National Institute for Public Health
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New scenarios for ozone depleting substances:
Results from the WMO/UNEP Scientific Assessment of Ozone Depletion (2010)

Abstract

New scenarios of ozone depleting substances (ODSs) are evaluated for the future chlorine levels and for the radiative forcing (RF) of climate. The Montreal Protocol is working. It has protected the ozone layer from much higher levels of depletion by phasing out ODSs. Due to the success of the Protocol, compounds and activities not controlled by the Protocol are becoming relatively more important to stratospheric ozone. The Protocol has also made large contributions toward reducing greenhouse gas emissions. In 2010, the decrease in ODS emissions under the Montreal Protocol is much larger than the target of the Kyoto Protocol for 2008-2012. Growth in HFCs used as ODS substitutes will offset at least a part of these climate benefits.

New ODS baseline scenario

Constraints for new ODS scenarios for 1980-2008:

- Observed mixing ratios of all ODSs
- Rate of change in mixing ratios + lifetime gives historic annual emissions
- Annual ODS production reported to UNEP

Assumptions for 2009-2100:

- Compliance with Montreal Protocol phase-out
- HCFCs: extrapolation of historic production
- Banks for 2008 from UNEP/TEAP (bottom up)
- Annual release from banks derived from historic emissions divided by bank sizes

Differences in the scenario

Mixing ratios of CFCs (Figure 1), halons and methyl chloroform are similar to those in the previous assessments (WMO, 2003; 2007). Future CCl_4 mixing ratios are higher than in WMO (2007) due to larger than expected emissions as derived from observed mixing ratios for 2004-2008. The budget of CCl_4 is not fully understood, which affects the lifetime and projections of mixing ratios.
The largest changes compared to WMO (2007) are found for the HCFCs. This is the result of increased production in developing countries and of the changed HCFC phase-out schedule for, especially, developing countries (2007 adjustment of the Montreal Protocol).

Ozone and climate metrics

The contributions of ODSs to metrics relevant to ozone depletion and to climate change are shown in Figures 2 and 3. The ozone layer metrics include the ODP-weighted emissions and Equivalent Effective Stratospheric Chlorine (EESC). The climate metrics include the GWP-weighted emissions and RF. In terms of EESC, the largest contribution in the past and future comes from the CFCs and natural CH_3Cl and CH_3Br emissions. In terms of RF the CFCs are also the most important ODSs, but the HCFCs are projected to contribute more than 0.05 W/m² at their peak.
The return of EESC to 1980-levels is frequently used as an indicator for recovery of the ozone layer from depletion by ODSs. EESC returns to 1980-levels by 2046 for mid-latitudes and by 2073 for the Antarctic.

HFCs as ODS replacements

With the global phase-out of HCFCs, much of the future application demand for refrigeration, AC and thermal-insulating foam production is likely to be met by HFCs (Figure 3). HFCs do not deplete the ozone layer but, along with CFCs and HCFCs, are greenhouse gases, which contribute to the RF of climate. Thus, the transition away from CFCs and HCFCs has implications for both the ozone layer and climate. HFCs are not controlled by the Montreal Protocol, but they are included in the Kyoto Protocol.
Total direct GWP-weighted emissions of ODSs peaked in 1988 at 9.4 $GtCO_2$-eq yr^{-1} and decreased after that. In a business-as-usual scenario, starting in 1987, without Montreal Protocol regulations the emissions of ODSs reach 15-18 $GtCO_2$-eq yr^{-1} by 2010 (Velders et al., 2007).
HFC emissions are projected to increase, primarily in developing countries, exceeding those of ODSs after about 2020 (Velders et al., 2009). HFC emissions could reach 5.5-8.8 $GtCO_2$-eq yr^{-1} by 2010. So, growth in HFC use could offset at least part of the climate benefits achieved by the Montreal Protocol.

Other compounds & activities

The ozone and climate impacts of several options for accelerating the recovery of the ozone are shown in Table 1. Potentially largest effects for ozone layer and climate combined are for capture and destruction of CFC banks and a stop in production of HCFCs. The potential effect of destruction of the banks decreases quickly with time.
Due to the ongoing success of the Montreal Protocol, compounds and activities not controlled by the Montreal Protocol, and other potential activities, are becoming or could become relatively more important to stratospheric ozone:

- Climate change (direct and indirect effects)
- Very-short lived species
- Geoengineering by injection of sulfur in stratosphere
- Emissions from rockets and aviation
- Emissions of biofuels
- Emissions of N_2O

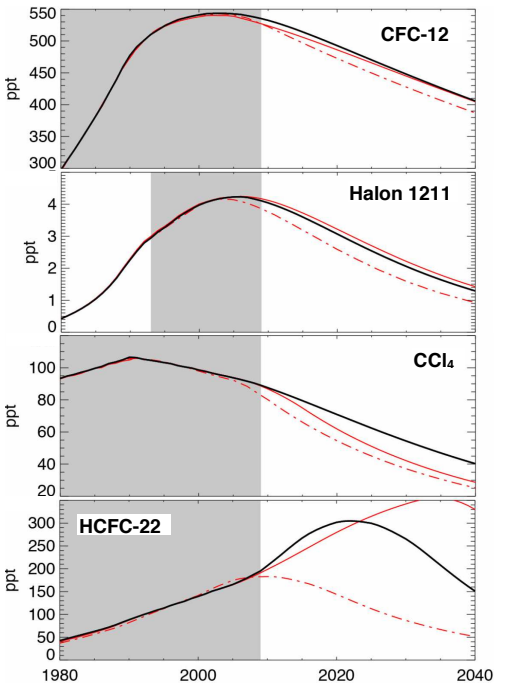

Figure 1. Mixing ratios of selected ODSs for the new baseline scenario (black), old baseline scenarios of WMO (2007) (solid red) and WMO (2003) (dashed red). Shaded regions: mixing ratios constraint by observations.

Table 1. Options related to ozone layer recovery

2011 - 2050	Reduction integrated EESC	Reduction integrated ozone column	Reduction cumulative GWP-weighted emissions $GtCO_2$-eq
2010 Bank capture and destruction			
CFCs	11%	0.13%	7.9
Halons	14%	0.15%	0.4
HCFCs	4.8%	0.07%	4.9
Production stop after 2010			
HCFCs	8.8%	0.15%	13.2
CH_3Br for QPS[1]	6.7%	0.09%	0.002
Emission stop after 2010			
CCl_4	7.6%	0.9%	
CH_3CCl_3	0.1%	0.004%	
Non-ODS emissions stop after 2010 (more scenario dependent)			
HFCs	0%	0%	up to 170
Anthropogenic N_2O		0.35%	130

1) Methyl bromide used for QPS (Quarantine and Pre-Shipment) is exempted from the Montreal Protocol.

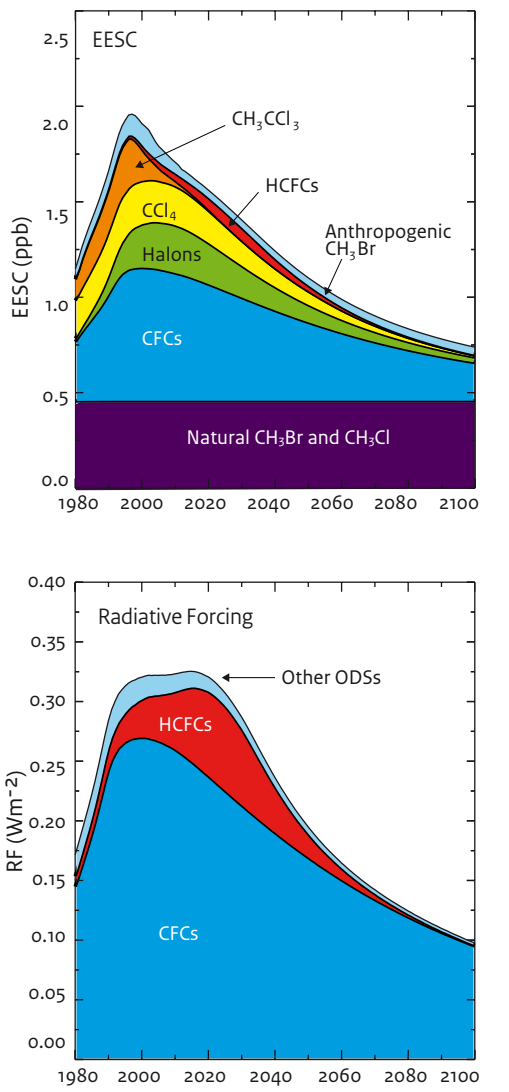

Figure 2. EESC and RF of the baseline scenario.

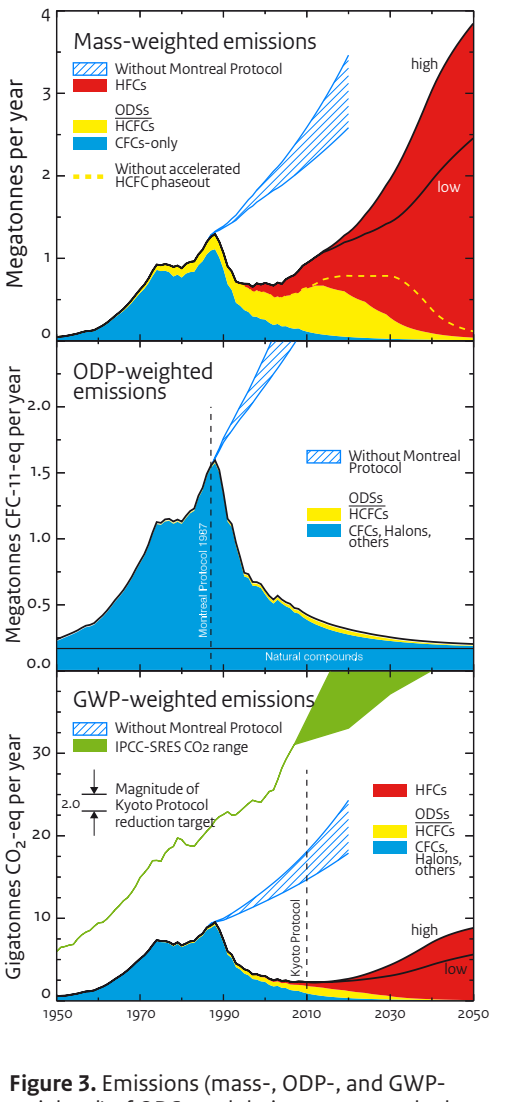

Figure 3. Emissions (mass-, ODP-, and GWP-weighted) of ODSs and their non-ozone-depleting substitutes (HFCs). The blue hatched regions indicate the emissions that would have occurred, in the absence of the Montreal Protocol, with 2–3% annual production increases in ODSs.

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