Geophysical Research Abstracts
Vol. 12, EGU2010-11525, 2010
EGU General Assembly 2010

Extreme events in total ozone over Arosa: Application of extreme value theory and fingerprints of atmospheric dynamics and chemistry and their effects on mean values and long-term changes

Harald E. Rieder (1), Johannes Staehelin (1), Jörg A. Maeder (1), Thomas Peter (1), Mathieu Ribatet (2), Anthony C. Davison (2), Rene Stübi (3), Philipp Weihs (4), and Franz Holawe (5)

(1) ETH Zurich, Institute for Atmospheric and Climate Science, Zurich, Switzerland (harald.rieder@env.ethz.ch), (2) Institute of Mathematics, EPF Lausanne, Lausanne, Switzerland, (3) Federal Office of Meteorology and Climatology (MeteoSwiss), Payerne, Switzerland, (4) Institute for Meteorology, University of Natural Resources and Applied Life Sciences, Vienna, Austria, (5) Institute for Geography and Regional Research, University of Vienna, Vienna, Austria

In this study tools from extreme value theory (e.g. Coles, 2001; Ribatet, 2007) are applied for the first time in the field of stratospheric ozone research, as statistical analysis showed that previously used concepts assuming a Gaussian distribution (e.g. fixed deviations from mean values) of total ozone data do not address the internal data structure concerning extremes adequately. The study illustrates that tools based on extreme value theory are appropriate to identify ozone extremes and to describe the tails of the world's longest total ozone record (Arosa, Switzerland – for details see Staehelin et al., 1998a,b) (Rieder et al., 2010a). A daily moving threshold was implemented for consideration of the seasonal cycle in total ozone. The frequency of days with extreme low (termed ELOs) and extreme high (termed EHOs) total ozone and the influence of those on mean values and trends is analyzed for Arosa total ozone time series. The results show (a) an increase in ELOs and (b) a decrease in EHOs during the last decades and (c) that the overall trend during the 1970s and 1980s in total ozone is strongly dominated by changes in these extreme events. After removing the extremes, the time series shows a strongly reduced trend (reduction by a factor of 2.5 for trend in annual mean). Furthermore, it is shown that the fitted model represents the tails of the total ozone data set with very high accuracy over the entire range (including absolute monthly minima and maxima). Also the frequency distribution of ozone mini-holes (using constant thresholds) can be calculated with high accuracy. Analyzing the tails instead of a small fraction of days below constant thresholds provides deeper insight in time series properties. Excursions in the frequency of extreme events reveal "fingerprints" of dynamical factors such as ENSO or NAO, and chemical factors, such as cold Arctic vortex ozone losses, as well as major volcanic eruptions of the 20th century (e.g. Gunung Agung, El Chichón, Mt. Pinatubo). Furthermore, atmospheric loading in ozone depleting substances lead to a continuous modification of column ozone in the northern hemisphere also with respect to extreme values (partly again in connection with polar vortex contributions). It is shown that application of extreme value theory allows the identification of many more such fingerprints than conventional time series analysis of annual and seasonal mean values. Especially, the analysis shows the strong influence of dynamics, revealing that even moderate ENSO and NAO events have a discernible effect on total ozone (Rieder et al., 2010b). Overall the presented new extremes concept provides new information on time series properties, variability, trends and the influence of dynamics and chemistry, complementing earlier analyses focusing only on monthly (or annual) mean values.

References:

Coles, S.: An Introduction to Statistical Modeling of Extreme Values, Springer Series in Statistics, ISBN:1852334592, Springer, Berlin, 2001.

Ribatet, M.: POT: Modelling peaks over a threshold, R News, 7, 34-36, 2007.

Rieder ,H.E., Staehelin, J., Maeder, J.A., Ribatet, M., Stübi, R., Weihs, P., Holawe, F., Peter, T., and A.D., Davison (2010): Extreme events in total ozone over Arosa – Part I: Application of extreme value theory, to be

submitted to ACPD.

Rieder, H.E., Staehelin, J., Maeder, J.A., Ribatet, M., Stübi, R., Weihs, P., Holawe, F., Peter, T., and A.D., Davison (2010): Extreme events in total ozone over Arosa – Part II: Fingerprints of atmospheric dynamics and chemistry and effects on mean values and long-term changes, to be submitted to ACPD.

Staehelin, J., Renaud, A., Bader, J., McPeters, R., Viatte, P., Hoegger, B., Bugnion, V., Giroud, M., and Schill,
H.: Total ozone series at Arosa (Switzerland): Homogenization and data comparison, J. Geophys. Res., 103(D5), 5827-5842, doi:10.1029/97JD02402, 1998a.

Staehelin, J., Kegel, R., and Harris, N. R.: Trend analysis of the homogenized total ozone series of Arosa (Switzerland), 1929-1996, J. Geophys. Res., 103(D7), 8389-8400, doi:10.1029/97JD03650, 1998b.