Comment on "Correlation between Cosmic Rays and Ozone Depletion"

In a recent Letter [1] the author reports that reliable satellite data in the period 1980–2007 clearly show "the correlation between cosmic rays (CR) and ozone depletion, especially the polar ozone loss (hole) over Antarctica," and "a strong correlation between total O_3 variation and CR intensity, given the data dispersion," and moreover, the author proposes to use the CR intensity as a predictor of the ozone hole (OH) severity.

In this Comment, it is pointed out that the use of CR intensity as a predictor of the OH severity, as suggested in [1], is inappropriate. It is argued that according to the data displayed in Fig. 4 of [1], the CR intensity variation explains only about 27% of total ozone variations, in a linear relationship. Therefore, other causes should be used to predict most of the variation of the ozone. Additionally, it has been omitted to discuss the current understanding of the evolution of the indicators for stratospheric OH severity, which are required, in order to pass from the mathematical correlation to a physical correlation case, between the analyzed variables.

The results presented in [1] are based on the relationship observed between data of CR intensity and the total ozone variation (using the hemispheric annual mean, annual and October mean over Antarctica). The best-fit linear line was computed to describe quantitatively the observed relationship; however, no measures of the linearity degree (as the correlation coefficient) are reported. These measures are fundamental in order to justify the use of CR intensity to predict the total ozone variations and/or the OH severity.

The statement "a strong correlation" is used in [1] to describe the observed relationship; usually this statement implies that the correlation coefficient (r) is close to 1 and that the independent variable explains most of the variation of the dependent variable.

However, using the values corresponding to the points shown in Fig. 4 of [1] to estimate the correlation coefficient (r), this is -0.5216. This result takes into account the rescaling used in Ref. [1] for the total ozone data over Antarctica during the year 2002, dividing the shown values for the annual and October averages by 0.75 and 0.7 respectively, in order to recover the original values.

Consequently, since the correlation coefficient is too low, CR intensity is not the principal variable to explain the total ozone variations and/or the OH severity, because it explains only about 27% (r^2) of the total ozone variation, in a linear relationship, so that other causes should be used to predict most of the variation of the ozone, shown in Fig. 4 of Ref. [1], as is well known.

In addition, in the relationship found between CR intensity and OH severity, it must be considered that the OH severity indicators, as the area where the ozone abundance is below 220 DU (Dobson units) (OH size) [2], depends strongly on the polar vortex structure. This pattern of winds (polar vortex) avoids the free ozone circulation at the polar latitudes, provoking an increase in the ozone depletion inside, causing the OH and limiting its maximum size [3]. If the polar vortex is not stable during a given year (for instance during 2002) the OH is anomalous, because the ozone outside the vortex reaches the polar latitudes, causing an increase in the O_3 abundance in the polar region, decreasing the size of the OH [4], regardless of the level of CR intensity. Therefore, physically the CR intensity cannot be considered as the principal means to estimate the variations of OH severity.

In a recent work Müller and Grooß [5] analyzed the CR-induced heterogeneous chemistry influence on stratospheric polar ozone loss. They conclude that CR-driven heterogeneous reactions can only be considered as a possible addition to the set of processes known to cause the Antarctic O_3 hole and not as an alternative mechanism. They also estimated that in the Antarctic there is no strong and significant correlation between CR activity and polar O_3 loss. Although the analysis in [5] does not use exactly the same data set employed by Lu [1], their results are consistent and support the results presented in this Comment.

Therefore, despite the low correlation, the case presented in [1] motivates us to a more detailed search for evidence of small fluctuations in the polar ozone variations, with frequencies similar to those of CR intensity [6], even if ozone fluctuations linked with the CR signal have not been identified in the midlatitude and tropical regions [7,8].

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