STRATOSPHERIC OZONE

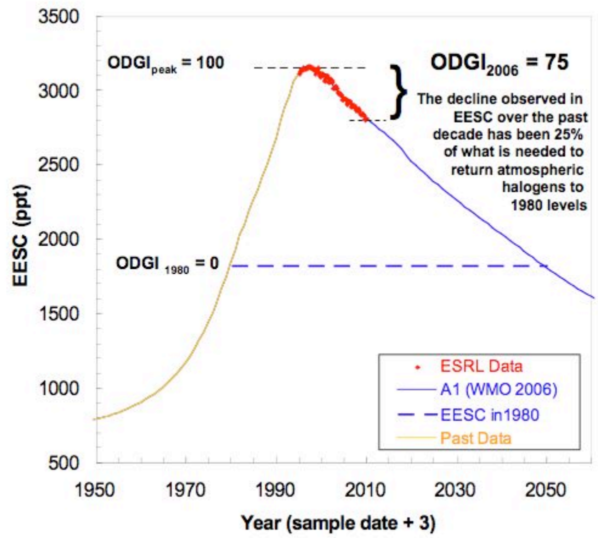
I. INTRODUCTION

ESRL scientists have been pivotal in monitoring atmospheric ozone and ozone depleting substances and their substitutes, in understanding and describing the key atmospheric processes that deplete ozone (including the unexpected occurrence of the Antarctic ozone hole and, more recently, the linkages between the ozone hole and climate in the Antarctic region), and in the search for possible substitutes for ozone depleting compounds.

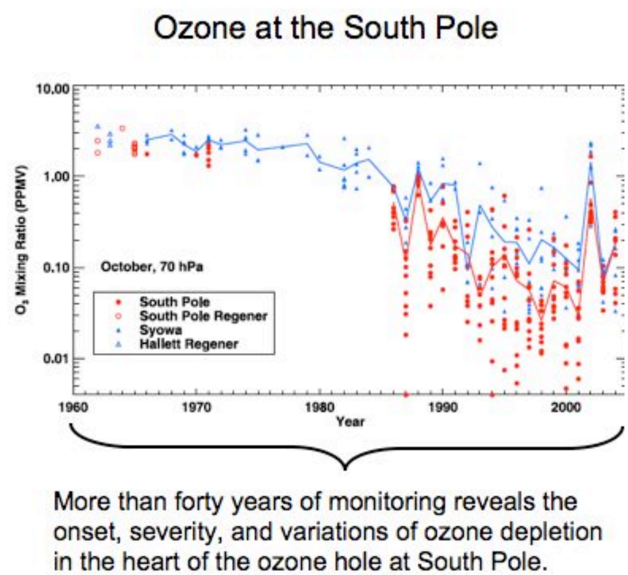
Moreover, a hallmark of our research on stratospheric ozone is its special emphasis on communicating discoveries, predictions, monitoring, and other scientific information in a form that meets the needs of end users in government, industry, and the public. We have been at the forefront of the dialogue between researchers and information users that provides this information service via periodic international state-of-scientific-understanding updates ("assessments") on the stratospheric ozone layer since 1989, and, since 2006, providing yearly updates of Ozone-Depleting Gas Index (the ODGI). Further, our work has allowed a new appreciation of the role of the Montreal Protocol in protecting climate as well as the ozone layer.

II. KEY ACHIEVEMENTS (last 4 years)

• GMD's monitoring and analysis of ozone depleting gases has allowed assessment of the degree to which the Montreal Protocol is succeeding at reducing the burden of chlorine and bromine in the atmosphere through accurate tracking. This approach has been fundamental to many efforts to better assess the timing of ozone recovery, including new and more quantitative estimates of when recovery of the global ozone layer and the Antarctic ozone hole may be expected [Cunnold et al., 2007; Newman et al., 2006; Hofmann et al., 2006; http://www.esrl.noaa.gov/gmd/odgi].



Evolution of the Ozone Depleting Gas Index (ODGI), showing observed progress towards expected recovery of the ozone layer.

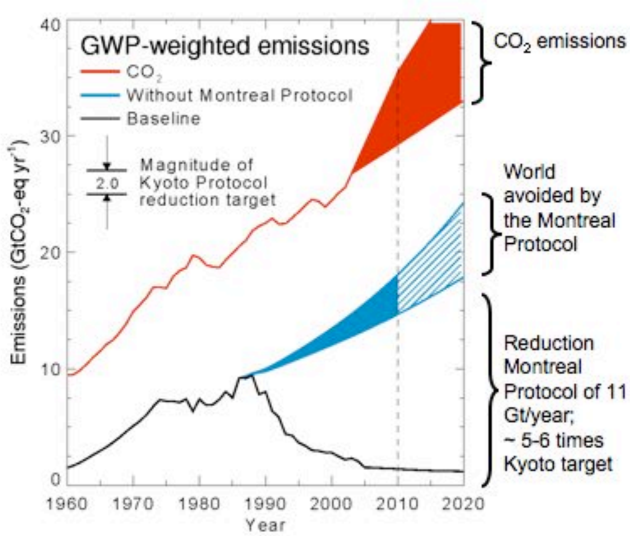


• Monitoring and analysis of stratospheric ozone at sites worldwide via Dobson and ozonesonde methods has been central to understanding how the ozone layer is changing. Operation of the World's Standard Dobson by ESRL has assured the determination of accurate global total ozone trends. Among other recent achievements is an improved understanding of the severity of

Antarctic ozone losses, how these vary from one year to another, and differences in ozone losses between the Arctic and Antarctic [Harris et al., 2005; Solomon et al., 2005].

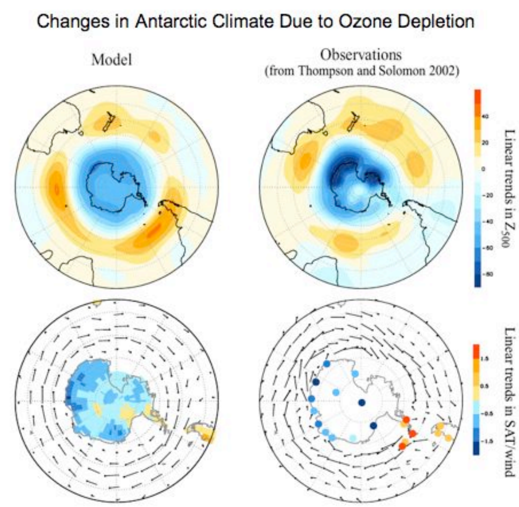
• CSD has been a key “honest broker” of information about the ozone-layer friendliness and climate friendliness of candidate substances for a variety of societal uses such as refrigeration, air conditioning, electronics manufacture, and fire protection. Early information about the suitability of a proposed substance is needed by industry *before* costly development investments are made [Rajakumar et al., 2005, 2006; Papadimitriou et al., 2008].

• CSD and GMD scientists have been leaders in work showing how the Montreal Protocol has benefited climate change. The ozone-depleting substances that are now banned under the Montreal Protocol are also powerful greenhouse gases, and reductions in their emissions have had a much larger benefit to reducing the total anthropogenic greenhouse warming effect than actions achieved thus far under the Kyoto Protocol [Velders et al., 2007; IPCC Special Report on Safeguarding the Ozone Layer and the Global Climate System, 2005; Hofmann et al., 2006].



Effect of Montreal Protocol on climate forcing

• CSD has provided leading research quantifying and understanding how the atmospheric temperature structure is affected by decreases in stratospheric ozone. This has included demonstration that the observed pattern of recent Antarctic surface temperature trends (cooling over the high plateau, accompanied by warming in the region of the Peninsula) is largely due to a change in southern hemisphere circulation that is related to ozone depletion [Thompson et al., 2005 and references therein; Keeley et al., 2007; Forster et al., 2007].



Changes in Antarctic climate linked to ozone depletion

III. PAYOFFS

Our research has contributed substantially to the scientific basis for national and international decisions to protect the ozone layer, namely, the U.S. Clean Air Act and the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer. Those decisions have been directly credited with achievements in dramatically curtailing the use of ozone-depleting substances. An ultimate, and perhaps incalculable, benefit to the U.S. taxpayer and to citizens worldwide is the protection of the public from detrimental effects of excessive exposure to ultraviolet radiation that would have occurred with a thinner ozone layer. It is estimated that without the international agreements of the Montreal Protocol, an additional 1.5 *million* skin cancer cases would occur *per year* in the U.S. alone. The vetting of potential new substitutes for ozone-depleting compounds has provided cost-savings for industry and consumers worldwide, e.g., industry (and ultimately the consumer) is spared about $25M per startup facility when a false start is averted by having an *early* picture of how ozone friendly and climate friendly a proposed new compound would be. By monitoring ozone depleting compounds and their substitutes, our findings show the policymaker and the public that the international progress to protect the ozone layer is largely "on track," and have demonstrated how changes in ozone affect climate (particularly in Antarctica). Finally, our observations and analysis laid the scientific foundation for a recent new international decision to better protect the climate as well as the ozone layer by more rapid phaseout of the hydrochlorofluorocarbons (HCFCs).

IV. FUTURE PLANS

• Monitor ozone through the GMD global network and the South Pole ozonesonde program, to detect the beginning of global ozone layer and Antarctic ozone hole recovery.

• Continue and augment the global-scale monitoring of ozone-depleting substances, their substitutes, and other halogenated compounds including short-lived gases with both natural and anthropogenic sources. Such data are essential to fully understand how atmospheric amounts of ozone-depleting halogens are responding to policy decisions and other influences (such as climate changes), and to determine the success of amendments to the Montreal Protocol regarding HCFCs.

• Provide, through a recently initiated sampling program focused on North America, regional estimates of North American emissions for ODSs and their substitutes.

• Continue monitoring the stratospheric aerosol layer using LIDAR at Mauna Loa, Samoa and Boulder to detect major volcanic eruptions, which can perturb both climate and the ozone layer.

• Conduct analyses to improve estimates of CFCs and Halons banked in existing equipment to better quantify their contributions to climate change and ozone depletion, and thereby to inform future policy regarding possible recovery and destruction of such banked substances.

• Conduct analyses and modeling of stratospheric ozone, with a goal of improving the understanding of the onset of the Antarctic ozone hole, the competition between dynamics and chemistry in ozone recovery, and the role of decreases in aerosols since the Pinatubo eruption in driving ozone changes.

• Conduct analyses and modeling of the processes linking changes in stratospheric ozone to changes in climate, not only in the Antarctic but also in the Arctic and in the tropics, to better quantify how ozone affects temperature and circulation patterns worldwide; this work is expected to provide better estimates of ozone radiative forcing and to better evaluate other influences of ozone on climate.

• Continue laboratory studies to evaluate the ozone and climate friendliness of potential ODS substitutes and their atmospheric degradation products. Continue laboratory studies designed to resolve issues concerning the photochemistry of the ClO dimer and to reduce uncertainties in key chemical processes.

• Complete CCSP assessment on ozone depletion in 2008, followed by the next international ozone assessment in 2010, with leadership by CSD and key participation by GMD.

• Participate actively in the international SPARC halogen initiative, aimed at assessing observational, laboratory, and modeling evidence for ozone depletion, and improving the basis for attribution of ozone losses.

Select Publication Highlights

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