The Geophysical Institute
QUARTERLY

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Vol. 6, No. 3 April 1988

Alaska weather data meets varied needs

Alaskans will be well supplied with records of past climates in years to come. The state climatologist's office at the Alaska Climate Center in Anchorage, long associated with AEIDC, now has been joined by a research-oriented climate center at the Geophysical Institute. This new arrangement will provide better service for users of weather data, as well as a better understanding of the vagaries of the Alaskan climate.

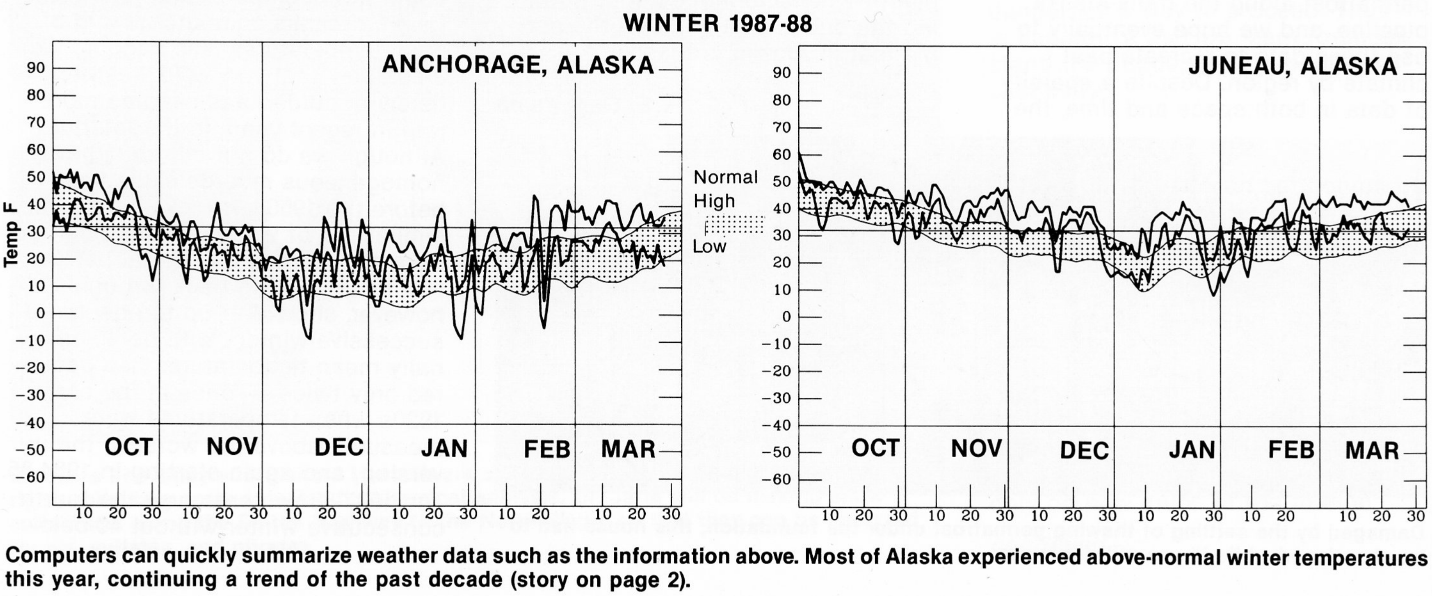
The Alaska Climate Center in Anchorage is the primary repository of surface weather observations. The paper and microfiche climate records are well suited to the needs of walk-in patrons, such as court attorneys and police investigators, looking for weather information at a known time and place. The Climate Center also does a good deal of applied climate research and has published reports on such topics as snowloads, design windloading, and avalanche hazards. Anchorage, the population center for the state, is the logical place to store weather records in order to serve a large number of people.

For many scientific research users, however, printed numbers on paper or film are not practical. Studies of permafrost, the effects of climate on animal populations and fisheries, and the interaction of climate and sea ice, as examples, generally require large amounts of data that must be manipulated in various ways. The preferred form of data for research into such climate problems is large computer-readable sets, currently on magnetic tape, but increasingly in the future on optical discs. The majority of the University researchers using this type of data are in Fairbanks. The Geophysical Institute at Fairbanks, already recognized as a major source of information by the national and international scientific community, and already in possession of large amounts of climate data, is an ideal location for a research-oriented climate center for archiving computer-readable data.

At present, our computerized data set includes daily surface climatological data for all Alaskan stations from 1950 onward, Northern Hemisphere surface and upper air maps (stored as data for each five degrees of latitude and longitude) for the full length of record (since the 1940s for upper air maps and since 1899 for surface maps), and the full set of Alaskan data for climate above the earth's surface.

Studies involving permafrost, snow depth statistics, and climate change have already made use of these data sets, and we have plans to expand the sets with the addition of a few long series of temperature and precipitation statistics. The gridpoint map data will likely be used in the future for a study of the transport of atmospheric impurities. This issue of the *Quarterly* demonstrates the kinds of studies that make good use of the climate data center at the Geophysical Institute.

Guest Editor
Sue Ann Bowling



Computers can quickly summarize weather data such as the information above. Most of Alaska experienced above-normal winter temperatures this year, continuing a trend of the past decade (story on page 2).

Things are heating up in Alaska

PERMAFROST

Experts tell us our permafrost may be warming up and disappearing. What is the cause of this phenomenon? Should we Alaskans be concerned about the warming of the permafrost?

Climate, particularly air temperature, changes continually over decades, centuries, and millenia — the time scales of importance for permafrost. The changing temperature penetrates slowly into the ground, so temperatures in the upper part of the permafrost may give a thermal record for the last hundred years or so. If the changing air temperature leads to warming of the permafrost to above freezing, any ice contained in that permafrost will melt. Thus permafrost both provides a record of past temperatures and may be catastrophically affected by temperature changes.

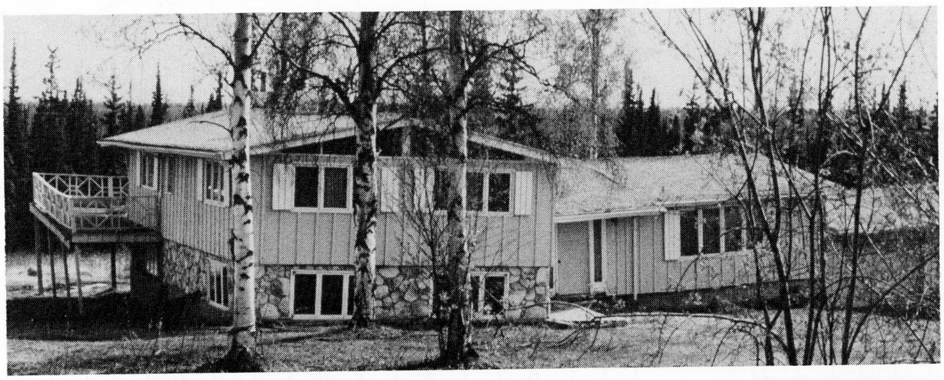
While northern regions have been subjected to climatic warming for about a century, evidence in interior Alaska and other areas indicates this warming trend has accelerated over the past dozen years. Climate models suggest a warming of several degrees Celsius over the next half century, caused by a predicted doubling of carbon dioxide in the atmosphere. Since most of the permafrost south of the Yukon River and on the Seward Peninsula is already within a few degrees of thawing, such a temperature rise could cause drastic changes in the ground.

We presently have about three dozen drill holes which are sited on north-south and east-west transects of Alaska. Data from the holes have given us temperature records for the permafrost along the trans-Alaska pipeline, and we hope eventually to use these data to recreate past climate by region. Despite a sparsity of data in both space and time, the results indicate that the permafrost on the North Slope has warmed 1.5 to 3 degrees Celsius during the last century but has cooled a few tenths of a degree since 1983. Data from the coastal plain of the Arctic National Wildlife Refuge show similar results. On the other hand, the area north from the Yukon River through the Brooks Range shows negligible or nonexistent warming of the permafrost. Of greatest concern to us are the data that show a persistent warming of the permafrost south from the Yukon River to the Copper River basin near Glennallen.

Why are we concerned about the warming? Thawing of the permafrost because of a warmer climate could create serious problems. Where permafrost contains massive ice or is ice-rich, thaw settlement occurs. This can cause severe maintenance and repair problems in damaged roads, buildings, houses and other structures. Lake and river shorelines may erode at an increased rate. Formerly stable slopes may not be stable when thawed, increasing the potential for erosion and the danger of landslides. Thaw settlement can also create an uneven surface relief, altering drainage patterns and changing the course of small streams. Though these problems start at the outset of permafrost thawing, they can also develop over a long span of time, since permafrost thaws very slowly.

What can be done about permafrost thawing? Virtually nothing. We should continue to keep track of the permafrost temperatures to assess the seriousness of the problem. We need to learn to live with this change, and, most important, we must be conscientious about informing the public that some of the permafrost in Alaska is thawing.

T. E. Osterkamp



Damaged by the settling of thawing permafrost under the foundation, this house had to be abandoned while it was still fairly new.

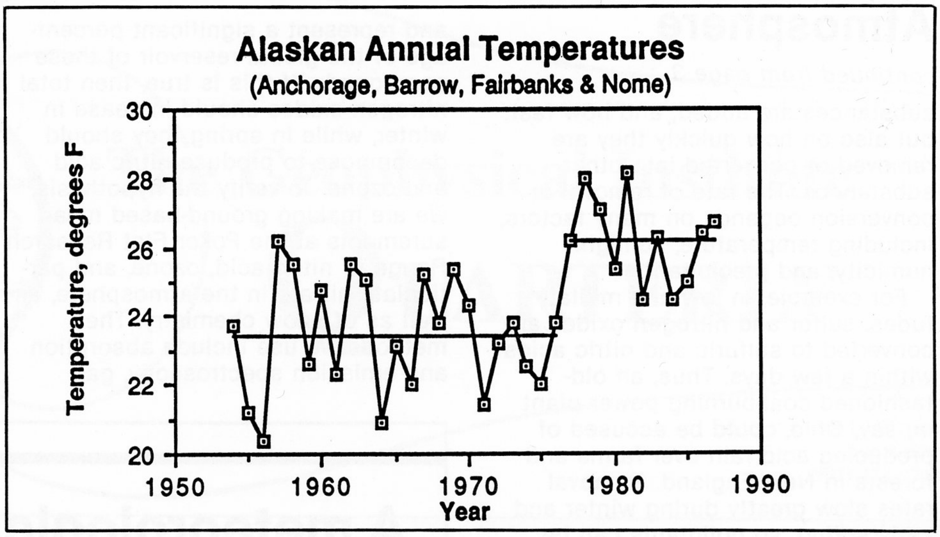
THE CLIMATE

Climate change in Alaska is one subject that interests scientists at both the Climate Data Center in Anchorage and at the Geophysical Institute. The differences between our approaches to the problem of the recent warming help emphasize our need for different types and formats of climate data.

Jim Wise at Anchorage has for several years been publishing seasonal summaries of how temperatures and precipitation in each of the climatic regions of Alaska have deviated from the long-term normals. At the Arctic Science Conference last year, he presented a tabulation of regional data showing the generally warm temperatures of the last 10 years. Numbers vary with regions, but the overall tendency of the last 10 years to be the warmest 30/ of the last 42 years is very impressive.

Here at the Geophysical Institute we have been looking at the same phenomenon, but asking somewhat different questions. What has caused this warming? Has anything similar happened in the historical record? What are the connections to weather events outside Alaska? What kinds of weather events have become more or less common? Is there a connection with greenhouse gases? Ultimately, will the warming last?

We certainly cannot answer all of these questions, and may never be able to answer the last one. But we know, for instance, that in interior Alaska the warming is concentrated in December, January, and the first half of February, while late February has actually become the coldest part of the winter. This information has come from computer analysis of the long Fairbanks computer record of daily temperatures (see page 4). We also know that very cold weather (40 below or colder) has become more rare in recent years in the Interior. Although we do not currently have homogeneous records extending before the 1950s, it looks as if a very similar run of warm winters occurred from 1934 through 1944. Fairbanks records extending back through 1917, however, show that up to now three successive winters with no 40-below daily mean temperatures had occurred only twice — once in the early 1920s when temperatures were measured above the worst of the inversion, and again starting in 1984-85. The 1987-88 winter is now the fourth consecutive winter without 40-below



Temperatures in the main land mass of Alaska warmed abruptly in 1977 and have remained warm since. This graph shows the combined mean annual temperatures for Anchorage, Barrow, Fairbanks, and Nome, along with the average temperatures for 1953-76 and 1977-87. Not a single year since 1976 has been as cold as the average for 1953-76, nor was a single year in the earlier period as warm as the average since 1976.

days. As we improve our computerized data sets, this kind of analysis will be extended to other parts of Alaska.

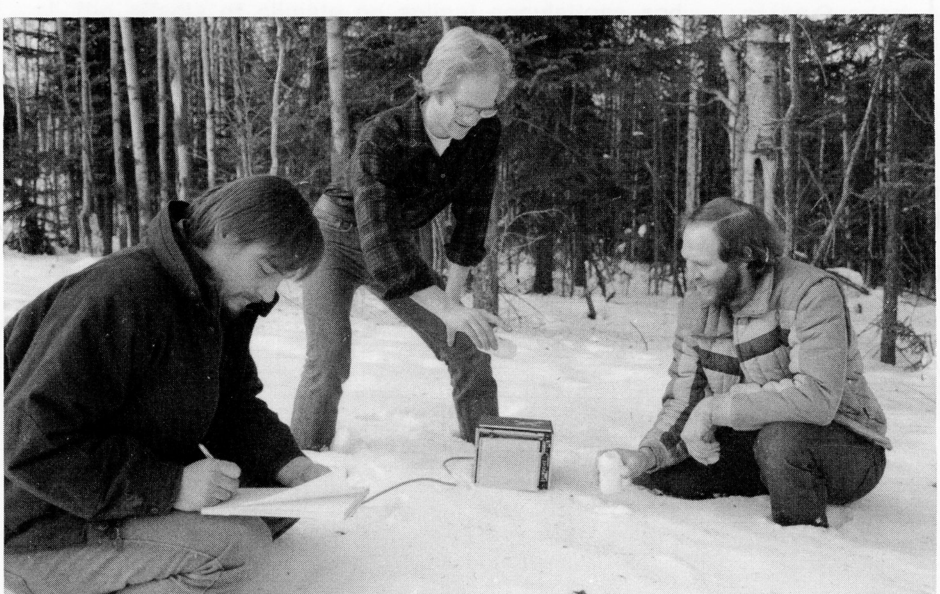
Our next step in research, now getting started, is to determine what changes in the large-scale circulation of the atmosphere have taken place to affect Alaskan temperatures. We know, for instance, that the "Siberian express," that mass of arctic air transported by the jet stream to the central and southeastern states, is often associated with warm Pacific air moving north over Alaska. We suspect that this pattern has increased while the flow of arctic air south over Alaska has decreased. In order to confirm this, we need to develop a means of classifying large-scale air flow over Alaska, and then see what kinds of flow have really increased or decreased since 1976.

Ultimately, we would like to know how these changes are related to possible global events — the increase in greenhouse gases or changes in sea surface temperature, for instance. Only then can we even hope to approach the final question — how long will it last?

Atmospheric conditions linked to modern human activities

The Geophysical Institute has added a new staff member this year, allowing us to address questions involving both local and global atmospheric chemistry. Dr. Dan Jaffe holds a joint appointment with the Department of Chemistry and the Geophysical Institute; his work encompasses both fields, as do the interests of the students assisting his research. They are Richard Honrath, who is seeking a Ph.D. in chemistry; John Herring and Dave Nesting, both undergraduates in chemistry; and Phil Utley, an undergraduate in physics.

For thousands of generations, the interaction between humanity and the atmosphere was a one-way affair—climate had an enormous impact on where and how people could live, but human effects on climate were confined to microclimates: a fire in a cave, clothing fitted to hold warm air against the skin, eventually a Franklin stove. As people grew in numbers and technologies, the effects grew; agriculture and grazing practices may have affected local climates. Now human activities are beginning to affect the atmosphere worldwide. Although we do not truly understand how this happens, we do know that we are not controlling the climate. Meanwhile, the effect of the atmosphere on our activities is as powerful as ever. By inadvertent tinkering, especially by treating the earth's atmosphere as a kind of global garbage dump, we may be instigating changes that will make life more difficult for ourselves and succeeding generations. That is too dangerous a way to proceed. Thus it is imperative that we learn to understand the atmosphere, including its chemistry.



Students Phil Utley and Richard Honrath are shown here with Dr. Dan Jaffe (left to right) collecting snow samples for chemical analysis. Dr. Jaffe will be making snow collections along the Dalton Highway to the North Slope, so that they can be analyzed for pH, sulfates, and nitrates.

A CHEMICAL SOUP

The atmosphere can be thought of as a chemical soup, where chemical and dynamic processes combine to oxidize and transport pollutants great distances from their sources. Understanding these complex processes is made even more difficult by the fact that there are some hundred or so chemical reactions known to be occurring, at various times, in the moving atmosphere. Changes in atmospheric chemistry depend not only on how much of the foreign

continued

Atmosphere

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substances are added, and how fast, but also on how quickly they are removed or converted into other substances. The rate of removal or conversion depends on many factors, including temperature, sunlight, humidity, and precipitation.

For example, in low and midlatitudes, sulfur and nitrogen oxides are converted to sulfuric and nitric acids within a few days. Thus, an old-fashioned coal-burning power plant in, say, Ohio, could be accused of producing acid rain over farms and forests in New England. Removal rates slow greatly during winter and early spring, so pollutants can be carried much farther—and the emissions from a factory in the Ukraine can end up in arctic haze above Barrow. Once there, the pollutants may stay a long time. In high latitudes during the winter, most removal processes are effectively turned off, so midlatitude pollutants moving into the Arctic, as well as those generated locally, may remain in the atmosphere for weeks.

OZONES AND OXIDES

Our new program in atmospheric chemistry is currently concentrating on the importance of nitrogen oxides in central Alaska to tropospheric ozone; research elsewhere has indicated that these oxides are a source for ozone, which is a dangerous pollutant in the troposphere (lower atmosphere) even though it is a vital shield against dangerous ultraviolet radiation in the stratosphere. Our working hypothesis is that during winter and spring, nitrogen oxides build up in the arctic troposphere and represent a significant percentage of the global reservoir of these compounds. If this is true, then total nitrogen oxides should increase in winter, while in spring they should decompose to produce nitric acid and ozone. To verify the hypothesis, we are making ground-based measurements at the Poker Flat Research Range of nitric acid, ozone, and particulate nitrate in the atmosphere, as well as of snow chemistry. The methods we use include absorption and emission spectroscopy, gas chromatography, and filter sampling. By next winter we hope to add additional measurements to our field sampling program.

These studies have a double purpose. First, we seek to identify the impact of atmospheric pollution on arctic regions. Second, we need to know the global implications of this pollution, and in what manner these compounds interact with global climate? Ultimately, these are questions of great significance; they are as important as the air we breathe.

A meteorological detective story

Getting usable daily temperatures that go back to the beginning of the climatological record in Alaska isn't easy, but the process of investigation reveals some interesting local history. It is especially important (and particularly difficult) to find out where the temperatures were taken in order to correct for site and elevation changes, which in Fairbanks can result in a significant temperature difference.

We set out to track down the Fairbanks daily temperatures and observation sites for 1904-1917. We knew they had been recorded because we had the monthly mean temperatures, but published daily values only went back through 1917. The Fairbanks Weather Service had earlier numbers for some months, but no information on where they were recorded.

Alaska Agricultural Experiment Station reports gave us the next step — the names of the early observers. Before the move to the experimental farm in 1912 (at the site of the present University of Alaska campus), observations were made by Archdeacon Hudson Stuck, Isabel Emberly, and Deaconess A. Knox. Episcopal Church records and early gazettes have confirmed that all three were at St. Matthews Hospital and Church in the downtown Fairbanks area. Now we're looking for early mission photos that might show the weather instruments.

We are still sorting out conflicts in early latitude, longitude, and elevation data for the observation sites. Once we finish piecing together this temperature "story" the information will become part of the climate data center at the Geophysical Institute.

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