BEHAVIOUR OF INDOOR COARSE PARTICLES IN THE LIBRARY

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INTRODUCTION

In the period 2008-2010 we performed detailed indoor air quality measurements in an old Baroque Library Hall (BLH), located in Clementinum historical complex in Prague.

INTRODUCTION

Founded in 1232, the Clementinum is one of the largest building complexes in Europe. Since 1930 it is currently in use as the National Library of the Czech Republic.

BAROQUE LIBRARY HALL

- 21 000 books
- 100 – 200 visitors
- Naturally ventilated
- Area 430 m^2
- Volume 4500 m^3

KEY QUESTION

Effect of visitors on the indoor air quality?

MEASUREMENTS

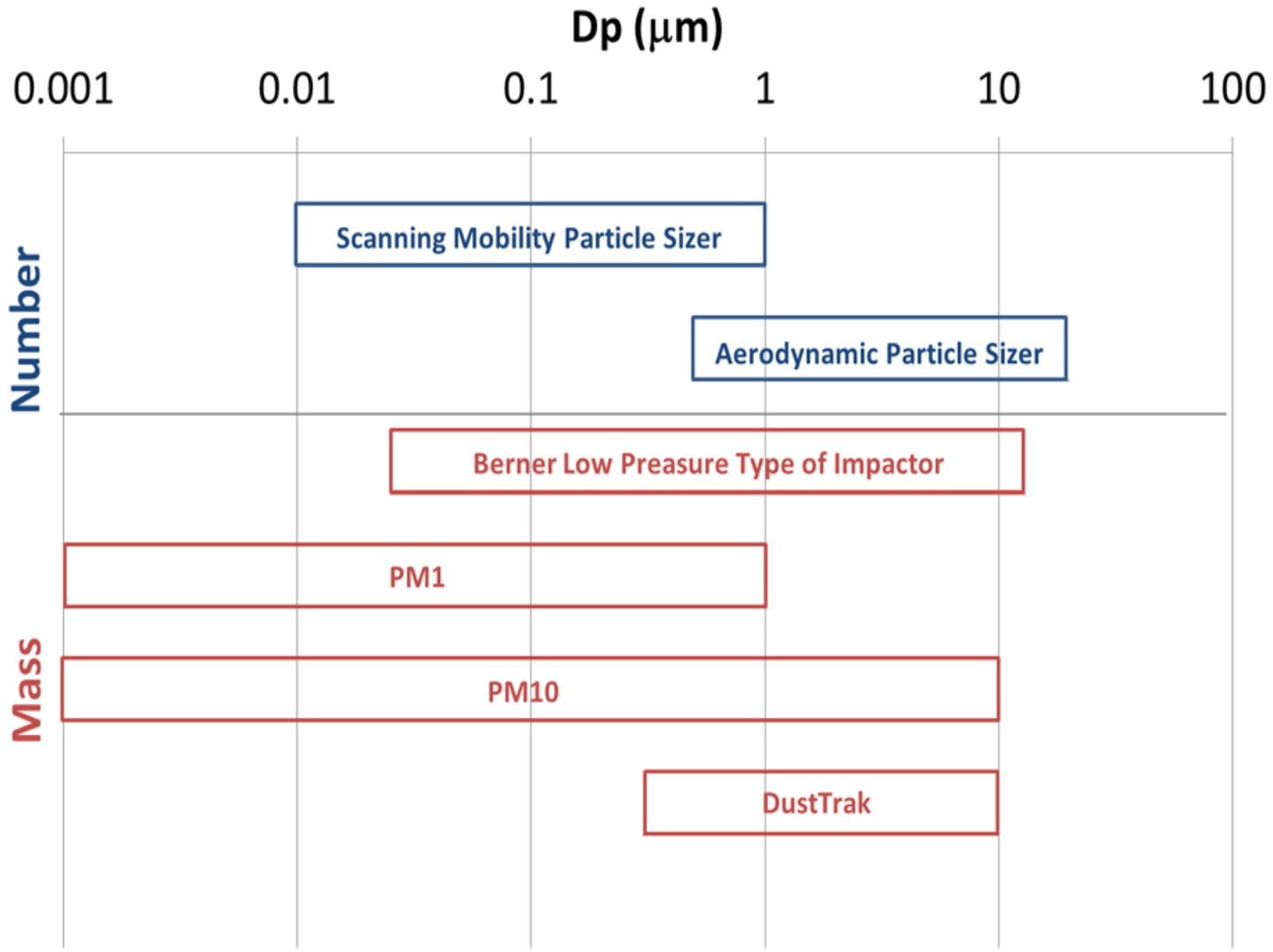
1 week 2008

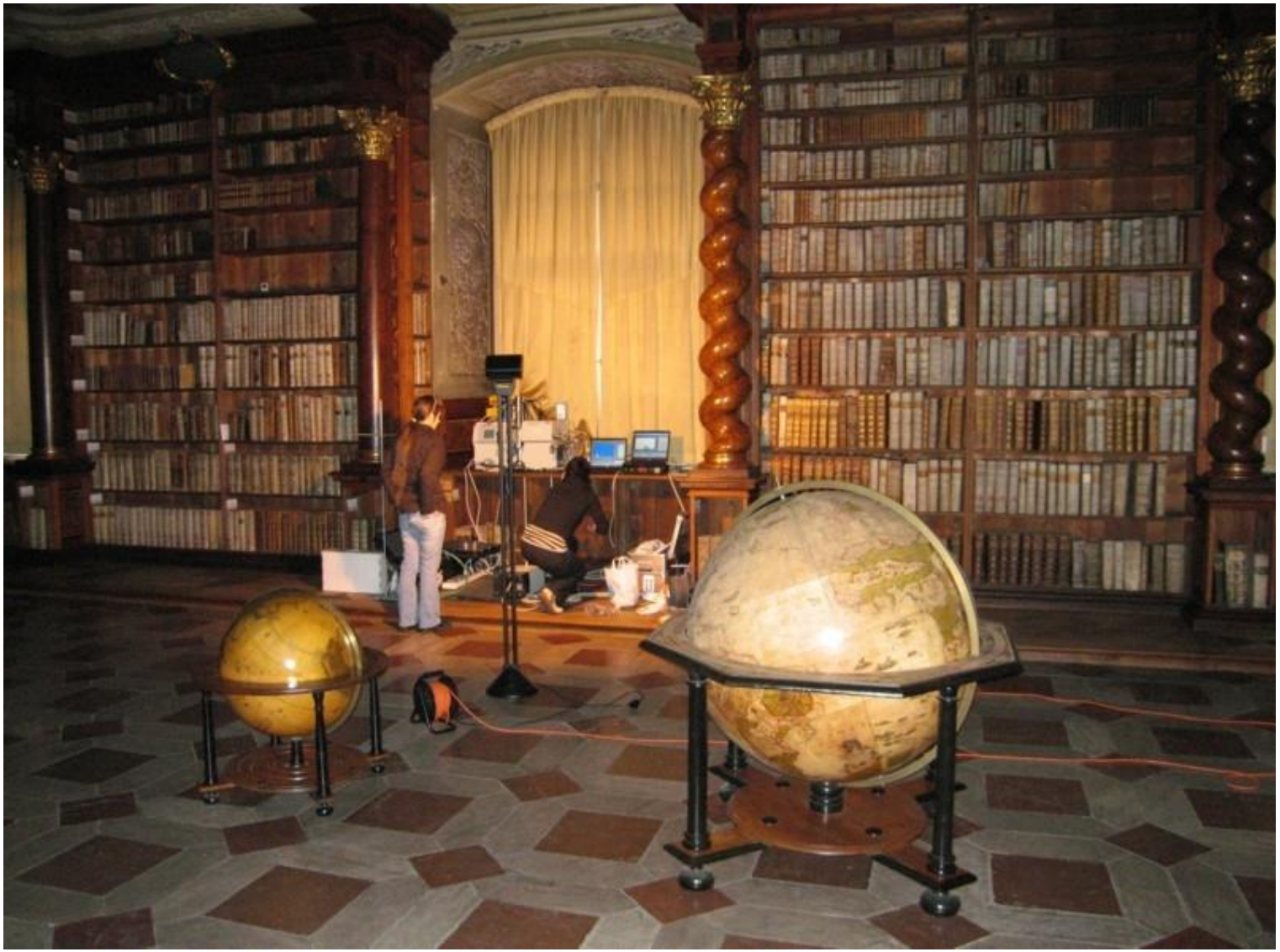
3 intensive campaigns: spring, summer, winter 2009

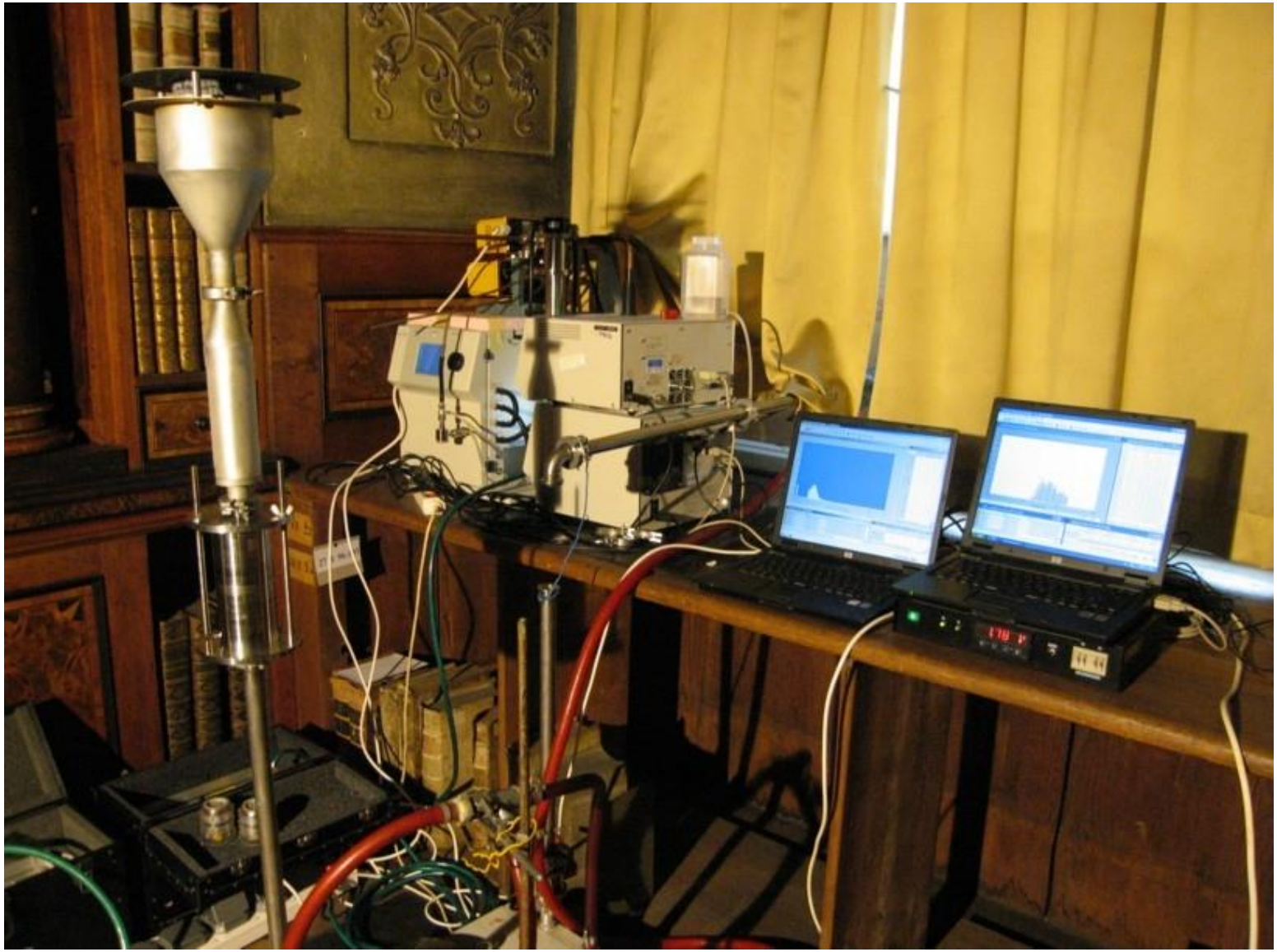
Indoor and outdoor

- Airborne particulate matter (PM)
  - Determination of chemical composition
  - Temporal variation
  - Spatial variation of indoor PM
- Gaseous pollutants
- Climatic parameters

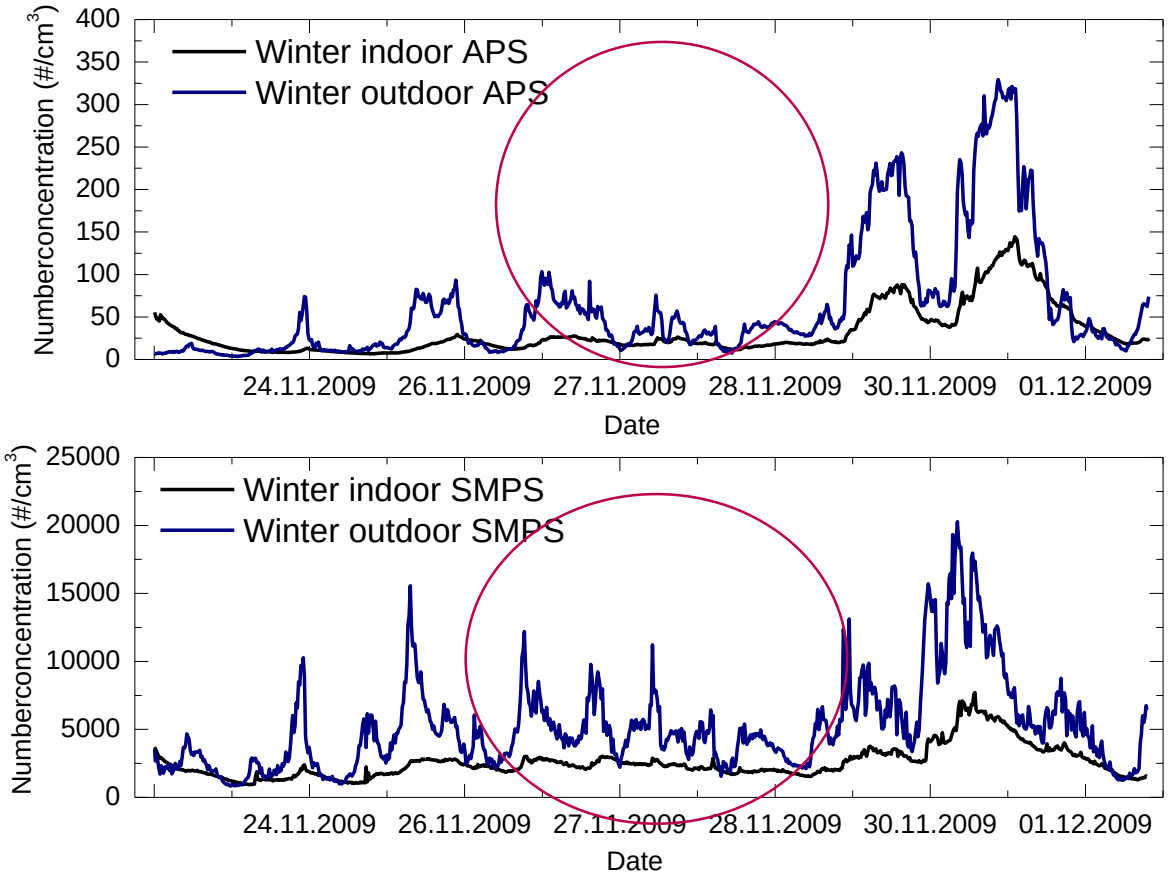
MEASUREMENTS







PREVIOUS ANALYSIS



Similar behaviour found in all 3 periods

DYNAMIC MASS BALANCE MODEL

$$\frac{dC_{in}}{dt} = PaC_{out} - aC_{in} - kC_{in} + \frac{S}{V}$$

C_{in}	indoor particle concentration (cm^{-3})
C_{out}	outdoor particle concentration (cm^{-3})
t	time (min^{-1})
V	volume of the area under study (cm^{-3})
P	penetration efficiency
a	air exchange rate (min^{-1})
k	deposition rate (min^{-1})
S	emission rate of particles (min^{-1})

$$C_{in}(t) = \underbrace{P}_{\text{Unknown}} a C_{out}(t)dt + \left[1-(a+\underbrace{k}_{\text{Unknown}})dt\right]C_{in}(t-1)$$

Different pairs of k and P

$k > 0$

$0 < P < 1$

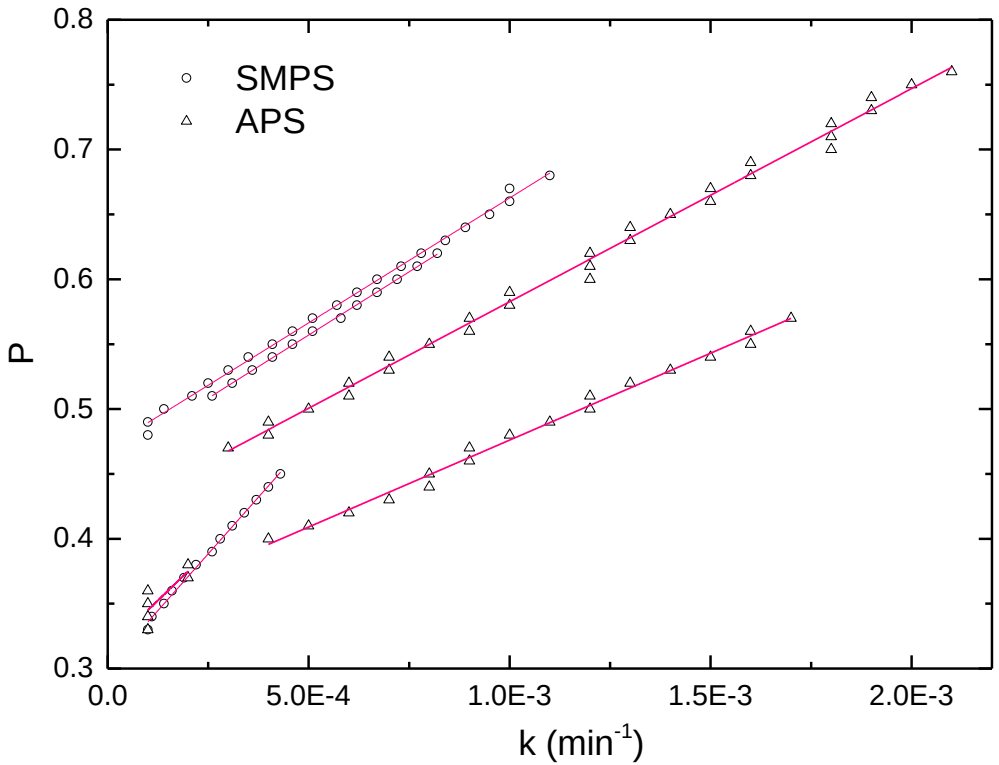
⇔ **Proportional** relationship

No unique solution

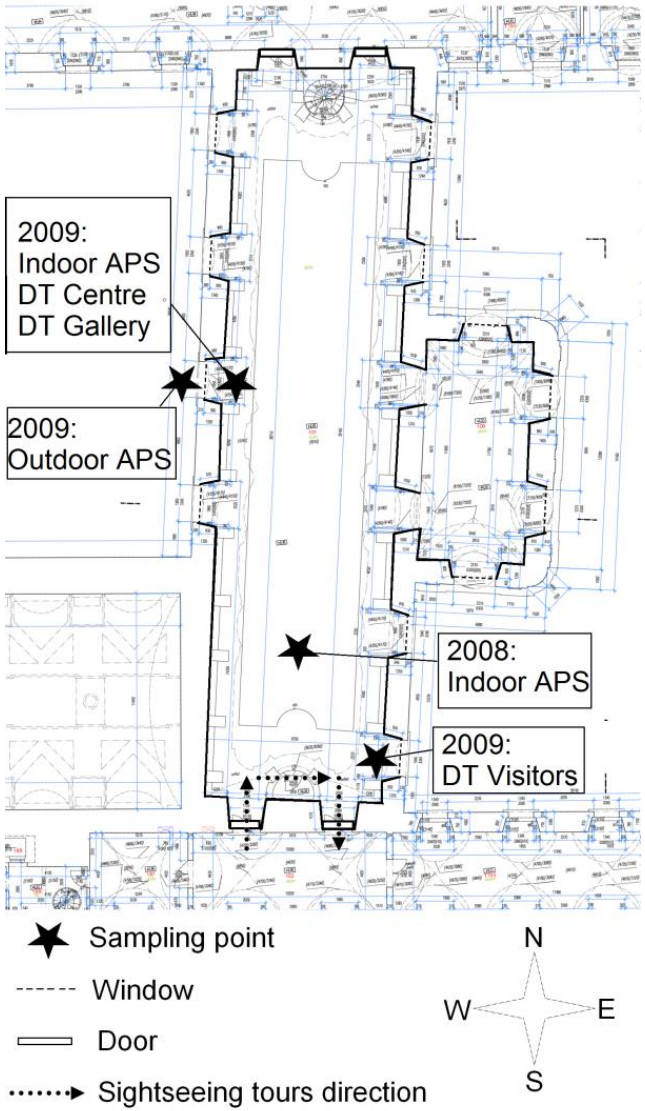
⇕

<u>*Final pair values*</u>:

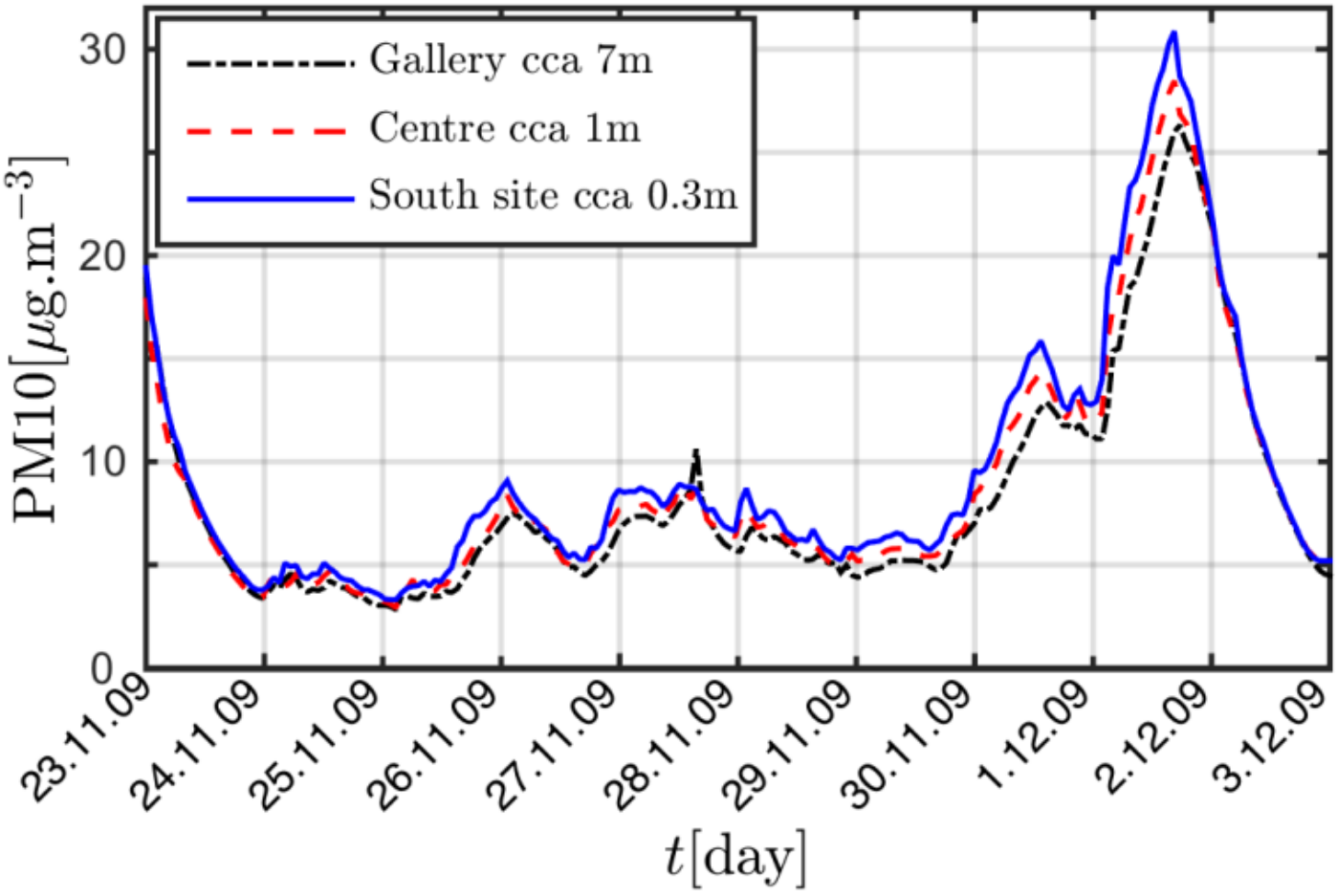
Best fit between measured concentration and modelled values (R^2)



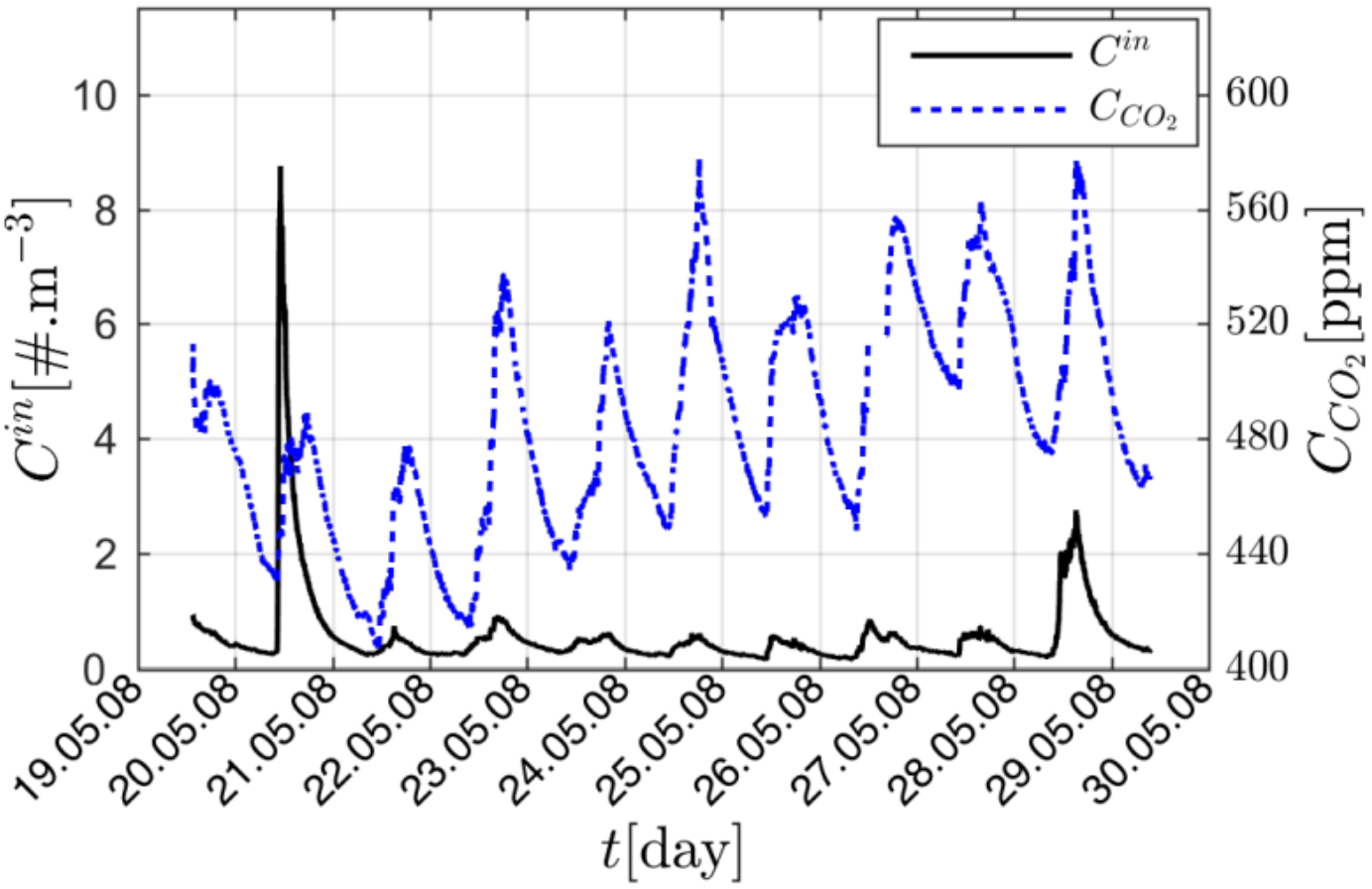
BLUEPRINT OF THE BLH



SPATIAL VARIABILITY



TEMPORAL VARIABILITY



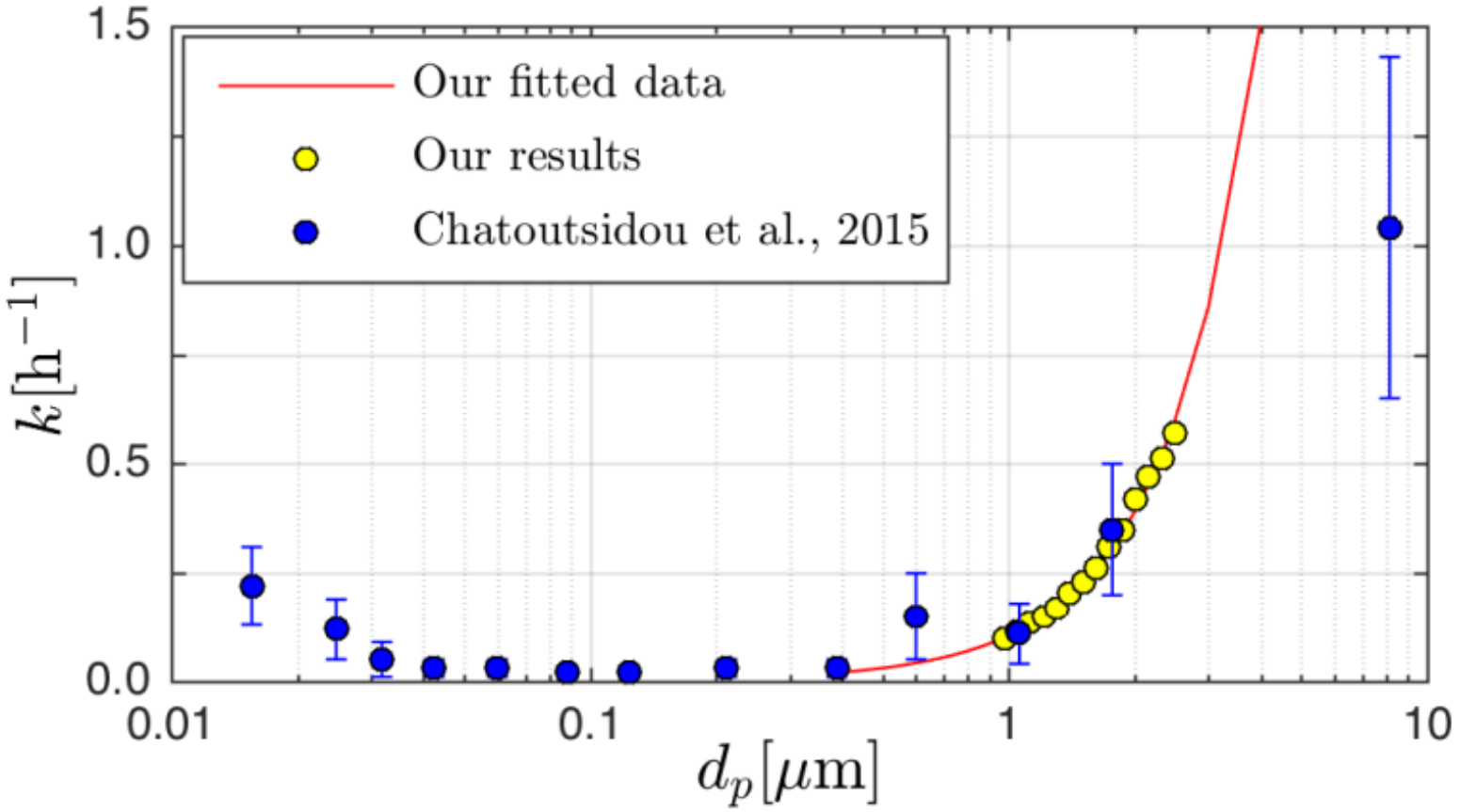
ANALYSIS

$$\frac{dC_{in}}{dt} = PaC_{out} - (a+k)C_{in} + \frac{S}{V}$$

$$\frac{dC_{in}}{dt} = -(a+k)C_{in}$$

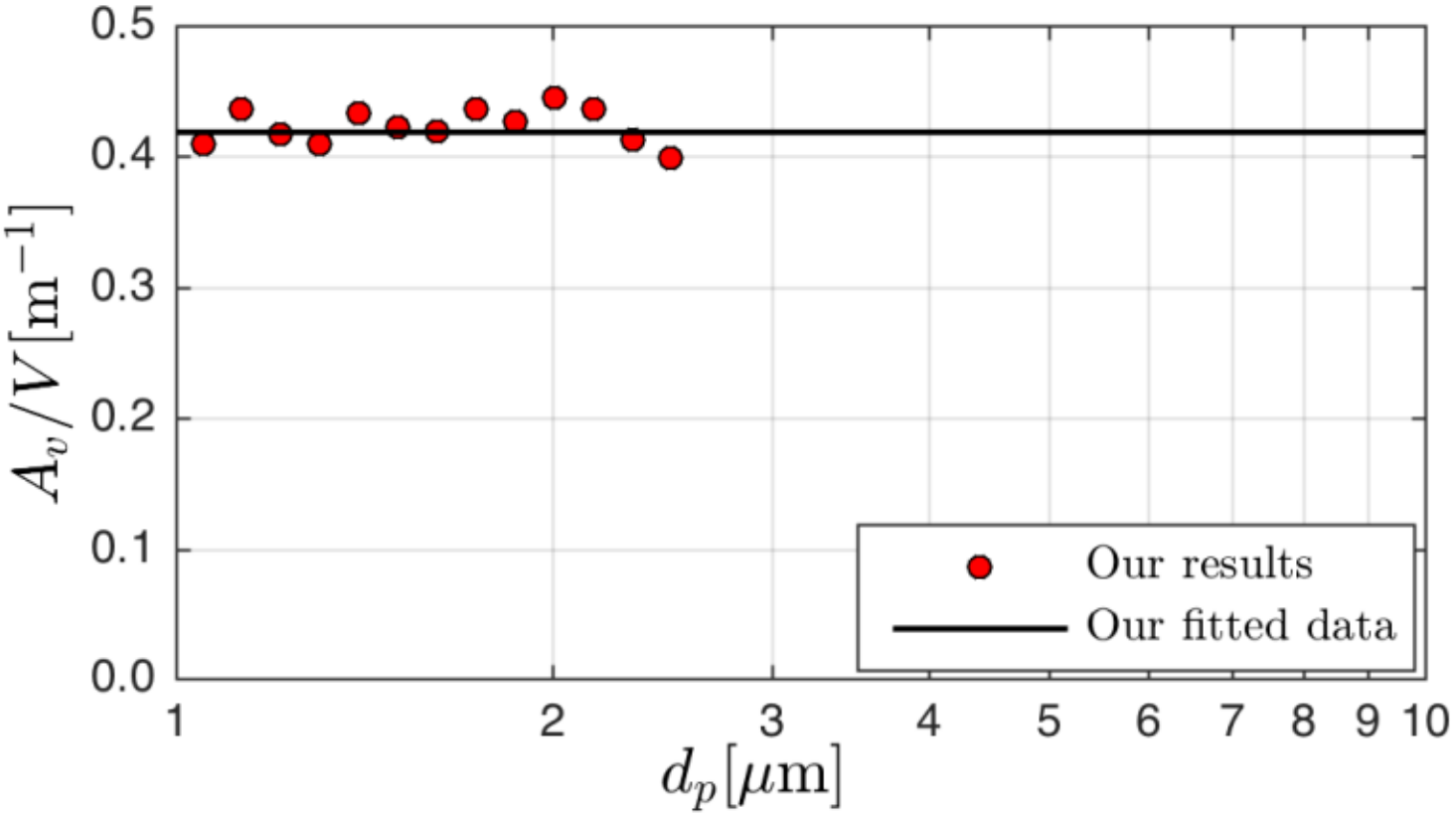
$$\frac{dC_{CO2}^{in}}{dt} = -a\left(C_{CO2}^{in} - C_{CO2}^{out}\right)$$

DEPOSITION RATE



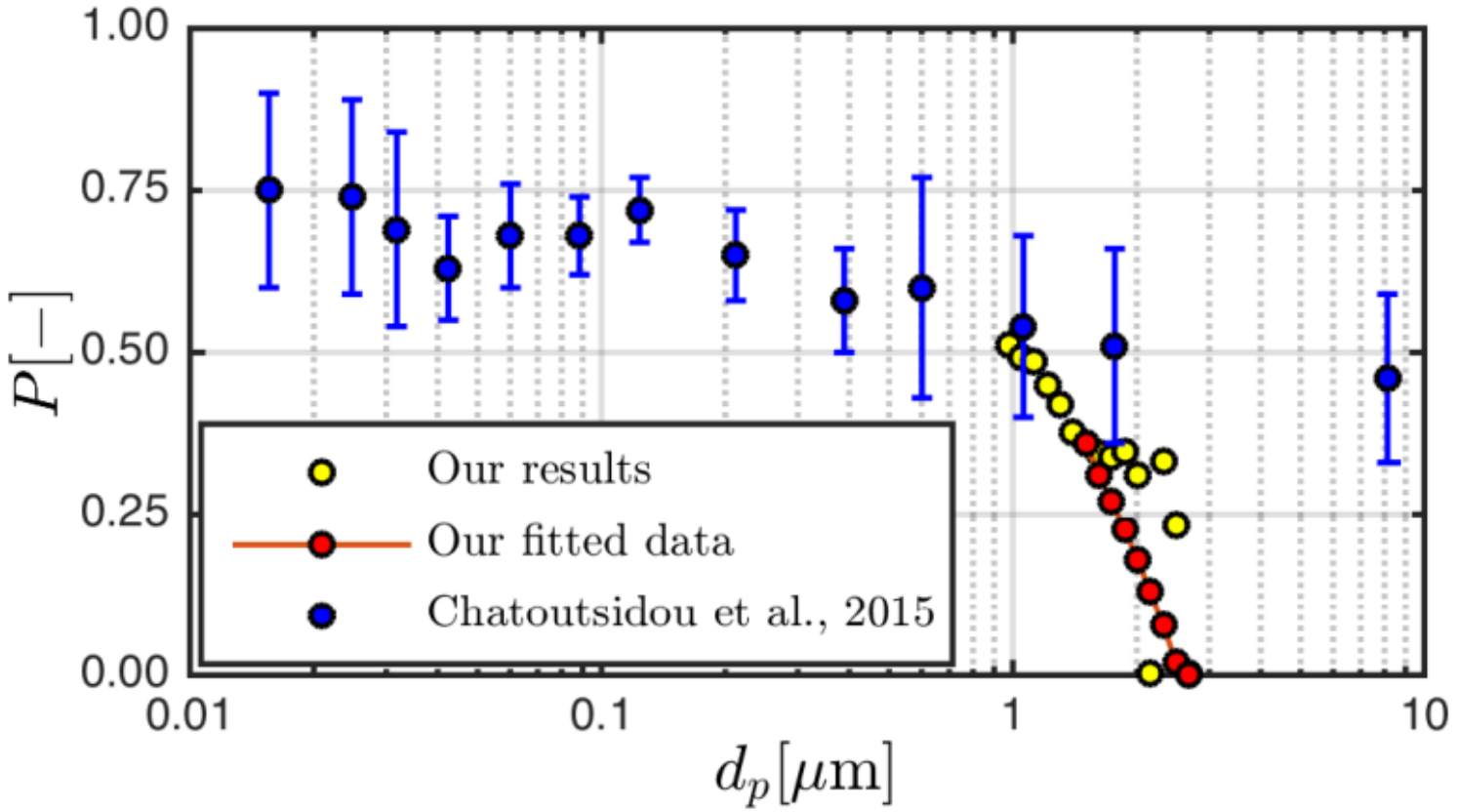
DEPOSITION RATE

$$k = \frac{A}{V} v_s$$



PENETRATION EFFICIENCY

$$\frac{dC_{in}}{dt} = PaC_{out} - (a + k)C_{in}$$



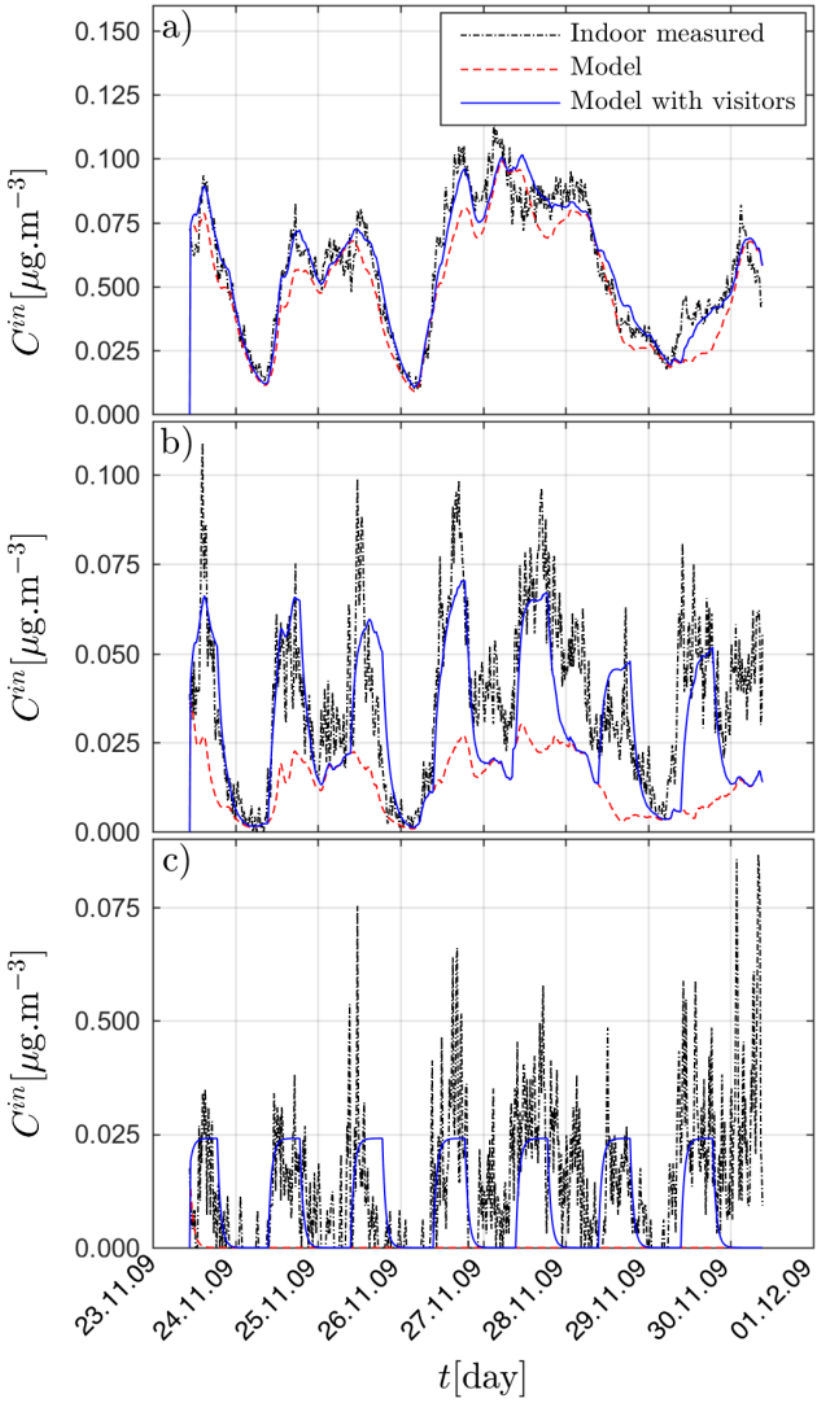
EMISSION RATE

$$\frac{dC_{in}}{dt} = PaC_{out} - (a+k)C_{in} + \frac{S}{V}$$

a) 1 µm

b) 2 µm

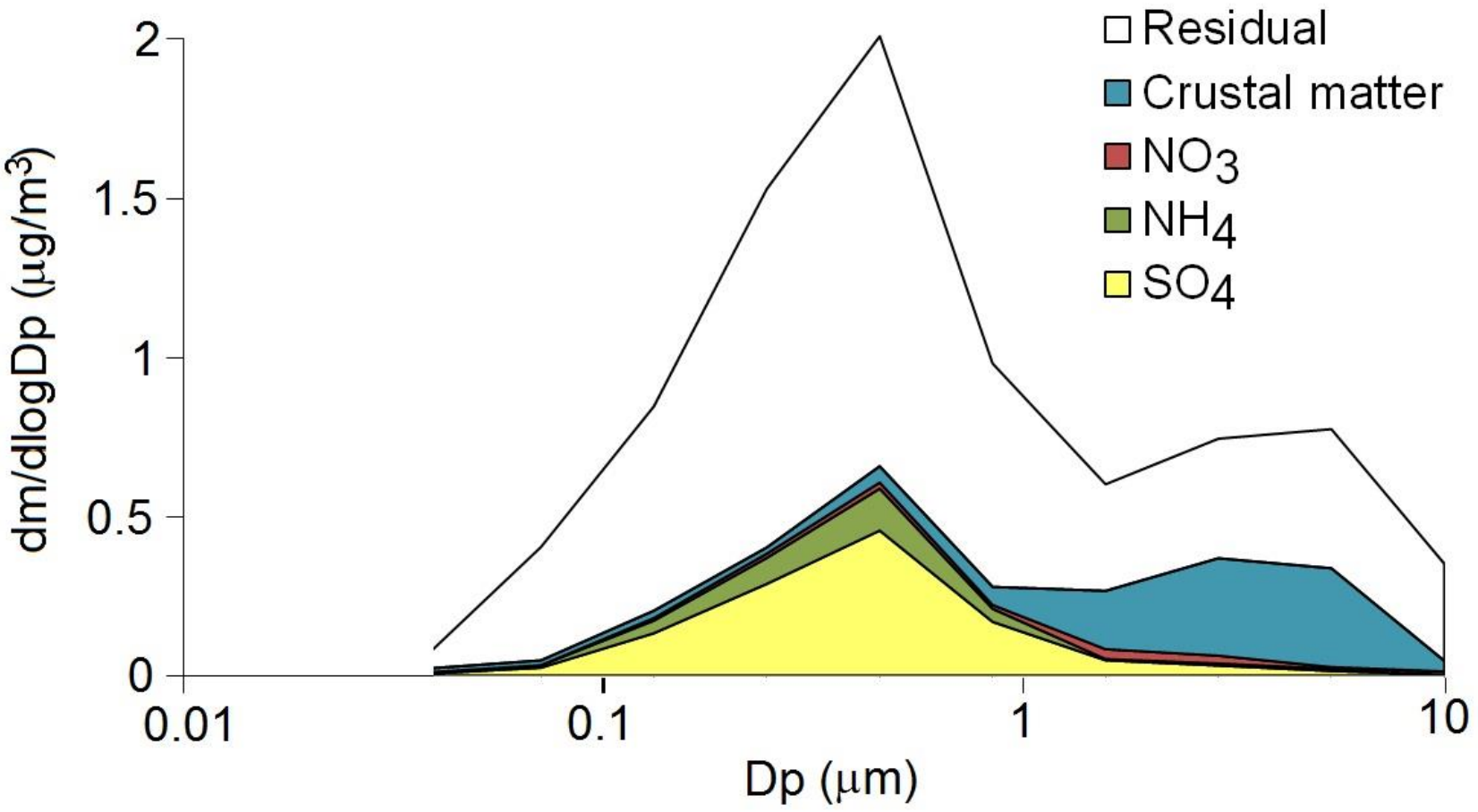
c) 3 µm



EMISSION RATE

Season 2009	$PM_{0.5-1}$ (mg min^{-1})	$PM_{1-2.5}$ (mg min^{-1})	$PM_{2.5-5}$ (mg min^{-1})	PM_{5-10} (mg min^{-1})
Spring	0.001	0.012	0.018	0.295
Summer	0.001	0.019	0.027	0.301
Winter	0.002	0.013	0.027	0.305

CHEMICAL COMPOSITION



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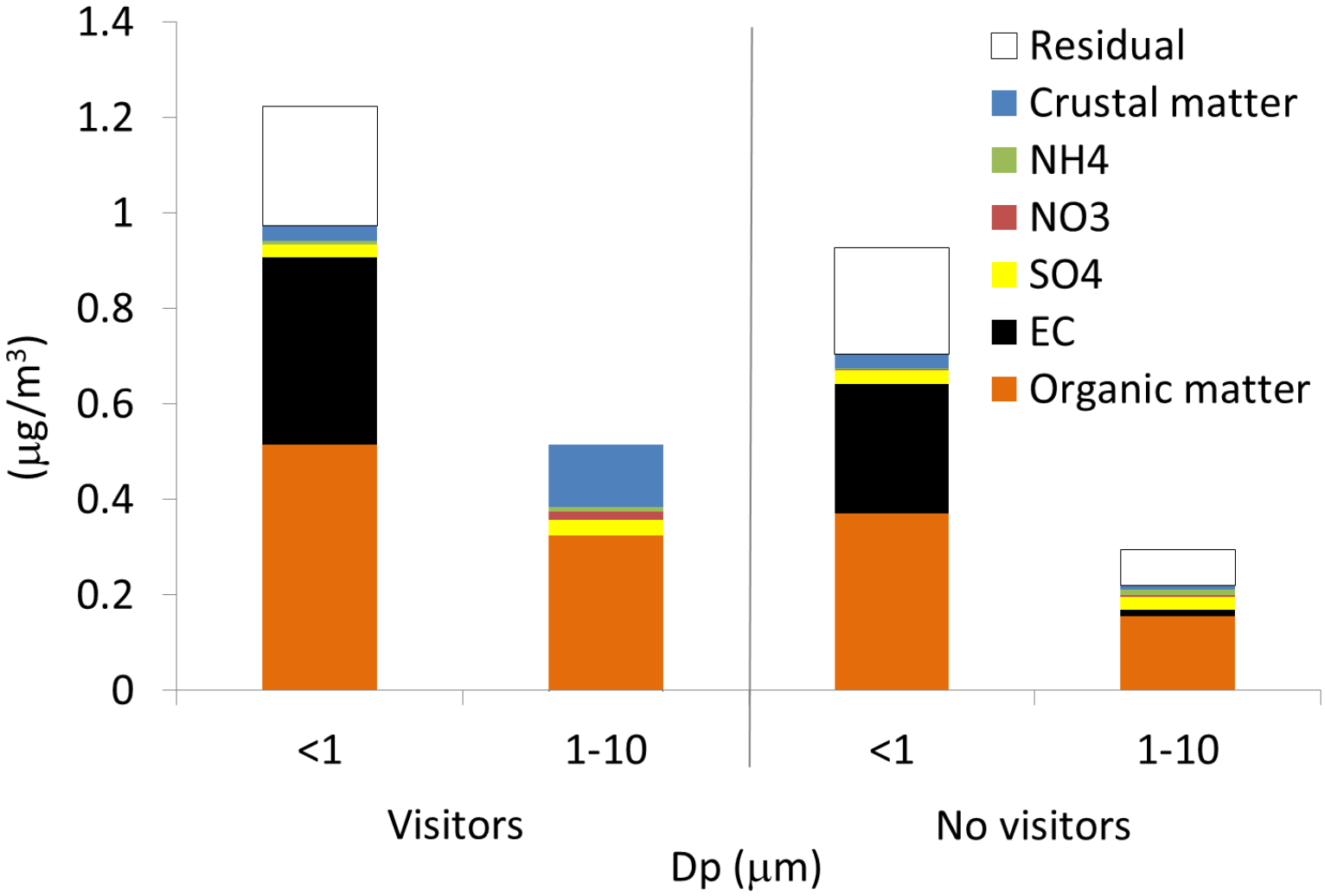

CHEMICAL COMPOSITION

- **Organic matter**: skin shedding, breathing, coughing, sneezing, etc.

- **Inorganic matter**: soil dust particles introduced by visitors, building activities

CONCLUSIONS

- Visitors contribute about 50 g of suspended coarse PM yearly
- Particles generated by visitors are larger than about 1 µm
- They consist mainly of organic and mineral matter

FINAL SOLUTION

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THANK YOU