Particle-based cloud microphysics modelling

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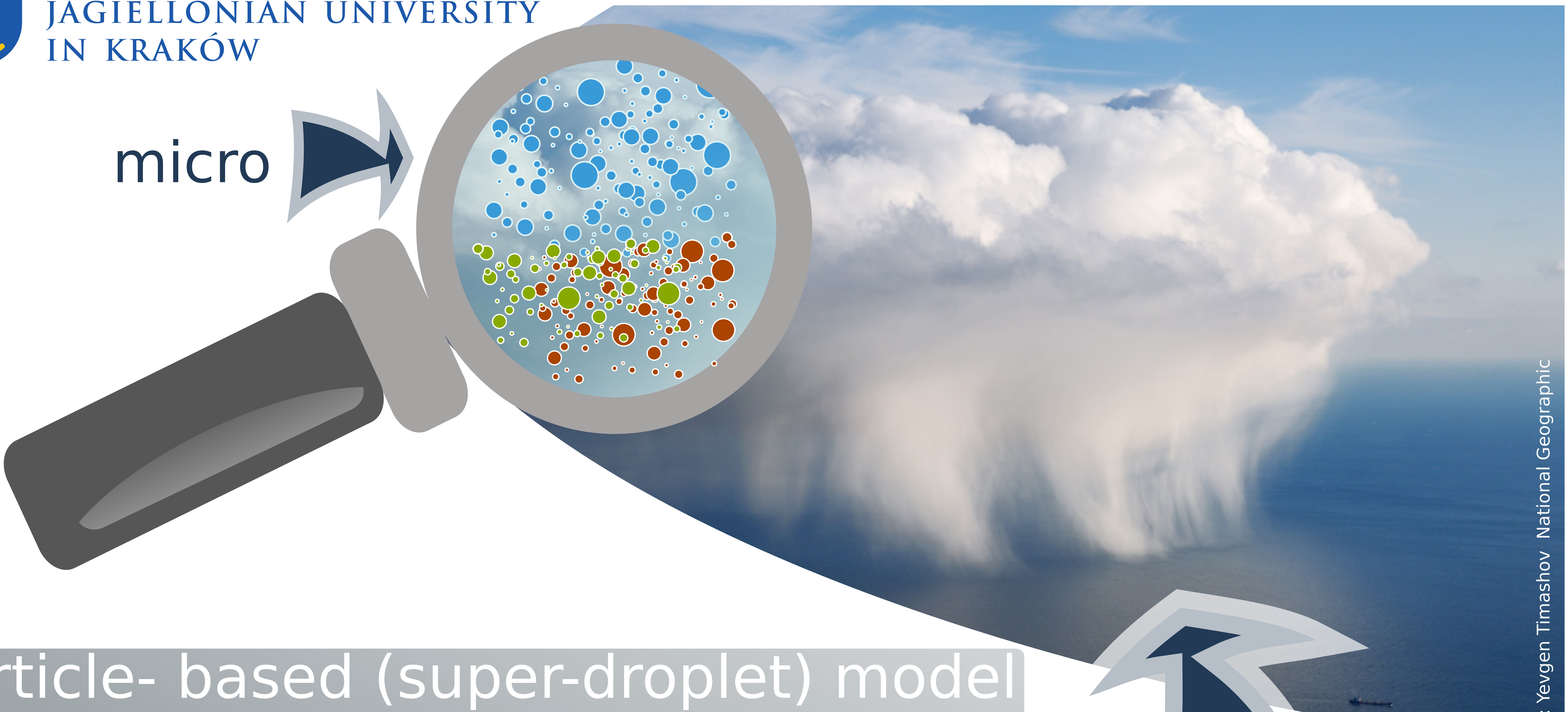
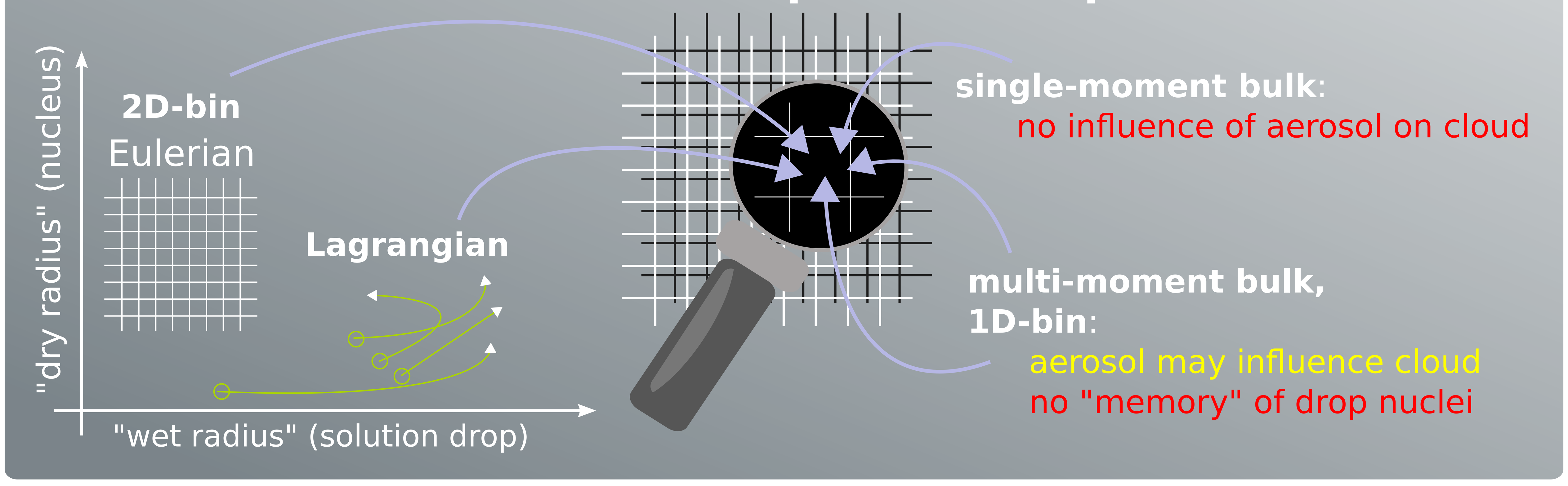


Particle- based (super-droplet) model



Particle-based cloud models, while challenging to implement, offer unique characteristics:

- first-principle-based particle-level formulation (as opposed to bulk volume-of-air formulations)
- lack of bogus numerical effects (numerical diffusion, spurious oscillations)
- availability of robust subgrid-scale dynamics representations (microphysics-turbulence interactions)
- favourable computational cost scaling with increasing number of particle physical and biochemical attributes (evading the curse of dimensionality, of particular importance for ice-phase processes, aqueous chemistry, **representation of isotopic compasition?**)
- particle lifetime tracing for interpreting complex aerosol-cloud-precipitation evolution pathways
- flexibility in terms of locally adjusting the resolution/fidelity of sampling the phase space (e.g., to represent rare but important giant cloud condensation nuclei)
- suitability for leveraging modern hybrid supercomputing platforms (simultaneous CPU/GPU usage)

References:

- seminal works: Andrejczuk et al. '08 (JGR), Shima et al. '09 (QJRMS), Sölch & Kärcher '10 (QJRMS)
- presenter's contributions: Arabas & Shima '13 (JAS), Arabas et al. '15 (GMD)
- recent review: Grabowski et al. '19 (BAMS): "Modeling of Cloud Microphysics: Can We Do Better?"

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