CHANGES TO THE BIOGENIC EMISSIONS INVENTORY SYSTEM VERSION 3 (BEIS3)

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BEIS3 Emissions Model

\[ Emission = [\varepsilon][\gamma_P \gamma_T][\rho] \]

= Standardized emission factor
\((30 \degree C; \text{PAR} 1000 \text{ mol m}^{-2} \text{ s}^{-1})\)

\(\gamma_P\) = Light adjustment factor

\(\gamma_T\) = Temperature adjustment factor

\(\rho\) = Foliar density
BEIS3 Emissions Model

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  (30°C; PAR 1000 \( \mu \)mol m\(^{-2}\) s\(^{-1}\))

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### Standardized Emission Factors - Isoprene

<table>
<thead>
<tr>
<th></th>
<th>BEIS3.12 (g C km(^{-2}) h(^{-1}))</th>
<th>BEIS3.13 (g C km(^{-2}) h(^{-1}))</th>
<th>Net Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spruce</td>
<td>10,500</td>
<td>5,250</td>
<td>-50%</td>
</tr>
<tr>
<td>USGS Coniferous</td>
<td>11,383</td>
<td>7,918</td>
<td>-19%</td>
</tr>
<tr>
<td>USGS Deciduous</td>
<td>8,232</td>
<td>6,707</td>
<td>-30%</td>
</tr>
</tbody>
</table>

Effect of Isoprene Emission Factor Change

Standardized Isoprene Emission Flux

BEIS3.13 – BEIS3.12

Min=-4.5e+06 at (103.95), Max= 0.0e+00 at (1.1)
Standardized Emission Factors - Monoterpene

<table>
<thead>
<tr>
<th></th>
<th>BEIS3.12 (g C km(^{-2}) h(^{-1}))</th>
<th>BEIS3.13 (g C km(^{-2}) h(^{-1}))</th>
<th>Net Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglas Fir</td>
<td>1064</td>
<td>585</td>
<td>-72%</td>
</tr>
<tr>
<td>Hemlock</td>
<td>126</td>
<td>665</td>
<td>+541%</td>
</tr>
</tbody>
</table>

Effect on Monoterpene Emission Factor Change

Standardized Alpha-Pinene Emission Flux

Min = -722004 at (21,78), Max = 10194 at (131,74)
Effect of Temperature

• Ambient temperature used as a surrogate for leaf temperature
• MCIP version 3 provides both 2m and 10m temperatures
• Choice of temperature height currently an input to BEIS3.13
• Different heights may be appropriate for different areas and biogenic emissions processes
Effect of Temperature

Domain Total Emission Flux

- Isoprene - 2 m temp.
- Isoprene - 10 m temp.
- Monoterpene 2 m temp.
- Monoterpene 10 m temp.

Emission flux (kg C h⁻¹)

Julian Day
Effects of Radiation – Radiation Model

- Bug fix (clnew.for)
- Empirical parameterization used to separate radiation into components (direct, diffuse, PAR, IR)
  - BEIS - Weis and Norman (1985)
  - GLOBEIS – Spitters et al (1986) w/ mods
Comparison of Direct and Diffuse Radiation

Bondville 2004 SURFRAD 3-Minute Data
Comparison of PAR Values

Bondville 2004 - SURFRAD Hourly Averaged Data

Normalized Mean Bias
BEIS = 7.5%
GLOBEIS = 9.7%
Effects of Radiation – Adjustment Factor

\[ \gamma_P = \frac{\alpha C_L Q}{(1 + \alpha^2 Q^2)^{0.5}} \]

  - \( \alpha = 0.0027; C_L = 1.066 \)
  - \( \alpha = 0.001 + 0.0085 \times \text{LAI} \)
  - \( C_L = 1.42 \times \text{exp}(-0.3 \times \text{LAI}) \)
  - LAI = cumulative LAI
  - BEIS assumes
    - LAI = 0 = Top of canopy

Diurnal variation of PAR adjustment factor using data from the Bondville, IL SURFRAD station for July 2004.
CMAQ Model Results

- CMAQ v4.5 (pre-release build)
- CB4 chemical mechanism
- July 2001; RPO North American Domain; 36 km grid size
- 2 m temperature from MCIP for BEIS3.13
Effect on Ozone Concentration

Layer 1 Ozone Concentration Difference

CMAQ with BEIS3.13 emissions – CMAQ with BEIS3.12 emissions

July 6, 2001 1:00:00
Min = -17.055 at (43,64), Max = 1.959 at (84,34)
Effect on Organic Carbon

Organic Carbon Concentration Difference

CMAQ with BEIS3.13 emissions – CMAQ with BEIS3.12 emissions

July 6, 2001 1:00:00
Min = -0.580 at (19,72), Max = 0.413 at (142,90)
# CMAQ Performance Statistics
## IMPROVE and AIRS Data – July 2001

<table>
<thead>
<tr>
<th></th>
<th>BEIS3.12</th>
<th>BEIS3.13</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8 hr O₃</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSE (ppmV)</td>
<td>0.013</td>
<td>0.013</td>
</tr>
<tr>
<td>NMB (%)</td>
<td>16.71</td>
<td>14.20</td>
</tr>
<tr>
<td>NME (%)</td>
<td>37.78</td>
<td>36.97</td>
</tr>
<tr>
<td><strong>PM2.5</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSE (ug/m³)</td>
<td>5.42</td>
<td>5.34</td>
</tr>
<tr>
<td>NMB (%)</td>
<td>-35.70</td>
<td>-37.65</td>
</tr>
<tr>
<td>NME (%)</td>
<td>47.80</td>
<td>46.89</td>
</tr>
<tr>
<td><strong>Organic carbon</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSE (ug/m³)</td>
<td>1.25</td>
<td>1.07</td>
</tr>
<tr>
<td>NMB (%)</td>
<td><strong>10.35</strong></td>
<td><strong>0.38</strong></td>
</tr>
<tr>
<td>NME (%)</td>
<td>72.65</td>
<td>63.51</td>
</tr>
</tbody>
</table>
Summary

• A few standardized emission factors for isoprene and monoterpene have been changed in BEIS3.13
• The coefficients in the equation used to calculate the light adjustment factor have been changed
• When compared to emissions from BEIS3.12, domain total isoprene emissions for July 2001 from BEIS3.13 are about 35% lower and monoterpene emissions are about 2% lower
• Using BEIS3.13 produced a notable improvement in CMAQ’s model performance for organic carbon
Future Work

- The Biogenic Emissions Landuse Database (BELD) will be upgraded to BELD3.2 using more recent agriculture data.
- New temporal corrections for isoprene:
  - Introduce a “green-up” period in spring (to transition from winter to summer factors for deciduous trees).
  - Introduce a senescence period in autumn (to transition from summer to winter factors for deciduous trees).
  - Incorporate a correction function that considers 8-hour average temperature and 4-hour average PAR (all tree species).
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Disclaimer

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