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How to Parameterize the Ionospheric Potential and Lightning in Modern Earth System Models?

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Much attention has been given recently to the question of parameterizing lightning flash rates (LFR) and the ionospheric potential (IP) in weather and climate models. On the one hand, issues related to forecasting thunderstorms and lightning are always of particular interest. On the other hand, there has been increasing interest in modelling both the DC and AC components of the global electric circuit (GEC), considering its possible role in the Earth's climate system, and as an excellent indicator of temporal trends in both terrestrial and space weather and climate.

This study considers various approaches to parameterizing LFR and the IP. The first sufficiently successful parameterization of lightning by Price and Rind (1992) linked LFR with the height of the convective cloud, and the exponent in the formula was significantly different for clouds over land and ocean. In recent studies of lightning parameterization, the main attention was paid to the influence of thermohydrodynamic (THD) factors (convective available potential energy, precipitation, wind shear), as well as cloud condensation nuclei and aerosols on the LFR (see, e.g., [1]). Our analysis shows that THD factors alone are able to produce a rather good correlation of simulated and observed patterns (and therefore can be considered sufficient to adequately parameterize LFR) over land, but they give a much poorer representation over the oceans. New mechanisms of the influence of aerosols on electrical processes in clouds [2] make possible future development of parameterizations of lightning flashes from first principles suitable for both land and ocean.

To study the variation of the DC GEC, we have developed a parameterization for contributions to the IP on the basis of cutting off the grid cells with weak convective activity and estimating the area covered by electrified clouds (which maintain the DC GEC) in each cell from the amount of precipitation [3]. This parameterization proved to be very good and allowed us to solve a number of new problems related to the DC GEC. It is interesting that a similar parameterization involving the product of convective available potential energy and precipitation has been recently suggested for LFR [4]. However, we have shown that from a physical perspective it seems more natural to identify this product with contributions to the IP, and it is not unlikely that it provides a satisfactory proxy for LFR just because of the existing correlation between the two quantities.

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