Lidar for atmospheric research over Africa

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OBJECTIVES

To develop a lidar system for atmosphere research over Africa, to measure:

- Particulate scattering in the atmosphere (sizes of 1 micron)
- Aerosol measurements and cloud characteristics
- Water vapor measurements in the lower troposphere region up to 8 km
- Ozone measurements in the troposphere regions up to 18 km

LIDAR SURVEY

A survey of ground-based lidars around the world was conducted via a web search. The survey is not by any means comprehensive and conclusive, and has been made with regard to lidar applications for atmospheric studies including pollutant monitoring. The following salient features emanated from the survey:

- Around 80% of the lidars are in the northern hemisphere
- Of the 20% in the southern hemisphere region, high concentrations exist in South America
- Lidars on the African continent are limited to two systems; both located in South Africa. One is a new mobile lidar system designed and developed at the CSIR National Laser Centre in Pretoria and the other is located in Durban at the University of KwaZulu-Natal, operated under a South Africa/France association.

PRESENT SCENARIO AND FUTURE PERSPECTIVES

The mobile lidar system designed at the CSIR National Laser Centre is operated for backscatter measurements (aerosols/clouds). The initial results conclude that the system is capable of providing measurements for the height region from ground to 40 km with a 10 m vertical height resolution. The measurements will elucidate the aerosol concentration, optical depth, cloud position, thickness and other general properties of the cloud that are important for a better understanding of the earth-radiation budget, global climate change and turbulence. Future plans include qualitative industrial pollutant measurements, 3D measurements using an XY scanner, a two channel lidar system, water-vapour measurements, the implementation of differential absorption lidar and ozone measurements.

The lidar measurements will be calibrated with other in-situ (for e.g., sun photometer, radios-metre, balloon borne) Stratocumulus Stratospheric Aerosol and Gas Experiment (SAGE). Cloud-aerosol and Infrared Pathfinder Satellite Observation (CALIPSO). Moderate Resolution Imaging Spectro-radiometer (MODIS) and different network data sets (Aerosol Robotic Network – AERONET, Network for the Detection of Atmospheric Composition Change – NDACC, Global Atmosphere Watch – Aerosol Lidar Observation Network (GALION)).

After calibration and initialization testing, the lidar was operated for the first time on 23 February 2008. The laser was directed vertically upward into the sky (see Figure 2) and the corresponding night was a cloudy sky. There was a passage of cumulus clouds that are normally found at lower height region from 3 km to 5 km. Since these clouds are generally optically dense, light is prevented from passing through. Figure 3 represents the lidar backscattered signal and it clearly distinguishes the cloud observation against the normal scattering from background particulate matter. It shows the sharp enhancement during the presence of cloud around 4.2 km and slowly decreased to 3.5 km. The measured high resolution data is also important when studying cloud morphology. The lower height regions indicate high intensity signal returns, which is due to the presence of dense fog and the boundary layer evolutions. The planetary boundary layer evolution can be detected using the range corrected signal (multiplied by the square of range) and found that the boundary layer is located around 2 km.

Lidar for atmospheric studies: The CSIR’s laser research into monitoring various pollutants in the lower atmosphere via active remote sensing gains momentum.

Lidar systems deployed around the world

Parameters Specifications

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Specifications</th>
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<tbody>
<tr>
<td><strong>Transmitter</strong></td>
<td></td>
</tr>
<tr>
<td>Laser source</td>
<td>Nd: YAG, Continuum</td>
</tr>
<tr>
<td>Operating wavelength</td>
<td>1064, 532, 355, 266 nm</td>
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<tr>
<td>Average energy per pulse</td>
<td>300, 150, 100 mJ</td>
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<td>Beam expander</td>
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<td>Pulse repetition rate</td>
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<td>I F Filter (BW)</td>
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Signal and data processing:

- PC based simultaneous analog and photon counting system operating under LICEL real-time software
- Range resolution: 10 m
- Maximum height: 40 km

Figure 1: Ladar systems deployed around the world

Figure 2: An external view of the mobile lidar system

Figure 3: Ladar signal on 23 February 2008

Lidar for atmospheric research over Africa

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