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

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Chemistry Climate Working Group

Boulder, Colorado

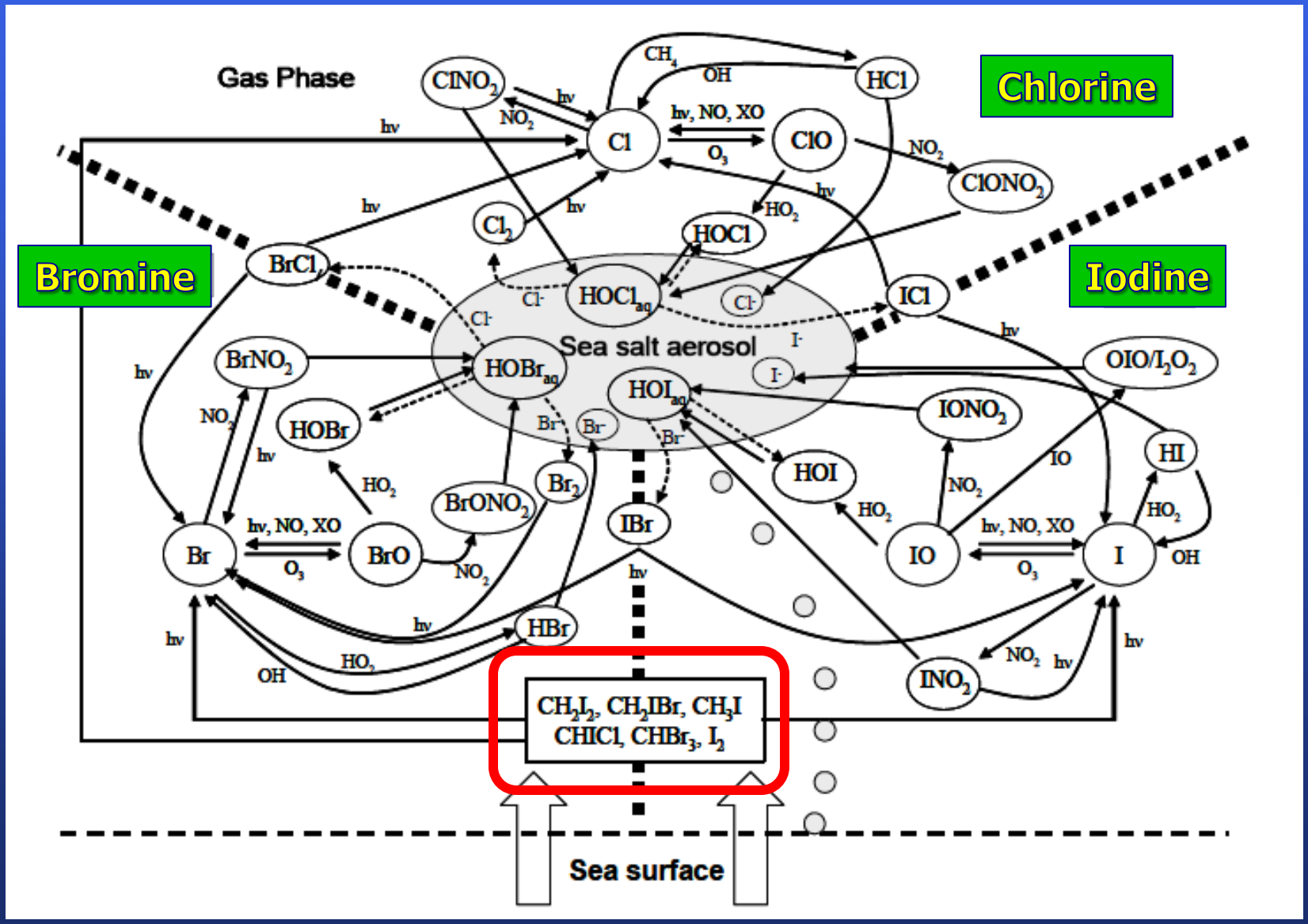
VSL Halogen Scientific Questions

- 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?

Paper submitted to Nature Geosciences

- 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?

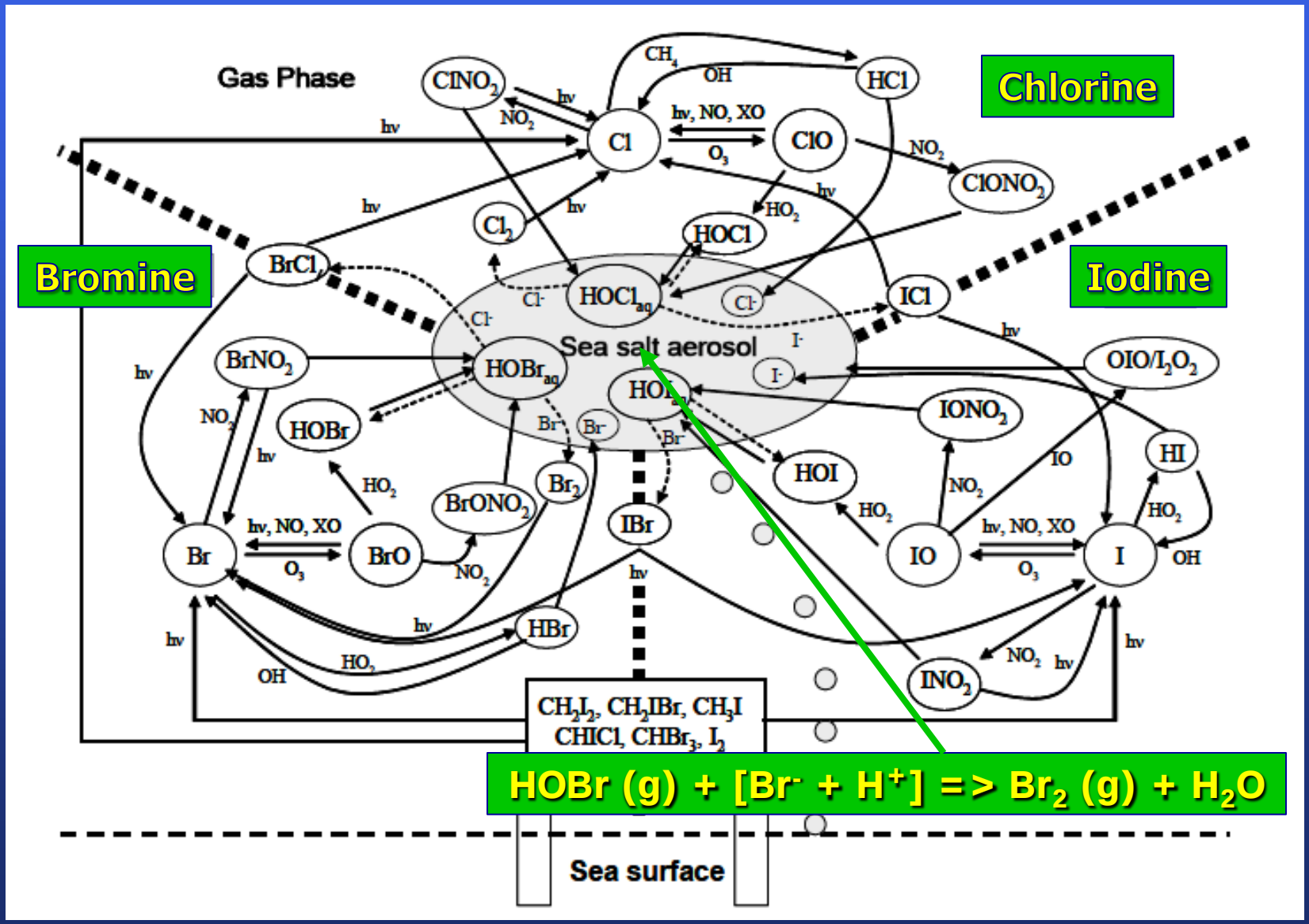
Tropospheric Halogen Chemistry



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	-

Tropospheric Halogen Chemistry



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 ~18
  - Inorganic species: Adds ~20
  - Photolysis Rxns: Adds ~23
  - Sulfate Het. Rxns: Adds ~5
  - Sea Salt Aer. Rxns: Adds ~9

- Emissions – Observations suggest that the biogenic production seems to come from seaweed, phytoplankton, algae etcs… [we use Chlorophyll-A obs from SeaWIFS]

Emissions of VSL Halogens

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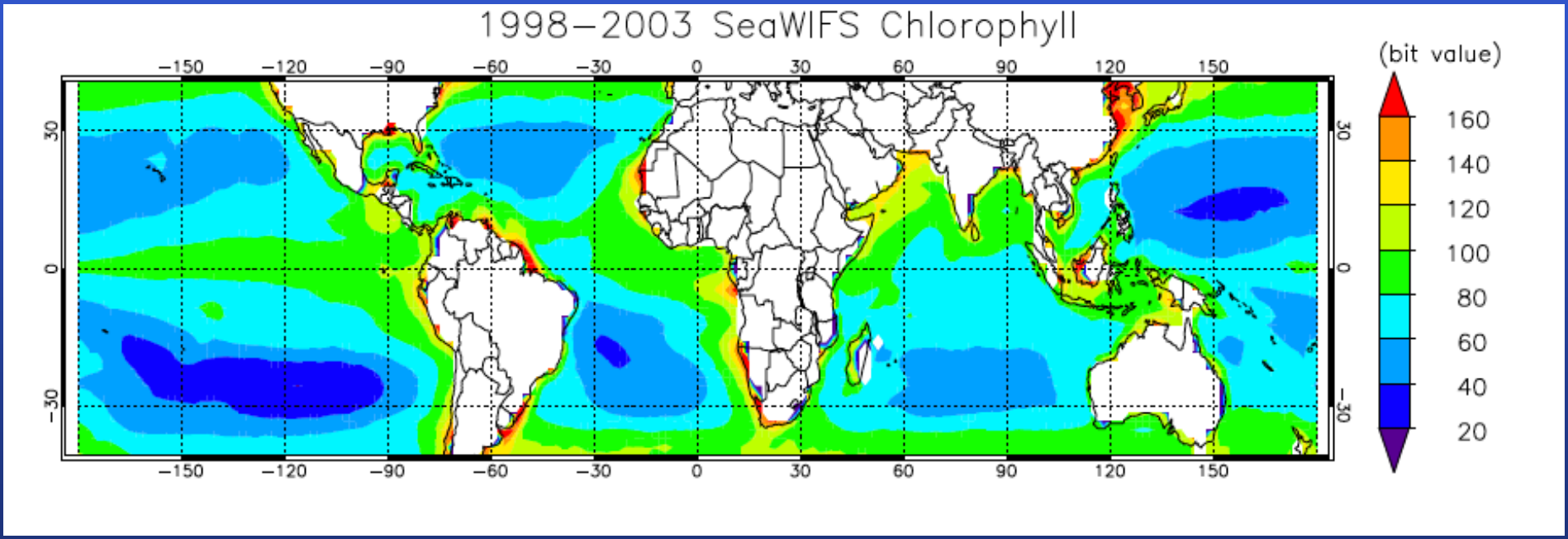
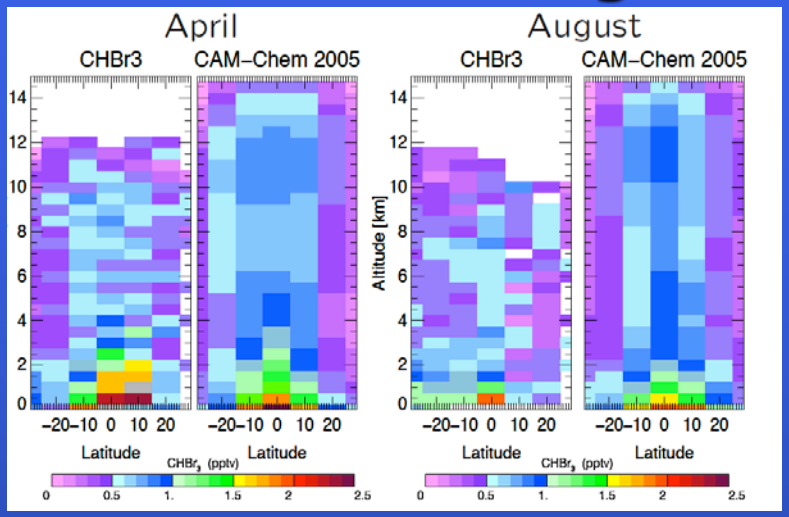
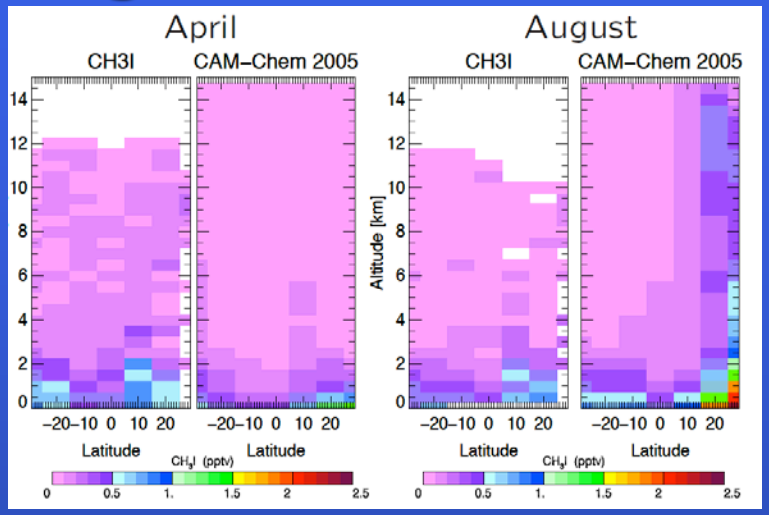
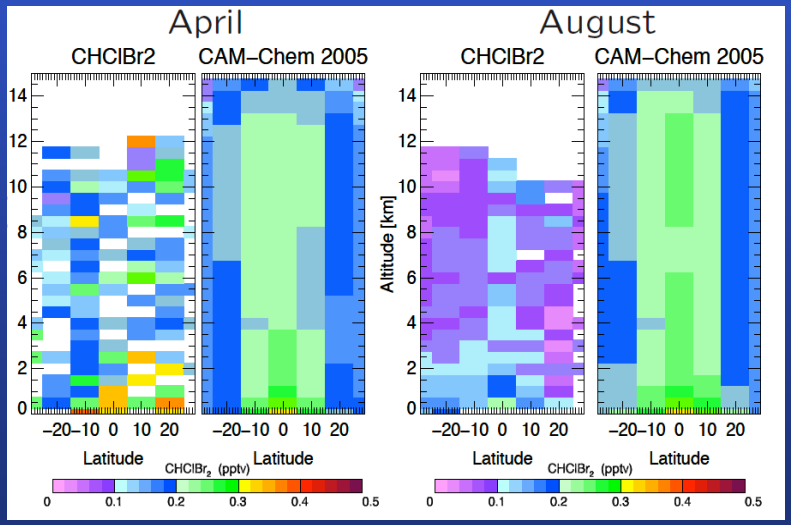


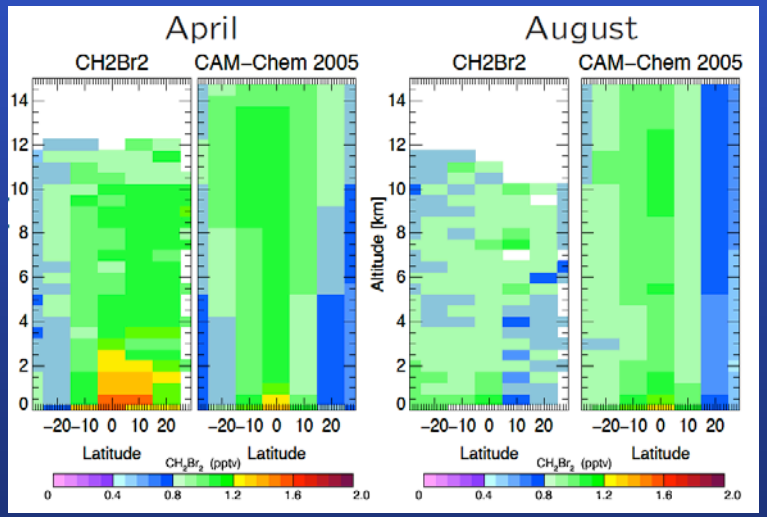
Results

Organic Halogens



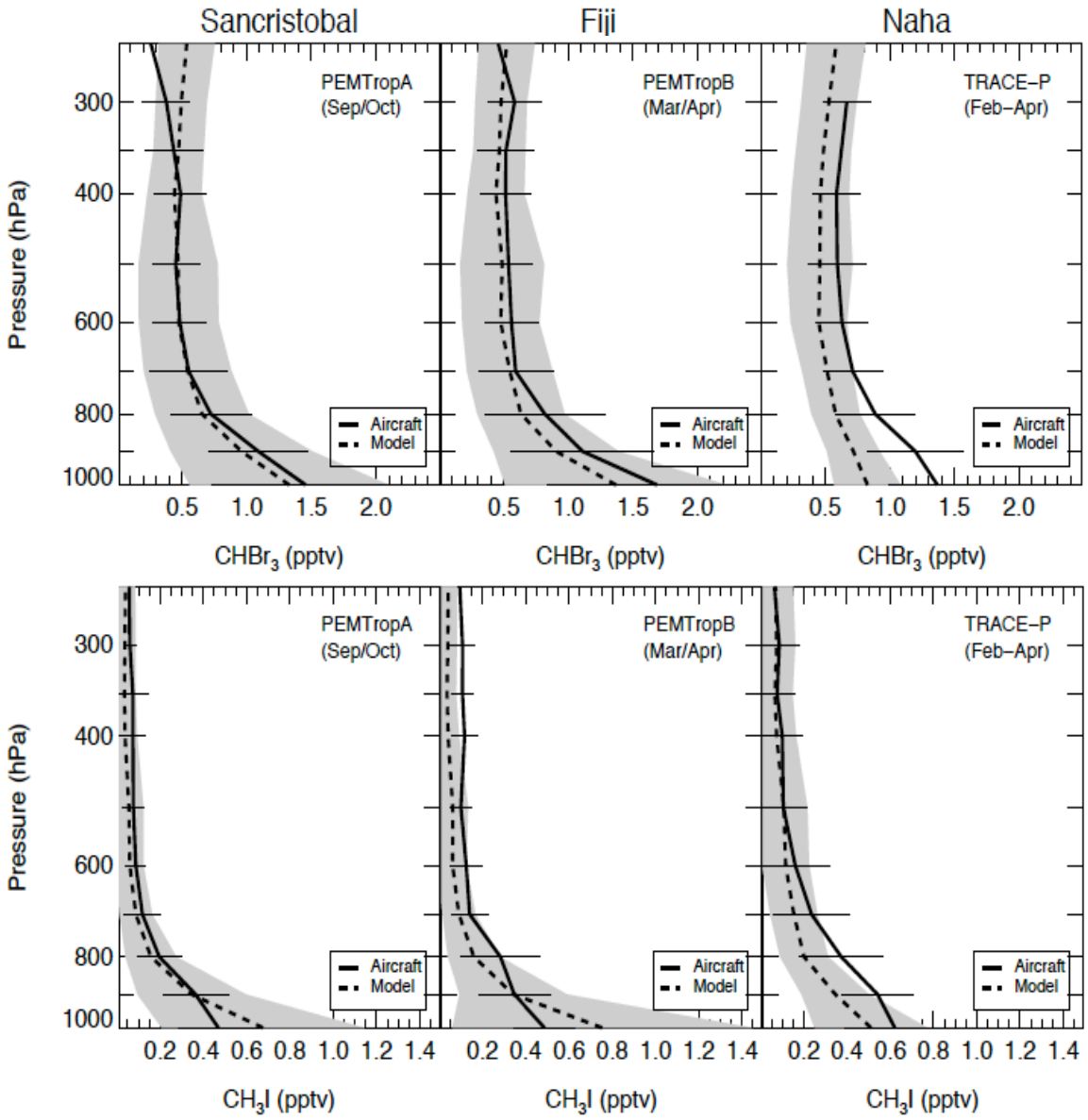




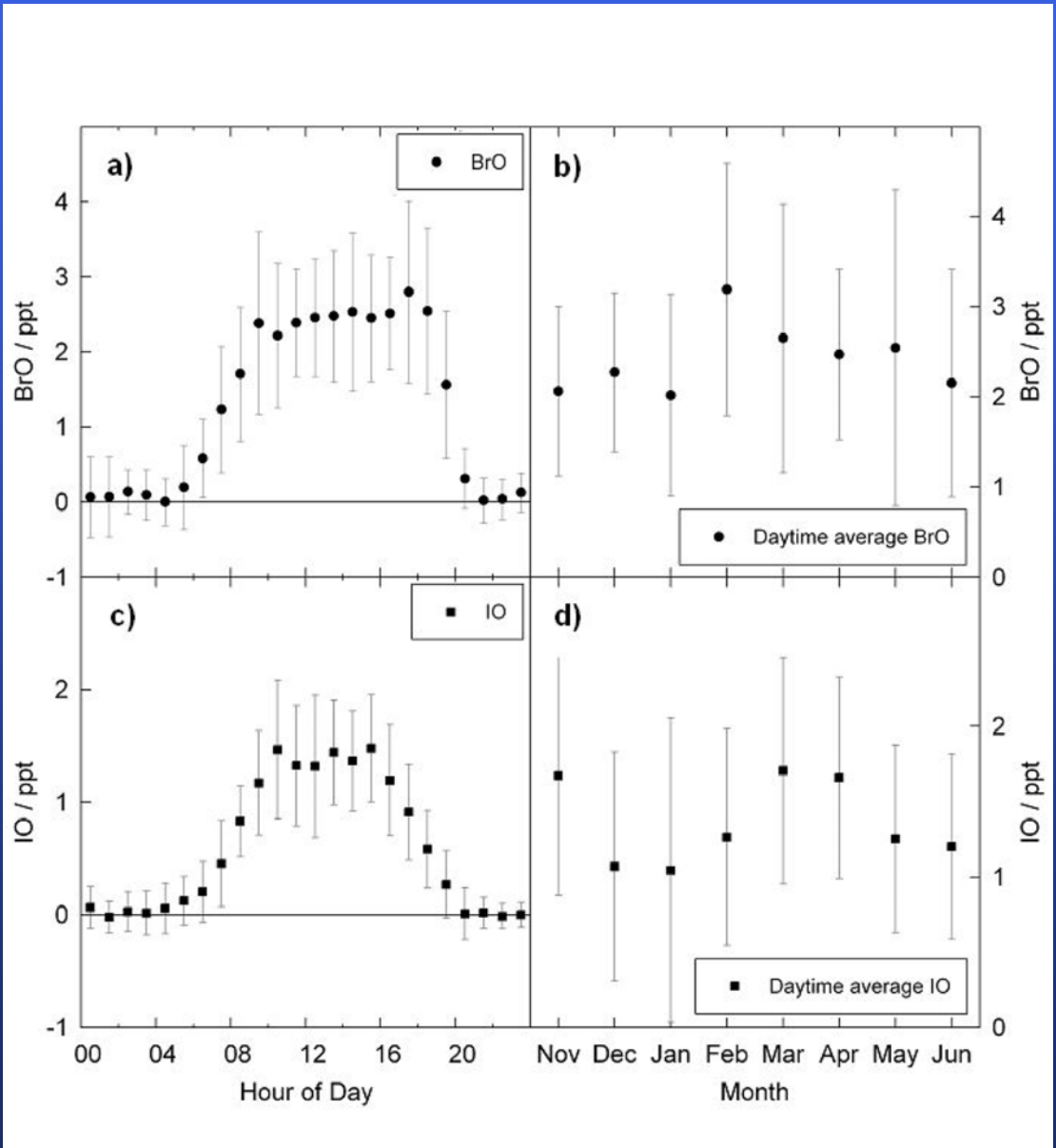


Comparison of modeled average vertical profiles of organic halogens with aircraft observations from the missions PEM-Tropics A, PEM-Tropics B and TRACE-P. Model results are averaged within the geographical region of each campaign, only considering latitudes between 30° N -30° S and matching seasons.

Organic Halogens



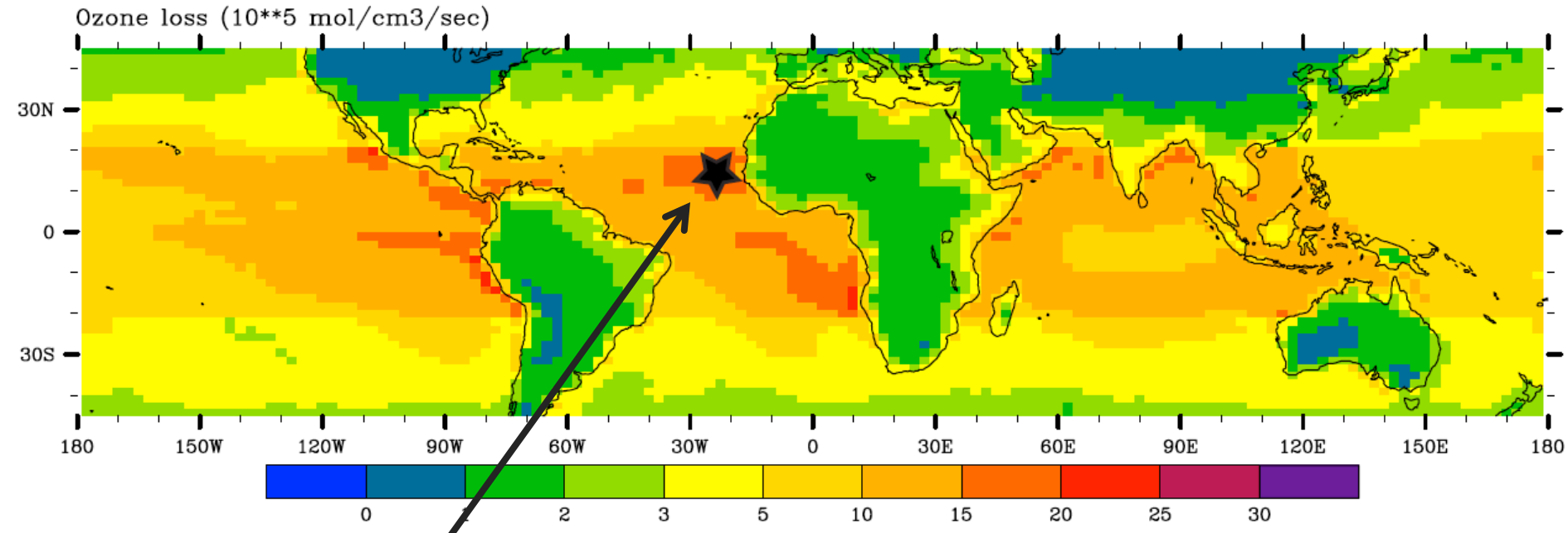
IO and BrO at Cape Verde

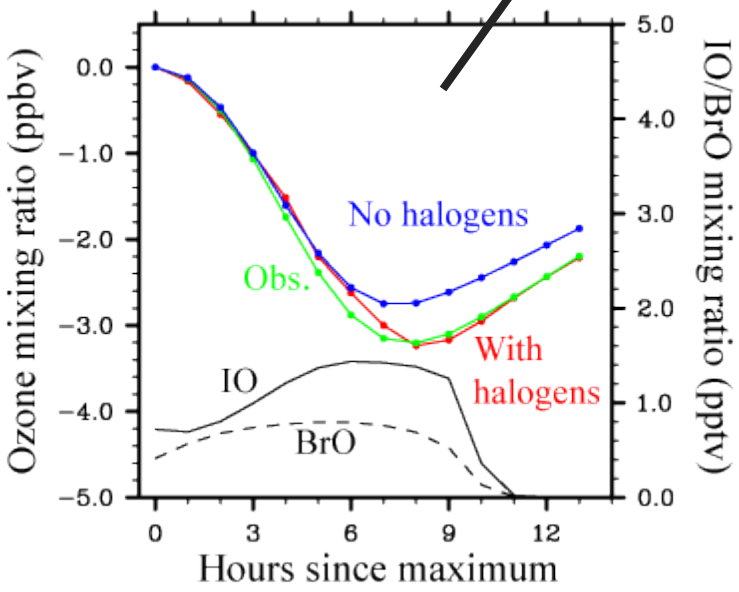


Read et al., Nature, 2008

- Cape Verde [16.85N, 24.87W]
- DOAS measurements.

Halogen Odd-Oxygen Loss [Surface]





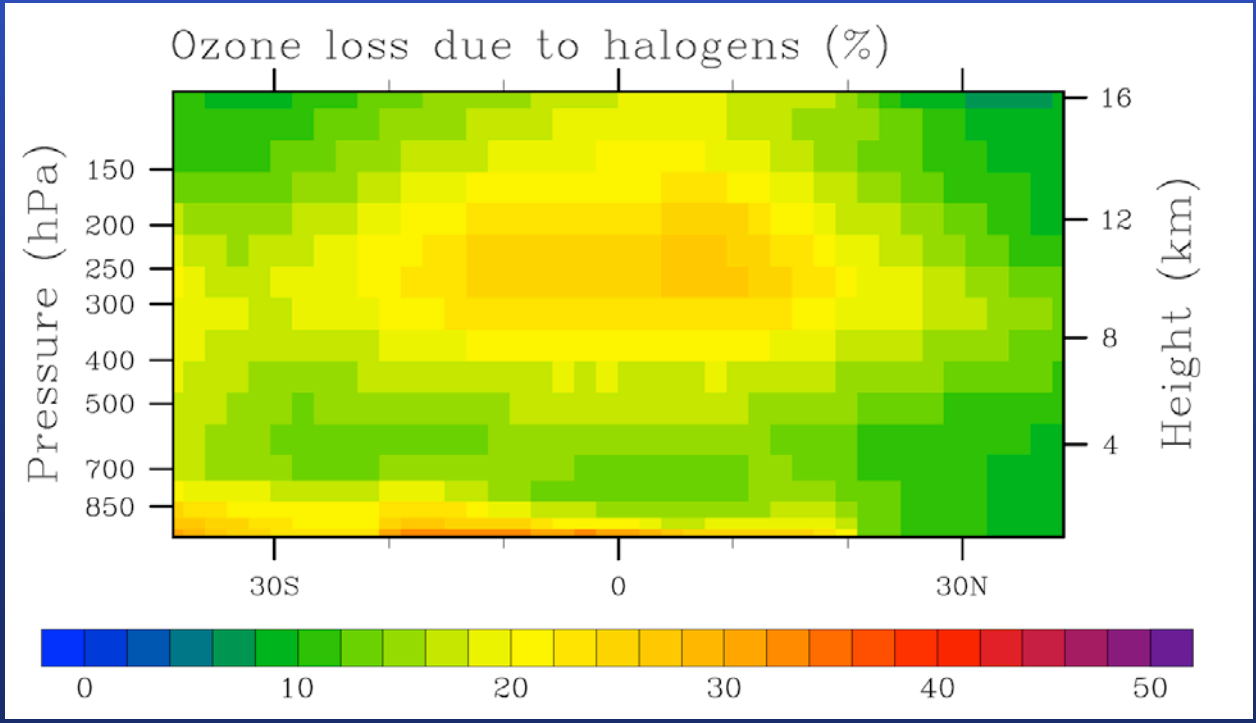
Top: Surface ozone loss (in 10^5 molec cm^{-3} s^{-1}) resulting from including tropospheric halogen chemistry in CAM-CHEM.

Left: Annual average of diurnal ozone loss observed and simulated by CAM-CHEM at Cape Verde. Model IO and BrO distributions are also shown.

Odd Oxygen Loss Partitioning

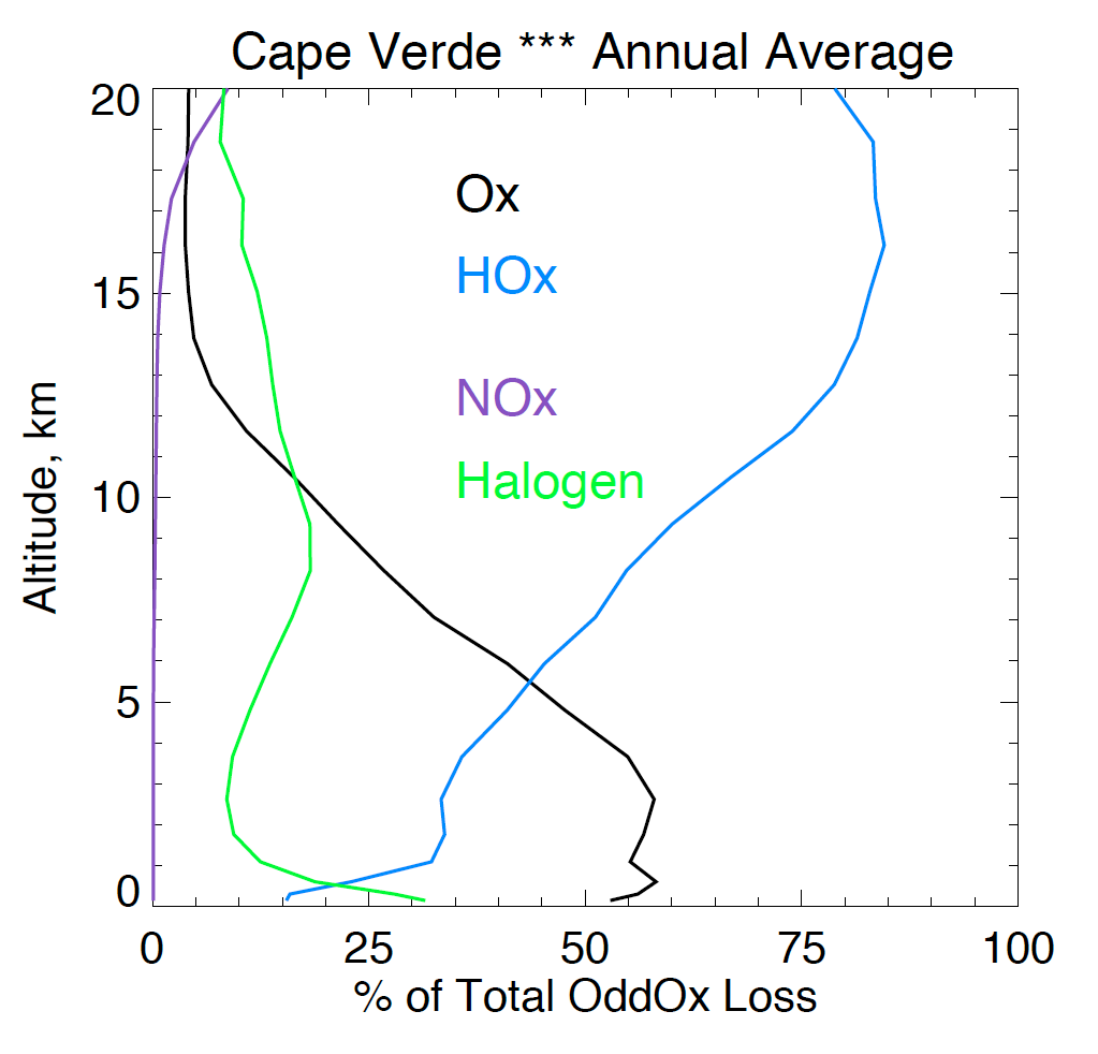
Percentage of the annual average chemical ozone loss due to halogens in the tropical troposphere. The primary odd-oxygen loss catalytic cycle is:

$$I + O_3 \Rightarrow IO + O_2$$
$$Br + O_3 \Rightarrow BrO + O_2$$
$$IO + BrO \Rightarrow I + Br + O_2$$
$$\text{Net: } 2O_3 \Rightarrow 3O_2$$

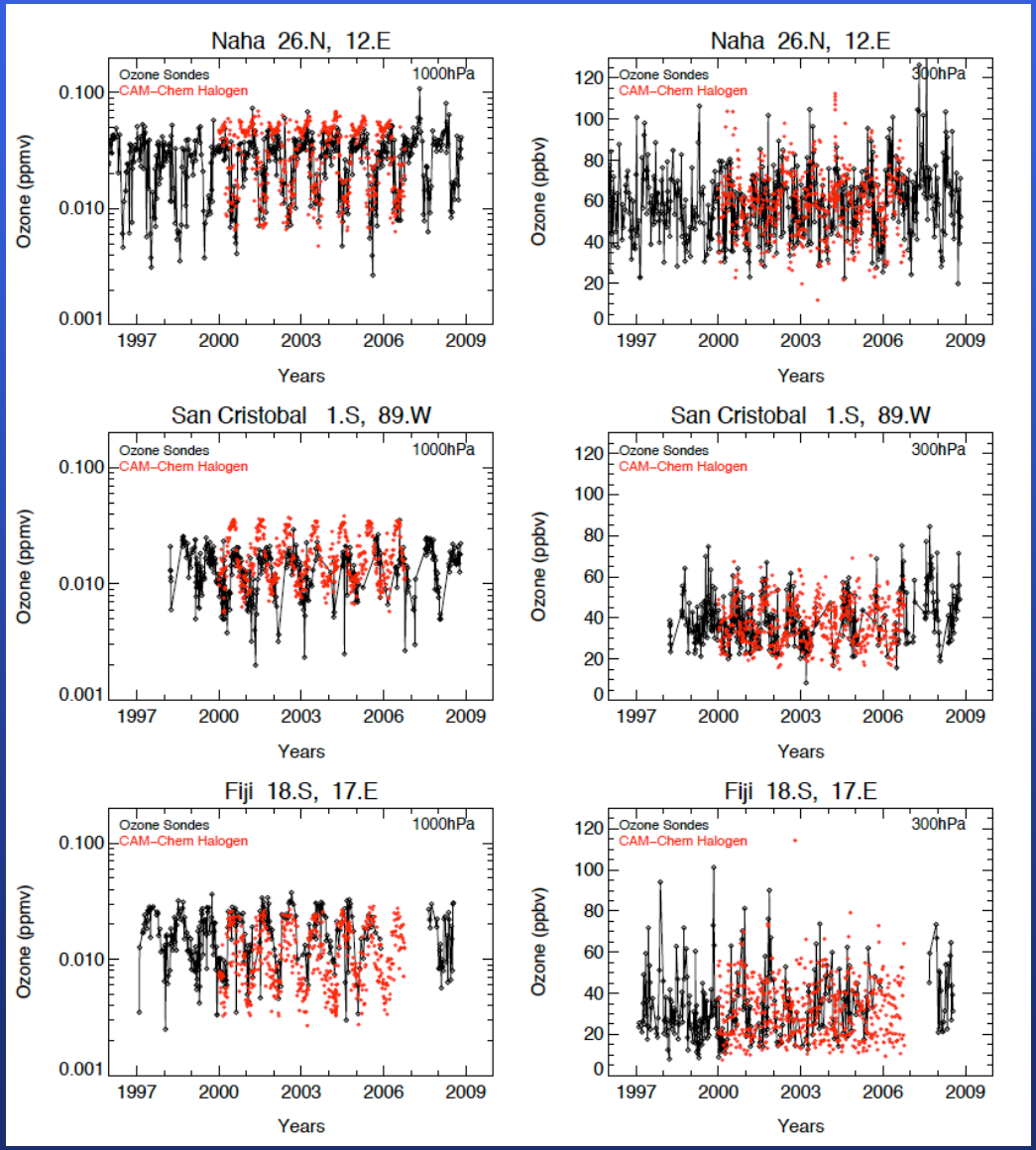


Odd Oxygen Loss Partitioning

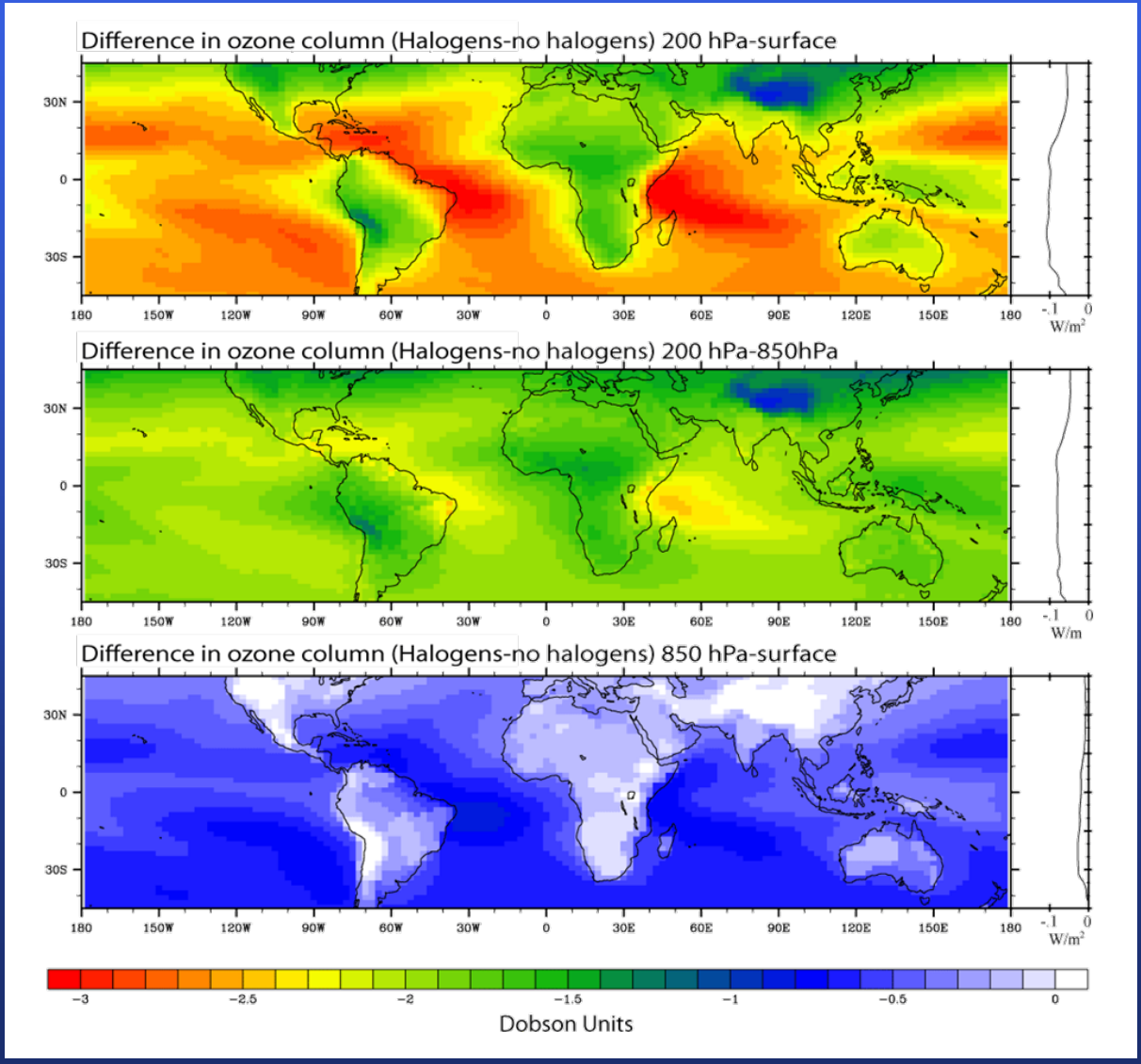
16.9° N, 24° W



Tropical Ozone comparisons from Sondes [Surface]



Tropospheric Column Ozone Difference (%)



Next Step

NASA Roses 10 A.14 – was funded!

- 50% Kinnison
- 50% Post Doc.

Model Development….

- Include emissions for mid-latitudes.
- Include emission processes for the polar regions.

Science questions

- Understanding transport pathways of VSL into the LS.
- What is the impact of VSL halogens on CH_4 lifetime through amplification of OH?
- What impact does VSL substances have on model derived Ozone trends?

The End!