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Modelling reversibility of central European mountain lakes from acidification: Part II – the Tatra Mountains

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Abstract. A dynamic, process-based model of surface water acidification, MAGIC7, has been applied to four representative alpine lakes in the Tatra Mountains (Slovakia and Poland). The model was calibrated for a set of 12 to 22-year experimental records of lake water composition. Surface water and soil chemistry were reconstructed from 1860 to 2002 and forecast to 2050 based on the reduction in sulphur and nitrogen emissions presupposed by the Gothenburg Protocol. Relatively small changes in the soil C:N ratios were not sufficient to simulate observed changes in NO_3^- concentrations, so an alternative empirical approach of changes in terrestrial N uptake was applied. Measured sulphate sorption isotherms did not allow calibration of the pattern of sulphate response in the lakes, indicating that other mechanisms of S release were also important. The lake water chemistry exhibited significant changes during both the acidification advance (1860 to 1980s) and retreat (1980s to 2010). An increase in lake water concentrations of strong acid anions (SAA; 104–149 μeq l^{-1}) was balanced by a decline in HCO_3^- (13–62 μeq l^{-1}) and an increase in base cations (BC; 42–72 μeq l^{-1}), H^+ (0-18 μeq l^{-1}), and Al_i^{n+} (0–26 μeq l^{-1}). The carbonate buffering system was depleted in three lakes. In contrast, lake water concentrations of SAA, BC, H^+, and Al_i^{n+} decreased by 57–82, 28–42, 0–11, and 0–22 μeq l^{-1}, respectively, the carbonate buffering system was re-established, and HCO_3^- increased by 1–21 μeq l^{-1} during the chemical reversal from atmospheric acidification (by 2000). The MAGIC7 model forecasts a slight continuation in this reversal for the next decade and new steady-state conditions thereafter. Gran alkalinity should come back to 1950s levels (0–71 μeq l^{-1}) in all lakes after 2010. Partial recovery of the soil pool of exchangeable base cations can be expected in one catchment, while only conservation of the current conditions is predicted for three lakes. Even though the pre-industrial alkalinity values of 16–80 μeq l^{-1} will not be reached due to the insufficient recovery of soil quality, the ongoing chemical improvement of water should be sufficient for biological recovery of most alpine lakes in the Tatra Mountains.

Keywords: MAGIC, atmospheric deposition, sulphate, nitrate, base cations, aluminium, alkalinity, pH

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