Modeling of the Ionospheric and Thermospheric Effects Caused by the Vertical Electric Currents Flowing across the Ionosphere Lower Boundary

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We have calculated the ionosphere and thermosphere disturbances caused by the vertical electric currents flowing across the lower boundary of the ionosphere from the below lying atmosphere. The global numerical Upper Atmosphere Model (UAM) has been used for the calculations with the vertical electric currents at its lower boundary (80 km) as a model input for the electric potential equation. Different locations, spatial configurations and intensities of the vertical electric currents have been investigated. Their physical nature has been discussed in relation with the mesoscale disturbances of the Global Electric Circuit, such as thunderstorm activity, typhoons, sandstorms, volcano eruptions, earthquakes, anthropogenic pollutions, etc.

The role of the non-electric forces in the vertical electric currents generation has been considered, and the aerosol content influence on their intensity has been estimated. The charges transported across the ionosphere lower boundary redistribute electric potential and field in the both hemispheres due to equipotentiality of the geomagnetic field lines. In the F2-layer disturbed electric field causes [$\boldsymbol{E} \times \boldsymbol{B}$] plasma drift, which increases or decreases the electron concentration and Total Electron Content (TEC).

Using the UAM we have calculated all these effects together with the corresponding ion and electron temperature, thermosphere densities, neutral temperature and wind disturbances. The model results have been compared with the electric-field measurements by the DEMETER satellite, pre-earthquake GPS observed TEC variations for major earthquakes ($M > 6$) in 2005-2007, and a good agreement has been obtained.