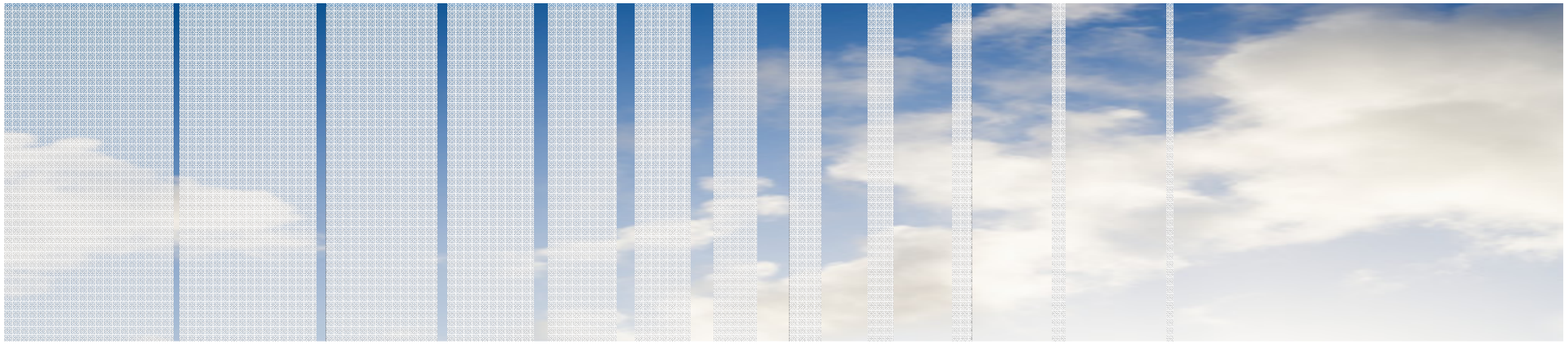
Netherlands Environmental Assessment Agency

Climate forcing from new HFC scenarios

Offsetting climate benefits Montreal Protocol

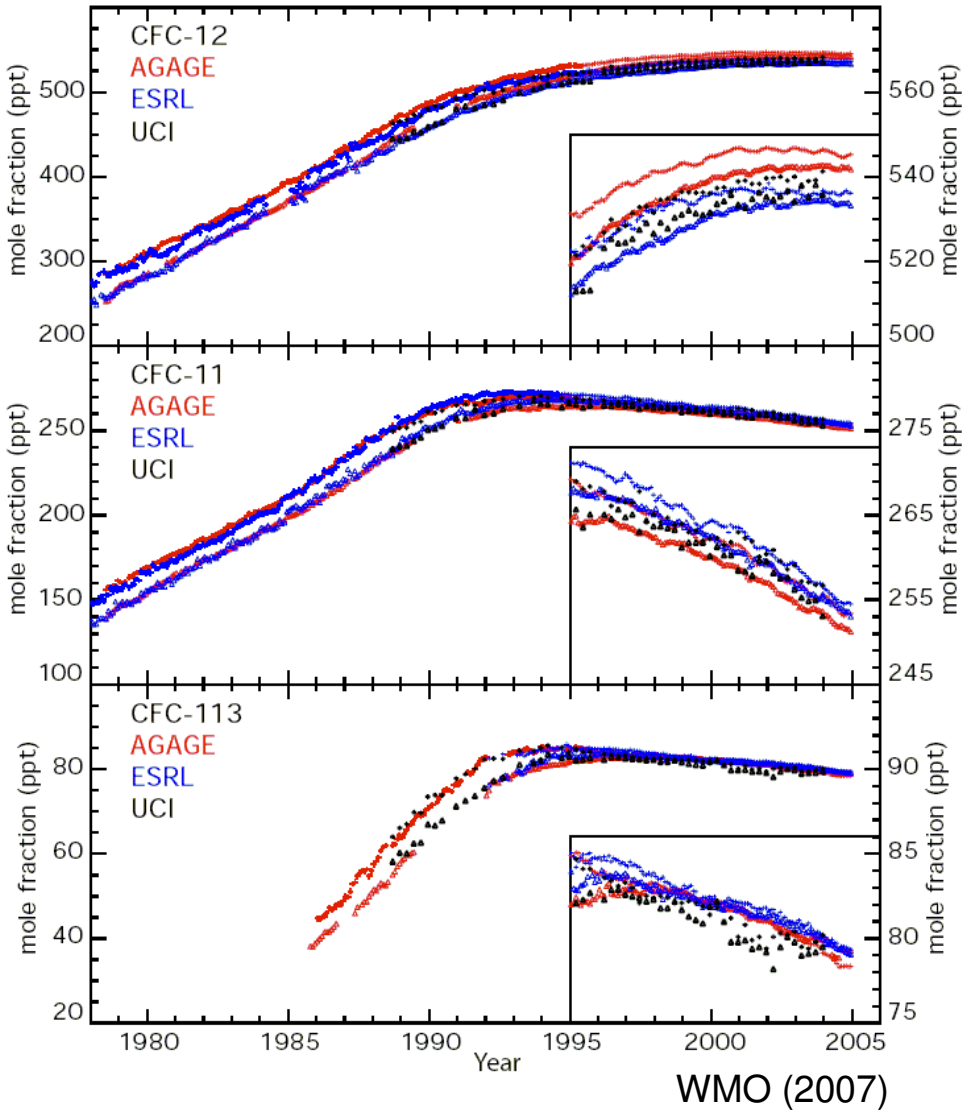
Guus Velders

NCGG-5, Wageningen, June 30, 2009



Well known benefits Montreal Protocol

- Large decreases in CFC production (>90%) and emissions (60-90%)
- Concentrations also decreasing
- Emerging evidence of start of ozone layer recovery
- Full recovery around 2050, later in polar regions



WMO (2007)

HFCs offset climate benefits Montreal Protocol

CFCs, HCFCs are greenhouse gases ➔

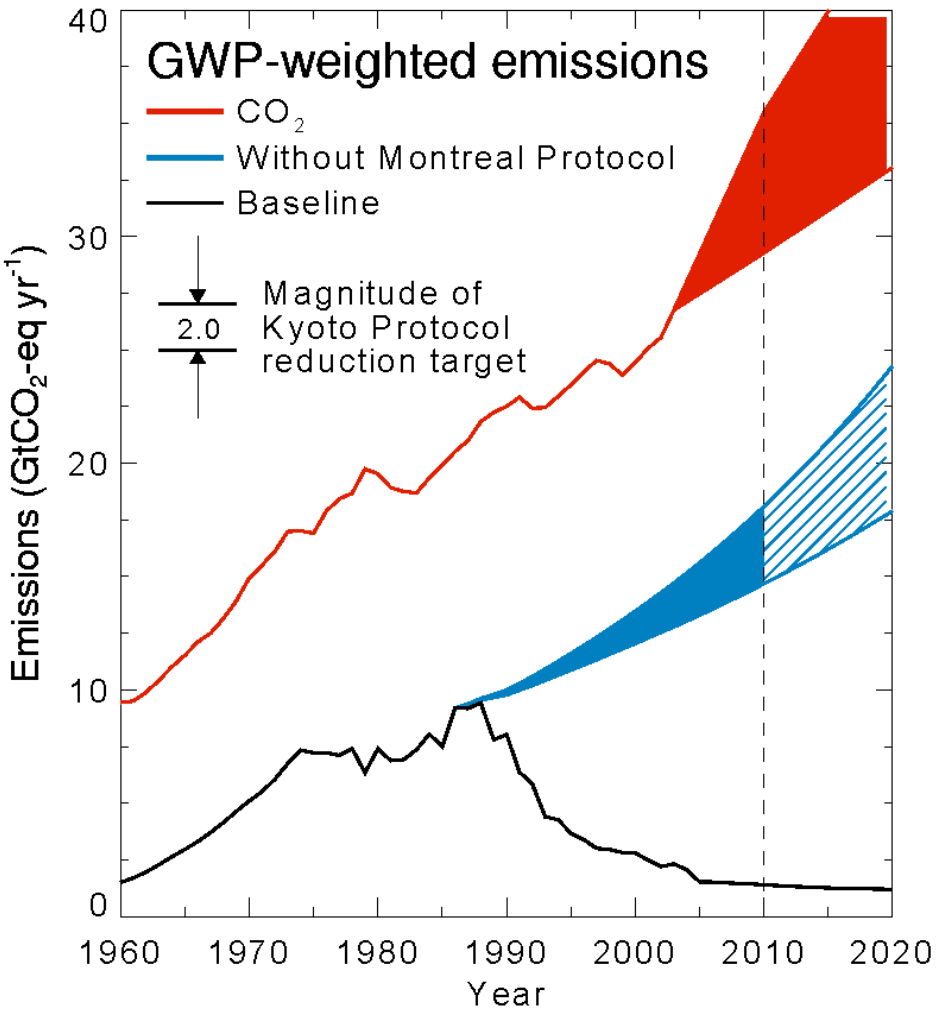
Dual protection Montreal Protocol: to Ozone layer and Climate change

Already achieved climate benefits 5-6 times larger than Kyoto Protocol targets for 2008-2012

New: Climate benefits can be offset by projected increases in HFCs by 2050

New: HFC emissions can reach 9-19% of CO_2 emissions by 2050

Effects Montreal Protocol on climate



CO_2 emissions

World avoided by the Montreal Protocol

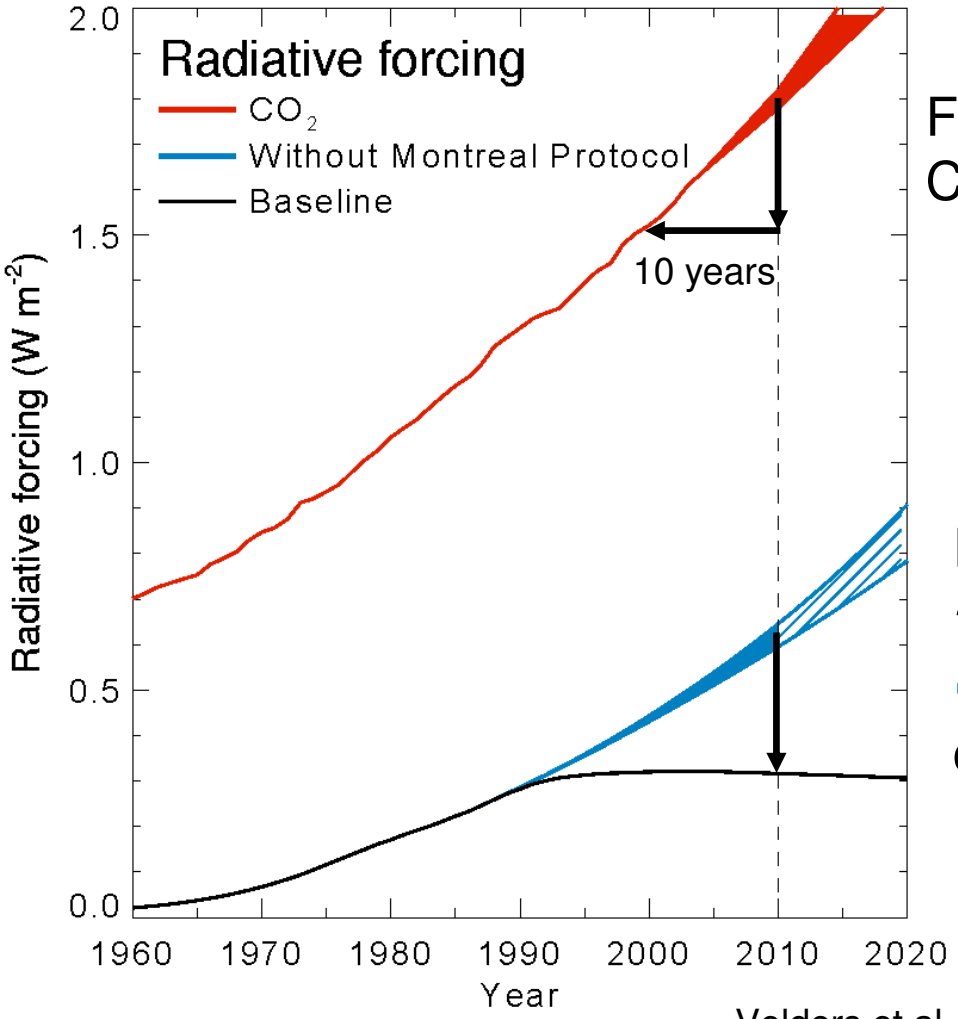
Reduction Montreal Protocol of ~11 $GtCO_2$-eq/yr

➔5-6 times Kyoto target

(incl. offsets: HFCs, ozone depl.)

Velders et al., PNAS, 2007

Radiative forcing leading to climate change



Forcing: delay of ~10 years cf CO_2 emissions

Reduction in radiative forcing of ~0.23 Wm^{-2} in 2010

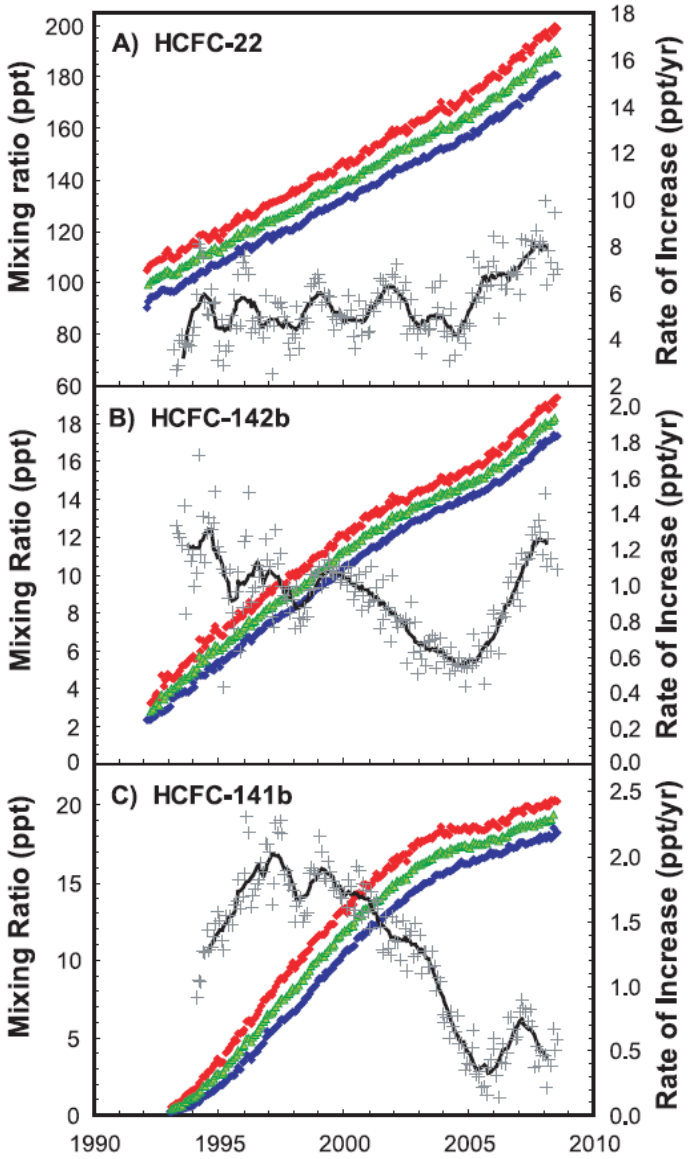
➔ about 13% of CO_2 emissions of human activities

Velders et al., PNAS (2007)

HCFCs: Accelerated increases

- Global phaseout of CFCs (1996, 2010) ➔ increases in HCFCs
- Accelerated increases from use in developing countries

- HCFC phaseout in developed (2020) and developing (2030) countries ➔



Montzka et al., GRL (2009)

Strong growth projected in HFC use

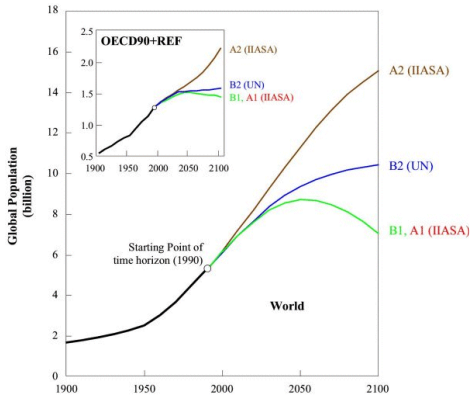
- Global phaseout CFCs and HCFCs
- ➔ Much of application demand for refrigeration, air conditioning, heating and thermal-insulating foam production to be met by HFCs

- Demand for HFCs increases globally

Photo W. Hoogakker, Jordan

Scenarios: update of previous estimates

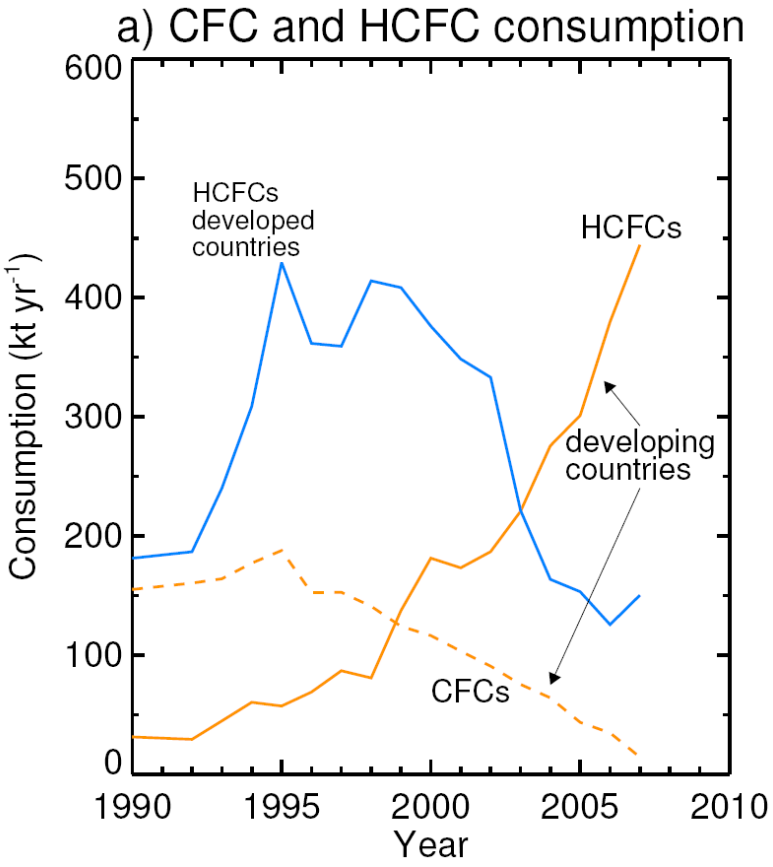
- Long-term scenario: IPCC/SRES (2000)
  - Developed countries: demand ~ population (0.1-0.4%/yr)
  - Developing countries: demand ~ GDP (4-6%/yr)
  - 1990s: HFCs hardly in use



- New information:
  - Increased HCFC consumption developing countries
  - Atmospheric observations of HCFCs and HFCs
  - Patterns of replacements of HCFCs by HFCs
  - Provisions of the 2007 accelerated HCFC phaseout
  - Increases in HFC-134a use in mobile air-conditioning
  - Saturation of HFC consumption
  - EU mobile AC regulation (past 2011/2017 GWP<150)

Scenarios: Increases in HCFC consumption

- Developed counties:
  - HCFC consumption decreases ➔ phaseout already in progress
- Developing countries:
  - HCFC consumption increase: 20%/yr
  - CFC+HCFC increase: 8%/yr
- HCFC consumption = starting point new scenarios



Data reported to UNEP

Replacing HCFCs with HFCs

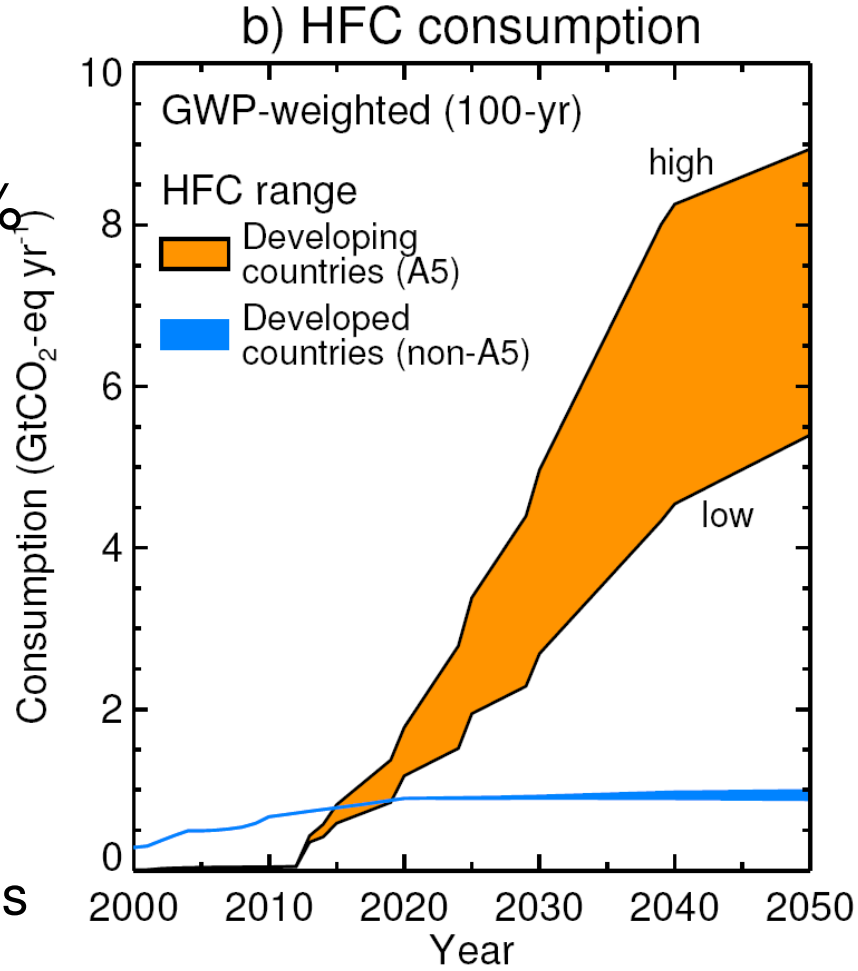
- Refrigeration, air conditioning, foam production
- Replacement scheme developed countries:
  - HCFC-22 ➔ 35% R404A, 55% R410A, 10% NIK
  - HCFC-141b ➔ 50% HFC-245fa, 50% NIK
  - HCFC-142b ➔ 50% HFC-134a, 50% NIK
  - R404A, R410A: Blends of HFC-32, -125, -134a, -143a
- Applied to developing countries

- Mobile AC: HFC-134a
- Foam, aerosol: HFC-365mfc,
  HFC-152a (minor use)

Large projected growth in HFC consumption

- HCFC phaseout schedule
- HFC consumption, emissions in developing countries up to 800% greater than in developed countries in 2050

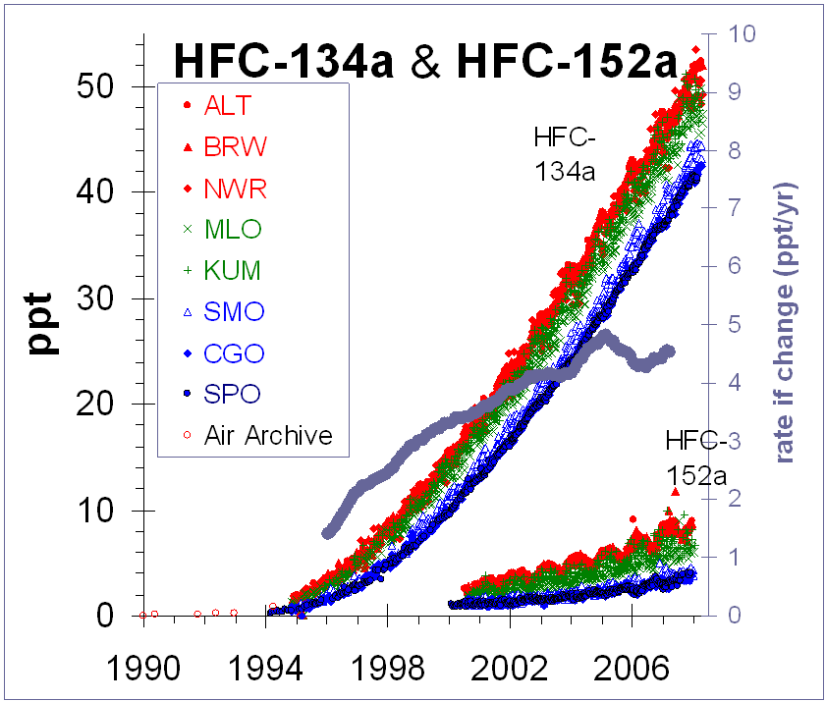
- Saturation in consumption:
  - Developed countries after HCFC phaseout in 2020
  - Developing countries consumption does not exceed per capita consumption in developed countries



Velders et al., PNAS (2009)

HFCs: Increases in mixing ratios

- HFCs do not deplete the ozone
- HFCs are greenhouse gases GWP(100 yr):
  - HFC-125 3,500
  - HFC-134a 1,430
  - HFC-143a 4,470
  - HFC-152a 120
- Observed mixing ratios and derived emissions constrain scenarios



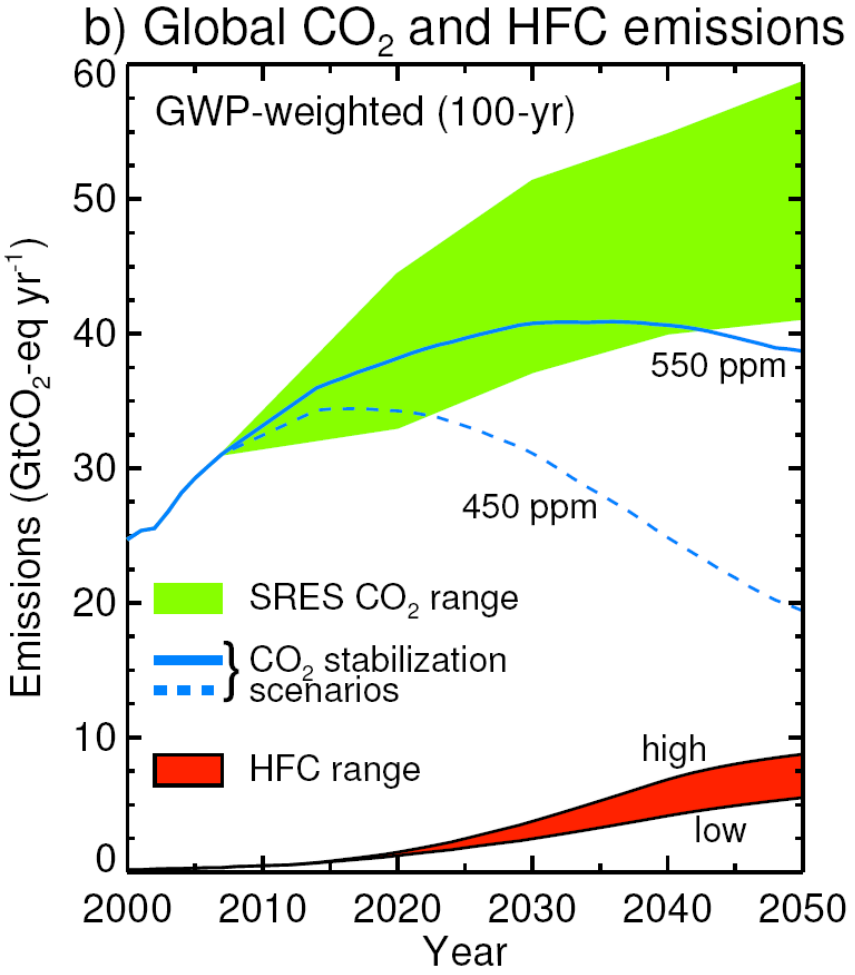
Montzka, NOAA/ESRL

Global emissions of HFCs

- Global HFC emissions in 2050: 5.5–8.8 $GtCO_2$-eq yr^{-1}

➔ equivalent to 9–19% of global CO_2 emissions BAU

- Larger in comparison with CO_2 stabilization scenarios from IPCC/AR4

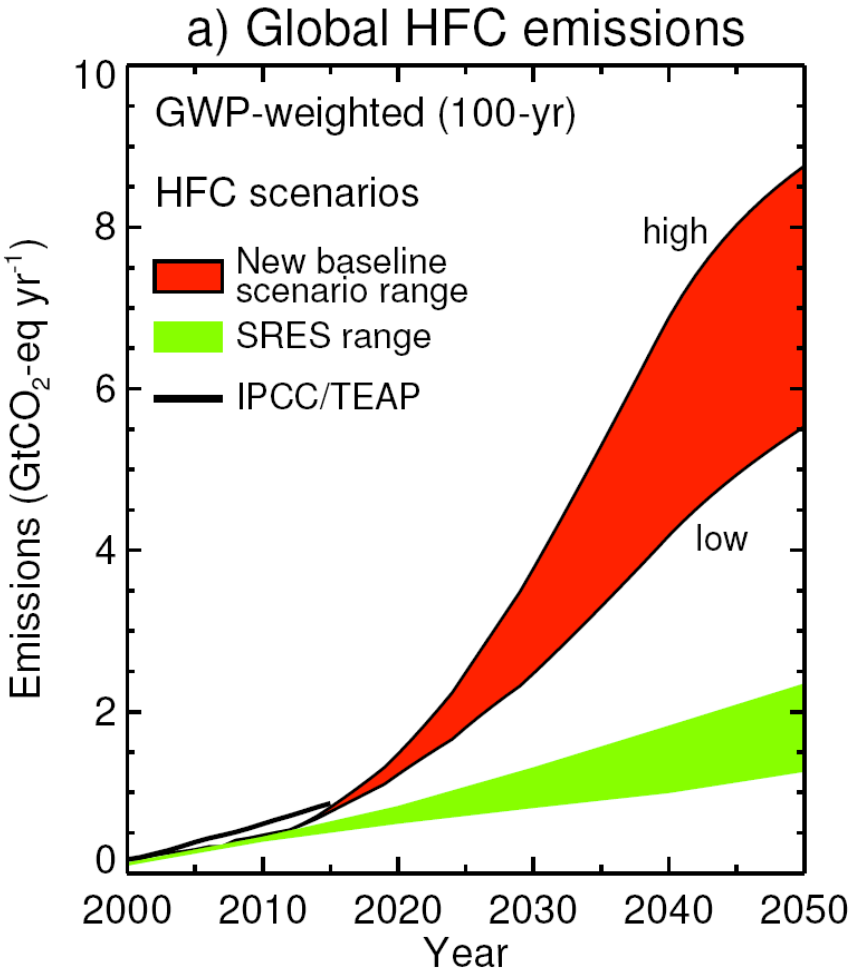


Velders et al., PNAS (2009)

Scenarios exceed previous estimates

- IPCC/SRES (2000) emissions up to 2100
- IPCC/TEAP (2005) emissions up to 2015

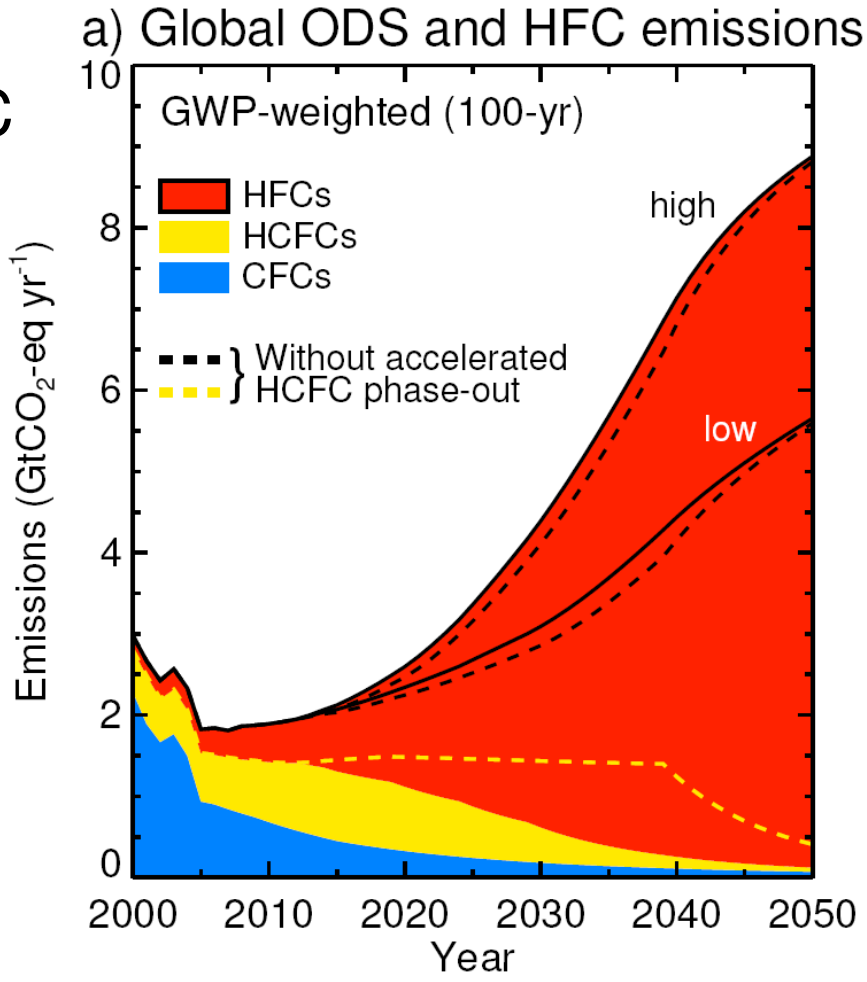
- Larger emissions past 2015:
  - Other HFCs than used in SRES: HFC-125, HFC-143a: use confirmed by observations
  - Higher starting point
  - Accelerated HCFC phaseout



Emissions from accelerated HCFC phaseout

- Montreal Protocol adjustment of Sept 2007 ➔ accelerated HCFC phaseout
- Effects on climate were considered
- Use of low-GWP alternatives advocated

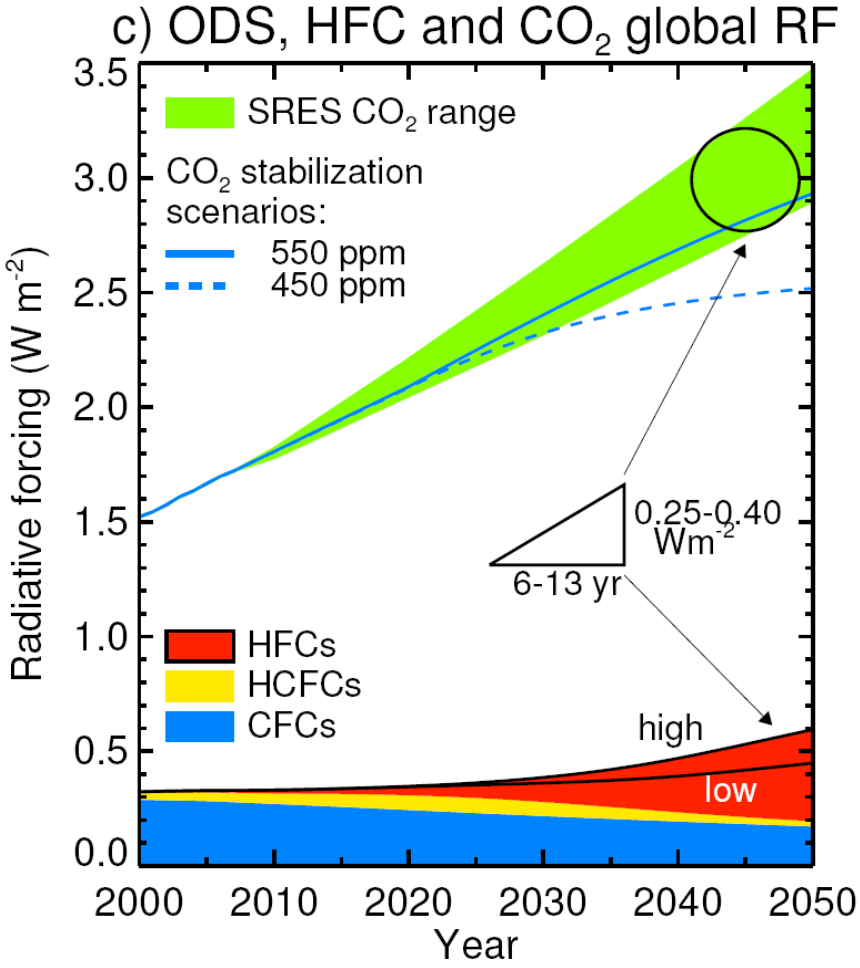
- These scenarios: HCFC decreases compensated by HFC increases



Radiative forcing of HFCs

- Global radiative forcing HFCs in 2050: 0.25–0.40 W m^{-2}
- Compared with CO_2 (BAU) of 2.9–3.5 W m^{-2}

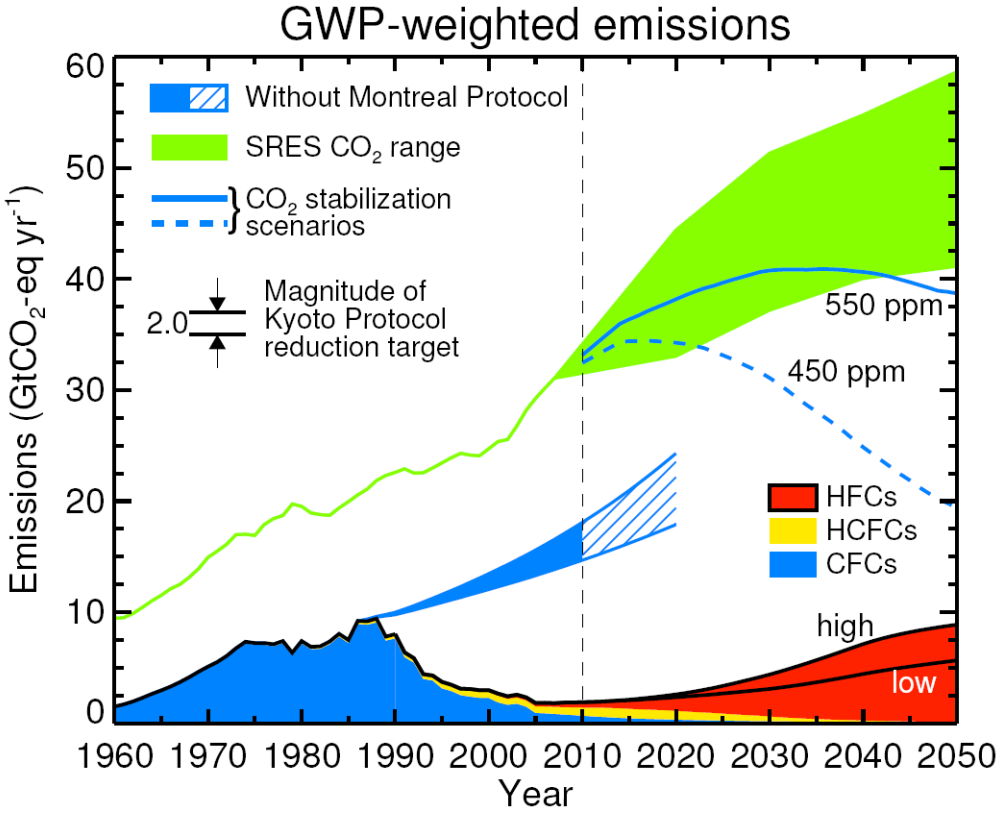
➔ HFCs equivalent to that from 6–13 years of CO_2 emissions



Velders et al., PNAS (2009)

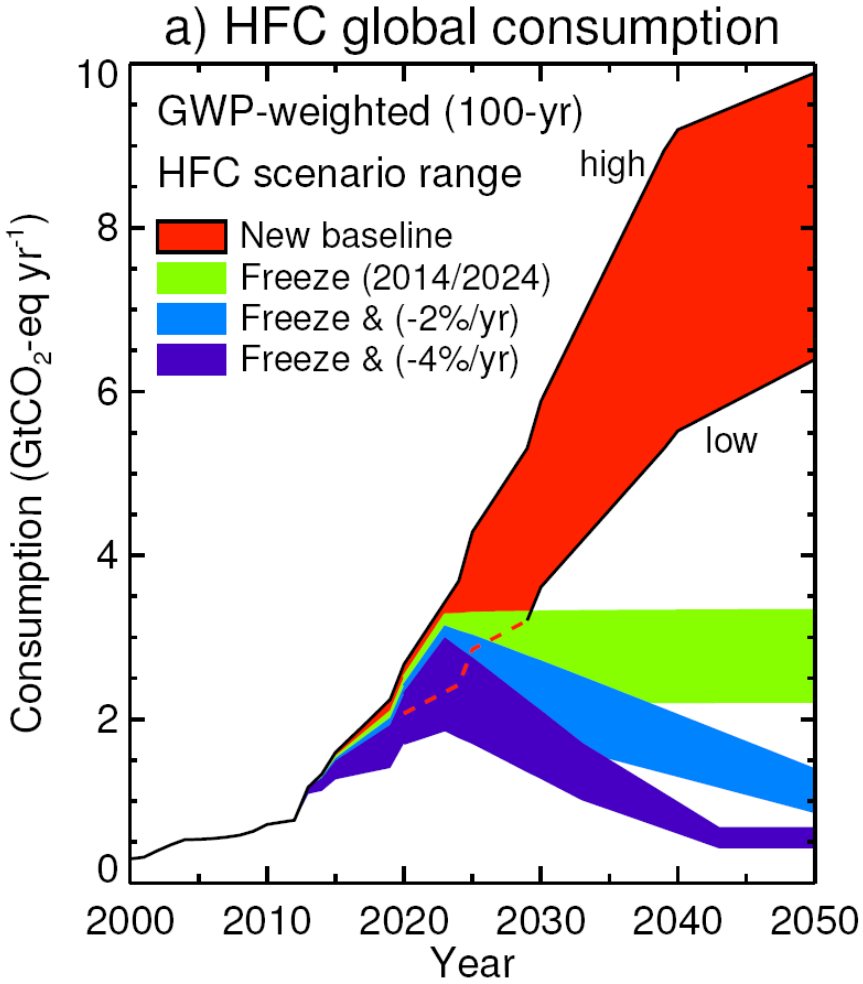
Offsetting climate benefits Montreal Protocol

- HFC emissions offset climate benefits Montreal Protocol:
  - CFC emissions peaked in 1988:
    9.4 $GtCO_2$-eq yr^{-1}
  - Could have reached by 2010:
    15–18 $GtCO_2$-eq yr^{-1}
    (in the absence of Montreal Protocol regulations)
  - HFC emissions by 2050:
    5.5–8.8 $GtCO_2$-eq yr^{-1}



Potential of HFC mitigation

- Hypothetical scenarios:
  - Global consumption freeze (cap) in 2014/2024
  - Followed by 2% and 4% annual reductions
- Other scenarios analyzed:
  - Lieberman-Warner
  - Mobile AC EU regulation applied globally
  - Effects much smaller



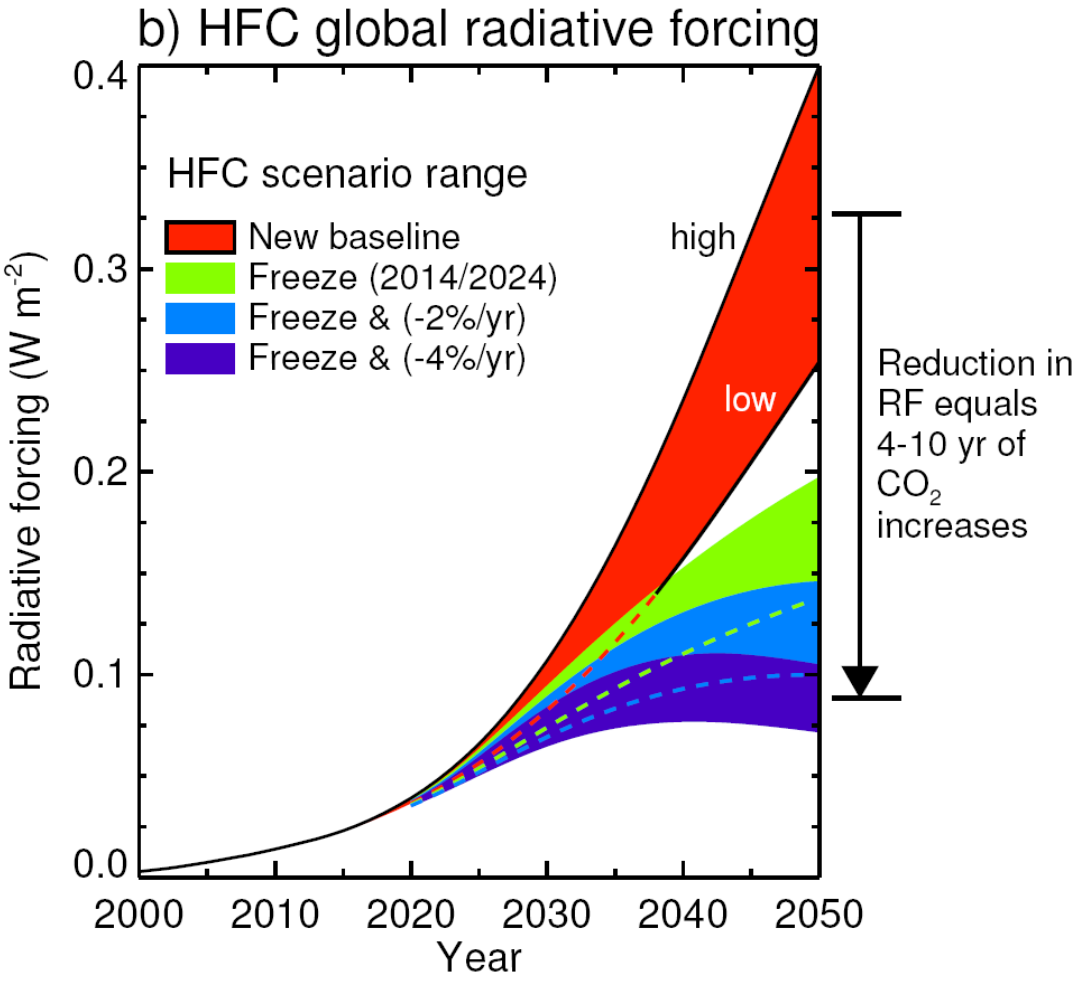
Velders et al., PNAS (2009)

Potential of HFC mitigation (2)

Scenario: freeze & -4%/yr

- Total HFC emissions reduced through 2050 by 70–113 $GtCO_2$-eq
- Radiative forcing HFCs peaks near 2040
- Radiative forcing HFCs reduced by 0.18–0.30 W m^{-2} in 2050

➔ Equivalent to CO_2 RF: from 6–13 years to 2–3 years



Are alternatives available?

- Not-in-kind alternatives:
  - Non-halocarbons, different technologies
  - Phaseout of CFCs in 1980-1990s ➔ 80% replaced with non-halocarbons alternatives
- For some applications: CO_2, ammonia, hydrocarbons
  - Flammability, toxicity considerations
- New halocarbons: Perflurobutenes, HFOs, etc.
  - Lifetimes days to weeks
  - GWP <10
  - Don't affect ozone layer: ODP = 0
  - Currently being developed; approval pending

Life cycle climate performance (LCCP)

- Important is the total effect on climate

- Direct climate forcings
  - GWP-weighted emissions, Radiative forcing
- Indirect climate forcings
  - Energy used or saved during the application lifespan
  - Energy used to during manufacturing

- Total effect on climate ➔ Life cycle climate performance

On the political arena

- US proposals
  - Waxman-Markey (accepted by the House, June 26)
  - Boucher-Dingell (House)
  - Lieberman-Warner (Senate)
  - Explicit reductions in HFC consumption
- UNFCCC: Climate negotiations Copenhagen (Dec. 2009)
- EC statement: controls on HFCs in new climate treaty
- Montreal Protocol
  - Geneva workshop (July 2009), preparing for MOP Cairo (Nov. 2009)
  - Micronesia, Mauritius: Proposal to include HFCs in Montreal Protocol
  - Effects on climate considered ➔

Montreal Protocol and Kyoto Protocol

Montreal Protocol:

- Protection of ozone layer (UNEP treaty 1987)
- Production and consumption
- Gases: CFCs, halons, HCFCs, methyl bromide, etc.
- Phase-out schedule (CFCs 2010, HCFCs 2030)
- Climate considerations taken into account

Kyoto Protocol:

- Protection of climate (UN treaty 1997)
- Emissions
- Basket of 6 gases: CO_2, CH_4, N_2O, **HFCs**, PFCs, SF_6
- ~5% reduction from 1990 by 2008-2012
- Does not cover ozone depleting compounds

HFCs in Montreal Protocol?

Yes, because:

- HFC uses are the result of phaseout of CFCs, HCFCs
- Same applications as CFCs, HCFCs
- Instruments and know-how available
- Climate considerations taken into account

No, because:

- HFCs do not deplete the ozone layer
- Already covered by Kyoto Protocol
- Kyoto: emissions reductions of “gases not covered by the Montreal Protocol”

HFCs offset climate benefits Montreal Protocol

Dual protection Montreal Protocol: to Ozone layer and Climate change

- Climate benefits can be offset by projected increases in HFCs
- HFC emissions can reach 9-19% of CO_2 emissions in 2050
- Large projected growth mainly in developing countries
- Energy used during whole life cycle is important

Study in close collaboration with …

- John Daniel, NOAA/ESRL
- Dave Fahey, NOAA/ESRL
- Mack McFarland, DuPont
- Steve Andersen, US-EPA

Thank you for your attention