

Global average temperature climbed to 14.52 degrees Celsius in 2002, supplanting 2001 as the second hottest year since recordkeeping began in the late 1800s, according to the Goddard Institute for Space Studies.<sup>1</sup> (See Figure 1.) Other centers of climate analysis, using roughly the same network of land and sea temperature gauges, also rank 2002 as second only to 1998 in warmth, and find that the nine warmest years have occurred since 1990.<sup>2</sup>

Scientists have linked the warming trend that took off in the twentieth century to the buildup of carbon dioxide (CO<sub>2</sub>) and other heat-trapping gases.<sup>3</sup> By burning fossil fuels, people released some 6.44 billion tons of carbon into the atmosphere in 2002, a 1-percent increase over the previous year, raising atmospheric CO<sub>2</sub> concentration to 372.9 parts per million by volume.<sup>4</sup> (See Figure 2.)

Measurements taken at the Mauna Loa Observatory in Hawaii show an 18-percent increase in CO<sub>2</sub> levels from 1960 to 2002.<sup>5</sup> Scientists estimate that levels have risen 31 percent since the onset of the Industrial Revolution around 1750.<sup>6</sup> The current concentration has not been exceeded in at least 420,000 years—and likely in 20 million years.<sup>7</sup>

Oscillations in the temperature of the tropical Pacific Ocean are linked to atmospheric CO<sub>2</sub> levels as well as to year-to-year fluctuations in temperature.<sup>8</sup> The world's oceans, which contain about 50 times as much CO<sub>2</sub> as the atmosphere does, are able to take up more carbon when cool.<sup>9</sup> When the sea surface warms in the equatorial Pacific, as it does during an El Niño event, the ocean absorbs less carbon, so atmospheric CO<sub>2</sub> levels rise, along with global temperature.<sup>10</sup>

In May 2002, ocean buoys in the central Pacific started reading warmer-than-average temperatures, heralding the onset of El Niño, which persisted into 2003, sharply changing patterns of rainfall, temperature, and winds in some regions and contributing to, for instance, droughts in India, Australia, and Africa and floods in Europe.<sup>11</sup> Scientists believe that this El Niño may help push global average tempera-

ture to a new high in 2003.<sup>12</sup>

Indicators of a warming world abound. Biologists are recording spring events such as the first flowering of plants and the arrival of migrant birds occurring earlier, and are finding the geographic ranges of birds, butterflies, and herbs moving poleward.<sup>13</sup> Mountaintop glaciers are retreating in Alaska, Asia, the Alps, Indonesia, Africa, and South America.<sup>14</sup> Global sea levels rose in the twentieth century about 1–2 millimeters a year, faster than in the nineteenth century.<sup>15</sup>

Poor nations are the most vulnerable to climate change. As temperatures have risen on mountaintops in Rwanda and in other African highlands, malaria-carrying mosquitoes have extended their range, infecting more people.<sup>16</sup> Cholera bacteria thrived in the warm ocean waters of the 1997–98 El Niño, which flooded the Indian Ocean coast, prompting cholera outbreaks in Djibouti, Somalia, Kenya, Tanzania, and Mozambique.<sup>17</sup> Over the last two decades, floods and other weather-related disasters were among the factors prompting some 10 million people to migrate from Bangladesh to India.<sup>18</sup>

Wealthy nations contribute the most to climate change. With less than 5 percent of the world's population, the United States is the single largest source of carbon from fossil fuel burning—emitting 24 percent of the world's total.<sup>19</sup> Per person, U.S. emissions are roughly double that of other major industrial nations and 17 times that of India.<sup>20</sup> (See Figure 3.) China, home to one fifth of the world's people, ranks a distant second to the United States in emissions, with just 12 percent of the total.<sup>21</sup>

Some progress toward reducing global carbon emissions was made in 2002, when Japan, Canada, and the 15 nations of the European Union ratified the 1997 Kyoto Protocol on climate change.<sup>22</sup> For the protocol to come into force, 55 nations representing 55 percent of the 1990 emissions of industrial and former Eastern bloc nations must ratify it. By the end of January 2003, 104 nations representing 44 percent of emissions had done so.<sup>23</sup> As the United States and Australia have pulled out of the process, Russia must ratify the protocol for it to come into force.<sup>24</sup>

**LINKS**  
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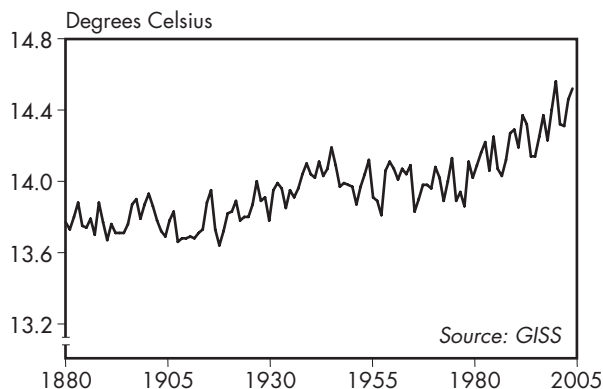


Figure 1: Global Average Temperature at Earth's Surface, 1880–2002

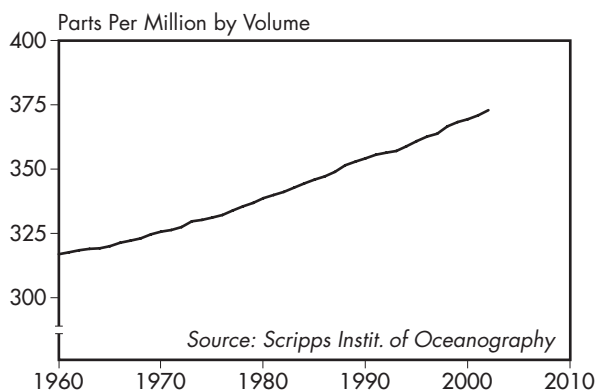


Figure 2: Atmospheric Concentrations of Carbon Dioxide, 1960–2002

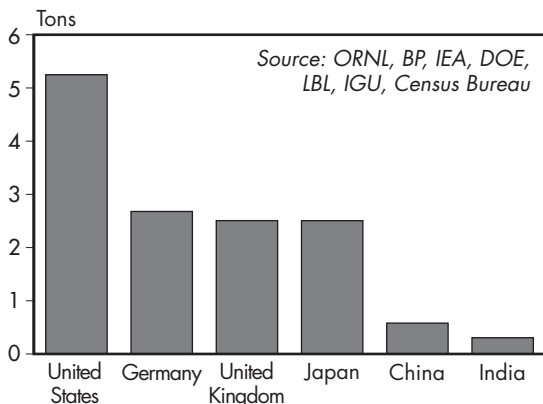


Figure 3: Carbon Emissions Per Person in Selected Countries, 2002

Global Average Temperature and Carbon Emissions from Fossil Fuel Burning, 1950–2002, and Atmospheric Concentrations of Carbon Dioxide, 1960–2002

Year	Temperature (degrees Celsius)	Emissions (mill. tons of carbon)	Carbon Dioxide (parts per mill. by vol.)
1950	13.87	1612	n.a.
1955	13.89	2013	n.a.
1960	14.01	2535	316.7
1965	13.9	3087	319.9
1970	14.02	3997	325.5
1975	13.94	4518	331.0
1976	13.86	4776	332.0
1977	14.11	4910	333.7
1978	14.02	4961	335.3
1979	14.09	5249	336.7
1980	14.16	5177	338.5
1981	14.22	5004	339.8
1982	14.06	4961	341.0
1983	14.25	4944	342.6
1984	14.07	5116	344.2
1985	14.03	5277	345.7
1986	14.12	5439	347.0
1987	14.27	5561	348.7
1988	14.29	5774	351.3
1989	14.19	5882	352.7
1990	14.37	5953	354.0
1991	14.32	6023	355.5
1992	14.14	5907	356.4
1993	14.14	5904	357.0
1994	14.25	6053	358.9
1995	14.37	6187	360.9
1996	14.23	6326	362.6
1997	14.40	6422	363.8
1998	14.56	6407	366.6
1999	14.32	6239	368.3
2000	14.31	6315	369.4
2001	14.46	6378	370.9
2002 (prel)	14.52	6443	372.9

Source: Goddard Institute for Space Studies, ORNL, BP, IEA, DOE, IGU, LBL, and Scripps Instit. of Oceanography.

**CARBON EMISSIONS AND TEMPERATURE CLIMB**  
(pages 40–41)

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