Observations on atmospheric electricity and aerosol-cloud interactions

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Atmospheric ions play an important role in the fair weather electricity. Atmosphere's fair weather condition concerns the electric field and the electric current in the air as well as the air conductivity. On the other hand, atmospheric ions are important for Earth's climate, due to their potential role in secondary aerosol formation. This can lead to increased number of cloud condensation nuclei (CCN), which in turn can change the cloud properties. Our aim is to quantify the connections between these two important roles of air ions based on field observations and existing data archives.

When studying atmospheric electricity, the air ions are essential. Small ions, or charged molecular clusters, carry electric currents in the atmosphere. These small ions are continuously present, and their lifetime in lower atmosphere is about one minute. It's essential to find out a connection between the production rate of cluster ions, ion-ion recombination, and ion-aerosol attachment, and their ambient concentrations, in order to understand electrical properties of air istelf.

Currently, there's an intensive discussion about the connection between the atmospheric electricity and climate change. Recently, changes in atmosphere's electric properties caught new interest, as a possible connection between ionizing galactic cosmic rays, cloud cover and climatic effects was suggested (Carslaw, Harrison and Kirkby, 2002; Kirkby et al. 2011). The most significant factor of uncertainty in climate research is caused by atmospheric aerosols, especially due to small particle effects. Secondary formation of new particles through a process of gas-to-particle conversion, beginning with a few gas molecules colliding to form a cluster of 1-2 nm in diameter, is believed to be the dominant source of aerosol particles in the atmosphere. Some studies suggest that the contribution of air ions is important or even dominant to secondary aerosol formation, whereas other studies show that their role is negligible.

We studied the interactions between atmospheric electricity (air conductivity, electric field, and ambient concentartion of small ions), aerosol particles, and cloud properties. In other words, the correlations and trends in atmospheric ionization, electricity, aerosols, and CCN properties were studied. Most of the work here is based on analysis of already existing data archives, and some new measurements are established as a part of already existing measurement networks. The electrical properties of the atmosphere have been measured over a century now, whereas the longest continuous time series of aerosol particle data available is little over decade old. Tammet (2009) has collected a dataset, which comprises the measurements of atmospheric electric field, positive and negative conductivities, air ion concentrations, and accompanying meteorological measurements at 13 stations, including 7 stations of the former World Data Centre network on Atmospheric Electricity at the Main Geophysical Observatory, St. Petersburg, Russia.

The ongoing field observations of atmospheric aerosols are mainly performed at Hyytiälä SMEAR site, Southern Finland (Station for Measuring Ecosystem-Atmosphere Relations). Hyytiälä provides extensive dataset of measured aerosol particle (physical, chemical, and optical) properties, external and radon radiation, CCN properties, trace gases, meteorological parameters, different flux measurements (micrometeorology), and forest ecology observations. The atmosphere's electricity is measured with the air ion spectrometers (Manninen et al. 2010) to determine air conductivity and with the electric field mills, which measures the strength of atmospheric electric field. The plan is to extend the measurements of atmospheric electricity to the Finnish Meteorological Institute (FMI) site at Pallas, Northern Finland, and to SMEAR site at Järvselja, Estonia. Hyytiälä and Pallas stations are part of ACTRIS (Aerosols, Clouds, and Trace gases Research InfraStructure Network) and GAW (Global Atmosphere Watch) networks.

The lightning activity and ion concentration was also investigated. The lightning flash counter data for Hyytiälä, Pallas, and Järvseljä is collected by FMI. The systematic ground lightning observations are performed with eight ground-based sensors in Finland. The Norwegian, Swedish, and Estonian sensors have been integrated, completing the coverage up to the whole Nordic countries.

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