COST
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

SHORT TERM SCIENTIFIC MISSION (STSM) – SCIENTIFIC REPORT

The STSM applicant submits this report for approval to the STSM coordinator

Action number: CA15211
STSM title: Instrumentation and calibration of atmospheric electrical potential gradient measurements
STSM start and end date: 30/07/2018 to 04/08/2018
Grantee name: Attila Buzás

PURPOSE OF THE STSM

The atmospheric electrical potential gradient (PG) measured near the surface under fair-weather conditions is a fundamental parameter of the atmospheric global electric circuit (GEC) and a quantity observed commonly all around the globe with various instruments (e.g., field mills, passive wire antennas). PG values obtained under fair-weather conditions provide useful information about the global state of the GEC.

Recently, much effort has been made to establish a globally coordinated network of atmospheric electricity measurements (GloCAEM, ELECTRONET COST Action) which enables us to detect possible global changes in the GEC and to monitor atmospheric electricity parameters simultaneously.

However, measuring the PG is a difficult task since it varies greatly on different spatial and temporal scales. Therefore, not only a careful data selection is needed but the instruments also must be well-calibrated, so the data obtained from different recording sites will be suitable for intercomparison.

- One main objective of this mission was to intercalibrate the portable BOLTEK EFM 100 field mill of the home institute (Geodetic and Geophysical Institute, Hungary, GGI) with a JCI131 field mill and with a passive wire instrument of the University of Reading. To this end, parallel potential gradient measurements were conducted at the Reading University Atmospheric Observatory (RUAO), United Kingdom.

- The intercomparison of simultaneous, parallel measurements conducted by different instruments was also among the aims of this mission. By means of these parallel measurements it is possible to evaluate the site-specific distorting effects at RUAO.

- This mission was also an outstanding opportunity for the grantee to deepen his knowledge in atmospheric electricity measurements and in the selection and data processing methods related to them.

- A passive wire antenna is operating at RUAO, which makes it possible to measure the potential gradient in a robust and accurate way. The grantee learned a lot about the modus operandii of the passive wire method and about the supporting electrometer system. This could prove to be particularly useful as a similar apparatus is planned to be installed at the observatory of the grantee’s home institute.

Funded by the Horizon 2020 Framework Programme of the European Union

DESCRIPTION OF WORK CARRIED OUT DURING THE STSM

- 30.07.2018.: Arrival to Reading, meeting with the host scientists, Professor Giles Harrison and Dr. Graeme Marlton at the Department of Meteorology, University of Reading. Visiting the atmospheric observatory, getting acquainted with the various instruments, learning some principles of the measurements. Discussing the working plan for the week.
- 31.07.2018.: Making parallel measurements with the BOLTEK field mill and the JCI131 apparatus, determining a conversion function between the two devices. Measuring the potential gradient along lines (line I-V.) in points of a grid at the observatory with a spatial resolution of 2 m in order to assess the extent of the site-specific effects at the height of the passive wire (1 m above ground) (Fig. 1). The grantee gave a seminar talk in the afternoon after conducting the measurements.

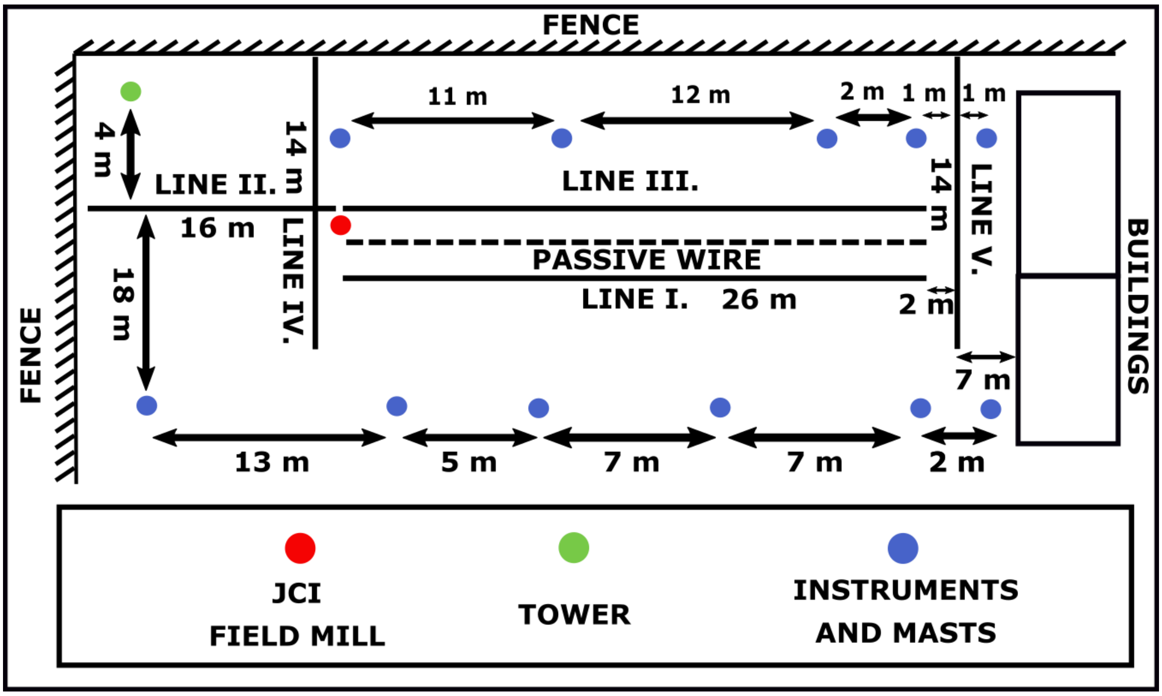


Fig. 1. Sketch of the measurement site, Reading University Atmospheric Observatory (RUAO).

Fig. 2. Photo of the portable BOLTEK EFM 100 and the JCI131 field mills.

- 01.08.2018.: Performing a parallel measurement with the BOLTEK, the JCI131 and the passive wire instruments (Fig. 2). Investigating the height variation of the instrument on an open field (at the sports ground). Evaluating the shielding effect of a tree on an open field.
- 02.08.2018.: Measuring PG at different heights at the observatory. Leaving the instrument at RUAO for the night, continuous parallel measurements for that time period.
- 03.08.2018.: Parallel measurements PG with BOLTEK and JCI field mills and the passive wire. Discussing the preliminary results and some important aspects of atmospheric electricity measurements. Negotiating possible future work.
- 04.08.2018.: Departure.

	Monday 30.07.	Tuesday 31.07.	Wednesday 01.08.	Thursday 02.08.	Friday 03.08.	Saturday 04.08.
morning	Arrival	Parallel and grid measurements	Parallel measurements	Height variation measurements at RUAO	Parallel measurements	-
afternoon and evening	visiting the observatory & discussing the working plan	Grid measurements, seminar talk, dinner with hosts	Measurements on the sports ground (height variation & shielding effect of trees)	Parallel measurements, discussing the preliminary results	Discussion with host scientists concerning the results so far & possible future research	Departure

DESCRIPTION OF THE MAIN RESULTS OBTAINED

Based on parallel measurements, during which the portable BOLTEK instrument was put next to the JCI instrument (red dot on Fig. 1), a conversion function was determined between the two apparatus (Fig. 3).

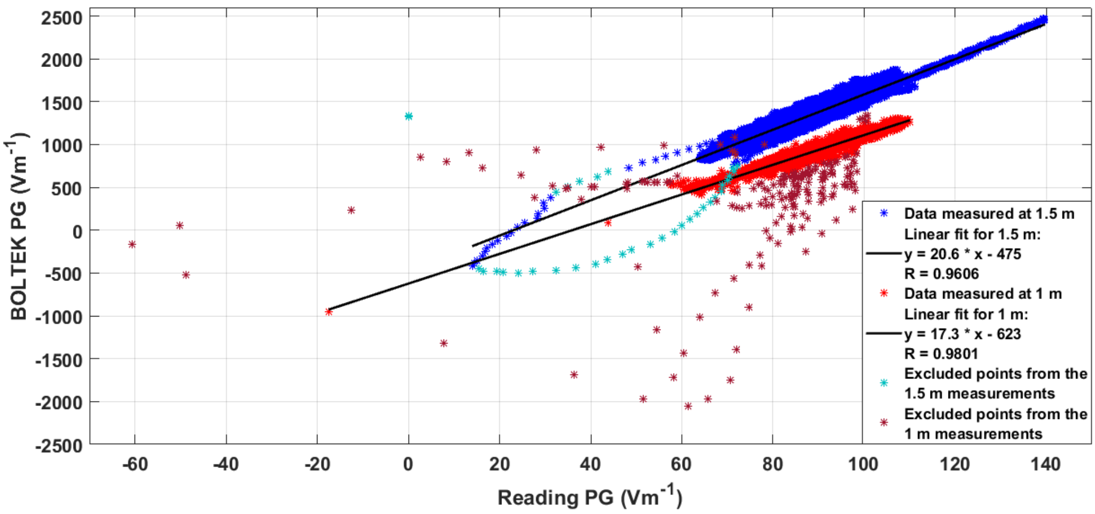


Fig. 3. Linear regression of the data obtained during the parallel measurements. Points with greater than 1 standard deviation were excluded.

According to the results of the linear regression two distinct linear trend were detected in case of the measurements at 1 m height and in case of those at 1.5 m height respectively (Fig. 3).

In case of the grid measurements to survey site-specific effects, the grantee used the linear trend determined for the data from the same day in order to exclude any drift effects (Fig. 4).

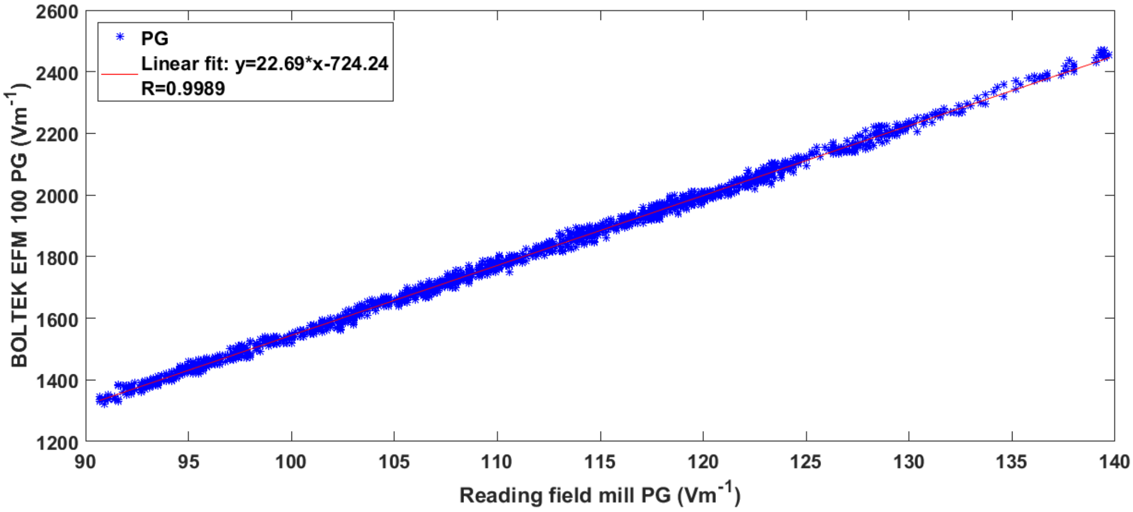
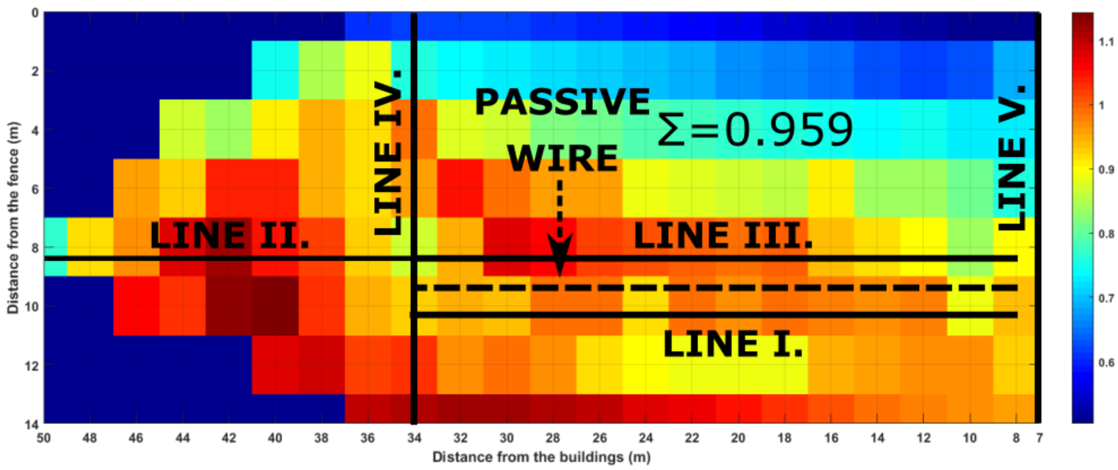


Fig. 4. Linear regression for the grid measurements based on parallel measurements made 10:21-11:00 31.07.2018 at 1.5 m height.



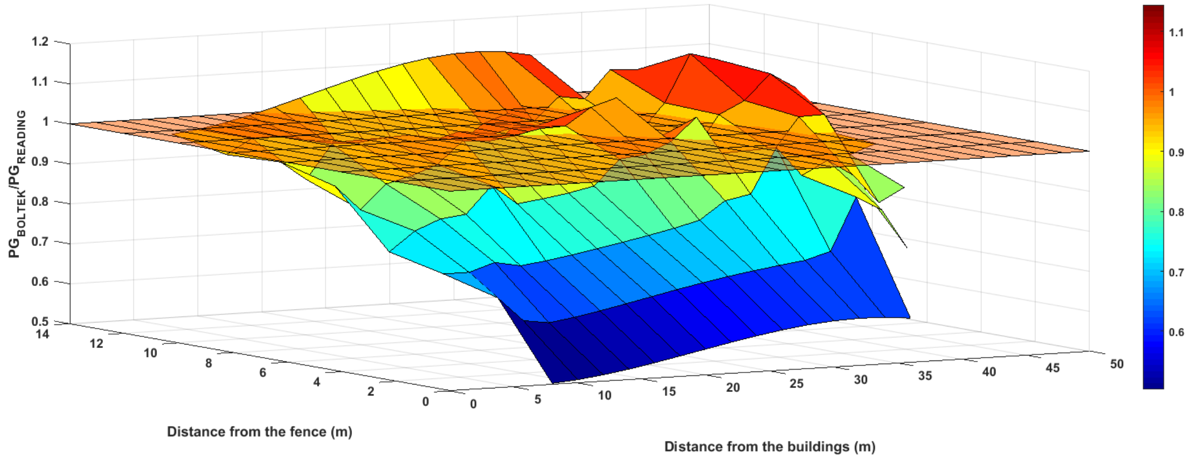
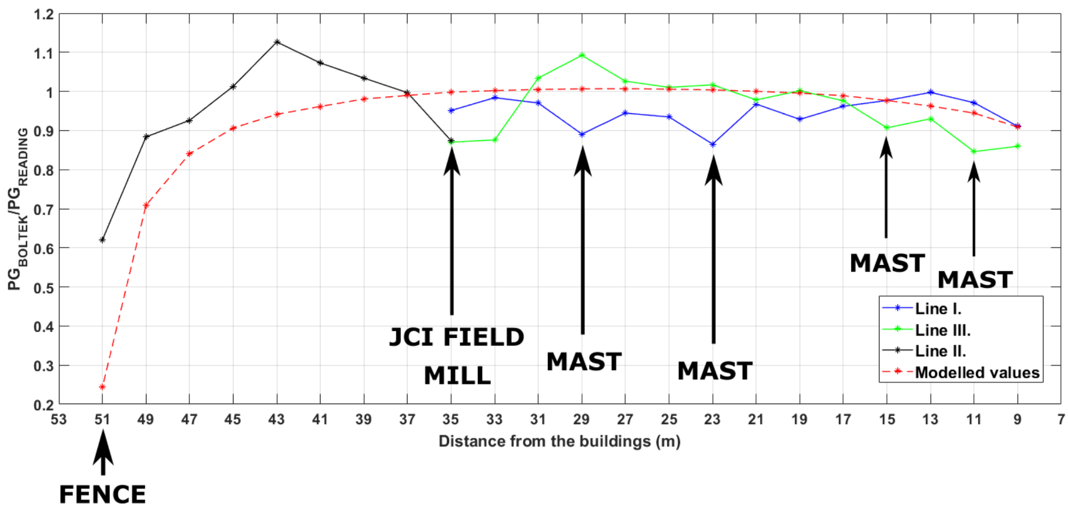


Fig. 5. Interpolated results of the grid measurements, the PG damping (upper and lower panel). The ratio of the BOLTEK PG and the Reading JCI field mill PG were derived by measuring in 53 points along 5 lines with a spatial resolution of 2 m at 1.5 m height. At each point the STSM fellow measured for 1-3 minutes then averaged these values. The transparent surface on the lower plot denotes the level where the PG ratios equal to one.

A mean field reduction was calculated along the passive wire with a value of 0.959. According to this, the shielding effect along the passive wire is negligible. The JCI field mill at RUAO is mounted at a height of 3 m, as the height of the fence is 2.5 m its shielding effect is unlikely to affect the measurements.

The grantee also applied an electrostatic modelling software (FEMM 4.2) so as to compare the measured values with the modelled ones (Fig. 6).



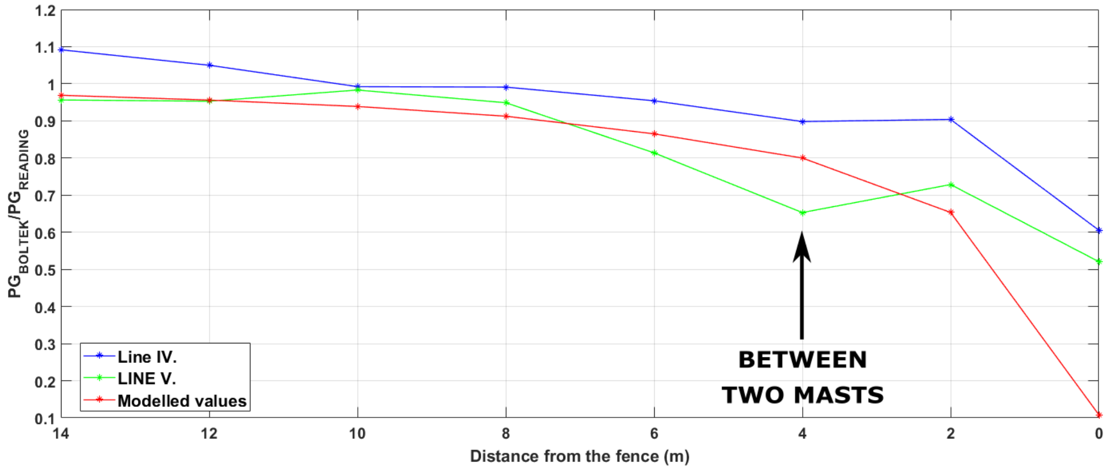


Fig. 6. Upper plot: measured and modelled values along the lines perpendicular to the buildings (Line I-III). Lower plot: the same for the lines perpendicular to the previous ones (Line IV-V).

As it can be seen on Fig. 6. there are some minor distortions caused by other instruments and their supporting poles. Note that these effects are probably not present or just with a much smaller magnitude at the height of the stationary JCI field mill (3 m).

According to the measurements the shielding effect of the fence distorts the E field to a distance of about 8 m which is a few meters smaller value than the one obtained from the modelling. This might be an effect of the perfect conductivity of the objects in the model.

An investigation regarding the height variation of the PG as measured by the BOLTEK EFM 100 instrument was also carried out (Fig. 7, 8). 10 minutes measurements were made on an open field, away from any distorting objects and at RUAO as well.

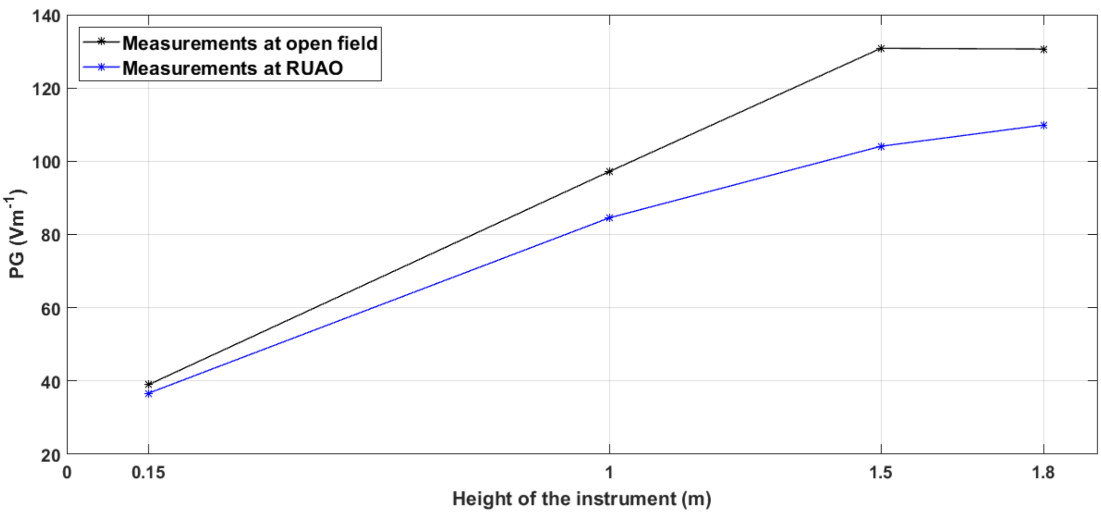


Fig. 7. The height variation of the BOLTEK instrument measured on an open field (+236 % from 0.15 m to 1.5 m) and at RUAO (+184 % from 0.15 m to 1.5 m).

This increase might be attributed to the fact that at 1 m the device was mounted to a tripod and at 1.5 m the geometry of the tripod was changed (Fig. 8). This may have caused more dense equipotential surfaces at the tip of the tripod, thus more intensified vertical electric field values.

Fig. 8. Photos about the installation of the BOLTEK EFM 100 field mill at different heights (15 cm, 1 m and 1.8).

A series of measurements were also performed on the sports ground (big, open field) to assess the shielding effect of a tree with a height of approximately 35 m (Fig. 9).

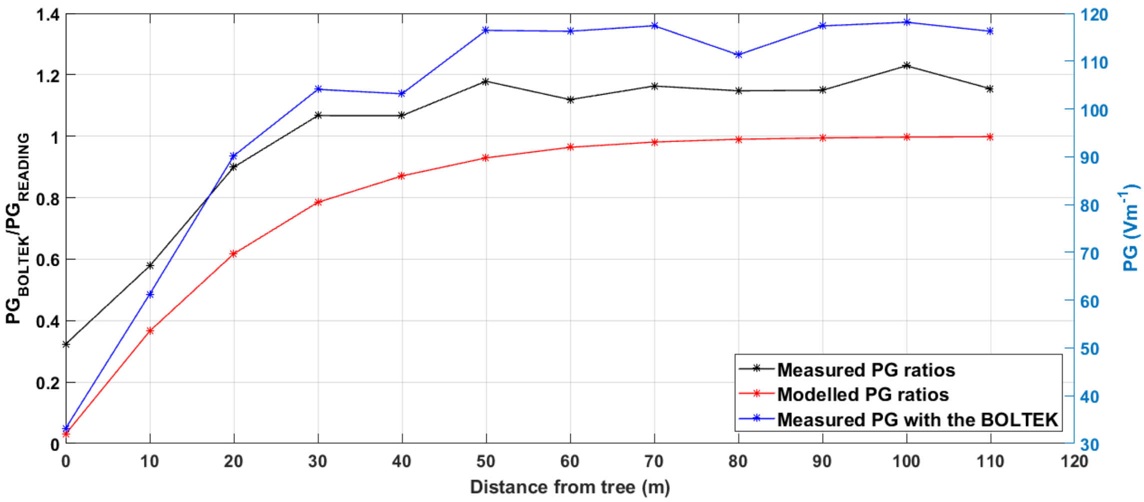


Fig. 9. The shielding effect of a tree. The blue, right hand axis corresponds to the blue curve.

Again, the modelling tends to overestimate the extent of the screening effect. It seems that the shielding effect becomes significant at a distance of about 30 m from the tree which is almost the same value as the height of the tree.

The distance between the sports ground and the observatory is 950 m. Similarities in the PG spectra measured on the sports ground and in RUAO were examined by averaging 4 simultaneous ten minutes PG time series measured on the sports ground and at RUAO respectively.

The strongest periodicity in their Fourier spectra (omitting the effect of the sampling time interval (600s)) is 149 s (0.0067 Hz) both in case of the sports ground and of the observatory (Fig. 10). Whereas the second largest peak is at 60 s (0.0167 Hz) in case of the sports ground, it is at 54 s (0.0184 Hz) in the averaged time series measured at RUAO. At RUAO there are two peaks at 2.035 s and 2.017 s (0.4908 Hz and 0.4958 Hz) as well. The presence of the 149 s periodicity might indicate some larger scale variations in the local atmospheric E field.

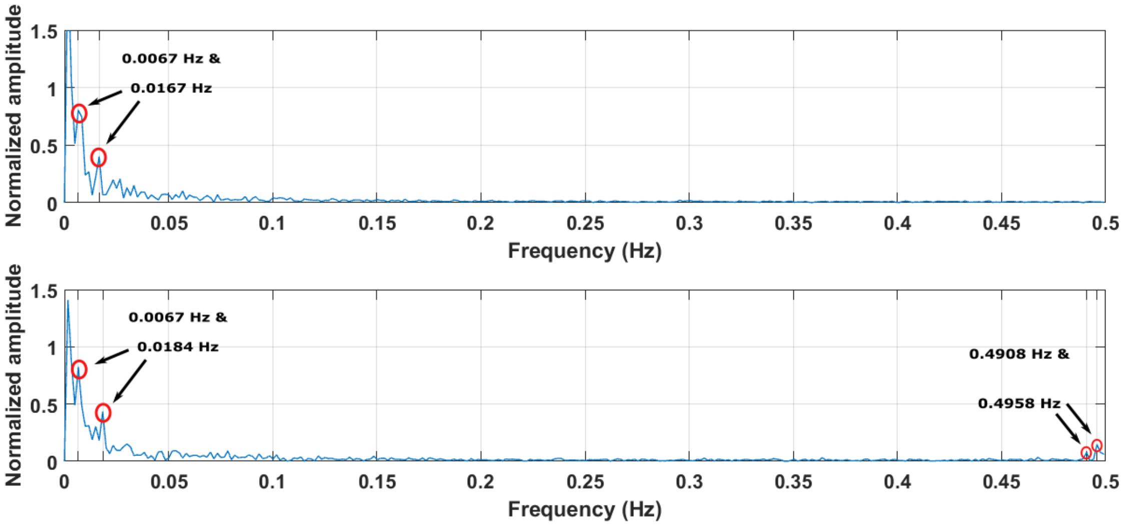


Fig. 10. Fourier spectra of 4 averaged 10 minutes measurements in case of the sports ground (upper plot) and in case of the observatory (lower plot).

On 03.08.2018. the BOLTEK field mill was put to a height of 1 m (the same as of the passive wire) and monitored the PG simultaneously with the passive wire and the JCI131 field mill.

The passive wire was operating with a Keithley electrometer. However, as it turned out subsequently, the guard generator was not working properly. Therefore, it was not possible to infer the exact potential values on the passive wire. Nevertheless, the raw voltages produced by the electrometer and the PG values obtained by the field mills are highly correlated (Fig. 11).

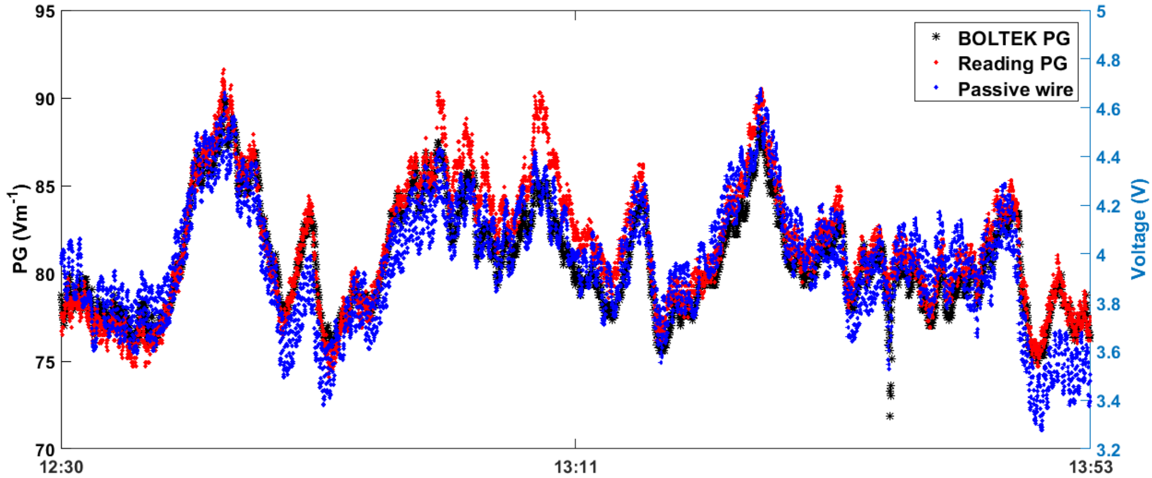


Fig. 11. The PG measured by the two field mills and the raw voltage outputs from the Keithley electrometer (the blue, right hand axis corresponds to the blue curve).

Ultimately, based on the presented results the following conclusions can be drawn:

- the behaviour of the BOLTEK EFM 100 field mill is quite different from that of the JCI131 instrument in Reading. However, a linear relationship could be determined,
- the electric field distortions due to the shielding effect of various objects are not significant and do not have a big impact on the ongoing measurements,
- the BOLTEK EFM apparatus shows a variation with the height which may be attributed to the fact that the mounting tripod intensifies the PG and usefully increases the sensitivity of the field mill to fair weather fields,

- in case of measurements conducted on an open, undisturbed field during fair-weather conditions the shielding effect of a lone, high tree was found to be in the same order as the height of the tree,
- there are some similar periodicities in the time series measured simultaneously at the observatory and on the sports ground with a distance of about 950 m between the two sites,
- the data measured by the field mills and the raw voltage values obtained by the passive wire are highly correlated and show a similar behaviour, although the voltage values derived from the passive wire have a higher standard deviation.

FUTURE COLLABORATIONS

The STSM to Reading was very beneficial to the grantee and the knowledge and know-how acquired there will aid him in his future work connected to research carried out in the framework of WG5. The calibrational techniques and instrumentational methods learned during the STSM will help to improve the PG measurements at the grantee's home institute.

The grantee aims to collaborate with the host institute in the future as well. One perspective is the analysis of the long-term (since 1963) PG time series measured at the observatory of the grantee's home institute. For instance, with applying meteorological reanalysis to these time series it would be possible to refine the used fair-weather selection methods and to retain more PG values.

The grantee wishes to express his gratitude to his hosts, Professor Giles Harrison and Dr. Graeme Marlton for their hospitality and professional advices.