Name of research institute or organization:

Bundesamt für Gesundheit; Sektion Umweltschutz, 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 Jungfraujoch: Activity Report 2013

An automatic aerosol radioactivity monitor FHT59S (total alpha and total beta activity) is operated at the Jungfraujoch 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/m^3. 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 2013:

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, 2013.

This figure shows that:

- Alpha radioactivity – i.e. Radon daughter products - is mainly transported up to the Jungfraujoch by air masses from the lowlands, since the highest values are usually observed in summer (from March to September) when thermal air convection is higher than in winter (see upper part of Figure 1).
- The highest α/β activities 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.
- At the end of February, the values of alpha concentration, relatively high for the season, are due to the passage of a cold and warm front where the air of the plateau, relatively rich in Radon, was transported to high altitude. This phenomenon was also observed with a same monitor situated at Weissfluhjoch, Davos at an altitude of 2690 m (see Figure 2).

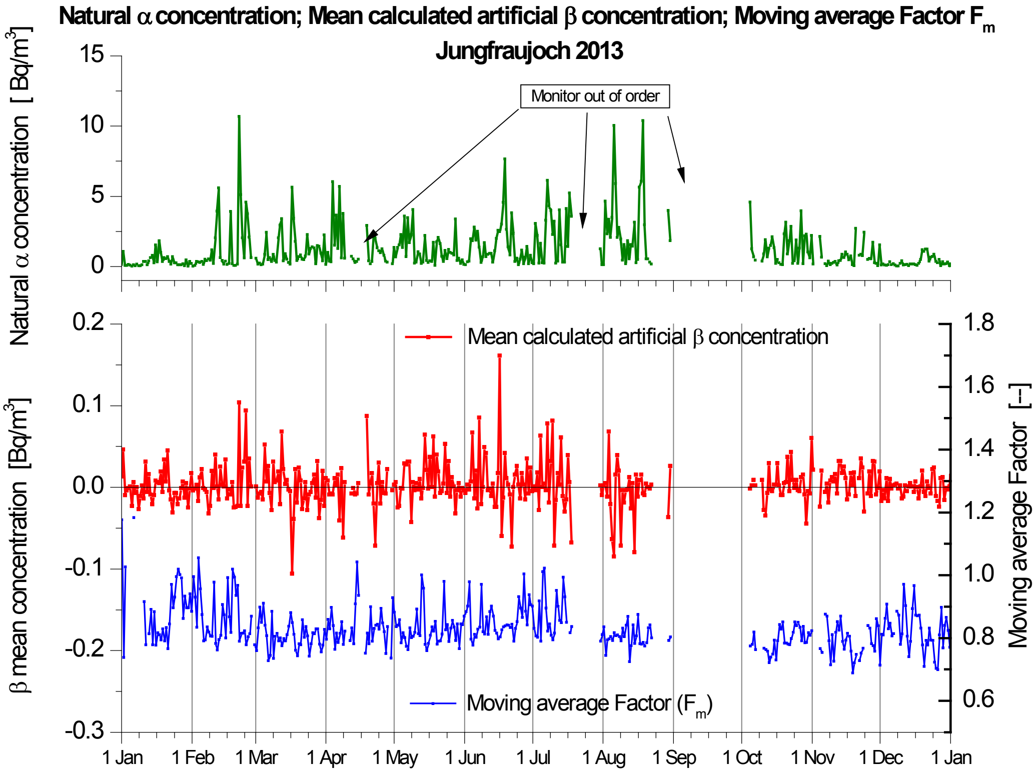

Figure 1. Results of RADAIR measurements in 2013.

Note: For a better readability of the graph, not all values are represented.

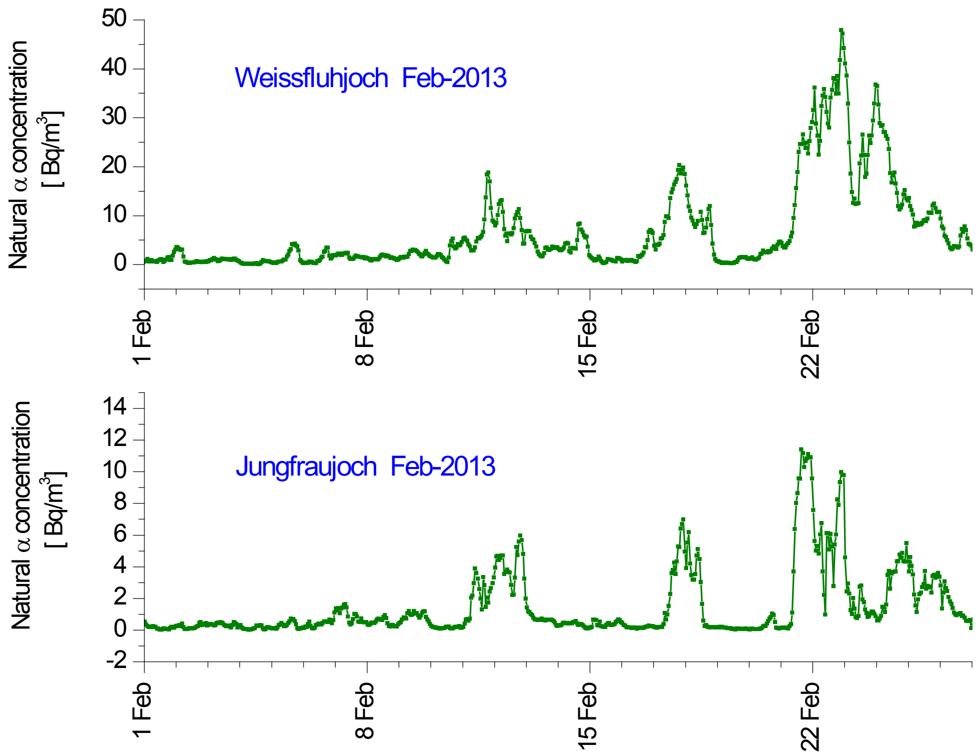

Figure 2. Alpha-concentrations of the stations at Jungfraujoch and Weissfluhjoch.

Figure 3 shows the histogram of the calculated artificial beta radioactivity in aerosol for 2013 (and 2012). 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 2013 was below 0.04 Bq/m^3.
- The histogram recorded for 2013 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 2012; the compensation technique is considered as adequate.
- The values of the histogram 2013 are better centered than those 2012, thanks to the application of the new moving average Factor (F_m) used in the formula of compensation (see below).

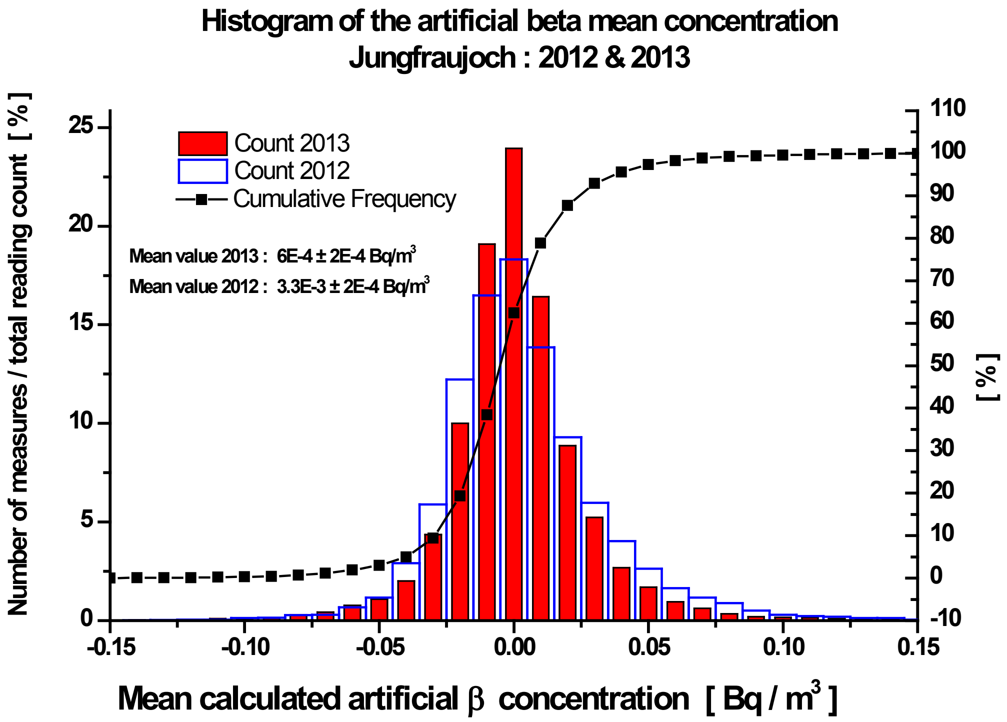

Figure 3. Histogram of calculated artificial beta concentrations.

For normal situations, i.e. with no artificial radioactivity in the air, the net Beta radioactivity at the Jungfraujoch, calculated using the Alpha-Beta compensation technique, is less than 0.10 Bq/m^3. 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/m^3 could therefore be detected.

Calculation of the artificial Beta activity:

Automatic α/β-compensation: this technique applied by our aerosol monitoring stations is based on the simultaneous 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: $B_n = B_g - (A_g / F)$. The constant factor α/β (F) may be adjusted either by the software or by the operator.

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 yield approximately 0.8.

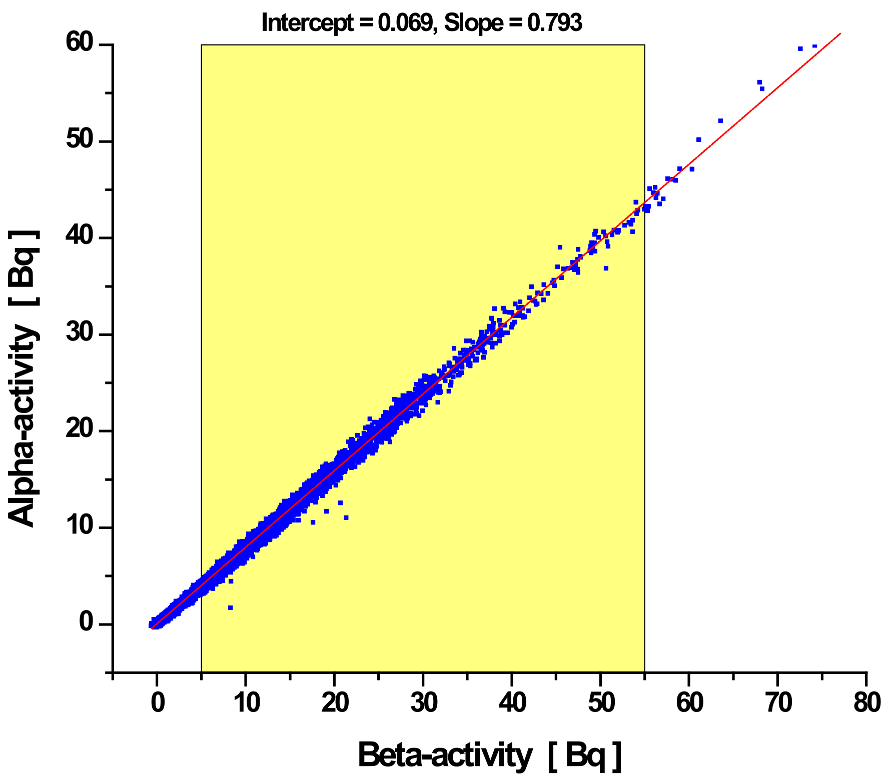

Figure 4. Correlations between the α-activity and β-activity.

With the current version of the software, the monitor calculates the average of the n (n>10) last ratios, as long as this latter is included between threshold 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: $B_n = B_g - (A_g / F_m)$

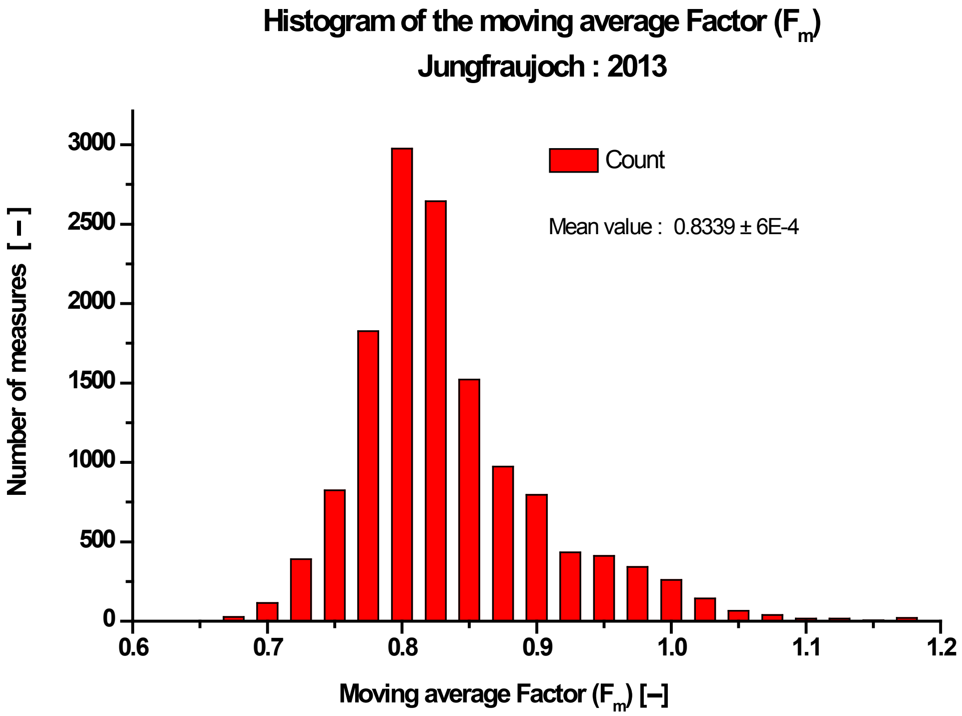

Figure 5. Histogram of the moving average of the ratio of α-activity / β-activity.

We can see that the maximum of the histogram of the moving average Factor (Fm) corresponds to 0.8. 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/m^3 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, the measurements were interrupted due to the failure of the computer startup following a configuration update.
At the end of August, a card for the printer of the filter overheated, the monitor was stopped. In September the computer was removed for repairs and reinstalled in October.

Digitel High-Volume-Sampler: Introduction
The Digitel DHA-80 High Volume Sampler (HVS) is an automatic air sampler with a typical air flow rate of 0.6 m^3/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 at the end of the 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-life's and time between sampling and measuring.

^{7}Be and ^{210}Pb are naturally occurring nuclides. ^{7}Be has a cosmogenic origin. Around 70% of ^{7}Be 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 (µBq/m^3) of ^{7}Be, ^{210}Pb, ^{131}I and ^{137}Cs between 2011 and 2013.

Concentrations of ^{7}Be and ^{210}Pb remained quasi constant. 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. ^{7}Be concentration seems to be slightly increased during summer, too. This is related to the tropopause thinning at mid-latitudes resulting in air exchange between stratosphere and troposphere.

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 significantly 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 achieved 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 in order to better follow possible inputs of stratospheric air over this time period.

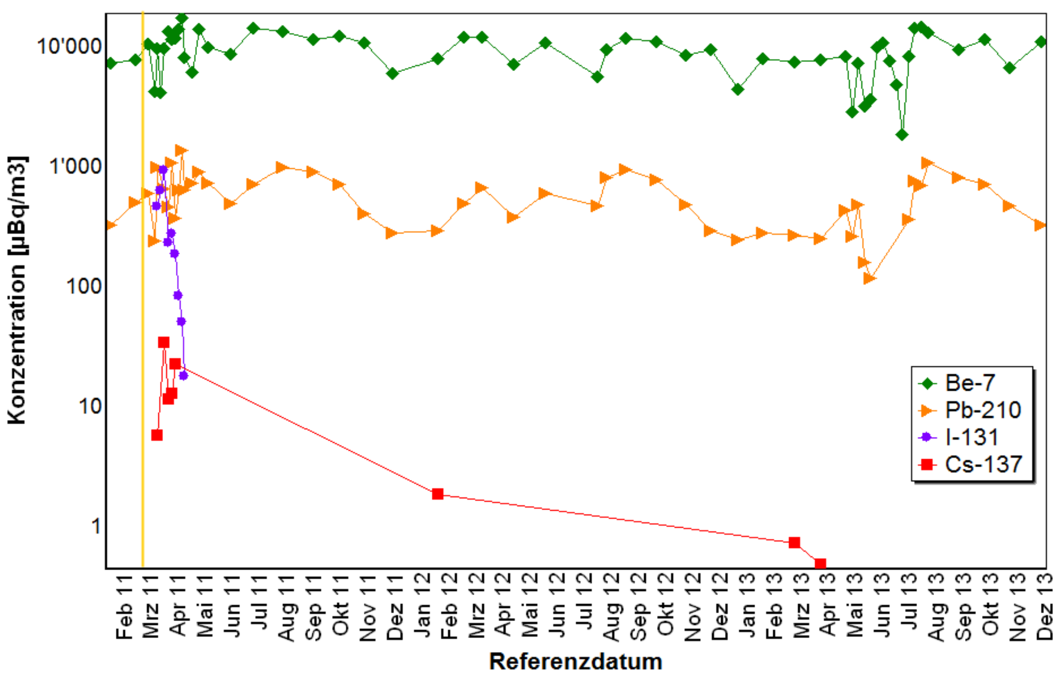

Figure 6. Concentration (µBq/m^3) of ^{7}Be, ^{210}Pb, ^{131}I and ^{137}Cs between 2011 and 2013, station Jungfraujoch. The yellow line indicates the date of the nuclear accident at the Fukushima Daiichi plant (March 11th 2011).

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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