Emission Inventory Validation and Improvement: A Central California Case Study

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Emission Inventories:

- Support air quality modeling and regulatory control strategy development
- Are continually being refined and improved
  - New emission factors
  - Updated activity data estimates
  - Improved mobile source models
Emission Inventory Validation:

- Sanity check (common sense review)
- Bottom-up evaluations (start with activity data collection)
- Top-down evaluations (compare emission estimates to ambient air quality data)
- Photochemical modeling simulations
Central California Ozone Study (CCOS):

- Multi-year program of monitoring, EI development, data analysis, and air quality modeling
- CCOS EI refinements
  - EMFAC (on-road model) updates
  - OFFROAD model updates
  - Stationary source revisions
- STI performed emission reconciliation on latest CCOS EI
Overall, the emissions data show better agreement with ambient data than previous emission inventories have.

<table>
<thead>
<tr>
<th>Air Basin</th>
<th>Ambient ratio/Emissions ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DRI 1990</td>
</tr>
<tr>
<td>Sacramento</td>
<td>2.2</td>
</tr>
<tr>
<td>Fresno</td>
<td>3.6</td>
</tr>
<tr>
<td>Kern</td>
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*This column shows the range of results from all sites evaluated in each air basin—including both urban and rural sites.
At some sites, the emissions data correlate with ambient data as closely as could be expected given analyses limitations*. 

* “ARB staff believes that an assessment such as this should only be expected to produce ambient/emissions ratios that are within approximately +/- 25 to 50% of 1.0.” (ARB, 1997)
EI generally under-predicts pollutant ratios

The EI validation techniques used in this project identified specific issues with the magnitude and spatial/temporal allocation of emissions.
Outline

- Overview of Approach
- Sites Selected
- Results
- Findings and Recommendations
- Questions & Discussion
Overview of Approach (1 of 2)

- Comparisons of ambient data to the emission inventory include:
  - TNMOC-to-NOx ratios
  - CO-to-NOx ratios
  - Ratios of individual species
  - Chemical composition of hydrocarbons
Overview of Approach (2 of 2)

- Spatial and temporal comparisons done by:
  - Weekday vs. weekend
  - Wind quadrants

Wind Quadrant 1 (1-90°)  Wind Quadrant 2 (91-180°)  Wind Quadrant 3 (181-270°)  Wind Quadrant 4 (271-360°)
## Monitoring Sites Selected

<table>
<thead>
<tr>
<th>Site</th>
<th>Tier</th>
<th>District</th>
<th>Site Name</th>
<th>TNMOC/NOx</th>
<th>CO/NOx</th>
<th>Species ratios</th>
<th>VOC fingerprints</th>
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<tbody>
<tr>
<td>BGS</td>
<td>1</td>
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<td>Bakersfield Stn. (Golden State)</td>
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<td>Clovis Stn.</td>
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<tr>
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<tr>
<td>SDP</td>
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<td>Sacto</td>
<td>Sacramento Stn. (Del Paso Manor)</td>
<td>X</td>
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<tr>
<td>SUN</td>
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<td>Sunol Stn.</td>
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<td>Parlier Stn.</td>
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<td>Elk Grove Stn.</td>
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<td>M29</td>
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<td>Madera Stn.</td>
<td>X</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>SHA</td>
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<td>SJV</td>
<td>Shafter Stn.</td>
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<td></td>
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<tr>
<td>SJ4</td>
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<td>San Jose Stn. (4th St.)</td>
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<tr>
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<td></td>
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</table>
Comparison of TNMOC/NOx Ratios

*Numbers represent the ratio of the derived median ambient ratio to the emission inventory ratio.

Elk Grove (1.4)
Folsom (1.5)
Sacramento - Natomas (1.2)
Sacramento - Del Paso (1.4 - 2.3)
Clovis (1.3 - 2.1)
Fresno - First St. (1.3)
Madera (6.3) [rural]
Parlier (1.3 - 2.5) [rural]
Arvin (1.5) [rural]
Bakersfield - Golden St. (3.3)
Shafter (2.6) [rural]
Comparison of CO/NOx Ratios

*Numbers represent the ratio of the derived median ambient ratio to the emission inventory ratio

Sacramento - Natomas (1.6)
Sacramento - Del Paso (1.1)

Turlock (2.4)

San Jose (1.6)

Clovis (2.2)
Fresno - First St. (1.7)

Bakersfield - Golden St. (2.3)
Bakersfield - California Ave (3.9)
Sacramento Area (1 of 3)

TNMOC/NOx

- Better agreement on weekdays
- Note poor agreement in wind quadrant 3 at Del Paso Manor

Error bars represent 25th and 75th percentiles
Sacramento (2 of 3)

Del Paso Manor

- Poorest agreement in wind quadrant 3
- Shopping center 1km southwest of site
- Possible issue capturing hot soak emissions in inventory
Sacramento Area (3 of 3)

CO/NOx

- Weekdays and weekends are similar
- Agricultural or heavy duty sources appear to be misrepresented (too high) in Natomas quadrant 3
- Del Paso ratios agree well
Fresno Area (1 of 2)

TNMOC/NOx

- Weekdays and weekends are similar
- Changes in real world growth between Clovis and Fresno compared to surrogates (CLO-quadrant 3)
- Rural Madera site with low emission density (doesn’t fully meet assumptions)

Clovis
- Weekdays and weekends are similar
- Changes in real world growth between Clovis and Fresno compared to surrogates (CLO-quadrant 3)
- Rural Madera site with low emission density (doesn’t fully meet assumptions)
Fresno Area (2 of 2)

CO/NOx

- Similar agreement on weekdays and weekend days
- Agreements not as good as in the Sacramento area
- May suggest overestimated heavy-duty NOx emissions in the area
Kern County (1 of 2)

TNMOC/NOx

- Ambient ratios are 2 to 4 times higher than emissions ratio (Much was worse than Sacramento/Fresno)
- Agreement does not vary between weekdays and weekends
- TNMOC emissions in quadrant 2 of Arvin are dominated by biogenics
Kern County (2 of 2)

CO/NOx

- At Calif. Ave., best agreement in wind quadrants 3 and 4

- Poor overall agreement at the Golden State site
Fingerprint Comparisons (1 of 5)

- Comparisons were performed for 10 sites
- Analyses showed:
  - Speciation of emission inventory is generally representative of the TNMOC composition detected by ambient monitoring sites
  - Ethane is consistently higher in the emission inventory
  - Propane is consistently lower in the emission inventory
  - Isoprene is consistently higher in the emission inventory
Ethane: livestock emissions spatially allocated using population density.
Generally Propane is associated with oil and gas extraction, except for major distribution center located at Elk Grove.
Isoprene: reactivity issues; possible overestimated biogenics at Arvin.
Fingerprint Comparisons (5 of 5)
Overall Findings

- Overall, the emissions data show better agreement with ambient data than previous emission inventories have.
- At some sites, the emissions data correlate with ambient data as closely as could be expected given analyses limitations.
- EI generally under-predicts pollutant ratios
- The EI validation techniques used in this project identified specific issues with the magnitude and spatial/temporal allocation of emissions.
Sample Results

- Urbanized Sacramento area:
  - Good agreement on weekdays
  - Poorer agreement on weekends

- Urbanized Fresno area:
  - Good agreement on weekdays and weekends

- Urbanized Bakersfield:
  - Poor agreement on weekdays and weekends
Questions and Discussion