One-year ACSM source apportionment of organic aerosol at the rural site

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Introduction

Atmospheric aerosol particles negatively affect human health and have important climate impacts[1]. Since organic aerosol (OA) represents the largest fraction of the aerosol composition in the fine mode and comprise huge variety of compounds[2], the molecular identification of OA constituents, their impact on physico-chemical properties as well as the corresponding source identifications remain challenging. Although source apportionment as a common approach for the OA source identification was much applied in field campaigns using Aerosol Mass Spectrometer (AMS), there is still a lack of knowledge regarding their seasonal variability over the run of a year. For this reason, we analyzed 12 months (from September 2016 to end of August 2017) OA source apportionment of Aerosol Chemical Speciation Monitor (ACSM) data set, from Melpitz as a rural station.

Methodology

Site

TROPOS research station Melpitz:

51.54° N, 12.93° E, 86 m a.s.l., 50 km to the northeast of Leipzig, Germany.

Model

Rolling mechanism by running PMF (ME-2) for a short time window in the order of 2 weeks/ 1 day shift, via SoFi Pro Module[3].

Instrumentation

- **Aerosol Chemical Speciation Monitor (ACSM):**
  PM_1 Chemical components, OA, SO_4, NO_3, NH_4 and Cl.
- **Multi-Angle Absorption Photometer (MAAP):**
  Equivalent black carbon mass (eBC).

Results

Overview_ ACSM & MAAP

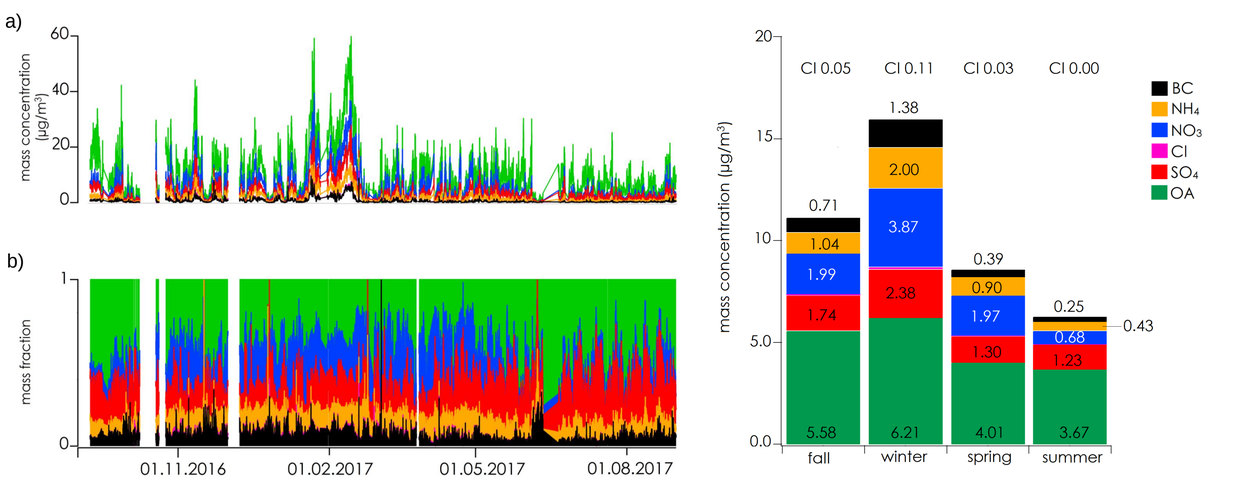

Fig. 1: **Mass concentration (top-a) and fraction (bottom-b) of the main submicromere components. Bar chart on the right corresponds to seasonal average composition over the entire time period.**

Yearly source apportionment PMF(ME-2)

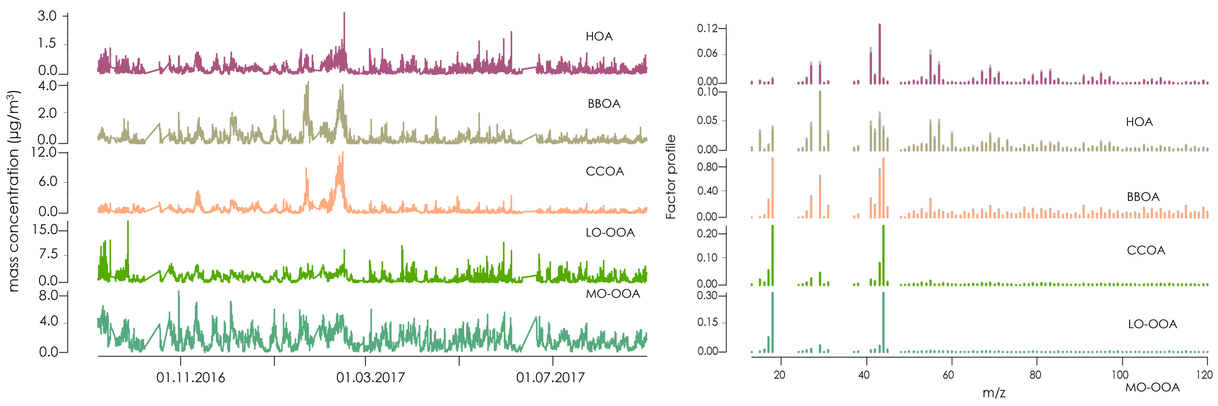

Fig. 2: **Organic aerosol source apportionment for 1 year: mass concentration time series (left) and factor profile (right).**

It was possible to split OA in 5-factors with a distinct temporal variability and mass spectral signature:

- **3 primary OA:** HOA, BBOA, CCOA.
- **2 oxygenated OA:** LO-OOA and MO-OOA.

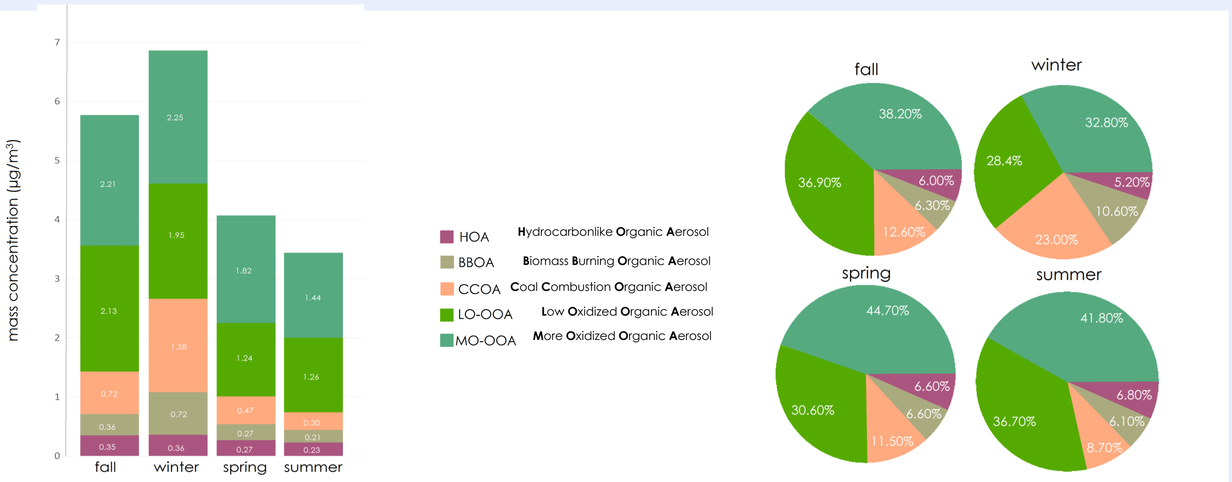

Fig. 3: **Seasonal average organic sources, mass concentration (left) and contribution of them (right).**

Influencing air mass

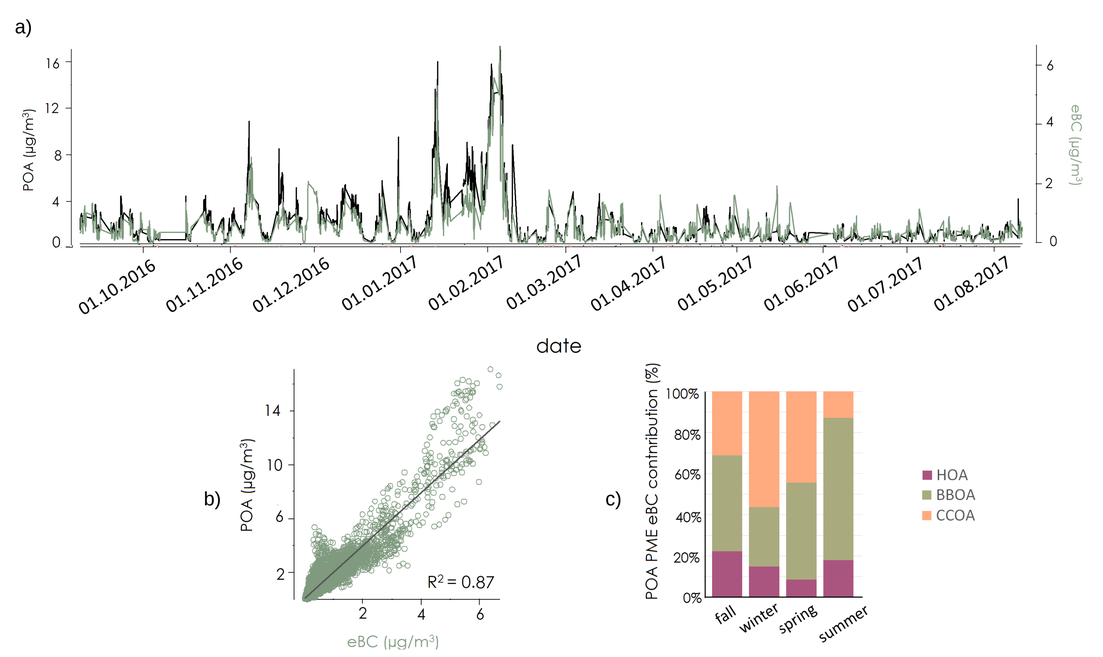

Fig. 4: **Contribution of the different POA factors to the eBC mass concentration, a) time series of POA and eBC, b) scatter plots and present the correlation between POA and eBC, and c) contributions of each sources to the eBC concentration.**

Conclusion

- Highest PM_1 concentration in the winter (15.95 µg/m³), lowest in the summer (6.24 µg/m³).
- OA is the main component of PM_1 during the whole measurement period (46%).
- Maximum contribution of OA is in summer (59%), minimum is in winter (39%).
- PM_1 concentration strongly increased from the warm months to the cold months.

- HOA with 6% average to total mass, recognized as a minor source of primary organic aerosols. Related to traffic and domestic heating, quite stable during seasons.
- BBOA (7.9%), mostly appearing by the coldest period. It is related to house heating in winter, but in summer it is due to spread of fire places/wood stoves, and transported pollutant from forest/agricultural fires and transported pollution.
- CCOA (15.4%) has strong correlation with eBC (R^2=0.83), which is related to coal combustion emissions and similar to BBOA, appeared mostly during the winter time.
- LO-OOA contribution increased from winter (28.4%) to summer (36.7%),where the LO-OOA concentration decrease during the day due to the dilution, evaporation and photochemical ageing into MO-OOA. This MO-OOA apportions a minimum 32.8% in winter and maximum 41.8% in early summer.

- The eBC was clearly associated with POA factors (sum of them, R^2=0.87). Therefore, eBC's contribution to each POA factor was estimated using a multi-linear regression model. It shows that more than 54% of the eBC was associated with CCOA (eBC-CCOA) in a yearly average with a maximum during summer (69% of total POA), 37% and 7% associated with BBOA (eBC-BBOA) and HOA (eBC-HOA) in a yearly average, respectively.

References

[1] Daellenbach, K, R., et al. (2020) Nature, 587(7834), 414–419.
[2] Zhang, Q., et al. (2007) Geophys. Res. Lett., 34(13).
[3] Canonaco, F. *et al.* (2021) *Atmos. Meas. Tech., 14(2), 923–943.*

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