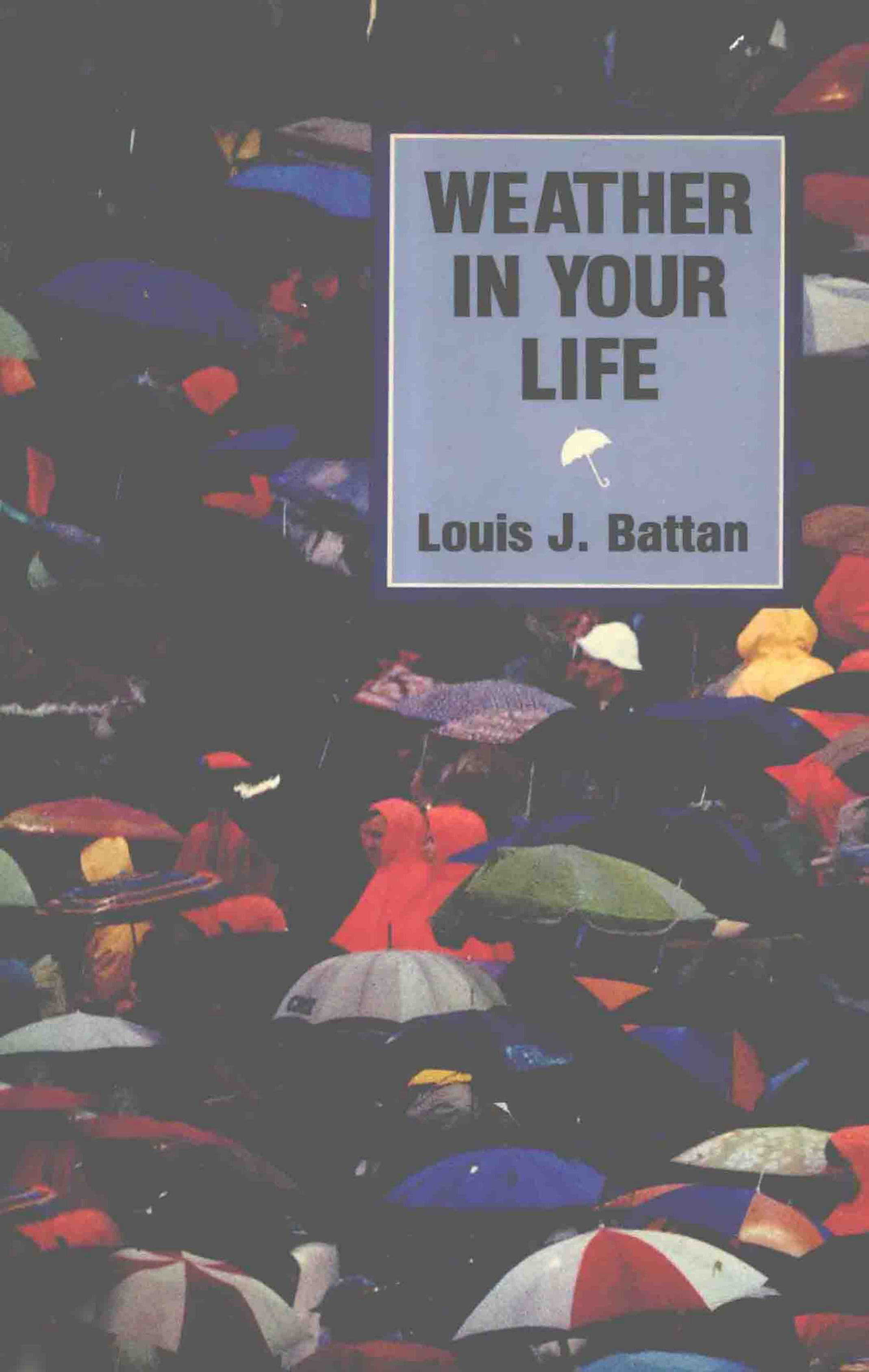
WEATHER IN YOUR LIFE

Louis J. Battan



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Louis J. Battan

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Project Editor: Judith Wilson
Designer: Sharon Helen Smith
Production Coordinator: William Murdock
Illustration Coordinator: Richard Quiñones
Artist: John Cordes
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PREFACE

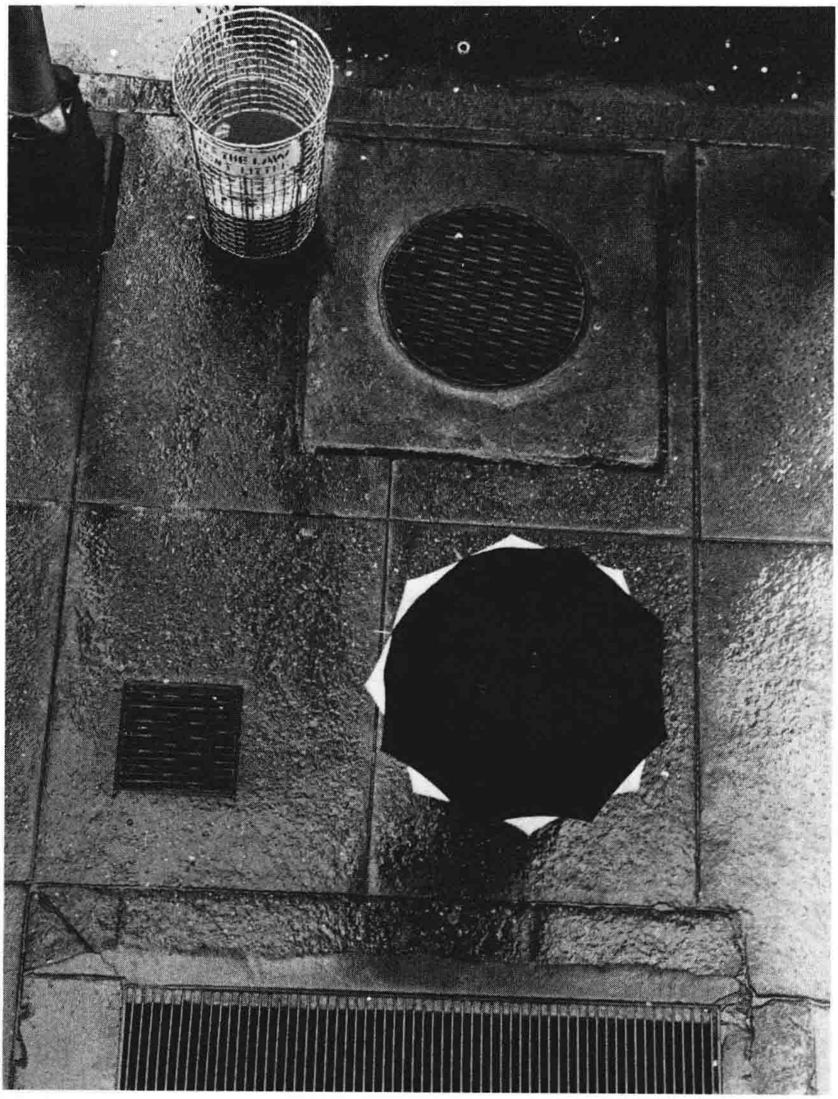
The atmosphere influences life in ways dramatic and subtle—sometimes causing trouble, sometimes giving pleasure. Science has not yet enabled us to master the environment, but a little knowledge enables us to enhance what is best and to avoid the worst. This book examines the weather and its effects and suggests how weather and climate information can be used to make life safer, healthier, and happier.

One of my goals is to introduce individuals with little scientific training to an understanding of the nature of the atmosphere. To this end, I have used familiar English units of measurement and avoided the temptation to include mathematical equations. Because *Weather in Your Life* presents a nontechnical introduction to the basic principles of atmospheric science, it is appropriate both for the general reader and for use as supplementary reading in a variety of undergraduate courses. Students enrolled in environmental studies, meteorology, and climatology should find this book appealing and informative. I hope many readers will acquire an interest that will lead them further.

I wish to thank Arnold Court, a friend of long standing, for his many helpful suggestions, and Robert E. Wanetick for his excellent editing.

Louis J. Battan

October 1982



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CHAPTER 1

Introduction

The weather affects the lives of everyone—sometimes in subtle, barely discernible fashions, at other times in dramatic, violent ways that leave permanent scars or even maim and kill. Since the earliest days of life on the earth, humans have cursed the storms and prayed for their cessation. They have pleasured in the warmth of early spring and been thankful for rains that allowed plants to grow and flower.

We still are slaves to the weather gods. Certainly, the shackles are looser than they used to be, but they are not loose enough; as we approach the end of the twentieth century equipped with devices of unbelievable power and sophistication, we still share many of the reactions of our earliest ancestors. We have computers performing tens of millions of operations a second, airplanes flying at twice the speed of sound, space vehicles measuring the properties of planets millions of miles away; yet we still experience the joys of good weather and the beauty of a rainbow, worry about lightning, tolerate blizzards, and suffer the misfortunes of violent storms.

In too many human endeavors, we do not know enough about the weather, and we fail to use the little that we do know. Every year, thousands of people ignore the realities of weather and buy or rent homes in low-lying land along streams and river channels. Then nature comes along in its normal course of events and brings a great deal of rain in a short period of time. The results are floods, human misery, and property losses, sometimes of staggering magnitudes.

Pilots, especially inexperienced ones flying their own airplanes, find it easy to overlook the perils of the weather. As a result, they sometimes find themselves groping blindly through clouds in airplanes not equipped with the necessary instruments. The hazards are amplified when a cloud contains turbulence that can shake and roll an airplane, hail that can hammer the leading surfaces of aluminum or glass, lightning that can burn off radio antennas and temporarily blind the pilot, or high concentrations of very cold water droplets that coat the airplane with layers of ice.

There seems to be a widespread perception among commercial-airline passengers that flying is hazardous. It still is not rare for them to applaud when an airplane has landed safely: Presumably, this is an expression of satisfaction of having survived the flight. Perhaps the newspaper headlines on the infrequent occasion of an airliner crash—or a feeling that human flight is an invasion of the birds' domain and, therefore, not natural—account for the lines at the insurance counters. But let us not forget that the highways claim very many more victims than the airways, and weather is often the cause. Fog on a high-speed turnpike, especially when patchy and thick, can cause the destruction of motor vehicles in bunches. Snow and ice also make roads treacherous; strong winds and flooded roadways pose still other hazards.

The weather has profound effects on agriculture, but do the farmers of the world know as much as they should about those effects and how to deal with them? Of course not! This critical lack of knowledge is not the fault of the farmers alone: They need advice from the weather experts, and they are not getting it.

What would happen if, as the old television commercial used to say, you took your sinuses to Arizona? Although the answer to this is still "up in the air," it is clear that atmospheric conditions influence, sometimes in dramatic ways, certain diseases such as asthma and arthritis. There is also evidence that the weather can have important psychological effects. When hot, dry gusty winds blow down mountain slopes, there is a greater likelihood of emotional traumas and even suicides. These are just a few examples of how the weather plays a role in human affairs.

Almost everyone makes weather-related decisions every day, some as minor as deciding to take an umbrella to work, some of enormous importance in terms of business or the preservation of life. For example, on November 14, 1969, a decision was made to launch *Apollo 12* into an overcast of clouds. The vehicle, with its three astronauts headed for the moon, was struck twice by lightning and disabled seriously—fortunately, only temporarily—and disaster was barely avoided. As another example, in 1978, California farmers decided to allow raisins to dry in the open a few days longer; a storm brought heavy rains, and losses ran into the millions of dollars.

This book contains other examples of how weather and climate information can be of value in making sound decisions of many different kinds. The need for a better understanding of the weather and climate and the importance of an appreciation of the values and limitations of weather forecasts are demonstrated.

This book consists of two parts: The first part gives a description of the atmosphere, weather, and climate and a discussion of weather forecasting and modification. The second part deals with the effects of the atmosphere on a wide spectrum of societal activities.

Scientists are learning to influence the weather; in the future, it may be possible to modify or even control it in a predictable fashion. Until that day comes, we have to deal with it as it is.

A greater knowledge of the factors influencing your life and your occupation should help you to improve them. This small volume can start you down that road. If it stirs your curiosity and leads you to a greater use of weather information, it will have been worth the effort.

CHAPTER 2
Air

The insubstantial substance called air, though crucial to life on earth, is taken for granted by almost everyone. It is always there, but who ever thinks about it—except on polluted days.

Few people realize how much air they breathe. A healthy person fills and empties his lungs about 20,000 times in 24 hours, inhaling about 30 pounds of air. In comparison, a person ingests an average of less than 3 pounds of food and 5 pounds of water in the same period. A person can survive approximately 5 weeks without food and 5 days without water, but only 5 minutes without air.

As Table 2-1 shows, air is actually a mixture of many gases. By volume, dry air is roughly 78 percent nitrogen (N_2) and 21 percent oxygen (O_2), with argon making up most of the remaining 1 percent. When water vapor,

Table 2-1 The Gaseous Composition of the Atmosphere

Dry Air: Constant Gases[1]		Variable Gases[2] (approximate)	
Constituent	Percent by volume	Constituent	Percent by volume
Nitrogen (N_2)	78.08	Water vapor (H_2O)	0–4
Oxygen (O_2)	20.95	Carbon dioxide (CO_2)	0.0340[3]
Argon (Ar)	0.93	Carbon monoxide (CO)	0–0.01
Neon (Ne)	0.0018	Ozone (O_3)	0–0.001
Helium (He)	0.00052	Sulfur dioxide (SO_2)	0–0.0001
Methane (CH_4)	0.00015	Nitrogen dioxide (NO)	0–0.00002
Krypton (Kr)	0.00011		
Hydrogen (H_2)	0.00005		

[1]The composition changes little up to an altitude of about 50 miles.
[2]Gases are variable from time to time and place to place.
[3]The annually averaged concentration of carbon dioxide in 1982 was about 0.0340 and is increasing by about 0.0001 percent per year (see Figure 2-3).

which may represent as much as 4 percent of the volume of air, is present, the other constituents are reduced proportionally.

Atmospheric nitrogen comes mostly from decaying agricultural debris and volcanic eruptions. It is removed from the air largely through biological processes involving vegetation and sea life. In addition, nitrogen is converted to nitrogen oxides by high-temperature combustion in the engines of motor vehicles and airplanes. The concentration of nitrogen in the atmosphere is essentially constant, indicating that inputs are roughly in balance with outputs.

The same can be said about atmospheric oxygen, which is produced largely through the photosynthetic growth of vegetation. In the formation of green matter, the leaves take up carbon dioxide and release oxygen. It is removed from the air by humans and animals, whose lungs take in oxygen and release carbon dioxide. Oxygen is also a component of the water of oceans and lakes; it is consumed as organic matter decays and when it combines with other substances, as in the rusting of iron and steel.

THE OZONE LAYER: AN ULTRAVIOLET SHIELD

Some gaseous constituents of air exist in small, even trace, quantities, but their importance cannot be inferred from the amounts. For example, ozone (O_3), whose molecules consist of three oxygen atoms each, constitutes up to only 0.001 percent of the atmosphere; but without ozone, life on the earth would be different from what it is today. Although ozone is found throughout the lower atmosphere, most of it exists in the stratosphere, the layer between about 40,000 and 160,000 feet above sea level (Figure 2-1). This *ozone layer* is maintained by a complicated series of processes involving the absorption of radiation from the sun.

The sun can be thought of as a huge, gaseous sphere that radiates as if it had a temperature of about 11,000°F. As a consequence of this high temperature, maintained by thermonuclear reactions in the interior, the sun radiates a tremendous quantity of energy, distributed over a wide spectrum of wavelengths (Figure 2-2). This energy is particularly intense at the visible wavelengths. Ultraviolet rays, when sufficiently intense, can cause severe sunburns, skin cancers, and other biological effects. Most ultraviolet radiation does not reach the surface of the earth because it is absorbed by ozone in the stratosphere. In the middle seventies, however, it became evident that certain substances, particularly the Freons used in refrigerators and aerosol spray cans, could cause a reduction in stratospheric ozone. Freon, a trade name for a class of substances called chlorofluoromethanes or fluorocarbons, is wonderful in many respects: Freons are volatile but not flammable, are odorless, and, in the lower atmosphere, are chemically stable and do not react with other substances. Unfortunately, when exposed to ultraviolet radiation, Freon molecules break down

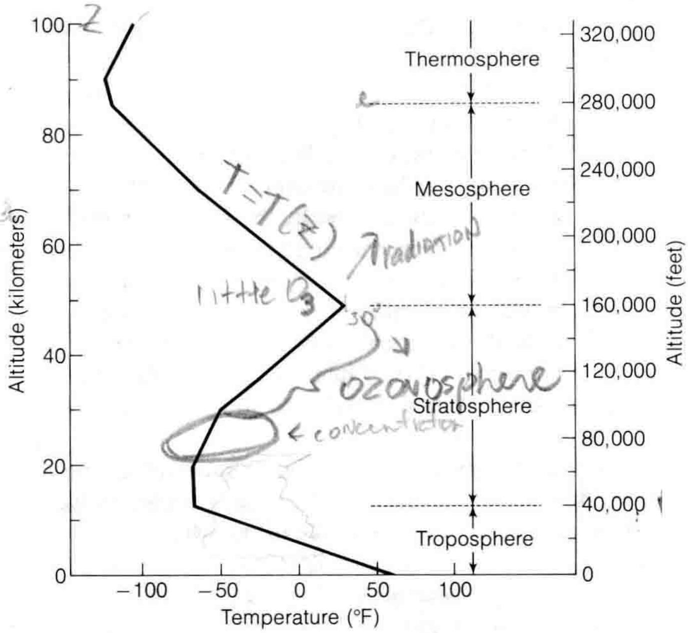

Figure 2-1 Air temperature shown as a function of altitude in the 1976 *U.S. Standard Atmosphere*—an average of many observations. The atmosphere is divided into layers, called "——spheres," according to how the temperature varies with height.

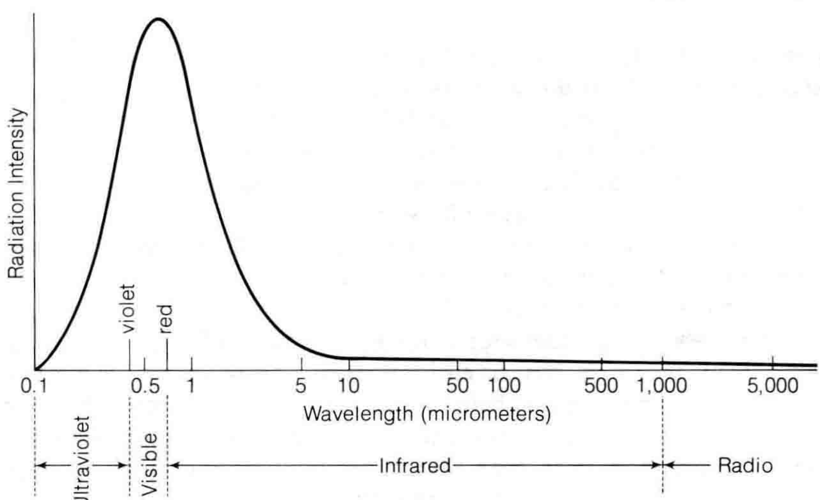

Figure 2-2 A schematic representation of the radiation spectrum of the sun. Note that the horizontal scale is logarithmic. One micrometer (μm) is one-millionth of a meter; i.e., 1 micrometer = 0.000001 meter = 0.00004 inch.

and release chlorine atoms. These, in turn, can react with and reduce the amount of ozone.

Fluorocarbons released at the earth's surface slowly rise, eventually (after 10 to 20 years) reaching the top of the ozone layer, where they are exposed to solar ultraviolet radiation. When this occurs, photochemical reactions slowly but steadily reduce the concentration of ozone. In view of the serious consequences of such a result, the United States government, in 1978, banned the use of fluorocarbons for aerosol spray cans except for certain critical purposes in medical facilities. Freons continue to be used in refrigerators because the annual release of fluorocarbons in such use is relatively small; also, the practical value of refrigeration is greater than that of hair sprays or deodorants. (Other countries, which have accounted for about half of the Freons emitted into the atmosphere, continue to produce and disperse them.)

Other widely used substances, such as nitrogen-based fertilizers and methyl chloroform, which is used as a cleaning agent and solvent, are also suspected of being possible threats to the ozone layer.

No one can be sure at this time if the effects of Freons, fertilizers, and other ozone-threatening substances are as deleterious as some scientists assert. Ozone is naturally highly variable, and small changes are difficult to detect. But in view of the potential seriousness of a substantial depletion of ozone, wisdom dictates a reduction of risks.

CARBON DIOXIDE

Carbon dioxide (CO_2) is a normal, minor constituent of air. Although it represents only about 0.03 percent of the total volume of air, this gas appears to play a major role in the global climate. Carbon dioxide has been getting a great deal of attention in recent years because its concentration in the atmosphere has been increasing. In 1890 it was present in concentrations of about 300 parts per million (ppm); that is, every million parts of air contained 300 parts of carbon dioxide. In 1982 the annual average concentration was about 340 parts per million and increasing by about one part per million per year (Figure 2-3).

Fossil fuels are the chief source of the additional carbon dioxide in the atmosphere: When oil, gas, or coal is burned, carbon dioxide is emitted into the air. Some scientists believe that the clearing of forest lands over the world has also significantly contributed to the increase of carbon dioxide. As mentioned earlier, trees take in carbon dioxide to produce green matter through photosynthesis. Although fewer trees means less carbon dioxide consumed, the evidence suggests that the effect of forest clearing is small compared with that of combustion of fossil fuels.

It is important to know how the concentrations of atmospheric carbon dioxide will change in the future. According to Charles C. Keeling and Robert B. Bacastow, of the University of California at San Diego, if we continue to rely heavily on fossil fuels (particularly coal, which is so abundant in the United States), carbon dioxide concentrations will be about 600 parts per million by the year 2050. Other experts have estimated that this level will be reached within one or two decades of that date.

Carbon dioxide has no effect on solar radiation but readily absorbs infrared radiation emitted by the earth. For this reason, an atmosphere rich in carbon dioxide is sometimes likened to a greenhouse. Water vapor also has little effect on solar radiation but absorbs infrared radiation. If radiation were the only energy transport process at work, it could be concluded that, as atmospheric carbon dioxide increased, the difference between incoming solar radiation and outgoing terrestrial radiation would increase proportionally, leading to an increase in temperature in the lower atmosphere.

In considering the effects of carbon dioxide, however, we must realize that the atmosphere is a complex system and that many factors and processes

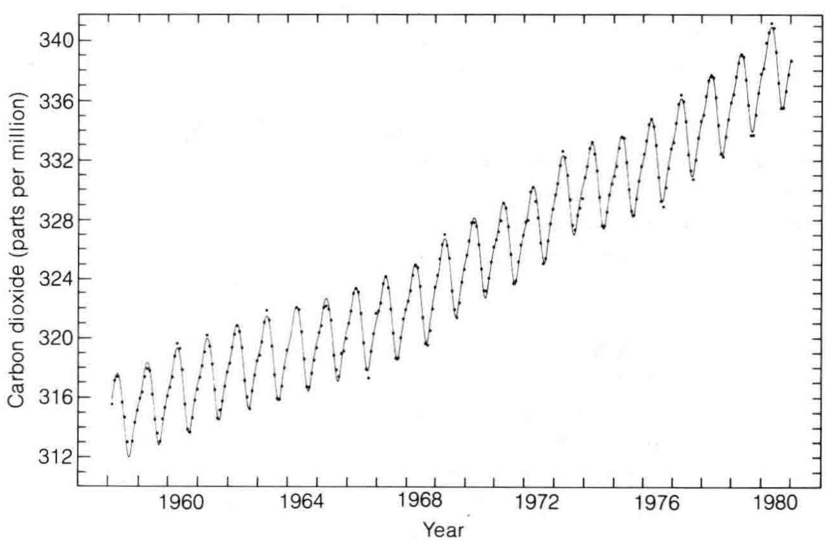

Figure 2-3 Variations of atmospheric carbon dioxide measured at the National Oceanic and Atmospheric Administration (NOAA) baseline station on Mauna Loa, Hawaii. The seasonal periodicities are caused by the seasonal variations in vegetation. Note the progressive increases of the annual averages. (Courtesy of C. D. Keeling and R. B. Bacastow, Scripps Institution of Oceanography.)