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RIVM'S STRATOSPHERIC OZONE LIDAR FOR NDSC STATION LAUDER: SYSTEM DESCRIPTION AND FIRST RESULTS

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NDSC

The Network for Detection of Stratospheric Change (NDSC) is a set of five primary high-quality, remote sounding research stations for observing and understanding the physical and chemical state of the stratosphere. These stations, where ozone and key ozone related parameters are measured, are complemented by both secondary stations and satellite observations. Currently, over 65 scientist of 15 countries are involved with the NDSC. The major aims of the NDSC are threefold: to make the earliest possible identification of changes in the ozone layer and to discern their causes; to provide an independent calibration for satellite sensors; to obtain data that can be used to test and improve multidimensional stratospheric chemical and dynamical models.

RIVM'S STRATOSPHERIC OZONE LIDAR IN LAUDER

RIVM contributes a stratospheric ozone lidar to NDSC primary station Lauder (45° S, 170° E), hosted by New Zealand's National Institute of Water and Atmospheric Research (NIWA). The system has been developed in Bilthoven, the Netherlands, over the past years and will be implemented in the network in the course of 1994. An extensive intercalibration with both ozone-sondes and ozone-lidar (NASA-GSFC) is planned.

OPERATIONAL DEMANDS

Standard NDSC monitoring typically requires profile measurements on a day to day basis, weather permitting. Some 200 observational nights per year are foreseen. In addition, since routine observation for trend analysis is a main goal, a measurement series of a decade or longer is planned. Remote access to the system and the measured data is mandatory, since the systems principal investigators will be half a globe away.

DESIGN

The basic system design is traditional, and uses 308 nm pulses from a XeCl excimer as the 'on' wavelength, and a second laser line around 353 nm as the 'off' wavelength. To cope with the interference from stratospheric aerosols we have adopted the approach of McGee et al[1], and implemented receiver channels for N_2-raman returns of 308 and 353 nm., at 332 and 385 nm respectively. With the demands stated above in mind we have designed the system to be as self-supporting as possible, interfacing all relevant system components to a central, high quality minicomputer with elaborate network facilities. Initially the system will be manually controlled from operator-consoles in either Lauder or Bilthoven, both with full access to the system. In due time we hope to eliminate the necessity of the presence of an operator during measurements.

SYSTEM DESCRIPTION

An overview of the emitter section is given in figure 1. For reasons of simplicity, low maintenance demands, low running costs and large mean time between failures, we use a single one cavity high power XeCl excimer laser without line-narrowing. Part of the radiation is shifted to 353 nm using stimulated raman scattering in hydrogen to create the reference wavelength. Beams are separated, and expanded 3.5 times to reduce divergence. Resulting emitter specifications are given in table 1.
The receiver section is shown in figure 2. A Newtonian telescope configuration is used, having the advantage of a small spotsize in the focal plane. A high speed chopper keeps low altitude echoes from reaching the detectors, thus avoiding signal-induced noise (SIN) effects. Dichroic band mirrors eliminate visible radiation. Dichroic long wave pass mirrors separate the four detected wavelengths. Interference filters spectrally purify these four wavelength channels. Finally, the two elastic echoes at 308 and 353 nm each are divided in a low altitude and high altitude channel with in-

tensity-ratio of about 1:100 to cope with the large dynamic range of the signal. Signals are detected by six high speed gated PMTs operating in photon counting mode. Table 2 summarizes some receiver characteristics.
The photoncounter system is CAMAC based. Each channel has a separate 150 MHz discriminator and a 100 MHz Multichannel Counter Scaler Averager. All channels share one non-jittering 'triggered burst' master clock which triggers the altitude-bin transitions. High altitude channels are gated off during the period that maximum countrate is exceeded. System timing and synchronization are controlled by three digital delay generators. The chopper functions as the master oscillator in the system, making it operate at a nominal frequency of 250 pulses per second.

MEASUREMENTS

In the development phase, we have had considerable problems with the divergence of the laser. Since this parameter is crucial for good system performance (both to allow the narrow field of view necessary for background light rejection, and to allow the fast chopping necessary for SIN-elimination) we spent considerable time on this subject. We have developed a technique to measure the beam footprint in the atmosphere at typical measurement altitudes (e.g. 10 km). A typical example is given in figure 3.
At the time of writing of this manuscript, we are still working on the system and the data-analysis. Therefore, the ozone profiles obtained still have a preliminary status. A typical example is given in figure 4. During this measurement no nitrogen ramanchannels were available, so data below 25 km is likely to be biased due to aerosol interference. Also, integration time used in this profile is about 20 minutes, considerably less than in a nominal measurement.

REFERENCE

1. McGee et al, Geophysical Research Letters, vol. **20**, no. 10, pages 955-958, May 21, 1993.

Laser	Lambda Physik LPX325i, unstable resonator, XeCl, 308 nm, 250 Hz, 400 mJ, 100 W (max.) 250 Hz, 280 mJ, 70 W (typical) Divergence: 0.8 mrad full angle, unexpanded, corrected
Expander	Focusing lens focal length: 2 meter Collimating lens focal length: 7 meter Expansion: 3.5 times
Emitted Beams	308 nm, 250 Hz, 200 mJ, 50 W, 0.45 mrad (typical) 353 nm, 250 Hz, 20 mJ, 5W, 0.35 mrad (typical)

Table 1. Emitter Specifications. Divergence is defined as the full angle containing energy levels > 10 % of the level of the center peak (see also fig 3).

Telescope	Newtonian type, 81 cm diameter (Optical Surfaces, Ealing) Focal Length 243 cm, F/3, Al+MgF_2 coated primary and secondary
Field of view	0.8 mrad typical, 2 mm diameter fieldstop in primary focus of telescope
Chopper	Bowtie design, 26 cm effective diameter at aperture, 125 Hz Linear speed at aperture: 102 m/s Time close-->open FOV: 20 µs typical Time block-->transmit beam : 10 µs typical
Interference filters	Center wavelengths: 308, 332, 353, 385 nm respectively (Barr Associates) Bandwidth: 2 nm fwhm, transmission > 50 % Blocking: 10^{-4} (200-650 nm), 10^{-5} (cross-repression between lines)
Detectors	Linear focused type photomultipliers (EMI 9883 QA) Bialkali photocathode, 2" diameter, 14 BeCu dynodes Active bases (SAFER), 10 microseconds gate on high altitude channels

Table 2. Receiver Specifications.

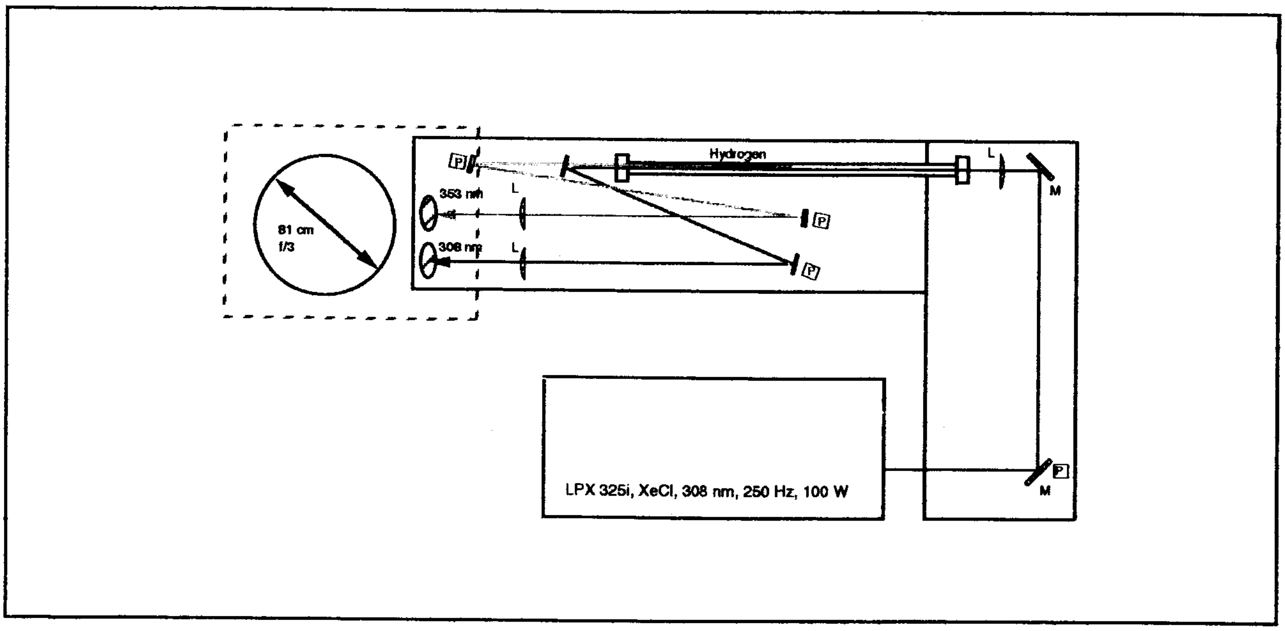

Figure 1. Emitter section overview. Mirrors are indicated by 'M', lenses by 'L', and power monitors by 'P' (see text for details). Receiving telescope is also shown.

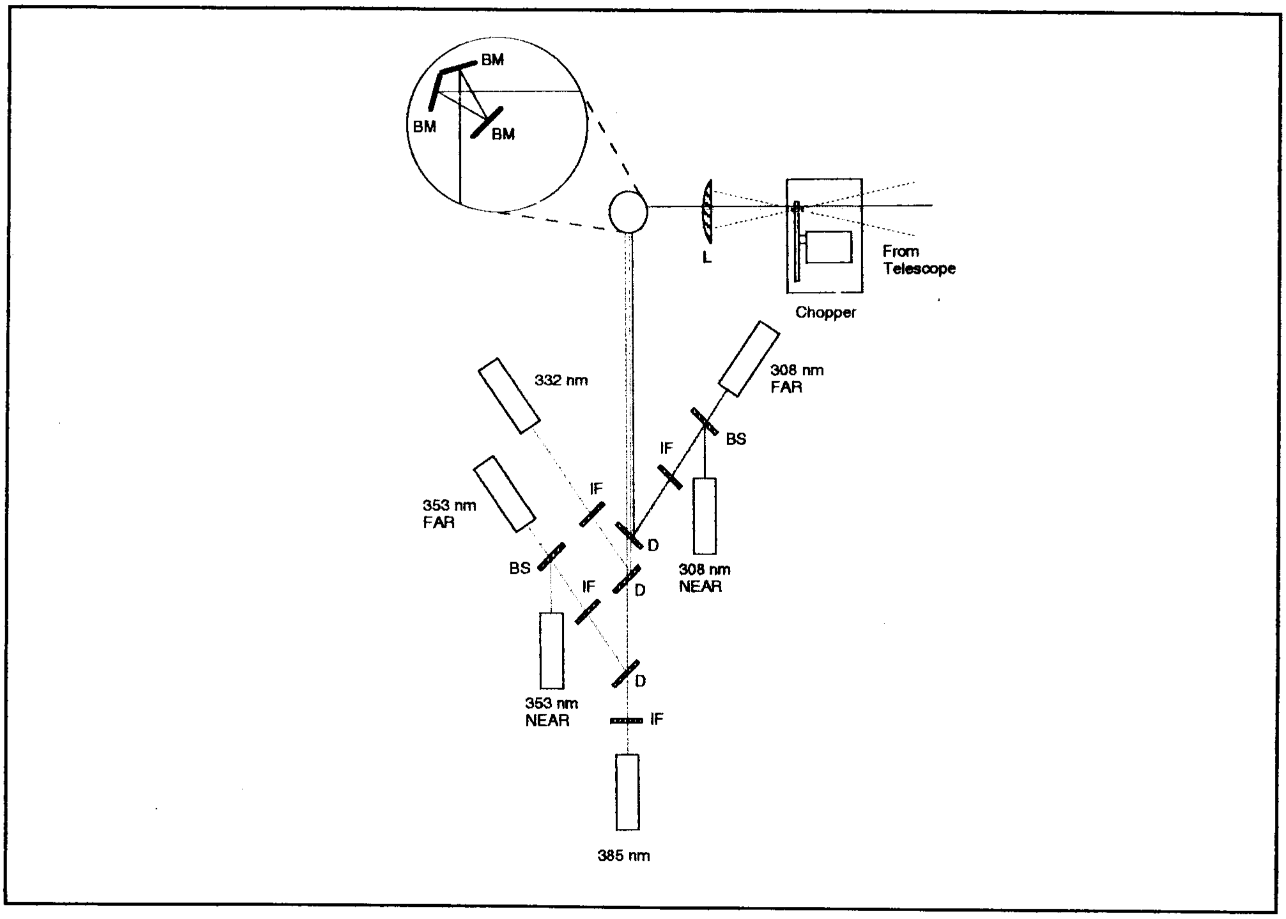

Figure 2. Receiver section overview. The collimating lens is indicated by 'L', band mirrors are labeled 'BM', long wave pass dichroic mirrors by 'D', interference filters by 'IF', and beamsplitters by 'BS' (see text for details).

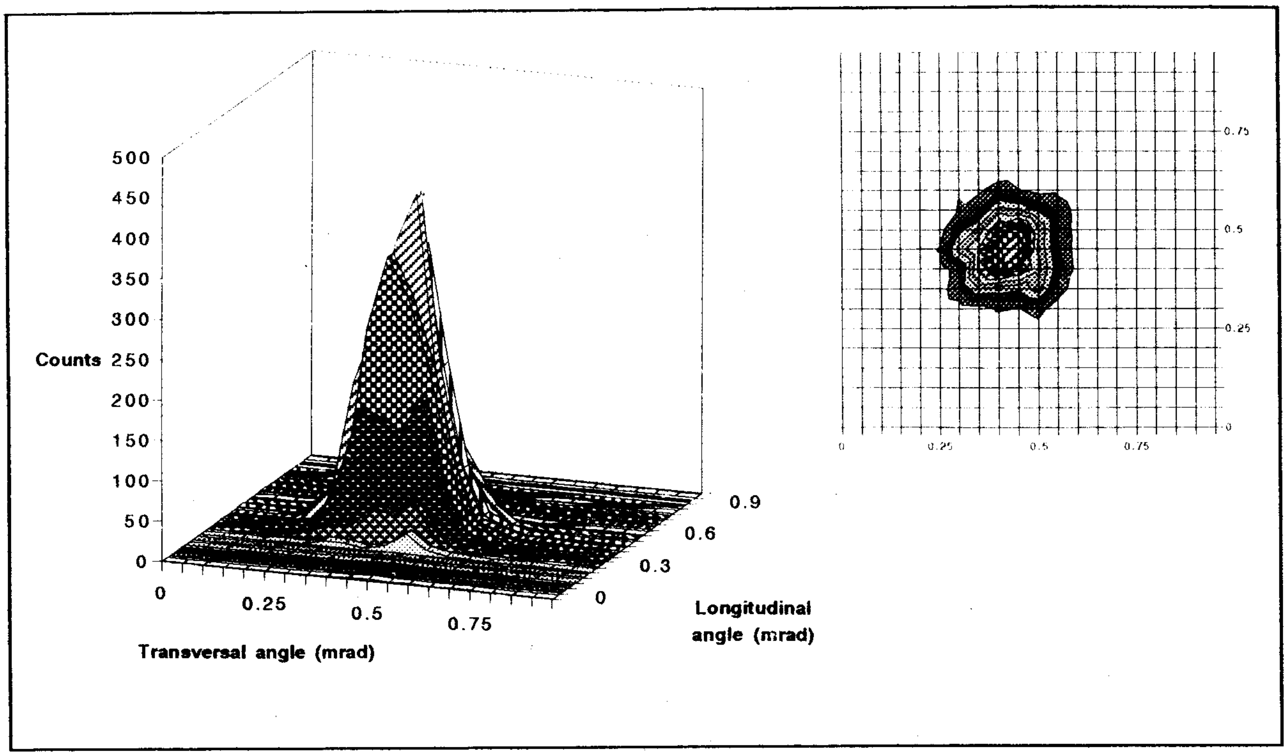

Figure 3. Footprint of the 353 nm beam at 10 km altitude, measured on a 1 * 1 mrad grid, with a resolution of .05 mrad. The left figure shows a 3-D view. The figure to the right shows a top view of the energy density with contour lines at 10 % intervals. The outer contour is drawn at 10 % of the peak intensity.

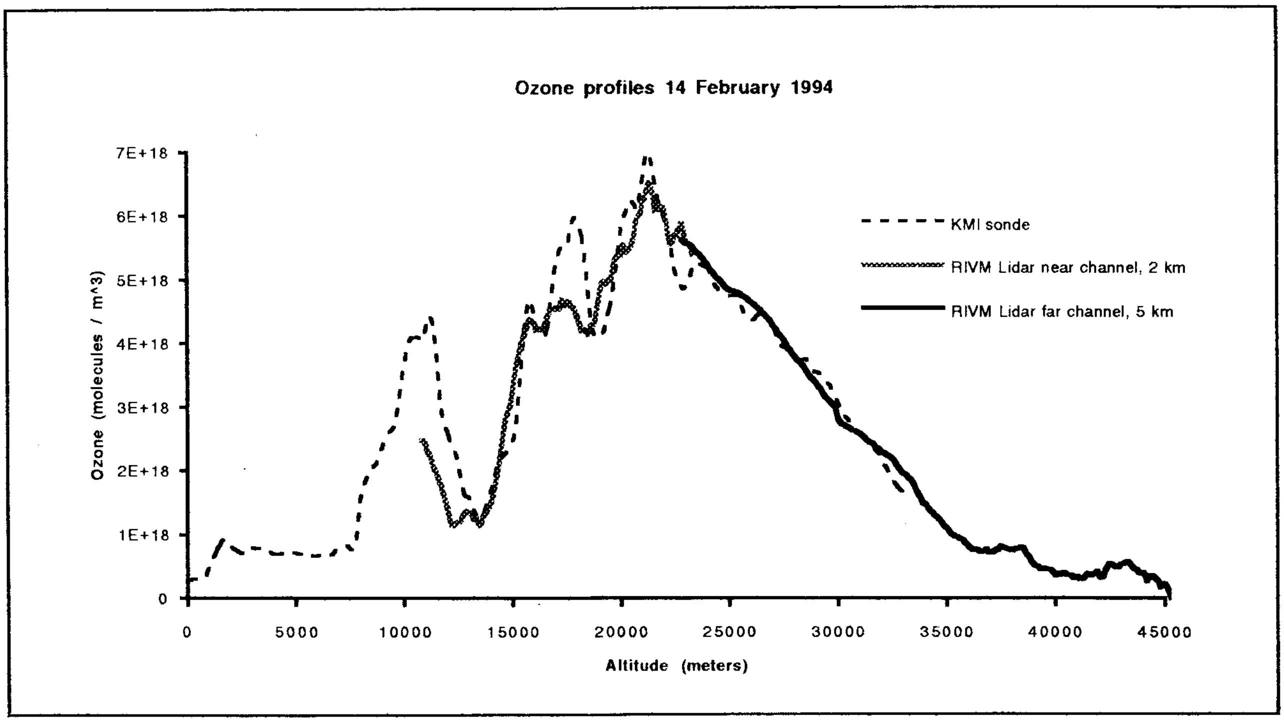

Figure 4. Ozone profiles measured at February 14, 1994 with lidar and sonde. Lidar data were taken in Bilthoven, the Netherlands, at 24:00 MET. Sonde data were taken in Uccle, Belgium at 12 :00 MET (de Muer and de Backer, private communication). Uccle and Bilthoven are separated by approximately 160 km. (See text for discussion).