Reg. No: 2015/19/P/ST10/02596; Principal Investigator: dr Wojciech W. Grabowski

Clouds are the key component of the climate system. They play an essential and still unclear role in radiative transfer across the atmosphere and in the cycling of the water substance through the climate system. They are also argued to play a critical role in the climate change because a relatively modest modification of their properties, such as the mean cloud coverage or the mean size of cloud particles, can offset warming of the climate system due to the increase of atmospheric concentration of the carbon dioxide. It follows that understanding processes affecting cloud properties is not only important from the fundamental cloud physics point of view, but it is also relevant to climate and climate change, an important issues facing mankind today.

Among various cloud types, those located close to the Earth surface, referred to as the boundary layer clouds, are often argued to be particularly important. Such cloud types include tropical and subtropical shallow cumulus and subtropical stratocumulus, both types occurring in regions where solar insolation is at its maximum. Boundary layer clouds reflect significant fraction of incoming solar radiation, but because they are close to the Earth surface their effect on the Earth thermal radiation is relatively minor. It follows that such clouds impose significant cooling of the climate system, in contrast to deep clouds for which effects on solar and Earth thermal radiation tend to balance. Second, since these clouds are typically relatively small-scale, that is, either of a small horizontal extent for the shallow cumulus case or just a few hundred meters deep for stratocumulus, they cannot be directly simulated by contemporary global climate models. It follows that such clouds are included in climate models using representations that encapsulate our understanding of small-scale physical processes (and their interactions) that determine those cloud properties.

The proposed investigation is to use numerical modeling to advance the understanding of key processes affecting microphysical and dynamical properties of shallow boundary layer clouds. We will focus on two specific aspects. For the shallow cumulus, we will investigate the role of cloud turbulence in shaping the spectrum of cloud droplets. Shallow cumuli are strongly diluted by environmental air from their immediate environment, and the impact of this dilution on the droplet spectra is poorly understood. For the stratocumulus, we will use recent observations to guide numerical model development and design numerical simulations to clarify the link between microphysical processes such as growth and evaporation of cloud droplets and the turbulent mixing near the stratocumulus top.