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Ozone variability and long-term trends deduced from the step-corrected Umkehr record of Arosa, Switzerland

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The long-term Umkehr series are most relevant for upper stratospheric ozone trends, because at this altitude range no other measurements exist before 1978 when satellite measurements started and the first signs of turnaround of ozone depletion by CFCs are expected to appear. The Umkehr ozone record of Arosa, Switzerland is the longest Umkehr dataset extending from 1956 to date. In this work we study the variability and the long-term trends of the recently step-corrected Umkehr ozone record of Arosa in order to unravel the anthropogenic and natural components contributing to mid-latitude stratospheric ozone trends. The Umkehr ozone layers have been retrieved from the step-corrected raw data using the improved retrieval algorithm alg-99. The measurements affected by the El-Chichon and the Mt. Pinatubo eruptions were excluded from the analysis. In order to attribute unambiguously the anthropogenic component to the observed long-term ozone changes, the contribution of various natural processes affecting stratospheric ozone has been taken into consideration in a multiple regression model. Trends were calculated for each Umkehr layer with linear multiple regression models by using as explanatory variables the time and either a combination of known climatic oscillations such the solar cycle, the QBO and the Arctic Oscillation or a combination of dynamical proxies such as the tropopause pressure, the equivalent latitude and the EP-flux. The results indicate that dynamical variability accounts partially for the lower stratosphere ozone trends while for the upper stratosphere there is evidence of reversal of the ozone trends by the turn of the 20th century.