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From ozone mini-holes and mini-highs towards extreme value theory: New insights from extreme events and non-stationarity

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Over the last few decades negative trends in stratospheric ozone have been studied because of the direct link between decreasing stratospheric ozone and increasing surface UV-radiation. Recently a discussion on ozone recovery has begun. Long-term measurements of total ozone extending back earlier than 1958 are limited and only available from a few stations in the northern hemisphere. The world´s longest total ozone record is available from Arosa, Switzerland (Staehelin et al., 1998a,b). At this site total ozone measurements have been made since late 1926 through the present day. Within this study (Rieder et al., 2009) new tools from extreme value theory (e.g. Coles, 2001; Ribatet, 2007) are applied to select mathematically well-defined thresholds for extreme low and extreme high total ozone. A heavy-tail focused approach is used by fitting the Generalized Pareto Distribution (GPD) to the Arosa time series. Asymptotic arguments (Pickands, 1975) justify the use of the GPD for modeling exceedances over a sufficiently high (or below a sufficiently low) threshold (Coles, 2001). More precisely, the GPD is the limiting distribution of normalized excesses over a threshold, as the threshold approaches the endpoint of the distribution. In practice, GPD parameters are fitted, to exceedances by maximum likelihood or other methods - such as the probability weighted moments. A preliminary step consists in defining an appropriate threshold for which the asymptotic GPD approximation holds. Suitable tools for threshold selection as the MRL-plot (mean residual life plot) and TC-plot (stability plot) from the POT-package (Ribatet, 2007) are presented. The frequency distribution of extremes in low (termed ELOs) and high (termed EHOs) total ozone and their influence on the long-term changes in total ozone are analyzed. Further it is shown that from the GPD-model the distribution of so-called ozone mini holes (e.g. Bojkov and Balis, 2001) can be precisely estimated and that the “extremes concept” provides new information on the data distribution and variability within the Arosa record as well as on the influence of ELOs and EHOs on the long-term trends of the ozone time series.

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