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Using water isotopic measurements for understanding model biases in model simulations of the hydrological cycle over Western Siberia

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The isotopic composition of water vapor and precipitation simulated by the LMDZ GCM over Siberia was evaluated using several datasets: TES and GOSAT satellite observations of tropospheric water vapor, GNIP and SNIP precipitation networks, and in-situ measurements of water vapor and precipitation at the Kourovka site in Western Siberia. Using δD vs humidity diagrams, we explore the complementarity of these two variables to interpret model biases in terms of the representation of physical processes. LMDZ captures the spatial, seasonal and daily variations reasonably well. LMDZ overestimates the δD in precipitation compared to the precipitation networks. Consistent with this result, LMDZ overestimates the δD observed in both the vapor and precipitation at Kourovka. This bias is most likely associated with a misrepresentation of air mass origin. LMDZ slightly underestimates the latitudinal gradient in δD compared to satellite datasets. LMDZ also underestimates the seasonality in the lower and middle troposphere at Kourovka compared to satellite datasets, but not at the surface compared to the in-situ data. Finally, LMDZ captures some aspects of the spatial and daily variations in d-excess.

The performance of LMDZ is put in the context of other isotopic models from the SWING2 models. There is significant spread among models in the simulation of δD, and of the δD vs humidity relationship. This confirms that δD brings additional information compared to humidity only. We specifically investigate the added value of water isotopic measurements to interpret the warm and dry bias featured by most GCMs over mid and high latitude continents in summer. LMDZ simulates the strongest dry bias on days when it simulates the strongest enriched bias in δD. The analysis of the slopes in δD vs humidity diagrams and of processes controlling δD and humidity variations suggests that the cause of the moist bias could be either a problem in the large-scale advection transporting too much dry and warm air from the south, or insufficient surface evaporation.