Ozone fluctuations in the stratosphere and troposphere

Good Ozone, Bad Ozone

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The trouble with ozone is that there is too little of it where it should be, yet too much where we do not want it

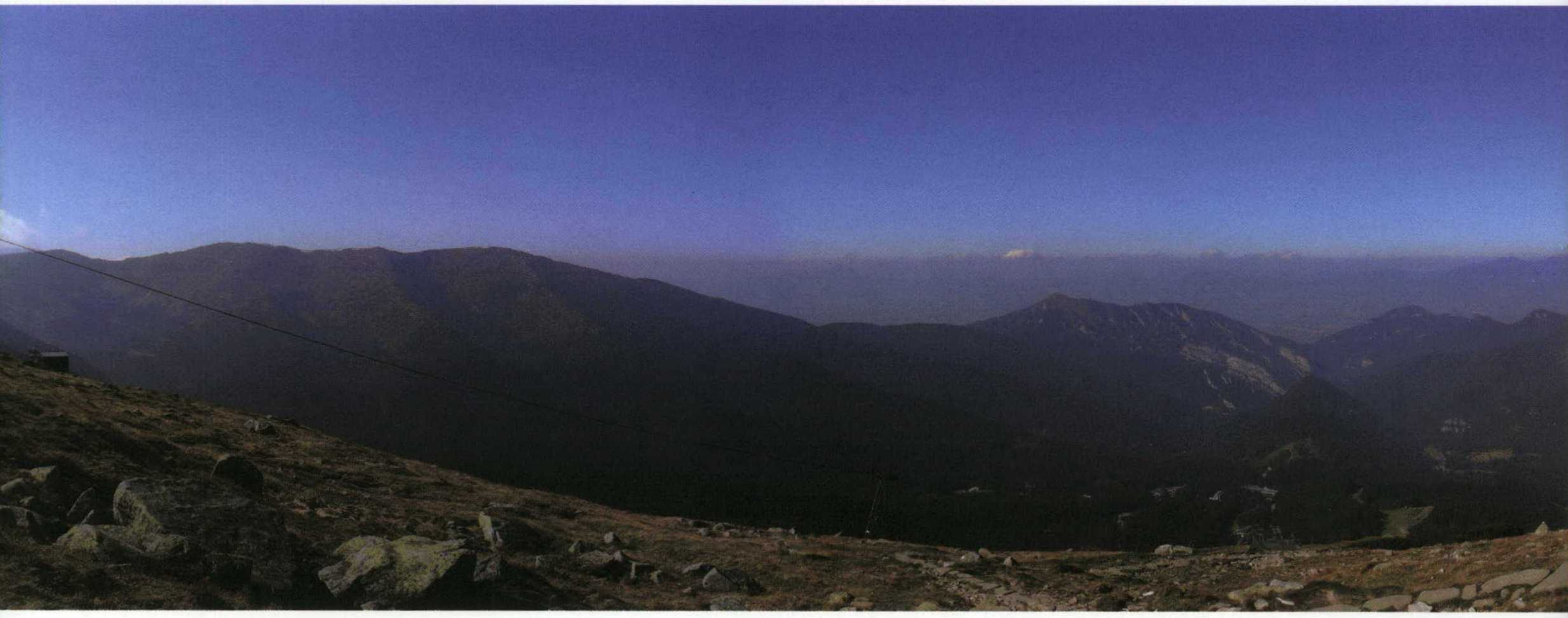
Although ozone accounts for only a very small share of the Earth's atmosphere when compared to the primary atmospheric gases (nitrogen and oxygen), it is a very important component because it absorbs ultraviolet radiation from the Sun that is harmful for living organisms. Ozone is especially effective at halting electromagnetic waves shorter than 280 nanometers, called UV-C, which essentially do not reach the surface at all. While absorbing such radiation, ozone simultaneously heats up the atmospheric layer it is located in, thus modifying the circulation of air.

Ozone would not be a subject of broader public interest if it were not for the fact that since the 1980s we have been bombarded with disturbing news about the dangerous "ozone hole" caused by its depletion in the atmosphere. On the other hand, ozone is also portrayed as a harmful substance that pollutes the air around us, being one of the main components of "photochemical smog" - a phenomenon that occurs in the summertime in large cities and industrialized regions around the world. Thus the very same gas appears in two very different guises: "good" ozone far above the clouds and "bad" ozone in the lower layer we live in.

Pollutant or savior?

Despite what is said about ozone, it does not form any distinct layer within the atmosphere. Rather, it occurs within the whole air column - from the surface up to a height of around 100 km. It is produced in a natural way when photons of the Sun's ultraviolet radiation collide with oxygen molecules. This process occurs most robustly at a height of 20-25 km (the lower stratosphere) and that is where the highest ozone concentrations are found. In the lower layers of the atmosphere and on the Earth's surface, where the most harmful ultraviolet radiation does not reach, ozone arises from a cycle of chemical reactions involving nitrogen oxides and hydrocarbons, usually derived from industrial or automotive exhaust gases. The overall ozone content in all layers of the atmosphere shows natural seasonal and even diurnal variability.

The problems with the alleged "ozone layer" are twofold. Since the 1980s, a gradual depletion of ozone (at a rate of several percent per decade) has been noted in the stratosphere, especially in the middle latitudes, including



over Poland. In the 1970s it was discovered that chlorine and bromine compounds (including freons and halocarbons) released into the atmosphere by certain types of industrial activity could contribute to the destruction of the stratospheric ozone.

Ozone depletion in the stratosphere is especially notable, even dramatic, in the Antarctic region. A so-called "ozone hole" has been observed there each spring for the past 30 years, involving a dip in total ozone concentrations to nearly one-third of their original values. This "hole" occurs at this specific place and time due to a special set of meteorological conditions that practically do not occur elsewhere on earth. Extraordinarily low temperatures during the polar night cause chlorine and bromine compounds to condense and become trapped in clouds. When the sun begins to shine again over the Antarctic in the spring time, chemical reactions with these compounds start to destroy the ozone.

As we noted above, ozone found nearer the Earth's surface is of completely different origin. Unlike in the stratosphere, here in the lower troposphere excessive quantities of ozone are undesirable due to its toxic effects on plants, animals, and human health - being an extraordinarily active molecule, ozone reacts with many other chemical compounds, destroying or modifying them. Since the end of the 19th century, when measurements of ozone concentrations on the Earth's surface began to be recorded, such values have risen several times over. The highest concentrations are observed during occurrences of photochemical smog.

Favorable trends

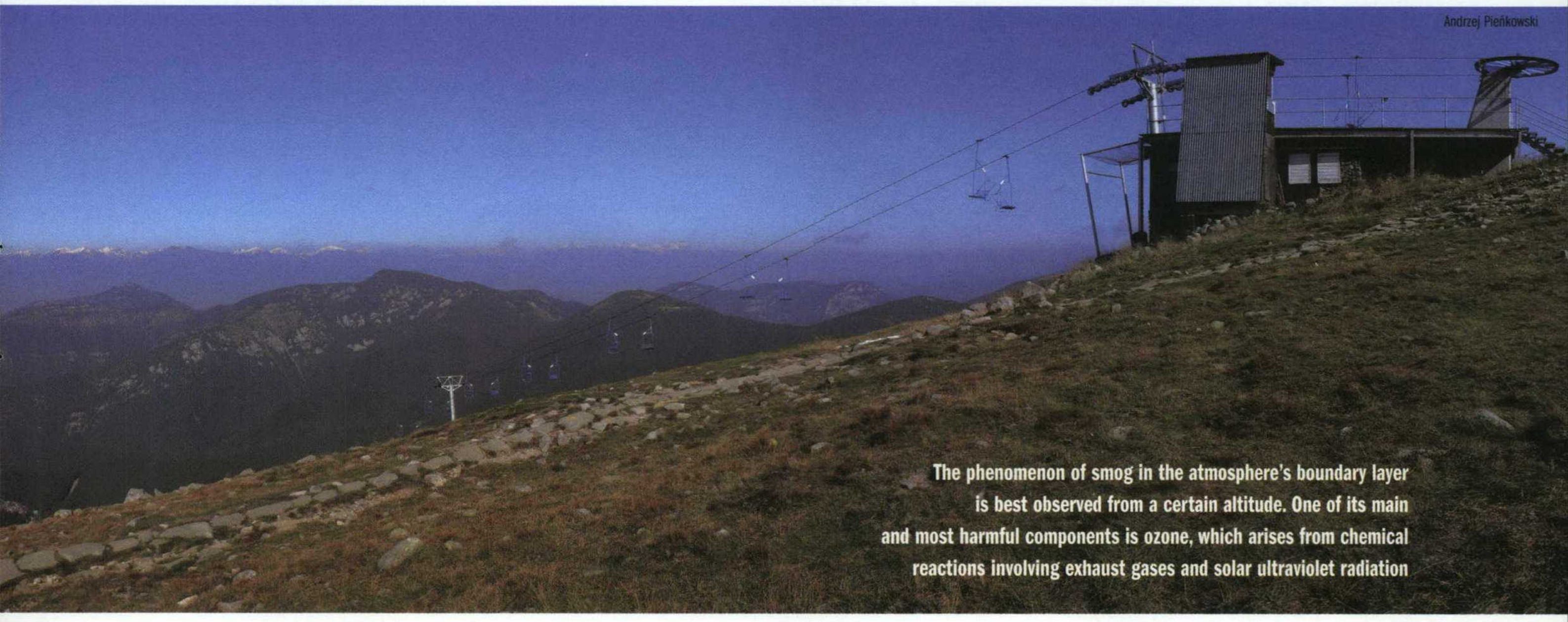
Before global ozone levels began to be observed by satellites, measurements were taken by a worldwide network including the Central Geophysical Observatory (Institute of Geophysics, Polish Academy of Sciences) in Belsk, some 50 km outside of Warsaw. Beginning in 1963, it has kept systematic records of both total ozone content and its vertical distribution using a Dobson spectrophotometer. This data set is one of the world's longest measurement series, highly valued due to its documented quality and utilized by numerous research centers in the world.

Recent studies on long-term changes in the ozone layer have pointed to the possibility that unfavorable trends in ozone levels may actually be reversing. These studies indicate that over the next few decades, the "ozone layer" can be expected to recover as a consequence of the implementation of a series of international agreements curbing emissions of ozone-destroying substances, especially the Montreal Protocol and subsequent annexes. Another source of optimism can be the lower troposphere ozone measurements taken at many locations in the world (at the Central Geophysical Observatory at Belsk starting in 1991). Growth in near-surface ozone levels has been seen to slow down in recent years and smog is now occurring more rarely, at least over Poland's territory. This is probably due to decreased emissions of pollutants, especially so-called ozone precursors like nitrogen oxides and hydrocarbons - their emissions have been reduced despite the growth in vehicle numbers in Poland. ■

Further reading:

Krzyścin J.W., Krizan P., Jarosławski J. (2007). Long-term changes in the tropospheric column ozone from the ozone soundings over Europe. *Atmospheric Environment., 41*, 606-616.

Scientific Assessment of Ozone Depletion (2006). http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2006



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The phenomenon of smog in the atmosphere's boundary layer is best observed from a certain altitude. One of its main and most harmful components is ozone, which arises from chemical reactions involving exhaust gases and solar ultraviolet radiation