Summary of the COST ELECTRONET Schumann resonance (SR) meeting

February 25-28, 2020, Santander, Spain

Number of participants: 21
(Germany, Greece, Hungary, Israel, Poland, Spain, Mexico, UK, Ukraine)

Purpose of the meeting

The meeting aimed at summarizing technical aspects of obtaining reliable ELF-band electric/magnetic field data, pre-processing, processing, and interpreting measured data, modelling of ELF-band electromagnetic fields in the Earth-ionosphere waveguide, and discussing hot topics and possible synergies in SR-related scientific research.

The meeting served the purpose of clarifying the interpretation of SR measurements, to summarize the state of the art of current SR research, and to discuss upcoming directions of SR research. SR measurements are of great interest from different workgroups in the Action, including people considering SR effects on living organisms. The meeting contributed to the common aim in the Action to make well established science utilizing high quality, reliable sets of SR data.

Conclusions of the meeting

Schumann-resonances (SR) and SR transient signals from intense lightning strokes can be measured most effectively in the horizontal magnetic (H_Φ) and vertical electric (Ez) components of the atmospheric electromagnetic (EM) field. Complete recording systems for monitoring the horizontal magnetic components of ELF-band radio waves are available commercially. Nevertheless, several research groups undertake building their own antennas, amplifiers, and/or data acquisition units to be able to adapt them better to the conditions of the actual measuring site and/or to tailor them to their specific needs (frequency range, dynamic resolution, amplification, local noise, etc.). Recording systems for measuring the Ez are all developed by research groups who monitor this field component. These research groups have various experiences regarding the technical challenges they have faced during the building, development, and installation of their instruments. Many of those experiences have been shared during the meeting. Participants agreed to share related publications and summarize this knowledge in a handout material or in a technical paper to aid other research group's work and further developments of the instrumentation for measuring SR.

Each recorded time series has different noise characteristics. Part of the noise comes from the recording system, another part is man-made EM noise (e.g., power line noise, electrified trains), and the third part is due to natural factors (e.g., mechanical vibration of the sensors due to wind, rain, earthquakes, animals passing, etc.). There was consensus in that identifying and proper handling of noise is of significant importance in studying SR and SR transients. Options for characterizing a station quantitatively from the point of view of studying SR are discussed. Participants agreed that the level of coherence in the phases of the measured field components indicates well the suitability of the signal for SR-related studies. Participants agreed to start an investigation to find a parameter which quantitatively describes this character of a time series.

Methods for obtaining the amplitudes and peak frequencies of SR as well as Q-factors of the Earth-ionosphere waveguide (EIWG) were overviewed and key differences in the methods were pointed out. Characteristic variations of these parameters in different time scales have been presented and their links to variations of the distribution of the global lightning activity as well as to changes of the EIWG, due to, e.g., variation of the solar activity are reviewed. The potential in SR transients to characterize specifically intense lightning, i.e., the segment of the total lightning activity which is excluded in SR-based studies, has been pointed out. Utilization of data from several ELF stations is emphasized in order to increase the reliability of the results and to verify/confirm the conclusions of new results. Unique role of ELF stations near the poles at conjugate locations, i.e., away from general lightning activity, is highlighted in SR research. Participants supported the idea that introducing a basic index which characterizes the lightning activity from the point of view of ELF/SR measurements would be generally useful. One suggestion was that the sum of the first three resonance amplitudes averaged over several, well calibrated ELF recording stations could serve well as an ‘SR index’.

Different approaches to model the distribution of EM field amplitudes in the EIWG due to a single lightning stroke as well as due to a given distribution of lightning strokes were presented. It was demonstrated that models which include the day-night asymmetry provide unambiguous results regarding the interpretation of the differences in the measured SR amplitudes. These models also resolve ambiguities arising from the symmetry of the uniform EIWG concept. It was shown that global analytical models run fast and describe well the large-scale distribution of EM field in the waveguide. On the other hand, grid-based models calculating the EM fields numerically may run slower but are able to describe smaller scale variations either in the distribution of source lightning strokes or in the EM properties of the EIWG. Participants agreed that greater accessibility to codes to run and experiment with different models would be warmly welcomed.

Several effects of ELF-band EM waves on living organisms have been investigated so far. A comprehensive review of published results was presented. On the other hand, an introduction was given on mechanisms by which various external effects, also including ELF fields, can cause changes in a living cell so that gene sequences are activated and deactivated and the cell starts producing different proteins. This mechanism allows monitoring some of the effects by measuring the corresponding biochemical indicators. The attention was also called on nanometer-scale particles of various origin. These particles interact with the human body differently depending on whether they are charged or not. The behaviour and charging of these nanoparticles depend on external EM fields. Participants agreed that effects on living cells or tissues due to variations of EM fields below 50 Hz may be studied using biochemical indicators. On the other hand, it was suggested to examine if nearby lightning has any effect on the physical properties of nanoparticles in air.