Comment on "Effects of Cosmic Rays on Atmospheric Chlorofluorocarbon Dissociation and Ozone Depletion"

In a recent Letter [1], the authors propose a new pathway contributing to the atmospheric ozone (O_3) depletion. In this Comment, we point out that the statistical correlations presented in this study require further careful examination. We argue that it has ignored some of the current understanding of stratospheric O_3 budget.

The work in [1] presents results based on the correlations observed between cosmic ray intensity and O_3 loss in various space-time regions. The peak O_3 loss at both the altitude and latitude regions as well as total column O_3 trends are fairly well understood based on the variations in solar irradiance due to the 11 year solar cycle, abundance of halocarbons [e.g., chlorofluorocarbons (CFCs), halons], greenhouse gases, and the polar stratospheric clouds (PSCs) [2].

In this study [1], the authors have not considered the O_3 loss and cosmic ray intensity change beyond one 11-year solar cycle when the correlation starts to disappear. In Fig. 1, we plot the O_3 loss against the sunspot numbers (anticorrelated with cosmic ray intensity). It does not reveal the correlation reported by the authors. A plot such as Fig. 3 of [1] for an extended period beyond a solar cycle would look different. The "suggested correlation" between cosmic ray intensity and O_3 loss rate during 1981–1991 tends to alter in the adjacent solar cycles, namely, 1970–1981 and 1991–present. Further, the El Chichon volcanic eruption in 1982 injected several megatons of sulphur gases into the stratosphere that led to manifold increase of PSC formation a couple of years later. The role of PSCs is to trigger ClO_x formation from their nonreactive reservoir species [2], resulting in an enhanced O_3 depletion. This suggests that the covariation of cosmic rays and O_3 loss with time should be examined carefully. In fact, the decrease in cosmic ray intensity near the ground is shown to be tightly correlated to the global cloud cover below 3 km (Ref. [3] in [1]).

The authors suggest that the differences in the CFC-12 distribution between the early spring Antarctic stratosphere (i.e., September) and the fall (i.e., March) could be related to cosmic radiation and PSCs in the winter polar stratosphere. However, such seasonal differences in the CFC-12 distribution are thought to be due to the changes in the stratospheric mean circulation. The stratosphere experiences downward transport in the winter hemisphere bringing the CFC depleted air from higher altitudes, whereas the rapid cross-isentropic mixing in the summer hemisphere supplies more CFCs to the higher altitude and latitude [3,4]. One could visualize this effect as a gradual decrease in CFC-12 concentration from equator to the poles, like a bell shape. This bell shape projects upward in the summer hemisphere.

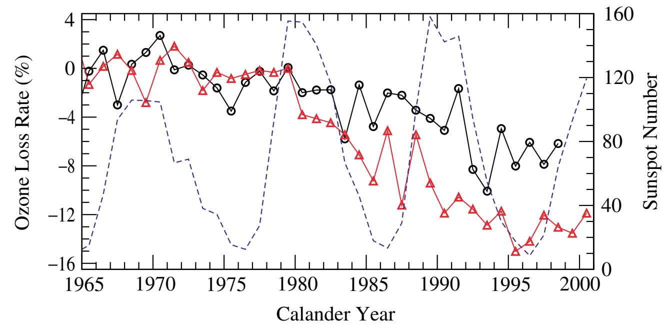

FIG. 1 (color online). Trends in total column O_3, from the two longest serving stations in the northern (Arosa; 46.8° N, 9.6° E; circle) and the southern (Halley Bay; 75.5° S, 26.5° W; triangle) hemispheres, are plotted along with sunspot number (dashed line). The trends are calculated with respect to the 1979 O_3 value. Loss rates for Halley Bay are multiplied by 0.5 to fit in the plot.

To summarize, we believe that the claimed correlation between the cosmic ray intensity and the O_3 depletion has not been clearly established. Second, the factors affecting the formation of polar stratospheric clouds, such as the El Chichon volcanic eruptions, have not been adequately accounted for. While the Letter [1] proposes a new pathway for O_3 depletion, it will require some more work, modeling and experiments, to establish its relative significance in the context of the currently known mechanisms for ozone depletion.

The O_3 data from Arosa [4] and Halley Bay [5], and sunspot numbers [6], can be obtained from the World Wide Web as indicated in Refs. [4–6].

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[1] Q.-B. Lu and L. Sanche, Phys. Rev. Lett. **87**, 078501 (2001).
[2] S. Solomon, Rev. Geophys. **37**, 275 (1999).
[3] A. Doglous *et al.*, Rev. Geophys. **36**, 274 (1998).
[4] J. Staehelin *et al.*, Rev. Geophys. **39**, 231 (2001); www.iac.ethz.ch
[5] A. E. Jones and J. D. Shanklin, Nature (London) **376**, 409 (1995); www.antarctica.ac.uk
[6] www.ngdc.noaa.gov

