Remote Sensing of the Atmosphere

Remote sensing is a technique for measuring, observing, or monitoring a process or object without physically touching the object under observation. Optical and radio telescopes, cameras, radars, lidars etc., are various types of remote sensing devices.

Two types of remote sensors.

(a) **Active remote sensors**

   Energy Source included in the measurement.

   The observer can control the source

   Eg. Radar, Lidar, Sodar, Sonar etc.

(b) **Passive remote sensors.**

   Energy source is not included in the measurement.

   They rely on the external source which is beyond the control of the observer

   Eg. Optical and Radio telescopes, Radiometers, Photometers, Spectrometers etc.
The Eye as a Remote Sensing Instrument

- Eyes are scanning the environment with up to 60 frames per second
**LiDAR Principle**

- LIDAR (Light Detection and Ranging)
- LiDAR employs a laser as a source of pulsed energy
- Lasers are advantageous because –
  - Monochromatic
  - Highly coherent, high collimated
  - Short pulse duration, high pulse energy

- Transmitted laser beam passing through the atmosphere causes scattering.
- Absorbtion by gases and particles attenuates the beam as it propagates
- Fraction of energy is backscattered in the direction of the LiDAR system and is available for detection.
...LiDAR Principle
Atmospheric backscattering depends upon -

(a) the wavelength of the laser energy used,

(b) the size, shape and refractive properties of the particles

(c) Backscattering increases with scatterers concentrations.

Advantages of LiDAR over Radar

• Shorter wavelengths allow the imaging of smaller particles.
• Narrow beam allows high resolution data to be obtained.
LiDAR Platforms

Airborne

Satellite

Phoenix Mars Mission

Mobile

Ground-based
System 3-D View
CAUTION PILOT !!!

There is a GREEN LASER BEAM

The CAA has no objection to the use of airspace as detailed above, but subject to any necessary approval by local authorities and any other applicable regulations not falling within the ambit of the CAA’s responsibility.

ATC Requirements: Operator to contact AFB WKL OPS Room @ (012) 672 3439 prior to operations every day. The officer at the OPS Room will advise CSIR whether there is flying or not in the WKL CTR, in which case the CSIR will not be permitted to continue during that period of time. If otherwise it can be proven that the beam will not affect any flying crew. Also call Radar Planner 30 min before Tel: 011 926 5448, to advise them of your operations. At no point may the laser beam be pointed to an aircraft and the skies must also be clear as there could be an aircraft in the cloud.

The Commissioner reserves the right to withdraw this approval in the public interest.

CAA to take NOTAM action.

Yours faithfully,
Initial Tests
Signal to Noise Performance

The chart shows the relationship between height (in kilometers) and the number of photons per second. The x-axis represents time, and the y-axis represents height. The data seems to indicate a decrease in photon count as height increases.
Preliminary Results

23 Feb 2008

Raw Photon count

Analog Signal

Deadtime corrected Photon count

Glued Photon count
Validation/Comparison

25 February 2008

Aerosol Extinction Coefficient (1/km)

Height (km)

25 February 2008

β (1/km)

Height (km)

Sun-Photometer @ 500 nm
LiDAR @ 532 nm

AOD

Month

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Fibre Auto-Alignment
University of Pretoria
CSIR – Natural Resources Environment
CSIR – Meraka Institute (Remote Sensing)
Portland Cement Factory
Boiler Industry

ESKOM

It is natural, when we request for funding.
Human Capital Development

2- Master degree students – 2007 & 2008
(3 months on internship from Addis Ababa University)

1- Ph.D degree student (full time) + 2 Ph.D (Partially)
(continuing from 2008, expected to be awarded by end of 2010)

Trainee + Honour degree students
6-Articles
(1 Book Chapter and 2 articles are accepted for publications)

5-Peer reviewed conference proceedings with ISBN

5-Popular articles
17-conference presentations
13-Scientific reports
South-African French LiDAR (SAFiR) network for study of upper troposphere and lower stratosphere aerosol distributions and dynamics
A combined research and academic training activity between the Council for Scientific and Industrial Research (CSIR) National Laser Centre (NLC) and the Department of Geography, Geoinformatics and Meteorology (GGM) at the University of Pretoria (UP) on ATMOSPHERIC REMOTE SENSING using state of the art Light Detection And Ranging (LiDAR) instrumentation and other active and passive remote sensing tools.
Last year, there were 35 students enrolled for bachelor degree programme and benefited.

First “Lidar Field Campaign”

- 2-day measurement campaign at University of Pretoria
- First 23-hour continuous measurement
Where does it go?
How does it impact?
Based on our earlier survey, there are no multi-channel LIDAR systems employed for atmosphere research in South Africa and African countries and X-Y dimensional mapping of the atmosphere have not been explored (except few countries around the world)
Studies on particulate matter afford knowledge on particle size and its concentrations in the atmosphere. Making use of the aerosol/cloud plays its role in the earth-radiation budget and LIDAR has unique capability of measuring the particle concentration in a particular place, in an effective manner by illuminating different harmonic of laser (say Nd:YAG). It also has the potential to locate the height and distribution of various cloud presences in the atmosphere.

OUR CHANGING PLANET
“Aerosols”
Expanding the limits of space science and technology

Space science and technology – South Africa should become a key contributor to global space science and technology, with a National Space Agency, a growing satellite industry, and a range of innovations in space sciences, earth observation, communications, navigation and engineering.

Earth observation involves all activities connected with the collection of information on the earth’s surface or atmosphere. Such information underpins virtually all public policy decisions, from public health to water resource management, to protection of the ecosystem.

In search of energy security

Science and technology in response to global change

Climate change science and responses
Important changes are taking place in the global climate, but there is still great uncertainty about how earth systems operate.

Global climate change science with a focus on climate change – South Africa’s geographic position enables us to play a leading role in climate change science. Mitigating climate change also provides an economic opportunity for South Africa; therefore the country needs to develop a strategy to take advantage of the so called “Green Economy”. 
KEY PRIORITY AREAS

4.1 Environment and Resource Management

- Environmental and geospatial monitoring
- Hydrological monitoring
- Climate change mitigation and adaptation
- Meteorological monitoring

4.2 Health, Safety and Security

- Disease Surveillance and Health risk
- Earth Observation
- Space science and exploration
Temporal variation of Aerosol Extinction coefficient at 525 nm
National Collaborators
Prof. Prince Ngobeni, Tshwane, University of Technology, Pretoria.
Prof. Hannes Rautenbach, University of Pretoria, Pretoria.
Prof. Stuart Piketh, University of Witwatersrand, Johannesburg.
Lidar Scientist….., University of KwaZulu Natal, Durban.
Dr. Mark Alexander Tadross, University of capetown, Capetown.
Dr. Sandile Malinga, Hermanus Magnetic Observatory, Capetown.
Dr Deon Terblanche, South African Weather Service Department

International Collaborators
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Funding Agency / Organizations

- Department of Science and Technology, South Africa
- Council for Scientific and Industrial Research
  National Laser Centre
- National Research Foundation
- Centre National de la Recherché Scientifique
- African Laser Centre
Laser Design: Lunar Laser Ranger

Lunar Laser Ranging uses laser pulses to accurately determine the distance between the Earth and Moon, up to a level of 3 mm.

There are only 3 other international stations that have this capability.

SA is developing a new concept Lunar Laser Ranger, at The Space Geodesy Programme of HartRAO (NRF Facility)

The National Laser Centre collaborates on this in assisting with the development of a new type of laser with better characteristics than available commercially

For LLR laser we would like:

• ~ 500-540 nm wavelength
• < 50 ps pulse length (FWHM)
• $M^2$ close to 1
• 200 – 400 mJ per pulse
• Pulse Repetition Rate: up to 1000 Hz
Laser Design: Lunar Laser Ranger
Laser Design: Lunar Laser Ranger
After climbing a great hill, one only finds that there are many more hills to climb.

-- Nelson Mandela