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Fifteen years of continual monitoring of ^{222}Rn activity concentration in the Bratislava atmosphere

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Introduction

The radon activity concentration in the surface layer of the atmosphere is not stable. It depends mainly on such meteorological parameters as the solar radiation, the wind velocity and the cloudiness. These parameters have a significant impact also on the rate of the vertical air mixing. Even several studies indicate that the variations of the radon activity concentrations are in a good agreement with the variations of the stability indexes of the atmosphere. So the results of radon measurements provide an information about the state of the atmosphere and more over they are utilizable for an interpretation of the behaviour of the other isotopes and pollutants in the atmosphere.

The extensive set of about 60 000 data of ^{222}Rn activity concentrations in the outdoor atmosphere was obtained by our continual monitoring. In this contribution the average daily courses of the ^{222}Rn activity concentration for the individual months and different years are presented. But the annual courses and long-term trends of ^{222}Rn activity concentration in the outdoor atmosphere are mentioned and discussed too. In addition a complex view on the daily and seasonal radon variations is provided.

Sampling site and methods

The measurements of radon were carried out at the open grass area in the campus of the Faculty of Mathematics, Physics and Informatics (48° 9' N, 17° 7' E, 164 m a. s. l.) since 1991. The air for the analysis was sucked at height of 1.5 m above the ground surface. The radon activity was continuously monitored using the large volume scintillation chamber. The flow rate of the air through the chamber was selected 0.5 l.min^{-1} in order that ^{220}Rn to be decayed still before the inlet of air into the chamber. The sensitivity of the scintillation chamber is 0.3 cpm at 1 Bq.m^{-3} of the ^{222}Rn activity concentration in the entering air. The radon monitor allows obtaining of almost 80% of the data of the radon activity concentration in the surface layer of the atmosphere with uncertainties less than 30 % in the counting interval of 2 hours.

Results and discussion

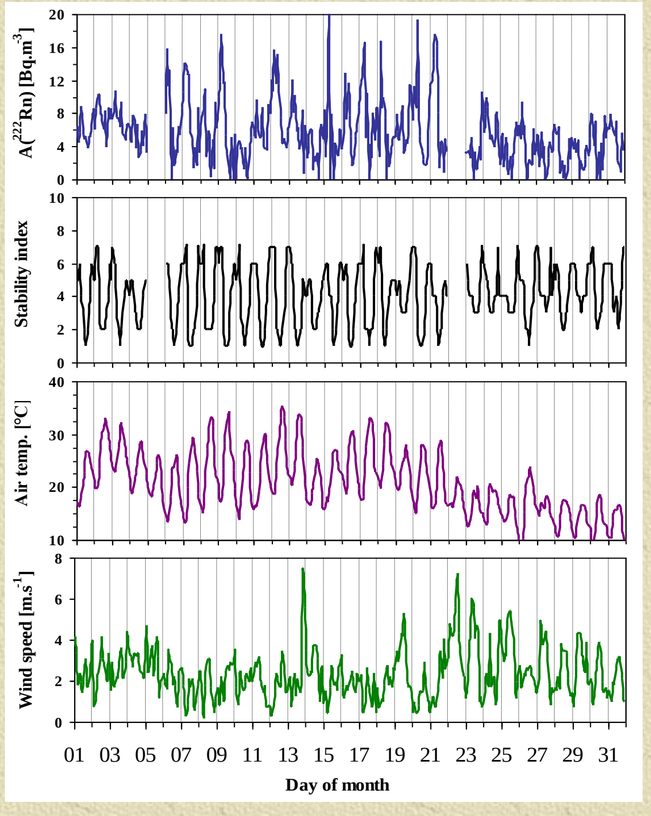

Fig. 1. Time courses of ^{222}Rn activity concentration in August 1998 along with calculated stability indexes according to Turner's method. Courses of meteorological parameters were compiled on the basis of the measurements carried out by the Department of Meteorology and Climatology, FMPI CU. We can see that radon activity concentration is in correlation with stability indexes and in anticorrelation with wind speed and temperature.

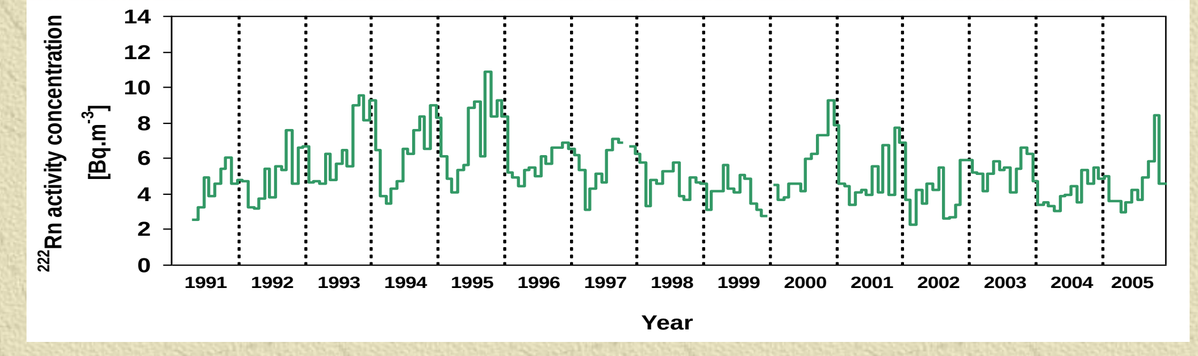

Fig. 2. The monthly mean values of the ^{222}Rn activity concentration in the surface layer of the atmosphere in Bratislava.

In Fig. 2 the spring minima and maxima occurring in various months of the second half-year can be seen in the annual ^{222}Rn courses for all the years. However, the individual years differ from each other quite considerably. The amplitude of the annual courses vary from 3.1 Bq.m^{-3} (1995) to 1.2 Bq.m^{-3} (1999). The years 1996 – 1999 show a decreasing trend of these amplitudes, predominantly as a consequence of the decreasing of the radon activity in the year's maxima. Simultaneously, a shift of the year's maxima from the late autumn and winter months towards the summer months is observed. This effect is due to the lowering of the radon activity concentrations in the minima of the daily cycles of the autumn and winter months with only mild change of amplitudes of the daily ^{222}Rn waves. This behaviour of the daily ^{222}Rn waves is clearly seen in Fig.3 where the monthly mean diurnal waves of the ^{222}Rn activity concentration are shown, too.

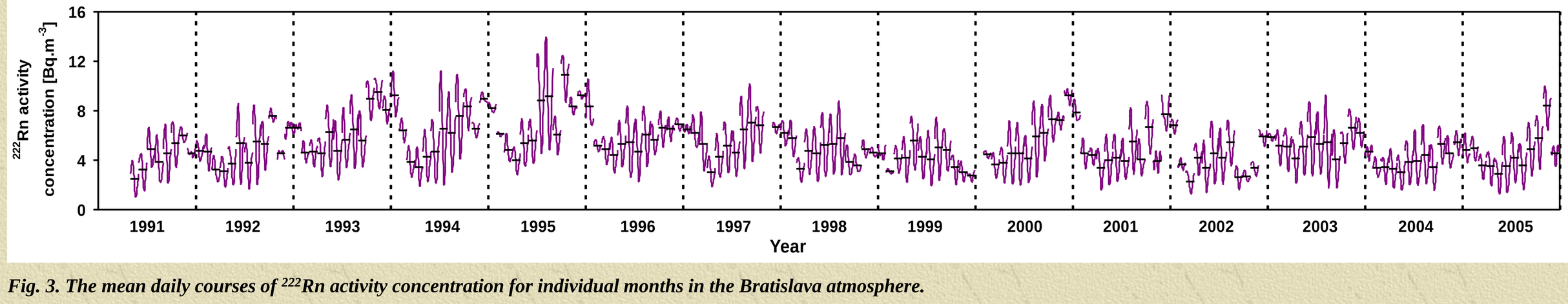

Fig. 3. The mean daily courses of ^{222}Rn activity concentration for individual months in the Bratislava atmosphere.

The average annual radon activity concentration vary from 4.1 Bq.m^{-3} to 7.2 Bq.m^{-3} (Fig. 4). The average radon activity concentration in years 1991 – 2005 is equal to 5.6 Bq.m^{-3}. The highest radon concentration in 1995 is caused by the high amplitude of average daily wave in this year (1.7 Bq.m^{-3}) and also by high average value of the radon concentration during a day (5.6 Bq.m^{-3}). In 1999 the minimum of the average daily wave is equal 2.6 Bq.m^{-3} and its amplitude is equal only to 1.2 Bq.m^{-3}. In investigated period, the highest amplitude of average daily wave was observed in 1994 (2.3 Bq.m^{-3}).

Fig. 4. The mean annual values (solid lines) and the mean diurnal courses (dotted curves) of the ^{222}Rn activity concentration in the Bratislava atmosphere.

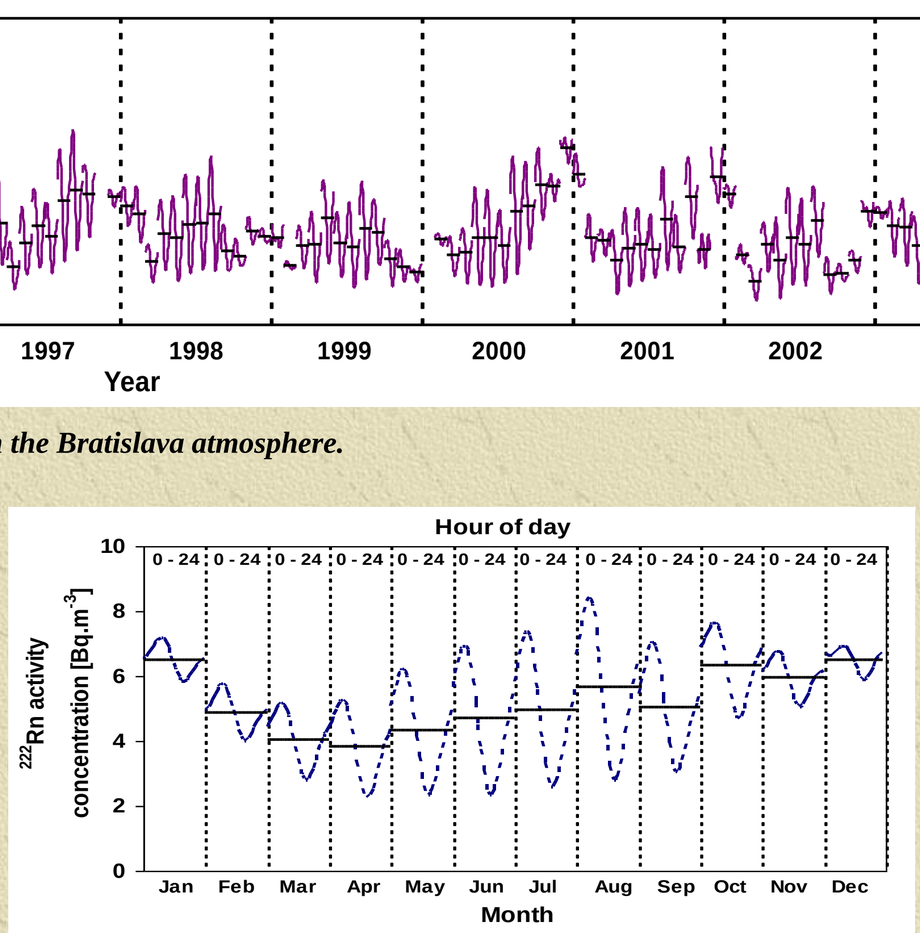

Fig. 5. The mean annual course (solid line) and mean daily courses of ^{222}Rn activity concentration for individual months (dotted line) in the Bratislava atmosphere. The courses were obtained by summation of the radon data from years 1991 – 2005.

In Fig. 5 we can see that the average daily courses of the ^{222}Rn activity concentrations (for individual months) have a form of waves with the maximum in the morning hours (between 4 and 6 a.m.) and with the minimum in the afternoon (between 2 and 4 p.m.). The maximal amplitudes of the daily waves are reached in the summer months from May till August (2.2 – 2.9 Bq.m^{-3}). The ^{222}Rn activity concentration reaches its average daily value at about 10 a.m. and at 9 p.m. Then, as follows from the Fig. 5, the lowest average volume activities during the year are observed in April (~ 3.9 Bq.m^{-3}) and the extreme values in months from October to January (~ 6.9 Bq.m^{-3}).

Conclusion

Extensive set of the ^{222}Rn data have been obtained in an inland environment with the variable pollution of the atmosphere. The seasonal and daily variations of the ^{222}Rn concentrations were observed. The monthly mean diurnal courses of the ^{222}Rn concentration have a quasi-harmonic shape with an amplitude of up to 3 Bq.m^{-3} in the summer months. During the winter months the amplitudes of the daily cycles are small and sometimes cannot be identified. A high correlation has been found between the diurnal courses of the ^{222}Rn concentration and the atmospheric stability indexes. It gives an opportunity to use the ^{222}Rn as a tracer of the distribution of other pollutants in the surface layer of the atmosphere.