MODELLING NO_2 CONCENTRATION USING CFD-RANS MODEL WITH HIGH RESOLUTION TRAFFIC EMISSIONS

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Summary
The aim of this work is to obtain high resolution maps of average pollutant concentration for a large period (several weeks) in real urban areas. To achieve this purpose, several meteorological scenarios are simulated by using CFD-RANS model taking into account high resolution emissions, the aerodynamical effects of vegetation and urban morphology. This study is focused on an urban area of Madrid (Fernández Ladreda square) where high NO_2 concentration values are registered. An intensive experimental campaign was carried out with a large number of passive samplers distributed around the square. These measurements are used to validate the modelling results.

Introduction
High resolution maps of average concentration over a large period of time are necessary for air quality management and the assessment of abatement measures. The Computational Fluid Dynamics (CFD) models are able to simulate airflow and pollutant dispersion with very high resolution (~1m). However, due to computational loads, it is not possible (within a reasonable CPU time) to run an unsteady CFD simulation of several weeks or months. The solution proposed (Santiago et al., 2013) is to run only a set of scenarios (corresponding to 16 wind directions) using steady CFD-RANS simulations. In this study, this methodology is applied to a complex urban area using emissions from a very detailed microscale traffic and emission model. This is an important issue because according to previous source contribution analysis, NO_2 ambient concentration levels in the innermost area of Madrid are strongly dominated by road traffic (Borge et al., 2014).

Methodology and Results
The size of the study area (Fig 1.) is 1km x 1km. The modelling domain comprises one tunnel, several kinds of vegetation and several streets with high traffic intensity. Emissions used to feed the CFD-RANS model cover a 300m x 300m around the square with a resolution of 5 m. Twelve emission scenarios corresponding to different traffic patterns for different periods of the day and days of the week are considered in this study. The final map of average concentration is made by means of a combination of the simulated scenarios considering concurrent wind patterns within the period analysed. Pollutant concentration is computed assuming i) non-reactive pollutants and ii) thermal effects negligible in comparison with dynamical effects. As a consequence tracer concentration at a certain hour depends only on emissions, background pollution and wind speed at that hour (no memory between one hour and the following one). In addition, the dynamic effects of vegetation are included in CFD simulations assuming the trees as a porous medium (Santiago et al., 2013). It should be noted that the period simulated in this study correspond to winter conditions (February 2015), where the pollutant concentrations are less affected by atmospheric chemistry and thermal effects are negligible. The methodology is assessed using experimental data from 200 passive samplers distributed around the square.

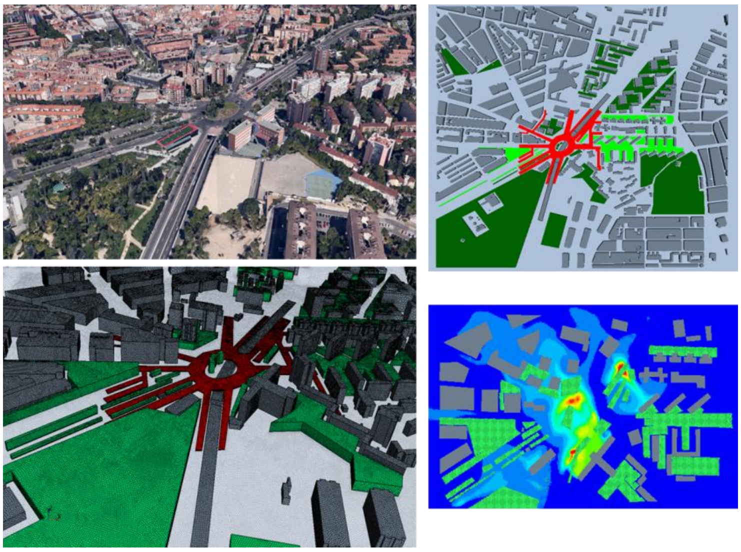

Fig1. *Real geometry, computational domain and pollutant distribution for SE wind direction*

Conclusions
A high resolution emission model has been satisfactorily implemented in the CFD-RANS model. The results obtained with this methodology are in agreement with experimental measurements of the campaign.

Acknowledgement
This study has been supported by the project TECNAIRE (S2013/MAE-2972) funded by The Regional Government of Madrid.

References
Borge, R, Lumbreras, J, Pérez, J, de la Paz, D, Vedrenne, M, de Andrés, JM, Rodríguez, ME, 2014: Emission inventories and modeling requirements for the development of air quality plans. Application to Madrid (Spain). Science of the Total Environment 466-467, 809-819.

Santiago JL, Martín F, Martilli A, 2013: A computational fluid dynamic modelling approach to assess the representativeness of urban monitoring stations. Science of the Total Environment 454-455, 61-72.