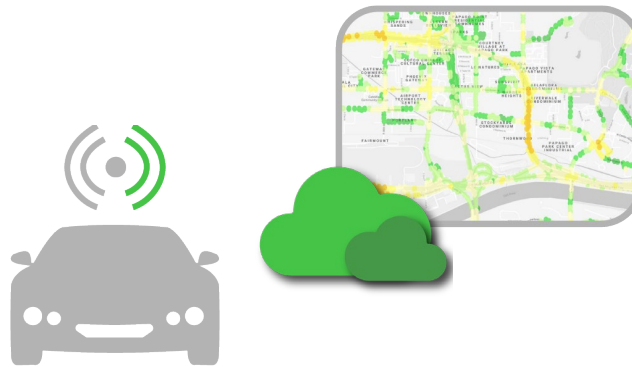


Improved vehicle cabin air quality by control of air recirculation using spatiotemporally-resolved interactive map



11th Annual International PEMS conference - March 2022

Herve Borrel, Paolo Taddonio, Airlib Inc. & Professor Heejung Jung, UC Riverside

Key facts

In-cabin pollution often reaches toxic levels

Traffic pollution is responsible for millions of deaths each year worldwide



Automotive Air Quality Sensor have been used for >30 years
(~ 8 million/yr)

Managing the recirculation flap is a must
but is reserved to high-end cars

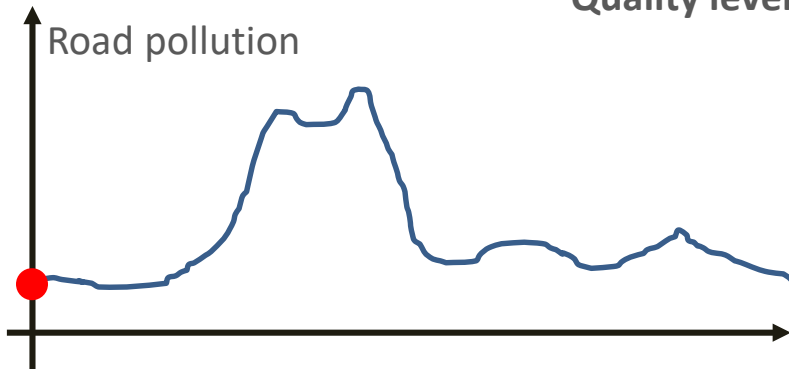
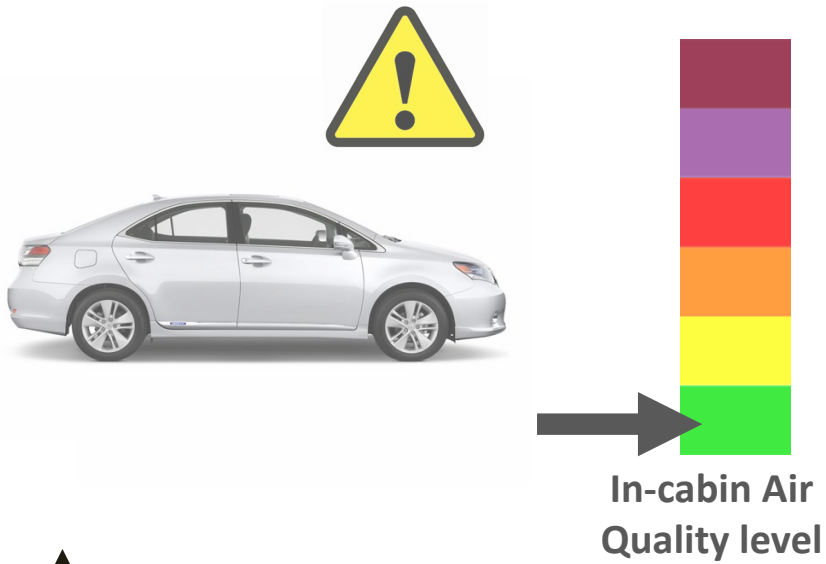


Purpose of the study

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

Why → Could be implemented on 100% of connected cars

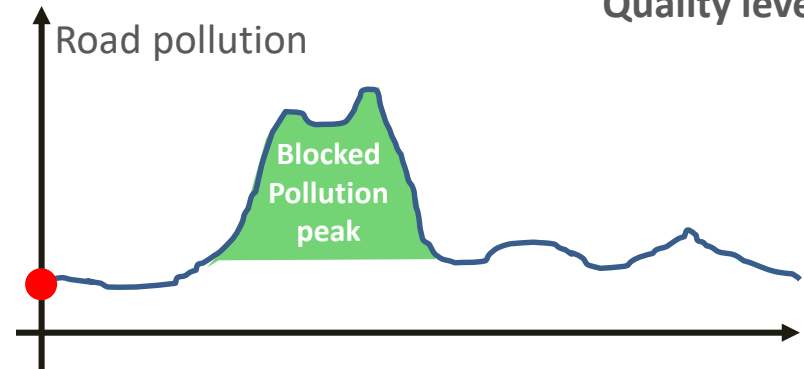
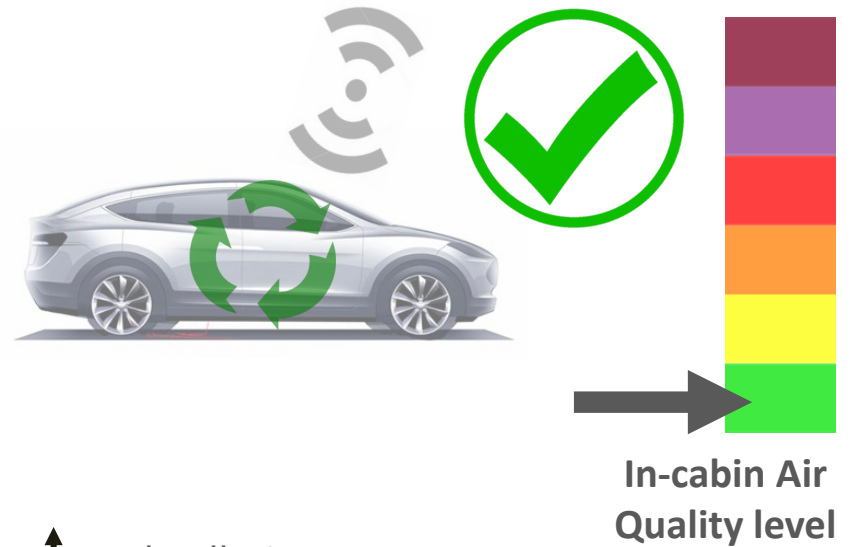
Your car today



**High pollution
inside the cabin**

Car connected to

AIRLIB

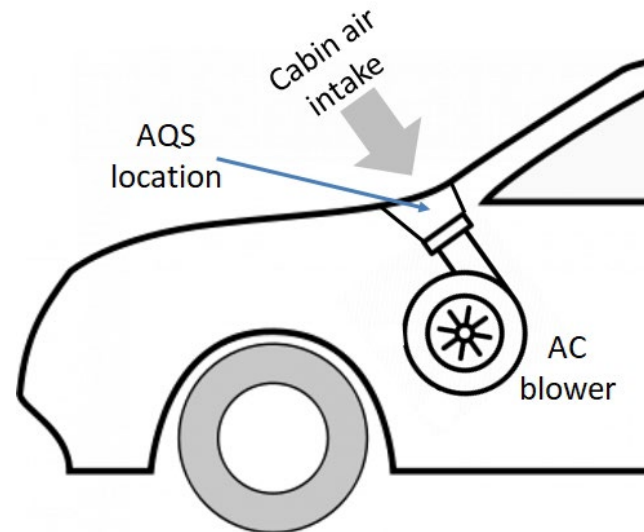


**Recirculation flap closed
Cleaner cabin air**

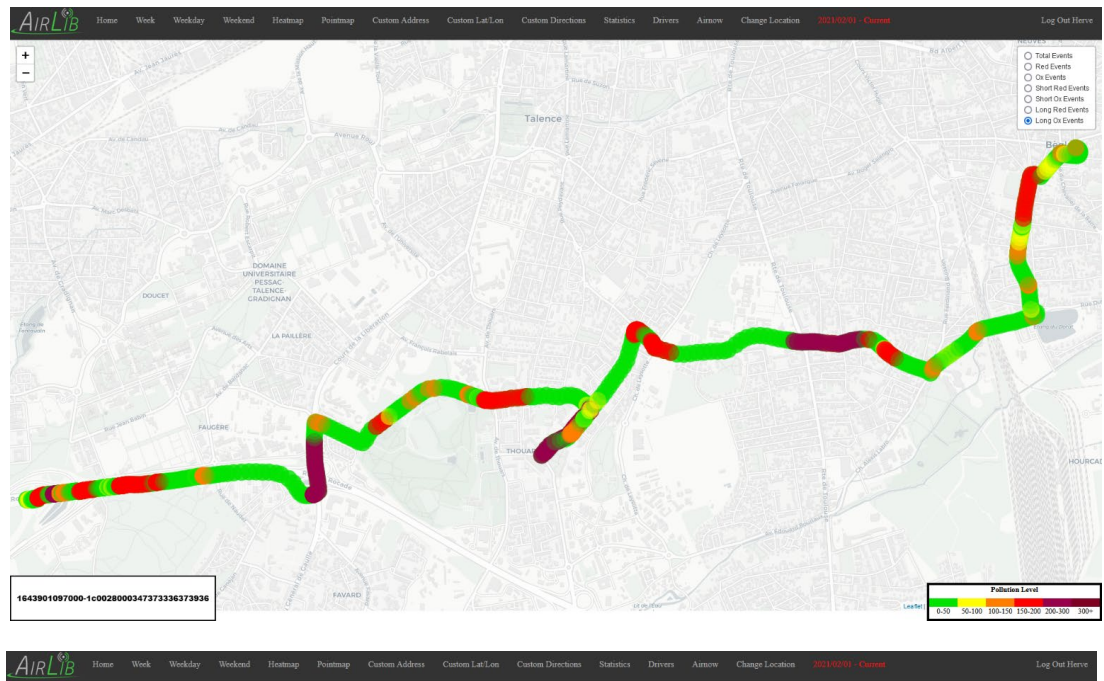
step 1: Data collection

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

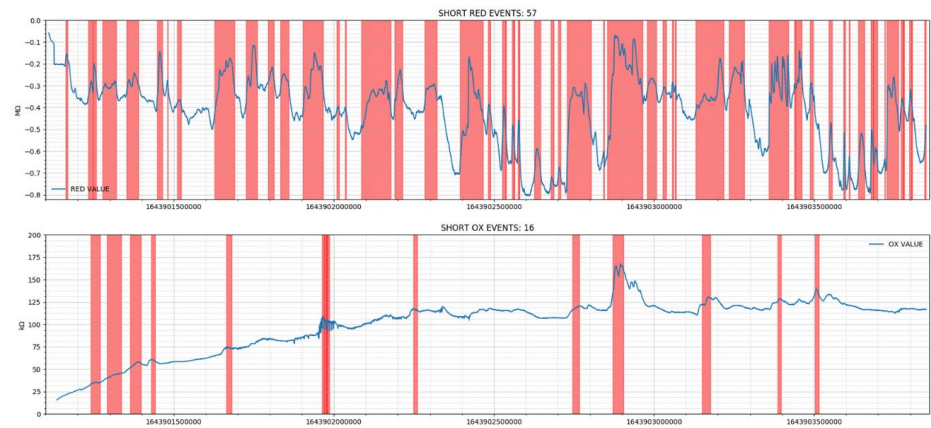
- GPS / GSM
- Metal oxide dual sensor
- CO-VOC & NO₂ values every 200ms
- European major city ~ 1 m inhab.
- Metro area ~ 500km², City center area 50 km²
- 40 cars / 9 months / > 10k trips



Trip path example



Sensor signals example



step 2: Air Quality maps

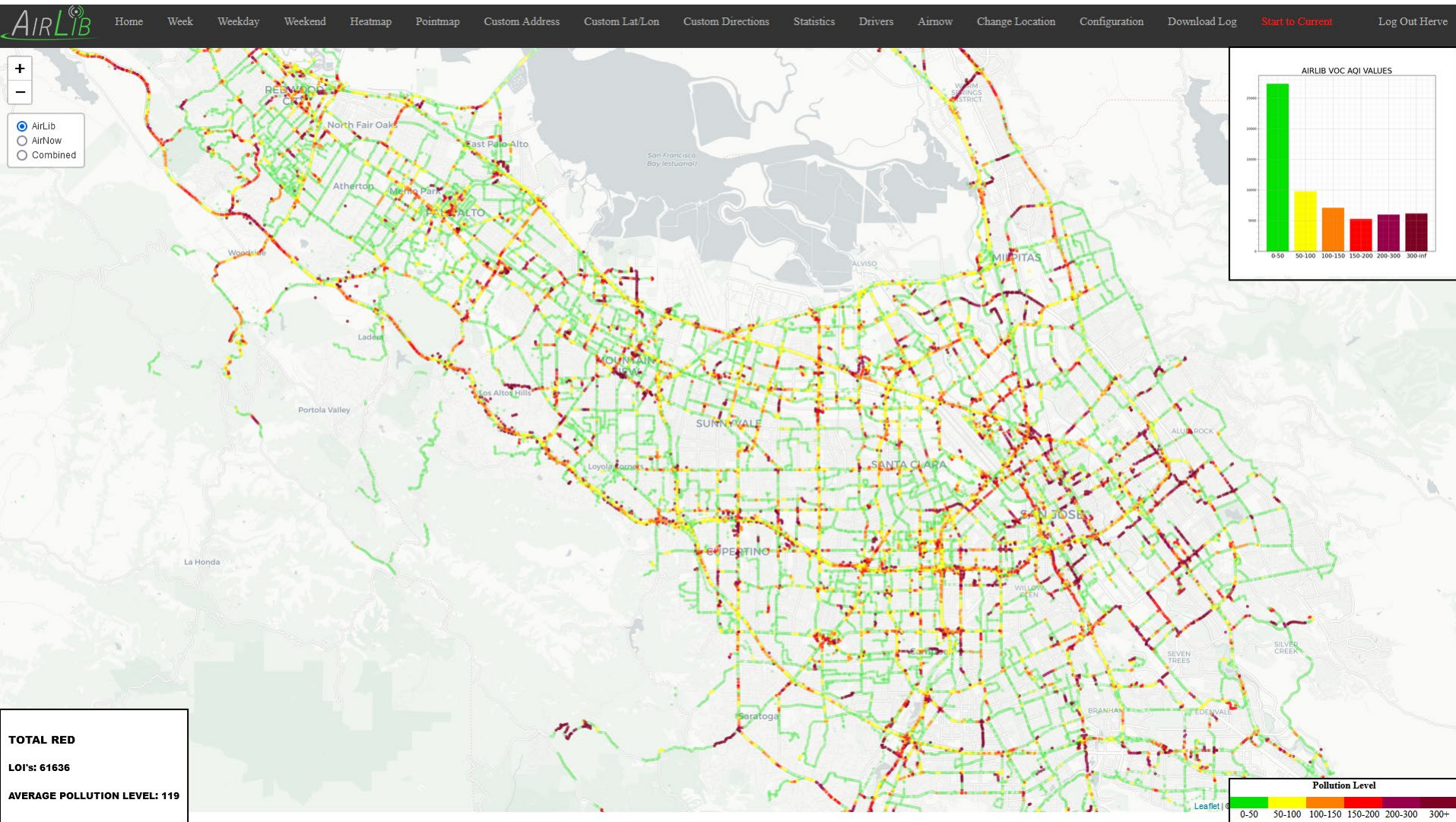
Calculation of high-resolution air quality maps using 10k trips data

- Approx 50 meter pitch
- ~ 32k gridpoints
- Based on detected “pollution events”
- Study done on CO/VOC only
- Average coverage ~40 times
- One Air Quality index per gridpoint



Map examples

Bay area



Map examples

Paris, France



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
- Minimum time between flap movement 60s
- Maximum close time 450s



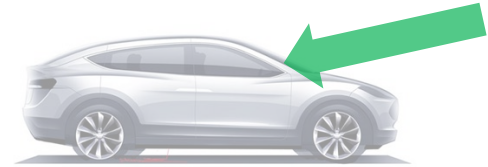
➔ Applied to trips as if the car received the flap recommendations real-time

step 4: Calculation of in-cabin pollution

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

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
(Air Change per Hour)



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 a set of 50 trips

- Case 1: map-based flap control
- Case 2: flap always open
- Case 3: periodic flap closures with same overall closed time as case 1
- 3 different Air Changes per Hour for each case: 12/h, 30/h, 40/h

Results

Exposure reduction vs open flap case

Passenger exposure reduction MAP-BASED FLAP CONTROL	
Average of 50 trips with ACH = 12/h	56%
Average of 50 trips with ACH = 30/h	45%
Average of 50 trips with ACH = 40/h	42%

- 42% to 56% exposure reduction vs open flap
- Reduction goes down when blower speed goes up (higher ACH)

Results

Comparison to periodic flap closures

	Passenger exposure reduction MAP-BASED FLAP CONTROL	Passenger exposure reduction PERIODIC CLOSED FLAP 66% of time
Average of 50 trips with ACH = 12/h	56%	26%
Average of 50 trips with ACH = 30/h	45%	9%
Average of 50 trips with ACH = 40/h	42%	5%

% reduction vs open flap case

- Improvement vs same closed time without map control is significant
- The delta goes up when the blower speed goes up

Conclusion

Map-based flap control improves in-cabin air quality significantly

Purely software solution

Deployable worldwide

Limited investment with important societal health benefits



Next steps

Requires data collection by cars with on-board AQS

AQS data from 100k cars could bring better air to > 200 million car users

A single OEM could enable it!

And make it available to all OEMs ...

... for example via Android automotive

THANK YOU !

