File Revision Date:
October 12, 2003

Data Set Description:

PI: Jean-Luc Baray & Sophie Godin Beekman
Instrument: Stratospheric ozone DIAL
Site(s): Reunion island (21S, 55.5E)
Measurement Quantities: ozone profiles (18-45 km)

Contact Information:

Name: Baray Jean-Luc
Address: Laboratoire de Physique de l'Atmosphère CNRS - UMR 8105.
Université de La Réunion, 15 av. René Cassin - 97715 St-Denis de la Réunion - France
Phone: 262 93 96 64
FAX: 262 93 86 65
Email: barray@univ-reunion.fr

Reference Articles:

Baray J-L., et al., Description and evaluation of a tropospheric ozone LIDAR implemnted on anexisting LIDAR in the southern subtropics, Appl. Opt., 38, 6808-6817, 1999.

Bencherif H., et al., LIDAR developments and observations over Reunion island (20.8 S, 55.5 E),Advances in Atmospheric. Remote Sensing with lidar, Springer-verlag, Eds. : A. Ansmann, R. Neuber, P. Rairoux, and U. Wandinger, 1996.

Godin S., et al.: Systematic Lidar Measurements of the Stratospheric Ozone vertical Distribution, Geophys. Res. Letters, Vol 16 No 16, 547-550, 1989

Godin S., et al., Ozone Differential Absorption Lidar Algorithm Intercomparison, Appl. Opt., Vol 38, 30, 6225-6236, 1999.

Portafaix T., ozone stratosphérique en zone tropicale sud : transport méridien et effets de barrière dynamique, PhD Thesis of the university Paris VI, obtained on 6 June 2001.

Portafaix T. et al., Fine scale study of a thick stratospheric ozone lamina at the edge of the southern subtropical barrier, J. Geophys. Res. 108, D6, 4196, doi: 10.1029/2002JD002741, 2003.

Instrument Description:

Ozone measurements are performed using the DIAL (Differential Absorption Lidar) technique which requires the simultaneous emission of two laser beams characterised by a different ozone absorption cross-section. The absorbed laser radiation is emitted by a XeCl excimer laser (Lumonics PM 844) at 308 nm and the reference line is provided by the third harmonic of a Nd:Yag laser (Spectra-Physics Lab 150) at 355 nm. The excimer laser (308 nm) operates at 40 HZ with an output energies 200 mJ. The Nd:Yag laser (355 nm) operates at 30 HZ with an output energies 150 mJ. An afocal optical system (magnification of the beam expander: x3) is used to reduce the divergence of the beam to 0.5 mrad.

The optical receiving system consists of four parabolic mirrors of 50 cm diameter, which correspond to an equivalent receiving surface of 0.78 meter diameter. Both laser beams are emitted in the center of the collecting area so that each mirror acts as the receiver of an elementary lidar but the whole system is quasi-coaxial. The light is collected by four optical fibers of 1 mm diameter mounted in the focal plane of each mirror. The fiber mounts can be moved manually in the vertical direction for focalization adjustment. After detection, the optical fibers transmit the backscattered light to the optical analyzing device which includes imaging optics, a mechanical chopper and a multichannel monochromator designed for the wavelength separation. The chopper consists of a 40 Watts cooled motor which drives a blade of 140 mm diameter and 20 mm width, rotating at 24000 rpm in primary vacuum. The monochromator uses a 3600 grooves/mm holographic grating characterized by a resolution of 3 A/mm and a global transmission for each wavelength 0.40. At the output of the monochromator, the elastically backscattered signal at 308 nm and 355 nm are separated into a low and a high altitude channel in order to account for the dynamic of the lidar signals in the measurement altitude range, so that in total the lidar set up includes 6 optical channels.

Optical signal detection is made by Hamamatsu photomultiplier tubes running on a counting mode. Counting gating is 1 microsecond providing a 150 meter vertical resolution. The signals are recorded on a 1024 microsecond time range which corresponds to roughly 150 km. In addition to the use of mechanical chopper, electronic gating is used on the high energy Rayleigh channels, in order to suppress signal induced noise resulting from the initial burst of light at lower altitudes. The whole experiment is run by a PC. Lidar signals are stored in 5400 (40 Hz) and 7200 (30 Hz) shots files providing a temporal resolution of 3 minutes. For each file, the raw signals are displayed during the experiment and a signal pre-processing is made in order to display the slopes of the signals.

Algorithm Description:

The algorithm has been developped in matlab language by Sophie Godin and Andrea Pazmino, and adapted for the Reunion LIDAR by Thierry Portafaix. The algorithm used for processing the Reunion data is then very closed to those used for processing the OHP, DDU and Argentina data. The main difference is the lack of Raman signals so the ozone vertical distribution is retrieved from the Rayleigh signals only. In the routine mode, the lidar signals are time averaged over the whole measurement period (2 to 3 hours in general) in order to increase the signal-to-noise ratio. Each averaged signal is then corrected from the background light which is estimated using a linear regression or a mean in the altitude range where the lidar signal is negligible (80 - 150 km). Another correction is applied on the lidar signals in order to account for the dead time effect in the photon counters mode. This correction is detailed below.

The ozone number density is retrieved from the derivation of the logarithm of the corrected lidar signals. It is also necessary in the DIAL technique to use a low-pass filter in order to account for the rapid decrease of the signal-to-noise ratio in the high altitude range. In our case, the logarithm of each signal is fitted to a 2nd order polynomial and the ozone number density is computed from the difference of the derivative of the fitted polynomial. The smoothing is achieved by varying the number of points on which the signals are fitted. The ozone number density is derived from the two lidar signal pairs detected by the experimental system: Rayleigh high energy (92%), and Rayleigh low energy (8%), which optimize the precision of the retrieved ozone profile in the high and the lower stratosphere.

The dead time correction is adjusted in order to obtain the best agreement between the low energy and the high energy Rayleigh slopes. The ozone profile is retrieved first by combining for each wavelength the slopes of the low energy and high energy Rayleigh signals. Finally, the ozone number density is corrected from the Rayleigh extinction using composite pressure-temperature profiles computed from nearby radiosoundings and the MAP85 model. Part of the present ozone algorithm can be found in Godin et al., 1999 and in Portafaix, 2001.

Expected Precision/Accuracy of Instrument:

The accuracy of the ozone lidar measurement depends on the correction of the differential molecular and aerosol scattering, the differential absorption by other constituents and on the temperature dependence of the ozone absorption cross-sections (Godin et al., 1989). The maximum residual random error after correction is estimated to 5-8 %. The precision of the measurement corresponds to the statistical error of the signal due to the random character of the detection process which follows basically the Poisson statistics. Among other parameters such as the power of the lasers and the telescope detection area, it depends on the duration of the measurements and the vertical resolution chosen to process the data. The total accuracy varies from about 5 % to 20 % in the 18-45 km altitude range, for a corresponding vertical resolution ranging from 0.4 to 6 km and a typical temporal resolution of 4 hours.

Instrument History:

Ozone measurements are made by radiosondes at Reunion Island since 1992.

In complement to these measurement, a lidar instrumentation has been developped at Reunion island: Raylaigh Temperature and aerosols in 1994, tropospheric ozone in 1998, Raman Temperature in 1999, tropospheric water vapor in 2001.

The stratospheric ozone DIAL system has been operated since June 2000.

The development of this system is issued from a collaboration between the Service d'Aeronomie of University Paris VI (S. Godin, J. Porteneuve), the Laboratoire de Physique de l'Atmosphere, of University of La Réunion (J.L. Baray, T. Portafaix, J.M. Metzger) and the university of Geneva (C. Hirt, C. Flesia).

One significant change in this instrument is the installation of the electronical obturation system in September 2002.

The other significant change is the choice of the disk-chopper.

May 2000 to May 2002, use of a disk chopper with 2 little windows: the signal is obtured at 85 km and it makes the sky noise correction difficult on some profiles

September 2002: use of a disk chopper with 2 enlarged windows: No problem for the sky noise correction, but this new disk was not stable and destroy the motor of the chopper after 2 nights on 14 September 2002

We are currently working on this problem (tests of other disks).