Modeling Second-by-Second Traffic Emissions in a Mega-Region

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ABSTRACT

Transportation based carbon dioxide emissions are important to consider when creating transportation policies in a society that continues to increase its eco-consciousness. In order to aid in the creation of such policies, transportation planners need models that will not only microsimulate transportation networks, but also generate the emissions from those networks on a person-by-person and second-by-second level. Until recently, transportation and emissions microsimulations have only calculated such emissions for specific, small geographical scale projects. This research expands that scale to a mega-region (Southern California) and uses the outputs of an agent-based simulation (SimAGENT) through a traffic microsimulator (TRANSIMS) to run the Comprehensive Modal Emissions Model (CMEM), a second-by-second emissions estimation model. The results are person-by-person and second-by second emissions information for each vehicle's engine runtime. These results are then displayed in a Geographical Information System (GIS) to show per second emissions per network link.

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INTRODUCTION

This paper discusses a method for integrating the Transportation Analysis and Simulation System (TRANSIMS) output with the Comprehensive Modal Emissions Model (CMEM), a second-by-second emissions estimation model. TRANSIMS was run for the Southern California Association of Governments (SCAG) as part of the Simulator of Activities Greenhouse Emissions, Networks, and Travel (SimAGENT) project to develop a suite of models to support an activity-based approach for the SCAG counties of: Imperial, Riverside, Orange, Los Angeles, Ventura, and San Bernardino. This area contains 17,317,284 persons within 5,721,914 households. SimAgent includes population synthesis that recreates the entire resident population of this region, provides locations for residences, workplaces, and schools for each person, estimates car ownership and type as well as main driver for each vehicle, and provides other key personal and household characteristics (1, 2). Then, a synthetic schedule generator recreates for each resident person in the simulated region a schedule of activities and travel that reflects intra-household activity coordination for a day (3). These synthetic activity and travel daily schedules are then converted to multiple Origin Destination (OD) matrices at different times in a day. These are in turn combined with other OD matrices (representing truck travel, travel from and to ports and airports, and travel generated outside the region) and assigned to the network in multiple periods in a day enabling the study of congestion. The assignment output is then used in the software EMFAC to produce estimates of fuel consumed and pollutants emitted (including CO_2) by different classes of vehicles. Numerical testing and proof of concept were successful and the Southern California Association of Governments (the planning agency responsible for the region surrounding Los Angeles) is developing a version that will be used in developing major investments in the new regional transportation plan. Of more interest for our paper here is the SimAgent capability of producing at fine spatial and temporal resolutions synthetic schedules of people in a day and the use of their vehicles as well as the vehicle traces pilot tested using TRANSIMS (a cellular automata microsimulation of vehicle movements). For further reading on how TRANSIMS was integrated into SimAGENT models, see Goulias et al. (4, 5). This paper represents the next progression for incorporating traffic microsimulation in a mega-region into a framework that will allow transportation models to include high spatio-temporal vehicle emissions resolutions for policy scenario testing.

Literature Review and Background

Because previous models tend to use average traffic speeds for their emissions calculations, it was impossible to test speed control or traffic calming policies. To address this, many efforts have successfully paired traffic microsimulation and emissions models for small scale scenario testing. In 2000, Hallmark et al. linked the Mobile Emissions Assessment System for Urban and Regional Evaluation (MEASURE) with signal timing scenarios to determine their impact on emissions (6). Park et al. 2001, joined the output of a microsimulation model (VSSIM), with a speed-based emissions database (MODEM) for a town in the United Kingdom and compared the results with a mesoscopic model. Park et al. identified the need for more research using microscopic emissions models to aid in policy testing (7). Since then, CMEM has been used extensively for such testing. In 2003, Stathopoulos and Noland used CMEM to test two small scale traffic flow scenarios in VISSIM to evaluate what impact traffic smoothing has on vehicle emissions (8). Servin, Oscar, Boriboonsomsin, and Barth, in 2006, evaluated the impact that intelligent speed adaptation had on energy use and emissions (9). In 2006, He and Wang tested the CMEM output against actual vehicle emissions and concluded that for the vehicle categories that they tested, CMEM showed encouraging consistency with the actual emissions (10). Also in 2006, Noland and Quddus used the VISSIM simulation environment to provide CMEM the inputs required to evaluate how changes in available road capacity influence vehicle emissions (11). Furthermore, in 2008, Boriboonsomsin and Barth examined the effects that high occupancy lane configurations have on vehicle emissions (12). These efforts using CMEM have shown that CMEM can be used reliably to test second-by-second vehicle emissions.

Other emissions models have been linked with traffic microsimulation models. Some recent examples include Rakha and Ahn (13) and Rakha et al. (14), who used the INTEGRATION model to show how previous emission simulation attempts have over-simplified the calculations and cannot capture the environmental impact of different Intelligent Transportation System (ITS) strategies. In 2006, Panis, Broekx, and Liu considered the effect that acceleration and deceleration have on emissions on a small simulated network (15). In 2009, Beckx et al. used an activity-based transportation model to calculate particulate matter exposure in an urban environment in a small Dutch town (16). In 2011, Qian, Gongbin, and Chung studied the impacts of eco-driving on emissions using a microsimulation (17).

All of the aforementioned work used microsimulation models joined with emissions models to test specific small-scale network orientation, signal timing, or driver behavior scenarios. This paper aims to add to the current work by being a first step in providing a large scale microsimulation-based emissions model that can be used for testing state, county, or city policies in the SCAG mega-region. While previous efforts have modeled emissions at the meso- and macro- scales for testing of regional policies, this research takes advantage of technological advances and improved data collection and modeling techniques to allow regional policies to be tested using micro-scale models to better estimate vehicle emissions. This will allow previously untestable policies to be evaluated at the individual and household levels.

TRANSIMS

The TRANSIMS microsimulation forecasting model uses a spatial database engine to process, store, and manipulate spatial data with explicit network topology (18). TRANSIMS uses transportation infrastructure, demographic, land-use, and human decision making data to generate a realistic model of traffic and congestion. TRANSIMS represents road design in a microscopic manner, as well as, incorporating such entities as the number of lanes, controlled intersections, etc. Each agent in TRANSIMS represents a person in the real world. These agents operate on the transportation network making plans about what to do throughout the modeled day. Agents can also choose different travel modes. Once the network is defined, agents have travel plans and are assigned transportation modes. The router in TRANSIMS decides what transportation links to utilize for each trip for each agent. This routing is done by implementing a version of Dijkstra's shortest path algorithm that has regular language constraints and solves problems with time-dependent edge delays using a general first-in-first-out model (19). This is an iterative process that allows for re-planning. Because routes are simulated by determining optimal mode choices based on the demographic and geographic characteristics of the population, forward causality is artificially introduced. In order to bring the system to a "relaxed state," TRANSIMS implements re-planning. Link delays observed in the simulation are sent to the route planner to iteratively re-plan a fraction of the agents. For example, if an agent runs into too much congestion, it will try another route. This interaction between the plans-making models and the microsimulation is repeated until expectations during plans making and conditions during plans execution are consistent (20).

CMEM

CMEM is an emissions model that places vehicles into generalized vehicle emissions categories to represent each vehicle in a fleet. From these categories, second-by-second emissions are calculated for each vehicle using individual acceleration and velocity data. CMEM was developed by the College of Engineering-Center for Environmental Research and Technology (CE-CERT) at the University of California, Riverside, with researchers from University of Michigan and the Lawrence Berkeley National Laboratory. CMEM development was funded by NCHRP project 25-11 starting in 1995. The original project was funded to model emissions of light-duty vehicles (LDV). Starting in 1999 the United States Environmental Protection Agency (EPA) provided funding to develop enhancements including developing models for heavy-duty vehicles (HDDV) (21).

CMEM is a "modal" model. Modal refers to using different vehicle operating modes based on vehicle technology categories and operating conditions to calculate emissions. Modal models have been found to be more accurate than models that just use average vehicle speeds and vehicle miles traveled. There are other modal models that have been used by the EPA for emissions calculations. Guensler et al. developed a mobile emissions model that estimates mobile source production of CO, Volatile Organic Compounds (VOCs), and NOx. They calculated emissions as a function of different vehicle operating modes within a GIS (Geographic Information System) framework and were found to be more accurate than the EPA's MOBILE 5a emissions (22 & 23). The EPA also has concluded that a physical type emissions model is more accurate than previous models and has included it in its Multi-scale Motor Vehicle and Equipment Emissions System (MOVES) (24).

METHODS

TRANSIMS

Until recently, as mentioned by Bachman et al. the massive amount of data required to run TRANSIMS for a large geographic area was too difficult to gather (6). By using a synthetically generated population for SCAG region and the detailed activity-based transportation data from the SimAGENT suite of models (1,2,3,4,5), TRANSIMS is able to microsimulate every vehicle in the SCAG region on a second-by-second time scale. This paper sets forth a method for producing second-by-second emissions from the vehicle trajectories produced by TRANSIMS and integrating them into a GIS environment.

The SCAG area contains about 18 million people. TRANSIMS microsimulates travel to and from each of these person's daily activities by transport mode (e.g. walk, personal vehicle, transit). This produces a relatively large amount of data. For this application to test feasibility, a random 1.5 percent sample of a 25 hour simulation period in TRANSIMS was used on the SCAG major roadways network of 49,528 links.

The link IDs are used by TRANSIMS and later by CMEM to keep track of the vehicles' locations through time. Table 1 shows a sample of the vehicle trajectory output file from TRANSIMS. The trajectory output provides the vehicle ID (VEHICLE_ID), speed (SPEED), the acceleration (ACCEL), link (LINK), direction (DIR), lane (LANE), offset (OFFSET), vehicle type (VEH_TYPE), that vehicle's driver (DRIVER), and number of passengers (PASSENGERS). Each vehicle modeled in the study area has a trajectory file for each second of engine run time.

TABLE 1 TRANSIMS Output Vehicle Trajectory Sample

VEHICLE_ID	SPEED	ACCEL	LINK	DIR	LANE	OFFSET	VEH_ TYPE	DRIVER	PASSEN- GERS
11305071	25	0	107661	0	3	725	4	1132	0
11305071	20	-5	107661	0	3	745	4	1132	0
11305071	20	0	107661	0	3	765	4	1132	0
11305071	25	5	107661	0	3	790	4	1132	0
11305071	5	-20	107661	0	3	795	4	1132	0
11305071	10	5	107661	0	3	805	4	1132	0
11305071	0	-10	107661	0	3	805	4	1132	0
11305071	0	0	107661	0	3	805	4	1132	0
11305071	0	0	107661	0	3	805	4	1132	0
11305071	5	5	107661	0	3	810	4	1132	0
11305071	10	5	107661	0	3	820	4	1132	0
11305071	15	5	106918	0	2	10	4	1132	0
11305071	15	0	106918	0	2	25	4	1132	0
11305071	20	5	106918	0	2	45	4	1132	0
11305071	25	5	106918	0	2	70	4	1132	0

CMEM

CMEM can run from two configurations, the core model and the batch model. The core model only calculates emissions for one vehicle at a time while the batch model calculates multiple vehicles simultaneously. This study uses the batch model and for the rest of this paper the phrases "CMEM" and "batch model" are used interchangeably. CMEM uses a vehicle activity file, a vehicle definition file, and a model control file as inputs.

Activity File

The vehicle activity file is used to define the trajectories of multiple vehicles. This file may also contain acceleration, road grade angle, and a secondary load factors flag for each second of each vehicle's trajectory. The secondary load factors flag is either 1 for on or 0 for off. These factors are predefined for each vehicle in each vehicle's respective vehicle category or can be overwritten in the control file. The vehicle activity file is formatted as column oriented, comma delimited. This activity requires three columns to run: time in seconds, vehicle ID, and velocity in predefined units specified in the control file. CMEM can compute acceleration or it can be user supplied to speed up run times. Road grade angle and secondary load factors are not necessary but lead to more accurate emissions calculations.

After some re-formatting, the trajectory file from TRANSIMS is used by CMEM as the vehicle activity file. This study uses the time in seconds, vehicle speed, and acceleration (both in miles per hour) supplied from the TRANSIMS output. Currently no road grade angles or secondary load factors are being used. Table 1 shows a sample of the reformatted trajectory file used by CMEM.

Definition File

CMEM uses the vehicle definition file to specify the vehicle categories, soak time values, and specific humidity for each run. This definition file is formatted as column oriented, tab delimited. Four columns are used in this file. The vehicle ID is used to link each vehicle to the vehicle activity file. Each vehicle has a unique ID that corresponds to that vehicle's technology category and configuration. CMEM uses 31 vehicle/technology categories, 28 light-duty categories, and 3 heavy-duty (HDDV) categories. Table 2 shows the vehicle/technology categories used by CMEM. CMEM uses soak time values to determine the engine's condition before it is started to calculate the emissions for that particular start. The soak time value is the amount of time elapsed between engine starts. CMEM also uses specific humidity defined in the vehicle control file to further aid in emissions calculations.

For this study the vehicle IDs are supplied from the fleet composition/car ownership model in SimAGENT. These vehicle IDs are maintained in TRANSIMS and used as the vehicle IDs in CMEM. These vehicle IDs represent vehicles assigned to specific households based on a number of factors, where the first digits in the ID represent the household ID and the last digit represents the vehicle number within that household. For example a vehicle ID of "1230" belongs to household "123" and is vehicle "0" for that household. Vehicle numbering starts at 0. Moreover, a vehicle ID of "332211" belongs to household "33221" and is vehicle "1" for that household. These vehicle IDs are then matched to the household database from SimAGENT to determine the year, make, and model for each vehicle and subsequently placed into one of the vehicle/technology categories in CMEM. Table 3 shows a sample of the vehicle composition data from SimAGENT showing 3 vehicles from household 74 and the body type (BODTYP), vehicle age category (AGECAT), vehicle make (MAKE), the household member that is the primary driver of that vehicle (PRIMDRV) and the annual mileage (ANNMIL). Similarly Table 4 shows the vehicle definition file used by TRANSIMS with the added columns LOCATION, TYPE, and SUBTYPE that the TRANSIMS format requires.

TABLE 2 CMEM Vehicle Technology Categories

Category #	Description
1	No Catalyst
2	2-way Catalyst
3	3-way Catalyst, Carbureted
4	3-way Catalyst, FI, >50K miles, low power/weight
5	3-way Catalyst, FI, >50K miles, high power/weight
6	3-way Catalyst, FI, <50K miles, low power/weight
7	3-way Catalyst, FI, <50K miles, high power/weight
8	Tier 1, FI, >50K miles, low power/weight
9	Tier 1, FI, >50K miles, high power/weight
10	Tier 1, FI, <50K miles, low power/weight
11	Tier 1, FI, <50K miles, high power/weight
12	Pre-1979 (<=8500 GVW)
13	1979 to 1983 (<=8500 GVW)
14	1984 to 1987 (<=8500 GVW)
15	1988 to 1993 <=3750 LVW
16	1988 to 1993 >3750 LVW
17	Tier 1 LDT2/3 (3751-5750 LVW or Alt. LVW)
18	Tier 2 LDT4 (6001-8500 GVW, >5750 Alt. LVW)
19	Runs lean
20	Runs rich
21	Misfire
22	Bad catalyst
23	Runs very rich
24	Tier 1 , >100K miles
25	Truck, Gasoline-powered, LDT (>8500 GVW)
26	ULEV
27	SULEV
40	Truck, Diesel-powered, LDT (>8500 GVW)
HDDV Category #	Description
5	HDD 1994-1997, 4 stroke, Electric, FI Normal Emitting
6	HDD 1998, 4 stroke, Electric, FI Normal Emitting
7	HDD1992-2000, 4 stroke, Electric, FI Normal Emitting

TABLE 3 SimAGENT Vehicle Definition Example

HID	VID	BODTYP	AGECAT	MAKE	PRIMDRV	ANNMIL
74	0	2	2	13	5	45.4288
74	1	3	6	2	1	45.4288
74	2	1	3	13	2	45.4288

TABLE 4 TRANSIMS Vehicle Definition Example

VEHICLE	HHOLD	LOCATION	TYPE	SUB-TYPE	BODTYP	AGECAT	MAKE	PRIM DRV	ANNMIL
740	74	172838	1	0	2	2	13	5	45.4288
741	74	172838	1	0	3	6	2	1	45.4288
742	74	172838	1	0	1	3	13	2	45.4288
4680	468	131379	1	0	9	6	5	1	13.6082

This study did not use soak times, so all starts were considered "cold starts" throughout the study time period. An average humidity of 75% was also used representing an "average day" in Southern California.

Control File

The control file for the CMEM model is used to set model running parameters and, if needed, overwrite category parameters. The control file determines the input units, desired output units, and if CO2 emissions are on or off. Input and output units may be English or Metric. If units are not defined, English units are assumed. All calculations are made using English units and converted if necessary. If CO2 emissions are turned on, CMEM adds second-by-second tailpipe CO2 emissions to the output file. New vehicle categories can also be defined and any part of existing vehicle categories can be modified or overwritten in the control file. For this study the input and output units are English, CO2 calculation is turned on, and no vehicle category parameters were overwritten.

Running CMEM

Once these files are formatted, CMEM can be run from the DOS command line. CMEM can only run 5 million lines (approximate) per vehicle activity file for any single run. A 1.5 percent sample of 18 million for the 25 hour study period yielded an activity file comprised of approximately 200 million lines (one line for each vehicle for each second of runtime). In order to work around this limitation, the trajectory data from TRANSIMS was divided into 40 files each containing approximately 5 million lines. For each of the 40 files, the following columns not needed by CMEM are removed: Link, Direction, Lane, Offset, Vehicle Type, Driver, and Passengers. These columns are preserved to be reinserted after emissions calculations are complete. The remaining columns are: Time, Vehicle ID, Speed, and Acceleration. These columns are then formatted to create the CMEM vehicle activity files.

The next step is to generate a vehicle definition file for each of the 40 smaller files. Each vehicle in the activity file must have a corresponding entry in the vehicle definition file to insure each vehicle is matched with the correct CMEM vehicle/technology category. After the vehicle

IDs are matched with their respective vehicle/technology categories, to comply with the required CMEM formatting, an external load column is added with a "0" value for every vehicle ID, insuring that external load is turned off. Additionally, a humidity column is added and all are assigned a humidity of 75%.

After formatting the 40 vehicle activity files and creating 40 vehicle definition files, CMEM was run to estimate emissions for each vehicle for every second of the sample time period. Each CMEM run generates a vehicle emissions file, summary file, and run file.

Emissions File

The emissions file supplies a time-ordered vehicle-ordered second-by-second emission output per run. Each emissions file contains seven columns if CO2 is excluded and eight columns if CO2 is included. These columns are: time, vehicle ID, vehicle speed, tailpipe hydrocarbon (HC) emissions, tailpipe carbon monoxide (CO) emissions, tailpipe Oxides of Nitrogen (NOx) emissions, fuel consumed, and tailpipe carbon dioxide (CO2) emissions. Default output formats are miles per hour for speed, grams per second for emissions, and grams per liter for fuel. Time starts at second 0 (0:00:00) and continues to second 90,000 (25:00:00). Table 5 shows a sample of the emissions file for run 20.

TABLE 5 Example Emissions From CMEM

TIME	VEHICLE	SPEED	HC	CO	NOX	FUEL	CO2
54846	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54847	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54848	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54849	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54850	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54851	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54852	11305071	0	0.000056	0.000063	0	0.231856	0.735228
54853	11305071	5	0.000406	0.003592	0.00482	1.91963	6.082653
54854	11305071	10	0.00045	0.004289	0.005936	2.102081	6.660199
54855	11305071	15	0.00052	0.005486	0.007883	2.383786	7.551737
54856	11305071	15	0.000072	0.000115	0	0.321168	1.018419
54857	11305071	15	0.000072	0.000115	0	0.321168	1.018419
54858	11305071	15	0.000072	0.000115	0	0.321168	1.018419
54859	11305071	15	0.000072	0.000115	0	0.321168	1.018419
54860	11305071	15	0.000072	0.000115	0	0.321168	1.018419
54861	11305071	15	0.000072	0.000115	0	0.321168	1.018419

This emissions file is then merged with the original trajectory file from TRANSIMS to calculate time-ordered, vehicle-ordered, and second-by-second, emissions by location (link), household, and driver. Table 6 shows a sample of the vehicle trajectory with emissions file from run 20. Figure 1 shows a graphical representation of a typical vehicle's CO2 emissions in grams versus speed in miles per hour for 120 seconds (21151 to 212710).

TABLE 6 Example of TRANSIMS Vehicle Trajectory Merged with CMEM Emissions

VEHICLE_ID	SPEED	HC	CO	NOX	FUEL	CO2	ACCEL	LINK	DIR	LANE	OFFSET	VEH_TYPE	DRIVER	PASSENGERS
11305071	25	0.000082	0.000155	0	0.375458	1.190549	0	107661	0	3	725	4	1132	0
11305071	20	0	0.000063	0	0.231856	0.735419	-5	107661	0	3	745	4	1132	0
11305071	20	0.000068	0.000101	0	0.29839	0.946199	0	107661	0	3	765	4	1132	0
11305071	25	0.000739	0.009735	0.015031	3.196576	10.12274	5	107661	0	3	790	4	1132	0
11305071	5	0	0.000063	0	0.231856	0.735419	-20	107661	0	3	795	4	1132	0
11305071	10	0.00045	0.004289	0.005936	2.102081	6.660199	5	107661	0	3	805	4	1132	0
11305071	0	0	0.000063	0	0.231856	0.735419	-10	107661	0	3	805	4	1132	0
11305071	0	0.000056	0.000063	0	0.231856	0.735228	0	107661	0	3	805	4	1132	0
11305071	0	0.000056	0.000063	0	0.231856	0.735228	0	107661	0	3	805	4	1132	0
11305071	5	0.000406	0.003592	0.00482	1.91963	6.082653	5	107661	0	3	810	4	1132	0
11305071	10	0.00045	0.004289	0.005936	2.102081	6.660199	5	107661	0	3	820	4	1132	0
11305071	15	0.00052	0.005486	0.007883	2.383786	7.551737	5	106918	0	2	10	4	1132	0
11305071	15	0.000072	0.000115	0	0.321168	1.018419	0	106918	0	2	25	4	1132	0
11305071	20	0.000614	0.007223	0.010771	2.743976	8.691325	5	106918	0	2	45	4	1132	0
11305071	25	0.000739	0.009735	0.015031	3.196576	10.12274	5	106918	0	2	70	4	1132	0

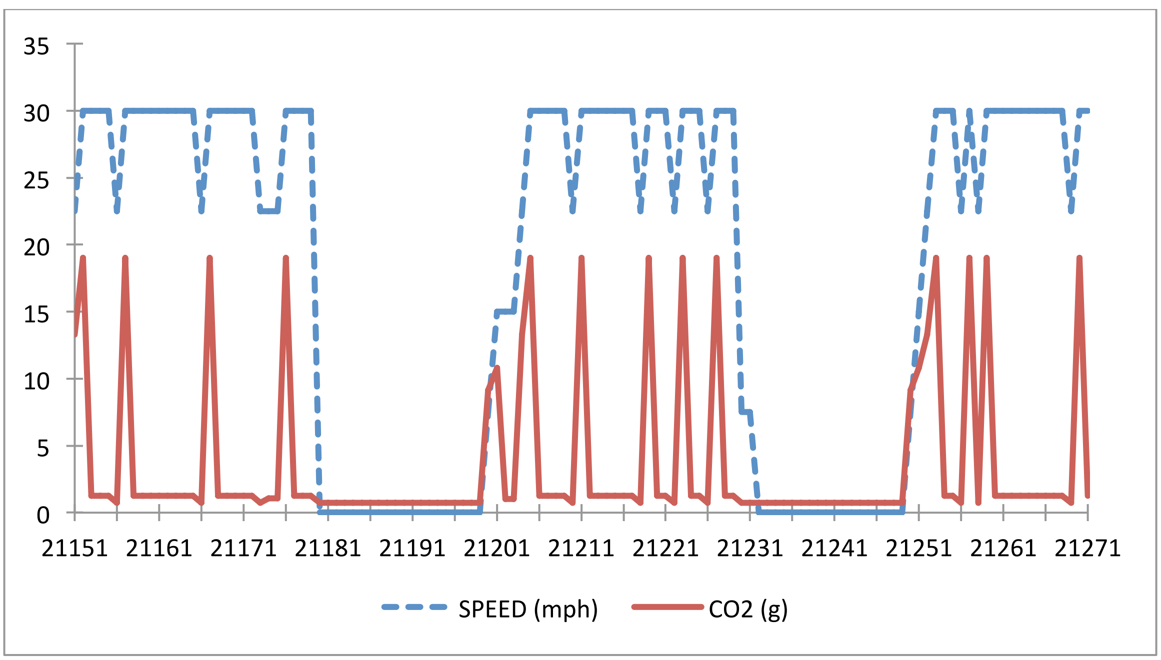

FIGURE 1 C02 Emissions Versus Speed, From Second 21151 to Second 21271.

Run File

The run file provides information on the CMEM run. The run file provides the input files used and the output files generated. Any parameters that were defined or overwritten in the control file are included here. The vehicle ID and vehicle/technology category map is also supplied. Table 7 shows an example of a CMEM run file.

Table 7 CMEM Run File Example

Input Files	Id 1	Id 211	Id 1	Id 211
Control File: sample.ctb	Condition Parameters	Condition Parameters	cCO = 0.0702	cCO = 0.1484
Activity File: sample.atb	Tsoak = 0	Tsoak = 0	bHC = 0.0114	bHC = 0.0099
Definition File: sample.def	SH = 75.00	SH = 75.00	cHC = 0.5523	cHC = 0.0564
			bNO = 3.5263	bNO = 2.8332
	Vehicle Parameters	Vehicle Parameters	cNO = 1.8926	cNO = 0.8011
Output Files	Ed = 2.50	Ed = 3.58	Lamb_0 = 1.2640	Lamb_0 = 1.2640
Model Run File: sample.rnb	Masslb = 3118.00	Masslb = 3142.33	lam_m = 0.9000	lam_m = 0.9000
Summary File: sample.smb	Trlhp = 12.14	Trlhp = 12.42	Pscale = 1.7869	Pscale = 1.7967
Sec-by-Sec File: sample.ssb	S = 25.39	S = 25.39	maxhc = 0.0000	maxhc = 0.0000
	Nm = 3300	Nm = 3389	hc_jk = 0.5000	hc_jk = 0.5000
	Qm = 142.00	Qm = 205.78	r_R = 0.1090	r_R = 0.1090
Id 1: Using calculated acceleration	Zmax = 153.50	Zmax = 151.53	spd_th = 2.4502	spd_th = 0.0091
Id 211: Using calculated acceleration	Np = 5250	Np = 4553	rO2 = 1.0000	rO2 = 1.0000
	Idle = 967.00	Idle = 967.00	COB1 = 1.2778	COB1 = 0.3665
	ng = 4	ng = 4	HCB1 = 257.3869	HCB1 = 170.0481
	Sload = 0.00	Sload = 0.00	NOB1 = 255.7078	NOB1 = 172.2391
OUT_UNITS set to ENGLISH			lam_cold = 1.2500	lam_cold = 1.2500
IN_UNITS not set. Defaulting to ENGLISH.	Calibrated Parameters	Calibrated Parameters	csHC = 12.3901	csHC = 8.3338
	K_0 = 0.1628	K_0 = 0.1023	csNO = 72.8559	csNO = 4.9682
	Edt3 = 0.0998	Edt3 = 0.0986	Tlamb = 37.6651	Tlamb = 30.0000
Overwritten Parameters by Category	C0 = 3.4397	C0 = 3.4397	id = 0.1155	id = 0.0295
	aCO = 0.0439	aCO = 0.0500	Csoak_co = 253.0160	Csoak_co = 190.8824
	aHC = 0.0001	aHC = 0.0020	Csoak_hc = 200.0023	Csoak_hc = 133.3358
Id Categories	rHC = 0.0121	rHC = 0.0167	Csoak_no = 20.1941	Csoak_no = 13.4644
Id 1 Category set to 26	aNO1 = 0.0259	aNO1 = 0.0250	Bcat_co = 133.0843	Bcat_co = 28.2273
Id 211 Category set to 27	aNO2 = 0.0210	aNO2 = 0.0263	Bcat_hc = 239.9024	Bcat_hc = 163.1304
	FRNO1 = -0.4770	FRNO1 = -0.4484	Bcat_no = 132.0022	Bcat_no = 10.4002
	FRNO2 = 0.4501	FRNO2 = 0.0464	Edt1 = 0.8265	Edt1 = 0.7967
	MAXCO = 99.9000	MAXCO = 99.9000	NH3_b = 100.0000	NH3_b = 100.0000
Id Fuel Type	MAXHC = 99.9000	MAXHC = 99.9000	NH3_s1 = 2.0000	NH3_s1 = 2.0000
Id 1 Fuel Type set to gasoline	MAXNO = 99.9000	MAXNO = 99.9498	NH3_s2 = 3.4000	NH3_s2 = 3.4000
Id 211 Fuel Type set to gasoline	bCO = 0.0558	bCO = 0.0193	NH3_i = 0.0450	NH3_i = 0.0450

SPSS

Because of CMEM's limitations, the above process needs to be repeated 40 times for this sample. SPSS 20 script is used to automate file formatting, file parsing, and CMEM input file creation. SPSS conveniently has the capability to run DOS commands. Once the required files are formatted and created in SPSS, CMEM is run from within SPSS using the "HOST COMMAND" function. The resulting emissions file is then automatically reformatted and merged with the original trajectory file for network analysis. Once all 40 runs are complete, they are merged within SPSS to create a file that contains all of the sample vehicle trajectories from TRANSIMS with the calculated CMEM emissions. This comprehensive file is then imported into a GIS and joined with the transportation network. Figure 2 shows the result of such a process for CO2 using ArcMAP 10 in West Los Angeles, California. These can be generated for any of the pollutants calculated by CMEM. By dividing the total CO2 emissions per link by the total number of vehicles that used that link for one second, Figure 2 visualizes the normalized CO2 emissions in grams per vehicle while on each respective link. This process can be done in a second-by-second manner to create a "moving" visualization of CO2 or any other calculated pollutant throughout the day.

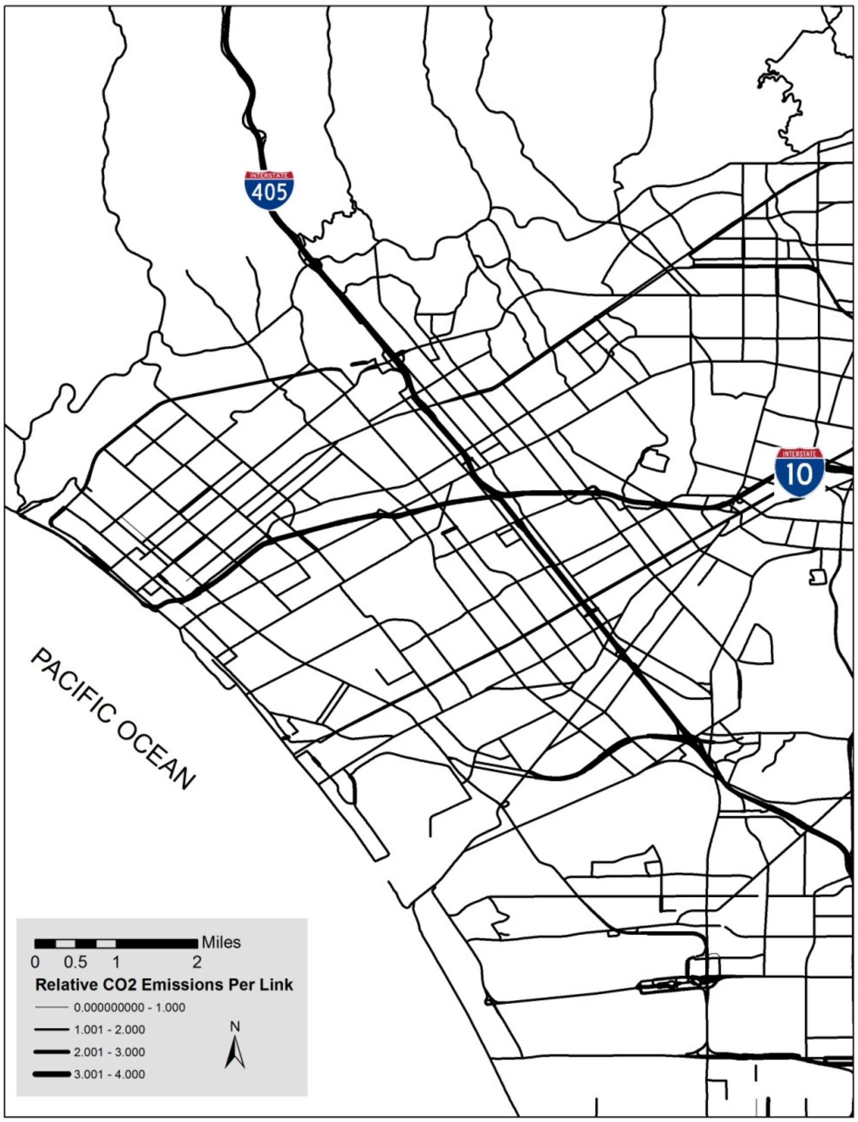

Figure 2 Relative CO2 Emissions in Grams Per Vehicle Per Link for One Second.

DISCUSSION OF RESULTS

The pairing of CMEM with the output of TRANSIMS for the SCAG mega-region has provided a comprehensive sample of household's and person's daily second-by-second CO2 emissions generated by their transportation utilization. These CO2 emissions can be manipulated by a GIS to provide second-by-second network production at the link level and paired with household Vehicle Miles of Travel (VMT) and emissions allocated to each parcel of land (25). Previous research has generated second-by-second CO2 emissions for specific small scale studies or small cities. This paper has also shown that though it is not easy to deal with such large datasets, it is possible to work around software limitations. With this type of methods we are able to move towards a carbon tax for households and assign charges based on simulated consumption (26) and to improve land use and transportation scenario development (27).

CONCLUSIONS

The SimAGENT models have provided TRANSIMS enough data to compute daily simulations of every vehicle in the SCAG region. A random 1.5% sample of the population of the SCAG region was successfully run through CMEM. These emissions were merged with the vehicle link locations by second. The result was a 1.5% sample of a mega-region. While this is not a complete population, it is a good first-step towards a 100% run for each of the 18,000,000 persons in the SCAG study area. This research has shown that given enough computing time, modeling a mega-region in this manner is possible.

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