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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 vapour 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 atmosphere 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.

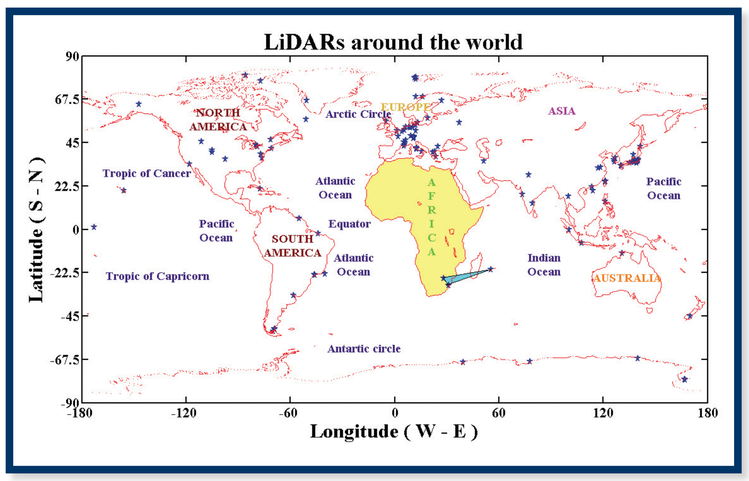


Figure 1: Lidar systems deployed around the world

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 photometre, radio-metre, balloon borne), Space-borne Stratospheric Aerosol and Gas Experiment (SAGE), Cloud-aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Moderate Resolution Imaging Spectro-radiometre (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 initial 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 cumulous clouds that is 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.

Figure 2: An external view of the mobile lidar system

It is important to note that the experiment has been carried out using two neutral density (ND) filters that attenuate 99% of the signal entering the photo multiplier tube (PMT). This means that the backscattered signal represented in the colour-map and in the height profiles corresponds to only 1% of the signal. The ND filters are employed to avoid signal saturation due to the presence of dense cloud at lower height region that significantly interrupts the laser from passing through. A future experiment with different filter options will be pursued to allow a greater percentage of the backscattered signal to observe and investigate higher altitude regions.

LIDAR SYSTEM SPECIFICATION

Parameters	Specifications
Transmitter	
Laser source	Nd: YAG, Continuum
Operating wavelength	1064, 532, 355, 266 nm
Average energy per pulse	300, 150, 100 mJ
Beam expander	3 x
Pulse width	8 nsec
Pulse repetition rate	10 Hz
Beam divergence	0.2 mRad
Receiver	
Telescope type	Newtonian
Diameter	407 mm
Field of view	1 mRad
I F Filter (BW)	0.7 nm
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

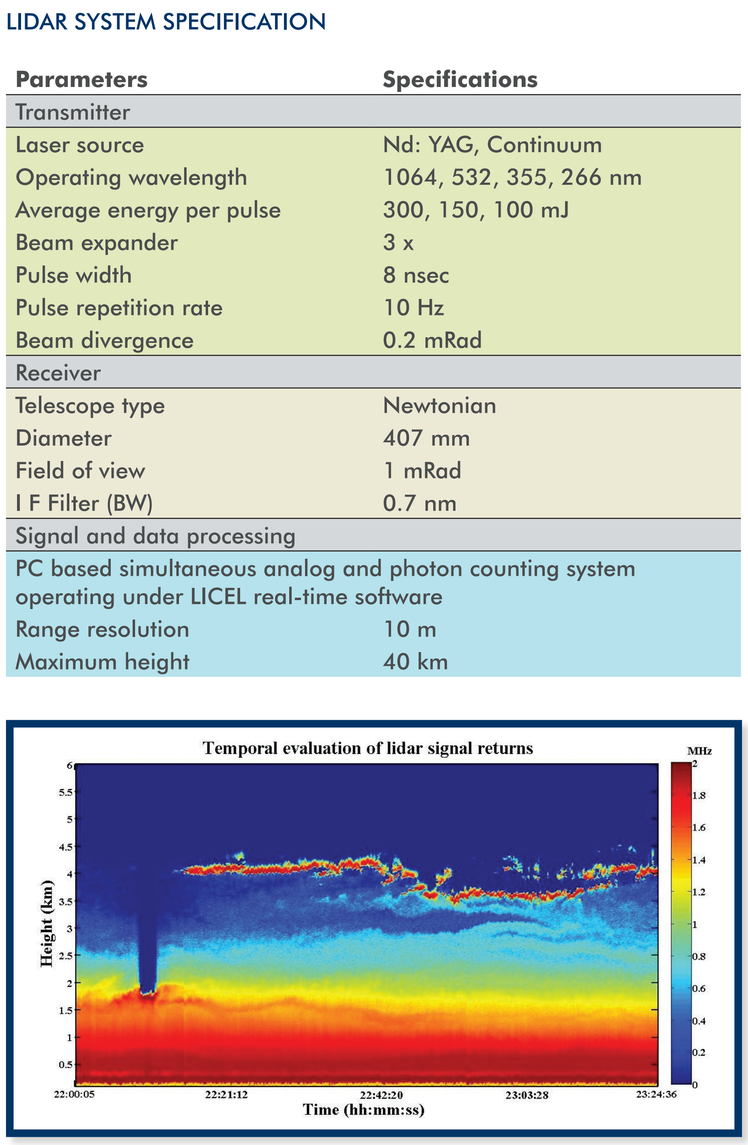
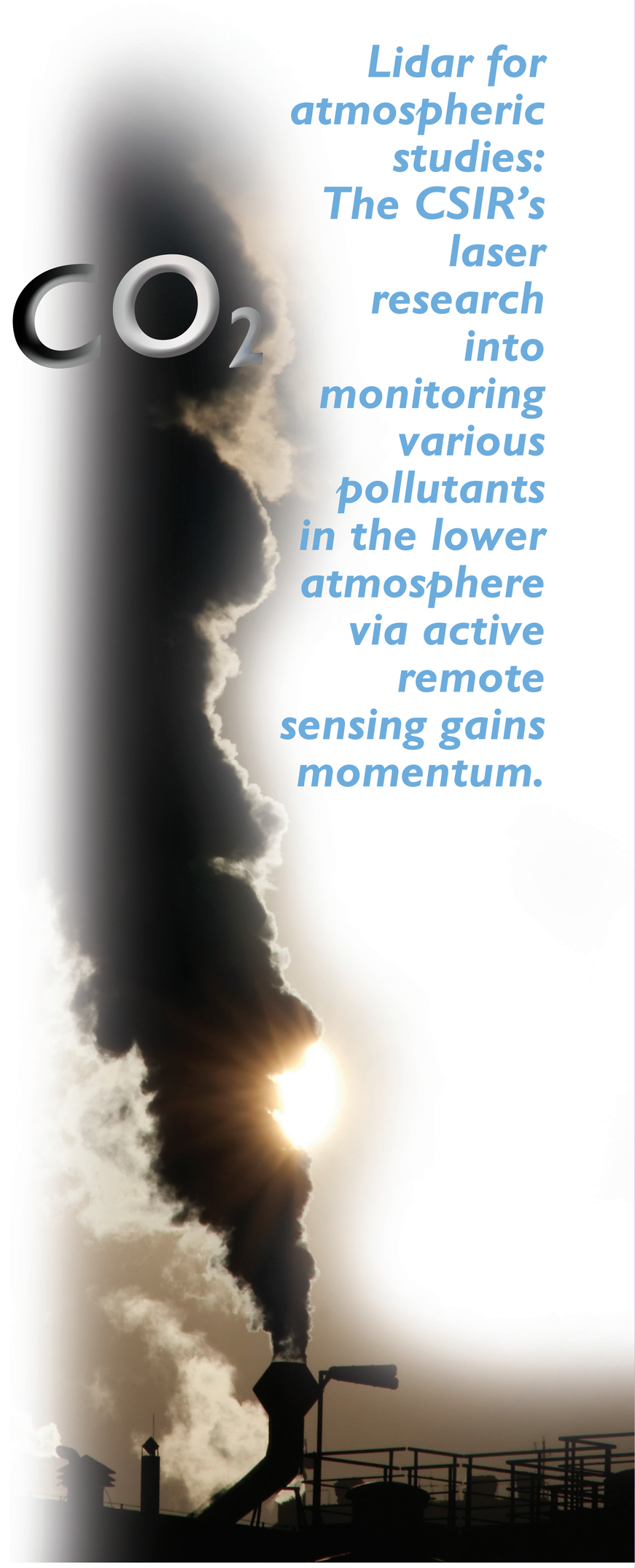


Figure 3: Lidar signal on 23 February 2008



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

COLLABORATION

Lidar for atmospheric studies is a tri-lateral research collaboration between the CSIR National Laser Centre and the University of KwaZulu-Natal in South Africa, Service d'Aéronomie - CNRS and Laboratoire de l'atmosphère et des Cyclone - CNRS in France and Addis Ababa University in Ethiopia.

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