NEW HALOGEN SCHEME CONCLUSIONS

<table>
<thead>
<tr>
<th></th>
<th>O$_3$ Global</th>
<th>O$_3$ Locally</th>
<th>OH Globally</th>
<th>OH Locally</th>
<th>CH$_4$ lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>↓ 19%</td>
<td>↓ 12 ppbv</td>
<td>↓ 8.2%</td>
<td>↓ 20%</td>
<td>↑ 10.8%</td>
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<tr>
<th></th>
<th>CH$_4$ loss</th>
<th>C$_2$H$_6$ loss</th>
<th>Iodine aerosol</th>
<th>O$_3$ RF Trop</th>
<th>Large regional impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss</td>
<td>2% Cl</td>
<td>26% Cl</td>
<td>remote source</td>
<td>↓ ~25%</td>
<td>O$_3$</td>
</tr>
</tbody>
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Bromine Chemistry
Sherwen et al., ACP, 2016a
Bromine and Chlorine Chemistry
Schmidt et al., JGR, 2016
Coupled I, Br, Cl
Sherwen et al, ACP, 2016b

Iodine Aerosol simulation
Sherwen et al, GRL, 2016
Radiative forcing simulation
Sherwen et al., ACP, 2016c
Regional simulations
Sherwen et al., Farad. Discuss. 2017
### NEW HALOGEN SCHEME CONCLUSIONS

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<th>Global Impact</th>
<th>Locally Impact</th>
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- Iodine Aerosol Simulation: Sherwen et al., GRL, 2016
- Radiative Forcing Simulation: Sherwen et al., ACP, 2016c
- Coupled I, Br, Cl Chemistry: Sherwen et al., ACP, 2016b
- Regional Simulations: Sherwen et al., Farad. Discuss. 2017

Johan Smidt

Tomas Sherwen
PROCESSES

Stratosphere

Br

Cl

Deposition

Br

Cl

O

XO

+O

HOX

HO

XO

+XO

+OH

OIO

+O

XO

-Br

-Cl

Air

Sea

Salt

Microalgae

Macroalgae

Biogenic

Anthropogenic

Sea-salt aerosol

O3 Deposition

ClNO2

+NO2

XNO3

HBr, HOBr

+Cl, Br

Aerosol

BrX, HOX

CH3X

CH2X2

CHX3

I2

HOI

I-

I-

I-

I-

I-

Geos-Chem

Global model of tropospheric chemistry and transport
IMPACT ON $O_3$

Troposphere $O_3$: ~9 average ppbv reduction compared to no halogens
~18% drop in burden
Ocean surface $O_3$: ~30% reductions
Halogen species are mainly responsible for controlling tropospheric ozone concentrations.}

**OZONE SINKS**

<table>
<thead>
<tr>
<th>Altitude (km)</th>
<th>% of ozone loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Photolysis**
- **HO$\times$**
- **Chlorine**
- **Bromine**
- **Iodine**

**Halogen Losses**

- Marine Boundary Layer: mainly iodine cycles.
- Upper Troposphere: increased role for bromine cycles.

Halogens form ~20% of the global tropospheric ozone sink.
Mass weighted mean OH drops 8.5% with halogens ($1.4 \rightarrow 1.28 \times 10^6$ cm$^{-3}$)
CH$_4$ lifetimes: 7.47 years (no halogens)
8.28 years for OH (with halogens)
8.16 years OH+Cl (with halogens)
Oxidation of VOCs (C₂H₆, C₃H₈, (CH₃)₂CO) by Cl can be relevant. Influence on C₂H₆ is especially large – 26%. Oxidation by Br is not significant.
Iodine in aerosol has been observed. Though to be from uptake of iodine oxides (?HIO₃)
Iodine compounds may nucleate new particles in some regions.
Halogens reduce the increase in trop O₃ between pre-industrial and present-day. Halogen reduction in O₃ RF likely larger in troposphere than stratosphere.
Halogen influence European $O_3$ in two ways: Background ozone and local chemistry

For the UK this improves the $O_3$ simulation (not sure of impact on rest of Europe).
NEW HALOGEN SCHEME

O₃ Global ↓ 18%

CH₄ lifetime ↑ 10.8%

O₃ Locally ↓ 12 ppbv

Local impacts

OH Globally ↓ 8.2%

Iodine Aerosol simulation
Sherwen et al, GRL, 2016
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OH Locally ↓ 20%

Iodine Chemistry
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V11.2

OH aerosol remote source

CH₄ lifetime ↑ 10.8%

Large regional impacts O₃

CH₄ loss 2%

Cl

Bromine Chemistry
Parrella et al., ACP, 2012

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