HCFCs and HFCs
An update from the SAP

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Findings of SAP 2006 report have been out for 2 years-assessed the HCFC issues.

Today:
Very brief summary of 2006 SAP finding and Findings since the assessment
“There is even stronger evidence since the 2002 Assessment that the Montreal Protocol is working.”

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Transition from CFCs to HCFCs

- CFC production and emission greatly reduced
- Use of HCFCs, in place of CFCs, increased
- Use of HFCs in place of HCFCs and CFCs continued
Updates on HCFC emissions

Emissions of HCFCs have continued

- HCFC-22 emissions continue to increase
- Reported emissions are roughly consistent with that estimated from atmospheric measurements.

- HCFC-142b reported emissions are smaller than those of HCFC-22.
- Emissions continue to increase slightly.
- Reported emissions are roughly consistent with that estimated from atmospheric measurements.

- HCFC-141b reported emissions are a third of that of HCFC-22.
- Emissions continue to increase slightly.
- Reported emissions are not consistent with that estimated from atmospheric measurements.

Data from Dr. Stephen Montzka, NOAA, ESRL-GMD, Boulder CO
Growth rate of HCFC-22 appears to be reasonably constant.
Growth rate roughly consistent with the reported emissions.

Growth rate of HCFC-142b appears to be roughly constant.
Growth rate roughly consistent with the reported emissions.

Growth rate of HCFC-141b appears to be decreasing.
Growth rate roughly consistent with the reported decreased emissions in the last few years.

Data from Dr. Stephen Montzka, NOAA, ESRL-GMD, Boulder CO
Trace gases other than CO$_2$ are shown to be potentially as important as CO$_2$ for long-term climate trends. The relative importance of the 30 or so trace gases included in this study depends on the problem under consideration. The inferred CO2 increase from preindustrial to the present causes an equilibrium warming of the model surface by 0.5 K, which is amplified by 50% by CH4, CFC13 (F11), CF2Cl2 (F12), and tropospheric ozone. For the projected increase from year 1980 to 2030, the other trace gases amplify the estimated CO2 warming of 0.7 K by about 110%: CFC13, CF2Cl2, ozone, and CH4 each contribute in the 0.1–0.2 K range followed by N2O, CHClF2 (F22), CH3CCl3, and CCl4 in the 0.03–0.1 K range. Finally, on a per ppb basis, about 12 trace gases are identified to be important: CBrF3, C2F6 (F116), CHF3, and CF3Cl (F13) have greenhouse effects comparable to those of CFC13 (F11) and CF2Cl2 (F12).

Because ODSs are known to be strong climate gases, all substitutes for ODSs were checked for their climate forcing- i.e., climate friendliness
The 2006 SAP Synthesis Findings

ODS contributions to climate forcing:

~7.5 Gt near 1990, about 33% of that year's CO₂ emissions from global fossil fuel burning

~2.5 Gt near 2000, about 10% of that year’s CO₂ emissions from global fossil fuel burning

Montreal protocol has helped reduce global climate change

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Benefits of Montreal Protocol for Climate

World avoided by the phase out of ODSs by Montreal Protocol?

Reduction Montreal Protocol of ~11 GtCO₂-eq/yr

⇒ 5-6 times global Kyoto target

Role of ozone depletion cooling due to CFCs?
Could reduce this by perhaps a third.

Velders et al., PNAS, 2007

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Contributions of HCFCs to ozone depletion and climate forcing

Ozone depletion by HCFCs

- HCFCs are small, but significant, contributor to ODS in the early 21st century.
- Their emissions are decreasing because MP actions!

Climate Forcing by HCFCs

- Reduction in HCFC emissions:
  - 12-15 GtCO₂-eq potential reduction if replaced with low-GWP alternatives or reduced through conservation/recycling.

Velders et al. 2007

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Transition to HFCs

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HFCs are “ozone safe”

HFCs do not contain chlorine, bromine, or iodine
They do not lead to catalytic ozone destruction by halogen radicals

Science, vol 263, pp: 71-75

Do Hydrofluorocarbons Destroy Stratospheric Ozone?

A. R. Ravishankara, Andrew A. Turnipseed, Niels R. Jensen, Stephen Barone, Michael Mills, Carleton J. Howard, and Susan Solomon

HFCs do not contribute to ozone destruction via other functional groups in them

HFCs do not deplete the stratospheric ozone- good “ozone-friendly” substitutes

Are there other environmental concerns with HFCs?--- Climate

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The 2006 SAP Synthesis Findings about HFCs

- HFC-23 emissions estimated from atmospheric measurements have increased from 6 Gg/yr in 1990 to about 13 Gg/yr in 2001 (an increase of approximately 120%).
- These are a byproduct of HCFC-22 production.
- HFC-23 mixing ratios (18 ppt in 2004) have continued to increase at approximately 0.7 ppt/yr (4%/yr) in 2001-2004. (SAP 2006)

- The atmospheric abundances of all measured HFCs are increasing due to their rapid introduction as CFC and HCFC replacements.
- HFC-134a reached 30 ppt in 2004 and increasing at 3.9 ppt/yr (13%/yr). Globally averaged HFC-125 and HFC-152a were ~3.1 ppt in 2004, increase by about 23%/yr and 17%/yr.

- Short lifetimes of HFCs mean that they will quickly respond to emission changes
- Their build up is not as large as for CO₂ or other longer-lived gases for same emissions

HFC emissions are expected to increase a great deal over the coming decades

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If emissions remain unchecked, HFCs will be a significant and rapidly growing contributor to climate forcing in the next four decades.
Substitutes for HFCs?

Examples of substitutes for high GWP HFCs include olefins

Advantage: short lifetime, low GWP, e.g., CF$_3$CF=CH$_2$ or CF$_3$CF=CHF substitutes for HFC-134a

Lifetime <10 days, GWP of <5; compare with HFC134a: lifetime 14 years, GWP ~1400

Other issues to be considered:
1. Can it give TFA (a known toxic substance)?
2. Does it lead to ozone pollution production?
3. Can it lead to ODSs?
4. Can it lead to HFCs with higher GWP?

Still needs some work to ensure safe substitutes for high GWP HFCs

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Summary

- Montreal Protocol has successfully led to decreases in ODSs—primarily CFCs and methyl chloroform
- HCFCs, substitutes for CFCs, are currently increasing as HCFCs are phased down
- HFCs are “ozone-friendly” and they are being phased in to replace CFCs and HCFCs— they are growing very rapidly
- There was a major “climate benefit” to the phase out of ODSs
- There will be a non-negligible ozone layer benefit from phase down of HCFCs
- The climate contribution by HFCs can be very significant in the coming decades if emissions continue to increase
- Some climate-friendly short-lived substitutes for CFCs, HCFCs, and high-potency HFCs are available— their environmental friendliness needs to be established
Thank you for your attention

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Continues to increase rapidly

Growth rate is not accelerating rapidly