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LIDAR DETECTION OF METALLIC SPECIES AT THE MESOPAUSE LEVEL

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The measurement alkali species present in the atomic form at the mesopause level has been performed by lidar for more than ten years. Atomic and ionic calcium density profiles are obtained for 3 years by the same technique in the visible range, at 423 nm for atomic calcium, and 393 nm for ionic calcium Ca^+. The experimental set-up and the preliminary results have been presented in Granier et al. (1985). The 423 nm wavelength is directly obtained by the emission of a dye laser pumped by the third harmonic of a Nd-Yag laser. For the generation of the 393 nm wavelength, we have used frequency mixing : the emission at 624 nm of a dye laser pumped by the 2nd harmonic of a Nd-Yag laser is mixed with the fundamental infrared emission (remaining after frequency doubling), in a non-linear KDP crystal, which gives the 393 nm emission.

Atomic calcium

Measurements of the atomic calcium densities have been performed over 31 nights between December 1982 and December 1985. The atomic calcium layer is situated between 80 and 105 km, and the calcium averaged total content is 1.8 10^7 cm^{-2}. We have compared the behaviour of the two atomic species, calcium and sodium, which are in the same altitude range, and besides present a similar abundance in the meteoric source. Simultaneous lidar measurements of these two species are available for 17 nights distributed over 3 seasons, summer, autumn and winter. Table 1 presents the averaged calcium contents and the corresponding sodium ones.

The atomic calcium content is always much lower than the sodium one, the averaged sodium to calcium abundances ratio being about 140. As it has been usually observed at mid-latitudes, the sodium content presents an important seasonal variation between summer and winter ; however, no significant seasonal variation can be noticed on the atomic calcium data. Typical calcium profiles obtained in different seasons will be presented and compared.

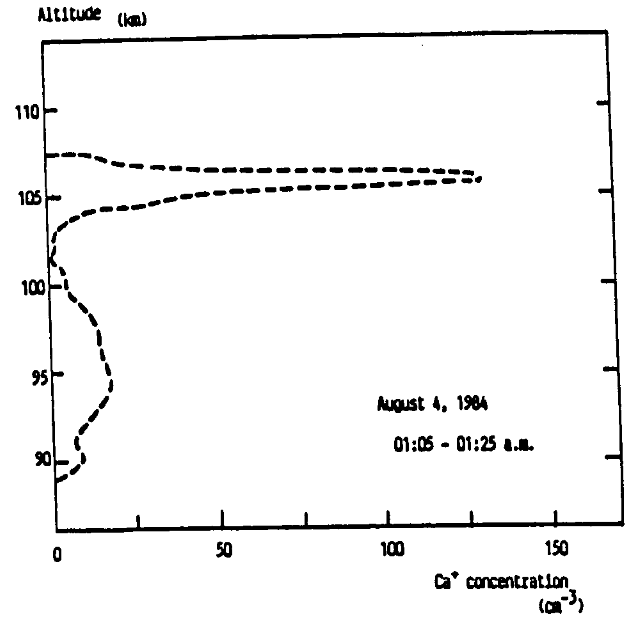
		Ca	Na
DECEMBER 1982	(1)	$9.1 \cdot 10^6$	$5.7\ 10^9$
OCTOBER 1983	(1)	$2.4\ 10^7$	$9.9\ 10^8$
JULY 1984	(3)	$1.2\ 10^7$	$1.2\ 10^9$
AUGUST 1984	(4)	$2.\ 10^7$	$2.1\ 10^9$
OCTOBER 1984	(2)	$2.3\ 10^7$	$2.3\ 10^9$
DECEMBER 1985	(6)	$1.9\ 10^7$	$3.2\ 10^9$
AVERAGED TOTAL CONTENT		$1.8\ 10^7$	$2.5\ 10^9$

Table 1 - Monthly averaged calcium and sodium total content (atoms.cm^{-2}).

Ionic calcium

For 45 % of the observations, no ionic calcium has been detected : the ionic calcium abundance was thus below the detection threshold, estimated to be 6.10^6 cm^{-2}. Contrasting with the density profiles of the atomic species, sodium and calcium, the ionic calcium profiles present important variations on small time scales.

For 50 % of the effective observations (19 nights), the density profile shows a very thin layer centered at altitudes higher than 100km, in which the ionic density varies very rapidly from 100 to 1000 cm^{-3}, which corresponds to total abundance values from 3.10^7 to 10^8 iono.cm^{-2}. The existence of such layers has been attributed to the presence of sporadic-E layers. For 20 % of the effective observations, the ionic layer is more diffused and centered around 91-95 km. The averaged ionic calcium content in these layers is about 2.10^7 cm^{-2}, which can be compared with the $1.8\ 10^7$ cm^{-2} value of the atomic calcium averaged content. The rest of the effective observations shows profiles combining the preceding features as shown for example in fig. 1, which represents a ionic calcium profile obtained on August 4, 1984.



Ca^+ content : $89.2 < z < 101.2$ km : $1.5\ 10^7\ cm^{-2}$
$101.8 < z < 107.8$ km : $1.4\ 10^7\ cm^{-2}$

Fig. Ionic calcium profile obtained on August 4, 1984, between 1.05 and 1.25 a.m.

The main characteristics of the atomic and ionic calcium behaviours we can deduce from these measurements are :

- the atomic calcium content is more than 100 times lower than the sodium one, though they have similar abundances in the meteoric source
- no significant seasonal variation of the calcium atom has been observed
- atomic and ionic calcium total contents have similar values, when profiles in the same altitude range are compared

<u>Other metallic elements</u>

In order to improve our knowledge on the atomic metallic species behaviour, it would be important to obtain measurements of at least one of the major metallic meteoric elements : the iron atom has a resonance wavelength in the visible range at 372 nm, and it is thus possible to detect it from the ground, as demonstrated by the photometric observations of Tepley et al. (1981). For lidar experiments, this resonance wavelength can be obtained by different techniques :

- frequency mixing of the fundamental emission of a Nd-Yag laser (1.064 µm) and of the 572 nm emission of a dye laser
- frequency doubling of the 744 nm emission of an Alexandrite solid laser possessing spectral narrowing and wavelength tunability

The feasability of this experiment is in progress.

References

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