The motion of air masses in the atmosphere may entrain the cloud droplets, ice crystals or snowflakes. A well-known, growing problem is the presence in the atmosphere of dust and smog that originate from transport and combustion of low quality fuels. The motion of small particles (either solid ones or liquid droplets) also accompanies volcanic eruptions and can affect the weather and aerial transport. Since the flow of atmospheric air has a complex and disordered nature, we call it turbulent or chaotic, and its exact mathematical description is impossible. Thanks to astonishing progress in computer technology, very fast multiprocessor machines are available. There are very helpful for weather forecasting as well as for other computations in industrial applications such as power generation and chemical engineering (combustion process, filtrations and many others).

The most important goal of the project is development of computational methods for such flows, both through a better account of physical aspects as well as through working out more efficient computing algorithms. In particular, both gravity (through the settling velocity) and turbulence affect the particle collision rate, their coalescence, up to the formation of rain.

The essence of the proposed model development will be an improved description of the so-called aerodynamic interactions that became significant for nearby droplets. Experimental studies are usually difficult, and sometimes even infeasible due to technical limitations of the recording devices, in particular when it comes to measurements directly in clouds. Therefore, the role of computational methods is important and still growing.

Our Polish research group owns an advanced computer code for solving the full form of the flow equations; such a method is known as DNS or direct numerical simulation. It employs the so-called spectral method, which features high accuracy and efficiency. The code has been developed for several years now and validated in a number of applications.

Thanks to its further extension, we will be able to address the problem of computations at a larger scale (after some averaging in space), by implementing so-called large-eddy simulations (LES). LES are typically used for modeling atmospheric processes in the boundary layer (up to 1-2 km above the earth's surface) and the dynamics of clouds. Moreover, LES are less expensive than DNS and are becoming more and more useful in the aforementioned industrial applications of turbulent flows with particles. For this reason, another objective of the project will be to employ the results of DNS to improve the LES approach, especially for the estimation of particle collisions and their aerodynamic/hydrodyamic interactions. The project will be carried out in collaboration with an experienced group of Chinese researchers. For many years they have been doing advanced modelling studies on the motion and mutual interaction of particles. They will perform simulations using other approach, complementary to the spectral method mentioned above. In particular, they will make simulations with a fully resolved flow around particles. This will allow us for a better parameterization of aerodynamic interactions, crucial for determining the collision rate and coalescence of droplets. Another aspect of the bilateral Polish-Chinese project will be cooperation in the field of preparing algorithms and conducting calculations on computers with very high efficiency.