Aerosol measurements over Southern Africa using LIDAR, Satellite and Sun-Photometer

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[4]Tshwane University of Technology, Pretoria 0001, South Africa

Asia Oceania Geosciences Society (AOGS), 11-15 August 2009

CSIR

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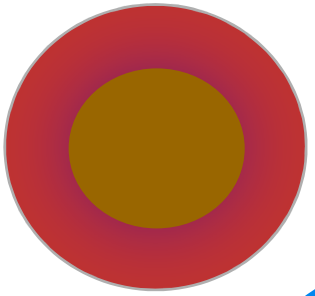
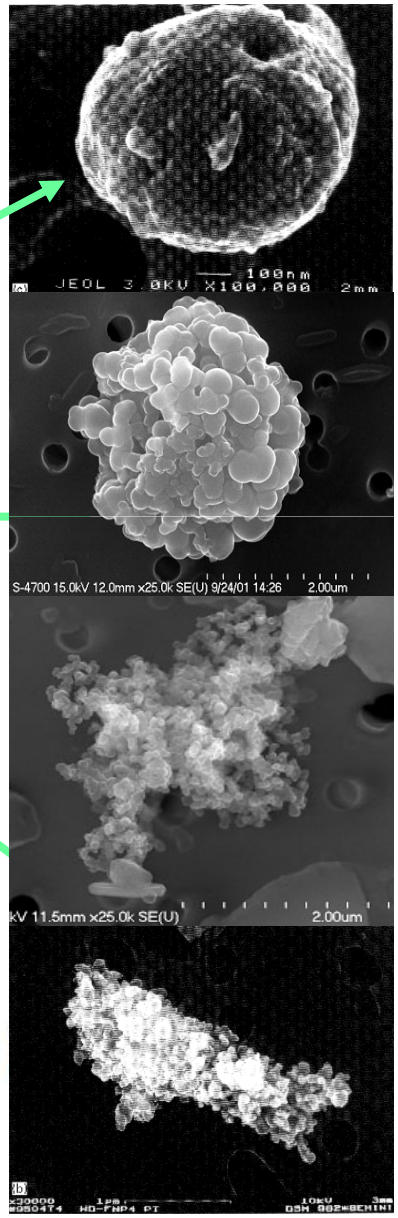
Aerosol Classification

Spherical



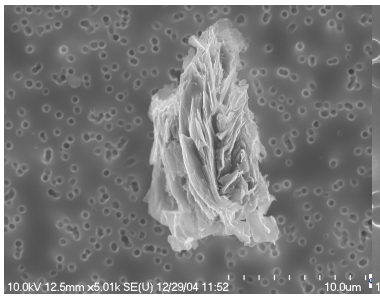
Anthropogenic



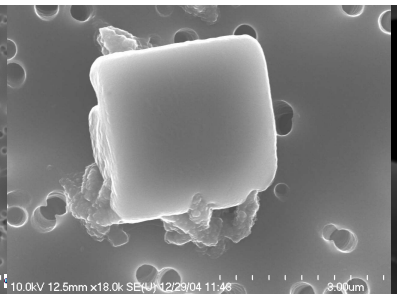
Composition and classification

Natural Particles

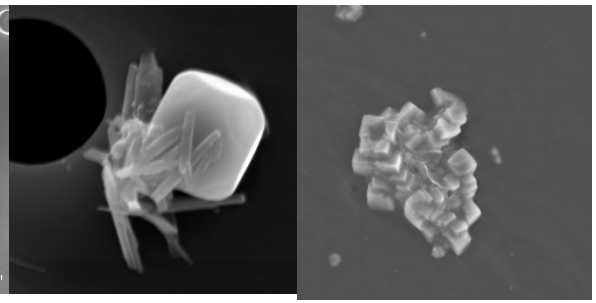
Dust



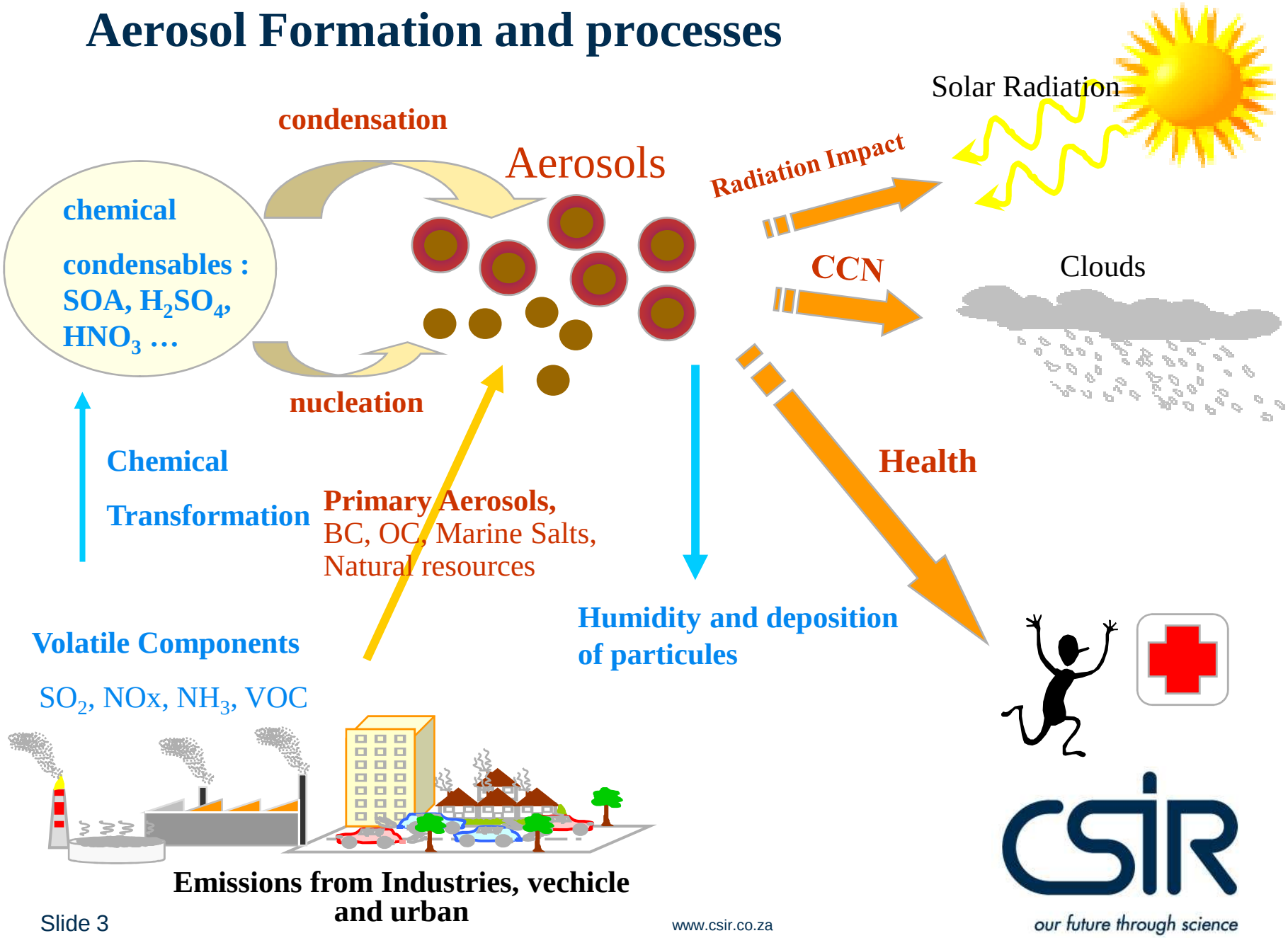
Sea Salt

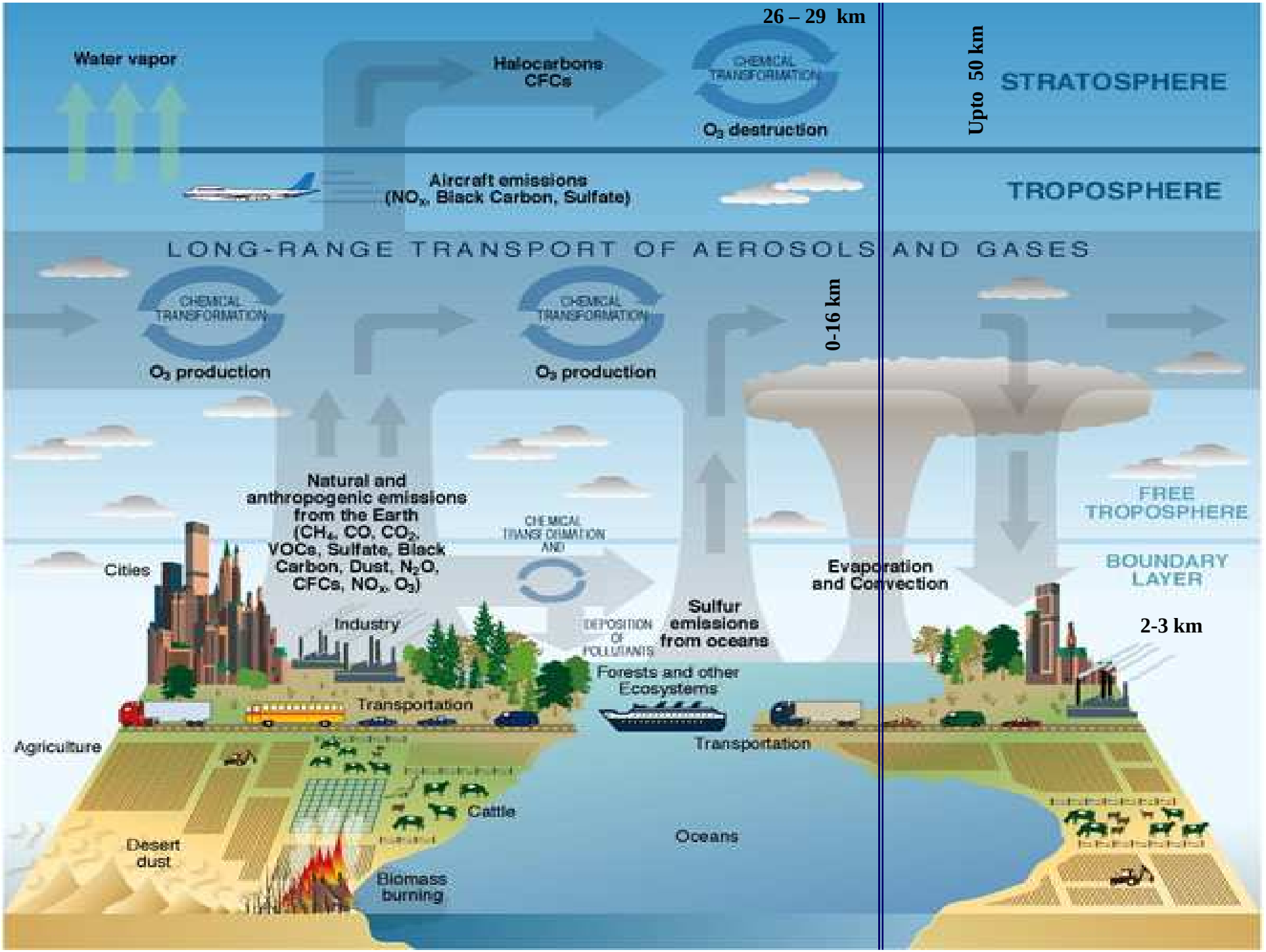


Giant nuclei



Aerosol Formation and processes




26 – 29 km
Upto 50 km
STRATOSPHERE
Water vapor
Halocarbons
CFCs
CHEMICAL TRANSFORMATION
O_3 destruction
Aircraft emissions
(NO_x, Black Carbon, Sulfate)
TROPOSPHERE
LONG-RANGE TRANSPORT OF AEROSOLS AND GASES
0-16 km
CHEMICAL TRANSFORMATION
O_3 production
CHEMICAL TRANSFORMATION
O_3 production
Natural and anthropogenic emissions from the Earth (CH_4, CO, CO_2, VOCs, Sulfate, Black Carbon, Dust, N_2O, CFCs, NO_x, O_3)
CHEMICAL TRANSFORMATION AND
DEPOSITION OF POLLUTANTS
Evaporation and Convection
FREE TROPOSPHERE
BOUNDARY LAYER
2-3 km
Cities
Industry
Sulfur emissions from oceans
Forests and other Ecosystems
Transportation
Transportation
Agriculture
Cattle
Oceans
Desert dust
Biomass burning

Data

- **LIDAR (Light Detection and Ranging)**

  Pretoria (25.45 S ; 28.16 E)

- **HYSPLIT**

  NASA

- **AERONET**

  University of Wits (26 S; 28 E) 2002 to 2008
  Skukuza (24 S ; 31 E) 1998 to 2008
  Bethlehem (28 S ; 28 E) 1996 to 2001

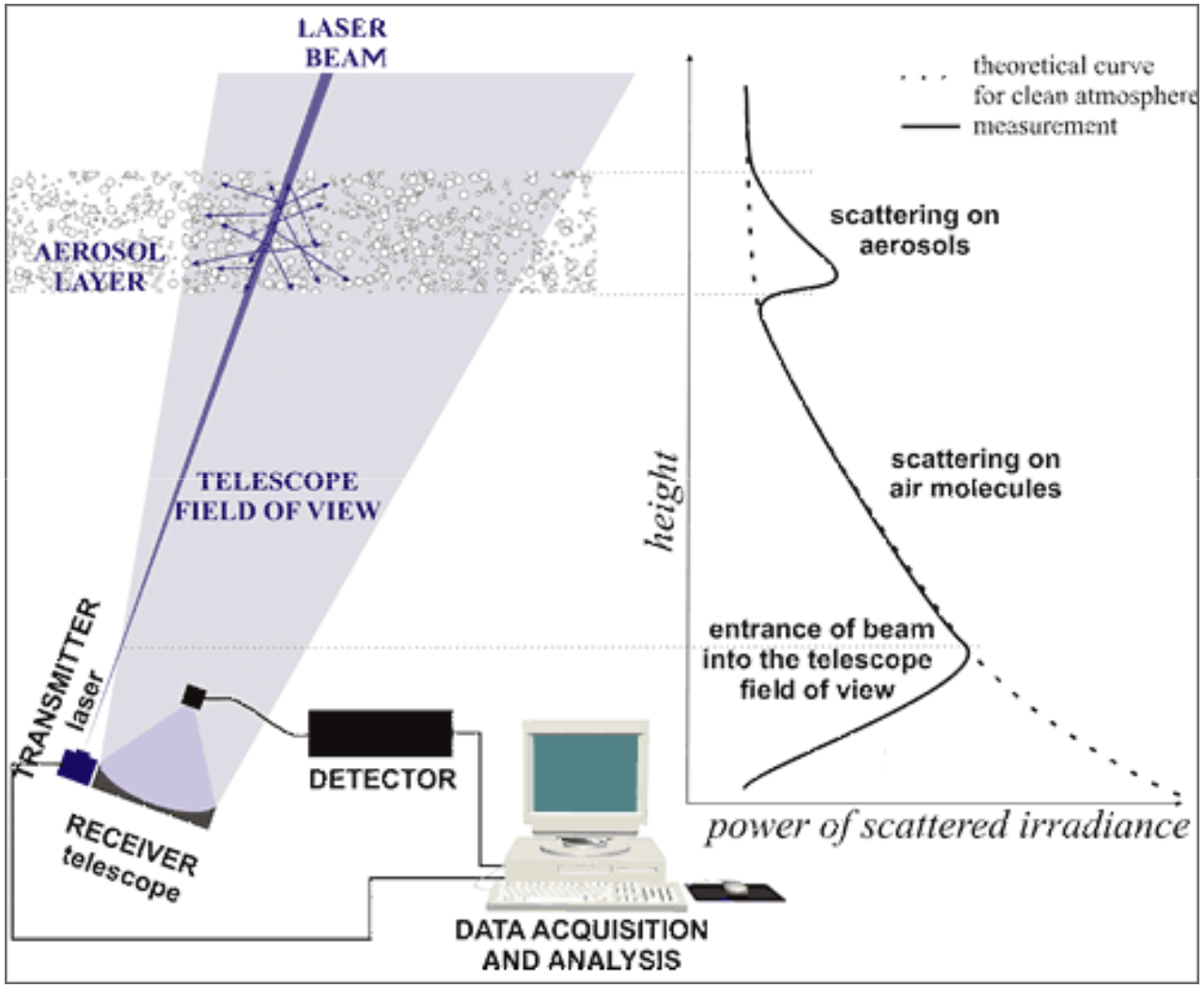
- **SAGE-II (Stratosphere Aerosol Gas Experiment – II)**

  Southern Africa (15 S ; 10 E to 40 S ; 40 E)

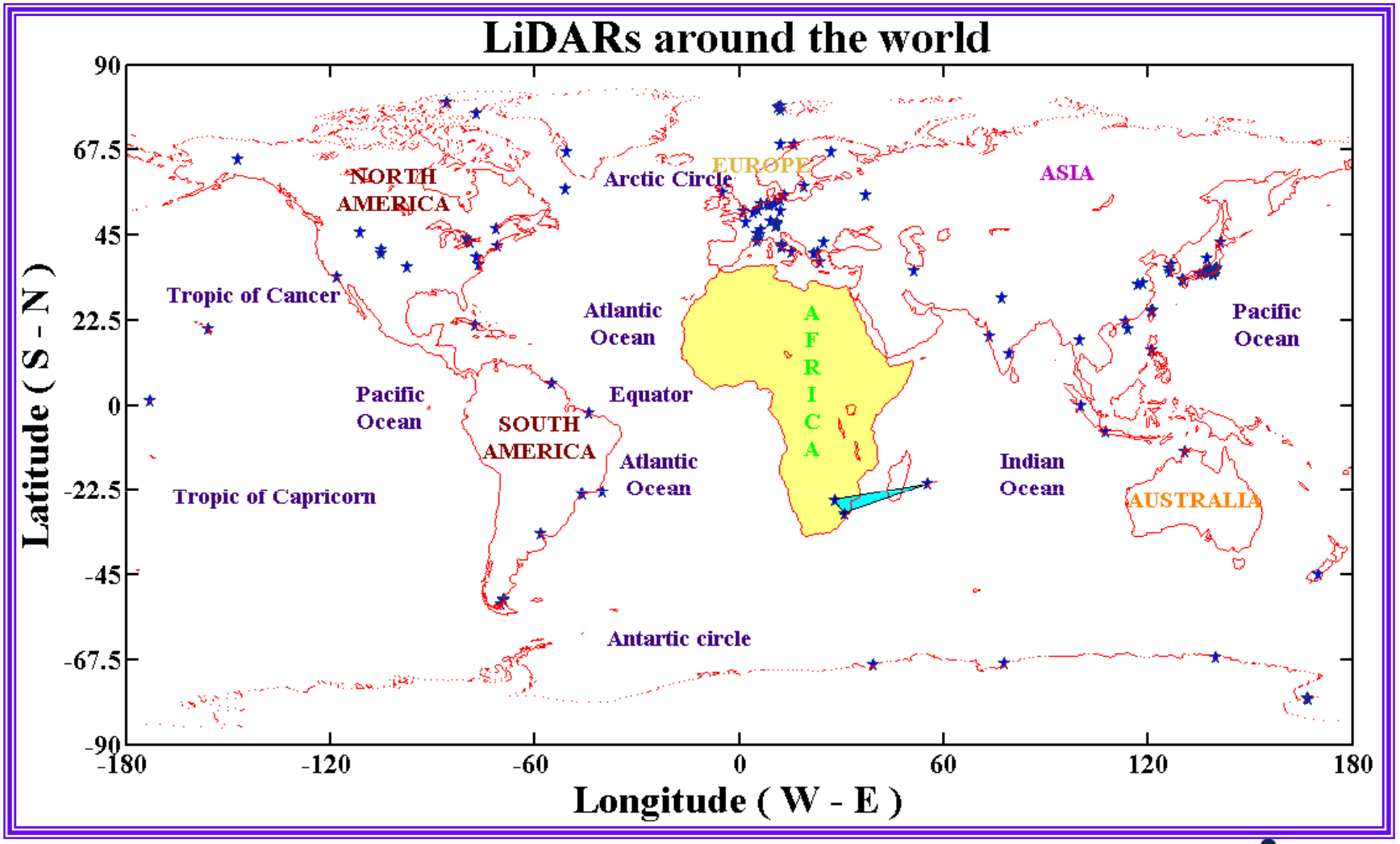
- **Model simulation study**

  In-house

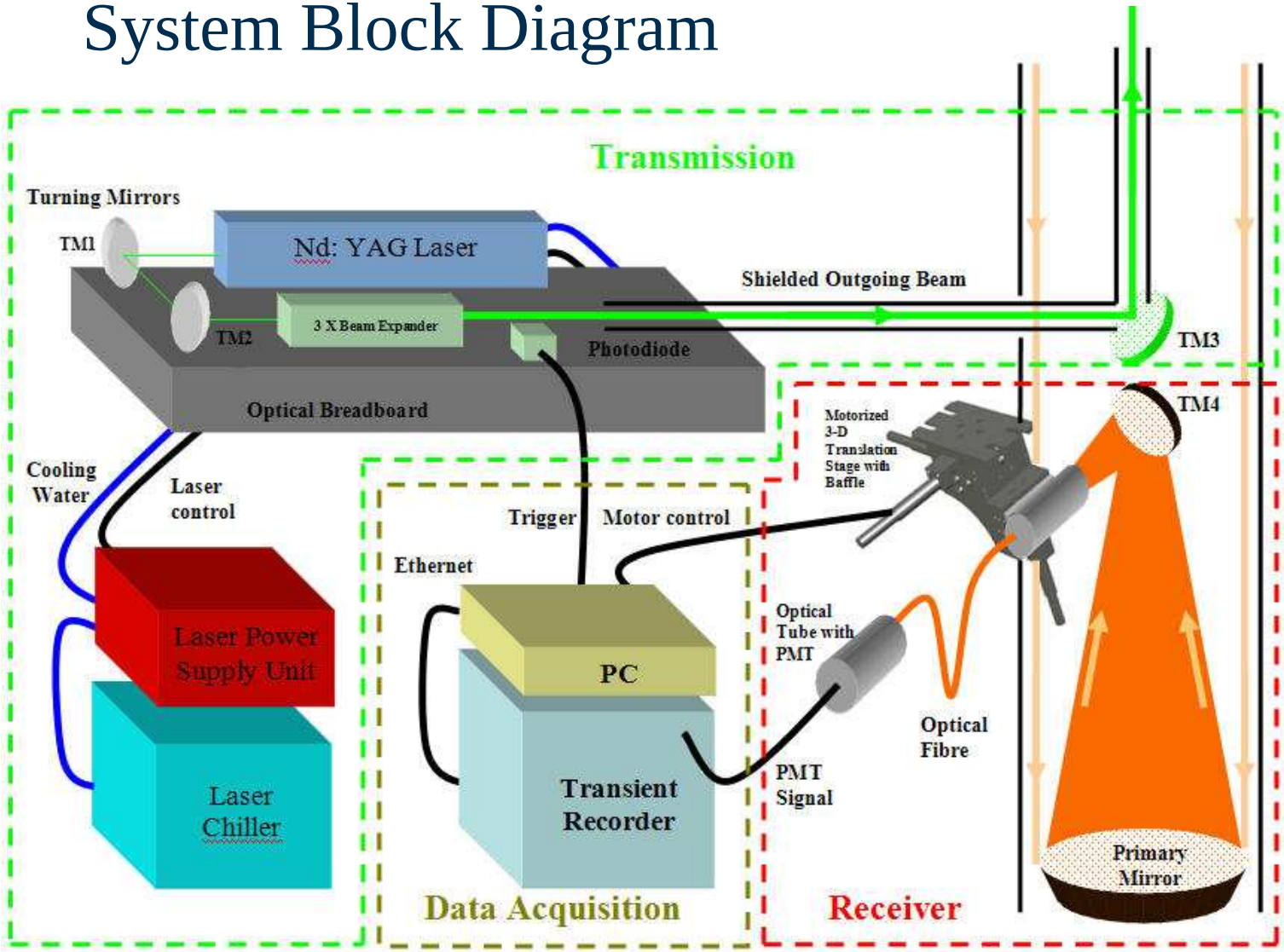
…LiDAR Principle



Centre for Atmospheric Research, University of Nova Gorica

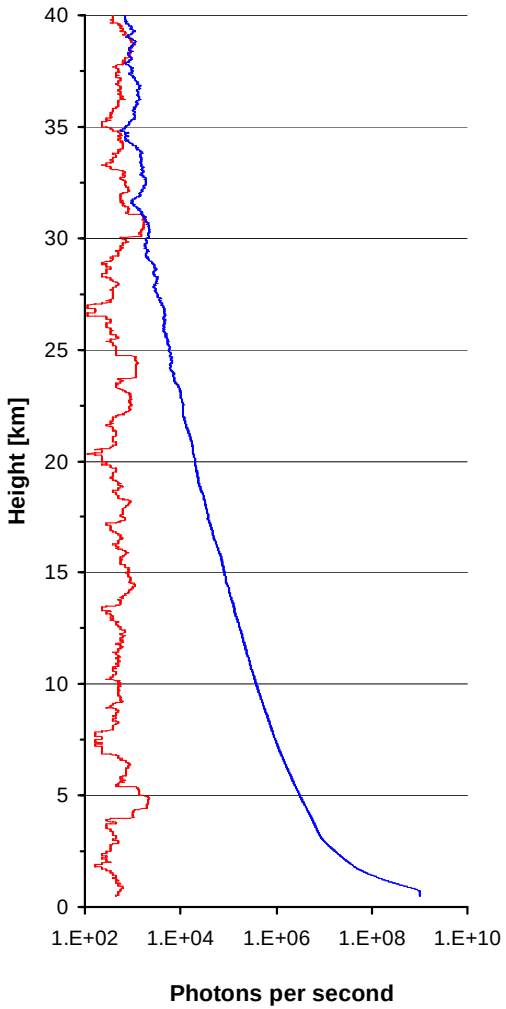


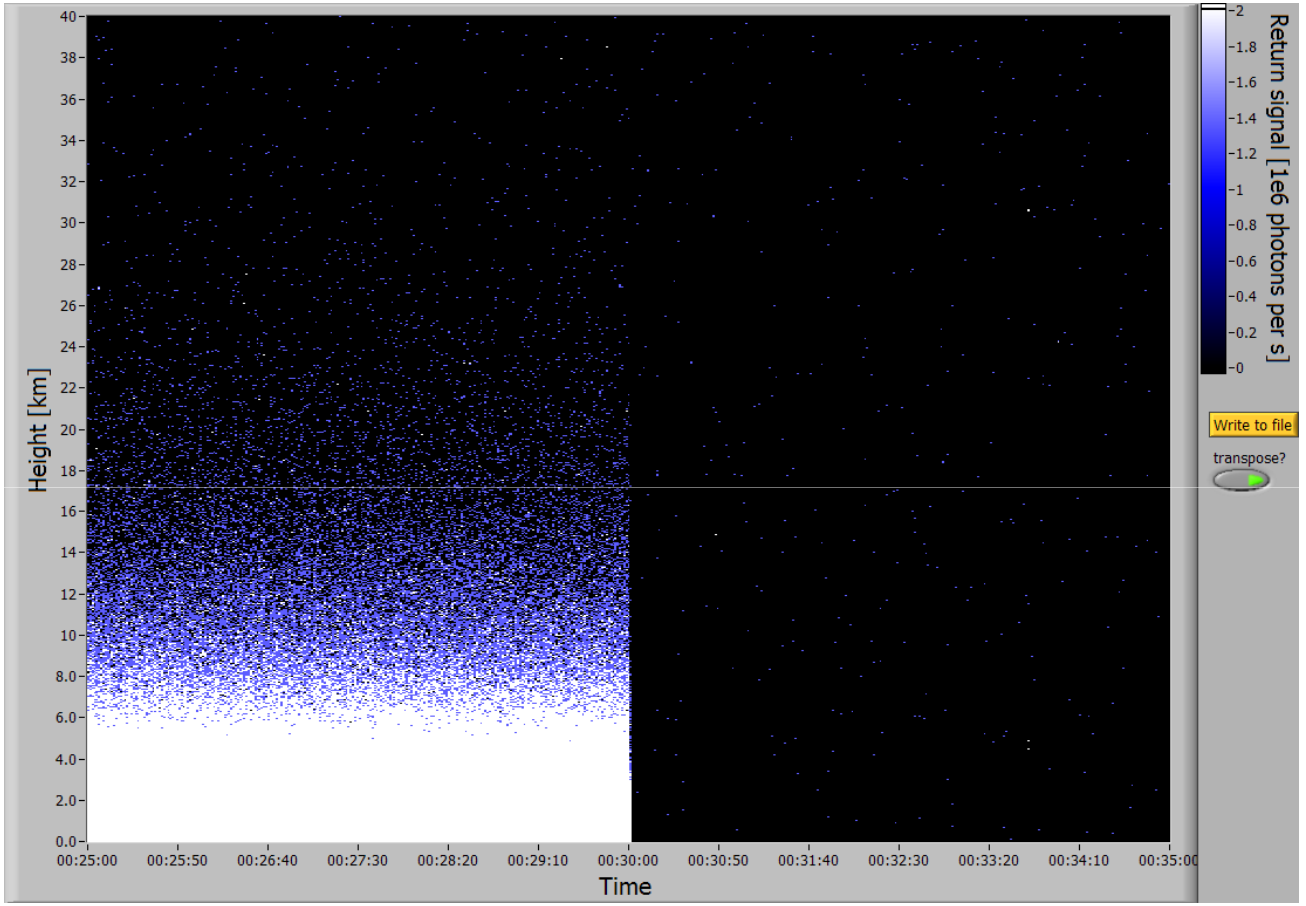
System Block Diagram



Initial Tests

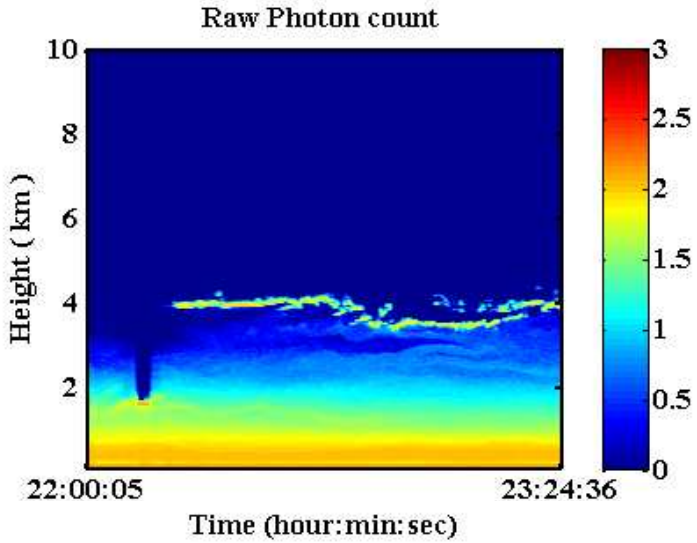
Signal to Noise Performance

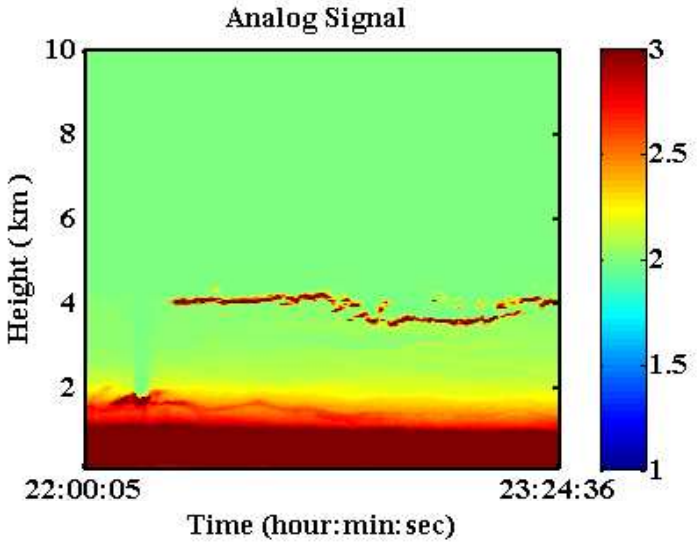


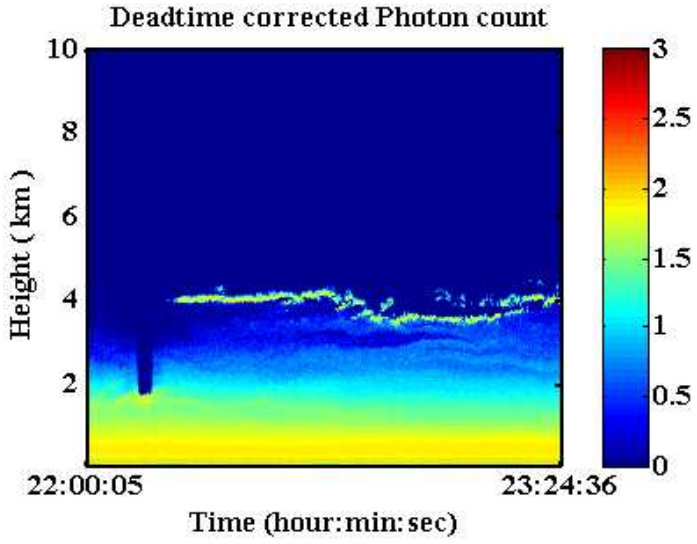


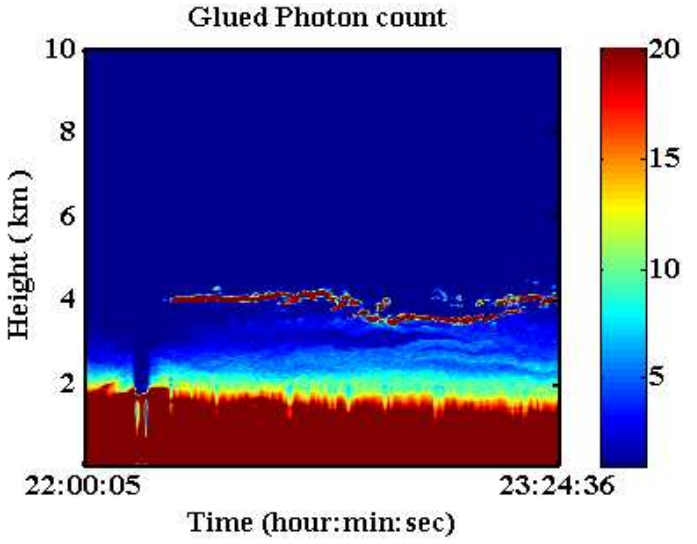
Preliminary Results

23 Feb 2008



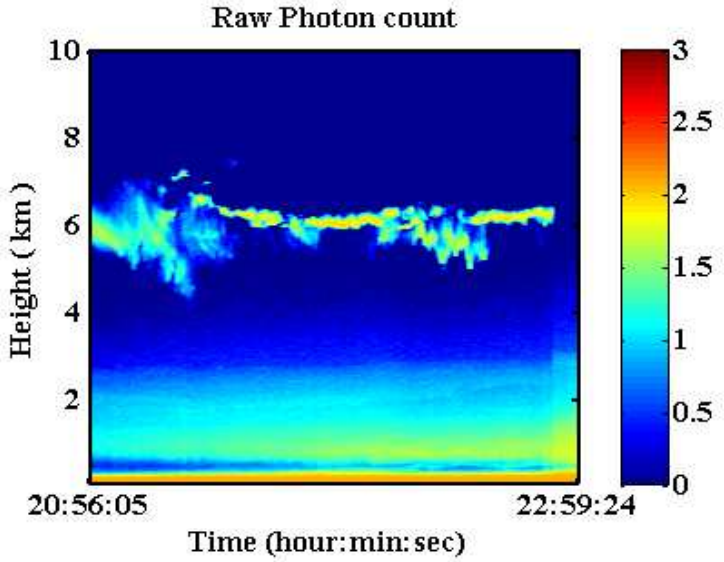


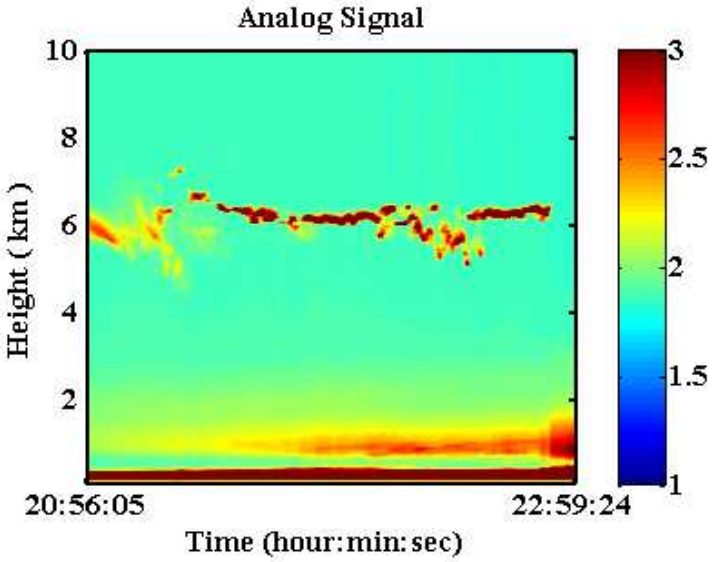


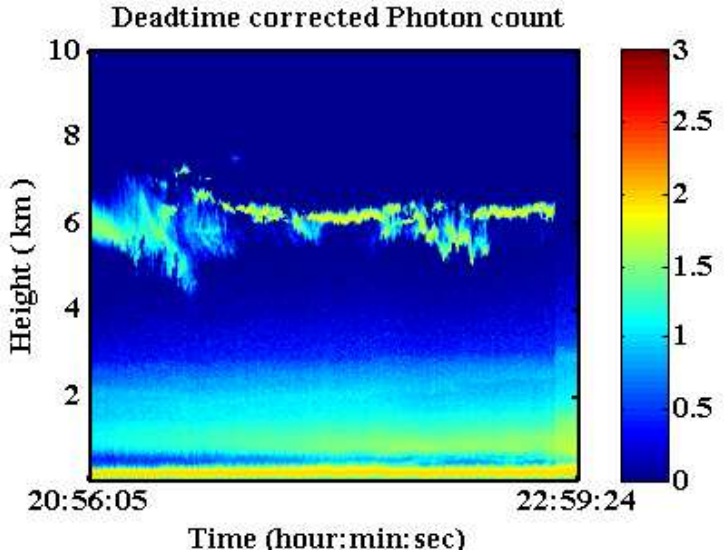


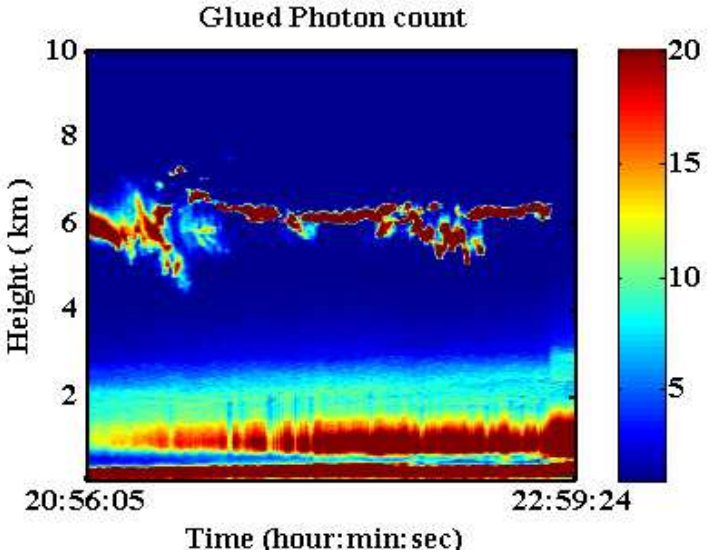
Preliminary Results

18 April 2008

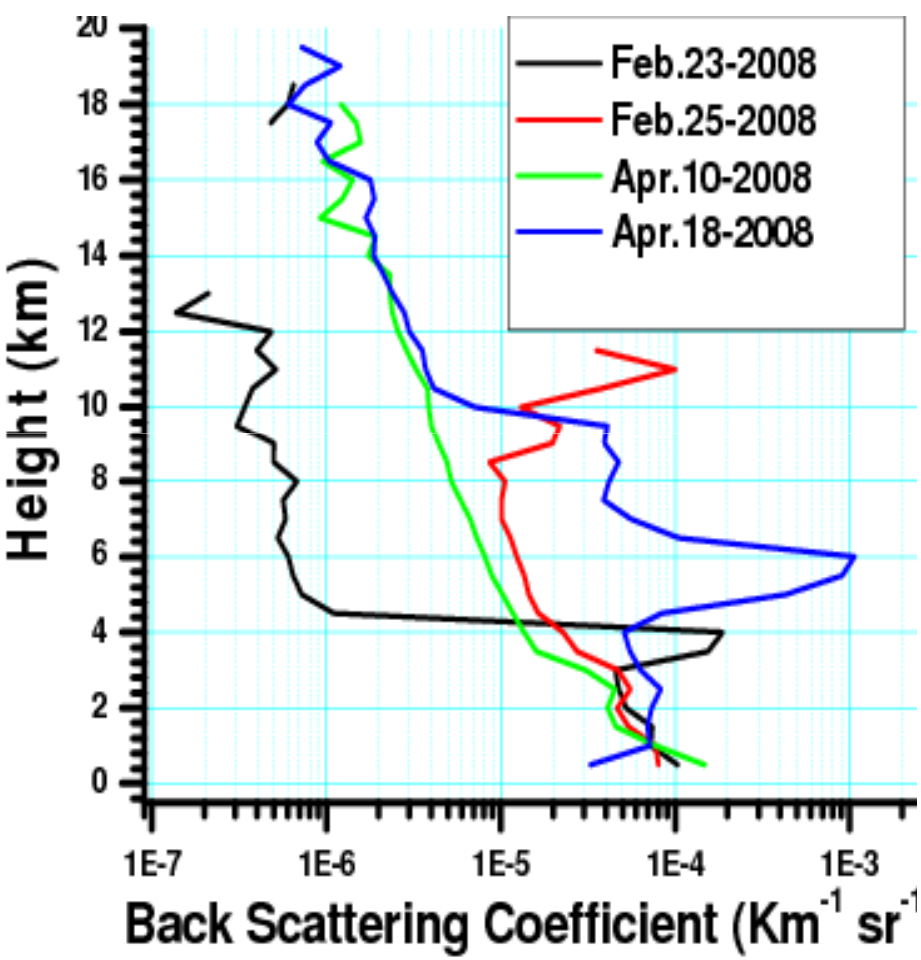


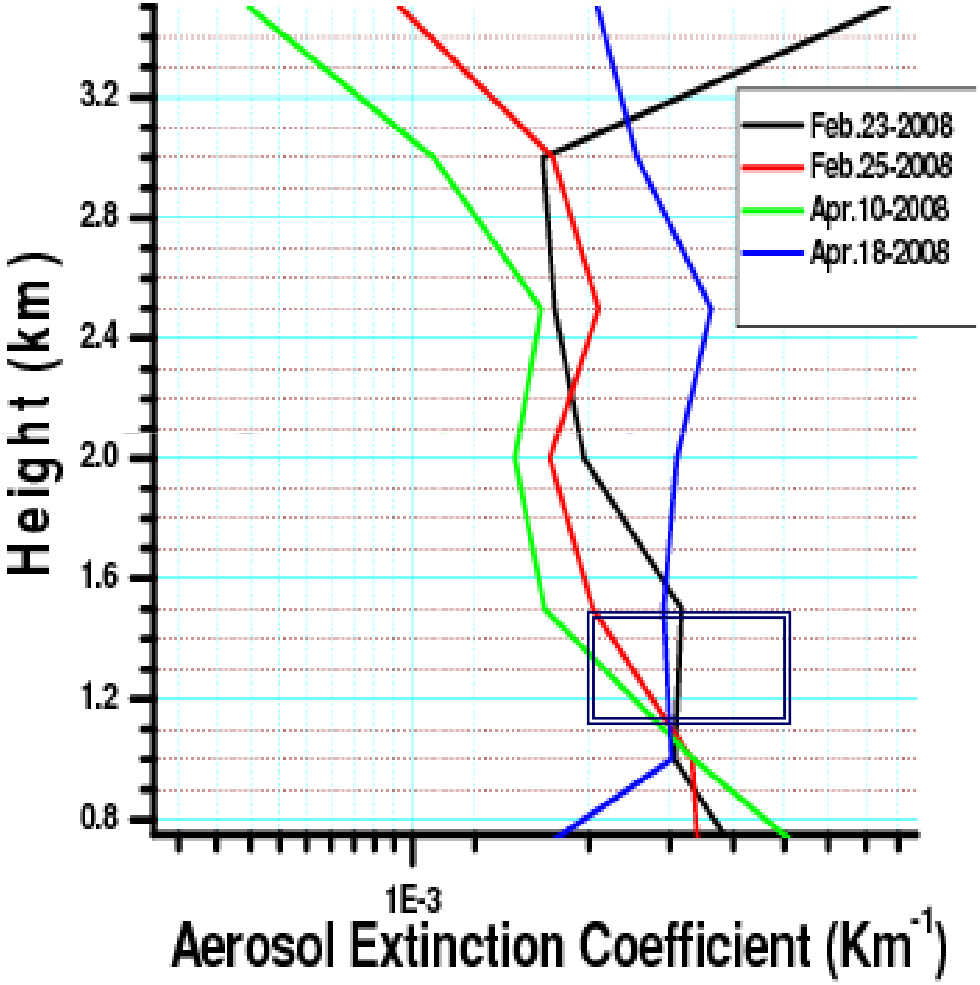




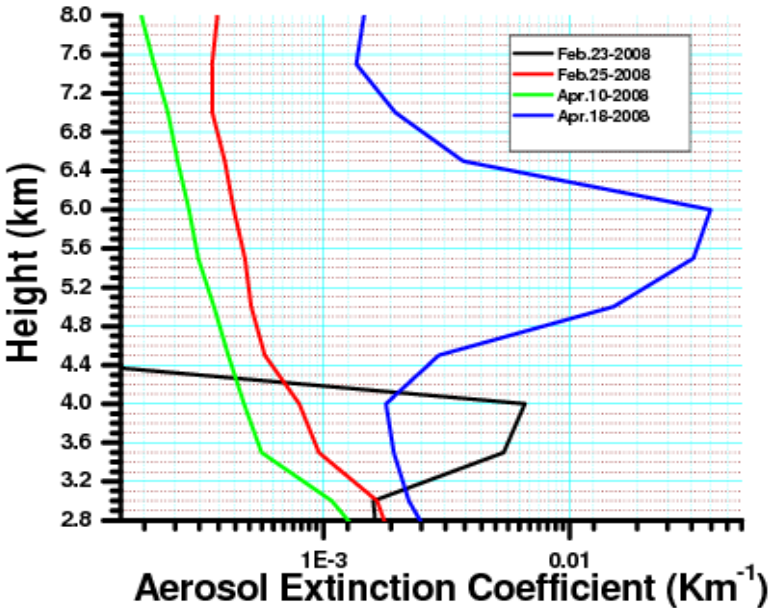


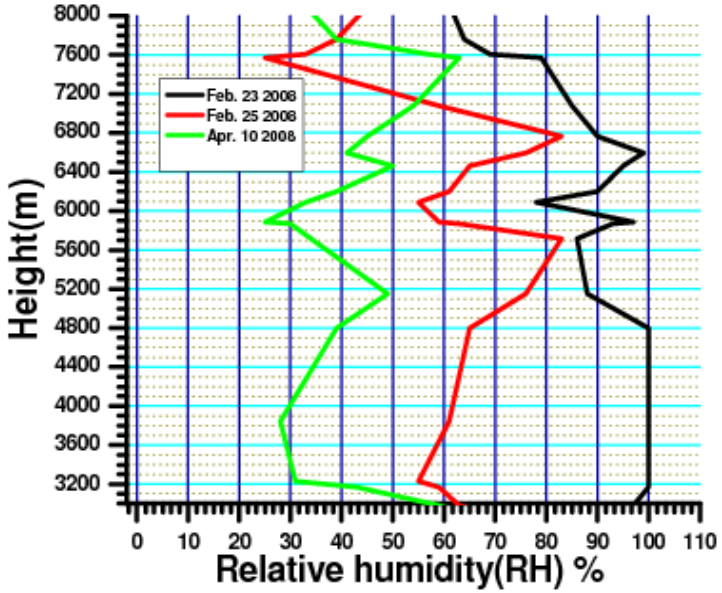
Retrieved aerosol properties : Backscattering and Extinction profile

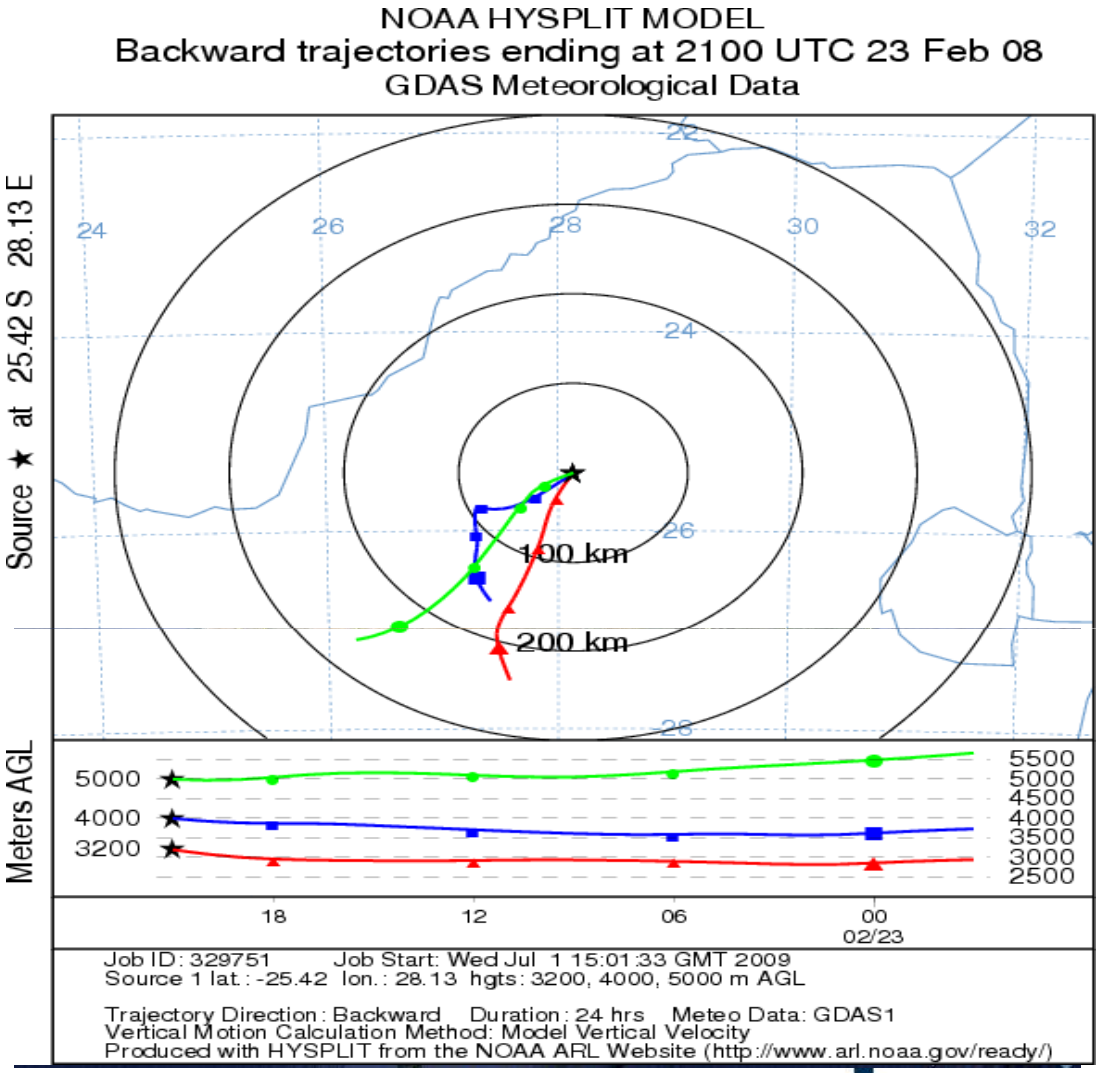


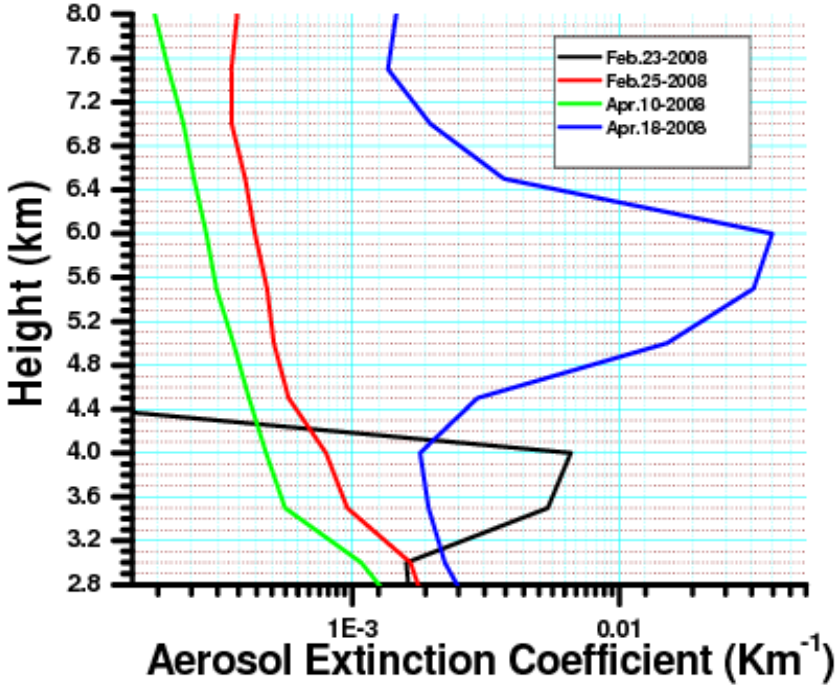


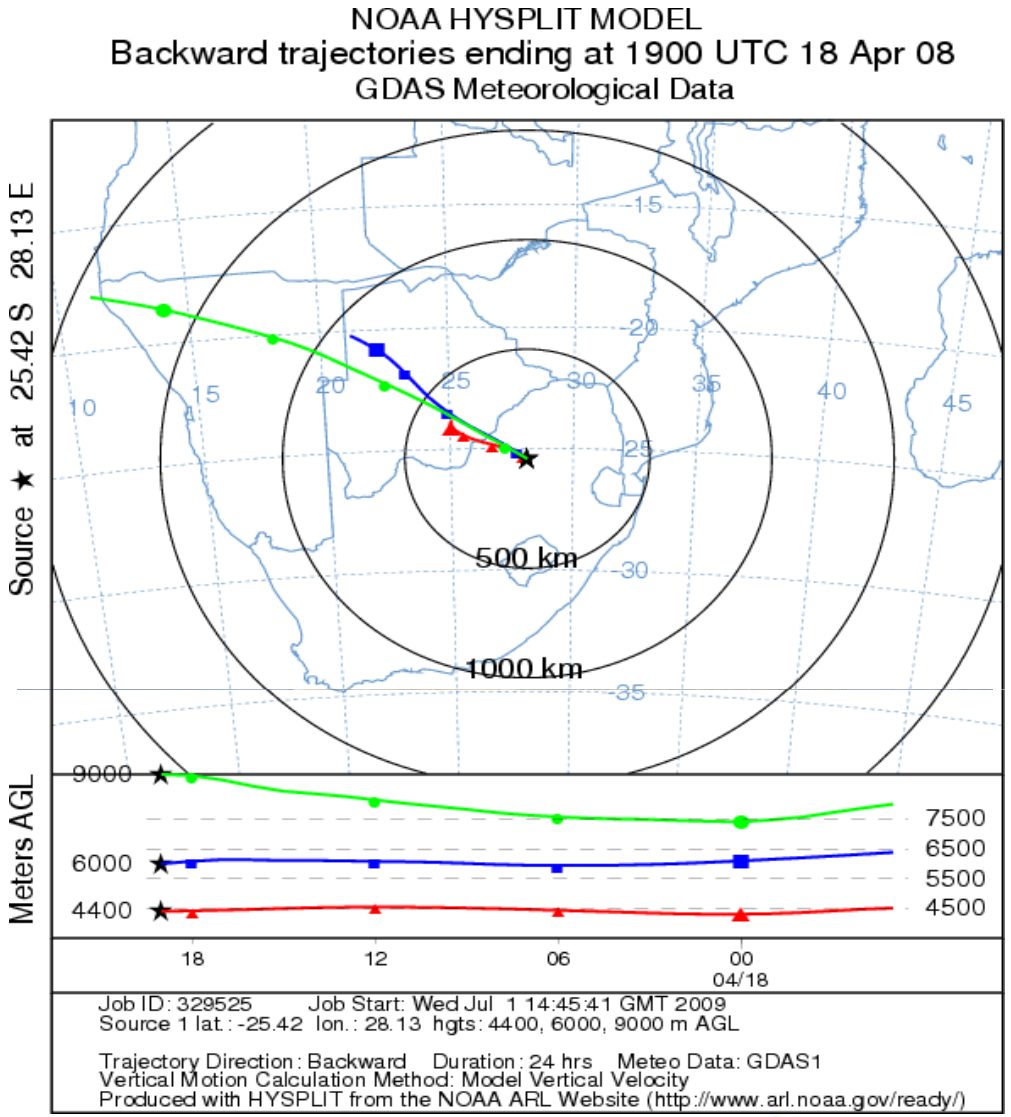
Back Trajectory Analysis (BTA)











For Apr. 18; 2008,

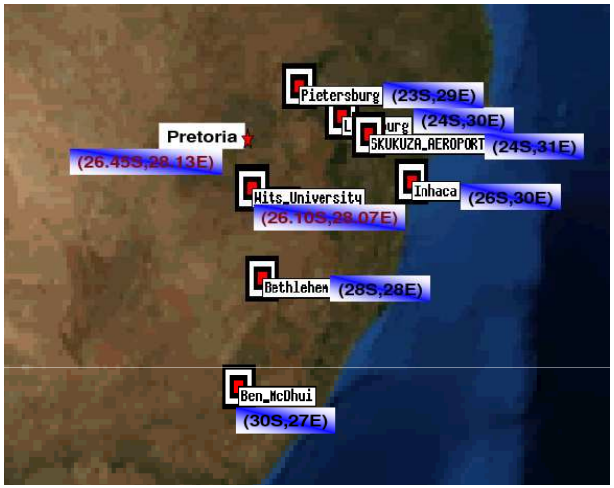
Morphological classification

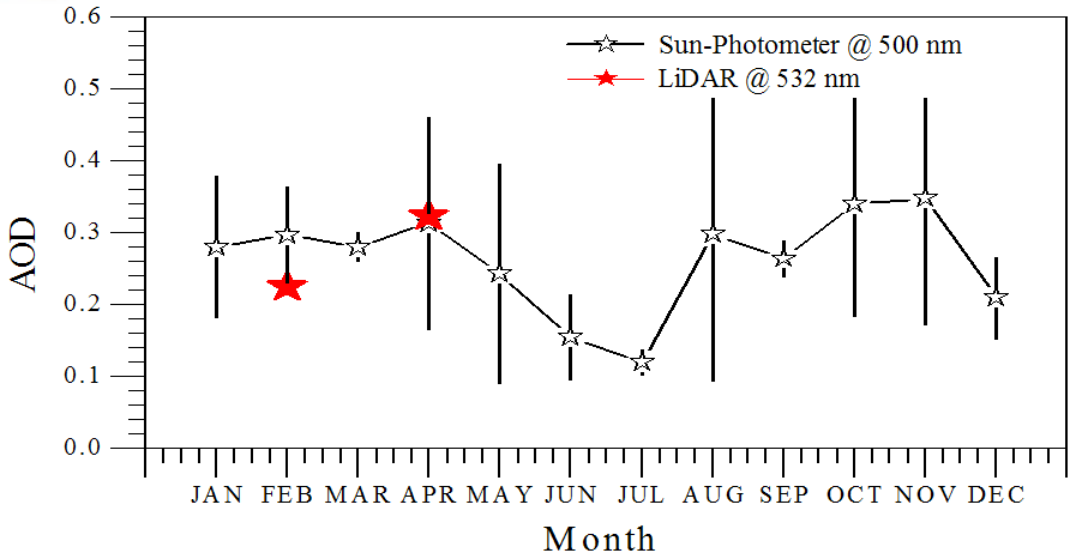
1 – 3.5 km 13.1 %
3.5 – 7.5km 80.3%
7.5 – 12km 5.6%.

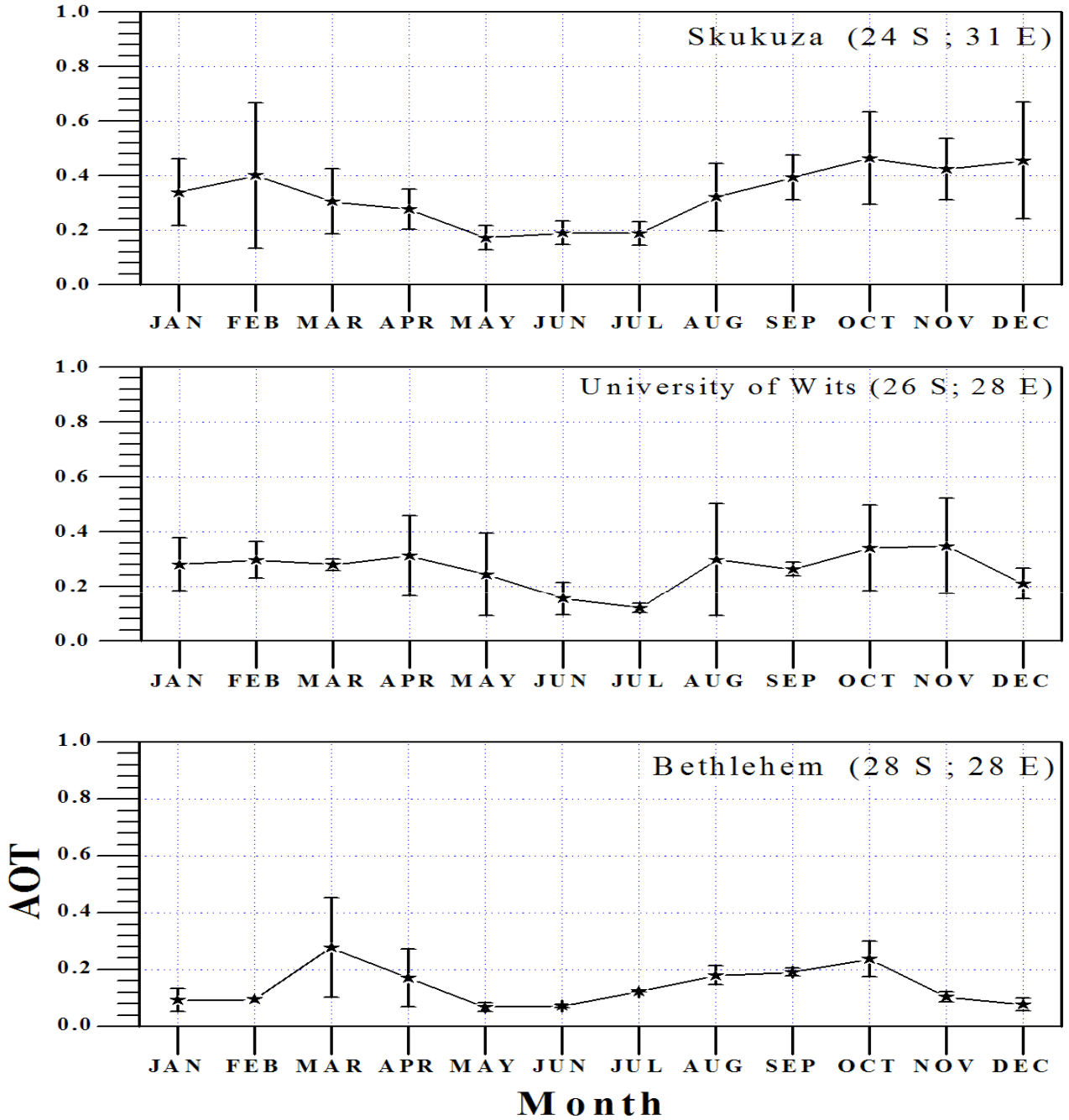
} **"troposphere loaded from the bottom".**

Validation / Comparison

Comparison with AErosol RObatic NETwork (AERONET) : Sun-Photometer Optical Depth measurements at 500 nm

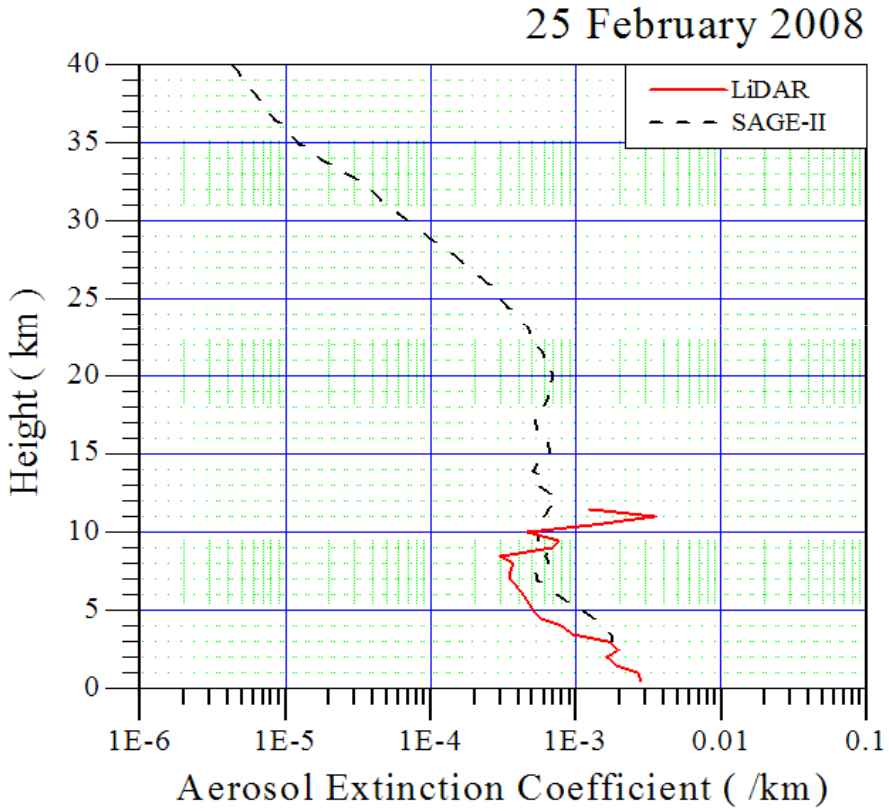






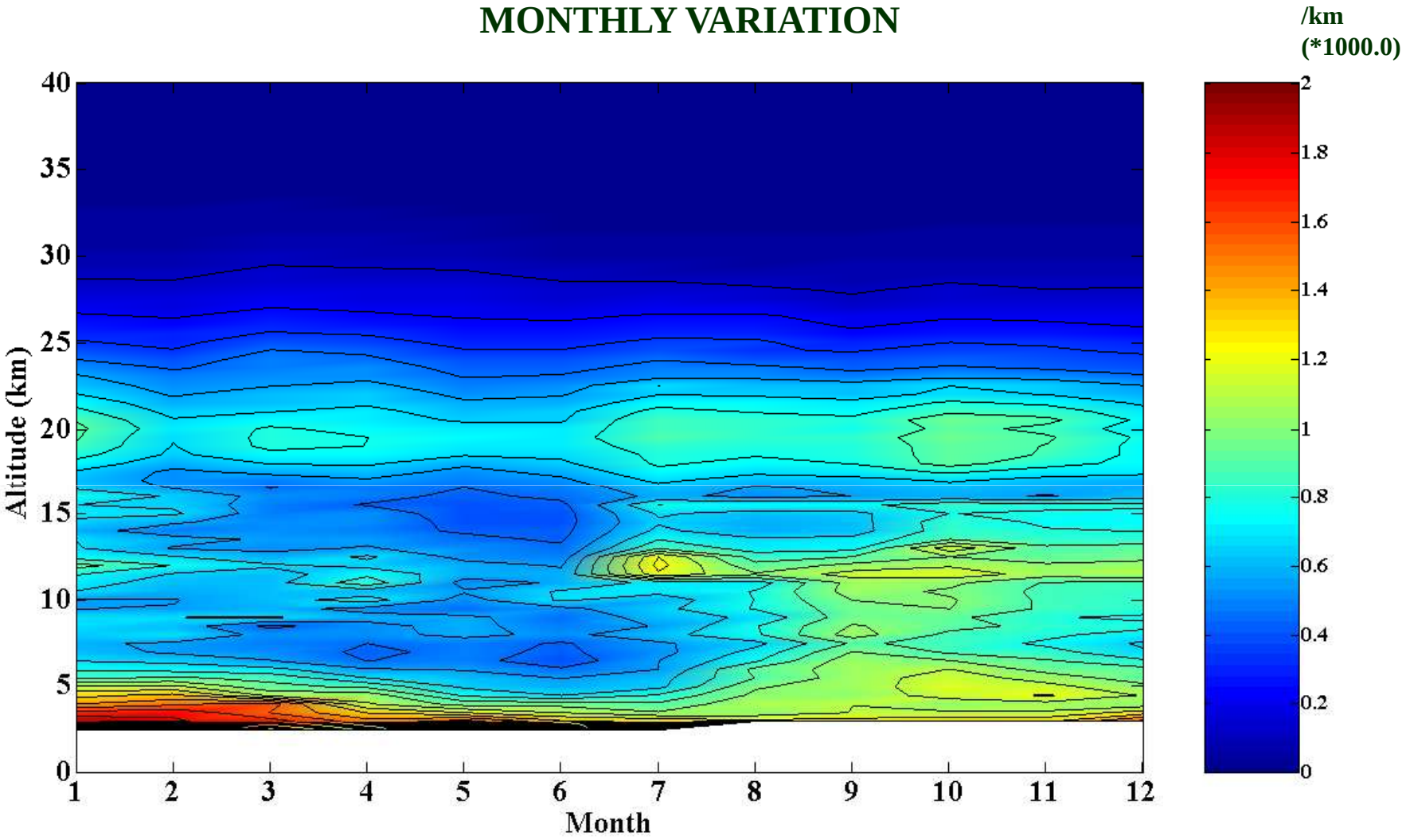
Validation / Comparison

Comparison with Stratosphere Aerosol Gas Experiment (SAGE)-II : Aerosol extinction measurements at 520 nm

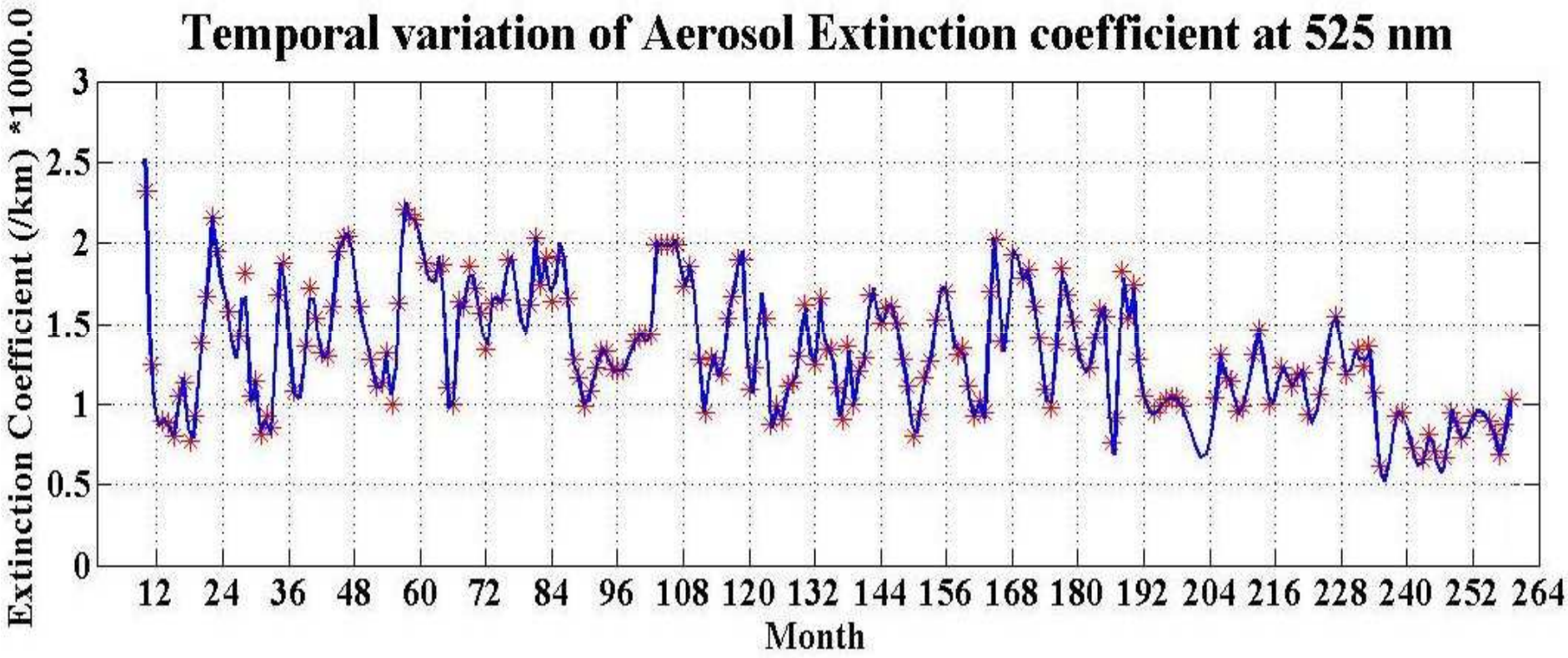


SAGE – II – AEROSOL EXTINCTION 525 nm OVER SOUTHERN AFRICA

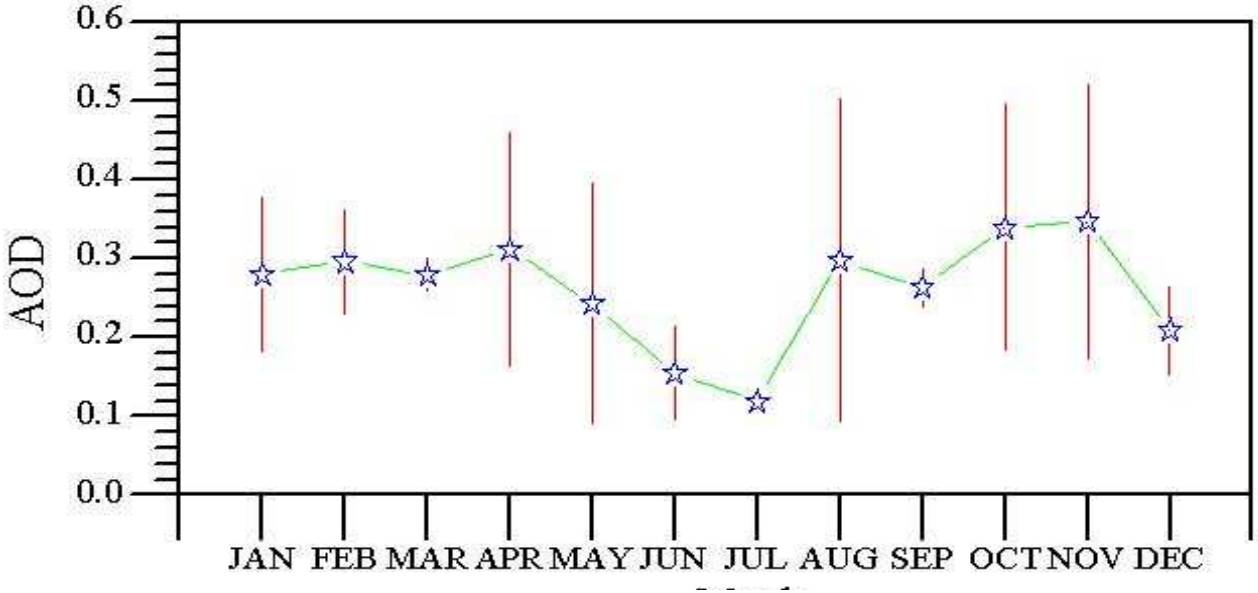
MONTHLY VARIATION

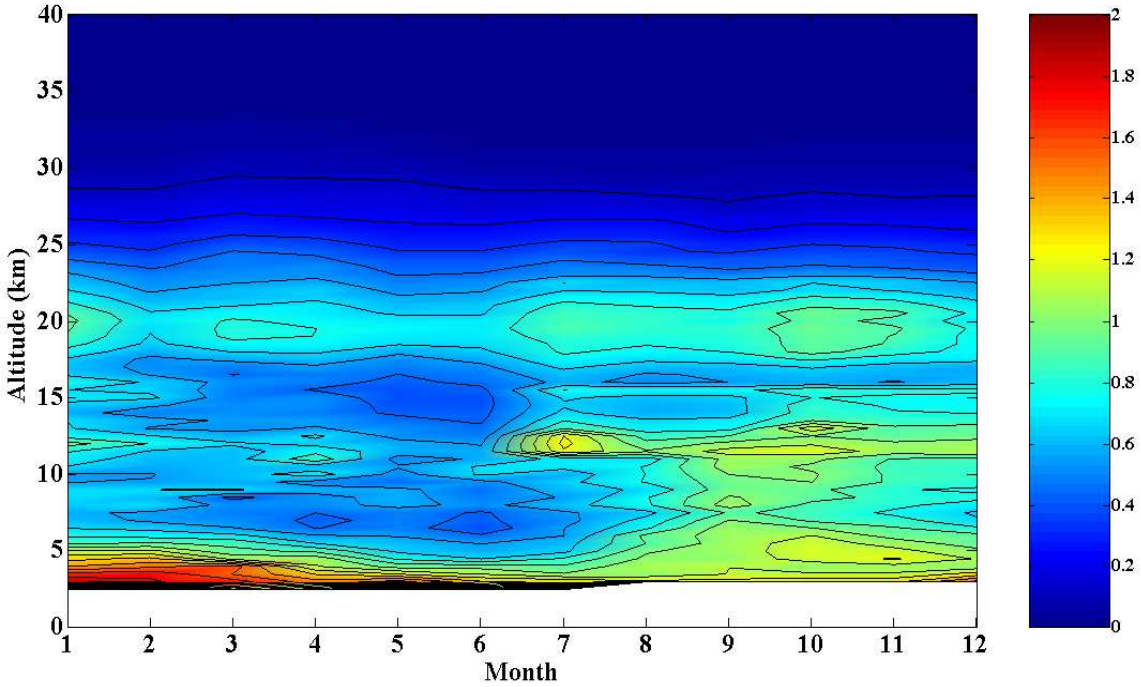


SAGE – II – AEROSOL EXTINCTION 525 nm OVER SOUTHERN AFRICA



AERONET – DATA : JOHANNESBURG (2002 to 2008)





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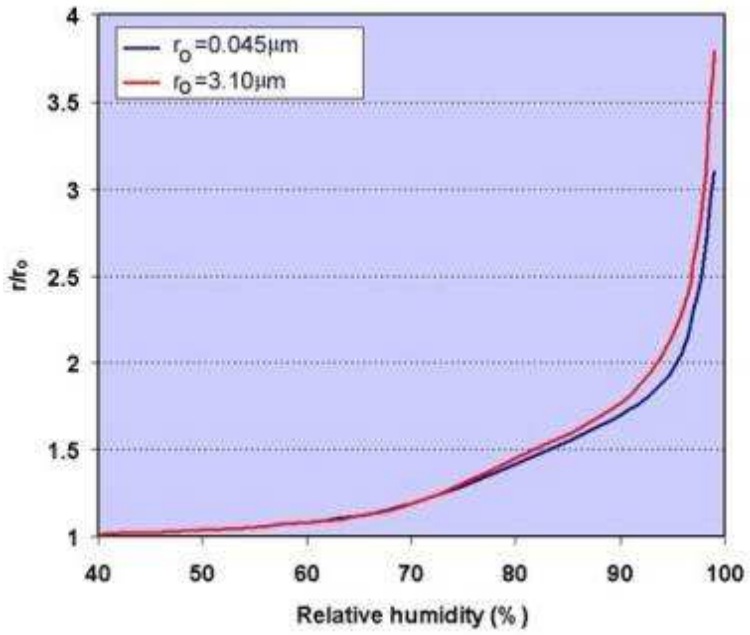
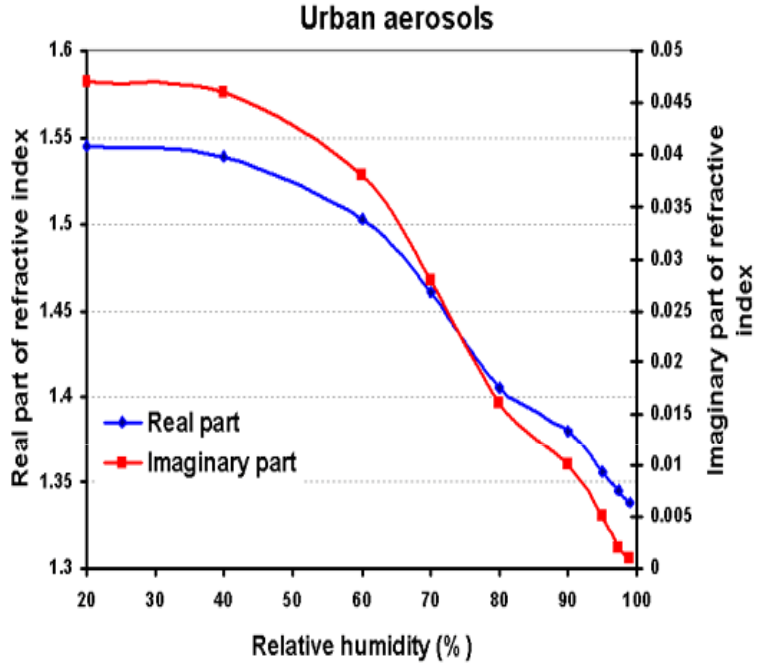
Validation / Comparison

Aerosol backscatter co-efficient measured by LIDAR and Radiosonde

Method Based on hygroscopic properties of Aerosol



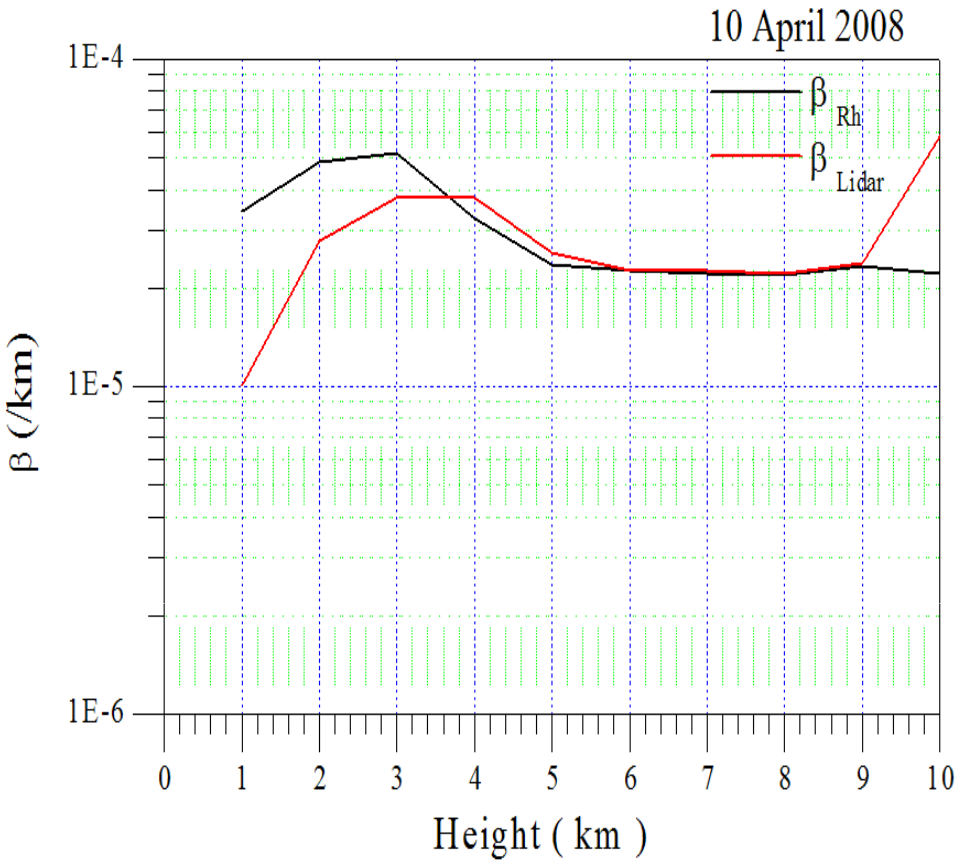


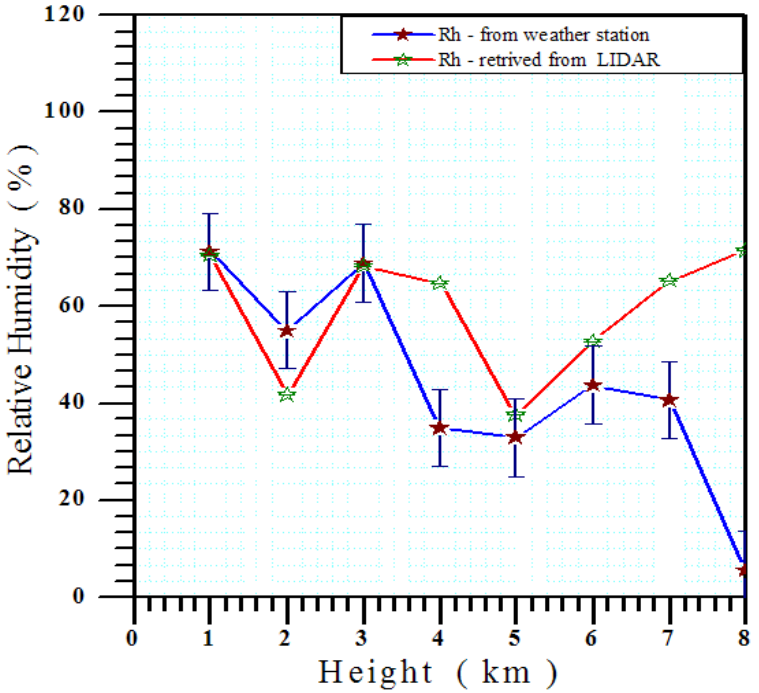
$$\frac{\beta^{a}(\lambda, r)}{\beta^{a}_{Rh}(\lambda, r)} = a\left(1 - \frac{Rh}{100}\right)^{-b}$$

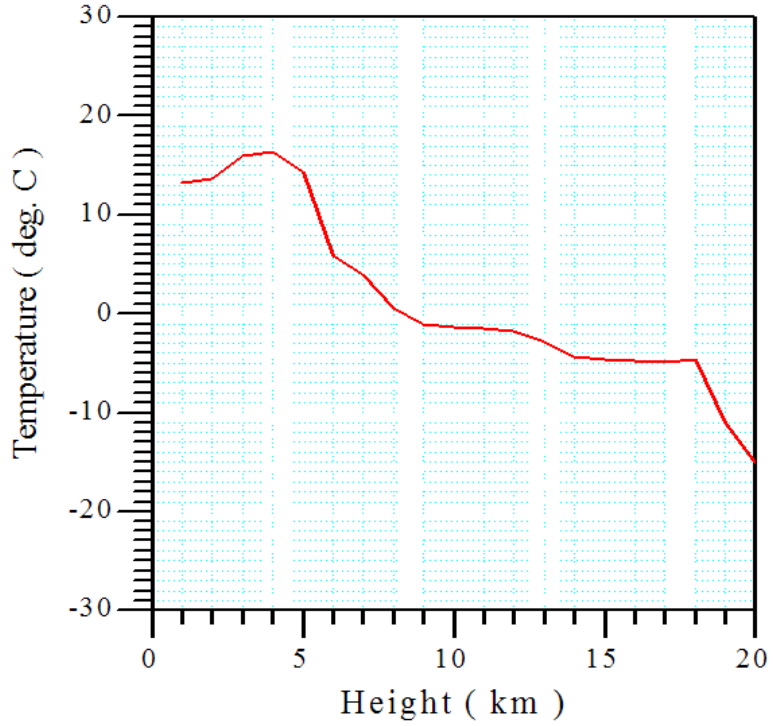
$\beta^{a}_{Rh}(\lambda, r)$ **the reference backscatter co-efficient for relative humidity of 70 % = 0.0005 (km-sr)$^{-1}$**

a=0.43 and b=0.3, for the regression co-efficient (R^2) = 0.85

Validation / Comparison

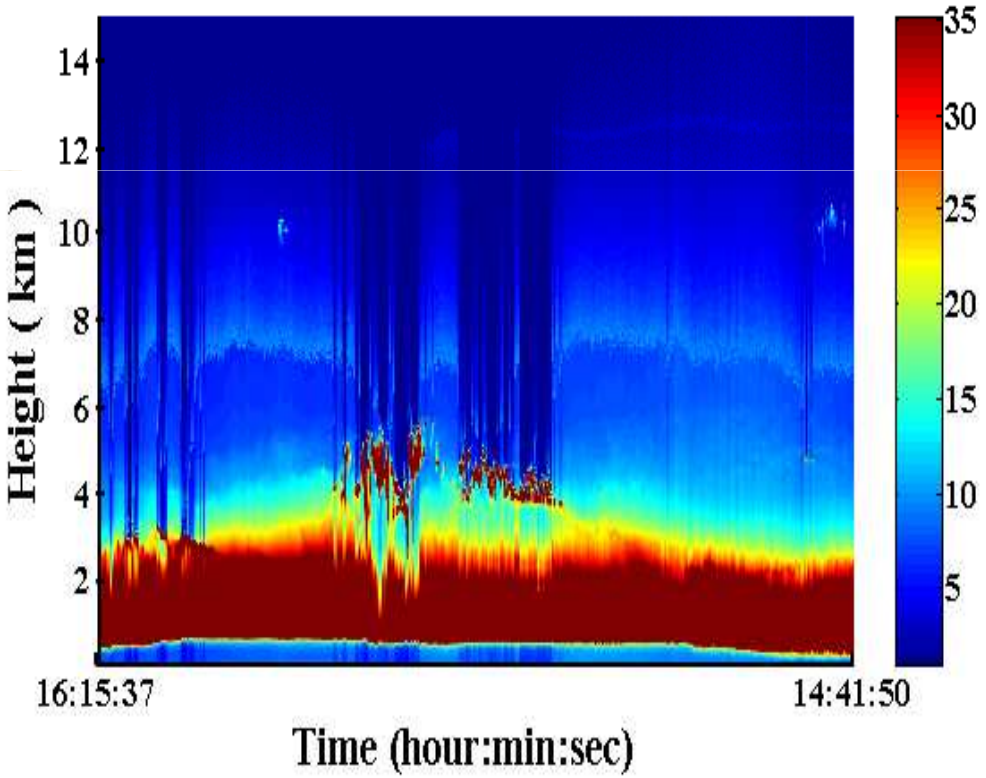




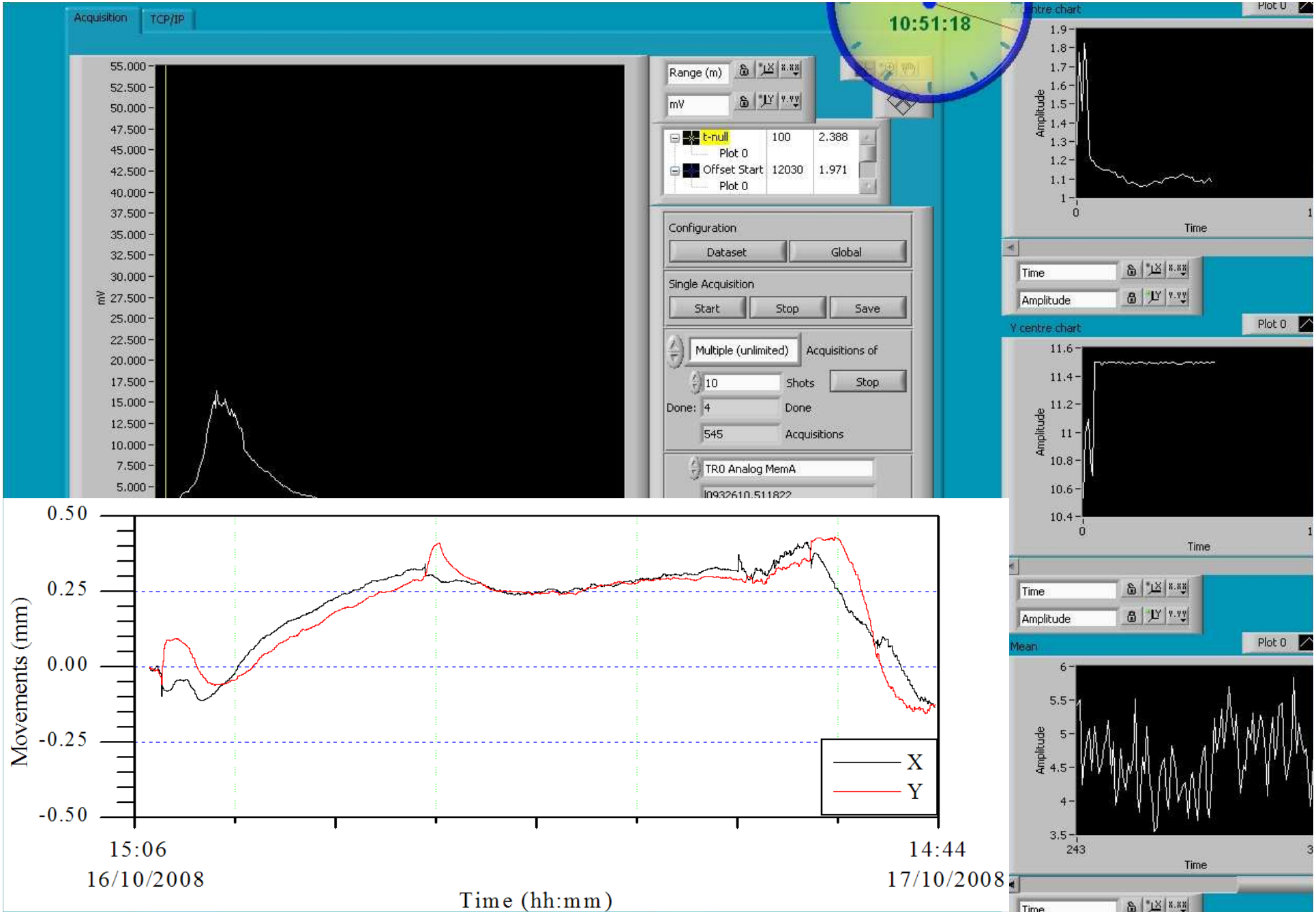


Water vapor doesn't exist after or near 0^0c.
The non-spherical and non-hygroscopic nature of aerosol particle may causes a considerable deviation from the real Rh value.

- 2-day measurement campaign at University of Pretoria
- First 23-hour continuous measurement

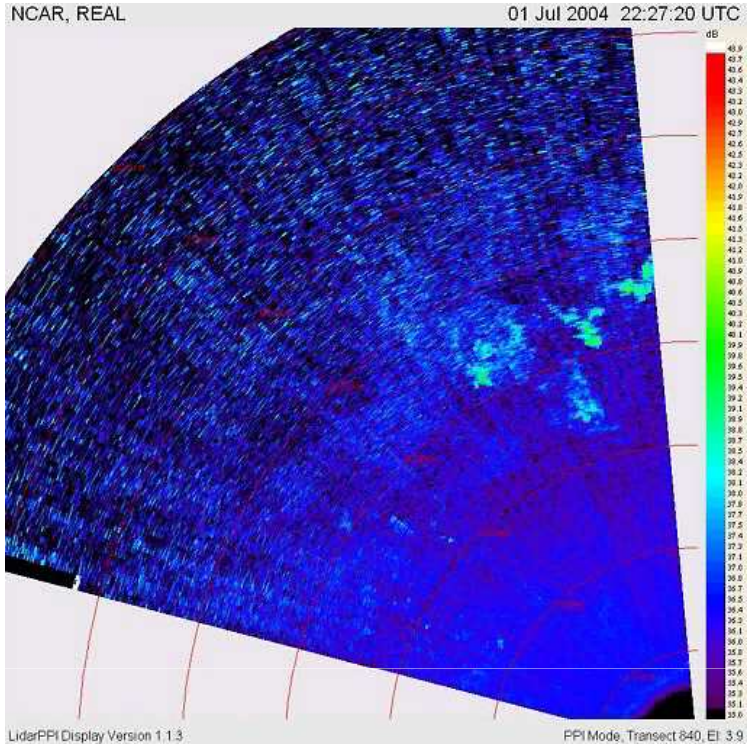


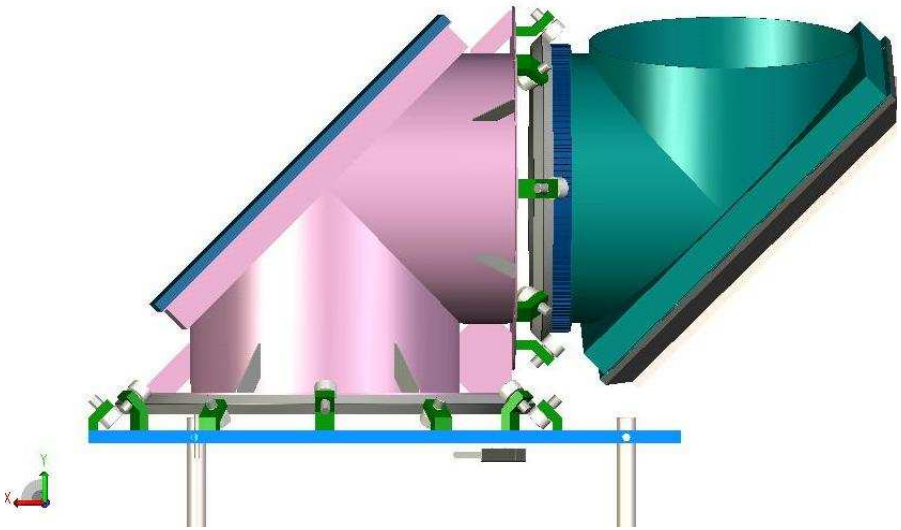
Fibre Auto-Alignment



Where does it go ?

How does it impact ?





Adopted from NCAR site

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)

➢Beautiful but dangerous….