

Methyl Bromide in the Atmosphere: A Scientific Overview and Update

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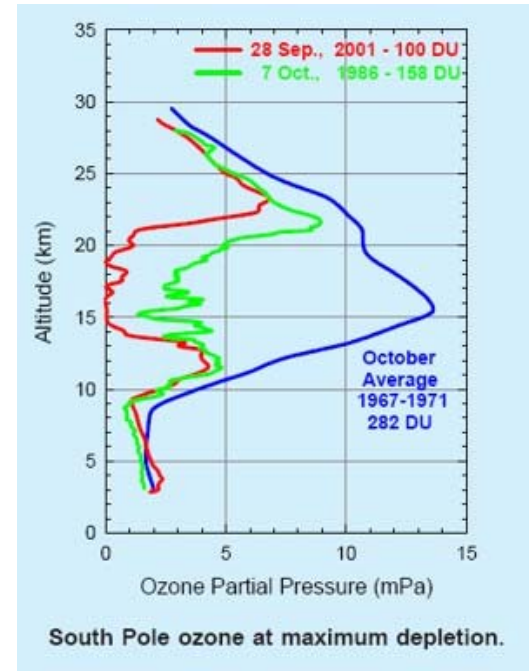
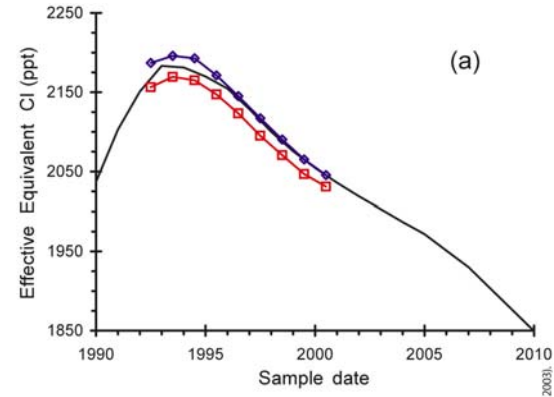
Overview

- ◆ **2002 Assessment of Ozone Depletion**
 - » Stratospheric Ozone
 - » Equivalent Chlorine
- ◆ **Methyl Bromide: Past**
 - » 1998 Assessment
 - » 2002 Assessment
- ◆ **Recent Results for Methyl Bromide**
 - » Calibration
 - » Observations
 - » Budget and Lifetime

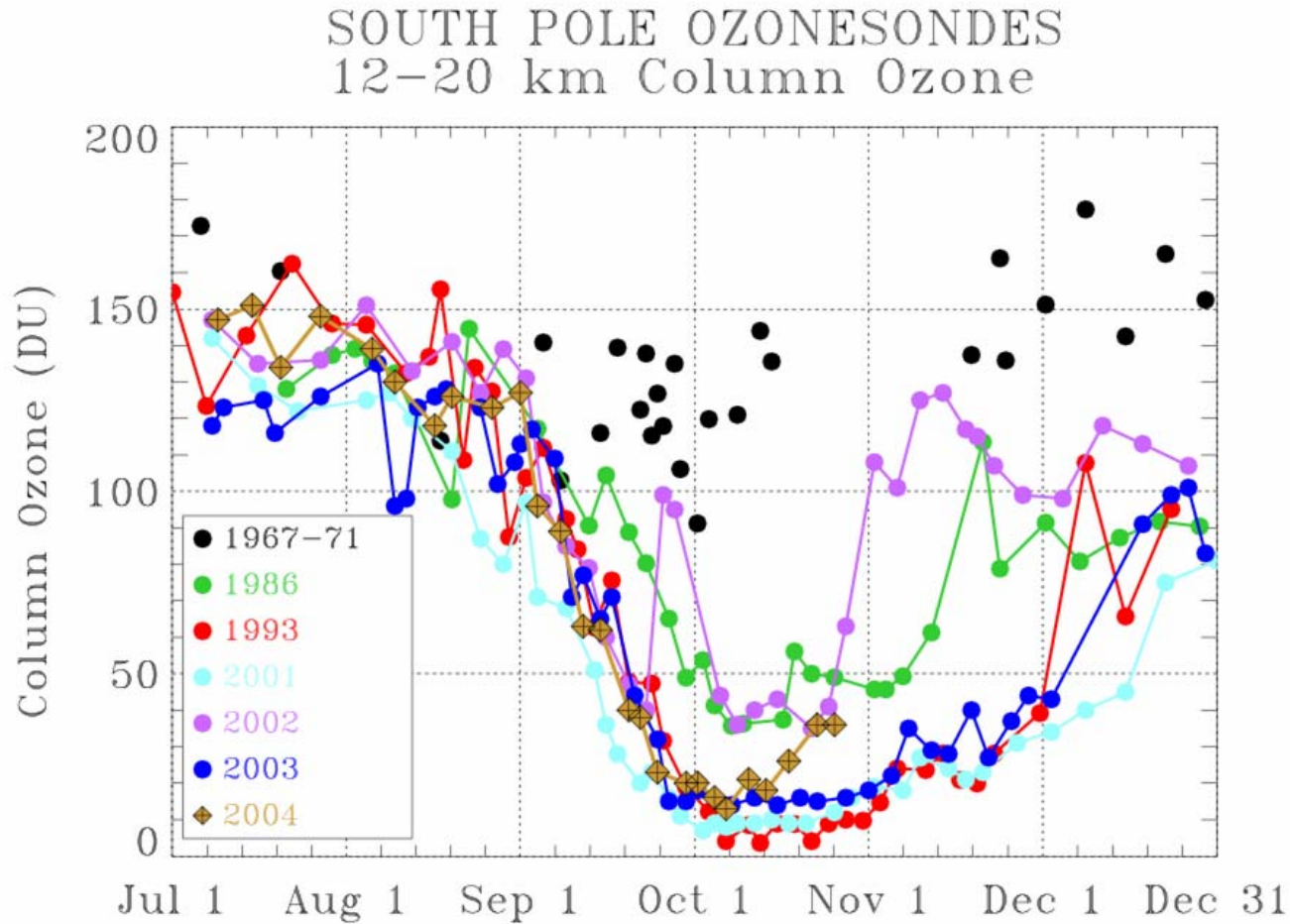


2002 Assessment

- ◆ Ozone depleting capacity of the atmosphere has dropped **6%** since 1992
- ◆ Stratospheric ozone recovery may be noticeable by 2010
- ◆ Montreal Protocol seems to be working
- ◆ The Antarctic **ozone hole** still exists
- ◆ **Column ozone remains lower** than during the 1960's -1980



Recent Ozone Results

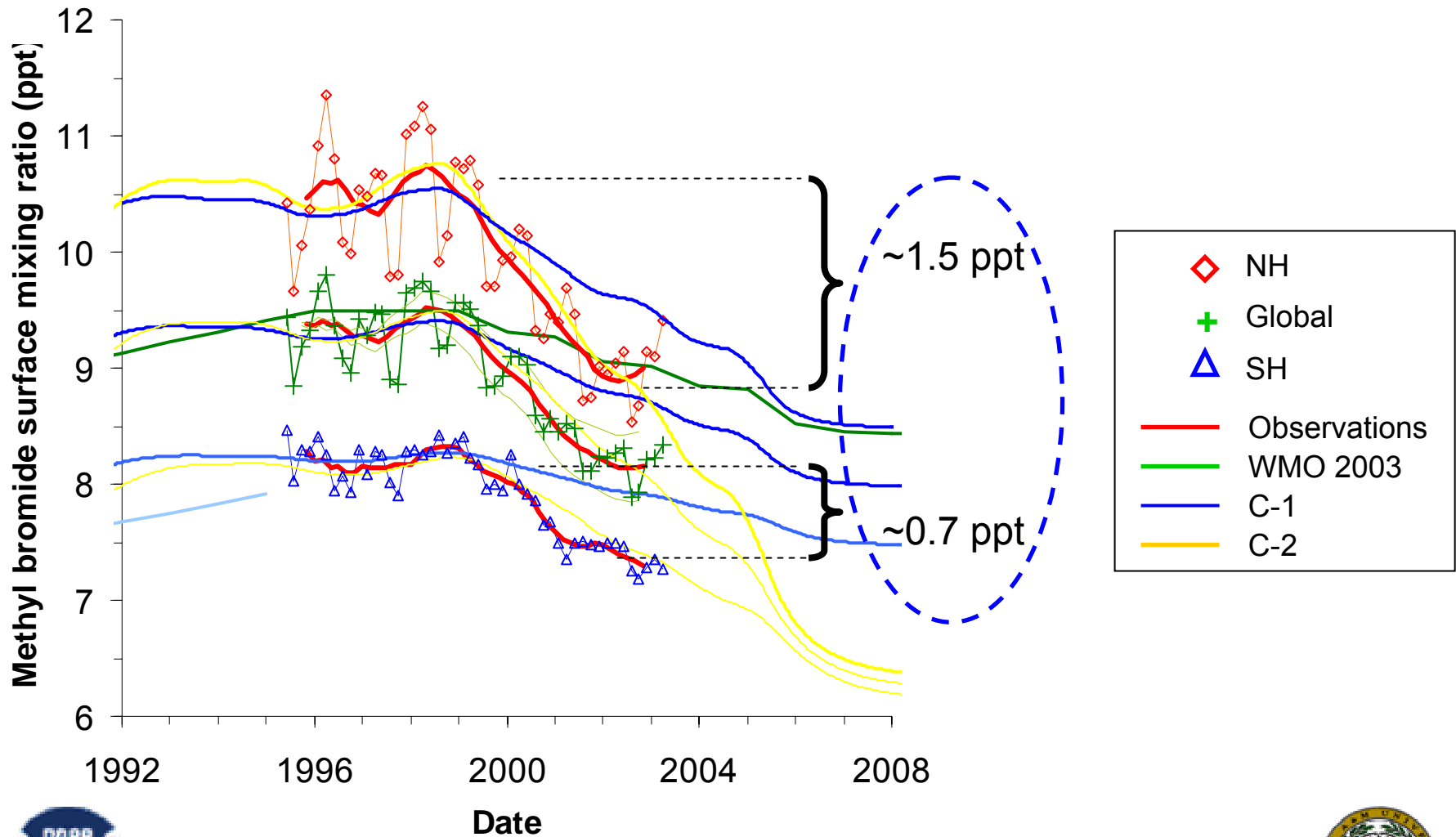


Methyl Bromide through 2002

- ◆ 1998 Scientific Assessment of Ozone Depletion
 - » Budget remains out of balance (sinks > sources by 83 Gg/y)
 - » Lifetime is 0.7 y
 - » Ocean is a small net sink
 - » Fumigation could account for 10-40% of all sources
- ◆ 2002 Scientific Assessment of Ozone Depletion
 - » 20th century atmospheric history obtained from firn
 - » Some new natural sources identified
 - » Budget is still out of balance (sinks > sources by 45 Gg/y), and lifetime remains 0.7 y with a small net ocean sink
 - » Fumigation release estimates remain at ~41 Gg/y



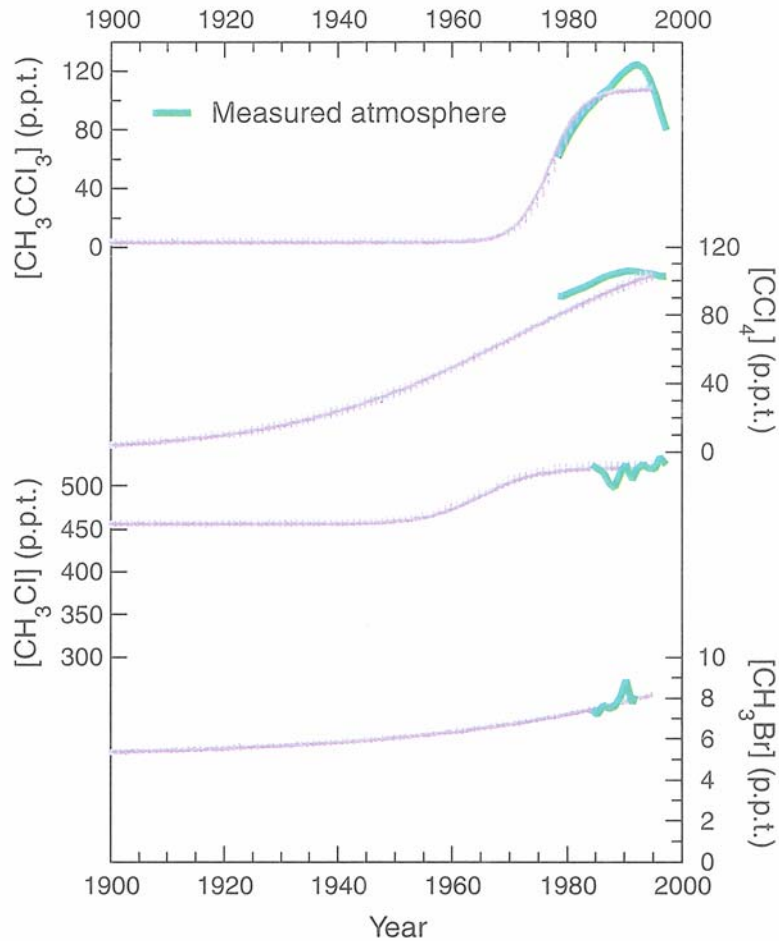
Methyl Bromide 2003



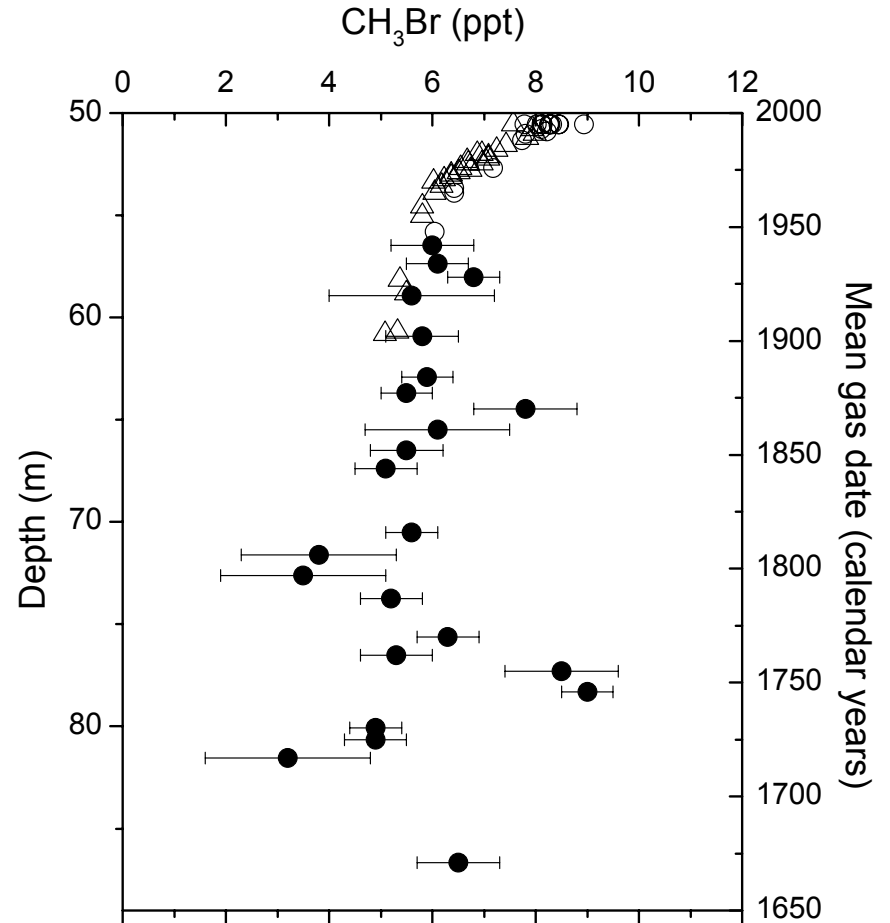
Adapted from Montzka et al, 2003



New in 2004: Ice Core Data



From Butler *et al.* [1999]



From Saltzman *et al.* [2004]



A New Model

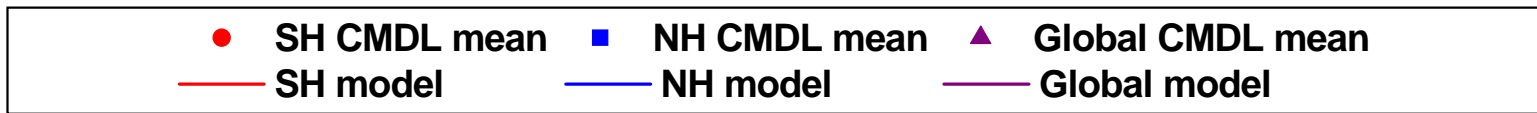
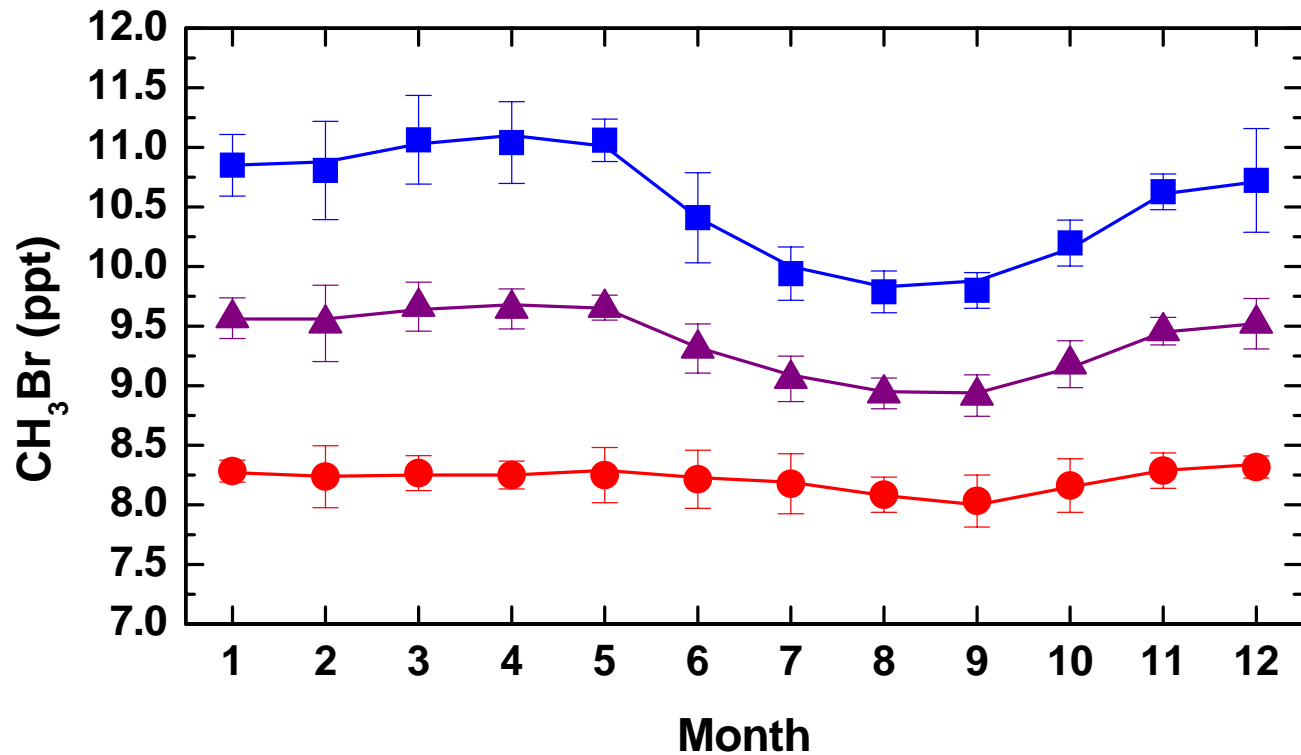
- ◆ Time dependent
- ◆ Two hemispheric atmosphere boxes
- ◆ NH/SH gridded ocean model used to determine oceanic production rates
- ◆ Seasonal NH/SH emissions – Anthropogenic, terrestrial, ocean, biomass burn.,
- ◆ Seasonal NH/SH loss rate constants – OH, ocean, soils - Lifetime is 0.7y
- ◆ Net ocean flux is allowed to vary with atm.
- ◆ “Missing” NH/SH sources tuned to observed seasonality (1995-1998)



Saltzman *et al.* [2004] and Yvon-Lewis and Saltzman, in prep.



Model Including Seasonalities



NH additional source: 18.3 Gg/y
SH additional source: 19.6 Gg/y



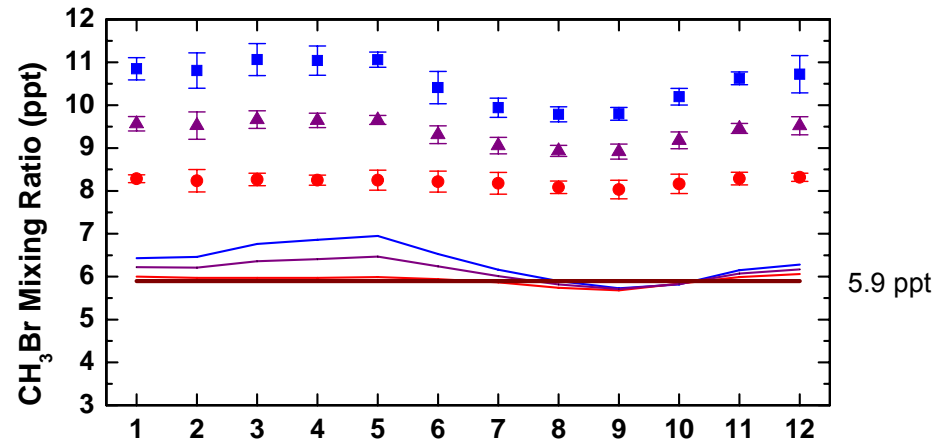
Best Pre-Industrial Scenarios

- ◆ Case 2: Remove all known anthropogenic emissions and reduce biomass burning source by 75%.
- ◆ Case 3: Assume all of the NH “unknown” source is anthropogenic and remove it with the known anthropogenic emissions.

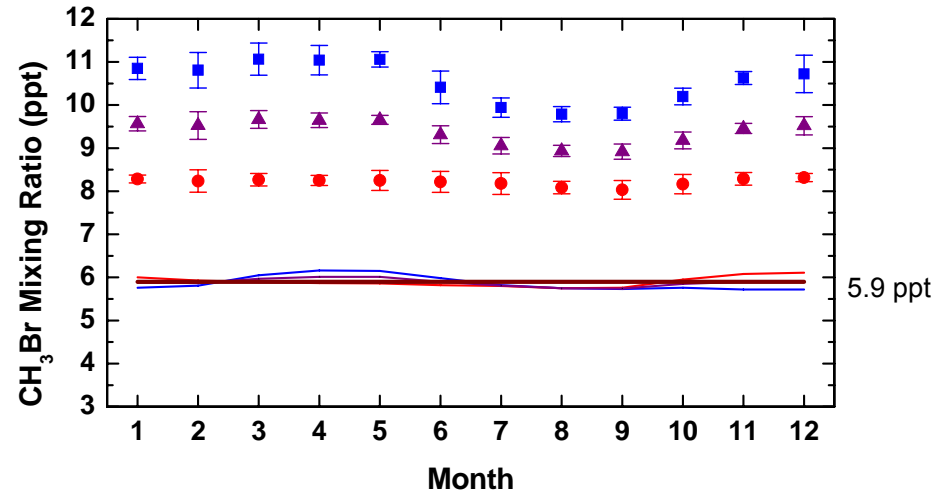


Pre-Industrial Best Fits

CASE 2



CASE 3



Phase Out

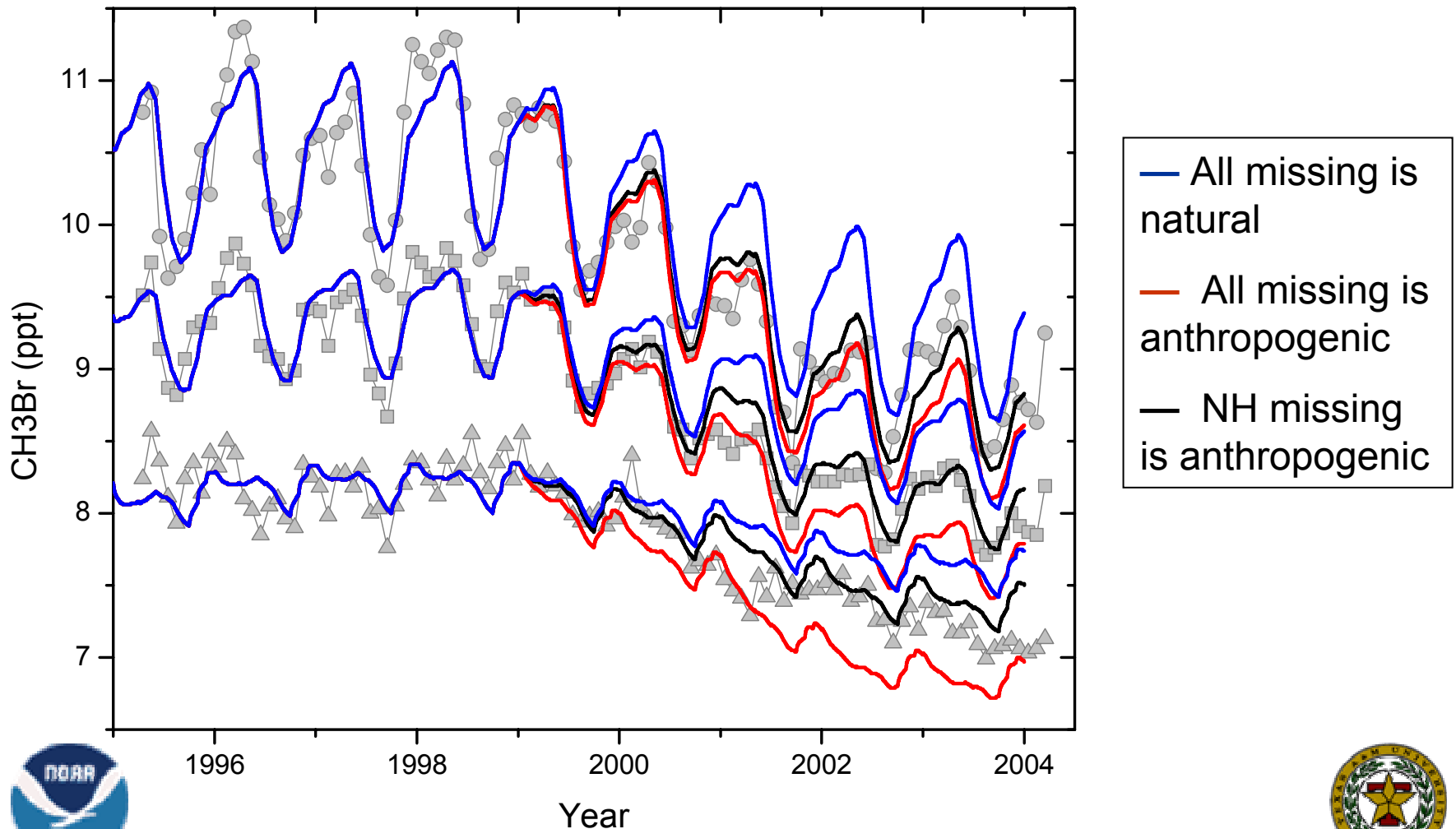
Year	Montreal Protocol	Model
1999	25% reduction	14 % *
2000		21% *
2001	50% Reduction	48% @
2002		(50%)
2003	70% Reduction	(70%)
2004		(70%)
2005	100% Reduction	---



* From UNEP [2002], @ From Montzka *et al* [2004]



Selected Phase Out Scenarios



Conclusions

- ◆ Atmospheric concentrations decreasing rapidly – Montreal Protocol is working
- ◆ Pre-industrial atmospheric concentration confirmed to be ~5.9 ppt
- ◆ Atmospheric lifetime 0.7y
- ◆ Fumigation emissions must have been closer to 61 Gg/y before reductions began
- ◆ Budget is more closely in balance (with a missing source of 18 Gg/y most likely located in the southern hemisphere)



Methyl Bromide Budget Evolution

	1992	1994	1996	1998	2002	2003	2004
Sources							
Ocean	120 (100-300)	90 (60-160)	40 (26-100)	56 (17-61)	63 (23-119)	54(23-119)	54(23-119)
Bio. Burn.	?	30 (10-50)	20 (10-50)	20 (10-40)	20 (10-40)	20 (10-40)	20 (10-40)
Gasoline	?	15 (0.5-22)	15 (0.5-22)	5 (0-10)	5 (0-10)	5 (0-10)	5 (0-10)
Fumigation	30 (15-55)	41 (30-62)	41 (30-62)	41 (30-62)	41 (30-62)	(65-80)	61
Plants (net)					30 (22-47)	30 (22-47)	30 (22-47)
Sinks							
Ocean	?(0-50)	40 (10-110)	57(24-65)	77(38-82)	77(38-82)	68(37-133)	68(37-133)
rxn. OH,hv	75 (60-100)	75 (60-100)	86(68-114)	86(68-114)	80(60-100)	70(60-100)	70(60-100)
Soils	?	?	42(32-74)	42(32-154)	42(32-154)	42(32-154)	42(32-154)
Plants			?	?	?	?	?
Other							
Lifetime (y)	2.0(1.5-2.5)	1.3(0.7-2.1)	0.8(0.6-1.4)	0.7(0.5-1.3)	0.7(0.5-1.3)	(0.8-0.9)	0.7(0.5-1.3)
I.H. ratio	1.3(1.1-1.5)	1.3(1.2-1.4)	1.3(1.2-1.4)	1.3(1.1-1.4)	1.2(1.1-1.3)	1.2(1.1-1.3)	1.2(1.1-1.3)
Net Ocn. Flux (Gg/y)	120(100-300)	50(40-80)	-17(-8 to-25)	-21(-11 to -32)	-14(-11 to -20)	-14(-11 to -20)	-14(-11 to -20)
1990's mol frac. (ppt)	11 (9-13)	11 (9-12)	10(9.5-10.5)	10(9.0-10.5)	10(9-11)	9.3(9-10)	9.3(9-10)
ODP	0.7	0.6	0.4	0.4	0.4	>0.4	0.4



Atm. Burden Revision

Source or Sink Type	Source or Sink Best Estimate (Gg yr ⁻¹)	
Sources		
Ocean	54	(From net flux of -14 Gg/y and uptake)
Fumigation-(soils, durables, perishables, structures)	41.8	(Kurylo et al., 1999)
Gasoline	5	(Kurylo et al., 1999)
Biomass Burning	20	(Mano and Andreae, 1994)
Wetlands	4.6	(Varner et al., 1999)
Salt Marshes	14	(Rhew et al., 2000)
Shrublands	1	(Rhew et al., 2001)
Rapeseed	6.6	(Gan et al., 1998)
Rice Fields	1.5	(Redecker et al., 2000)
Fungus	1.7	(Lee-Taylor and Holland, 2000)
Peatlands	0.9	(Dimmer et al., 2001)
<i>Subtotal (Sources)</i>	<i>150</i>	
Sinks		
Ocean	-68	(Yvon-Lewis and Butler, 1997; 2002)
OH and hv	-71	(De More et al., 1997)
Soils	-42	(Shorter et al., 1995; Varner et al., 1999)
Plants	(not quantified)	
<i>Subtotal (Sinks)</i>	<i>-181</i>	
Total (Sources + Sinks)	-31	

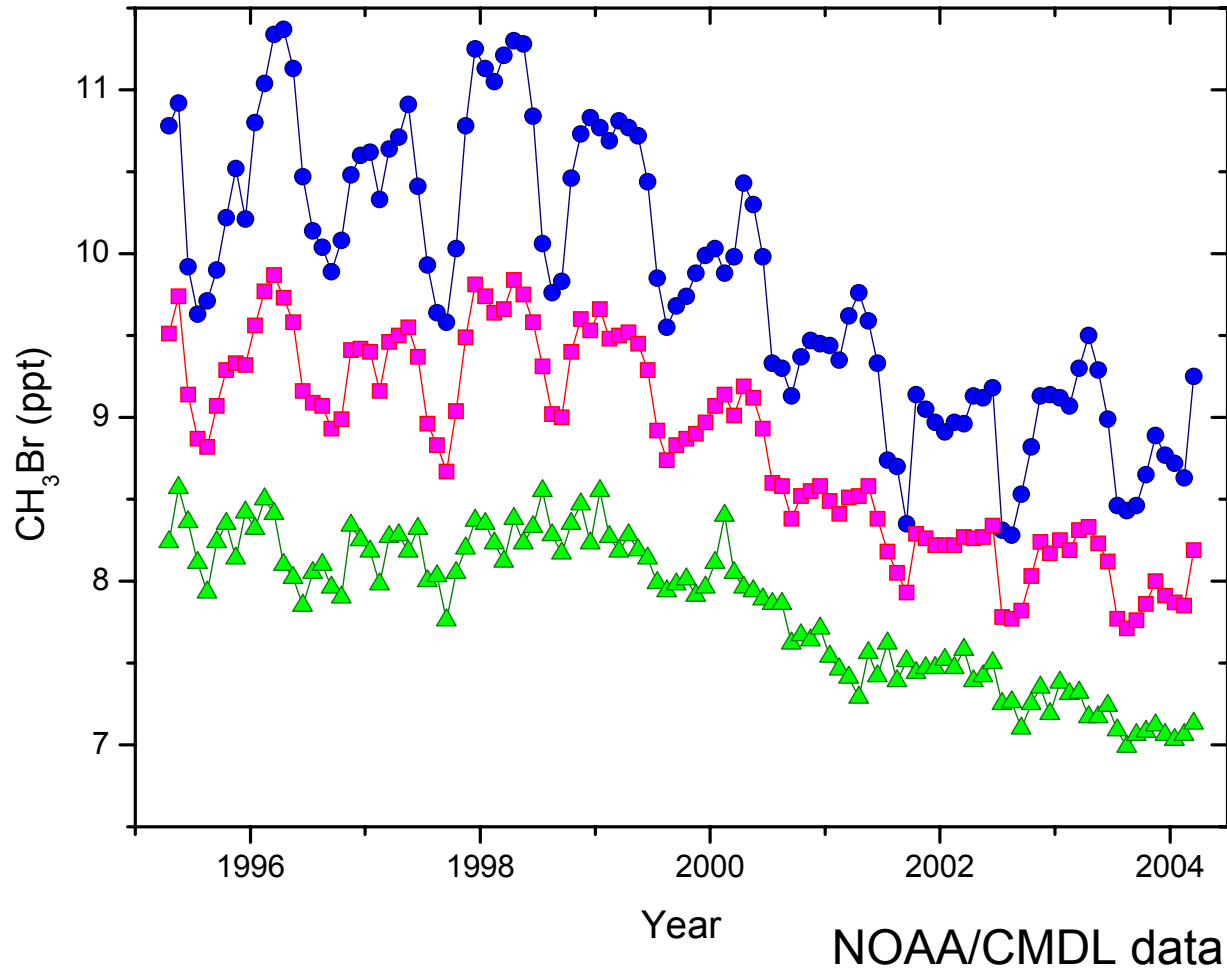
$$\tau = 0.7y$$



Revised from WMO 2002 Report



Observations 2004



Phase Out Best Fit

(Case 3: All NH missing source is anthropogenic)

