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Are Things Warming Up?

How Climate Changes Could Affect Texas

by Ric Jensen
Information Specialist, TWRI

Many scientists believe that the 1980s are the warmest decade in recorded history and they warn the worst is yet to come. They say the earth's climate may change more in the next century than it has in the last 18,000 years.

Scientists who have been studying the world's climate believe the earth may be experiencing the early symptoms of global warming associated with a phenomenon commonly known as the "greenhouse effect.. Researchers are utilizing complex computer programs called general circulation models (GCMs) to simulate future climate conditions.

Fossil fuel emissions increase atmospheric concentrations of carbon dioxide (CO_2) and other trace gases that could lead to global warming. Meanwhile, deforestation is reducing the amount of CO_2 consumed by plants. Measurements indicate that there are now record high levels of CO_2 in the atmosphere. Texas produces more CO_2 and nitrous oxide than any state (Machado and Piltz, 1988).

Results from the computer models suggest that even if actions are taken now, it may be too late to stop some global warming from taking place. Most GCMs divide the atmosphere into grid boxes. Typical models divide the atmosphere vertically into nine layers and horizontally into boxes that are about the size of France. The models are linked together mathematically so they can adjust to simulated temperature changes. Although GCMs can paint a broad picture of how the climate may change over a wide area, they can't provide detailed estimates of how the weather may change in a given state or region. Another problem is that models have not yet been developed that incorporate such critical variables as ocean currents or cloud patterns into forecasts. Some experts speculate that

increased cloud cover could result in lower temperatures (Revkin, 1989) or that ocean systems may delay the onset of global warming because it takes the massive seas so long to warm. More data are needed on rainfall distribution, cloud formation and ocean temperatures.

Despite the shortcomings, the models have been able to simulate average global temperature rises during the past 30 years with 99% accuracy. Many scientists are convinced that global temperatures will rise throughout the 21st century and beyond.

It may be hard to envision how a warming of a few degrees could affect Texas, but the impact on the state's water supplies could be significant. Rainfall in inland Texas is generally expected to decline. By the year 2050, temperatures in the Rio Grande Valley could be as much as 9_ F warmer, roughly 5_ F hotter in central Texas, and up to 4_ F higher on the High Plains (Begley, 1988). In Dallas, the number of days per year with temperatures above 100_ F could skyrocket from 19 to 78. This would increase evaporation and transpiration from native vegetation, crops, and landscape plants. It could also increase competition between recreation, agriculture, urban and other water users for limited supplies.

Rivers and streams could lose a large part of their flows. Many experts believe that the impact could be similar to the droughts of the 1950s when streamflows slowed to just half of normal levels. Low streamflows caused by warmer temperatures and less than average rainfall could severely reduce water quality. Rivers often dilute the concentration of wastewater and pollutants generated by cities and industries. With less water in the rivers, water quality may deteriorate. Projected population increases in cities that depend on rivers for water supplies could make the problem even worse.

Low river flows could also lessen the amount of fresh water that supports fragile bays and estuaries. Without enough fresh water, these areas could become too saline for valuable fish and shellfish species that need lower salinities during portions of their life cycles.

Sea levels in the Gulf of Mexico are expected to rise. Low-lying areas may be more flood-prone, and beaches may have to be rebuilt or abandoned after being ravaged by larger, stronger storms. Salt water from the Gulf of Mexico could contaminate aquifers and rivers. Severe hurricanes may be more common.

Global warming may also disrupt natural ecosystems. Many experts believe that the climate will change too quickly for animals and plants to adapt or migrate to new areas. Inland fish populations may be unable to escape high water temperatures or habitats may disappear.

Studies are now under way to prepare for the possible impact of global warming. Scientists hope to learn how rivers will respond to higher temperatures, to project when the warming will begin, to develop strategies to adapt to the warmer climate, and to increase agricultural and urban water use efficiency.

What is Global Warming?

The earth's temperature is determined by a number of factors including the amount of sunlight it reflects and the extent to which the atmosphere retains heat. When sunlight strikes the earth, it warms the surface, which then radiates heat back to space. However, water vapor, CO2 and other atmosphere gases such as methane and nitrous oxide absorb a large portion of the infrared radiation emitted by the earth's surface and redirect some of the infrared energy back to the surface. This provides additional heat and raises temperatures. Because the atmosphere prevents heat from escaping, causing higher surface temperatures, many have compared the process to what takes place in a greenhouse and the process is commonly referred to as "the greenhouse effect" (see Figure 1).

During the last century, the earth's temperature has risen roughly 1_ F. Although this may seem insignificant, even a slight change in climate can have immense consequences. In the last ice age, temperatures were only about 9_ F colder than they are today. Over time, naturally occurring climate changes have brought about the extinction of species and have changed the world's geography by flooding some once dry areas and evaporating seas to cause land masses to appear.

During the last 20 years, CO2 levels have risen from 315 parts per million (ppm) to more than 340 ppm *(Changing Climate*, 1983). Most of the increase has been attributed to the burning of fossil fuels. Concentrations of gases such as methane and nitrous oxide are also rising. During the 1980s, atmospheric methane concentrations increased by 1% per year. Major sources of methane include rice production, livestock operations, wetlands, landfills and the burning of biomass and fossil fuels. The impact of increased levels of these gases on global temperatures could equal that of CO2 concentrations.

If CO2 levels double in the 21st century (experts say there is a 75% chance this will happen), average global temperatures could rise by up to 7_ F (See Figure 2). The increase will be most profound in polar regions where temperatures could rise by as much as 25_ F, melting ice caps during summer months. Since a warmer atmosphere should hold more water, 7 to 11% more precipitation is predicted worldwide. The added precipitation will not fall uniformly and could be offset by increased evaporation (Poster, 1988).

Modeling the Earth's Climate

Scientists are simulating the earth's future climate using computer models. These models utilize data on such factors as clouds, ice levels on seas and polar ice caps, ocean currents, soil moisture, groundlevel heat losses, the transfer of heat within the atmosphere, and others. From these variables, the models can simulate what the future climate may be like.

Most of the models make their predictions based on the assumption that CO2 levels will double by a certain point in time. Other models estimate climate scenarios based on

varying CO2 levels. The most currently used models include the GISS (NASA Goddard Institute for Space Studies), the GFDL (Geophysical Fluid Dynamics Laboratory Model at Princeton University), the NCAR (National Center for Atmospheric Research at Boulder, CO), and an EPA model at Oregon State University.

Climatologists are now attempting to develop simulation models that could be specific to Texas. In the near future, Gerald North, a researcher in the Climate System Research Program at Texas A&M University, hopes to begin work on a model that may more accurately simulate the Texas climate using a supercomputer. The longterm goal of the project is to model climate change over areas as small as river basins or watersheds. North has also been working with NASA to develop instruments that could be put aboard satellites to provide in depth information on tropical rainfall patterns, biological changes in rivers and lakes, ocean circulation, and other phenomena. North says it is essential to gather this data so that accurate simulations of global warming can be developed.

Impacts on Texas Rivers

Several models predict that much of Texas will receive less winter rainfall, reducing recharge to aquifers and runoff to river systems. The Texas coast could receive more summer rainfall than the rest of the state. Unfortunately, much of that could come in heavy storms.

A study of the Pease River on the Texas-Oklahoma border near Vernon suggests that a 10% drop in rainfall and a 4% increase in evaporation could cut runoff in half (Nemac and Schaake, 1982). Global warming could also increase evapotranspiration from crops and landscapes. Roughly 87% of Texas' precipitation is now evaporated or transpired. An 8_ F temperature rise could increase evapotranspiration rates to 95% (Dudek, 1987a), reducing wafer supplies.

A temperature rise of 4_ F and a 10% drop in precipitation would decimate some of the state's rivers, according to another study (Revelle and Waggoner, 1983). Results predict the Rio Grande would suffer a 75% drop in its streamflow and other Texas rivers emptying into the GuK of Mexico could see streamflows cut in half.

Global warming may reduce water quality by reducing streamflows, which are vital to dilute wastewater and other pollutants and to provide crucial freshwater flows to bays and estuaries. Without freshwater inflows, salinities in the bays could rise and species which depend on low salinity waters during certain stages of their life cycle could be threatened.

Global warming also creates a two-pronged dilemma in which both hurricanes and droughts could be more likely, making it more difficult to manage reservoirs. To guard against droughts, more water could be stored in reservoirs. To protect against flooding, reservoirs could be drawn down more than usual. Choosing the wrong reservoir management strategy could increase the risk of flooding or water shortages.

Impacts on Coastal Texas: Sea Level Rise

Sea levels could rise by 3 to 4 feet in the next century (6 to 9 inches for each 1_ Frise) because polar ice caps and glaciers could melt and because seas expand as they warm. Sea level rise may permanently flood some areas, erode beaches, and result in salt water contamination of fresh water supplies. Higher sea levels may also provide a higher base for storm surges to build on making severe floods more likely.

In Texas, the impact of sea level rise could be significant. Some coastal areas in Texas experienced as much as 3 feet of sinking in the 20th century because of excessive groundwater use, and some coastal cities are already near sea level. One study examined if sea level rises of more than 2 feet and storm surges would increase flooding on Galveston Island (Leatherman, 1984). Results indicate that Galveston Island could become more vulnerable to floods and that parts of Bolivar Island could suffer increased erosion. The combined impact of sea level rise and subsidence at Galveston could be as much as 8 feet by the year 2100 (Titus, 1988). An EPA study found that a 1 foot sea level rise would erode most sandy beaches along the Gulf of Mexico (Hoffman and others 1983).

Sea level rise has also created a debate about the best way to preserve existing developments and wetlands. Constructing bulkheads and levees may protect coastal developments against sea level rise, but may also prevent new wetlands from forming. Building bulkheads and levees to guard against a sea level rise of 3 feet could cost as much as $111 billion nationwide (Titus, 1988). However, more than 84% of existing Texas wetlands could be test if these barriers were erected to protect current developments. Wetlands near the Texas-Louisiana border could be especially vulnerable. Experts recommend that low-lying coastal cities and developed areas should be protected, but sparsely populated areas should adapt to changing shorelines.

An EPA report (Smith and Tirpak, 1988) estimated the cost of adjusting to sea level rise. The report projected it would cost more than $83 million for Corpus Christi, TX, to adjust to a 7-foot sea level rise by building bulkheads and relocating buildings, roads and utilities. The cost of pumping sand to replace eroded beaches along the Texas coast could be more than $17.6 billion.

Impacts on Agriculture

Global warming may bring a mixed bag of blessings and curses for agricultural producers. Milder winters may reduce the risk of freezes that cripple citrus crops in the Rio Grande Valley and could expand tropical crop production into central Texas. Conversely, inland areas such as the Texas High Plains could experience significantly higher temperatures, causing more plant stress. Increased CO2 concentrations may help crops use water more efficiently, boosting yields. Climate variability could increase, ruining crops in some years and creating bumper crops in others. Global warming could also create milder winter temperatures, increasing pests and plant disease problems. Droughts, hailstorms, and freezes could become more common.

Dryland farming may be particularly affected because rainfall is expected to decline as plant water needs increase because of greater evapotranspiration. Some hard hit dryland farming areas will probably have to be abandoned or converted to other uses. Dryland crop yields could drop by 18 to 44% and irrigated yields could be reduced by up to 21% unless crops can be developed to take advantage of high CO2 levels (Smith and Tirpak, 1988).

Irrigated agriculture is expected to be less affected as long as water sources are not severely impaired. The amount of water needed to irrigate crops is expected to rise by 5 to 25%, and irrigated acreage on the Texas High Plains is predicted to increase by as much as 30,000 acres (Clarkson and King, 1989). Projections suggest that sensitive aquifers such as the Ogallalla and Edwards could be overdrafted by up to 6%.

In the Texas High Plains, winter wheat could replace spring wheat and grain sorghum could replace corn. As a result, grain sorghum production is expected to increase by 30% as global warming takes place. In west Texas, agricultural acreage is expected to decrease significantly, and demand for irrigation could increase by up to 25%.

Ironically, higher CO2 concentrations could benefit agricultural production. Plants in a CO2 enriched environment may grow faster and use water more efficiently since leaf openings narrow. If CO2 levels rise to 600 ppm, wheat, oats, rice, soybeans and barley could reap the greatest benefits. Grain sorghum, corn and sugar cane would be less affected (Rosenberg, 1987). Experts note that higher temperatures caused by global warming may occur prior to an actual doubling of atmospheric CO2 levels.

One study suggested that crop yields could increase by 5 to 30% as a result of doubled CO2 levels (Dudek,1987b). However, the study also said crop yields could drop 5% for every 2_ F rise in temperature and net farm income in the southern U.S. could decline by up to $7 billion annually.

Summary

Although global climate change isn't a "sure thing" - scientists can't guarantee that these consequences will take place - the current scientific consensus is that some global warming is on the way.

Climate change may have direct impacts on Texas' water supplies. Droughts could be more common, coastal areas may be threatened by more violent storms and increased flooding and erosion. There could be less water for irrigation at a time when demand swill increase. Agriculture could be severely impacted in arid areas of the state and dryland farming regions.

Research may be the best defense to cope with the effects of climate change or to delay its coming. Water- saving strategies and technologies that make water use more efficient could help Texas cope with global warming. Studies in reservoir management may develop strategies that satisfy both the needs of flood control and water storage. Research

to develop alternative fuels and improve long-term weather forecasting could also help solve the global warming problem.

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