Very-Short Lived (VSL) Halogen Chemistry in CAM-CHEM:

Alfonso Saiz-Lopez, Jean-François Lamarque, Simone Tilmes, and Doug Kinnison.

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VSL Halogen Scientific Questions

- What is the Role that VSL organic bromine and iodine species have on the ozone budget in the tropical lower troposphere?
- What are the climatic impacts of VSL halogens?
- What is the impact of VSL halogens on CH$_4$ lifetimes through amplification of OH?
- Can observation of VSL halogens help constrain transport pathways into the tropical UTLS in a 3D CCM?
- What impact does VSL substances have on model derived Ozone trends?
Tropospheric Halogen Chemistry

Chlorine

Bromine

Iodine

Sea salt aerosol

CH$_3$I$_2$, CH$_2$IBr, CH$_3$I, CHICl, CHBr$_3$, I$_2$
Subset of the VSL Halogenated Substances currently being added the CAM-CHEM mechanism (≈20 SG)

<table>
<thead>
<tr>
<th>Source Gas</th>
<th>Formula</th>
<th>Local Lifetime (days)</th>
<th>Main Loss processes</th>
<th>WAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bromochloromethane</td>
<td>CH$_2$BrCl</td>
<td>150</td>
<td>OH</td>
<td>✓</td>
</tr>
<tr>
<td>Trichloromethane (chloroform)</td>
<td>CHCl$_3$</td>
<td>150</td>
<td>OH</td>
<td>✓</td>
</tr>
<tr>
<td>Methylene chloride</td>
<td>CH$_2$Cl$_2$</td>
<td>140</td>
<td>OH</td>
<td>✓</td>
</tr>
<tr>
<td>Dibromomethane</td>
<td>CH$_2$Br$_2$</td>
<td>120</td>
<td>OH, hv</td>
<td>✓</td>
</tr>
<tr>
<td>Bromodichloromethane</td>
<td>CHBrCl$_2$</td>
<td>78</td>
<td>OH, hv</td>
<td>✓</td>
</tr>
<tr>
<td>Tribromomethane (bromoform)</td>
<td>CHBr$_3$</td>
<td>26</td>
<td>hv</td>
<td>✓</td>
</tr>
<tr>
<td>Methyl iodide</td>
<td>CH$_3$I</td>
<td>7</td>
<td>hv</td>
<td>✓</td>
</tr>
<tr>
<td>Trifluoriodomethane</td>
<td>CF$_3$I</td>
<td>4</td>
<td>hv</td>
<td>-</td>
</tr>
</tbody>
</table>
Tropospheric Halogen Chemistry

HOBr (g) + [Br− + H+] => Br2 (g) + H2O
Modeling the Troposphere with VSL Halogens

- Need a model with representation of Tropospheric O$_3$ chemistry (e.g., NMHCs; Emissions, etc...).

- Need a model that includes a VSL organic and inorganic mechanism.
  - Organic species: Adds $\sim 18$
  - Inorganic species: Adds $\sim 20$
  - Photolysis Rxns: Adds $\sim 23$
  - Sulfate Het. Rxns: Adds $\sim 5$
  - Sea Salt Aer. Rxns: Adds $\sim 9$

- Need Emissions – Observations suggest that the biogenic production seems to come from seaweed, phytoplankton, algae etcs... [we use Chlorophyll-A obs from SeaWIFS]
Results
Organic Halogens [Surface]

January

April

August
IO and BrO at Cape Verde

Read et al., Nature, 2008
• Cape Verde [16.85N, 24.87W]
• DOAS measurements.
IO and BrO at Cape Verde – daytime average

**BrO at Cape Verde**

![Graph showing BrO concentrations at Cape Verde with data from November (N) to July (J).](image)

**IO at Cape Verde**

![Graph showing IO concentrations at Cape Verde with data from November (N) to July (J).](image)
Halogen Odd-Oxygen Loss [Surface]

The halogen odd-oxygen loss is ~ 25% of the total loss.
Odd Oxygen Loss Partitioning

16.9° N, 24° W

Cape Verde *** Annual Average

Altitude, km

% of Total OddOx Loss

Ox
HOx
NOx
Halogen
Ozone comparisons from Sondes [Surface]
Ozone comparisons from Sondes [Surface]

Samoa Surface Ozone

14°S, 170°W

Data
- CAM-Chem Halogen
- CAM-Chem
Ozone at Cape Verde (16.9° N, 24° W)

O$_3$ at Cape Verde

VSL Halogens

O$_3$ *** Halogen - No Halogen
Tropospheric Column Ozone Difference (%)

Halogens – no Halogens / no Halogen
Next Step

- What is the role that VSL organic bromine and iodine species have on the ozone budget in the tropical lower troposphere?

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- Include emission processes for the polar regions.
The End!