# 2. THE MEASURING STATION

## 2.1. Location

Tahkuse Observatory (58°31'N 24°56'E) is located in a sparsely populated rural region of 27 km north-east of the city of Pärnu, and 100 km south of Tallinn, the capital of Estonia. Pärnu, with 52000 inhabitants, is located on the coast of the Gulf of Riga, at the east coast of the Baltic Sea (Figure 1). The observatory has been positioned in an one-storied farmhouse. The terrain surrounding the observatory consists of flat open country with some tree groups (about 100 trees in a radius of 100 m), small woods, grassland and agricultural land. The Pärnu River is 50 m to the northwest. The nearest neighboring farm is about 200 m to the west, the next about 400 m to the northeast, the local center Jõesuu (about 300 inhabitants) is located 4 km to the SSW. A road with little automobile traffic passes about 180 m east from the measurement point. The average traffic frequency was about 10 motor vehicles per day, mainly from 7 to 19 LST, in 1993–1994. The *Soomaa National Park* (Swampland) extends at distances from 6 to 30 km southeast.


**Figure 1**. Location of Tahkuse Observatory.

## 2.2. Meteorological characterization

According to the Köppen classification system [*Ahrens*, 1993], Estonia belongs to the region of moist mid-latitude climate with severe winters, subclass of humid continental climate with long cool summers (Dfb). The meteorological description of the annual period of 1993/1994 is given according to the measurements of four stations of meteorological service, surrounding Tahkuse Observatory at the distances of 27–52 km (Pärnu 27 km to the SW, Kuusiku 52 km to the N, Türi 43 km to the NE, and Viljandi 44 km to the SE) [*Agrometeorological survey*, 1993–1994]. The annual cycle of the duration of sunlight (by Pärnu and Kuusiku stations), air temperature and amount of precipitation with respect to climatic standard are presented in Figure 2.

The weather during the measuring period was quite unsteady (due to the action of cyclones and anticyclones); especially in the cold season from November 1993 to March 1994 the weather was far from the long-term average climatic standard. In November and February, the weather was one of the coldest (about 5 °C less than the long term climatic standard) and driest of this century in Estonia; the precipitation was recorded only on few days (1–3); the average temperature and the amount of precipitation were –6 ºC, 8 mm and –12 ºC, 9 mm, respectively. On the contrary, in December and January the weather was relatively warm (–2 ºC) and rich in precipitation, 90 mm and 71 mm, respectively. The amount of precipitation was high also in March, 89 mm. The number of days in December, January and March with precipitation (snow, sleet, and sleet with rain) more than 1 mm per day was 14–19. The stratus overcast was often present at that time. The active cyclones prevailed in December, January and March, and stable anticyclones in November and February [*Berliner Wetterkarte*, 1993–1994].

The weather was unsteady also during the warm season. The air temperature in September 1993 was about 4°C less and in July 1994 about 4°C higher than climatic standard. In July (also in the first decade of August), the weather was exceptionally stable, hot and sunny (durable anticyclones) with the average temperature of 20 ºC. In July the precipitation more than 1 mm per day was recorded only on few days (1–3). The number of days with precipitation more than 1 mm per day was 8–13 in September and October 1993 and from April to August (except July); and 13–17 from September to October 1994.

The soil was frozen since the beginning of November till the third decade of April. The freezing-depth grew rapidly during November up to 50 cm at the end of the month, the maximum 60 cm was recorded in February. Stable snow cover was formed in the second decade of November, and it melted during the last decade of March. At the end of November the depth of snow cover was 2–9 cm, maximum 12–19 cm in the beginning of February. The active vegetation period of plants (daily mean air temperature above 5°C) lasted from April 23 to October 15, 1993 and from April 22 to October 16, 1994.

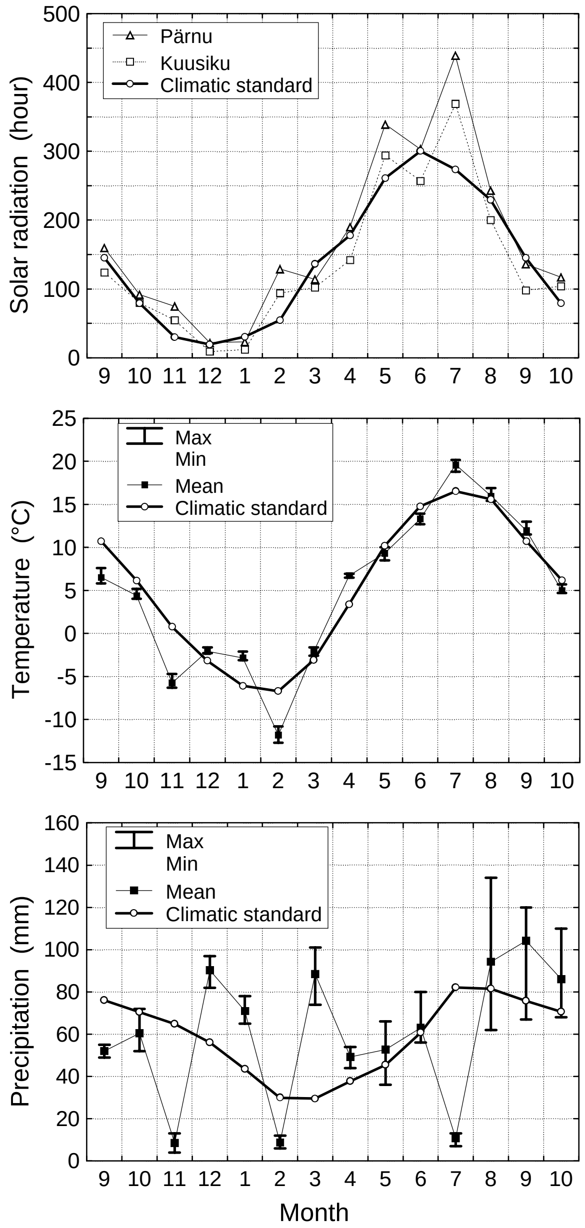


**Figure 2**. Annual variation of meteorological parameters: duration of solar radiation, air temperature and amount of precipitation. Sept. 1993 – Oct. 1994. Descriptive statistics: average of four weather stations and whiskers (min and max of monthly mean value of four different weather stations), and a long term climatic standard.

The wind speed (hourly average) was moderate during the measurement period: the average and standard deviation was $2.3 \pm 1.6$ m s$^{-1}$, the absolute maximum 10.2 m s$^{-1}$ was recorded in April 1994. The distribution of wind by directions shows that the prevailing winds were westerly winds, the secondary maximum was placed at the ENE (see Figure 3). The relatively higher wind speeds (average about 3 m s$^{-1}$) were characteristic to the period from October to March, except February. In summer, wind speed was lower (average below 2 m s$^{-1}$) and nocturnal calms were frequently recorded. Calm and strong inversions were characteristic of February. Calm (hourly wind speed less than 0.5 m s$^{-1}$) prevailed about 18.5 % of all the measuring time.

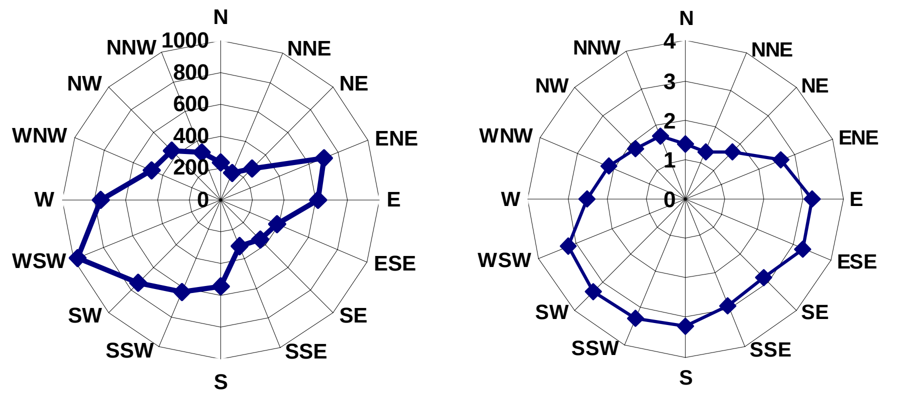


**Figure 3.** Wind rose (frequency distribution, left) and distribution of median wind speed (m s$^{-1}$) by directions (right). Wind speed more than 0.5 m s$^{-1}$. September 1993 – October 1994, Tahkuse Observatory.

## 2.3. Air pollution

### 2.3.1. Dependence of air pollution on wind direction

Commonly used atmospheric electrical parameters of air pollution are air conductivity, small ion concentration and heavy large ion concentration. In the case of constant ionization rate, the concentration of small ions is inversely proportional to the diameter concentration of aerosol particles. The conductivity is defined as the product of ion concentrations, their mobility and charge, summed over all mobilities. The concentration of heavy large ions is related to the content of Aitken mode aerosol particles (20–80 nm) in the air.

The air coming from the sector from the W to the NNW is characterized with higher concentrations of small air ions (0.5–3.14 cm$^2$V$^{-1}$s$^{-1}$) and few heavy large ions (mobility 0.00041–0.0042 cm$^2$V$^{-1}$s$^{-1}$, diameter 22–79 nm) (Figure 4). This sector is expected to be relatively clean compared with others. In the warm season also the sector from the N to the ENE shows higher concentration of small ions (respectively less heavy large ions). The conductivity of air that is closely correlated with the concentration of small ions shows the same regularities as small ions presented in Figure 4: maximum of polar conductivity 6.2 fS $m^{-1}$ corresponds to the NW and minimum 4.8 fS $m^{-1}$ to the ESE direction. The polar conductivities are nearly equal.

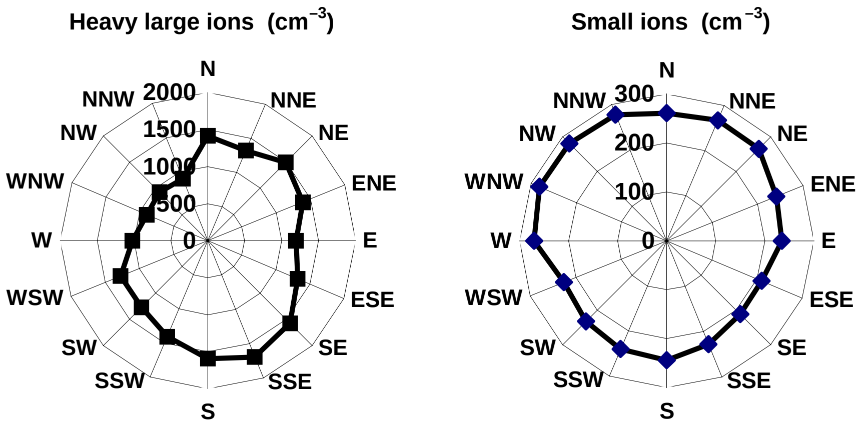


**Figure 4.** The distribution of positive heavy large ion and small ion concentration by wind directions. Wind speed more than 0.5 m $s^{-1}$. September 1993 – October 1994.

In general, the more polluted air was coming with southerly winds (from the ESE to the WSW). The nearest town Pärnu (27 km, the SW direction) does not influence significantly the measurements at Tahkuse. The direct propagation of pollutants from Tallinn and other industrial centres (located about 100–200 km from the N to the NE) was not supported by prevailing winds. The influence of local air pollution to the measurements due to the heating of the observatory building could happen with low winds from the NNW to the NNE or during the low level temperature inversions. The effect is minimized by relatively low contribution of winds from the NNW–NNE sector, and can be detected by the $NO_2$ measurements. The found regularities are in general accordance with the former measurements at Tahkuse in 1985 [*Hõrrak et al.*, 1988a].

### 2.3.2. Summary of $NO_2$ measurements

$NO_2$ is one of the atmospheric pollutants emitted by combustion sources. The annual variations of the concentration of $NO_2$ at Tahkuse in 1991–1996 show a maximum in winter and minimum in summer [*Hõrrak et al.*, 1998d]. Such a variation could be caused by an increase in the emission and accumulation of $NO_2$ in winter, when the vertical mixing of atmosphere is weaker. During the cold season in 1993–1994, the median concentration of $NO_2$ was 4.0 µg $m^{-3}$ in November, 3.5 µg $m^{-3}$ in December, 2.9 µg $m^{-3}$ in January and 5.2 µg $m^{-3}$ in February. Sometimes very high concentrations up to 44 µg $m^{-3}$ (hourly average) were observed. Low median concentrations (about 2 µg $m^{-3}$) and the absence of high spikes were characteristic to the warm season. The frequency distribution (histogram) of the concentration of $NO_2$ is presented in Figure 5. In general, the concentration is at a low background of about 2–3 µg $m^{-3}$, only 0.9% of about 9000 hourly average concentrations exceeds 14 µg $m^{-3}$.

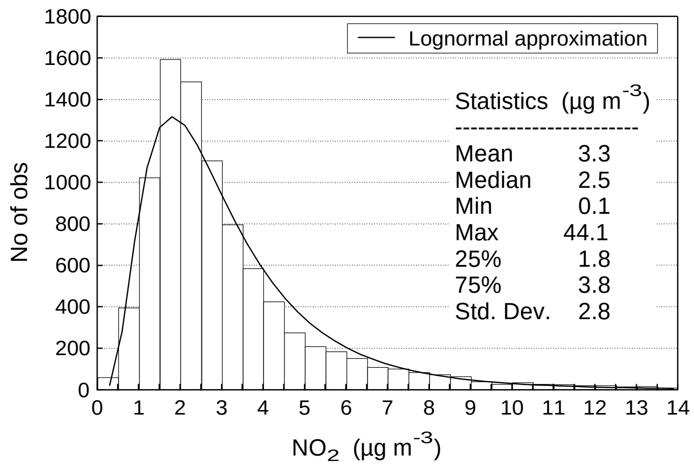


**Figure 5**. The frequency distribution (histogram) of the concentration of $NO_2$. September 1993 – October 1994, Tahkuse.

During the wintertime the concentration of $NO_2$ was correlated with the concentration of heavy large ions (0.00041–0.0042 $cm^2V^{-1}s^{-1}$, 22–79 nm), the correlation coefficients calculated for the monthly periods from November to February were in the range of 54–77%. The closer correlation was probably due to the emission of both species by combustion sources.

The analysis of the dependence of $NO_2$ concentration on wind direction shows that the median concentrations are at a low background (2–3 µg $m^{-3}$) considering all directions. The episodes of increased concentrations (maximum of hourly average more than about 15 µg $m^{-3}$) occurred with the SW and the NE winds. The long-range transport of $NO_2$ from remote regions is not excluded.

Sometimes in the summertime, clear diurnal variation of $NO_2$ concentration was recorded with maximum during nocturnal calm periods (up to 10 µg $m^{-3}$ in July 1994). The elevated concentrations were probably caused by fluxes of $NO_2$ from the soil due to microbiological processes.

### 2.3.3. Characterization of air pollution by Sheftel method.

*Sheftel* [1994] estimated the anthropogenic atmospheric pollution level from the comparison of the air conductivity measured on weekdays with the data measured on Sundays, when the work-related pollution activities are reduced. The ratio of the air conductivities on Sundays to weekdays was from 1.2 to 1.38, considering different monitoring stations near the industrial centres of former Soviet Union.

At Tahkuse the ratio was 0.96, taking into account the whole period of 14 months, and 1.01 during the cold period (November–April). The ratio is close to 1, and Tahkuse station could be considered as a background monitoring station.

A detailed analysis of the effect of weekdays on the air conductivity and heavy large ion concentration (0.00041–0.0042 $cm^2V^{-1}s^{-1}$; 22–79 nm) shows that during the cold period (November–April) both quantities had an average weekly variation (Figure 6). That could be explained by the accumulation of aerosol pollutants during weekdays and the subsequent removal during Sunday and Monday. The lowest concentration of heavy large ions (the highest air conductivity, respectively) recorded on Monday and arise on Tuesday, probably refers to the propagation time of pollutants. Such a weekly variation was recorded in November, December, January and in April, but not in February (the coldest month with strong temperature inversions).

The weekly variation of the concentration of $NO_2$ shows nearly the same character as heavy large ions with a maximum of 5.3 $\mu g\ m^{-3}$ recorded on Friday and a minimum of 3.7 $\mu g\ m^{-3}$ on Monday.

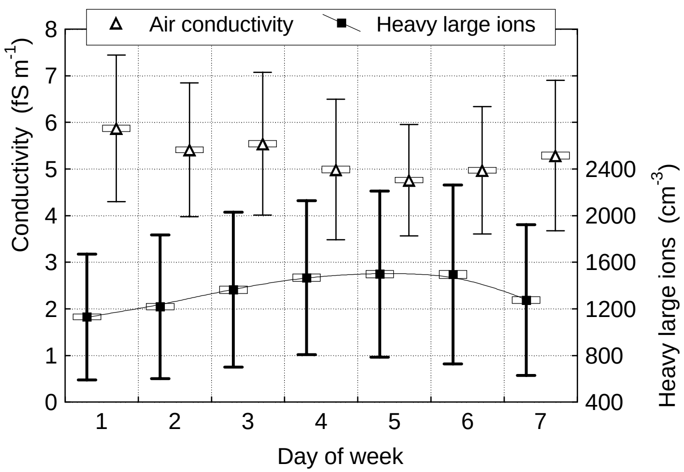


**Figure 6**. Weekly variation in air conductivity and heavy large ion concentration during the cold season. November 1993–April 1994. Number 1 refers to Monday, 7 to Sunday. Descriptive statistics: mean, box (mean – standard error, mean + standard error) and whiskers (mean – standard deviation, mean + standard deviation).