VIAQ-25-05

November 9th 2022

Improved in-cabin air quality with map-based air recirculation control

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KEY FACTS

- In-cabin pollution often reaches toxic levels
- Traffic pollution causes millions of deaths each year worldwide
- Automotive Air Quality Sensor have been used for >30 years
- Automatic recirculation flap management in high-end cars

What We do

01 Collection of real-time data from AQS in traffic

02 Calculation of hyperlocal air quality maps

03 Air quality data platform → Airmaps

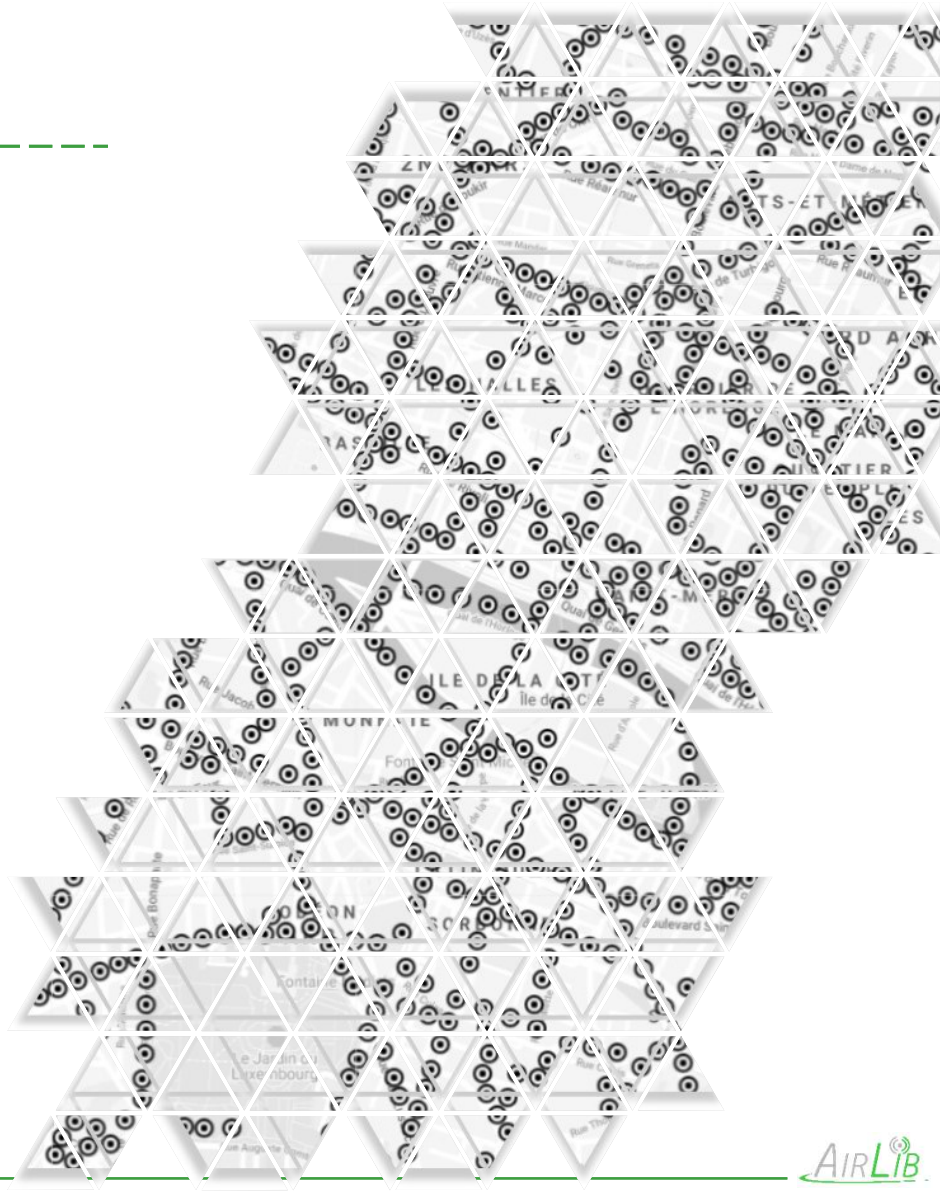
04 Map-based flap control algorithm

05 Car service for improved in-cabin air quality

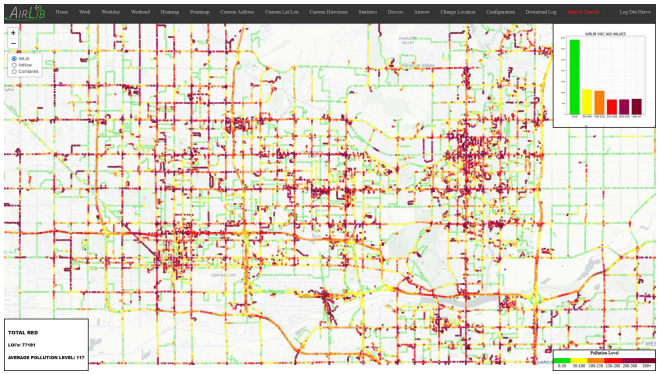
Airlib air quality maps

Why are they unique?

- ☑ From real data rather than model based
- ☑ Unprecedented resolution in time and space
- ☑ Scalable worldwide at realistic cost
- ☑ Actionable for auto and non-auto applications

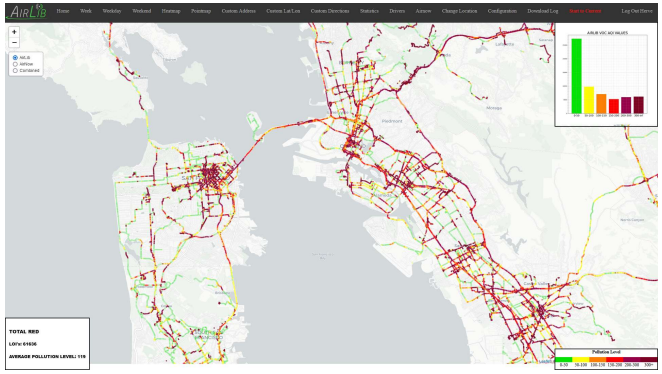


Pilots done in several cities



Phoenix, Arizona

> 15000 trips > 100 000 locations mapped

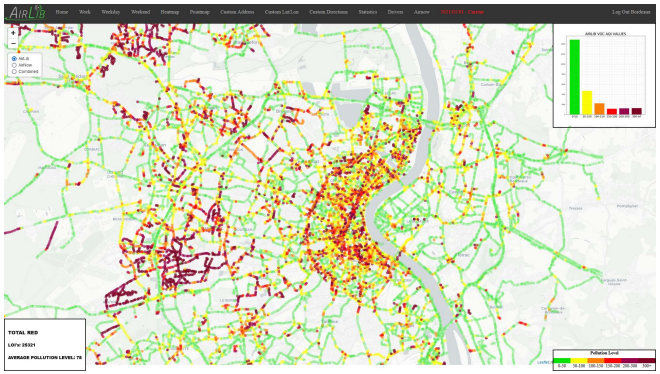


Bay area CA

>5000 trips > 60 000 locations mapped

Paris, France

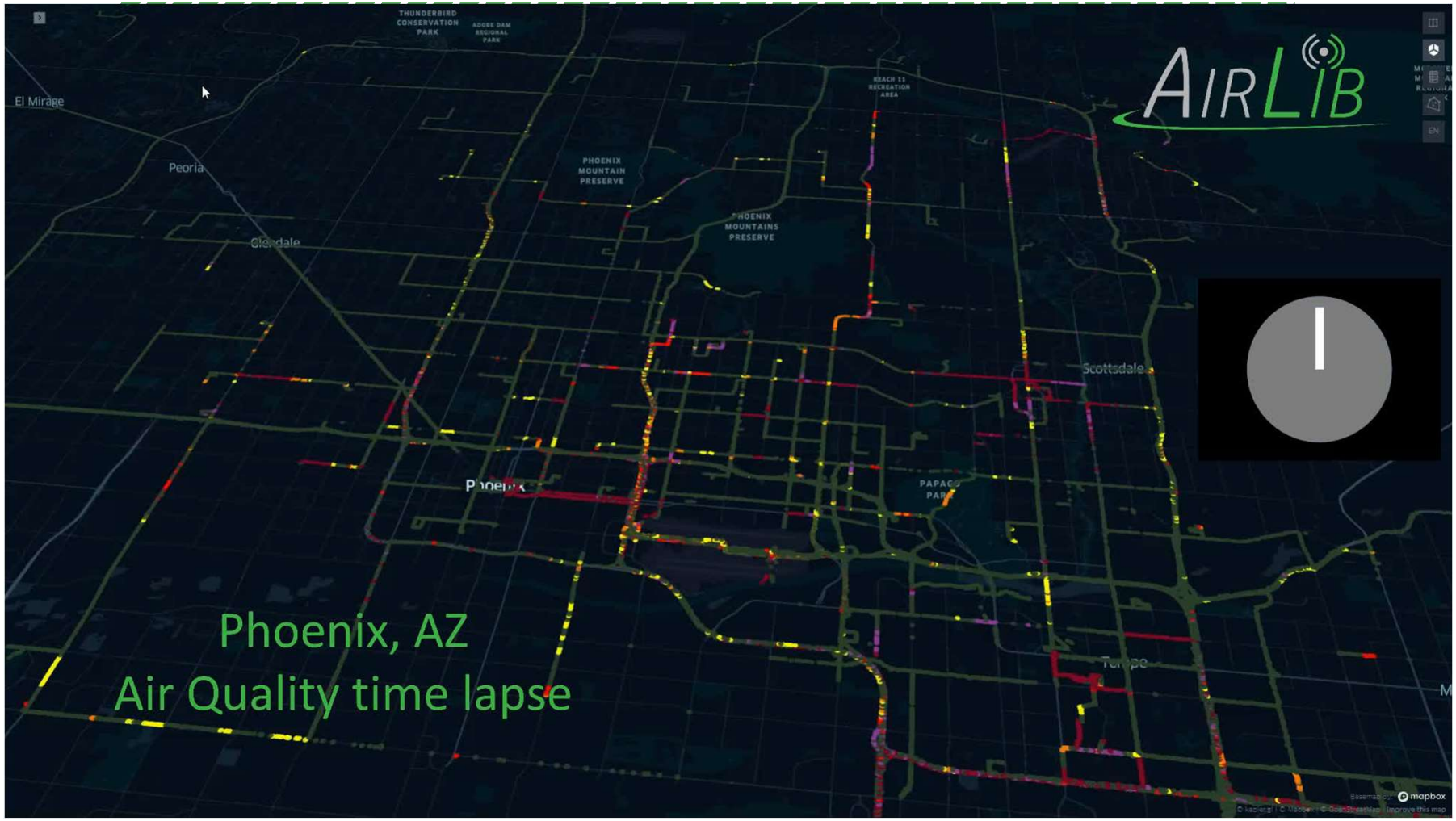
> 5000 trips > 30 000 locations mapped



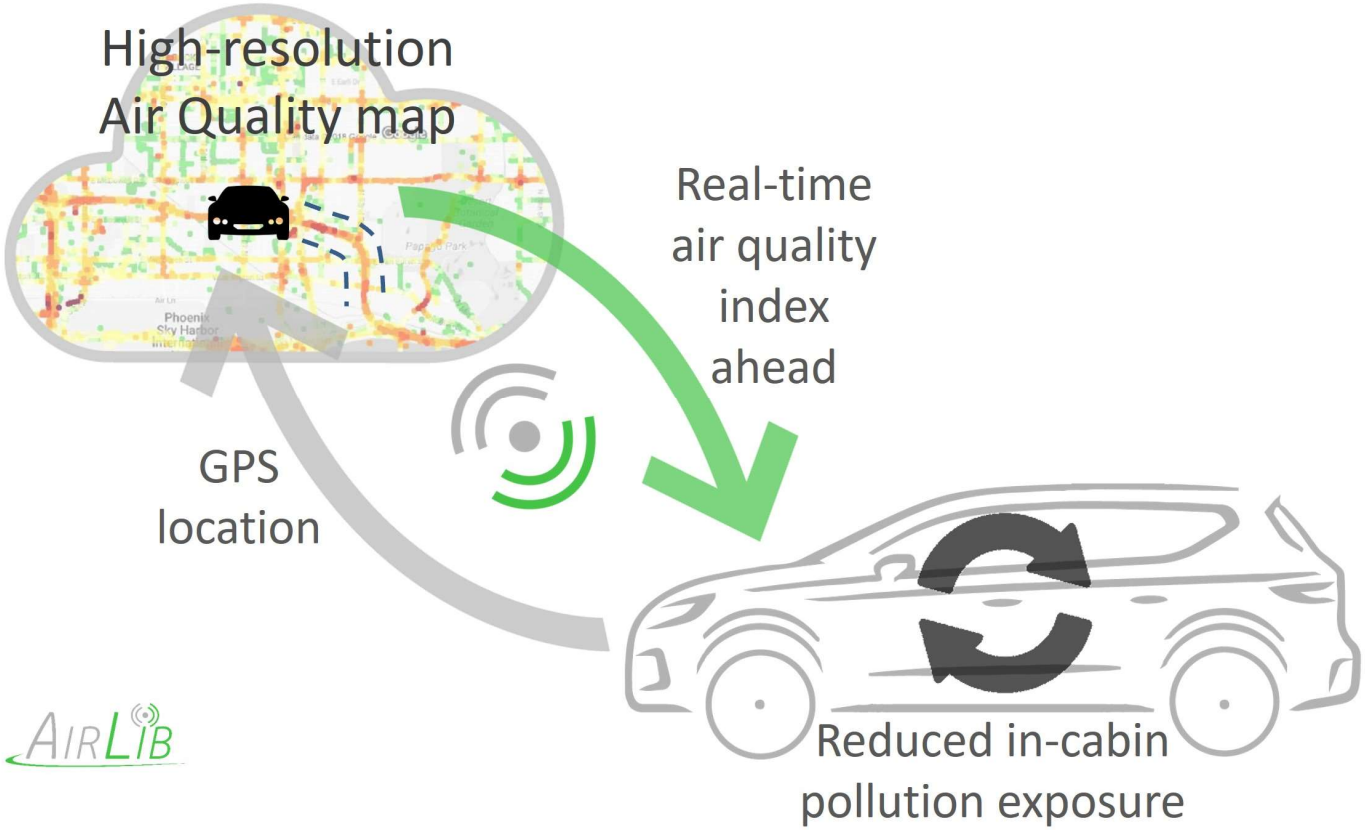
Bordeaux, France

> 20000 trips > 40 000 locations mapped

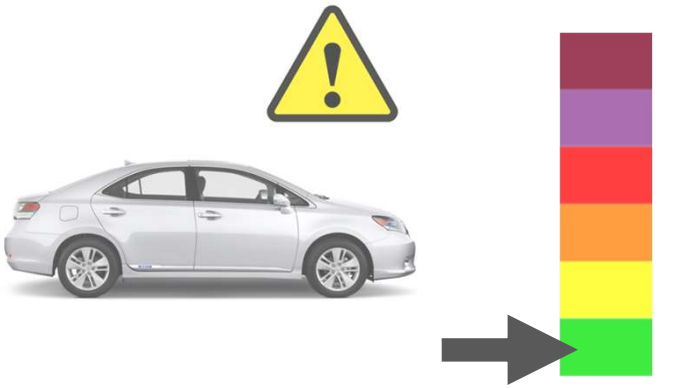
Time lapse


AIRLIB
El Mirage
Peoria
Glendale
Scottsdale
Phoenix, AZ
Air Quality time lapse

Map based pollution exposure reduction



Your car today



High pollution inside the cabin

Car connected to AIRLIB

Recirculation flap closed

Cleaner cabin air

PURPOSE OF THE STUDY

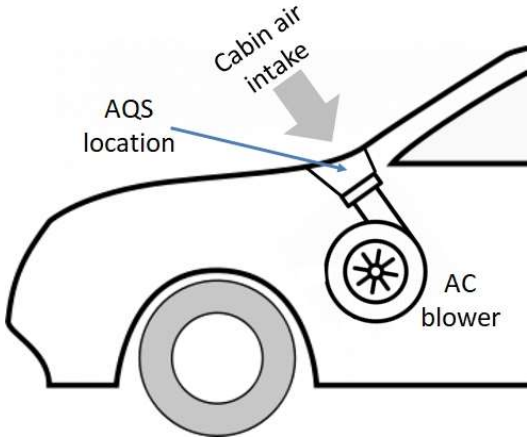
Evaluate in-cabin pollution reduction
with map-based flap control

Why? ➔ Could be implemented on ALL cars

STEP 1: DATA COLLECTION

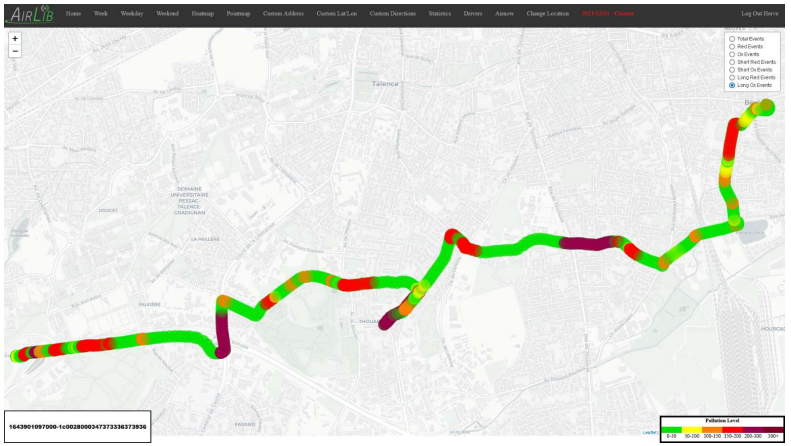
Collection of data from Automotive Air Quality Sensors on-board city cars

- Metal oxide dual sensor
- CO-VOC & NO_2 values every 200ms
- GPS / GSM
- 2 major cities: one in the USA, one in Europe
- Each ~ 50 cars / > 18 months / > 15k trips

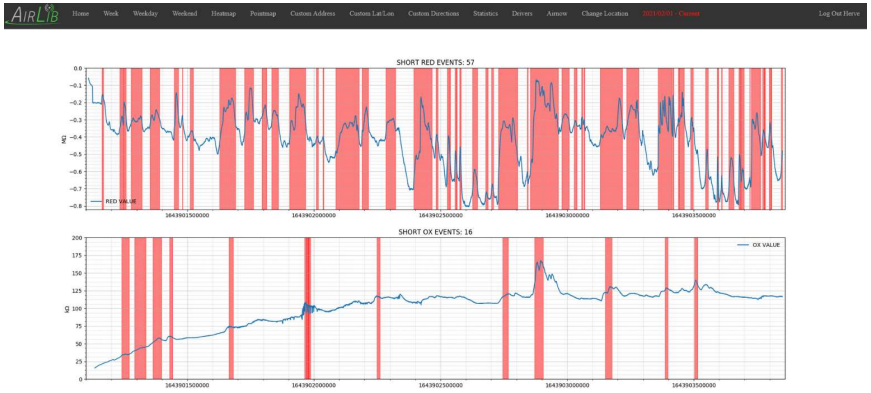


TRIP EXAMPLES

Trip path



Sensor signals



STEP 2: AIR QUALITY MAPS

Calculation of high-resolution air quality maps from trip data

- Approx 50 meter pitch
- 40k-100k gridpoints
- Based on detected “pollution events”
- City center coverage > 100 times
- One Air Quality index per gridpoint

STEP 3: FLAP CONTROL

Recirculation flap control algorithm based on map indices

- Closes if pollution ahead of car is high
- Reopens if pollution ahead is lower
- 60s minimum time between flap movements
- 450 seconds maximum close time

➔ Applied to stored trips as if the car received the flap recommendations real-time

STEP 4: CALCULATION OF IN-CABIN POLLUTION

Simplifying assumptions:

- AC blower speed is constant
- The car is airtight
- The flap is either 100% closed or 100% open
- The initial in-cabin pollution is zero
- In-cabin air “dilution” varies with the ACH

STEP 4: CALCULATION OF IN-CABIN POLLUTION

"Dilution" of the in-cabin air with external air when the flap is open

Flap open ➔ dilution by external air

Flap closed ➔ no dilution

Total Passenger Exposure over trip = $\sum$ in-cabin pollution indices

STEP 5: COMPARISONS

The Total Passenger Exposures* were calculated for sets of 50 trips for each city

- Case 1: flap always open
- Case 2: map-based flap control
- Case 3: periodic flap closures with same overall “closed-time” as case 2
- Case 4: flap control based on on-board Air Quality Sensor

Each case with 3 different Air Changes per Hour ➔ 12/h, 30/h, 40/h

* VOCs only. Similar results obtained with NO2 in Europe

RESULTS

Map-based exposure reduction versus open flap case

Averages over 50 trips	Passenger exposure reduction MAP-BASED FLAP CONTROL*	
	European city	US city
ACH = 12/h	59%	63%
ACH = 30/h	46%	42%
ACH = 40/h	42%	36%

- 36% to 63% exposure reduction vs open flap
- Reduction goes down when blower speed goes up (higher ACH)
- Similar results for the US and European city

** Use of predictive path algorithm to identify likely locations ahead*

RESULTS

Comparison to periodic flap closures

Averages over 50 trips of each city	Passenger exposure reduction MAP-BASED FLAP CONTROL	Passenger exposure reduction PERIODIC FLAP CLOSURES
	Average of European and US cities	Average of European and US cities
ACH = 12/h	61%	40%
ACH = 30/h	44%	17%
ACH = 40/h	39%	11%

The map-based control has a clear advantage

➔ For a given total “closed-flap” time, the timing of the flap closures is critical

RESULTS

Comparison MAP versus SENSOR

Averages over 50 trips of each city	Passenger exposure reduction MAP-BASED FLAP CONTROL	Passenger exposure reduction SENSOR-BASED FLAP CONTROL
	Average of European and US cities	Average of European and US cities
ACH = 12/h	61%	39%
ACH = 30/h	44%	31%
ACH = 40/h	39%	29%

The **map-based control** has better performance than the on-board sensor

CONCLUSIONS

The map-based flap control improves in-cabin air quality significantly

More efficient than an on-board Air Quality Sensor

A pure software solution

Deployable worldwide on all cars, connected or not

Limited investment with important societal health benefits

NEXT STEPS

Collect Air Quality Sensor data from ~ 0.02% of cars

(new data collection pilot coming up with Particulate Matter (PMs) in addition to CO/VOC-NO2)

A single OEM can enable the solution in the USA … or even on several continents

Market the dataset to extract high revenues

THANK YOU

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