Water vapour isotope anomalies during an atmospheric river event at Dome C, East Antarctica

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Abstract

On December 19-21 2018, an atmospheric river hit the French-Italian Concordia station, located at Dome C, East Antarctic Plateau, 3 269 m above sea level. It induced a significant surface warming (+ 15∘C in 3 days), combined with high specific humidity (multiplied by 3 in 3 days) and a strong isotopic anomaly in water vapour (+ 15 ‰ for δ18O). The isotopic composition of water vapour monitored during the event may be explained by (1) the isotopic signature of long-range water transport, and by (2) local moisture uptake during the event. In this study, we use continuous meteorological and isotopic water vapour observations, together with the atmospheric general circulation model LMDZ6iso, to describe this event and to quantify the influence of each of these processes. The presence of mixed-phase clouds during the event induced a significant increase in downward longwave radiative fluxes, which led to high turbulent mixing in the boundary layer. These fluxes are well represented by LMDZ6iso, as are the near-surface temperature and specific humidity. The surface vapour δ18O is accurately simulated during the event, despite an overestimated amplitude in the diurnal cycle outside of the event. Using this LMDZ6iso simulation, we perform a water vapour mass budget in the boundary layer and we show that the primary driver of the positive δ18O anomaly in vapour is surface sublimation, which becomes significantly stronger during the event compared to typical diurnal cycles. The second contribution arises from large-scale moisture advection associated with the atmospheric river. Consequently, the isotopic signal monitored in water vapour during this atmospheric river event reflects both long-range moisture advection and interactions between the boundary layer and the snowpack. Only specific meteorological conditions driven by the atmospheric river can explain these strong interactions. Enhancing the representation of local processes in climate models, especially by incorporating isotopic fractionation during sublimation, could substantially improve the simulation of the isotopic signal over Antarctica. Given the importance of air-snow vapour exchanges at the surface and in the atmosphere and their influence on the isotopic composition of surface snow, such simulations could provide valuable insights into how moisture advection events might affect the climate-scale isotope signal in ice cores.

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