



Contribution of an additional network of air quality sensors

Deployment of eLos in Grenoble over 11 months

From June 2020, eLichens thanks volunteers for installing and hosting an eLos station at their home or office.



eLichens outdoor air quality monitoring stations

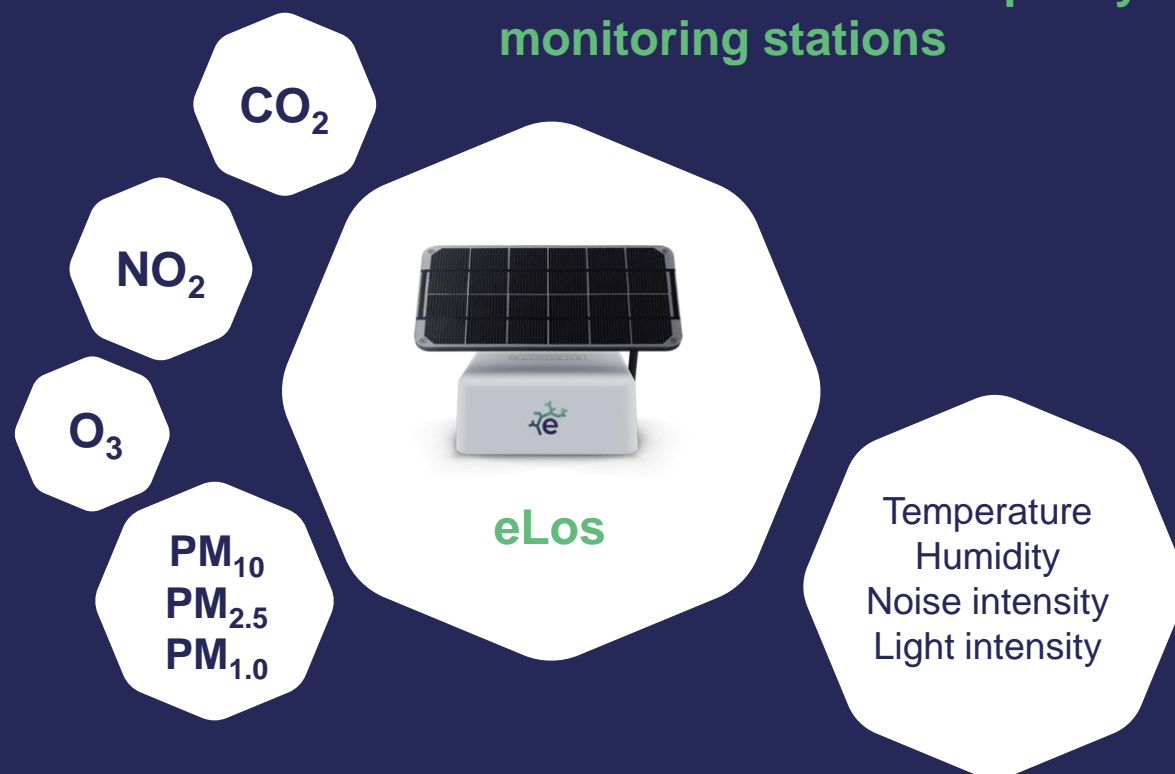


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Air quality data at high-resolution: many services but accuracy challenge.

→ Experimental eLos station network to evaluate the contribution of high-resolution air quality data accuracy.

Experimental air quality network

Grenoble city



- Reference stations (local air quality agency)
- eLos station (eLichens)

Air quality model

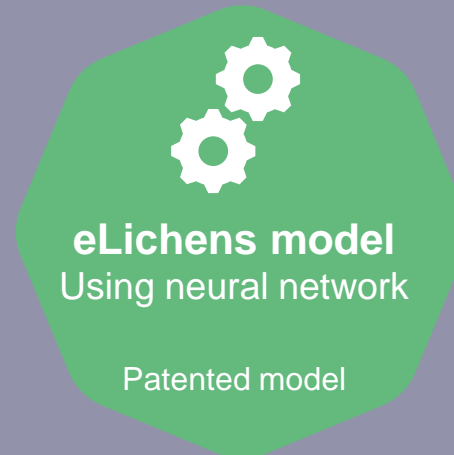
Background pollution



Weather conditions



Geographic & traffic information



High resolution air quality data

Also visible on eLichens Air mobile application



Many services: building exposition map, mobility policies assessment, ...

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Experimental eLos station network

Presence rate of eLos stations between 01/06/20 and 01/05/21



Air quality network with 5 reference air quality stations and 16 eLos stations.

- eLos were deployed by volunteers in their homes or offices from 1 June 2020.
- Deployment **mainly in living-street***, i.e., station sites are more of a **background type** station (not close to traffic emission sources).
- Diversity of outdoor installation; balcony, roof, garden, maximum floor height: 3rd (except one eLos)

* [Street category](#) according Open Street Map



Campaign conditions

eLos station

Autonomous hourly measurements:

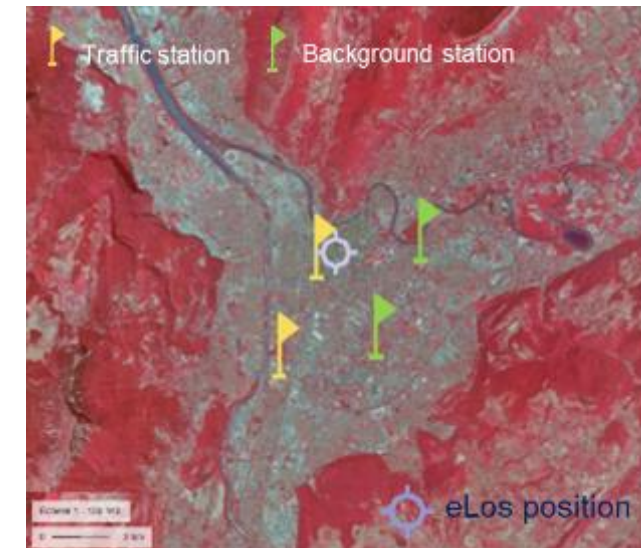
- NO₂, O₃, PM₁₀, PM_{2.5}, PM_{1.0}, CO₂
- Noise, light intensity
- Temperature, Humidity, Pressure

Automatic recalibration process:

- No user intervention
- Increased measurement reliability over deployment



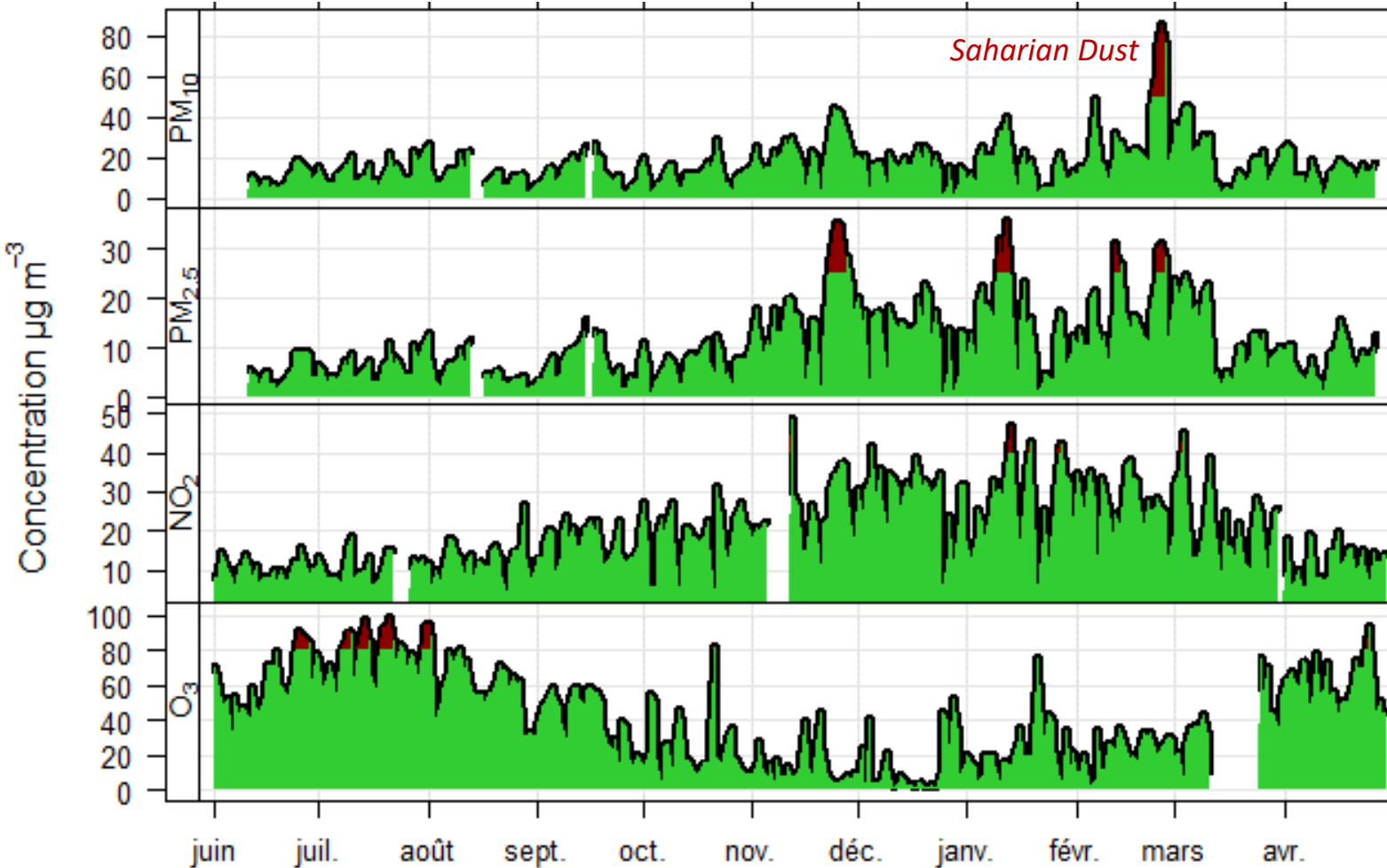
Real-time remote calibration process of measurements





When homogeneous concentrations can be estimated over the city, recalibration parameters are updated with average reference concentration value.

Environmental conditions of the campaign

Background station "Saint-Martin-d'Hères"



 Values < [PM₁₀ daily regulatory threshold / PM_{2.5}, NO₂ annual regulatory threshold / O₃ threshold _ AOT40 (plant protection)]
 Values > [PM₁₀ daily regulatory threshold / PM_{2.5}, NO₂ annual regulatory threshold / O₃ threshold _ AOT40 (plant protection)]

During the 11 months of the campaign:

Pollutant concentrations → **low or below regulatory thresholds** except:

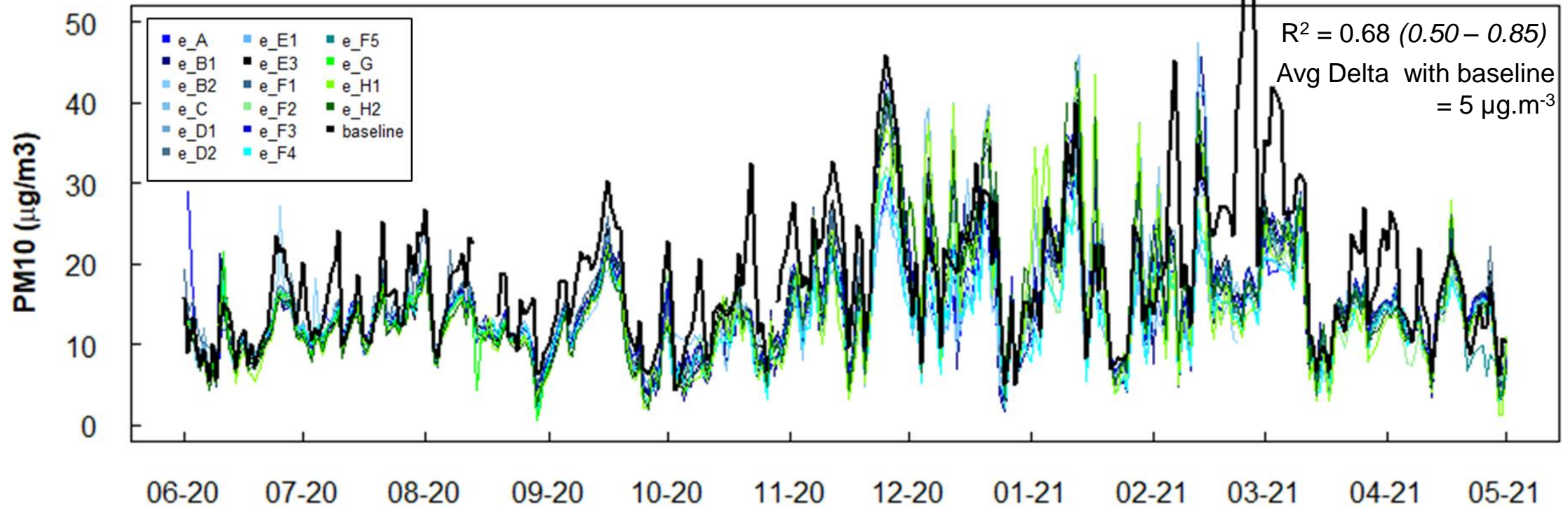
- one episode with PM₁₀ daily concentrations >50 µg/m³ (Saharian dust),
- short PM pollution episodes in winter 2021, and
- O₃ pollution episodes in July and Aug. 2021.

Concentration levels were often close to the detection limits of the sensors

Example: Evolution of PM₁₀ daily concentrations

Baseline = average of reference measurements at background stations

R² and average difference between the 3 reference stations : >0.90 ; < 3 μg.m⁻³

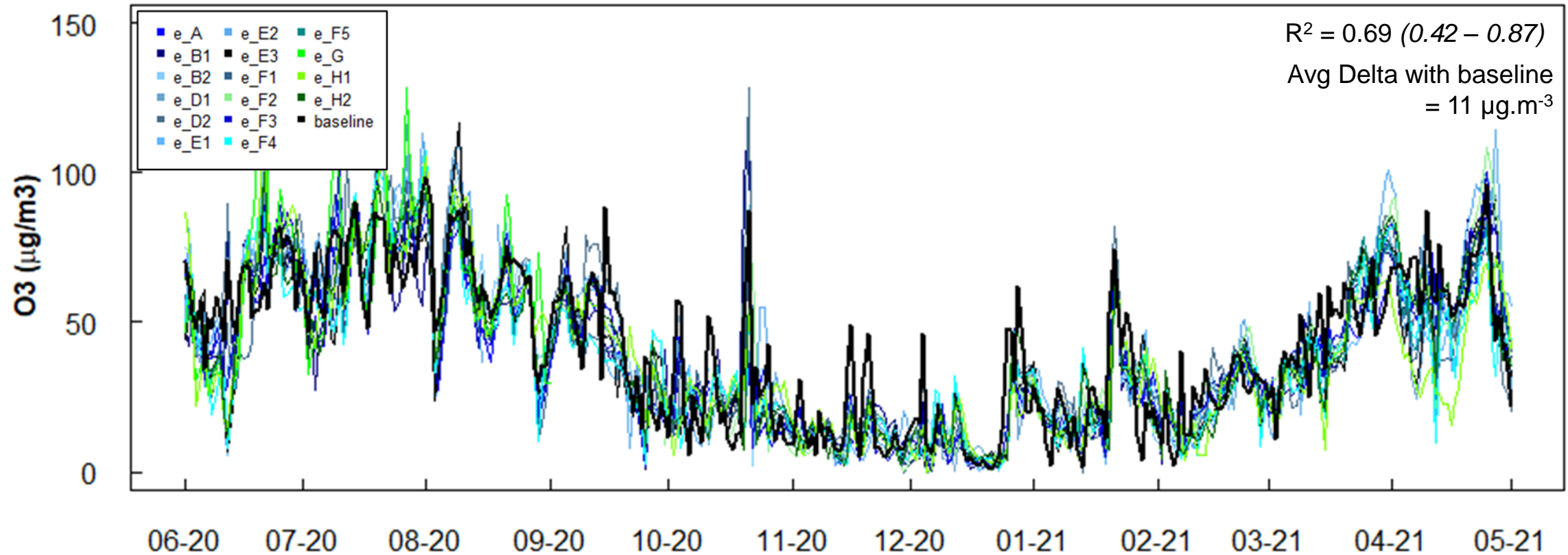


Except Saharian Dust, PM₁₀ daily concentrations of eLos network are close to reference background measurements, even with diversity installation of eLos (balcony, roof, floor height, garden).

Example: Evolution of O₃ daily concentrations

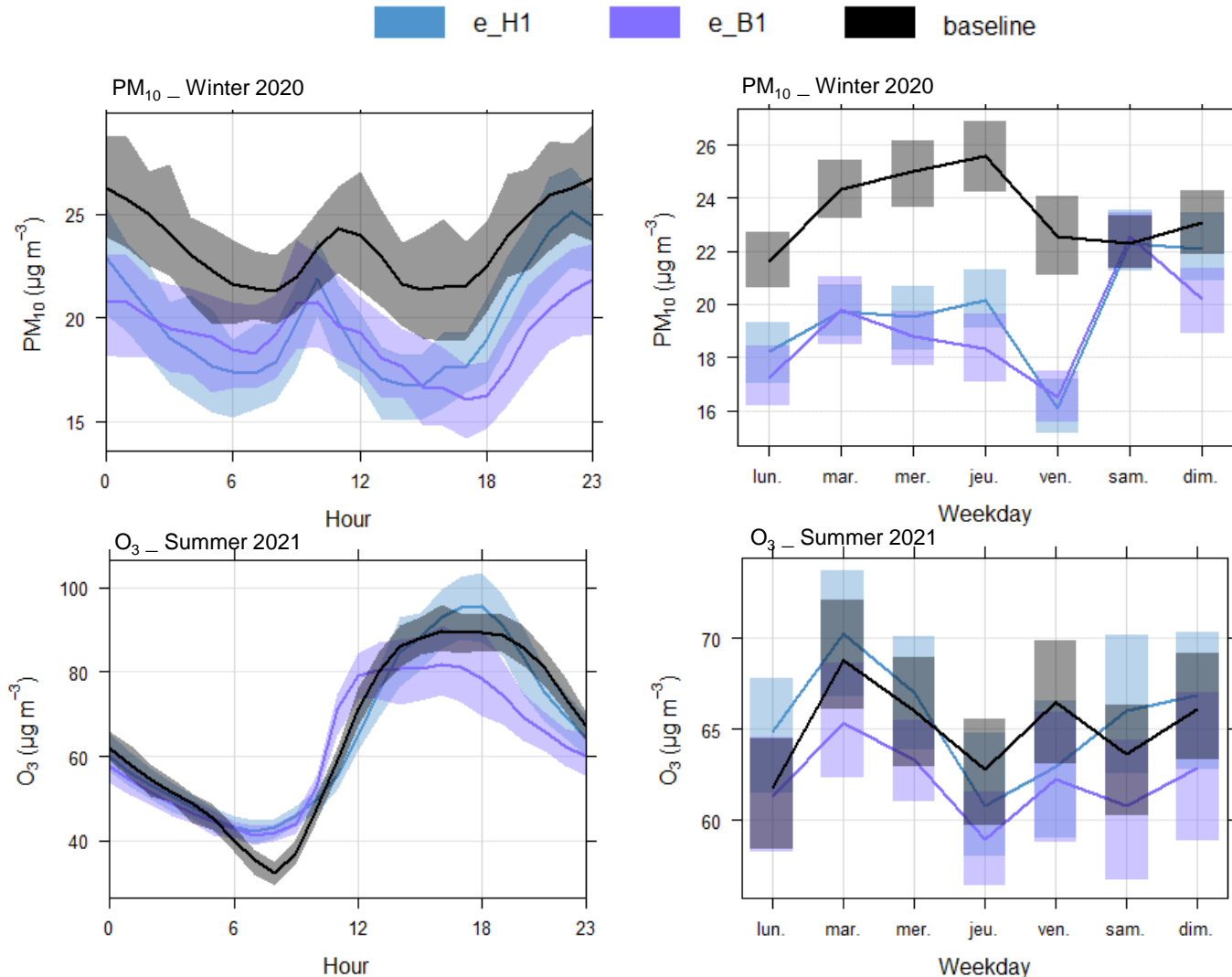
Baseline = average of reference measurements at background stations

R² and average difference between the 3 reference stations : >0.92 ; < 5 µg.m⁻³



O₃ daily concentrations of eLos network at close to reference background measurements.

Example: Comparison of O₃ and PM₁₀ daily cycle



Comparison of baseline and 2 distant eLos in the network (e_B1 and e_H1) .

Globally, PM₁₀ and O₃ daily and weekly cycle are similar between eLos and reference.

However, differences are observed that may be related to the existence of spatial variability.

Variabilities of air quality in the city

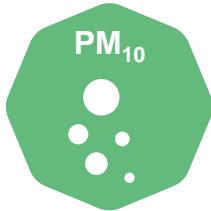
Potential spatial variability by eLos network

The eLos implementation **allows to investigate the spatial variability of urban background sites** which are located far from traffic emission sources.

The spatial variabilities investigated are:



Potential variability link to street distance according Grenoble' center and eLos installation



Potential variability in winter link to existence of wood heating emissions



Potential variability in summer according the day hour link to distance with O₃ precursors emissions

NO₂ variability has not currently been investigated due to high uncertainties of measurements (low level concentrations)

Spatial variability of noise intensity

Monthly Noise intensity of March 2021



Noise is measured by a microphone: limited range but enough for this network (no saturation effect)

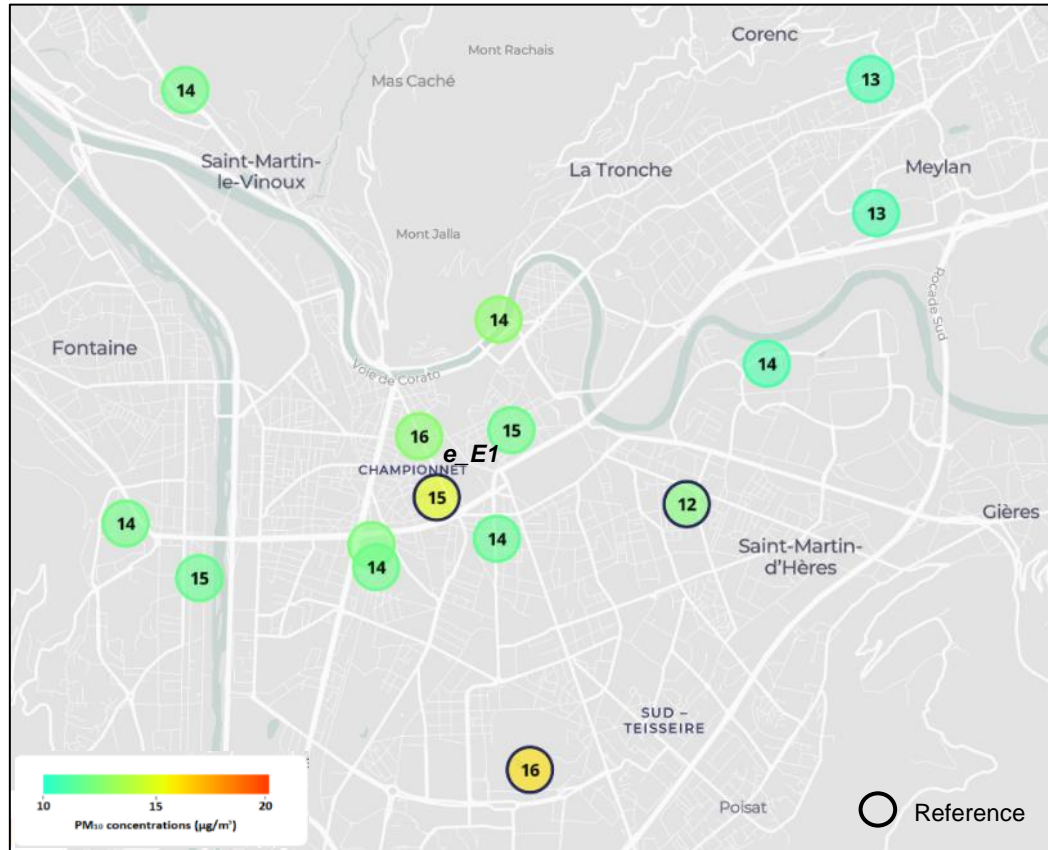
The measurements show **temporally constant but spatially variable** levels (differences up to 25 dB) and daily amplitudes varying between 1 and 9 dB depending on the eLos.

Levels are consistent with the eLos location: eLos closest to major roads (e_F1, e_C, e_E1) show high levels while eLos located in peri-urban areas (e_H1, e_H2) measure much lower levels.

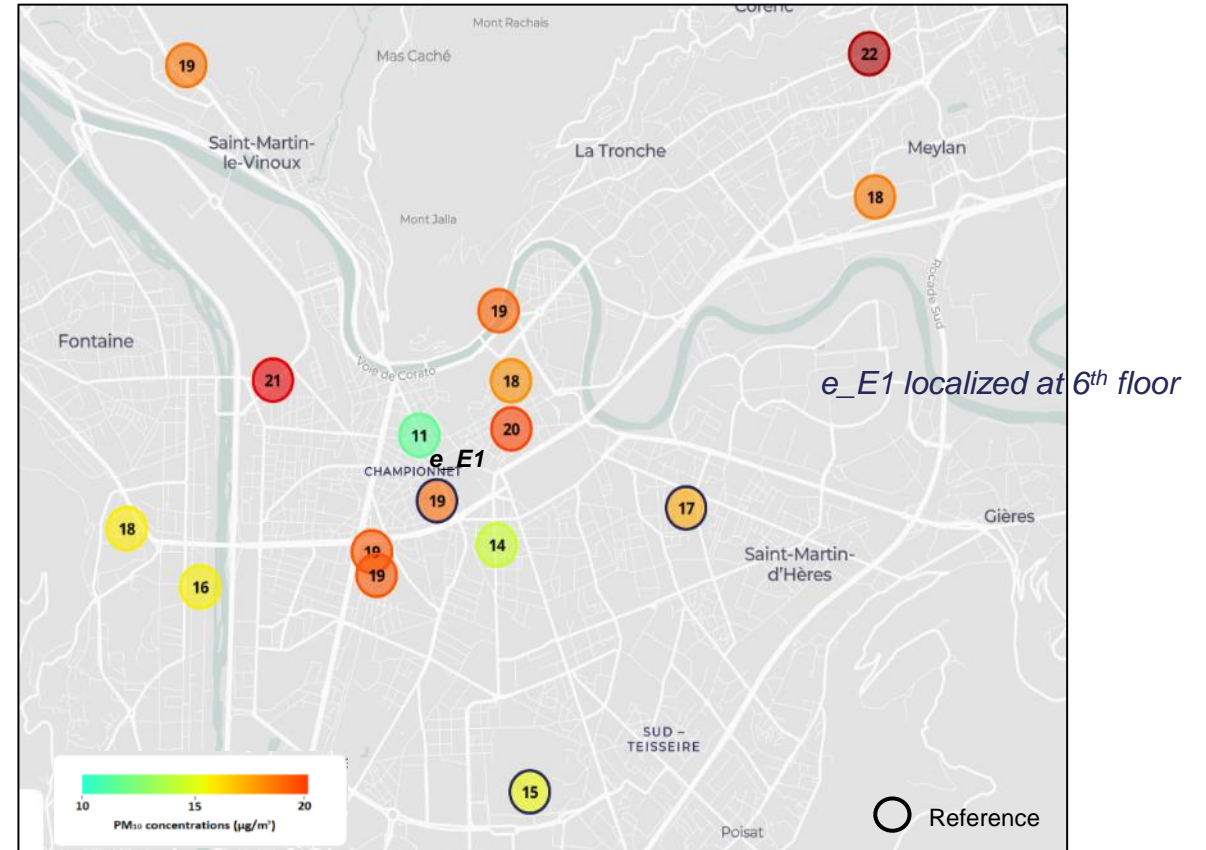
30 dB = "Bedroom" 40 dB= night threshold above which extra auditory effect occur (WHO)
60 dB = "Busy market" 80 dB = "High traffic street" and risk level

Spatial variability of PM₁₀

Monthly PM₁₀ concentration of August 2020



Monthly PM₁₀ concentration of January 2021



Compared to the summer period, **PM₁₀ levels show spatial variability in winter** in the network with lower levels in the south of the city (less potential wood heating appliances in this area).



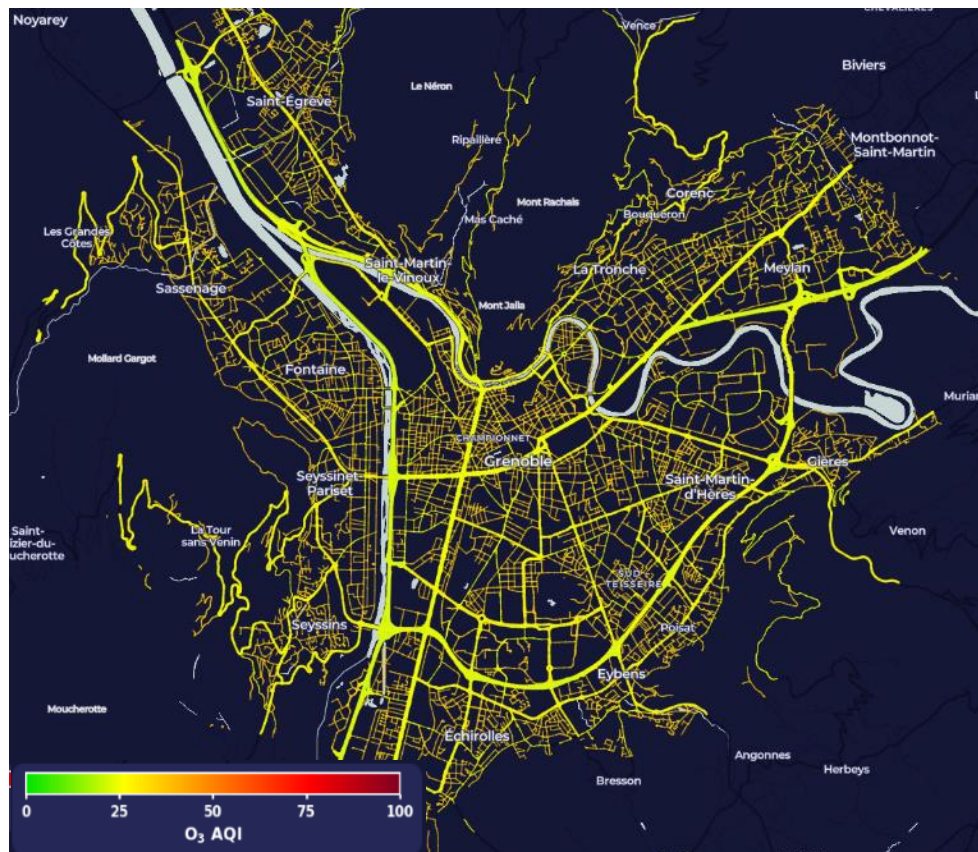
Pollution level estimation improvement with eLos data

Impact of measured spatial variability for the air quality map

The assimilation of eLos measurements assimilation into eLichens air quality model allows the mapping of the measured spatial variabilities.

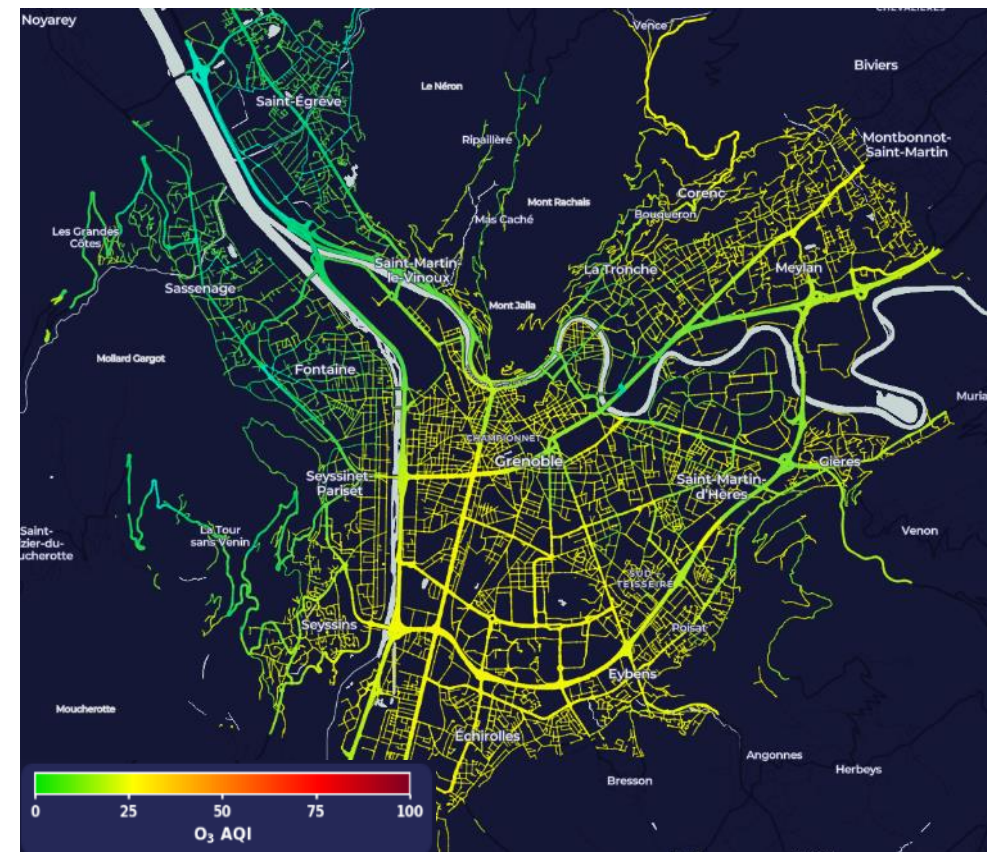
Example with O₃ in a summer day: eLos data assimilation corrects concentration overestimation in some areas.

O₃ concentration map based the air quality model



14/09/2020 _ 17h

O₃ concentration map with eLos data assimilation



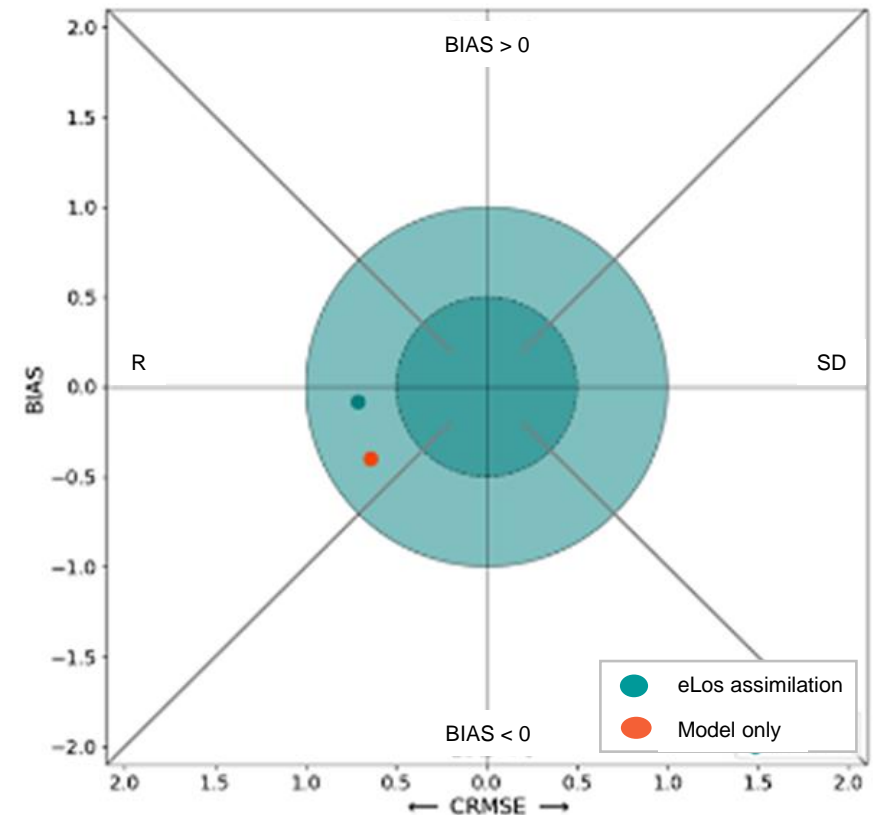
14/09/2020 _ 17h

- ❑ Preliminary accuracy assessment was performed with the comparison of **data model point** located near Caserne de Bonne background station with **reference background measurements**.
- ❑ eLos colocalized & CB reference station → not assimilated with the model
- ❑ Evaluation performed with **target diagram***

A look at the performance of a model in a glimpse:

Over/under-estimation? → BIAS
Error dominated by R or SD? → CRMSE
One summary metric → MQI

Results for NO₂ in winter



Quality objective :
MQI < 1 = points inside the colored circle

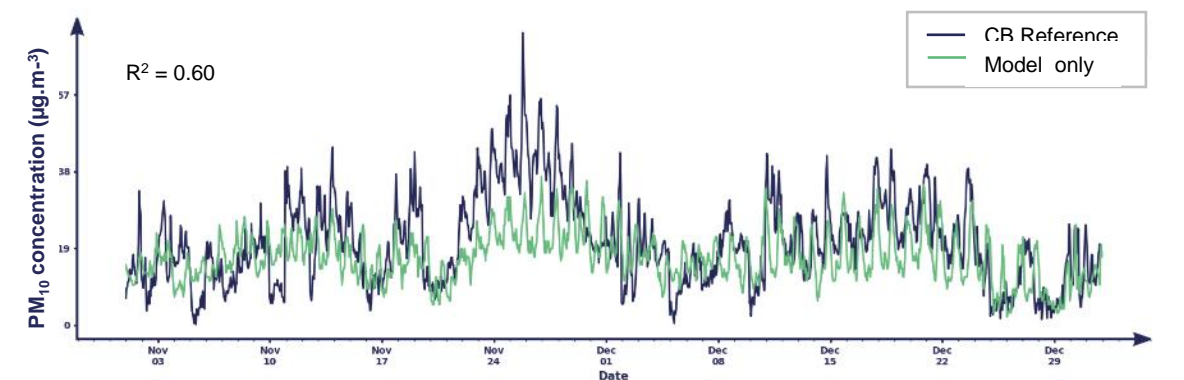
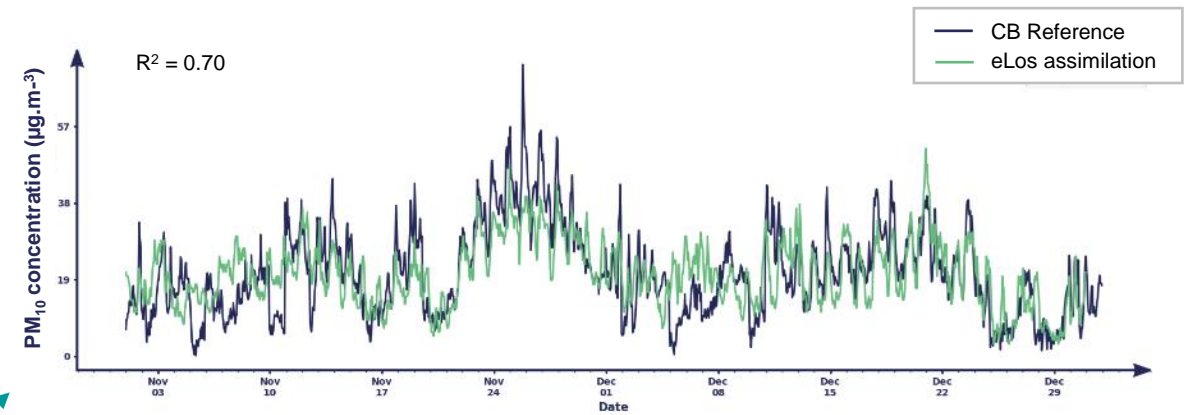
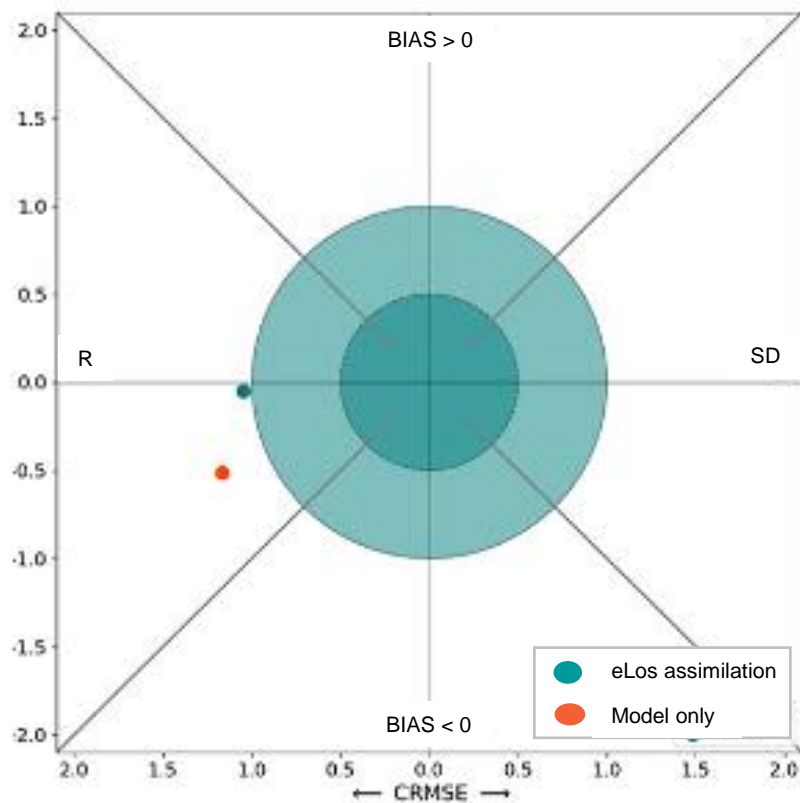
*From the Forum for air quality modelling in Europe
https://fairmode.jrc.ec.europa.eu/document/fairmode/WG1/Guidance_MQO_Bench_vs2.1.pdf

Impact of data assimilation on the air quality map accuracy

eLos assimilation improve accuracy of air quality data, notably PM_{10} in winter with a bias decrease.

Optimization of the assimilation process is on going to further improve the high-resolution air quality data.

Results for PM_{10} in winter



Conclusions

- ❑ The deployment of eLos is complementary with the existing air quality network of reference stations.
- ❑ Having a denser air quality network of sensors shows the evidence of spatial variabilities, even in background sites
- ❑ Data assimilation of eLos measurements improves the accuracy of our air quality model, resulting in a high-resolution hourly air quality map

Perspectives

eLichens air quality map and data are available on eLichens Air (Android & iOS)



Improvement of the automatic recalibration process

Development of a mobile air quality station



Optimization of the data assimilation process



Thank you !



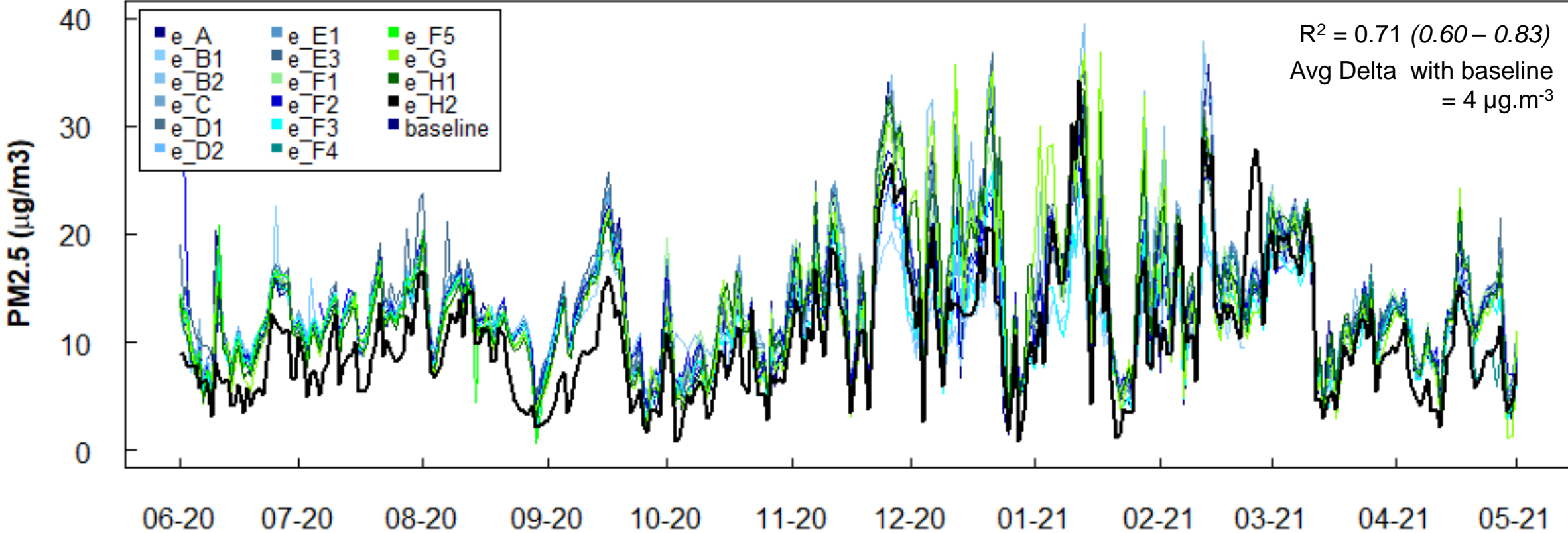
Want to know **more ?**

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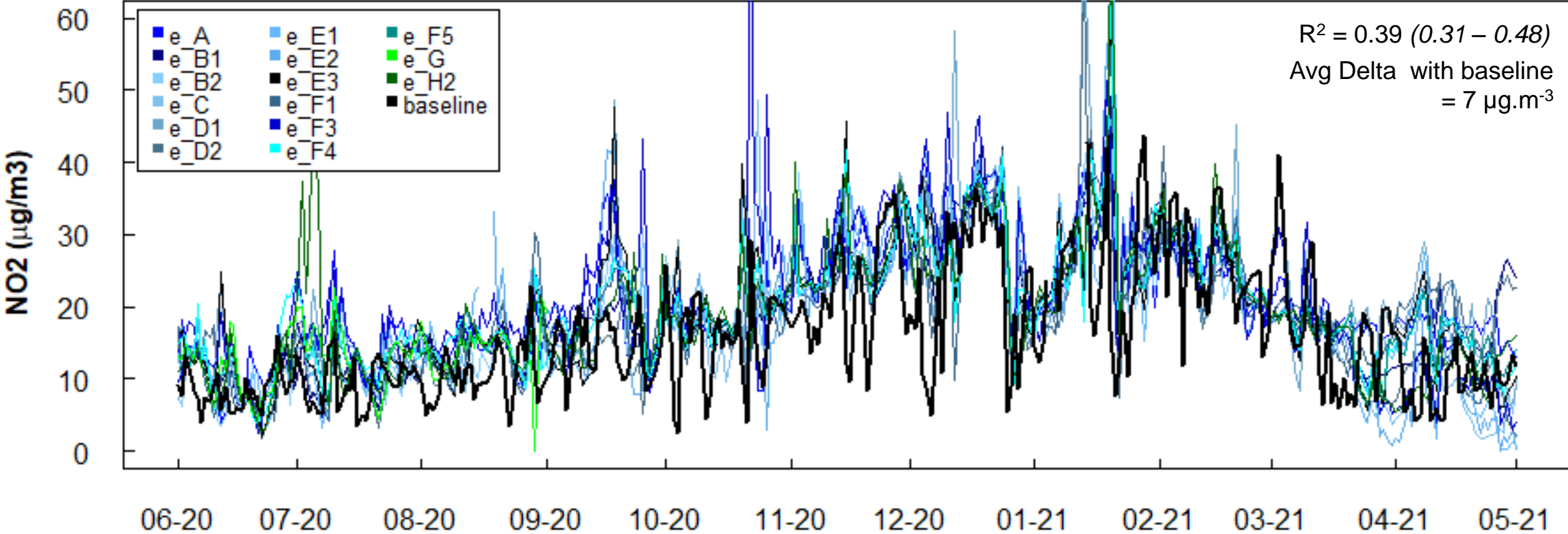
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Annex: Evolution of PM_{2.5} daily concentration



Annex: Evolution of NO₂ daily concentration



Annex: Comparison of NO₂ and PM_{2.5} daily cycle

