FOCUS ON ENVIRONMENT

How Can We Visualize Global Warming?

Global warming is certainly one of the most discussed issues of our time. But how serious is the problem, and how can we decide whether the warming is caused by human activity or by natural cycles of Earth's climate? These questions can be addressed statistically, and, like many statistical ideas, they are best visualized with graphics.

The obvious starting point for the scientific study of global warming is to find out how much warming is actually occurring. You might at first guess that we could learn about temperature trends simply by comparing local temperatures from old newspapers with temperatures in the same places today. However, global warming refers to an increase in the *average* temperature of our whole planet, which means individual localities may warm more or less than this average. Indeed, we should expect that some places might actually get colder even as the planet as a whole warms up. If we want to learn whether our planet is warming up, we therefore need data that can tell us how the *global average temperature*—the average temperature of the entire Earth—is changing with time.

Today, orbiting satellites provide data that allow us to determine the global average temperature quite accurately, because they give us a view of our entire planet. We can validate these records with "ground truth" measurements recorded at more than 7,000 weather stations around the world, along with measurements of ocean temperatures generally obtained by measuring the temperature of water collected by ships' intake valves. As a result, we have reliable temperature data for the approximately four decades for which we have satellite observations of our planet. The data become somewhat less reliable for years prior to the satellite era, because we can look only at data for specific locations, and the number of locations is smaller as we look further back into the past couple of centuries. Moreover, most past temperature records were kept in cities, which tend to become warmer over time for reasons independent of global warming (see Section 2.2, Example 1). Scientists can often account for this "urban heat island" effect, but even then are left primarily with data for land temperatures and few records of temperatures over the oceans that cover three-fourths of Earth's surface. Scientists have devoted a lot of effort in the past few years to examining past temperature data in detail. Through statistical analysis, it is possible to reconstruct a fairly reliable temperature history for most of the past two centuries, though the uncertainties become larger as we look further back.

Figure 3.60 shows the reconstructed history of Earth's global average temperature since 1860. Despite the uncertainties, the overall conclusion is clear: Global average temperatures have risen by about 0.8°C (1.4°F) in the past century. Moreover, most of the warming (about 0.6°C) has occurred in just the last thirty years, the period for which the data are most reliable. The warming trend also seems to be accelerating. For example, nine of the ten hottest years on record occurred in the most recent 10-year period shown on the graph.

With the temperature data showing a clear warming trend, the next question is how much we might expect the temperature to increase in the future. As we'll discuss further in Chapter 7 (see the "Focus" on p. 328), the rise in temperature is clearly linked to an increase