Baseline characterisation of air masses using radon-222

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1. Project description

The main objective of our project is to acquire high-quality atmospheric radon data that allows to assess the influence of boundary layer air on Jungfraujoch. For this purpose, we continuously operate a radon detector at the research station. Data is freely available at our website (radon.unibas.ch). Raw data is also transferred daily to the *ICOS Atmosphere Thematic Centre*, operated by the Laboratoire des Sciences du Climat et de l´Environnement at Gif-sur-Yvette, France, where it is validated and radon concentrations are calculated according to a standard protocol (https://www.icos-ri.eu/icos-central-facilities/icos-atc). Together with radon data from other ICOS stations, our contribution allows to validate atmospheric transport models at a regional scale. It is currently being used in at least two such validations by groups in Germany and in Sweden.

In addition, we used our data to shed light on two specific issues. First, to identify situations during which Jungfraujoch may have been within the well-mixed boundary layer. Second, to identify stratospheric intrusion events. The first issue was addressed by combining data from Jungfraujoch with data from a second, identical radon detector operated on the roof of the Physics Institute in Bern in collaboration with the research group *Environmental Isotopes and Gases* at the University of Bern. The longterm median concentration of radon at Bern is around 5.5 Bq m^{-3}. Due to its short half-life of 3.8 days, most of the radon emitted from land surfaces decays within the boundary layer. Only little is transported to greater height. At Jungfraujoch the longterm median concentration is only about ¼ of what it is at Bern. However, there are situations in which radon concentrations are similar at Jungfraujoch and at Bern, indicating that Jungfraujoch might be within the well-mixed boundary layer. For the years 2016 to 2018, close to 23'000 parallel hourly measurements at both stations are available. In about 1% of these hours, the ratio of radon at Jungfraujoch to radon at Bern was larger than 0.8, while absolute concentrations at both stations were relatively low (< 2 Bq m^{-3}), indicating efficient and deep mixing in the lower troposphere. Such situations can occur due to anabatic mountain winds efficiently transporting boundary layer air to Jungfraujoch on clear summer days, but also during the passage of weather fronts across the Alps (Figure 1). An initial analysis of the years 2016 to 2018 suggests a majority of situations when Jungfraujoch is within the well-mixed boundary layer occurs during the passage of weather fronts across the Alps, in particular during the month of March.

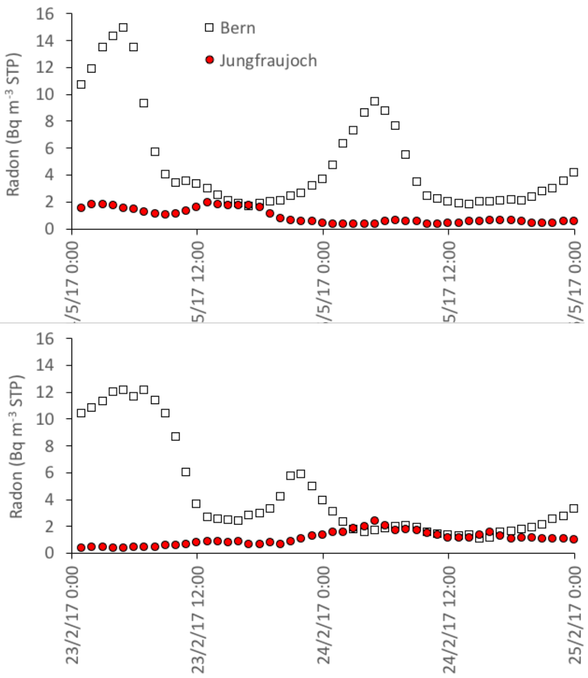

Figure 1. Two contrasting situations when radon concentrations at Jungfraujoch and at Bern were very similar during several hours. One (top: 24.05.2017, afternoon) was caused by thermally driven mountain winds. The Climate Bulletin of MeteoSwiss (May 2017) reports for that day: "The powerful summer sun provided Switzerland on 24 May the first hot day of the year." *(https://www.meteoschweiz.admin.ch/). A different situation had been observed a few months earlier (bottom: 24. February 2017, early morning to afternoon). Here, the Climate Bulletin (February 2017) reports that* "Extremely mild air masses swashed into

Switzerland with stormy south-westerly winds on 23 February." *During late evening on 23. February the front must have reached Bern, where it broke up the nocturnal boundary layer in which radon had started to accumulate since late afternoon. At about the same time as the accumulation was interrupted, radon concentrations began to increase at Jungfraujoch. Although the additional radon observed at Jungfraujoch must have arrived from south of the Alps, very similar concentrations and temporal variations at Bern and at Jungfraujoch suggest a passage of the same, well-mixed air mass past both stations during about 12 hours.*

Apart from sometimes offering a view into the well-mixed boundary layer (around 1% of the time), Jungfraujoch can also offer a glance into the lower stratosphere. However, such episodes are even more rare. We have screened hourly radon and ozone data of the years 2016 to 2018 for situations when enhanced ozone concentration (> 70 ppb) coincided with radon concentrations below the 10th percentile of a moving 30-day window. Ozone, CO and NOy are monitored together with other air constituents at Jungfraujoch by the *National Air Pollution Monitoring Network* (NABEL). According to our criteria, there was no intrusion episode in 2016, one in 2017 (June; Figure 2), and six in 2018 (April to August). All identified episodes could be confirmed by concurrent strong decreases in relative humidity and NOy/CO ratio. Such episodes may allow to estimate the stratospheric residence time of various halogenated compounds, also continuously monitored on Jungfraujoch within CLIMGAS-CH (HALCLIM) / AGAGE, operated by the group *Climate Gases* at the Swiss Federal Laboratories for Materials Science and Technology (Empa).

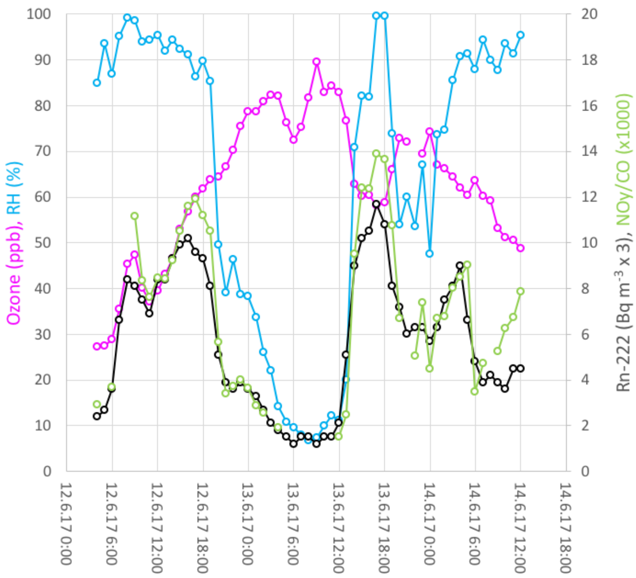

Figure 2. Example of a stratospheric intrusion episode at Jungfraujoch in June 2017 as identified through increasing ozone concentrations and simultaneously decreasing radon concentrations, relative humidity and NOy/CO ratio.

Collaborating partners / networks

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