



Multi-sensor data collection for personal exposure monitoring: ICARUS experience

<u>David Kocman</u>, Tjaša Kanduč, Rok Novak, Johanna A.Robinson, Ondrej Mikeš, Celine Degrendele, O. Sanka, J. Vinkler, R. Prokeš, Danielle Vienneau, Benjamin Flückiger, Alberto Gotti, J.Visave, F. Bugnoni, Marco G. Persico, Saul Garcia Dos Santos, B. Nuñez-Corcuera, Thomas Magos, A. Stamatelopoulou, D. Pardali6 D. Saraga, Dimitris Chapizanis, I. Petridis, S. Karakitsios, E. Boldo, R. Izquierdo, G. Sarigiannis,Denis A Sarigiannis

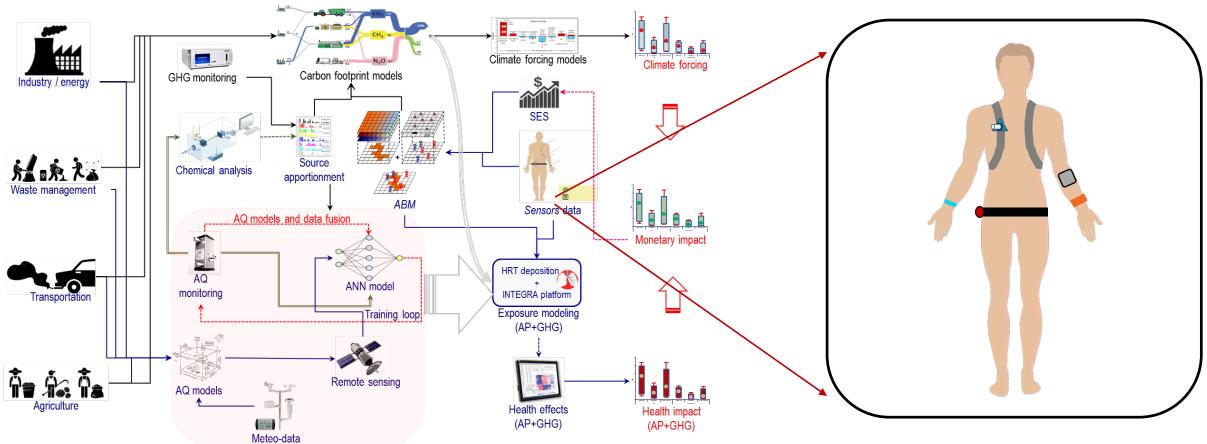








26-27/10/2020



Estimating exposure to air pollutants using new monitoring approaches



Study design: sensors selection criteria



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- Parameters measured
- Portability
- Reliability of captured data
- Cost
- Data collection and transfer protocols / GDPR
- Unobtrusive to the wearer
- User-friendliness

Citizens become aware of the effects of their lifestyle choices







Study design: tools used



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Garmin Vivosmart 3

Steps/Distance, Intensity of activity, Heart rate, Stress levels

waterproof – wear it forget it



Silicone wristband

Passive sampler Organic Chemicals wear it, forget it

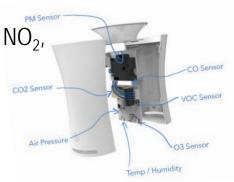


ICARUS PM sensor

PM1, PM2.5, PM10, Coordinates, Temperature, Humidity

wear it when in transit – attached to belt or arm/bag – not noisy

uHoo static sensor CO, CO₂, VOCs, PM2.5, O₃, NO₂, Temperature, Humidity, CO2 Senso Air pressure Air Pressur Place it, forget it – not noisy



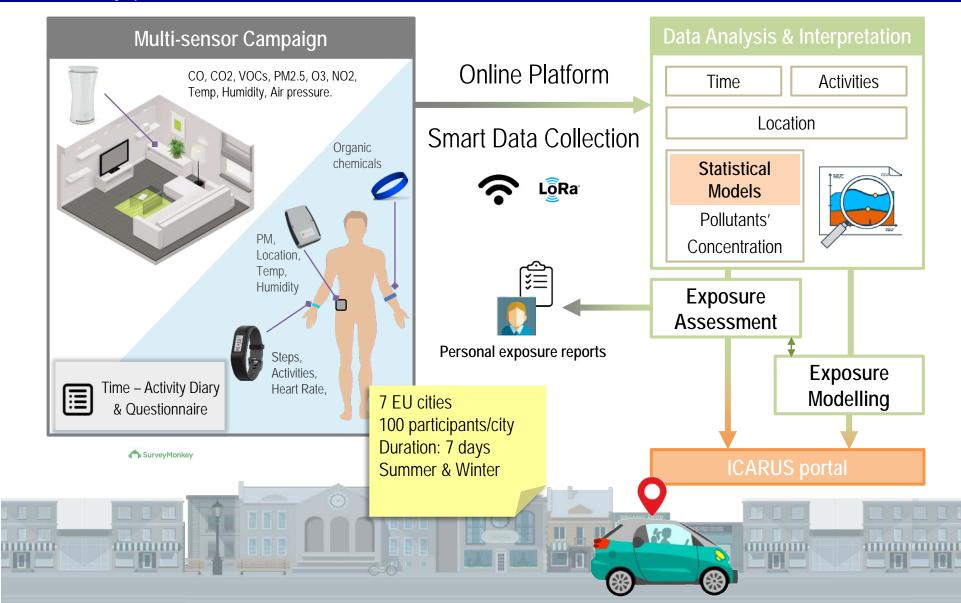
Ouestionarres & Time Activity Diary

| e Activity Dialy | | | | | | N | | | | | | Aktivnost | | | | | | | | | | | | | | | |
|-----------------------------|-------|---|---|---|--------------|--------|--------|------------------|------|----------------|------|------------|--------|---------------|--------|-----|-------|-------------------|---------|----------|------|------------|----------------|-------------------|--------|-----|-----------------|
| | | | | | Na prostem | | | Način prevažanja | | | | V prostoru | | | | | | Pogoji v prostoru | | | | Na prostem | | | | | |
| | | | | | Dom (vrt) | Stutte | Ostalo | Artobus | A110 | Motomo kolo | Kalo | Pei | Ovtake | Prosti Las | Spanje | Ipa | Sport | Kuhanje | Kajenje | Cilitaça | Delo | Sveča | Odprta skna | AC/ Vestilator | Kaunin | Tek | Dragi ipersi |
| O Ponedeljek | 0:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O Torek | 1:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 🔾 Sreda | 2:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cetrtek | 3:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O Petek | 4:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O Sobota | 5.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 🔿 Nedelja | 6:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 7:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Datam: | 8:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 9:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 10:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 11:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 12:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 13:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ô | 0 | 0 | 0 | 0 | Ô | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 14:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 15:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 16:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ô | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 17:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 18:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 19:00 | 0 | 0 | 0 | 0 | Ô | 0 | 0 | 0 | Ô | Ô | 0 | 0 | 0 | 0 | Ô | Ô | 0 | Ô | Ô | Ô | 0 | 0 | Ô | 0 | 0 | 0 |
| | 20:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 21:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 22:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Ô | Ô | Ô | 0 | 0 | Ô | Ô | 0 | 0 | 0 | 0 | Ô | 0 | 0 | 0 | Ô | 0 |
| | 23:00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |



ICARUS campaigns overall approach





- Exposure assessment at individual level (location, activity, AQ in microenvironment)
- Support/validation of models
- User experience



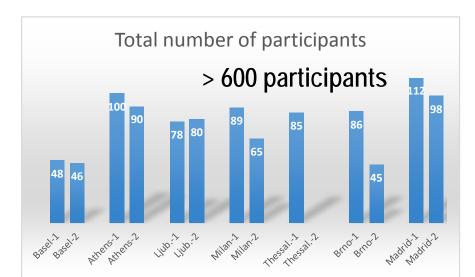
ICARUS cities in numbers

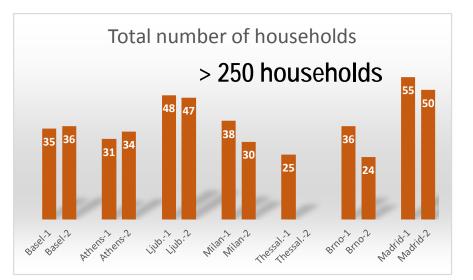


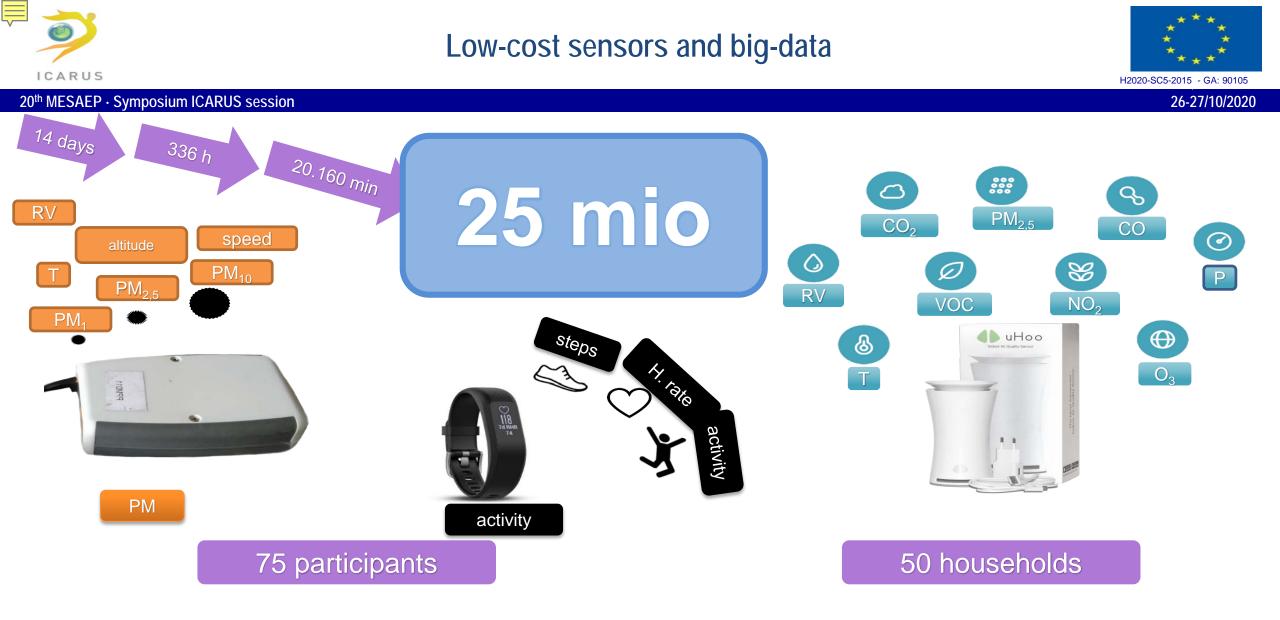












7 cities => over 150 mio records

Results- indoors

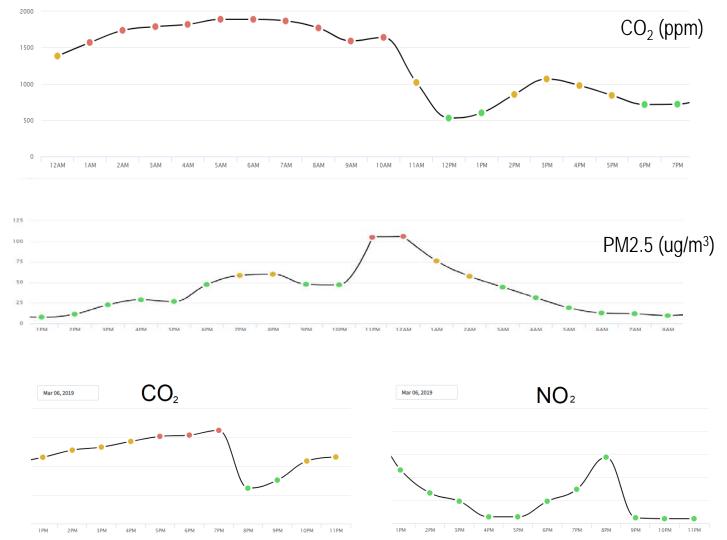


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ICARUS

- Insufficient ventilation (independent of the system)
- Increased values of pollutants linked to a few short-term daily events (e.g. cooking, heating)

Time and duration of ventilation (depending on activity and location)



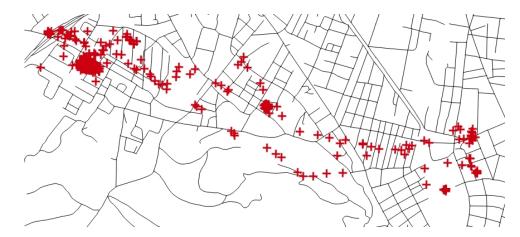


Results - outdoors



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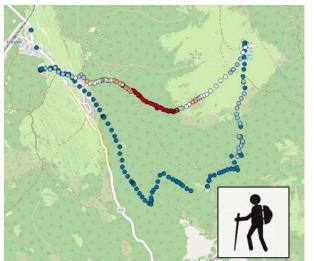
The monotony of the living space





– AQ & outdoor activity







Data harmonization: challenges



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| | | | | ICARU | S PM se | nsor | | | Garmin | | | TAD | | | |
|--|-------|-------|----------------------|-------|---------|-------------|-----------------------|----------|------------|-------------------------------|---|-------|--|---|--------------------------------------|
| Time step | | | 1min | 1min | 1min | 1min | 1min | 1min | 15sec | 15min | 15min | | 1h | 1h | 1h |
| 00:00:15 00:00:30 00:00:45 00:01:00 | 00:01 | - | PM1 PM2.5 PM10 | Temp | Hum | Coordinates | Steps | Distance | Heart rate | | | | | | |
| 00:01:15 00:01:30 00:01:45 00:02:00 | 00:02 | | | ug/m3 | °C | % | Latitude Longitude | count | meters | | | | | | |
| | 00:03 | | | | | | | | | Type of activity | Intensity of activity e.g. Sedentary, Active, Highly-active, | | | | |
| | 00:04 | 00:15 | | | | | | | | e.g. Sleeping, Walking, | | | | | |
| | 00:05 | | | | | | | | | Running, Swimming, | | | Type of Location | Type of Activity | Household Conditions |
| | | | | | | | | | | | | 01:00 | e.g. Indoors, Outdoors, In transit, | e.g. Sleeping, Walking, Running, | e.g. Windows ON/OFF, AC ON/OFF |
| 00:14:15 00:14:30 00:14:45 00:15:00 | 00:15 | | | | | | | | | | | | Home, Office | Swimming, | |

• Personal exposure and activities information at 1min step





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Considerations....

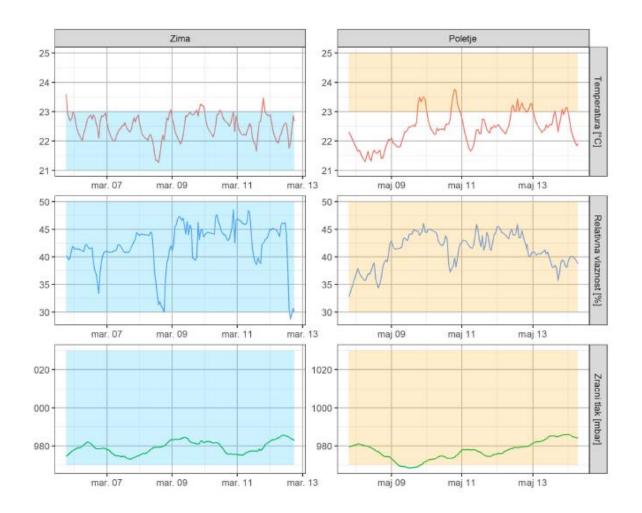
- Uncertainties related to data coming from low-cost sensing devices (clear explanation/disclaimer)
- We must assume that the **user is a layman** in terms of air pollution and its impact on health.
- Report must be **brief and concise**. Too much information creates distraction

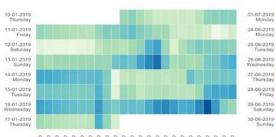


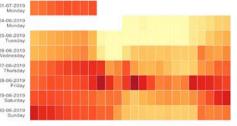
Reports to participants



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CO2 low

10-01-2019 Thursday

11-01-2019 Friday

12-01-2019 Saturday

13-01-2019 Sunday

14-01-2019 Monday

15-01-2019 Tuesday 16-01-2019 Wednesday

17-01-2019 Thursday

10-01-2019 Thursday

11-01-2019 Friday

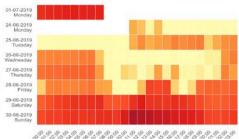
12-01-2019 Saturday

13-01-2019 Sunday

14-01-2019 Monday

15-01-2019 Tuesday

16-01-2019 Wednesday 17-01-2019 Thursday 



high

TVOC low



NO2 low

hial

high



TVOC low high

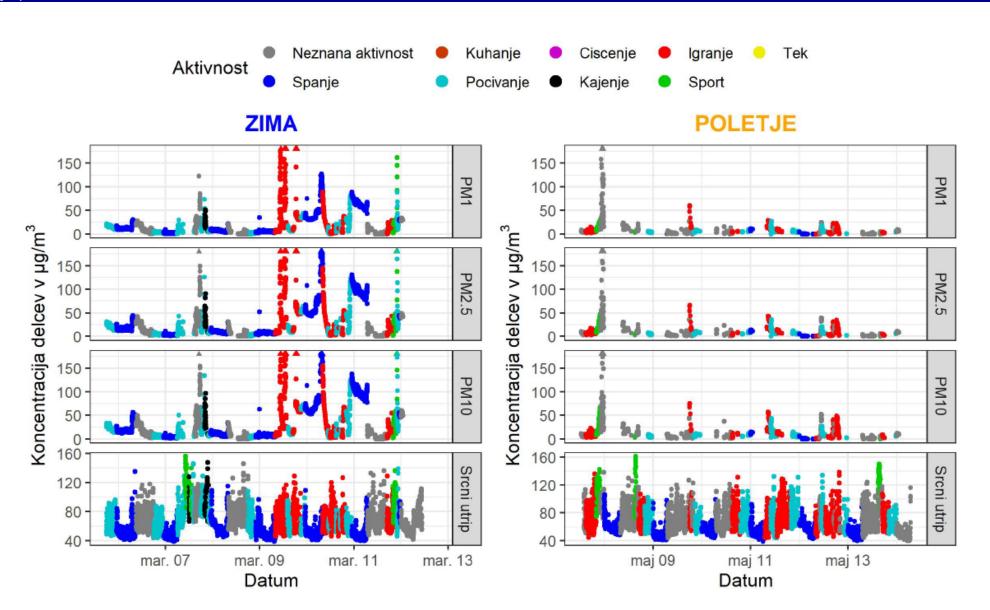
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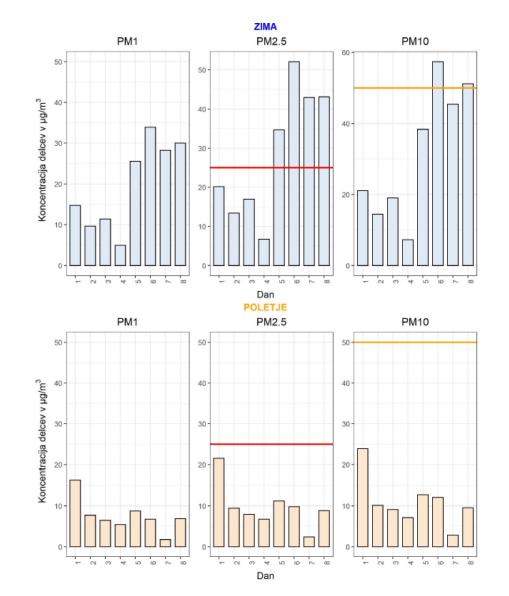


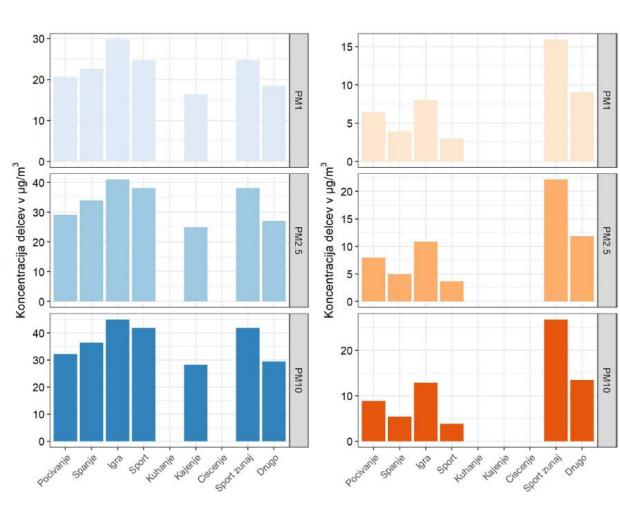
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Reports to participants









ICARUS campaigns – participants feedback



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- Really satisfied about the way the study was organised
- Participants actively shared pictures on social media
- Interested in getting back results / personal reports
- Duration of the study was fine
- ✓ Very satisfied with the wearing and using of the Garmin device.
- Especially children were very excited to participate in the study.
- > The custom-built PM sensor was well accepted. Only a few complaints about its size
- In a few cases, participants forgot to charge the PM sensor and/or to carry the PM sensor with them.
- TAD: time consuming and difficult to be filled out (e.g. for activities with small duration).
- Two cases of allergic reaction (skin rash) due to nickel in the Garmin-device (Basel)











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Thank you very much for your kind attention!