Issues in Modeling Population Exposures to multiple, co-occurring airborne VOCs

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by
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Need for Modeling Exposures to Multiple, Co-occurring Pollutants

• Several HAPs are co-occurring
  • Resulting from primary emissions or secondary formation
  • Possible mixture effects at toxicological level

• Use of “virtual individuals” and random samples from distributions of exposure parameters
  • Need to maintain consistency from one model simulation to another
  • In theory, it is possible to maintain consistent state across simulations
  • In practice, it is desirable to have a bottom-up design for multiple chemicals

• Examples:
  • Regional Scale: CMAQ model [“One Atmosphere” concept]
  • Local Scale: Reactive plume models
  • Indoor Environment: Indoor models employing “dark photochemistry”
  • Biological Scale: Generalized Physiologically Based Toxicokinetic Models
Steps in MENTOR-1A for assessing inhalation exposures and doses to co-occurring air pollutants

MENTOR-1A: Modeling ENvironment for TOtal Risk studies (MENTOR) using a "One Atmosphere" (1A) setting
MENTOR-1A Application:
Modeling domain for the CMAQ/ SAPRC-99 toxics simulation (CMAQ simulation results obtained from USEPA ORD)

- Entire year of 2001
- 4km resolution around the Philadelphia, PA region
- Emissions-based modeling of 20 air toxics in addition to ozone
  - Acetaldehyde
  - Acrolein (Total/Primary)
  - Acrylonitrile
  - Benzene
  - 1,3-butadiene
  - Chloroform
  - Dichloropropene
  - Ethylene dibromide
  - Ethylene dichloride
  - Ethylene oxide
  - Formaldehyde (Total/Primary)
  - Methylene chloride
  - Naphthalene
  - Perchloroethylene
  - Primary higher aldehydes (ALD2)
  - Propylene dichloride
  - Quinoline
  - Tetrachloroethane
  - Trichloroethylene
An overview of the exposure and dose modeling study area
(498 Census Tracts in the Urban Philadelphia region)

- Year-long simulation at an hourly resolution
- 500 virtual individuals simulated per census tract (total: 249,000)
- Spatio-temporal interpolations of ambient concentrations
- Season and weekday/weekend specific activity patterns
- *Indoor benzene sources: smoking, garages, and wood flooring*
Spatiotemporal patterns of surface formaldehyde (top) and benzene (bottom) concentrations predicted by CMAQ (at 12 km resolution) for January and July of 2001.
Benzene spatial distributions (annual and seasonal) and sample hourly time series predicted by CMAQ (at 4 km resolution) for 2001
Formaldehyde spatial distributions (annual and seasonal) and sample hourly time series predicted by CMAQ (at 4 km resolution) for 2001.
MENTOR-1A estimates of the 90th percentile of annual/seasonal averages of hourly local (census tract) ambient benzene concentrations (ppb) for 2001.
MENTOR-1A estimates of the 90th percentile of annual/seasonal averages of hourly local (census tract) personal exposure benzene concentrations due to outdoor air for 2001.
MENTOR-1A estimates of the 90th percentile of annual/seasonal averages of daily personal benzene intake ("dose") (µg) due to outdoor air for 2001.
MENTOR-1A estimates of the 90th percentile of annual/seasonal averages of daily personal formaldehyde intake ("dose") (μg) due to outdoor air for 2001
Modeling impact of commuting patterns

• Databases
  • Commuting database at Census Tract level
    - Provides probabilities of commuting from one census tract to another
      o all census tracts in the US, based on Census 2000
    - Data source: USEPA (contractor: Mantec)
  • Census 2000 database
    - Information on employment, etc.
  • CHAD database
    - Information on activities and locations (school, office, etc.)

• Approach
  • Obtain the census tract level commuting probabilities and assign work tracts
  • For commuting outside the modeled domain, use home tract
    - Other approaches: ignore those sampled individuals or increase modeling domain
  • For ambient concentrations for “auto”, use average of home tract and work tract concentrations for weekday
  • Use home tract concentration for weekend
Modeling road-way concentrations: Benzene levels

• Data
  • Probability distributions for “roadway adjustment factors” (Johnson and Long, personal communication)
    - Weekday and weekend dependent distributions

• Approach
  • Roadway concentrations assumed to be proportional to background ambient concentrations
  • Proportionality factors sampled from the distributions
    - Distributions are weekday/weekend specific
    - Independent factors are sampled for different seasons
    - Provision to incorporate more detailed distributions
      - e.g. roadway based, season and county specific databases
Modeling indoor sources: Benzene emissions from garages

• Databases
  • Outdoor/garage/indoor ratios from Nelson 1989 and Thomas 1993
    - Database of Indoor Microenvironmental Emissions (DIME; Johnson and Long, 2005 – based on Thomas 1993)
  • Housing characteristics
  • Garages in households
    - US DOE’s Residential Energy Consumption Survey (RECS) (www.eia.doe.gov/emeu/recs/), 2001 data
    - Middle Atlantic Region data used for developing distributions
  • Garage Usage
    - Cincinnati survey (Johnson, 1989), which is part of the Consolidated Human Activity Database (CHAD; McCurdy 2000)

• Approach
  • For each sampled individual, assign house type
  • Assign attached garage and usage (Census; RECS; Garage use dist.)
  • Assign outdoor/garage/indoor ratio from the distributions (or)
    Assign emission flux (garage to house) from emission rate distribution
Modeling indoor sources: Benzene emissions from flooring material (wood parquet)

• Databases
  • DI ME database (Johnson and Long, 2005)
    - Probability distributions for Benzene emission flux from wood parquet
  • US DOE’s Residential Energy Consumption Survey (RECS)
    - 2001 data from www.eia.doe.gov/emeu/recs/
    - Floor area for households
    - Middle Atlantic Region data used for developing distributions
  • Census 2000 database
    - Information on housing characteristics

• Approach
  • Assume correlation between house type and floor area range
  • For each sampled individual, assign floor area
    - based on housing distributions for the census tract, and floor area range
  • Assign percentage of floor covered by wood parquet
  • Assign emission rate flux from the distributions for emission rates
Calculation of Microenvironmental Concentrations

For the indoor \textbf{residential} microenvironment, a single compartment, \textit{steady-state mass balance equation} (Ozkaynak et. al., 1996) is used

\[
C_{\text{residential}} = (P \times \text{ach}/(\text{ach} + k)) \times C_{\text{ambient}} + \\
(E_{\text{smk}} \times N_{\text{cig}} + E_{\text{cook}} \times t_{\text{cook}} + E_{\text{other}} \times T)/((\text{ach} + k) \times V \times T)
\]

where
\[
\begin{align*}
C_{\text{ambient}} &= \text{ambient outdoor PM concentration (\text{\(\mu g/m^3\)})} \\
P &= \text{penetration factor (unitless)} \\
k &= \text{deposition rate (h\textsuperscript{-1})} \\
\text{ach} &= \text{air exchange rate (h\textsuperscript{-1})} \\
E_{\text{smk}} &= \text{emission rate for smoking (mg cig\textsuperscript{-1})} \\
N_{\text{cig}} &= \text{number of cigarettes smoked during model time step} \\
E_{\text{cook}} &= \text{emission rate for cooking (mg min\textsuperscript{-1})} \\
t_{\text{cook}} &= \text{time spent cooking during model time step (min)} \\
E_{\text{other}} &= \text{emission rate for other source (mg h\textsuperscript{-1})} \\
T &= \text{model time step (h)} \\
V &= \text{residential volume (m}^3\text{)}
\end{align*}
\]
Comparison of formaldehyde doses with (right) and without (left) assigning commuting tracts (No significant difference for population exposure distributions)
Preliminary Results: Comparison of benzene doses with/without commuting and indoor sources cigarettes, garage emissions, and wood parquet

Note: Impact of garage emissions is modeled through empirical indoor/outdoor relationship distributions.
Sensitivity of benzene doses to different treatment of emissions from garages

Garage emissions modeled using outdoor/garage/indoor relationships (empirical distributions)

Garage emissions modeled using emission rates from garages to indoors and mass balance ("mechanistically correct" way)
State of Indoor “Emissions Estimates”: Benzene

**Indoor Emission Rates Grouped by Pollutant and Source Type**

### Benzene

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Source Name</th>
<th>Ref ID</th>
<th>Type</th>
<th>Units</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td></td>
<td>Attached garage</td>
<td>A1g004a</td>
<td>C</td>
<td>ug/m^3</td>
<td>1.5</td>
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<td></td>
<td>Attached garage</td>
<td>B1t006a</td>
<td>L</td>
<td>ug/h/unit</td>
<td>1454</td>
<td>3952</td>
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<tr>
<td></td>
<td>Attached garage</td>
<td>C1h003a</td>
<td>L</td>
<td>ug/h/unit</td>
<td>2700</td>
<td>2.69</td>
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<tbody>
<tr>
<td>Flooring, wood parquet</td>
<td>D1l001a</td>
<td>U</td>
<td>ug/h/m²</td>
<td>1</td>
<td>6</td>
<td>0</td>
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<tr>
<td>Residence, whole</td>
<td>E1o005a</td>
<td>C</td>
<td>ug/h/m²</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Residence, whole</td>
<td>F1m005a</td>
<td>L</td>
<td>ug/h/unit</td>
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### Source Type: Product (P)

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<tr>
<td>Aromatic incense (after burning)</td>
<td>G1n004a</td>
<td>C</td>
<td>ug/unit</td>
<td>1312</td>
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<td>Aromatic incense (burning)</td>
<td>H1o04a</td>
<td>C</td>
<td>ug/unit</td>
<td>910.7</td>
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<td>Church Incense (after burning)</td>
<td>J1p004a</td>
<td>C</td>
<td>ug/unit</td>
<td>354.1</td>
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<tr>
<td>Church Incense (burning)</td>
<td>K1q004a</td>
<td>B</td>
<td>ug/unit</td>
<td>188.1</td>
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<tr>
<td>Cigarette ETS (Full flavor brand; sidestream and mainstream)</td>
<td>L1r005a</td>
<td>N</td>
<td>ug/unit</td>
<td>274</td>
<td>73</td>
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<tr>
<td>Cigarette ETS (Full flavor low tar; sidestream and mainstream)</td>
<td>M1s005a</td>
<td>N</td>
<td>ug/unit</td>
<td>278</td>
<td>53</td>
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<tr>
<td>Cigarette ETS (Ultra low tar; sidestream and mainstream)</td>
<td>N1t005a</td>
<td>N</td>
<td>ug/unit</td>
<td>238</td>
<td>96</td>
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<tr>
<td>Cigarette smoke (Mainstream)</td>
<td>O1u005a</td>
<td>C</td>
<td>ug/unit</td>
<td>0.3</td>
<td>0</td>
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<tr>
<td>Cigarette smoke (Mainstream)</td>
<td>P1v005a</td>
<td>C</td>
<td>ug/unit</td>
<td>34</td>
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</tbody>
</table>

Source Type: G = Garage, M = Material, P = Product

Distribution Type: L = lognormal (geom. mean, geom. S.D.); N = normal (mean, S.D.); T = triangular (min, max, mode); U = uniform (min, max); E = exponential (shape); D = data set (# of data points, values); C = central tendency (value); B = best estimate (value)
# State of Indoor “Emissions Estimates”: Formaldehyde

## Formaldehyde

<table>
<thead>
<tr>
<th>Source Type</th>
<th>Source Name</th>
<th>Ref ID</th>
<th>Type</th>
<th>Units</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>1/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air filter, HVAC system</td>
<td>Morrison1996a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>4</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>38</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Air filter, HVAC system</td>
<td>Tucker2001a</td>
<td>U</td>
<td>ug/h/unit</td>
<td>250</td>
<td>3000</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Cabinet doors, UF fiberboard, acid-cured finish</td>
<td>Kelly1996a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>2</td>
<td>480</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Cabinet doors, UF fiberboard, bare</td>
<td>Kelly1996a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>2</td>
<td>364</td>
<td>535</td>
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</tr>
<tr>
<td>Carpet, PVC hard-backed (18-hr)</td>
<td>Hodgson1993a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>1</td>
<td>18.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Carpet, PVC hard-backed (24-hr)</td>
<td>Hodgson1993a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>1</td>
<td>57.2</td>
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<tr>
<td>Carpet, synthetic fiber</td>
<td>Tucker2001a</td>
<td>U</td>
<td>ug/h/m²</td>
<td>8</td>
<td>100</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Carpet, synthetic fiber (1 month)</td>
<td>Tucker2001a</td>
<td>C</td>
<td>ug/h/m²</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>Carpet, synthetic fiber (1 year)</td>
<td>Tucker2001a</td>
<td>C</td>
<td>ug/h/m²</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Carpet, synthetic fiber (18-h)</td>
<td>Tucker2001a</td>
<td>C</td>
<td>ug/h/m²</td>
<td>5</td>
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<td>Carpet, synthetic fiber (1)</td>
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<td>ug/h/m²</td>
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<td>Carpet, synthetic fiber (24-h)</td>
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<td>C</td>
<td>ug/h/m²</td>
<td>10</td>
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<tr>
<td>Ceiling tile (first 24-hr)</td>
<td>Tucker2001a</td>
<td>U</td>
<td>ug/h/m²</td>
<td>800</td>
<td>12000</td>
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<tr>
<td>Ceiling tiles, fiberglass</td>
<td>Kelly1996a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>4</td>
<td>11</td>
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<td>18</td>
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<td>Ceiling: painted gypsum board</td>
<td>Molhave1996a</td>
<td>D</td>
<td>ug/h/m²</td>
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<td>Classroom (whole), relocatable</td>
<td>Hodgson2004a</td>
<td>D</td>
<td>ug/h/m²</td>
<td>23</td>
<td>42</td>
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<td>Door, interior w. particleboard core</td>
<td>Kelly1996a</td>
<td>D</td>
<td>ug/h/m²</td>
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<td>7</td>
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<tr>
<td>Duct liner, fiberglass, new</td>
<td>Morrison1998a</td>
<td>D</td>
<td>ug/h/m²</td>
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<td>10</td>
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<td>Duct liner, fiberglass, new</td>
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<td>ug/h/m²</td>
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<td>Duct liner, fiberglass, used</td>
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**Source Type:** G = Garage, M = Material, P = Product

**Distribution Type:** L = lognormal (geom. mean, geom. S.D.); N = normal (mean, S.D.); T = triangular (min, max, mode); U = uniform (min, max); E = exponential (shape); D = data set (# of data points, values); C = central tendency (value); B = best estimate (value)
State of Indoor “Emissions Estimates”: Formaldehyde

<table>
<thead>
<tr>
<th>Material Description</th>
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Source Type: G = Garage, M = Material, P = Product
Distribution Type: L = lognormal (geom. mean, geom. S.D.); N = normal (mean, S.D.); T = triangular (min, max, mode); U = uniform (min, max); E = exponential (shape); D = dataset (# of data points, values); C = central tendency (value); B = best estimate (value)
# State of Indoor “Emissions Estimates”: Formaldehyde

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<th>Material Type</th>
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<td>1.9</td>
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</tr>
<tr>
<td>Stile, vinyl 3 sides and MDF on front frame</td>
<td>Hodgson2002a</td>
<td>ug/h/m²</td>
<td>330</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Strandboard, 3/4&quot; PF oriented</td>
<td>Kelly1996a</td>
<td>ug/h/m²</td>
<td>2</td>
<td>8.8</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Unprocessed decorative film</td>
<td>Risholm-1999a</td>
<td>ug/h/m²</td>
<td>400</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Urea formaldehyde formal insulation</td>
<td>Godish2001a</td>
<td>ug/h/m²</td>
<td>50</td>
<td>800</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Varnish, conversion, acid-catalyzed (115 day)</td>
<td>Howard1996b</td>
<td>ug/h/m²</td>
<td>1</td>
<td>170</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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</tr>
<tr>
<td>Varnish, conversion, acid-catalyzed (30 day)</td>
<td>Howard1996b</td>
<td>ug/h/m²</td>
<td>500</td>
<td>700</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Varnish, conversion, acid-catalyzed (48 day)</td>
<td>Howard1996b</td>
<td>ug/h/m²</td>
<td>1</td>
<td>400</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Wall paneling, prefinished UF hardw plywood, 1/4&quot;</td>
<td>Kelly1996a</td>
<td>ug/h/m²</td>
<td>2</td>
<td>140</td>
<td>181</td>
<td>0</td>
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<tr>
<td>Wallpaper, paper-based (15.5-hr)</td>
<td>Kelly1996a</td>
<td>ug/h/m²</td>
<td>1</td>
<td>27</td>
<td>0</td>
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<tr>
<td>Wallpaper, paper-based (initial emission)</td>
<td>Kelly1996a</td>
<td>ug/h/m²</td>
<td>1</td>
<td>891</td>
<td>0</td>
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</tr>
<tr>
<td>Walls: particle board / gypsum board</td>
<td>Molhave1993a</td>
<td>ug/h/m²</td>
<td>5</td>
<td>20</td>
<td>20</td>
<td>20</td>
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<td>20</td>
<td>20</td>
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</tr>
<tr>
<td>Water-based paint (1 month)</td>
<td>Tucker2001a</td>
<td>ug/h/m²</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Water-based paint (1 year)</td>
<td>Tucker2001a</td>
<td>ug/h/m²</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water-based paint (168-hr)</td>
<td>Tucker2001a</td>
<td>ug/h/m²</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Water-based paint (1-hr)</td>
<td>Tucker2001a</td>
<td>ug/h/m²</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Water-based paint (24 hr)</td>
<td>Tucker2001a</td>
<td>ug/h/m²</td>
<td>10</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

*Source Type: G = Garage, M = Material, P = Product*

*Distribution Type: L = lognormal (geom. mean, geom. S.D.); N = normal (mean, S.D.); T = triangular (min, max, mode); U = uniform (min, max); E = exponential (shape); D = data set (# of data points, values); C = central tendency (value); B = best estimate (value)*
Need and Applicability to Atmospheric Modeling:
- Quickly assess the impact in changes in concentrations on exposures/doses
  - quick “sensitivity” testing of the whole source to dose modeling process
- Avoid variability introduced in multiple model simulations

Need and Applicability to Emergency Response Modeling:
- Database of tables for response strategies, e.g., evacuation/shelter in place
- Quickly make assessments regarding optimal response strategy
- Useful for training exercises for emergency responders

Approximate estimates of computer resources for a year long exposure assessment using MENTOR-1A for an urban area.
Motivation: Performing multiple sensitivity/uncertainty simulations with a major subset of options held constant.
Linear relationships between exposures and ambient levels

- For each activity/exposure event
- Piece-wise (event-wise) linear relationships
  - Different from “a linear factor approach”
- The approach extensible to nonlinear relationships too

Methodology: Obtaining pre-computed factors for simple “microenvironmental factors” based calculations

\[
C_{\text{microenvironmental}} = F_{\text{additive}} + F_{\text{penetration}} \cdot F_{\text{proximity}} \cdot C_{\text{ambient}}
\]

\[
C_{F,\text{microenvironmental}} = F_{\text{penetration}} \cdot F_{\text{proximity}}
\]

\[
C_{A,\text{microenvironmental}} = F_{\text{additive}}
\]

Perform calculations for each:

- activity \( m \) on
- day \( n \) for
- individual \( i \) in
- census tract \( j \)
Methodology: Obtaining pre-computed tables for linear relationships
Indoor microenvironment with sources

\[ C_{\text{residential}} = \frac{P \cdot A}{A + k} \cdot C_{\text{ambient}} \]

or

\[ C_{F,\text{residential}} = \frac{P \cdot A}{A + k} \]

\[ C_{A,\text{residential}} = \frac{S_{\text{indoor}}}{(A + k) \cdot V \cdot T} \]

Subsequent model runs:

\[ C_{\text{exposure};i,j,m,n} = C_{A;i,j,m,n} + C_{F;i,j,m,n} \cdot C_{\text{ambient}}(j,t_{\text{activity}};m,n) \]
Methodology: Obtaining pre-computed tables for intakes/ doses

\[ R_{\text{ventilation}} = BMR \cdot METS \cdot EETOVO2 \cdot VQ \]
\[ D = C_{\text{exposure}} \cdot \Delta T \cdot R_{\text{ventilation}} \]
\[ = (C_A + C_F \cdot C_{\text{ambient}}) \cdot \Delta T \cdot R_{\text{ventilation}} \]
\[ D_F = C_F \cdot \Delta T \cdot R_{\text{ventilation}} \]
\[ D_A = C_A \cdot \Delta T \cdot R_{\text{ventilation}} \]

Dose for individual \( i \) in census tract \( j \) on day \( m \)

\[
D_{i,j,m} = \sum_{n=1}^{N_{\text{activities};i,j,m}} \left( D_A(i, j, m, n) + D_F(i, j, m, n) \cdot C_{\text{ambient}}(j, t_{\text{activity};i,j,m}) \right)
\]

Perform calculations for all individuals in all census tracts to obtain population estimates
Pre-Computed Modeling Approach for Rapid Assessment of Exposures and Doses to Atmospheric Contaminants

Framework:
- Piece-wise (event-wise) linear relationships for each activity/exposure event
- Extensible to complex, nonlinear relationships

Highlights of the Approach:
- Develop pre-computed models and store the corresponding tables
  - analogous to tables of endgame strategies in chess
- Planning for scenario developments
- Full model has to be run for each scenario (sets of census tracts, etc)

Advantages: Simplicity of Use:
- Scientists can quickly apply scenario-specific modules
  - without having to understand all the complexities in the models
  - without having to download large datasets
- Quick estimates of individual/population exposures/doses
  - execution time reduced from several days to < 1 hr
- Results identical to running the full model
- Synchronized with the full model
- Amenable to iterative refinement

Advantages: Speed and Synchronization
- Quick estimates of individual/population exposures/doses
  - execution time reduced from several days to < 1 hr
- Results identical to running the full model
- Synchronized with the full model
- Amenable to iterative refinement
Discussion

• Bottom-up multi-pollutant exposure modeling
• Population exposure modeling remains computationally demanding
  • Storage and CPU needs
  • Makes uncertainty analyses impractical
  • Main stream applications are not yet common
• A pre-computed modeling approach can facilitate systematic sensitivity studies
  • Execution time can be reduced from several days to under an hour
  • However, the full model has to be run “at least once”
  • Facilitates the use of the system by “non-specialists”
Discussion Continued

• Sparse monitoring data for evaluation of ambient model outputs
• Incorporation of indoor emission sources into population exposure models needs significant work
  • Different chemicals have different types and number of major sources
    - Benzene: garages, smoking, and wood parquet
    - Formaldehyde: tens of consumer products
  • Each source type distribution results in one more “random” dimension
  • Brute force Monte Carlo simulations may not be adequate
• Parameterizations in exposure models can differ substantially
  • Example: probabilities of smoking, cooking; distributions of air exchange rates; etc., are sometimes hard coded

Needs

• Systematic sensitivity analyses of exposure models
  • Computationally intensive; need efficient techniques
• Comparative application of population exposure models
  • APEX vs MENTOR-1A comparison ongoing for Philadelphia, PA
    - Benzene, Formaldehyde, and Ozone
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• TRJ, Inc: T. Johnson, T. Long

USEPA

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  - Development of MENTOR (Modeling Environment for Total Risk studies)

ACC

• American Chemistry Council – Long Range Initiative

NJ DEP

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