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TECHNICAL DIGEST**

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Remote Sensing of Structure Properties in the Middle Atmosphere Using Lidar

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ABSTRACT

The results from a mobile lidar have been used to derive density and temperature profiles between 25 and 85 km over central Alaska during February-April 1986.

INTRODUCTION

During the period between February and April 1986 a new mobile lidar, GLINT (Ground-based Lidar INvestigation-Transportable), was used to obtain data on the variations which occur in the high latitude region of the atmosphere between 20 and 85 km. The lidar measurements were undertaken to provide an improved data base on which the reentry flight characteristics of the Space Shuttle descent from a polar orbit could be based. The lidar can measure profiles with improved altitude and time resolution compared to standard rocket techniques. This is important for better understanding of the dynamical processes of the middle atmosphere. Data was obtained on 26 nights during the program. Standard meteorological balloon and rocket payloads were used to make measurements and provide a comparison study with the lidar data. More than a thousand profiles of atmospheric density were obtained with the lidar and twenty meteorological rockets were launched.

The measurement campaign has resulted in several conclusions: (1) the lidar data has provided the opportunity to observe small-scale variations and the background granularity of the atmosphere, (2) planetary waves may be associated with more than half of the total density variation in the middle atmosphere, (3) density and temperature variations can be used to study the source, intensity, and propagation characteristics of gravity waves in the high latitude winter atmosphere, (4) these measurements provide a major step in demonstration of the capabilities of lidar as a tool for routine meteorological and atmospheric measurements.

The properties of the mobile sounder are shown in Table I. The mobile sounder is housed in a 32 foot trailer which is air transportable. The trailer uses an undercarriage which can transport the trailer over the road. Adjustable jacks have been included to allow the trailer to be lowered onto a solid base and leveled at an operating site. Figure 1 shows a drawing of the trailer configuration and a layout of the hardware within the facility. Figure 2 shows the arrangement of the laser, small detector and the beam steering mirror. A 30 cm telescope is co-aligned with the laser beam and a mirror is used to steer over a range of elevation and azimuth. A larger receiver of 62 cm dia. is used for zenith measurements.

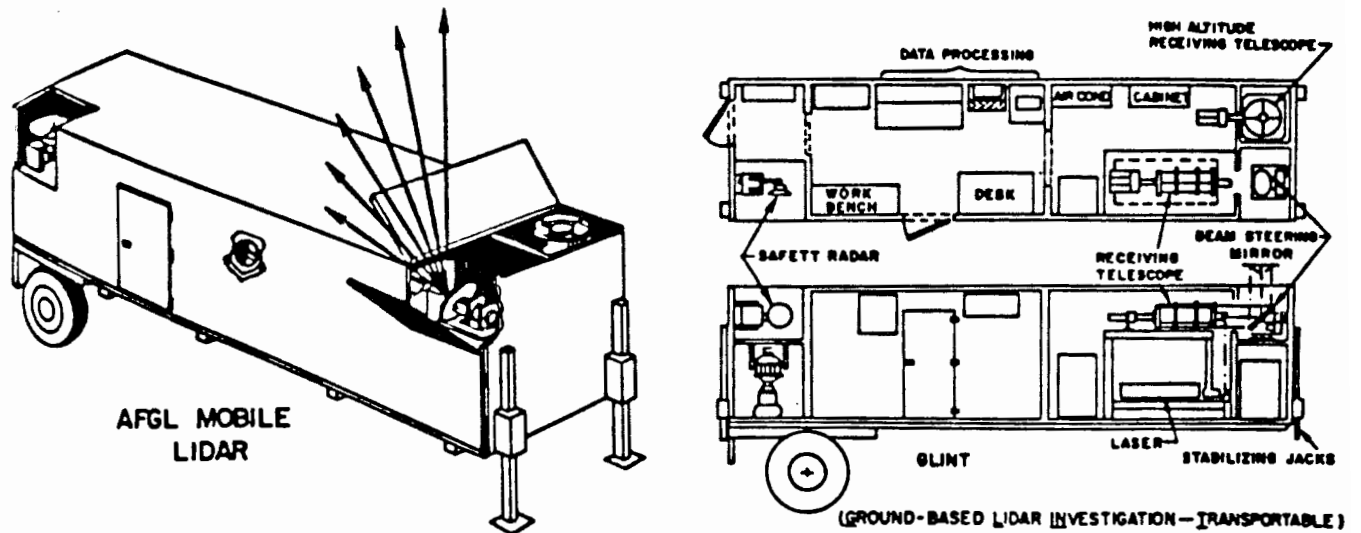


Figure 1. An artist sketch of the GLINT trailer and the primary components of the lidar. Top and side views of the lay-out of the equipment in the trailer are shown.

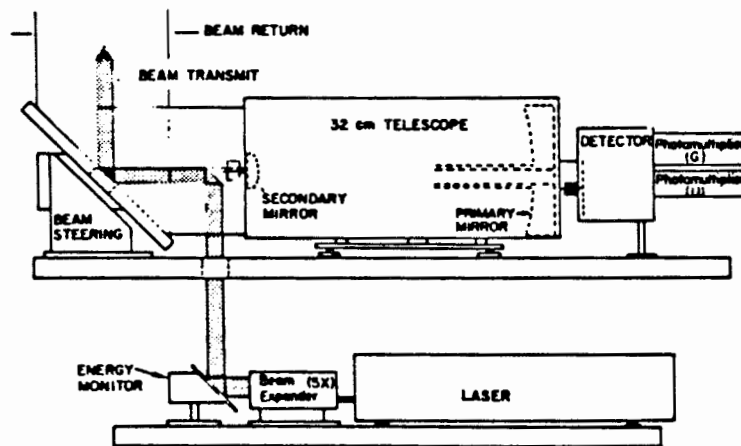


Figure 2. A side view of the optical layout of the lidar shows the principle components and the relationship of the transmit beam path and the collected signal.

Table I. The principle components of the mobile lidar.	
Transmitter	- Nd:YAG laser, 10 Hz, Q-switch, 15 watt 600 mj @ 532 nm, 250 mj @ 355 nm
	5X beam expander with final divergence 0.16 mrad
Receiver	- 32 cm telescope (steerable) photon counting with shutter closed below 15 km and variable aperture up to 40 km - nominal fov 1.0 mrad
	- 62 cm telescope (vertical pointed) photon counting with mechanical shutter below 40 km
Data System	- Lecroy 3500 multichannel scaler with 2 microsecond range bins (300 meter resolution) for each detector - data stored on magnetic disk
Safety System	- Electrical interlocks and radar used to automatically disable the laser

SUMMARY OF RESULTS

On each evening of lidar operation, a series of 3-5 profiles were obtained using the ultraviolet wave length at 355 nm and the visible wavelength at 532 nm, simultaneously. Figure 3 shows an example of the profiles measured by the green and ultraviolet detectors on the 32 cm telescope. Above 30 km, the profiles are in complete agreement and below 30 km, the signal from the green detector is significantly higher than that for the ultraviolet detector. The ultraviolet return is relatively larger for the molecular scattering and thus less sensitive to the particulate scattering. This fact is due to the $1/\lambda^4$ dependence of the molecular scattering cross section. By using the two colors, green and ultraviolet, it is possible to resolve the question of what altitude regions can be properly analyzed as pure Rayleigh scatter from which density and temperature can be directly determined.

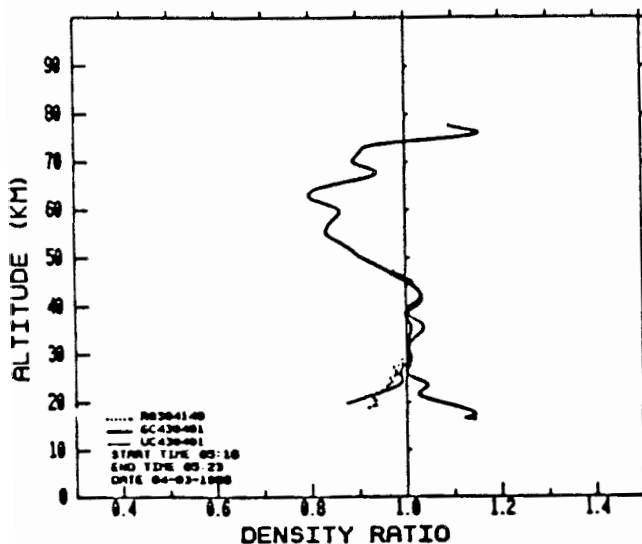


Figure 3. Comparison of the visible and ultraviolet lidar profiles.

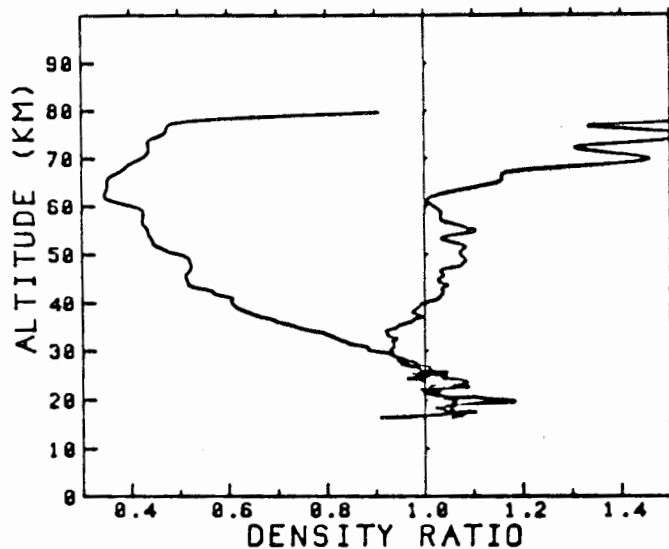


Figure 4. Comparison of the seasonal extremes measured on 14 February and 27 April.

Figure 4 shows an example of the extremes of the measured conditions. The profiles are shown as a density ratio to the USSA76 model. The profile of 14 February is typical of the lower winter density in the mesosphere and the higher density of the summer is represented by the 27 April profile. The high latitude atmosphere exhibits these large seasonal changes due to the change from complete darkness in winter to continuous sun in the summer. The solar control drives large changes in the circulation of the atmosphere in the polar region. Note that the region between 18 and 25 km exhibits intense narrow layers. This signal is due to the aerosols, polar stratospheric clouds, and volcanic dust.

The measurements conducted during this campaign represent the first serious attempt to compare lidar data and profiles from meteorological rockets. An example of the lidar profile obtained during the flight of a datasonde is shown in Figure 5.

The size of the $\pm 1\sigma$ error bar is shown on the lidar data with a spacing which indicates the length of the smoothing interval. The example exhibits rather strong wave activity, which was observed frequently in March. Cases of both excellent agreement and significant difference between the rocket and lidar results were obtained. Figure 6 shows an example of the planetary wave variations measured with the lidar during a major stratospheric warming which peaked on 20 February. The mean night profiles provide a graphic picture of the development of the stratospheric warming.

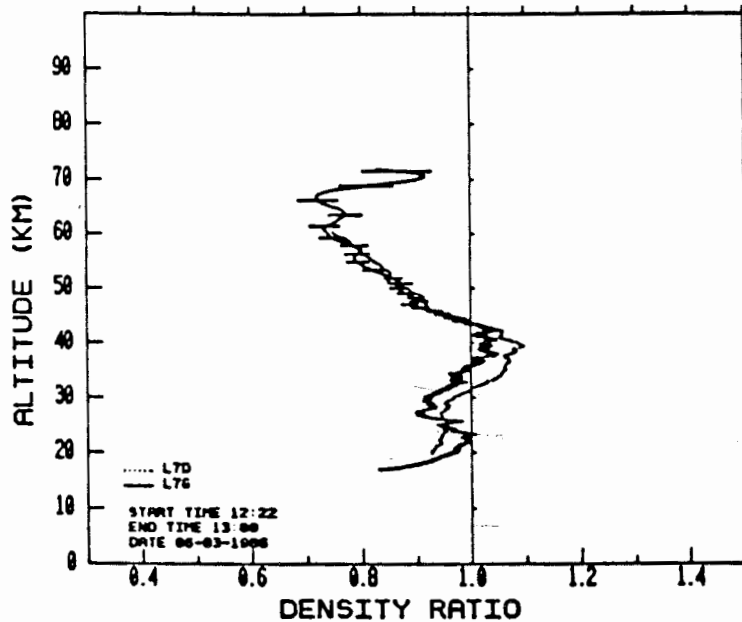


Figure 5. Comparison of the lidar profile from the 32 cm telescope detector(G) with a standard datasonde profile(D).

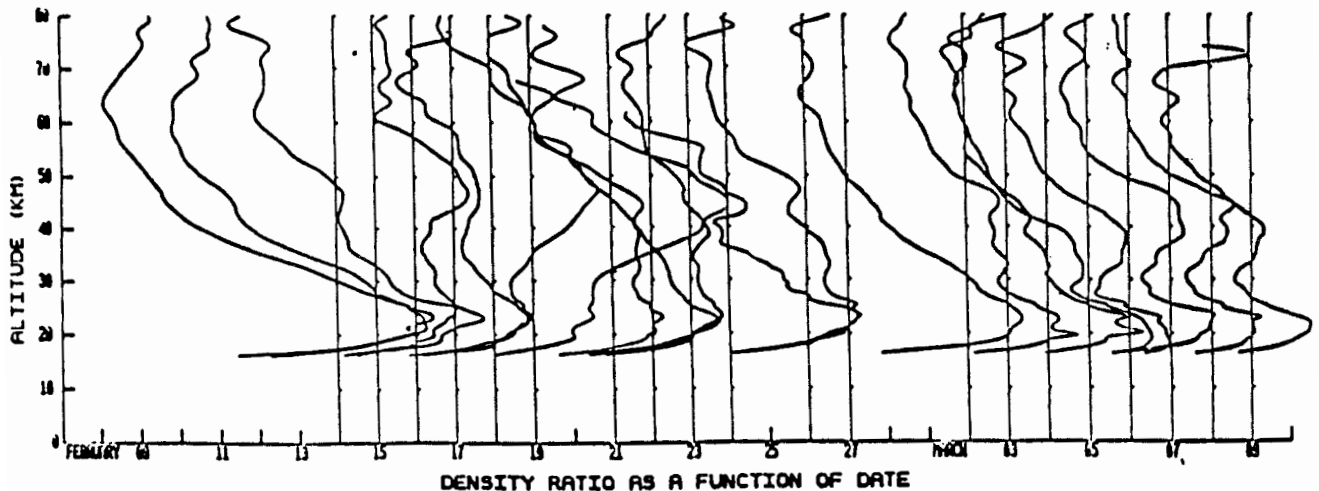


Figure 6. Sequence of mean night profiles of the density ratio to the USSA model which show the change in response to a major stratospheric warming.