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A joint soil-vegetation-atmospheric modeling procedure of water isotopologues with WRF-Hydro-iso: Implementation and application to present-day climate in Europe and Southern Africa

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Water isotopologues, as natural tracers of the hydrological cycle on Earth, provide a unique way to assess the skill of climate models in representing realistic atmospheric and terrestrial water pathways. In the last decades, many global and regional models have been developed to represent water isotopologues and enable a direct comparison with observed isotopic concentrations. This study presents the recently developed regional model, WRF-Hydro-iso, which is a version of the coupled atmospheric – hydrological modeling system WRF-Hydro enhanced with a joint soil-vegetation-atmospheric description of water isotopologues motions. WRF-Hydro-iso is applied to two regions in Europe and Southern Africa under present climate condition. The setup includes an outer domain with a 10 km grid-spacing, an inner domain with a 5 km grid-spacing, and a subdomain with a 500 m grid spacing that can be coupled with the inner domain in order to represent lateral terrestrial water flow. A 10-year slice is simulated for 2003-2012, using ERA5 reanalyses for the boundary condition. The boundary condition of the isotopic variables is specifically provided with climatological values deduced from a 10-year simulation with the Community Earth System Model Version 1. For both Europe and Southern Africa, WRF-Hydro-iso realistically reproduces the climatological variations of the isotopic concentrations $\delta_P{}^{18}O$ and $\delta_P{}^{2}H$ from the Global Network of Isotopes in Precipitation. In a sensitivity analysis, it is found that land surface evaporation fractionation increases the isotopic concentrations in the rootzone soil moisture and slightly decreases the isotopic concentrations in precipitation, an effect that is modulated by the change in evaporation – transpiration partitioning caused by lateral terrestrial water flow. The ability of WRF-Hydro-iso to account for a detailed description of terrestrial water transport makes it as a good candidate for the dynamical downscaling of global paleoclimate simulations and for the comparison to isotopic measurements in proxy data such as plant wax fossils.