

## The 20th anniversary of the Montreal Protocol and the unexplainable 60% of ozone loss

Costas A. Varotsos

Received: 20 July 2008 / Accepted: 11 August 2008 / Published online: 22 August 2008  
© Springer-Verlag 2008

We are now approaching the 20th anniversary of the Montreal Protocol ratification (signed in 1987 and entered into force in 1989), which established legally binding controls on the production and consumption of the most ozone-destroying chemicals such as chlorofluorocarbons (e.g., HCFC22, a refrigerant) and halons (e.g., halon 1301, a flame suppressor).

The presence of ozone in the atmosphere results in a number of problems that should be considered in the context of global environmental change (Varotsos 2005; Schiermeier 2007). Of course, the most important problem is conservation of the ozone layer in the stratosphere for the protection of life against harmful ultraviolet solar radiation (Kondratyev et al. 1995; Varotsos et al. 1995, 2000; Zerefos and Crutzen 1975). The long-living chloride compounds from anthropogenic emissions of chlorofluorocarbons are the main cause of ozone losses in both hemispheres. The cessation of the emissions of the most ozone-destroying chemicals into the atmosphere is a prerequisite to solve this problem. However, remnants of these long-living chemicals are likely to linger in the atmosphere for at least another 50 years.

Very recent experimental data at the Alfred Wegener Institute of Polar and Marine Research in Potsdam, Germany, provided evidence that the rate of photolysis of

$\text{Cl}_2\text{O}_2$  (a key reaction in the chemical model of ozone destruction) reported by chemists at NASA's Jet Propulsion Laboratory in Pasadena, California (Molina and Molina 1987) is almost an order of magnitude lower than the currently accepted rate. However, by applying the revised photolysis rate, it would not be possible to produce the adequate number of chlorine radicals so to explain the observed ozone losses at high latitudes, and, therefore, at least 60% of ozone destruction at the poles seems to be due to unknown mechanisms (Schiermeier 2007). In this regard, it was recently suggested that a chemical pathway involving a  $\text{Cl}_2\text{O}_2$  isomer might be responsible.

In the light of these very important conclusions, it is time that atmospheric scientists begin to think about new plausible mechanisms, which could fill the aforementioned gap between the observed and theoretical data of ozone depletion, thus, improving our understanding of how ozone holes are formed. We suggest that other plausible mechanisms, which are closely associated with the extent of the interaction between gaseous species and solid particles, may be candidates for the justification of the missing ozone loss—to be experimentally investigated. For example, it has long been known that this interaction depends on the physico-chemical properties of the solid particles and their variation with air temperature and pressure. Specifically, it is known that such various physical properties as the dielectric properties are affected to change the pressure (and hence altitude; Varotsos 1978; Varotsos and Alexopoulos 1980) and/or the composition (Varotsos 1980). In addition, the conductivity of an ionic solid (or ionic solid solution or ionic mixed system) increases by increasing the temperature (Lazaridou et al. 1985).

---

C. A. Varotsos (✉)  
Department of Applied Physics, University of Athens,  
University Campus Bldg. Phys. V,  
Athens 15784, Greece  
e-mail: covar@phys.uoa.gr  
e-mail: covar@atmos.umd.edu

## References

- Kondratyev KY, Pokrovsky OM, Varotsos CA (1995) Atmospheric ozone trends and other factors of surface ultraviolet radiation variability. *Environ Conserv* 22(3):259–261
- Lazaridou M, Varotsos C, Alexopoulos K, Varotsos P (1985) Point defect parameters of LiF. *J Phys C: Solid State* 18:3891–3895
- Molina LT, Molina MJ (1987) Production of  $\text{Cl}_2\text{O}_2$  from the self-reaction of the ClO radical. *J Phys Chem* 91:433–436
- Schiermeier Q (2007) Chemists poke holes in ozone theory. *Nature* 449:382–383
- Varotsos PA (1978) Estimate of pressure dependence of dielectric constant in alkali halides. *Phys Status Solidi B* 90:339–343
- Varotsos P (1980) Determination of the dielectric constant of alkali halide mixed crystals. *Phys Status Solidi B* 100:K133–K138
- Varotsos C (2005) Modern computational techniques for environmental data; Application to the global ozone layer. *Lect Notes in Comp Sci* 3516:504–510
- Varotsos P, Alexopoulos K (1980) Negative activation volumes of defects in solids. *Phys Rev B* 21:4898–4899
- Varotsos C, Kondratyev KY, Katsikis S (1995) On the relationship between total ozone and solar ultraviolet radiation at St Petersburg, Russia. *Geophys Res Lett* 22(24):3481–3484
- Varotsos CA, Kondratyev KY, Cracknell AP (2000) New evidence for ozone depletion over Athens, Greece. *Int J Rem Sens* 21(15):2951–2955
- Zerefos CS, Crutzen PJ (1975) Stratospheric thickness variations over northern hemisphere and their possible relation to solar-activity. *J Geophys Res-Atmos* 80(36):5041–5043