores of ice the two teams extracted from these holes provide a record of climate going back more than 110,000 years (SN: 12/11/93, p. 390).

At first, the researchers focused on the most obvious and dramatic turnovers—the sudden warmings and coolings that punctuated the last ice age. More recently, though, several members of the U.S. team have turned their attention to the subtler Holocene, where they have found some unexpected cool spans.

Suzanne R. O'Brien of the University of New Hampshire in Durham and her colleagues studied the chemistry of the ice to glean information about the source of the snow that accumulated and packed down, layer by layer, upon Greenland. In the Dec. 22, 1995 SCIENCE, they report that the concentration of sea salts and land dust in the ice increased dramatically four times in the last 10,000 years.

Such changes bear the fingerprint of a climatic cooling. As the temperatures dropped, wind speeds would have increased and land areas would have grown more arid—effects that would have put more dust and sea salts into the atmosphere.

The strongest, most recent cooling coincides with the Little Ice Age, a well-documented span of frigid temperatures lasting from the start of the 15th century through the middle of the 19th century. During this period, Europe shivered through particularly harsh winters, and mountain glaciers advanced down slopes in the Alps, Alaska, and New Zealand.

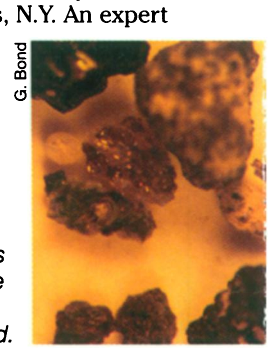
From the ice core data, scientists can tell that temperatures plummeted abruptly by geologic standards. "In terms of the chemistry, the Little Ice Age started in a couple of decades or less, between about A.D. 1400 and 1420," says Paul A. Mayewski of the University of New Hampshire and the chief scientist for the U.S. drilling project, known as the Greenland Ice Sheet Project (GISP) 2.

Going back in time, the ice core shows evidence of another strong cooling, this one between 6,100 and 5,000 years ago. Lesser chills lasted from 3,100 to 2,400 years ago and from 8,800 to 7,800 years ago.

Putting the series together, O'Brien and her colleagues observed that the climate apparently followed a rough cycle, swinging from cold to warm and back again about every 2,600 years.

Among the many researchers intrigued by the GISP 2 cycle was Gerard Bond of the Lamont-Doherty Earth Observatory in Palisades, N.Y. An expert in seafloor sediments, Bond decided to look for corroboration within sediment cores.

The search yielded hints of a Holocene climate cycle within a core



From the depths: Specks of Icelandic gravel on the ocean bottom signal when the sea turned cold.

taken between Iceland and Greenland. In the layers of sediment, Bond spied distinct increases in the number of tiny rock grains transported to this deep-sea location. He surmised that the grainy layers represent cold times, when heavy winter sea ice carried volcanic ash from Iceland to this remote site. During warmer years, the sea ice would not survive long enough to transport the grains that far, he said in December 1995 at the annual meeting of the American Geophysical Union.

From carbon-14 dating of the sediment core layers, Bond pinpointed the ages of the peak coolings to 1,050, 3,050, 3,950, 5,650, and 8,050 years ago, with each cold spell lasting about 800 years. All of these dates, with the exception of the one 3,950 years ago, match the coolings seen in the ice core, says Bond.

The sediment and ice core records reflect what was happening in the immediate neighborhood of Greenland, but the Holocene cycle may have affected the entire planet. O'Brien and her colleagues note that the timing of the cold events they report corresponds to records of glacial advances at many sites around the world. Various studies of pollen and tree rings also show coolings at these times.

Another clue comes from the archaeological evidence of climate change in Mesopotamia proposed by Weiss. "Within the uncertainty of the dating techniques... the date we get [from sediment layers] is essentially the same as what they get for the sudden disappearance of the civilization," says Bond. This correspondence between sedimentary and archaeological evidence suggests that climate across the globe may have turned nasty at this time.

Other scientists, however, question that Holocene coolings affected the entire world. The Greenland ice core, for example, does not show the marked climate jump at the time of the Mesopotamian collapse. What's more, records from different locations are not dated as precisely as the ice core, making it difficult to prove that climate changed at the same time around the globe.

"Perhaps they are not synchronous around the world. Because these Holocene events are smaller and shorter in duration than the big glacial events, it becomes more difficult to identify exactly when they occurred," says NOAA's Overpeck, who is studying sediment cores from an ocean basin near Venezuela. These cores do not show signs of the 2,600-year cycle that Bond detected.

Even as they search for connections elsewhere, scientists are trying to figure out what drives the Holocene climate cycle.

According to Bond, the pattern of coolings may have a long history. It appears to continue a temperature oscillation that ran throughout the ice age. In the past, scientists were tempted to blame such shifts on the ice sheets that covered much of the northern continents at the time. Periodic advances and retreats of these sheets might cause such swings from cold to warm.

But most of the huge glacial sheets disappeared early in the Holocene. "The fact that this cycle runs through the Holocene rules out ice as the ultimate origin of the oscillation," says Bond.

With the ice sheets exonerated, scientists have turned their attention to a couple of other suspects. One candidate is the global ocean, which thoroughly mixes itself about once every 2,000 years. In the Pacific, natural oceanic oscillations give rise to El Niño warmings every 3 to 7 years. Perhaps the global ocean undergoes a similar sort of oscillation every couple of millennia, speculates Bond.

Another potential culprit is the sun. Some scientists suggest that solar output could slowly flicker every few thousand years, dimming enough to cause marked variations in conditions on Earth (see sidebar).

Whatever its cause, the Holocene cycle probably continues to influence the climate, says Mayewski. "Unequivocally, part of what is going on today has a natural component. There's no doubt about that in my mind. But it is not so clear which way the natural component is going."

Without knowing the source of this cycle, climate experts cannot tell how it has contributed to the global warming seen over the last century and most prominently during the last 2 decades. The natural Holocene variation could have either accelerated or slowed the temperature increase caused by greenhouse gas pollution.

"It's hard to say," admits Bond. "We just don't know enough about this cycle to say anything with certitude." □

Signs of a solar link to climate

A decade ago, scientists roundly rejected the idea that variations in the sun's rays could change Earth's climate. Theories of this sort had burned researchers far too often for them to take the notion seriously.

Yet support for the sun-climate connection is growing. In part, the change of sentiment stems from satellite measurements made since 1979. These show that the solar output indeed strengthens and weakens in synchrony with the well-known 11-year sunspot cycle (SN: 10/24/92, p. 282; 12/3/94, p. 380).

L. Thompson

In a Chinese glacier, dark bands every 11 years may record solar variations.

The flickerings are weak—only a 0.1 percent change in solar energy—but even so, they may influence temperatures on Earth. In the November 1995 QUATERNARY RESEARCH, Minze Stuiver and his colleagues from the University of Washington in Seattle identify a cycle within the Greenland ice core. Wiggles in the ratio of two oxygen isotopes—which tracks precipitation temperature—rose and fell about every 11 years, a period matching the solar cycle.

At the annual meeting of the American Geophysical Union last December, Lonnie G. Thompson of Ohio State University in Columbus described similar 11-year cycles within ice cores taken from Tibet and Peru.

The mere presence of 11-year cycles in the ice cores does not prove the sun is responsible. "You can find fairly good correlations between lots of things that have nothing to do with each other because that is a matter of statistics," says Stuiver. "It is suggestive, but it is not absolute proof."

Even more troublesome is the question of long-term solar influence on climate. Scientists simply do not know whether the sun's output weakens and strengthens enough over the millennia to cause the coolings seen about every 2,600 years throughout the Holocene.

Again, the correlations prove tantalizing. Suzanne O'Brien of the University of New Hampshire in Durham and her coworkers note in the Dec. 22, 1995 SCIENCE that the Holocene coolings recorded at Greenland occur about the same time as variations in the atmospheric concentration of carbon-14, thought to reflect changes in the sun.

"All of this points to the sun having some role in climate," says solar physicist Judith Lean of the Naval Research Laboratory in Washington, D.C.

By making assumptions about solar output in the past, Lean and her colleagues estimate that the sun may account for roughly half the global warming that occurred between 1860 and 1970, they report in the Dec. 1, 1995 GEOPHYSICAL RESEARCH LETTERS.

In the last quarter century, however, the sun's activity has not kept pace with rapidly rising global temperatures. Solar influences can account for only one-third of the warming since 1970. The rest must stem from forces closer to home, such as natural climate fluctuations and greenhouse gas pollution.

— R. Monastersky