2026 Helmholtz – OCPC – Program

for the involvement of postdocs in bilateral collaboration projects

Title of the project:

From VOC emissions to aqueous-phase SOA formation: pathways and impacts on aerosol–cloud interactions

Helmholtz Centre and/or institute:

Karlsruhe Institute of Technology

Project leader:

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Description of the project (max. 1 page)**:**

Secondary organic aerosol (SOA) and secondary inorganic aerosol constitute major fractions of tropospheric aerosol particles and are central to atmospheric chemistry, cloud formation, and air quality (Hallquist et al., 2009; Fan et al., 2016). SOA exhibits high chemical complexity, provides molecular fingerprints of aerosol sources and aging, and modulates the cloud-forming properties of internally mixed aged aerosol particles. It is predominantly generated through oxidation of biogenic volatile organic compounds by reactions in the gas phase, but also in aqueous solution droplets (Ervens et al., 2011; Bianco et al., 2020, Top et al., 2025). Anthropogenic pollutants like NO_x, SO_2, and NH_3 can substantially modify SOA formation pathways and resulting aerosol properties. Key parameters governing these processes remain poorly constrained and are largely missing in current models. Therefore, realistic simulation chamber experiments and targeted field studies are essential to improve aerosol process parameterizations in transport models and to validate them.

This project aims to investigate the role of reactions in aqueous solution droplets and cloud droplets for SOA formation and aerosol aging, as well as their impact on cloud and fog formation. This will be achieved through a combination of field observations and simulation chamber studies. Aerosol photochemistry and cloud processing will be studied in well-defined scenarios (e.g. forest, urban)

using the unique AIDA aerosol and cloud simulation chamber at KIT. Experiments will vary precursor mixtures, seed particles, temperatures, and humidity to derive realistic model parameterizations based on mechanistic understanding of main processes. These parameterizations may be implemented in the ICON-ART transport model co-developed at KIT (Hoshyaripour et al., 2025). Aerosol chemical composition will be measured on-line in both the gas and particle phases using advanced mass spectrometers (FIGAERO-CIMS, CHARON-PTR-MS, and AMS) (Huang et al., 2019; Song et al., 2024). Additional analysis may include particle absorption, volatility, cloud condensation activity, and source apportionment using PMF. Field campaigns will be conducted at locations with significant emissions of biogenic VOC and moderate anthropogenic influence. Field observations of aerosol composition and cloud-forming properties will be linked to independent remote sensing of clouds and fog. These datasets will be used to evaluate and improve transport models such as ICON-ART.

The precise research focus will be adapted to the PostDoc's expertise and interests, enabling rapid scientific progress and timely publication of initial results during the project period.

Bianco et al., 2020, Photochemistry of the cloud aqueous phase: A review, Molecules 25, 1–23, DOI: 10.3390/molecules25020423.

Ervens, et al., 2011, Secondary organic aerosol formation in cloud droplets and aqueous particles (aqSOA): a review of laboratory, field and model studies, Atmos. Chem. Phys., 11, 11 069 – 11 102, DOI: 10.5194/acp-11-11069-2011.

Fan et al., 2016, Review of Aerosol–Cloud Interactions: Mechanisms, Significance, and Challenges, J. Atmos. Sci., 73(11), 4221–4252, DOI: 10.1175/JAS-D-16-0037.1.

Hallquist et al., 2009, The formation, properties and impact of secondary organic aerosol: current and emerging issues, Atmos. Chem. Phys., 9, 5155–5236, DOI: 10.5194/acp-9-5155-2009.

Hoshyaripour et al., 2025, The Atmospheric Composition Component of the ICON modeling framework: ICON-ART version 2025.04, EGUsphere [preprint], DOI: 10.5194/egusphere-2025-3400.

Huang et al., 2019, Chemical Characterization of Highly Functionalized Organonitrates Contributing to Night-time Organic Aerosol Mass Loadings and Particle Growth, Environ. Sci. Technol., 53, 1165-1174, DOI: 10.1021/acs.est.8b05826.

Song et al., 2024, Sources of organic gases and aerosol particles and their roles in nighttime particle growth at a rural forested site in southwest Germany, Atmos. Chem. Phys., 24, 6699–6717, DOI: 10.5194/acp-24-6699-2024.

Top et al., 2025, Influence of Relative Humidity and Seed Particles on Molecular Composition of -Pinene Secondary Organic Aerosol, Environ. Sci. & Techn. Air, 2, 1565 – 1574, DOI: 10.1021/acsestair.5c00064.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

We plan to establish a cooperation with the State Key Laboratory of Atmospheric Environment and Extreme Meteorology, Institute of Atmospheric Physics (IAP), Chinese Academy of Sciences (CAS), Beijing, China. The laboratory focuses on fundamental and applied research on physical and chemical processes in the atmosphere and their coupling mechanisms. It has achieved significant progress in investigating the impact of atmospheric chemistry and aerosols on air quality and aerosol-cloud interaction, using a combination of field measurements, modelling and remote sensing. With the project, we hope to build collaboration with IAP on studying atmospheric chemistry, aerosol and cloud processes by employing the complementary capabilities and scientific experiences of the partners.

Required qualification of the postdoc:

- PhD in Environmental Sciences, Atmospheric Chemistry or related fields
- Experience with with atmospheric chemical processes, aerosols, and clouds
- Additional skills in in chemical analytics (MS) and field studies
- Language requirement: fluent in English