
Water vapor amounts in the stratosphere are much lower, typically on the order of 4 to 6 parts per million by volume (0.004 to 0.006 %). Yet even this water vapor plays a significant role in the energy budget of the atmosphere. Water vapor is radiatively active, absorbing and reradiating the thermal (or infrared) energy from the surface. It also plays a key role in the formation of particles in the stratosphere, such as aerosols and at very low temperatures, special types of clouds known as polar stratospheric clouds.

2.2.2 Methane -- Though methane has a global average of just 1.7 ppmv of air in the well-mixed layer of the lower atmosphere, it displays, like other trace gases, considerable spatial variation in concentration at the surface. Near its source regions, concentrations are much higher; in sink regions, concentrations are lower than the global average. Two source regions for methane are feedlots, specifically, cattle flatulence, and rice paddies. Both sources reside at the surface. As a result, methane at higher altitudes must be mixed up from below. Such vertical mixing of air in the stratosphere is relatively slow, thus limiting

warmer than it would otherwise be. Indeed, it is because of this ozone layer that the temperatures rise with height, giving rise to the structure of the stratosphere. It is contrasted with the troposphere (see Section 3).

Ozone is formed by the reaction of an O atom (created by the photodissociation of O₂) and an O₂ molecule to form O₃. In addition to creating ozone, UV radiation also destroys it, as do a number of chemical reactions.

Although ozone is constantly being created and destroyed, the amount of ozone at a given location remains relatively constant. This amount of ozone, also known as the steady state concentration of ozone, peaks at roughly 5×10^{12} molecules per cubic centimeter at around 30 km in altitude. Considerable natural variation in ozone occurs, however, due to transport.

Ozone is also produced at the surface in two ways, both of which are related to human activities. One way is in the form of photochemical smog that arises from industrial pollution reacting with sunlight. Another is in so-called "biomass burning". This refers to burning of jungle, savannah, and existing farm land. It is primarily due to human agricultural needs, though lightening can also trigger wildfires that result in biomass burning-related ozone creation. These forms of ozone are unhealthy, while stratospheric ozone, by blocking dangerous UV light, is essential for life on Earth's surface.

UV light, is essential for life on Earth's surface. Our focus here is on this beneficial ozone created by energetic UV light, principally in the stratosphere.

2.3 Trace Species as Greenhouse Gases

The trace gases such as carbon dioxide, water vapor, ozone, and methane, as well as the manmade chlorofluorocarbons (CFC's), are all also categorized as "greenhouse gases." This is because each one of them has the ability to affect Earth's energy balance and change the temperature at the surface and in the atmosphere. They do this through the way in which they absorb incoming shortwave energy (radiation) from the sun and reradiate it upwards and downwards as longwave radiation in the form of infrared or thermal energy, which we can feel as sensible heat.

How they do this, and what is meant by longwave and shortwave radiation is explored in depth in Chapter 4.

2.5 Additional Atmospheric Components: Aerosols and Ions

In addition to gaseous species in the atmosphere, there are suspended solid or liquid particulates as well. Known as aerosols, they are typically on the order of magnitude of micrometers to millimeters in size. Dust, sea salt, and volcanic emissions are natural sources for aerosols. Sulfur dioxide from volcanic eruptions and from power plant emissions react to form tiny sulfuric acid droplet aerosols. These particles form cloud condensation nuclei for cloud water droplets and frozen cloud ice crystals. Sulfuric acid droplets high in the stratosphere form the so-called Junge Layer. Aerosols are also involved
