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# Trends in Air Pollutant Concentrations at a Rural Site in Central Europe

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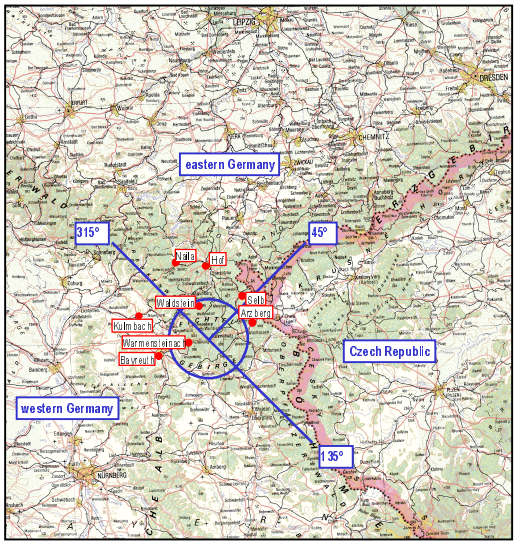
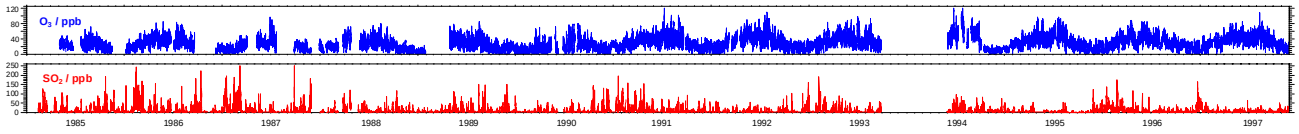
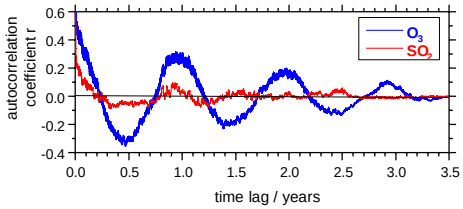


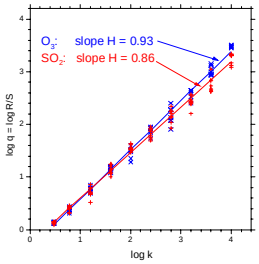

← **Figure 1:** Our research site is in the heart ♥ of Europe. The "Fichtelgebirge" mountains reach altitudes just above 1000 m a.s.l. The station was located in forest clearings, because we are interested in the effect of air pollutants on vegetation. The station was located in "Warmensteinach" (at 575 m a.s.l.) between 1985 and 1993, and at the "Waldstein" site (765 m a.s.l.) since 1994. To the North of our site, there is the area of former East Germany, to the East, there is the Czech Republic, and to the South and West, there is the area of former West Germany.

↓ **Figure 2:** The entire data records (hourly mean values, 1985 → 1997) of $O_3$ and $SO_2$ show the typical seasonality of the $O_3$ and the episodic nature of high $SO_2$ concentrations. The records of the nitrogen oxides ($NO_x$) are less complete. Ammonia ($NH_3$) is measured continuously since January 1997.

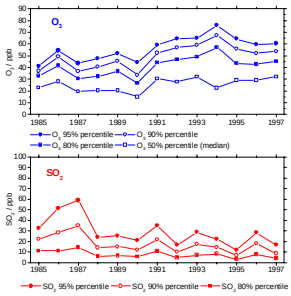


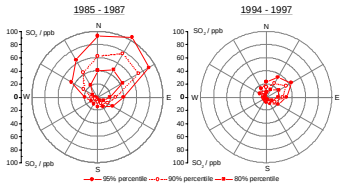

↑ **Figure 3:** Autocorrelation analysis shows that there are annual cycles (more pronounced in the $O_3$ data) but auto-correlations fall below significance after about 3 years.




↗ **Figure 4:** The quantification of long-term persistence (extension of periods with systematic deviations from the overall mean) was performed with the rescaled range statistics. The test statistics q is expected to vary with the time scale k according to $q \propto k^H$, where H is the Hurst exponent. Normally, H is between $0.5 \le H \le 1.0$; the lower limit corresponds to Brownian motion, the upper limit to very high persistence. The Hurst exponents H for our $O_3$ and $SO_2$ data sets are high (0.93 and 0.86, resp.) and significantly different from each other. High concentrations tend to occur in extended periods. The extensions are longer for $O_3$ than for $SO_2$.




↑ **Figure 5:** $O_3$ increases significantly over the 13-year period, $SO_2$ decreases significantly




↑ **Figure 6:** The analysis of $SO_2$ together with the wind direction shows that the decrease of $SO_2$ occured at all wind directions. The strongest decrease occured at northerly winds due to reductions of $SO_2$ emissions in eastern Germany, and to a lesser gedree at easterly winds due to reductions in the Czech Republic.

**Conclusions:**

- High $O_3$ and $SO_2$ concentrations occur in extended periods. The extensions of the periods are governed by meteorological patterns (for $SO_2$) or by meteorological and photochemical conditions ($O_3$)
- $SO_2$ exhibits a significant decreasing trend
- the steepest decrease was found for northerly wind directions
- $O_3$ exhibits a significant increasing trend
- $O_3$, $NO_x$, and $NH_3$ show no dependance of concentrations on wind direction (data not shown)
- We apply more statistical measures (spectral analysis, complexity, recurrence, ...) to further characterize our data sets.

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