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Ozone

Ozone (O_3) is one of the essential gas compounds in the earth's atmosphere, and in two respects. On the one hand, it has a negative effect with regard to the layers of air close to the surface of the earth, causing the so-called "summer smog" and problems to the respiratory system. On the other hand, due to its presence in the atmosphere between 10 and 50 km, ozone play a beneficial role as a shield absorbing the major part of the sun UV rays that are harmful to humans, animals and plants. Without that protective layer, life on earth as it exists at the moment would simply be impossible.
The creation and distribution of atmospheric ozone, which differs according to altitude, has gradually evolved over the course of the preceding millennia and has allowed the creation of life on earth. Thanks to a dynamic equilibrium, the ozone layer has remained stable even during different climatic cycles.

However, from the beginning of the 80s, the first signs of major disruption to the ozone layer were recorded above the South Pole. It was possible to prove that the ozone layer had deteriorated first and foremost due to anthropogenic substances with a long life cycle, such as the chlorofluorocarbons (CFCs). These gases were principally used as propellants in sprays and in refrigeration systems as well as in certain industrial activities. The relationship between human activities and the disruption in the global scale of atmospheric equilibrium was the first tangible sign of climate change of anthropogenic origin. This wake-up call regarding the depletion or even temporary destruction of the ozone layer led to the signing of the Montreal Protocol in 1987. This protocol and its subsequent amendments led to the banning of the use of certain substances that affected the ozone layer.

In addition to its role as protection against the sun's harmful rays, ozone is also an important greenhouse gas and therefore plays a vital role in climate change. It is therefore of the utmost importance that its evolution should be monitored over time.

Ozone measurement in Switzerland

In Switzerland, there is a very long tradition of measuring the ozone column, beginning in Arosa as far back as 1926. As a signatory to the Montreal Protocol, Switzerland is committed to continuing these measurements, and the responsibility for this has been given to MeteoSwiss.

Figure 1
Solar spectrophotometer of the Brewer type on the terrace of the laboratory in Arosa

The measurement of the ozone is based on the absorption of the sun's rays by the ozone that is present in the atmosphere. In the spectrophotometer the beam of light from the sun meets with either a prism (of the Dobson type) or a diffraction grating (of the Brewer type) which triggers its spectral decomposition into a "rainbow". Some wavelengths in the ultraviolet spectrum are then selected, which, by means of comparison, allows the quantity of ozone met by the beam of light in the atmosphere to be determined.
There are currently six pieces of equipment that measure the column of ozone: 3 are of the Brewer type (Figure 1) and 3 are of the Dobson type (Figure 2). The redundancy thus obtained allows a reliable measurement of the variations in the ozone layer to be made.

Figure 2
View of a solar spectrophotometer of the Dobson type for measuring the ozone column

Payerne station

Beginning with the measurements in Arosa, the total quantity of ozone above the station and its distribution according to altitude is also estimated.
From its station in Payerne, MeteoSwiss also has two different methods at its disposal for measuring the ozone profiles: one is a measurement in situ thanks to a sounding balloon (Figure 3) and the other is a remote sensing measurement using a microwave radiometer (Figure 4).
Three times a week, an ozone sensor is attached to the aerological balloons released from Payerne in order to measure temperature, humidity, air pressure and wind. This means that the amount of ozone according to altitude can also be measured. These types of measurements have been taken on a regular basis since 1968. The profiles thus captured show the vertical distribution of the ozone up to the altitude where the balloon bursts, at about 30-35 km.

Figure 3
Release of an upper air sounding balloon to measure the ozone profile and other meteorological parameters

In order to find out about the distribution of the ozone at higher altitudes and at a higher frequency, a measurement of the energy emissions of the ozone molecules in the region of microwaves was started at Payerne in 2000. It has thus been possible to record an hourly profile of the ozone by day and night, which has enabled the measurement of the daily variations of the ozone depending on the altitude.

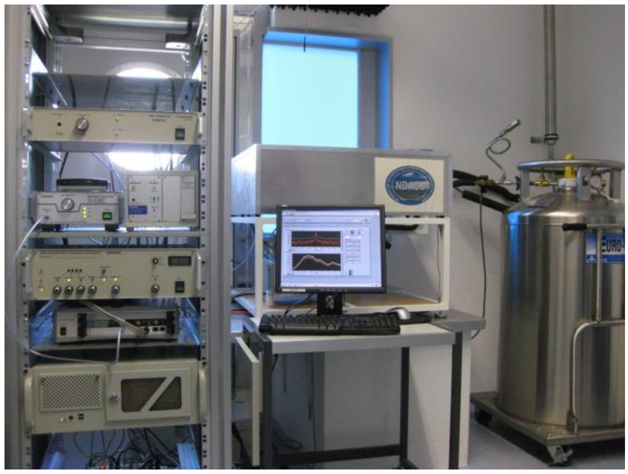

Figure 4
SOMORA microwave radiometer measuring the vertical distribution of the ozone above Payerne

A combination of these measurements has made it possible to measure the distribution of ozone from ground level up to an altitude of 65 km and to follow its developments on a daily basis.

Analysis of the ozone measurements

The analysis of the series of measurements of the ozone column and the ozone profiles has made it possible to measure the evolution of the quantities of ozone over very long periods of time (trend calculation). The depletion of the ozone layer during the period 1980 – 2000 attributable to CFCs can thus be quantified, as well as its stabilisation afterwards. It has also been possible to draw a correlation between the changes in temperature observed in the various layers of the atmosphere and the changes in the ozone layer and vice versa.
The continuous measurement of the amount of ozone above Payerne has also made it possible to detect mini holes in the ozone layer that last from several hours to several days.

Additional information
www.meteoswiss.ch