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XeF LIDAR MEASUREMENTS OF DENSITY AND TEMPERATURE IN THE MIDDLE ATMOSPHERE

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In recent years, it has been widely recognized that vertically propagating internal gravity waves in the middle atmosphere play an important role in determining the large-scale wind field by their momentum transport and deposition.[1] However, very little is known about them in the upper stratosphere and lower mesosphere (between 30-60 km altitude range) because of the lack of adequate techniques to observe small-scale motions. The works by Chanin et al.[2] proved that a Rayleigh lidar, using a high-power frequency doubled Nd:YAG laser (532 nm), is a very useful tool to study gravity waves in this height range through the observations of the density and the temperature.

In this paper, we used an XeF excimer laser for the Rayleigh lidar observation.[3] The characteristics of our XeF lidar system are show in Table 1. The wavelength of the XeF laser (~351 nm) is in the region that is ozone absorption free, and the Rayleigh scattering cross section is 5 times larger than in 532 nm. We have discussed in detail the advantages of using the XeF laser, as against the YAG laser, for the measurements of density and temperature in Ref.3.

Fig.1 a and b show density and temperature profiles between the altitude range of 30 and 70 km measured with this lidar system. The accuracy of the density and the temperature measurements is less than ±3% and 10 K at 60 km for an observation time of 15 min. Due to the first repetition rate, the XeF laser is suitable for the observation of the short term fluctuation in the density. Fig.2 shows the time-height section of the density fluctuation on 25-26 November. To take this data, we continuously emitted about 1.3×10^6 laser shots without changing the laser gas. Isolines are for zero density change, and separate the zones of positive difference (hatched area) from the negative difference. In this case the phase of the waves is downward propagating, and an average vertical wavelength is about 10 km. The results on the gravity waves by the observation through about one year since April 1985 will be presented.

References

1. Fritts, D.C., Rev. Geophys. Space Phys. Vol.22 275(1984)
2. Chanin, M.L. and A. Hauchecorne, J. Geophys. Res. Vol.86 9715(1981)
3. Shibata, T. et al., Appl. Opt. 1 March (1986)

Table 1 Characteristics of the XeF lidar system

Transmitter	
Laser	XeF
Wavelength	351,353 nm
Energy per pulse	200 mJ
Pulse duration	20 nsec
Pulse repetition rate	80 Hz
Beam divergence	1 mrad
Receiver	
Telescope	50 cm diameter Coude-type
Field of view	2 mrad
Photomultiplier	EMI9558QB
Filter FWHM (transmission)	3 nm (30 %)
Photon counter	
vertical resolution	1 μsec
channel number	1000
memory	floppy disk

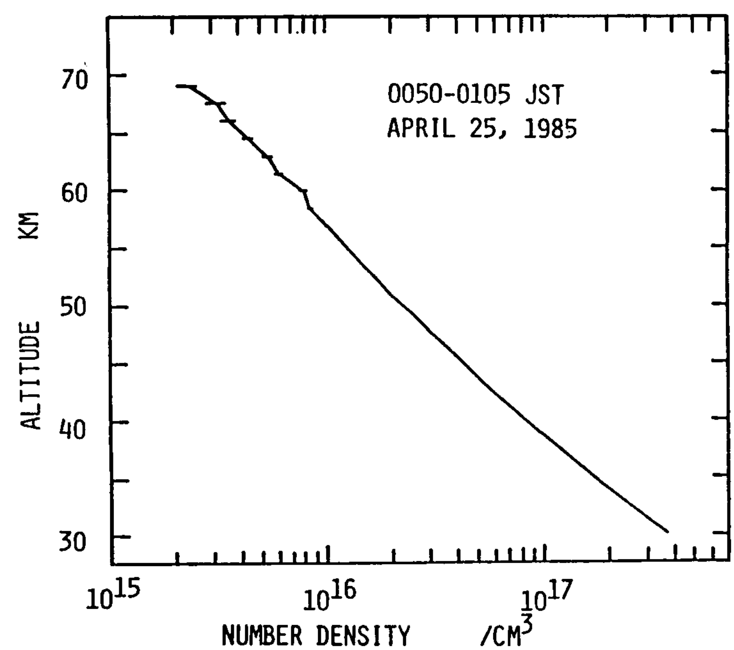

Fig. 1a Density profile measured between 0050 and 0105 JST on 25 April, 1985. The profile was normalized at 39 km with CIRA '72.

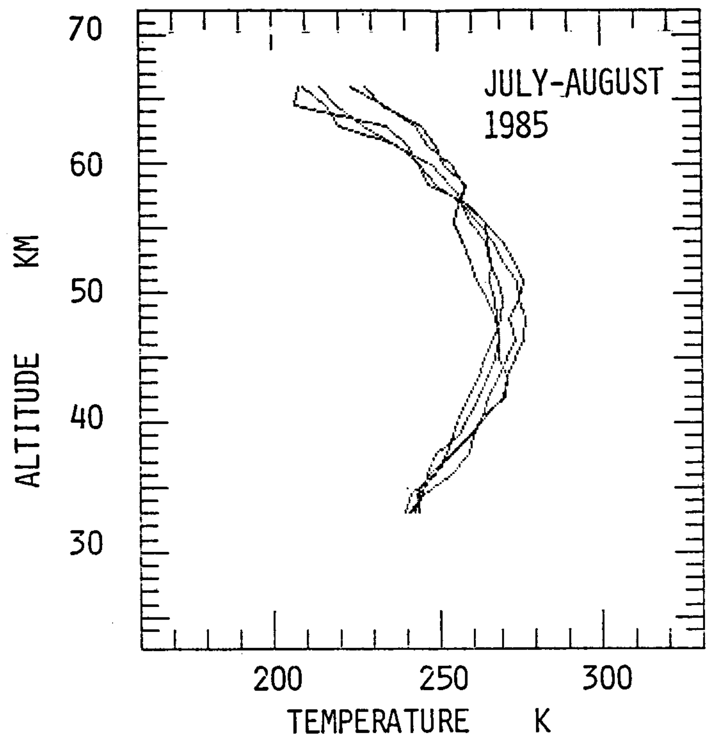

Fig.1 b Temperature profiles in July and August, 1985

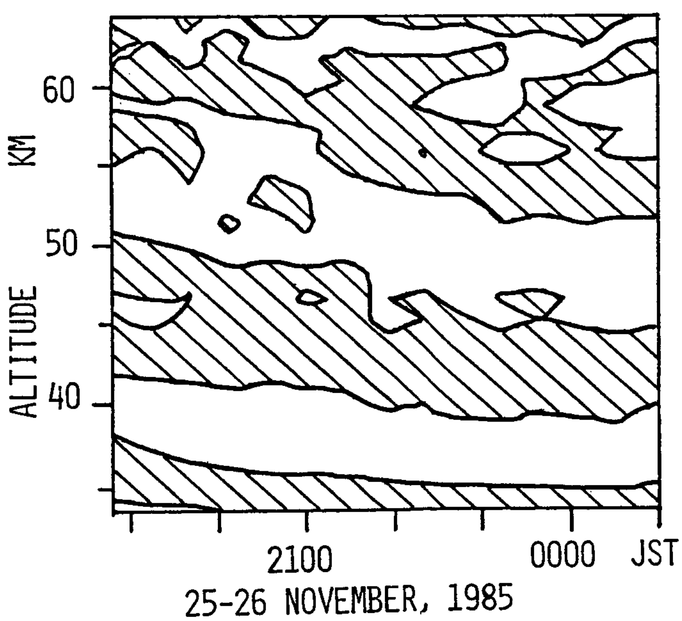

Fig. 2 Time-height section of the density fluctuation