A New Method for Describing Long-Term Changes in Total Ozone

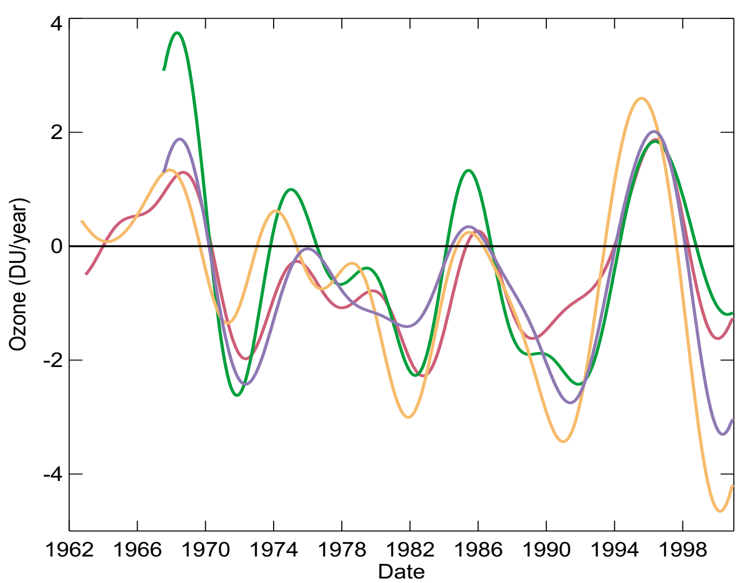
J. M. Harris[1], S. J. Oltmans[1], P. P. Tans[1], R. D. Evans[1], and D. M. Quincy[2]

[1]NOAA Climate Monitoring and Diagnostics Laboratory, 325 Broadway, Boulder, CO 80305; 303-497-6684, Fax:303-497-5590, E-mail: jharris@cmdl.noaa.gov
[2]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder

A method for visualizing long-term changes in total ozone was developed that combines autoregressive (AR) modeling with smoothing in the frequency domain and bootstrap determination of statistical parameters. Using this technique, total ozone variations with periods longer than that of the QBO are described. The technique is designed to be more flexible than traditional trend determination because it can track total ozone tendency in both positive and negative directions. Monthly averages of total ozone Dobson data archived at the WMO World Ozone and Ultraviolet Radiation Data Centre, Downsview, Ontario, Canada, were used. The method first removes "explained" variations in total ozone by regressing to a constant, a cubic polynomial, solar and QBO indices, seasonal harmonics, and detrended temperature at 500 and 100 hPa. The purpose of this step is to reduce the residual variation and to eliminate autocorrelation in the residuals. The cubic function is added back to the residuals of the AR model fit. The next step fits a total ozone tendency curve consisting of a cubic function plus data that have been filtered in the frequency domain. The derivative of the tendency curve is the total ozone growth-rate curve. The overall growth rate is determined by averaging all monthly values along the growth-rate curve. The standard error is determined from the bootstrap samples.

Six midlatitude sites (Bismark, ND; Boulder, CO; Caribou, ME; Nashville, TN; and Wallops Is., VA; and Arosa, Switzerland) all have statistically significant negative growth rates in the range of 1-2% per decade, considering records starting in the 1960s. A decline in total ozone is evident at these sites starting in the early 1970s. As of the end of 2000, ozone recovery is not achieved; in fact, the total ozone tendency at all sites continues downward.

Coherence on a 4- to 12-year time scale was found among the growth rate curves for Bismark, Wallops Is., Caribou, and Arosa (Figure). The growth rate pattern of the tropical sites is also coherent but different from that at midlatitude sites. Samoa's growth rate pattern leads that of Mauna Loa along the entire record by more than a year. The causes for growth rate coherence on this time scale is not known, although meteorological and dynamical regional patterns are one possibility.



Total ozone growth rates for Arosa (blue), Bismark (magenta), Caribou (orange), and Wallops Is. (green). The zero growth rate is the black line.