

Cloud chemistry during HCCT-2010: Mono- and dicarboxylic acids

Dominik van Pinxteren¹, Monique Teich¹, Stephan Mertes¹,
Taehyoung Lee², Jeff Collett², Hartmut Herrmann¹

1 Leibniz-Institut für Troposphärische Research, Permoserstr. 15, 04318 Leipzig, Germany
2 Colorado State University, Department of Atmospheric Science, Fort Collins, CO 80523, USA



INTRODUCTION

- Hill Cap Cloud Thuringia 2010 (HCCT-2010): Ground-based cloud-experiment on cloud chemistry and aerosol-cloud interaction
- Conducted in September and October 2010 at the Schmücke mountain, Thuringia, Germany
- Similar campaign philosophy as during FEBUKO 2001 and 2002 experiments (Herrmann, 2005)
- Joint project with partners from Germany (Leipzig, Mainz, Frankfurt), France (Lille, Lyon), Great Britain (Leeds), and the US (Fort Collins, CO)

- Lagrangian-type approach with three sampling sites (Fig. 1):
 - Upwind site for incoming aerosol (cloud condensation nuclei (CCN) and gas phase)
 - In-cloud site for cloud water and interstitial aerosol characterisation
 - Downwind site for residual particles and gas phase after cloud dissipation

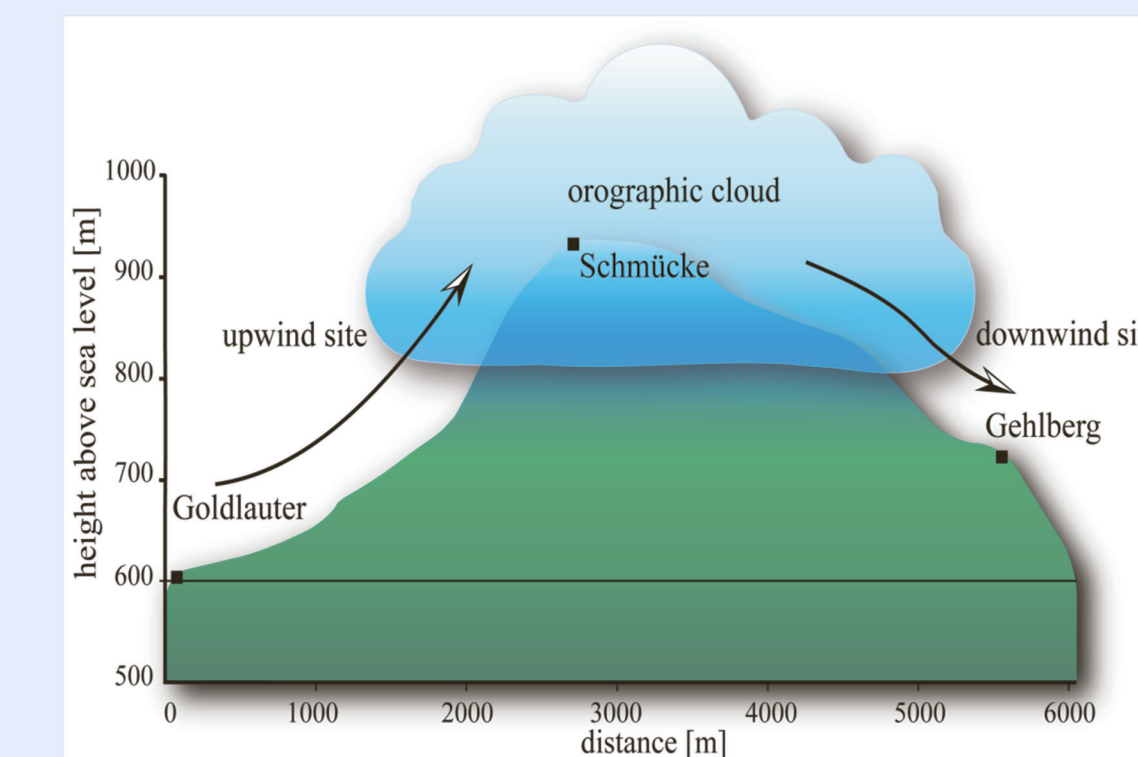


Figure 1: Scheme of the campaign area.

EXPERIMENTAL

Table 1: Full Cloud Events with cloud water sampling

Rating	FCE /Date
1	FCE11.3 02-10, 14:30 – 20:00
2	FCE1.1 14-09., 11:00 – 15:09, 2:00
3	FCE26.2 24-10, 9:15 – 11:45
4	FCE26.1 24-10, 1:30 – 8:45
5	FCE22.1 19-10, 21:30 – 20-10, 3:30
6	FCE13.3 06-10, 12:15 – 07-10, 3:15
7	FCE11.2 01-10, 22:30 – 2-10, 5:30
8	FCE13.1 05-10, 19:15 – 06-10, 4:30
9	FCE7.1 24-9, 23:45 – 25-09, 1:45
10	FCE12.1 05-10, 11:00 – 13:00
11	FCE13.2 06-10, 5:15 – 6:15
12	FCE20.1 15-10, 23:00 – 23:45

- 73 hours of cloud water sampling during “Full Cloud Events” (Table 1)
- Cloud water sampling by Caltech Active Strand Cloud Water Collectors (CASCC)
- Bulk sampler CASCC2 (Demoz et al., 1996), 3-stage CASCC (Raja et al., 2008), and 5-stage CASCC (Moore et al., 2002)
- Particle Volume Monitor (PVM) for liquid water content (LWC) of clouds
- Forward Scattering Spectrometer Probe (FSSP) for droplet distributions
- Analysis of short-chain mono- and dicarboxylic acids by capillary electrophoresis (CE) (Neusüß et al., 2000)
- Analysis of longer-chain acids by hollow-fibre liquid phase microextraction and CE-MS (van Pinxteren et al., 2012)

BULK CONCENTRATIONS

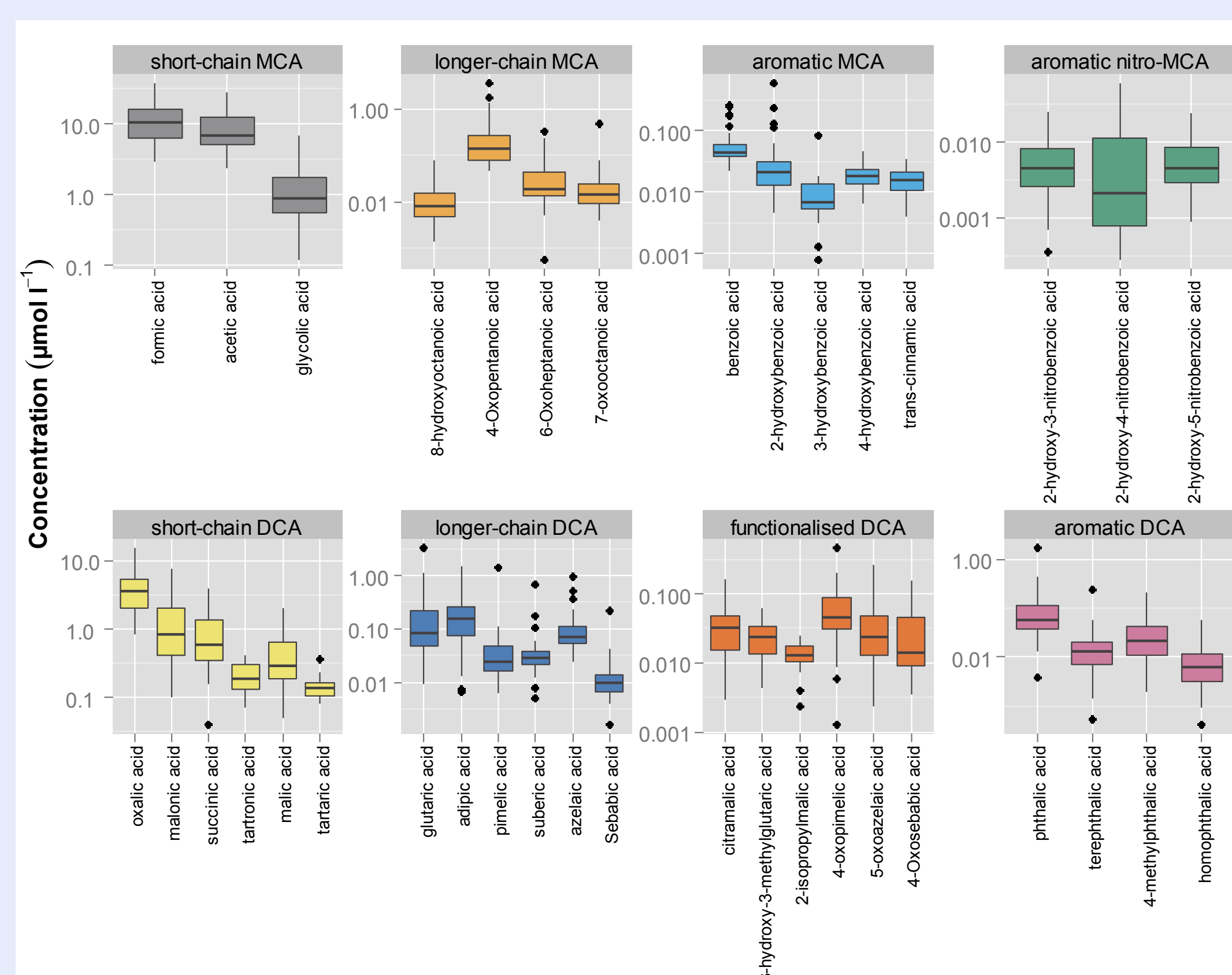


Figure 2: Bulk cloud water concentrations ($\mu\text{mol l}^{-1}$) of all determined carboxylic acids

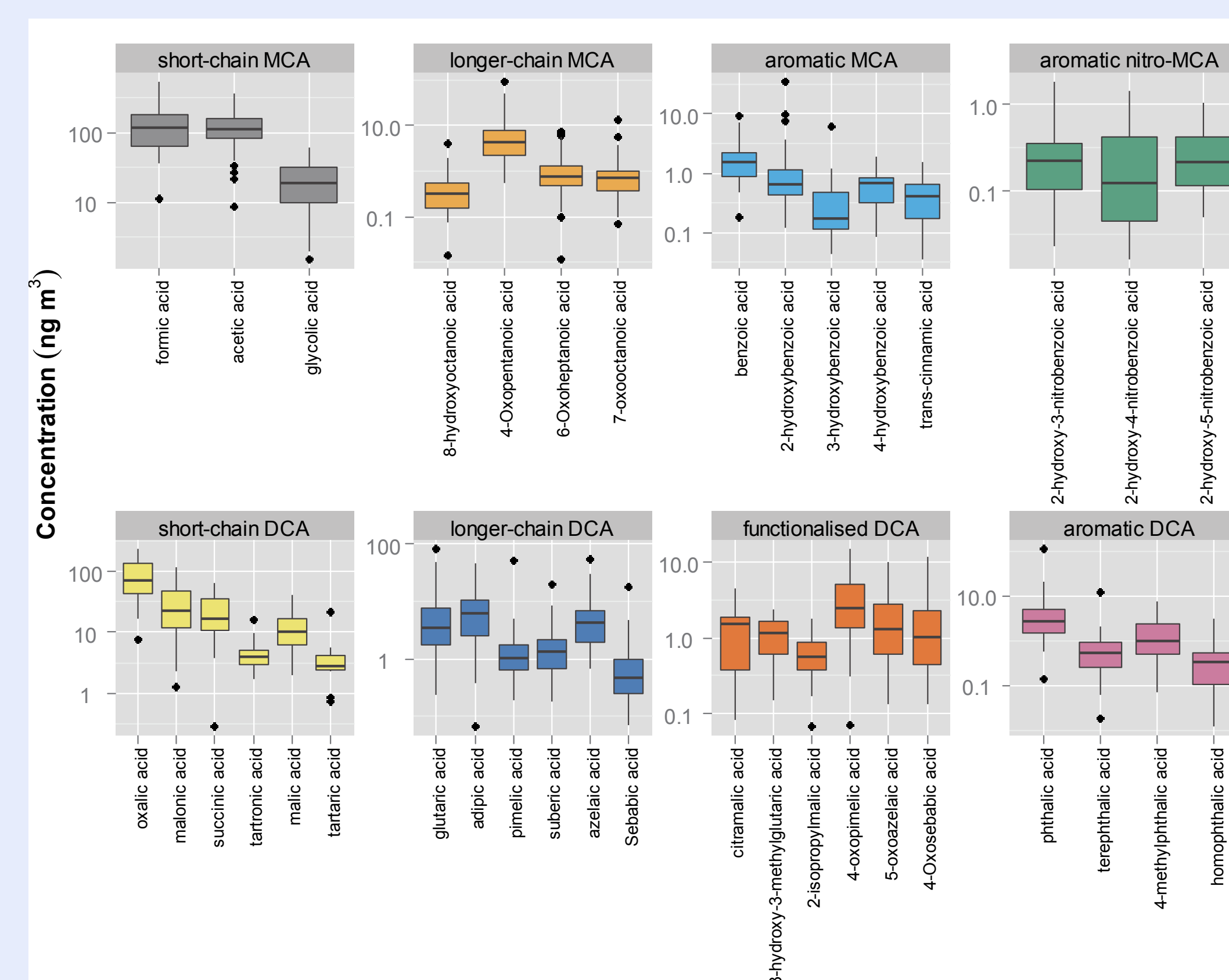


Figure 3: Bulk cloud water loadings (ng m^{-3}) of all determined carboxylic acids

- Wide range of concentrations for different acids (~ 0.001 - $10 \mu\text{mol l}^{-1}$) (Fig. 2)
- Short-chain (C1-C2) monocarboxylic acids (MCA) show highest conc., followed by short-chain (C2-C4) dicarboxylic acids (DCA)
- All further acids (except C5-C10 straight-chain DCA) determined for the first time from cloud water samples
- Cloud water loadings (CWL) in ng m^{-3} obtained from aqueous

- phase conc. and measured LWC (Fig. 3)
- \rightarrow equivalent aerosol concentration
- Uptake of acids into cloud water either by dissolution from CCN (esp. DCAs) or scavenging from gas phase (esp. short-chain MCAs)
- Aromatic nitro-acids potentially important due to light absorbing properties (“brown carbon”)

SIZE-RESOLVED CONCENTRATIONS

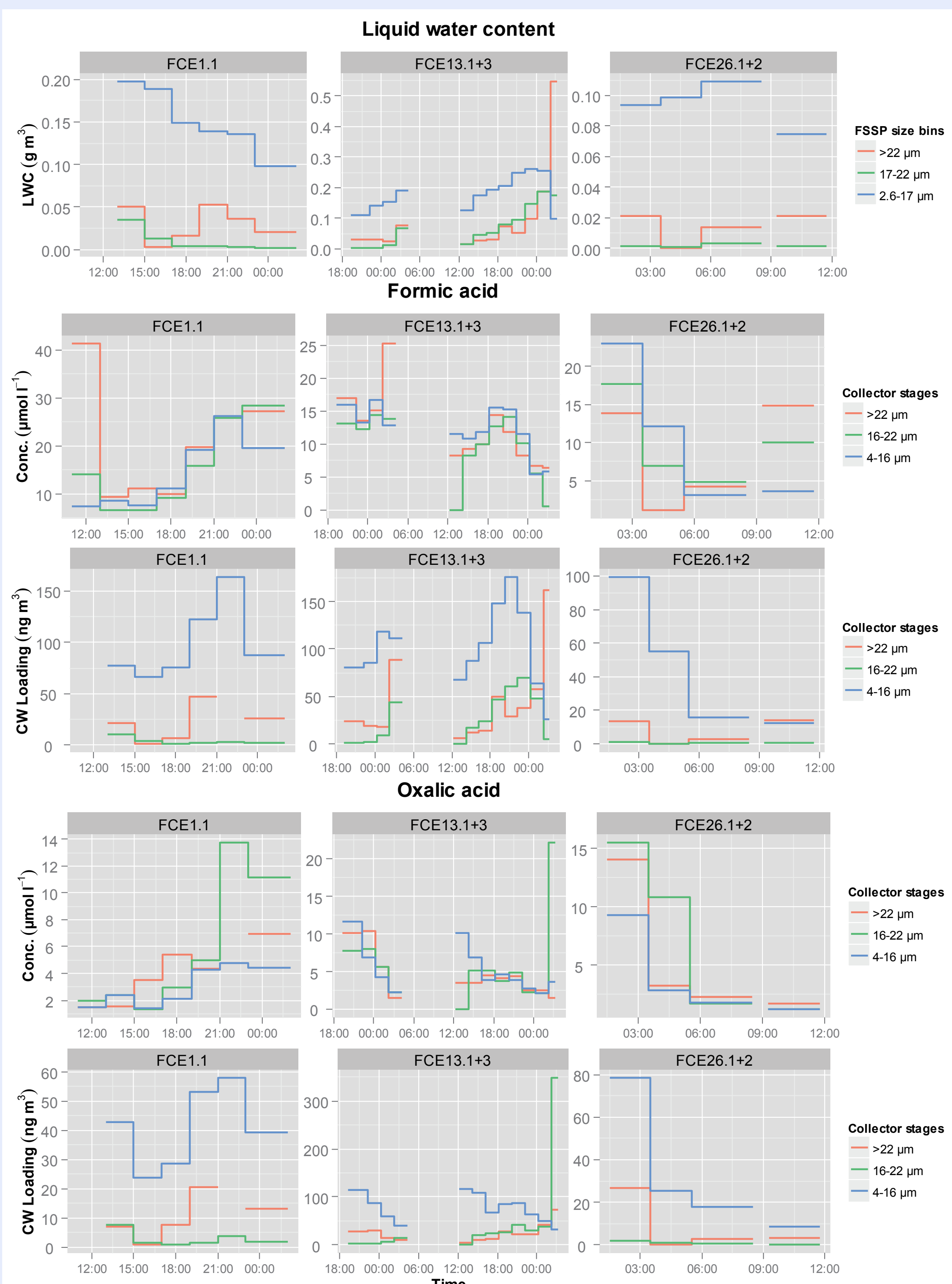


Figure 4: Results from 3-stage CASCC: LWC within collector size classes and concentrations and CWLs for formic and oxalic acid

- LWC usually highest in droplets of 9–17 μm (Fig. 4)
- Aqueous phase concentrations of formic and oxalic acid often similar among different collector stages (droplet size classes) (Figures 4 and 5)
- Notable exception: Very high aqueous phase conc. (up to $120 \mu\text{mol l}^{-1}$ for formic and $40 \mu\text{mol l}^{-1}$ for oxalic acid) in very small cloud droplets (4–10 μm from 5-stage CASCC)
- \rightarrow low water content of small droplets
- Different time profiles of formic and oxalic acid
- \rightarrow different sources and uptake mechanisms

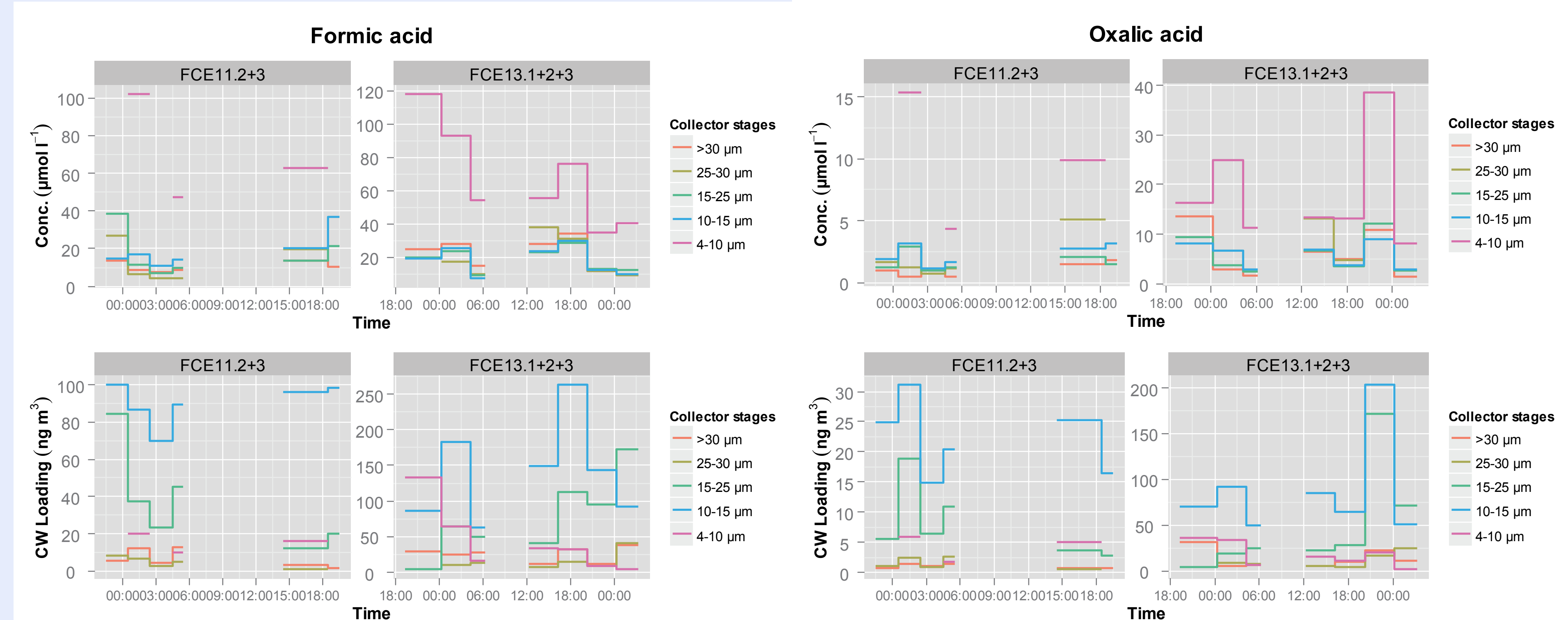


Figure 5: Results from 5-stage CASCC: LWC within collector size classes and concentrations and CWLs for formic and oxalic acid

REFERENCES AND FUNDING

Demoz et al., 1996, *Atmos. Res.* 41(1), 47-62
Herrmann (Ed.), 2005, *Atmos. Environ.* 23-24, special issue
Moore et al., 2002, *Atmos. Environ.* 36(1), 31-44
Neusüß et al., 2002, *J. Geophys. Res.* 105, 4513-4527
Raja et al., 2008, *Atmos. Environ.*, 42(9), 2048-2061
van Pinxteren et al., 2012, *J. Chrom. A*, in press
Funding by German Research Foundation (DFG), Bonn, Germany