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:
2011 – the year of the Fukushima accident

An automatic aerosol radioactivity monitor FHT59S (total alpha and total beta activity) is operated at 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 detection of any increase of radioactivity in 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 made 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 2011:
Figure 1A shows the natural alpha radioactivity, the calculated artificial beta radioactivity and the ratio between α and β activities during the period January 1 to December 31, 2011.

Figure 1B shows the same parameters for the period following the Fukushima accident, from 20 March to 20 April. These figures show 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 April 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 activities ratios fluctuates then between 0.8 and values greater than 1.5;
- In January 2012, after changing the high voltage of the sensor and a new calibration, the value of the mean α/β activities ratio changed from 0.6 to 0.8;

After the Fukushima accident (see Figure 1B), no increase in calculated artificial beta activity could be detected because the concentrations of the Iodine and Cesium isotopes were below the detection limit of our aerosol monitor; the α/β activities ratio

remained stable around 0.8. An increase of the artificial beta activity would have led to a decrease of this ratio to a value of about 0.5 – 0.3. However, radioactivity from Fukushima was detected in the Digitel samples (see below).

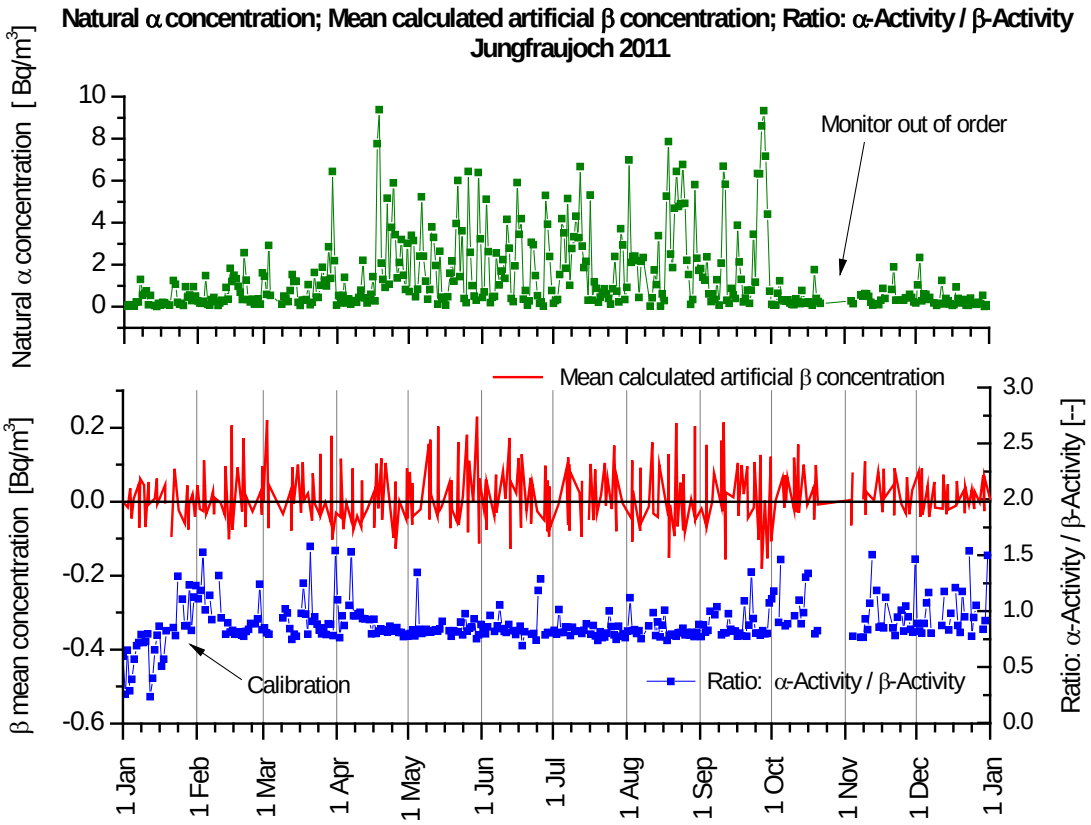


Figure 1A. *Results of Radair measurements in 2011.*

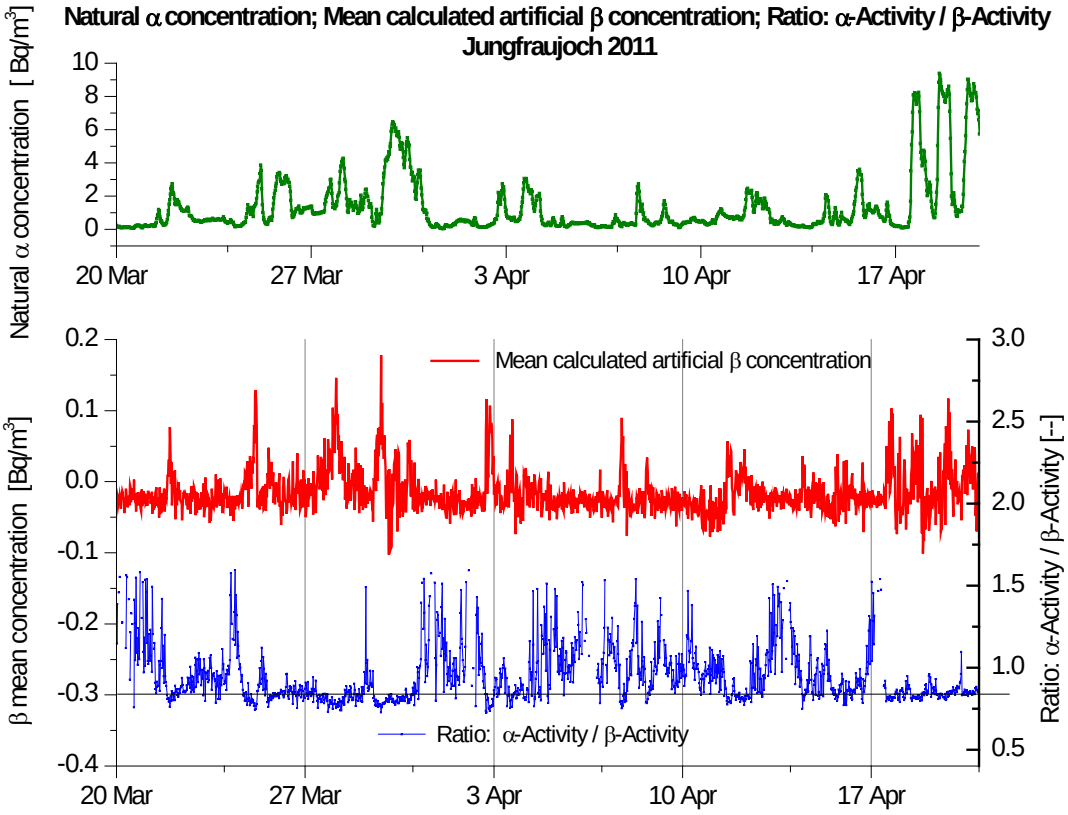
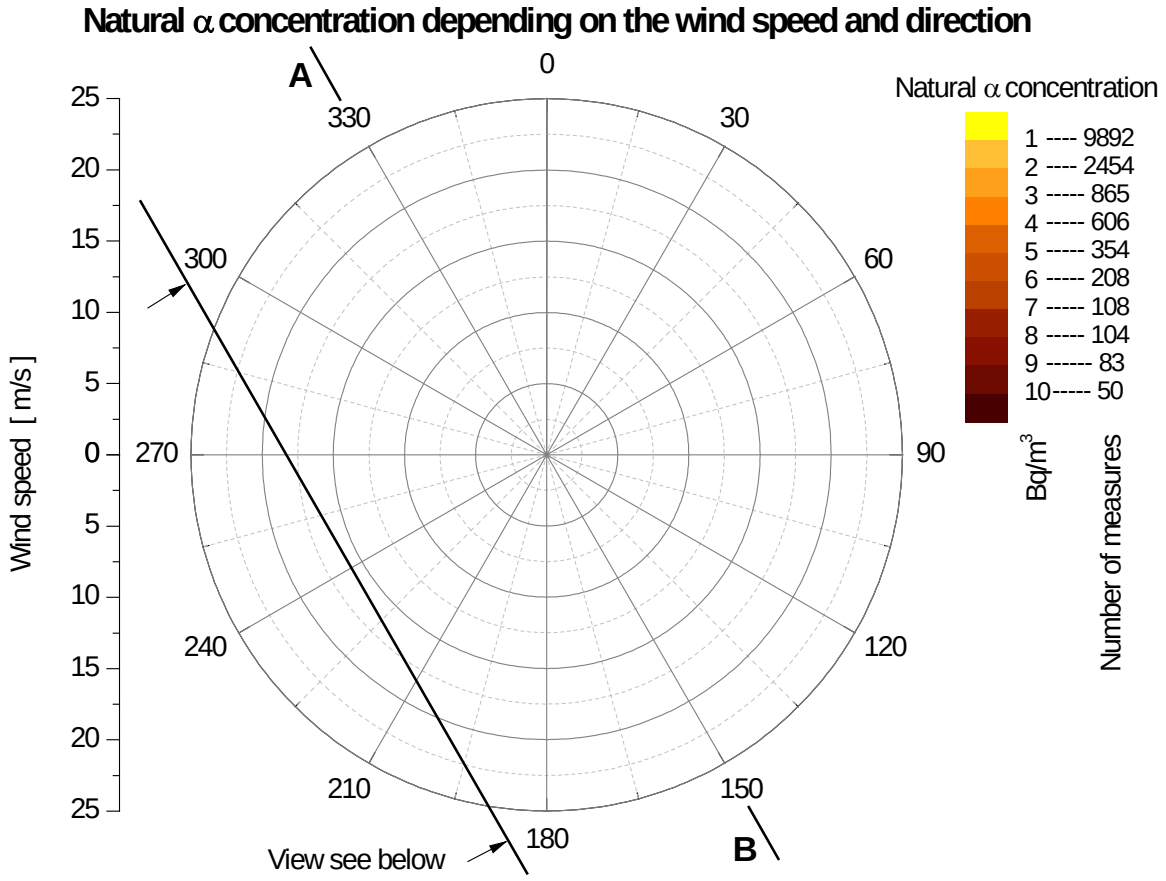


Figure 1B. *Details of Radair measurements during March/April 2011*

Figure 2 (top panel) shows the natural alpha concentration as a function of the wind direction and wind speed. We observe that when the main winds blow strongly, especially the North-West, the natural radioactivity decreases due to the dilution in the air. The highest concentrations are recorded with more gentle South-South-Easterly winds.



View Axis: A – B:

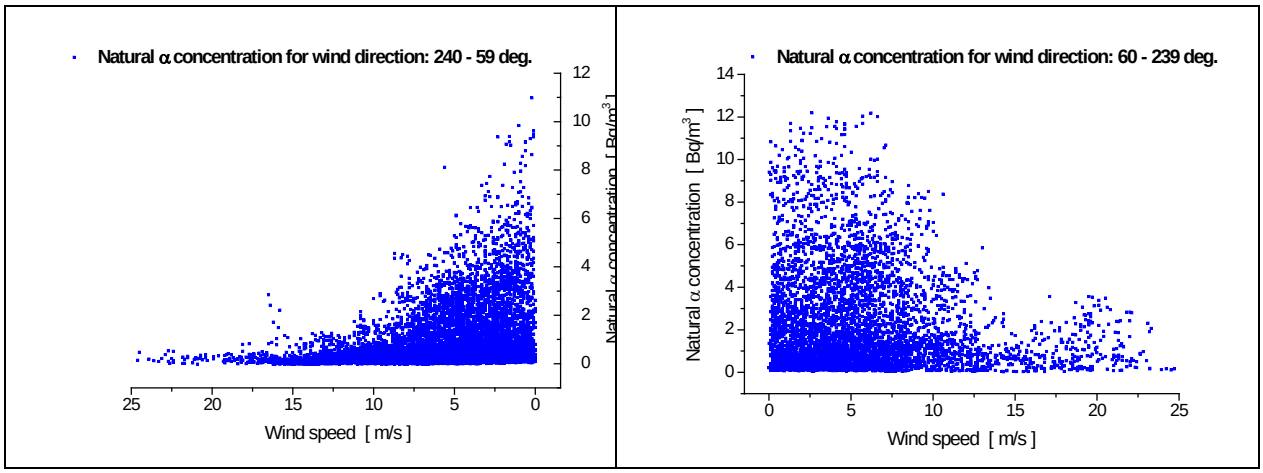


Figure 2. *Natural alpha concentrations and prevailing winds.*

Figure 3 shows the histogram of the calculated artificial beta radioactivity in aerosol for 2011 (and 2010). 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;
- As shown in the histogram below, some 95 percent of the beta concentrations recorded in 2011 were below 0.08 Bq/m^3.
- The histogram recorded for 2011 is rather symmetric; this shows that the automatic compensation technique was good. Note that even if the histogram recorded for 2011 is slightly less symmetric than the one recorded for 2010, the compensation technique can however be generally considered as adequate.
- The tail on the right side indicates that beta concentrations are more difficult to compensate when the alpha concentrations are a little higher than normal. When the alpha concentration decreases quickly, the compensation technique can't follow. Some values are therefore greater than 0.1 Bq/m^3.

Due to some failures of the monitor, there were fewer measurements in 2011 than in 2010.

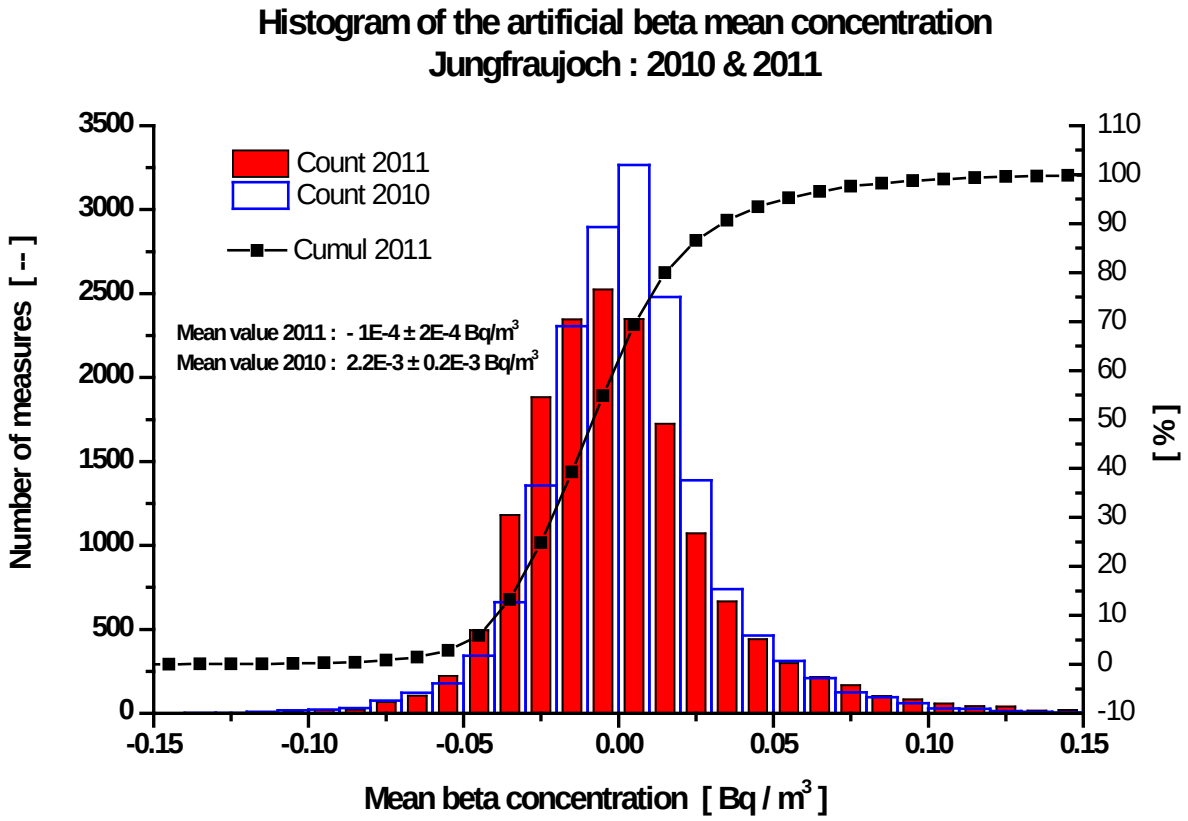


Figure 3. *Histogram of calculated artificial beta concentrations*

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 0.1 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 0.1 Bq/m^3 could therefore be detected.

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: $B_N = B_G - f \times A_G$. The constant factor α/β (f) can be adapted either by the software program or by the operator. Note that since 2009, the post compensation was not applied any more; but the factor α/β (f) is periodically adjusted for each monitor.

Comments on technical aspects (Radair):
Except some minor interruptions due to change or repositioning of the filter (March and August), some power cut and a problem of automatic restart of the computer after a power outage (October), there was no major breakdown of the aerosol monitor in 2011.

Digitel High-Volume-Sampler: Introduction
A Digitel DHA-80 High Volume Sampler (HVS) automatic air sampler with a typical air flow rate 0.6 m3/min is operated at the Jungfraujoch by the FOPH. Aerosols are collected on glass fibre filters of 150 mm in diameter. The pump maintains a constant flow rate independent of dust load on the filter. The filters are automatically changed once a week and are measured as a combined sample at the end of the month in the laboratory using a high purity coaxial germanium gamma-ray detector during 1-2 days. Thereafter activities of radioactive isotopes are calculated by considering the corresponding half-lifes and time between sampling and measuring.

During nuclear accident of Fukushima in March 2011 filters were measured individually directly after collection (one week or less) in order to detect radioactive isotopes released by the nuclear power plant more quickly. Therefore, the time between sampling and measuring was significantly shorter than with the routine procedure.

^{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 of the radioisotope measurements of the Digitel filters
Figure 4 shows the conce ntration (µBq/m3) of 7Be, 210Pb, 131I and 137Cs for 2010 and 2011. The gray vertical line indicates the date of nuclear accident at the Fukushima power plant (March 11th 2011).

Concentrations of ^{7}Be and ^{210}Pb remained rather constant during 2010 and 2011. A slight increase of ^{210}Pb during summer 2010/11 can be observed, which is due to convection of ^{210}Pb-rich air masses. 7Be concentration seems to be slightly increased during summer too. This can be related to the air exchange between stratosphere and troposphere.

Iodine-131 and ^{137}Cs released during the accident at the Fukushima nuclear power plant have been clearly detected at Jungfraujoch. First increased concentrations were measured by the end of March 2011 and a maximum was observed at the beginning of April. Iodine-131 has never been detected at Jungfraujoch since the installation of the Digitel-sampler in 2006, whereas ^{137}Cs was detected only occasionally at much lower concentrations.

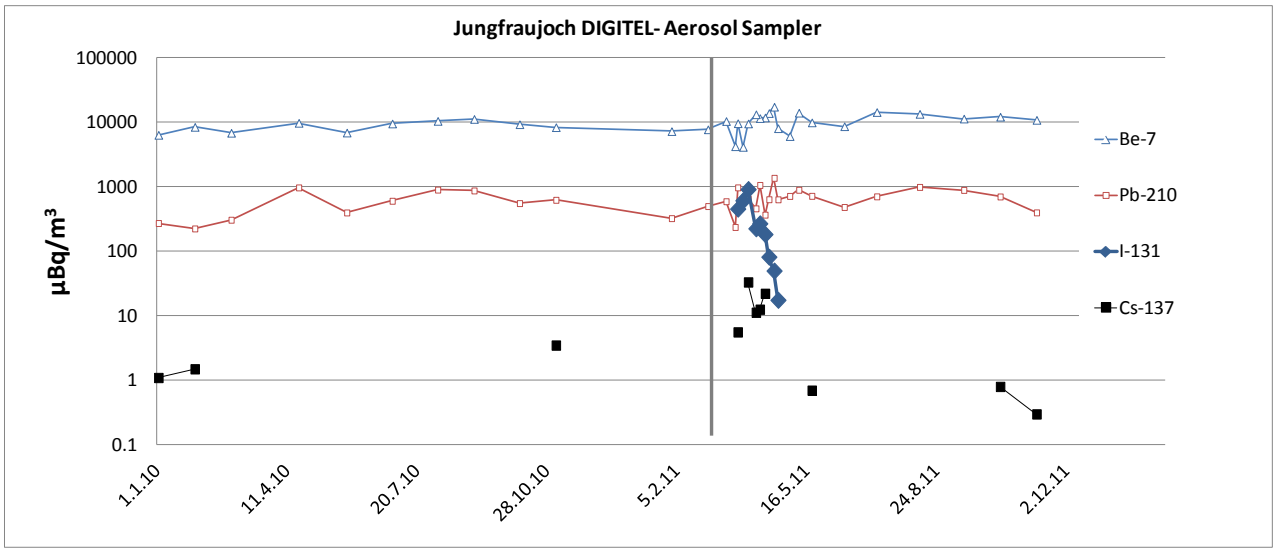


Figure 4. *Concentration (µBq/m^3) of ^{7}Be, ^{210}Pb, ^{131}I and ^{137}Cs between 2010 and 2011, HVS Station Jungfraujoch. The yellow line indicates the date of nuclear accident (March 11th 2011).*

Key words:

RADAIR, Digitel, Radon, radioactivity, aerosols, radioisotope, Fukushima

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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