Lidar and SAGEII comparison of aerosol characteristics over Gadanki, a tropical station in India

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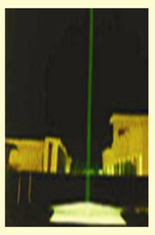
1. Objectives

- ✓Study the Upper Troposphere (UT) and Lower Stratosphere (LS) aerosol characteristics over the tropical station Gadanki (13.5°N, 79.2°E).
- ✓Extensive comparison of long term data (1998-2005) using 0.532μm LIDAR & 0.525μm SAGEII aerosol extinction coefficient $ß_{ext}$ during volcanically quiescent conditions following the coincident criteria.
- ✓Signatures of minor volcanic eruptions
- ✓Study the non-spherical particles just after the volcanic eruption.
- ✓Seasonal variations of wavelength exponent.

2. System Description

LIDAR Transmitter

Laser Source	Nd:YAG
Operating Wavelength	532nm
Average energy per pulse	550mJ
Average o/p power	11W
Pulse width	7nsec
Pulse repetition rate	20Hz
Beam Divergence	0.1mRad

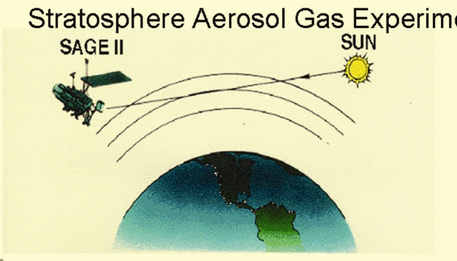


Receiver

Mie Channel	
Telescope type	Schmidt Cassegrain
Diameter	350mm
Field of View	1 mRad
Range Resolution	300m
Time Resolution	250sec
Maximum Transmission	48%

SAGEII

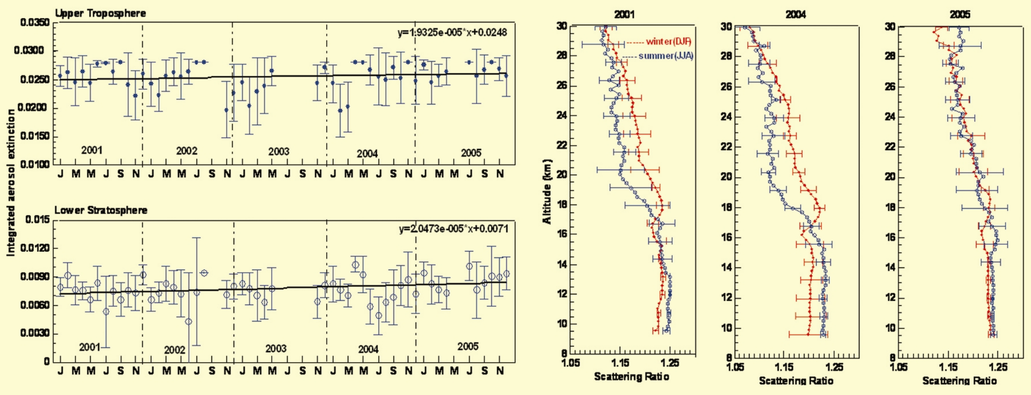
Stratosphere Aerosol Gas Experiment



Period	Oct 1984-Aug 2005
Wavelengths	0.385,0.453,0.525 & 1.02μm
Altitude	10-40km
Resolution	500m
Version	6.2 l

3. Importance of UTLS

- ✓Scattering Ratio (SR) is found to exhibit a relation with tropopause altitudes, SR values apparently experience a shift in altitude corresponding to seasonal change in cold point tropopause (Kulkarni et al 2008).
- ✓UT & LS yielded a weak correlation coefficient of –0.4, suggesting UT aerosols could be a source of LS aerosols.
- ✓At LS, a general increase in SR values during winter than in summer & vice versa at UT.



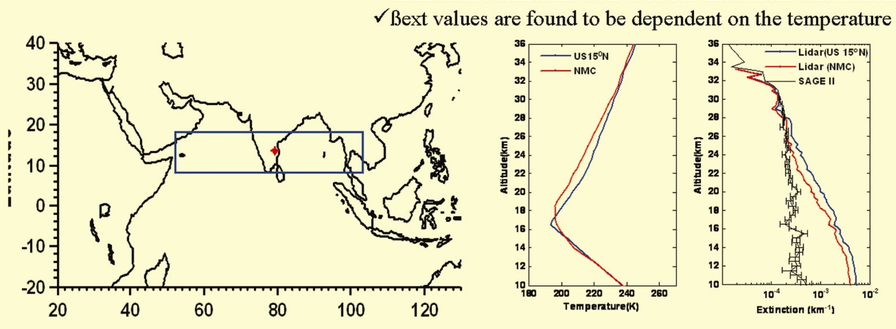
4. Coincident Selection Criteria for SAGEII

- 37 coincident profiles during Mar1998-Aug 2005 Klett Method for LIDAR

Selection Criteria
Within ±5° in latitude, ±25° in longitude
& ±24 hours in time

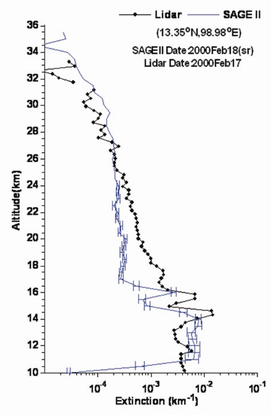
$$\beta_z = \frac{\exp(S - S_m)}{\frac{1}{\beta_m} + 2\int_Z^{Z_m} \frac{\exp(S - S_m)\,dz}{B_a}}$$

- ✓Standard atmosphere, NMC measured profiles from each SAGE II events and Ba(sr^{-1}) is the ratio between aerosol backscattering & extinction coefficient 0.02 used for Lidar ßext calculations.
- ✓ßext values are found to be dependent on the temperature profile



5. Results & Discussions

Comparison between LIDAR & SAGEII



Comparison of SAGE II & Lidar extinction observations

(i) Good agreement throughout the altitude range of 10-35km.
(ii) Agreement in the LS but disagreement in the UT.
(iii) Good agreement in observation of high altitude cloud height.
(iv) SAGE II profiles are more smoother than lidar profiles.
(v) Systematic different between 2 instruments below 25km due to presence of higher aerosol extinction.

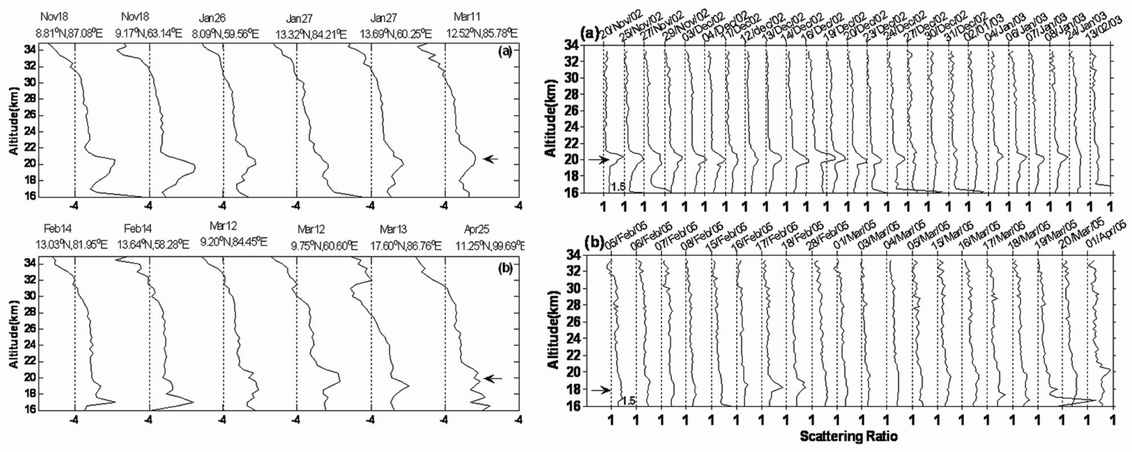
Uncertainties in Lidar and SAGE II aerosol extinctions could arise due to

SAGE II	LIDAR
(i) measurement errors.	(i) measurement errors.
(ii) calculated Rayleigh profiles caused by the uncertainty in the temperature profile.	(ii) difficulty of determining an aerosol free region.
(iii) reference altitude.	(iii) Rayleigh profile.
(iv) removal of other gaseous species.	(iv) use of constant Ba (sr^{-1}) 0.02.

Minor Volcanic Eruption Layers

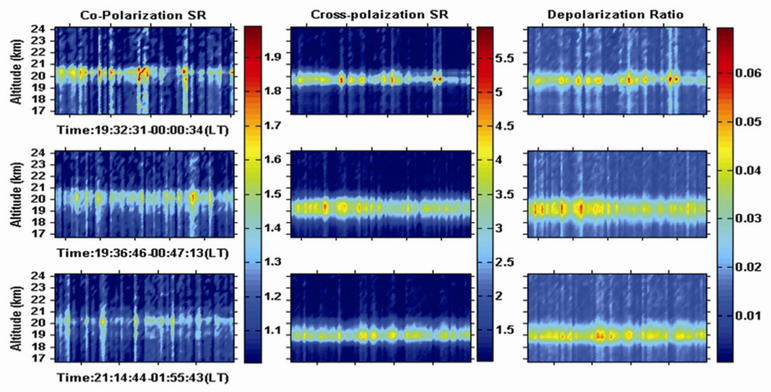
Two minor volcanic eruption aerosol signatures are inferred from SAGE II & Lidar in the tropical LS

a. 3 November 2002 of El Reventador (0.077ºS, 77.65ºW), at 19-21km
b. 27-28 January 2005 of Manam Volcano in Papua New Guinea (4.10ºS,145ºE), at 18-19km



Depolarization of aerosols in the LS from LIDAR

- ✓Lidar backscatter technique is uniquely sensitive to particle shape,size & orientation
- ✓Depolarization measurements are used to retrieve information on non-spherical particles



Linear Depolarization Ratio (LDR)

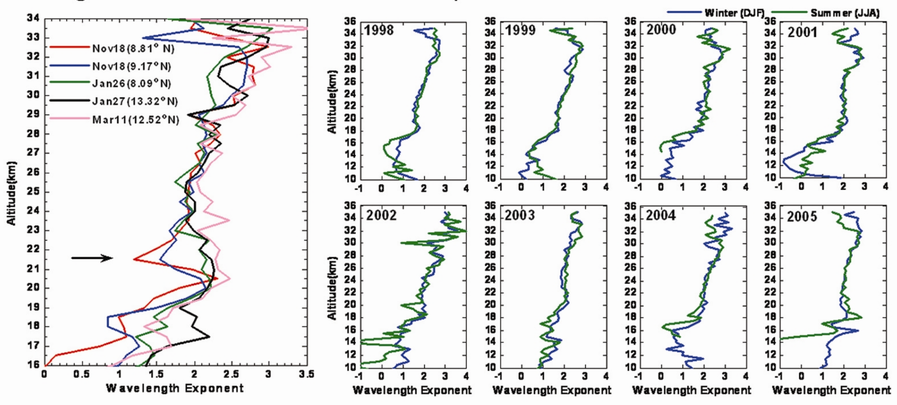
$$\delta(z) = \delta_m \left[\frac{SR_{\perp}(z)}{SR_{II}(z)} \right]$$

δ_m= 0.014, air molecular depolarization
$S_{\perp}$ = Cross polarized scattering
S_{II}=Co-polarized scattering

- ✓Just after an eruption, the monomodal size distribution becomes bimodal & some particles may be non-spherical because of additional volcanic material, leading to depolarization as shown.

Spectral Variation from SAGEII ßext

- Ångström coefficient describes the spectral variation of the aerosol extinction



Ångström law
$$\sigma = \beta\lambda^{-\alpha}$$

Higher α value indicate the dominance of smaller size aerosols while a smaller α suggest the dominance of coarse mode aerosols in the size distribution.

- El Reventador eruption α values are lower around 21km indicating presence of higher aerosol loading.
- α increases with increase in altitude indicating the presence of smaller size particles at stratospheric altitudes.
- No significant seasonal variation is seen in α over Gadanki

6. Summary

- ***Most extensive comparison between SAGE II and Lidar ßext is done during 1998-2005 using coincident criteria.***
- ***Seasonal ßext from Lidar & SAGEII are found to exhibit a good agreement in the 16 to 32 km altitude range.***
- ***El Reventador volcanic signatures were strong & present for almost 4 months in both SAGE II & Lidar results.***
- ***Depolarization ratios are 0.03-0.06 (small but significant) & α values are 1.19 after El Reventador volcanic eruption indicating non-spherical & larger size particles.***
- ***No significant seasonal variation in α is seen in the 10 to 36km within ±5º in latitude band around Gadanki.***

References

Kulkarni, P., S. Ramachandran, Y. Bhavani Kumar, D. Narayana Rao, and M. Krishnaiah (2008), Features of upper troposphere and lower stratosphere aerosols observed by lidar over Gadanki, a tropical Indian station, *J. Geophys. Res.*, doi:10.029/2008JD009411, (in press)

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