Since the industrial revolution, humans have been changing the atmosphere. Agricultural, industrial, and other activities have increased the concentrations of heat-trapping “greenhouse” gases such as carbon dioxide, methane, nitrous oxide, low-level “tropospheric” ozone, and halogenated carbon compounds. These gases now affect the climate.

### The Top Five Climate-Changing Gases

<table>
<thead>
<tr>
<th>Heat-Trapping Gas</th>
<th>Radiative Forcing (W/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>+1.66</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>+0.48</td>
</tr>
<tr>
<td>Low-level ozone (O₃)</td>
<td>+0.35</td>
</tr>
<tr>
<td>Halogenated carbons</td>
<td>+0.34</td>
</tr>
<tr>
<td>Nitrous oxide (N₂O)</td>
<td>+0.16</td>
</tr>
</tbody>
</table>

Carbon dioxide (CO₂)

Because we release so much of it, carbon dioxide is, by far, the most important greenhouse gas. It has a number of human sources, but the major ones are fossil fuel burning power plants (shown above) and deforestation.

The “Keeling Curve” shows that the concentration of CO₂ in air has increased since 1958. Human sources cause the long-term increase. The smaller annual cycles are caused by seasonal patterns of plant growth in the Northern Hemisphere. Atmospheric CO₂ has risen ~35% in 150 years, and is now rising faster than ever.

Low-level ozone (O₃)

Low-level or “tropospheric” ozone can be produced from chemical reactions between car exhaust pollutants such as carbon monoxide (CO) and nitrogen oxides (NOₓ). Unlike “the ozone layer”, tropospheric ozone is found close to the earth’s surface, and is harmful to health.

Methane (CH₄)

Besides rice fields, another major source of methane is ruminants (hoofed animals with multiple stomachs like cattle, shown above, and sheep). Methane is released during digestion and from their manure.

Halogenated carbons

Halogenated carbons are carbon compounds with halogen atoms (fluorine, chlorine, etc.) like chlorofluorocarbons (CFCs) or carbon tetrachloride (CCl₄). These halogenated compounds are used in refrigerators and car air conditioners.

Nitrous oxide (N₂O)

A large proportion of human-produced nitrous oxide comes from agricultural soils that use large amounts of nitrogen-based fertilizers (shown above), and from cattle waste in feedlots.

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Created by Novem Auyeung for the Boston Area Climate Experiment.

This poster was designed during the class “Climate Change: Mechanisms and Biological Impacts,” at the University of Massachusetts Boston, Fall 2006.

**Reference:**

Intergovernmental Panel on Climate Change. 2007. IPCC Fourth Assessment Report.