Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2018-119-RC1, 2018

Geoscientific Model Development Discussions

Interactive comment on "Evaluation of Monte Carlo tools for high energy atmospheric physics II: relativistic runaway electron avalanches" *by* David Sarria et al.

A Chilingarian (Referee)

chili@aragats.am

Received and published: 29 June 2018

Comments on the paper submitted to Geoscientific Model Development (GMD) "Evaluation of Monte Carlo tools for high energy atmospheric physics II : relativistic runaway electron avalanches" by David Sarria, Casper Rutjes, Gabriel Diniz, et al.

The authors compare simulations made by several M-C codes and come with useful recommendations on simulation procedures (energy cuts, etc..). The analysis is detailed and there are no doubts that all codes in own limits produce rather coherent results. The code verification and comparisons of different code options, as well as different codes, are necessary first step of simulation experiments and constructing of

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Discussion paper

models to be compared with experiment.

However, we have to understand, that M-C simulations for such a complicated domain as High-energy Physics in Atmosphere (HEPA) is not a precise tool! We don't know the distribution of the electric charges in the cloud and, therefore, strength and elongation of the emerging electric fields. Therefore, very time-consuming and detailed verification of different M-C programs, for opinion of this referee is not too important on the present stage of HEPA progress. As I mention in my review to the first paper of this series in 2016, the validation of the available experimental observations is vital for the progress of HEPA. There are published numerous gamma ray energy spectra observed on the mountain altitudes and few electron energy spectra; why not to try to compare simulations with observations? Continuous simulations with different codes and arbitrary parameters (sometimes nonrealistic, see my comment below to 4.3.1) can make illusion of intense scientific research; however only comparisons with observations and physical inference on the observed phenomena really values. Sure, authors will argue that model validation is out of scope of their paper. And they will be right. However, I can ask, when they will use their verified models for coming with comprehensive model of HEPA? When they will develop models with realistic parameters and compare it with data (energy spectra measured on Earth's surface and in the space)?

To be not too didactic, I'll cite our old paper, where we try for the first time to compare simulated energy spectra with measured ones and establish a TGE model (see Figs 8-12 of Chilingarian, Mailyan and Vanyan, 2012).

"With newly estimated thundercloud height, we re-estimate several phenomenological parameters of the RREA process as the following: the most probable height of thundercloud (and electrical field therein) is ∼50 m. The number of electrons with energies above 1 MeV at the exit from the cloud is 1.97âĹŮ107 electrons/m2/min; if we assume that the radiation region in the thundercloud has a radius of 1 km the total number of electrons crossing this region in a minute is ∼6âĹŮ1013.

Sure, we use not optimized M-C; and, maybe we make some mistakes in our inference. We discuss possible sources of the systematic errors:

“We do not measure the electric field within the thundercloud; near surface electric field is not a good proxy of the intracloud fields accelerating electrons downward. We also do not measure vertical extension of the field and only estimate the height of the cloud. Therefore, simulations of the RREA process in the atmosphere with chosen parameters, although are in an agreement with the available measurements of electric fields in the thunderclouds, cannot be used for direct comparisons with TGE measurements. However, these simulations give us understanding of the RREA scale and MOS processes and expected behavior of the energy spectra.”

However, it was the first time we present gamma ray and electron energy spectra along with simulations and achieve overall agreement. Now we develop a new method of cloud height estimation and can approach observations with more realistic simulations with more reliable better parameters. What I want to demonstrate is that simulation should be paired with experimentation; and each should profit from other.

After our recently observation of Long Lasting Low energy TGEs (LLL TGEs) – a hours extending flux of gamma rays of 0.3 – 3 MeV energies, we started a cycle of simulations to get answer if remote Extensive Cloud Showers (ECSs) can contribute to this flux, or we should consider stochastic electron acceleration by a “sea” of randomly distributed charges in the thundercloud. Thus, simulations are pairing with observations and with hypothesis testing.

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The emerging field of High Energy Atmospheric Physics studies events producing high energy particles and associated with thunderstorms, such as terrestrial gamma-ray flashes and gamma-ray glows. Without mentioning Thunderstorm Ground Enhancements (TGEs) this statement is biased.

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The difference in duration between TGF and gamma-ray glows can be explained by two possible different scenario to create runaway electrons... Largest TGE detection prove that long duration can be explained by the continuous acceleration and multiplication of seed electrons entering strong prolonged electric field. Such a condition can sustain for minutes and, so called, extensive cloud showers (ECSs) will produce fluxes of electrons, gamma rays and neutrons on the earth's surface, i.e. TGEs (see Chilingarian et al., 2017). 1.3 5 The physics behind TGF, TGF afterglows and gamma-ray glows are studied with the help of computer simulations, which necessarily involves model reduction and assumptions. Hopefully physics is experimental science and most of results are obtained by experimentation, not simulation. 4.3.1 5 Figure 7 compares the electron spectra recorded at 128 meters, for an electric field E = 0.80 MV/m, for a RREA generated from 200 seed electrons with ε = 100 keV. Do you especially choose the field never measured in the atmosphere (0.8 MV/m)? Or it is not in atmosphere? Why 128 m? Where do you inject 200 electrons?

15 One way of deciding which model is the most accurate might be to compare these results with experimental measurements. but in the context of TGF and Gamma-ray glows it is complicated to get a proper measurement of electron spectra produced by RREA. Finally, yes, only way to decide which model is true is the comparison with experiment that is missing in this paper.

References

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2018.