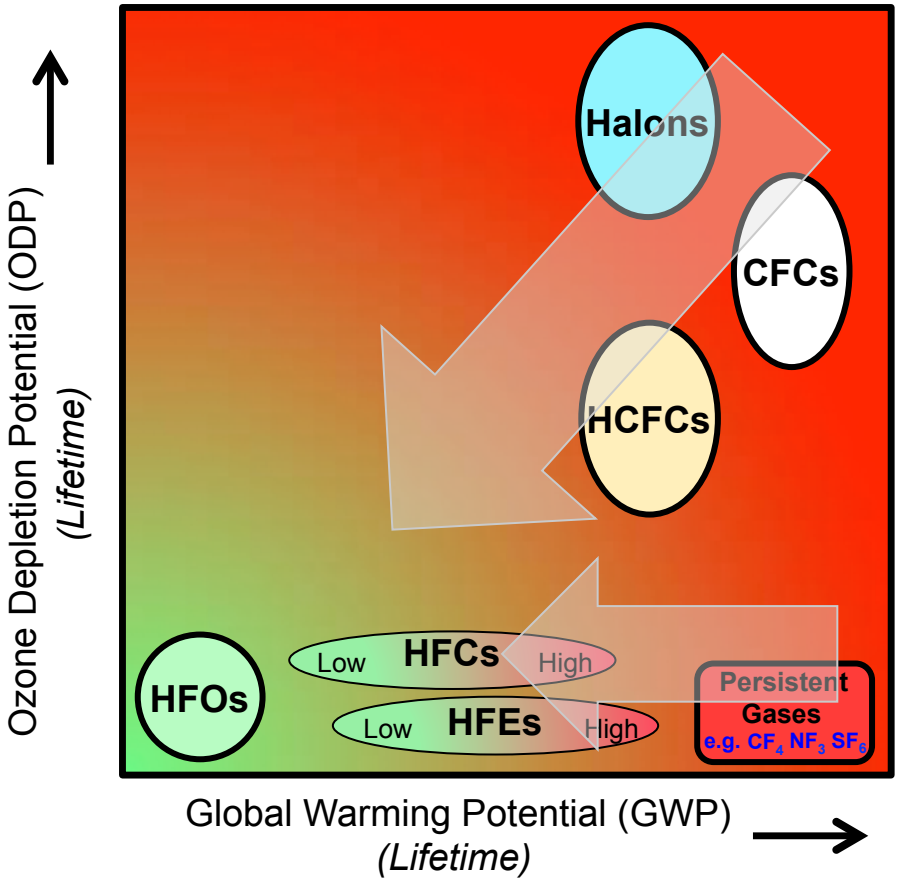
Laboratory studies of replacement compounds for ozone depleting substances

James Burkholder

NOAA Climate Research Goal: Stratospheric Ozone and Radiative Forcing

Montreal Protocol: A Plan to Phase-out Ozone Depleting Substances



Industry: Identify Suitable Replacements

Key Metrics for Suitability

Ozone Depletion Potential (ODP)

Global Warming Potential (GWP)

Depend on Substances Atmospheric Lifetime

CSD Laboratory Studies Provide Atmospheric Lifetime Information

Loss Processes

- Reaction Rates (OH, $O(^1D)$, Cl, …)
- UV Photolysis Rates

Study elementary chemical processes relevant to Earth's atmosphere under well-controlled conditions

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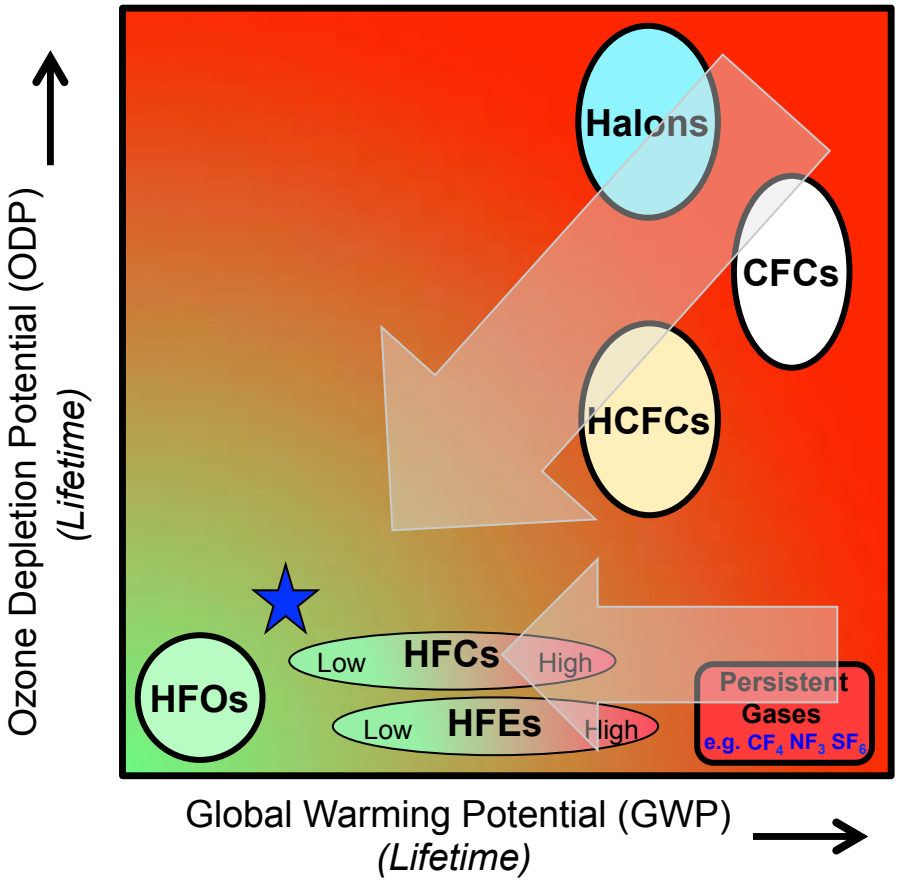

CSD Laboratory

Independent Broker of Information

* Expertise
* Technical Capability
* Identify Relevant Species and Chemical Processes

Stakeholders

Industry
Regulatory Agencies

Assessments (e.g. WMO, IPCC)

Laboratory Data Evaluations
Atmospheric Models (*forecasts*)

Laboratory Studies → Modeling → Improved Understanding: Projections/Impacts → **Policy (Protocols)**

Laboratory studies of replacement compounds for ozone depleting substances

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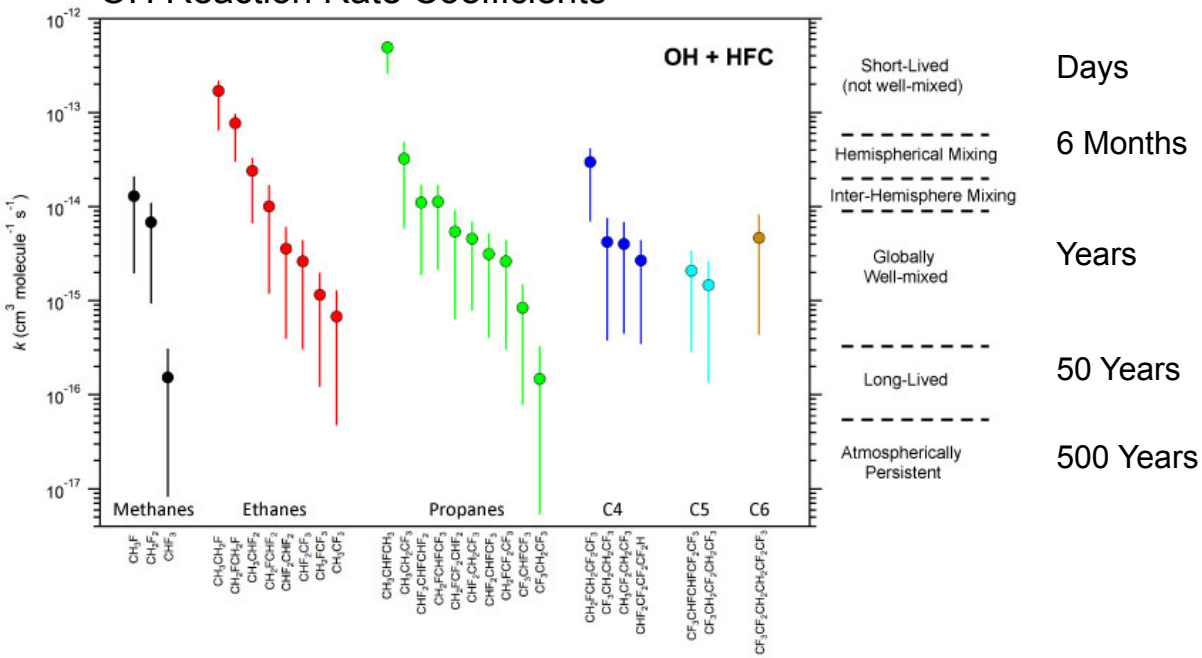
Not all compounds in a Class behave the same

OH Reaction Rate Coefficients



Degradation Region	Lifetime
Short-Lived (not well-mixed)	Days
Hemispherical Mixing	6 Months
Inter-Hemisphere Mixing	
Globally Well-mixed	Years
Long-Lived	50 Years
Atmospherically Persistent	500 Years

Informed Research

- Industry
- Regulatory Agencies
- Field observations
- Assessments
- Experience

Collaborators

Industry/Academic/Gov't

- NOAA/CSD: modeling
- NASA/Goddard modeling
- NOAA/GMD
- AGAGE network/MIT/EMPA
- Scripps Res. Inst.
- DuPont
- Honeywell

Laboratory Measurements Tailored to the Compound

- ***Not all compounds require the same laboratory measurements***
- ***A complete study ~4-6 months***
- ***Informed decisions on systems to study required***

NOAA Laboratory Capabilities: Poster and Lab Tour

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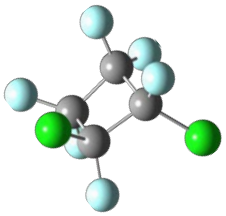
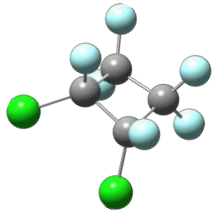
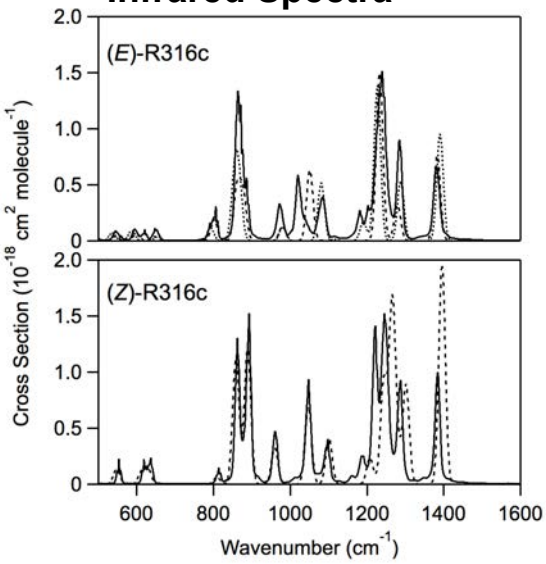


Example: R-316c, 1,2-$C_4Cl_2F_6$ (*E*,*Z*)



Infrared Spectra



* **Potent GHG**

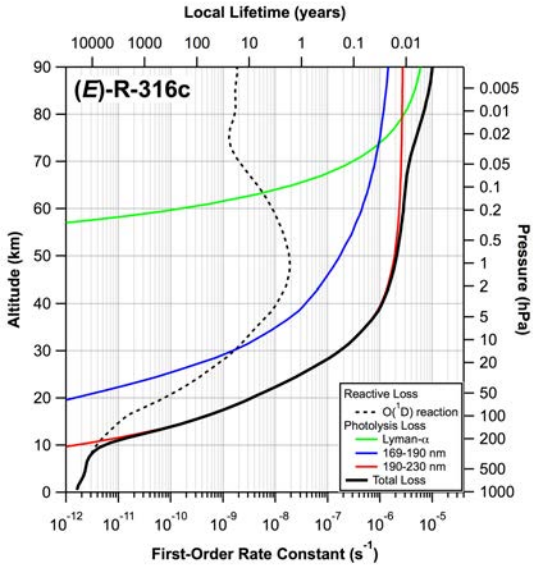
$k(O(^1D) = 1.6 \times 10^{-10}$ cm^3 s^{-1}

Reaction yield = 0.88 ± 0.02

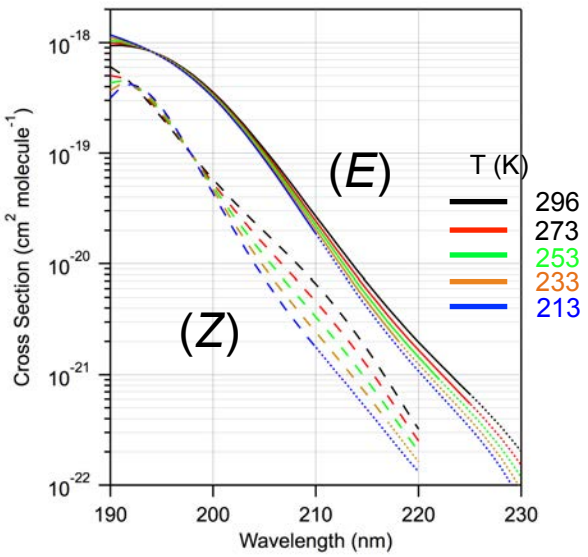
R-316c → c-C_4F_6

O(^{1}D) and hv

High yield product



UV Absorption Spectra



* **Photolysis is primary loss process**

* Quantum yield = 1 (2 Cl atoms)

Removal in the Stratosphere

2-D model (NASA/Goddard)

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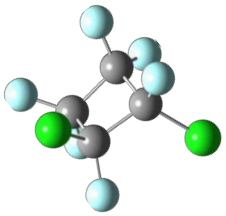

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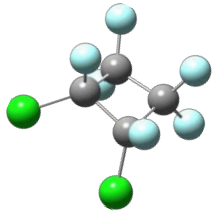
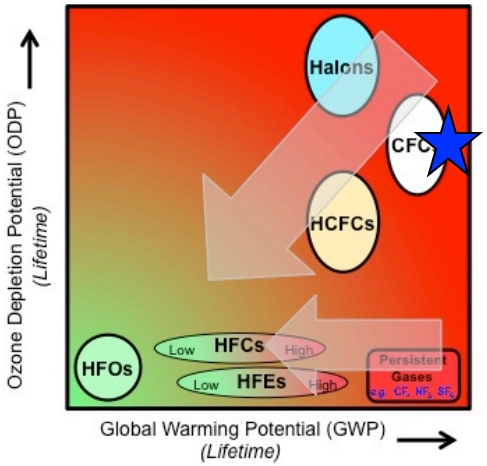


Laboratory Results Summary

	(*E*)	(*Z*)	
Lifetime (yrs)	75	114	High
ODP	0.46	0.54	High
GWP (100)	4160	5400	High



R-316c withdrawn from consideration

* **Laboratory studies provide critical policy relevant information**
* **CSD Laboratory Enables: Timely study capability**

Poster: Summary of Other Studies (>25 ODS and replacement compound studies)

Future Directions/Issues

Poster

New Compounds

High molecular wt. fluoro-amines proposed: Long-lived GHGs

Chlorinated and brominated HFOs (e.g. HFO-1233zd, $CF_3CH=CHCl$)

Mixtures of Compounds:

- Isomers
- Minor components may be most important

Degradation Mechanisms

Accumulating degradation products

Identification of minor, but long-lived, degradation products

Policy Issues

Environmental impacts of short-lived compounds: ODP/GWP/Regional Air Quality

5 Min Presentation and Poster: Jim Roberts, Tuesday