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:

Dr. Sybille Estier, project leader
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Project description:

Aerosol Radioactivity Monitoring at the Jungfraujoch:
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 2016:
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, 2016.

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. It is the inverse from what is observed at the lowland sites. During autumn and winter, the Radon daughter products are kept below the Jungfraujoch altitude due to the thermic inversion in the lowlands (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 (see lower part of Figure 1).
- The highest values of beta mean concentration, about 0.8 Bq/m^3, occur during fast increases of the alpha concentration (see also Figure 4).

Meteorological conditions strongly influence the natural alpha concentration. Figure 2 shows the total (natural) alpha concentration as well as the wind speed and the atmospheric pressure recorded at Jungfraujoch from the 15th to the 22nd of December 2016. It can be seen that the steep increase of the total alpha concentration on the 19th of December after a long period of low concentration is related to a rapid decrease of the pressure reinforced by the arrival of a strong wind of the SSW.

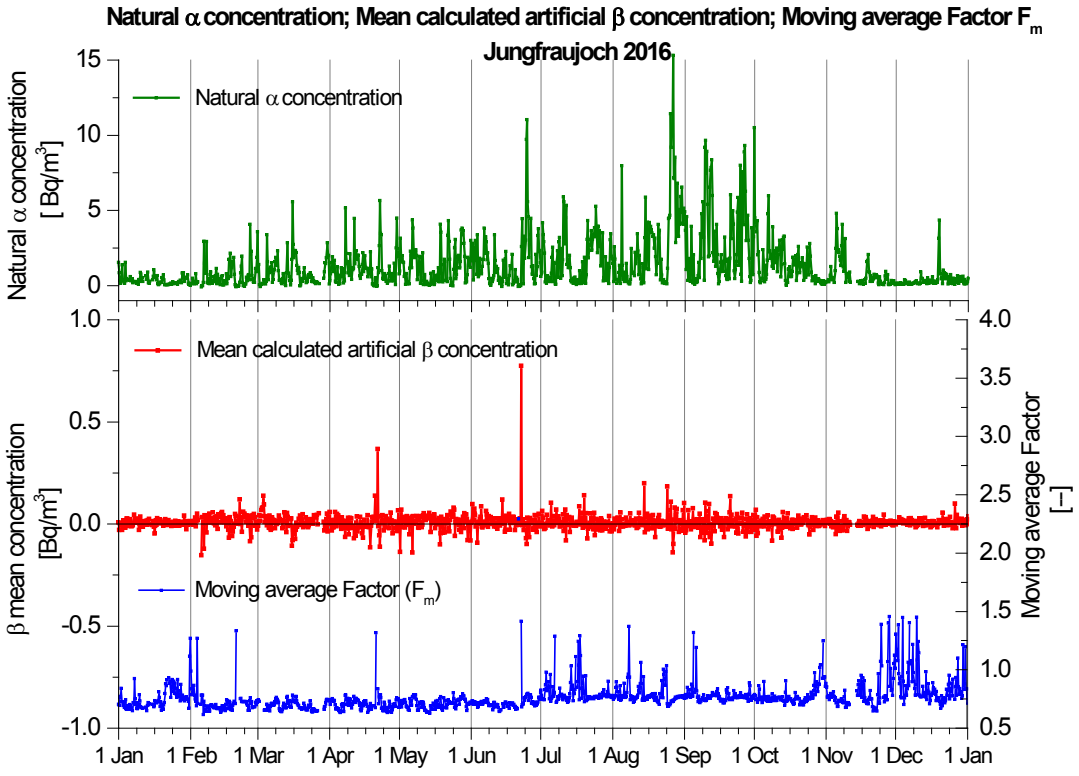

Figure 1. Results of RADAIR measurements in 2016.

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

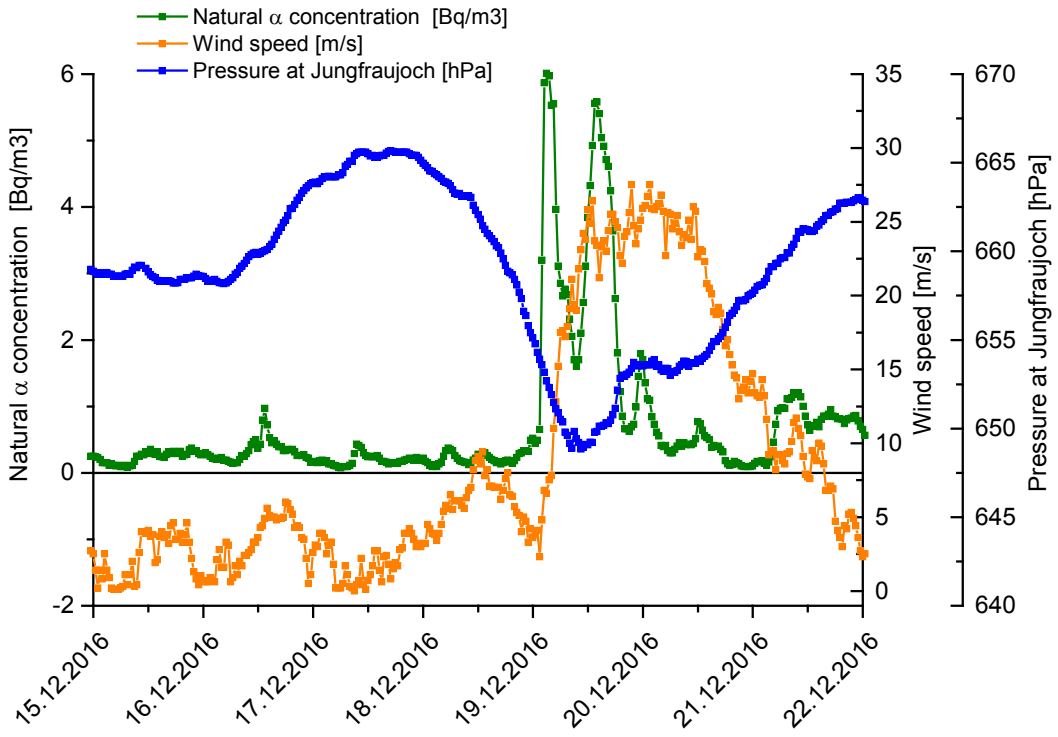

Figure 2. Increase of (natural) total α concentration depending on meteorological parameters on December 19, 2016.

Figure 3 shows the histogram of the calculated artificial beta radioactivity in aerosol for 2016 (and 2015). 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 2016 were below 0.05 Bq/m^3.
- The histogram recorded for 2016 is rather symmetric; this shows that the automatic compensation technique was good.
- Note that there are some values greater than 0.15 Bq/m^3 (see Figures 1 and 4).

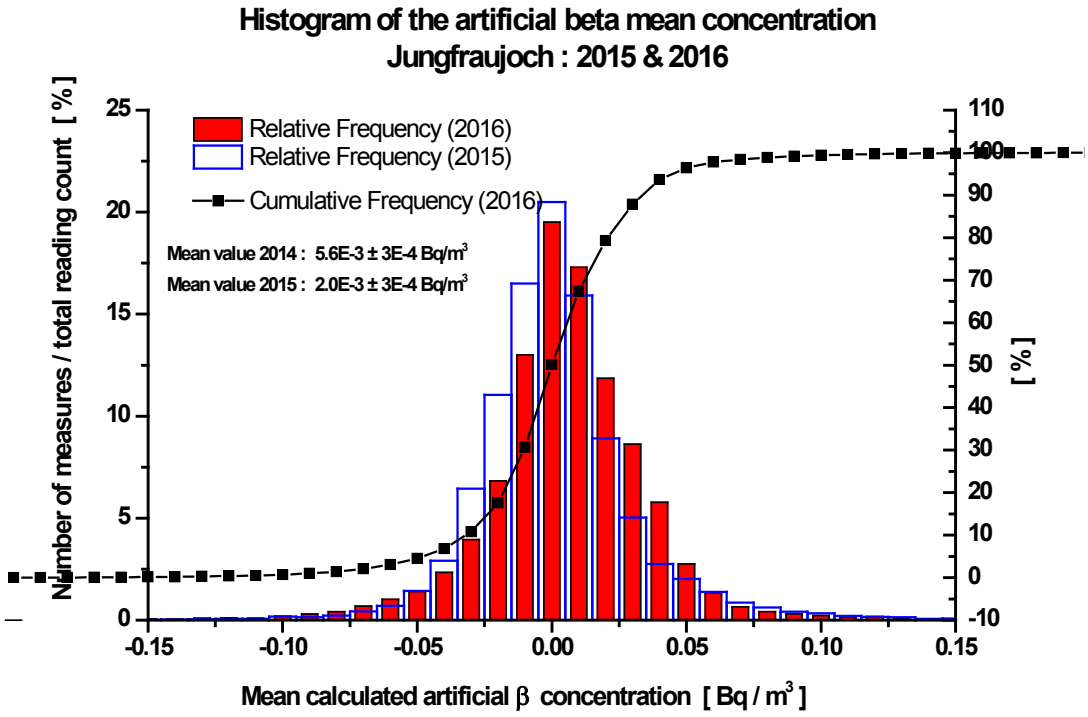

Figure 3. Histogram of calculated artificial beta concentrations.

There are cases where the total alpha concentration increases very steeply, in such circumstances the ratio between the total alpha activity and the beta activity does not remain constant with the total beta activity increasing even stronger. Consequently, the calculated residual beta concentrations < 0.6 Bq/m3 are difficult to automatically compensate and some false peaks of artificial beta may appear.

For example, on the 22nd of June 2016 the total alpha concentration was very low for some hours (see Figure 4) and consequently the moving average factor (F_m) at the upper thresholds when the total alpha concentration increased steeply at 12.00 h. In that case the artificial beta mean concentration was therefore over compensated. On the contrary, when the total alpha concentration increased on June 23, the moving average factor (F_m) was correct and therefore the artificial beta mean concentration was appropriately compensated.

In most cases, when the alpha concentration increases slowly, the beta concentration may be correctly compensated.

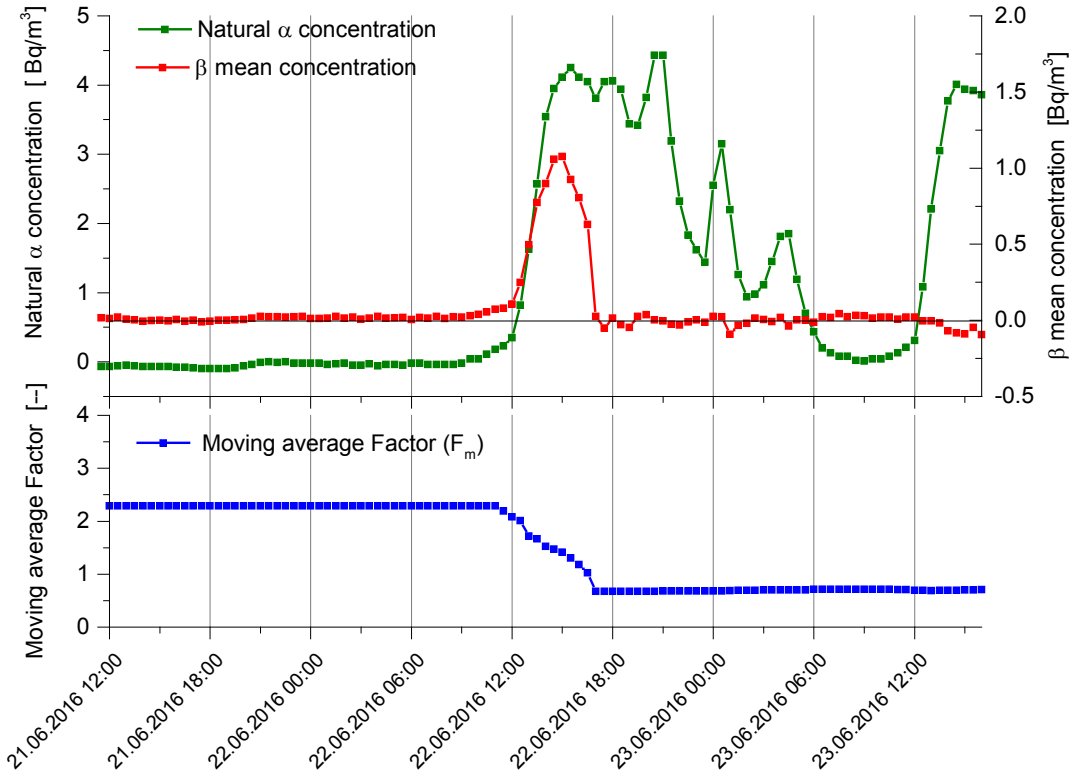

Figure 4. (Natural) total α concentration, calculated "artificial" (residual) β mean concentration and the ratio between α and (natural) β activities (moving average factor) for the period June 21st to 23rd, 2016.

For normal situations, i.e. with no artificial radioactivity in the air, the net Beta radioactivity at 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 within 30 minutes.

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: $B_n = B_g - (A_g / F)$.

Figure 5 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 0.73 for 2016.

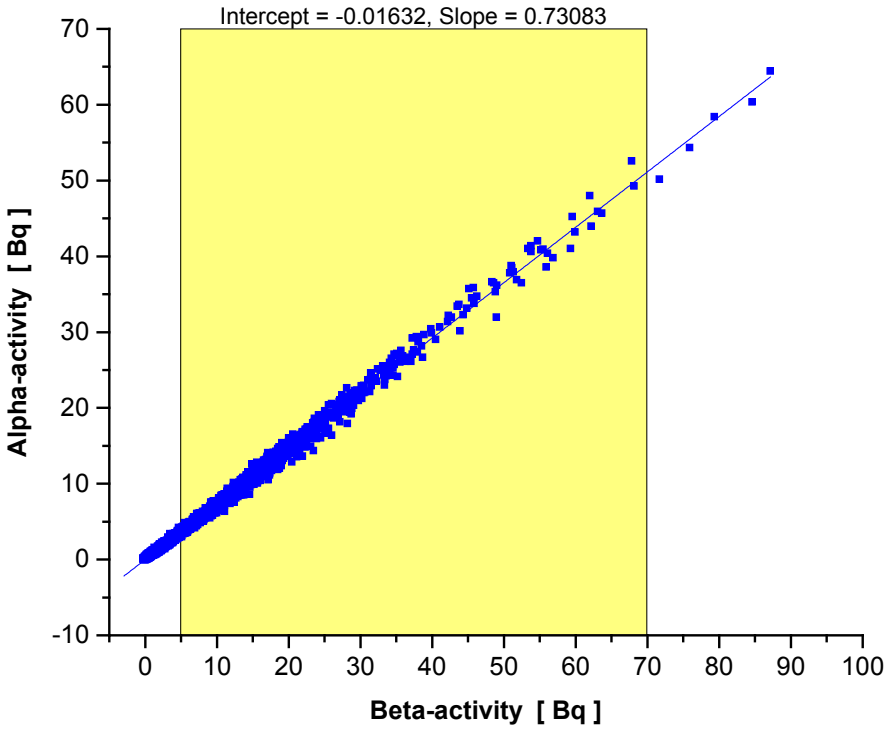

Figure 5. Correlations between the α-activity and β-activity in 2016.

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 threshold values (here 0.6 and 2.3). 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: $B_n = B_g - (A_g / F_m)$

Comments on technical aspects (RADAIR):

In 2016, the FHT59S monitor did not have any major failures except some communication problems. But at Jungfraujoch short power failures are frequent and therefore an uninterruptible power supply was installed.

Digitel Jungfraujoch 2016

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-lifes and the 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 2016.

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 a week in order to better follow possible inputs of stratospheric air over this time period.

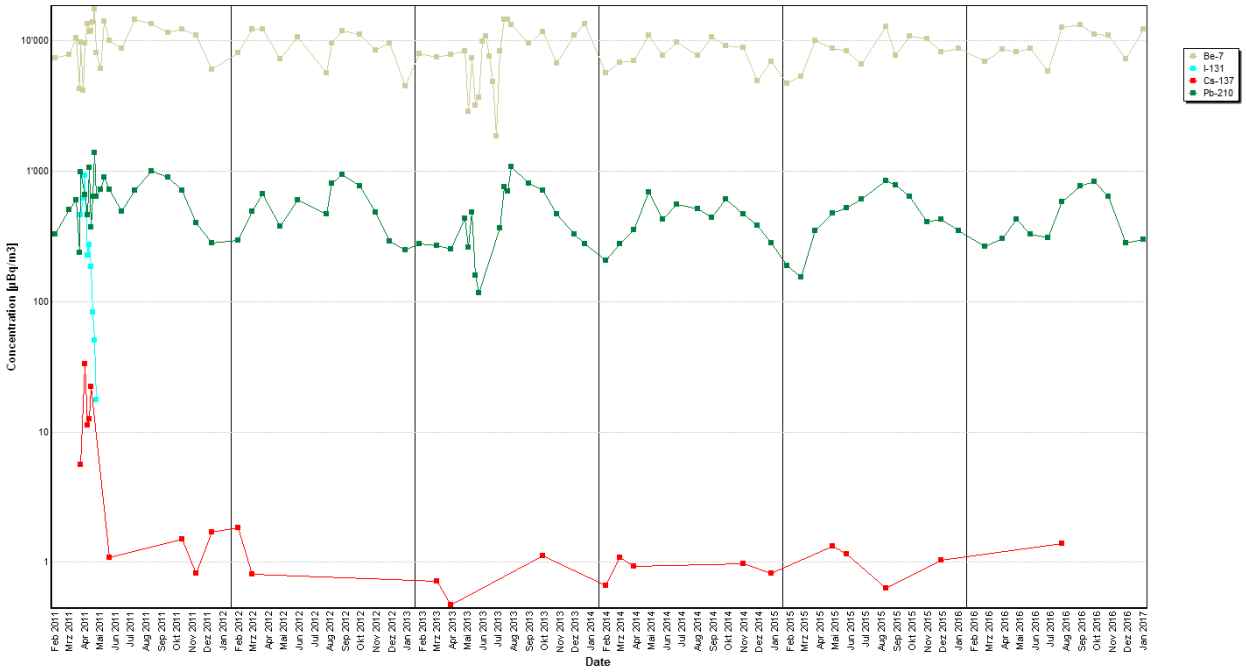

Figure 6. Concentration (µBq/m^3) of ^{7}Be, ^{210}Pb, ^{131}I and ^{137}Cs between 2011 and 2016, station Jungfraujoch.

Key words:

RADAIR, Digitel, Radon, radioactivity, aerosols, radioisotope

Internet data bases:

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

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