MicroFac - A New Microscale Motor Vehicle Emission Model: Determination of Neighbourhood Air Pollution for Human Exposure Assessment

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Strategic Partnership

- **Collaboration** "Tools for the assessment and prediction of traffic related air quality exposures"
- Expertise in emissions, dispersion, regional chemical transport and human exposure modeling

Project Focus and Purpose

- *MicroFac* – the most accurate tool to date for determining emissions from traffic on busy transportation corridors for quantifying exposure in a human health context
- Target audience: provincial policy makers, municipal/transportation planners, public health units – tool for Environmental Impact Assessment, Growth Management Strategies, and Transportation Demand Management
- Emphasize local action and policy advocacy addressing air pollution

Research Considerations

- Increases in vehicular traffic offset emission control improvements
- Ambient concentrations of pollutants do not reflect personal exposures accurately
- Greater exposure of pedestrians, urban cyclists/joggers, etc. to vehicular pollutants
- Greater danger to occupations and age groups spending significant periods outdoors
- Sub-populations need to be identified geospatially in proximity to points of exposure
- Maps can be generated for any municipality with such variables as:
  - ✓ Demographics (e.g. <18 yrs. +/or >65 yrs. Old)
  - ✓ Aggregated cardio-respiratory disease morbidity data plotted by postal code
  - ✓ Locations of parks, school fields, retirement homes, hospitals, community centres and sports fields
  - ✓ All show proximity to major transportation corridors

Emissions from Transport Sector

- **Road vehicle emissions in Ontario account for**
  - ✓ 45% of Carbon Monoxide (CO), 35% of Nitrogen Oxides (NOx), 22% of Volatile Organic Compounds (VOCs), 12% of Particulate Matter
  - ✓ more than half of transportation related GHG emissions
- **Densely populated downtown cores, such as Toronto, have much higher proportion of air pollution from local transportation sources at street level**
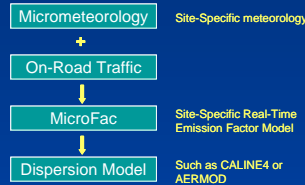 - ✓ 90% CO, 80% NOx, 60% SOx

MOBILE Emission Model

- *MOBILE* modelling approach
  - ✓ Time averaged emission estimates over a large area based on Vehicle Kilometre Travelled (VKMT)
- *MOBILE* is designed for
  - ✓ Designed for county-scale (minimum), not street-scale, emission estimates
  - ✓ Not designed for application for air quality and human exposure modelling

MicroFac Microscale Emission and Exposure Model

- *MicroFac* is a site-specific vehicle emission model based on real-time vehicle fleet to provide pollutant concentration in roadway environments
- *MicroFac* gives emissions in significant microenvironments such as roadside, in-vehicle, street canyons, etc.
- United States Environmental Protection Agency's Consolidated Human Activity Database (CHAD) provides input data for exposure modeling and risk assessments
- CHAD must be integrated with local data such as time spent outdoors
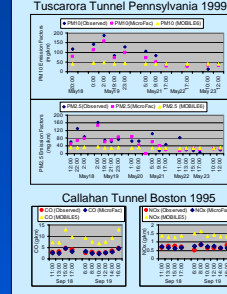- Local transportation data and traffic counts are also needed

Application in Air Quality Modeling

Micrometeorology	Site-Specific meteorology
+	
On-Road Traffic	
MicroFac	Site-Specific Real-Time Emission Factor Model
Dispersion Model	Such as CALINE4 or AERMOD

MicroFac Models

- 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
- Provides lane-by-lane emissions at very high temporal (starting from 5 minutes) and spatial resolution (starting from 10 metres)
- Input requirements are simple
  - ✓ Date and time
  - ✓ Ambient temperature and relative humidity
  - ✓ Average vehicle speed
  - ✓ Road gradient
  - ✓ Fuel composition
  - ✓ Vehicle fleet characterization
- Designed for application in
  - ✓ Street level air quality modelling
  - ✓ Identifying hot spots
  - ✓ Human exposure assessment
  - ✓ Project level analysis

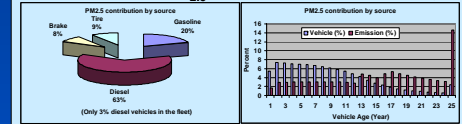### MicroFac Process Flow Diagram

MicroFac + CALINE4: Waterloo Region

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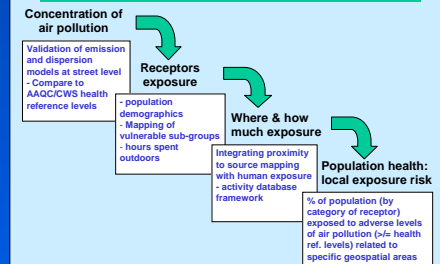

Cambridge – Hespeler Road

Background

The *MOBILE* emission model (developed by the US EPA) is not suitable to provide emission inputs to air quality models at the micro scale. The *Waterloo Centre for Atmospheric Sciences* has developed a new emission factor model for the North American motor vehicle fleet, which provides more detailed temporal and spatial emissions data than *MOBILE* models. *MicroFac* will support accurate assessments of human exposure to emissions from motor vehicle traffic in specific urban areas and improve our understanding of PM and ozone formation from vehicles.

Performance of MicroFac

Tuscarora Tunnel Pennsylvania 1999
Callahan Tunnel Boston 1995

Contribution of $PM_{2.5}$ by Source and Vehicle Age

PM2.5 contribution by source: Tire/Brake 8%, Tire 9%, Gasoline 20%, Diesel 63% (Only 3% diesel vehicles in the fleet)

Draft Conceptual Exposure Model: Air Quality & Traffic Emissions

Region of Waterloo: Public Survey (2003) Hours spent outdoors (annual average)	weekdays	weekends
0-2 hours	41.2%	13.5%
3 - 5 hours	36.2%	40.7%
6+ hours	19.6%	43.2%

Demographic & Disease Mapping

Region of Waterloo

Cambridge, Kitchener and Waterloo 2001 Hospitalizations due to COPD (ICD-9 Codes 490-496)

Conclusions

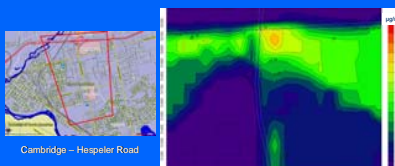- Site-specific real-time emissions are needed for modeling air transport/dispersion and human exposure in various roadway microenvironments
- *MicroFac* models will provide emissions at fine resolution critical for the prediction of traffic related impacts on local air quality and assessment of exposure conditions in micro-environments