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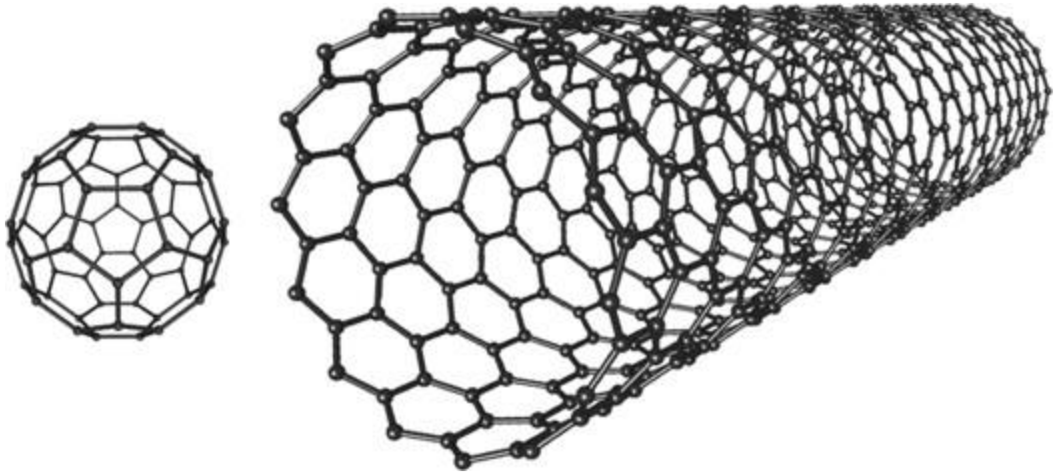

SP-AMS PMF with fullerenes

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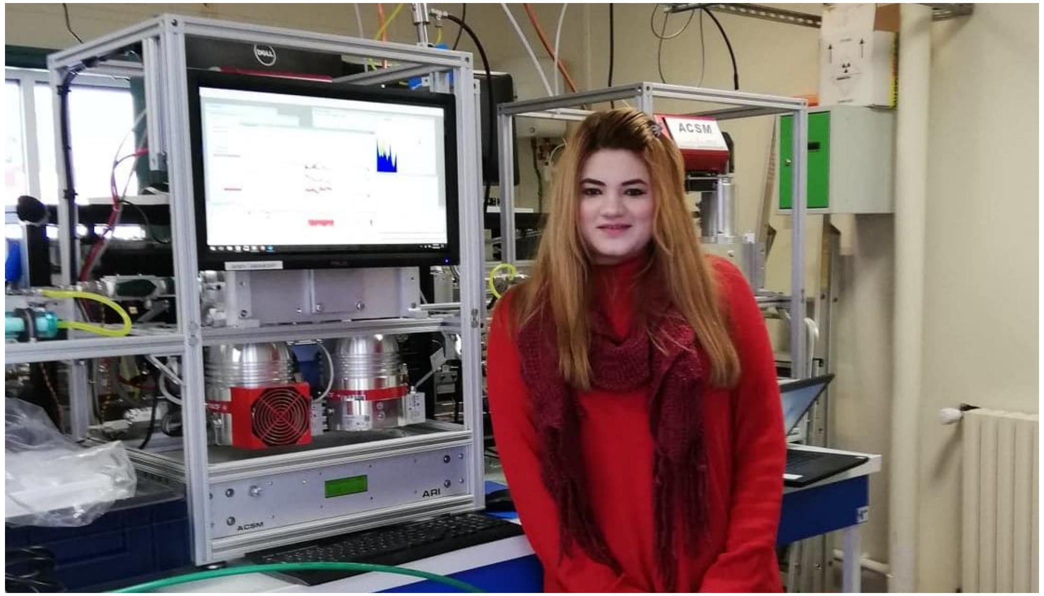
The person who did the actual work

- Zainab Bibi (pictured)
- Paper currently in review at ACP: https://acp.copernicus.org/preprints/acp-2020-890/
- Due to submit thesis in the coming year



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BC apportionment/attribution

- Methods for BC source apportionment include:
  - Optical (e.g. Aethalometer, PAS)
  - Use of tracers (e.g. levoglucosan, potassium, fossil fuel tracers)
  - Isotopic analysis, principally ^{14}C
- Existing established methods typically split BC into two sources, e.g.:
  - Black vs brown carbon
  - Traffic vs wood burning
  - Modern vs fossil carbon
- The SP-AMS delivers mass spectral data. Can we do better by applying PMF?

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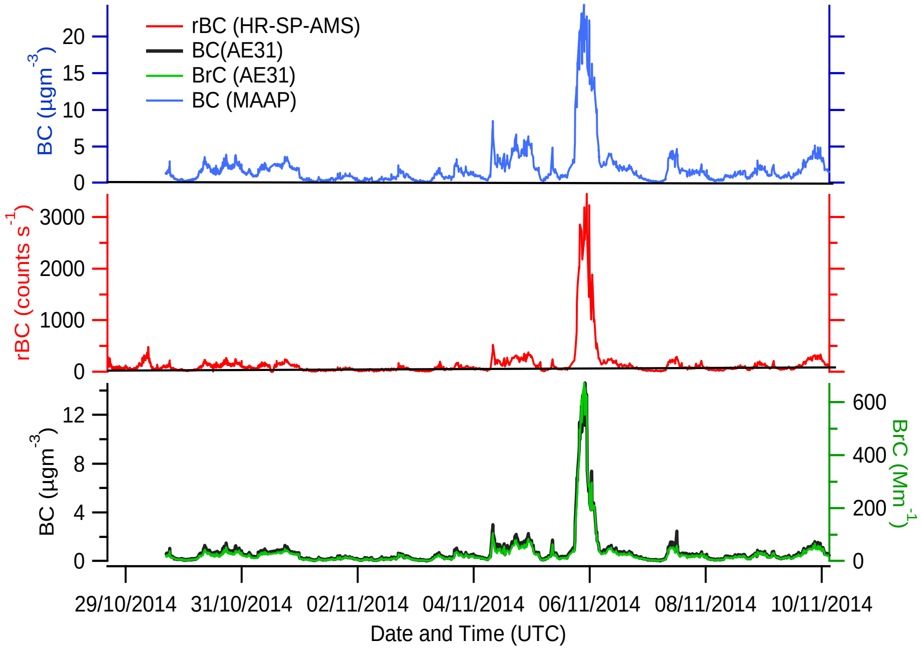
Fullerenes

- The C_x peaks can be grouped into ‘low’ (C_{1-5}), ‘mid’ (C_{6-31}) and ‘high’ ($C_{>31}$) m/z ranges (Onasch et al., 2012)
- The ‘low’ C_x peaks do not show enough variation and the ‘mid’ C_x peaks get lost amongst organics in ambient spectra. Can we get better PMF factorisation through inclusion of ‘high’ C_x peaks in the mass spectral matrix?
- Previous studies have reported fullerenes in the high C_x range from certain soot sources in the SP-AMS (Fortner et al., 2012)
    - Not sure whether they are produced in the flame or the instrument
    - Some ‘weird’ behaviour has been noted, so must be taken with a pinch of salt

The case study

- Bonfire night, an annual festival on or around the 5th of November celebrating the gunpowder plot in 1605
- In 2014 we ran a suite of instruments at the lab in Manchester for that night and a week either side of it
- Fortuitously, that year a strong nocturnal inversion formed, presenting a very good case study of biomass burning and fireworks against typical wintertime UK urban background
- The subject of four papers involving the AMS/Aethalometer (Reyes Villegas et al., 2018), TOF-CIMS (Priestley et al., 2018), SP2 (Liu et al., 2017) and now SP-AMS (Bibi et al., in review)

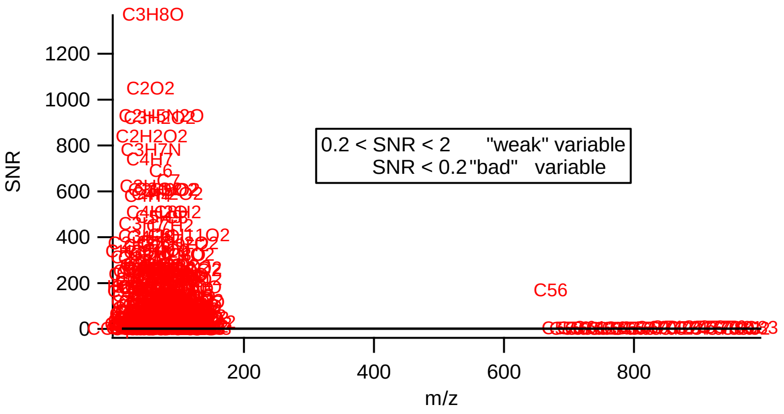


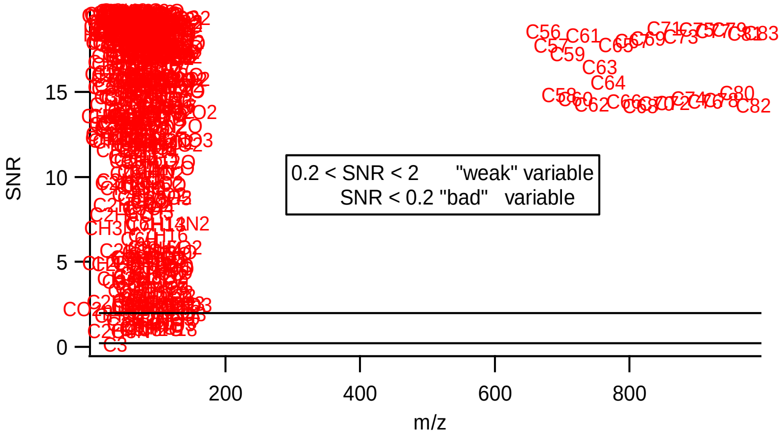
SP-AMS configuration

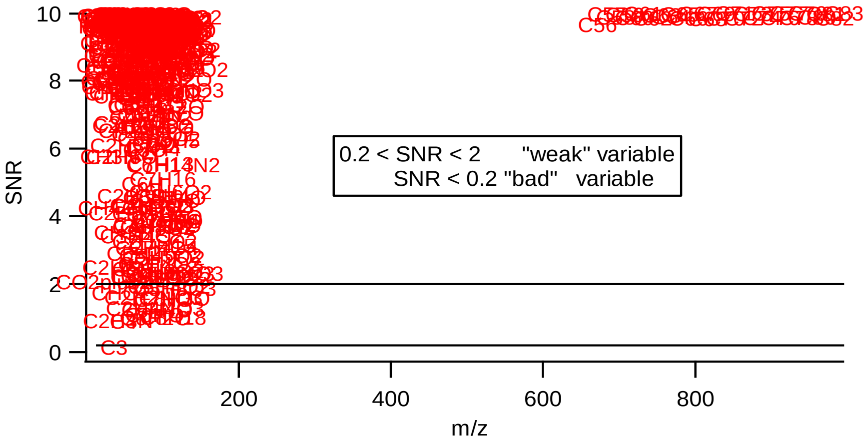
- The SP-AMS alternated between the standard ‘V’ and ‘W’ modes, with an extra ‘fullerene’ modes, which was ‘V’ mode with a much lower pulsing frequency (allowing the study of m/z’s of 1000s)
  - ‘W’ mode proved unusable
  - The lower m/z channels were analysed with PIKA, whereas UMR was used to provide the fullerene data
- Was not calibrated for rBC (didn’t have a protocol at the time) – all data is presented in counts per s
- Also alternated with a catalytic stripper, not presented here (that can wait for another time…)

Error treatment

- The use of a combination of large and small signals ensured factors were dominated by splits in the large signals, overcome by application of the 'model error' parameter
- Through trial and error, a value of 0.1 was settled on as giving the 'best' PMF outputs
- A more rigorous approach such as Corbin et al. (2015) was not possible due to the combination of PIKA and UMR data

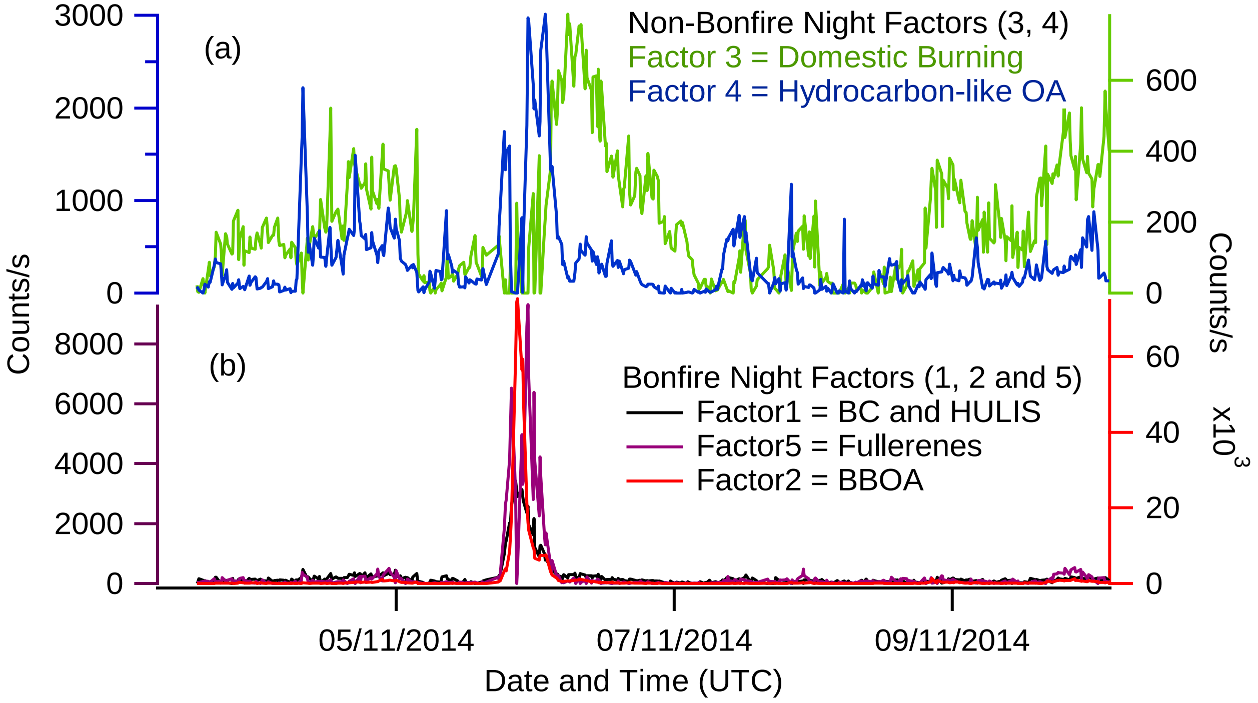


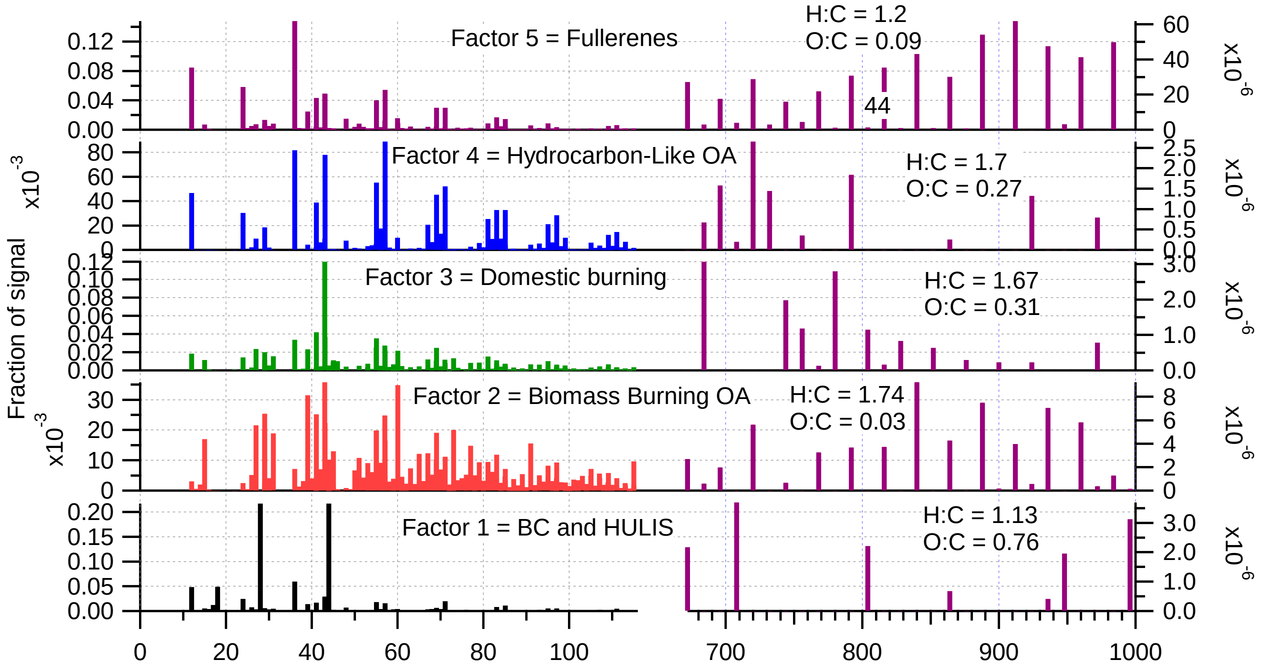




5 factor solution

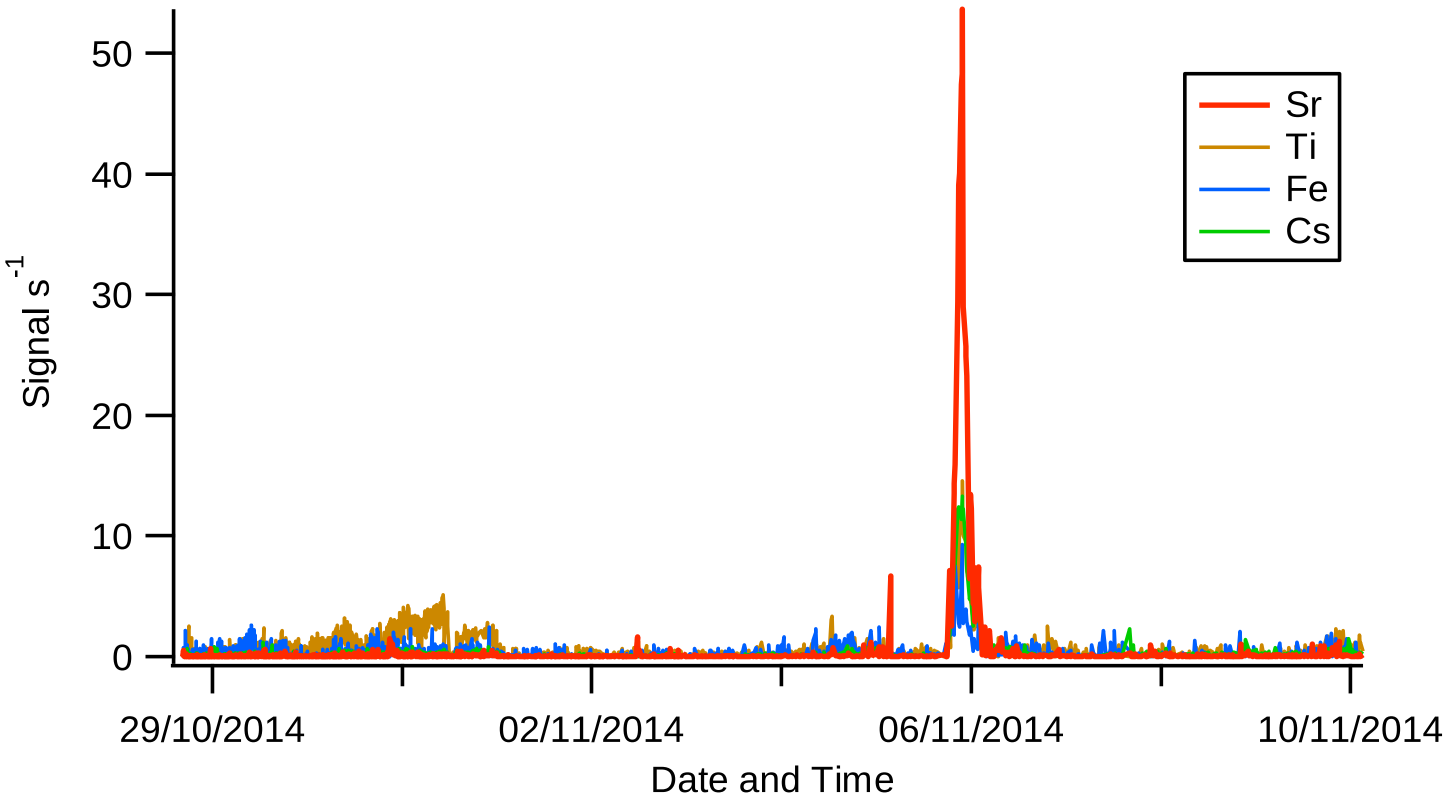
- Fullerenes present in 2 factors, both associated with bonfire emissions
- Fullerenes not present in traffic or domestic BBOA
- Only one ambiguous factor, one with HULIS (associated with both bonfire and other sources





What about fireworks?

- Many metals were found associated with fireworks, with Sr (red colorant) was found to be most specific
- Was not part of any factors, even when forced by artificial upweighting, suggesting fireworks did not influence the rest of the data



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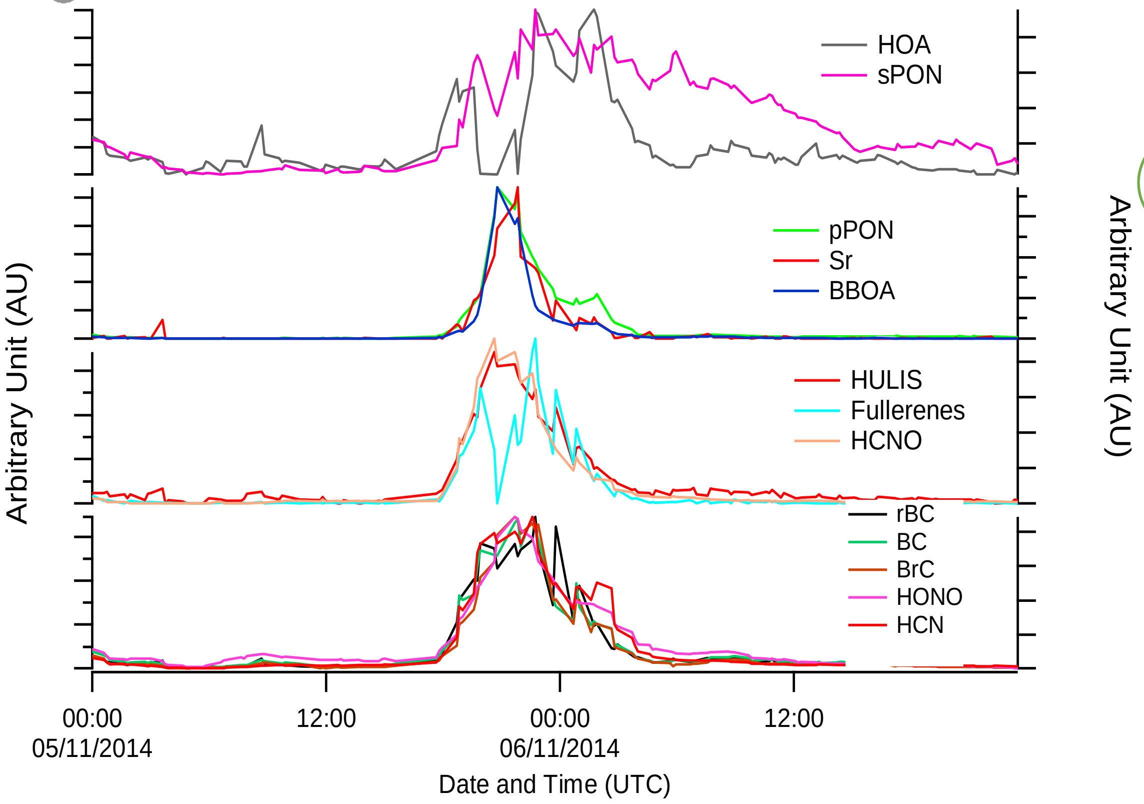
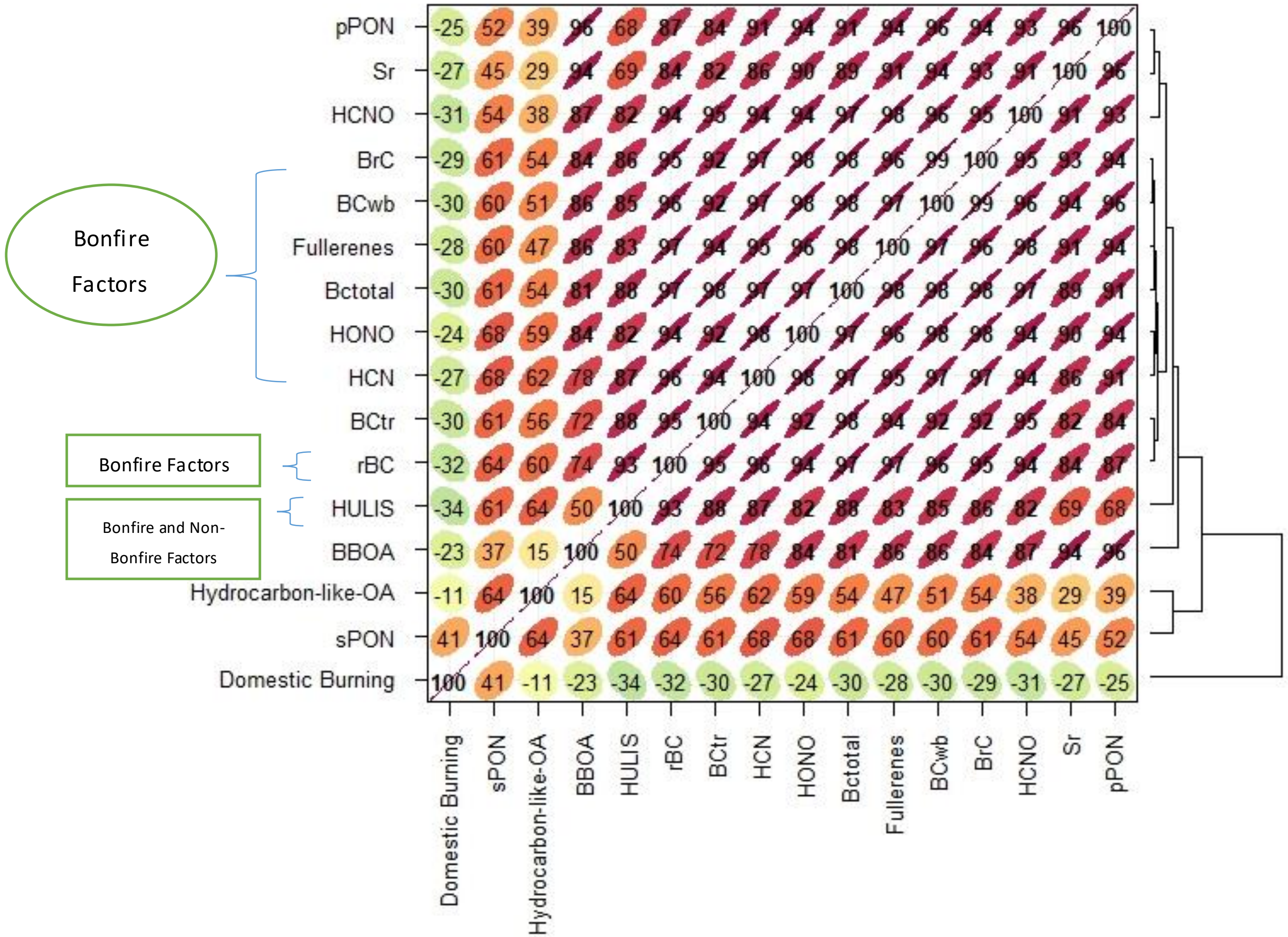
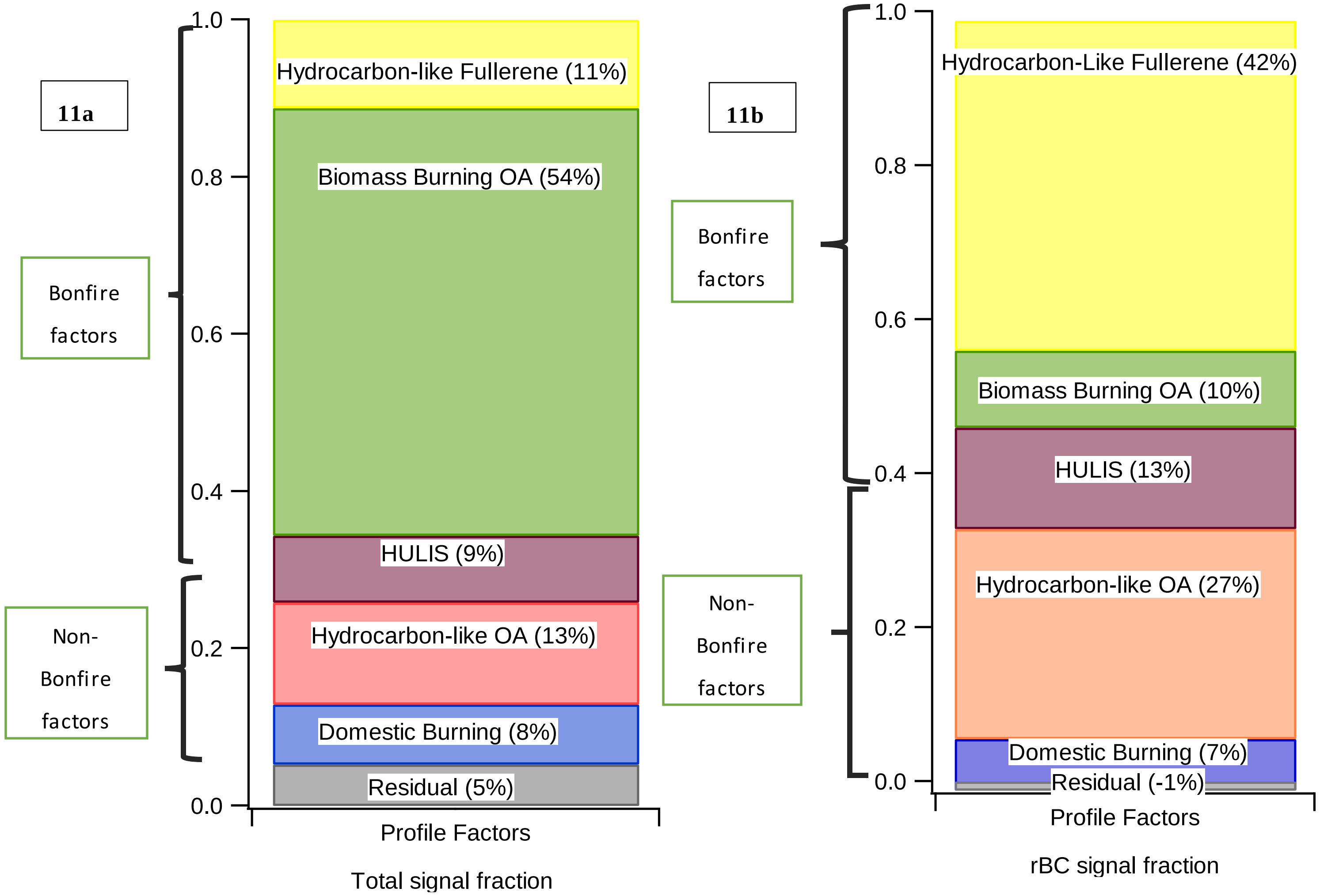
Comparisons with other data (Reyes Villegas et al. 2018)





Budgeting BC

- The contribution of the factors to the overall signal and the rBC (C_x) signals can be calculated
- This can be applied to another BC measure (e.g. AE31) to apportion the BC



Conclusions

- This case showed that we can use the SP-AMS, incorporating fullerene signals, to resolve more than two BC sources and budget for BC
- It is not vital to quantitatively calibrate the SP-AMS providing a collocated measure of BC is present (e.g. Aethalometer)
- The SP-AMS can also detect firework signals in the form of metals, with strontium proving the best tracer
- Would be interesting to repeat this in other BC-rich environments