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Simulating collisions of charged cloud drops in an ABC flow

Torsten Auerswald and Maarten Ambaum
University of Reading, Department of Meteorology, Reading, United Kingdom of Great Britain and Northern Ireland
(t.auerswald@reading.ac.uk)

Calculating the electric force between cloud drops is not straightforward. Since water drops are conducting, the electric force is not just simply the force between point charges, but instead the charge in each drop induces an infinite number of image charges in the other drop. The effect of these image charges can cause the electric force between two like charged cloud drops to become attractive on very short distances, when only applying Coulomb's law would result in a repulsive force. The attractive effect of image charges could potentially increase the collision rate of cloud drops. Within the United Arab Emirates Rain Enhancement Program (UAE REP) we are investigating the potential for rain enhancement by charging clouds.

Simulating the behaviour of cloud drops is numerically very expensive. A large number of drops needs to be simulated to obtain stable collision statistics. Additionally, the drops move in a complex turbulent environment with eddies spanning several orders of magnitude in size. Simulating the turbulent flow alone is an expensive task. Because of the typical sizes of cloud drops, their motion is predominantly influenced by the smallest turbulent scales in the flow. Therefore, Direct Numerical Simulation (DNS) is necessary and used to simulate the influence of turbulent flow on drop motion. In this work, instead of using DNS, we use an ABC flow to simulate the turbulent effect on cloud drops. This simple approximation for the turbulent flow allows to simulate the drop motion using much less computational resources then needed by DNS and therefore, allows to include the very expensive effect of electrical drop charge in our simulation of colliding drops in a turbulent environment.

To investigate the effect of electrical charge on drop collisions, a Lagrangian particle code for the interaction of cloud drops is used. It calculates the motion of individual drops based on the aerodynamical force due to the ABC flow and the gravitational force and registers drop collisions from which collision statistics can be calculated. In the cloud model all drops carry positive charges. The effect of the electric force is calculated by an approximation which uses Coulomb's law for the effect of the point charges and an additional term to approximate the effect of image charges which produce an attractive force on short distance.

Results for the collision kernel with and without charge will be presented. The effect of the additional term to Coulomb's law will be shown for different drop sizes and drop charges. It will be discussed if the attractive force for like charged drops on short distances can lead to an enhancement in drop collisions and under which conditions the effect is the largest.