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The response of the ozone layer to the solar UV input: analysis of nonlinear trends

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The response of the climate system to different forcings is a complex and challenging problem due to the nonlinear nature of the Sun-Earth interaction mechanisms. One of these mechanisms is related to the interaction between stratospheric ozone (O_3) and solar ultraviolet (UV) radiation. Indeed, stratospheric ozone mainly absorbs solar UV radiation at wavelengths into the range $120 \leq \lambda \leq 240$ nm and reemits it as thermal longwave radiation (heat) which keeps the stratosphere warmer that it would otherwise be.

In this work, we present the analysis of the ozone data between 1967 and 2010 through the Empirical Mode Decomposition which we use to extract a nonlinear time-dependent trend. In this way, we can investigate local acceleration and deceleration of the trend, obtaining richer informations with respect to the usual linear model. These informations can be useful for the interpretation of the long-term evolution of the stratospheric ozone layer. Moreover, the ozone trend is compared with trends referred to three bands of the solar ultraviolet radiation.

We found that the decreasing ozone trend is similar to the decreasing of UV-C and UV-B bands and that their time derivatives have a minimum (corresponding to changes in acceleration/deceleration properties) about 2 years after the 22th solar cycle maximum. Moreover, we found that the ozone trend acceleration process is well correlated with the UV-B decreasing, while UV-C trend acceleration process is faster with respect the ozone one. We also note that ozone trend presents an opposite behaviour with respect to UV-A trend because this range of solar UV wavelengths is not associated with photochemical reaction processes.

Finally, a time-latitude analysis of the ozone trends can be carried out showing differences between the two hemispheres. A time-latitude distribution of the ozone trends reveals the existence of an asymmetry between northern and southern hemispheres, while the mid-latitude and equatorial regions are not affected by changes in time of the ozone trends.