# Tackling structural uncertainty in aerosol model representation

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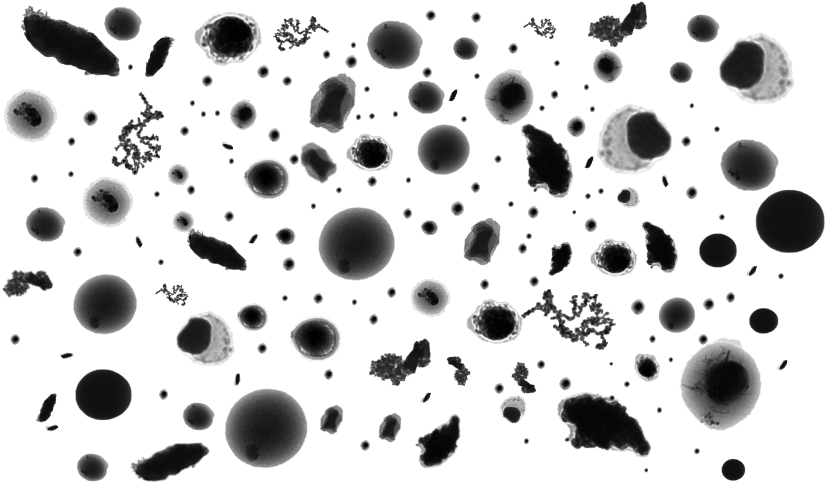
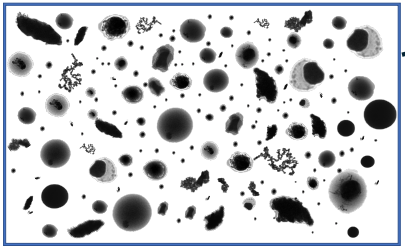
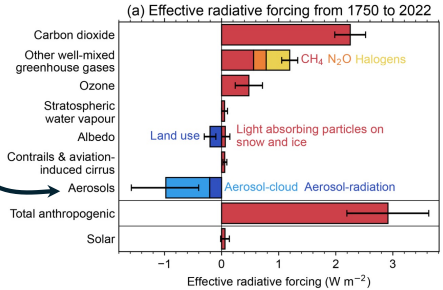
# The aerosol state



Aerosol images courtesy of Prof. Miriam Freedman, Penn State

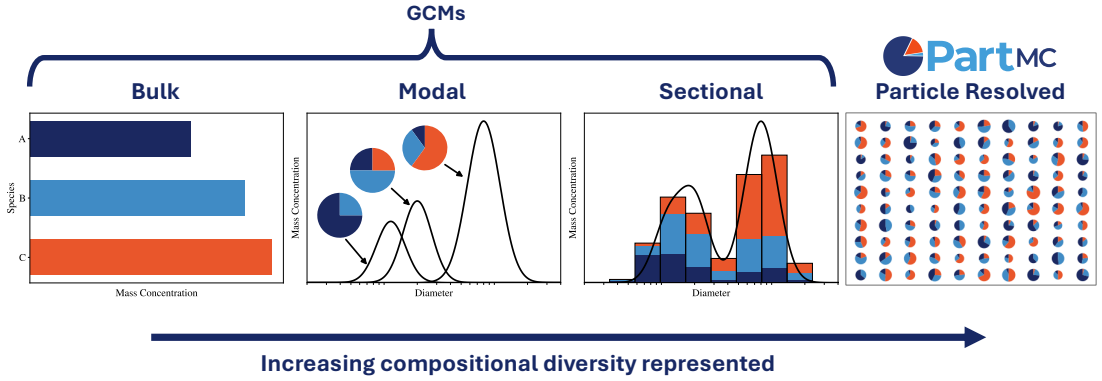
# Estimating aerosol radiative forcing





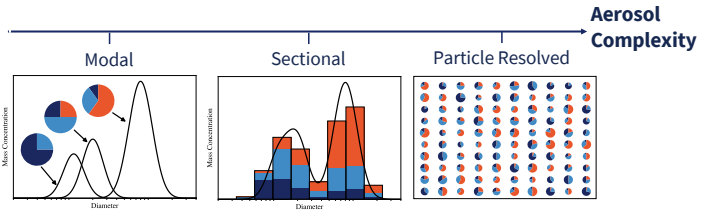

- Aerosol particles are diverse in size, shape, and composition.
- Representing aerosols in large-scale models requires gross simplifications.
- There is no one way to simplify—this causes structural uncertainty.

# Model representation choices

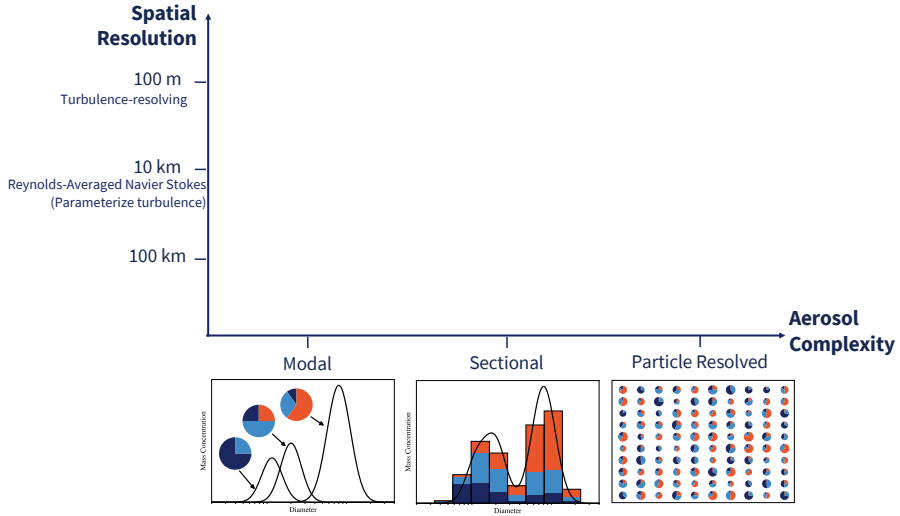



- Laura Fierce's talk on Wednesday, 9:10am: "Confronting structural uncertainty in aerosol-cloud interactions through process-level benchmarking"

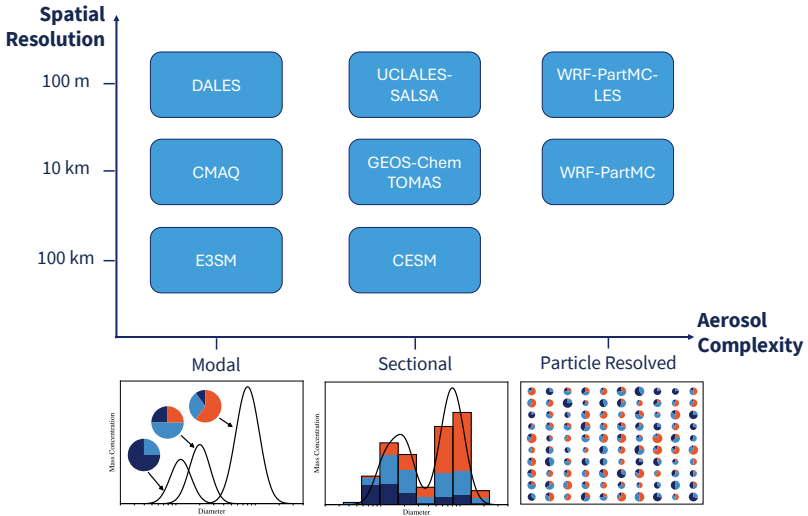
# Structural uncertainty: Aerosol complexity



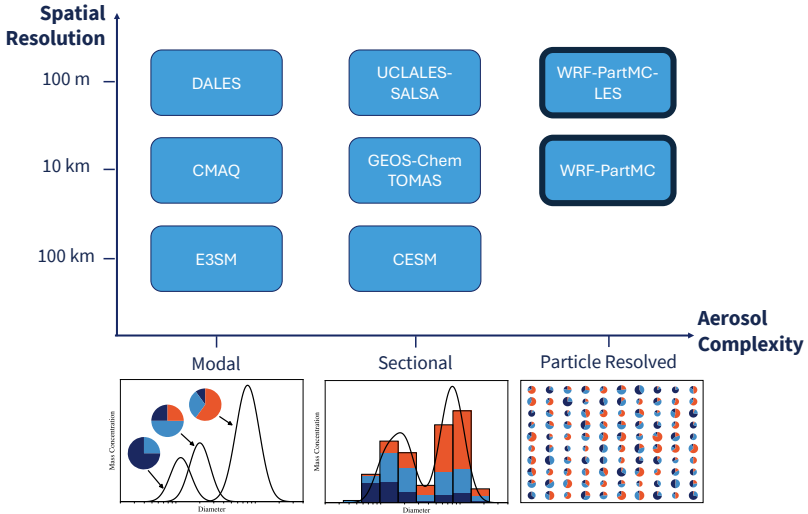
# Structural uncertainty: Spatial resolution



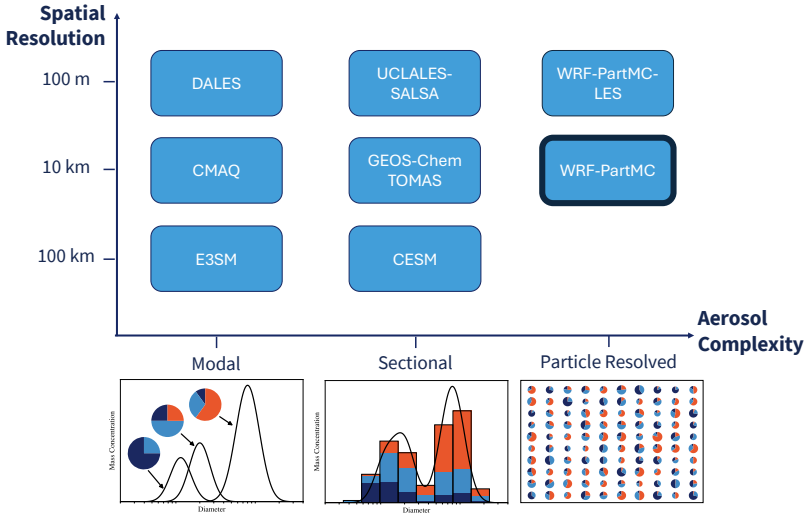
# Spatial resolution and aerosol complexity



# Spatial resolution and aerosol complexity

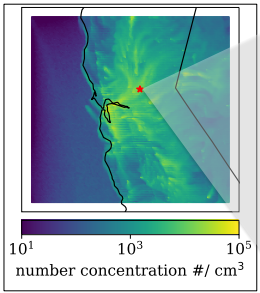


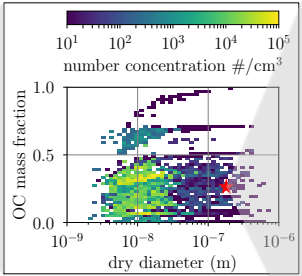
# WRF-PartMC: Particle-resolved model on the regional scale

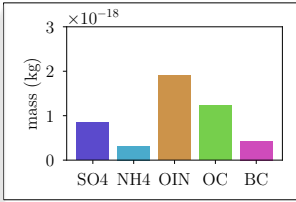


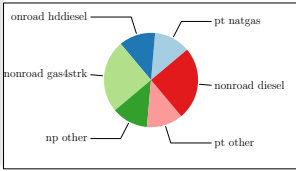
# WRF-PartMC: Particle-resolved model on the regional scale

- Host model: WRF
- Aerosol model: PartMC-MOSAIC
- 170 x 160 x 40 domain
- 6656 cores
- 5000 particles per grid cell to capture aerosol mixing state
- 10 billion total particles in the simulation domain



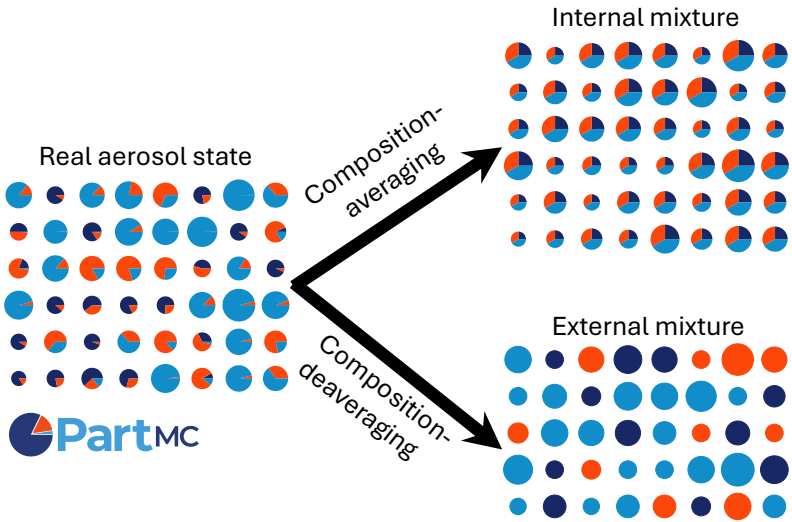




PartMC

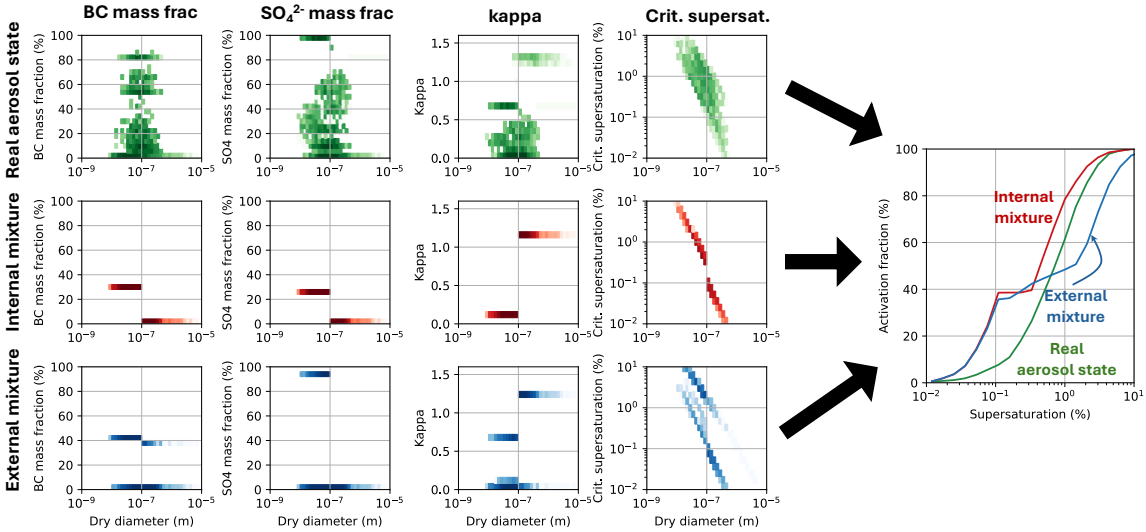
- Each grid cell contains the full aerosol state.

Riemer et al., 2009; Curtis, Riemer, West, GMD, 2017; GMD 2024

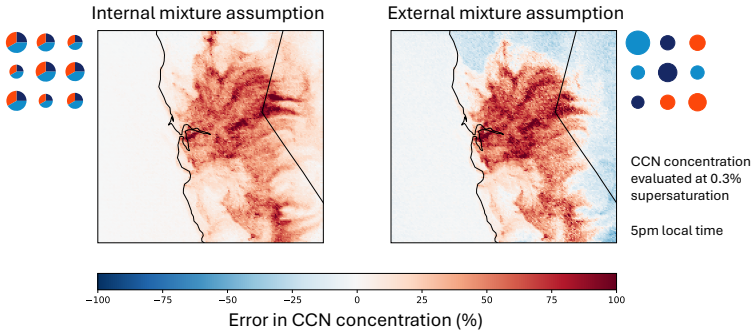
# Exploring impact of popular mixing state assumptions



# Consequences of mixing state simplifications

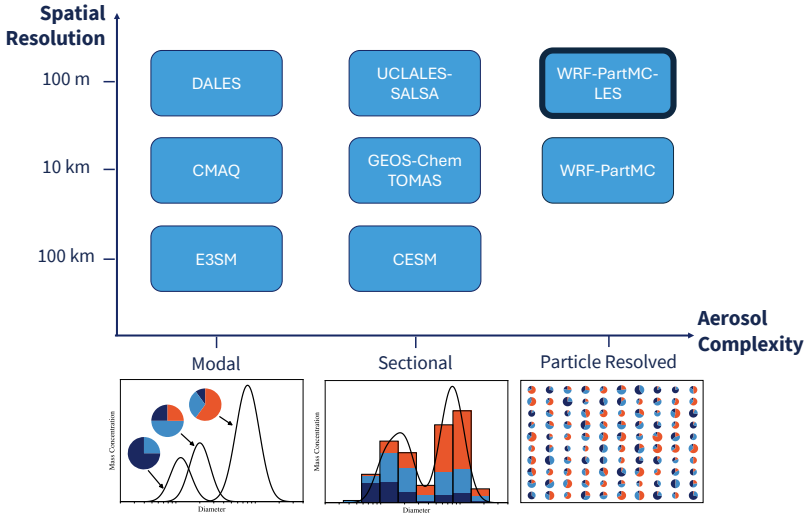


# Errors introduced in CCN predictions

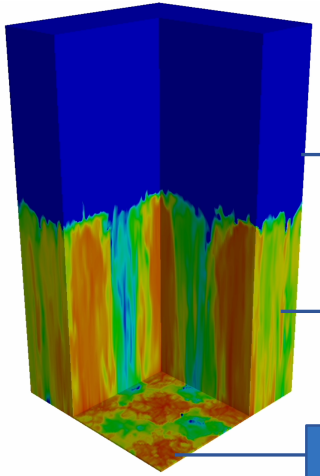



- Assuming internal mixture: overestimation of CCN concentration
  - More pronounced in source areas.
- Assuming external mixture: overestination or underestimation are possible
  - Depends on supersaturation threshold and underlying actual mixing state.

# WRF-PartMC-LES for investigating spatial heterogeneity impacts



# Impact of emission spatial heterogeneity on cloud properties



Cloud properties

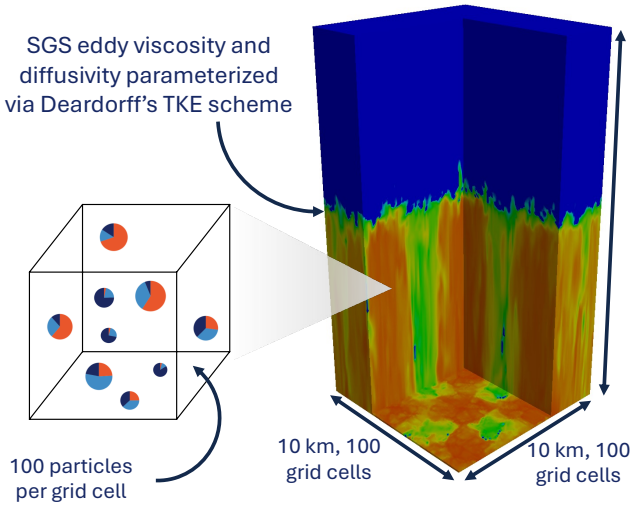
Spatial heterogeneity impact?

Aerosol sub-grid processes

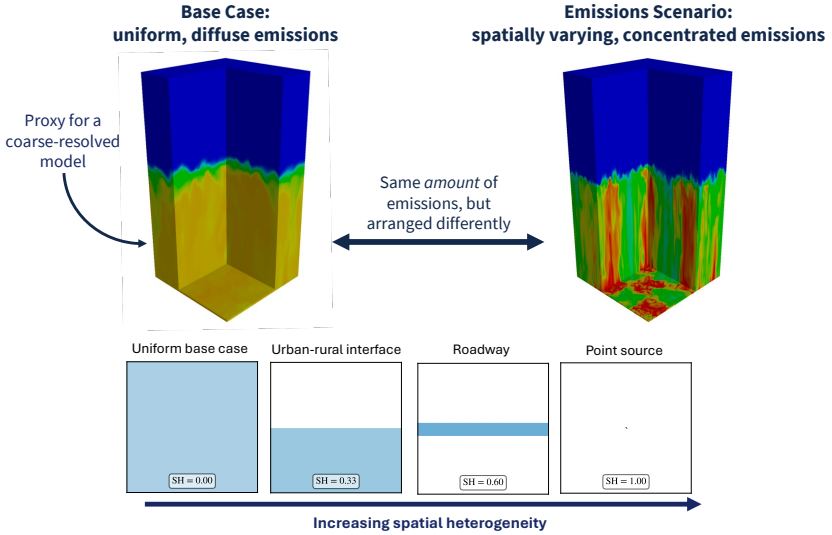
Spatial heterogeneity impact?

Drivers (Emissions)

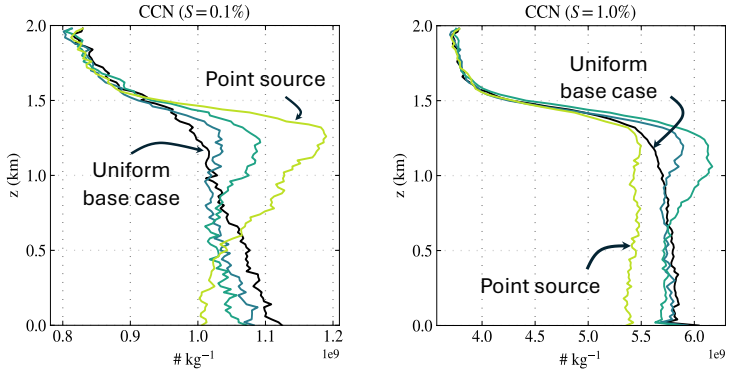
# WRF-PartMC-LES simulation setup



# Setup of emission scenarios

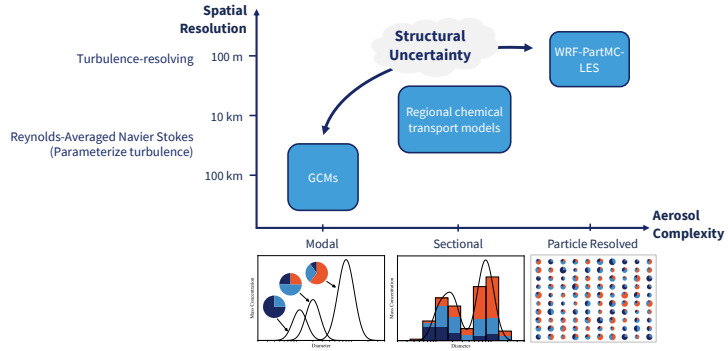


# Spatial heterogeneity impact on CCN concentrations




- Increased spatial heterogeneity has competing effects:
  - More coagulation (= less CCN), but also more nitrate in upper BL (=more CCN).
- CCN response depends on environmental supersaturation.

# Summary




- Development of a high-resolution aerosol-transport modeling framework offers a benchmark for evaluating other models.

# PartMC is open source