TROPOSPHERIC OZONE POLLUTION: THE CAPTOR EXPERIENCE

Alice De Marco
Torino, 7 maggio 2019
What is ozone?
What is tropospheric ozone?

STRATOSPHERIC OZONE
(forms the Earth’s protective ozone layer)

≠

TROPOSPHERIC OZONE
(affects human health and vegetation)
How is tropospheric ozone formed?

*Ozone precursors*

Nitrogen oxides

\[ \text{NO}_x \text{ (NO & NO}_2) \]

Carbon species

\[ \text{VOCs (CO & CH}_4) \]

\[ \text{Tropospheric ozone } \text{O}_3 \]
How is tropospheric ozone formed?

Ozone precursors

Nitrogen oxides
\[ \text{NO}_x \] (NO & NO₂)

\[ \text{VOCs} \]

Anthropogenic

Biogenic
Ozone in Europe

Large interannual variability dependent on meteorology
Ozone in Europe

EU target value for protection of human health (120 microg/m³)
- 17% of stations > O₃ target value for protection of human health.
- 17% (2016) << 41% (2015), but higher than in 2014 - interannual variability.

WHO AQ guideline (100 microg/m³)
- 96% of stations > WHO AQG value for O₃.

Table ES.1 Percentage of the urban population in the EU-28 exposed to air pollutant concentrations above certain EU and WHO reference concentrations (minimum and maximum observed between 2014 and 2016)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>EU reference value (°)</th>
<th>Exposure estimate (%)</th>
<th>WHO AQG (°)</th>
<th>Exposure estimate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM₂.₅</td>
<td>Year (25)</td>
<td>6-8</td>
<td>Year (10)</td>
<td>74-85</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>Day (50)</td>
<td>13-19</td>
<td>Year (20)</td>
<td>42-52</td>
</tr>
<tr>
<td>O₃</td>
<td>8-hour (120)</td>
<td>7-30</td>
<td>8-hour (100)</td>
<td>95-98</td>
</tr>
<tr>
<td>NO₂</td>
<td>Year (40)</td>
<td>7-8</td>
<td>Year (40)</td>
<td>7-8</td>
</tr>
<tr>
<td>BaP</td>
<td>Year (1)</td>
<td>20-24</td>
<td>Year (0.12) RL</td>
<td>85-90</td>
</tr>
<tr>
<td>SO₂</td>
<td>Day (125)</td>
<td>&lt; 1</td>
<td>Day (20)</td>
<td>21-38</td>
</tr>
</tbody>
</table>

EEA Air Quality in Europe, 2018
CAPTOR: Objectives

- To foster bottom-up collaboration of local communities, citizens, NGOs, and scientists, to raise awareness of air pollution problem, and especially of tropospheric ozone.
  - To engage a network of local communities in three European regions for monitoring tropospheric ozone.
  - To give technical support in developing low-cost sensors and data manager.
  - To empower citizens and engage them in promoting active participation in decision making to drive solutions.
Study areas

**Italy:**
Piedmont, Lombardy, Emilia Romagna and Veneto

**Spain:**
Barcelonès, Vallesos, Maresme and Osona

**Austria:**
Burgenland, Steiermark and Niederösterreich
Citizen measurement campaigns of tropospheric ozone
Low-cost sensors developed

**CAPTOR**: metal oxide low-cost sensors (UPC)

**RAPTOR**: electrochemical low-cost sensors (UCA)

<table>
<thead>
<tr>
<th></th>
<th>Captors</th>
<th>Raptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Italy</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Austria</td>
<td>0</td>
<td>15</td>
</tr>
</tbody>
</table>
Low-cost sensors developed
Low-cost sensors calibration
Where to check the data?

https://captorair.org/list/

The data generated by the CAPTOR nodes should only be considered informative and not be used for regulatory compliance purposes.

NOT for compliance-checking purposes!
Sensor data useful to assess:
- Geographical variability: Italy/Spain/Austria
- Temporal variability: relative differences 2017 – 2018
Sensor data are more conservative than reference stations – no social alarm created.
Results: limitations

Ripoll et al., 2019

Sensor: Metal oxide

Sensor: Electrochemical

Linear calibration

Non-linear calibration

$y = 0.9644x + 12.206$
$R^2 = 0.8879$

$y = 0.9502x - 0.3511$
$R^2 = 0.9269$
Results: limitations

Sensor performance: acceptable for mean concentrations, but not for peaks (high and low)
Results: limitations

UNIT-TO-UNIT VARIABILITY

10 Captor + 1 Raptor nodes co-located at a reference station (May-June)

Intra-unit variability increased significantly during Calibration2 period (Sept-Oct)

Cause: lower concentrations? Ageing?
Uncertainties

QUANTIFICATION OF UNCERTAINTIES

Ozone concentration (microg/m³)

Relative difference between reference station & CAPTON (%)
Uncertainties

QUANTIFICATION OF UNCERTAINTIES

- 8-29 µg/m³
- 8-24 µg/m³
- 10-85 µg/m³
- <30%
- <90%
- <940%
- <90%
- <30%
- <30%
- <40%
- <20%
Conclusions

- Ozone pollution is an issue in Southern and Central Europe, mainly affecting rural areas

- High interannual and spatial variability

- CAPTOR: Sensors were deployed in a citizen science approach

- Ozone data obtained has good scientific quality for sensor research and for awareness raising

- Peak concentrations not recorded by sensors

- Uncertainties = 20-40%, depending on ozone concentration

- Sensor data are more conservative than reference stations – no social alarm created
THANK YOU FOR YOUR ATTENTION!

COLLECTIVE AWARENESS PLATFORM FOR TROPOSPHERIC OZONE POLLUTION