Chasing large climate model uncertainties: Aligning experimental and model perspectives on atmospheric nanoparticle growth

Experiments:
Limited experimental understanding of nanoparticle growth processes in the atmosphere:
- Wide range of vapors (up to 10000 organic molecules with unknown vapor pressures) and processes (condensation, chemical reactions and collective phenomena) potentially contributing to nanoparticle growth
- State-of-the-art box models can fail to predict nanoparticle growth rates from gas-phase measurements of condensable vapors
- Observations show little variation in growth rates, while condensable vapor concentrations span 3 orders of magnitude

Environmental Impact:
Cloud Condensation Nuclei & Particulate Matter Pollution

Atmospheric processing:
Chemical production of low volatility molecules

Phase transition – New Particle Formation:
Nucleation and clustering needs to be followed by fast nanoparticle growth

Large-scale models:
Over-simplifications are responsible for too low secondary organic aerosol levels in air quality models and too low sensitivity in global climate models:
- Comparison of 4 Earth System Models from CMIP6 show little sensitivity of CCN to the inclusion of organics in growth
- Single particle growth is assumed in the models using a limited subset of condensable vapors only: Low NPF over oceans buffers global effect
- Aerosol dynamics schemes are highly simplified and apparently do not reproduce atmospheric nanoparticle growth: Inclusion of a sectional scheme for growth changes CCN by more than 30%

D. Stolzenburg, R. Cai, S.M. Blichner, J. Kontkanen, P. Zhou, R. Makkonen, M. Kulmala, I. Riipinen, and J. Kangasluoma

"Atmospheric nanoparticle growth", Rev. Mod. Phys. 95, 045002

Emissions:
Volatile gases are emitted from the bio- and anthroposphere

Limited subset of condensable vapors

CCN

PM2.5