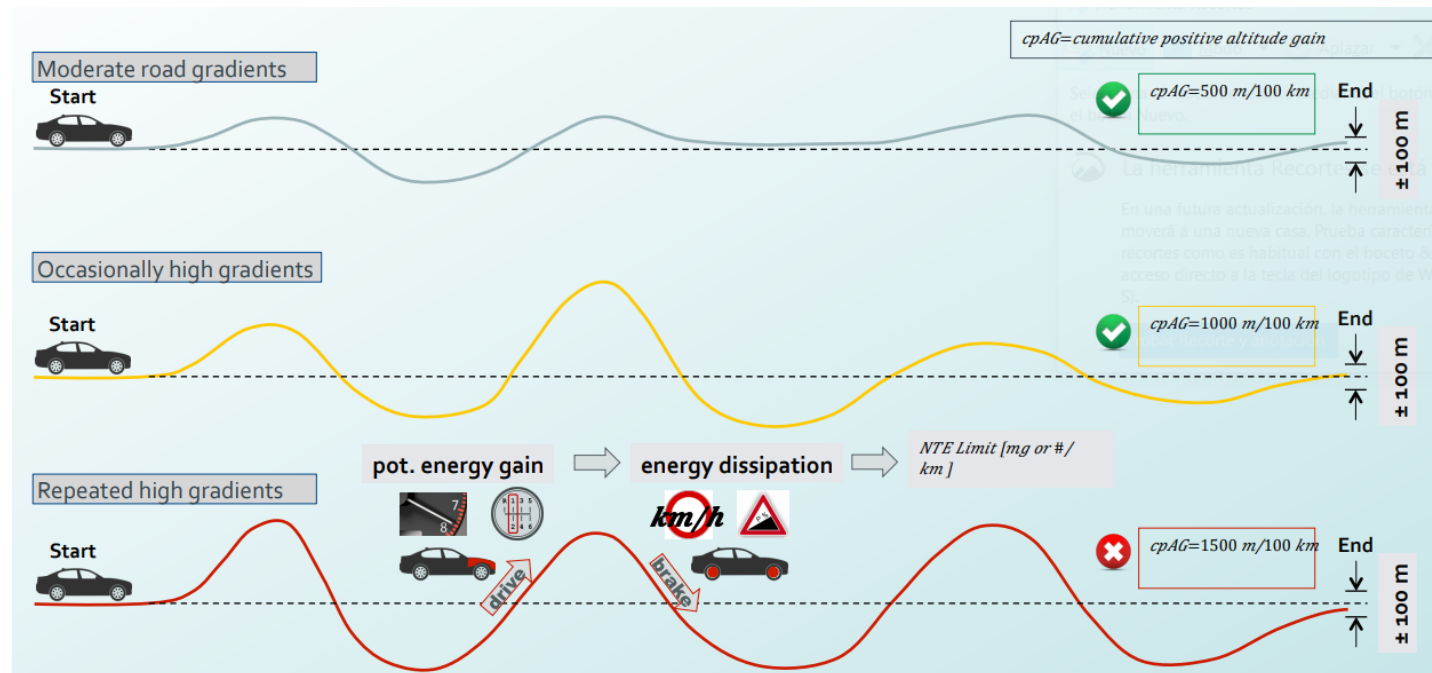


# Influence of altitude beyond the boundary conditions of the RDE cycle, on the emissions of nanoparticles from a TSI E6 vehicle



## Motivation

European  
regulation

Roads of  
Europe

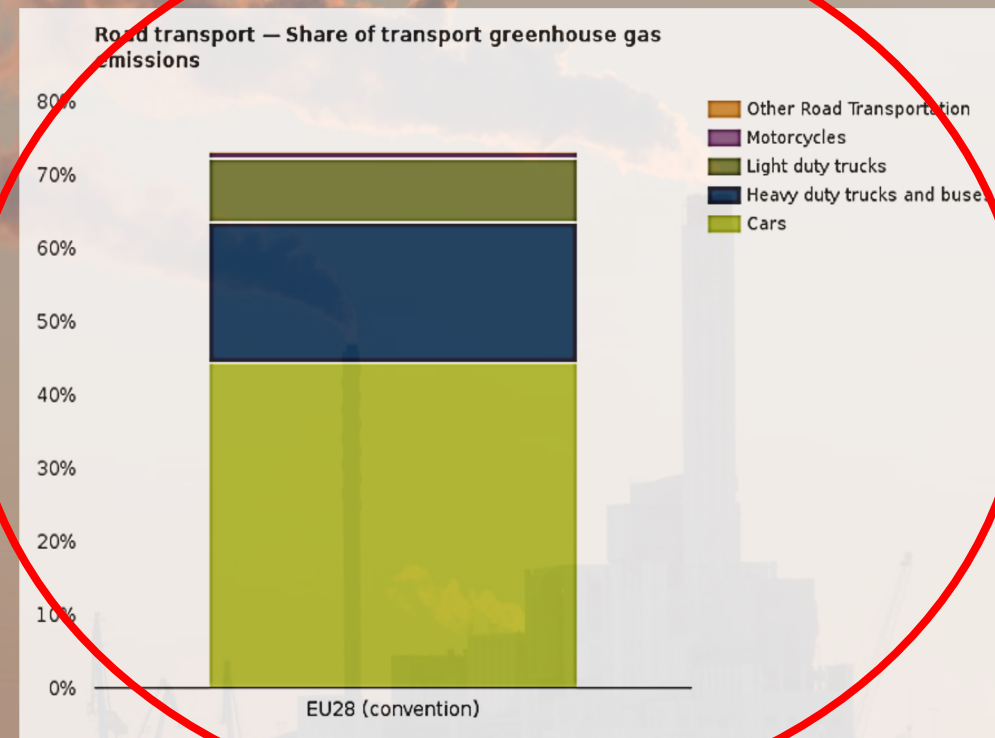
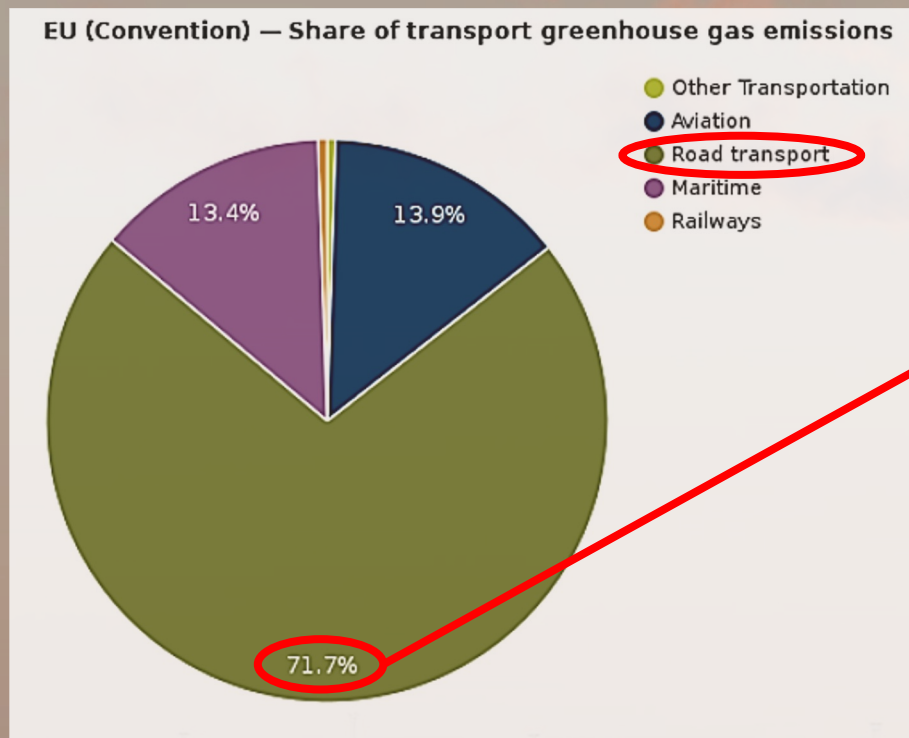
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# The emission of greenhouse gases



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# Real Driving Emissions (RDE)

Approved in 2015 as part of the Euro 6 regulation legislation.

RDE arises from the need to evaluate nitrogen oxides and particulate matter.

The trip requirements for the cumulative positive altitude gain are limited to 1,200m/100km.

RDE boundary conditions PER 2016/427/EC.

Parameter	Requirements per 2016/427/EC	
Altitude	Moderate: 0 to 700 m	(Extended: 700 to 1300 m)
	< 100 m altitude difference between start and finish The cumulative elevation gain is limited to 1200 m/100 km <sup>a</sup>	
Ambient temperature	Moderate: 0 °C to 30 °C	(Extended: -7 °C to 35 °C and 30 °C-35 °C)
Dynamics <sup>a</sup>	Max: 95th percentile of $v \cdot a$ (speed*positive acceleration)	Min: RPA (relative positive acceleration)
Maximum speed	145 km/h (160 km/h for 3% of the motorway driving time)	
Payload	Maximum 90% of the maximum vehicle weight (driver + equipment)	
Stop percentage	Between 6% and 30% of the urban driving time	
Use of auxiliary systems	Operated as in real life (air conditioning etc.), not to be recorded	

<sup>a</sup> Added by means of the 2nd RDE package.



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# Roads of Europe

## Karakaya Hill

- Elevation of 3,148 meters above the sea level.

## Col de la Bonette

- Elevation of 2,715 meters above the sea level.

## Stelvio Pass

- Elevation of 2,757 meters above the sea level.

## Observatorio del Pico Veleta

- Elevation of 2,856 meters above the sea level.

## Testa Grigia

- Elevation of 3,471 meters above the sea level.

## Ötztal Glacier

- Elevation of 2,830 meters above the sea level.





# Mobile laboratory

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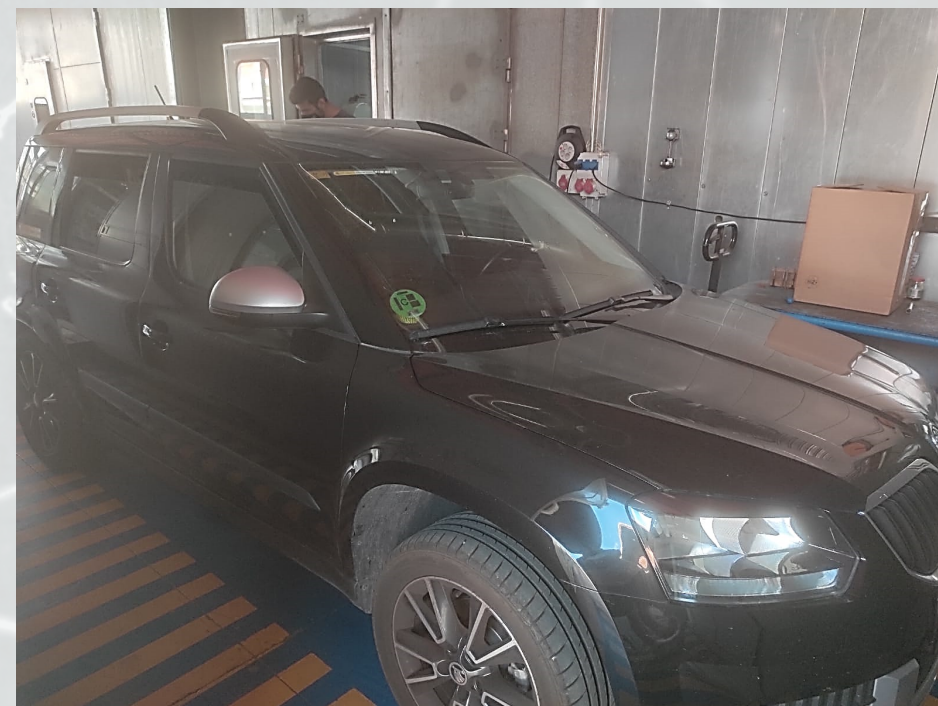
References

Skoda Yeti 1.2 TSI 110 CV

Turbocharged engine

Direct stratified injection

4-Cylinder





Motivation

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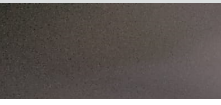
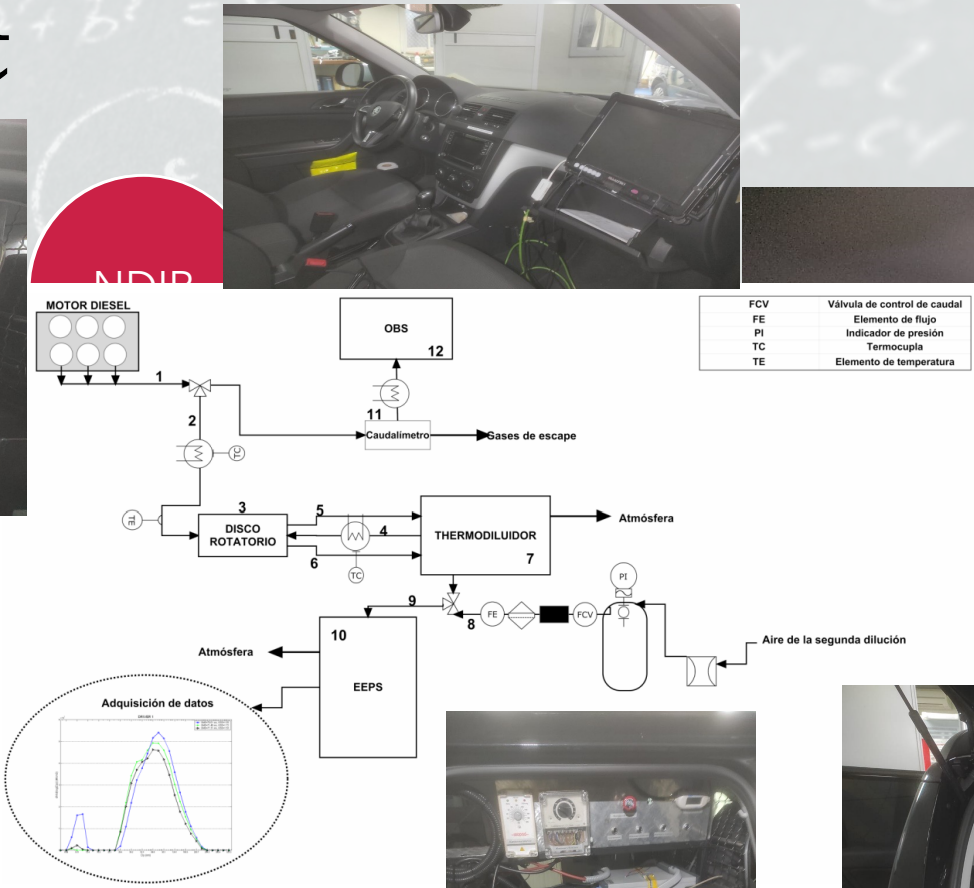
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# Equipment





# Urban area

Motivation

European regulation

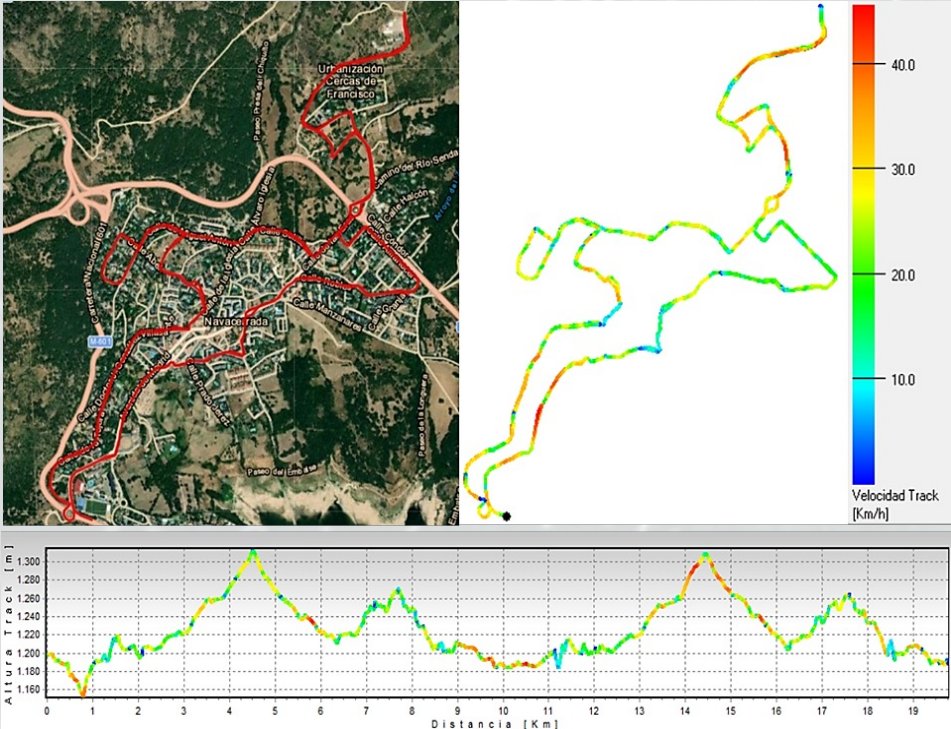
Roads of Europe

Methodology

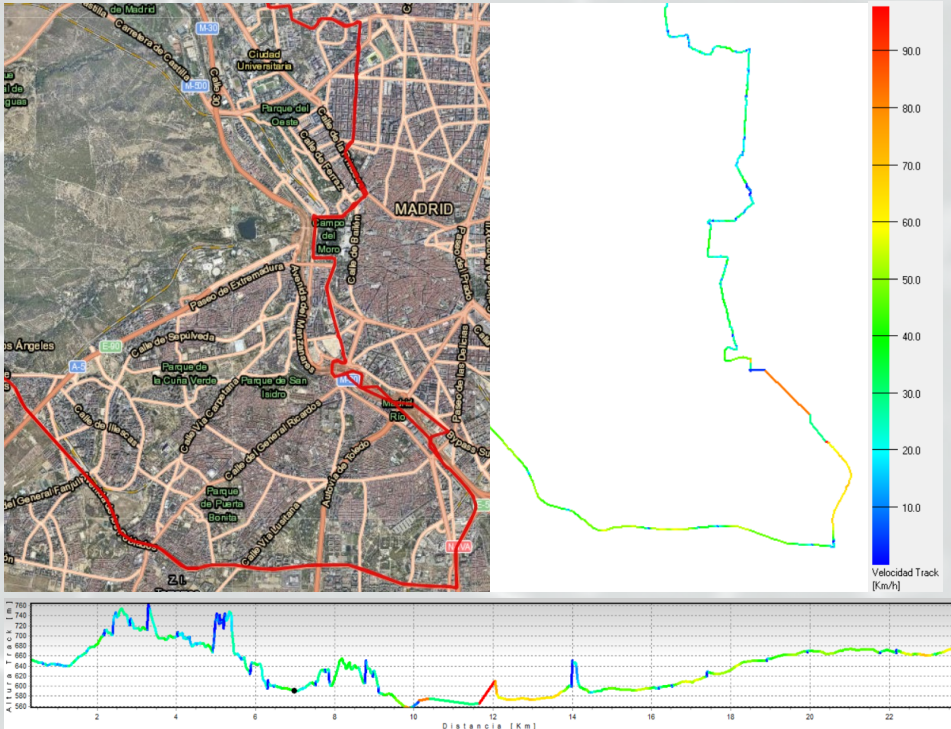
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Urban area beyond the altitude limits



Urban area within the altitude limits



# Rural area

Motivation

European regulation

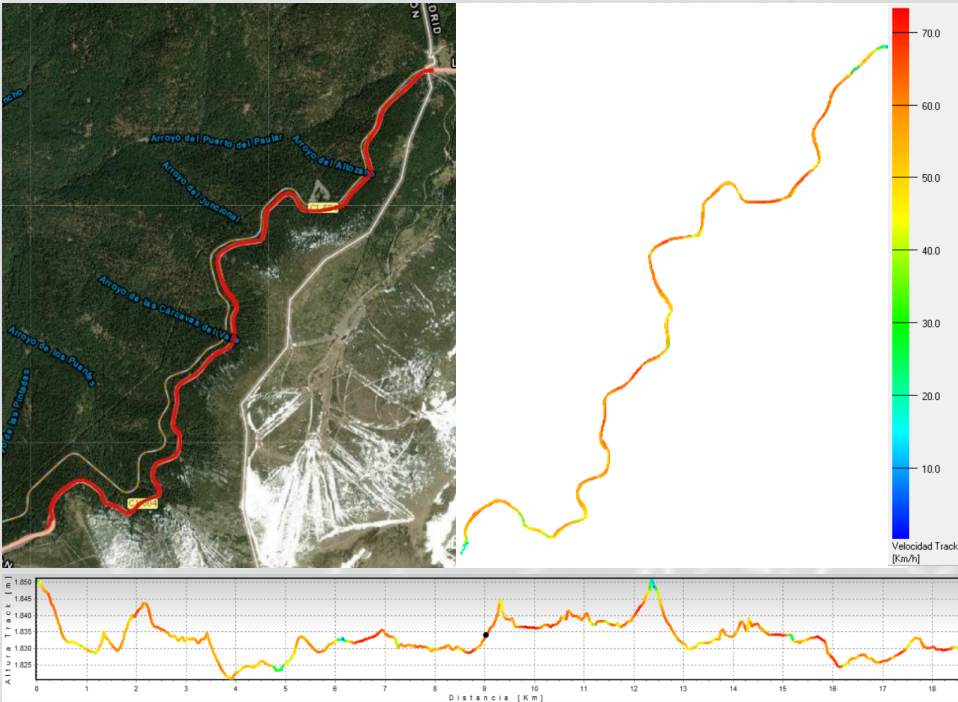
Roads of Europe

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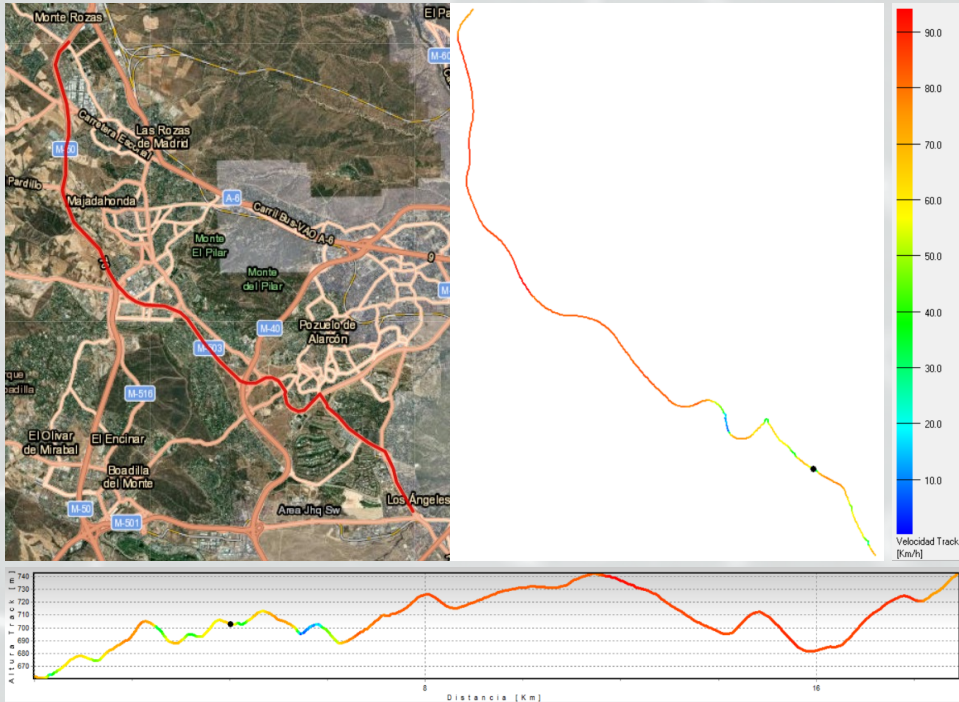
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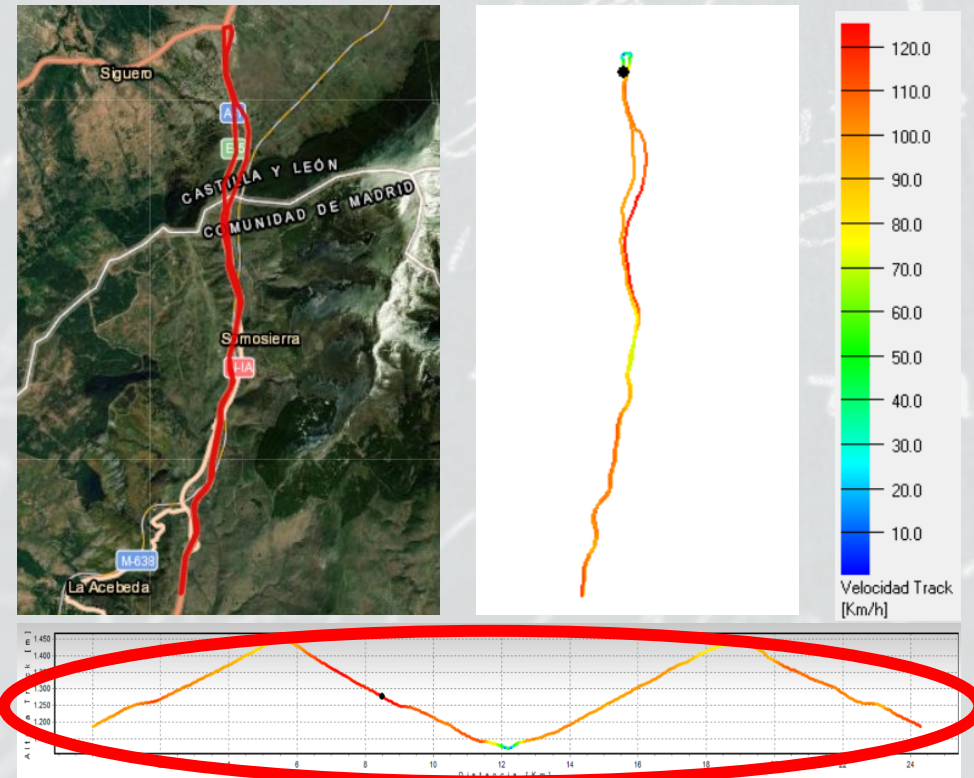
Rural area beyond the altitude limits



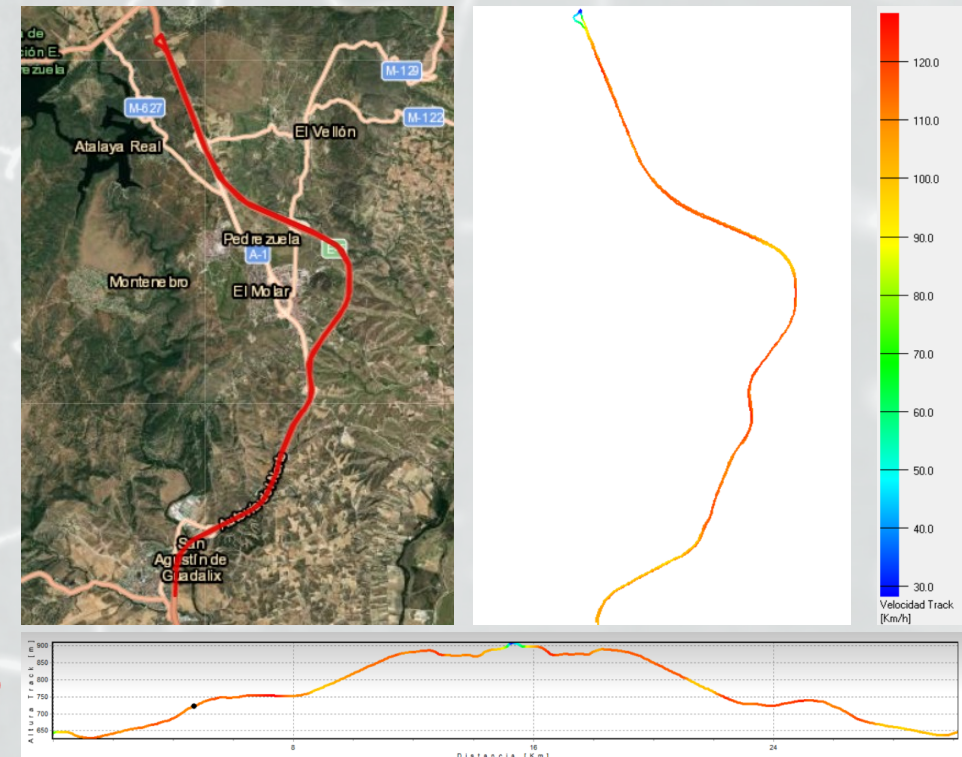
Rural area within the altitude limits



# Motorway area



Motorway area beyond the altitude limits



Motorway area within the altitude limits

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# Torque and fuel consumption

Within the altitude limits	
Area	Torque (Nm)
Urban	52.03
Rural	65.84
Motorway	121.03
Beyond the altitude limits	
Area	Torque (Nm)
Urban	48.41
Rural	61.75
Motorway	138.96



Within the altitude limits	
Area	Fuel consumption (l/h)
Urban	3.07
Rural	5.06
Motorway	10.42
Beyond the altitude limits	
Area	Fuel consumption (l/h)
Urban	2.64
Rural	4.70
Motorway	12.19



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# Air~Fuel Ratio

>14,7 Lean mixture

= 14,7 Stoichiometric mixture

< 14,7 Rich mixture

Within the altitude limits	
Area	A/F
Urban	15.9
Rural	14.8
Motorway	15.5
Beyond the altitude limits	
Area	A/F
Urban	16.1
Rural	16.4
Motorway	13.8

# Nanoparticles emissions

Motivation

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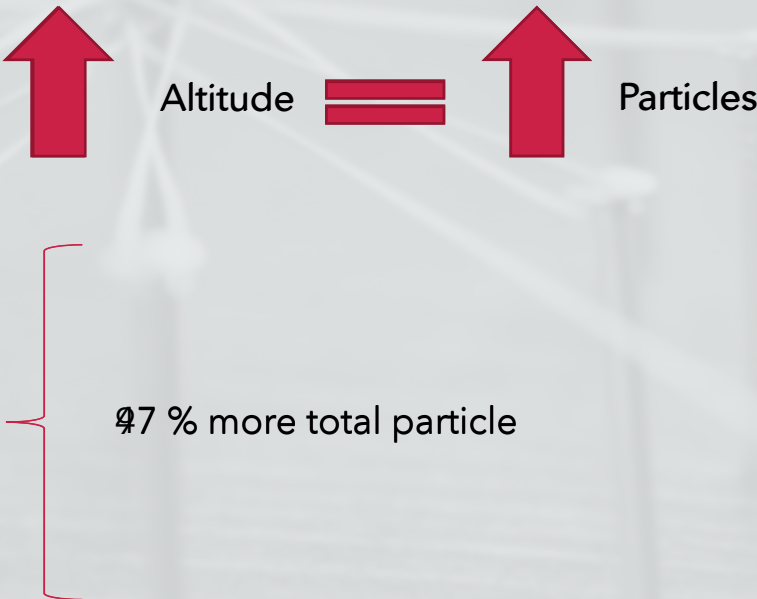
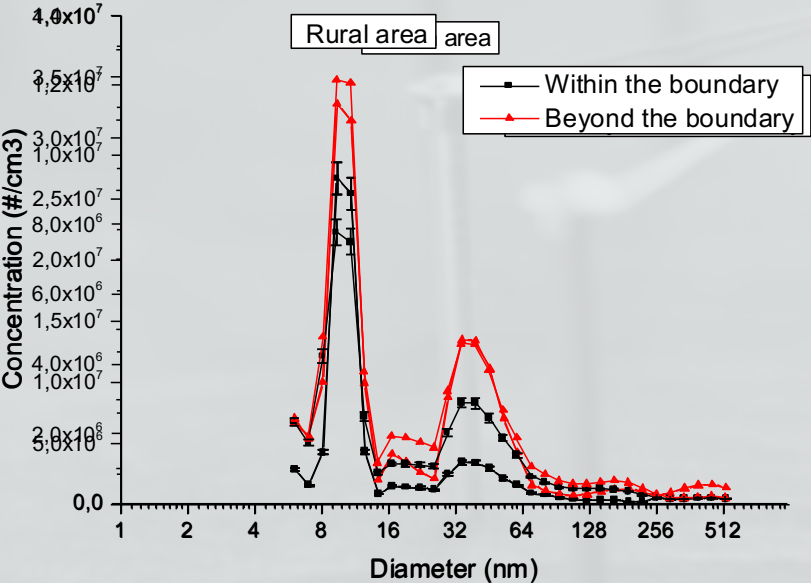
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# NO<sub>x</sub> emissions

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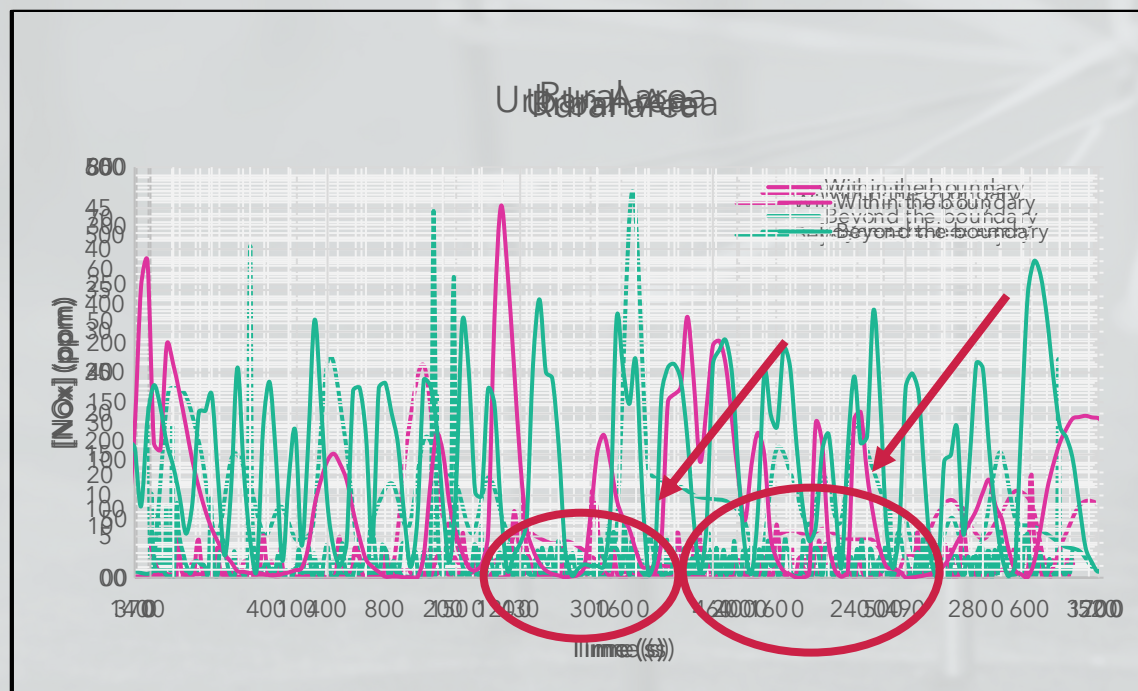
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 Altitude = 
 
 NO<sub>x</sub>


 More than 17% NO<sub>x</sub>



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# Other emissions



12% less total particle emission is observed in the motorway area beyond the altitude limits.



More than 17% NO<sub>x</sub> emission in the motorway area beyond the altitude limits.

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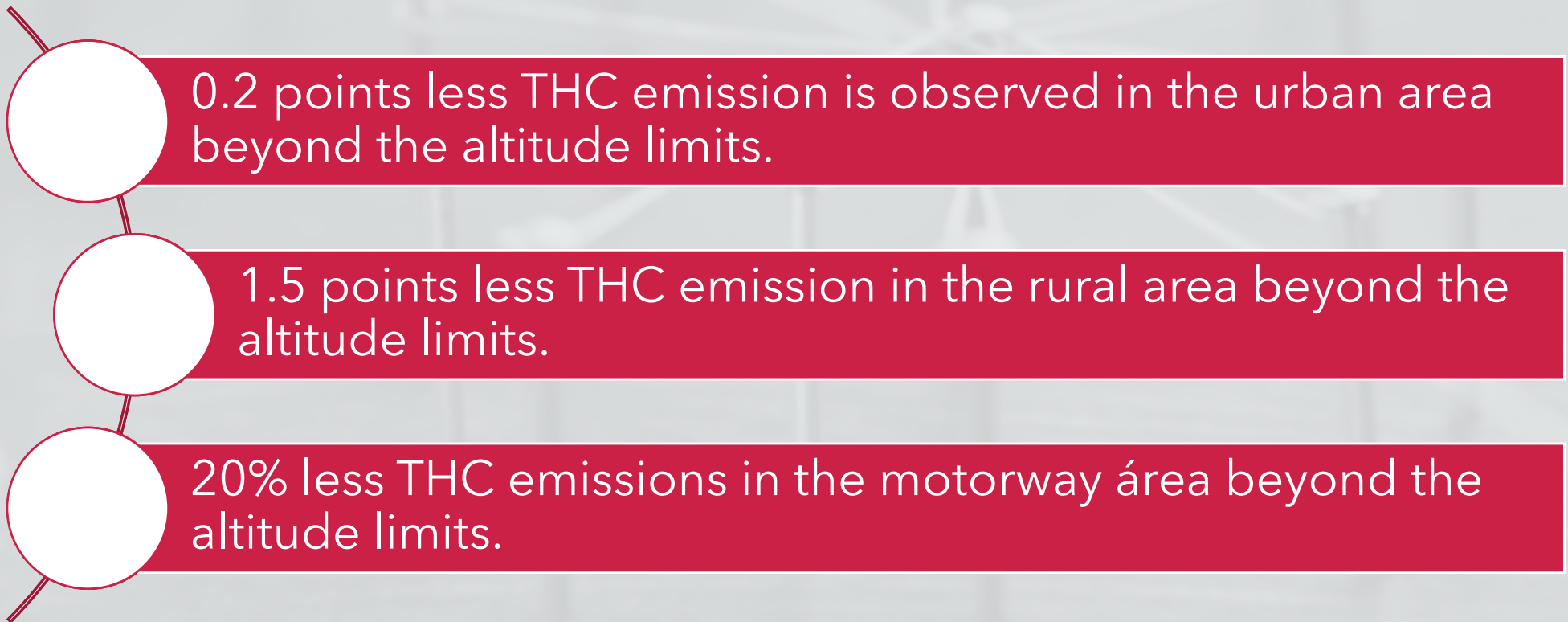
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# Other emissions



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# General conclusions

An increase in altitude affects vehicle emissions.

The altitude limits of the RDE cycle are quite restricted, implying the need to be extended.

Nanoparticles are the most affected emissions.

EOBD leans the mixture as altitude increases.

The temperature of the catalyst in post-cold start conditions has a great influence on emissions.



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# References

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OICA (International Organization of Motor Vehicle Manufacturers)

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DGT (Dirección General de Tráfico)

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Agencia Europea de Medioambiente (EEA).

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[www.dangerousroads.org](http://www.dangerousroads.org)

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Contribución al estudio del número y distribución de tamaños de partículas emitidas por motores en tráfico urbano, Aida Domínguez Sáez

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Hooftman, N., Messagie, M., Van Mierlo, J., & Coosemans, T. (2018). A review of the European passenger car regulations - Real driving emissions vs local air quality.

Thank you very  
much for your  
attention

