The Schmücke Cloud Observatory (SCO): A unique Lagrange-type natural laboratory

Dominik van Pinxteren, Uwe Käfer, Laurent Poulain, Khanneh Wadinga Fomba, Erik Hoffmann, Andreas Tilgner, Kay Weinhold, Markus Hermann, Stephan Mertes, Silvia Henning, Heike Wex, Frank Stratmann, Mira Pöhlker and Hartmut Herrmann

Leibniz Institute for Tropospheric Research, Leipzig, Germany

TROPOS Leibniz Institute for Tropospheric Research

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GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

ACTRIS GERMANY

FONA Forschung für Nachhaltigkeit

Location & three-site setup

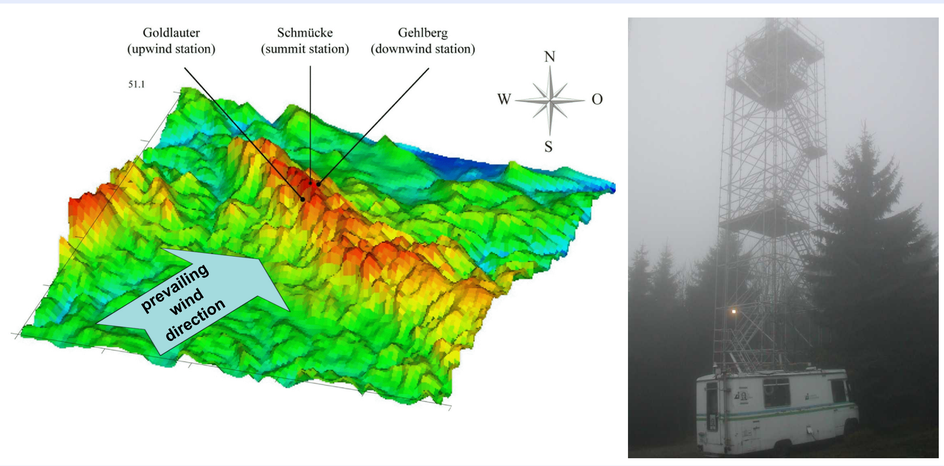


Fig. 1: Location of the SCO in the Thuringian Forest (left) and measurement tower (right)

- Located 150 km south-west of Leipzig in the Thuringian forest
- Three-site setup with valley stations in Goldlauter (upwind) and Gehlberg (downwind) and a summit station with measurement tower (937 m asl)
- Enables Lagrange-type experiments using the cloud as a natural flow-through reactor

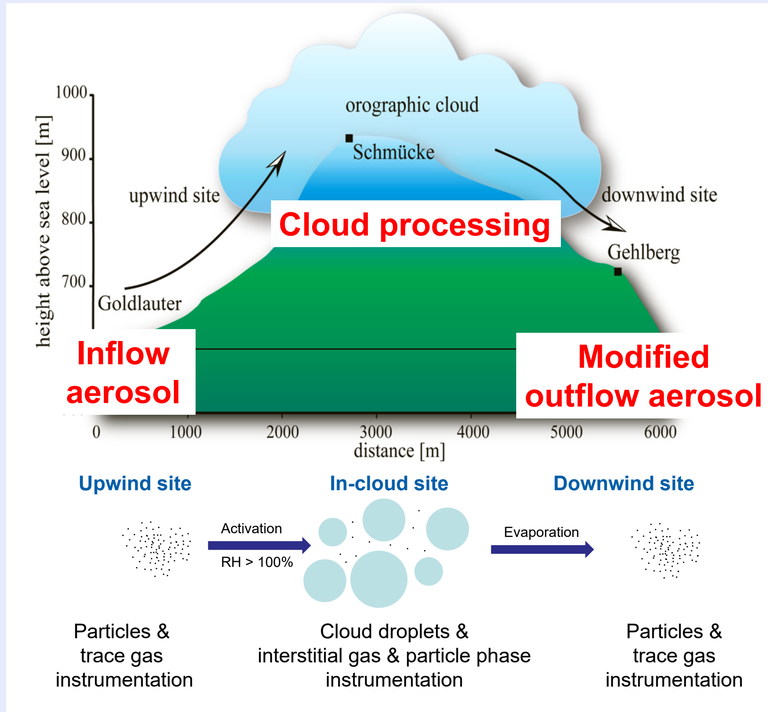
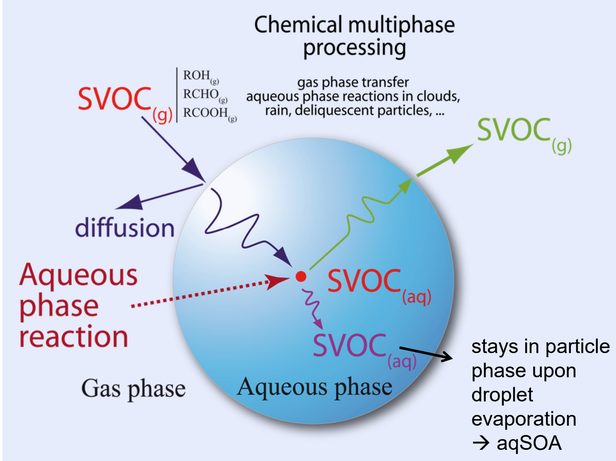


Fig. 2: Three-site setup of the SCO

Droplet reactor



- Organic and inorganic soluble gases enter cloud droplets by diffusion
- Aqueous phase reactions convert organics to higher oxidation states
- Newly formed compounds with lower vapor pressure stay in the particle phase after droplet evaporation

→ Clouds act as a chemical reactor, modifying both particle and gas-phase composition

Impact of cloud chemistry on particle properties

Uptake of gases into cloud droplets

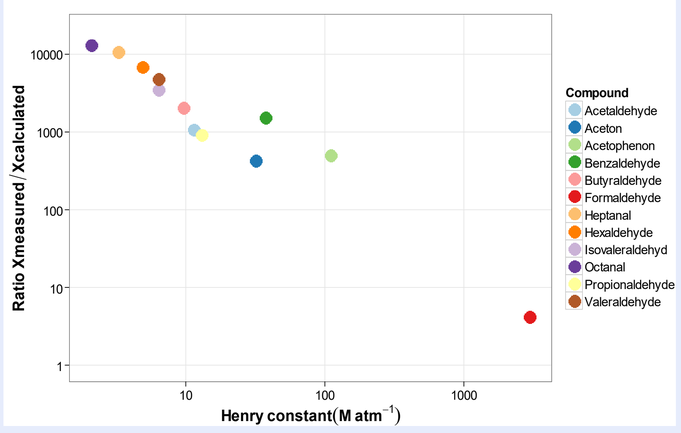


Fig 3.: Ratio of measured and calculated concentration of hydrophobic analytes in cloud water vs. their Henry constant

⇒ Uptake of soluble gases approx. as expected

⇒ **Less soluble gases** (lower Henry constant) often **highly supersaturated** in cloud water

Formation of new particle mass: sulfate and cloudSOA

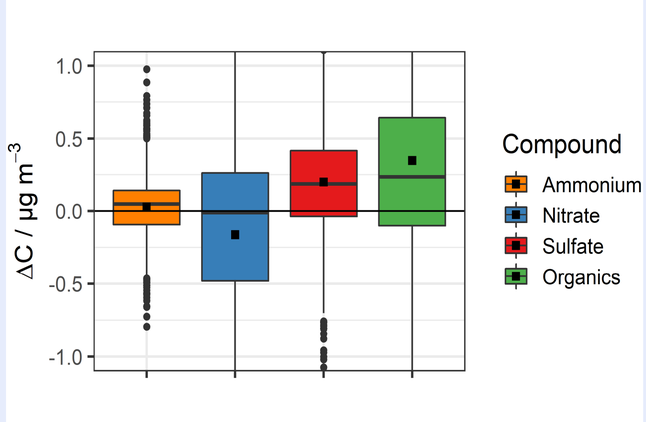


Fig 4.: Concentration change (ΔC) of selected substances after cloud processing (downwind minus upwind concentrations)

⇒ After correction for physical losses, **sulfate** and **organics** show **increased concentrations** in the order of ca. **0.2 – 0.3 µg m⁻³** after a mean **in-cloud time of 15 min**

Modification of number size distributions

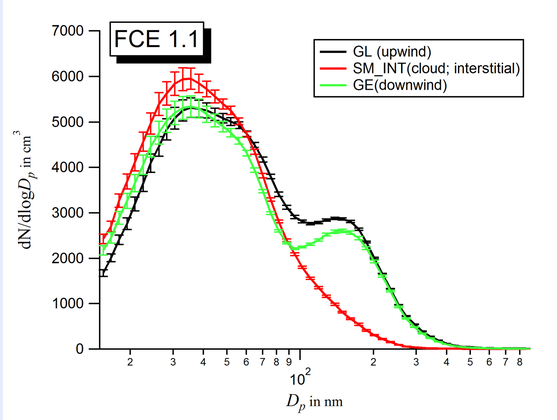


Fig 5.: Particle number size distribution before (black) and after (green) cloud processing

⇒ **Shape of NSD changes** from upwind to downwind

⇒ **Growth of activated particles** (ca. > 100 nm) due to additional non-volatile mass after cloud passage

Modification of CCN activity

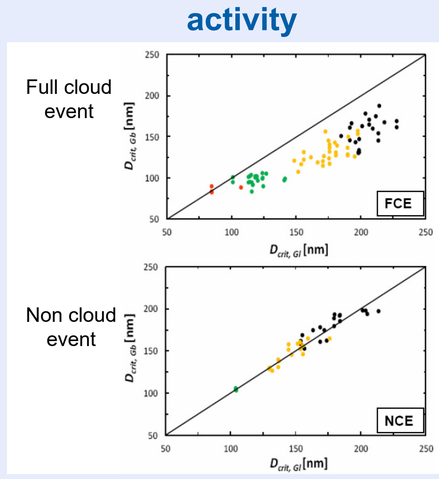


Fig 6.: D_{crit} before (GL) and after (GB) cloud processing during cloud events (FCE) and reference non-cloud events (NCE)

⇒ **Smaller D_{crit} downwind**, i.e. after cloud processing

⇒ Increased particle hygroscopicity, due to **new (hygroscopic) particle mass**

⇒ Particles will activate more easily in next cloud cycle

Activities at SCO in ACTRIS

Continuous aerosol & cloud characterization at three connected sites

- Cloud processing in different seasons
- Impact of different air mass inflow, i.e. different gas & particle compositions
- Impact on processed particle physical properties

→ **Long-term trends and impacts of changing atmospheric composition on cloud chemical processing of aerosol**

→ **Long term trends in aerosol (PM, BC, CCN, INP) abundance, composition and properties at a regional background site in a changing climate**

→ **Identification and quantification of sources, transformation and sinks of gases and aerosol particles**

→ **Chemical and physical interactions of gases and aerosol particles with clouds**

Provide access to unique type of natural cloud experiments

- Dedicated campaigns with additional state-of-the-art instrumentation for comprehensive process studies

→ **Improve multiphase system understanding and provide testbed for model evaluations**

Contact

PI: Prof. Dr. Hartmut Herrmann (herrmann@tropos.de)

Contact Chemistry: Dr. Dominik van Pinxteren (dominik@tropos.de)

Contact Microphysics: Dr. Markus Hermann (hermann@tropos.de)

Instruments & variables

	Instrument	Variable	Upwind	In-cloud	Downwind
Aerosol in-situ (ECAC)	Aerosol chemical speciation monitor (ACSM)	Particle composition	✓	TOT & INT	✓
	Cloud condensation nuclei counter (CCNC)	Cloud condensation nuclei (CCN) concentrations	✓	TOT	✓
	Mobility particle size spectrometer (MPSS)	Particle number size distribution	✓	TOT & INT	✓
	Nephelometer	Particle light scattering	--	TOT	--
	Aethalometer	Particle light absorption, BC & BrC	✓	TOT & INT	✓
	Sunlab online OC/EC instruments	OC & EC	✓	--	✓
Trace gases (CiGas)	Proton transfer reaction mass spectrometer (PTR-MS)	Volatile organic compounds	✓	INT	✓
	Trace gas monitors	NO_x, SO_2, O_3, CO	✓	INT	✓
Cloud in-situ (CIS)	Particle Volume Monitor (PVM)	Liquid water content, effective droplet radius		✓	
	Droplet spectrometer	Droplet size distributions		✓	
	Cloud water collectors	Offline analysis of chemical composition		✓	
	Filter samplers	INP characterization		✓	

*TOT: total inlet; INT: interstitial inlet