



## **Radon-222 in urban atmosphere: assessing the local fluxes of CO<sub>2</sub> and CH<sub>4</sub>**

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Radon-222 is an inert, alpha-emitting radioactive gas with the half-life of 3.8 days. It is a product of decay of <sup>226</sup>Ra which belongs to <sup>238</sup>U-decay series. Uranium-238 and its decay product <sup>226</sup>Ra are ubiquitous in the upper Earth's crust and in the soils. Radon-222 which is being released into the pore space of soils, diffuses into the atmosphere where it decays to lead <sup>210</sup>Pb. The release rate of <sup>222</sup>Rn is controlled by source term (<sup>226</sup>Ra content in the soil and its vertical distribution) and by physical properties of the upper soil layer (mineral structure, porosity, water content). It depends also on the position of groundwater table and fluctuations of atmospheric pressure.

Anthropogenic emissions of greenhouse gases such as CO<sub>2</sub> and CH<sub>4</sub> constitute an important component of the carbon budget, both on global and regional scales. For heavily industrialized and populated areas such as western and central Europe, a large proportion of the total CO<sub>2</sub> flux entering the atmosphere is attributed to burning of fossil fuels. Also CH<sub>4</sub> has important anthropogenic sources (leakages of gas networks, landfills, cows, etc.). Global and regional models of carbon cycle rely mainly on emission statistics to quantify the magnitude and variability of anthropogenic CO<sub>2</sub> and CH<sub>4</sub> fluxes into the atmosphere. Direct measurements of those fluxes, particularly in urban environment, are very difficult. Therefore, alternative ways of assessing their magnitude and variability are needed.

Krakow (50°04'N, 19°55'E, 220 m a.s.l.) is a large urban agglomeration located in the southern Poland, with about 1 million inhabitants, rapidly growing car traffic and significant industrial activities. Consumption of coal, gas and oil for communal and

transport purposes generates major fluxes of anthropogenic CO<sub>2</sub> within the region. Leakages of old-fashioned city gas network constitute an important source of CH<sub>4</sub> in the area. In addition, due to prevailing westerly air circulation, the Krakow region is under substantial influence of a large coal mining and industrial centre (Upper Silesia) located approximately 60 km west of the city with its substantial sources of anthropogenic sources of CO<sub>2</sub> and CH<sub>4</sub>.

Radon-222 has been monitored in Krakow since June 2004 using filter method. The air intake is located ca. 30 meter above the ground, on the roof of the Faculty building. In the same location, quasi-continuous measurements of CO<sub>2</sub> and CH<sub>4</sub> mixing ratios in the local atmosphere are performed. Rn-222 exhibits substantial seasonal and diurnal fluctuations. The maximum of mean monthly <sup>222</sup>Rn concentration occurs usually in October (ca. 10 Bqm<sup>-3</sup>), while minimum is recorded in March or April (ca. 2.5 Bqm<sup>-3</sup>). Daily mean values fluctuate between ca. 1Bqm<sup>-3</sup> and 18 Bqm<sup>-3</sup>.

Radon-222 can be used as a proxy for assessing surface emissions of other gases which have their sources distributed roughly uniformly on the surface. This is the case of CO<sub>2</sub> and CH<sub>4</sub> in an urban environment where CO<sub>2</sub> and CH<sub>4</sub> emissions are controlled by multitude of small sources (car traffic, local heating systems, leakages from gas network, etc.). If the flux of <sup>222</sup>Rn into the atmosphere on the given area is known or can be reasonably assessed, the surface fluxes of other gases, such as CO<sub>2</sub> and/or CH<sub>4</sub>, can be calculated for the periods of time when concentrations of <sup>222</sup>Rn and those gases in the lower atmosphere are controlled mainly by intensity of sources. This typically happens during periods of atmospheric inversion. The record of <sup>222</sup>Rn specific activity, available for the period June 2004 – June 2007, was analysed in combination with CO<sub>2</sub> and CH<sub>4</sub> mixing ratios data with the aim to obtain quantitative assessment of monthly mean fluxes of carbon dioxide and methane into the urban atmosphere of Krakow.

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