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Interannual variability in isotope-climate relations: Model-data comparisons for the northern Great Plains of North America

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The incorporation of water isotope tracers into atmospheric general circulation models (AGCMs) has provided a critical independent test of the models ability to consistently partition and conserve both mass and isotopes in the water cycle. Comparisons between the isotope fields generated by AGCMs and measured precipitation isotope compositions compiled by the International Atomic Energy Agency/World Meteorological Organization Global Network for Isotopes in Precipitation (GNIP) have demonstrated the ability of AGCMs to reproduce the spatial distribution of long-term means as well as the seasonal cycle of water isotopes in precipitation. However, on interannual time-scales local controls on isotope records (temperature and precipitation amount) are much weaker and model analysis is needed to deconvolute the isotope signals into local and regional influences.

Here we present model-data comparisons from a number of simulations using the global AGCM ECHAM4 and the regional model (REMOiso) focusing on the northern Great Plains. Monthly precipitation water isotope values from three Canadian GNIP stations over the 1970s and 80s show strong circulation effects, with isotope anomalies and the δ^{18}O-T relation both varying with the strength of the ridge and trough pattern over western Canada (i.e., the Pacific North American) index. To better understand this decoupling of temperature and isotope signals, we perform a set of ensemble simulations forced with observed 20^{th} century SSTs. In the extra tropics circulation is only poorly controlled by SSTs so our analysis also includes a nudged ECHAM4 simulation in which the isotopic water cycle is unaltered but with model dynamics

modified to match the reanalysis fields from the ECMWF climate center (ERA40). Additional simulations using REMOiso are used to investigate the importance of the spatial representation of topography on the simulation of moisture transport across the Rockies. This study represents an important step towards developing better understanding of the complexity of the isotope signal on interannual time scales that is necessary for interpretation of millennium scale isotopic archives. The blending of modern observations with paleo-archives will provide the isotope time-series necessary for quantitative comparisons with millennium scale coupled AGCM simulations currently in progress.