Supplementary

Synergistic role of sulfuric acid, ammonia and organics in particle formation over an agricultural land

Lubna Dada[a,b,*], **Magdalena Okuljar**[a,β], **Jiali Shen**[a,β], **Miska Olin**[c], **Yusheng Wu**[a], **Laura Heimsch**[d], **Ilkka Herlin**[e], **Saara Kankaanrinta**[e], **Markus Lampimäki**[a], **Joni Kalliokoski**[c], **Rima Baalbaki**[a], **Annalea Lohila**[d], **Tuukka Petäjä**[a], **Miikka Dal Maso**[c], **Jonathan Duplissy**[a,f], **Veli-Matti Kerminen**[a], **Markku Kulmala**[a,*]

This document contains one supplementary table and 11 supplementary figures.

Table S1. Management of the agricultural land site at Qvidja farm in 2019.

Date	Management	Output	Input	in C
		(kg DW ha^{-1})	(kg ha^{-1})	(g m^{-2})
8th of May 2019	Fertilization		-4606	-43
11th of Jun 2019	Harvest	3107		130
26th of Jun 2019	Fertilization (mineral)			
20th of Aug 2019	Harvest	1029		43

Figure S 1 Location and land use information about Qvidja (agricultural land) and Hyytiälä (boreal forest), marked with yellow and blue respectively. Maps in (A) and (B) are extracted from Google Maps©, the land use cover in map (C) are extracted from ESA WorldCover ©.
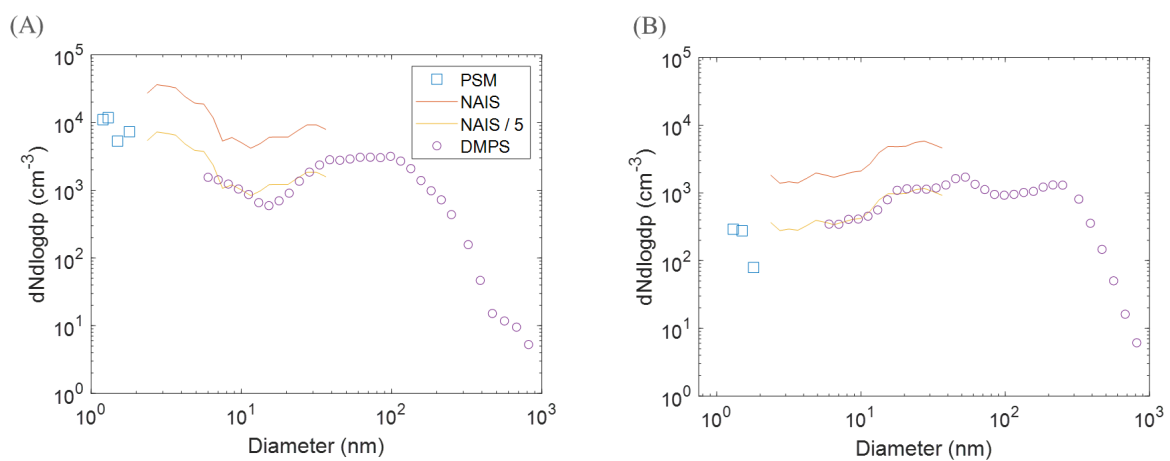
(A)

(B)

Figure S 2 Example averaged particle number size distribution measured during particle formation event on May 16 and nonevent on May 23.
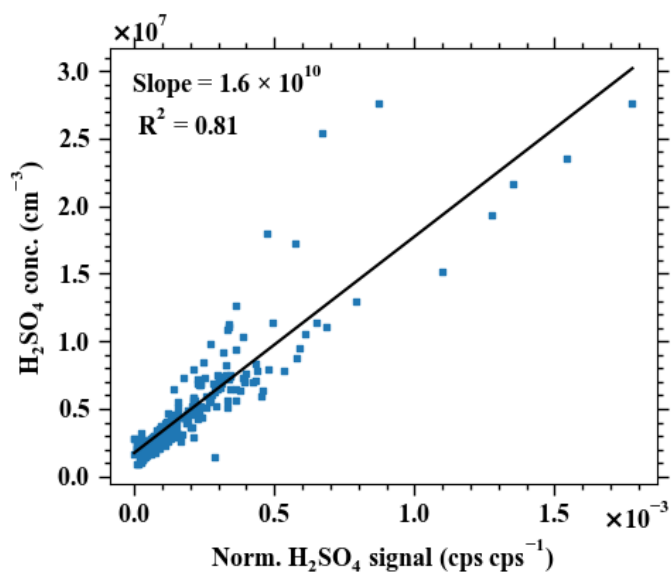
Figure S 3 Linear fit between NO_3^--CIMS (y-axis) and NO_3^--MION-CIMS (x-axis) for the overlap time (13-23 June 2019) shows that the H_2SO_4 calibration coefficient in NO_3^--MION-CIMS is around three times larger than that of NO_3^--CIMS.
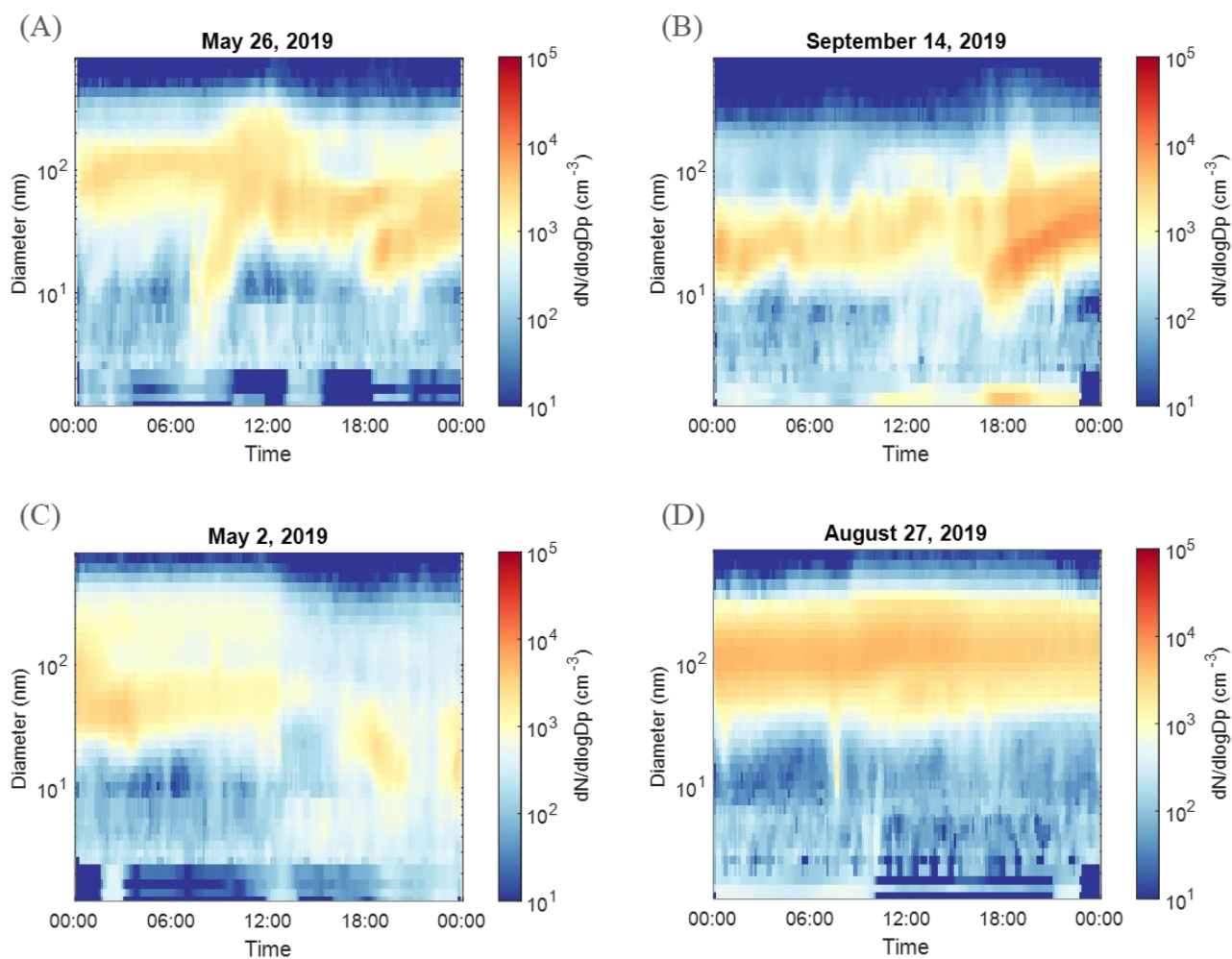
Figure S 4 Examples of regional NPF events during (A) spring and (B) autumn. Examples of non-events during (C) spring and (D) autumn.
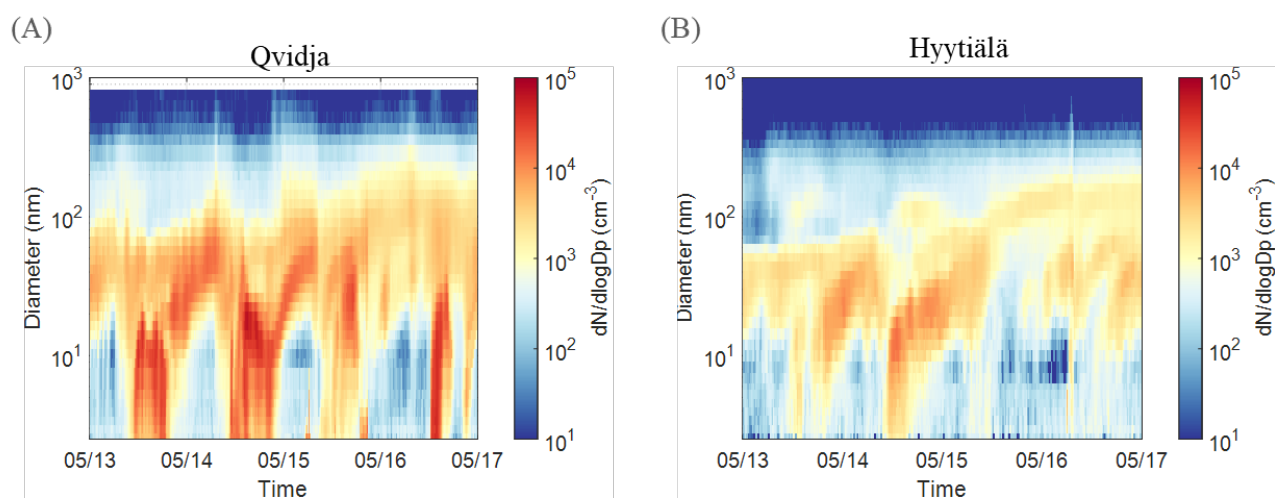
Figure S 5 Particle number size distribution during simultaneous intense NPF events in Qvidja and Hyytiälä in May 2019. Comparison shows the higher intensity and smaller starting diameter of the events in Qvidja compared to Hyytiälä.
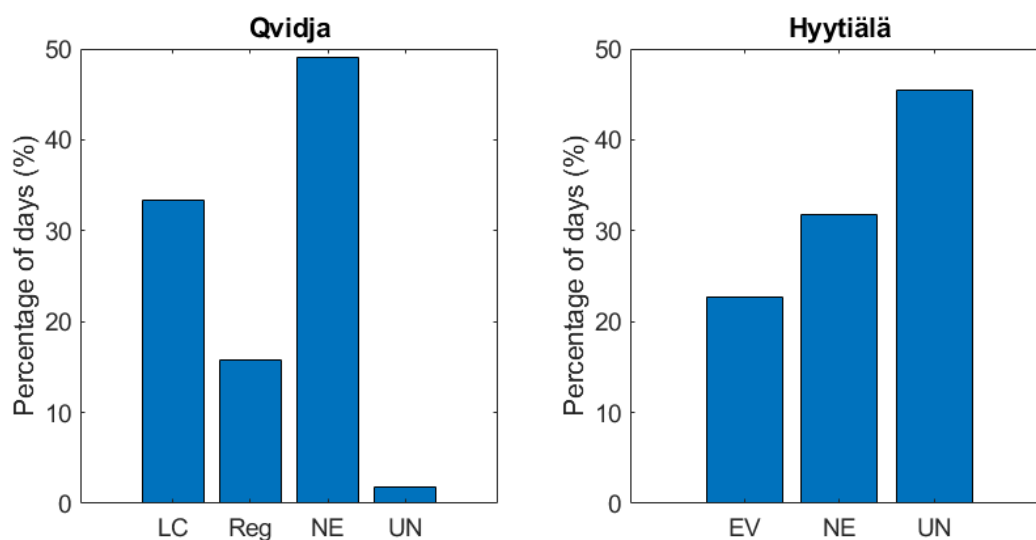
Figure S 6 New particle formation event frequency at Qvidja and Hyytiälä. The acronyms LC, Reg, NE, UN, and EV stand for local clustering, regional NPF, non-event, undefined and event days, respectively. See methods section 3.1 for details on classification. Data from both sites includes same dates: spring and autumn 2019.
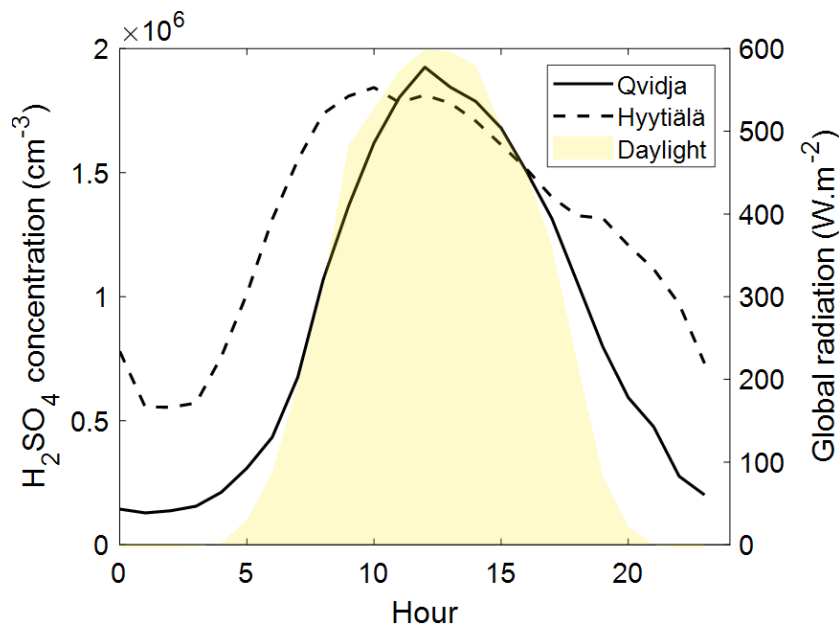
Figure S 7 Diurnal sulfuric acid concentration in Qvidja (solid) and Hyytiälä (dashed) in May 2019. The shaded area represents daytime hours.
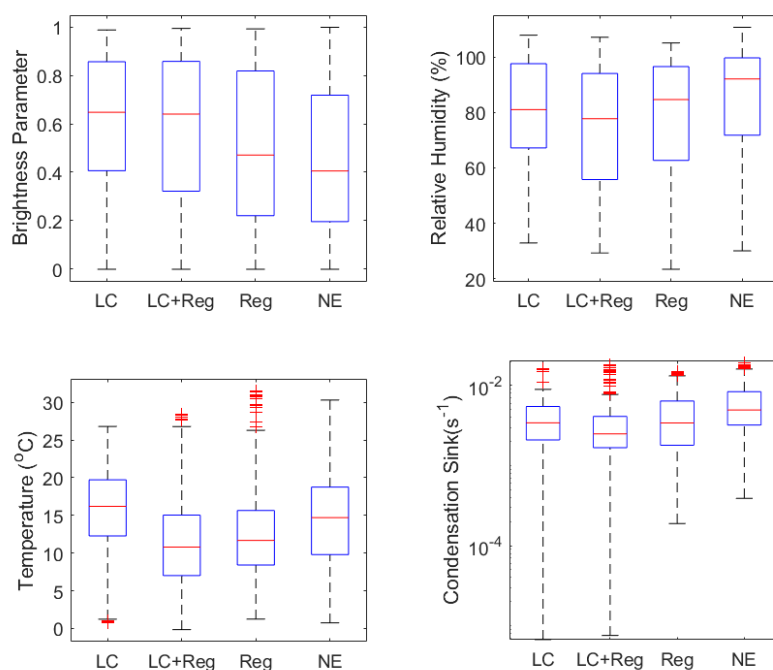
Figure S 8 Brightness parameter, relative humidity, temperature and condensation sink on different days. The acronyms LC, Reg, and NE stand for local clustering, regional NPF and non-event. The red line represents the median of the data and the lower and upper edges of the box represent the 25th and 75th percentiles of the data. The lines extending from the central box represent the minimum and the maximum of the data.
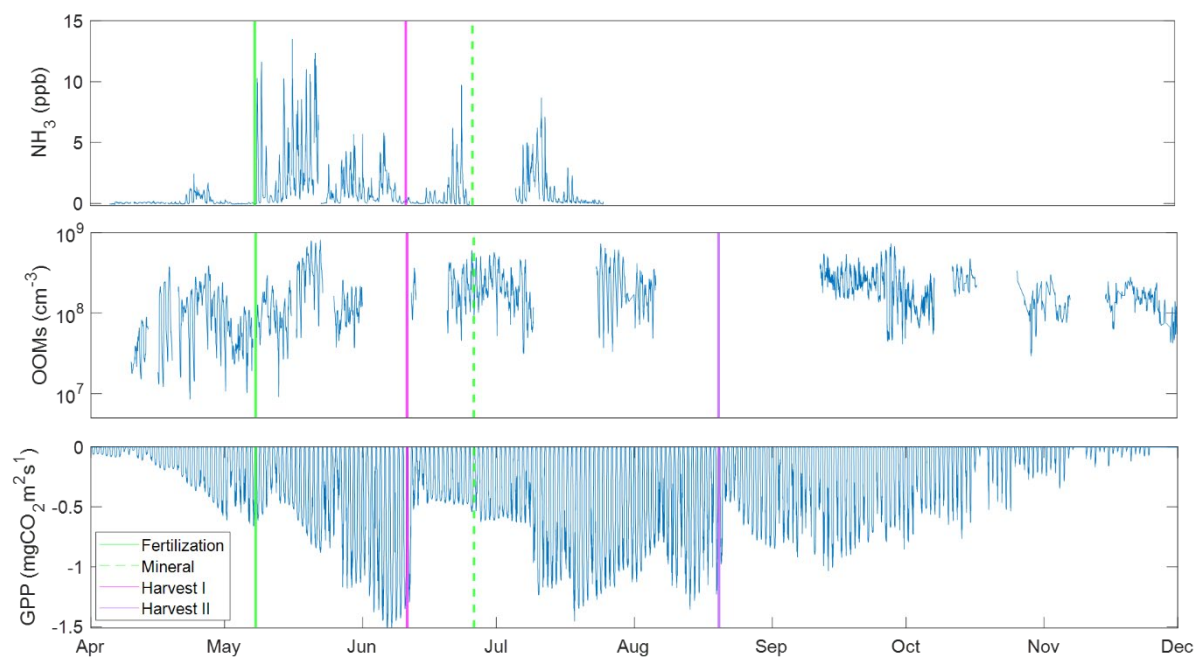
Figure S 9 Agricultural land management during the year 2019 and its effect on ammonia (NH₃) – NH₃ was below detection limit after august, on total oxygenated organic molecules concentration (OOMs), and on gross primary production (GPP).
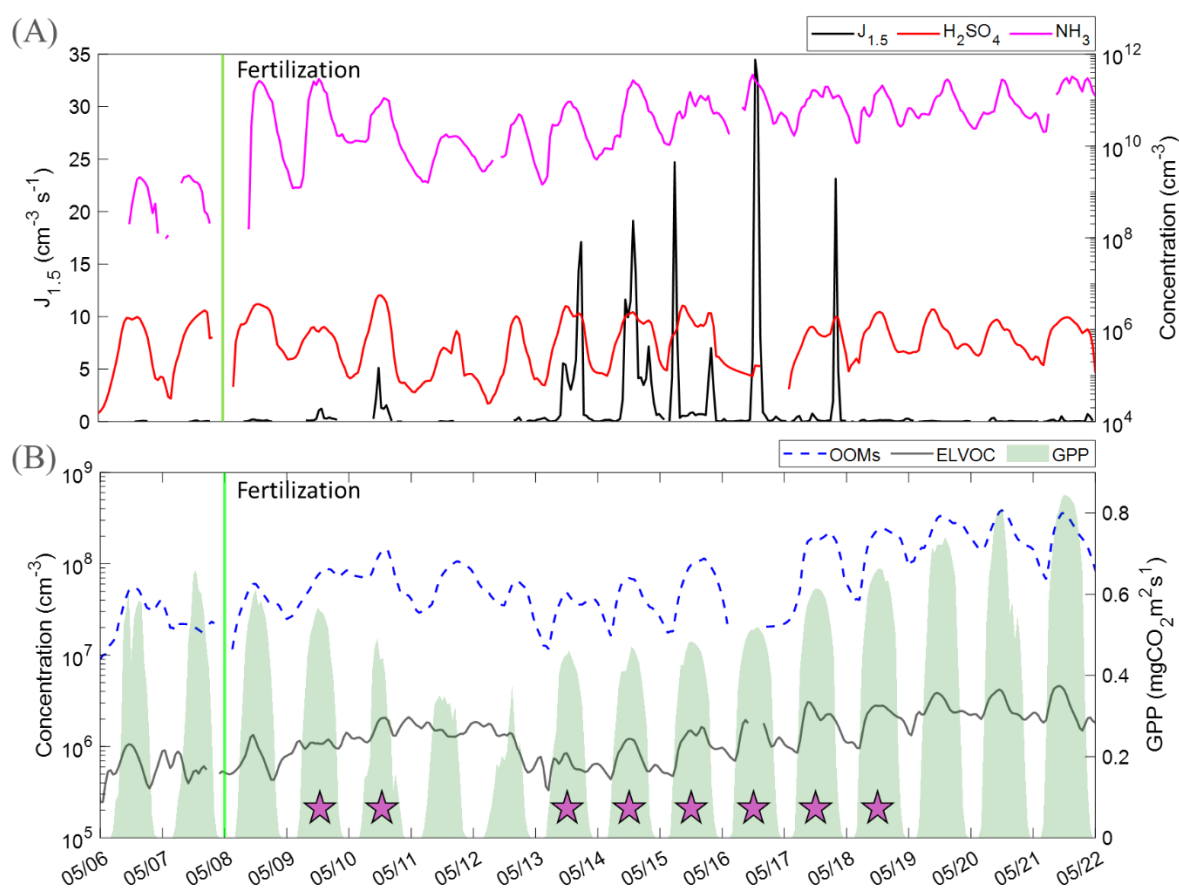
Figure S 10 Excerpt of particle formation mechanism in Qvidja. (A) Time series of particle formation rates ($J_{1.5}$), and concentrations of sulfuric acid (H_2SO_4) and ammonia (NH_3). (B) Time series of gross primary production (-GPP) and concentration of oxygenated organic molecules (OOMs) and extremely low volatility organic compounds (ELVOC) during May 2019 in Qvidja. Clustering events are marked with a star. The fertilization day is marked with a green vertical line.
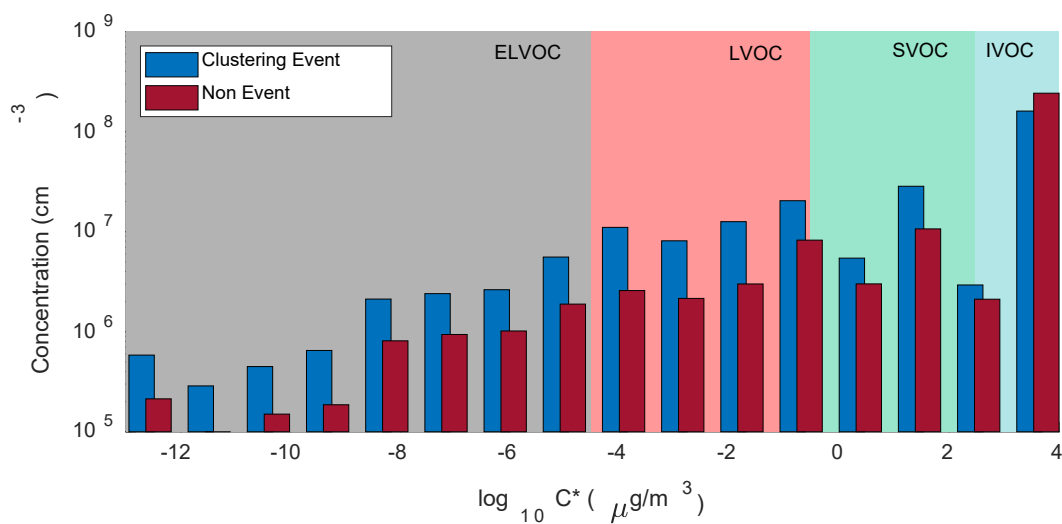
Figure S 11 Volatility distribution bins of molecules measured on a local clustering event day on May 15, 2019 and on a non-event day May 6, 2019. See also the mass defect plots in Fig. 6. ELVOC, extremely low-volatility organic compound; IVOC, intermediate-volatility organic compound; LVOC, low-volatility organic compound; SVOC, semi-volatile organic compound.