Stable water isotopes (deltaD and delta^{18}O) from polar ice cores are often used as local temperature (Tsite) proxies in palaeoclimate reconstructions. The deuterium excess signal (d) is a second order isotopic parameter recording conditions in the oceanic source region, including in sea surface temperature (Tsource). Studies combining both water isotopes and d estimate past changes in Tsite and Tsource. These palaeo-records indicate dynamic changes in the atmospheric water cycle, including significant variability in the location of moisture sources to high-latitudes around the Last Glacial Maximum (LGM).

Field observations constraining the relationship between d in water vapour and oceanic surface conditions are limited. We aim to improve the estimate of this observed relationship through multiple climate simulations using the Goddard Institute of Space Studies ModelE-R, a fully coupled atmosphere-ocean general circulation model equipped with water isotope tracers. In addition, we incorporate a novel suite of vapour source distribution tracers to assess the skill of d as a proxy for Tsource variability during a variety of climate changes.

We simulate mean climate conditions during various time slices, including pre-industrial, mid-Holocene (6 kyr) and LGM PMIP coordinated experiments, and compare to palaeo-reconstructions from Greenland and Antarctica. We find that the drivers of d variability are complex and dynamic, and linked to changes in atmospheric circulation, water vapour transport and mixing, together with changes occurring in the vapour source region. This study demonstrates the utility of integrated model-data comparisons in constraining isotope-climate relationships and for interpreting variability in water isotope records.