Variations of ^{222}Rn activity concentrations and stability indexes in the outdoor atmosphere

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Introduction

To put it simply, atmospheric stability is a measure of susceptibility of an air volume to vertical displacement. For this reason it is a good indicator of the scale of dispersion of atmospheric pollutants. Commonly used methods of determining the atmospheric stability are Pasquill method [1], Turner method [2] and their modifications. On the basis of meteorological data like intensity of solar radiation, cloudiness, cloud ceiling, time of day (daytime or nighttime) and wind speed a stability index can be determined. Considering the complexity of determining the stability indexes it would be desirable to get a picture about it by other means, most preferably by measurement of a single variable. The aim of this study was to examine the relation between stability indexes and ^{222}Rn activity concentration. Some studies indicate that the variations of radon activity concentrations are in good agreement with variation of quantities used for determining the stability indexes [3].

Methods

^{222}Rn activity concentrations were measured on the Faculty of Mathematics, Physics and Informatics, Comenius University (FMPI CU) campus, Bratislava. The sampling air was collected at a height of 1.5 m above the earth's surface and sucked through a large volume (4.5l) scintillation chamber with a flow rate of 0.5 l/min [4]. Subsequently, radon activity concentrations belonging to two-hour intervals were determined from the recorded count rates using Ward method [5]. Meteorological parameters needed for determining the stability indexes were acquired at the former Department of Meteorology and Climatology, FMFI CU. The stability indexes were determined by Turner's method of atmospheric stability classification modified by Nester and Reuter [6]. This classification comprises 7 degrees of atmospheric stability – from 1 (extremely unstable) to 7 (extremely stable), in the middle lies stability index 4 (neutral conditions).

Results and discussion

Intensity of solar radiation and wind speed belong to the variables that have a significant impact on the size of stability indexes. Variations of temperature (which is directly dependent on the intensity of solar radiation) and wind speed are depicted along with time courses of activity concentration and stability indexes in Figure 1.

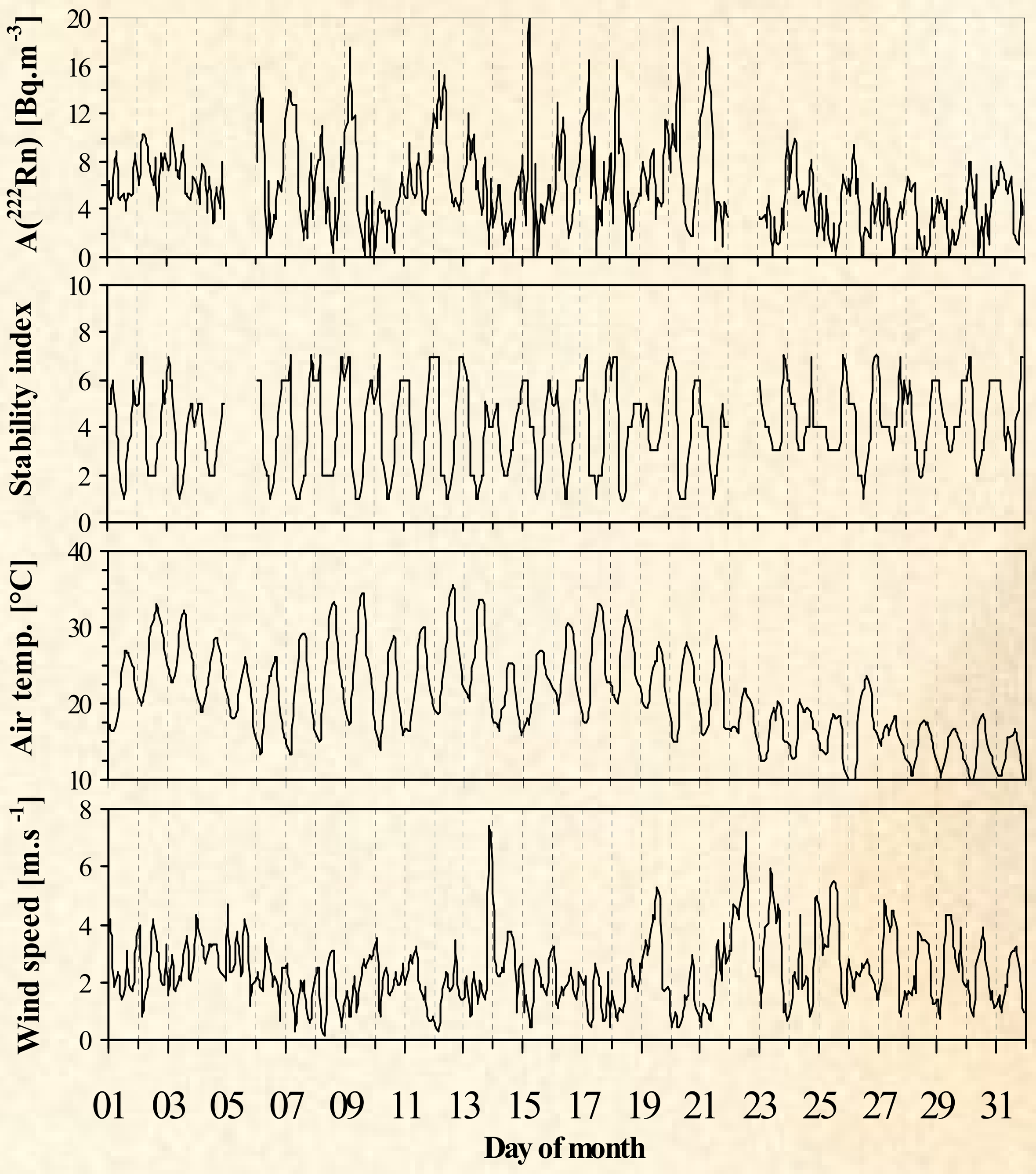

Fig. 1. *Time courses of ^{222}Rn activity concentration in August 1998 along with calculated stability indexes. Courses of meteorological parameters were compiled on the basis of the measurements carried out by the Department of Meteorology and Climatology, FMPI CU.*

We can see that correlations exist between radon activity concentration and temperature and between radon activity concentration and wind speed. For the time period from 1.8. to 21.8.1998 the correlation coefficient between radon activity concentration and wind speed is -0.39 and between radon activity concentration and temperature -0.36. Furthermore, if the data are smoothed and radon activity concentrations are shifted 2 hours back in time, the correlation coefficients improve to -0.47 and -0.52, respectively. These results are also confirmed by other studies [7, 8]. Since the degree of correlation is high, there is a justified assumption that the variations of radon activity concentration and stability indexes will also correlate.

In order to get a better picture, the variations of radon activity concentration and stability indexes were plotted on a single chart and smoothed. We can see the result in Figure 2. The variations are similar, the correlation coefficient is 0.24. An interesting finding is that the variations are mutually shifted.

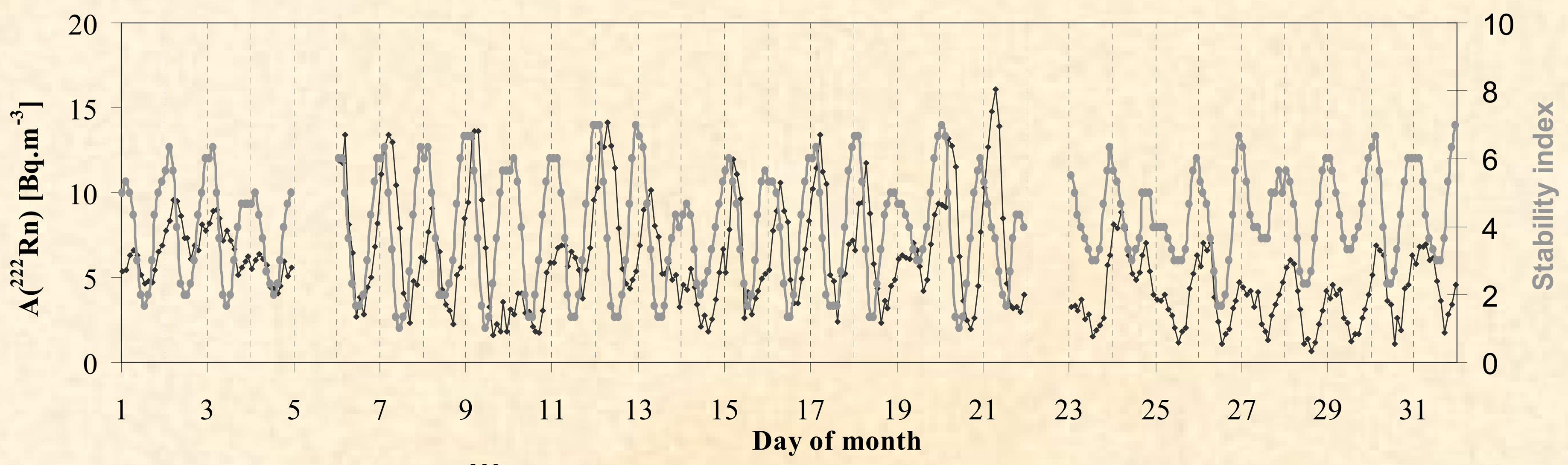

Fig. 2. *Variations of smoothed ^{222}Rn activity concentration and smoothed stability indexes in August 1998.*

We therefore decided to shift the stability indexes 2, 4 and 6 hours forward in time, respectively. The highest degree of correlation was achieved by 4-hour shift of stability indexes against radon activity concentration, which is also shown in Figure 3. The correlation coefficient improved from 0.24 to 0.58.

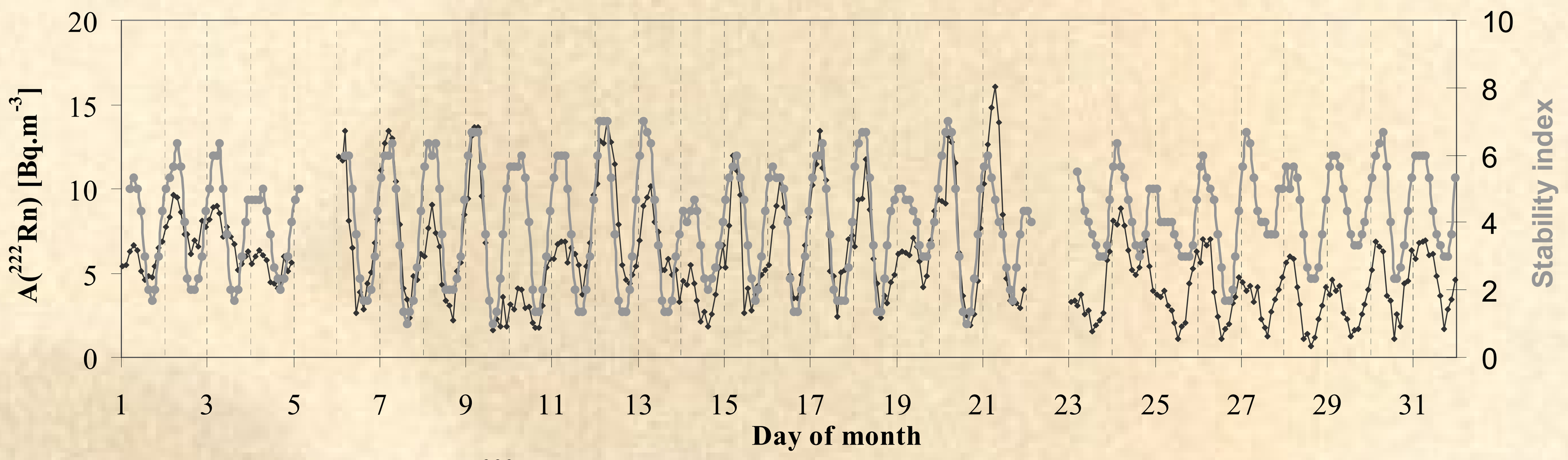

Fig. 3. *Variations of smoothed ^{222}Rn activity concentration and smoothed stability indexes in August 1998. Time-courses of stability indexes were shifted 4 hours forward in time.*

Mutual shift of variations of radon activity concentration and stability indexes is even better visible on mean daily courses of these variables. They are shown in Figures 4 and 5. For better visual interpretation the data points were fitted by a curve, the parameters of which were determined by Fourier analysis in the Microcal Origin scientific application.

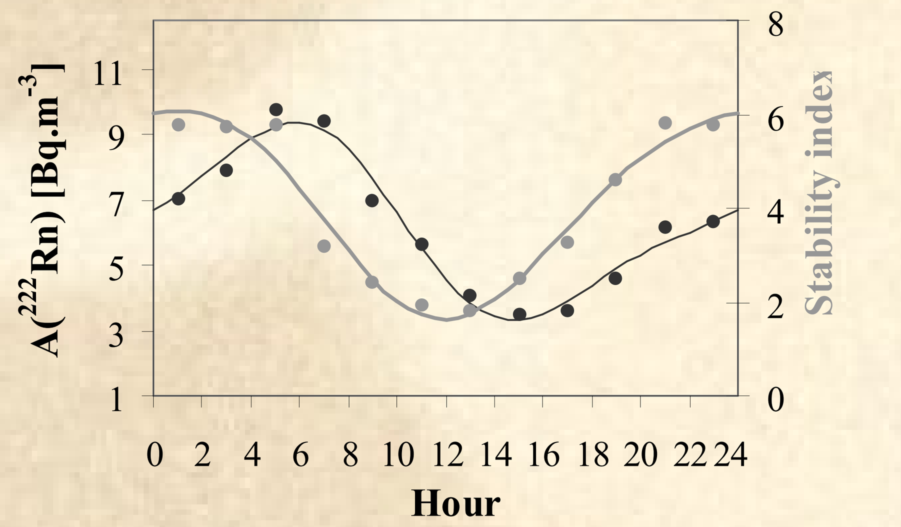

Fig. 4. *Mean daily wave of ^{222}Rn activity concentration and stability indexes in August 1998 without shift of data.*

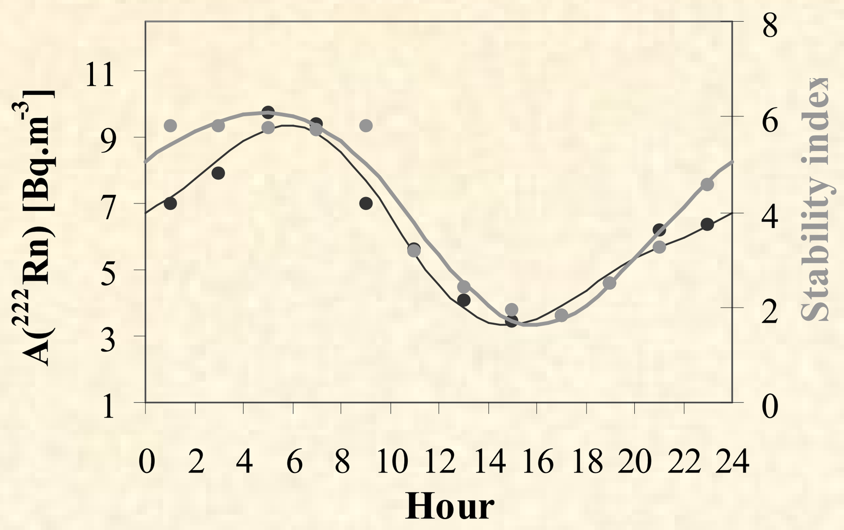

Fig. 5. *Mean daily wave of ^{222}Rn activity concentration and stability indexes in August 1998 with 4-hour shift of data.*

This shift can possibly be caused by an immediate reaction of stability indexes to a change of meteorological parameters (because they are defined by table values) which is in contrast with the fact that naturally it must take some time until the change in radon concentration occurs. As an illustrative example let us imagine a situation that after a long period of overcast conditions the sun has started to shine. Stability indexes will react on such a change immediately, yet it always needs some time until the sun rays heat the ground, subsequently the ground will heat the adjacent air until the air temperature rises to such an extent that a volume of air near the ground will start to rise upwards and as a result we will observe a decrease in radon activity concentration near the surface.

Conclusion

This research was aimed at studying the relations between radon activity concentration and atmospheric stability. It was confirmed that there is a good agreement between the variations of these variables. It is probably connected with the fact that the variations of some of the meteorological parameters used for determining the stability indexes show a good degree of correlation with radon activity concentration. Further on, from the analyses follows that there is about 4-hour shift between the time courses of radon activity concentration and stability indexes. A possible cause of this is that while the reaction of stability indexes to a change of meteorological parameters is immediate (because they are defined by table values), it must obviously take some time until an appropriate change in the atmosphere and in radon concentration occurs.

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