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Bayesian assessment of chlorofluorocarbon (CFC), hydrochlorofluorocarbon (HCFC) and halon banks suggest large reservoirs still present in old equipment

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Summary of Prior distributions

Below, we outline prior assumptions for each of the input parameters in the simulation model, parameters in the likelihood function, and the timeframe for the simulation model and observational data.
Mean estimates of the priors for each of the input parameters are derived from AFEAS estimates, or previously published data, as indicated below. Large uncertainties are specified for each of the prior distributions. If the prior distributions resulted in simulated mole fractions that did not encompass observed mole-fractions then prior uncertainties were increased until observed mole fractions were within uncertainty of the prior mole fraction distributions.

HCFC-22 model specifications

<table>
<tr><td>Equipment Categories</td><td>Short bank</td><td>Medium bank</td><td>Long bank</td><td>Feedstock</td></tr>
<tr><td colspan="5">Release Functions</td></tr>
<tr><td>Year 1 emissions:

Prior Distribution</td><td>83% of production

1 – Year 2 distribution</td><td>As a fraction of production:
1944-1977: 20%
1977-1984: 10%
1984-1993: 7%
1993-2019: 6%

Beta Distribution with parameters 6, 6 centered on above values with lower bounds = 0, and upper bound twice the value.</td><td>NA</td><td>Release of 2% of feedstock production

Lognormal distribution such that:
$\mu = 2\%$
$\sigma = 1\%$</td></tr>
<tr><td>Subsequent Year emissions:

Prior Distribution</td><td>Year 2: 17% of production.

Beta Distribution with parameters 4, 4, centered on 17% such that:
$\mu = 17\%$
$\sigma = 6\%$</td><td>Release of 10% of bank a year

Lognormal distribution such that:
$\mu = 10\%$
$\sigma = 5\%$</td><td>Release of 2% of bank a year

Lognormal distribution such that:
$\mu = 2\%$
$\sigma = 1\%$</td><td>NA</td></tr>
<tr><td colspan="5">Production</td></tr>
<tr><td colspan="5">Developed using AFEAS data (https://agage.mit.edu/sites/default/files/documents/em-hcfc-22.pdf) to partition production into short, medium and long banks. Production is then scaled to match UNEP total production estimates for A5 and non-A5 countries. Following 2003, AFEAS data is no longer available and we assume total production is discretized into the AFEAS categories at the same proportion as is reported in 2003. Amounts of HCFC-22 used for feedstock production are available annually (UNEP/TEAP, 2021). A prior mean leakage rate of 2% was assumed during production, which reflects a medium value between different facilities (MCTOC, 2019). For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are;

$$Prod_t \sim Prod_{0,t} \times (0.2 * Log(0, 0.5) + 0.90)$$
Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1.</td></tr>
<tr><td colspan="5">Details of Simulation Model</td></tr>
<tr><td colspan="5">The simulation model is run between 1944 – 2019. Each equipment type is simulated separately (short, medium, long), and total banks the sum of the three. Emissions are the sum of the three equipment type emissions along with feedstock emissions which have a leakage rate prior distribution specified above.</td></tr>
</table>

Likelihood Function
Posteriors are conditioned on observed mole fractions between 2004– 2019. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a beta distribution with lower bound at 3% and upper bound at 6% of observed mole fractions. A correlation of R = 0.98 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.

HCFC-141b model specifications

Equipment Categories	Short bank	Medium bank	Long bank
Release Functions			
Year 1 emissions: Prior Distribution	83% of production 1 – Year 2 distribution	30% of production Beta Distribution with parameters 4, 4 centered on 0.3 with lower bounds = 0.15, and upper bound = 0.45	10% of production Beta Distribution with parameters 4, 4 centered on 0.1 with lower bounds = 0, and upper bound = 0.2
Subsequent Year emissions: Prior Distribution	Year 2: 17% of production. Beta Distribution with parameters 4, 4, centered on 17% such that: $\mu = 17\%$ $\sigma = 6\%$	4.5 year lifetime or ~ 20%/year loss rate. Beta distribution with parameters 4,4 centered on 0.2, with lower bound 0 and upper bound 0.4	Release of 4.5% of bank a year Lognormal distribution such that: $\mu = 4.5\%$ $\sigma = 0.9\%$

Production
Developed using AFEAS data (https://agage.mit.edu/sites/default/files/documents/em-hcfc-141b.pdf) to partition production into short, medium and long banks. For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.2 * Log(0, 0.5) + 0.90)$$ Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1. No feedstock production is included in the analysis.
Details on Simulation model
The simulation model is run between 1944 – 2019. Each equipment type is simulated separately (short, medium, long), and total banks and emissions are the sum of the three.
Likelihood Function
Posteriors are conditioned on observed mole fractions between 2004 – 2019. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a beta distribution with lower bound at 3.5% and upper bound at 6% of observed mole fractions. A correlation of R = 0.95 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.

HCFC-142b model specifications

Equipment Categories	Short bank	Medium bank	Long bank	
Release Functions				
Year 1 emissions: Prior Distribution	83% of production 1 – Year 2 distribution	30% of production Beta Distribution with parameters 4, 4 centered on 0.3 with lower bounds = 0.15, and upper bound = 0.45	32.5% of production Beta Distribution with parameters 4, 4 centered on 0.325 with lower bounds = 0.15, and upper bound = 0.5	2% of feedstock production. Lognormal distribution such that: $\mu = 2\%$ $\sigma = 1\%$
Subsequent Year emissions: Prior Distribution	Year 2: 17% of production. Beta Distribution with parameters 4, 4, centered on 17% such that: $\mu = 17\%$ $\sigma = 6\%$	4.5 year lifetime or ~ 20%/year loss rate. Beta distribution with parameters 4,4 centered on 0.2, with lower bound 0 and upper bound 0.4	Release of 4.5% of bank a year Lognormal distribution such that: $\mu = 3\%$ $\sigma = 0.6\%$	NA
Production				
Developed using AFEAS data (https://agage.mit.edu/sites/default/files/documents/em-hcfc-142b.pdf) to partition production into short, medium and long banks. Amounts of HCFC-142b used for feedstock production are available annually (UNEP/TEAP, 2021). A prior mean leakage rate of 2% was assumed during production, which reflects a medium value between different facilities (MCTOC, 2019). For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.3 * Log(0, 0.5) + 0.95)$$ Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1.				
Details on Simulation model				
The simulation model is run between 1944 – 2019. Each equipment type is simulated separately (short, medium, long), and total banks and emissions are the sum of the three.				
Likelihood Function				
Posteriors are conditioned on observed mole fractions between 2004 – 2019. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard that is inferred from a beta distribution with lower bound at 2.8% and upper bound at 5% of observed mole fractions. A correlation of R = 0.96 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.				

Halon-1211 model specifications

Equipment Categories	Single category
Release Functions	

Year 1 emissions: Prior Distribution	Prior to 1990: 20% of production 1990 - present: 5% of production Beta Distribution with parameters 2, 2. Prior to 1990: Centered on 0.2 with lower bounds = 0, and upper bound = 0.4 1990 - present: Centered on 0.05 with lower bounds = 0, and upper bound = 0.1 *Note that these priors reflect large unknowns in direct emissions during production as this hasn't been well documented to our knowledge. This high upper bound comes from McCulloch (1992) that suggests that People's Republic of China lost 30-40% of annual production each year to direct emissions.
Subsequent Year emissions: Prior Distribution	Prior to 1990: 6% of production 1990 - present: 4% of production Beta distribution with parameters 2,2 Prior to 1990: Centered on 0.06 with lower bounds = 0, and upper bound = 0.12 1990 - present: Centered on 0.04 with lower bounds = 0, and upper bound = 0.08 *These priors are developed from the HTOC report https://ozone.unep.org/sites/default/files/assessment_panels/HTOC_assessment_2018.pdf as well as values from Chapter 9 from SROC.
Production	
Developed using McCulloch (1992) up to 1990, following 1990, UNEP data is used. McCulloch reports varying levels of uncertainty for different time periods, these are used to develop production priors for three different time periods that are independent from one another: Pre-1980, production follows a log normal distribution built on reported production, $Prod_{0,t}$, with the widest uncertainties such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.5 * Log(0, 0.5) + 0.80)$$ 1981-2019, uncertainties are smaller: $$Prod_t \sim Prod_{0,t} \times (0.3 * Log(0, 0.5) + 0.95)$$ Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1. The correlation term is included for three distinct time periods, (pre-1980, 1981 – 1990, 1991 – 2019), to reflect that we expect there to be common biases in reporting within those time periods, but that the correlation does not necessarily apply across time periods when reporting practices change.	
Details on Simulation model	
The simulation model is run between 1963 – 2019. Each equipment type is simulated separately (short, medium, long), and total banks and emissions are the sum of the three.	
Likelihood Function	
Posteriors are conditioned on observed mole fractions between 2004 – 2019. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 4% and upper bound equal to 6% of observed mole fractions. A correlation of R = 0.7 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.	

Halon-1301 model specifications

Equipment Categories	Single category
Release Functions	

Year 1 emissions: Prior Distribution	Prior to 1990: 20% of production 1990 - present: 5% of production Beta Distribution with parameters 2, 2: Prior to 1990: Centered on 0.2 with lower bounds = 0, and upper bound = 0.4 1990 - present: Centered on 0.05 with lower bounds = 0, and upper bound = 0.1 *As in Halon-1211, these priors reflect large unknowns in direct emissions during production as this hasn't been well documented to our knowledge. This high upper bound comes from McCulloch (1992) that suggests that People's Republic of China lost 30-40% of annual production each year to direct emissions.
Subsequent Year emissions: Prior Distribution	Prior to 1990: 5% of production 1990 - present: 4% of production Beta distribution with parameters 2,2 Prior to 1990: Centered on 0.06 with lower bounds = 0, and upper bound = 0.12 1990 - present: Centered on 0.04 with lower bounds = 0, and upper bound = 0.08 *These priors are developed from the HTOC report https://ozone.unep.org/sites/default/files/assessment_panels/HTOC_assessment_2018.pdf as well as values from Chapter 9 from SROC.

Production

Developed using McCulloch (1992) up to 1990, following 1990, UNEP data is used.
McCulloch reports varying levels of uncertainty for different time periods, these are used to develop production priors for three different time periods that are independent from one another:
Pre-1972, production follows a log normal distribution built on reported production, $Prod_{0,t}$, with the widest uncertainties such that yearly production values are;

$$Prod_t \sim Prod_{0,t} \times (0.5 * Log(0, 0.5) + 0.80)$$

1973-2019, uncertainties are smaller:

$$Prod_t \sim Prod_{0,t} \times (0.3 * Log(0, 0.5) + 0.95)$$

Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1. The correlation term is included for three distinct time periods, (pre-1980, 1981 – 1990, 1991 – 2019), to reflect that we expect there to be common biases in reporting within those time periods, but that the correlation does not necessarily apply across time periods when reporting practices change.

Details on Simulation model

The simulation model is run between 1963 – 2019. Each equipment type is simulated separately (short, medium, long), and total banks and emissions are the sum of the three.

Likelihood Function

Posteriors are conditioned on observed mole fractions between 2004 – 2019. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 3% and upper bound equal to 6% of observed mole fractions. A correlation of R = 0.7 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.

CFC-11

Equipment categories	Non-hermetic Refrigeration	Blowing Agents Closed Cell Foam	Open Cell Foam, Aerosols and Others
Release Fractions			

Year 1: Prior Distribution	Year 1: 7% release Lognormal with parameters such that μ= 7% and $\sigma = 3.5\%$	NA	Year 1: 83% release for Open Cell Foam, 50% release for Aerosols Beta, parameters 8, 6 which gives: $\mu = 57\%$, $\sigma = 13\%$
Subsequent years: Prior Distribution	Life years: 10 years Lognormal μ = 10 years, σ =2 year	3.66% of bank Lognormal with parameters such that $\mu = 3.66\%$ and $\sigma = 1.83\%$	Year 2: 17% release for open cell foam, 50% release for aerosols Modeled jointly with Year 1 distribution. (1 – Year 1 release)
Production			
Developed using AFEAS data up until 1989 (https://unfccc.int/files/methods/other_methodological_issues/interactions_with_ozone_layer/application/pdf/cfc1100.pdf) and augmented by UNEP data following 1989. AFEAS data is used to partition production into the various equipment types. For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.2 * Log(0, 0.5) + 0.95)$$ Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1. Following (Lickley et al., 2020), we address the unexpected emissions, as identified by (Montzka et al., 2018), by adding an unreported production term that has a linearly increasing upper bound starting at 0 in 2000 and increasing to 61,000 tonnes in 2012, after which point the upper bound is held constant through the remainder of the simulation period. The distribution following 2000 is a uniform distribution between 0 and the upper bound in each year, to reflect the level of uncertainty in production throughout that time period.			
Details on Simulation Model			
The bank simulation model runs from 1955-2018.			
Likelihood Function			
Posteriors are conditioned on observed mole fractions between 1980 – 2018. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 2% and upper bound equal to 4% of observed mole fractions. A correlation of R = 0.96 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.			

CFC-12 Model Specifications

Equipment categories	Non-hermetic Refrigeration	Hermetic Refrigeration	Blowing Agents Closed Cell Foam	Open Cell Foam, Aerosols and Others
Year 1: Prior Distribution	Year 1: 7% release Lognormal with parameters s.t. μ= 7%, $\sigma = 3.5\%$	Year 1: 2% release Lognormal with parameters s.t. μ= 2%, $\sigma = 1\%$	Year 1: 50% release Beta Distribution with parameters 2, 2 which gives: $\mu = 50\%$, $\sigma = 22\%$	Year 1: 83% release for Open Cell Foam, 50% release for Aerosols and others Beta, parameters 2, 2 which gives: $\mu = 50\%$, $\sigma = 22\%$

Subsequent years: Prior Distribution	Life years: 10 years Lognormal μ = 10 years, σ =2 year	Life years: 20 years Lognormal μ = 20 years, σ =4 year	Year 2: 50% release Modeled jointly with Year 1. (1 – Year 1 release)	Year 2: 50% release Modeled jointly with Year 1. (1 – Year 1 release)
Production				
Developed using AFEAS data up until 1989 (https://unfccc.int/files/methods/other_methodological_issues/interactions_with_ozone_layer/application/pdf/cfc1200.pdf) and augmented by UNEP data following 1989. AFEAS data is used to partition production into the various equipment types. For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.2 * Log(0, 0.5) + 0.95)$$ Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1.				
Details on Simulation Model				
The bank simulation model runs from 1955-2018.				
Likelihood Function				
Posteriors are conditioned on observed mole fractions between 1980 – 2018. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 1.5% and upper bound equal to 3% of observed mole fractions. A correlation of R = 0.98 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.				

CFC-113 Model Specifications

Equipment categories	Short Bank	Long Bank
Year 1: Prior Distribution	Year 1: 50% release Beta Distribution with parameters 12, 12 which gives: $\mu = 50\%, \ \ \sigma = 10\%$	Year 1: 2% release Lognormal with parameters s.t. μ= 2%, σ = 1%
Subsequent years: Prior Distribution	Year 2: 50% release Modeled jointly with Year 1. (1 – Year 1 release)	Life years: 20 years Lognormal μ = 20 years, σ =4 year
Production		
Developed using AFEAS data up until 1989 (https://agage.mit.edu/sites/default/files/documents/em-cfc-113.pdf) and augmented by UNEP data following 1989. AFEAS data is used to partition production into the various equipment types. Amounts of CFC-113 used for feedstock production are available annually (UNEP/TEAP, 2021). A prior mean leakage rate of 2% was assumed during production, which reflects a medium value between different facilities (MCTOC, 2019). For short bank and long bank uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.4 * Log(0, 0.5) + 0.70)$$		

For CFC-113 feedstock, production follows a log normal distribution;

$$Prod_t \sim Prod_{0,t} \times (0.3 * Log(0, 0.5) + 0.95)$$

Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1.

Details on Simulation Model

The bank simulation model runs from 1955-2018.

Likelihood Function

Posteriors are conditioned on observed mole fractions between 2004– 2018. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 1% and upper bound equal to 4% of observed mole fractions. A correlation of R = 0.95 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.

CFC-114 Model Specifications

Equipment categories	Short Banks	Long Banks
Year 1: Prior Distribution	Year 1: 50% release Beta Distribution with parameters 8, 8 which gives: $\mu = 50\%,\ \ \sigma = 12\%$	Year 1: 2% release Lognormal with parameters s.t. $\mu = 2\%, \sigma = 2\%$
Subsequent years: Prior Distribution	Year 2: 50% release modeled jointly with Year 1. (1 – Year 1 release)	Lifetime: 20 years Lognormal bank emissions s.t. $\mu = 4.88\%$ release, $\sigma = 2.44\%$

Production

Developed using AFEAS data up until 1989 (https://agage.mit.edu/sites/default/files/documents/em-cfc-114.pdf) and augmented by UNEP data following 1989. AFEAS data is used to partition production into the various equipment types. For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are;

$$Prod_t \sim Prod_{0,t} \times (0.2 * Log(0, 0.5) + 0.90)$$

Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1.

Details on Simulation Model

The bank simulation model runs from 1935-2019.

Likelihood Function

Posteriors are conditioned on observed mole fractions between 2004– 2019. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 1% and upper bound equal to 3% of observed mole fractions. A correlation of R = 0.7 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.

CFC-115 Model Specifications

Equipment categories	Short Bank	Long Bank
Year 1: Prior Distribution	Year 1: 50% release Beta Distribution with parameters 8, 8 which gives: $\mu = 50\%, \ \ \sigma = 12\%$	Year 1: 7% release Beta Distribution with parameters 4, 4 centered on 7% which gives: $\mu = 7\%, \ \ \sigma = 2.33\%$
Subsequent years: Prior Distribution	Year 2: 50% release modeled jointly with Year 1. (1 – Year 1 release)	Lifetime: 10 years Lognormal bank emissions s.t. μ = 9.5% release, σ =4.75%
Production		
Developed using AFEAS data up until 1989 (https://agage.mit.edu/sites/default/files/documents/em-cfc-115.pdf) and augmented by UNEP data following 1989. AFEAS data is used to partition production into the various equipment types. For each of the uses, production follows a log normal distribution built on reported production, $Prod_{0,t}$, such that yearly production values are; $$Prod_t \sim Prod_{0,t} \times (0.2 * Log(0, 0.5) + 0.9)$$ Year-to-year values deviate from reported production with a correlation term drawn from a beta distribution with parameters 2, 2, and lower bound of 0.5 and upper bound of 1.		
Details on Simulation Model		
The bank simulation model runs from 1935-2019.		
Likelihood Function		
Posteriors are conditioned on observed mole fractions between 2004– 2010. The likelihood function is a multivariate normal likelihood function of the difference between yearly observed and modeled mole fractions is used with mean equal to zero and standard deviation that is inferred from a prior following a beta distribution with lower bound equal to 5% and upper bound equal to 8% of observed mole fractions. A correlation of R = 0.3 is included in the multivariate covariance function to represent an assumed correlated error between modeled and observed mole fraction.		

Bank estimates assuming total end of life decommissioning

Figure SM1 shows banks of CFC-11, CFC-12 and HCFC-22 where an end-of-life decommissioning of materials is inferred in the analysis. For CFC-11, the end-of-life of the materials is incorporated for closed-cell foams, whereas for CFC-12 and HCFC-22, end-of-life of materials is incorporated for non-hermetic refrigeration. These materials were chosen as they represent the largest banks. To model end-of-life decommissioning we update equations 1 and 2 of the modeling framework to account for the assumption that emissions of all remaining banked material occur once the bank has reached its lifetime, LT. We assume that prior to LT years, the bank yearly release fraction is equivalent to exp(-1/LT). Banks of the above-mentioned materials are then modeled as;

$$B_{j,t+1} = (1 - RF_{j,t}) \times B_{j,t} + (1 - DE_{j,t}) \times P_{j,t} - B_{j,t-LT} \times \exp(-1) \quad (1)$$

And emissions are modeled as ;

$$E_{j,t+1} = RF_{j,t} \times B_{j,t} + DE_{j,t} \times P_{j,t} + B_{j,t-LT} \times \exp(-1) \quad (2)$$

Where $RF_{j,t} = \exp\left(-\frac{1}{LT}\right)$. Prior distributions of LT and thus release fractions are developed as explained in the main text and reported in the Supplement. As is done for all other parameters, posterior LT and thus release fraction values are then inferred based on observations.

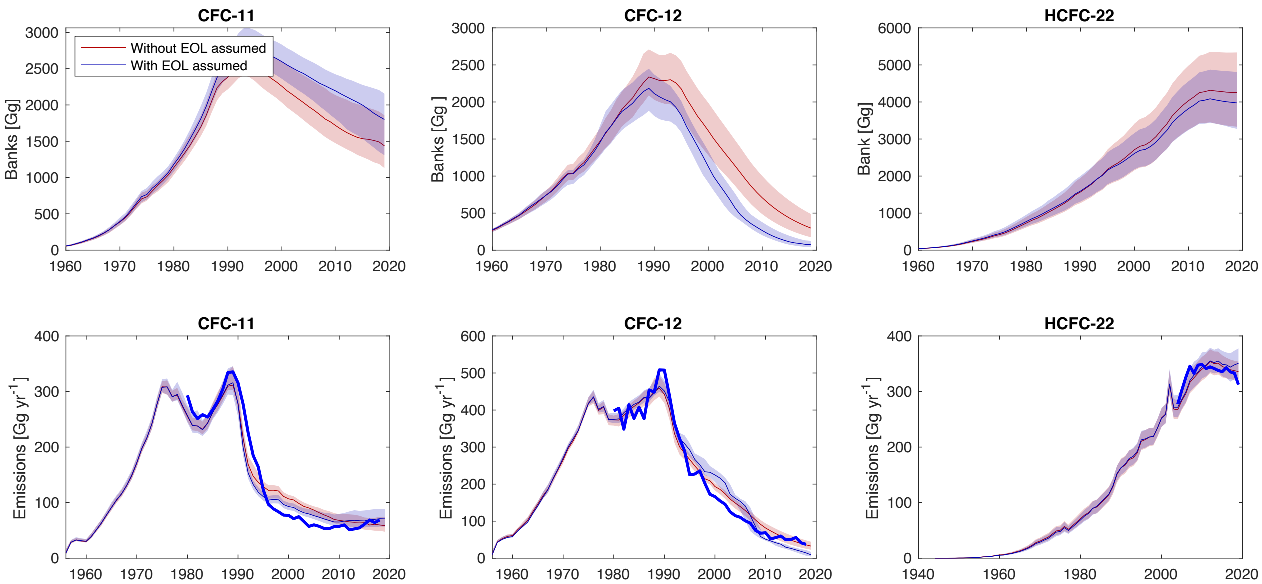

Figure S1: Posterior bank (top) and emissions (bottom) estimates. Red values show the median and 90% confidence interval usingassumptions outlined in the main text. Blue is the equivalent to red but assumed end-of-life (EOL) decommissioning occurs for closed-cell foams (CFC-11) and non-hermetic refrigeration (CFC-12 and HCFC-22). Observationally-derived emissions assuming the SPARC multi-model mean is shown in the blue line.

References:

Ashford, P., Clodic, D., McCulloch, A. & Kuijpers, L. Emission profiles from the foam and refrigeration sectors comparison with atmospheric concentrations. Part 1: Methodology and data. Int. J. Refrig. 27, 687–700 (2004).

Hong, B., Strawderman, R. L., Swaney, D. P. & Weinstein, D. A. Bayesian estimation of input parameters of a nitrogen cycle model applied ot a forested reference watershed, Hubbard Brook Watershed Six. Water Resour. Res. 41, W03007 (2005).

Gamlen, P. H., Lane, B. C., Midgley, P. M. & Steed, J. M. The production and release to the atmosphere of CCl3F and CCl2F2 (chlorofluorocarbons CFC 11 and CFC 12). Atmos. Environ. 20, 1077–1085 (1986).

Lickley, M., Solomon, S., Fletcher, S. *et al.* Quantifying contributions of chlorofluorocarbon banks to emissions and impacts on the ozone layer and climate. *Nat Commun* **11,** 1380 (2020). https://doi.org/10.1038/s41467-020-15162-7

Lickley, M., Fletcher, S., Rigby, M. *et al.* Joint inference of CFC lifetimes and banks suggests previously unidentified emissions. *Nat Commun* **12,** 2920 (2021). https://doi.org/10.1038/s41467-021-23229-2

McCulloch, A. (1992). Global production and emissions of bromochlorodifluoromethane and bromotrifluoromethane (halons 1211 and 1301). *Atmospheric Environment. Part A. General Topics*, *26*(7), 1325-1329.

McCulloch, A., Midgley, P. M., & Lindley, A. A. (2006). Recent changes in the production and global atmospheric emissions of chlorodifluoromethane (HCFC-22). *Atmospheric Environment*, *40*(5), 936-942.

Montzka, S. A. et al. An unexpected and persistent increase in global emissions of ozone-depleting CFC-11. Nature 557, 413 (2018).

Poole, D. & Raftery, A. E. Inference for deterministic simulation models: the Bayesian melding approach. J. Am. Stat. Assoc. 95, 1244–1255 (2000).

Velders, G. J. M. & Daniel, J. S. Uncertainty analysis of projections of ozone depleting substances: mixing ratios, EESC, ODPs, and GWPs. Atmos. Chem. Phys. 14, 2757–2776 (2014).