Climate Change - The Alaska Response

Climate change is considered any systematic change in the long-term statistics describing the climate system that is sustained over several decades or longer. Climate change is one of the most widely debated topics on Earth, and research is underway worldwide to answer some of the most pressing global climate change questions that remain unresolved. Through the U.S. Climate Change Science Program, nearly every aspect of climate change is currently being researched with a total annual expenditure of approximately $2 billion across 13 federal scientific agencies. Human and natural causes are being explored, as well as the impacts of a changing climate on both human and natural systems.

One global climate change concern scientists are addressing is the impact of human activities upon the greenhouse effect. The greenhouse, or atmosphere, effect is a natural process that helps regulate the temperature of our planet and is essential for life on Earth. The greenhouse effect is the process by which the atmosphere absorbs and radiates infrared radiation resulting in warming of the earth. Sunlight, in the form of shortwave radiation, passes through the earth's atmosphere with minimal depletion. This energy heats the earth's surface, which in turn, emits energy back toward space in the form of infrared radiation. Atmospheric greenhouse gases absorb a large percentage of this energy, and are so named because they effectively trap heat in the lower atmosphere. The greenhouse gases radiate some of the trapped energy back to the earth's surface, adding heat to the earth's surface that would otherwise be lost to space. Without a natural greenhouse effect, the temperature of the Earth would be about 0°F instead of its present 57°F. The concern is not the fact that the greenhouse effect exists, but whether human and natural activities are leading to an enhancement of the greenhouse effect.

Many greenhouse gases occur naturally in the atmosphere, such as carbon dioxide, methane, water vapor, and nitrous oxide, while others are synthetic. Man-made greenhouse gases include the chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). With increased reliance on fossil fuels such as coal, oil and natural gas, emissions of greenhouse gases have risen. While gases such as carbon dioxide occur naturally in the atmosphere, human contribution to the carbon cycle moves substantial amounts of carbon from solid storage to its gaseous state, thereby increasing atmospheric concentrations.

Average global surface air temperatures rose approximately 1.1^{o} F during the 20th century with significant regional and temporal variations. For example, from 1910 through 1940, most of the globe experienced a warming trend, but from the 1940s - 1970s, a period of slight cooling occurred. Since the early 1980s, most of the globe has been warming.

Indirect evidence of temperature trends from ice cores and glacial moraines indicates that temperatures fluctuate on a variety of timescales. The Little Ice Age, which occurred from 1550-1850, is a prime example of widespread cooling that resulted in the advance of most mountain glaciers. Additional factors that can modify the climate are volcanic eruptions and small changes in the sun's output.

Over the past 20 years, researchers in climate centers of expertise around the world have been using numerical computer models to predict changes to the earth's climate system. These computer-based mathematical models attempt to simulate the behavior and interactions of the climate system. The models incorporate recorded and proxy environmental records such as temperatures, tree rings, and ice core samples. These models are constantly improving based on both our understanding of the climate system and increases in computer power.

Climate models must also account for a variety of interrelated climate oscillations such as solar cycles and El Nino-Southern Oscillation that occur for years or decades at a time. The periodic warming of the eastern equatorial Pacific Ocean, El Nino, is a chain reaction in nature that tends to reverse normal weather patterns all around the globe, beginning at the equator. Normally, trade winds blowing from east to west in the equatorial Pacific Ocean push warm surface seawater off the coast of Peru toward Indonesia and the Philippines, where the moisture evaporates into seasonal monsoons. The colder water that remains behind drops to the ocean floor, then flows back to South America and rises again, resulting in normally cool seas in the eastern Pacific and dry, sunny weather. During an El Nino winter that cycle stalls. The easterlies off Peru die down, the ocean there grows warmer, and the west coast of South America receives strong storms. The opposite phase of an El Nino is the known as a La Nina. In this case cooler than normal water is found in the equatorial eastern Pacific.

In the Lower 48 states during an El Nino, generally the southeastern states turn cooler and the northwestern states turn warmer. High pressure systems bring clear skies over western Canada and Southeast Alaska. These highs force the warm Aleutian storm track that normally trends toward Southeast Alaska and western Canada to bend northward sending storms to Southcentral and Southwest Alaska. During La Nina episodes, a ridge of high pressure often forms over the Bering Sea, generating cooler than normal temperatures across most of the state.

The typical pattern and the El Nino pattern are shown in Figure 1. In a typical winter, the jet stream carries storms off the Aleutians toward the Lower 48 states, leaving the Alaska mainland generally cool and cold. In contrast, during an El Nino winter, high pressure that settles off southeastern Alaska and western Canada forces the storm track northward carrying warmer air.

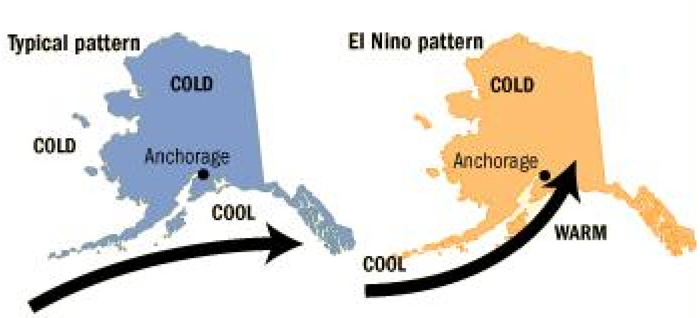

Figure 1. Changes in the Jet Stream

For eight previous El Nino events dating back to 1976-77, seven resulted in warmer than normal winter temperatures in Alaska. Figure 2 shows an average of Anchorage daily winter temperatures taken between November 1 and March 31. The red dots represent winters that were affected by an El Nino weather pattern. Two of those events were dramatically warmer, and only one ended with cooler than normal temperatures. It is interesting to note that prior to 1976-1977 most El Nino's produced cooler temperatures in Southcentral Alaska. It appears that a major shift in the regional climate occurred sometime in the 1976 to 1978 period.

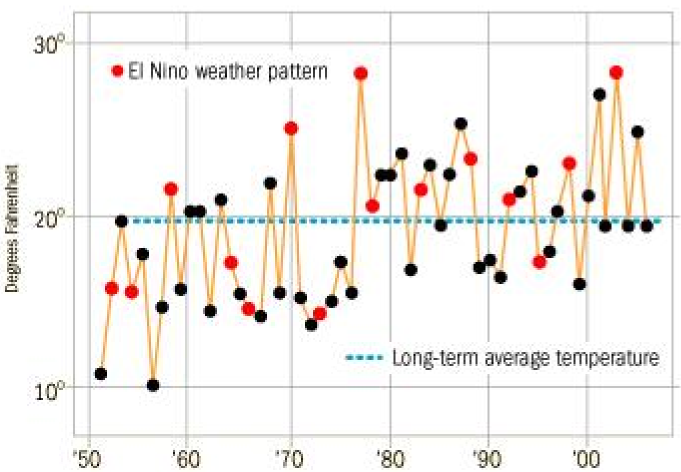

Figure 2. Anchorage Average Daily Winter Temperatures

The interaction of El Ninos and La Ninas with a gradual warming of global temperatures is not understood at this time. There has been a slight increase in the frequency of El Ninos since the late 1970's, however there has been a significant decrease in the number of La Ninas. Whether the frequency of these two types of events is linked to global climate change is still elusive to climate researchers.

What we do know with some confidence is that virtually all of the computer models indicate that temperature trends will vary from one region of the globe to another, and the Arctic will warm at a faster rate than other regions. In the Arctic Ocean, a small warming of the air and ocean will result in decreases in the thickness and aerial extent of sea ice. Initial warming limits the production of sea ice the following season. Over several decades, the accumulated effect is a large reduction in the amount of pack ice able to withstand the summer melt season. Satellite estimates indicate that since 1977, Arctic sea ice extent has decreased 10%. The smaller ice pack, and to some degree, smaller areas covered with snow over land, decrease the amount of sunlight reflected back to space. Thus more of the sun's energy is absorbed into the earth's surface, enhancing the warming. It appears the warming in the Arctic is limited to the lowest few thousand feet of the atmosphere. Outside the Arctic, temperature increases are distributed over a deeper layer of the atmosphere. The net result is a larger warming in the Arctic than at lower latitudes for a given increase in greenhouse gases.

Observed air temperatures in Alaska indicate a considerable warming over the past six decades. Observations show the warming is not uniform over time, and the amount of warming varies within the state. For instance, Barrow has warmed over 2^{o}F since 1977, but Kodiak has only exhibited a $.5^{o}$F increase because it is surrounded by water. Also, the warming is far stronger in the winter than in the summer months. Considerable variability exists from season-to-season and year-to-year. Trends spanning decades are commonly referred to as "climate regime shifts."

There is considerable uncertainty on future air temperature trends in Alaska. The most likely scenario is that Alaska will experience a continued gradual increase in temperatures with short cycles of several years of warmer or cooler periods superimposed on this trend. This means that Alaska will still experience cold periods, however, these periods will be less frequent than in earlier decades.

On the Web:
NOAA NESDIS National Climatic Data Center:
http://www.ncdc.noaa.gov/oa/climate/globalwarming.html
NOAA NWS Climate Prediction Center: http://www.cpc.noaa.gov
NOAA Arctic Theme Page: http://www.arctic.noaa.gov
NOAA NWS WFO Anchorage Research Papers: http://pafc.arh.noaa.gov/papers.php
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Western Region Climate Center: http://www.wrcc.dri.edu
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NOAA Pacific Marine Environmental Laboratory: http://www.pmel.noaa.gov
NOAA NWS Alaska Region Headquarters: http://www.arh.noaa.gov
Alaska Center for Climate Assessment and Policy (ACCAP): http://www.uaf.edu/accap