# Water isotopes during the Last Glacial Maximum: New GCM calculations

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The application of water isotopes to estimate the glacial-interglacial cycle of temperature ($T$) assumes the validity of the present-day spatial relationship between $T_a$ and $\delta^{18}O$ in precipitation ($\delta^{18}O_{ppt}$) to estimate temporal changes of the temperature at a fixed location. We explored how and why the spatial relationship between annual mean $T_a$- $\delta^{18}O_{ppt}$ is different from the temporal relationship at one location. Our GCM-isotope model exhibits a spatial slope of 1.22‰/°C between annual mean temperature at the top of the inversion layer ($T_i$) and $\delta^{18}O_p$ over Antarctica, comparable to the observed value of 1.25‰/°C from [1]. Over the southern ocean (45°-60°S), local evaporation accounts for 50% of precipitation, and this evaporative flux (mean $\delta^{18}O_e$ of ~-1‰) increases the $\delta^{18}O$ of vapor (mean $\delta^{18}O_v$ of -16‰). During the Last Glacial Maximum (LGM: 21,000 years ago), the isotopic composition of the vapor near the ice edge (~60°S) is calculated to be similar to the present values because evaporative recharge also accounts for ~50% of the precipitation over the southern ocean. As a result, the isotopic composition of vapor during the LGM is close to the present values at the ice edge. The apparent temporal slope over eastern Antarctica is half of the observed spatial slope. Our LGM experiment estimates an Antarctic cooling of 13°C at Vostok, much colder than previous estimates. Our experiments with two specifications of LGM sea surface temperatures suggest that the value of the temporal slope is related to the temperature decrease over the southern ocean.

[1] Dahe *et al.* (1999).

# Tracing the sources of nitrate in the Han River watershed in Korea, using a dual isotope approach

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The dissolved nitrate concentrations and their nitrogen and oxygen isotopic ratios were analyzed in seasonal samples from Korea's Han River to ascertain the seasonal and spatial variations of dissolved nitrate and its possible sources. Nitrate concentrations in the South Han River (SHR) were much higher than those in the North Han River (NHR), probably because of the more extensive distribution of agricultural fields, residential areas and animal farms in the SHR drainage basin. The nitrogen isotopic composition of dissolved nitrate indicates that nitrate-nitrogen is derived mainly from atmospheric deposition and/or soil organic matter in the NHR but comes principally from manure or sewage, with only a minor contribution from atmospheric deposition or soil organic matter, in the SHR. The oxygen isotopic compositions of dissolved nitrate suggest that most atmospheric nitrate undergoes microbial nitrification before entering the river.

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