Development and Application of a Micro scale Emission Factor Model (MicroFac) for Mobile Source Emissions

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Why MicroFac?

- Current emission models such as the MOBILE family only deal with time-averaged regional-scale emissions.
- They lack:
  - Real-time description
  - Site specificity
- MicroFac has these capabilities and many more.
MOBILE Models

- Historically, MOBILE6/5 has been used for vehicle emissions modelling in Canada.

- **MOBILE** is
  - Designed for county-scale (minimum), not street-scale, emission estimates
  - Not designed for
    - microscale modeling
    - application in air quality modeling
    - human exposure modelling
The MicroFac algorithm gives emissions in terms of the specific vehicle fleet being considered. The composite emission for a specified fleet is built up from the contributions of the individual vehicles as follows:

\[ CEF = \sum_{ij} ER_{ij} \times VEH_{ij} \]

Where:
- \( CEF \) = composite emission factor for the fleet
- \( ER_{ij} \) = composite emission factor for vehicle type \( i \) and model year \( j \)
- \( VEH_{ij} \) = fraction of vehicles in the fleet for vehicle type \( i \) and model year \( j \)
MicroFac Process Flow Diagram

- MicroFac output takes account of the characteristics of the individual vehicles in the fleet as shown below.

![Diagram showing MicroFac Process Flow Diagram]

- Driving-Cycle-Based Normal Exhaust Emission Rates per Vehicle Class and Model Year
- Driving-Cycle-Based High Exhaust Emission Rates per Vehicle Class and Model Year
- Normal Exhaust Emission Rates per Vehicle Class and Model Year
- High Exhaust Emission Rates per Vehicle Class and Model Year
- Brake, Tire and Re-entrained Road Dust
- Vehicle Fleet
- Evaporative/Running Loss
- Composite Emission Factors in g/km/veh
MicroFac Input Requirements

- Date and time
- Ambient temperature and relative humidity
- Average vehicle speed
- Road gradient
- Fuel composition
- Vehicle fleet characterization
MicroFac Evaluation

- Tunnel studies
  - for CO, NOx and CO\textsubscript{2}
    - Callahan Tunnel, Boston 1995
    - Lincoln Tunnel, New York 1995
    - Deck Park Tunnel, Phoenix 1995
  - For PM\textsubscript{10} and PM\textsubscript{2.5}
    - Tuscarora Tunnel, PA 1999

- Speed, traffic fleet and age distribution were known
Performance of MicroFac (Boston)

- Average Speed = 26.4 (14.1-35.3) mph
- Average Ambient Temperature = 62.1 (50.0-69.1)°F
Performance of MicroFac
(New York)

- Average Speed = 27.1 (20.4-30.0) mph
- Average Ambient Temperature = 84.6 (79.5-91.0)°F

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**CO (g/km)**

- Aug 16
- Aug 17
- Aug 18

**NOx (g/km)**

- Aug 16
- Aug 17
- Aug 18

**CO2 (g/km)**

- Aug 16
- Aug 17
- Aug 18

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Performance of MicroFac (Phoenix)

- **Average Speed**: 59.7 (58.0-61.9) mph
- **Average Ambient Temperature**: 103.2 (84.9-110.8) °F
Performance of MicroFac (Pennsylvania)

- Average Speed = 56.8 (53.6-61.7) mph
- Light-duty percentage = 56.5 (13.68-88.61) %
Application in Air Quality Modeling

Micrometeorology + Site-Specific meteorology

On-Road Traffic → Site-Specific Real-Time Emission Factor Model

MicroFac

Dispersion Model → Such as CALINE4 or AERMOD
Application of MicroFac
(Windsor, ON)

1, 2 Normal traffic + Trucks: Free flow
3, 4, 6. Normal traffic: Free flow
5. Trucks only: Queued

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MicroFac + CALINE4/AERMOD
(Windsor, ON)

- Monitoring limitations
- No road dust

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MicroFac + CALINE4
(Waterloo Region, ON)

July 15, 2002, 11:00; Wind Direction 275°; Wind Speed 2.1 m/s

Cambridge – Hespeler Road

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Application in Remote Sensing

Remote sensing devices (RSD)

- Concentrations of material emitted by vehicles in ppm
- Can be converted to emissions in g pollutant (CO, NOx, HC) / kg fuel used
- Assumed fuel economy rate is used to convert to emission factors
- Suitable only for inventory and qualitative assessment

MicroFac fuel consumption model convert RSD concentrations to emission factors g/km at any speed and driving conditions

- RSD data analysis and conversion to emission factors for individual vehicles and vehicle fleet
Conclusions

- Site-specific real-time emissions are critical for modeling air transport/dispersion and human exposure in various roadway microenvironments.

- MicroFac models for
  - CO and NO\textsubscript{x}
  - PM\textsubscript{10} and PM\textsubscript{2.5}
  - Fuel consumption model
    - CO\textsubscript{2} model
    - Remote sensing applications
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