CEDEUS
Centro de Desarrollo Urbano Sustentable

Medellín, Colombia
CASAP X
CONGRESO COLOMBIANO Y CONFERENCIA INTERNACIONAL DE CALIDAD DE AIRE, CAMBIO CLIMÁTICO Y SALUD PÚBLICA

Identifying spatiotemporal patterns in air quality: applications in source apportionment

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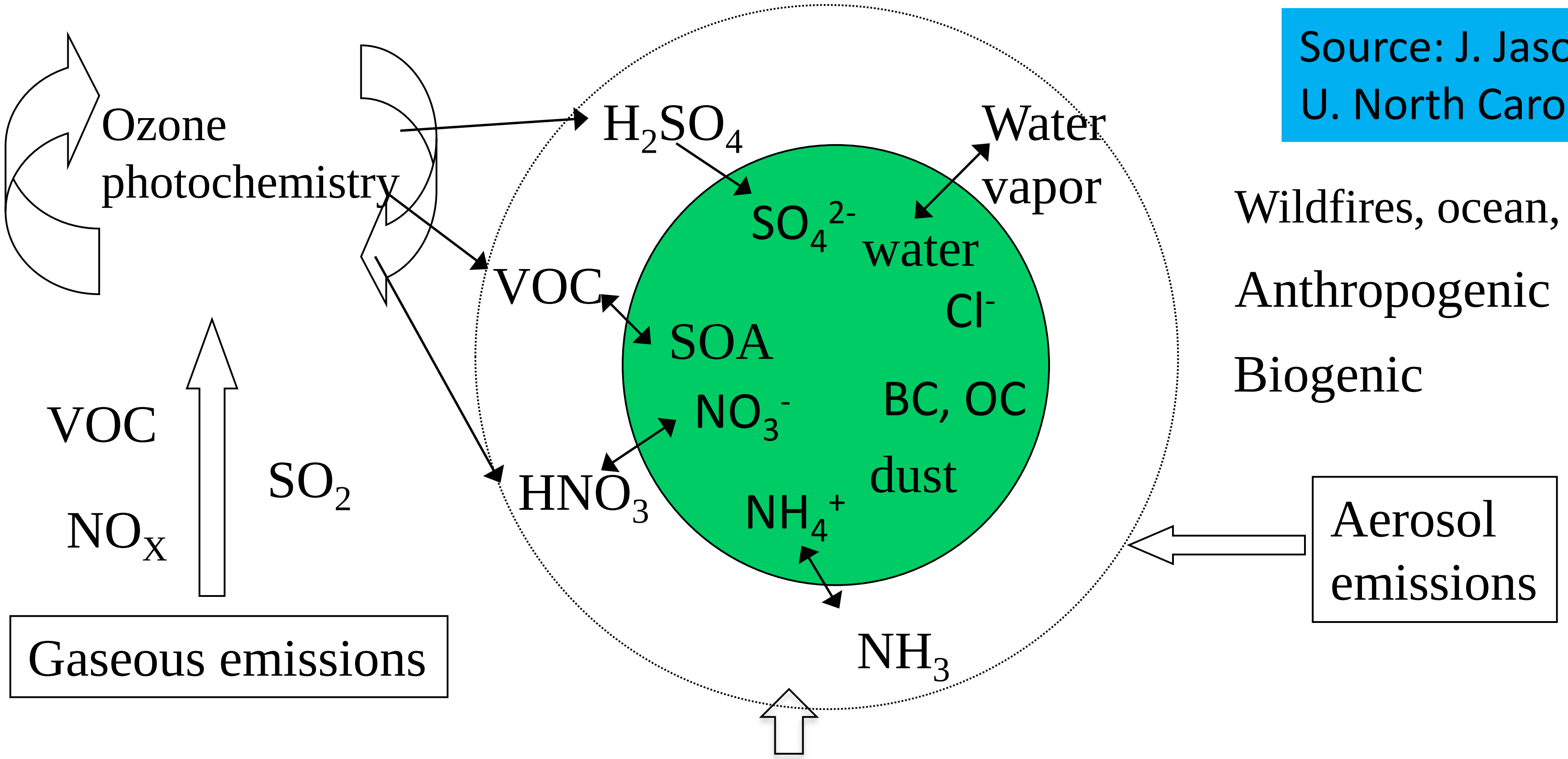
- The NLHPC infrastructure and their supporting staff}
- Comité organizador CASAP X

Introduction: how to handle air pollution?

“Too many moving parts”

Source: J. Jason West
U. North Carolina



Wildfires, ocean, deserts

Anthropogenic

Biogenic

IVOC/SVOC emissions (VBS)

Which emission controls are better?

Introduction: Source Apportionment approaches

- Air Quality Modeling (AQM): applicable to all pollutants, gases and particles
  - Problem: error propagation is hard to quantify
  - Advantage: generate spatiotemporal (STP) distribution of pollutants
- Receptor Modeling (RM): applicable only to particulate matter
  - Problem: expensive to carry out, cannot be applied retrospectively, only a few sites are characterized per city
  - Advantage: uncertainties are easier to estimate, results must obey the mass balance for tracers

A new approach: fuzzy clustering

- Assumption:
  - Total pollutant concentration = sum {source contributions}
- Traditional cluster analysis is a hard classification
- Outliers pose additional problems
- Fuzzy clustering approach:
  - Each observation ‘i’ may belong to one or more clusters ‘j’
  - Probability is the membership function u_{ij}
  - FC is mass preserving by design (partitioning)
  - Outliers are explicitly handled

Fuzzy Spatiotemporal apportionment (FUSTA)

- Observations: X={SO_2/PM_{10}/$PM_{2.5}$,w. speed, w. direction, temp., press.}

$$\min_{U,C} J_{FKMNE} = \sum_{i=1}^{n}\sum_{k=1}^{p} u_{ik}\cdot\|x_i - c_k\|^2 + t\cdot\sum_{i=1}^{n}\sum_{k=1}^{p} u_{ik}\cdot\log(u_{ik}) + \sum_{i=1}^{n}\delta^2\left(1-\sum_{k=1}^{p} u_{ik}\right)^2$$

- $s.t. \quad u_{ik} \in [0,1]; \sum_{k=1}^{p+1} u_{ik} = 1$

- Computations are carried out using package *fclust* in R environment (Ferraro and Giordano, 2019)

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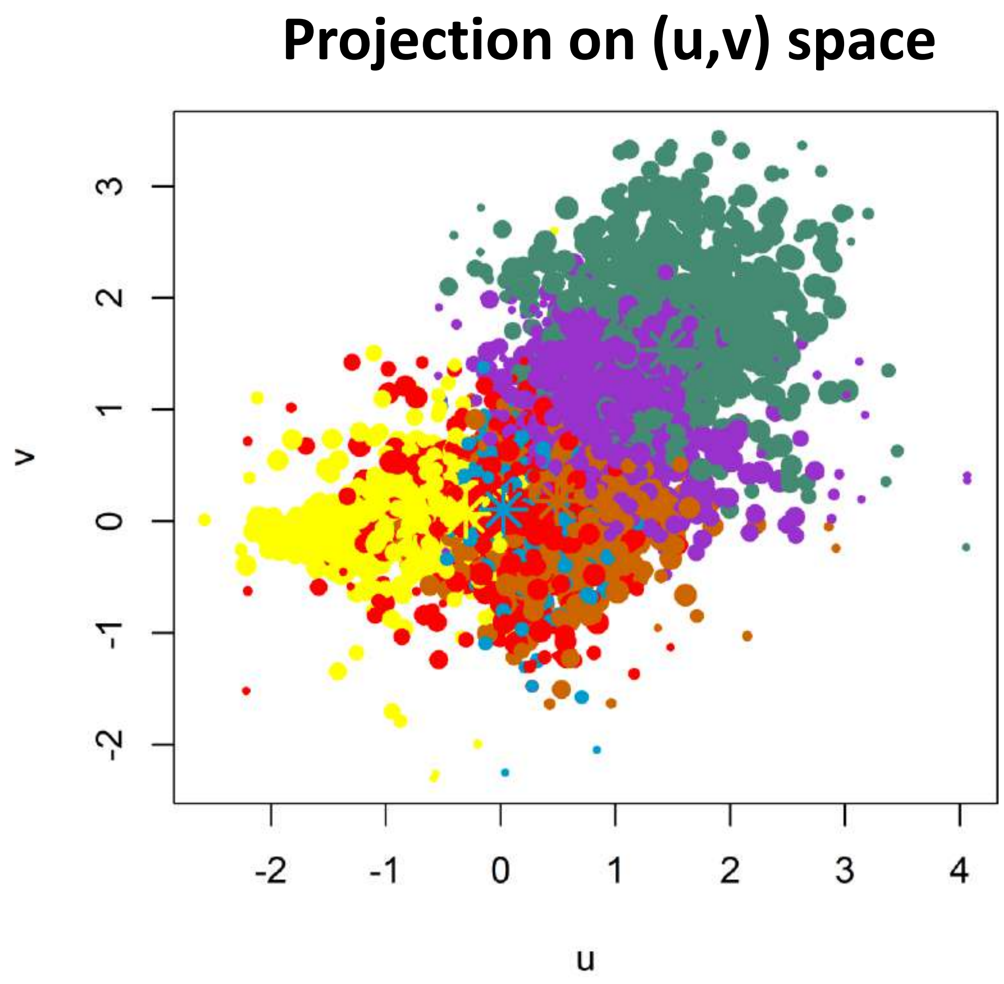
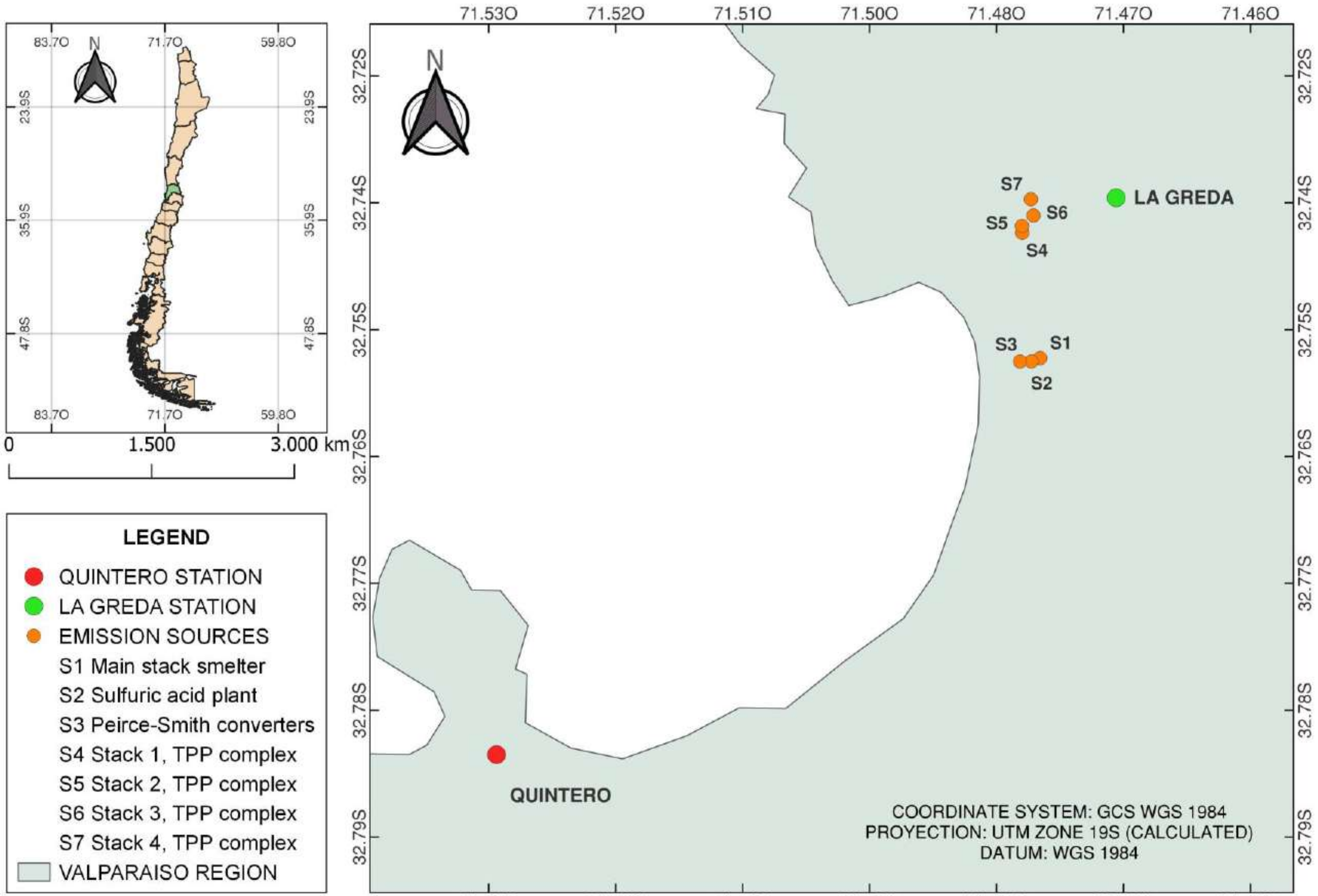
Example of application with p=5



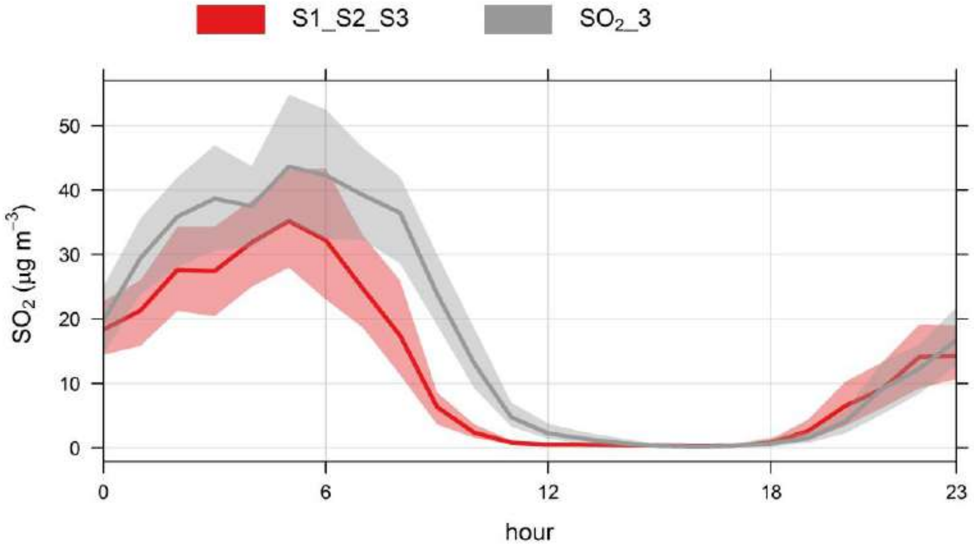
Symbol magnitudes proportional to the membership values.
Noise cluster is implicit.

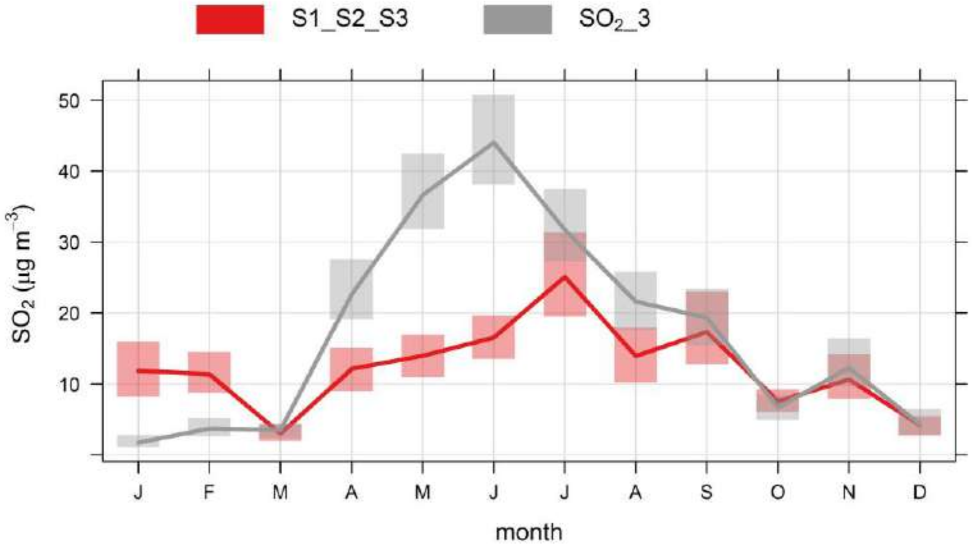
Case study 1: industrial area

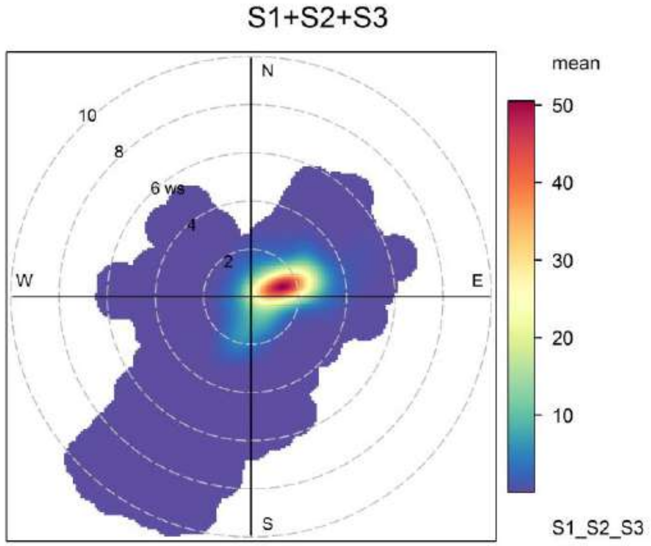


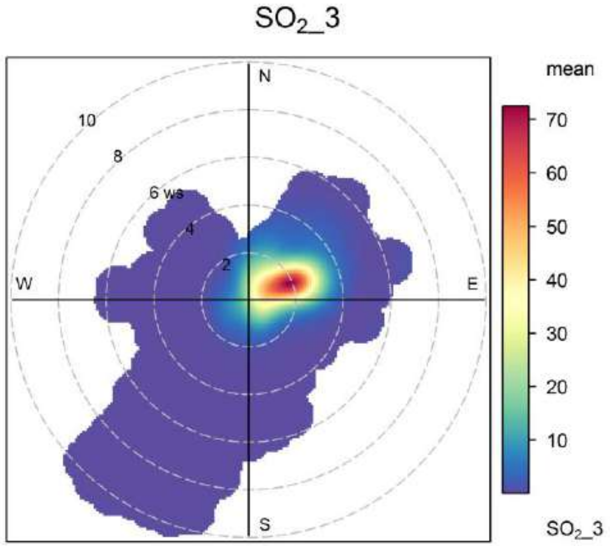
Jorquera H., Villalobos A.M.
Journal of Hazardous Materials,
443 B, 130335, 2023.

Case study 1: predicted contributions of copper smelter on red receptor





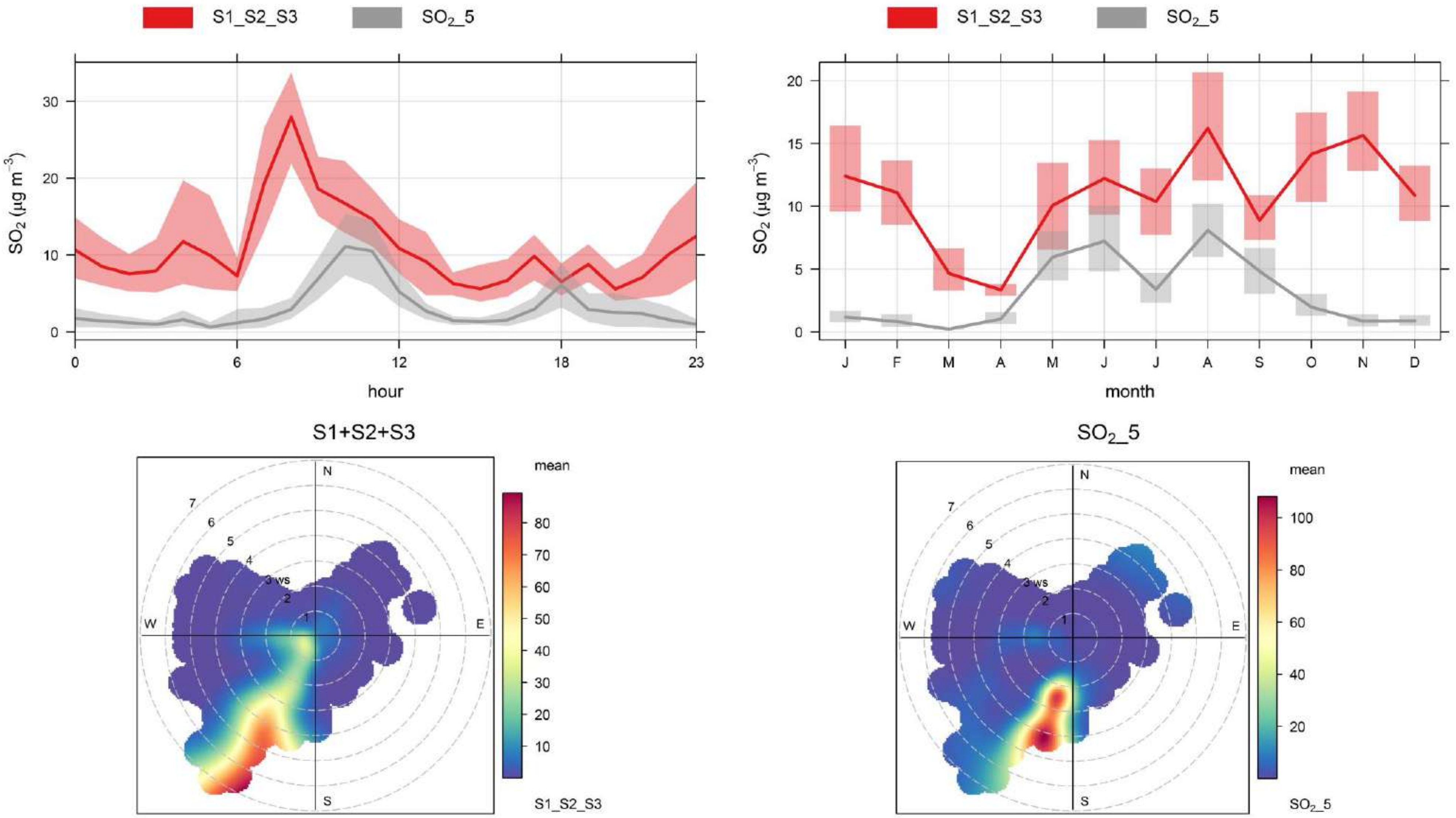




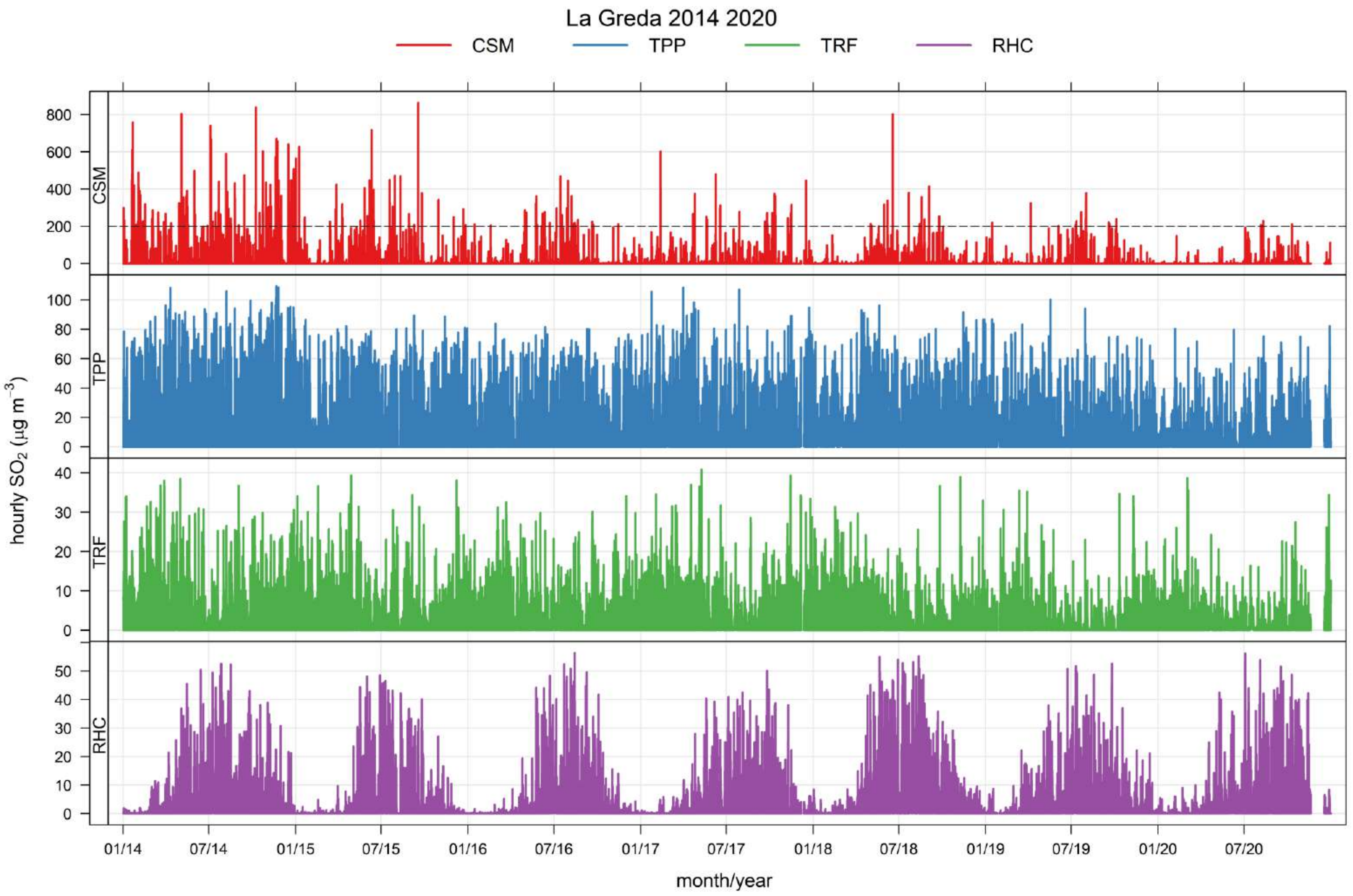
AQM: WRF-CALPUFF+
CEMS emissions

Case study 1: predicted contributions of copper smelter on green receptor

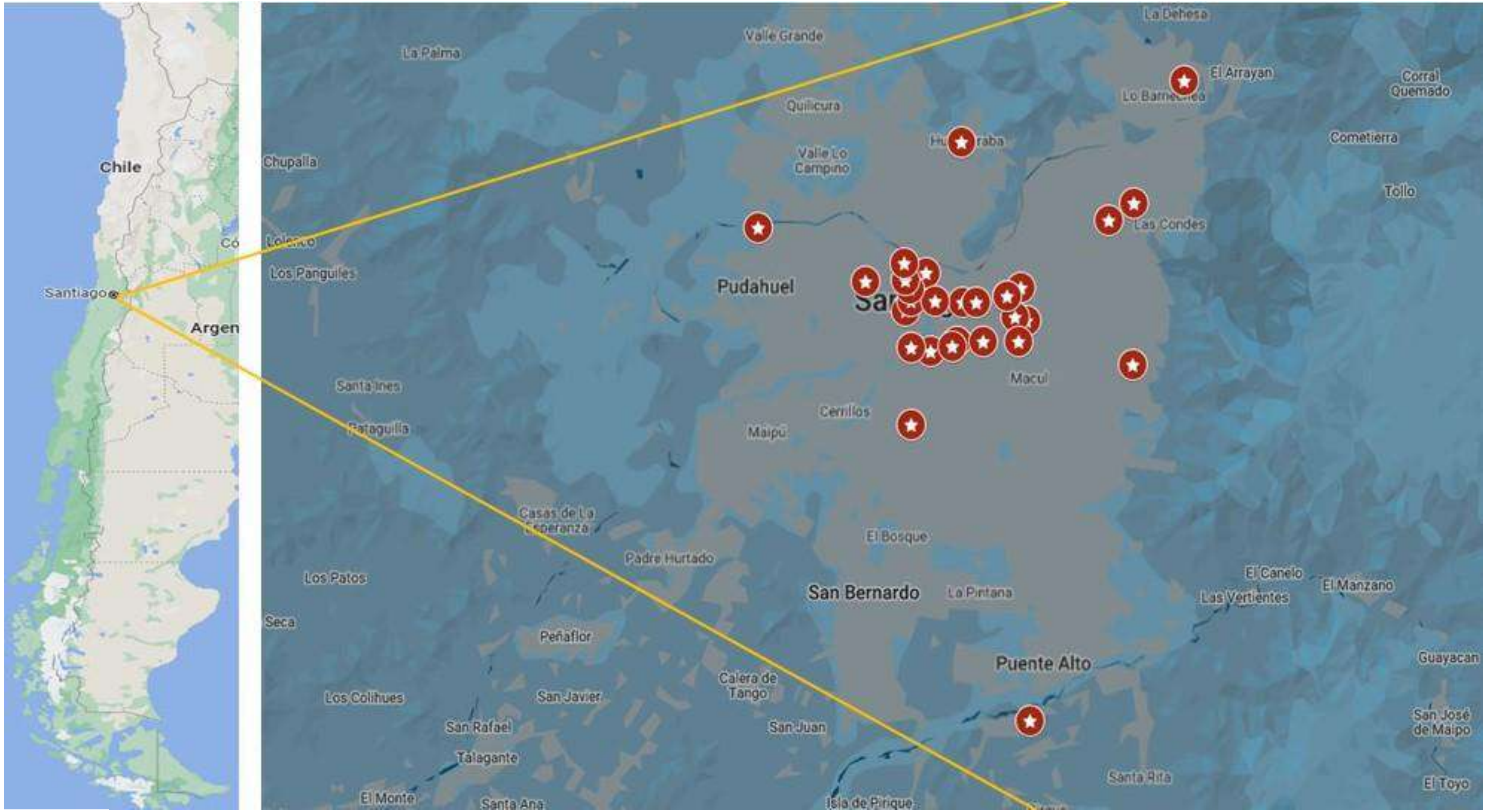
AQM: WRF-CALPUFF+
CEMS emissions



Long-term SO_2 SA



Case study 2: outdoor/indoor $PM_{2.5}$ in schools



S. Nourani and H. Jorquera, Environmental Science - Processes & Impacts, 2024, december

Monitoring campaign

30 naturally ventilated schools

The measurement was carried out with low-cost sensors.

Temperature, relative humidity (RH) and CO_2 concentration were measured using HOBO® CO2 loggers.

S5- Far classroom

S11- Outdoor

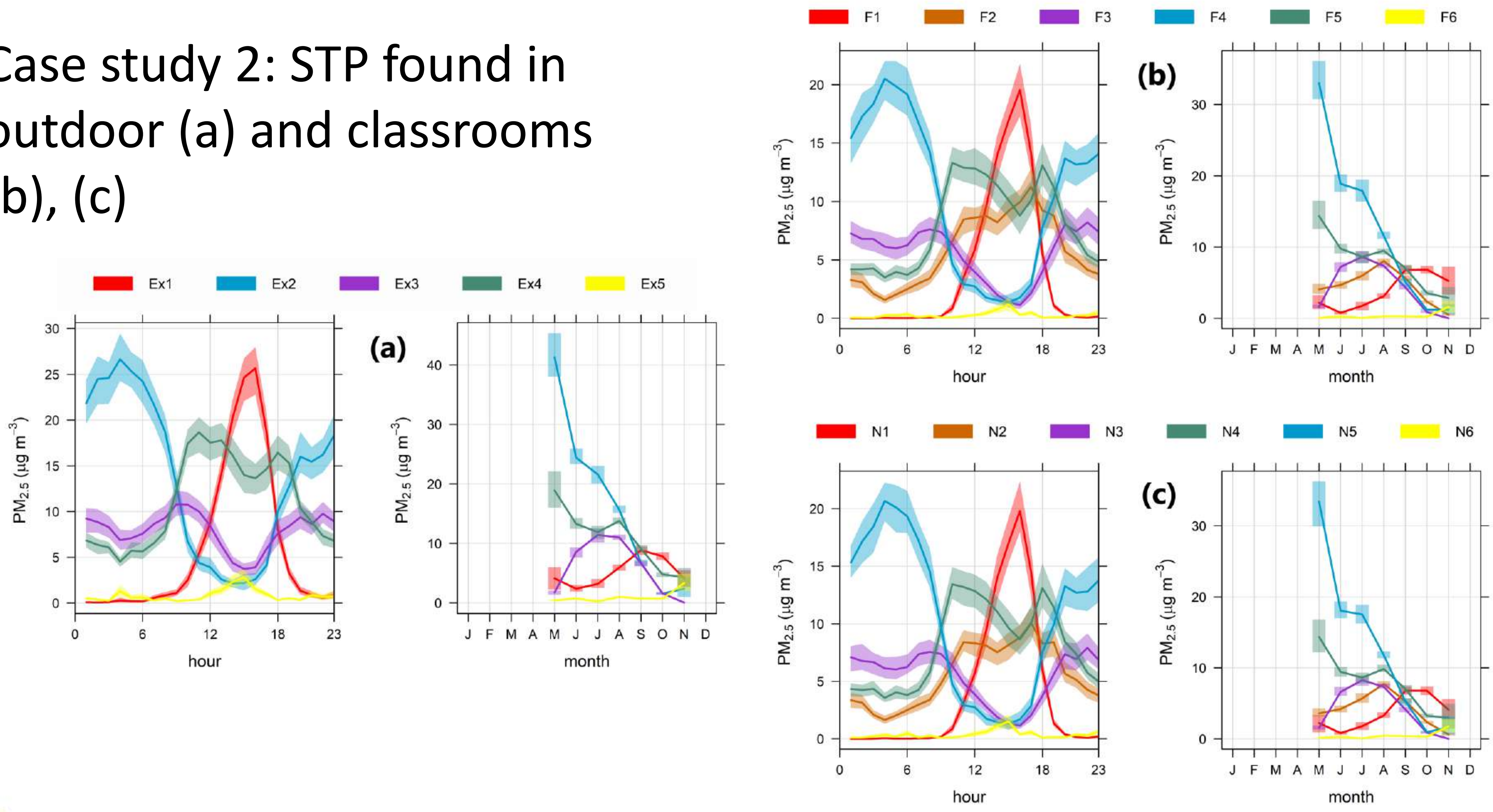
PurpleAir Inc, UT, USA

Onset HOBO MX1102A

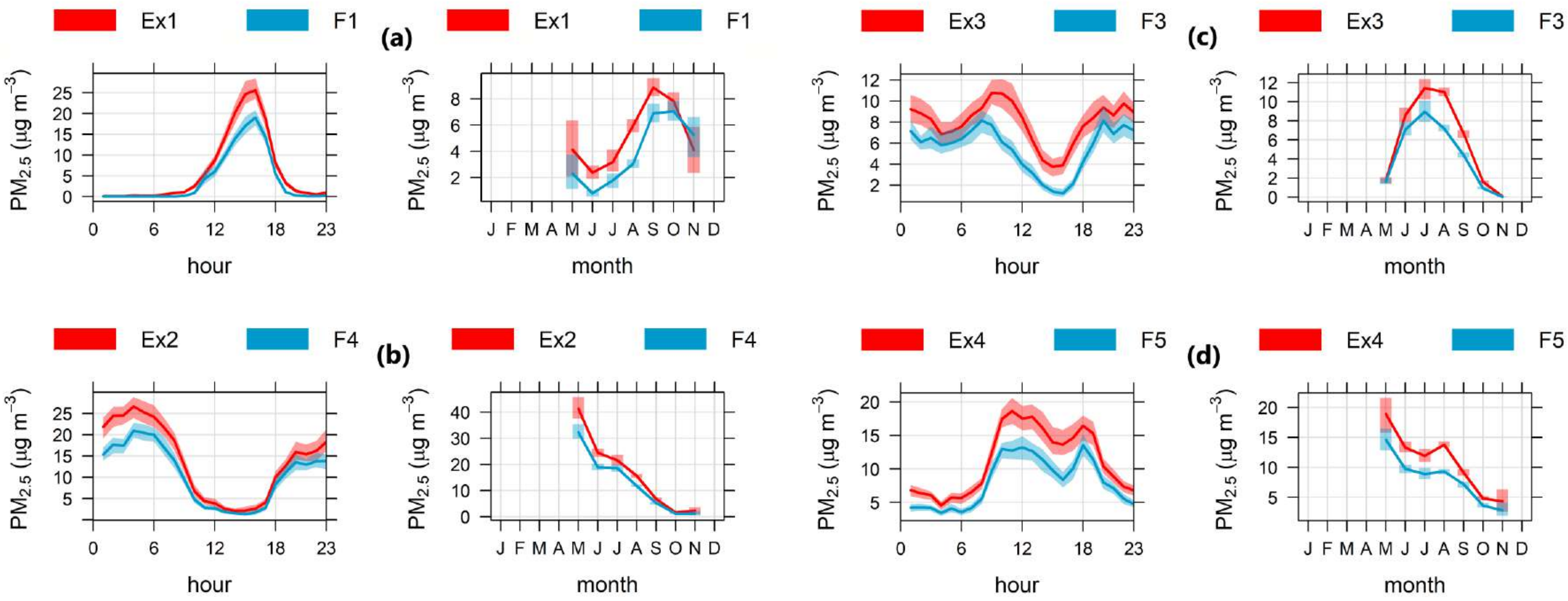
S30- Near classroom

12

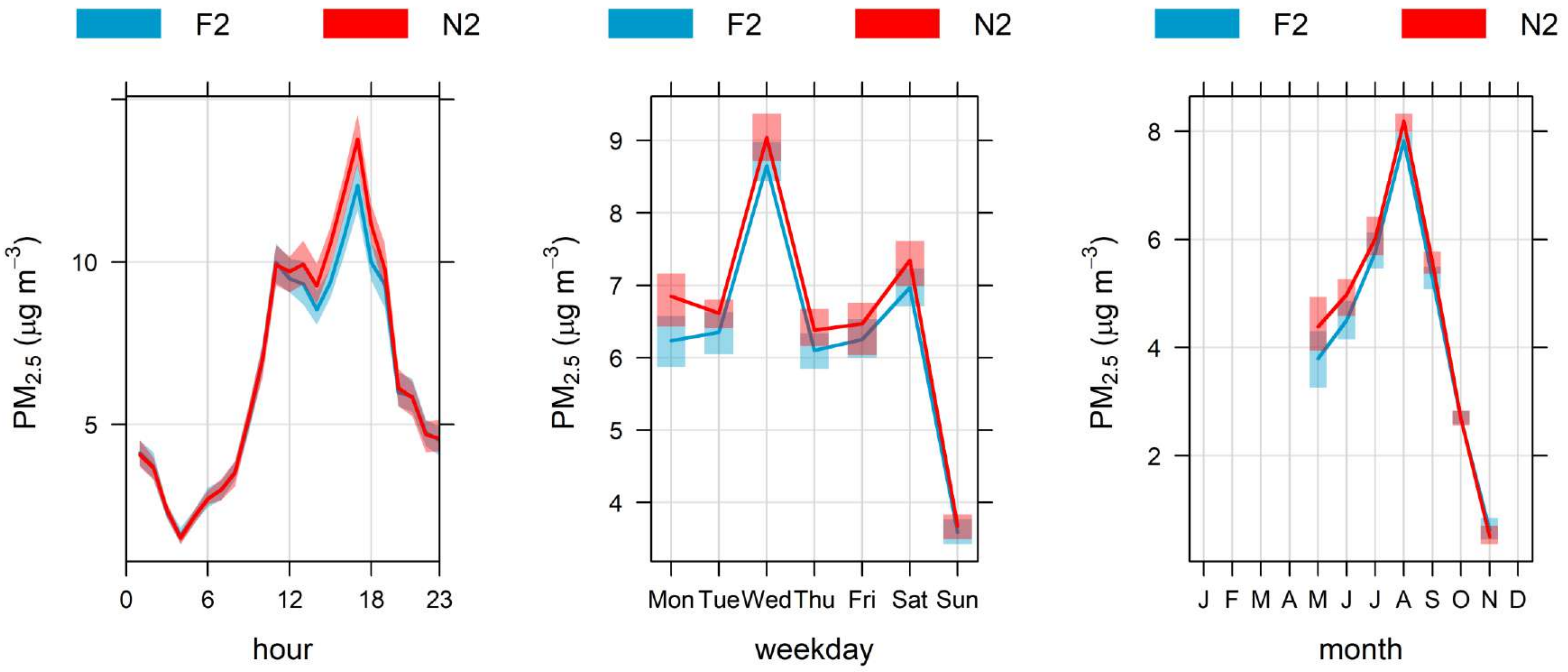
Case study 2: STP found in outdoor (a) and classrooms (b), (c)



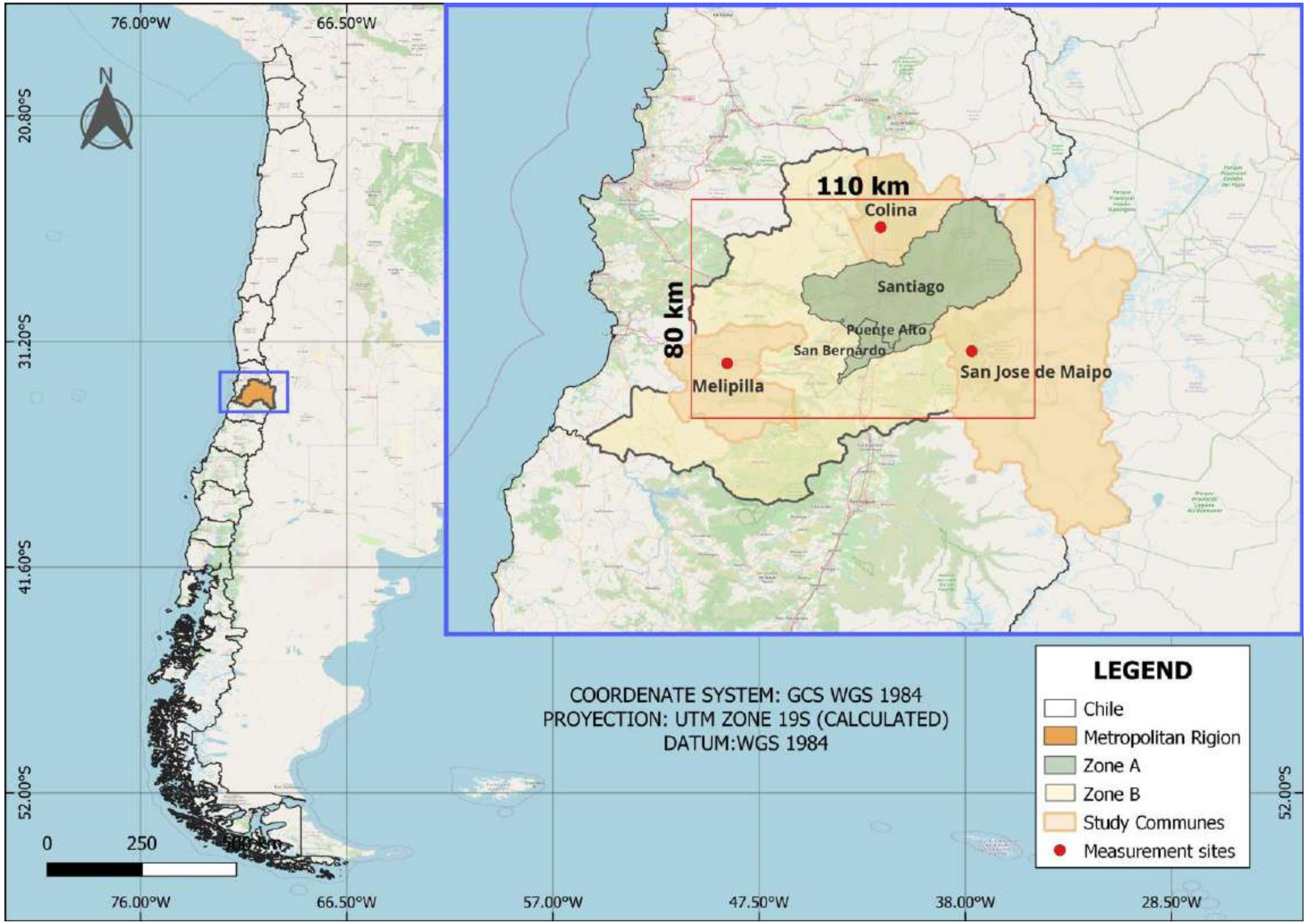
Case study 2: outdoor/indoor $PM_{2.5}$ by cluster



Case study 2: indoor generated $PM_{2.5}$

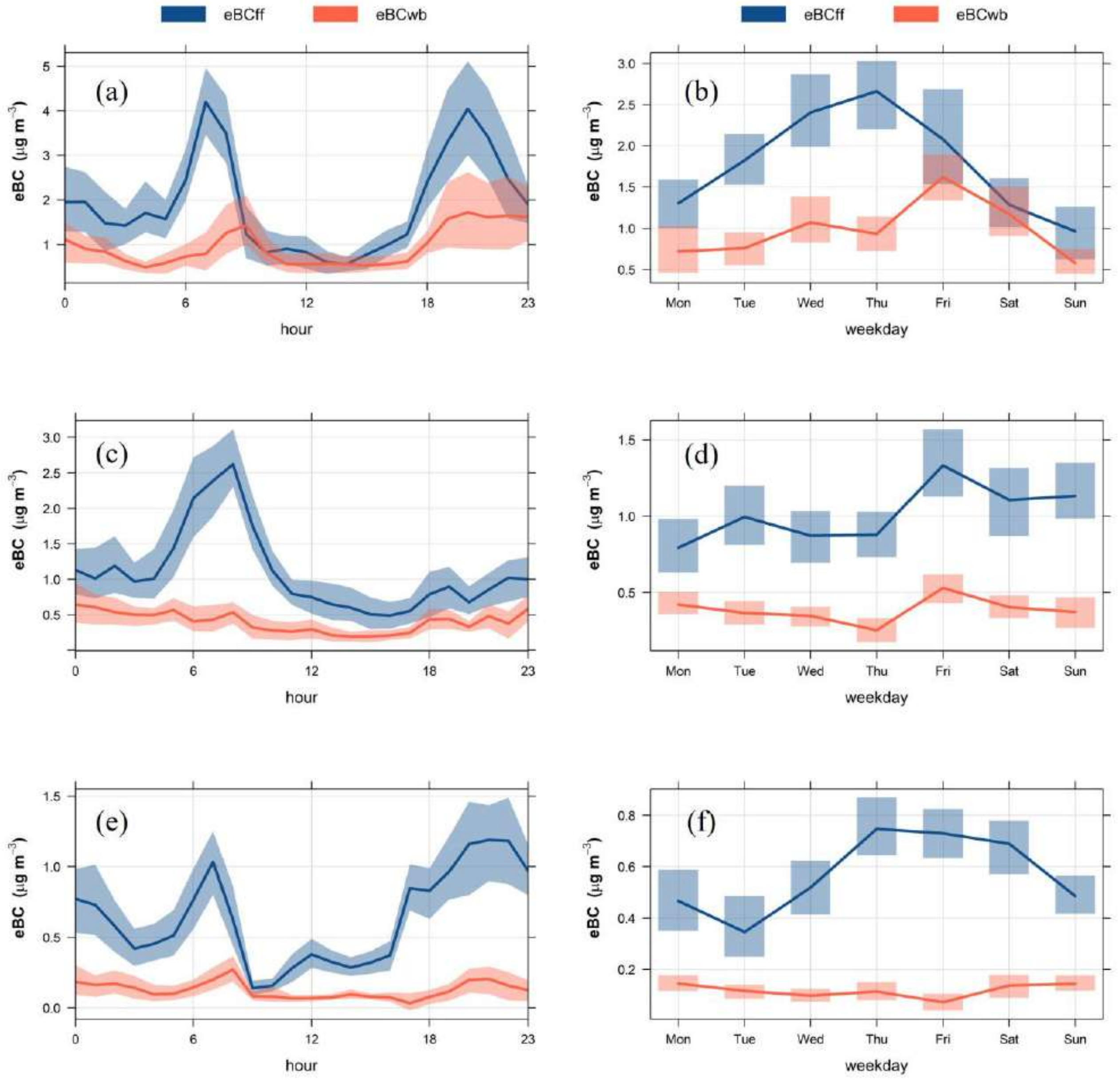


Case study 3: estimating local and non-local BC contributions in three suburbs of Santiago, Chile

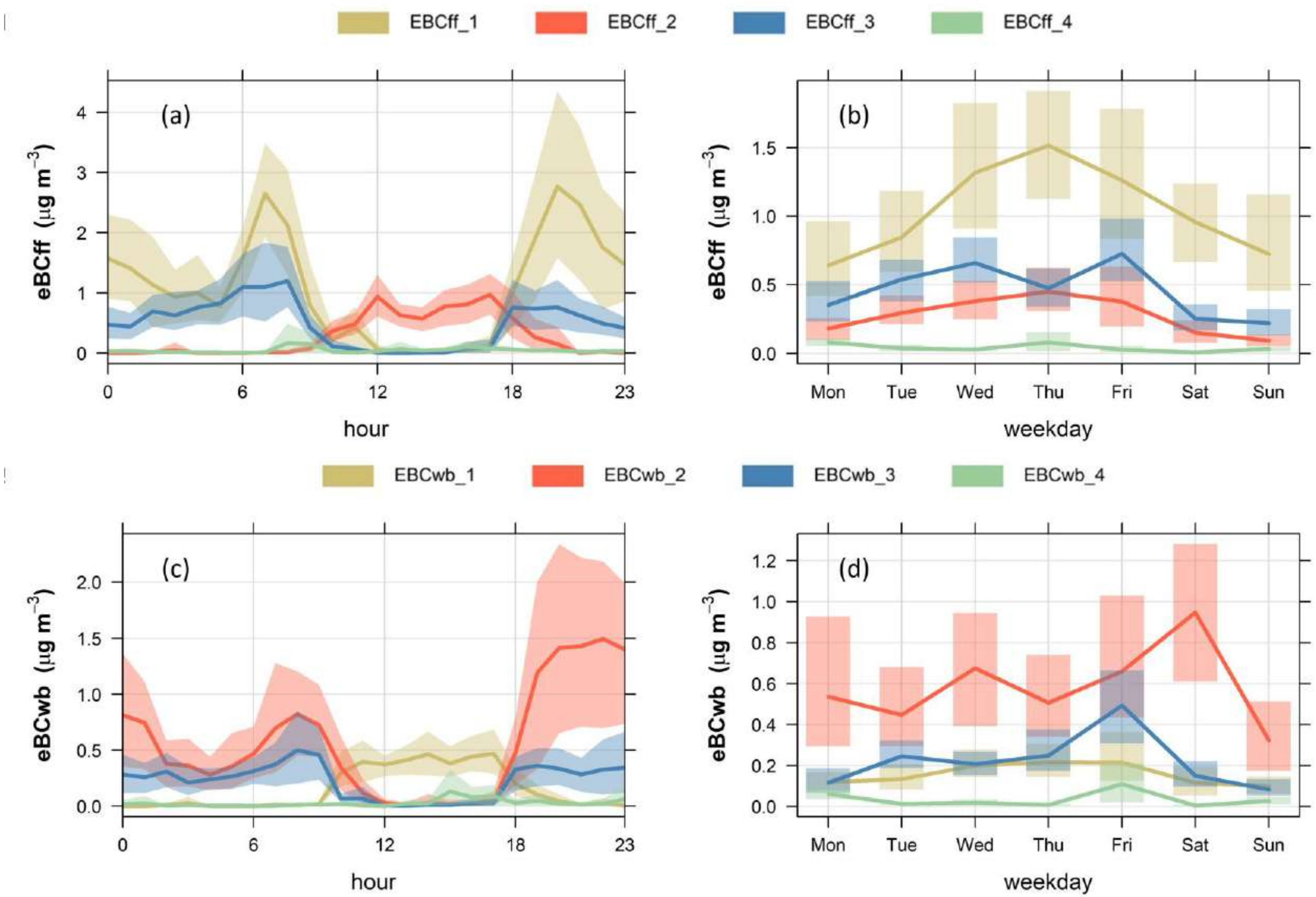


J. Rodríguez, AM Villalobos, J. Castro-Molinare, H. Jorquera, Environmental Pollution, Volume 346, 2024, 123568

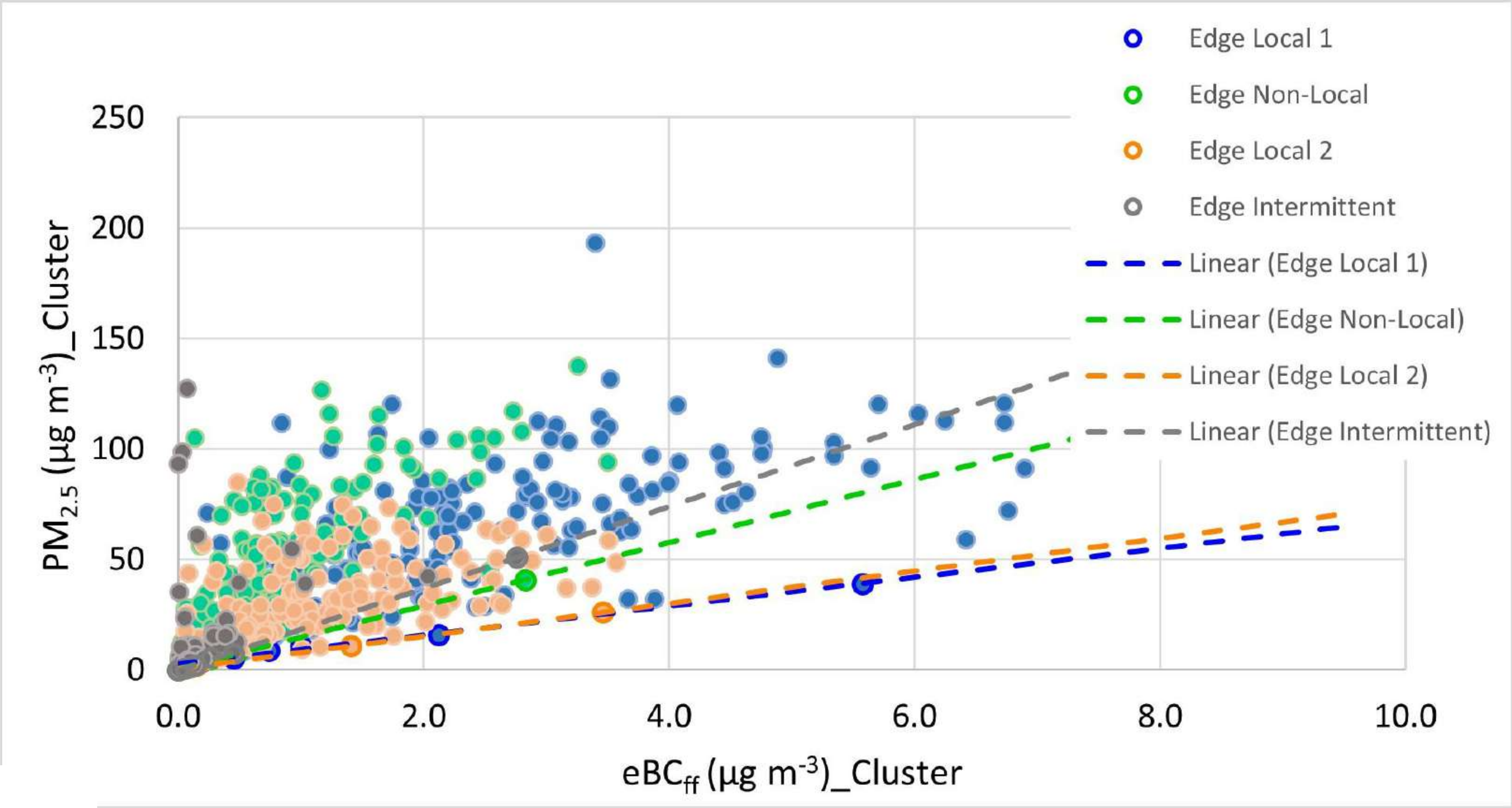
Case study 3: standard BC source contributions by applying aethalometer model to multiwavelength optical absorption data



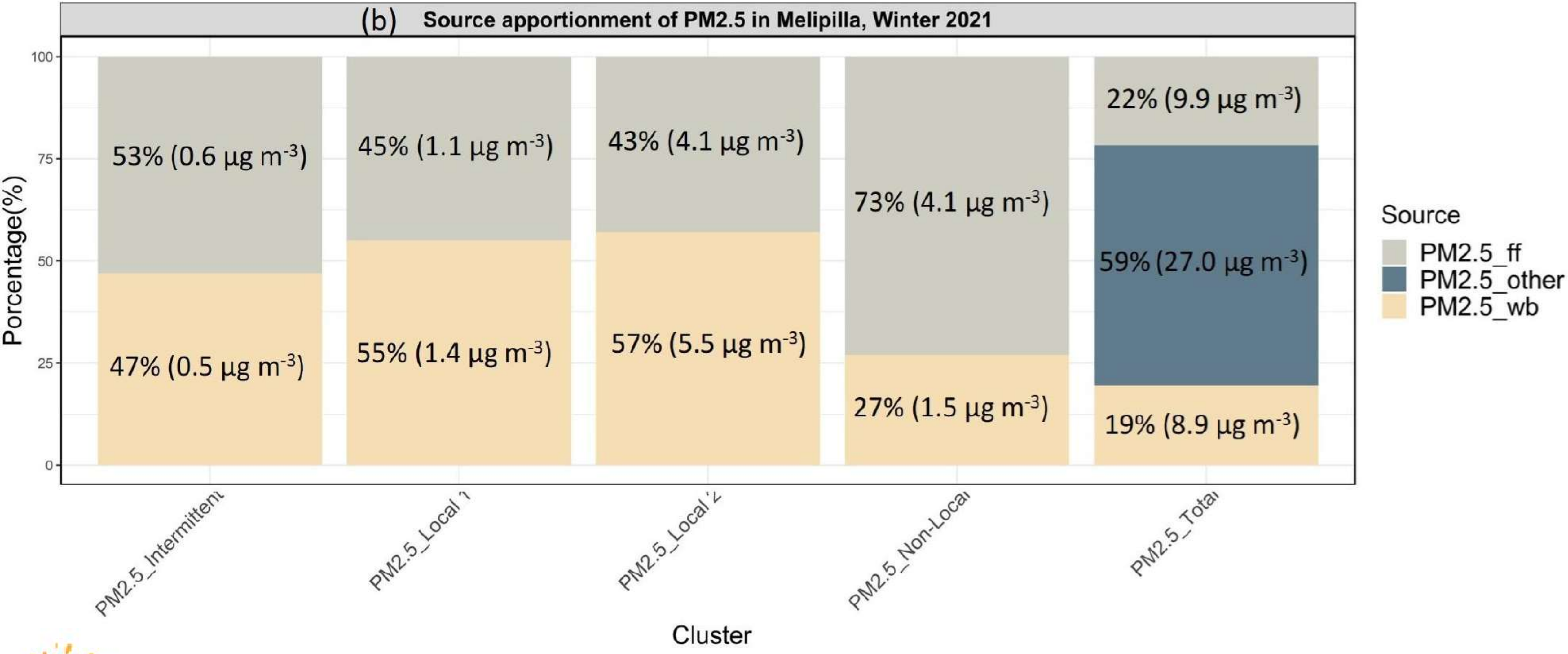
Case study 3: FC applied to eBC fractions (Colina site)



Case study 3: Implications for tracer method



Case study 3: Source identification results



CONCLUSIONS

- FUSTA is a new data-driven method for source identification
- It only requires ambient data for a pollutant and meteorology
- The method can handle pollutant outliers
- Applications include:
  - Source apportionment of gaseous pollutants
  - Discriminating among local and non-local pollution sources
  - Estimating indoor-generated PM contributions
- Results may be used to constrain specific emission sources
  - By using AQM without boundary conditions