The Impact of Temperature Inversions on Black Carbon and Particle Mass Concentrations from Wood Burning in a Mountainous Area

Kristina Glojek, Griša Močnik, Honey Alas, Andrea Cuesta-Mosquera, Luka Drinovecb, Asta Gregorič, Matej Ogrin, Kay Weinhold, Irena Ježek, Thomas Müller, Martin Rigler, Maja Remškar, Dominik van Pinxteren, Hartmut Herrmann, Martina Ristorini, Maik Merkel, Miha Markelj and Alfred Wiedensohler

University of Ljubljana, Faculty of Arts, Department of Geography

Contact: kristina.glojek@ff.uni-lj.si

MOTIVATION

The issue of quality of air in rural hilly and mountainous areas remains neglected and is often underestimated (Holmes et al., 2015; Largeron & Staquet, 2016 and the reference therein).

The aim of the study:

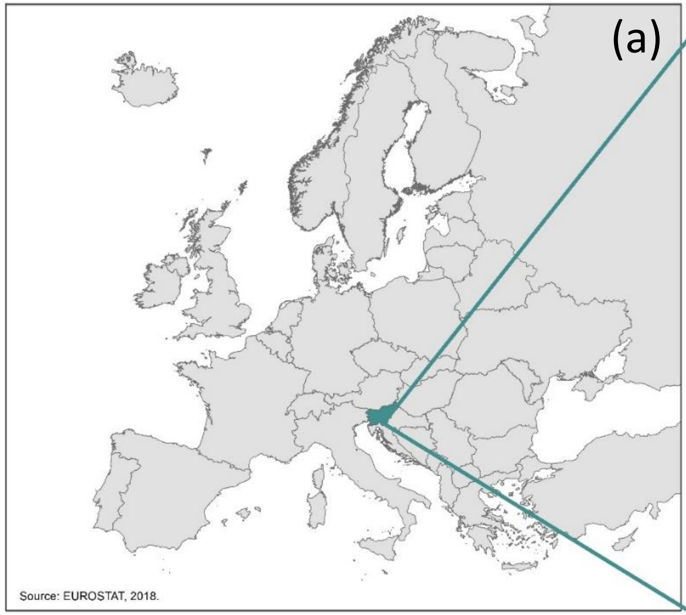
to quantify the influence of ground temperature inversions on spatiotemporal variability of wood combustion aerosol pollution in mountainous regions, an example of which is the model region Loški Potok, Slovenia.

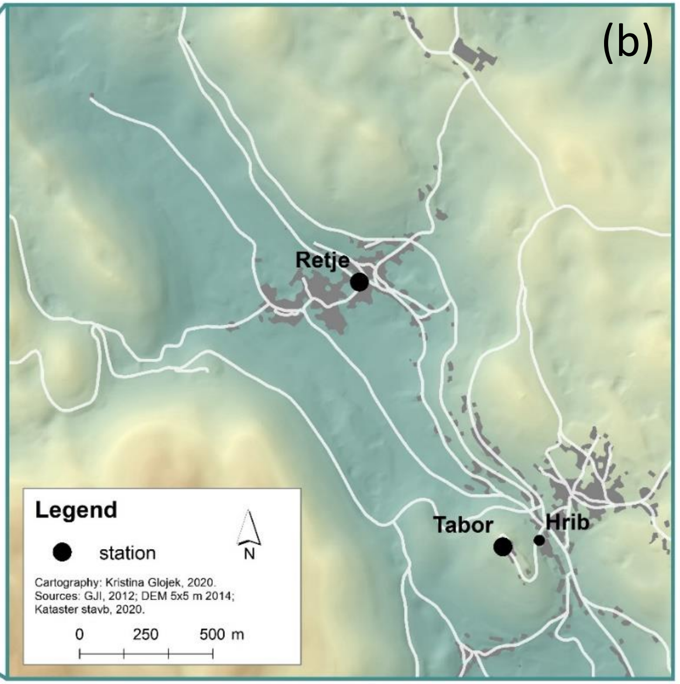
Measurement site

Model region Loški Potok, Slovenia.

The studied area with two air-quality stations (Retje, Tabor) and a meteorlogical station (Hrib) (b).*

Location of Slovenia (a).

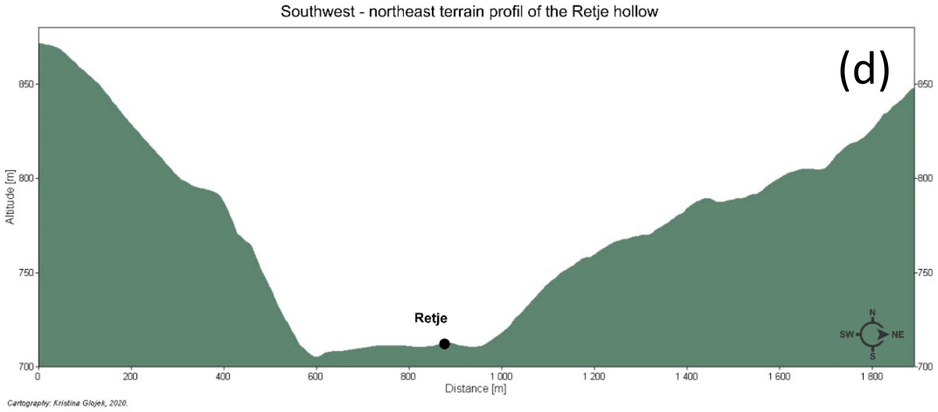




* Retje (715 m a.s.l) – rural village; Tabor (815 m a.s.l) – rural background.

View of the Retje karst hollow from the station Tabor (c).

Profile of the terrain across the Retje karst hollow with the village at the bottom (d).



METHODS
Instrumentation

Description of mobile and reference instruments

Parameter	Instrument	Specifications	Time resolution	Measurement
Equivalent black carbon (eBC)	microAethalometer AE51, AethLabs	λ: 880 nm σ: 12.1 m^2/g	10 sec	Mobile
	Aethalometer AE-33, Magee Scientific	λ: 880 nm σ: 7.7 m^2/g	1 min	Stationary (reference)
Particulate matter (PM)	Optical particle size spectrometer OPSS, 3330, TSI	Size range: 0.3-10 µm	10 sec	Mobile
	Mobility particle size spectrometer MPSS, TROPOS & TSI	Size range: 0.01- 0.8 µm 0.01- 0.6 µm	5 min	Stationary (reference)
T, RH, p	Meteo. Sensor, TPR 159, AMES	± .15 °C; ± 2 % RH; ± 1 mbar	1 min	Stationary

λ – wavelength
σ – mass absorption cross-section (coefficient)

Mobile measurements

- A fixed route across the hollow.
- „Runs“ with two instrumented backpacks, three times a day.
- A 10- & 20-min intercomparison between mobile and reference instruments for each run.
- Winter 2017/18.

Methodological approach for high quality mobile measurements introduced by Dawn C. Alas, H. et al. (2019).

Performance of micro Aethalometers in the campaign presented in Dawn C. Alas, H. et al. (2020).

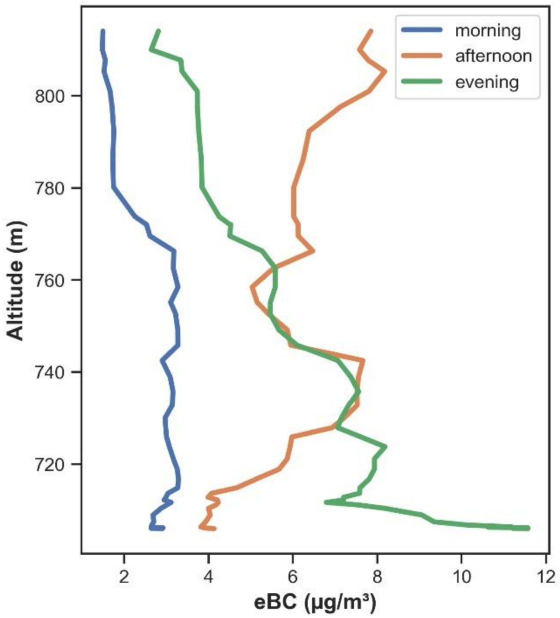
Selection of temperature inversion periods

- The vertical temperature gradient method (Whiteman et al., 2004):
  - increasing temperature with height → *temperature inversion*
  - decreasing temperature with height → *mixed atmosphere*
- Determination of the mixing height (MH) during temperature inversion periods from eBC profiles (Ferrero et al., 2010).

Number of mobile measurement runs during the campaign.

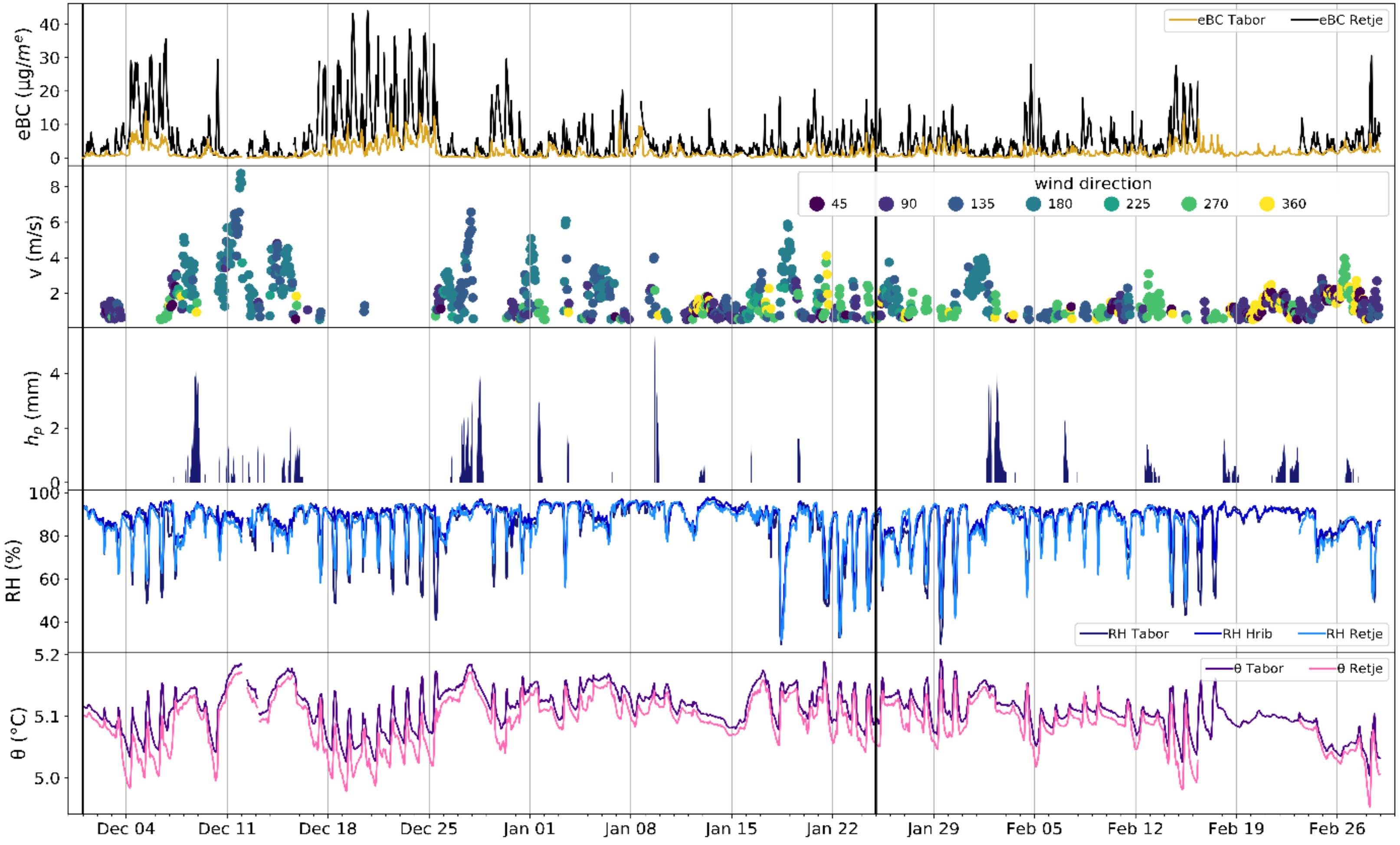
Time of day (CET)	# of runs with T inversion	# of runs with mixed atmosphere
6.30–9am	21	17
12–2pm	7	13
5–7pm	15	18
altogether	43	48

Average vertical eBC profile during T inversions.

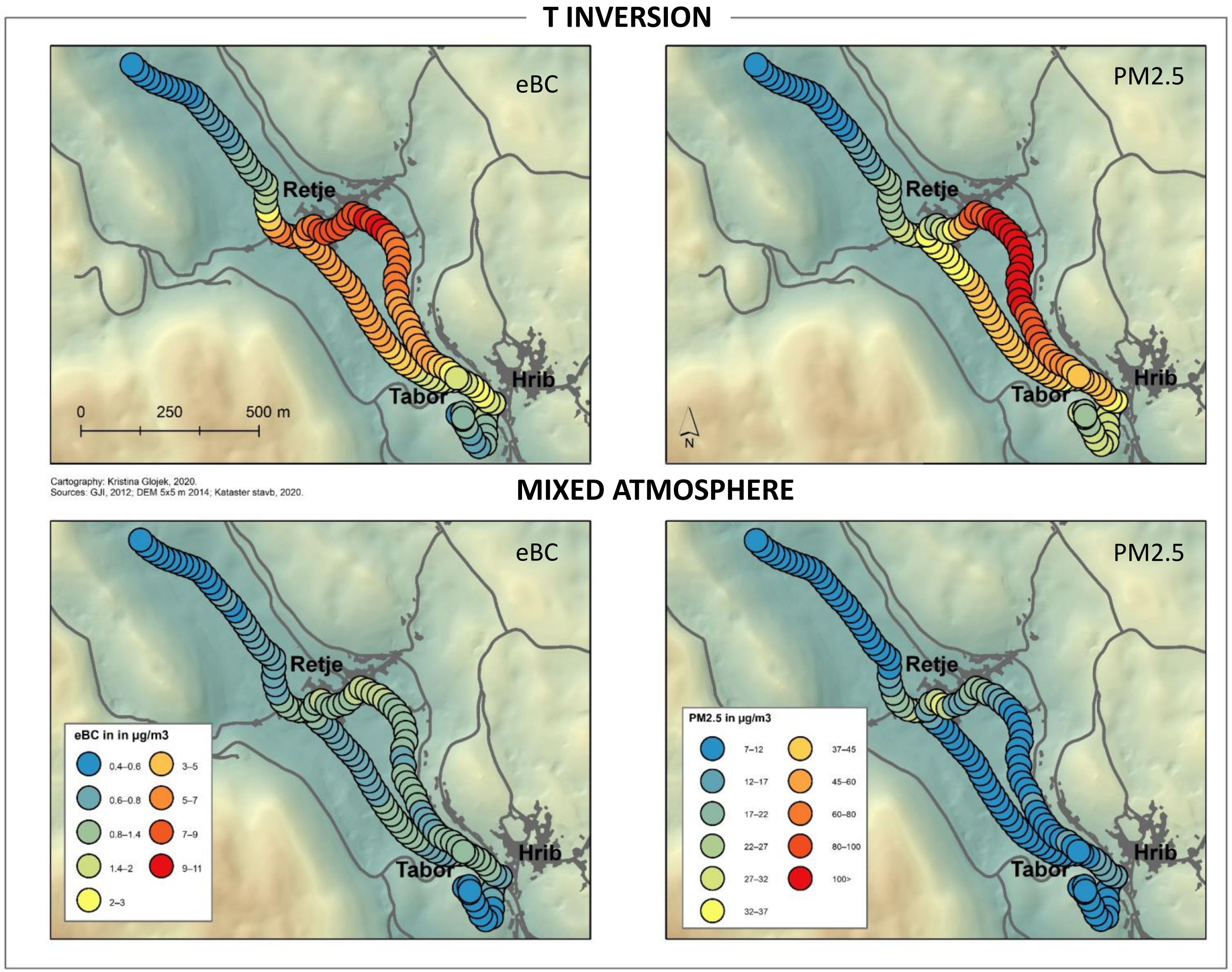


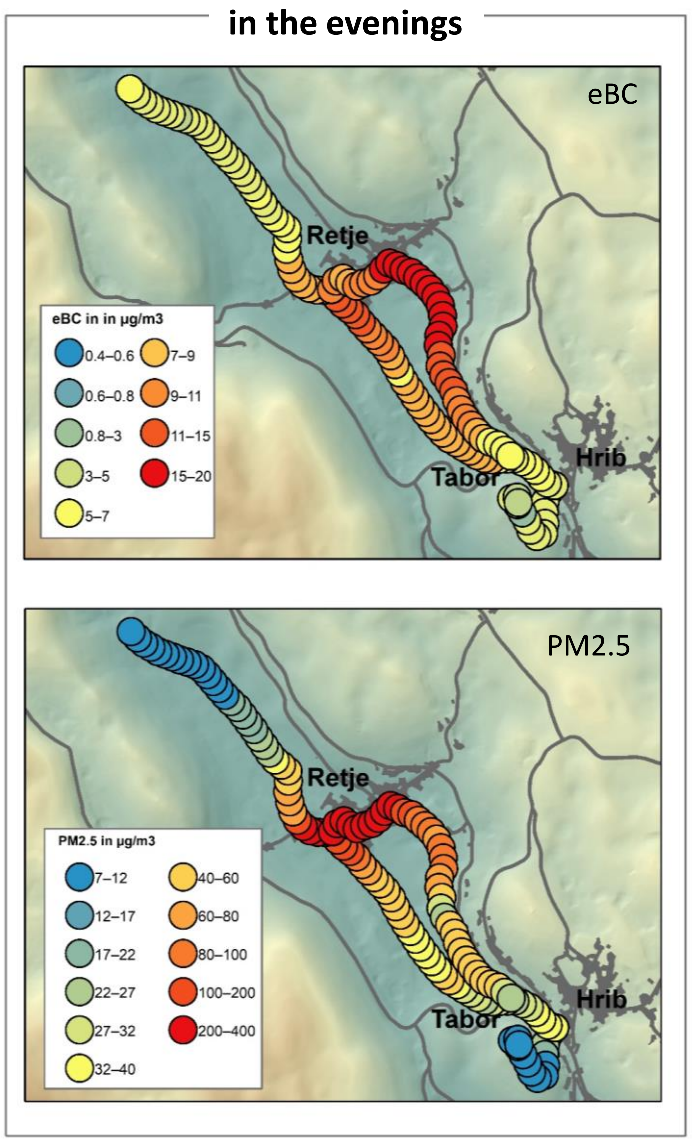
RESULTS
Meteorology

Time series of meteorological and air quality data for winter: the period of mobile measurements is marked with a black bold solid line.



Spatiotemporal Variability of eBC and PM2.5





CONCLUSIONS

- There is a high time and space variability of pollutant concentrations due to residential wood burning and the shallow thickness of an inversion layer.
- During temperature inversions with high local wood burning emissions pollutant concentrations increase dramatically.
- Similar conditions can be expected in other hilly and mountainous regions with residential wood combustion.


(photo: M. Markelj)

Acknowledgement

Financial support:

- the Slovenian Research Agency,
- the COST Action CA16109,
- the Municipality of Loški Potok.

Help with the field measurements:

- Martina Ristorini,
- Miha Markelj, Danijela Strle and other volunteers.

Research cooperation and support:

TROPOS Leibniz-Institut für Troposphärenforschung

Aerosol

Jožef Stefan Institute

UL100

Thank you.

References

- Alas, H. D. C., Weinhold, K., Costabile, F., Di Ianni, A., Müller, T., Pfeifer, S., … Wiedensohler, A. (2019). Methodology for High Quality Mobile Measurement with Focus on Black Carbon and Particle Mass Concentrations. *Atmospheric Measurement Techniques Discussions*, (April), 1–27. https://doi.org/10.5194/amt-2019-66
- Alas, H. D. C., Weinhold, K., Müller, T., Kecorius, S., Birmili, W., Wiedesohler, A., Tamayo, E., Simpas, J., Vallar, E., Cayetano, M., Costabile, F., Di lanni, A., Di Liberto, L., Glojek, K., Ristorini, M.., Gregorič, A., Drinovec, L., Močnik, G. (2020). *Performance of microAethalometers: Real-world field intercomparisons from multiple mobile measurement campaigns in different atmospheric environment. Aerosol and Air Quality Research,* manuscript in preparation.
- Ferrero, L., Perrone, M. G., Petraccone, S., Sangiorgi, G., Ferrini, B. S., Lo Porto, C., … Bolzacchini, E. (2010). *Vertically-resolved particle size distribution within and above the mixing layer over the Milan metropolitan area*. *Atmos. Chem. Phys* (Vol. 10). Retrieved from www.atmos-chem-phys.net/10/3915/2010/
- Holmes, H. A., Sriramasamudram, J. K., Pardyjak, E. R., & Whiteman, C. D. (2015). Turbulent Fluxes and Pollutant Mixing during Wintertime Air Pollution Episodes in Complex Terrain. *Environmental Science and Technology*, *49*(22), 13206–13214. https://doi.org/10.1021/acs.est.5b02616
- Largeron, Y., & Staquet, C. (2016). Persistent inversion dynamics and wintertime PM 10 air pollution in Alpine valleys, *135*, 92–108. https://doi.org/10.1016/j.atmosenv.2016.03.045