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Supplementary Information of

25 years of atmospheric and ecosystem measurements in a boreal forest — Seasonal variation and responses to warm and dry years

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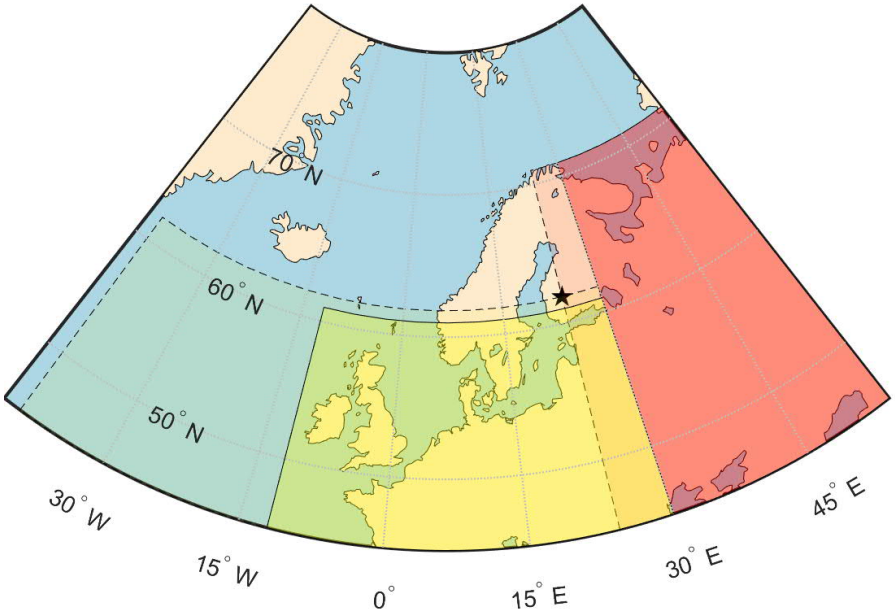

Fig. S1. Sectors used in air mass classification, (previously also used by Heikkinen et al., 2020). The star symbol shows the location of Hyytiälä. The darker yellow shading indicates the "Europe" sector and the darker red shading the "Russia" sector, while the remainder is considered the "clean" sector. Lightly shaded areas with dashed-line edges show where the sectors overlap.

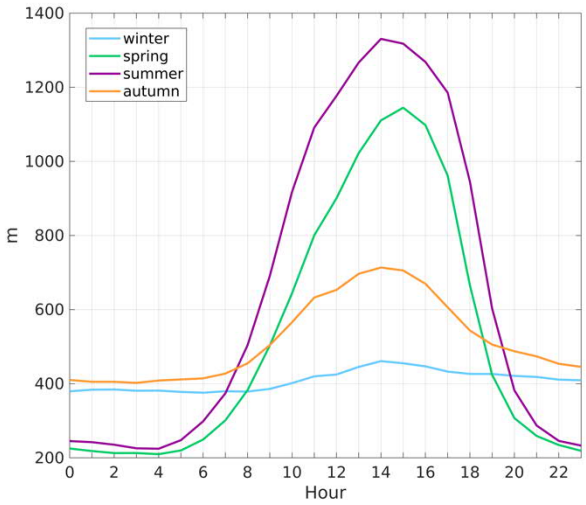

Fig. S2. Diurnal cycles of boundary layer height. Seasons are denoted with colors; winter: light blue, spring: green, summer: purple, autumn: orange. The time zone is UTC+2. Data from years 1996–2019 is included.

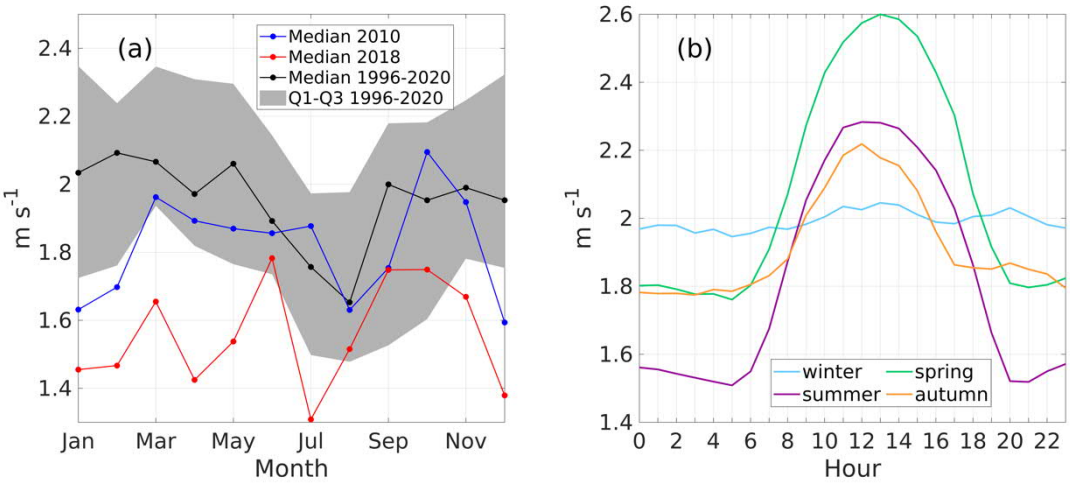

Fig. S3. over 1996–2020 is shown in black and interquartile range (IQR) in grey shading. Monthly medians of the years 2010 and 2018 are shown in blue and red, respectively. In subplot b), seasons are denoted with colours; winter: light blue, spring: green, summer: purple, autumn: orange. The time zone in the diurnal plot is UTC+2.

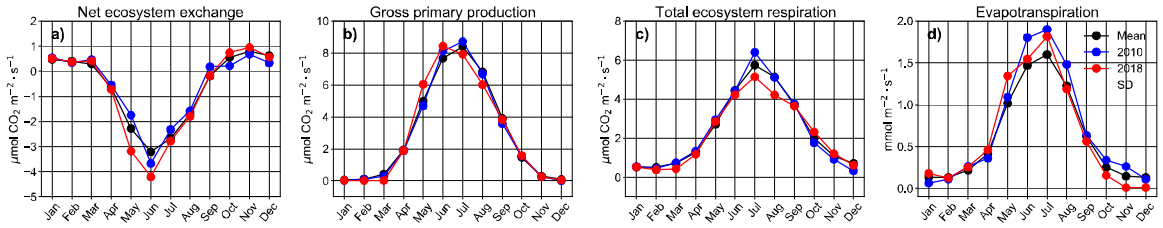

Fig. S4. Monthly means of NEE (a), GPP (b), R_E (c), and ET (d). The mean over all years is shown in black and mean ± standard deviation in grey shading. Monthly means of years 2010 and 2018 are shown in blue and red, respectively. Data coverage of all four variables is 2001–2020.

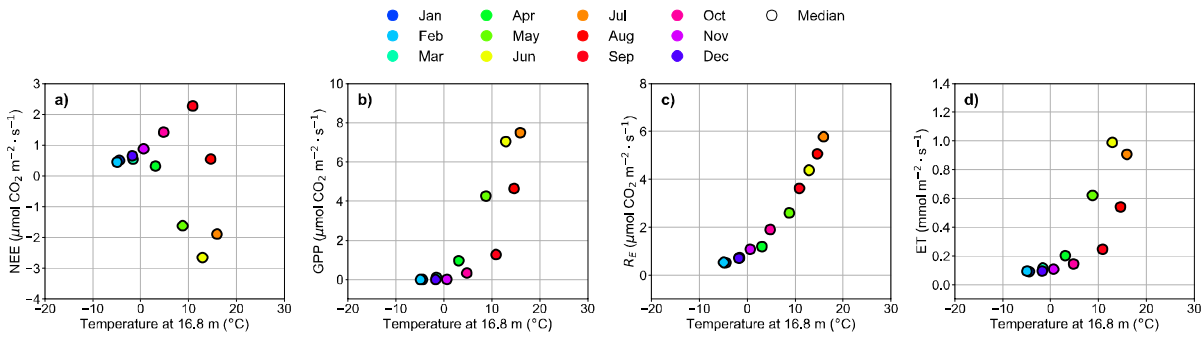

Fig. S5. (a) Net ecosystem exchange (NEE), (b) gross primary production (GPP), (c) total ecosystem respiration (R_E), and (d) evapotranspiration (ET) vs. air temperature at 16.8-m height. Monthly medians of single years are indicated with different colours and the medians of monthly medians over all years are indicated with black outline. Data from years 2001–2019 is included.

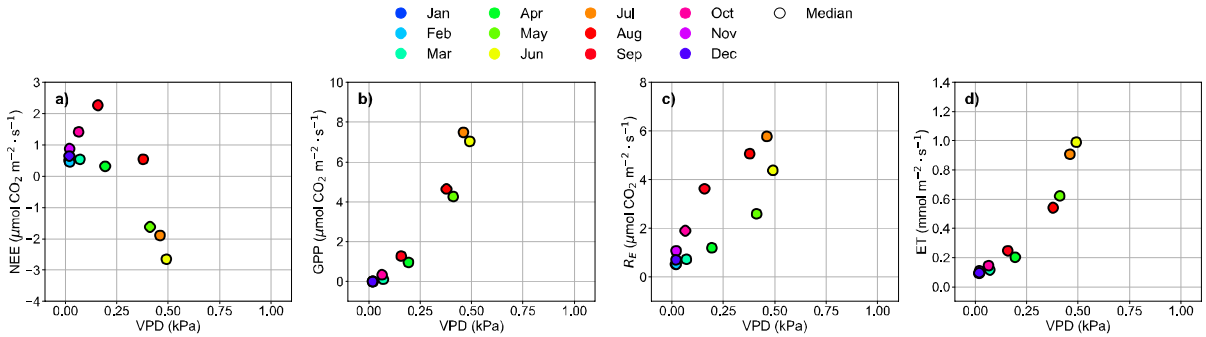

Fig. S6. (a) Net ecosystem exchange (NEE), (b) gross primary production (GPP), (c) total ecosystem respiration (R_E), and (d) evapotranspiration (ET) vs. vapour pressure deficit (VPD). Monthly medians of single years are indicated with different colours and the medians of monthly medians over all years are indicated with black outline. Data from years 2001–2019 is included.

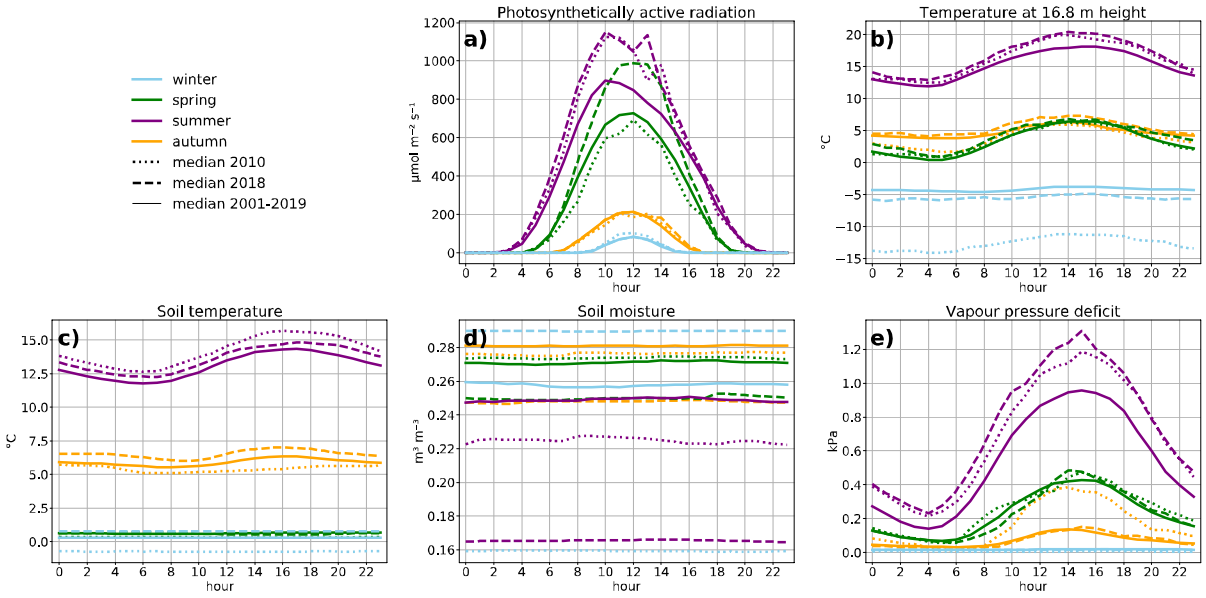

Fig. S7. Diurnal cycles of (a) photosynthetically active radiation (PAR), (b) air temperature at 16.8 m height, (c) soil temperature, (d) soil moisture, and (e) vapour pressure deficit (VPD) during different seasons. Seasons are denoted with colours; winter: light blue, spring: green, summer: purple, autumn: orange. Medians over the whole period are denoted with solid lines and medians for 2010 and 2018 with dotted and dashed lines, respectively. Data from years 2001–2019 is included.

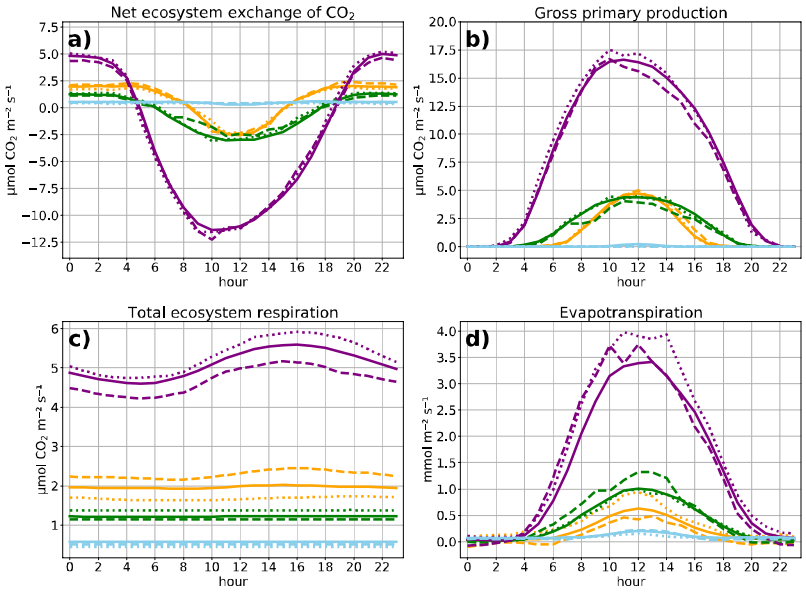

Fig. S8. Diurnal cycles of (a) net ecosystem exchange, (NEE) (b) gross primary production (GPP), (c) total ecosystem respiration (R_E), and (d) evapotranspiration (ET). Seasons are denoted with colours; winter: light blue, spring: green, summer: purple, autumn: orange. Medians over the whole period are denoted with solid lines and medians for 2010 and 2018 with dotted and dashed lines, respectively. Data from years 2001–2019 is included.

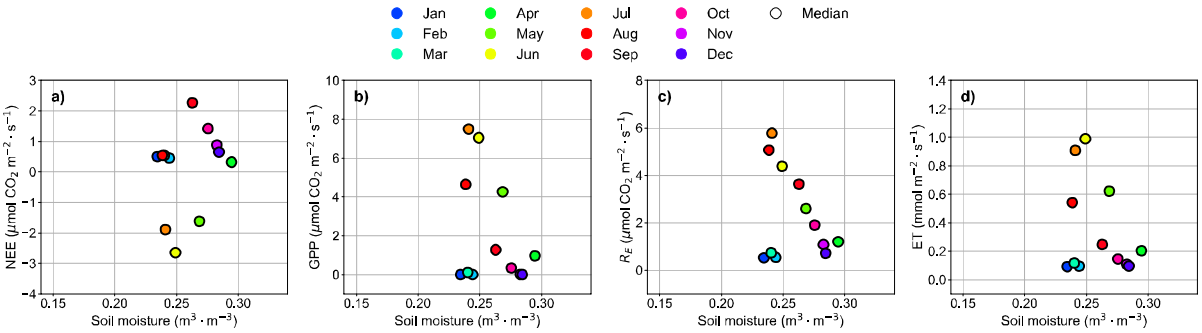

Fig. S9. (a) Net ecosystem exchange (NEE), (b) gross primary production (GPP), (c) total ecosystem respiration (R_E), and (d) evapotranspiration (ET) vs. soil moisture. Monthly medians of single years are indicated with different colours and the medians of monthly medians over all years are indicated with black outline. Data from years 2009–2019 is included.

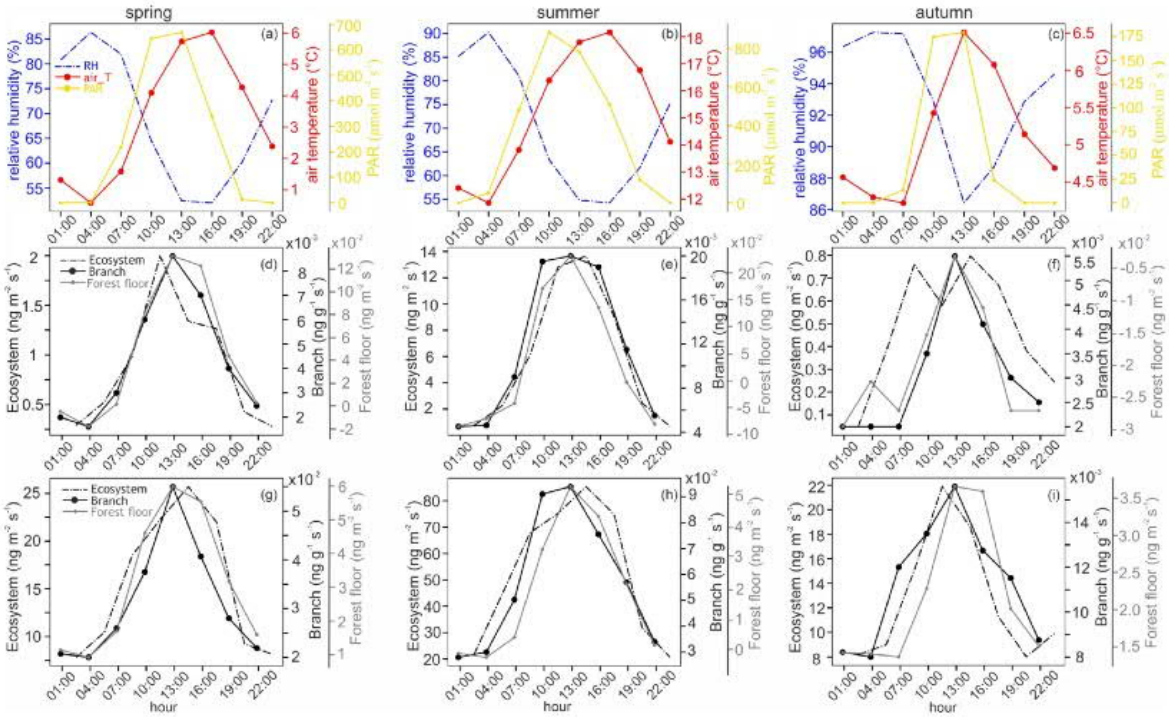

Fig. S10. Diurnal variation of monthly median (a, b, c) meteorology data, (d, e, f) isoprene and (g, h, i) monoterpene emissions from ecosystem, Scots pine branches and forest floor in spring (left), summer (middle), and autumn (right).

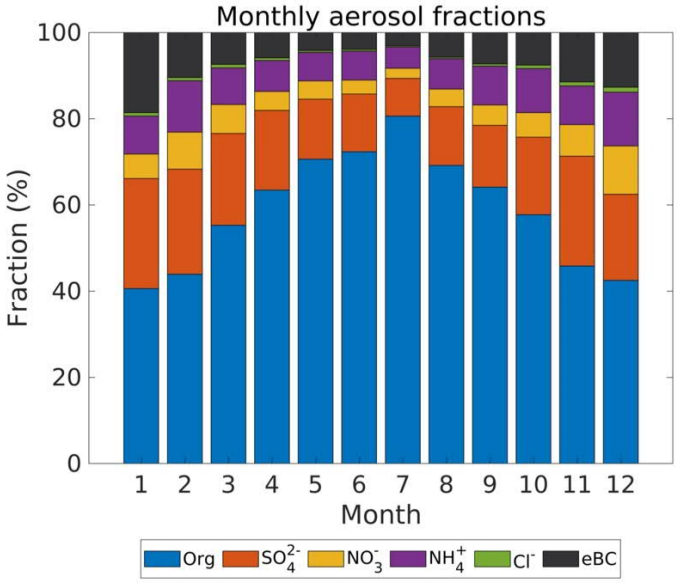

Fig. S11. Monthly medians of aerosol composition (2012–2019) given in fractions.

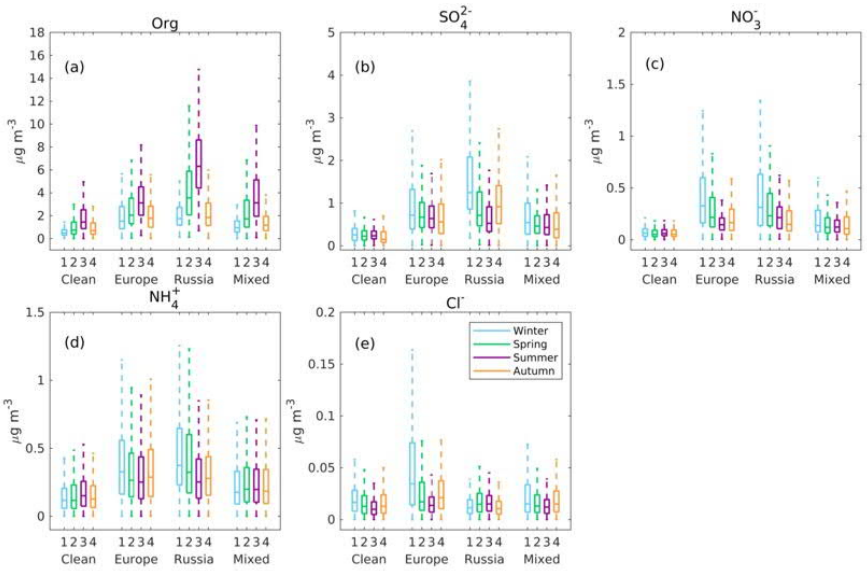

Fig. S12. Boxplots of hourly a) organic (Org), b) sulphate (SO_4^{2-}), c) nitrate ($NO_3^=$), d) ammonium (NH_4^+), and e) chloride (Cl^-) aerosol concentrations and air mass source areas: clean, Europe, Russia, and mixed during different seasons. Here, 1 represents the winter season, 2 spring season, 3 summer season, and 4 autumn season. Seasons are denoted with colours; winter: light blue, spring: green, summer: purple, autumn: orange. The central mark represents the median while the bottom and top edges represent the 25th and 75th percentiles. The whiskers indicate the most extreme data points that are not considered outliers.

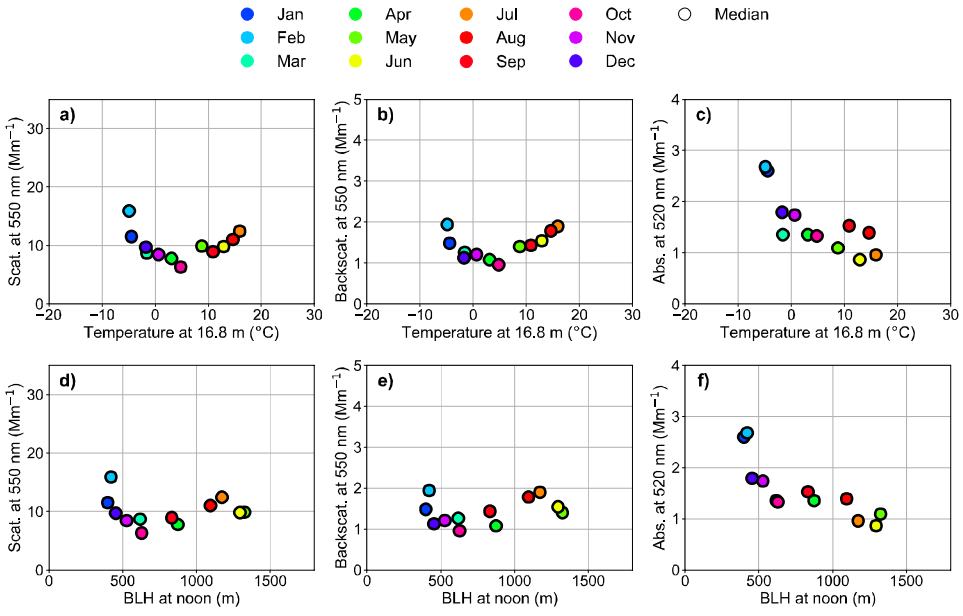

Fig. S13. Scattering coefficient at 550 nm, Backscattering coefficient at 550 nm, and absorption coefficient at 520 nm vs. (a,b,c) air temperature at 16.8 m and (d,e,f) boundary layer height (BLH) at noon. Monthly medians of single years are indicated with different colours and the medians of monthly medians over all years are indicated with black outline. Data from years 2006–2019 is included.

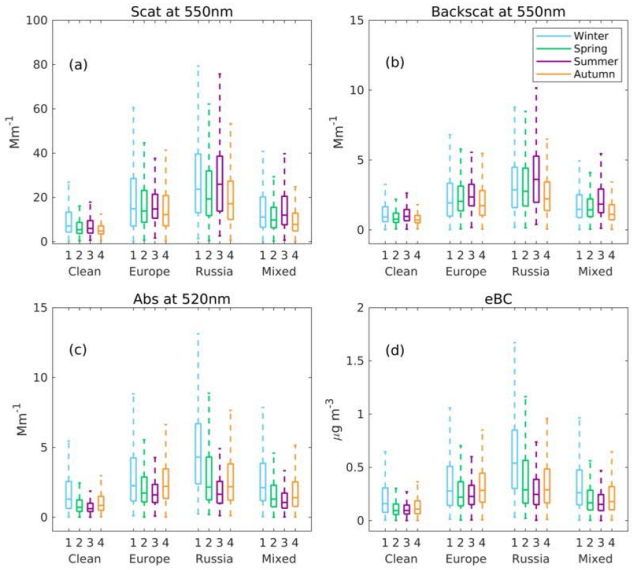

Fig. S14. Boxplots of hourly a) scattering coefficients at 550 nm, b) backscattering coefficients at 550 nm, c) absorption coefficients at 520 nm, and d) equivalent black carbon (eBC) concentrations and air mass source areas: clean, Europe, Russia, and mixed during different seasons. Here, 1 represents the winter season, 2 spring season, 3 summer season, and 4 autumn season. Seasons are denoted with colours; winter: light blue, spring: green, summer: purple, autumn: orange. The central mark represents the median while the bottom and top edges represent the 25th and 75th percentiles. The whiskers indicate the most extreme data points that are not considered outliers.

Table S1. Full names of the shortened variable names in Fig. 2.

Abbreviation or shortened name	Full name
Abs.520	Absorption at 520 nm
Accum.mode	Accumulation mode particle concentration
Aitken.mode	Aitken mode particle concentration
BLH	Boundary layer height
Cl	Cl^- concentration
CS	Condensation sink of H_2SO_4
ET	Evapotranspiration
F.Isoprene	Flux of isoprene
F.MTs	Flux of monoterpenes
GPP	Gross primary production
GlobRad	Global radiation
HOM.dimer.log10	HOM dimer concentration (logscale)
HOM.monomer.log10	HOM monomer concentration (logscale)
H2SO4.log10	H_2SO_4 concentration (logscale)
Isoprene	Isoprene concentration
Monoterpene	Monoterpene concentration
NH4	NH_4^+ concentration
NO3	NO_3^- concentration
N.sub2nm	Sub 2 nm particle concentration
Nucl.mode	Nucleation mode particle concentration
Org	Organics concentration
O3	O_3 concentration
PM1	Particulate matter below 1 μm
Prec	Precipitation
RE	Total ecosystem respiration
RH	Relative humidity
Scat.550	Scattering at 550 nm
SO4	SO_4^{2-}
Temp	Air temperature
VPD	Vapour pressure deficit
WS	Wind speed