

Name of research institute or organization:

Bundesamt für Gesundheit, Sektion Umweltradioaktivität, Bern

Title of project:

Aerosol radioactivity monitoring RADAIR and DIGITEL

Project leader and team:

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Project description:

Aerosol Radioactivity Monitoring at the Jungfrauoch: Activity Report 2014

An automatic aerosol radioactivity monitor FHT59S (total alpha and total beta activity) is operated at the Jungfrauoch research station by the Swiss Federal Office of Public Health. This monitor is part of the RADAIR Network and has the following particular features:

- Real-time (30 min) detection of any increase of radioactivity in the air at the altitude of 3400 m above sea level.
- A detection limit for artificial beta radioactivity as low as 0.1 Bq/m³. Such a high sensitivity is possible due to the very low Radon daughter concentration at this altitude.

Additional aerosol samples are taken using a Digitel High-Volume-Sampler. These samples are sent to the laboratory in Berne and are analyzed for radioisotopes using HPGe-Gamma-spectrometry.

Comments on the alpha/beta (Radair) measurements performed in 2014:

Figure 1 shows the natural alpha radioactivity, the calculated artificial beta radioactivity and the ratio between α and (natural) β activities for the period January 1 to December 31, 2014.

This figure shows that:

- Alpha radioactivity – i.e. Radon daughter products - is mainly transported up to the Jungfrauoch by air masses from the lowlands, since the highest values are usually observed in summer (from Mars to September) when thermal air convection is higher than in winter (see upper part of Figure 1).
- The highest α/β activity ratios are observed when the (natural) alpha radioactivity concentrations are the lowest. The α/β activity ratios lower than 0.5 and greater than 1.5 were removed, since these are not significant.
- Between July and August, there is a jump from 0.8 to 0.7 of the moving average factor (F_m), because a measuring circuit card monitor was defective in July. It was replaced in August.

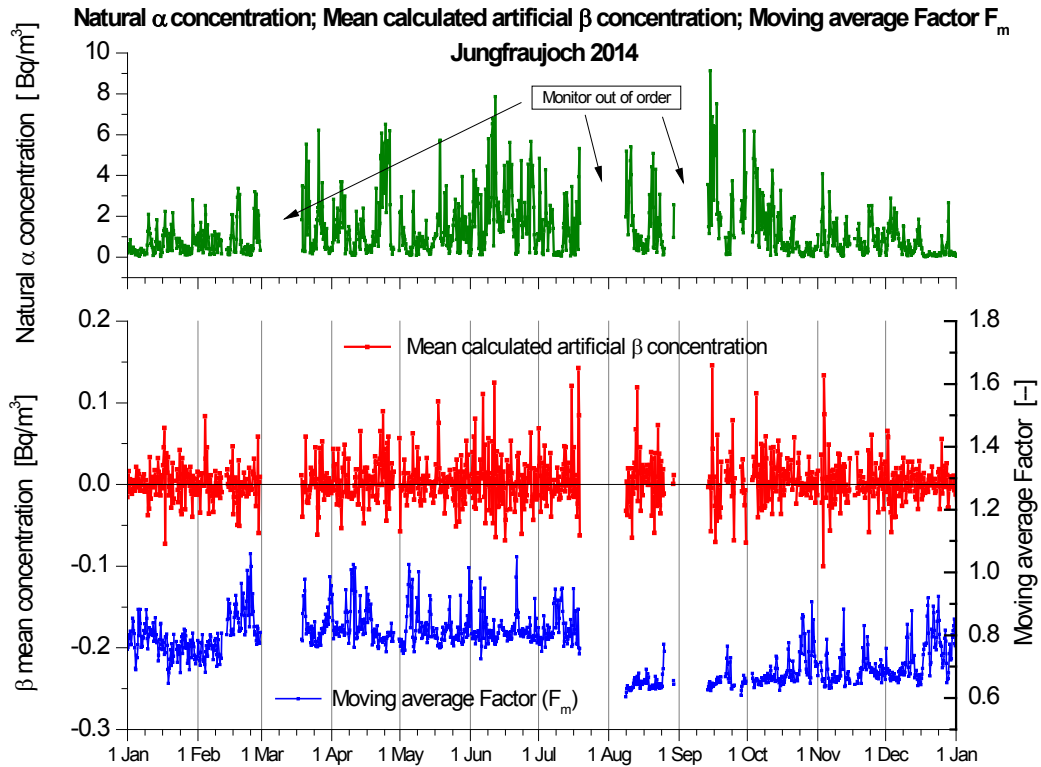


Figure 1. Results of RADAIR measurements in 2014.
Note: For a better readability of the graph, not all values are represented.

Figure 2 shows the histogram of the calculated artificial beta radioactivity in aerosol for 2014 (and 2013). The calculation is done automatically by the monitor by applying an α/β -compensation technique (see below for more details).

- No calculated artificial beta concentration above the detection limit (i.e. the background signal) was observed.
- 95 percent of the beta concentrations recorded in 2014 were below 0.05 Bq/m^3 .
- The histogram recorded for 2014 is rather symmetric; this shows that the automatic compensation technique was good. Note that the dispersion of the histogram recorded for 2013 is slightly lower than the one recorded for 2014; the compensation technique is considered as adequate.
- Also note that the 2014 histogram is weakly shifted to the right because of a slight overcompensation of the moving average factor (F_m). This is explained by the fact that alpha activity often increases slower (over about 20 to 50 measuring intervals) and then drops relatively faster (over 8 to 15 intervals). Therefore, the moving average factor (F_m), calculated from the last 12 intervals, remains too high during the decay of the alpha activity and consequently the artificial beta activity is overcompensated (see Figure 3).

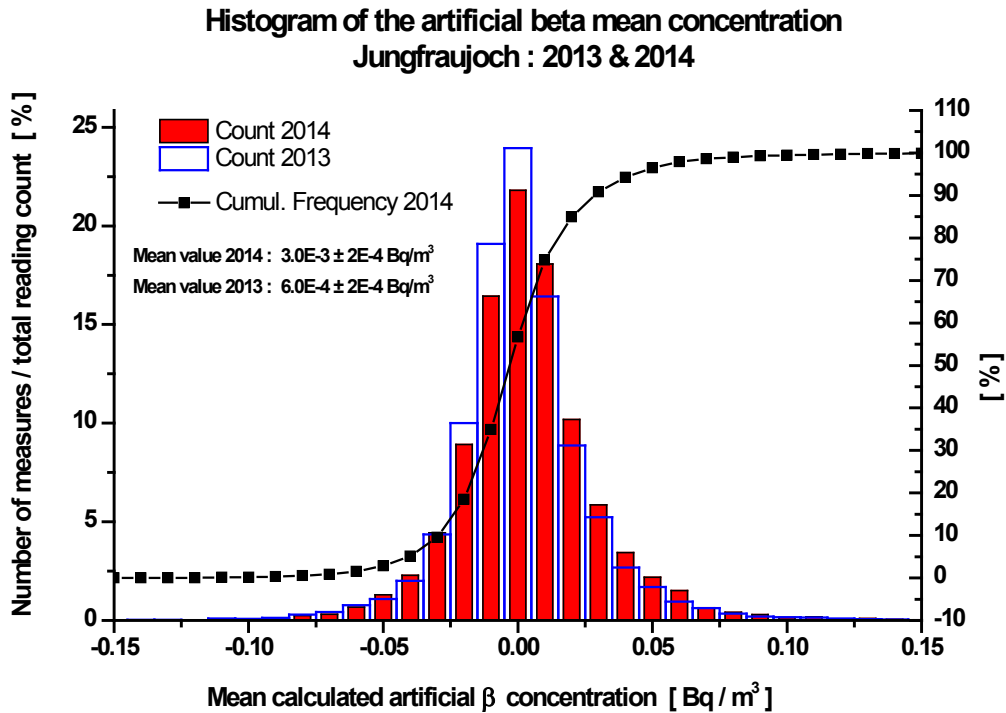


Figure 2. Histogram of calculated artificial beta concentrations.

For normal situations, i.e. with no artificial radioactivity in the air, the net Beta radioactivity at Jungfrauoch, calculated using the Alpha-Beta compensation technique, is less than 0.10 Bq/m³. At the top of Europe, a radiation incident causing an increase of the artificial beta radioactivity in the atmosphere of as low as 0.10 Bq/m³ could therefore be detected.

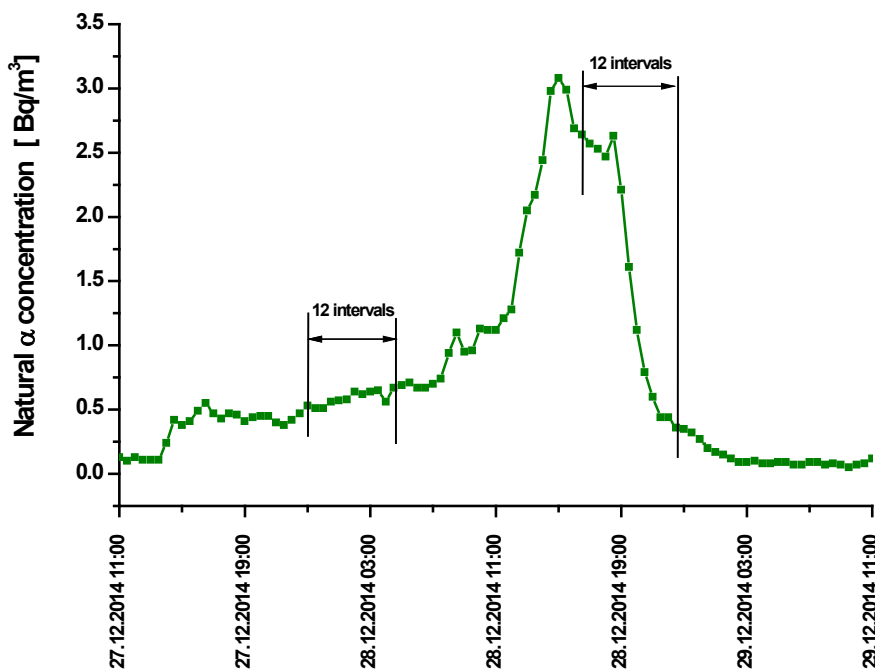


Figure 3. Increase and decrease of alpha activity.

Calculation of the artificial Beta activity:

Automatic α/β -compensation: this technique applied by our aerosol monitoring stations is based on the simultaneously measurements of gross Alpha (A_g) and gross Beta (B_g) radioactivity of the aerosols collected on a filter. The net (artificial) Beta radioactivity (B_n) is then calculated by the following formula: $B_n = B_g - (A_g / F)$.

Figure 4 shows how the factor α/β (F) was determined.

The ratio (A_g/B_g) corresponds to the slope of the curve of the α -activities as a function of β -activities. We observe that it is relatively constant and yields approximately 0.78.

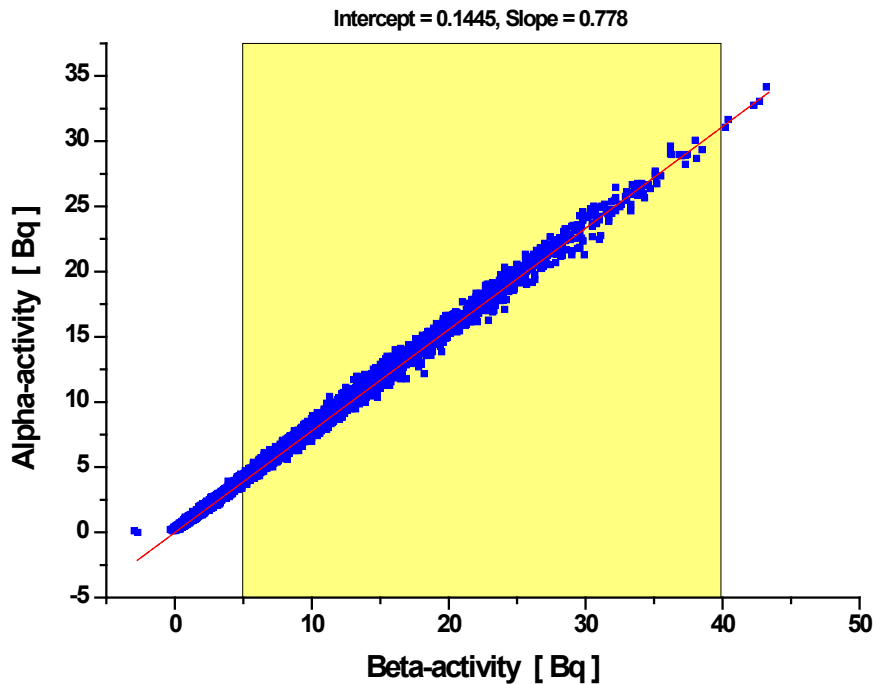


Figure 4. Correlations between the α -Activity and β -Activity.

With the current version of the software, the monitor calculates the average of the n ($n > 10$) last ratios (A_g/B_g), as long as this latter is included between thresholds values (here 0.6 and 1.2). This mean ratio will give the factor F_m with which the net (artificial) Beta radioactivity (B_n) will be calculated.

This gives a new correction equation: $B_n = B_g - (A_g / F_m)$

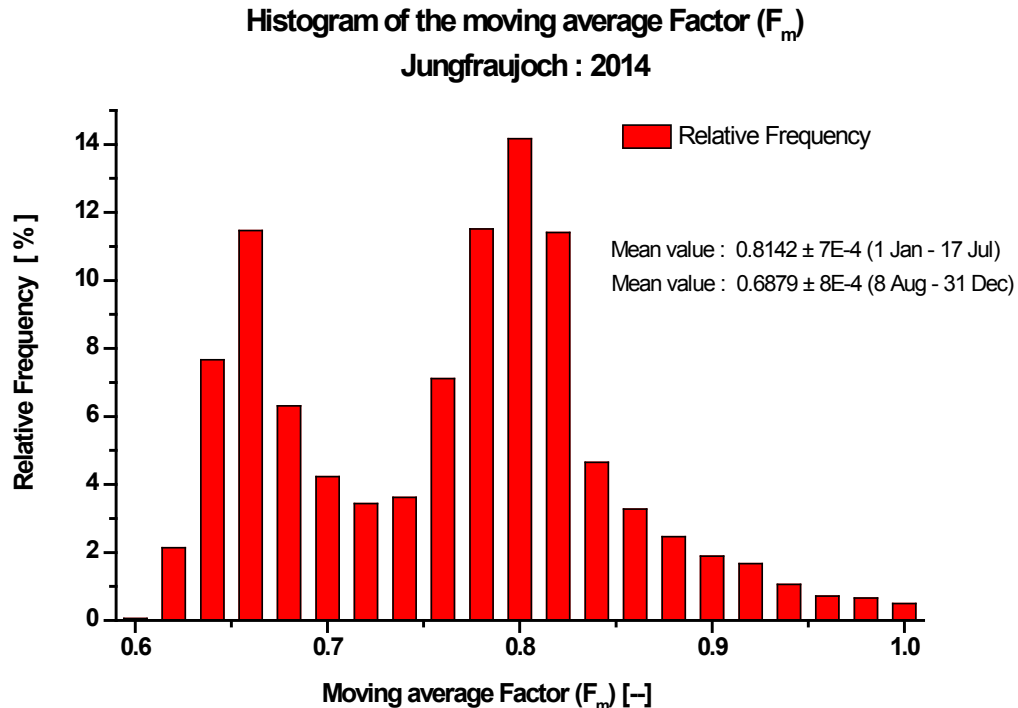


Figure 5. Histogram of the moving average of the ratio of α -activity / β -activity.

We can see that there are two maximums in the histogram of the moving average factor (F_m) which correspond at about 0.68 and 0.8. The gain of the new measuring circuit card was different from the old and no calibration has been done following this change.

The tail on the right side has to do with the fact that the α -concentrations are sometimes very low, in the order of 0.1 to 0.5 Bq/m³ and that in such cases the α/β activities ratio (α -activity / β -activity) is much larger than 1.2. When these cases occur, the algorithm blocks the moving average factor (F_m) at the last obtained value as long as the α/β activities ratio of the last measurement is not smaller than the predefined upper threshold, in this case 1.2.

Comments on technical aspects (RADAIR):

In July, it missed measures because of several power interruptions. The measuring circuit card has become defective and had to be changed by the guardian of the research station.

During September and March, there were several power failures and interruptions of the computer network. The data was lost.

Digital High-Volume-Sampler: Introduction

The Digital DHA-80 High Volume Sampler (HVS) is an automatic air sampler with a typical air flow rate of 0.6 m³/min. Aerosols are collected on glass fibre filters of 150 mm in diameter. The pump maintains a constant flow rate independent of the dust load on the filter. Filter change intervals are programmed in advance and the sampler is controlled remotely by an internet connection.

The filters are automatically changed once a week and are measured as a combined sample at the end of each month in the laboratory using a coaxial HPGe gamma-ray detector during 1-2 days. Thereafter activities of radioactive isotopes are corrected by considering corresponding half-lives and the time between sampling and measuring.

^7Be and ^{210}Pb are naturally occurring nuclides. ^7Be has a cosmogenic origin. Around 70% of ^7Be is produced in the stratosphere by spallation of carbon, nitrogen and oxygen. ^{210}Pb is a long-lived decay product of uranium series (^{238}U) which gets into the air from radioactive noble gas ^{222}Rn exhaled from the earth's crust.

Results

Figure 6 shows the concentration ($\mu\text{Bq}/\text{m}^3$) of ^7Be , ^{210}Pb , ^{131}I and ^{137}Cs between 2011 and 2014.

The concentrations of ^7Be and ^{210}Pb vary around $8000 \mu\text{Bq}/\text{m}^3$ and $500 \mu\text{Bq}/\text{m}^3$, respectively. A slight increase of ^{210}Pb during summer can be observed, which is due to convection of ^{210}Pb -rich air masses from the Plateau. ^7Be concentration seems to be slightly increased during summer, too. This is again related to increased convection mixing Be-7 from the upper troposphere down to mid-troposphere altitudes.

As a consequence of the nuclear accident of Fukushima in March 2011, filters were measured directly after changing (once a week) in order to detect radioactive isotopes released by the nuclear power plant more quickly. Therefore time between sampling and measuring was smaller than before.

The increased concentration of ^{131}I and ^{137}Cs in 2011 can be clearly related to the nuclear accident of Fukushima. First increased concentrations were measured by the end of March 2011 and reached a maximum at the beginning of April. ^{131}I could never be detected at Jungfraujoch before the nuclear accident and has not been since the end of April 2011. ^{137}Cs was occasionally detected also before March 2011.

Between Mai and August 2013, the filters were measured once a week in order to better follow possible inputs of stratospheric air over this time period.

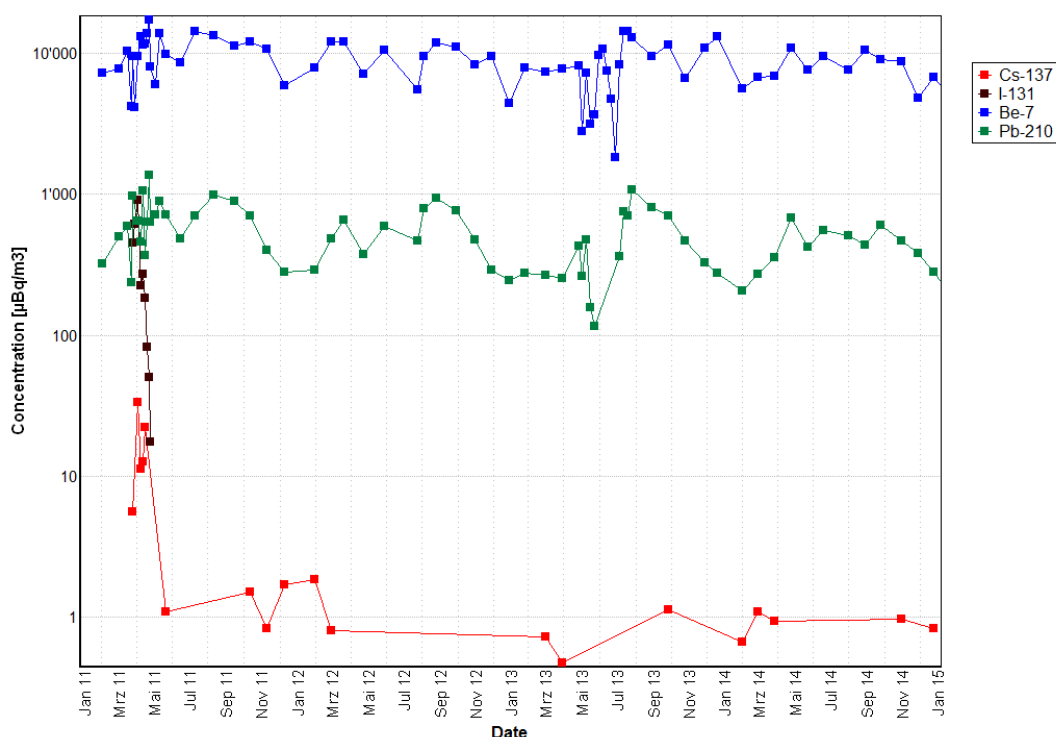


Figure 6. Concentration ($\mu\text{Bq}/\text{m}^3$) of ^7Be , ^{210}Pb , ^{131}I and ^{137}Cs between 2011 and 2014, Station Jungfraujoch.

Key words:

RADAIR, Digitel, Radon, radioactivity, aerosols, radioisotope

Internet data bases:

<http://www.radair.ch>

<http://www.bag.admin.ch/themen/strahlung/00043/00065/02239/index.html?lang=de>

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