Statistical characterization of air ion spectra at Tahkuse Observatory 1993–1994

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Abstract. Air ion spectrum in mobility range of 0.00032–3.2 $cm^2V^{-1}s^{-1}$ is continuously measured and recorded at Tahkuse Observatory, Estonia. Statistical characteristics of the air ion mobility spectra are presented for the period from September 1, 1993 to October 27, 1994.

A survey of early results about air ion mobility spectra is presented in a well known book (Israël, H. *Atmospheric Electricity*, Washington and Jerusalem, 1970). First wide range mobility spectrum similar to contemporary measurements is published in paper (Yunker, E.A. The mobility spectrum of atmospheric ions, *Terr. Magn. Atmos. Electr.* **45**, 127–132, 1940). An innovation is responsible for this result: Yunker has introduced the multichannel technique.

The air ion mobility spectrum varies with weather and long-term measurements are necessary to draw statistically founded conclusions. A complication is the inconvient maintenance of the instrumentation. We know only two sites where the long-term measuring of full range air ion mobility spectra has been running during last years: Tahkuse, Estonia, and Pune, India.

The air ion measuring in Tahkuse has started eleven years ago. A full mobility scale air ion spectrometer was installed 1988. A resume of results until 1989 has been reported in the paper (Hõrrak, U., H. Iher, A. Luts, J. Salm, and H. Tammet, Mobility spectrum of air ions at Tahkuse Observatory, *J. Geophys. Res*., **99**, 10679–10700, 1994.). The statistical synopsis for the latter subperiod from September 1, 1993 to October 27, 1994 is given in the present report.

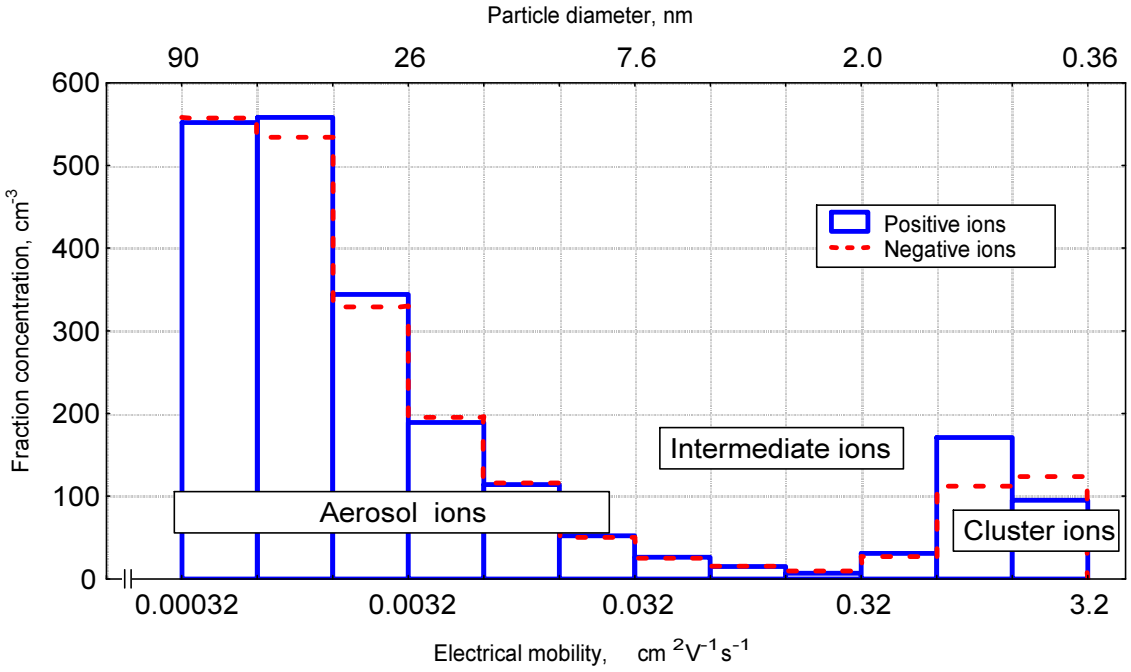
Tahkuse Observatory is located in a sparsely populated rural region. The air inlet is electrostatically shielded by trees at a height of about 5 m from the ground. The instrument consists of three multichannel DMA tubes.The whole range of mobility is logarithmically divided into 20 intervals:

9 intervals in the subrange of 0.00032–0.25 $cm^2V^{-1}s^{-1}$

11 intervals in the subrange of 0.25–3.2 $cm^2V^{-1}s^{-1}$.

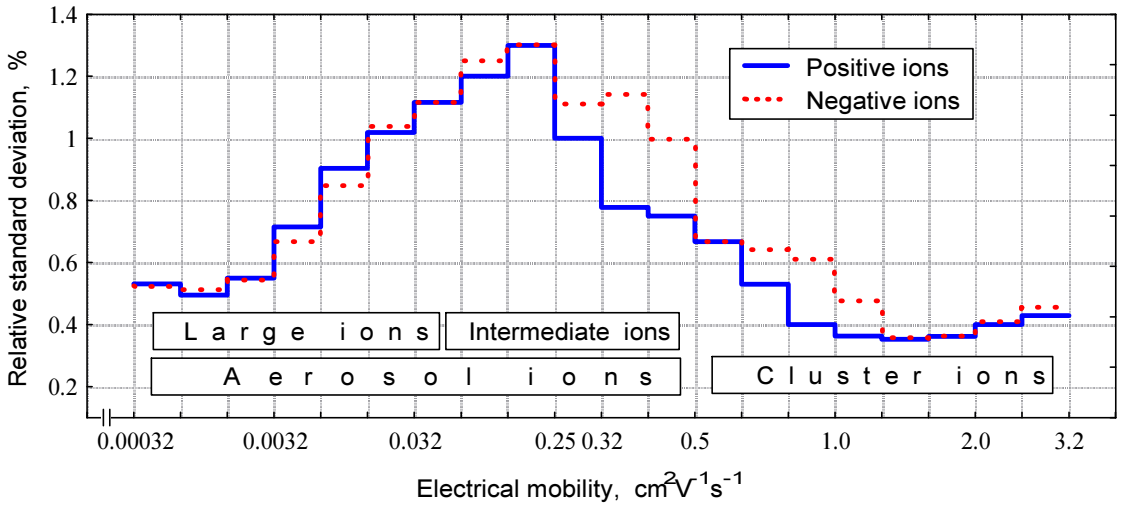
The positive and negative air ion mobility spectra were measured in every 5 minutes. Simultaneously measured quantities are: wind direction, wind velocity, atmospheric pressure, temperature, relative humidity, and concentration of NO_2.

The period under the analysis involves 10224 hours. Due to pauses and failures, about 12% of the possible measuring time was lost and 8948 hourly mobility spectra of both sign are available.



Average mobility spectra of positive and negative air ions.

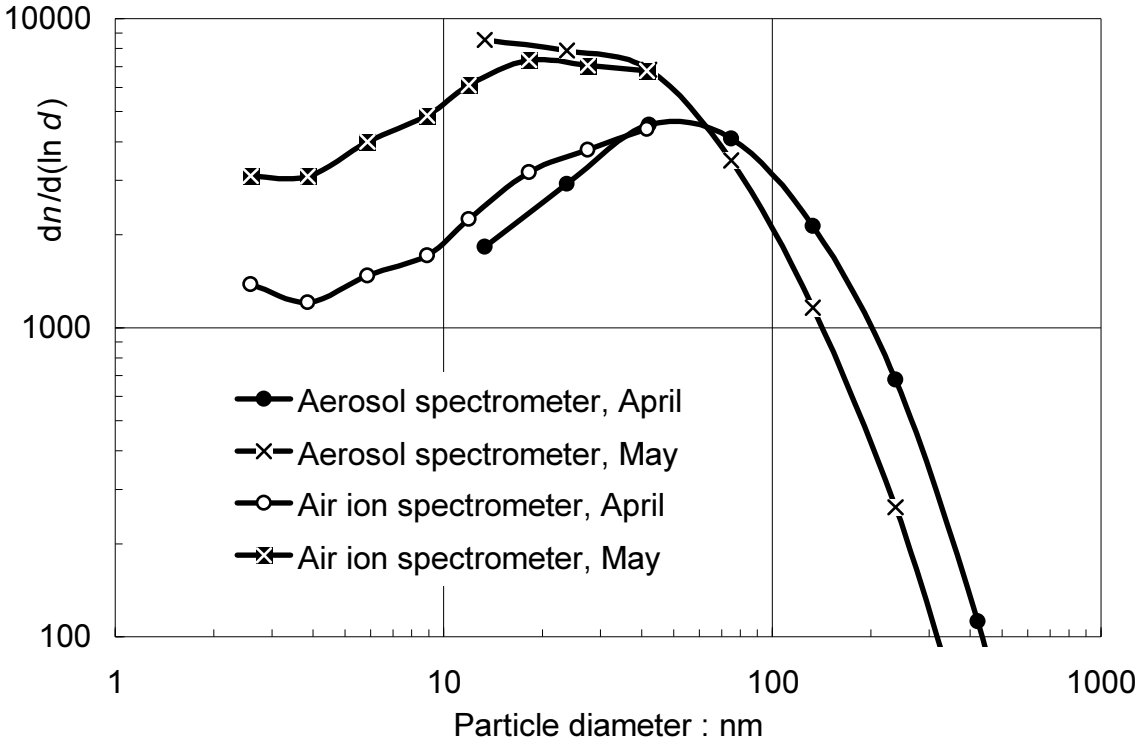
The average concentration the intermediate ions (0.05–0.5 $cm^2V^{-1}s^{-1}$) is about 50 cm^{-3}.



Relative standard deviations of the air ion fraction concentrations.

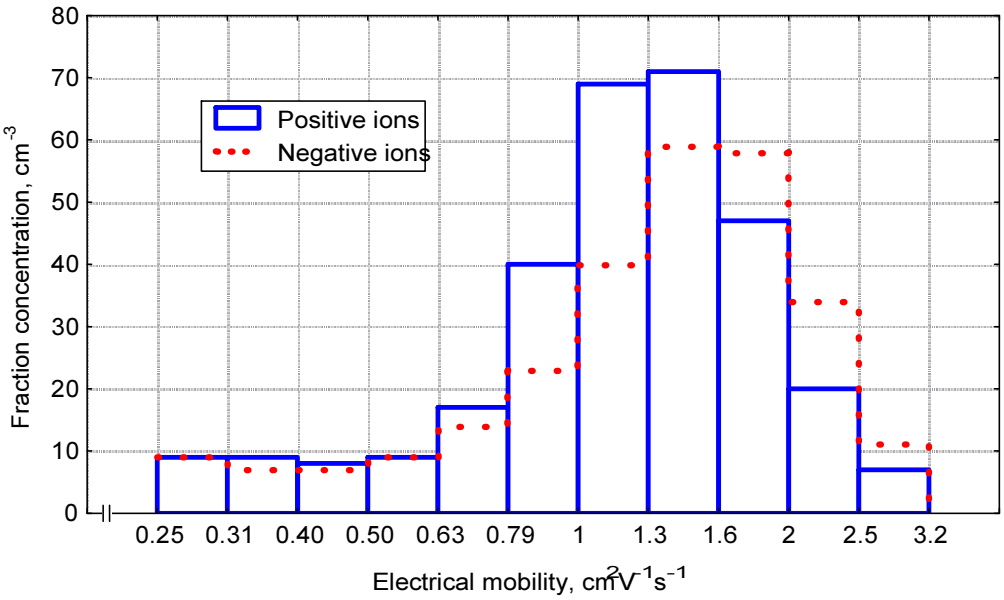
September 1, 1993 – October 27, 1994. Tahkuse Observatory.

When comparing the data of 1993–1994 with earlier measurements of 1988–1989 (Hõrrak *et al.*, 1994), the fraction concentrations of negative large ions appear to be reduced about 1.5 times. In the case of positive large ions analogous reduction touches only two fractions of the lowest mobility. The general shape of the spectra in the range of large ions is in accordance with average aerosol size distribution and the theory of bipolar charging of aerosol particles (Salm, J., The average mobility spectrum of large ions of the troposphere, *Res. Lett. Atmos. Electr*., **8**, 21–24, 1988). It seems, the information obtained by large air ion measuring is largely the same as the information obtained by direct measuring of atmospheric aerosols. Actually, the air ion measuring is essentially complementing the traditional aerosol measurements:



Size distributions of atmospheric aerosol at Tahkuse, 1994, directly measured by an aerosol size spectrometer and calculated according to large air ion measurements.

(Hõrrak, U., J. Salm, E. Tamm, and H. Tammet "Derivation of the size spectrum of aerosol particles from a mobility spectrum", submitted to the 14th ICNAA, Helsinki, 1996)



Average mobility spectra of intermediate and cluster ions.
September 1, 1993 – October 27, 1994. Tahkuse Observatory.

The average concentrations of small air ions

$$n_- = 248 \text{ cm}^{-3} \qquad n_+ = 280 \text{ cm}^{-3}.$$

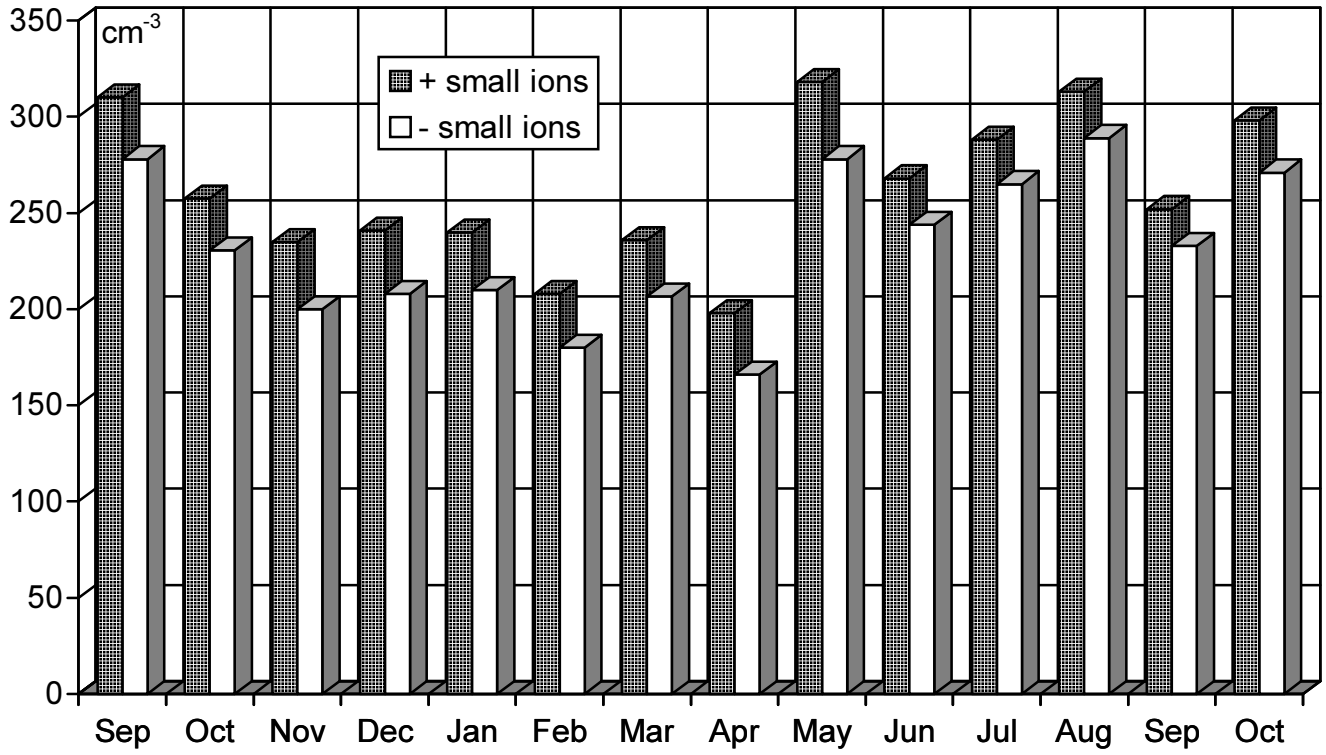
are about 20% less than during the period of 1988–1989 and 45% less than during 1985–1986. The average unreduced mobilities of small air ions

$$k_- = 1.51 \text{ cm}^2\text{V}^{-1}\text{s}^{-1} \qquad k_+ = 1.35 \text{ cm}^2\text{V}^{-1}\text{s}^{-1}$$

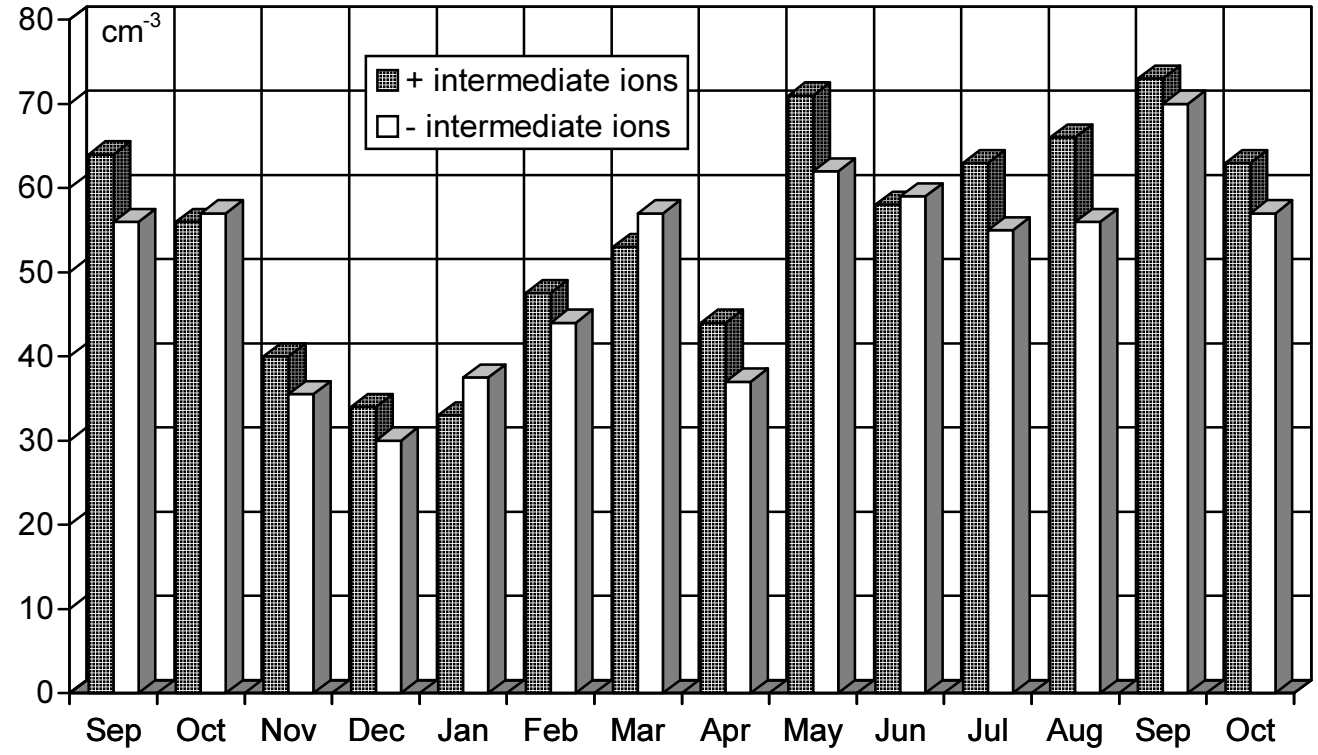
are nearly the same for all three measuring periods. The average polar conductivities caused by small ions were

$$\lambda_- = 6.25 \text{ fSm m}^{-1} \qquad \lambda_+ = 6.33 \text{ fSm m}^{-1}.$$

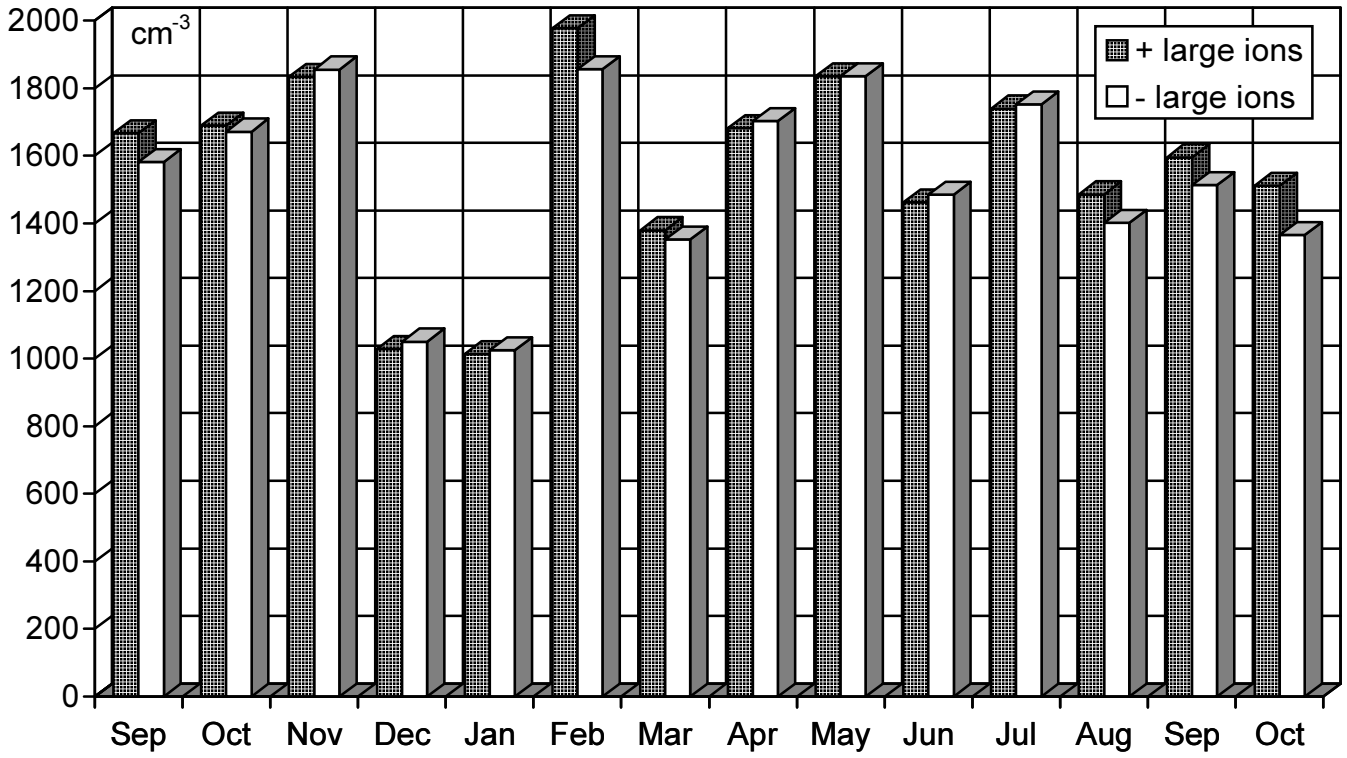
Small ions are responsible for 96%, intermediate ions for 3%, and large ions for 1% of total conductivity.



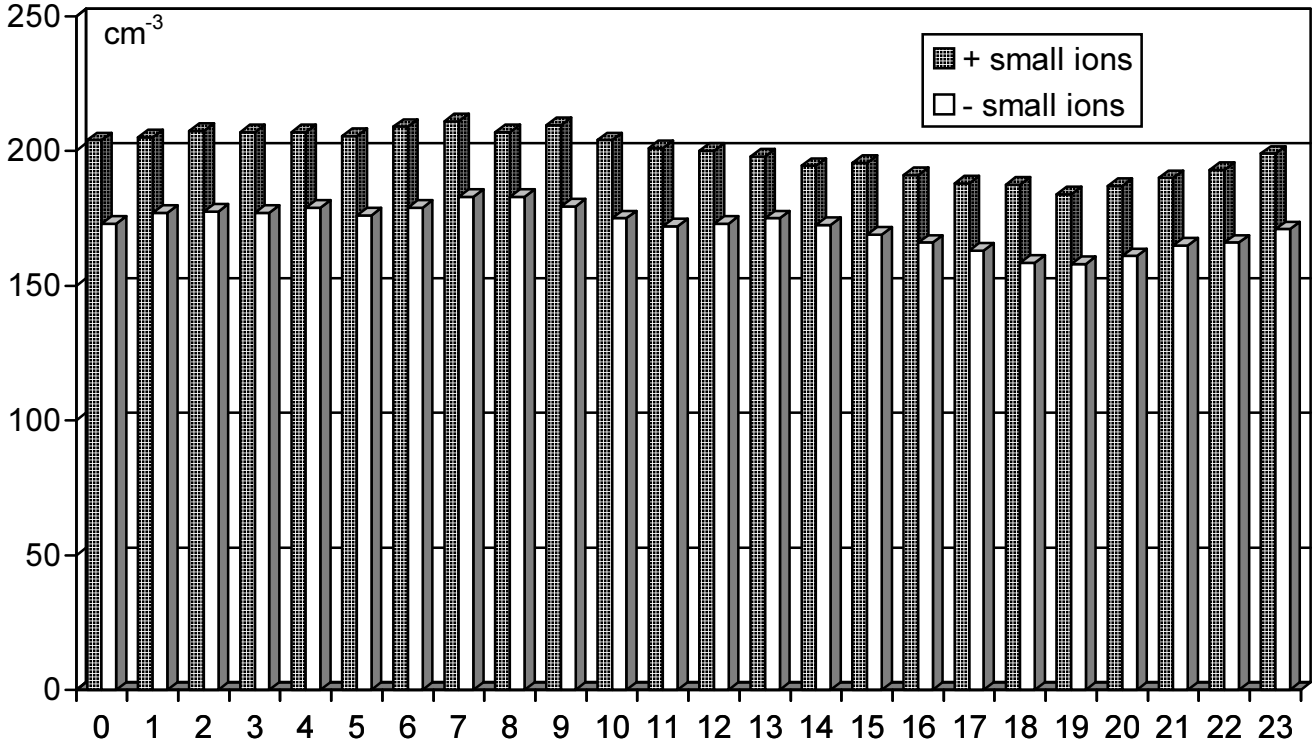
Monthly average air ion concentrations at Tahkuse 1993–1994
(Mobility 0.5–3.2 $cm^2V^{-1}s^{-1}$)



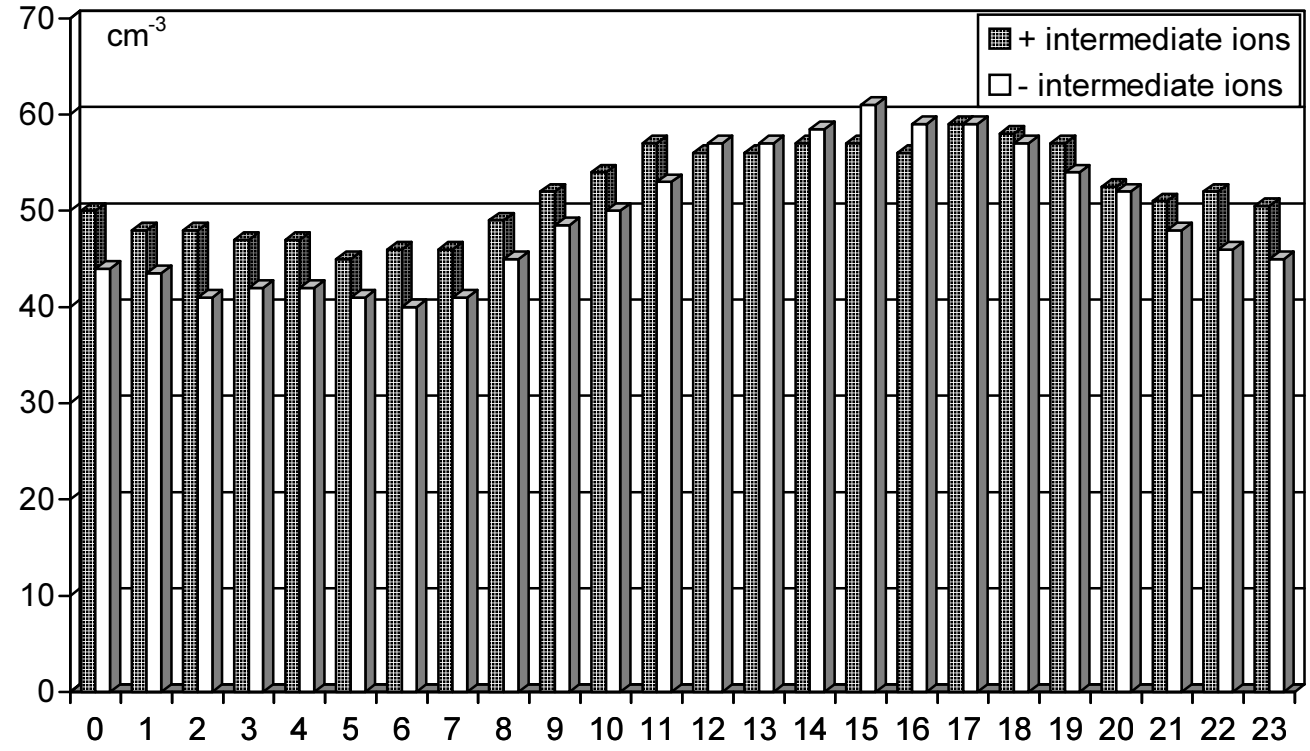
Monthly average air ion concentrations at Tahkuse 1993–1994
(Mobility 0.032–0.5 $cm^2V^{-1}s^{-1}$)



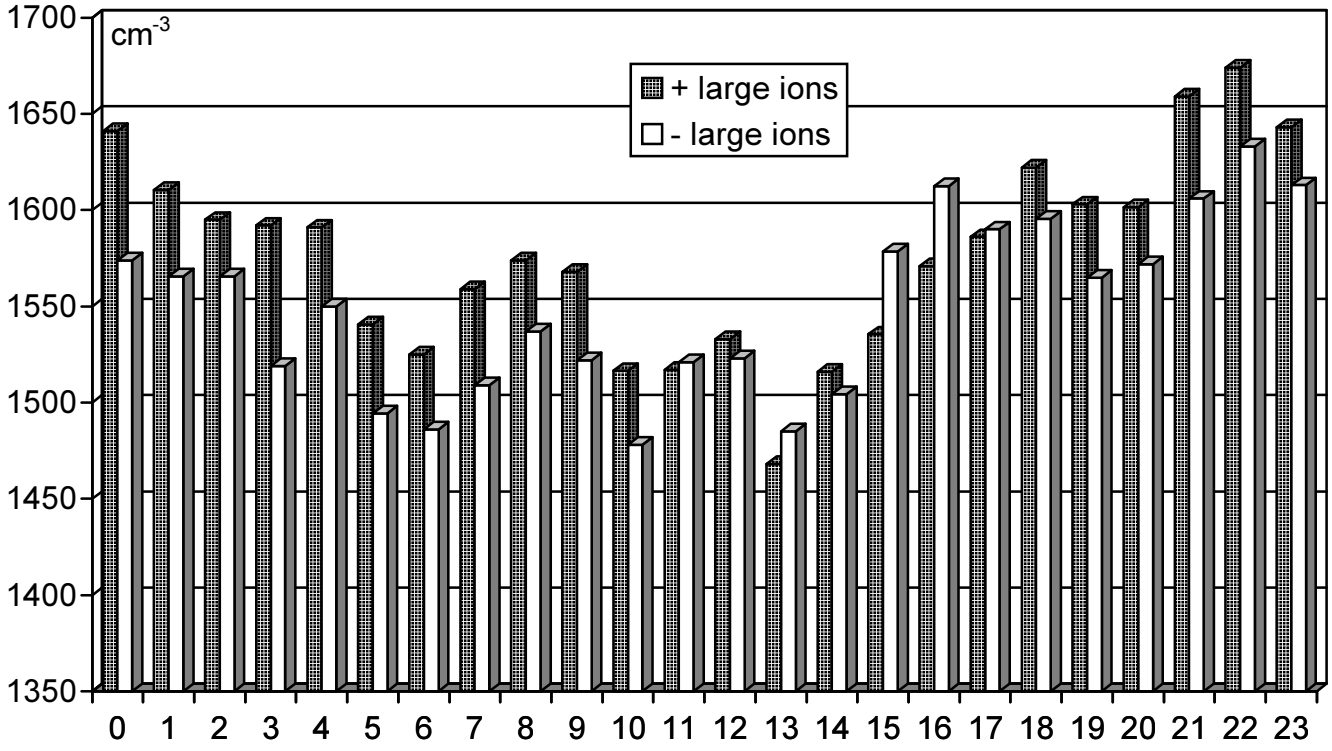
Monthly average air ion concentrations at Tahkuse 1993–1994
(Mobility 0.00032–0.032 $cm^2V^{-1}s^{-1}$)



Hourly average air ion concentrations at Tahkuse 1993–1994
(Mobility 0.5–3.2 $cm^2V^{-1}s^{-1}$)



Hourly average air ion concentrations at Tahkuse 1993–1994
(Mobility 0.032–0.5 $cm^2V^{-1}s^{-1}$)



Hourly average air ion concentrations at Tahkuse 1993–1994
(Mobility 0.00032–0.032 $cm^2V^{-1}s^{-1}$)

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