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Air ion properties in relation to atmospheric radioactivity

Xuemeng Chen (1), Susana Barbosa (2), Jussi Paatero (3), Veli-Matti Kerminen (1), Anti Mäkelä (3), Tuukka Petäjä (1), and Markku Kulmala (1)

(1) Institute for Atmospheric and Earth System Research / Physics, Faculty of Science, University of Helsinki, Finland, (2) INESC TEC - INESC Technology and Science, Porto, Portugal, (3) Finnish Meteorological Institute, Helsinki, Finland

Ionising radiation provides the energy to split air molecules into primary ions. In the lower atmosphere, due to the presence of trace gases and aerosol particles, the initially formed primary ions are partially saved from recombination and other sink processes via clustering, coagulation and condensational growth, which allow these short-lived primary ions to transform into detectable air ions. The lower-atmosphere ionising radiation consists of both cosmic and terrestrial radioactivity. Radon is a radioactive gas of terrestrial origin that decays in the air contributing also to the ionisation of air molecules and thereby air ion production.

Driven by the potential gradient in the Earth-Atmosphere electric field, air ions migrate vertically in the atmosphere. Such movement of air ions makes air conductive under fair weather conditions that counterbalances with the influence of lightning activities on the Earth-Atmosphere electric field [Tinsley, 2008]. The overall outcome is a potential gradient in the atmosphere of about 100 V/m in the fair-weather regions. Since the formation of air ions roots from ionisation of air molecules, air ions are the key medium connecting lower-atmospheric radioactivity to surface atmospheric electricity. However, in the lower atmosphere air ions participate in aerosol processes, owing to the presence of trace gases and aerosol particles [Chen et al., 2016], through which the generation of space charges can potentially distort the local fair-weather electric field [Bennett and Harrison, 2008].

In this study, in order to investigate the connection of lower-atmospheric radioactivity to surface atmospheric electricity, we analysed air ion number size distributions, gamma radiation and atmospheric electric field, together with meteorological parameters, collected from ambient observations made during June-November, 2017 at Hyytiälä SMEAR II station (61°51 ´N, 24°17 ´E, 181 m above sea level) in southern Finland. Precipitation and atmospheric new particle formation are the two primary natural processes that produce air ions in the size range of 1.7-7 nm. We observed that 1.7-7 nm ion concentrations increased with an increase in the electric field strength on fair-weather days. During precipitation episodes, our results likely suggest that elevated gamma radiation levels resulting from the washout of radon progeny contribute to the precipitation-induced ion formation.

References:
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