Separating 'free tropospheric conditions' from those 'influenced by the planetary boundary layer'

Franz Conen[1], Lukas Zimmermann[1]

[1] Department of Environmental Sciences, University of Basel, Basel, Switzerland

franz.conen@unibas.ch

Part of this programme: ICOS

Keywords: planetary boundary layer; free troposphere; tracer

1. Project description

A wide range of atmospheric constituents are measured at Jungfraujoch. During the analysis of acquired data, one often asks whether *'free tropospheric conditions'* prevailed or whether measurements were *'influenced by the planetary boundary layer'* during a particular time interval. To inform judgements on that matter we continuously monitor the concentration of radon (^{222}Rn) in air aspired from outside the Research Station Jungfraujoch. Land surfaces are the source of radon in the atmosphere, where its sole sink is radioactive decay (half-life: 3.8 days). Thus, radon is a tracer of recent land contact of an air mass and it indicates, in principle, whether a measurement was *'influenced by the planetary boundary layer'*. However, setting a threshold in radon concentration above or below which either condition is met, was so far a largely arbitrary judgement. For this year's report, we analysed the probability density function (PDF) of all radon concentration values acquired during the past five years, a total of 42'450 one-hour measurements made between November 2015 and December 2020. The PDF of the log-transformed values can closely be reproduced by the sum of two fitted normal distributions. They most likely represent air masses *'influenced by the planetary boundary layer'* and *'free tropospheric conditions'* (Figure 1). Other allocations of the two distributions, say to summer and winter, or southern and northern approach of air masses seem less likely because the differences in radon concentrations between these categories are less pronounced and not so systematic. The best-matching relative weights found in the fitting process were 0.415 for the PDF 'free troposphere' and 0.585 for the PDF 'boundary layer'. In other words, *'free tropospheric conditions'* seem to have occurred over the past five years less often (41.5%) than conditions *'influenced by the planetary boundary layer'* (58.5%). Between the median of the distributions is a difference of 1.7 Bq m^{-3} (STP) or 1.1 Bq m^{-3} (local conditions). However, the distributions also have some overlap. Roughly, the highest 10% of 'free troposphere' values are larger than the lowest 10% of 'boundary layer' values (Table 1). Still, we think the separation of both distributions provides for a more informed judgement than before in setting of a threshold radon concentration below which *'free tropospheric conditions'* are likely.

When in doubt regarding the condition during an atmospheric measurement at Jungfraujoch, we can now say with about 90% confidence (10% false positives) that it was done in *'free tropospheric conditions'* when the concurrent radon concentration was below 1.0 Bq m^{-3} (STP) or below 0.64 Bq m^{-3} (local conditions; note: concentration values displayed on our website (radon.unibas.ch) are for local conditions).

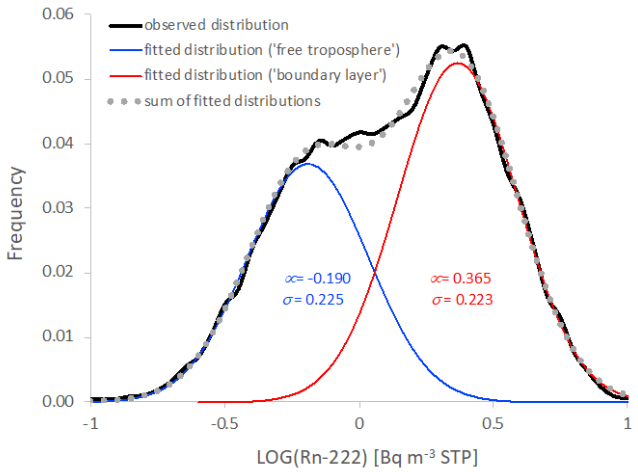

Figure 1. Probability density function (PDF) of radon concentration values (log-transformed) observed during the past five years at Jungfraujoch. The observed PDF is closely reproduced by the sum of two weighed PDFs most likely representing 'free troposphere' and air masses influenced by the 'boundary layer'.

Table 1. Back-transformed median, upper and lower 10th perentile of the two fitted distributions shown in Figure 1. Note: values displayed on our website (radon.unibas.ch) are for local conditions.

		median	percentile	
			10th	*90th*
'free troposphere'	*STP*	0.6	0.3	1.3
	local conditions	0.4	0.2	0.8
'boundary layer'	*STP*	2.3	1.2	4.5
	local conditions	1.5	0.8	2.9

Collaborating partners / networks

Dr. M. Gysel, Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Villigen, Switzerland
Dr. S. Reimann, Dr. C. Hüglin, Dr. M. Steinbacher, Ms. C. Zellweger-Fäsi, and Dr. A. Fischer, Laboratory for Air Pollution/Environmental Technology, Swiss Laboratories for Material Science and Technology (Empa), Dübendorf, Switzerland
Dr. Alastair Williams, Dr. Alan Griffiths, Dr. Scott Chambers, Australian Nuclear Science and Technology Organisation (ANSTO), Sydney, Australia

Address

Department of Environmental Sciences
University of Basel
Bernoullistrasse 30
CH-4056 Basel
Switzerland

Contacts

Dr. Franz Conen
Tel.: +41 61 207 0481
e-mail: franz.conen@unibas.ch