



Evaluation of inversion algorithm sensitivity in stratospheric ozone DIAL profile.

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SUMMARY

The DIAL system belonging to Observatorio Atmosférico de la Patagonia Austral, Río Gallegos, Argentina has been included in the NDACC since December 2008. One caveat of large networks such as NDACC is the difficulty to report information of similar nature consistently from one research group (or instrument) to another. The inversion algorithm used in the stratospheric ozone DIAL measurements involves different source of systematic and statistic errors. Due to the rapid decrease of the signal-to-noise ratio in the high stratosphere, it is necessary to degrade the vertical resolution of the measurement in order to limit the statistical error at this altitude range, to reasonable values. The final statistical error on the measurement is the result of a compromise between the experimental system characteristics such as the duration of the measurement and the final vertical resolution. The aim of this study is test the DIAL algorithm resolution used to retrieve the ozone profile comparing with the synthetic ozone profile. This synthetic ozone profile is calculated by mean of lidar equation using an ECC sonde profile as input parameter. This ozone profile was measured with an ozonesonde launched in Río Gallegos in March 2011 as part of intercomparison campaign.

Key words: DIAL, vertical resolution, ozone profile.

INTRODUCTION

Use of Differential Absorption Lidar (DIAL) systems is becoming more widespread for monitoring the ozone vertical distribution throughout the world (Sophie Godin et. al., 1999). In Observatorio Atmosférico de la Patagonia Austral (OAPA) was installed a Lidar system which retrieve ozone profiles in the stratosphere since 2005. In 2008 this lidar joined to the Network for the Detection Composition Change (NDACC) for the long-term monitoring of stratospheric ozone.

To achieve the goals of the NDACC, the ozone profile supplied to the NDACC archive have been extensively checked in intercomparison campaigns. However, uncertainty exists with respect to the interpretation of altitude resolutions reported by various ozone DIAL instruments (Georg Beyerle et.al., 1999).

For a DIAL system, ozone number densities $n_{O_3}(z)$ are calculates by

$$n_{O_3}(z) = \frac{1}{\sigma_{on} - \sigma_{off}} \left[\frac{1}{2} \left(\frac{d}{dz} \ln \frac{P_{off}(z)}{P_{on}(z)} \right) \right] - [\alpha_{on}(z) - \alpha_{off}(z)]$$

where the contribution from aerosols has been neglected; σ_{on} and σ_{off} are the ozone absorption cross section for wavelength λ_{on} and λ_{off} respectively; α_{on} and α_{off} are the extinction coefficient for molecular scattering for the mentioned wavelength; and P_{on} and P_{off} are the lidar signals.

The evaluation of the term $d/dz \ln [P_{off}(z)/P_{on}(z)]$ is an essential element of the analysis. Generally, differentiation

has the effect of applying a high-pass filter to a signal. In DIAL analysis this fact represents a problem, as the signal counts P at stratospheric altitudes contain high-wave-number noise contributions

Typically, the altitude resolution $\Delta z(z_i)$ of ozone profiles is defined in terms of the derivative filter. Because various filters are used, values of $\Delta z(z_i)$ from different data analyses are generally not comparable.

Here we test the algorithm used in the DIAL system of OAPA to retrieve the vertical ozone variation. To that end we use the synthetic ozone profile measured by ozonesonde like an input to calculate the lidar signal for then obtain the ozone profile from the DIAL algorithm. This profile calculated is compared with the ozonesonde. The lidar signals are calculated without noise.

METHOD AND RESULTS

In a pure molecular atmosphere (i.e. neglected the aerosols) the lidar signal for an altitude z of the atmosphere and for a wavelength can be written like

$$P(z) = k \frac{\beta_{molec}}{z^2} e^{-2 \left[\int_{z_0}^z \beta_{molec} \frac{8\pi}{3} dz + \int_{z_0}^z \sigma_{O_3} n_{O_3} dz \right]}$$

where β_{molec} is the Rayleigh backscatter coefficient; $8\pi/3$ is the ratio between extinction and molecular backscatter; σ_{O_3} is the

ozone cross section and n_{O_3} is the ozone number density. The value of 2 before the exponent indicate that the laser bin pass through the atmosphere two times between z_0 (site altitude) and z . The first term of the exponent counts the extinction of the atmosphere due to scattering of molecules only for a given wavelength while the second term take in account the absorption of ozone at this emitted wavelength. To obtain the synthetic lidar signal for λ_{on} and λ_{off} we need to calculate the backscatter coefficient and the second term of the exponent for both wavelengths. The backscatter coefficient β was calculated from the density of the atmosphere using the pressure and temperature profile measured by a sonde launched in Punta Arenas, Chile, near of OAPA. Knowing the ozone cross section for two interest wavelengths, we can calculate the second term of the exponent from the ozone profile measured by the ozonesonde between 0 and 32 km as input of the DIAL algorithm. This profile was completed with the Fortuin & Kelder(1998) climatology profile.

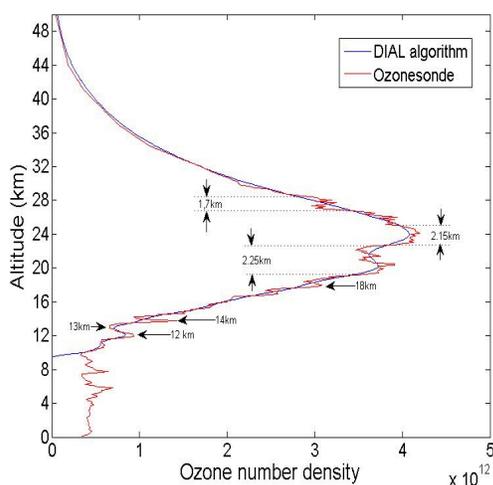


Figure 1. Comparison of both calculated ozone profile from the DIAL algorithm in the OAPA (blue) and the synthetic ozone profile obtained from measured by ozonesonde (red).

Figure 1 shows a comparison between the ozone profile calculated (DIAL algorithm) and ozone profile measured by the ozonesonde which was used as an input to calculate the lidar signals. Although the lidar signals in λ_{on} and λ_{off} (308nm and 355nm respectively) was calculated without noise, the algorithm has an intrinsic resolution. The calculate profile is like the measured one but more smoothed. The highlighted zones show the altitudes where the variations of ozone number density are greater. Around the 12 and 13 km have two local peaks where the resolution (figure 2) is 0.8km. The calculated profile follows the behavior of measured but not reaches the local maximum and minimum of the peak. At 14 km there is other local peak but more narrow. The resolution at this altitude is 0.8km and the wide of the peak is 0.4 km. For this reason is probably that the calculated profile can't "see" this layering. Around 20 km the ozone profile measured by the sonde shows a large variation. The measured profile presents four peaks.

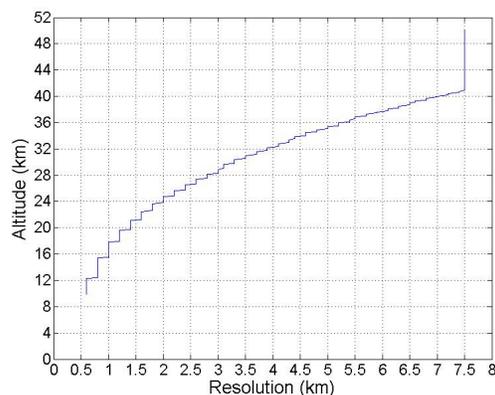


Figure 2. Vertical resolution used in the DIAL algorithm.

The calculate profile follows the ozonesonde but very smooth. Figure 2 shows the resolution increase with the altitude and in that altitude (around 20 km) the calculated profile doesn't follow the thin peaks. Around the 28 km where the resolution is of 3km, the measured profile presents a variation similar to 12 and 13 km. We observe that the DIAL algorithm profile don't follow this trend due that the resolution in this altitude is greater than the resolution at lower altitude.

CONCLUSIONS

We presented a descriptive study of a vertical ozone profile obtained by the DIAL algorithm used in Rio Gallegos. This study shows how act the DIAL algorithm smoothing the ozone profile calculated respect of the measured and variations in the shape of ozone profile in same layer is lost. It is important to note that the calculated profile was obtained without noise. In future studies we try to introduce a modeled noise to obtain lidar signals more real.

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