# Temporal and Spatial Detail in Mobile Source Emission Inventories for Regional Air Quality Modeling

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## ABSTRACT

Accurate spatial and temporal characterization of emissions is necessary to inform air quality planning. The purpose of this paper is to quantify the impacts of using detailed traffic activity data on mobile source emissions estimates and air quality in the Denver urban area.

This study compares on-road mobile source emission inventories developed for eleven counties covering the Denver Metropolitan Area and North Front Range (DMA/NFR) in Colorado and reports the spatial and temporal differences of ozone precursor emissions and their effects on modeled ozone concentrations. Three on-road mobile source emission inventories were developed to generate the gridded hourly chemically speciated emission inputs for photochemical grid modeling of the DMA/NFR nonattainment area (NAA) to support the Denver 8-hour ozone State Implementation Plan (SIP).

1) Link-Level modeling for the DMA/NFR, using emissions processing software CONCEPT Motor Vehicle v2.1
2) Non-Link Level modeling for Colorado including DMA/NFR, using emissions processing software SMOKE v3.0 with SMOKE-MOVES Integration Tools
3) County Level modeling for the U.S., using MOVES2010a Inventory Calculation

Emissions differences are apparent in the overlapping DMA/NFR region between the three scenarios, resulting from the methods of how MOVES2010a emission factors were combined with vehicle activity, such as vehicle miles traveled and speed. Key differences in modeling approaches include hourly fleet mix, hourly link-level speeds, spatial allocation of off-network emissions and treatment of meteorology, which impacts the spatial distribution, magnitude and the timing of total organic gases (TOG) and oxides of nitrogen ($NO_X$) emissions from vehicles. Compared with SMOKE-MOVES, the use of detailed transportation data with CONCEPT MV decreases the on-road TOG/$NO_X$ ratio and results in modeled ozone differences up to 1.5 ppb in 8-hour average ozone on the highest 2008 ozone day in Denver. This study has important implications for any urban area where motor vehicles are significant contributors to overall emissions.

## INTRODUCTION

The ability of air quality models to predict ozone concentrations that track well with observation relies partly on an accurate estimate of emissions sources, including emissions from highway motor vehicles. Historically, on-road emission inventories have been prepared by combining emission factors from U.S. Environmental Protection Agency's (EPA's) regulatory on-road emissions model with estimates of vehicle miles traveled (VMT) from local transportation data to estimate average daily emissions. The daily emissions are then allocated to hours of the day and days of the week for the air quality modeling episode using typical temporal profiles developed by EPA (EPA, 2012a). However, significant inaccuracies can result from generating inventories at a larger scale spatially and temporally (e.g., county-wide, average annual day) than is required for air quality modeling (grid cells, hourly).

To address this problem, detailed emissions processors have been developed to estimate on-road mobile emissions on a more refined scale for large geographic areas. Two such emissions processors that are freely available for public use include the CONsolidated Community Emissions Processor Tool, Motor Vehicle (CONCEPT MV), developed by ENVIRON and Alpine Geophysics, and the Sparse Matrix Operator Kernel Emissions (SMOKE) model with SMOKE-MOVES Integration tools developed by UNC and ENVIRON (EPA, 2012b). Both CONCEPT MV and SMOKE-MOVES require gridded meteorological data and lookup tables of emissions factors from MOVES, among other inputs. Emission factors for a specific combination of temperature and relative humidity by hour (and speed, if calculating running emissions processes) are looked up for each grid cell and hour in the modeling domain and are then multiplied with estimates of VMT or vehicle population for the hour and grid cell. The main difference between CONCEPT MV and SMOKE-MOVES is the source of VMT data that are combined with the MOVES emission factors but other important differences include speed calculations and spatial allocation methods.

CONCEPT was designed to interface between emission factors and link-level VMT activity derived from Travel Demand Models (TDM) developed by local planning agencies, whereas SMOKE-MOVES was designed to interface between emission factors and annual VMT estimates by county, vehicle class and roadway type. CONCEPT calculates vehicle speeds on each link for every hour, whereas SMOKE takes input speeds (hourly or daily average) by road type. Third and finally, CONCEPT has an advanced methodology of allocating off-network emissions to grid cells using vehicle trips data and the location of Transportation Analysis Zones (TAZs) included in TDMs, whereas SMOKE allocates off-network emissions using a combination of EPA spatial surrogates for roadways and human population.

While it is has been demonstrated that accurately characterizing the temporal and spatial detail of on-road emissions results in large on-road emission inventory differences (Lindhjem et al., 2012), until now the effect on modeled ozone has not been studied. For this study, ENVIRON performed sensitivity analyses of on-road emissions on ozone predictions using the air quality model *Community Air quality Model with extensions* (CAMx). The purpose of the sensitivity simulations was to better understand the effect, if any, that the on-road emissions processing methodology has on ozone prediction. ENVIRON and Alpine Geophysics prepared emissions for all sources in support of Colorado's 8-hour ozone State Implementation Plan (SIP) which included three different levels of on-road emissions, which are summarized in Table 1. The processing methods were designed to cover areas near the ozone monitors with the most refined approach and less detail moving away from the urban core DMA/NFR counties.

**Table 1.** On-Road emissions inventory preparation approaches.

| Approach | Description | Area Covered |
|---|---|---|
| CONCEPT MV | Link level activity; MOVES emission factors | DMA/NFR 11 counties: Adams, Arapahoe, Boulder, Broomfield, Clear Creek, Denver, Douglas, Gilpin, Jefferson, Weld, and Larimer |
| SMOKE-MOVES | Roadway type activity; MOVES emission factors | Outside the 11-county DMA/NFR, within Colorado |
| MOVES Inventory with SMOKE | Processed as an area source; MOVES county-level emission inventories | Outside Colorado, within the United States |

For the base year air quality model, the on-road emissions file prepared by the third (least detailed) approach in Table 1, MOVES Inventory, was trimmed to remove the emissions inside Colorado. Likewise, the second most detailed approach SMOKE-MOVES was trimmed to remove emissions inside the 11-county DMA/NFR area. Finally, the CONCEPT, SMOKE-MOVES, and MOVES Inventory on-road emissions, each covering unique areas, were merged into a single on-road inventory with seamless coverage over the continental U.S. Because the emissions and air quality model setup were already available, ENVIRON prepared additional CAMx scenarios for sensitivity analysis without CONCEPT MV, without SMOKE-MOVES, and without any on-road motor vehicle emissions.

This paper describes the methodological differences between emissions processors, focusing on CONCEPT MV v2.1 and SMOKE v3.0 with the SMOKE-MOVES integration tool. First, the emissions processing methods that distinguish CONCEPT MV from SMOKE-MOVES are described. Next, daily total emissions differences between CONCEPT MV and SMOKE-MOVES are shown, and finally impacts on air quality modeling are presented.

## METHODS

### Emission Factors

The ENVIRON-Alpine team used EPA's MOVES2010a model with database version *movesdb20100830* for all on-road emissions and emission factor development for this work. On-road emission factors for use within Colorado were generated by running the model at the *County Domain/Scale* in 'Emission Rates Calculation' mode using local data provided by the Colorado Department of Public Health and the Environment (CDPHE). Background emissions outside Colorado were prepared by running MOVES at the *National Domain/Scale* in 'Inventory Calculation' mode using model default data.

On-road emission estimates inside Colorado were prepared as lookup tables of emission factors created for use in the emissions processors CONCEPT MV and SMOKE-MOVES. The lookup tables prepared for CONCEPT MV and SMOKE-MOVES were from different MOVES runs due to minor differences in the formats expected by the two processors (e.g., CONCEPT uses source type IDs from MOVES and SMOKE requires SCCs), but the inputs to MOVES for both sets of lookup tables were identical. Thus, emission factor differences are not a cause of the emissions or air quality differences to be discussed in this paper. Outside of Colorado, background MOVES emissions were generated as mass totals for each month and county in the continental U.S.

### Activity Data

Vehicle Miles Traveled data are available through the Highway Performance Monitoring System (HPMS) typically as average day VMT by roadway classification and county. More detailed estimates of VMT are available as a byproduct of transportation planning activities, through output of Travel Demand Models (TDMs).

Local governments and agencies use TDMs primarily to plan for the expected demand on local transportation facilities. The traffic models can also provide high-quality data that greatly improves the accuracy of on-road emissions estimates. TDMs contain spatial representation of an urban area's roadway network divided in to line segments called *links*, which represent roadway distances as short as one city block or a long section of highway. Each link has coordinates that spatially define its start and end points on a 2D grid, and it also contains link-specific attributes including number of lanes, distance, free flow speeds, and capacity. The geographic area underlying the roadway network is divided into irregularly shaped sub-areas called Transportation Analysis Zones (TAZs), whose boundaries are typically drawn around meaningful areas such as a business district or residential neighborhood.

Transportation planners use survey data to estimate vehicle trips from origin TAZs to destination TAZs by time of day, and these trips load the link network with the appropriate volume of motor vehicles. Vehicle travel from trips starting and ending within a single TAZ are termed *intrazonal*, and this activity is estimated separately from the link VMT. Typically the trip starts, ends, and loaded volumes are estimated for several multi-hour time periods on an average weekday. Time periods include congested periods such as morning and afternoon peaks, midday, and overnight. TDMs have internal speed adjustment algorithms, often in the form of a Bureau of Public Records (BPR) equation, to reduce free flow speeds when volumes are high relative to capacity (i.e., during peak travel periods).

The Denver Regional Council of Governments (DRCOG) and the North Front Range Metropolitan Planning Organization (NFRMPO) each provided their TDM model outputs and BPR speed adjustment equations. Figure 1 shows the TDM link coverage over the urban core area around the Denver Metropolitan Area and the North Front Range (DMA/NFR).

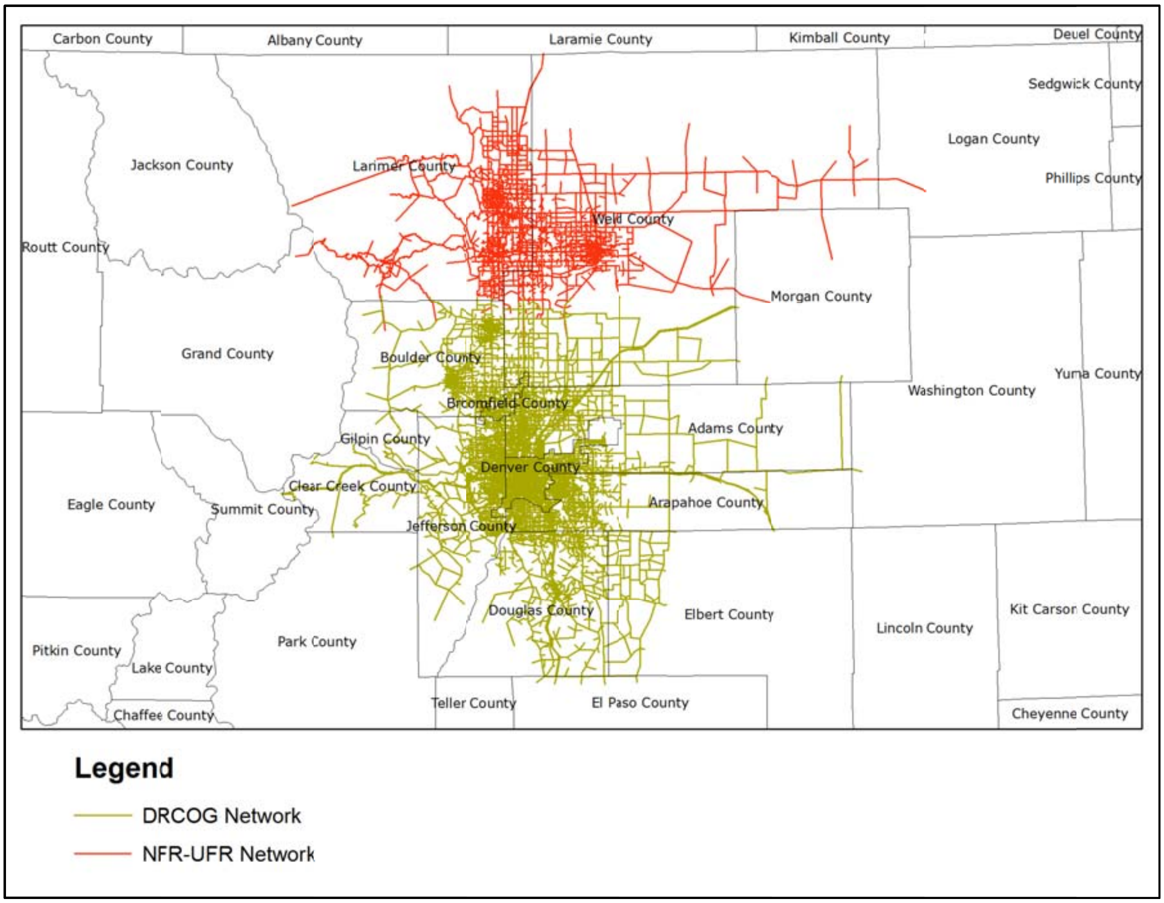


**Figure 1.** DMA/NFR road link network.

TDMs provide weekday VMT totals by multi-hour time period, but additional data available from state departments of transportation provide the means to break out the period into hourly volumes and by vehicle class, based on roadway functional classification. Automatic traffic recorder (ATR) continuous traffic count data from DMA roadways were used to develop temporal allocation profiles. Specialized ATRs at some monitoring sites are able to distinguish vehicle class based on the number of axels and their spacing, combined with methods developed by Lindhjem and Shepard (2007) to map classified volume data to vehicle types. Total volume temporal profiles developed from continuous (hourly) volume counts at ATRs throughout the year, provides data to develop month-of-year, day-of-week, and hour-of-day volume adjustments to model the activity in other seasons (e.g., specific days during a high-ozone episode) inside CONCEPT MV.

In SMOKE-MOVES, VMT must be input to the model as an annual or day total by county and Source Category Code (SCC), a numeric code specifying vehicle class, fuel, and road type. SMOKE includes in its ancillary data multiple prepared on-road temporal profiles as well as human- and roadway-based spatial surrogates for allocating VMT and parked vehicles to grid cells of a modeling domain and hours of the episode day. The temporal profiles provided with SMOKE are not derived from locally specific ATR data, but provide a reasonable average estimate of relative diurnal distribution of VMT.

Vehicle speeds are an important activity parameter to properly characterize because MOVES emission factors are much higher magnitude at low speeds. In SMOKE-MOVES, vehicle speed in the same level of detail as VMT: one average daily speed per SCC and county. SMOKE is also capable of taking speeds by hour of day, but for this SIP modeling effort we did not run SMOKE with hourly speeds because of the available speed data from CDPHE. The daily average speeds provided by CDPHE were prepared based on a fraction of speed limit by road type and county. By comparison, speeds are calculated in CONCEPT for each link and hour. CONCEPT was configured to adjust link free flow speeds according to the methodologies used in the TDMs. Figure 2 shows an example of typical weekday and weekend speeds averaged across all DRCOG TDM links classified as Urban Interstate.

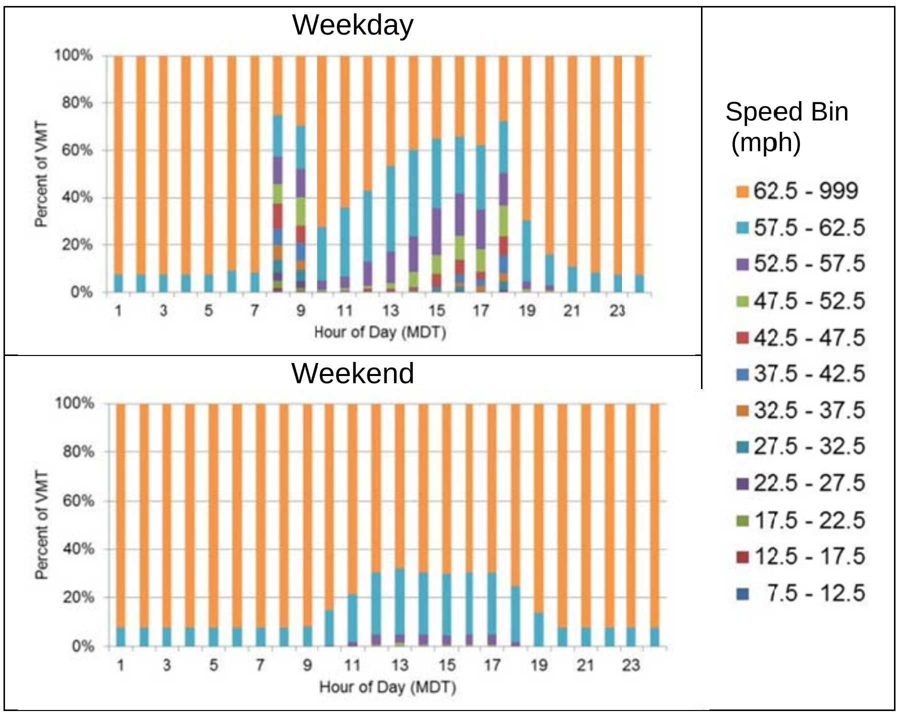


**Figure 2.** Urban interstate speeds by hour of a weekday and weekend day, DRCOG network roadway links.

The above Figure 2 speed summaries resulting from the CONCEPT processing shows that most (90%) of the urban interstate VMT is occurring at speeds above 60 mph during early morning and late night hours on a weekday and on most hours of day on weekends. However, weekday speeds from 8AM until 7PM show significantly lower speeds. Diurnal speed characterization is important because the vehicle speed and emission factors tend to be higher when there is more VMT and lower during off-peaks, affecting the timing of motor vehicle emissions into the atmosphere.

Third and finally, another important feature of CONCEPT MV is improved spatial allocation of off-network emissions. "Off-network emissions" in this paper refers specifically to all pollutants from engine start exhaust and also hydrocarbons evaporating from parked vehicles by emission processes leaks, permeation, and fuel tank vapor venting. The traditional approach to modeling these emissions—

and what is currently done in SMOKE-MOVES—is to spatially allocate them to the modeling grid using roadway or human population spatial surrogates (or combination of the two). CONCEPT, however, was designed to use the known distribution of trip starts and ends by TAZ and time period from an urban area's TDM. Trips by TAZ data is an improvement for spatially placement of these emissions because trip starts and ends occur near homes, businesses, and commercial areas, not necessarily along major roads. Furthermore, the spatial pattern of trips changes throughout the course of a day. For example, on a typical weekday prior to morning commute, one might expect that engine starts are more often occurring in residential areas, whereas during midday and afternoon rush hour they are more likely to occur in commercial districts. The characterization of where starts occur in the modeling domain is especially important because emissions during a start are much larger than during hot, stabilized running emissions.

## EMISSION PROCESSING RESULTS

This section presents visual and tabular summaries of on-road emissions resulting from different preparations of the DMA/NFR area emissions: (1) CONCEPT MV v2.1 vs. (2) SMOKE v3.0 with SMOKE-MOVES Integration Tools. The two approaches have much in common, including use of the same gridded meteorological data, same speciation profiles (CB6), and identical MOVES inputs that produced their emission factor lookup tables. However a few important differences include:

1) Hourly temporal allocation of VMT
2) Treatment of vehicle speeds
3) Spatial allocation off-network emissions

### Temporal Distribution

The effect on VMT distribution by hour of the week of using local ATR data (CONCEPT) versus EPA's temporal profiles (SMOKE) is illustrated in Figure 3. Figure 3 shows VMT totals across the 11-county DMA/NFR by hour of a particular episode week of July 10 to July 16, 2008. The seven blocks of hourly profiles represent days of the week moving from a Thursday to the following Wednesday. Trends between the two emission processors track well in terms of weekday/weekend differences and reflecting the weekday commuter peaks. However, a striking difference between the two models is that SMOKE's temporal profiles consistently underallocates VMT in the weekday morning peak relative to CONCEPT. Averaged over the seven days of week, VMT processed through SMOKE and CONCEPT matched within 0.4% for the average day total, but the effect of local data is important and affects the timing of when ozone precursors from the running emissions are injected into the atmosphere.

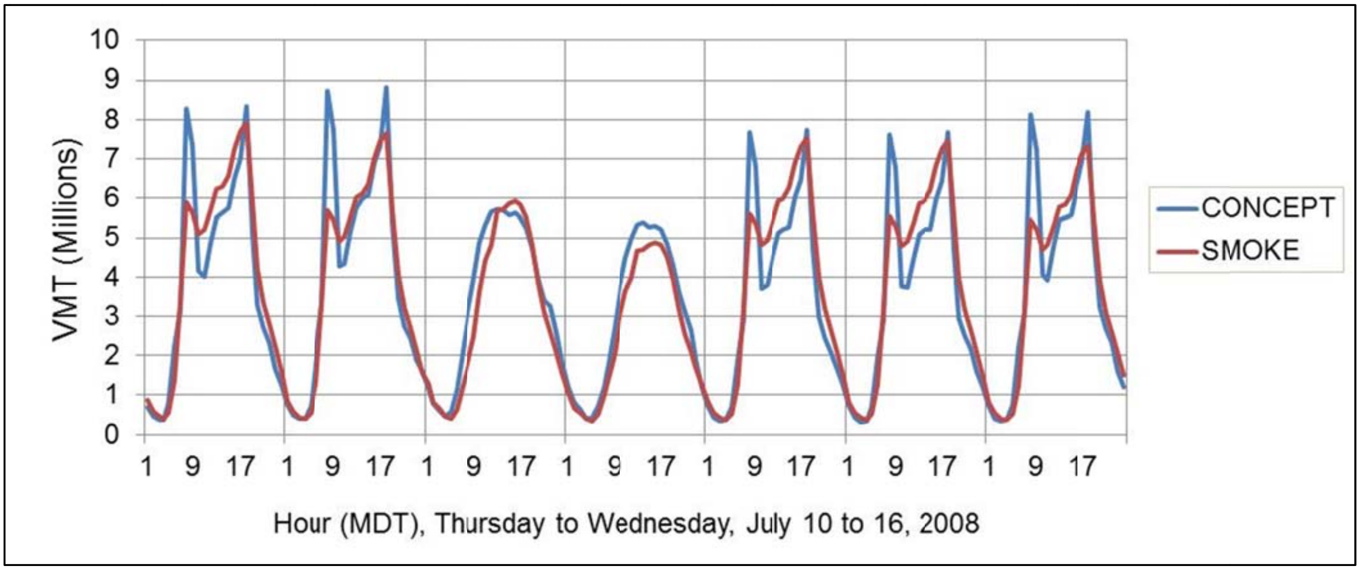


**Figure 3.** Hourly VMT for a July episode week, CONCEPT and SMOKE.

**Spatial Distribution**

Most emission factors' magnitudes depend on temperature and humidity, and emission processors allocate vehicle activity to grid cells so that grid-cell specific meteorology can be used to determine which emission factor to apply. In both CONCEPT and SMOKE, the two types of activity allocated to grid cells are VMT and vehicle population. Emission factors from the MOVES lookup table *ratePerDistance* (units of grams/mile) are combined with the VMT activity and emission factors from the *ratePerVehicle* and *ratePerProfile* lookup tables (units of grams/vehicle/hour) are combined with vehicle count.

CONCEPT MV allocates link-level VMT to grid cells based on the spatial overlap of network links. It similarly allocates vehicle population to grid cells based on the overlap of TAZs and grid cells but also combined with the trip distributions by TAZ normalized over the network by time period. The population distributed using trip origins by TAZ is used to allocate population for purposes of start exhaust emissions calculations. Likewise, the trip ends by TAZ distributions are used to allocate population for calculating parked-vehicle evaporative emissions.

SMOKE allocates roadway- and county-level VMT to grid cells using roadway spatial surrogates for urban and rural, primary and secondary roads, and human population for the smallest local roads. The vehicle population is spatially allocated using a combination of two gridding surrogates: total roadways (75%) and human population (25%).

Figures 4 through 6 show the effects of spatial emissions differences. Figure 4 shows paraffin emissions from evaporative fuel vapor venting emission process for the episode day July 14, 2008 at 3PM, as estimated by CONCEPT (Figure 4 left) and SMOKE (Figure 4 right). SMOKE puts a larger percentage of the emissions on roadways, which is a striking difference next to CONCEPT gridded emissions, which reflect that the emissions are concentrated where trips end around 3PM, mainly clustered around Denver County but also with hot spots further North around the city of Boulder in Bolder County and Fort Collins in Larimer County.

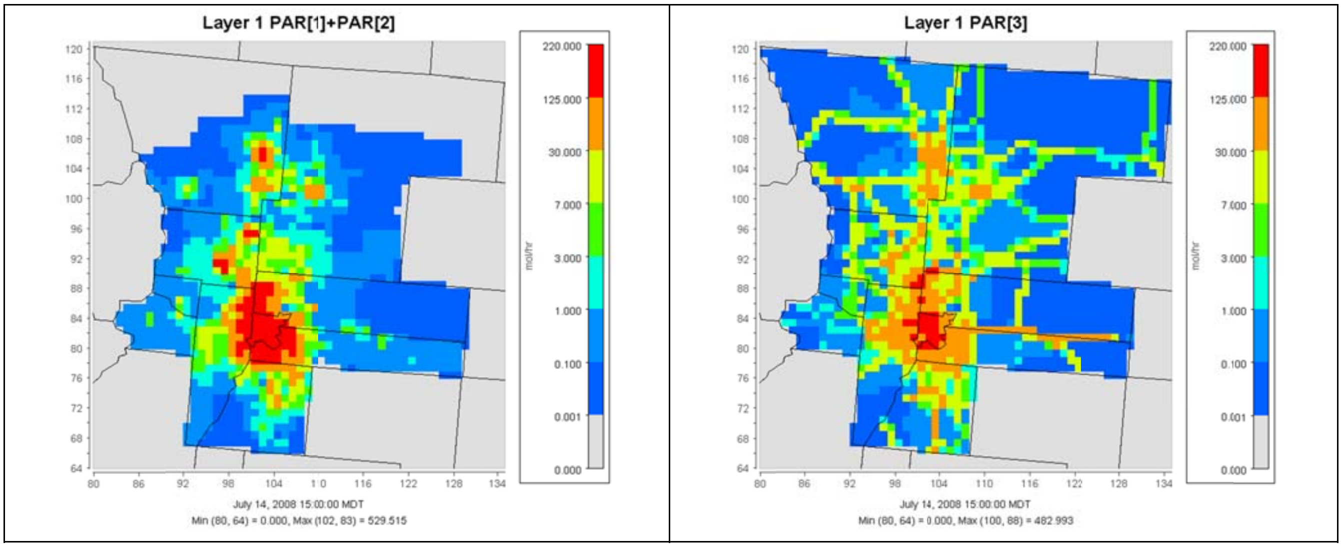


**Figure 4.** Off-Network evaporative fuel vapor venting paraffin emissions, July 14, 2008, 3PM MDT estimated by CONCEPT (left) and SMOKE (right).

Figure 5 shows the differences in carbon monoxide (CO) start exhaust emissions at 7AM on the episode day July 14, 2008. Once again, SMOKE (Figure 5 right) estimates these emissions as occurring primarily on roadways whereas CONCEPT (Figure 5 left) calculates these emissions in grid cells where trip starts occur according to DRCOG and NFRMPO TDMs.

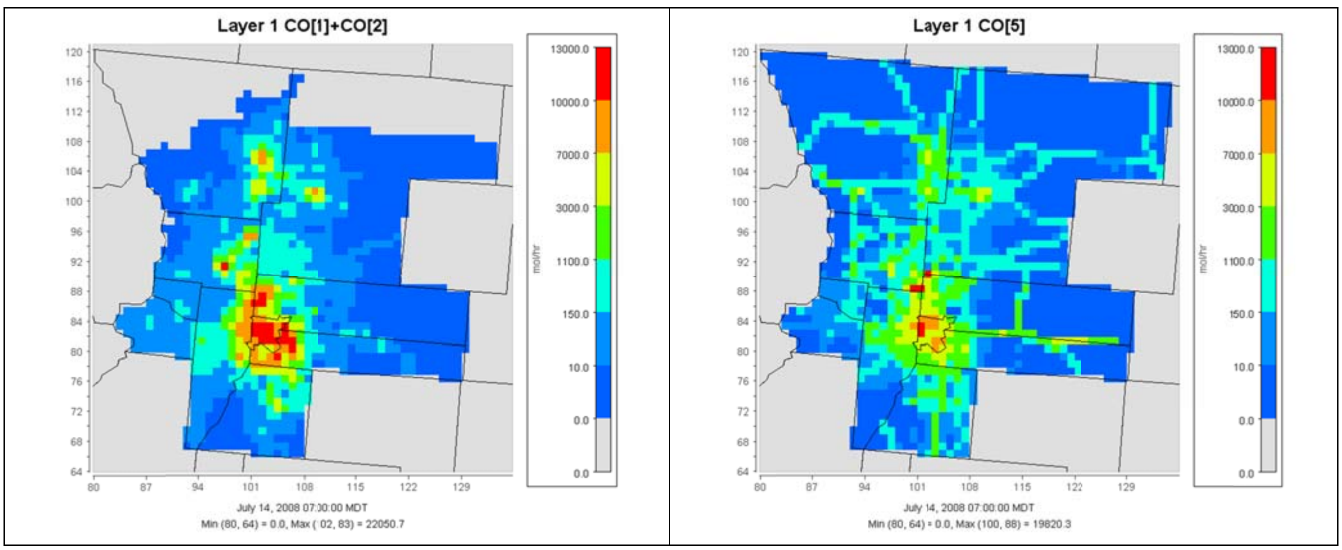


**Figure 5.** Off-Network start exhaust carbon monoxide (CO) emissions, July 14, 2008, 7AM MDT estimated by CONCEPT (left) and SMOKE (right).

Figure 6 shows spatial differences for running exhaust nitrous oxide (NO) emissions at 5PM on episode day July 14, 2008. The relative spatial differences between CONCEPT and SMOKE are less pronounced since running exhaust is allocated primarily from grid cells with high volume links or spatial surrogates. CONCEPT (Figure 6 left) shows a wider-spread, high concentration of emissions surrounding a larger area around the DMA (oranges and reds) compared to SMOKE (Figure 6 right). Interestingly, the highest emissions-containing grid cell in the SMOKE result is 6201 moles NO per hour, which is over 60% larger than CONCEPT's maximum grid cell value of 3779 moles NO per hour. SMOKE appears to concentrate the running exhaust emissions into fewer grid cells.

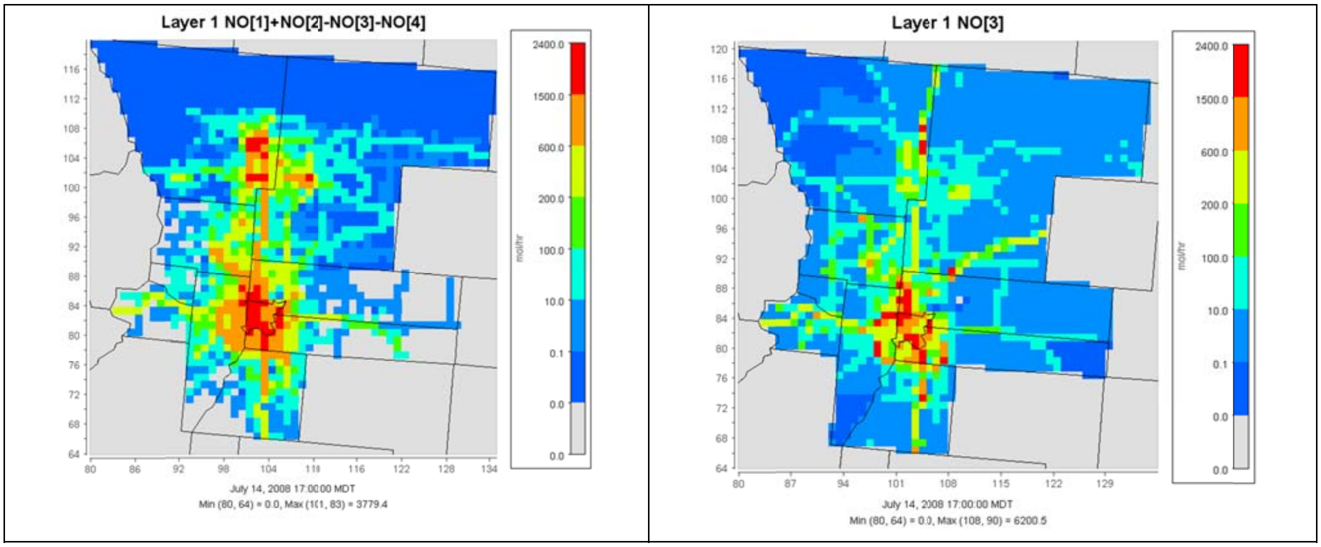


**Figure 6.** Running exhaust nitrous oxide (NO) emissions, July 14, 2008, 5PM MDT estimated by CONCEPT (left) and SMOKE (right).

**Daily Emission Totals**

The next set of emissions results reveal the net effects of CONCEPT and SMOKE methodology differences by showing daily total emissions in Tables 1 and 2 for a sample episode week during the 2008 ozone season. Table 1 shows the $NO_X$ and TOG daily emissions and the percent difference of results from SMOKE compared to CONCEPT calculated as (SMOKE - CONCEPT)/CONCEPT. SMOKE predicts lower on-road $NO_X$ and higher TOG compared to CONCEPT.

**Table 1.** CONCEPT and SMOKE estimates of daily $NO_X$ and TOG for the 11-county area.

| | | $NO_X$ | | | | TOG | | |
|---|---|---|---|---|---|---|---|---|
| **Episode Date** | **Day of Week** | **CONCEPT (TPD)** | **SMOKE (TPD)** | **% Difference** | | **CONCEPT (TPD)** | **SMOKE (TPD)** | **% Difference** |
| 7/11/2008 | Fri | 221.5 | 169.1 | -24% | | 109.0 | 132.1 | 21% |
| 7/12/2008 | Sat | 161.7 | 139.6 | -14% | | 78.1 | 116.3 | 49% |
| 7/13/2008 | Sun | 144.8 | 124.4 | -14% | | 81.1 | 111.9 | 38% |
| 7/14/2008 | Mon | 191.5 | 160.0 | -16% | | 97.6 | 128.0 | 31% |
| 7/15/2008 | Tue | 189.0 | 165.1 | -13% | | 96.5 | 129.0 | 34% |
| 7/16/2008 | Wed | 195.0 | 163.1 | -16% | | 100.6 | 128.8 | 28% |
| 7/17/2008 | Thu | 181.9 | 171.3 | -6% | | 93.3 | 129.2 | 38% |

SMOKE estimates lower $NO_X$ than CONCEPT by between -6% and -24% due to different hourly fleet mix of vehicle types. Emission factors of $NO_X$ are much higher for heavy duty vehicles (HD) than light duty vehicles (LD), and thus small changes in the HD constituent of VMT has large impacts on the on-road mobile $NO_X$ inventory. The HD fraction in CONCEPT ranges from 2% to 11% by hour of the day, whereas SMOKE processing assumes a flat 2.5% to 2.8% HD fraction across all hours.

SMOKE estimates higher TOG than CONCEPT by between 21% and 49% due to one evaporative emission process: evaporative fuel vapor venting from parked vehicles. Excluding the evaporative emission process from the TOG totals, CONCEPT and SMOKE agree within ±3%. The average day parked vehicle evaporative fuel vapor venting TOG is much larger in SMOKE at 47.6 TPD, compared to 16.7 TPD in CONCEPT, averaged over July 11-17. This discrepancy is caused by the averaging methodologies of the raw gridded MET data required by CONCEPT and SMOKE. The evaporative fuel vapor venting process is handled differently from all other emissions processes in

MOVES because the fuel evaporation from the tank into the atmosphere is a function of temperature gradient; therefore, the previous hour temperature and current hour temperature is needed to determine the current hour emission factor. SMOKE requires that MOVES be run with daily temperature profiles with daily minimum/maximum combinations rounded to 10°F increment bins by default, and then SMOKE uses a unique episode day's diurnal temperature profile to determine the closest binned temperature profiles and interpolates (Baek and DenBleyker, 2010). By contrast, CONCEPT requires that MOVES be run for each individual episode day and so it is more specific to the modeled conditions.

**Table 2.** CONCEPT and SMOKE estimates of daily CO and $SO_2$ for the 11-county area.

| | | **CO** | | | | **$SO_2$** | | |
|---|---|---|---|---|---|---|---|---|
| **Episode Date** | **Day of Week** | **CONCEPT (TPD)** | **SMOKE (TPD)** | **% Difference** | | **CONCEPT (TPD)** | **SMOKE (TPD)** | **% Difference** |
| 7/11/2008 | Fri | 932.5 | 1026.6 | 10% | | 0.046 | 0.044 | -2% |
| 7/12/2008 | Sat | 733.1 | 769.2 | 5% | | 0.045 | 0.045 | 0% |
| 7/13/2008 | Sun | 695.2 | 700.4 | 1% | | 0.041 | 0.041 | 2% |
| 7/14/2008 | Mon | 837.1 | 942.2 | 13% | | 0.046 | 0.048 | 3% |
| 7/15/2008 | Tue | 832.7 | 961.8 | 15% | | 0.048 | 0.048 | -1% |
| 7/16/2008 | Wed | 872.7 | 959.5 | 10% | | 0.048 | 0.048 | 1% |
| 7/17/2008 | Thu | 859.8 | 950.9 | 11% | | 0.053 | 0.051 | -4% |

In the context of all Colorado emissions, the on-road $NO_X$ is the largest source of any category at 32% of total NOx, while TOG emissions from motor vehicles are approximately 20% of the TOG inventory (Morris et al., 2012). In order to better understand the impact of motor vehicle processing on air quality the following CAMx sensitivity runs were performed:

1) MOVES Inventory processed as an area source, all counties inside Colorado
2) SMOKE-MOVES Integration Tools processing, all counties inside Colorado
3) Zero out all on-road emissions

The baseline CAMx run was the most highly-detailed modeling for on-road, combining CONCEPT MV emissions over the DMA/NFR 11-county area, SMOKE-MOVES emissions throughout the rest of Colorado, and MOVES Inventory emissions outside the state. Emissions from all other sources were constant between the four sets of runs.

## AIR QUALITY MODELING IMPACTS

The baseline and three sensitivity scenarios for on-road emissions were analyzed for June and July 2008 episode days. The ozone impacts at specific ozone monitors located in Figure 7 (Left) were then compared between observed and modeled for each scenario for those monitors close to the urban core where most on-road emissions occur: South Boulder Creek, Rocky Flats North, Welby, Arvada, NREL, Welch, Carriage, DMAS/Jason, and Chatfield stations. The highest ozone day recorded in summer season 2008 occurred on July 10, 2008 with exceedances of the 75 ppb standard at most monitors. Figure 7 (Right) shows CAMx-estimated daily maximum ozone concentrations in DMA/NFR region on July 10, 2008 with observed daily maximum ozone values. The highest observed 8-hour ozone concentration was 96 ppb at the Welch monitor in the DMA, whereas the highest predicted 8-hour ozone concentration was 93 ppb and occurred just east of Welch. Observed daily maximum 8-hour ozone concentrations in the DMA on this day ranged from 81 to 96 ppb with modeled values at the same locations ranging from 80 to 85 ppb.

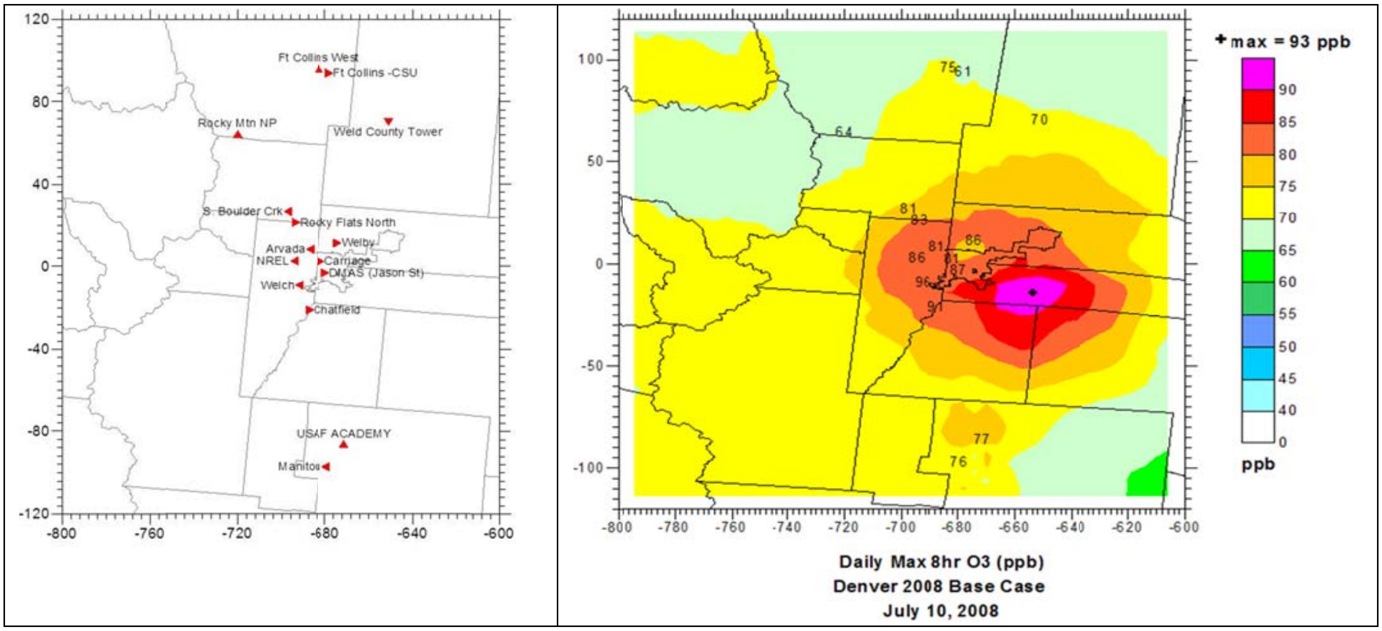


**Figure 7.** 2008 AQS ozone monitoring sites near Denver (Left) and July 10, 2008 observed 8h ozone (Right, text at monitor locations) and model-predicted 8h ozone (Right, color regions).

The motor vehicle contribution to ozone from each processing method scenario was determined by subtracting the zero-out scenario's ozone from each on-road emissions preparation scenario: CONCEPT, SMOKE-MOVES and MOVES Inventory. On the highest ozone day, the overall on-road emissions contributed between 0.5 to 5.5 ppb toward the 8-hour average, depending on monitor location and on-road processing method. Figure 8 shows the motor vehicle contributions by monitor and modeling approach. At Jason and Welby stations the difference in 8-hour ozone between CONCEPT and SMOKE processing is approximately 1.5 ppb.

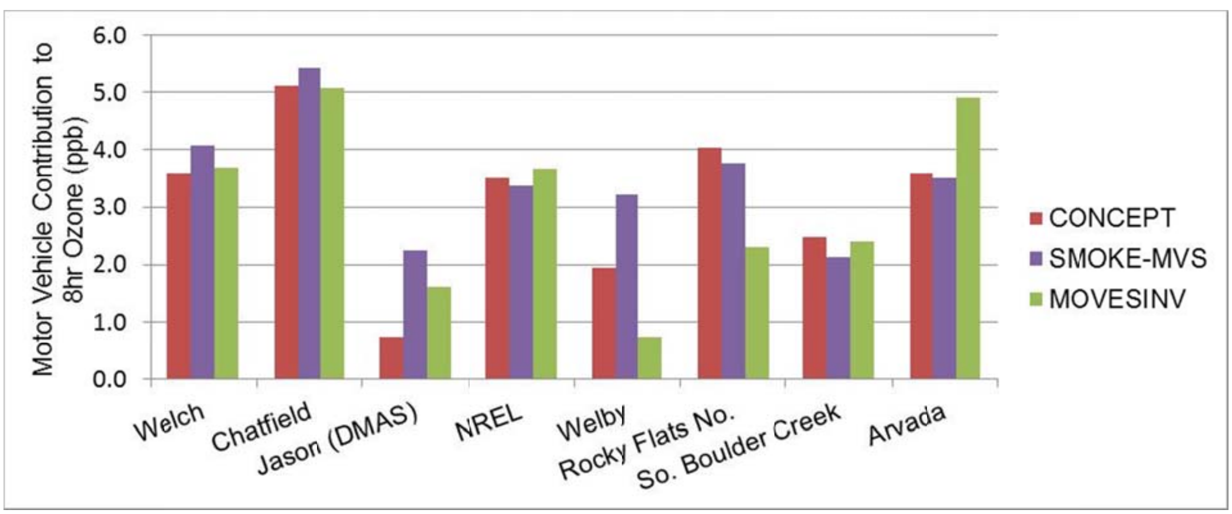


**Figure 8.** Motor vehicle contribution to 8-hr ozone (ppb) by monitor on July 10, 2008.

**CONCLUSION**

Air quality planners rely on air quality models for decision-making on matters of ozone reduction strategies. Thus, it is important to estimate the local emissions and local air quality as accurately as possible. CONCEPT MV is the most detailed emissions processor available because it makes use of local ATR vehicle counter data, link-level speed adjustment algorithms used by local transportation planning experts, and advanced off-network emissions spatial allocation methods. This work demonstrated that the on-road emissions processing methods CONCEPT MV or SMOKE-MOVES impacts not only the motor vehicle daily total emissions and $TOG/NO_X$ ratio but also the overall ozone prediction by as much as 1.5 ppb on a high ozone day in Denver where the observed 8-hour concentrations ranged from 80-96 ppb of which the on-road contribution was 0.5-5.5 ppb. The impact in other areas could be larger or smaller, depending on factors including the relative magnitude of on-road emissions to other local sources and ozone transport from other areas. Air quality managers should consider whether the ozone differences resulting from more detailed emissions processing methods could impact the evaluation of candidate controls measures for ozone reduction.

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**KEY WORDS**

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