Evaluation of carbon reduction traffic measures employing a novel approach to micro-simulation modelling of real-world emissions

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Introduction

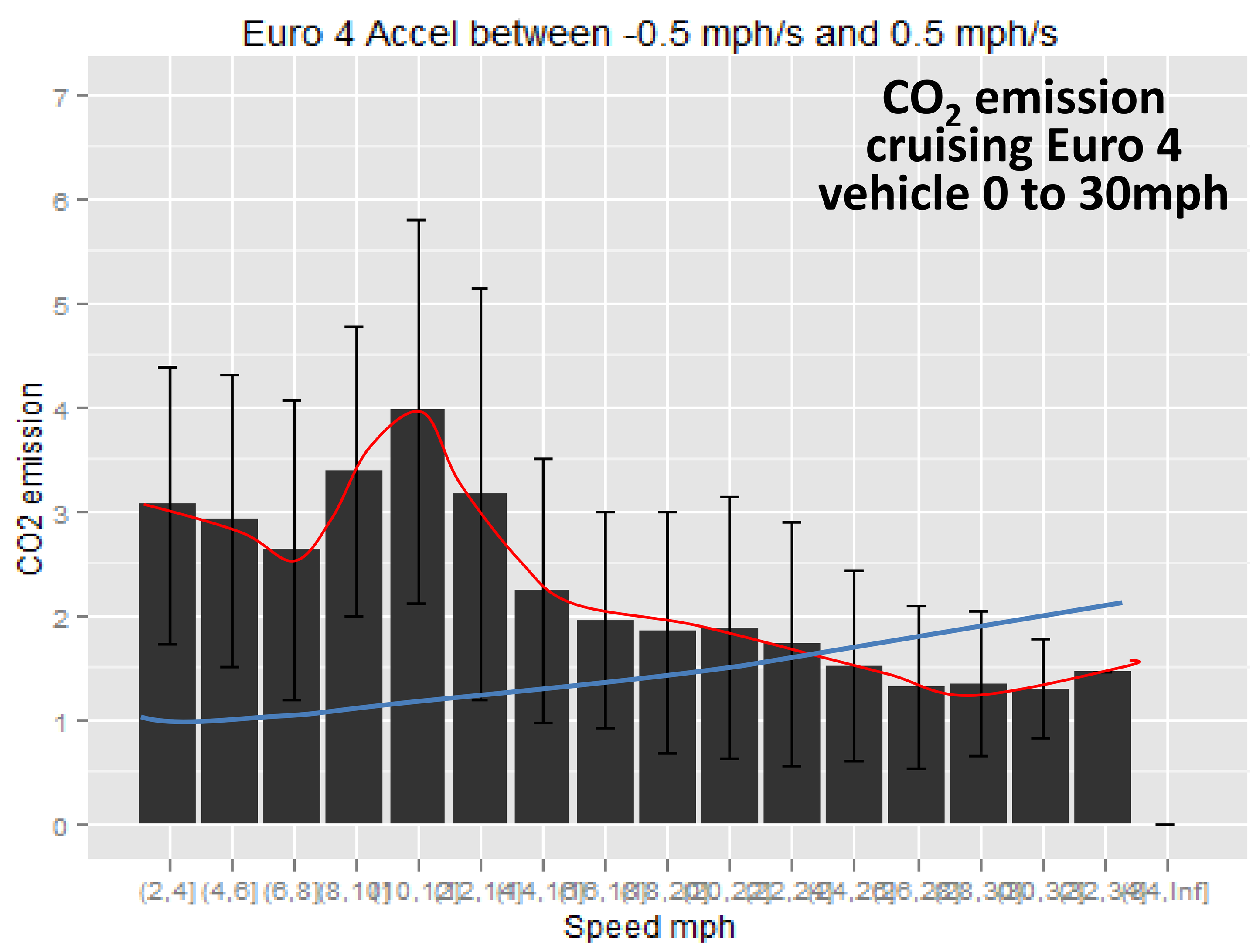
Transport plays a significant role in carbon dioxide, CO_2, emissions accounting for a quarter of the UK inventory. CO_2 emissions can be reduced by driver training, by improving traffic operations and through traffic congestion alleviation and smoothing flow. Quantifying the real-world emission benefits of such traffic management measures requires a modelling framework that realistically models the variability of the emissions associated with driving habits, different vehicles' performance and traffic states, such as quiet, smooth flow, unstable flow and congested.

Emissions Factors

Emissions Factors used in air quality models are associated with average speed and average traffic flow on each road/link of a network. Although they provide a reasonable estimate of total emissions over an area, they result in an underestimate of emissions in particular urban streets and at junctions, where congestion prevails for a high proportion of the day. As a consequence emissions benefits of technologies and traffic management measures are underestimated.

Real-world emissions

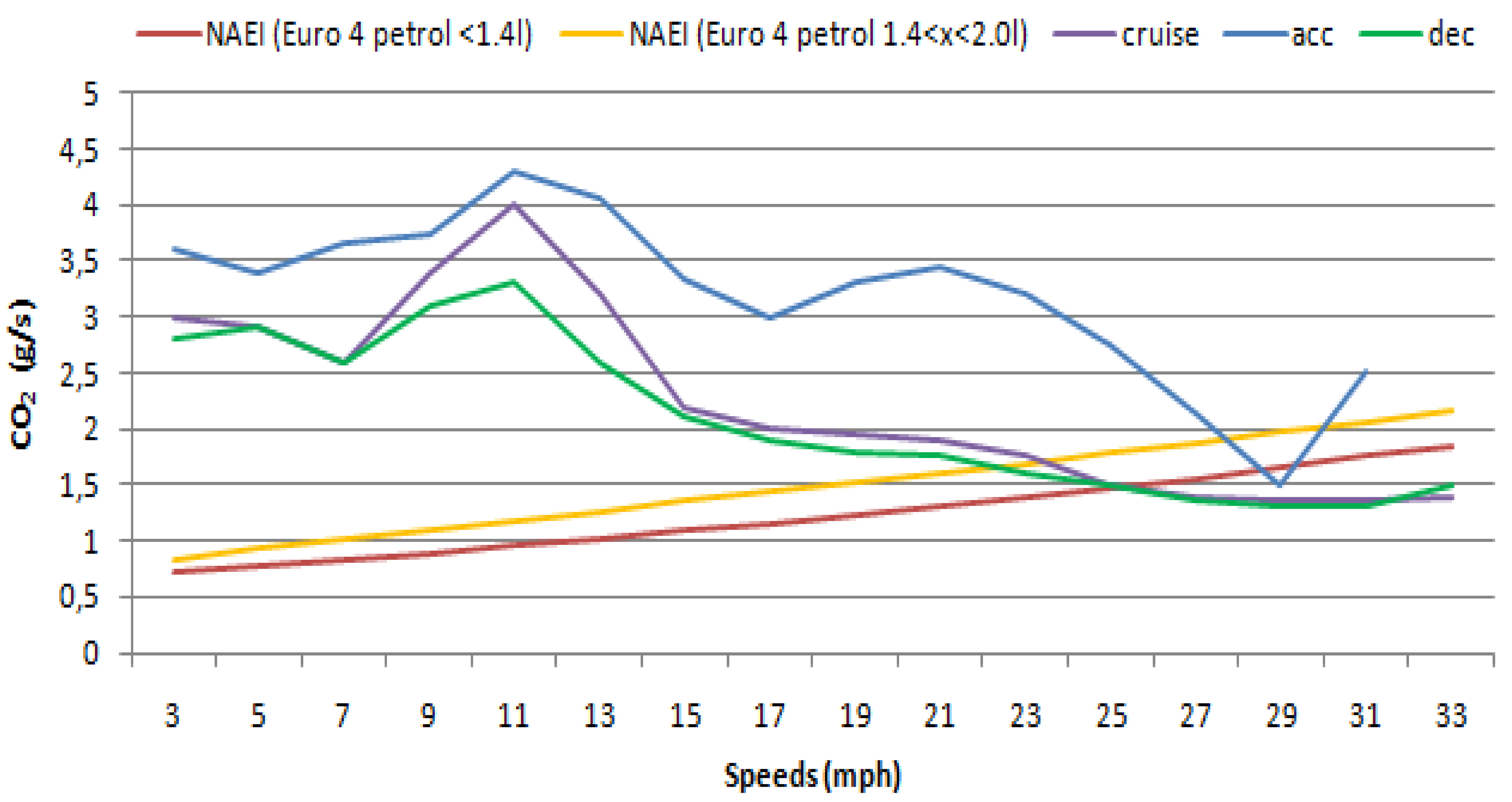
Real-world second-by-second tailpipe emissions measurements from Euro2&4 vehicles were analysed for different driving regimes namely acceleration, deceleration and cruising and further disaggregated by vehicle speed. The figure shows that real-world CO_2 emissions (grams/second) at lower speeds are always higher leading to a consistent underestimation in congested areas.



Methodology

The instantaneous emission model embedded within a micro-simulation (the Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks) uses emission factors based on the blue line, derived from the National Atmospheric Emissions Inventory (NAEI). Real-world scaling Factors, were derived respectively for Acceleration (AEF), Deceleration (DEF) and Idling (IEF).

A study of the differences in emissions between the real-world and average speed emissions estimates showed emissions were typically 20-30%, lower mid-link when cruising at 20mph, but up to 260% higher, when experiencing stop-start events and congestion.



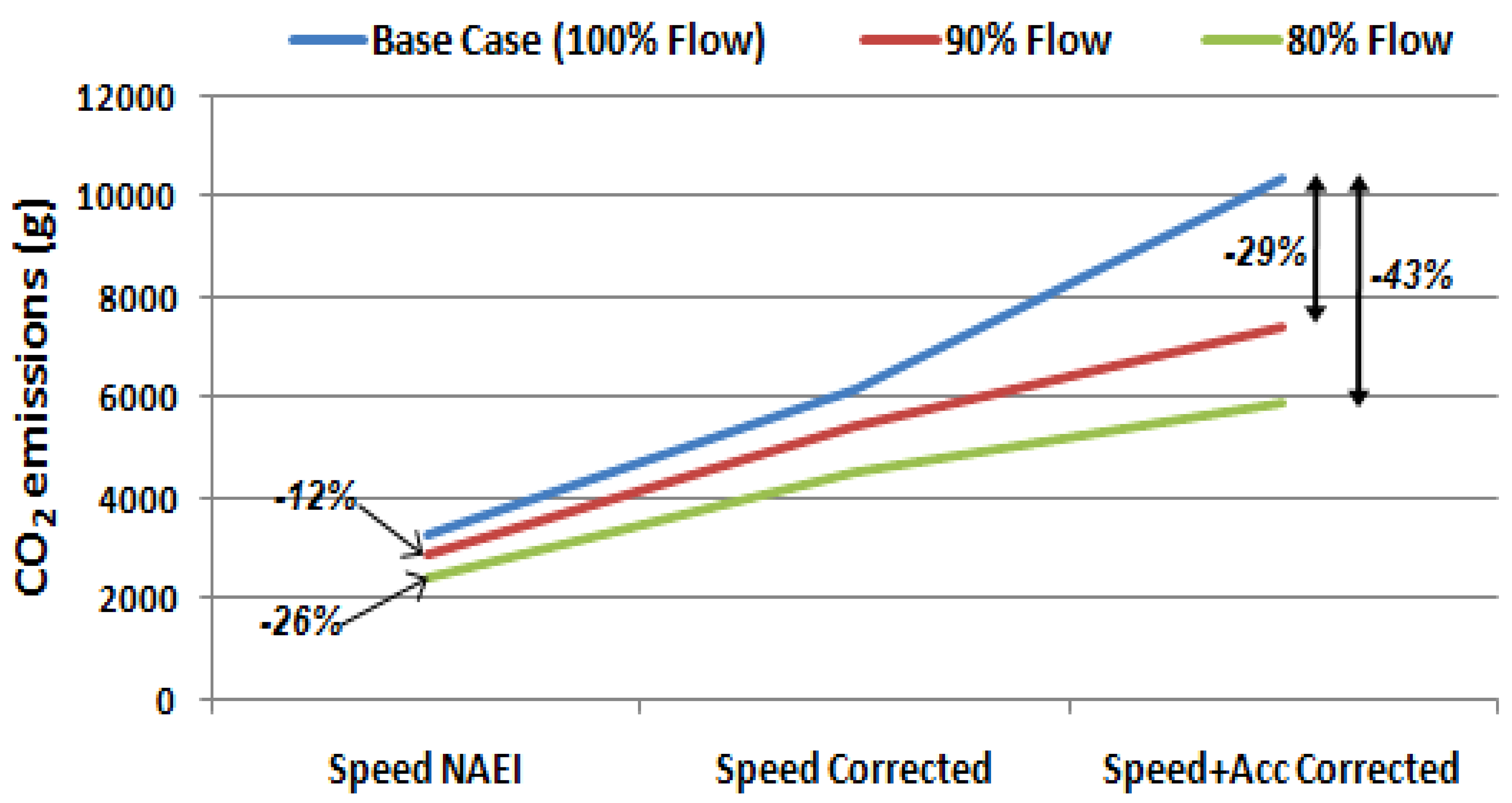
Micro-simulation modelling of scenarios in Leicester

A calibrated and validated micro-simulation network of Leicester City was used to test three different scenarios that reduced speeds from 30 to 20 mph: a) all roads 30mph, b) secondary roads only at 20mph and c) all roads at 20mph. Two further scenarios explored the impact on congestion and emissions of reducing traffic flows across the network to d) 90% and e) 80% of the Base Case traffic flow.

Results

The modelling results for scenarios a to c showed no statistically significant difference (0±2%) from the Base Case flows compared with the speed reduction scenario, except for emissions of CO and CO_2 which increased by 9% and 3% respectively in the scenario c.

The modelling results indicated that, using average speed-flow factors, CO_2 emissions were reduced by 12% and 26% for scenarios d and e respectively. Using the real-world factors, the reductions were 29% and 43% respectively: a factor of 2 greater on average.



Conclusions

A comprehensive analysis of tailpipe emissions data has enabled an additional set of scaling factors to more realistically model the effects of driver behaviour and the different traffic flow regimes in micro-simulation. This allows a much richer understanding of the spatial and temporal variation in emissions across networks. Results using the enhanced model suggest that traditional air quality models underestimate urban street emissions by a factor of 2. Using the enhanced model it has been shown that reducing flows by 10% and 20% , CO_2 emissions reduce by 29% and 46% a speed of 20mph on all roads, increases CO and CO_2 emissions by 9% and 3% respectively.

Acknowledgements

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