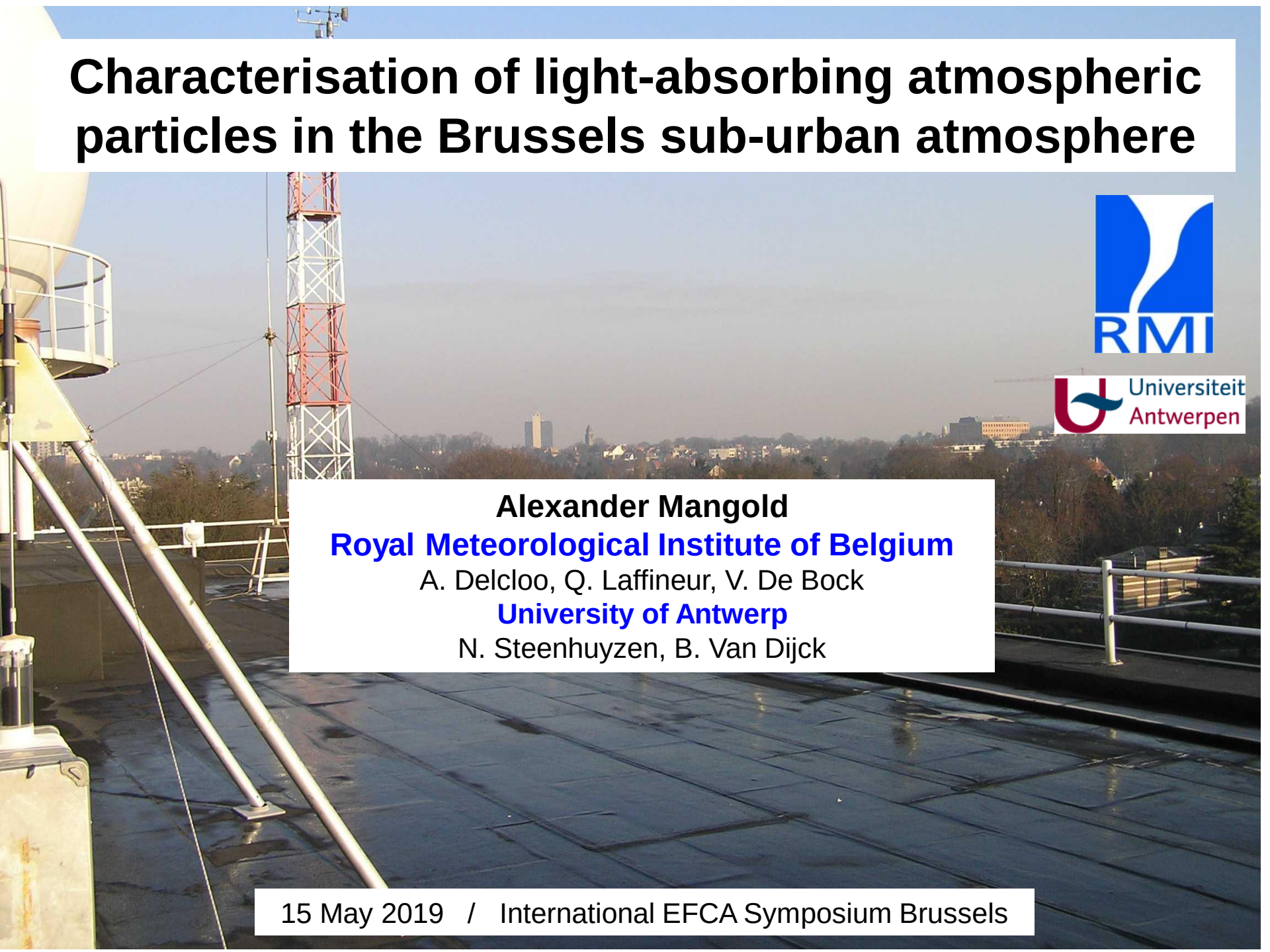
Characterisation of light-absorbing atmospheric particles in the Brussels sub-urban atmosphere



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Motivation & Outline

- ultra-fine particles in urban atmosphere important for air quality
- relevant part of UFP are light-absorbing particles
- important sources in cities and residential areas are traffic emissions, heating, and wood-burning stoves
- relative contributions need to be known in order to be able to apply effective reduction measures
- meteorology important factor for variations in concentrations

- Instruments
- Measured aerosol properties and implications for composition
- Influence of meteorology
- Summary

Instruments

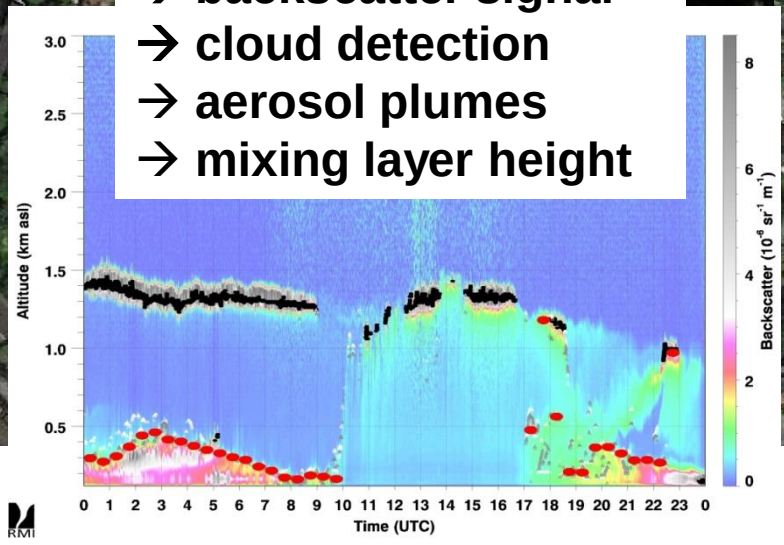
Aethalometer
Magee Sci AE31

→ aerosol light absorption coefficient
→ mass concentration of light-absorbing aerosol
→ 7 wavelengths
UV-A to near–IR

wavelength dependency
→ information on aerosol type

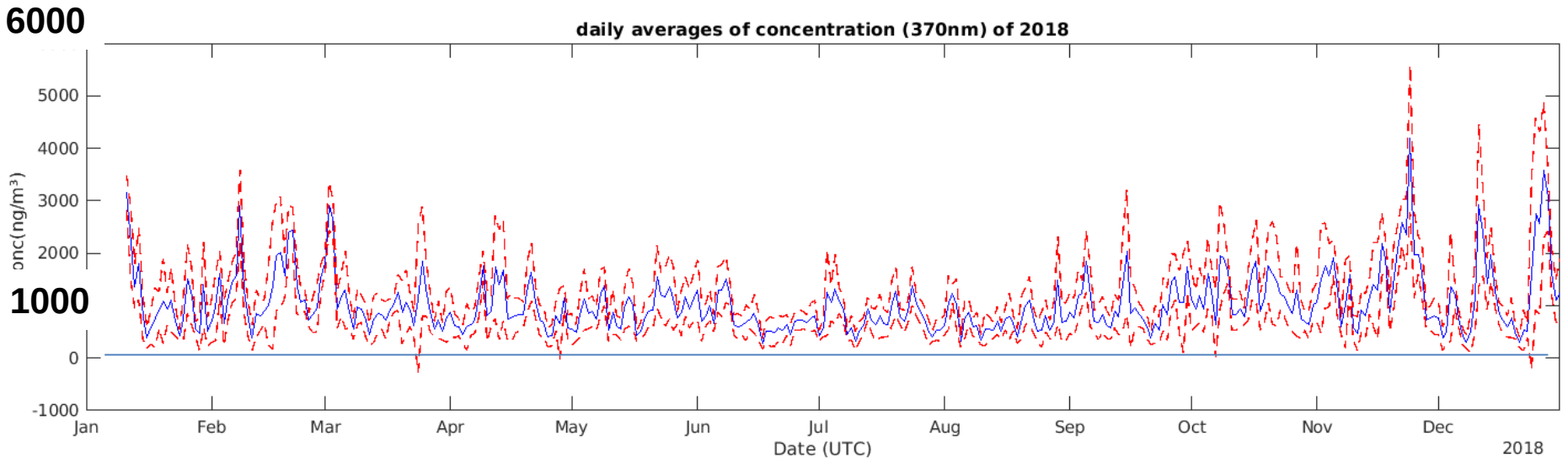
Ceilometer
Vaisala CL 31

→ backscatter signal
→ cloud detection
→ aerosol plumes
→ mixing layer height



Aerosol Absorption Properties

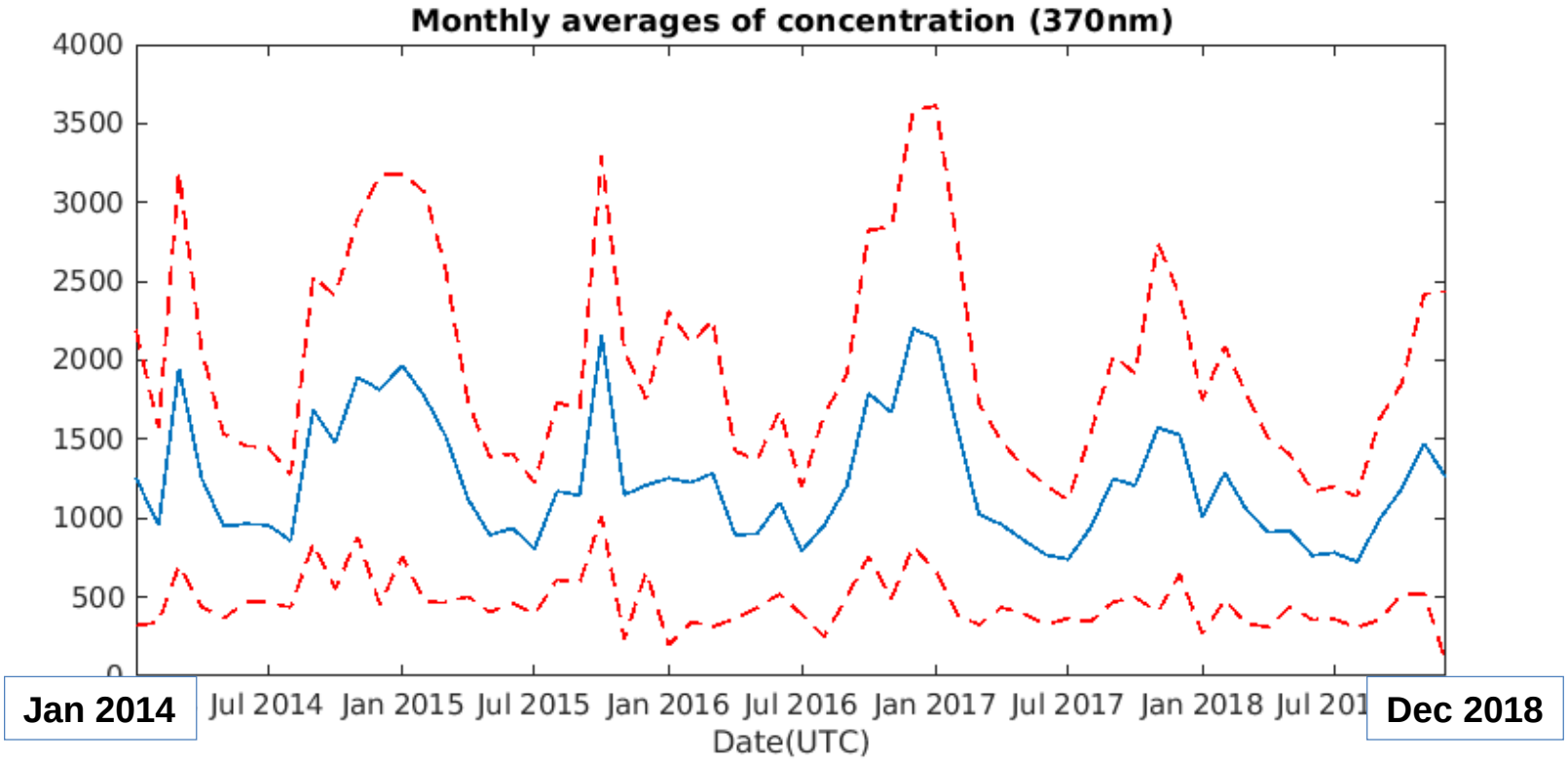
mass concentration ng/m^3 / light-absorbing aerosol / daily means 2018



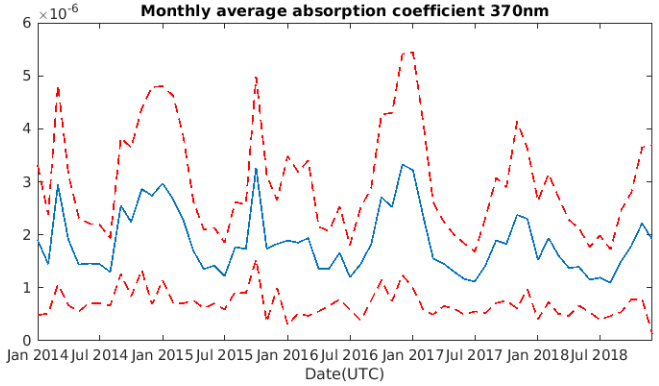
seasonal cycle – higher values in winter – lower values in summer

Aerosol Absorption Properties

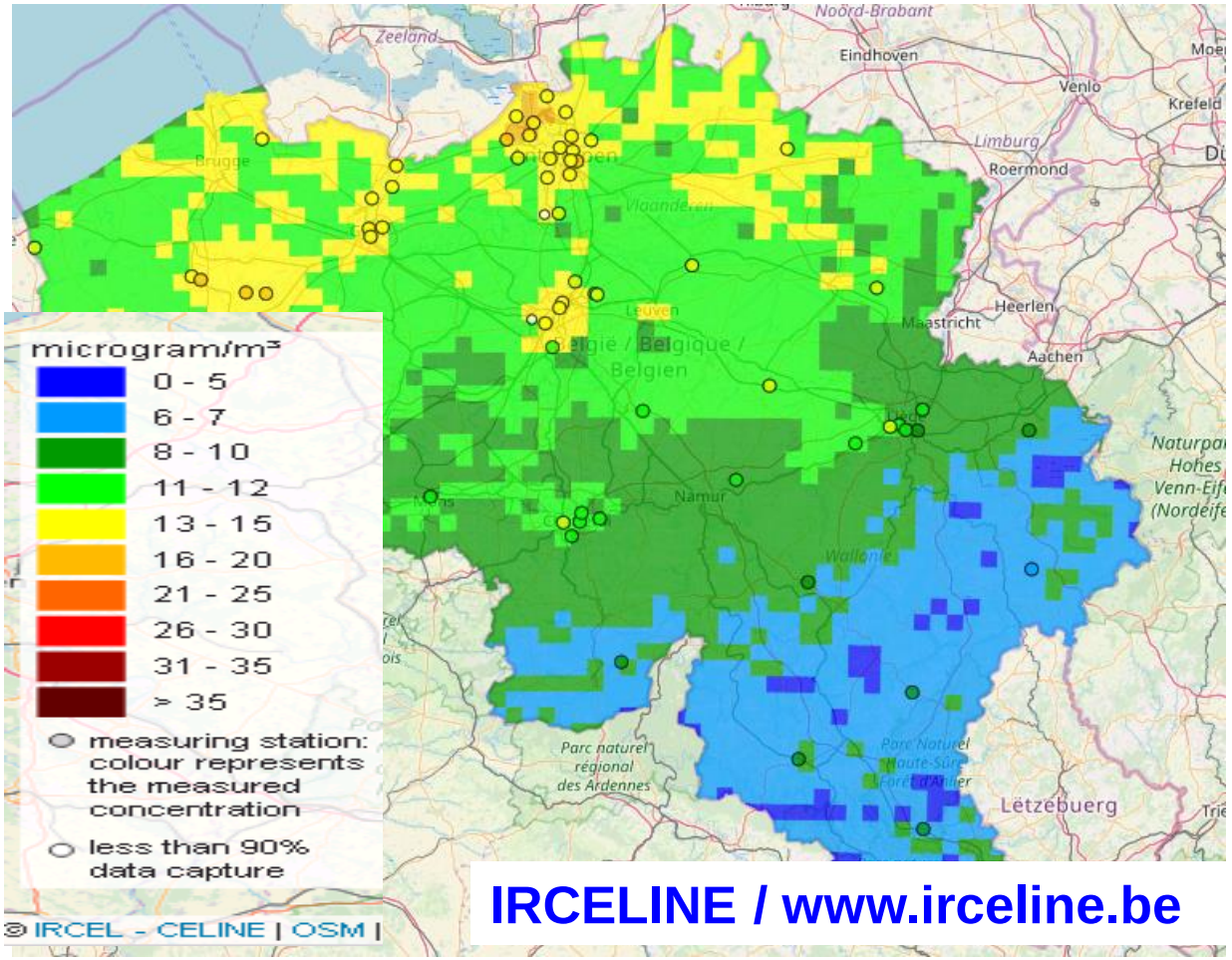
mass concentration ng/m^3 / light-absorbing aerosol / monthly means



seasonal cycle
– higher values in winter
– lower values in summer

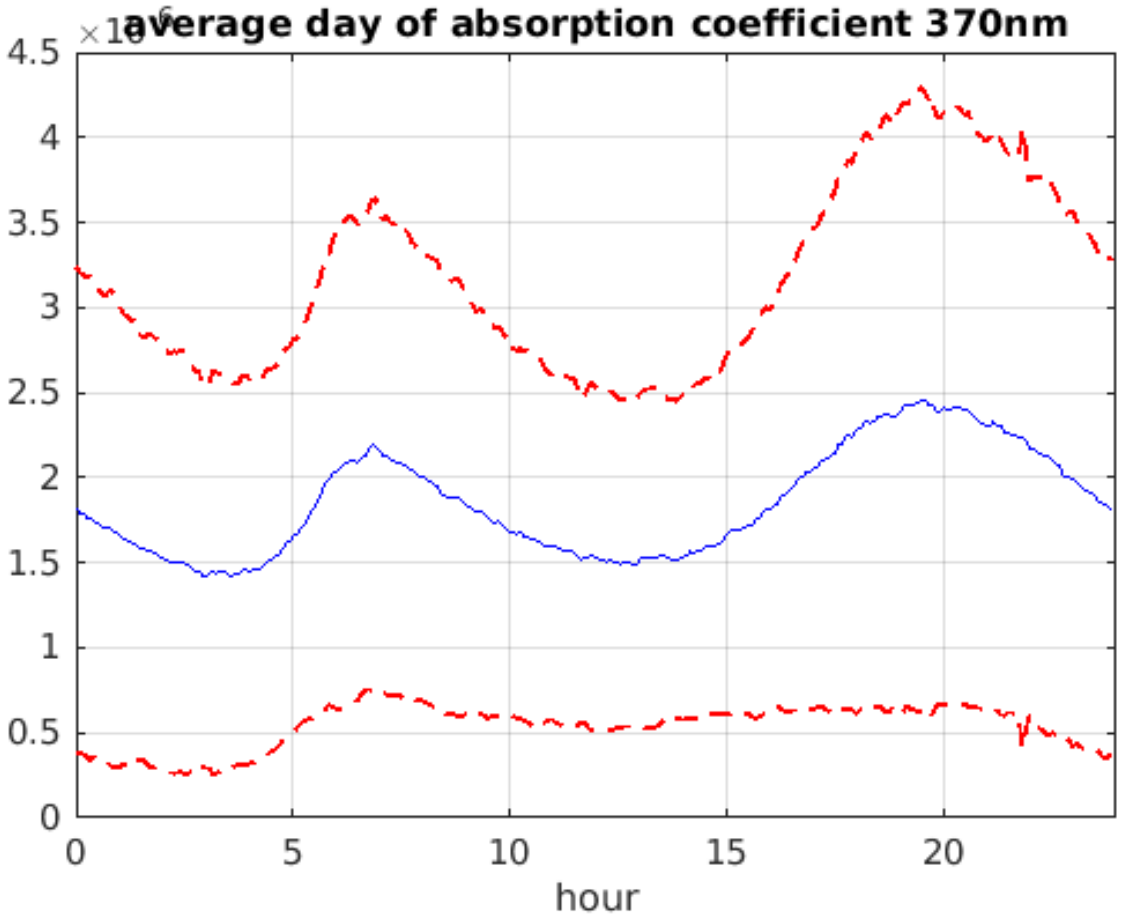


Belgium / annual mean PM2.5 / 2018



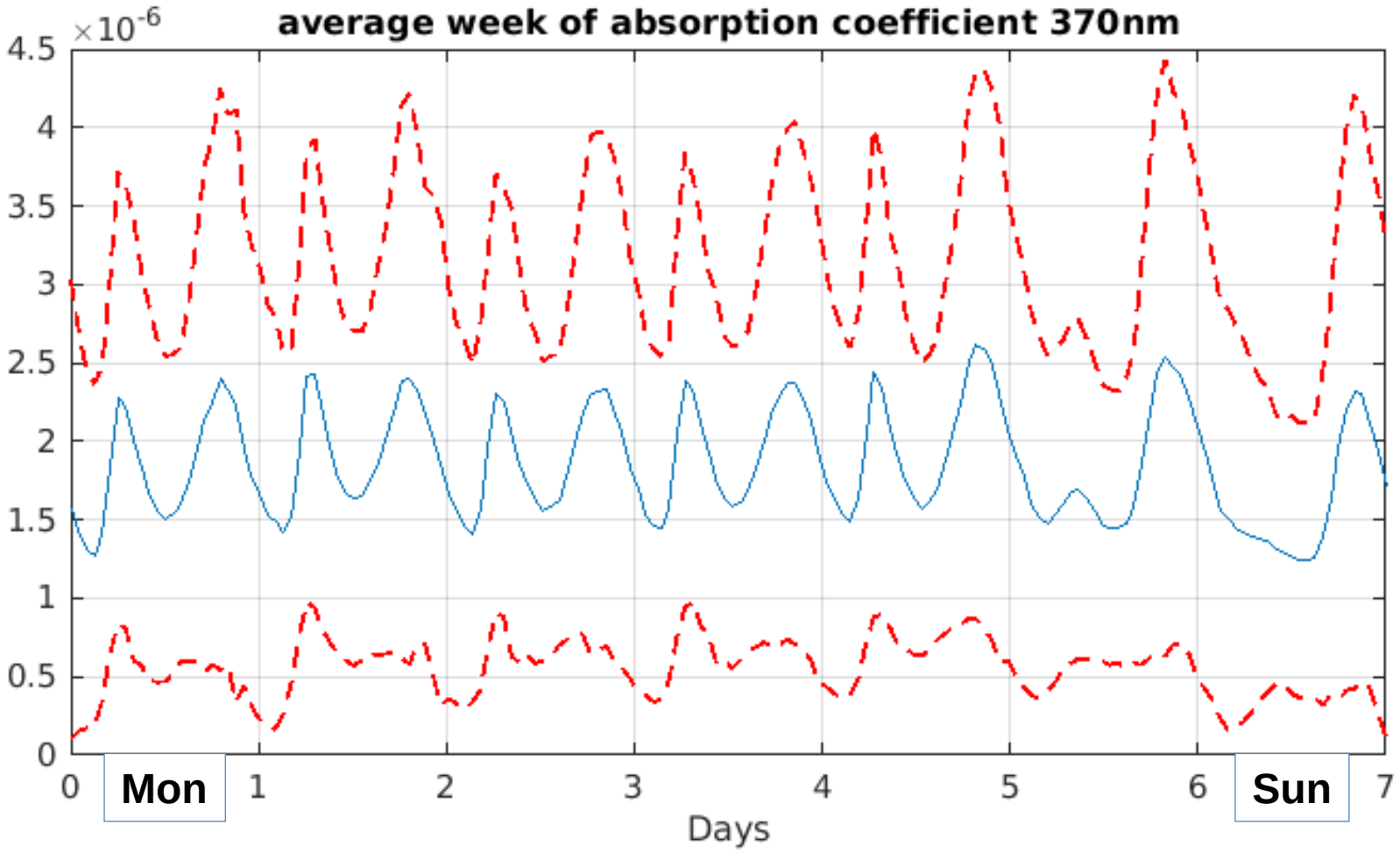
our measurements in sub-urban Brussels:
average light-absorbing aerosol around 1 to 1.5 µg/m3
5 – 10 % of PM2.5

aerosol absorption coefficient [Mm^{-1}] / average day



sharp morning peak, broader evening peak

aerosol absorption coefficient [Mm^{-1}] / average week

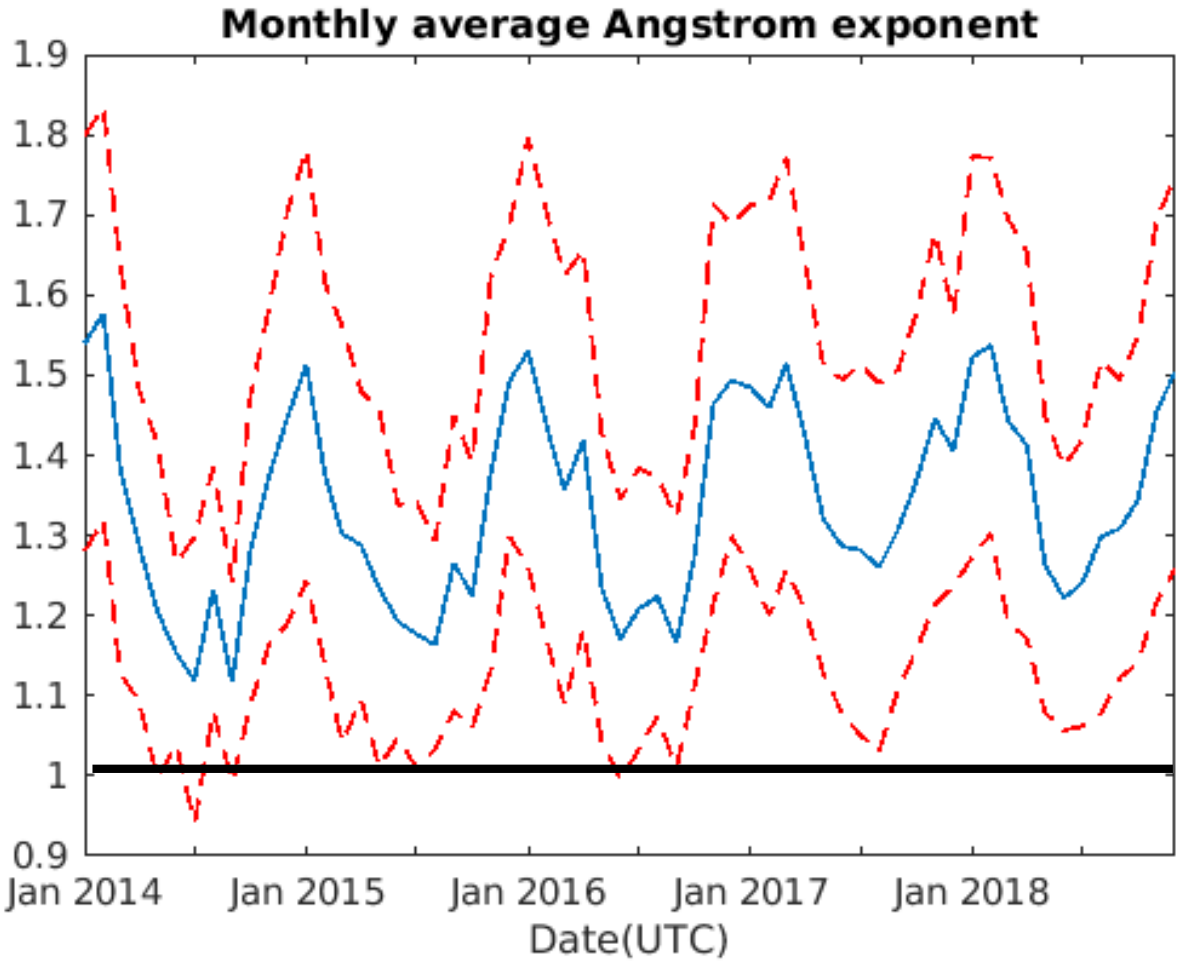


during the week: sharp morning peak, broader evening peak
weekend: morning peak distinctly less

Absorption Angstrøm Exponent / monthly means

Absorption Angstrøm Exponent AAE =

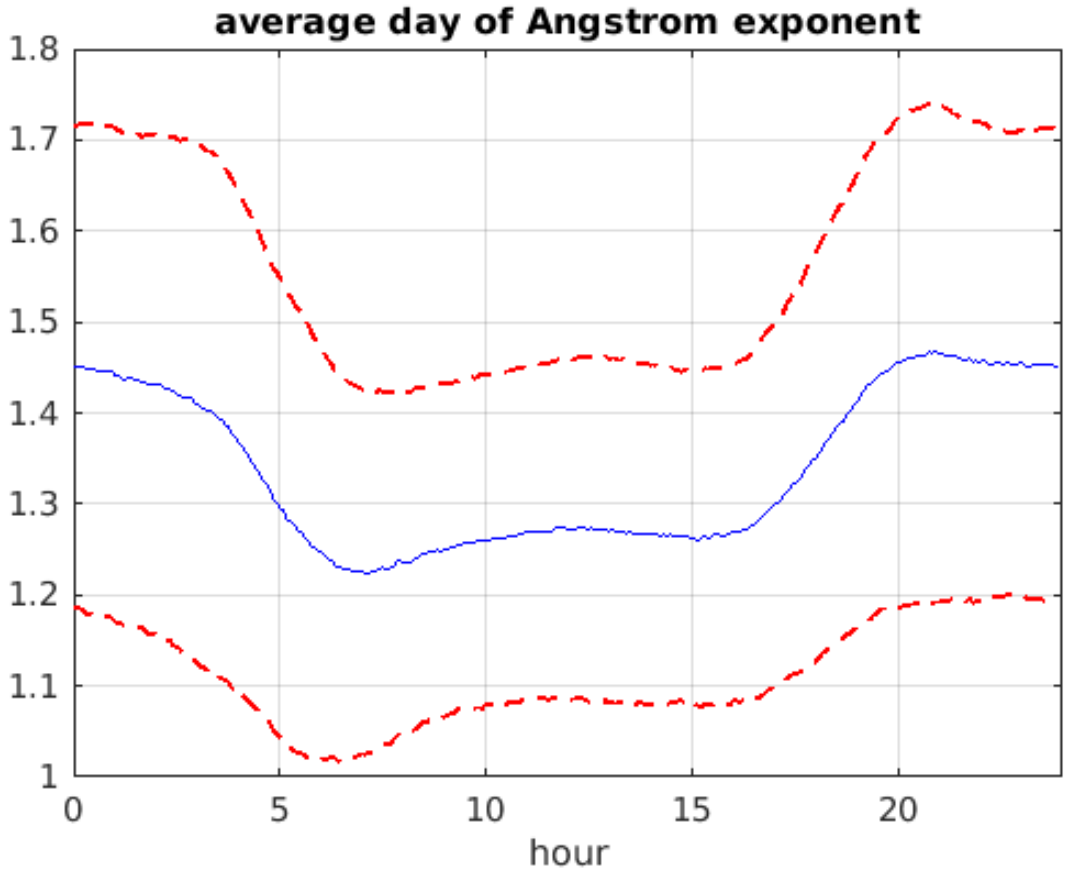
$$-\frac{\ln(abs370 \div abs880)}{\ln(370 \div 880)}$$



AAE ~ 1 indicates fresh soot

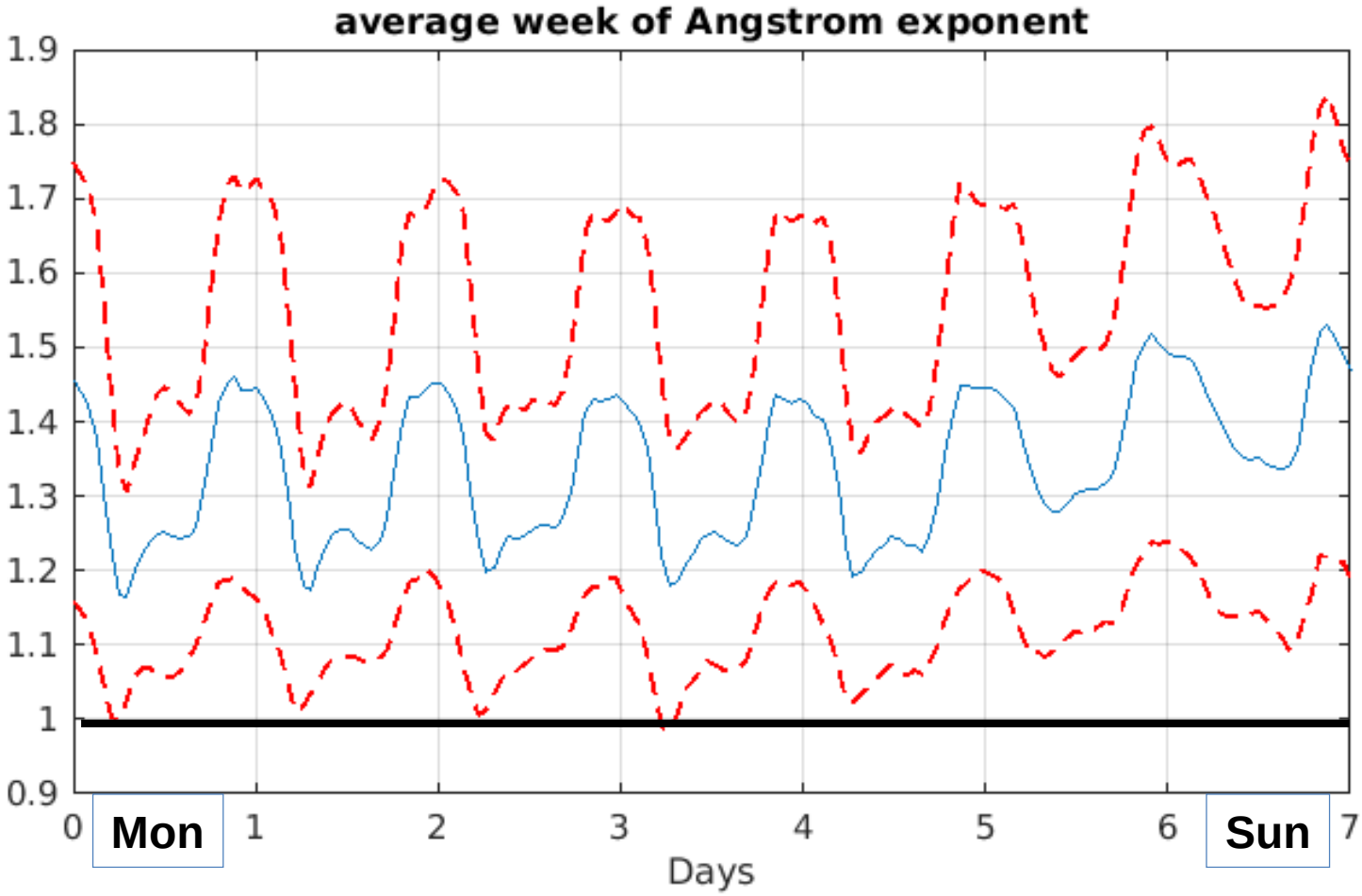
AAE > 1 indicates other compounds, absorbing stronger in the UV

Absorption Angstrøm Exponent / average day



AAE low during rush-hours: traffic dominates
AAE high during night: accumulation of different types of light-absorbing aerosol

Absorption Angstrøm Exponent / average week



AAE Monday–Friday: working week pattern

AAE weekend: traffic less pronounced / other sources become important

derivation of soot (traffic) fraction within light-absorbing aerosol

Absorption Angstrøm Exponent AAE equation : $-\frac{\ln(abs370 \div abs880)}{\ln(370 \div 880)}$

AAE = 1 → ~ fresh soot

assumption that absorption @ 880 and 950 nm due to soot

soot almost completely from traffic in Brussels

inverting formula to get 'soot'-absorption @ 370 nm

$abs370_{traffic} = \frac{abs880 + abs950}{2} \times \left(370 \div \frac{880 + 950}{2} \right)$

$abs370_{traffic} < abs370_{meas}$ → difference equals other sources

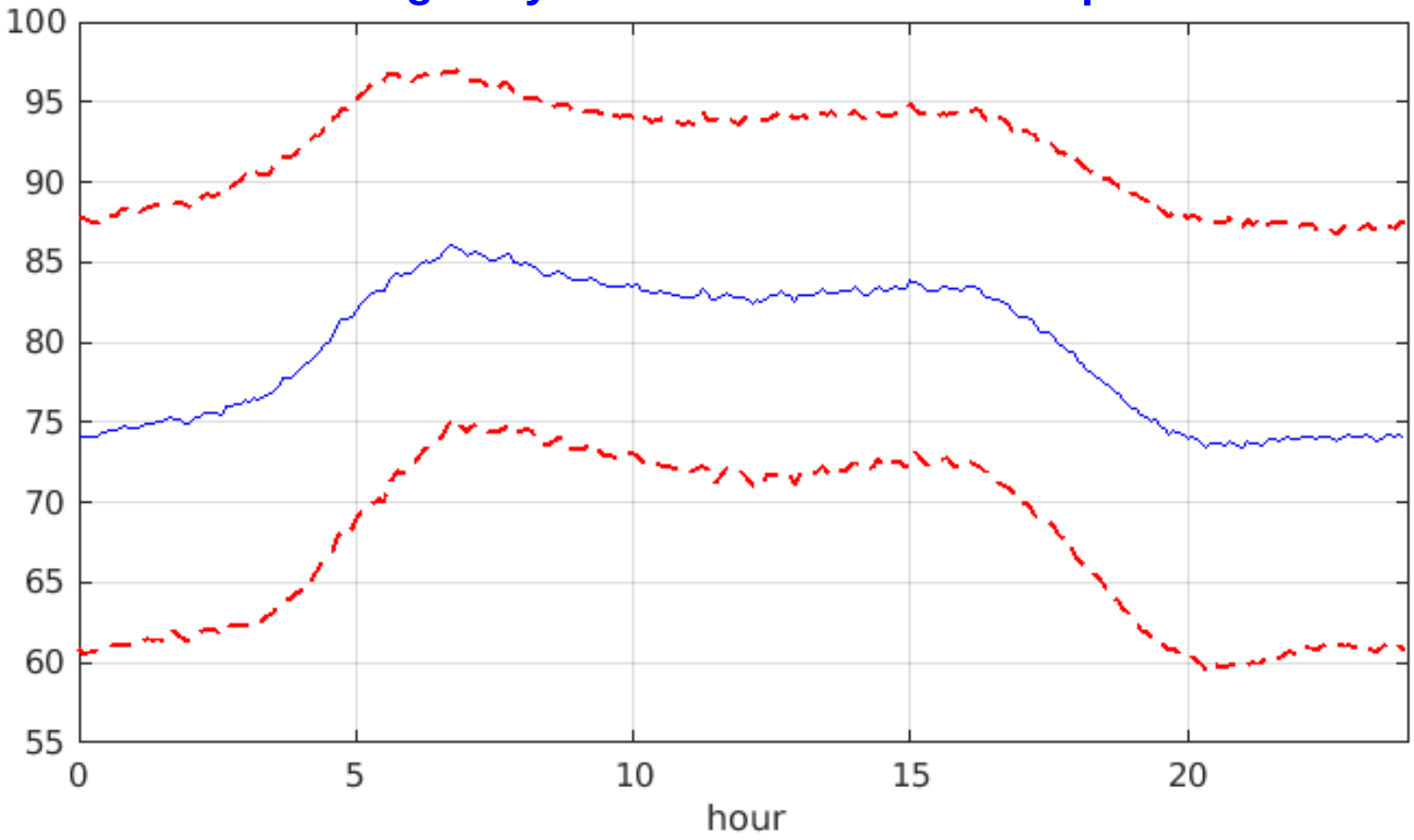
$abs370_{traffic} > abs370_{meas}$ → set to be equal

soot (traffic) fraction within light-absorbing aerosol

$abs370_{traffic}$ < $abs370_{meas}$ → difference equals other sources

which percentage of $abs370_{meas}$ comes from $abs370_{traffic}$?

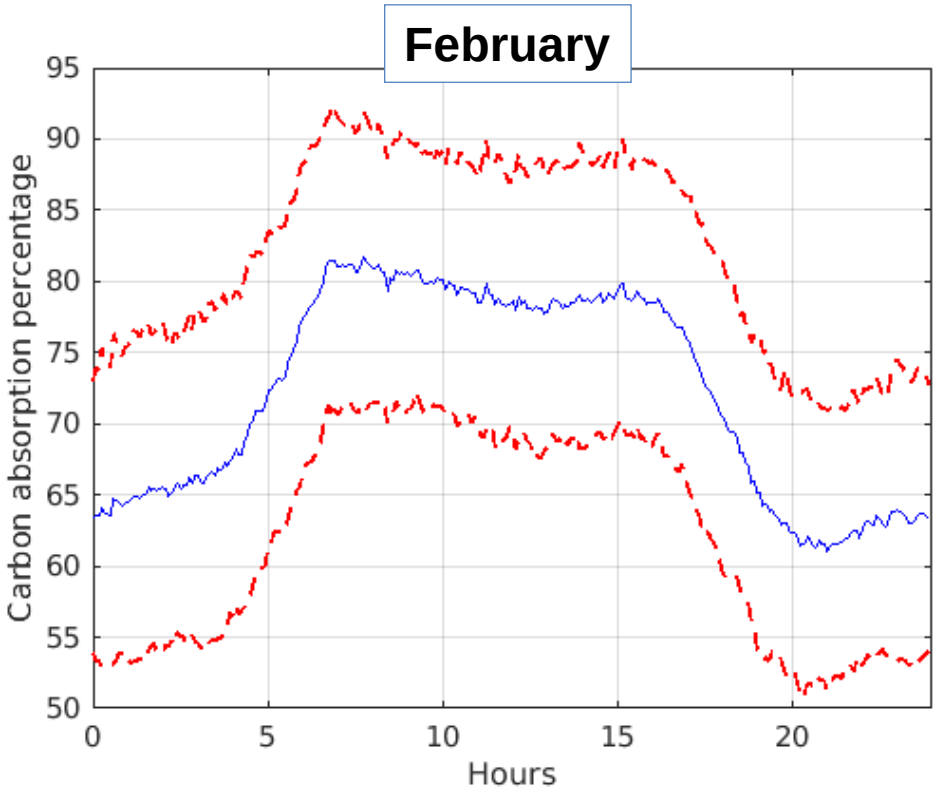
average day over whole observation period

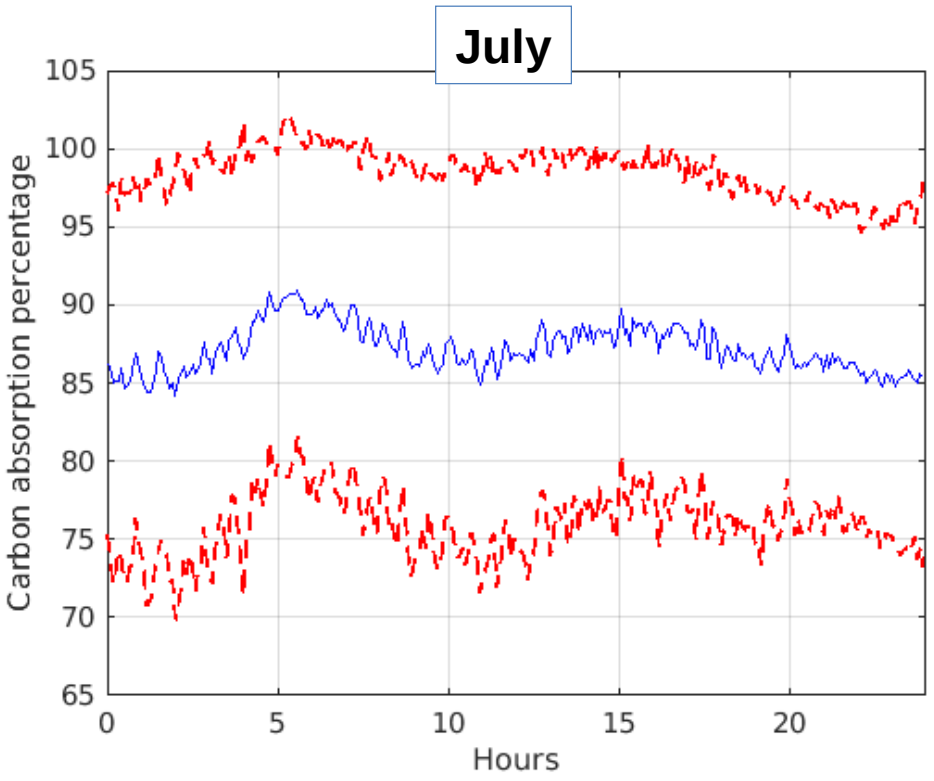


soot (traffic) fraction within light-absorbing aerosol

$abs370_{soot}$ < abs370meas → difference equals other sources

which percentage of $abs370_{meas}$ comes from $abs370_{soot}$?



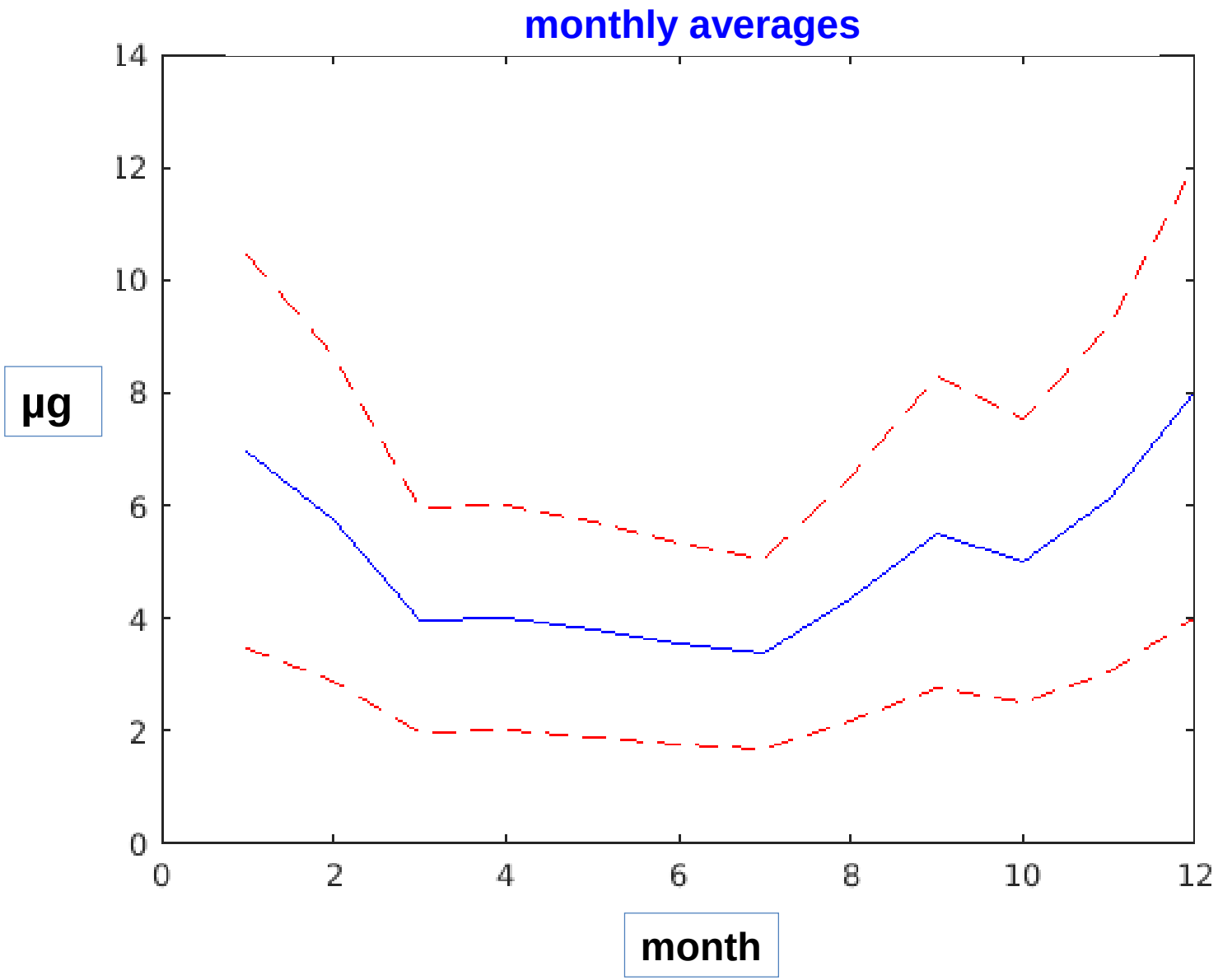


derivation of potentially inhaled traffic-related soot

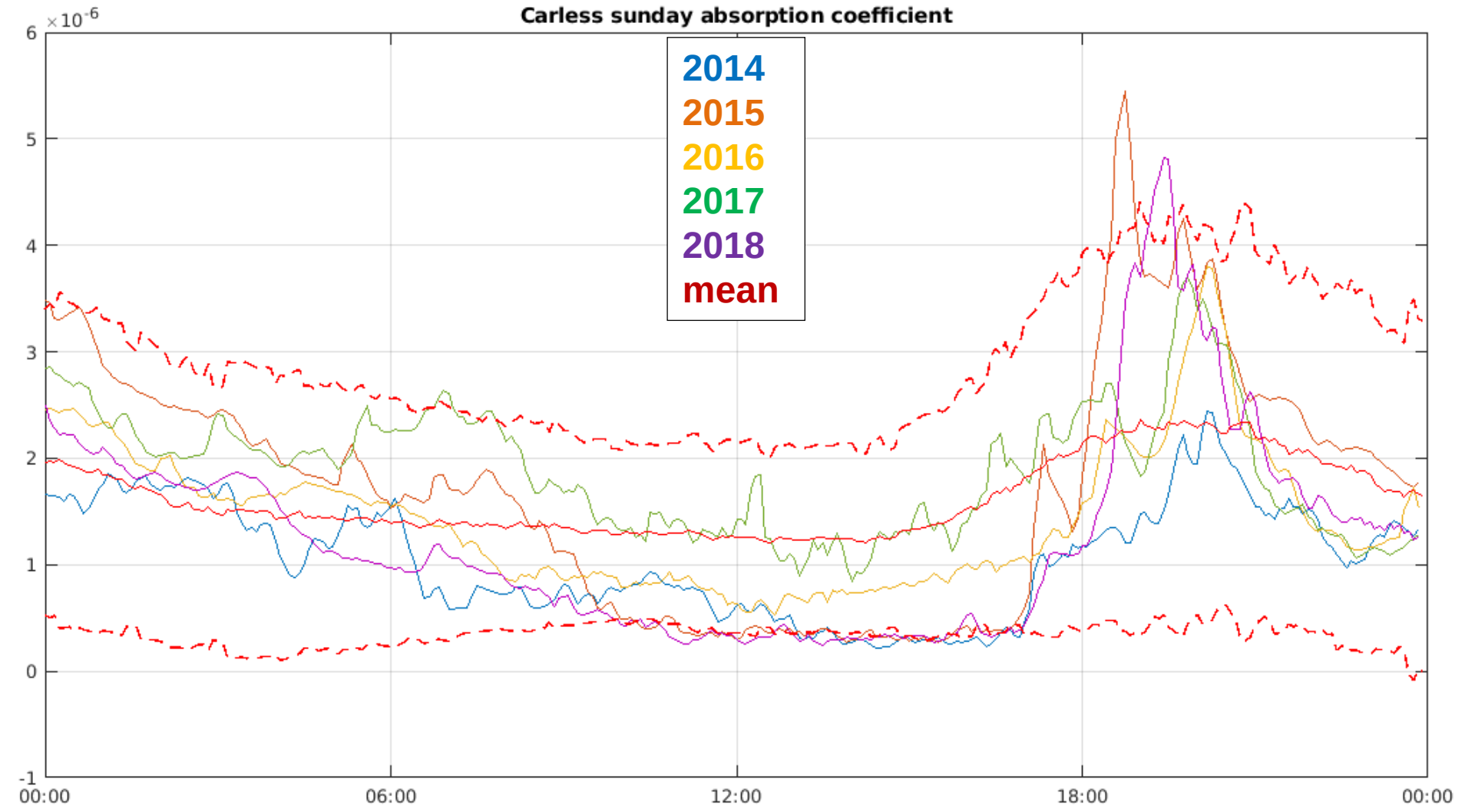
- **Aethalometer collects on its filter tape the ambient particles**
- **when current spot is optically saturated – filter tape advances**
- **From specific calibration of aethalometer, the collected mass of the optically saturated spot is known, output in metadata (1.59 ± 0.02 µg)**
- **From number of saturated spots per months → total mass per month, per day derived**
- **From percentages of $abs370_{traffic}$ → amount of traffic-related soot derived**

- **aethalometer samples with 3.5 L/min**
- **an average person breathes per minute around 12 x 0.4 L = 4.8 L/min**
- **calculating inhaled traffic-related soot with factor 4.8/3.5 (~ 1.37)**

potentially inhaled traffic-related soot per day



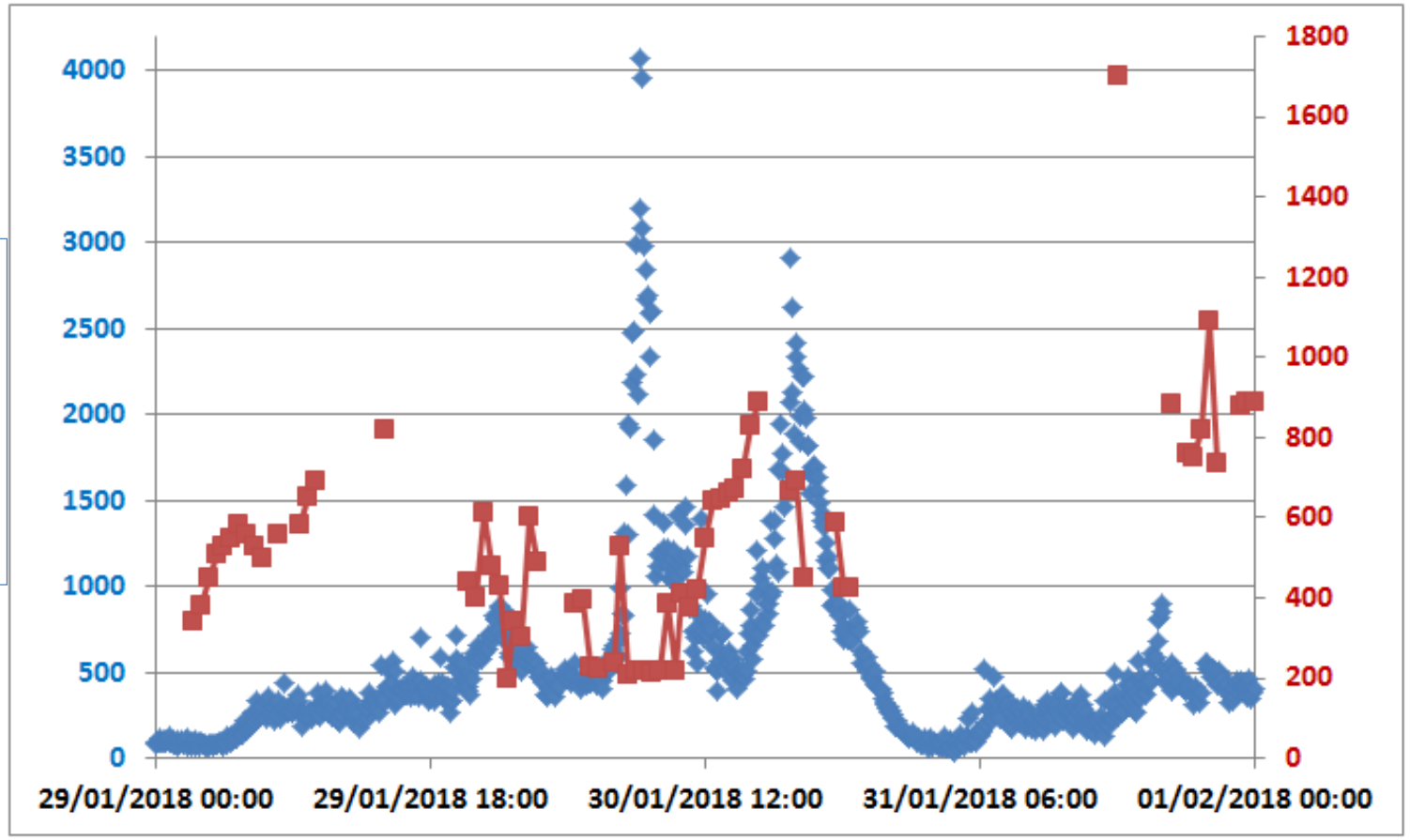
Brussels car-free day / clear effect



effect of mixing layer height

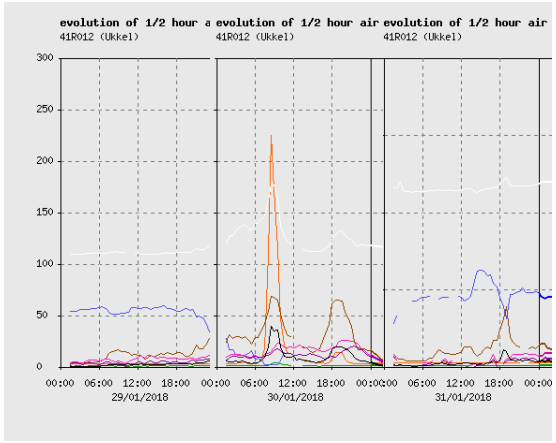
ng / m^3

mass light-absorb. Part.



[m]

mixing layer height



Summary / Conclusions

light-absorb. Part.	mass concentration	composition (AAE)
daily cycle	morning sharp peak evening broad peak	morning: traffic evening: mixture
weekly cycle	Mon–Fri: both peaks Sat: morning peak weak Sun: no morning peak	Mon-Fri: traffic strong Sat: traffic less Sun: traffic low
seasonal cycle	winter: high summer: lower	winter: traffic + heating summer: traffic domin.

Summary / Conclusions

- **average mass concentration of light-absorbing particles:**
  → around 1 to 1.5 µg/m^3 (5 – 10 % of PM2.5)

- **traffic-related soot:**
  → 75 – 85 % of total mass light-absorbing particles
  → winter 65 – 80 % / summer: 85 – 90 %
  → other sources probably from heating

- **potentially inhaled traffic-related soot:**
  → summer 4 µg / winter 6-8 µg / per day / sub-urban Brussels

- **specific measures like car-free day have clear effect**

- **influence of meteorology on (peak-) concentrations**
  → aim to use measured MLH in NWP models
  → improved forecasts of peak concentrations


THANK YOU VERY MUCH
FOR YOUR ATTENTION