Use of GMI to Study Tropospheric and Stratospheric Bromine Budgets

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Motivation

- Measurements of BrO imply Br_y concentrations 4-8 pptv greater than models which include only CH_3Br + halons
- BrO provides reaction partner to ClO, which is most important in lower stratosphere
- This additional Br_y has large effect on stratospheric ozone trends, particularly during times of volcanic aerosol loading
- Tropospheric effects on O_3, OH, HO_2, H_2O_2, DMS, SO_2

Relevant Compounds and Sources

Compound	**Abundance**	**Sources**
CH_3Br	9-10 pptv	Fumigation, biomass burning, phytoplankton
$CHBr_3$	0.6-3.0 pptv	phytoplankton, macroalgae
CH_2Br_2	0.8-3.4 pptv	phytoplankton, macroalgae
CH_2BrCl	0.1-0.5 pptv	phytoplankton, macroalgae
$CHBr_2Cl$	0.1-0.5 pptv	phytoplankton, macroalgae
$CHBrCl_2$	0.1-0.6 pptv	phytoplankton, macroalgae
$C_2H_4Br_2$	0.3-0.5 pptv	Industrial, biogenic?

Emissions and Lifetimes

Compound	Lifetime	Emission Strength
CH_3Br	0.7 yr	112-454 Gg/yr
$CHBr_3$	26 days	200-285 Gg/yr
CH_2Br_2	4 months	55-67 Gg/yr
CH_2BrCl	5 months	2.9 Gg/yr
$CHBr_2Cl$	69 days	4.2-12 Gg/yr
$CHBrCl_2$	78 days	5.5-7.0 Gg/yr
$C_2H_4Br_2$	84 days	77-151 Gg/yr

GMI 2-Species Calculations

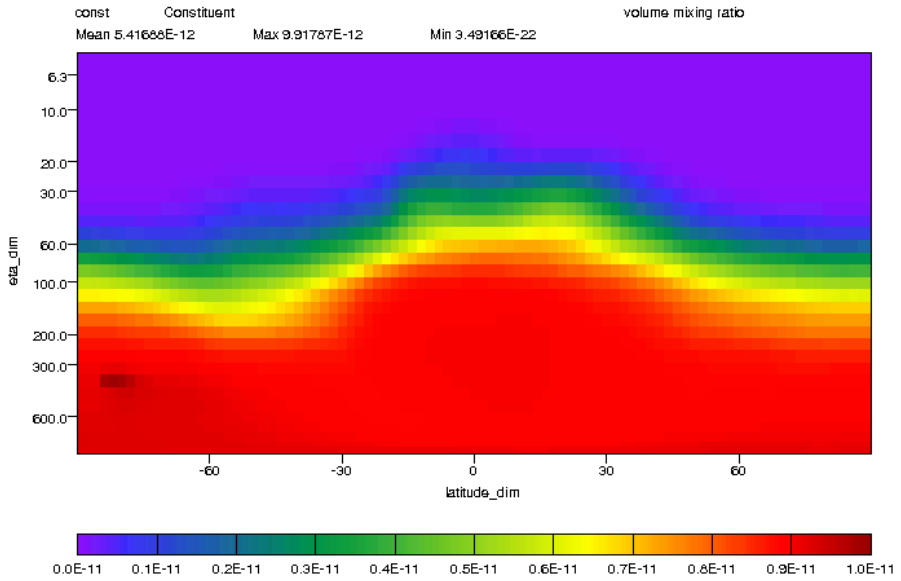
$$CH_mBr_n + hv \rightarrow nBr_y$$
$$CH_mBr_n + OH \rightarrow nBr_y$$
$$CH_mBr_n + O^1D \rightarrow nBr_y$$
$$CH_mBr_n + Cl \rightarrow nBr_y$$

- Solve for CH_mBr_n and Br_y
- OH, O^1D, Cl, H_2O, O_3 fixed species
- CH_3Br, $CHBr_3$, and CH_2Br_2 done
  - Their photolysis cross-sections already in FastJX

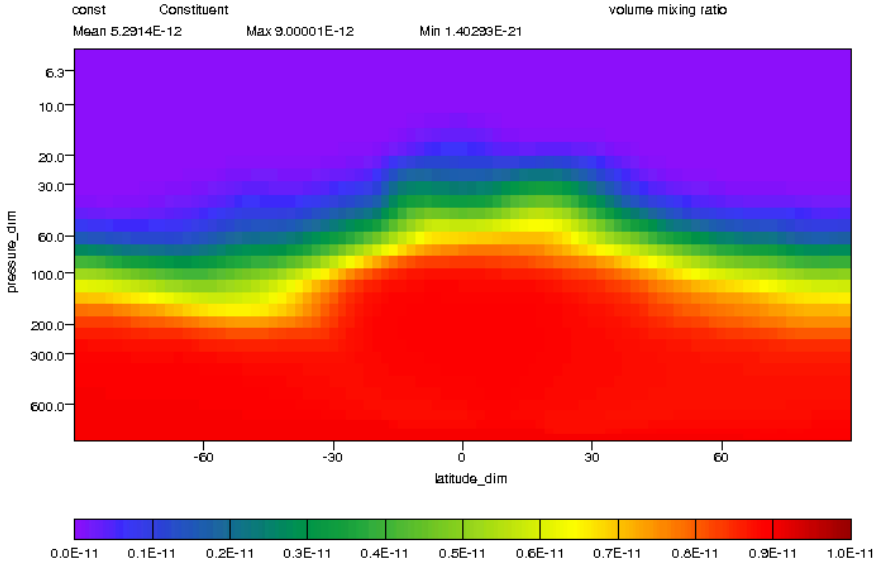
GMI Runs Initial Setup

- Similar to Aura 2005 Combo calculation
- 2°x2.5°x42 geometry
- Convection (NCAR option)
- Diffusion (DAO2 vertical diffusion=1.0)
- FastJX, clear sky
- Dry_dep=F, Wet_dep=T (Br_y coeff=1.0), wetchem=T
- Fixed species from Aura 2005 Combo Calculation
- GEOS4DAS-2005 met fields repeated annually
- Fixed mixing ratio boundary conditions
- Run on Discover with 36 processors, 5.5 hr/yr

CH_3Br from Aura 2005 Combo Run - September

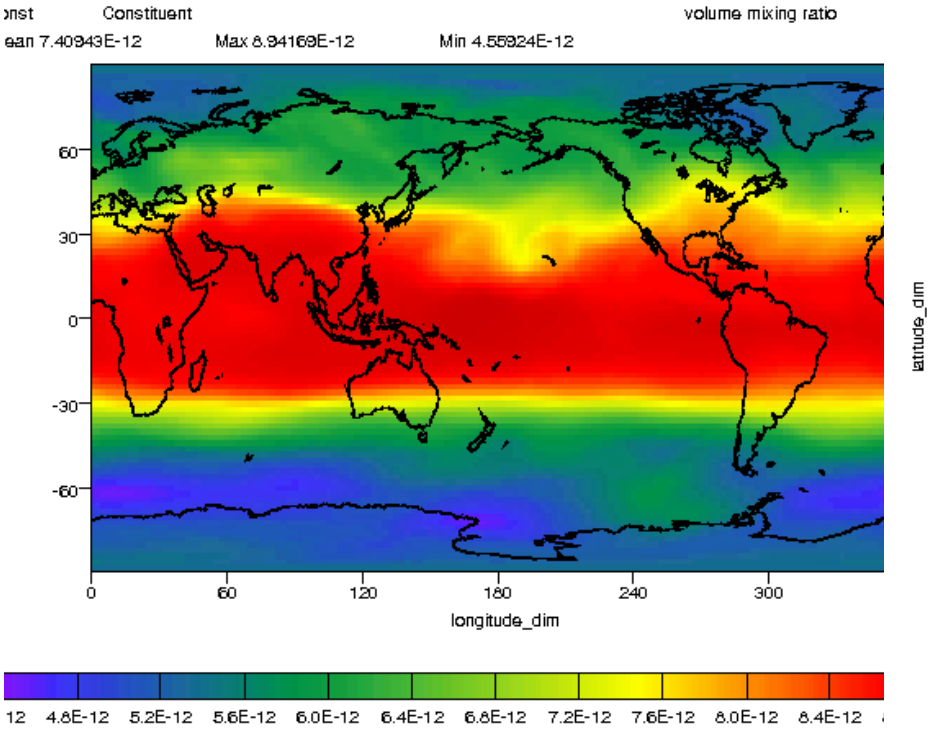


CH_3Br from Bromine-only DAS 2005 Run - September

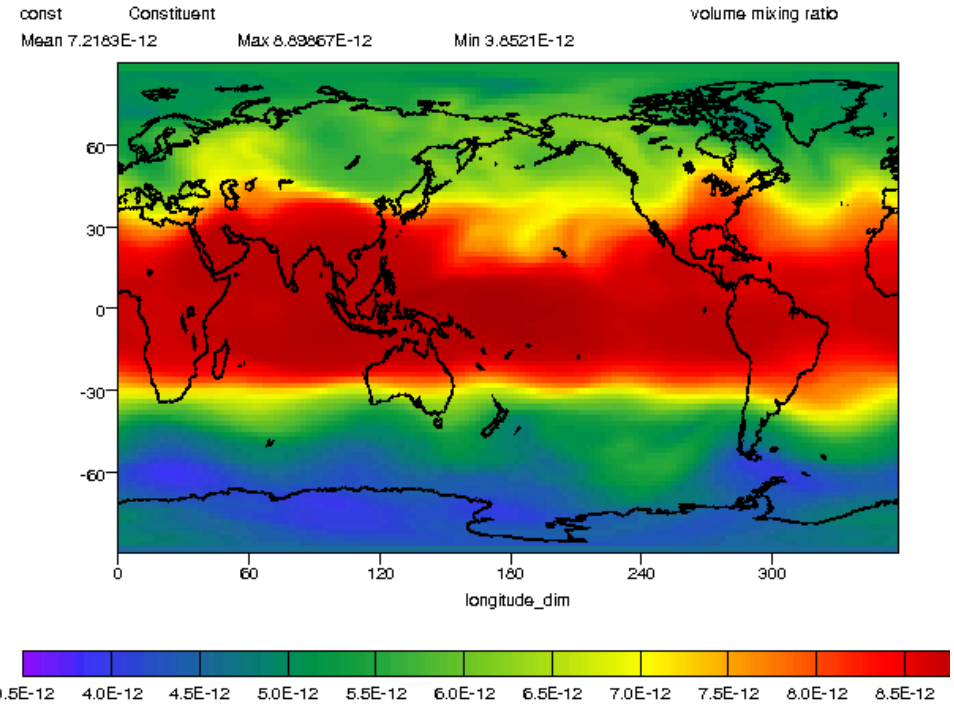


Boundary conditions different (time-dep vs fixed)

CH_3Br from Aura 2005 Combo Run - June 100mb



CH_3Br from Bromine-only DAS 2005 Run - June 100 mb

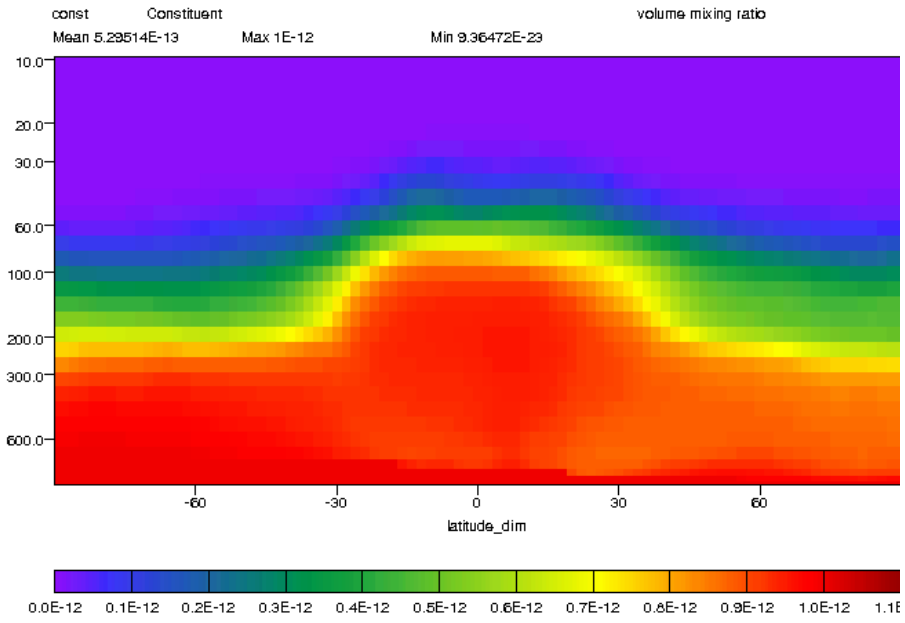


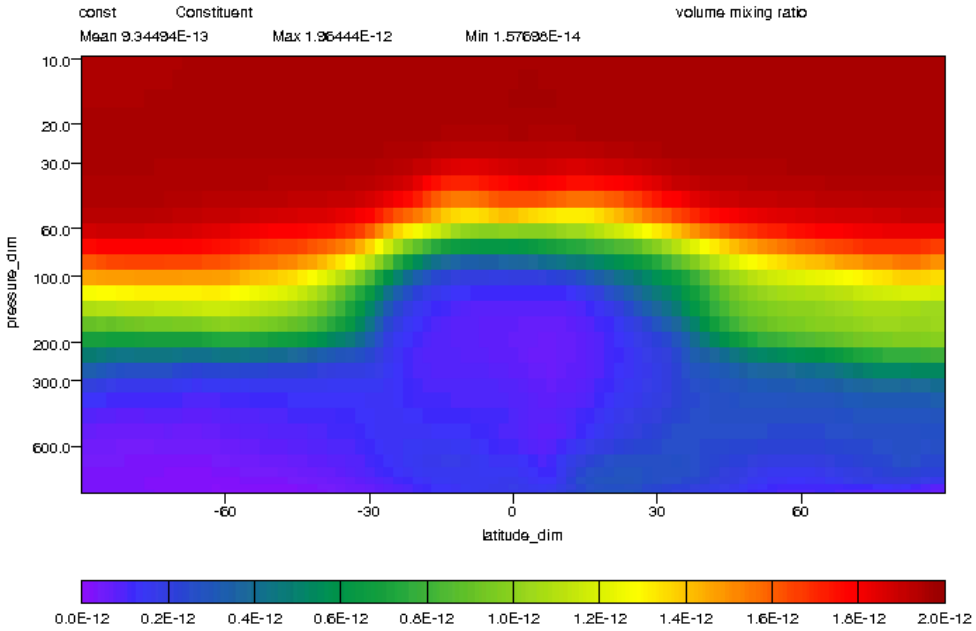
Boundary conditions different (time-dep vs fixed)

GMI Bromine-only Calculations

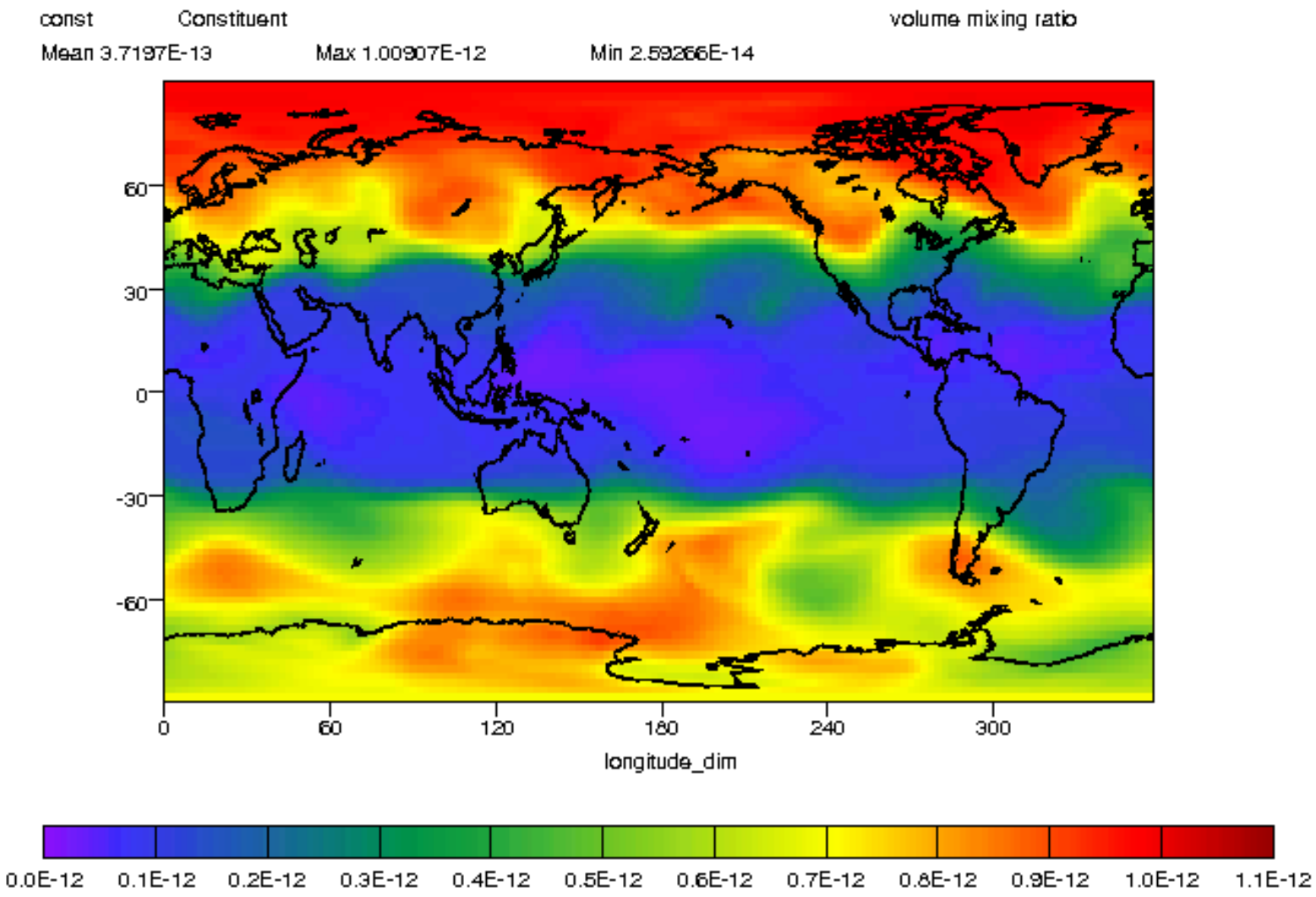
- CH_3Br at 9 pptv
- CH_2Br_2 at 1.0 pptv
  - DAS 2005 meteorology
  - Fvgcm 1998 meteorology
- $CHBr_3$ at 1.3 pptv
  - DAS 2005 meteorology
  - DAS 2001 meteorology
  - Fvgcm 1998 meteorology
- OH, O^1D, Cl, O_3, H_2O always from Aura Combo with DAS meteorology for 2005

CH_2Br_2 and Br_y Zonal Means in June



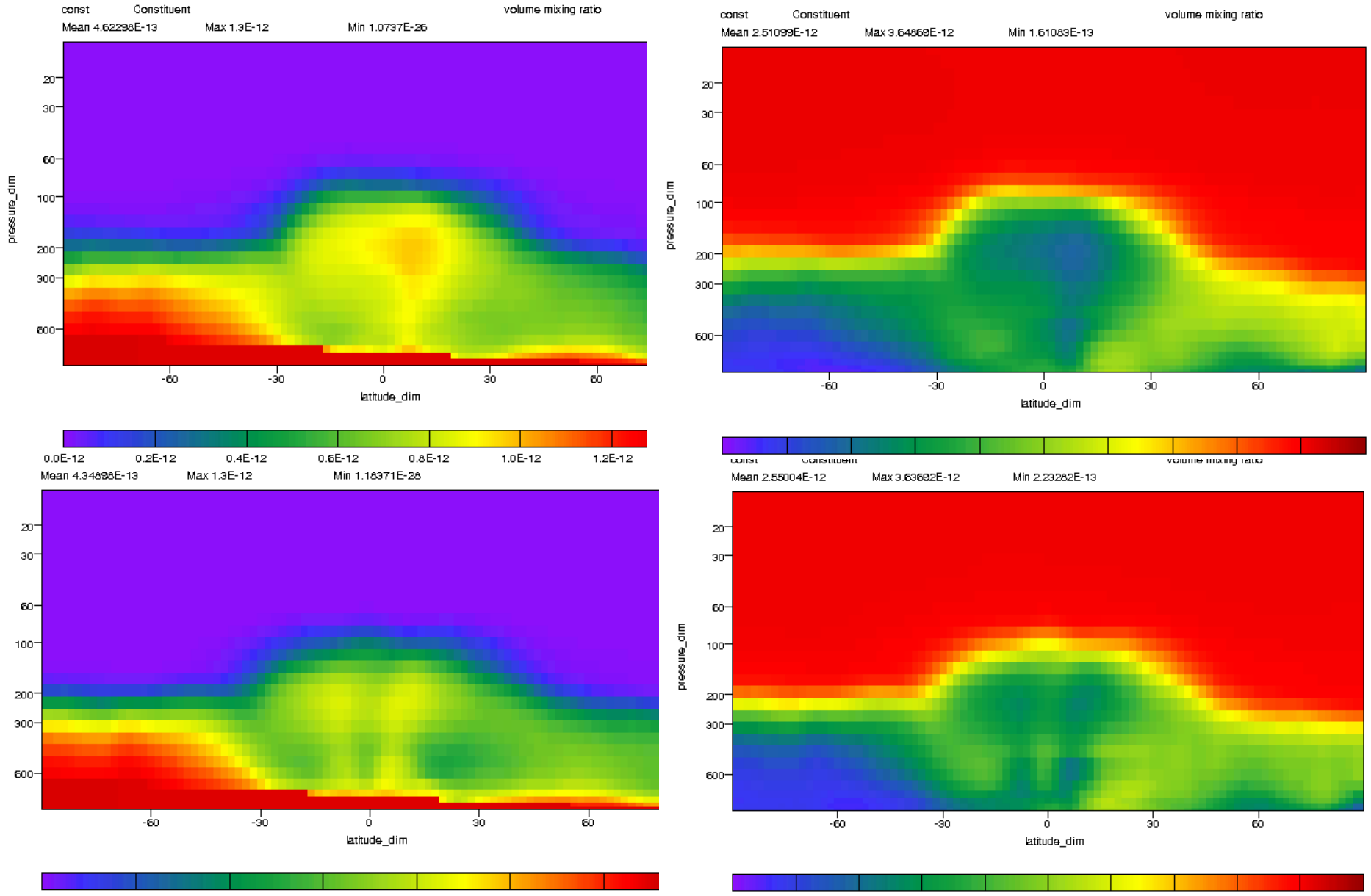


Br_y from CH_2Br_2 at 200 mb in June



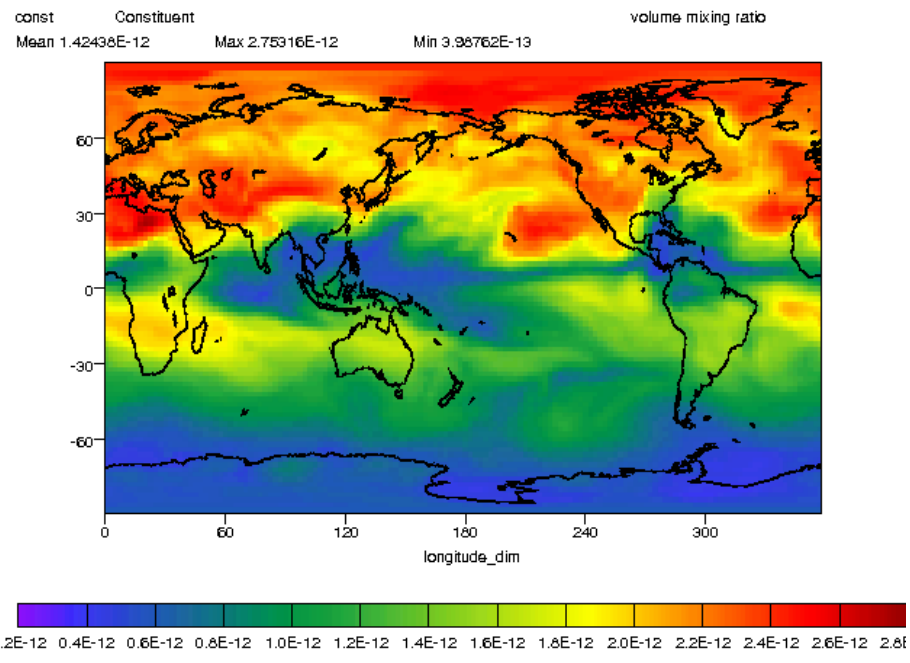
$CHBr_3$ and Br_y Zonal Means in June

top DAS2005, bottom fvgcm1998

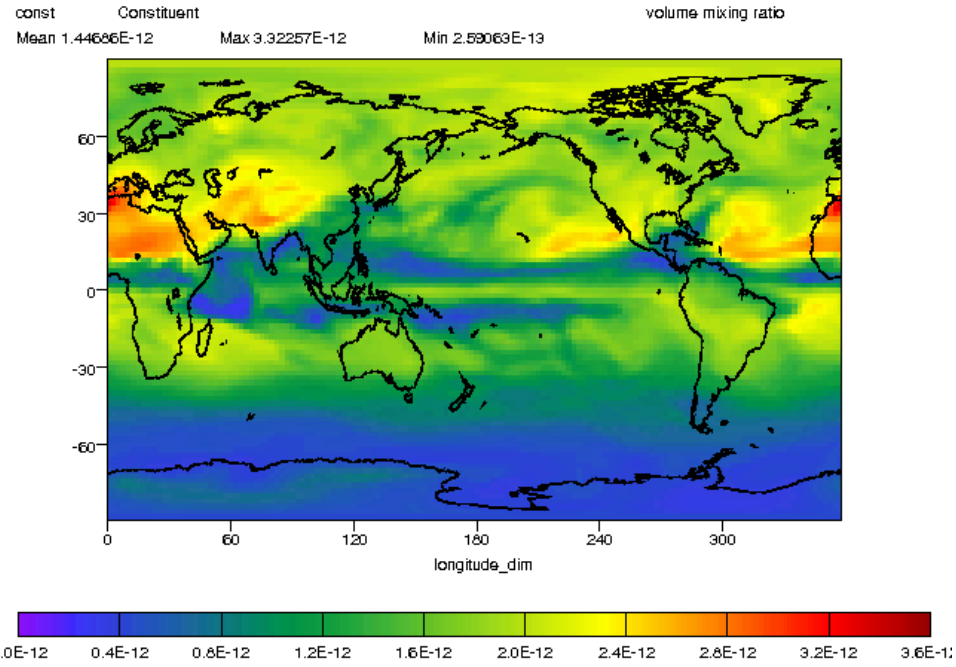


Br_y from $CHBr_3$ at 500 mb in June

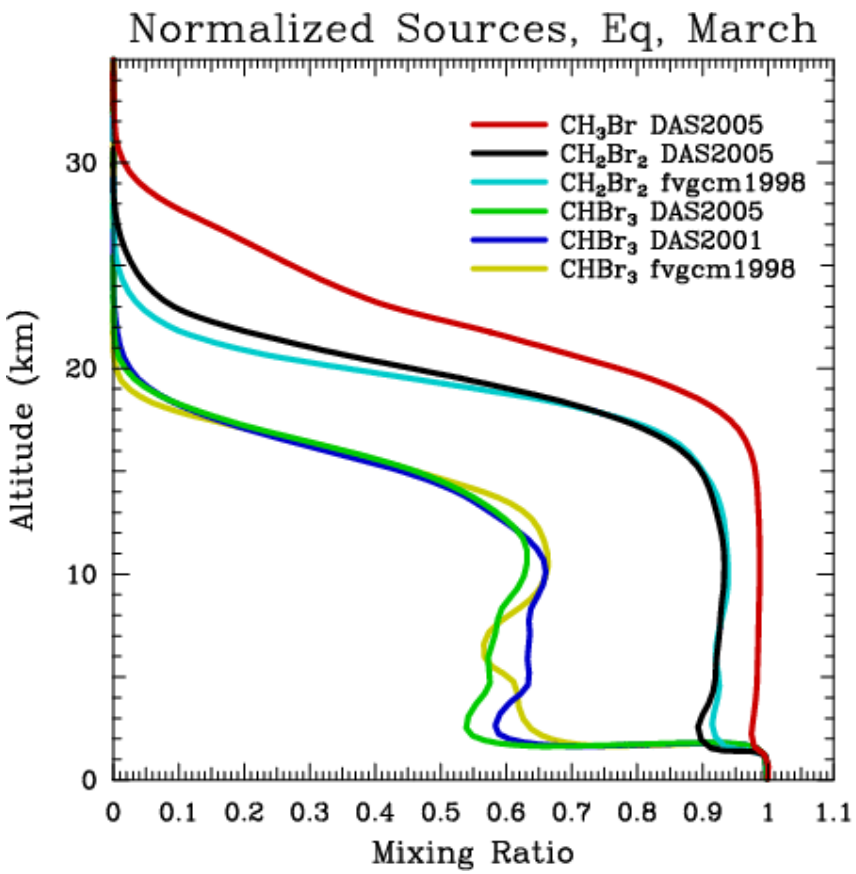
DAS2005 met fields

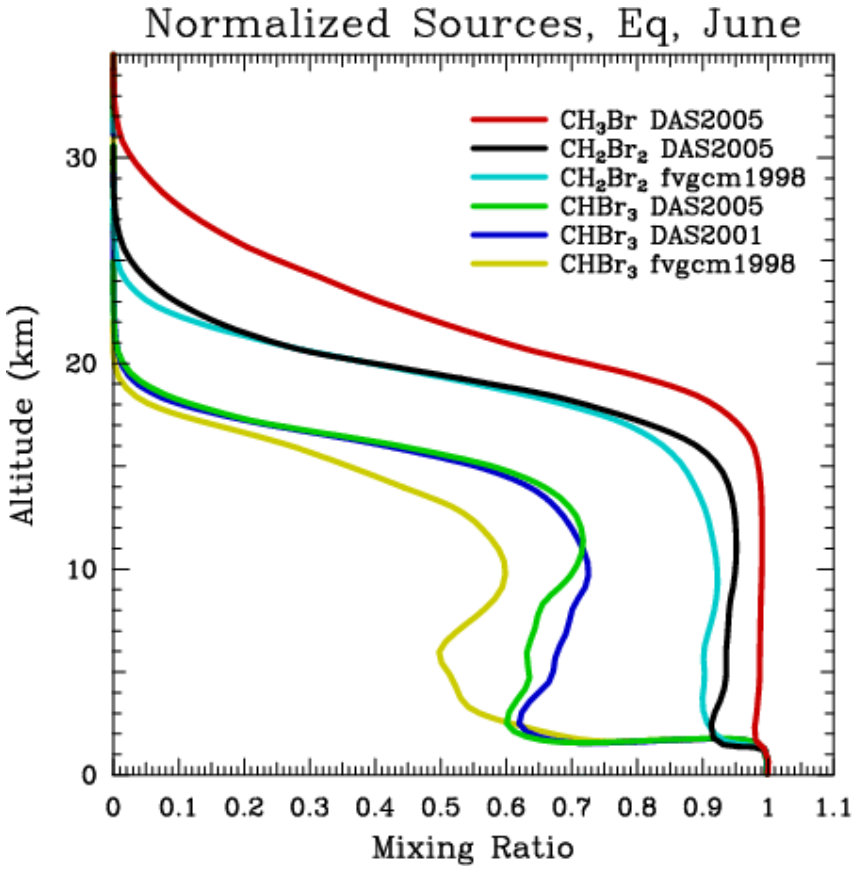


fvgcm 1998 met fields

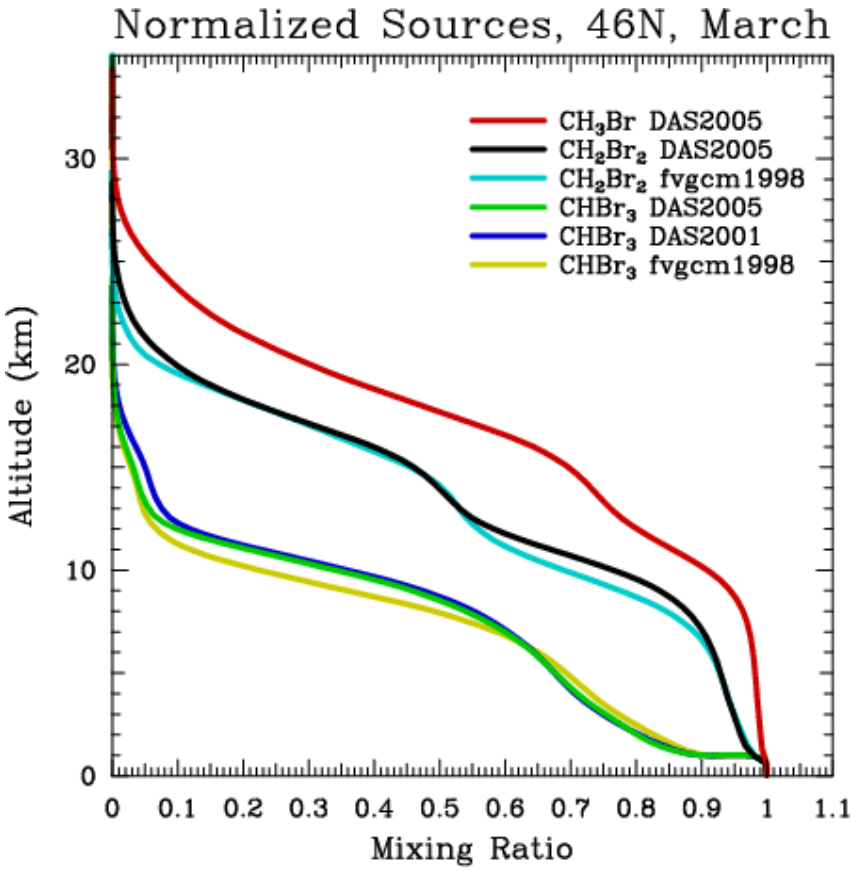


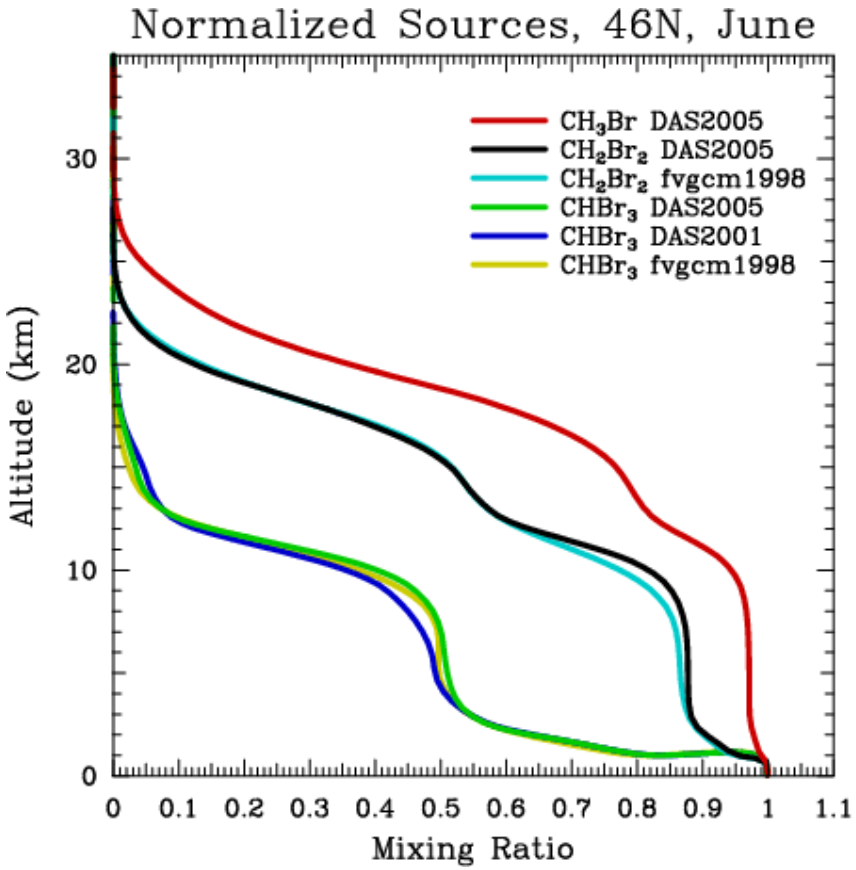
Normalized Source Gas Concentrations



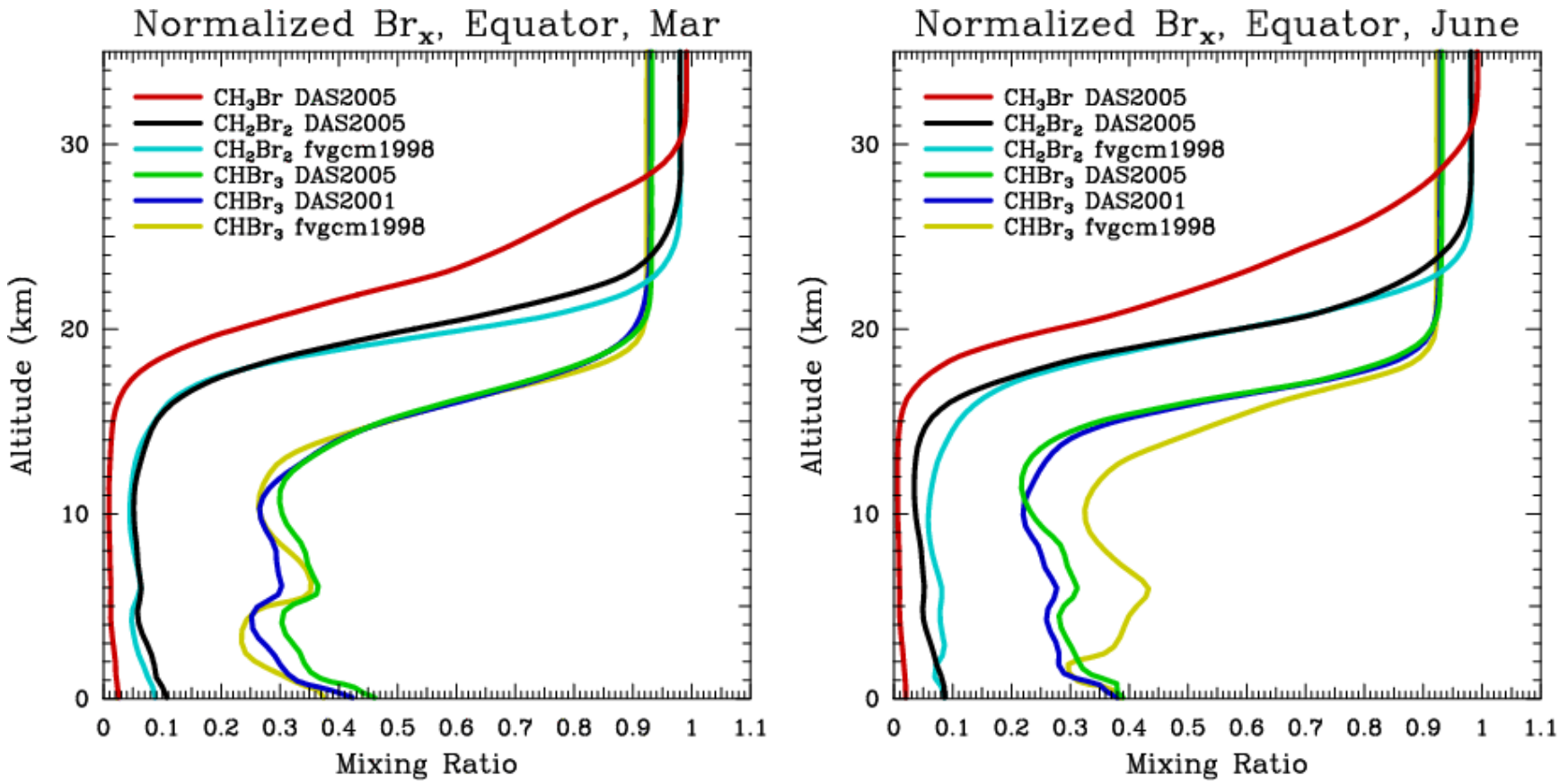


Normalized Source Gas Concentrations

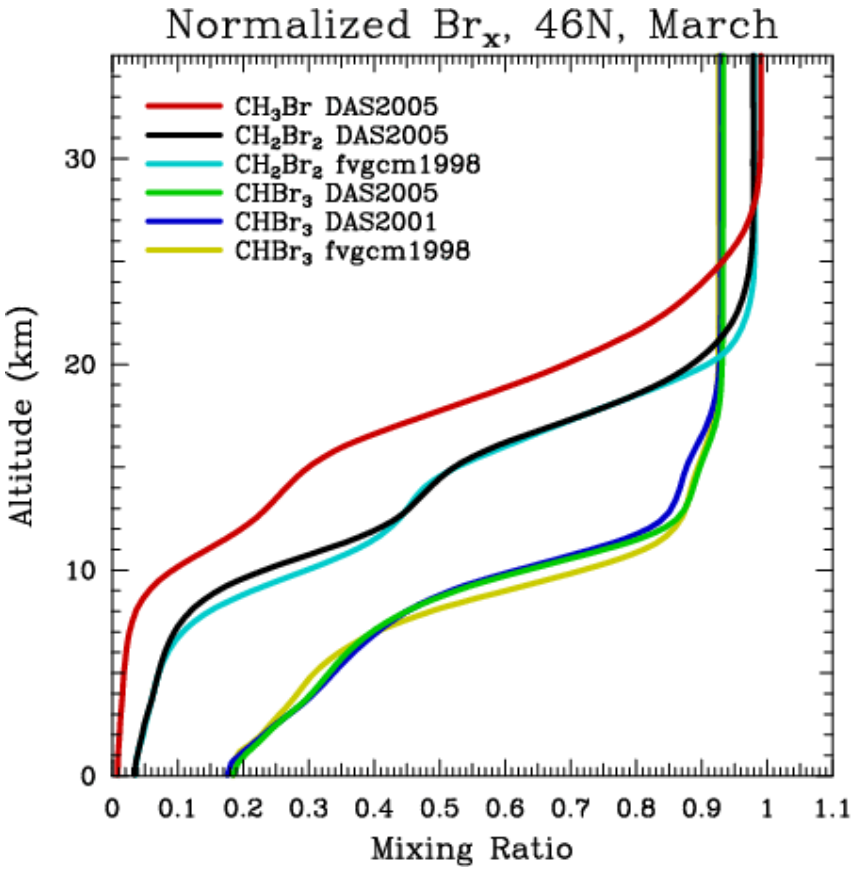


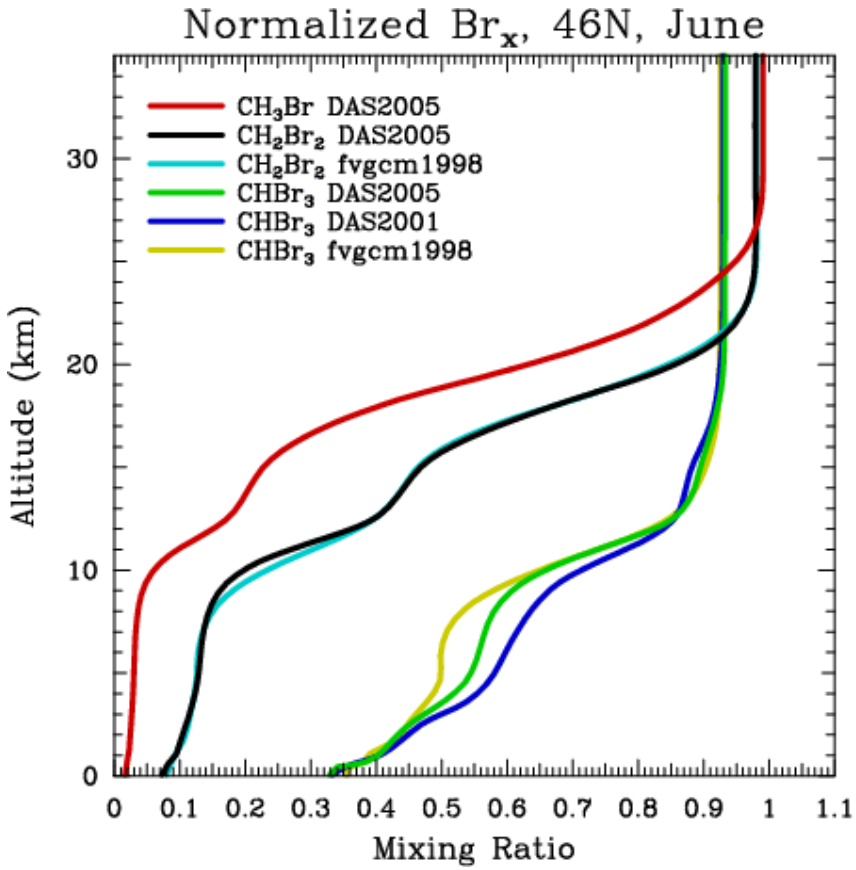


Normalized Br_y from Individual Source gases



Normalized Br_y from Individual Source gases





Next Steps

- Emissions, using sea salt as example
- Comparisons to observations of source gases
- Combine all bromine source gases and calculate BrO
- Compare BrO to observations
- Add additional Br species to Combo model
- Analyze changes in stratospheric and tropospheric chemistry

New Funding from ACMAP ROSES06

- To continue aerosol work with GMI
- Add sectional sulfate aerosol module to GMI for stratospheric applications
- Interface modal dust, sea salt, OC, BC to sectional aerosol model
- Small $$, so will write new proposal to MAP for science applications of GMI strat-trop aerosol model