Hydrology and Earth System Sciences
An Interactive Open Access Journal of the European Geosciences Union

Hydrol. Earth Syst. Sci., 7, 583-595, 2003
www.hydrol-earth-syst-sci.net/7/583/2003/

Coherent response of lakes in Ontario, Canada to reductions in sulphur deposition: the effects of climate on sulphate concentrations

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Abstract. Sulphate deposition in south-central Ontario declined between 1976 and 2000 by more than 50%, whereas lake sulphate (SO_4^{2-}) concentrations decreased by, on average, only half as much. To investigate the factors that controlled this slower than expected response, the temporal patterns in lake SO_4^{2-} concentrations were compared with patterns in both deposition and climate, since climate has a major influence on the hydrological cycle in this part of the continent. To do this, the temporal coherence in SO_4^{2-} concentrations between 9 lake basins was estimated using the intraclass correlation from a repeated-measures analysis of variance and two subsets of lakes were found (six in one group, four in the other), each with lakes having synchronous patterns. One subset (4 lakes) included the 3 with the longest water replenishment times (>3.4 yr) which are expected to respond to decreases in SO_4^{2-} deposition more slowly. However, the average pattern reflecting the temporal changes of each of the two subsets was very similar. The response of both subsets of lakes to the decreasing SO_4^{2-} deposition over two decades was independent of the degree of acidification or sensitivity to acidification of the lakes. In a determination of which factors best predicted each of those two subsets' SO_4^{2-} time series, good predictive models were produced by regional/global-scale climate indices, specifically the Southern Oscillation Index (SOI) describing the El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation Index (NAOI), as well as by SO_4^{2-} deposition indices. When the predictor variables were combined, models which described the long-term changes in lake SO_4^{2-} concentration best included the SOI, the NAOI and SO_4^{2-} deposition. Thus, large-scale climate factors play a major role in determining the response of aquatic systems to changes in SO_4^{2-} deposition, perhaps through their influence on lake and/or catchment processes that effectively delay recovery.

Keywords: Atmospheric deposition, lake recovery, temporal trends, climate, temporal coherence

Final Revised Paper (PDF, 862 KB)

Citation: Dillon, P. J., Somers, K. M., Findeis, J., and Eimers, M. C.: Coherent response of lakes in Ontario, Canada to reductions in sulphur deposition:

the effects of climate on sulphate concentrations, Hydrol. Earth Syst. Sci., 7, 583-595, 2003. Bibtex EndNote Reference Manager