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Simulating cloud drop collisions in an ABC flow

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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 propose using 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 for simulations with many more drops and larger model domains or more complex cloud physics.

To investigate the performance of ABC flow in simulating cloud drop collisions, a Lagrangian particle code for the interaction of cloud drops was developed. 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. Results for the collision kernels for different sizes of cloud drops from several simulations will be presented. The sensitivity of the collision statistics to a change in length scale and flow velocity will be discussed and the results will be compared to published results from DNS. It will be shown that a simple ABC flow gives a good approximation of the turbulence effect experienced by cloud drops. The results show larger deviations from the DNS results for collisions between drops of similar sizes and a strong dependence on the length scale and flow velocity. We suggest that the use of ABC flow gives an accurate and computationally efficient means to assess the effects of small scale turbulence in drop collision simulations.