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A NOVEL OZONE SENSOR FOR VARIOUS ENVIRONMENTAL APPLICATIONS

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ABSTRACT

A small, lightweight and fast-response ozone sensor for various environmental applications is described. At a flow rate of 100 l min^{-1} the ozone sensor has a response time of significantly better than 0.1 s with a detection limit lower than 100 pptv. The ozone sensor was successfully tested in various environmental applications, i.e. in measuring directly the vertical ozone flux onto agricultural land utilising the eddy correlation or covariance technique and in monitoring horizontal and vertical ozone profiles in the troposphere and stratosphere.

1. INTRODUCTION

Despite the various ozone analysers which are commercially available, there is an obvious need for

a small, light-weight ozone sensor, which combines simplicity with low cost and low electric power consumption. Furthermore, the commercial ozone analysers feature fairly slow response times of approximately 10 seconds and a detection limit of about one ppb. For various applications such as the eddy correlation technique or aircraft measurements, fast and more sensitive ozone sensors are needed. We will present here various applications of a novel, fast and sensitive ozone sensor.

2. EXPERIMENTAL

The measuring principle of the novel ozone sensor is the chemiluminescence of an organic dye adsorbed on dry silica gel in the reaction with ozone. Details about the prototype ozone sensor and its application are given in Refs. 1 and 2.

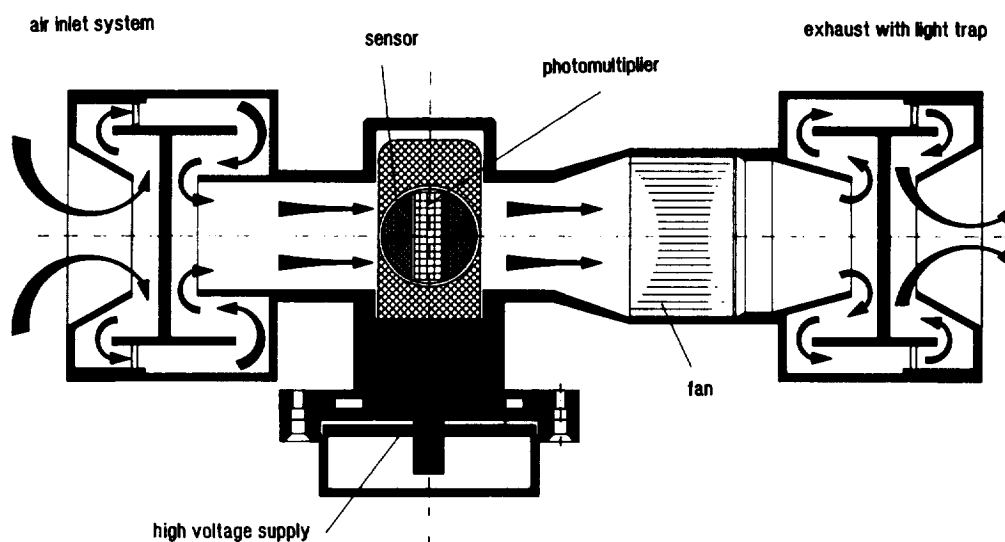


Fig. 1 Schematic of the novel ozone sensor (GFAS Corporation, Germany).

The novel ozone sensor* which is now commercially available, is depicted in Fig. 1. Its basic features are a cheap, blue-sensitive side-window photomultiplier, a high-performance miniature fan producing a rate of air flow through the detector of more than 100 liter min⁻¹, and a thin chemiluminescent disc.

All three components are housed in a black metal rod equipped with light and aerosol traps. A fast flow of air is sucked through the narrow gap between the photomultiplier and the disc surface. The intensity of the chemiluminescence light is directly proportional to the ambient ozone concentration. For various applications in the environment, e.g. eddy correlation technique, aircraft or balloon-based measurements of vertical or horizontal ozone profiles, different versions of the ozone sensor* are available.

The advantages of the novel ozone sensor over conventional ozonometers are:

- a detection limit lower than 100 ppt,
- a response time significantly better than 0.1 second,
- no interference from other atmospheric trace gases like NO_x, H₂O₂ and PAN,
- its small size, light weight (< 1 kg) and ease of handling.

3. ENVIRONMENTAL APPLICATIONS

Continuous eddy flux measurements of ozone on towers over long periods [2,3,4] or on aircrafts

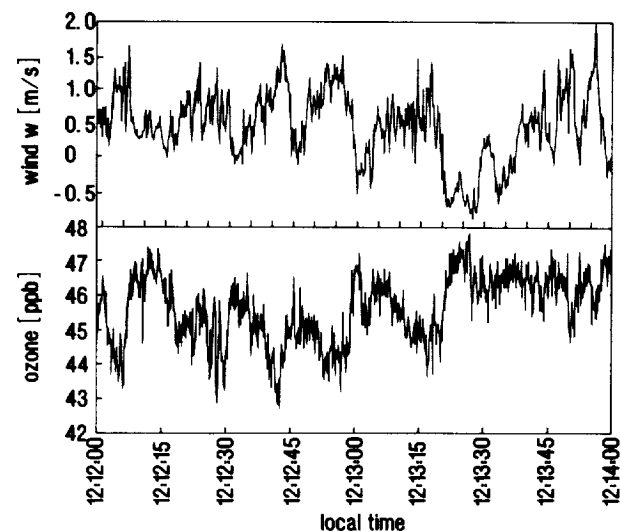


Fig. 2 Time series of vertical wind velocity and ozone concentration, simultaneously measured with 10 Hz resolution.

In Figure 2 a time series of the vertical wind and ozone concentration simultaneously measured with 10 Hz resolution over a wheat field demonstrates the excellent resolution of the signals around a mean

value of about 0.5 m s⁻¹ and 45 ppb, respectively. The vertical ozone flux is computed as the covariance of the fluctuations of both entities [2,3].

Aircraft-based measurements of vertical ozone profiles in the troposphere

Figure 3 displays the vertical ozone and temperature profiles below and above the atmospheric boundary layer, measured on board of a small airplane over the Rhine valley and the Black Forest on January 30, 1992. In the Rhine valley a distinct lamination of the ozone profile within the boundary layer can be observed.

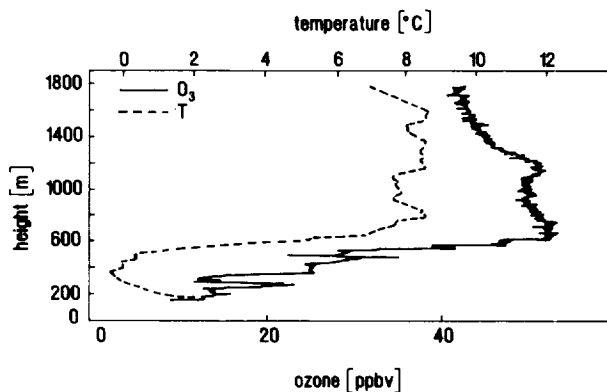


Fig. 3 Vertical ozone and temperature profiles in the lower troposphere, measured on board of a small airplane over the Rhine Valley and the Black Forest on January 30, 1992.

Monitoring vertical ozone profiles in the stratosphere

Figure 4 shows the vertical ozone profile in the stratosphere, measured during a balloon flight launched from Hohenpeißenberg Meteorological Observatory on October 23, 1989 [1].

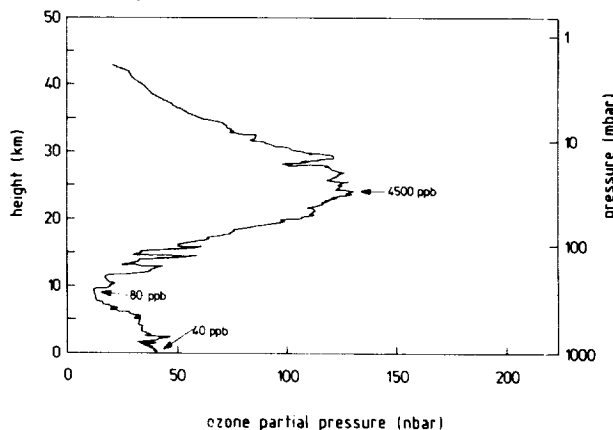


Fig. 4 Vertical ozone profile in the stratosphere, measured during a balloon flight launched from Hohenpeißenberg on October 23, 1989.

*Licensee: Fa. GFAS, Fritz-Kopp Str. 2, D-7997 Immenstaad, Germany.

The ozone profile nicely demonstrates a pronounced laminar structure in the lower stratosphere, a recently much discussed phenomenon /5/.

Due to the fast response time, the ozone profiles obtained in a tandem balloon flight with a Brewer-Mast ozone sensor display a better spatial resolution in comparison to the latter sensor /6/.

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