Description for the general public

Clouds are integral component of the Earth atmosphere, and they play an important role in weather and climate. The way clouds interact with the climate system through precipitation and radiative processes is strongly influenced by their microphysical properties. Microphysics refers to processes occurring in scales of order of centimeters. Microphysical properties are characterized by the droplet-size spectrum, that is, the local (in time and space) distribution of cloud droplets. The droplet-size spectrum is shaped mostly by the condensational growth of cloud droplets. Condensation occurs if the environment has an excess of water vapor over the equilibrium (saturation) value. The relative degree of water-vapor pressure exceeding the saturation value is called supersaturation. This is the driving force of condensational processes by which cloud droplets form and grow.

Most of microphysical processes, such as the diffusional growth of a cloud droplet in a homogeneous water vapor field or the gravitational collision-coalescence growth of cloud droplets, are well understood in isolation. In natural clouds those processes do not occur in idealized conditions. They happen in an environment, where the supersaturation varies in space and time under the influence of omnipresent small- and large-scale turbulent fluctuations. A fluctuating forcing thus drives microphysical processes. This feature has far-reaching implications for the droplet spectrum evolution. Despite intensive efforts, the problem of droplet spectral evolution in convective clouds remains unresolved.

The overall goal of the research proposal is to advance our understanding of the fundamental role of turbulence on the processes that shape the droplet spectrum in convective clouds.

An efficient way to study clouds is through numerical modeling. We will use a model that applies a novel representation of aerosol and cloud microphysics (called the super-droplet method) that has been recently developed at the Institute of Geophysics (Faculty of Physics, University of Warsaw). The new microphysics based on superdroplets is a unique method to represent all particles involved in cloud formation and rain development: aerosols on which cloud droplets form, cloud droplets, and drizzle/rain drops. To accomplish the goal of the research project, we will develop and equip our model with a novel numerical approach that introduces a physically sound stochastic description of the microphysical processes and turbulent transport occurring at scales not resolved by the cloud model.

The proposed project will not only advance our understanding of fundamental cloud physics processes, but will also help to develop improved representations of shallow convective clouds for modeling weather and climate.