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How to combine different microsimulation tools to assess the environmental impacts of road traffic? Lessons and directions

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ABSTRACT

In the last decades, traffic microsimulation platforms have a growing complexity allowing a detailed description of vehicle traffic dynamics in a second-by-second basis. However, to project spatially their outputs, some precautions must be followed. Therefore, we analyze some variables used in the microscopic traffic models which have a high impact on further applications, especially when a spatial projection is required. To assess these objectives, a microsimulation framework which includes traffic and emission models was defined to characterize traffic flows and to evaluate vehicular emissions. This general methodology was then applied in a European medium sized city using two scenarios: (i) considering a Lagrangian approach and (ii) using an Eulerian approach of the simulation road traffic platform. The Lagrangian approach shows that if we have long links (some hundred meters, e.g. >500 m), we lose the spatial detail on emissions. On the other hand, using the Eulerian approach to define very small links (some few meters, e.g. <30 m), a significant statistic representation of traffic dynamics, in that link, was not obtained, particularly in areas with low traffic flow. The latter situation can occur because the vehicle speed can be high enough that did not allow recording any information in that link, even considering a high time resolution analysis (second-by-second). Thus, a non-linear trend of the error is identified when such data are analyzed geographically. Accordingly, depending on the use of those microsimulation tools, we identify some best practices related with the traffic model design that must be followed to minimize those errors.

Introduction

The increase in computational speed, the exponential growth of traffic data collected by different on-board devices (as GPS devices), and the possibility of storing such data quickly and cheaply has allowed an increase of the expectations regarding the efficiency improvement in the use of existing infrastructures. As a result, the use of complex software applications has grown. However, as explained by Jakeman et al., 2006 these models are often used by people without a strong background of model-building. Therefore, according with these authors some best practices must be followed. This includes not only a clearly description of the objectives but also a justification of the techniques used to calibrate the model. A detailed analysis, testing and discussion of the model performance must be also followed. These best practices are some of the general rules. Nonetheless, each research area has their particular constraints.

With the recent widespread deployment of microsimulation platforms a detailed description of data is possible. In the case of traffic microsimulation platforms, the vehicle traffic dynamics in a second-by-second basis can be provided. These

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data have been used to perform simulation and develop models. However, beyond the measures proposed by Jakeman et al. (2006), in the case of traffic microsimulation platforms additional practices of disciplined modeling are needed, namely when the information need to be combined among different frameworks.

Table 1 lists the most relevant studies combining road traffic modeling with emission and/or air quality modeling. About 60% of the analyzed studies includes only road traffic modeling and emission modeling (e.g. Abou-Senna et al., 2013; Boriboonsomsin and Barth, 2008). The integration of air quality modeling with traffic simulation models was done in only 30% of the studies analyzed (e.g. Misra et al., 2013; Namdeo et al. 2002). According to Borrego et al. (2004) although the time-consuming spending in the preparation of data, the benefits of integrating different modeling tools is still high. This occurs because usually models allow a more efficient use when compared with the traditional methods generally used by local authorities.

Table 1
Studies that include integration of road traffic, emission and air quality models.

Reference	Models																		
	Road traffic									Road emission								Air quality	
	Microscopic					Mesos-copic	Macroscopic			Instantaneous					Average speed			Local	Urban
	1	2	3	4	5	5	6	7	8	1	2	3	4	5	6	7	8		
Abou-Senna et al. (2013)	■											■							
Amirjamshidi et al. (2013)					r_1								■						a_1
Anya et al. (2014)				■						■									
Bandeira et al. (2011)									r_2						■				a_2
Boriboonsomsin and Barth (2008)		■											■						
Borrego et al. (2004)						■		■							■			a_3	
Chen and Yu (2007)	■												■						
Csikós and Varga (2012)	■										■					■			
Dias et al. (2014)	■														■				a_4
Fontes et al. (2014)	■									■						■			
Gulliver and Bridges (2005)							■										e_1		a_5
Jie et al. (2013)	■										■								
Lin et al. (2011)						■						■							
Madireddy et al. (2011)		■									■								
Mandavilli et al. (2008)			■											e_2					
Mensink and Cosemans (2008)		■															e_3	a_6	a_7
Misra et al. (2013)		■											■					a_8	a_9
Mumovic et al. (2006)							■										e_4	a_{10}	
Namdeo et al. (2002)							■										e_5		a_5
Nejadkoorki et al. (2008)							■										e_6		
Nesamani et al. (2007)		■												e_7					
Noland and Quddus (2006)	■												■						
Panis et al. (2006)					r_3									e_8					
Sider et al. (2013)								■									e_9		
Xie et al. (2012)		■										■							
Zegeye et al. (2013)									■								e_{10}		
Zhao and Sadek (2013)		■										■							
Zhang et al. (2009)	■									■									
Zhang et al. (2013)			■									■							

Notes:
Traffic models: 1: VISSIM; 2: PARAMICS; 3: aaSIDRA; 4: AIMSUM; 5: Other models; 6: DinusT; 7: SATURN; 8: VISSUM; 9: METANET.
r_1: METANET; r_3: TRANUS; r_3: DRACULA.
Emission models: 1: VSP; 2: Versit + Micro; 3: MOVES; 4: CMEM; 5: Other models; 6: TREM; 7: COPERT or EMEP/EEA methodology; 8: Other models.
e_1: SATURN; e_2: SIDRA; e_3: MIMOSA (derived from COPERT II); e_4: EFT; e_5: ROADFAC; e_6: Lu et al. (2002); e_7: MOBILE; e_8: Panis et al. (2006); e_9: VT-micro; e_{10}: MOVES.
Air quality models: a_1: gaussian plume model; a_2: TAPM; a_3: VADIS; a_4: URBAIR; a_5: ADMS; a_6: OSPM; a_7: ISCST3; a_8: AERMOD; a_9: QUIC a_{10}: PHOENICS.