Atmospheric Electricity and Aerosol-Cloud Interactions:

Synthesis based on Existing Data Archives and New Results

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ABSTRACT: 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.

INTRODUCTION

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 itself.

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. 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. According to present knowledge the particles affect the Earth's climate mainly by cooling it.

EXISTING DATA ARCHIVES

Most of the work here is based on analysis of already existing data historical sets. 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

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accompanying meteorological measurements at 13 stations.

FIELD OBESERVATIONS AND RESULTS

The ongoing field observations of atmospheric ionization, electricity, aerosols, and CCN properties are performed at Hyytiälä SMEARII site (Station for Measuring Ecosystem-Atmosphere Relations), Southern Finland [Hari and Kulmala, 2005]. In other words, we study the interactions between atmospheric electricity (e.g. air conductivity, atmospheric electric field, and ambient concentration of small ions), aerosol particles, and cloud properties. Hyytiälä provides extensive dataset of aerosol particle properties, external and radon radiation, CCN properties, trace gases, meteorological parameters, different flux measurements (micrometeorology), lightning activity 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 challenge is that the atmosphere's electrical properties and variables are highly dependent on wide range of atmospheric processes, ranging from microphysical scale to global scale. For example, the measurements of electric field are sensitive to variations in the turbulent flux of local space charge and aerosol concentrations, as well as to variations in the global thunderstorm activity [4]. Thus, the lightning activity is also included to this study. The lightning flash counter data is collected by the Finnish Meteorological Institute. 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. Also, the role of air pollution versus secondary particle formation was considered while studying the time series of the atmospheric electric field.

Possible theoretical and experimental connections between the atmospheric electricity, atmospheric particles, and the climate change, might help the long-term air conductivity observations to be interpreted in a new retrospective way.

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