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Effective strategies to mitigate traffic emissions using Black Carbon as an indicator

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Aerosol d.o.o.

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Strategies to mitigate traffic emissions

Reducing vehicle fleet emissions

- Vehicle technology improvements
- Fuel quality

Traffic management

- Restricting traffic to specific areas
- Low emission zones - restricting access to vehicles with high emissions

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS
a UNEP convened initiative

UN environment programme

Black Carbon (BC)

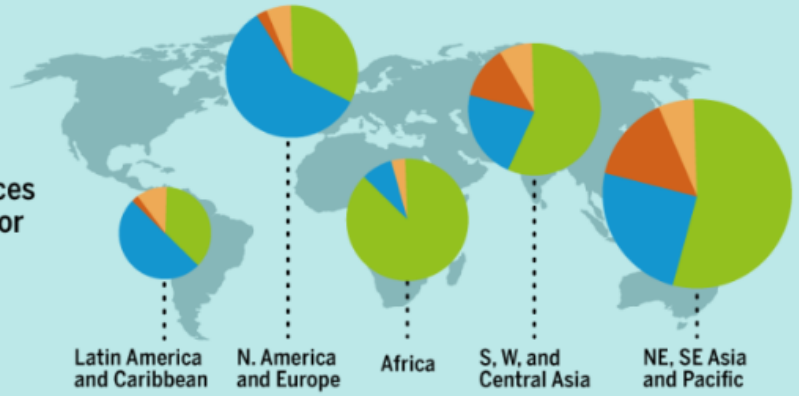
and Co-pollutants from Incomplete Combustion

Black carbon particles are formed from the incomplete combustion of biomass and fossil fuels. It is a powerful climate forcer and dangerous air pollutant.

LIFETIME IN ATMOSPHERE
Days

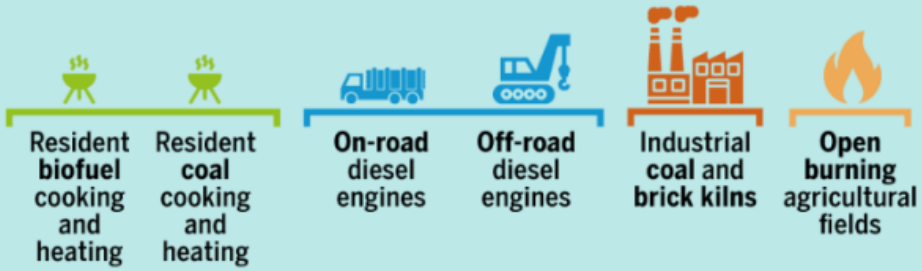
EMISSIONS

Main BC-rich sources by region and sector (2005)



PRIMARY BLACK CARBON-RICH SOURCES

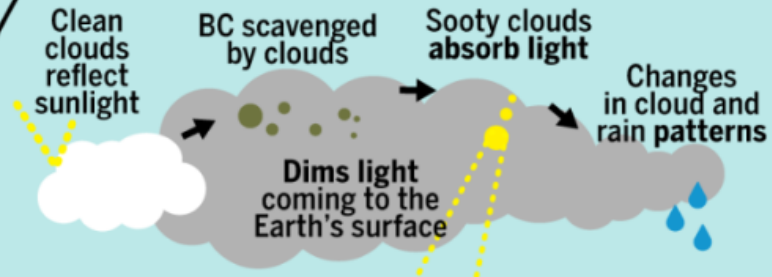
BC is always emitted with co-pollutant particles, some of which have a cooling effect on climate. The ratio of BC to co-pollutants varies by source and determines if a measure has a **net warming or net cooling effect.**

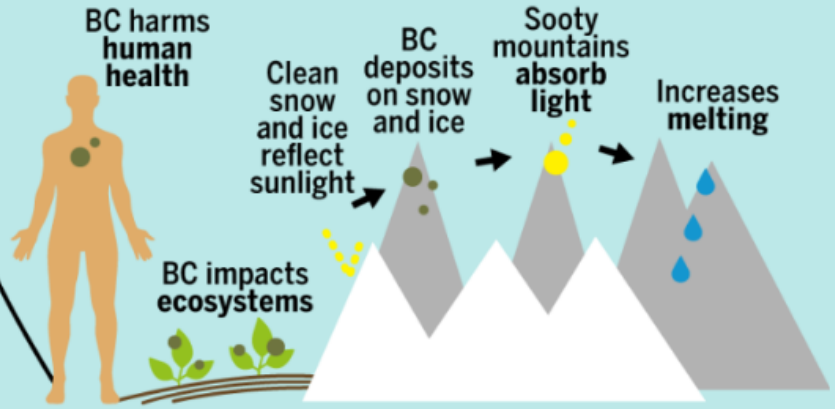


IMPACTS

Suspended in the atmosphere, BC particles contribute to **global warming** by absorbing energy and converting it to heat

BC is a dangerous local air pollutant which can also be **transported across the globe**



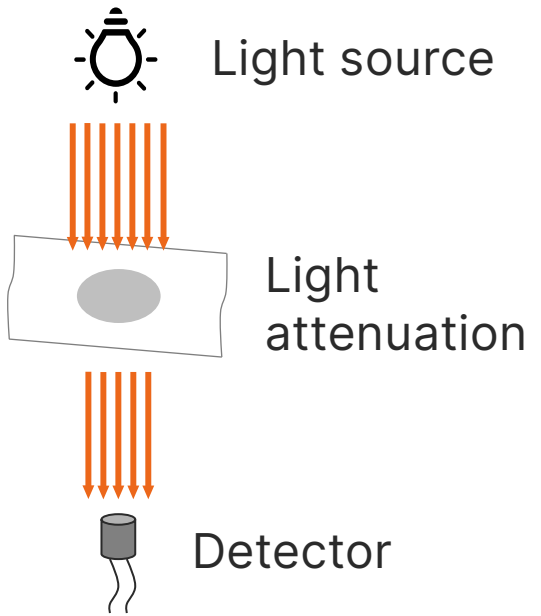


CCAC

https://www.ccacoalition.org/short-lived-climate-pollutants/black-carbon

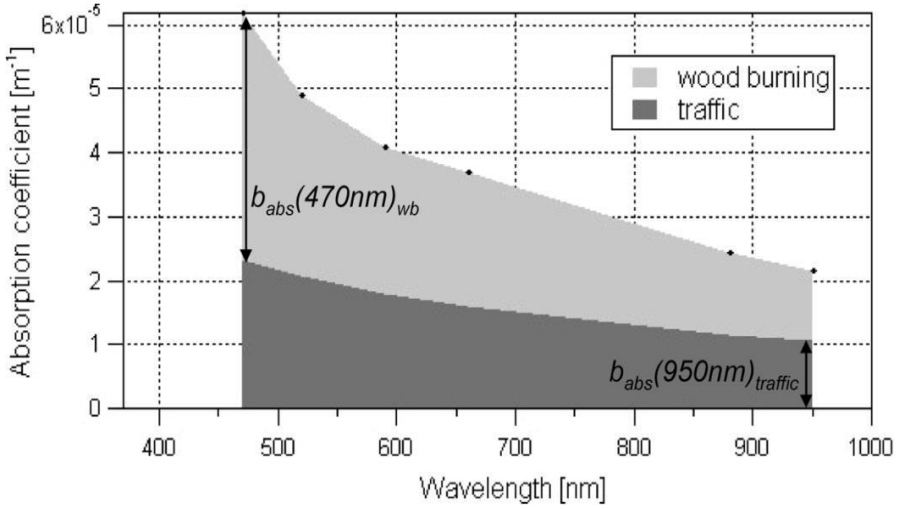
How Do We Measure BC?

Aethalometer - principle of operation



$$\text{eBC} = \frac{\boldsymbol{S}}{\boldsymbol{F}} \frac{\Delta\text{ATN}}{\Delta \boldsymbol{t} \ * \boldsymbol{\sigma} * \boldsymbol{C}} \boldsymbol{f}(\text{ATN})$$

Measurement at 7 wavelengths for source apportionment



Sandradewi et al., 2008

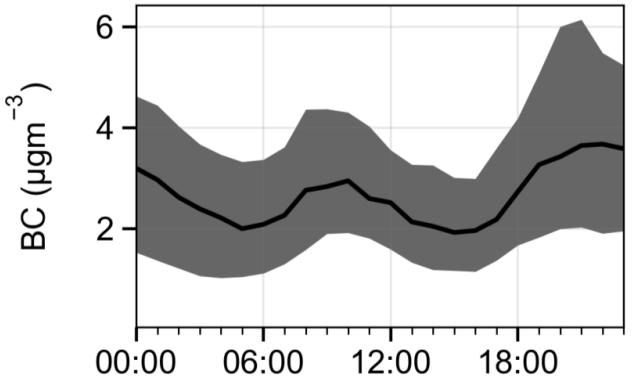
General Ängstrom exponent (α):

$$b_{\text{ABS}} \sim \lambda^{-\alpha}$$

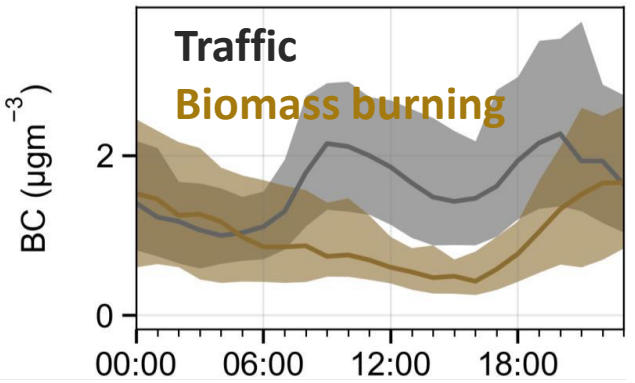
Traffic: $\alpha \approx 1$

Biomass burning: $\alpha \approx 2$

BC measured at 880 nm

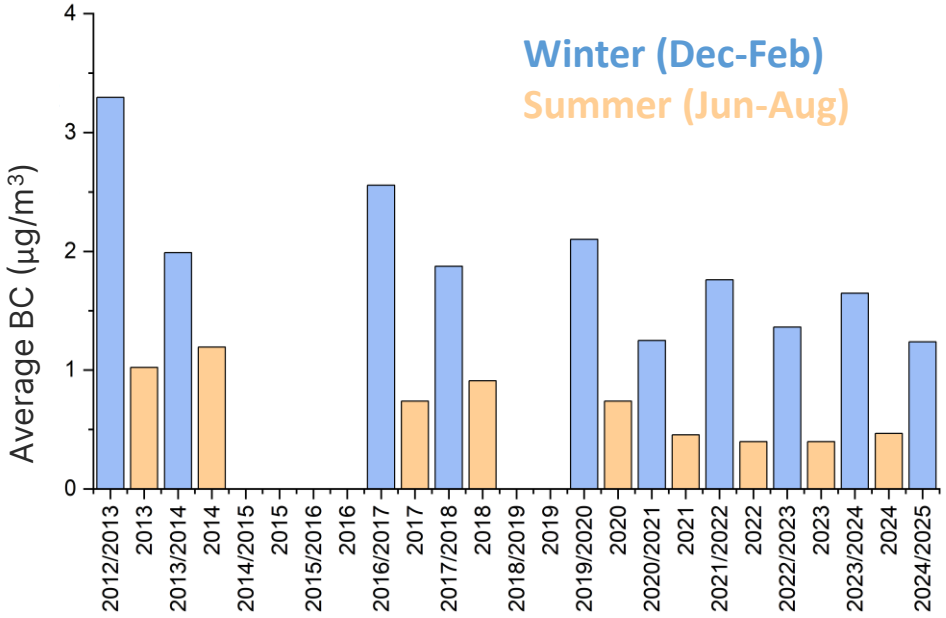


BC apportioned to sources

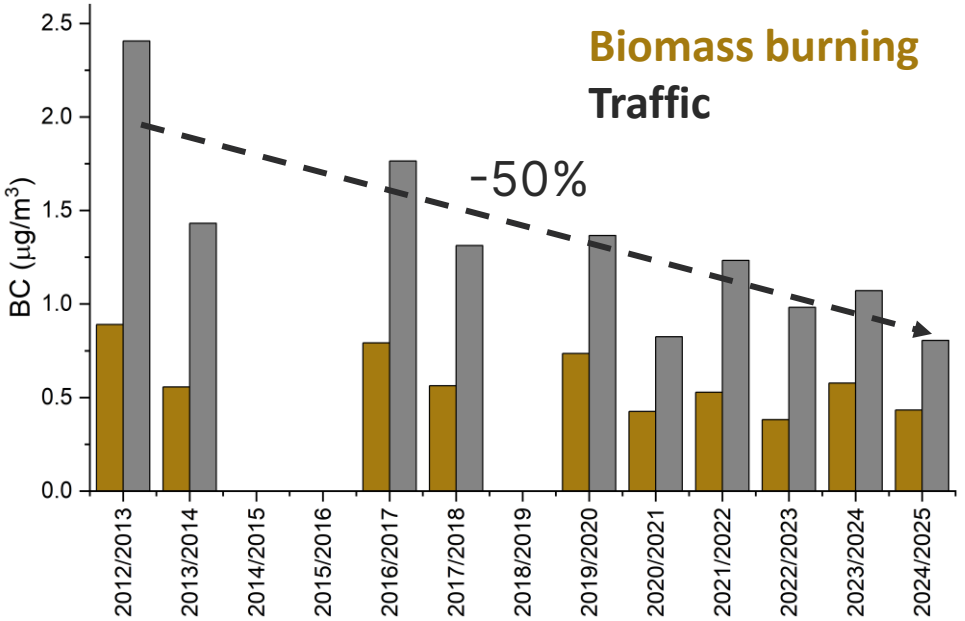


Long-Term Trends in Ljubljana

BC concentration in Ljubljana 2012 – 2025 are decreasing. Reason: lower BC emissions from traffic.

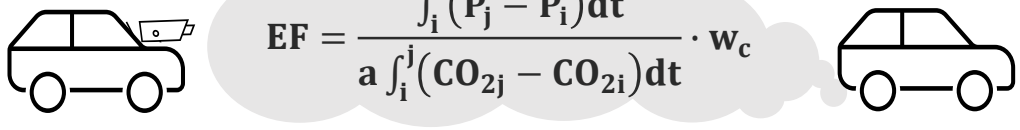


Winter period (Dec-Feb)



Monitoring effects of improved vehicle technology

On-road chasing measurement campaigns

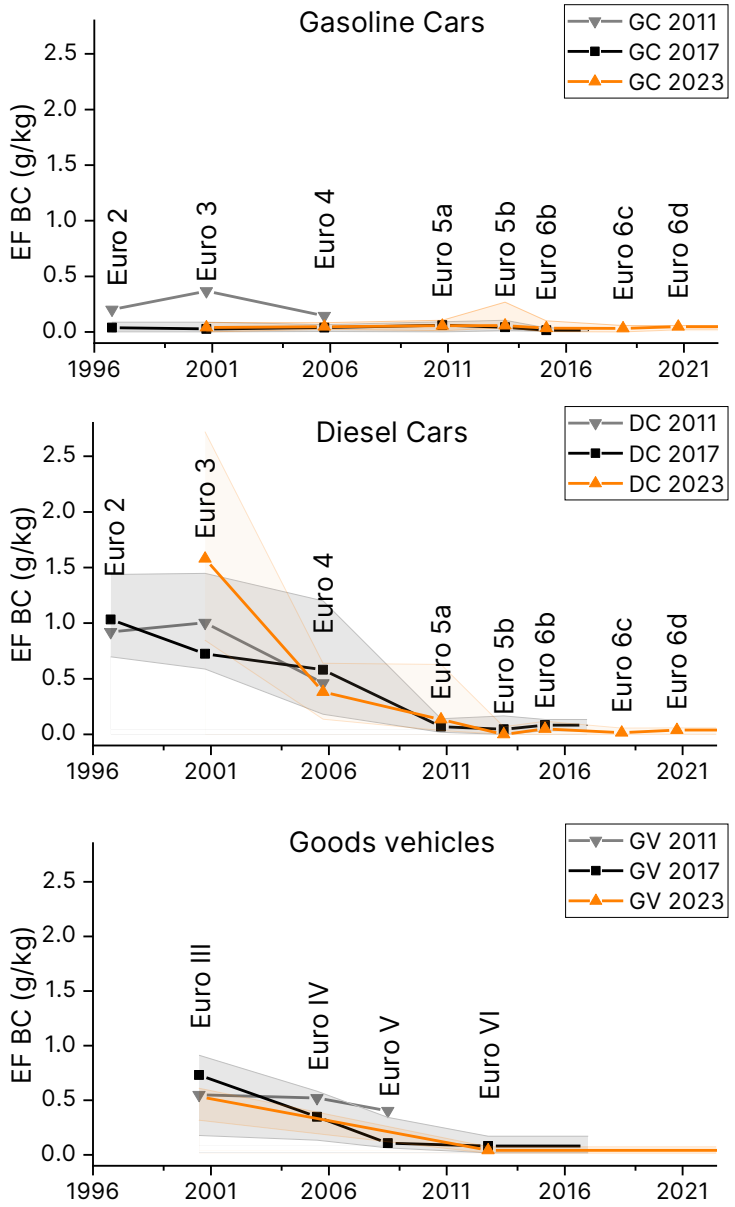


$$EF = \frac{\int_i^j (P_j - P_i)dt}{a \int_i^j (CO_{2j} - CO_{2i})dt} \cdot w_c$$

[g/kg]

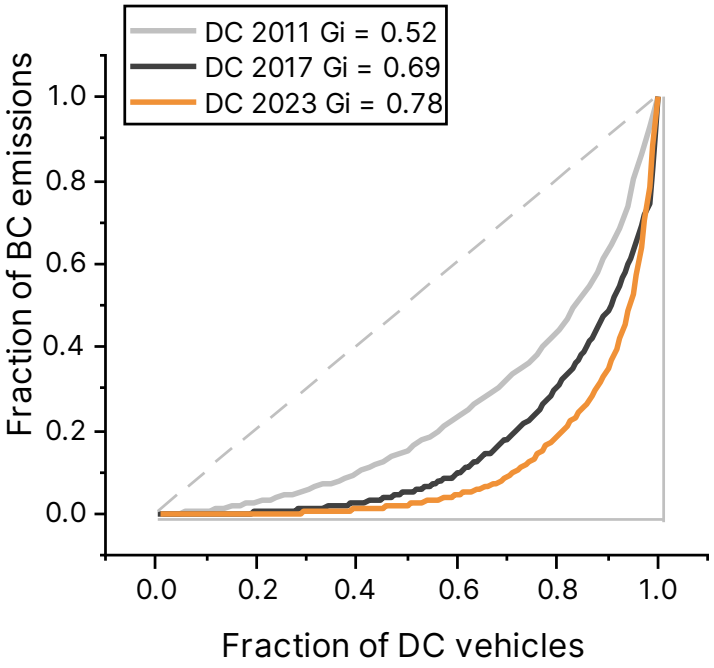
(Hansen and Rosen, 1990; Ježek et al., 2015a; Ježek et al., 2015b)

BC emission factor (EF) decreased after DPF became mandatory in diesel-powered cars (88% reduction) with the Euro 5a standard.



Ježek Brecelj, et. al., Atmos. Chem. Phys., 25, 9113–9125, https://doi.org/10.5194/acp-25-9113-2025, 2025.

Super polluters are vehicles that disproportionally contribute to total fleet emissions.



Cumulative fraction of vehicles from lowest to highest emitters

10 % of the highest-emitting diesel cars contributed

- 36% in 2011
- 51% in 2017
- 65% in 2023

of the total diesel-car fleet's BC emissions.

Finding and excluding super polluters could provide more efficient measures for cities to reduce traffic pollution.

Ježek et al., Atmo. Envir., 2018

Ježek Brecelj, et. al., Atmos. Chem. Phys., 25, 9113–9125, https://doi.org/10.5194/acp-25-9113-2025, 2025.

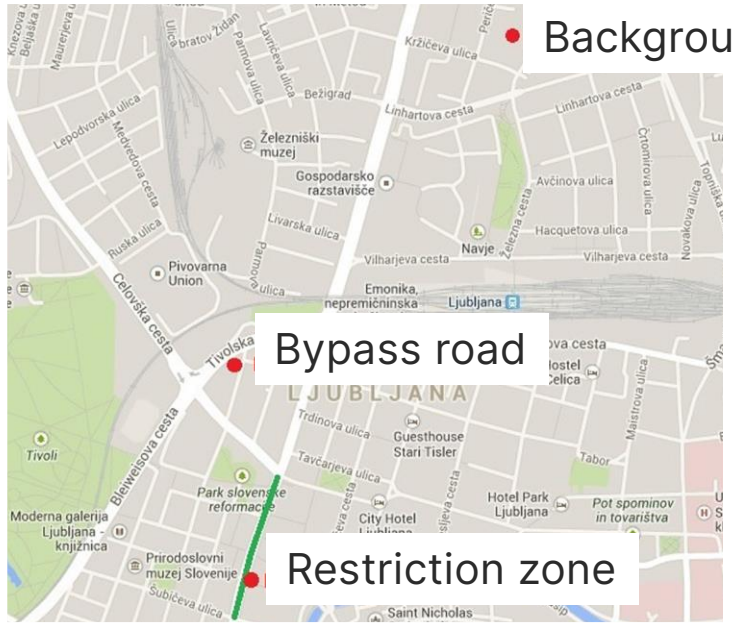
Road closure impact

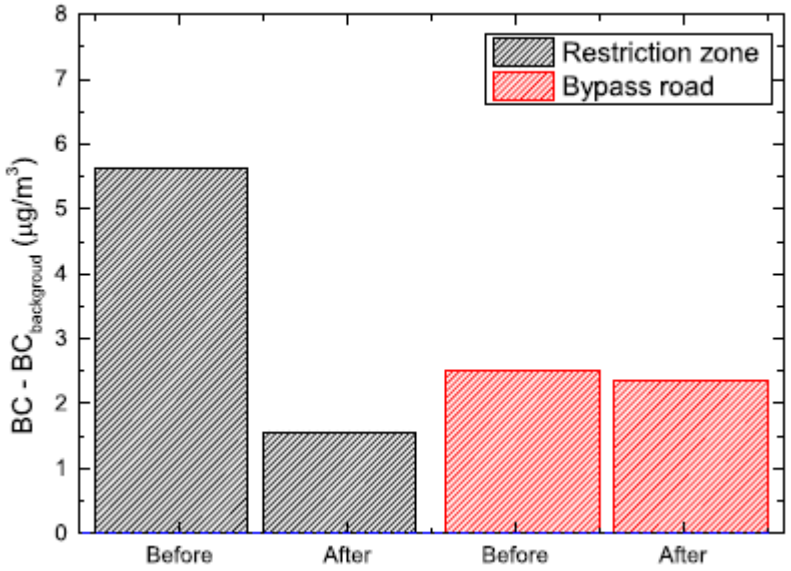
The municipality closed a 400 m section of the street for all traffic except public buses and taxis as an abatement measure.

RESULT: a 72% reduction of local BC was observed after the restriction was implemented without increasing pollution on the bypass road.

Closing streets to private traffic significantly benefits air quality.

Titos et al., 2015, http://dx.doi.org/10.1016/j.atmosenv.2015.05.027





Conclusions

- Black Carbon is a powerful indicator for monitoring traffic emission mitigation.
- Emission standards have significantly reduced BC levels.
- Targeting super polluters and implementing traffic restrictions can further improve air quality.

Together, these strategies not only protect human health but also help combat climate change.

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Thank you for your attention!

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