11 - Year Variations of Atmospheric Conductivity and Electric Currents from Thunderstorms to Ionosphere during Solar Cycle - Quasi-Static Modeling of the Coupling Mechanism

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Possible ways, by which solar activity can influence the elements of the global atmospheric electric circuit, are studied. Thunderstorms at the Earth act as tropospheric electric generators in the global electric circuit, since they create currents, which flow into the ionosphere. A key factor for these currents is the atmospheric conductivity. The conductivity in lower stratosphere is provided by galactic cosmic rays (GCR), which produce maximal ionization at Pfotzer maximum at about 12-18 km, as dependent of the latitude. Since the GCR flux is modulated by solar activity, the conductivity can suffer long-term variations (with 11- and 22-year solar cycle), so that it is expected to be higher in the lower stratosphere during solar minimums, and vice versa. This suggestion is supported by observation that the current ‘Ionosphere-Earth’ varies by a factor of about twice at middle latitudes, in a good correlation with solar activity. In respect to this, our goal is to study the possible impact of the solar activity to the thunderstorm-ionosphere currents through presumable 11-year variations of the stratospheric conductivity. In order to estimate this possible influence, two cases are considered, respectively, of solar maximum and of solar minimum. We propose an analytical model, based on the Maxwell equations under quasi-static conditions, by which the temporal and spatial behavior of both the conduction and the Maxwell currents over a single thundercloud cell are computed. This model takes into account the capacitive properties of the atmosphere, and thus it describes the physical picture more adequately than the DC models. The electric structure of a thunderstorm cell is presented by a time-dependent vertical positive dipole, which is maintained by a source current of charge separation. The thunderstorm is described by recurrent negative and positive cloud-to-ground discharges and intra-cloud discharges. We study the efficiency of such thundercloud cell, as electric generator, in the global electric circuit, expressed by the ratio of the average conduction current into the ionosphere, to the average source current. The computations demonstrate, in general, changes of this ratio with variations of the stratospheric conductivity. During a solar minimum, when conductivity in the lower stratosphere is presumably higher, the current to the ionosphere is bigger, than during a solar maximum. A complex dependency of the efficiency ratio on other factors is studied together with the role of the conductivity.