

Sources and fate of nitrate and sulfate in a sandy aquifer: A multi-isotope study

YAN-CHUN ZHANG¹, CAROLINE P. SLOMP¹,
HANS PETER BROERS², HILDE F. PASSIER²,
MICHAEL E. BÖTTCHER^{3,4}
AND PHILIPPE VAN CAPPELLEN^{1,5}

¹Faculty of Geosciences, Utrecht University, the Netherlands
(*correspondence: yanchun.zhang@geo.uu.nl)

²TNO – Built Environment and Geosciences, Utrecht, the Netherlands

³Institute for Baltic Sea Research, Warnemünde, Germany

⁴MPI-MM, Bremen, Germany

⁵School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, USA

Nitrate and sulfate are common pollutants in groundwater in areas with intensive agriculture. In this study, we combine multi-isotope analyses ($\delta^{34}\text{S-SO}_4$, $\delta^{18}\text{O-SO}_4$, $\delta^{15}\text{N-NO}_3$, $\delta^{18}\text{O-NO}_3$) with geochemical analyses and groundwater age dating ($^3\text{H}/^3\text{He}$) to identify the sources, sinks and the relevant transformation processes of nitrate and sulfate in a sandy aquifer at Oostrum, the Netherlands. We specifically focus on the role of denitrification coupled to pyrite oxidation and compare results for sites in cultivated land to a site in an adjacent forested area.

The groundwater in our study area is characterized by extremely high nitrate and sulfate concentrations, with maximum concentrations of 8 mM (500 mg/L) and 4 mM (400 mg/L), respectively. The isotope composition of groundwater from shallow depths (<10 m) at cultivated and forested sites is, in general and regardless of age, rather similar, suggesting mostly common sources of nitrate and sulfate. Only at the forest site, a slightly higher atmospheric deposition is inferred from both $\delta^{18}\text{O-SO}_4$ and $\delta^{18}\text{O-NO}_3$ values. Sulfate concentrations increase and nitrate concentrations decrease in groundwater in a “reaction zone” between 10 and 20 m depth in groundwater in cultivated areas. The changes in isotopic composition of the groundwater in this reaction zone confirm geochemical analyses suggesting that denitrification is coupled to pyrite oxidation in this aquifer [1]. Isotope analyses of groundwater from the deeper part of the aquifer (> ~25m) indicate sulfate removal through microbial sulfate reduction.

[1] Zhang *et al.* (2008) *GCA* **72**, A1090.

Global-through-urban WRF/Chem: A unified model for modeling aerosol-climate interactions

Y. ZHANG^{1*}, Y. PAN¹, X.-Y. WEN¹, Y.-S. CHEN¹,
P. KARAMCHANDANI², D.G. STREETS³ AND Q. ZHANG³

¹North Carolina State University, Raleigh, NC, 27695, USA
(*correspondence: yang_zhang@ncsu.edu)

²Atmospheric and Environmental Research, Inc., San Ramon, CA 94583, USA

³Argonne National Laboratory, Argonne, IL 60439, USA

Introduction

Simulating aerosol-climate interactions presents a major challenge in quantifying the impacts of air pollution on climate change. A unified Global-through-Urban Weather Research and Forecasting Model with Chemistry (GU-WRF/Chem) is being developed at North Carolina State University to accurately simulate feedbacks among meteorology, chemistry, aerosols, clouds, and radiation at all scales. This study highlights recent model developments and application over nested domains from global to urban scales.

Model Development and Application

The main model developments include the incorporation of the U.S. EPA's 2005 Carbon Bond Mechanism (CB05) using the Kinetic PreProcessor (KPP), the extension of CB05 to simulate halogen and mercury chemistry and stratospheric chemistry involving greenhouse gases, and heterogeneous reactions for global applications (referred to as CB05 for global extension (CB05GE)), the coupling of CB05GE with the Model of Aerosol Dynamics, Reaction, Ionization, and Dissolution (MADRID) and aqueous-phase chemistry, and the incorporation of an aerosol activation module to simulate indirect aerosol effects via serving as cloud condensation nuclei (CCN) and affecting cloud droplet number concentration (CDNC). Nested simulations are being conducted for 2001 over multiple domains such as a global domain at 4° (Lat) \times 5° (Lon), a Trans-Pacific domain covering Asia, Pacific, and North America at $1.0^\circ \times 1.25^\circ$, the continental U.S. and China at $0.33^\circ \times 0.42^\circ$, and the eastern U.S. at $0.11^\circ \times 0.14^\circ$. Model evaluation using surface and satellite data is being conducted to assess the model capability in reproducing meteorological and chemical observations. The feedbacks of aerosols to simulated meteorology, radiation, and CCN and CDNC as well as associated seasonalities are being examined. Major challenges in simulating aerosol-climate interactions will be discussed.