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Optimization of Lidar System Parameters for Short Range Ozone Surveys in Urban Areas

by

David L. Cunningham and Stephen E. Moody
Orca Photonic Systems, Inc.
Bellevue, WA USA

Abstract

We describe a design study which is aimed at selecting an optimum Lidar design for measuring ozone in the urban environment. This design is intended to produce a system which can be compact, easy-to-use, and inexpensive, while meeting the specific measurement needs of urban ozone studies.

A full quantitative understanding of ozone production, transport, and dispersal is becoming increasingly important in all industrialized regions. #xcess ozone is generally produced indirectly from the products of air pollution; it is not possible to estimate the production by simple monitoring of industrial sources. Extensive numerical modeling of the photochemical production and transport of ozone has therefore become one important tool for assessing the severity of the urban ozone problem. However, these models must be anchored to a database of actual measurements, including time and spatial variations. Short range Lidar surveys of ozone in the urban boundary layer appear to be one excellent way to develop a calibration map for these models.

Existing Lidar systems for ozone measurement depend heavily on excimer laser technology (augmented with Raman shifting), or on tunable dye lasers upconverted into the ultraviolet. These systems have demonstrated extraordinary technical performance in measuring under a wide range of conditions. However, Lidar systems built around these traditional technologies will have difficulty meeting the *operational* needs of broad-based ozone measurement programs. To meet the needs of this new type of user, the Lidar community must produce systems which are readily transportable, easy to use, reliable, and relatively inexpensive.

The first step in meeting these requirements is to design specifically for the measurement performance needed for the urban survey mission. Table I gives working Lidar system requirements used in performing this study. Because of the relatively high ozone densities, the wavelength set used for the measurement must be at approximately 285 nm or longer. A set of three wavelengths is also required, rather than the usual two used for DIAL. The spacing between wavelengths is quite large because of the large absorption feature, and results in biases due to gradients of aerosol backscatter when only two wavelengths are used.

Table I
Working Requirements for Urban Ozone Lidar System

Parameter	Value	Comment
Range	0-2 km	
Range Resolution	100 m	
Ozone Density	30-200 ppb	
Accuracy	±15%	@ 1km
Measurement Conditions	Daylight	hazy through clear urban atmospheres
System volume	< 1 m^3	
System power	< 1 kVA	
System cost	≤US$250k	typical configuration
Reliability	≥1 month	Preventative/corrective maintenance interval in normal use

The key to the "personality" of such a Lidar system is the laser transmitter. Neither multiple excimer lasers, nor conventional laboratory dye lasers are compatible with the requirements of Table I. Instead, we propose to use a grid of fixed wavelengths which can be generated by nonlinear conversion of a single Nd:YAG laser. The grid is "filled in" by using an optical parametric oscillator to generate additional wavelengths for summing. Figure 1 shows just one possible architecture. A KTP OPO is pumped at 1064 nm, with its output at 1570 nm. Three wavelengths are generated: 355 nm (3x1064 nm), 317 nm (2x1064 nm + 2x1570 nm) and 289 nm (3x1064 nm + 1570 nm).

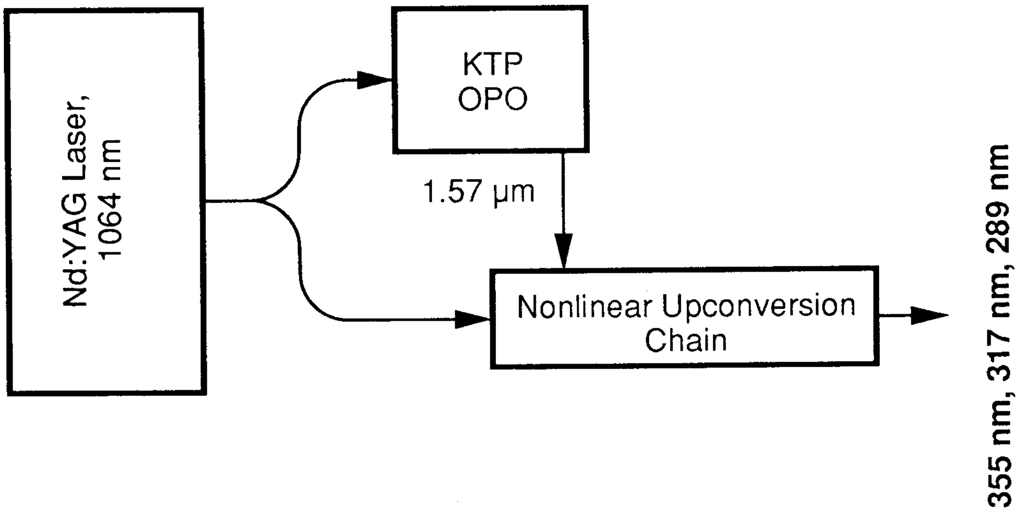

Figure 1. Candidate solid-state transmitter architecture.