

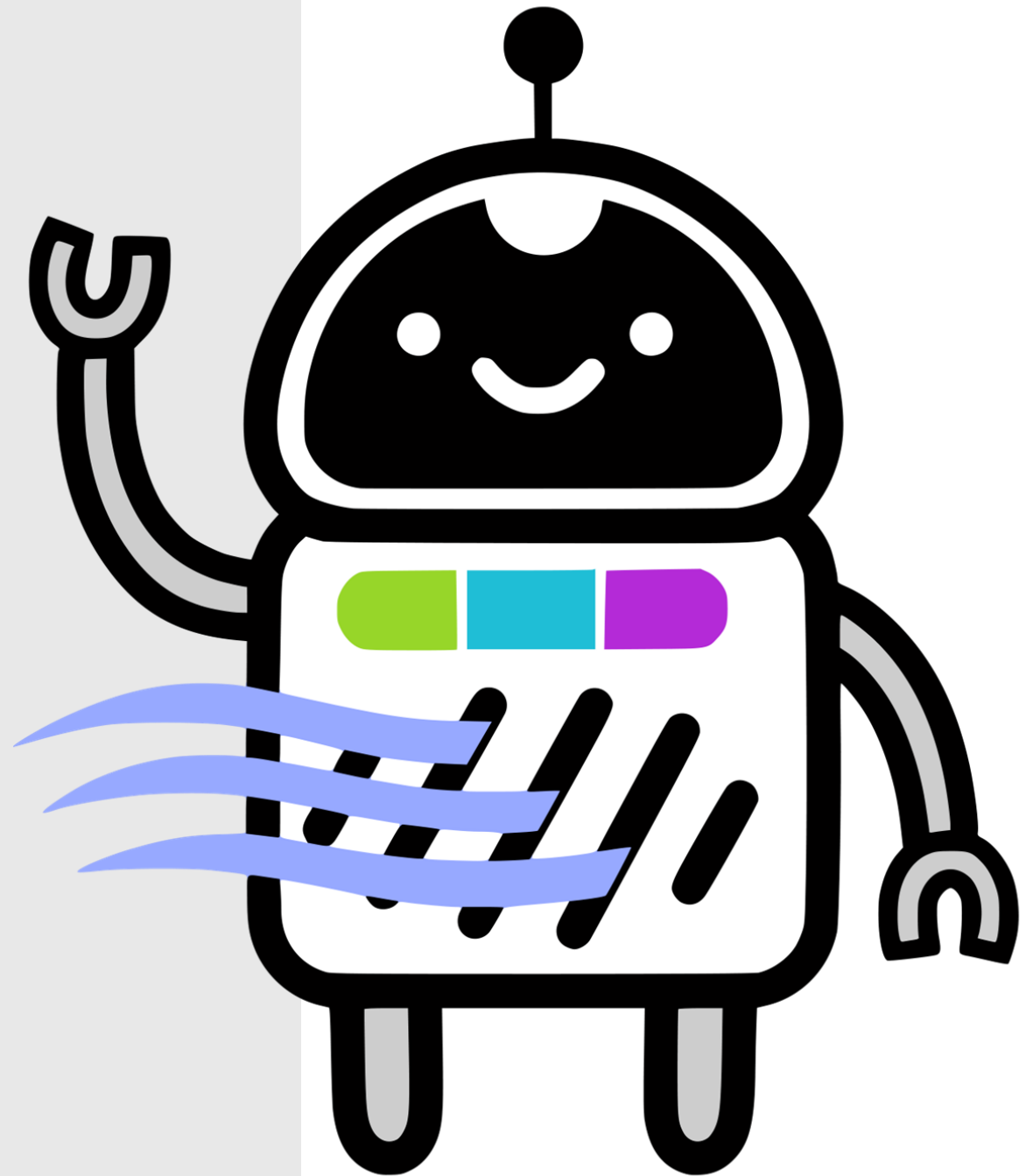
# Particulate Matter in UK School Classrooms

Alice Handy



**SAMHE**  
SCHOOLS' AIR QUALITY MONITORING  
FOR HEALTH AND EDUCATION

**IMPERIAL**



# Particulate matter and indoor air quality

- Robust links between particulate matter (PM) and health effects ... and children can be more vulnerable
- Most of us spend more than 80% of our time indoors
- School indoor air quality (IAQ) can be important for:
  - health,
  - attention levels,
  - attainment
- Sources of PM in schools from indoors and outdoors



These are some of the issues SAMHE is aiming to address ...



# What is SAMHE?



- **Schools' Air quality Monitoring for Health and Education**
- **UK's first national dataset of school indoor air quality**
- **Schools receive a FREE high spec air quality monitor**
- **Measuring:**
  - Carbon dioxide
  - Temperature
  - Humidity
  - Particulate Matter
  - TVOCs
- **Novel Methodology**



# The SAMHE process

Over 1400 monitors sent out  
Over 800 monitors connected

Schools receive  
and set up a  
SAMHE monitor



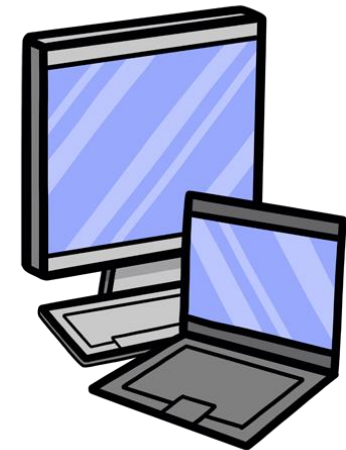
SAMHE scientists set  
activities on the  
SAMHE Web App



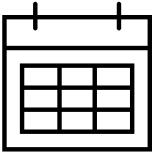
Pupils complete fun  
activities, learning about  
air quality and inputting  
important contextual data



The data goes to SAMHE  
scientists so they can  
analyse and report on air  
quality in UK classrooms



# PM<sub>2.5</sub> in UK schools: data in this study



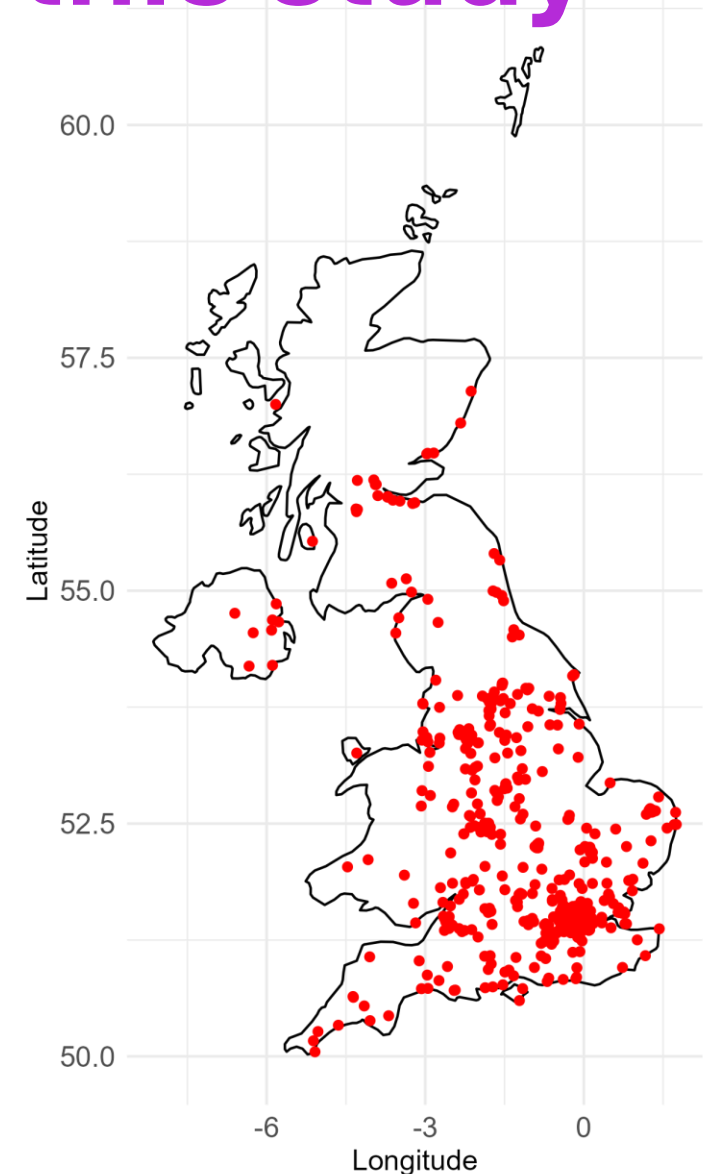
**Academic year 2023 – 2024**

295 days, 133 school days

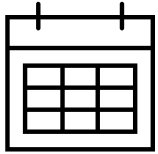
## **SAMHE Schools**

Total: 490 schools

SAMHE PM<sub>2.5</sub> concentration



# PM<sub>2.5</sub> in UK schools: data in this study



**Academic year 2023 – 2024**

295 days, 133 school days

## **SAMHE Schools**

Total: 490 schools

**SAMHE PM<sub>2.5</sub> concentration**

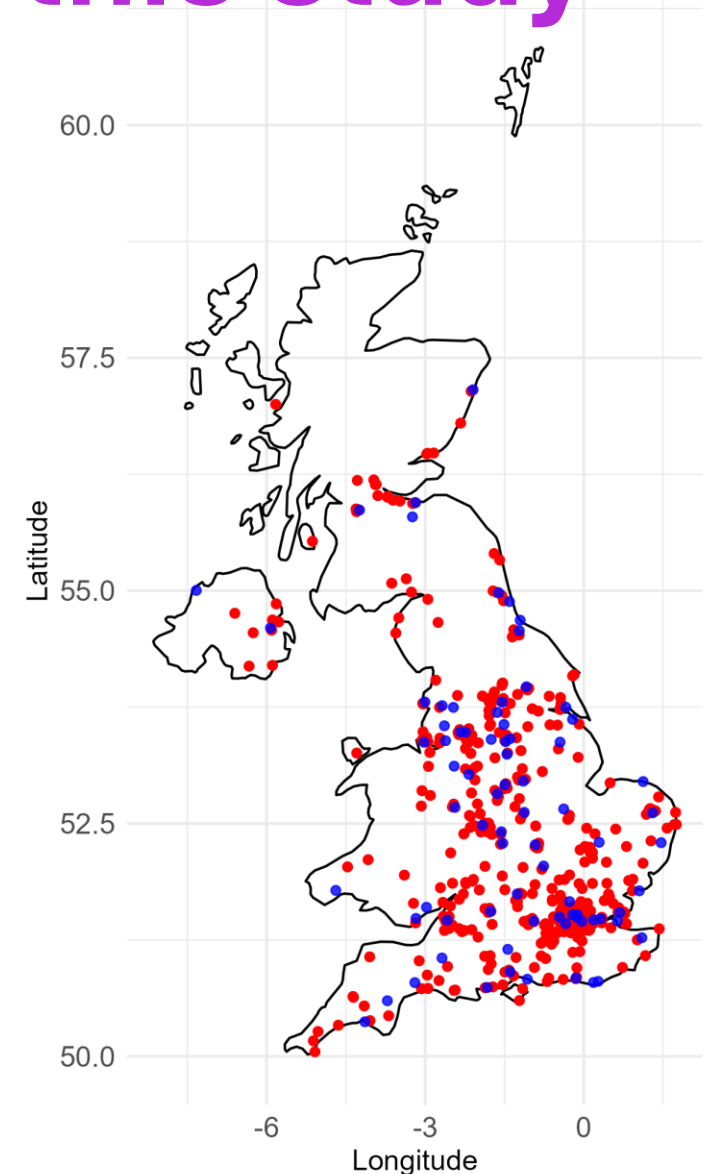
## **Ambient outdoor: AURN sites**

Nearest background AURN site nearest to each school

Average distance between schools and AURN sites: 14.2 - 19.2 km

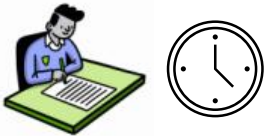
Total: 77 sites

**AURN PM<sub>2.5</sub> concentration**

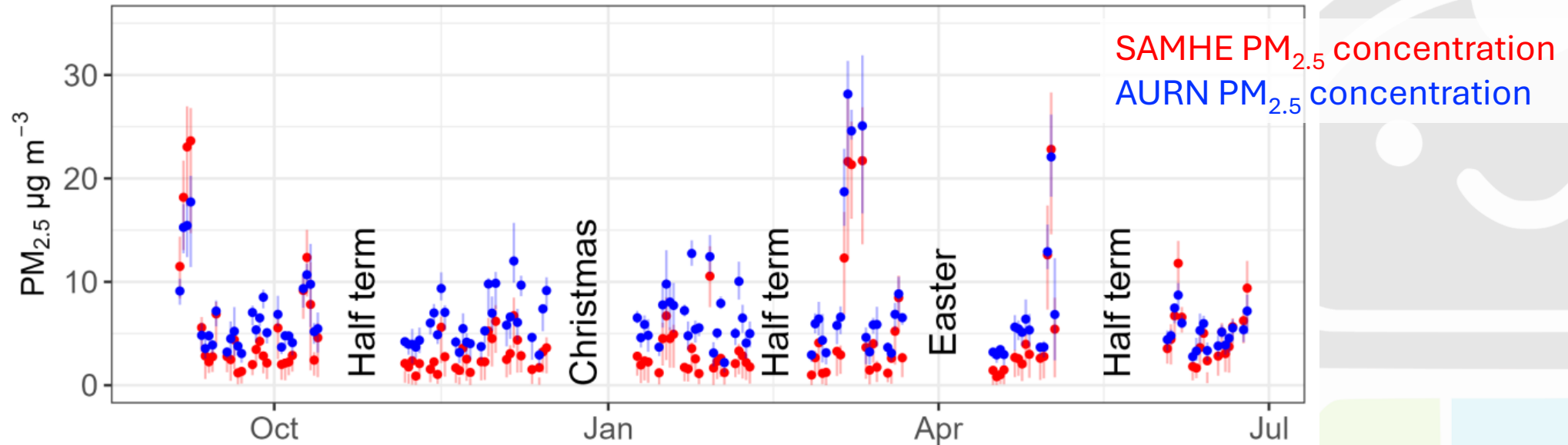


# Temporal trends over the year

School days



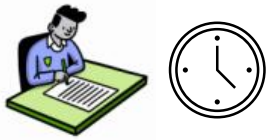
09:00 - 16:00



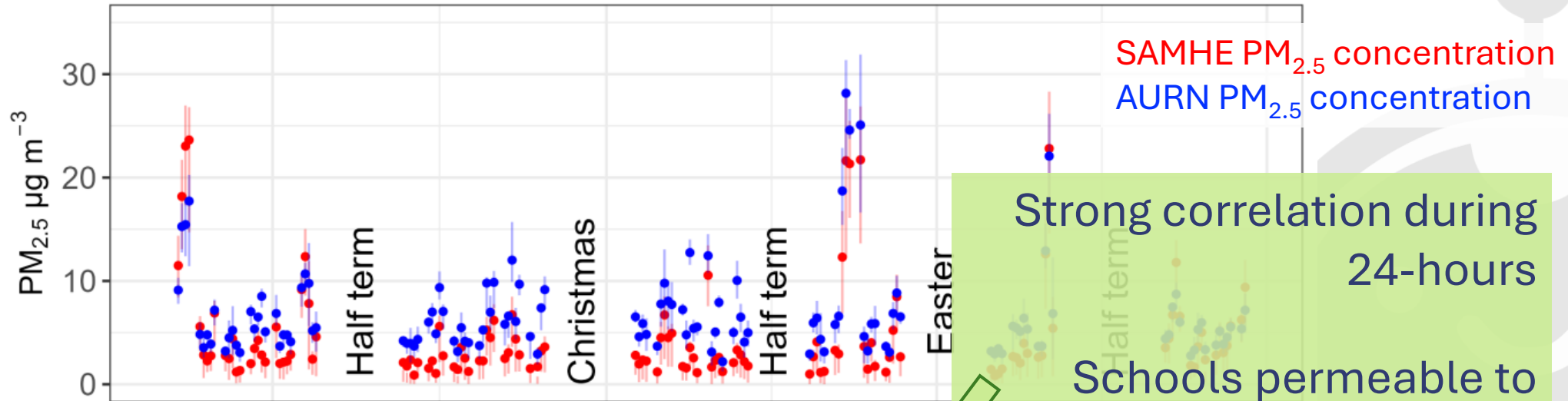
- AURN PM<sub>2.5</sub> concentration higher than SAMHE PM<sub>2.5</sub> concentration
- SAMHE and AURN strongly correlated

# Temporal trends over the year

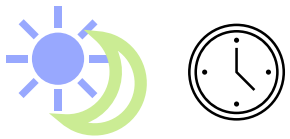
School days



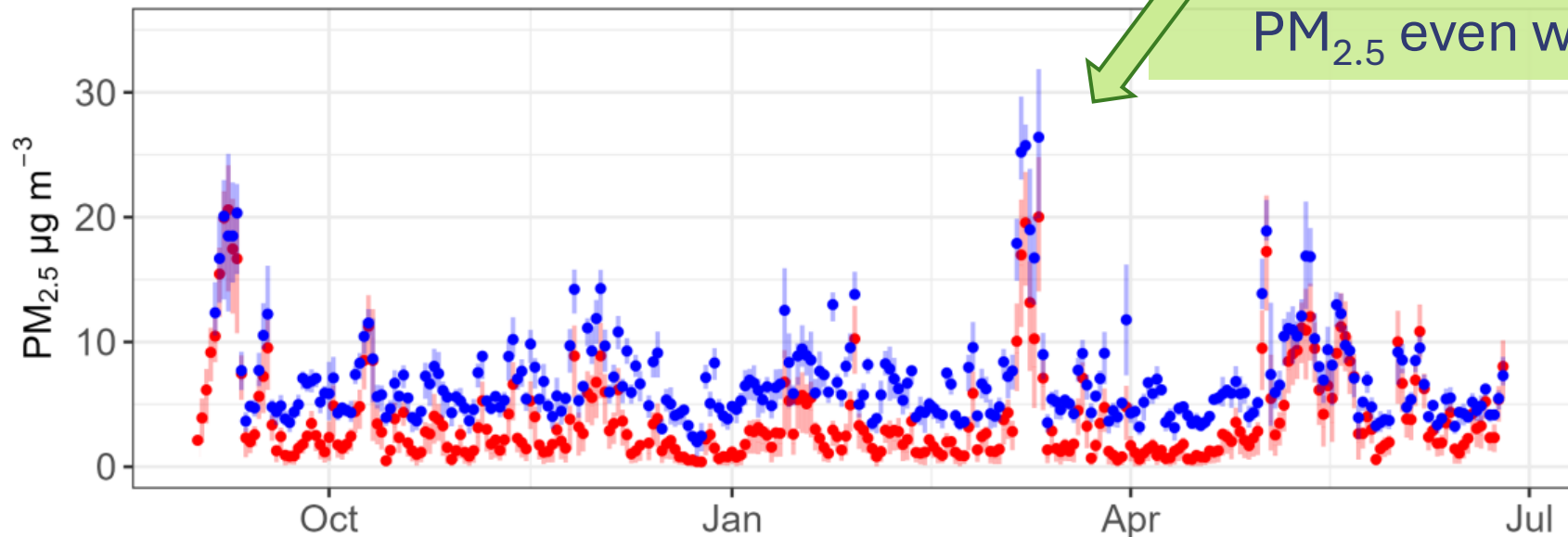
09:00 - 16:00



Every day



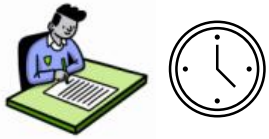
24 hours





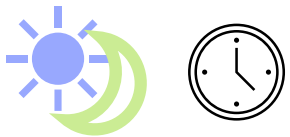
# Temporal trends over the year

School days

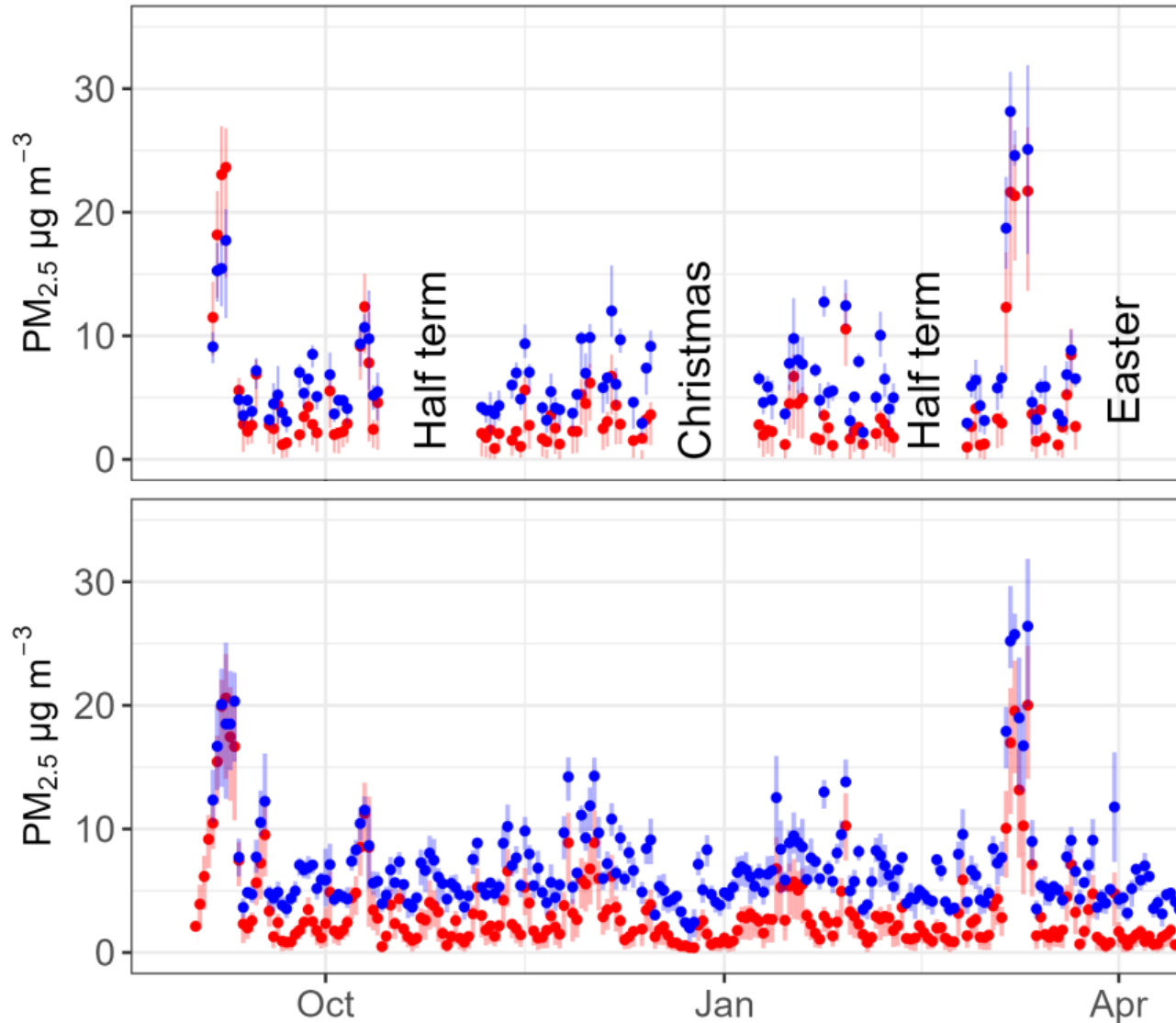


09:00 - 16:00

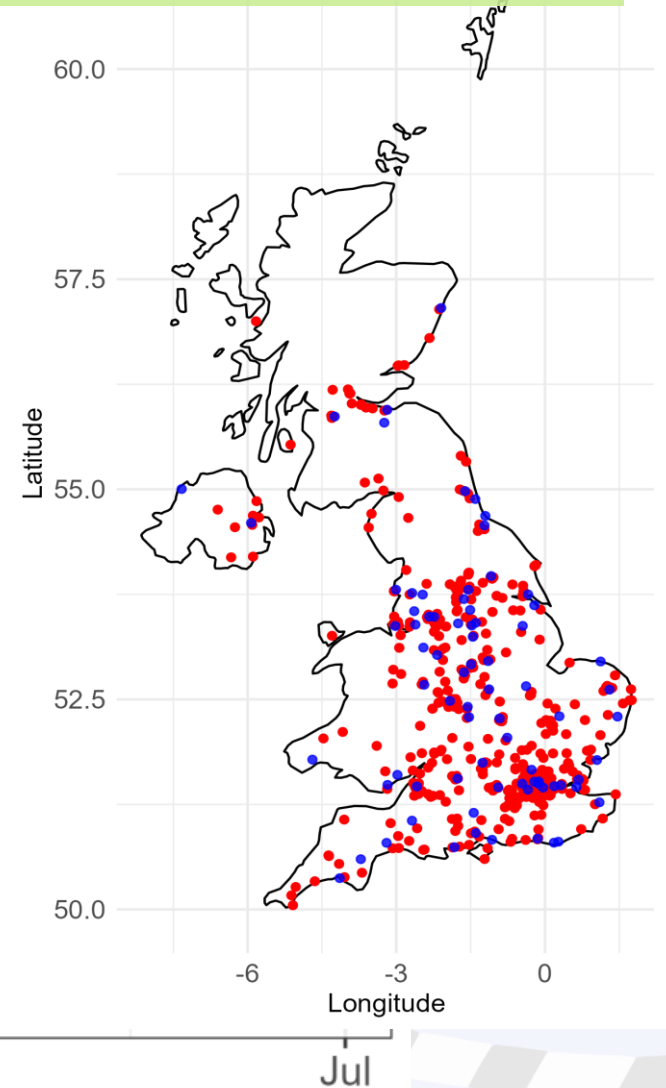
Every day



24 hours



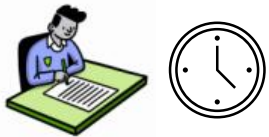
National trend



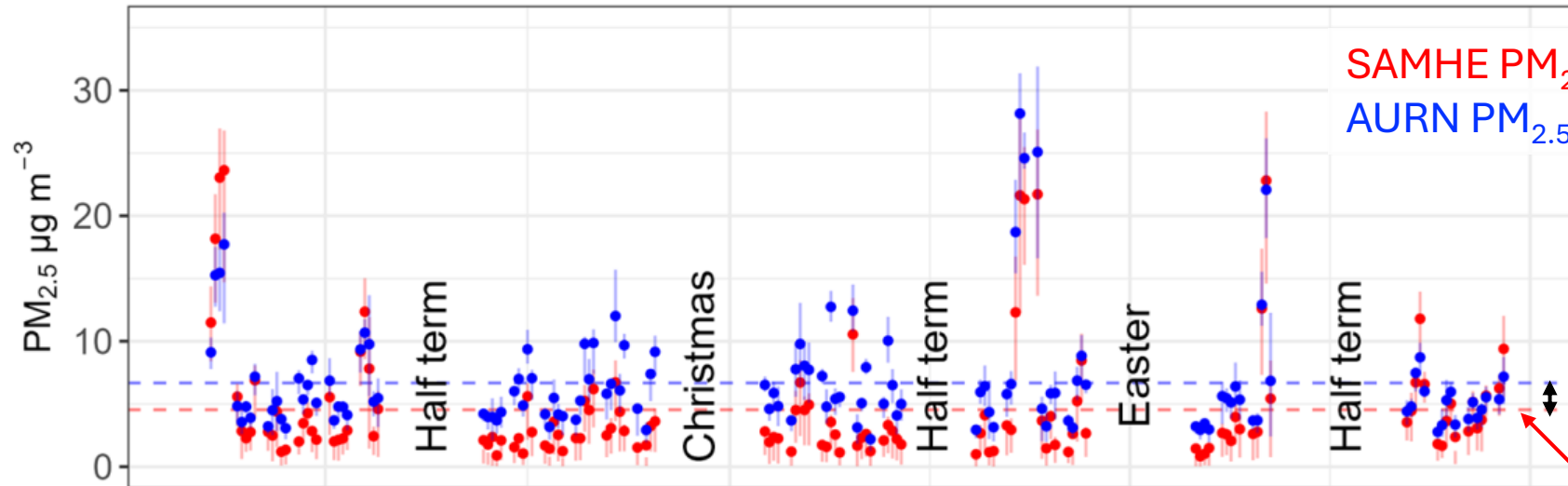
on  
1

# Temporal trends over the year

School days



09:00 - 16:00



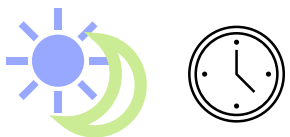
SAMHE PM<sub>2.5</sub> concentration

AURN PM<sub>2.5</sub> concentration

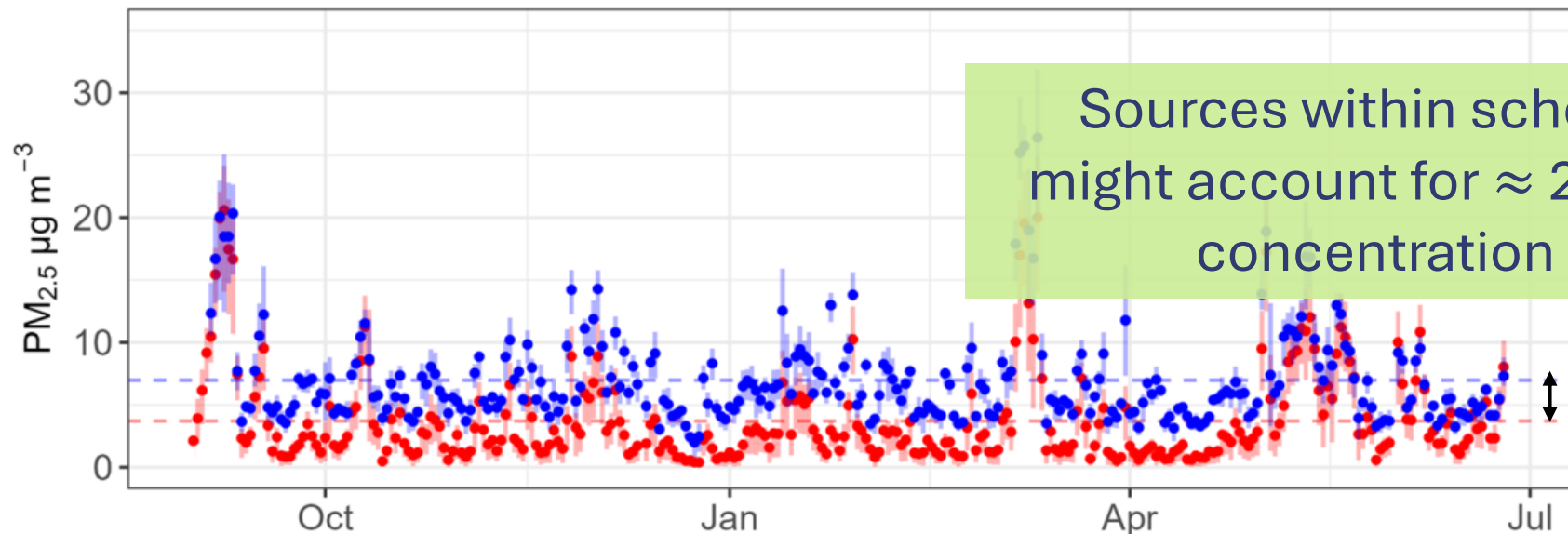
$\Delta = 2.14 \mu\text{g}/\text{m}^3$

$4.54 \mu\text{g}/\text{m}^3$

Every day



24 hours



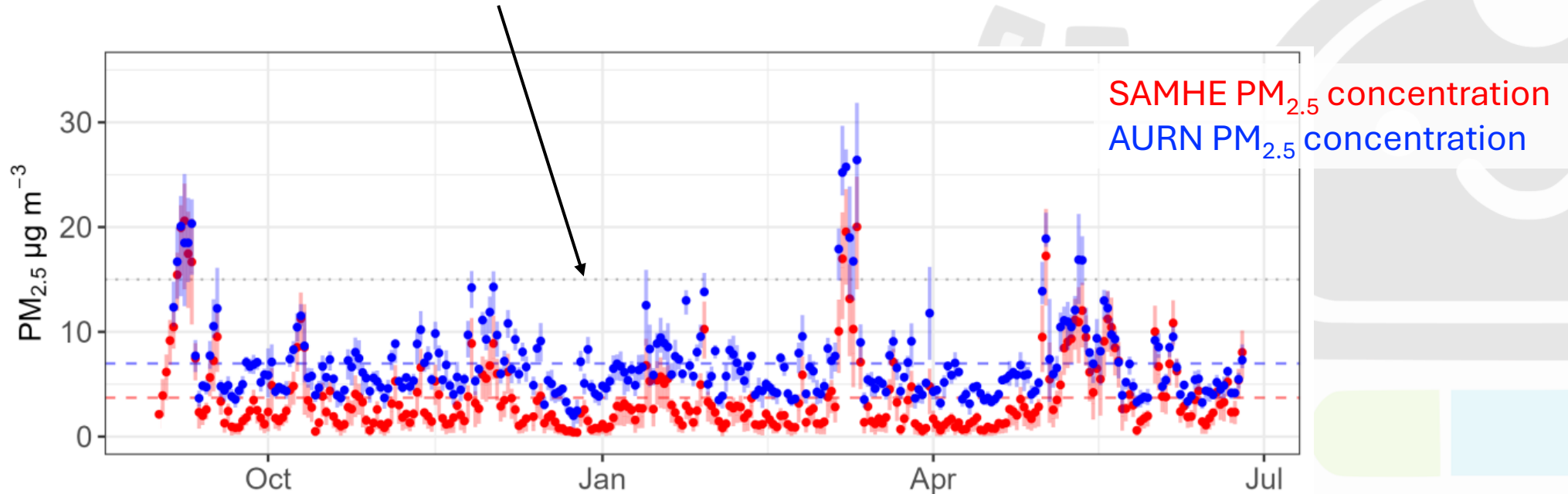
Sources within schools  
might account for  $\approx 25\%$  of  
concentration

$\Delta = 3.26 \mu\text{g}/\text{m}^3$

# Impact of elevated outdoor concentrations

## Health-based guidance on PM<sub>2.5</sub>

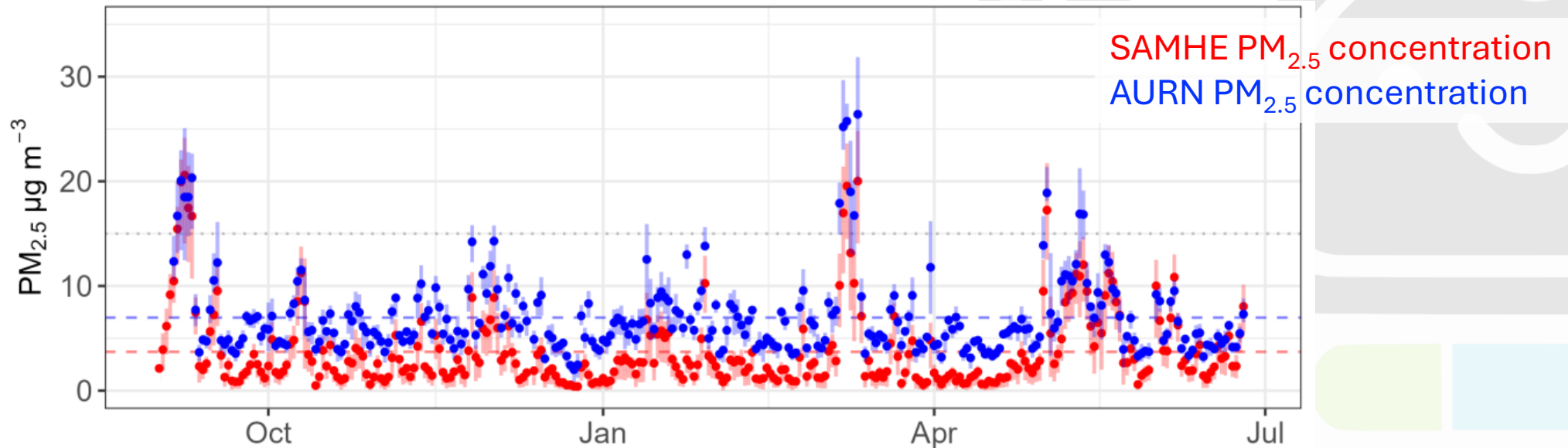
WHO guideline: 24-hour mean PM<sub>2.5</sub> concentration < 15 µg/m<sup>3</sup>



# Impact of elevated outdoor concentrations

Outdoor WHO PM<sub>2.5</sub> event:

AURN 24-hour mean PM<sub>2.5</sub> concentration > 15 µg/m<sup>3</sup>

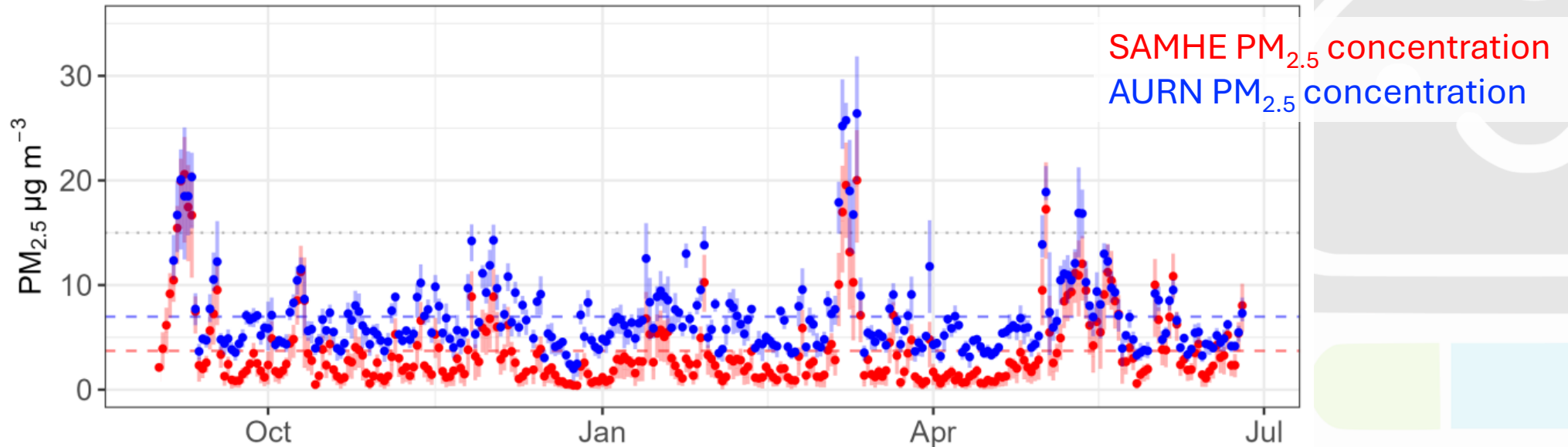


# Impact of elevated outdoor concentrations

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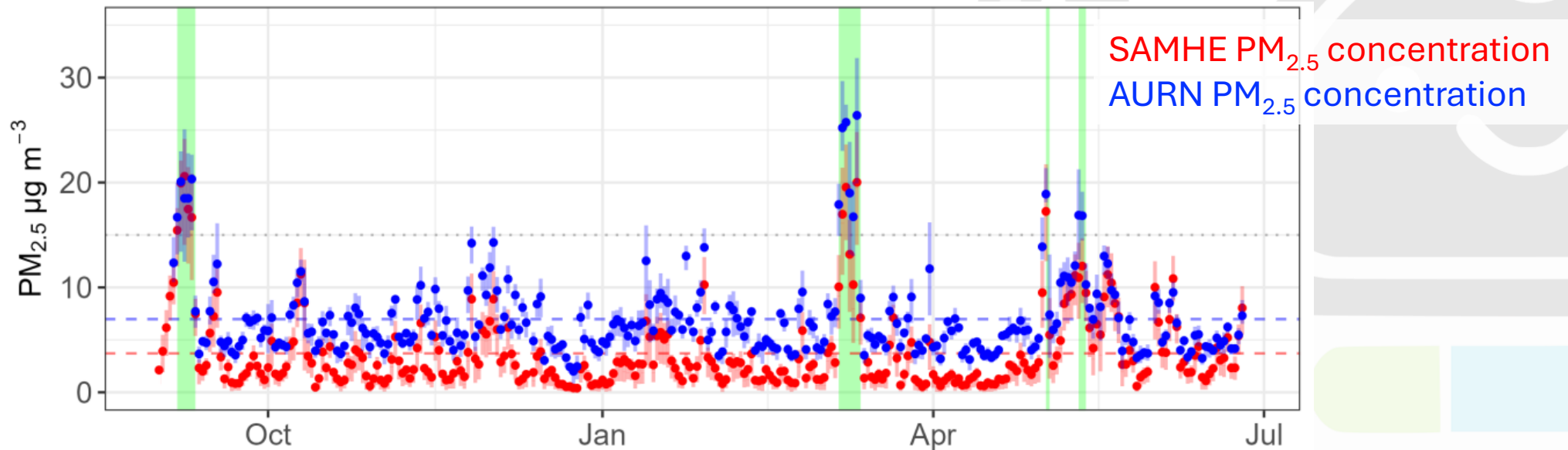
Are these events detected in schools?



# WHO Outdoor PM<sub>2.5</sub> events

Outdoor WHO PM<sub>2.5</sub> event:

AURN 24-hour mean PM<sub>2.5</sub> concentration > 15 µg/m<sup>3</sup>



Outdoor WHO PM<sub>2.5</sub> events lead to elevated concentrations in schools

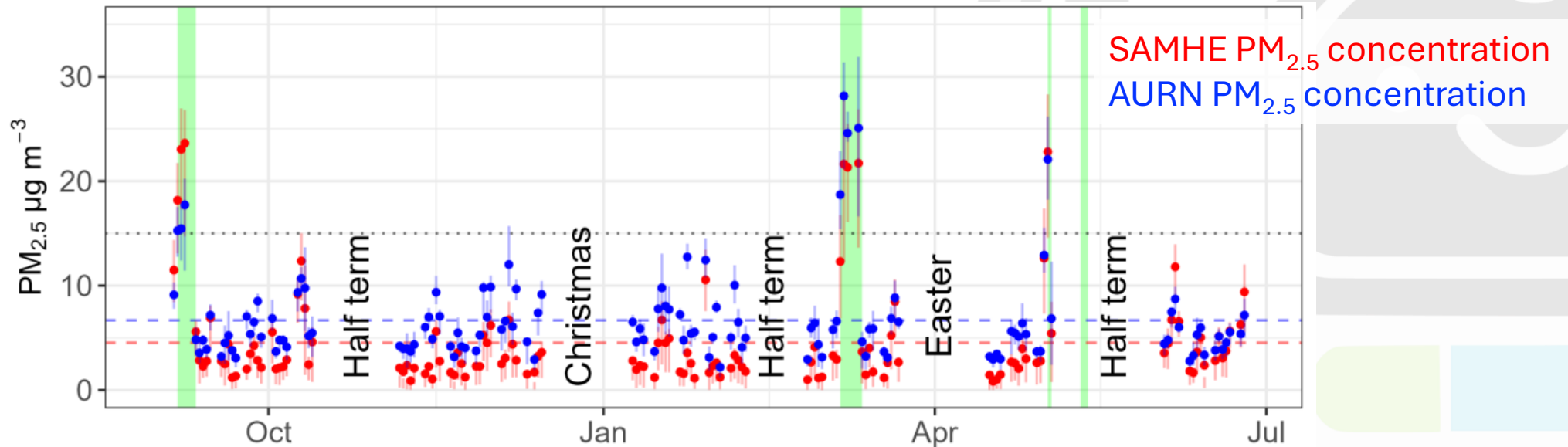
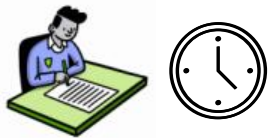
# WHO Outdoor PM<sub>2.5</sub> events

Outdoor WHO PM<sub>2.5</sub> event:

AURN 24-hour mean PM<sub>2.5</sub> concentration > 15 µg/m<sup>3</sup>

Are these events detected on school days?

School days  
09:00 - 16:00

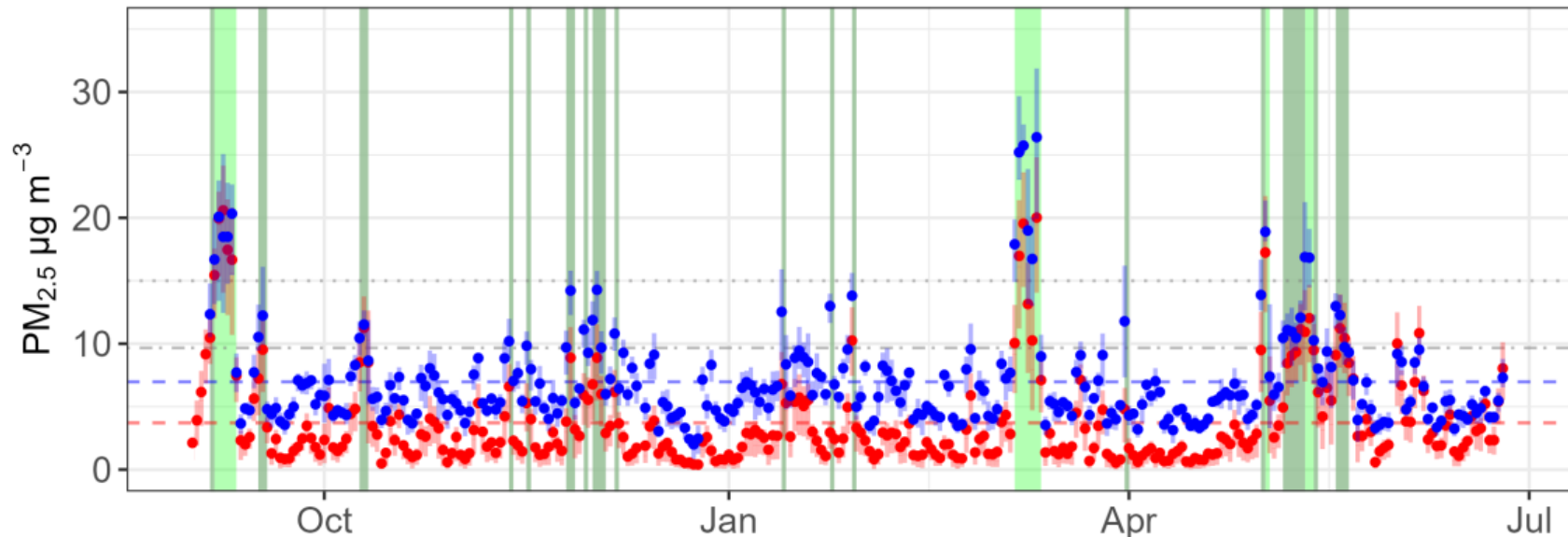


Outdoor WHO PM<sub>2.5</sub> events lead to elevated concentrations in schools

# Moderate Outdoor PM<sub>2.5</sub> events

Investigate more frequent but less extreme events

Threshold = median + standard deviation over year = 9.6  $\mu\text{g}/\text{m}^3$

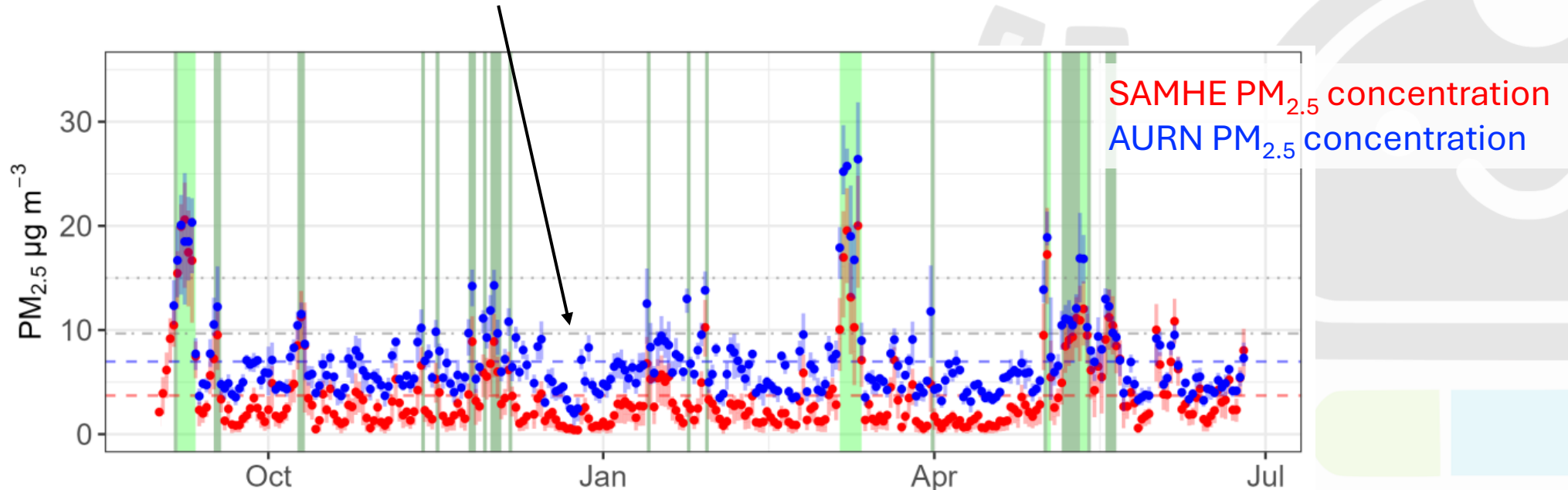




# Moderate Outdoor PM<sub>2.5</sub> events

Outdoor Moderate PM<sub>2.5</sub> event:

AURN 24-hour mean PM<sub>2.5</sub> concentration > 9.6 µg/m<sup>3</sup>



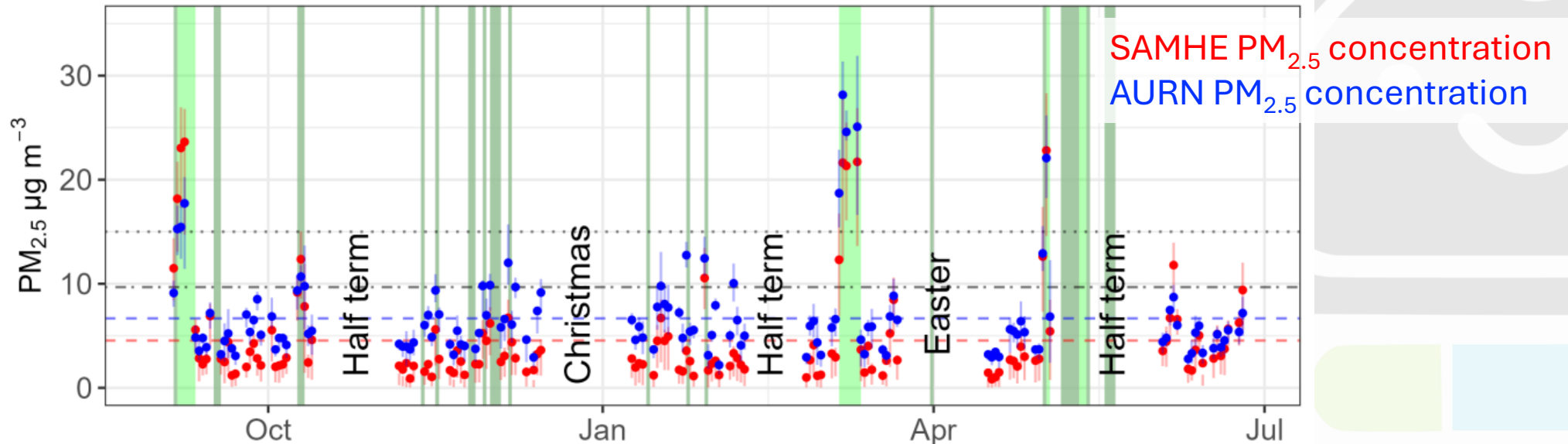
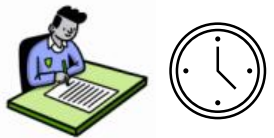
**Some** outdoor moderate PM<sub>2.5</sub> events lead to elevated concentrations in schools

# Moderate Outdoor PM<sub>2.5</sub> events

Outdoor Moderate PM<sub>2.5</sub> event:

AURN 24-hour mean PM<sub>2.5</sub> concentration > 9.6 µg/m<sup>3</sup>

School days  
09:00 - 16:00

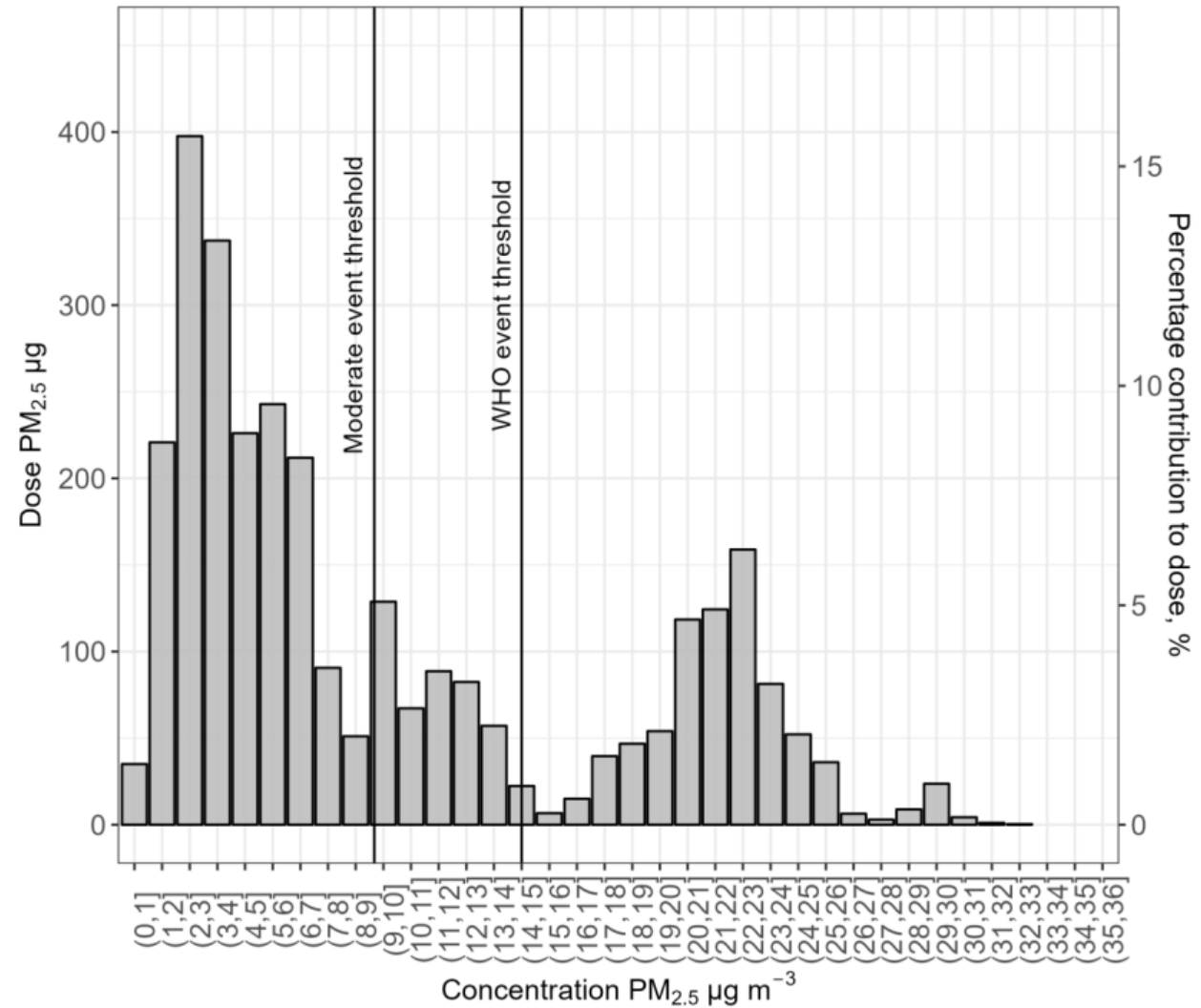
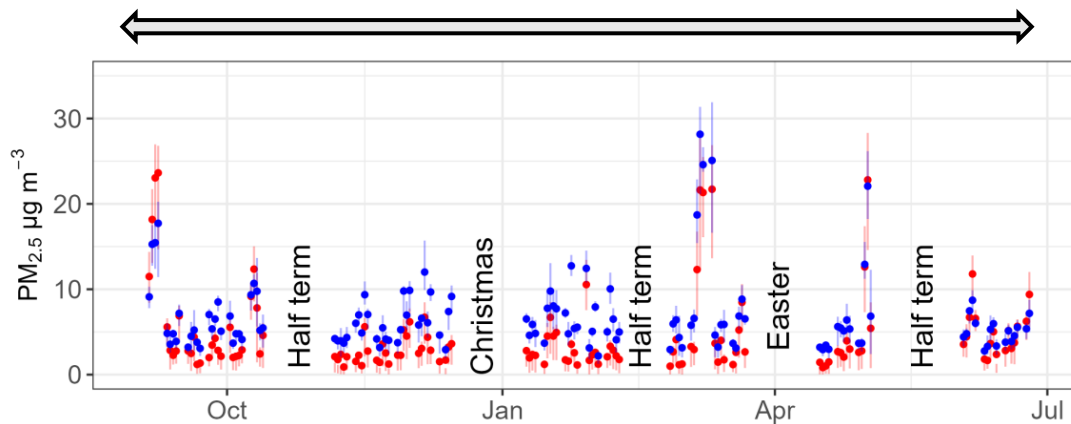


Fewer moderate PM<sub>2.5</sub> events occur on school days  
On only four days SAMHE PM<sub>2.5</sub> concentration > threshold

# Potential implications of PM<sub>2.5</sub> in schools

Estimating the potential dose of PM<sub>2.5</sub> received over the academic year

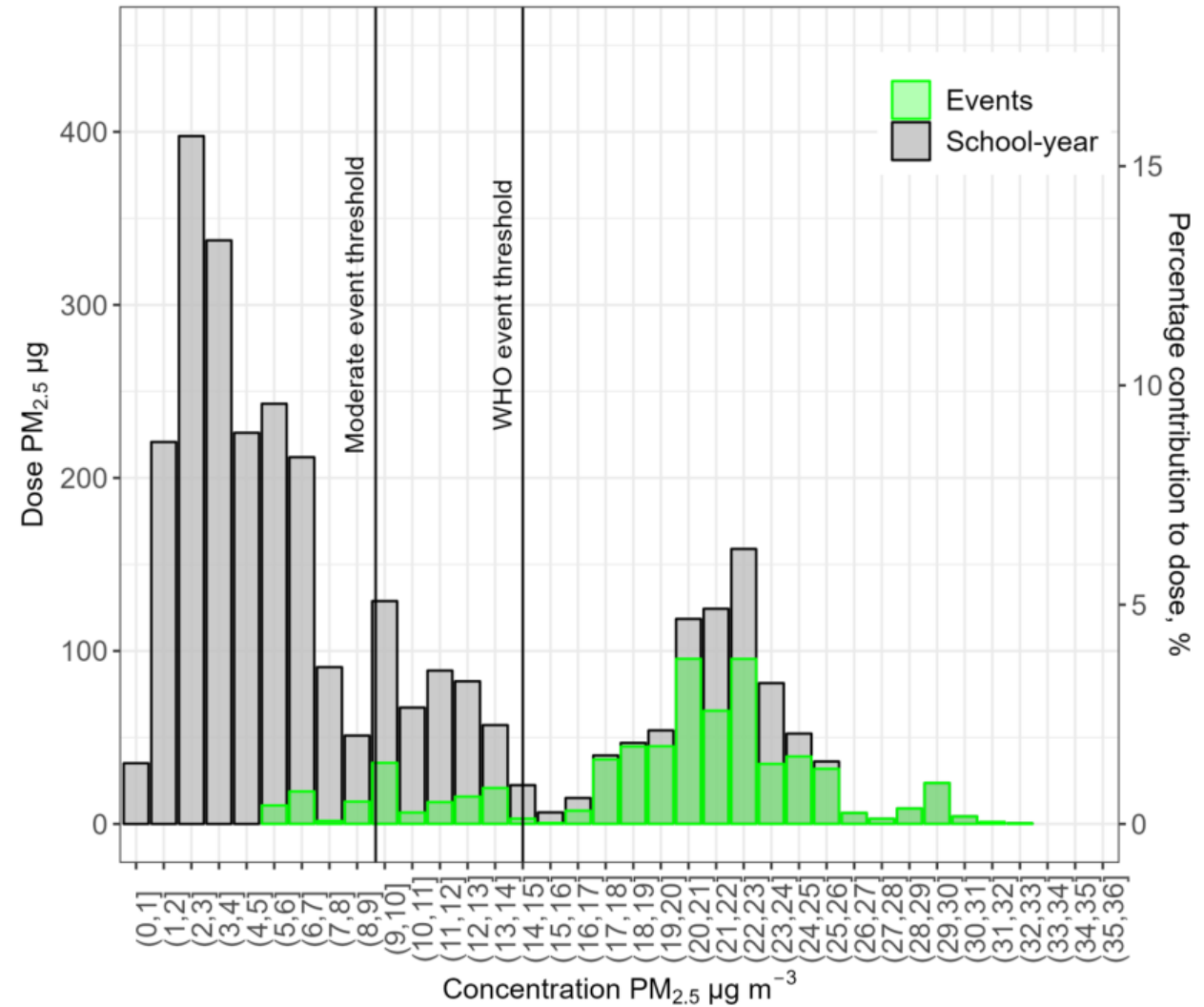
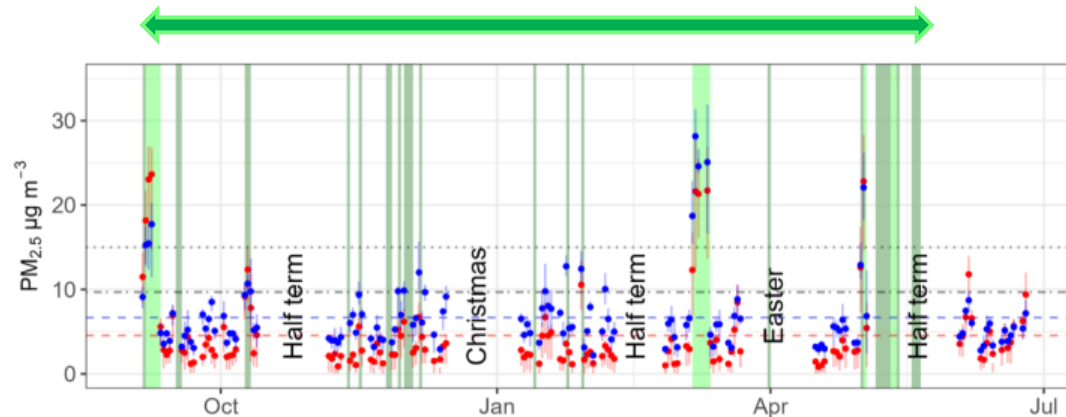
$$\text{Potential dose } (\mu\text{g}) = \int Q C dt$$



# Potential implications of PM<sub>2.5</sub> in schools

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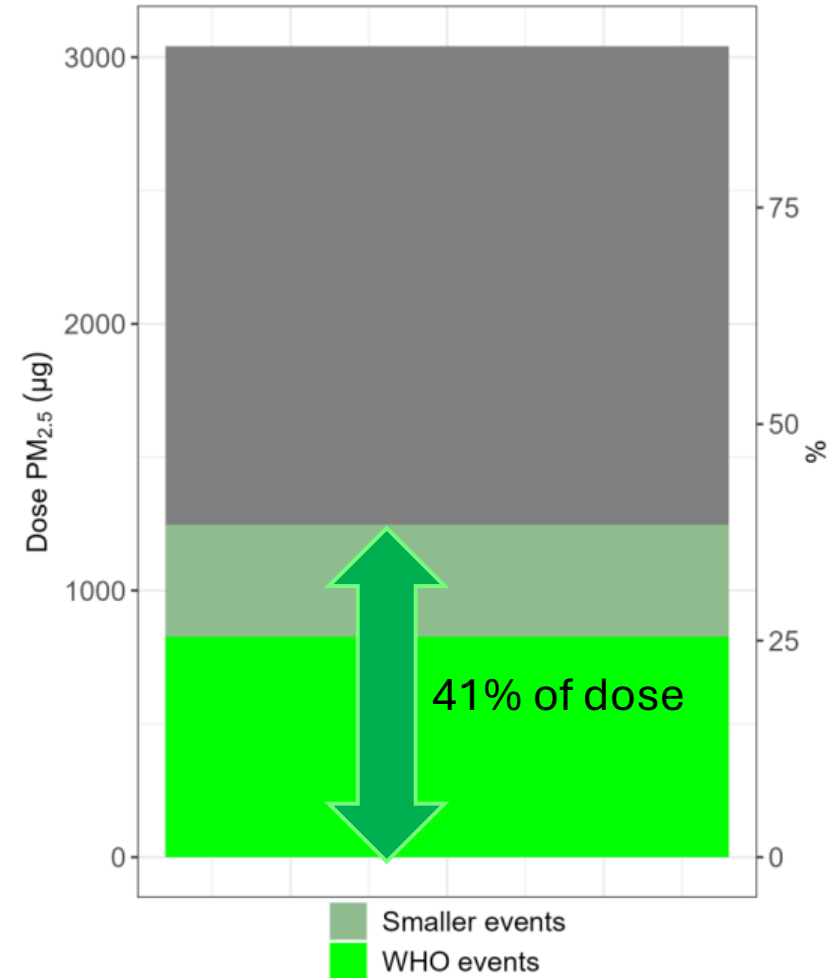
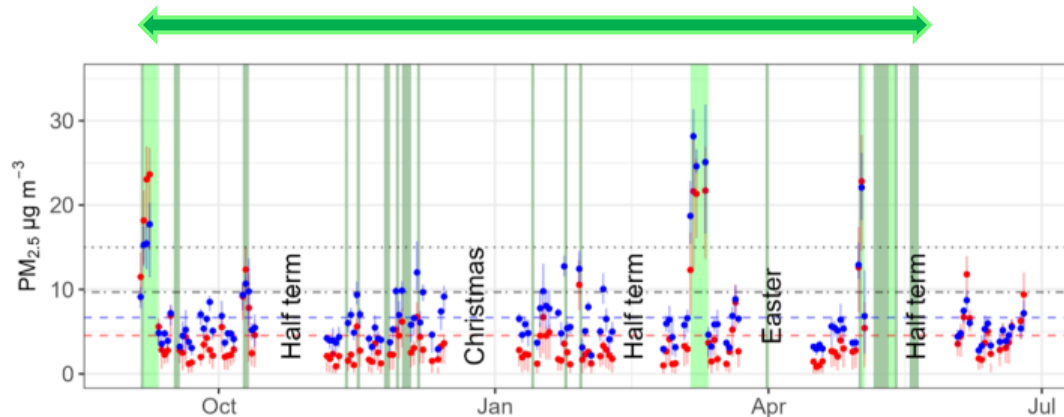


# Potential implications of PM<sub>2.5</sub> in schools

Estimating the potential dose of PM<sub>2.5</sub> received

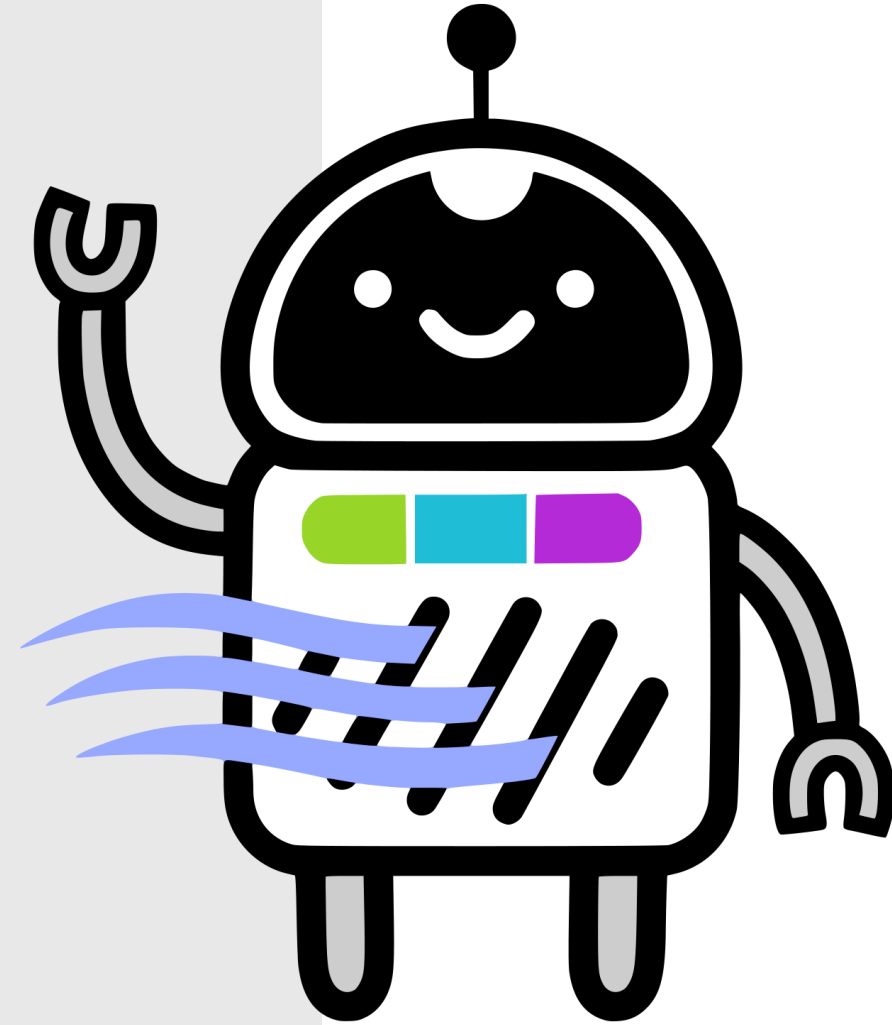
$$\text{Potential dose } (\mu\text{g}) = \int Q C dt$$

13% of school days



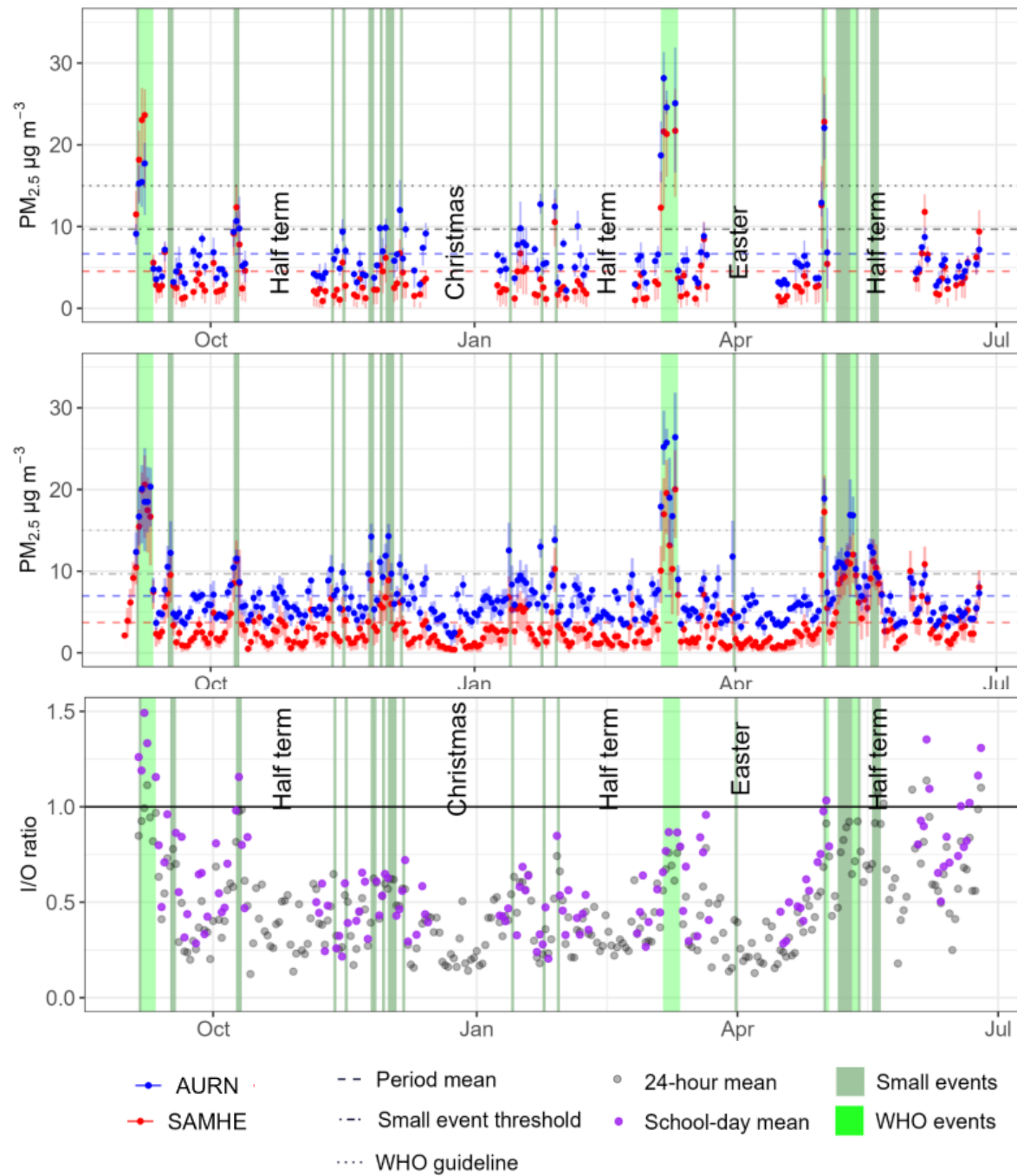
# Conclusions

- Classroom PM<sub>2.5</sub> concentrations closely linked to outdoor PM<sub>2.5</sub> concentrations
- Outdoor air is a significant source of PM<sub>2.5</sub>
- Whilst long-term exposure is predominantly due to low concentration days, 'outdoor PM<sub>2.5</sub> events' contribute significantly





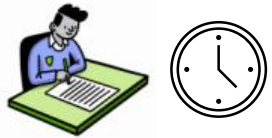
# I/O ratio



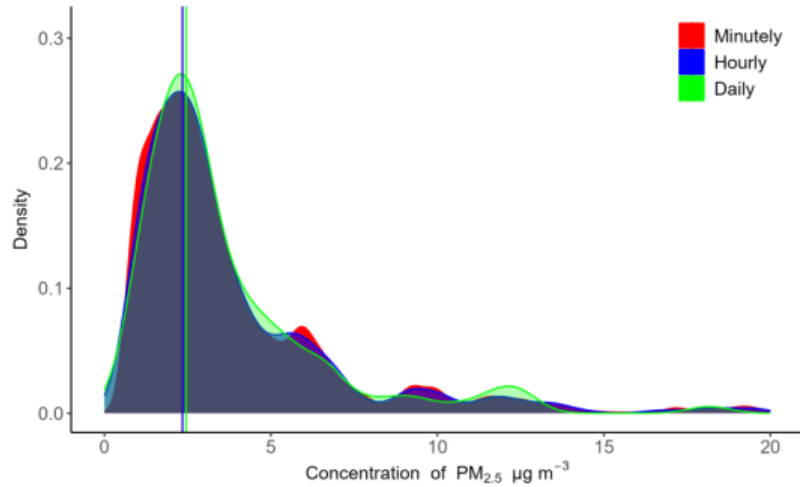


# Time resolution

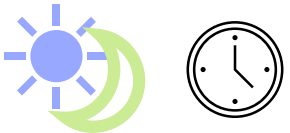
School days



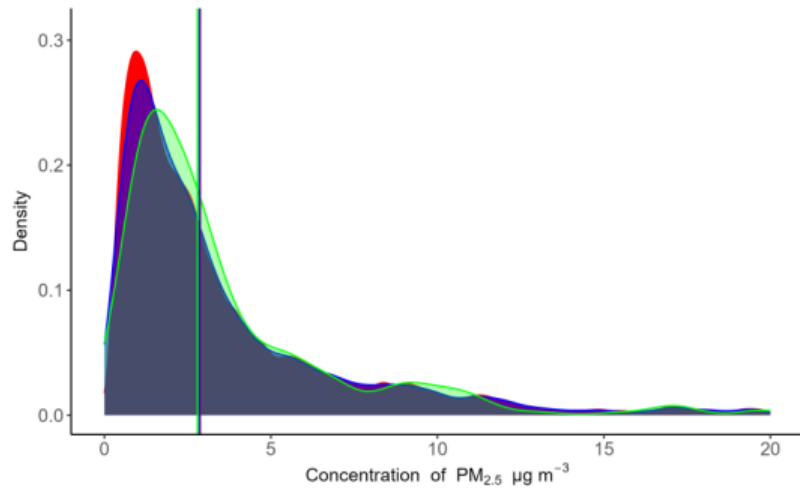
09:00 - 16:00



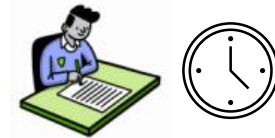
Every day



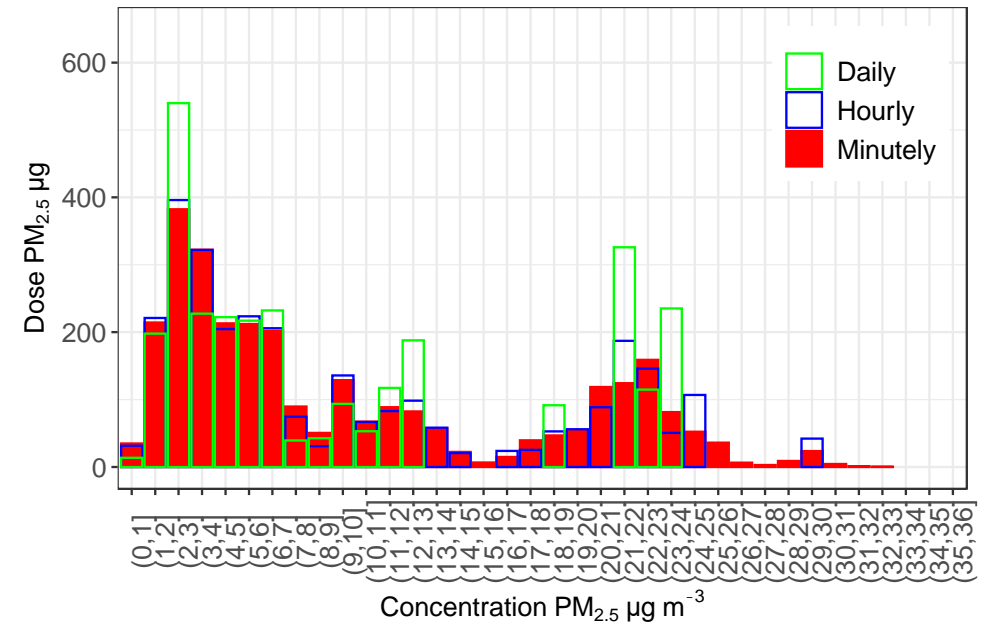
24 hours



School days



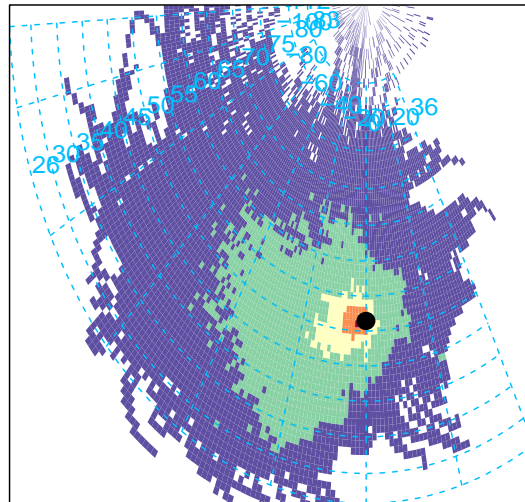
09:00 - 16:00



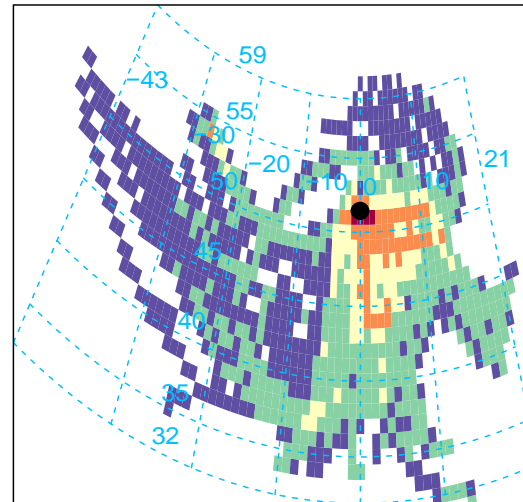
# Events

Gridded frequency

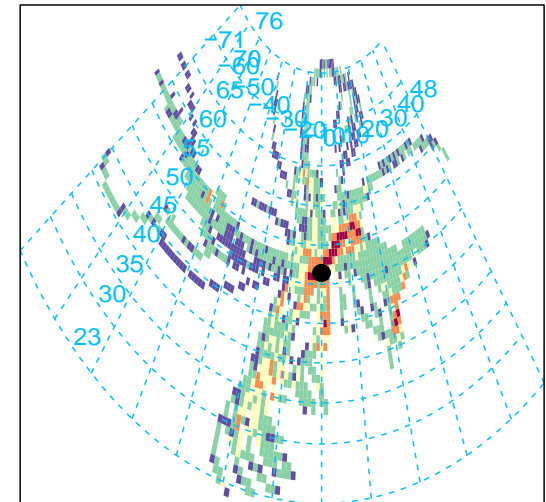
Entire Year



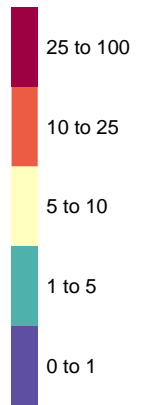
WHO PM<sub>2.5</sub> Events



Moderate PM<sub>2.5</sub> Events



% trajectories



Clustered back trajectories

