Particle-based cloud microphysics: rationale, state of the art and challenges

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Representation of aerosol-cloud-precipitation interactions in numerical models of atmospheric flows has recently been subject to a paradigm shift towards particle-based approaches. The particle-based (Lagrangian) microphysics models contrast the conventional Eulerian approach of representing aerosol, cloud and precipitation particle populations as separate categories of trace constituents modelled with continuous density fields. Among the key advantages of the particle-based methods there are: lack of numerical diffusion in physical and size-spectral dimensions; by-design non-negativity of the derived density fields; ab-initio-like representation of particle-level processes; suitability of Monte-Carlo methods for solving particle coagulation; robustness to spatial resolution changes of the CFD solver; and favourable GPU-parallelization characteristics. The talk will aim at giving an overview of the past decade of developments, at highlighting the novel results obtained with particle-based models, and at bringing attention to some remaining challenges and opportunities.