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A Novel Technique for Measuring Radial Wind and Temperature in the Mesopause Region

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Since the realization of different narrowband Na lidar techniques by Fricke and von Zahn [1985], and She et al. [1990], research based on active probing of temperatures in the mesopause region continues and several publications with geophysical significance have already appeared in the literature [Lubken and von Zahn, 1991; She et al., 1991; Bills et al., 1991; Bills and Gardner, 1993; She et al., 1993].

Studies of the middle atmosphere are incomplete without detailed knowledge of its wind structure and/or associated momentum fluxes. In the mesopause region, these quantities can also be measured by the same Na lidar if it is modified to probe Doppler shift as well as Doppler broadening in Na fluorescence. This requires a minimum of two intensity ratio to be measured. We report such a modification using an acoustooptic frequency shifter, and initial observation of temperature and radial wind carried out on Sep 3, 4, and 21 (UT) over Fort Collins, CO (40.6^{o}N, 105^{o}W).

In principle, the two required intensity ratios for temperature and wind measurements may be obtained by exciting Na fluorescence at three chosen frequencies, ν_a=-652MHz, ν_s=-172MHz, and ν_c=188MHz. As it was done previously [She et al., 1992] the Doppler-free fluorescence spectrum of a laboratory cell is used to tune the laser to ν_a, and ν_c. By locking the cw laser to ν_a, a uniquely constructed acoustooptic frequency shifter as shown in Fig. 1 is inserted between the cw ring dye laser and the pulsed dye amplifier (PDA) of the narrowband Na temperature lidar [She et al., 1992] to shift the laser frequency from ν_a to $\nu_s=\nu_a+2\Delta f$ as desired.

For the initial measurements, the laser beam and receiving telescope as limited by the geometry of our "observatory" were pointed at the North-East direction, 15^{o} off Zenith. The operational procedure for the new lidar with acousto-optic modulator is no more complicated than the one without it as a computer is used to automatically set the laser transmitter to the desired frequencies in a pre-selected sequence. The system worked smoothly without any problem.

A pair of individual temperature and radial wind profiles is obtained every 2 min with 1.5 km and 6 min resolution; these profiles may be used to study thermal and dynamical activities in the mesopause region as well as their correlation and variability. Shown in Figs. 2(a) and 2(b) are, respectively, a sequence of 20 individual radial wind and temperature profiles taken from 8.5 h to 9.1 h (UT), on Sep 21, 1993. It is possible to identify upward propagating waves in these profiles as indicated by the slant parallel lines drawn in Figs. 2(a) and 2(b); downward propagating phase fronts at a phase speed of 0.55 m/s are quite observable in different parts of radial wind and temperature profiles. These phase fronts appear short-lived due to the existence of other interfering wave components. For example, one such phase front sequence with nearly zero phase speed is seen near 97 km in the radial wind profiles, Fig. 2(a), but not in the temperature profiles, Fig. 2(b).

The operational principle of this new Na Wind/Temperature lidar in general and the novel acoustooptic modulator in particular will be explained. The data analysis procedure as well as other results of these initial observations will be discussed in the meeting.

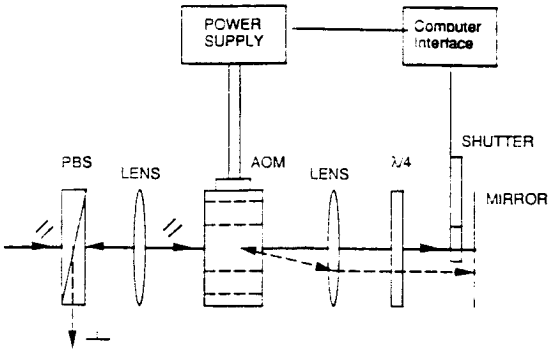

Fig. 1 The schematic of a uniquely constructed acousto-optic frequency shifter.

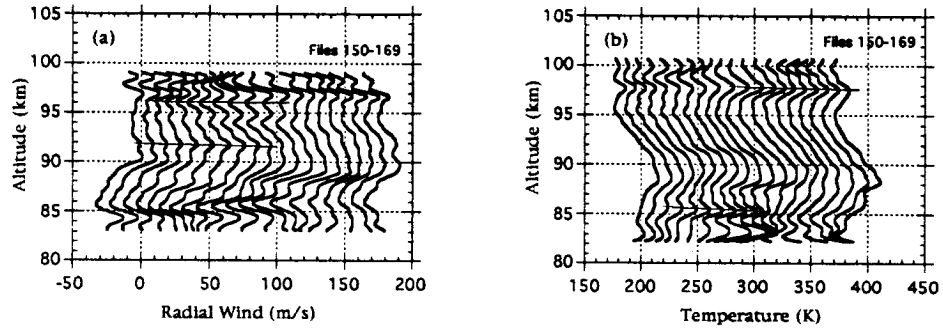

Fig. 2 Time series of (a) radial wind and (b) temperature profiles taken from 8.5 h to 9.1 h, UT, on Sep 21, 1993 over Fort Collins, CO showing wave structure and evidence of downward propagating phase fronts at a speed of 0.55 m/s. The scales in (a) and (b) apply respectively to the first radial wind and temperature profiles; successive profiles are each spaced by 10 m/s for (a) and 10 K for (b).

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