
Tropospheric Halogen Chemistry in CAM-CHEM

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plus...**

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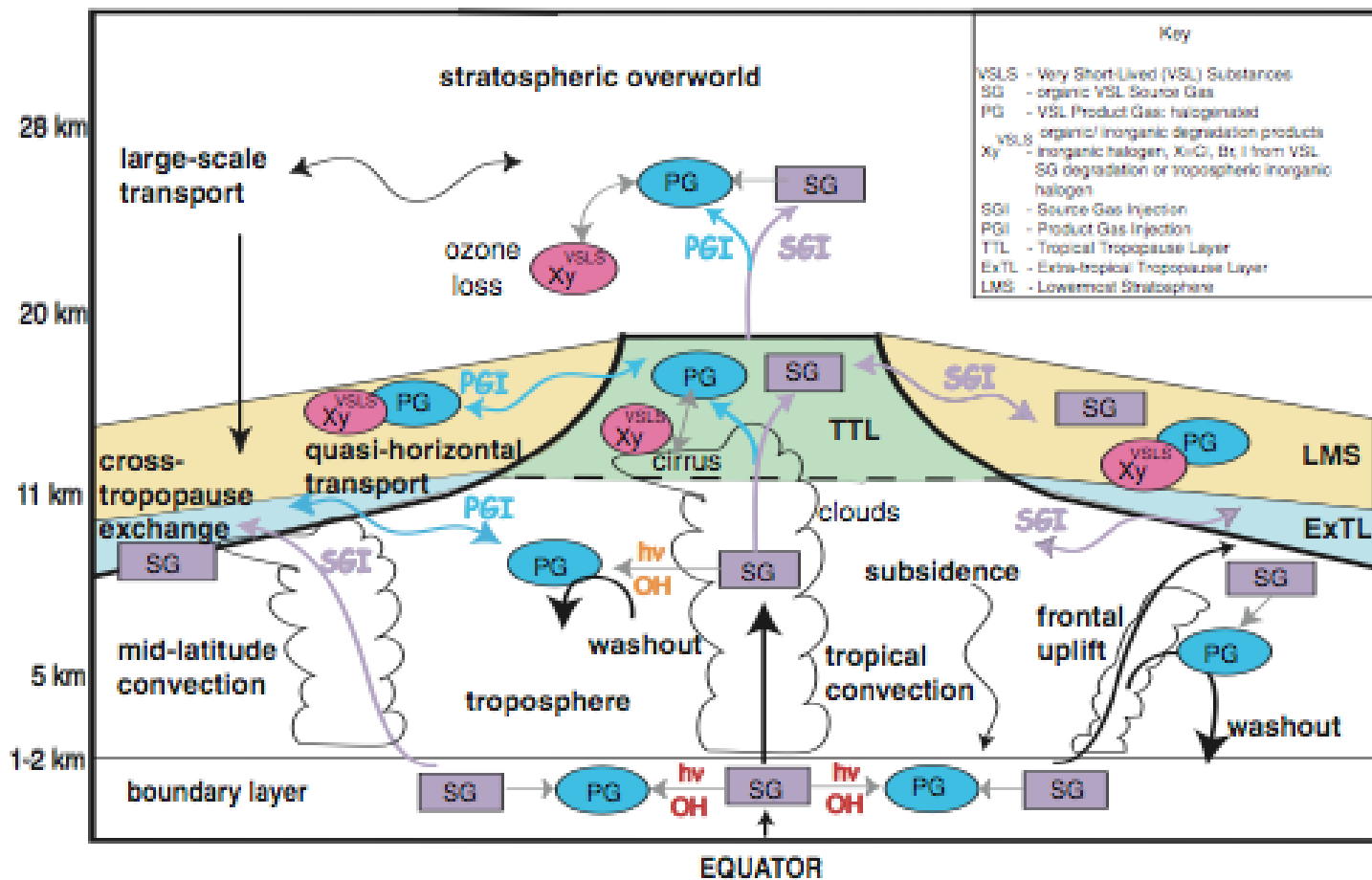


Scientific Questions

- 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?
- What is the Role that VSL organic bromine and iodine species have on the ozone budget in the tropical lower troposphere?
- What is the impact of VSL halogens on CH_4 lifetimes through amplification of OH
- What are the climatic impacts of VSL halogens?

Very Short-lived Substances (VSLs)

Chemical and Dynamical Processes Affecting VSLs



- **SG** = Organic VSL Source Gas
- **PG** = VSL Product gas
- Xy^{VSLs} = inorganic halogens from organic SG degradation.

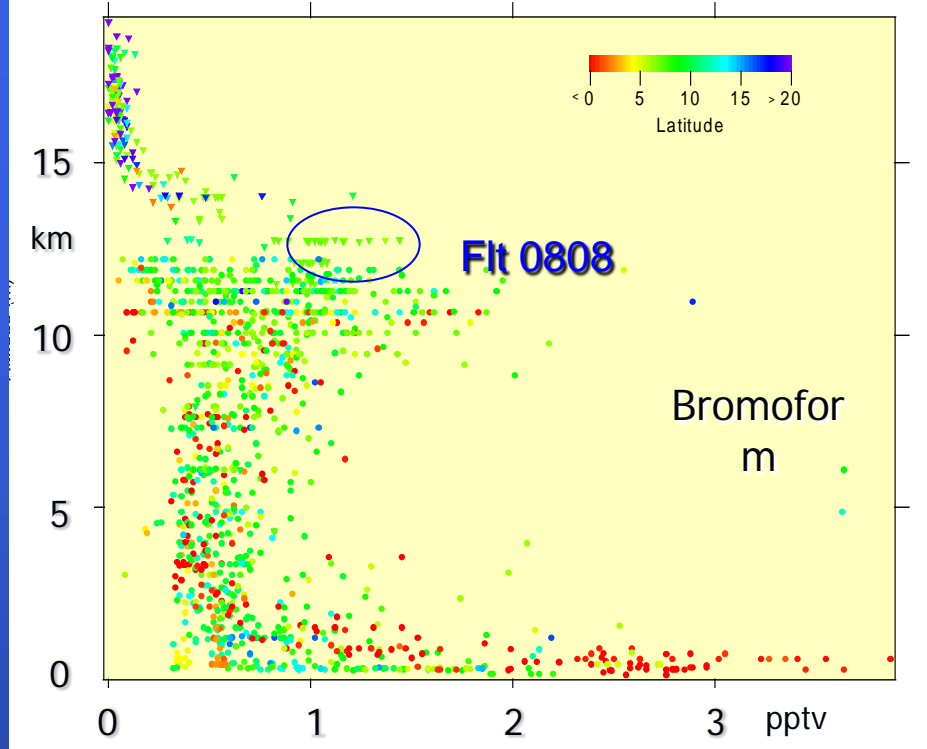
Figure 2-1. Schematic showing principal chemical and dynamical pathways transporting VSL source gases (SG) and organic/inorganic product gases (PG). Stratospheric halogen loading is maintained by transport of source gases followed by their degradation in the stratosphere (the SGI pathway), and transport of intermediate products and inorganic halogens produced in the troposphere (the PGI pathway). Tropospheric inorganic halogens can derive from degradation of VSL SGs, or from inorganic halogen sources. This figure is an update to Figure 2-2 in WMO (2003); courtesy of K.S. Law (Service d'Aéronomie/CNRS, France) and P.H.

Subset of the VSL Halogenated Substances currently being added the CAM-CHEM mechanism (~20 SG)

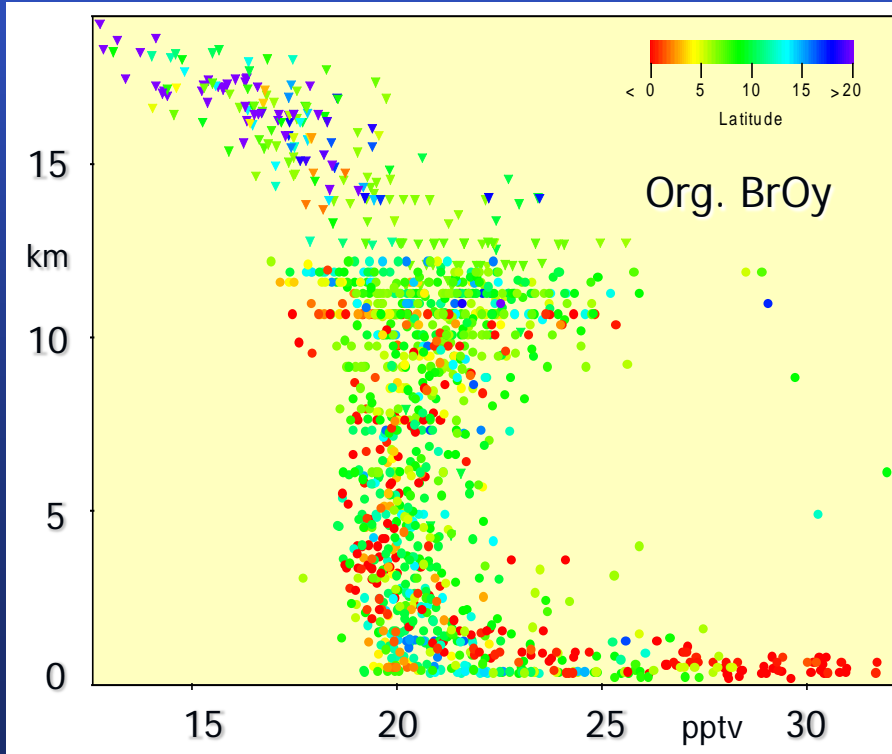
Source Gas	Formula	Local Lifetime (days)	Main Loss processes	WAS
Bromochloromethane	CH_2BrCl	150	OH	✓
Trichloromethane (chloroform)	CHCl_3	150	OH	✓
Methylene chloride	CH_2Cl_2	140	OH	✓
Dibromomethane	CH_2Br_2	120	OH	✓
Bromodichloromethane	CHBrCl_2	78	OH, hv	✓
Dibromochloromethane	CHBr_2Cl	69	hv, OH	✓
Tribromomethane (bromoform)	CHBr_3	26	hv	✓
Methyl iodide	CH_3I	7	hv	✓
Trifluoroiodomethane	CF_3I	4	hv	-

TC4, Whole Air Sampler, Schauffler, Atlas, et al., AGU, 2007

Good Profile Data!



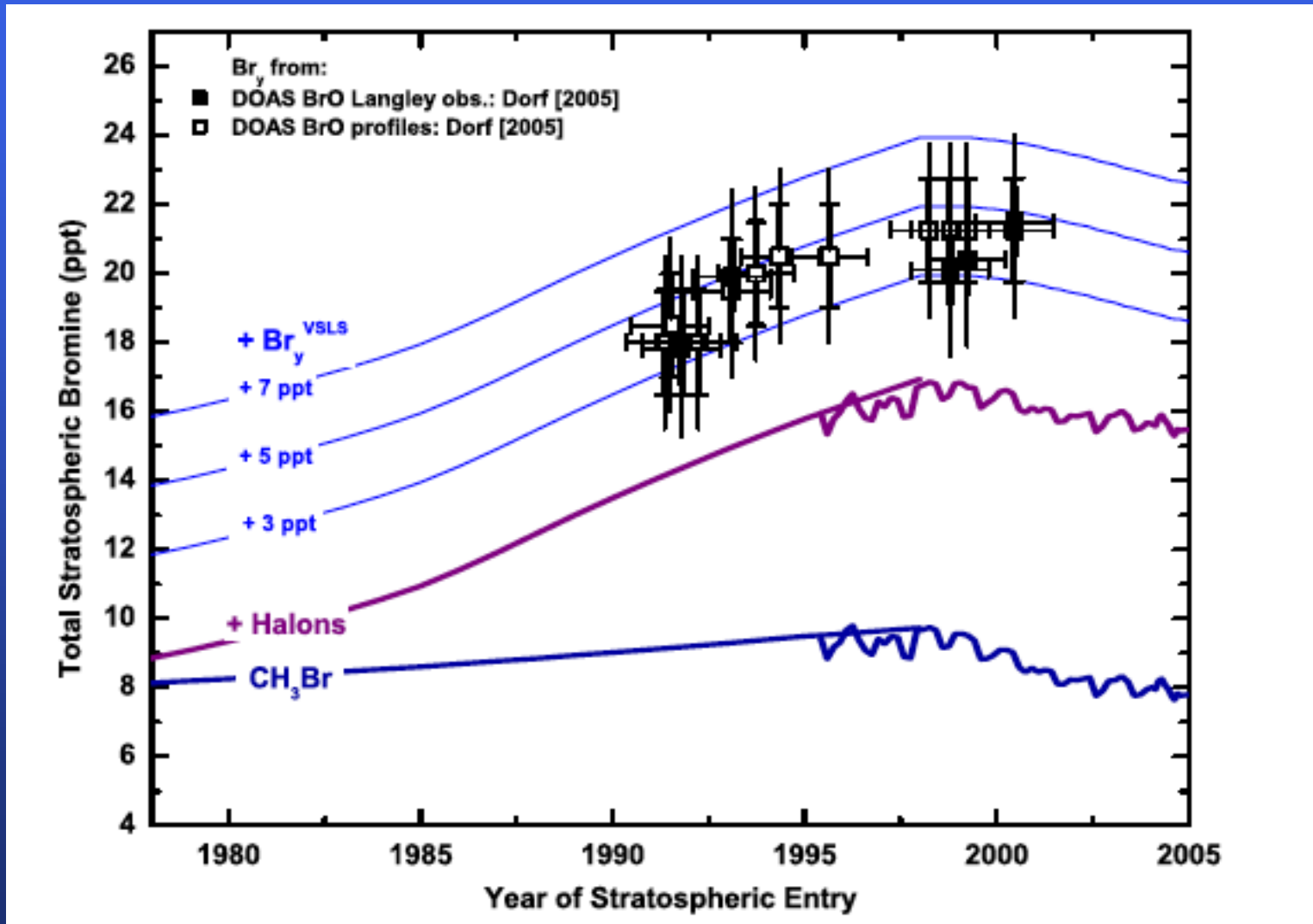
- Convection lofting VSLS into the TTL.
- Influencing the total inorganic bromine abundance.
- Transported to ExTL?



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Total Inorganic Bromine Loading



Ozone Trends

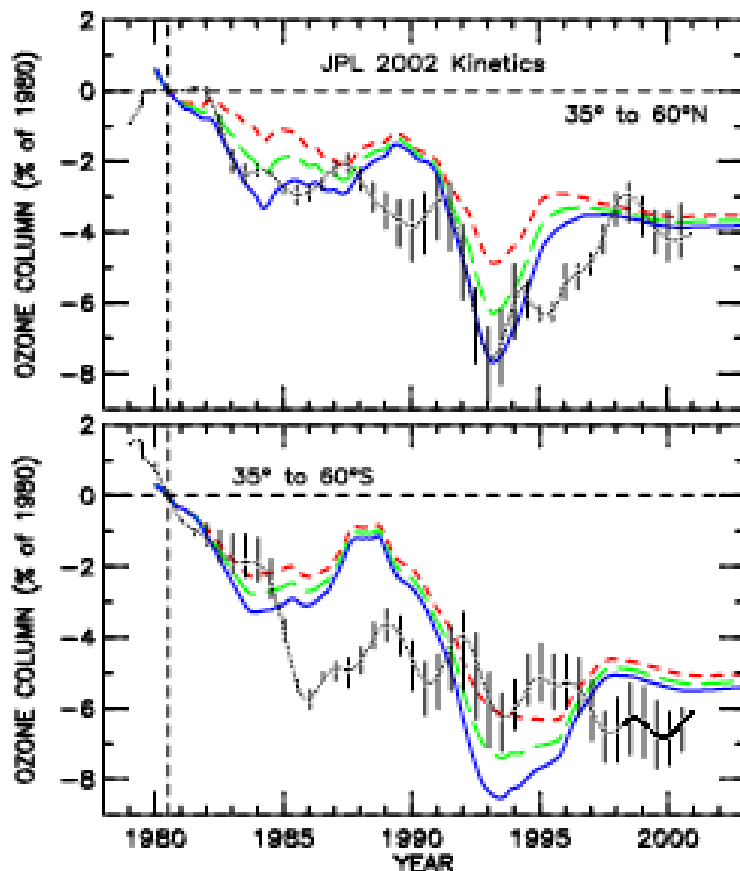


Figure 2-12. Calculated change in column ozone relative to 1980 levels using the AER 2-D model for stratospheric $\text{Br}_y^{\text{VSLs}}$ of 0 (red), 4 (green), and 8 (blue) ppt for 35°N-60°N (top) and for 35°S-60°S (bottom), compared with observed trends in total ozone (black line). Based on Salawitch et al. (2005).

- WACCM and CAM-CHEM will be used to investigate the impact of enhanced BrO_y on model derived ozone trends.
- The baseline simulation has been completed (CCMVal REF-B1)

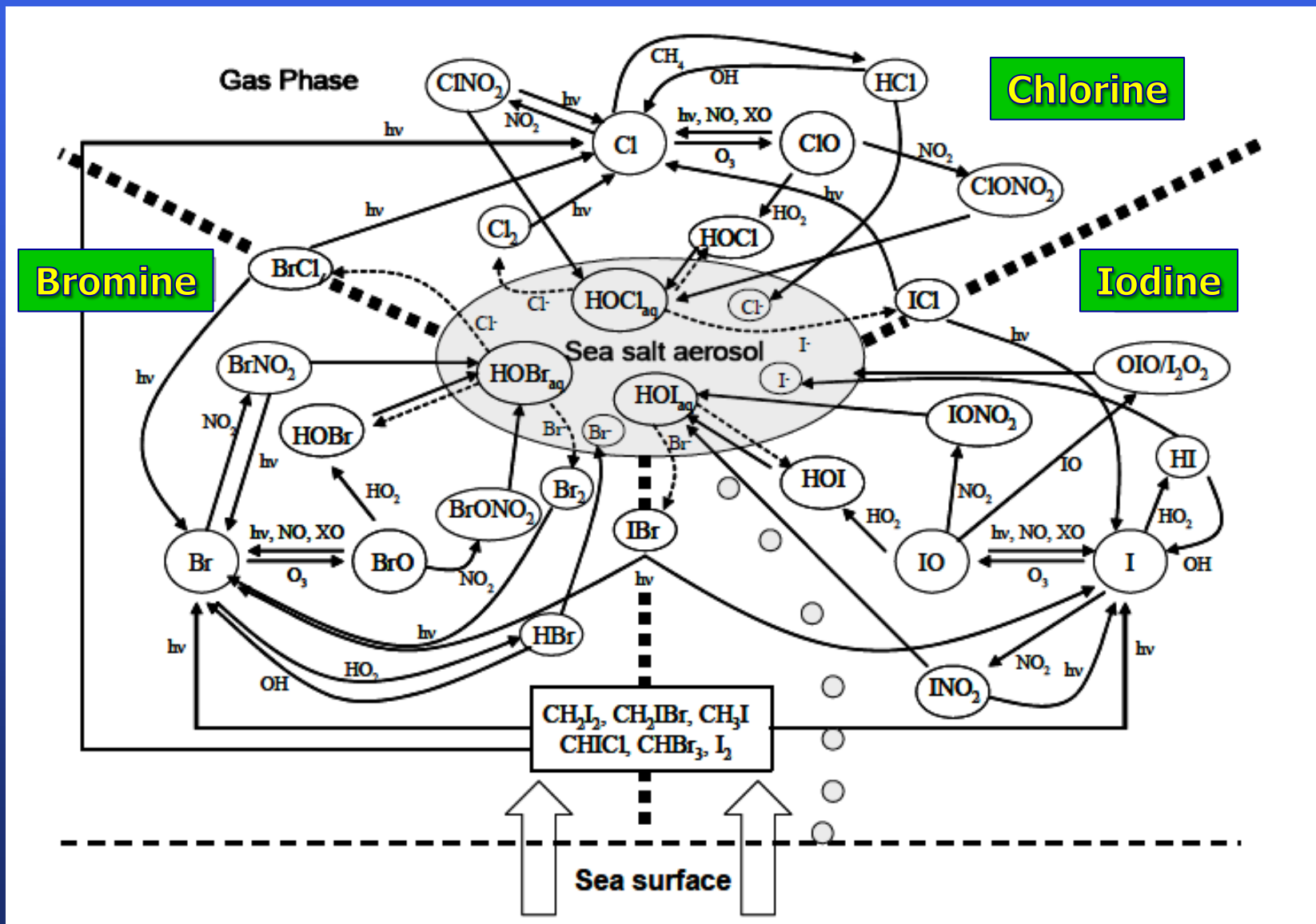
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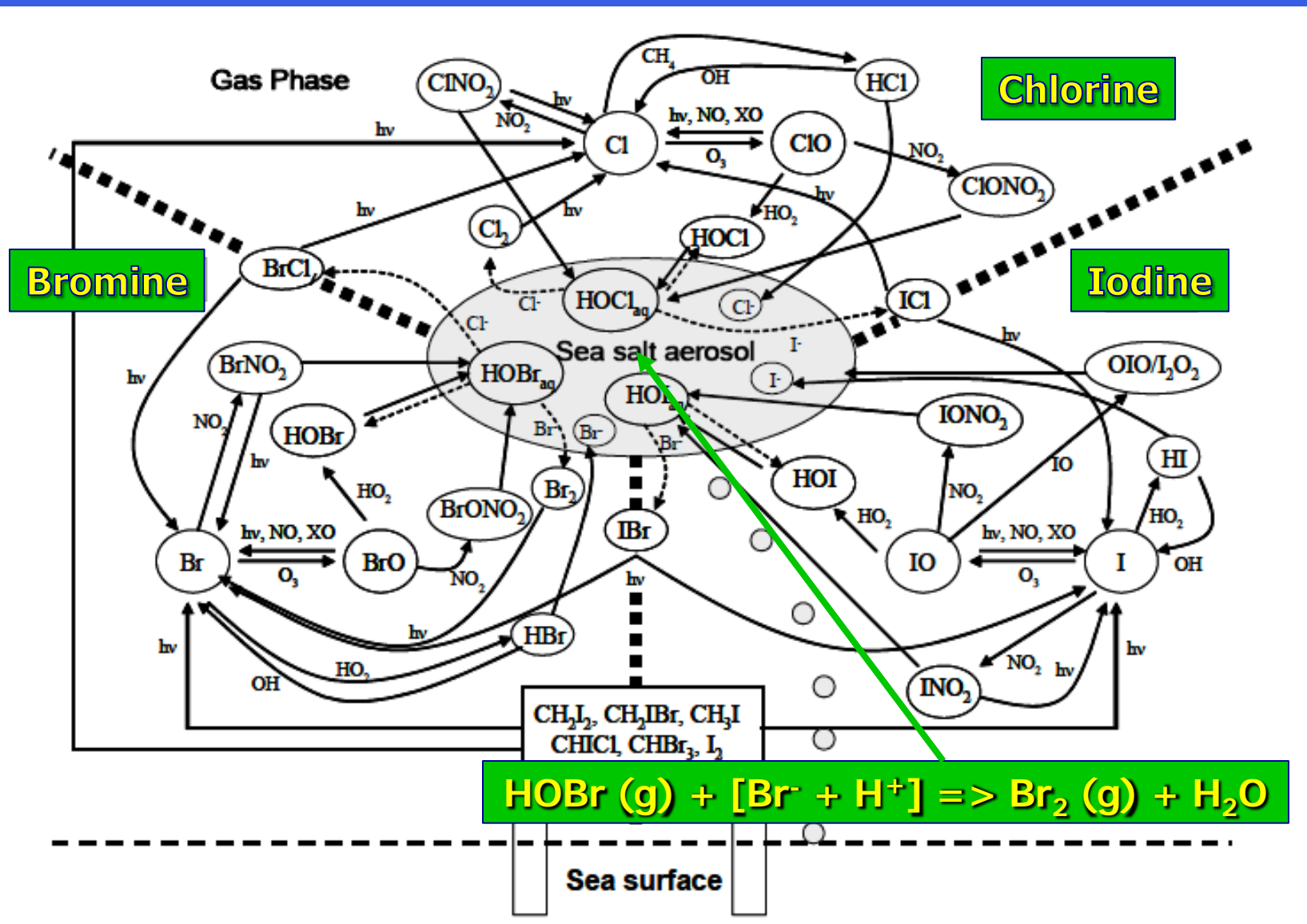
Modeling the Troposphere with VSLS

- **Need a model with representation of Tropospheric O₃ chemistry (e.g., NMHCs; Emissions, etc...).**
- **Need a model that includes a VSL organic and inorganic mechanism.**
 - Organic species: Adds ~18
 - Inorganic species: Adds ~20
 - Photolysis Rxns: Adds ~23
 - Sulfate Het. Rxns: Adds ~5
 - Sea Salt Aer. Rxns: Adds ~9
- **Need Emissions** – Observations suggest that the biogenic production seems to come from seaweed, phytoplankton, algae etc... [we use Chlorophyll-A obs from SeaWiFS]

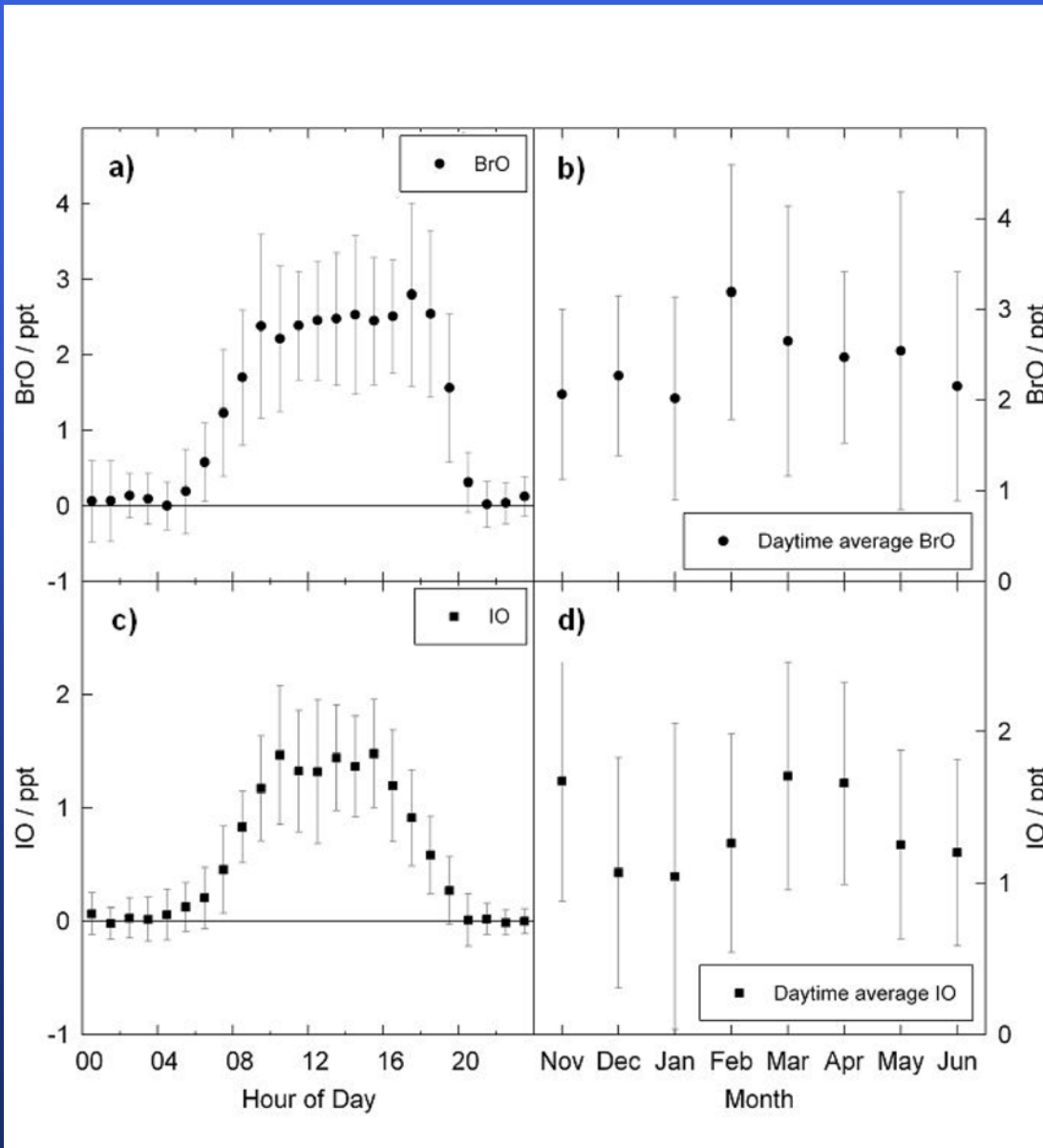
Tropospheric Halogen Chemistry



Tropospheric Halogen Chemistry



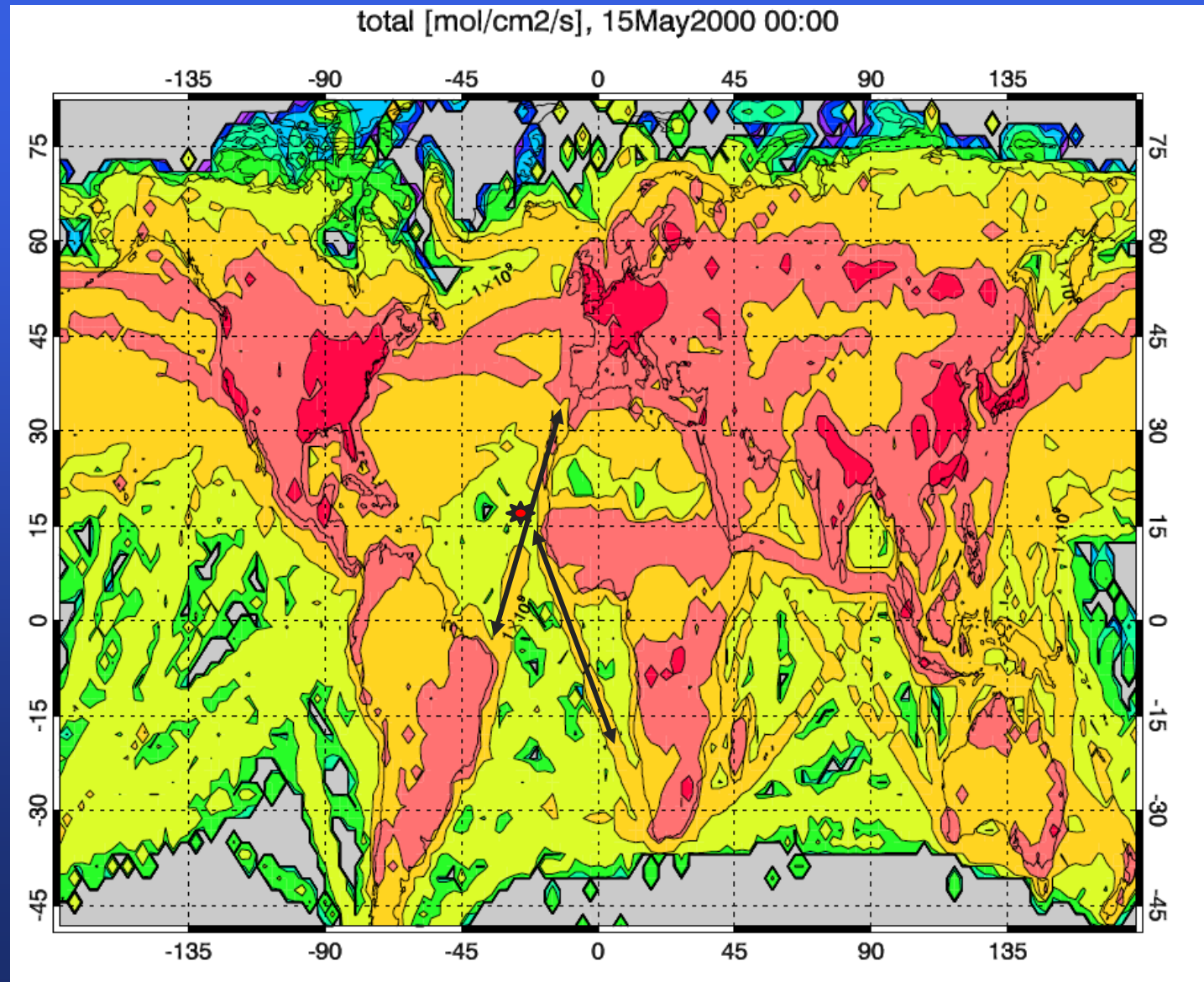
Tropical Lower Troposphere



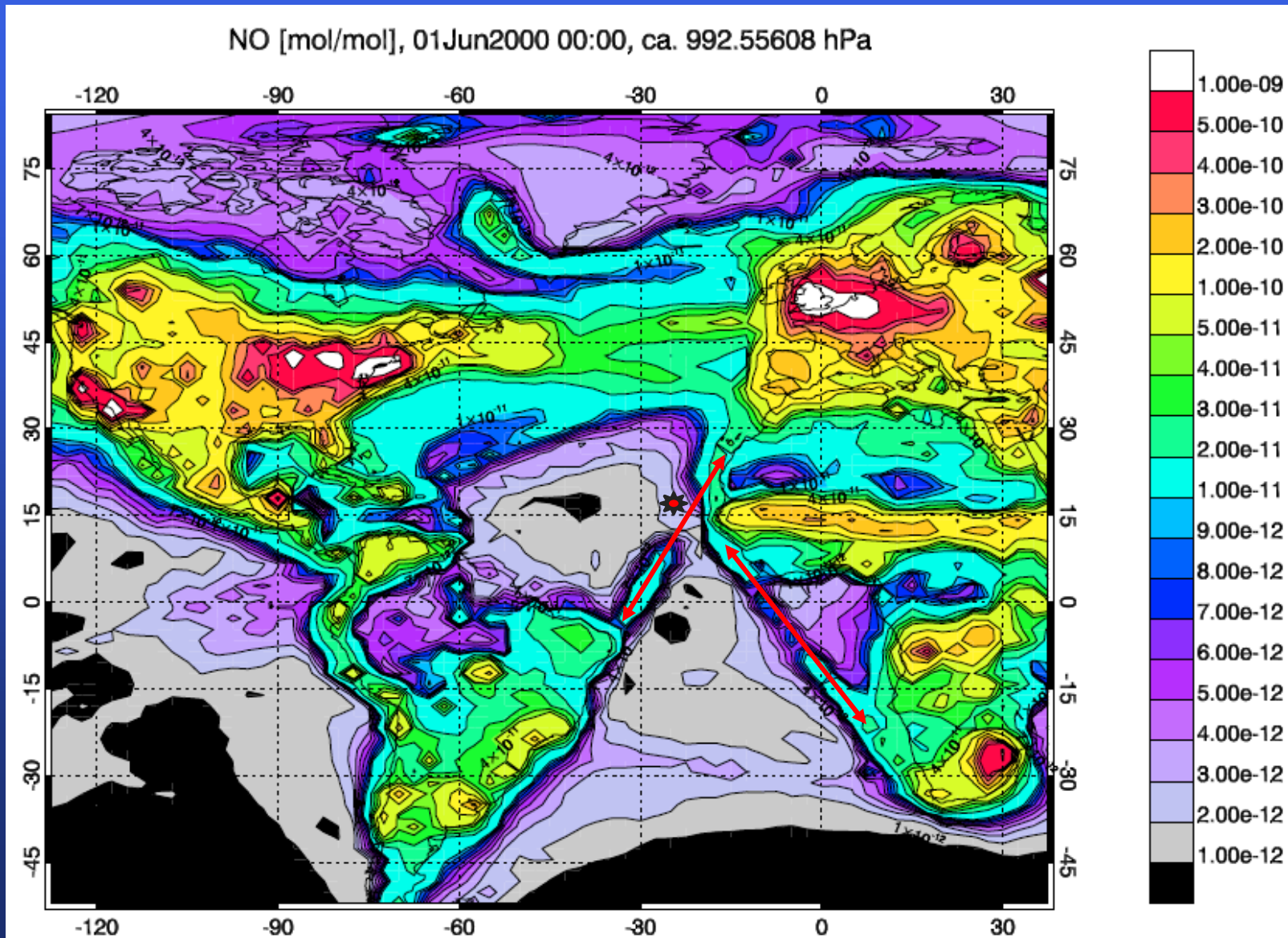
Read et al., Nature, 2008

• Cape Verde [16.85N,
24.87W]

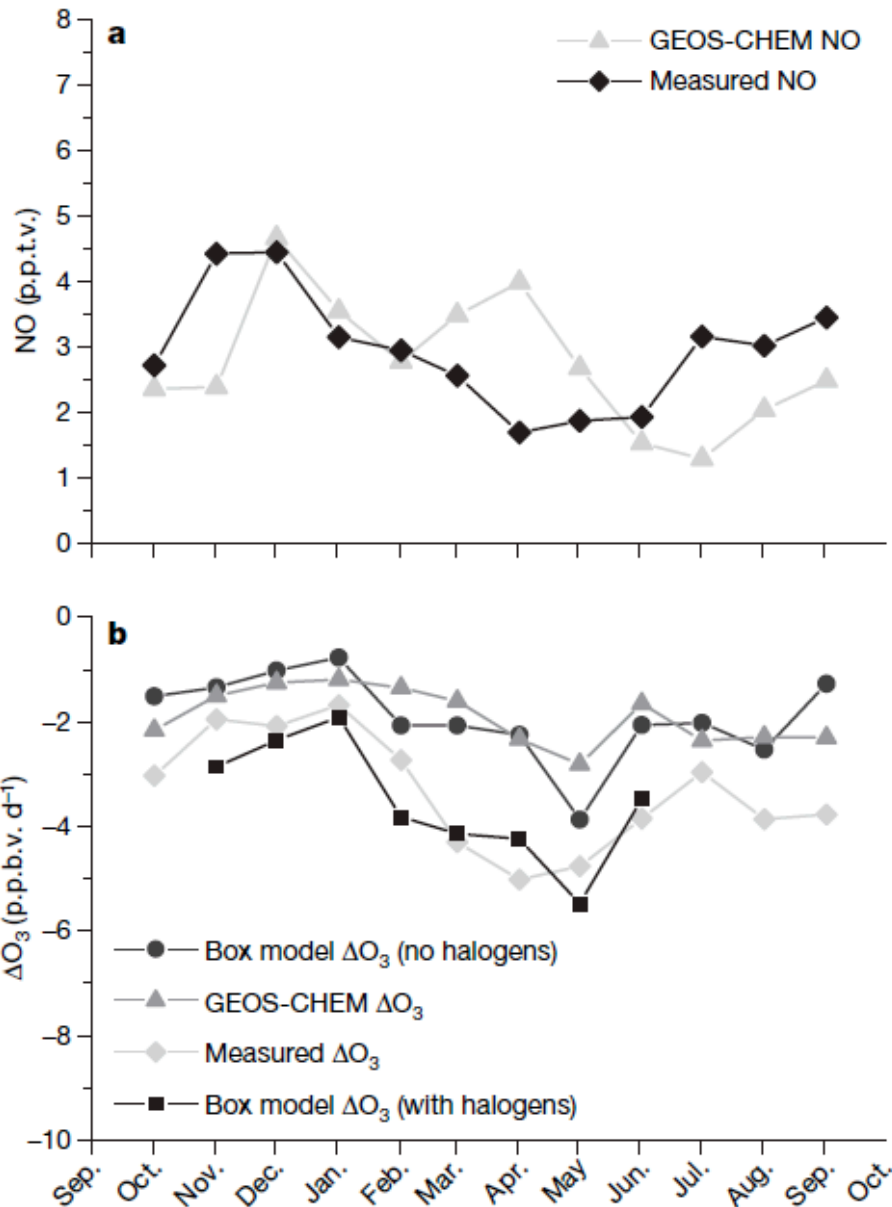
NOx Emissions



NO (vmr) – Baseline Simulation

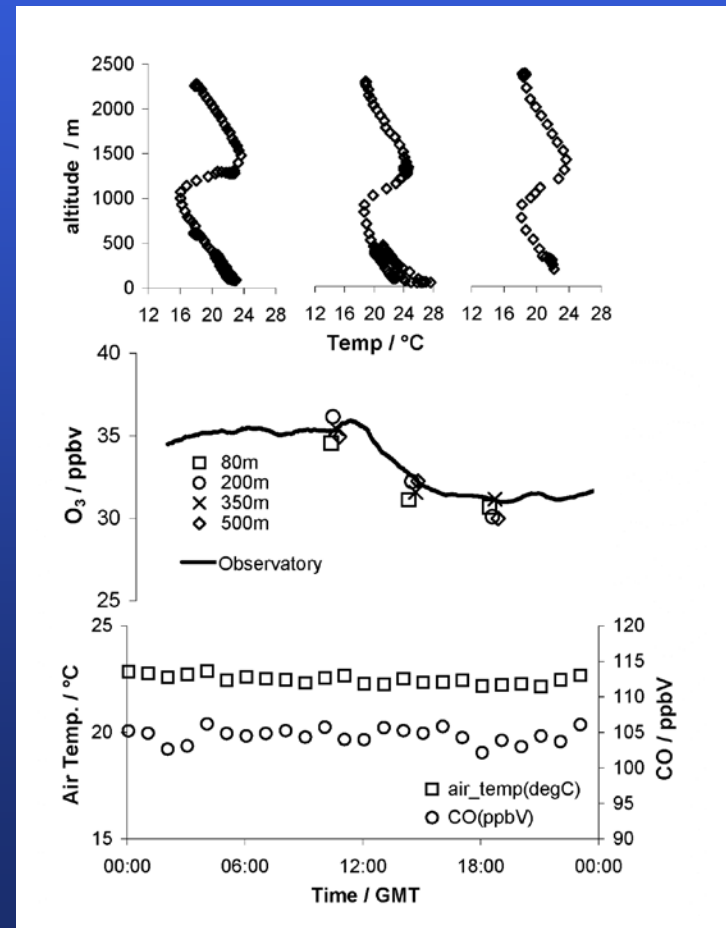


O₃ and NO in Tropical Lower Stratosphere



Read et al., Nature, 2008

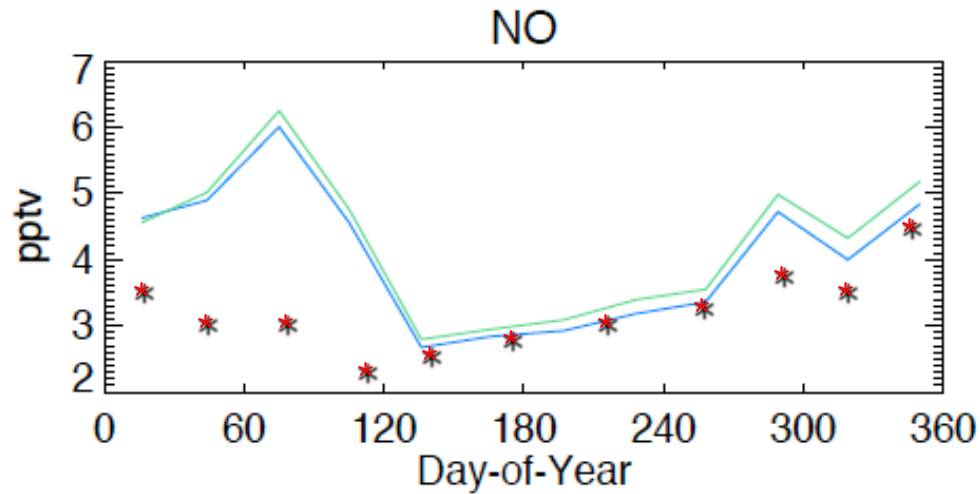
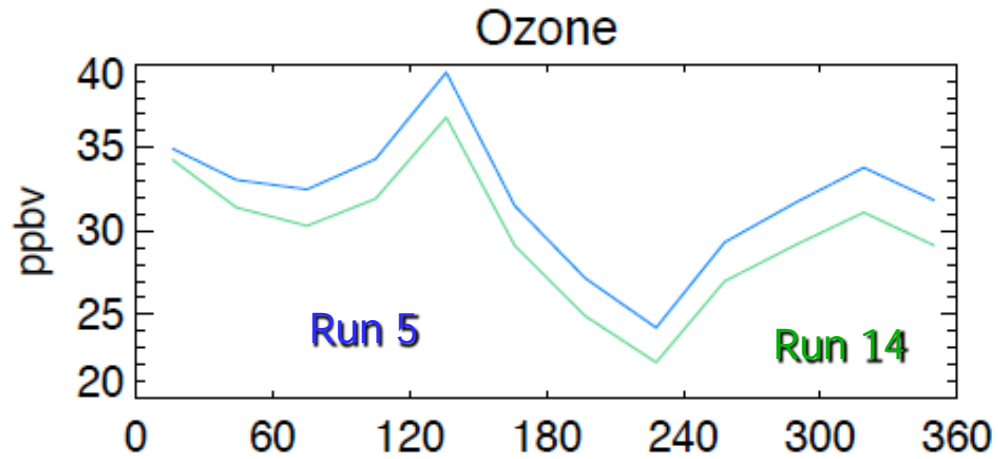
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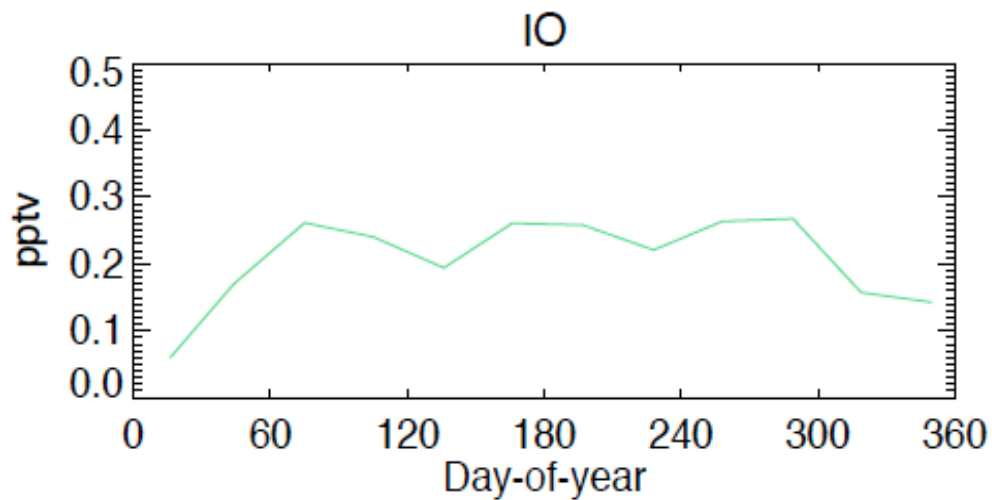
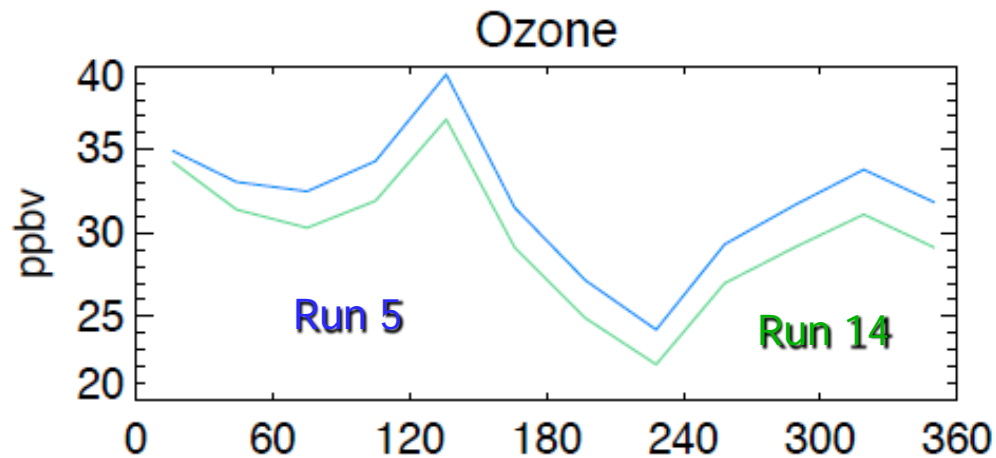
Preliminary Simulations

Sim #	Ship NOx Emiss.	Long-lived halogens	VSL Org Bromine Emissions	VSL Org Iodine Emissions	Recycling on SSA	Climate Feedback
Run 01 CAM3.6 – AR5	Reduced Ship Emissions	CCMVal	NA	NA	NA	ON
Run 05 [Detailed Halogen mechanism]	Same	CCMVal	Zero	Zero	OFF	OFF [Fixed Rad. Active gases]
Run 14	Same	CCMVal	Included	Included	OFF	OFF
Run 16	Same	Same	Included	Included	ON	OFF

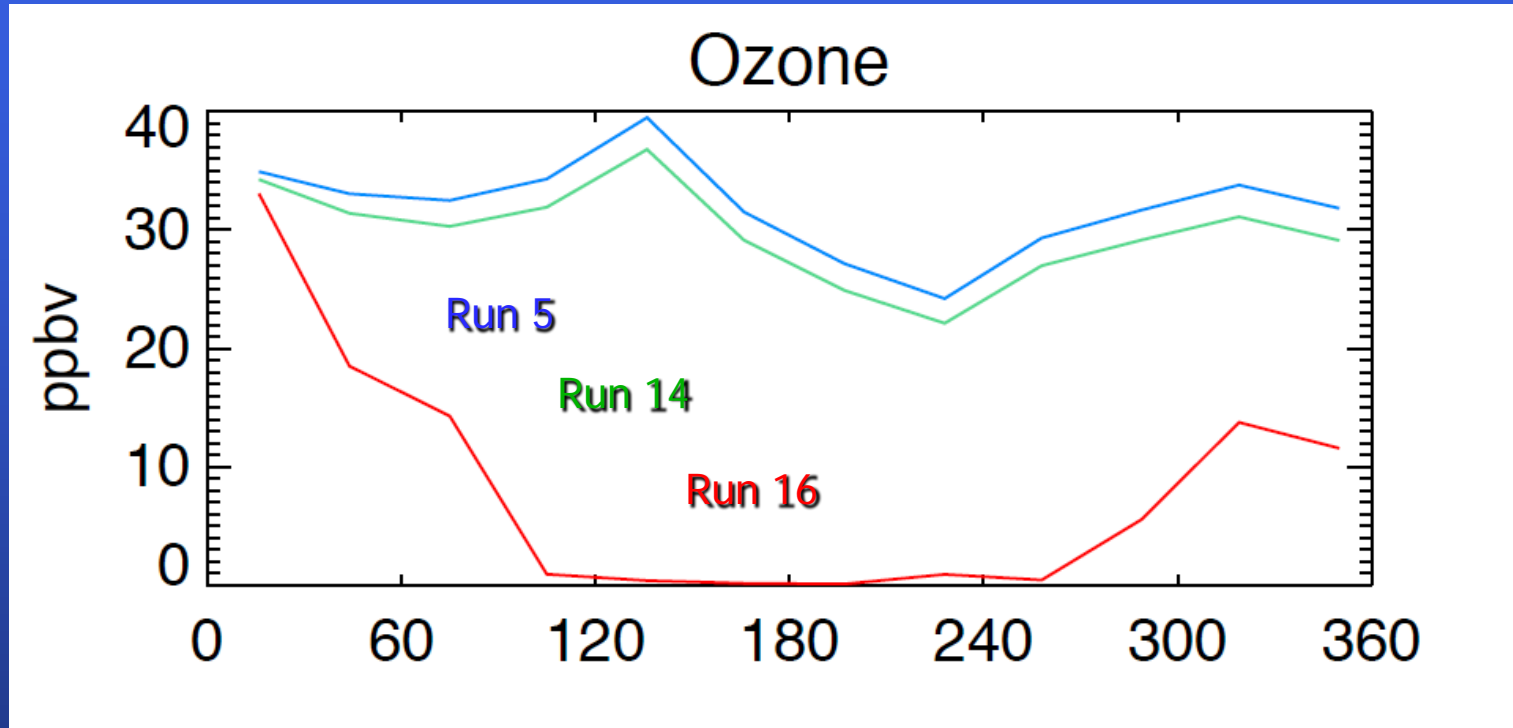
Ozone and NO at Cape Verde



Ozone and NO at Cape Verde



Ozone at Cape Verde with SSA Recycling: First Attempt!



The End!