[Radioactivity and ELECTric field monitoring campaign at Hyytiälä, RELECT]

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- **Introduction and motivation**

The atmospheric electric field is a relevant parameter for climate since it influences the formation of aerosols and consequently the cloud properties and the radiative balance of the atmosphere. The electric properties of the atmosphere are dependent on the air ionisation, which in turn is strongly influenced, near the Earth's surface, by radon gas concentration and terrestrial gamma radiation, and at high altitudes, by solar energetic particles and secondary cosmic rays.

This project is motivated by the need of continuous observations on both the electric field and the surface sources of air ionisation, particularly radon, in order to advance understanding on the physical processes driving air ionisation and the temporal variability of the atmospheric electric field.

- **Scientific objectives**

The main objective of the project is to perform simultaneous measurements of radon gas concentration, gamma radiation and local electric field at the Hyytiälä research infrastructure. Hyytiälä is a particularly appealing location given it's geographical location at high latitude, making it very suitable for addressing the influence of cosmic rays and solar energetic particles on the local electric field.

Furthermore, Hyytiälä is one of the very few places in Europe where some continuous measurements of radon and gamma radiation have already been performed, and also includes substantial observations for the study of ions and aerosols. It is therefore very adequate for the simultaneous monitoring of the local electric field and of environmental radioactivity.

- **Methodology and experimental set-up**

Continuous sensors measuring the local electric field, radon gas concentration in soil, and gamma radiation in air were installed at the Hyytiälä research infrastructure (Fig. 1). All the sensors operated continuously from June to November 2017.

Fig. 1: Location of the sensors installed at the Hyytiälä research infrastructure.

The radon gas concentration is monitored with a Barasol sensor (Algade, France) installed in soil (Fig. 2), which measures radon concentration (in Bq.m-3) by spectral counting of alpha particles from the radioactive decay of radon radionuclides. The integration window was set to two hours.

Gamma radiation is measured with a NaI(Tl) scintillometer with a 3" crystal (Scionix, Holland) installed at 1 meter from the ground on the nearest tower (less than 20 meters) to the soil measurements of radon gas (Fig.

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3). The sensor counts gamma rays in the energy window from 475 keV to 3 MeV with an integration time of 5 minutes.

The atmospheric electric field is measured with a field-mill (Campbell Scientific Cs110) with measurements every 1-second being averaged every minute. The field mill (Fig. 4) was installed in the area closest to the lake, in order to avoid as much as possible the effect of trees.

Fig. 2: Radon sensor installation: June 2017 (left) / November 2017 (right).

Fig. 3: Gamma sensor installation: June 2017 (left) / November 2017 (right).

Fig. 4: Field mill installation: June 2017 (left) / November 2017 (right).

- **Preliminary results and conclusions**

The project enabled the collection at the research infrastructure of time series of radon concentration (Fig. 5), gamma radiation (Fig. 6) and atmospheric electric field (Fig. 7). All the collected data are publicly available:

https://rdm.inesctec.pt/dataset/cs-2017-011 (radon concentration every 2-hours in Bq.m-3)
https://rdm.inesctec.pt/dataset/cs-2017-010 (gamma radiation in counts.minute-1 every 5-minutes)
https://rdm.inesctec.pt/dataset/cs-2017-009 (electric field in V.m-1 every 1-minute)

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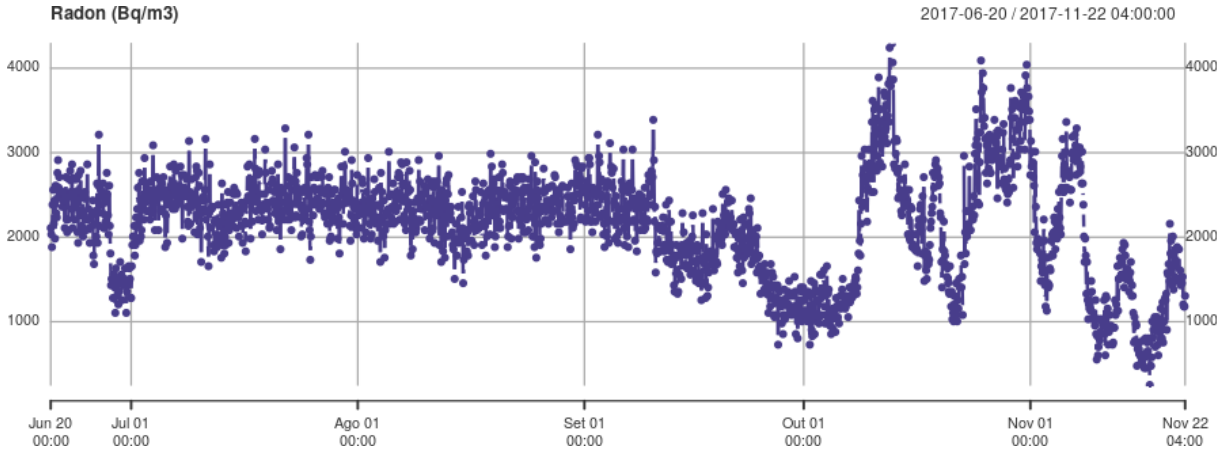

Fig. 5: time series of radon concentration measured at the research infrastructure.

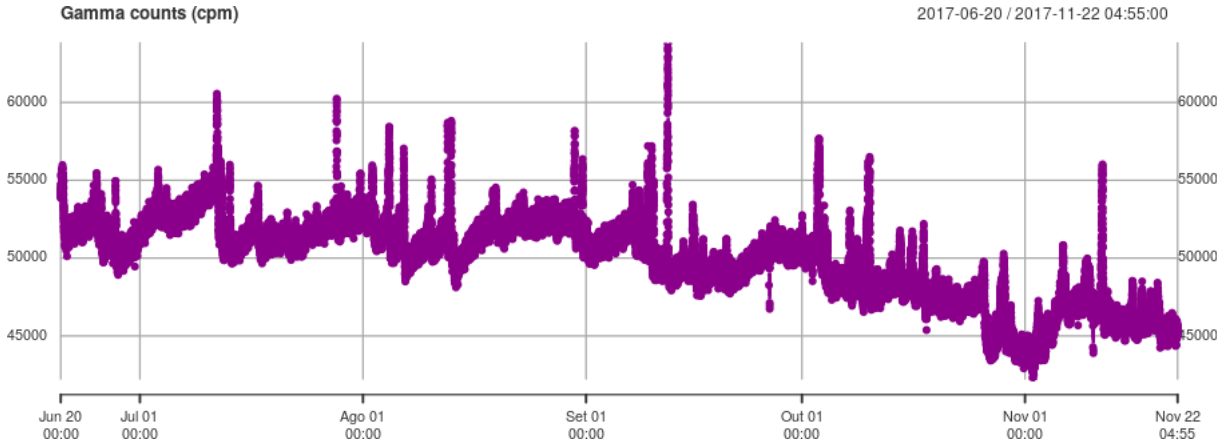

Fig. 6: time series of gamma radiation in counts per minute (cpm) measured at the research infrastructure.

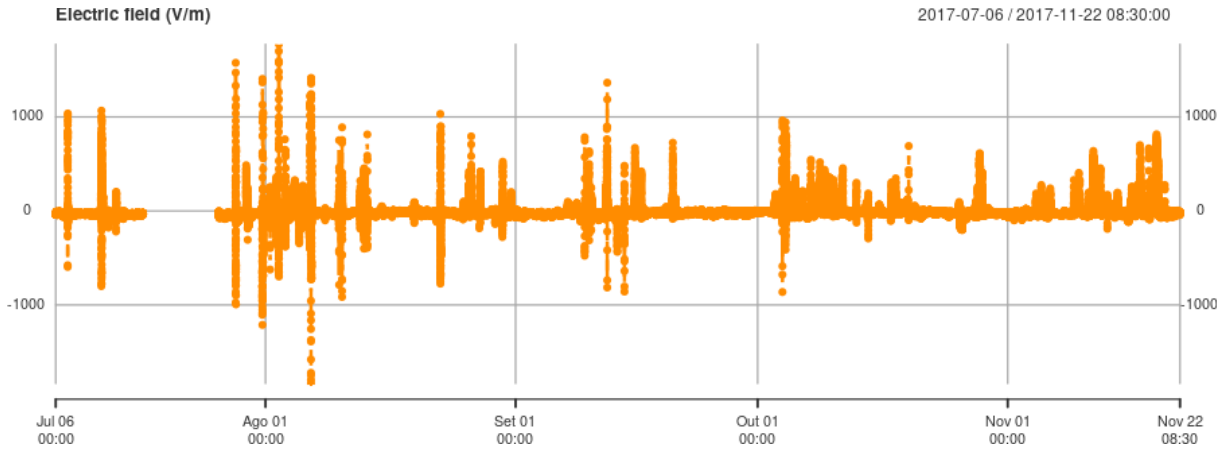

Fig. 7: time series of vertical electric field (in V/m) measured at the research infrastructure.

The results allow to conclude that the measured parameters display complex temporal patterns, reflecting the expected interplay of different surface and atmospheric effects. The temporal variability of the gamma radiation time series is consistent with results from another infrastructure (Barbosa et al, 2017a).

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- **Multidisciplinary approach**

The research topic, environmental radioactivity and atmospheric electricity, is associated with both atmospheric and solid-earth processes. Radiation is produced in the atmosphere from the interaction of cosmic rays and upper-atmosphere gases, and at the Earth's surface from the radioactive decay of primordial radionuclides in the crust. Terrestrial natural radioactivity from radionuclides in soils and rocks, as well as radon gas and its airborne progeny, are a fundamental source of high-energy particles causing air ionization in the troposphere and influencing the atmospheric electric field. Radon is a very appealing proxy for the study of solid-earth / atmosphere interactions since its release from the surface is dependent on properties of the soil (composition, permeability, water content,...), while it's concentration in air is dependent on the thermal and mechanical stability of the atmosphere. The substancial information on meteorological, soil, and ionisation conditions that is available at the infrastructure allows to add subtsancial value to the data acquired in the campaign and advance understanding on the interaction between surface and atmospheric processes.

- **Outcome and future studies**

Preliminary results of the campaign were presented at a COST workshop (Barbosa et al 2017b) and at a seminar at the university of Helsinki.

The data collected in the RELECT campaign, in conjunction with data already available from the research infrastructure, will be used in several multidisciplinary studies from which corresponding papers are expected in the near future. In particular research efforts will be focused on:

- detailed inter-comparison of electric field measurements from the sensor installed during the campaign and the field mill operating at the infrastructure
- study of the response of air ions to variations in environmental radioactivity
- study of the influence of soil moisture / snow on environmental radioactivity
- study of temporal changes in the local electric field associated with lightning
- study of potential effects of the strong solar event of September 2017 on radiation and electric field
- study of the effect of precipitation on the temporal variability of radiation and air ionisation, linking to recent results from the ENA station in the Azores (Barbosa et al, 2017a)

- **References**

Barbosa SM, Miranda P, Azevedo EB, 2017a. *Short-term variability of gamma radiation at the ARM Eastern North Atlantic facility (Azores)*. Journal of Environmental Radioactivity, 172, 218-231.

Barbosa SM, Chen X, Guimarães D, Monteiro C, 2017b. *Simultaneous monitoring of environmental radioactivity and atmospheric electricity at Hyytiälä - the RELECT campaign*. COST Action CA15211 workshop, WG5 meeting, Porto, September 2017.

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