It is straightforward to show that

$$(1) \qquad \hat{\sigma}_j = \bar{y}_{+j+}, \quad \hat{\alpha}_j = \bar{y}_{+j+}\log[N_{+j}/p_{+j}].$$

This gives some idea about the magnitudes of σ and α and provides an alternative initial estimate for the likelihood; the method mentioned by Smith based on the Gumbel distribution also comes from taking $k_j = 0$. From (1), $\hat{\alpha}$ decreases as p_{+j} increases. This may happen even if k_j is not fixed at zero, so that one must be careful in how to deal with missing values at hours when the ozone levels are typically low.

Finally I have some comments referring to Sections 4 and 5. The mean exceedance rates are based on a unit of a cluster and so one must take into account the average number of days in a cluster in order to compare with the quantities specified by air quality standards. Chock (1982) raises the question of whether it is reasonable to count an adverse multi-day meteorological event several times as having exceeded a threshold.

Smith points out that the analysis needs to be repeated at other sites to get a firm indication of a downward trend in crossing rates at high levels. Walker (1985) reports on ozone trends in California and Texas over a period of 10 years and concludes that there is little evidence that annual average ozone or average peak ozone has been reduced. Walker's analysis is not an extreme value analysis, but he does mention two confounding factors for the ozone trend that are relevant here. These are trends in analytical methodology (for measurements) and data quality assurance. The EPA made ultraviolet photometry the basic calibration procedure for all official ambient ozone monitors in 1979, and data prior to this year are generally adjusted (calibrated) in order to study trends from 1973 on. Was this true of the ozone data in this analysis? Concerning the data quality trend, Walker states that more recently many high values are invalidated as outliers where earlier they were accepted. The methodology in this paper has wide applicability but one must be careful with potential confounding factors in making conclusions.

In conclusion, Professor Smith is to be commended for an excellent paper that develops statistical methodology for an important application and mentions important areas of developing research.

ADDITIONAL REFERENCES

CHOCK, D. P. (1982). On the non-randomness of high-pollution days. *Atmospheric Environment* **16** 2855–2862.

CLEVELAND, W. S., KLEINER, B. and WARNER, J. L. (1976). Robust statistical methods and photochemical air pollution data. *J. Air Pollution Control Assoc.* **26** 36–38.

DUAN, N. (1982). Models for human exposure to air pollution. *Environment International* **8** 305–309.

HIRTZEL, C. S. and QUON, J. E. (1981). Statistical analysis of continuous ozone measurements. *Atmospheric Environment* **15** 1025–1034.

O'BRIEN, G. L. (1987). Extreme values for stationary and Markov sequences. *Ann. Probab.* **15** 281–291.

ROOTZÉN, H. (1988). Maxima and exceedances of stationary Markov chains. *Adv. in Appl. Probab.* **20** 371–390.

WALKER, H. M. (1985). Ten-year ozone trends in California and Texas. *J. Air Pollution Control Assoc.* **35** 903–912.

Comment

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I enjoyed Richard Smith's study of ground-level ozone data using extreme value theory. Smith should be commended for undertaking this project, and congratulated for his lucid analysis and exposition.

After describing the data, Smith gives some theoretical background, just enough for the reader who is not an expert in extreme value theory to understand the analysis that follows. The paper as a whole was written in a free-flowing format that makes it interesting and enjoyable to read. The author applied simple descriptive methods (tables, histograms, boxplots, etc.) as well as sophisticated ones (generalized extreme value models, generalized Pareto models with and without trend, etc.). The latter have been developed to a large extent by Smith himself in earlier works.

Due to time pressure, I will only make a few short comments.

1. EXTREME VALUE ASPECTS

I totally agree with Smith's decision to concentrate on high exceedances. Ozone as well as other pollutants become serious health-hazards when they exceed certain levels (thresholds). The current ozone standard, as Smith puts it, permits no more than three exceedances above 12 parts per 100 million in any 3-year period. Hence, looking at high exceedances is only

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