ODP *and lifetime* calculations with GMI

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Code 613.3 NASA GSFC

Motivation (1)

- CFC lifetimes are needed
  - Estimate the size of banks
  - Produce scenarios for assessment calculations (both ozone response and climate change)
- Lifetime estimates changed during the 90s but have not changed since 1998; models have changed dramatically since then (e.g., age-of-air, tropical isolation)
- Douglass et al. (2007) show that simulations that produce realistic mean age have longer lifetimes than used by WMO to project future evolution of source gases.

Motivation (2)

- ODP estimates are needed for regulation
- ODP is defined as the ratio of global loss of ozone due to given substance and global loss of ozone due to CFC-11 of the same mass
  - Wuebbles (1983) uses the ODP and only considers chlorine containing compounds.
  - The concept was developed before there was knowledge of heterogeneous chemical reactions that lead to ozone loss in the polar and midlatitude lower stratosphere.

Questions

- How do lifetime estimates for circulation with ‘good mean age’ compare with WMO estimates?
- Is the ODP sensitive to the circulation (evaluated using comparisons with mean age)?
- ODP was originally developed to compare the impact of various chlorine containing constituents on ozone. Noting that models have systematic biases compared with data, is it appropriate to extend the ODP to compare the impact of molecules that do not contain chlorine on stratospheric ozone?

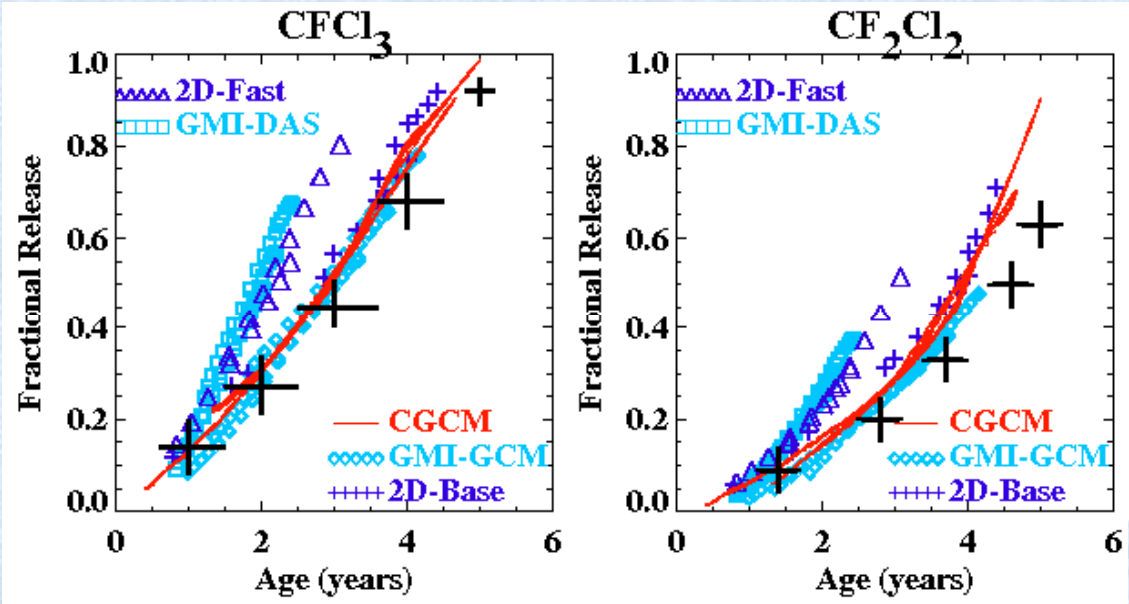
Question 1:
Do GMI lifetimes differ from prior estimates?

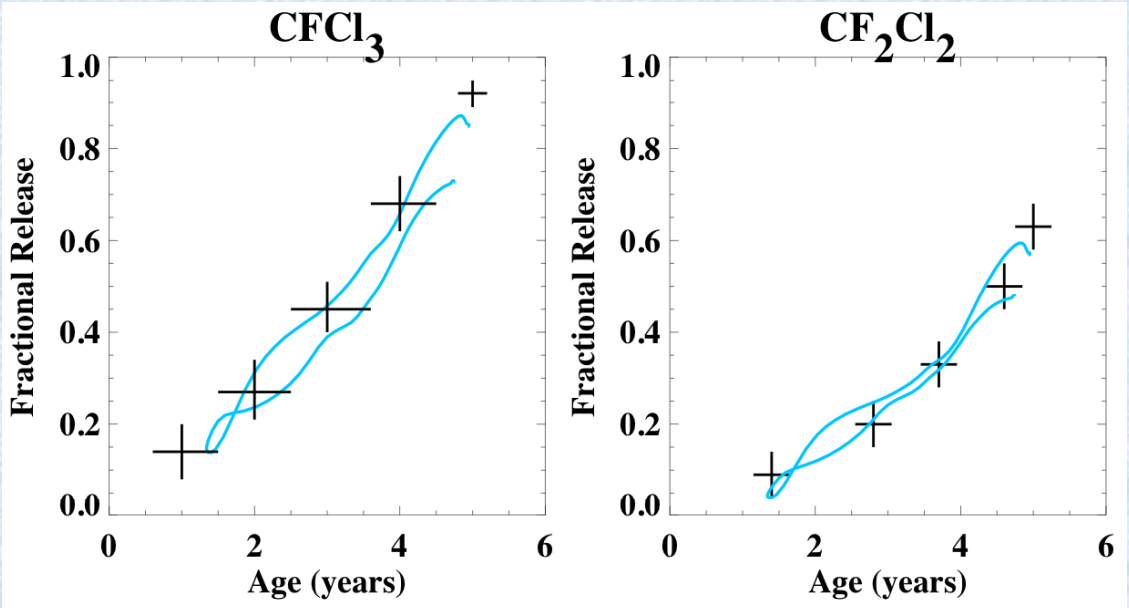
Species	GMI	WMO 2007	Wuebbles 1983
CFCl3	65	45	63.8
CF2Cl2	106	100	107.8
CH3CCl3	7.5	5.0	9.7
HCFC22	17	12	27.7
CCl4	59*	26	57
CFC-113	93	85	88.3
N2O	121	114	

YEARS

Answer 1: Lifetimes are longer

*atmospheric loss only





Douglass et al. (2007) report
1. Good agreement of simulated mean age with that derived from observations and
2. Good agreement of the simulated relationship between the fractional release and mean age with that derived from observations (Schauffler et al. 2003).

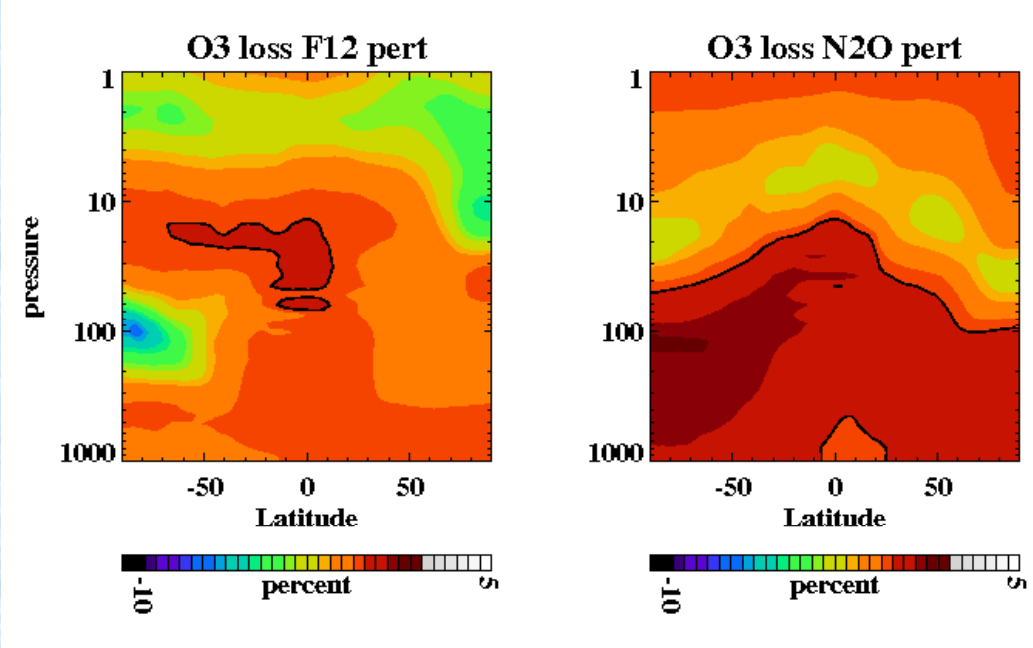
Both support the longer computed lifetimes.

Question 2:
Is the ODP sensitive to the circulation?

Species	GMI ODP	Semi-empirical	Montreal Protocol	Wuebbles 1983
F11	1.0	1.0	1.0	1.0
F12	0.8	1.0	1.0	0.86
CH3CCl3	0.13	0.12	0.1	0.15
HCFC22	0.04	0.05	0.055	0.05
CCl4	1.1	0.73	1.1	1.11
CFC113	0.73	1.0	0.8	0.8
N2O	0.011			

The ODPs from 1983 are remarkably similar to those calculated using the current 3D model for chlorine species. Our hypothesis is that although the ODP as originally formulated essentially compared the amount of chlorine released per unit mass of some species relative to the amount of chlorine released per unit mass of F11. Model deficiencies would cancel.

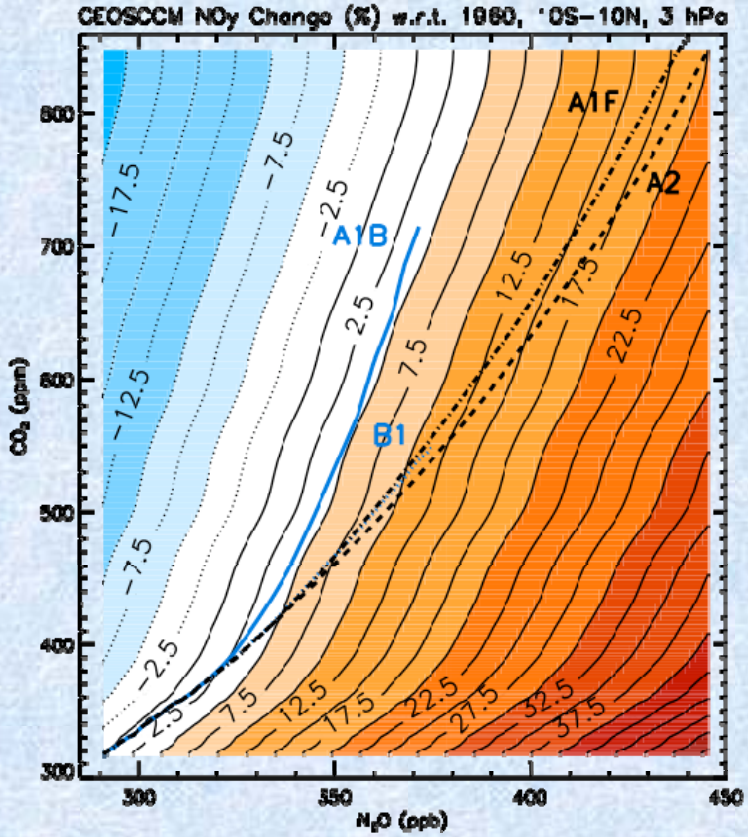
What about applying the concept to some non-chlorine containing species (e.g., N2O)?



Patterns are completely different. More than 20% of the global annual ozone loss due to chlorine is due to winter polar loss. Present models tend to underestimate the polar ozone loss processes. Model deficiencies impact the N2O PDF. If simulated ozone sensitivity to chlorine is underestimate, the ODP for N2O will be overestimated (and vice versa).

Other things to think about

CO2



N2O

The net change in NOy is a function of temperature; amount of NOy produced per N2O decreases as the stratosphere cools as N + O2 is less important at cooler temperatures, making N + NO more efficient and destroying NOy.

Conclusions

- Observationally derived relationship of fractional release to mean age supports longer lifetimes for several CFCs than presently adopted by WMO
- ODPs for chlorine species are insensitive to model specifics
- ODP for non-chlorine containing species may be sensitive to model deficiencies and should be applied with care.
- Changes in climate may also contribute to the net sensitivity of ozone to constituent change.