Modelling water isotopes using a global non-hydrostatic model with explicit convection scheme for investigating model’ s bias and uncertainty

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The stable water isotopes (SWIs) (δ^{18}O and δD) are used as an indicator of the intensity of the atmospheric hydrological cycle due to their large variability in time and space. SWIs are used for investigating the model’ s bias and uncertainty. In this study, we incorporated water isotope process into a single-moment cloud microphysics scheme, and developed a new global non-hydrostatic atmospheric model equipped with SWIs (NICAM-WISO). We applied the new model to conduct three current climate simulations: CTRL, LRES, and HRES. These simulations used the same physical process but at a different horizontal resolution (LRES, 224 km; CTRL, 56 km; HRES, 14 km). We conducted the simulations on the supercomputer Fugaku. The annual means of precipitation isotopic ratios were validated against limited station observation data derived from Global Network of Isotopes in Precipitation. CTRL reproduced isotope effects including latitude, altitude, and continental effects. However, there were two types of biases in CTRL. First, CTRL had a positive bias in precipitation δD in northern Andes region. The positive bias was related to the setting of horizontal resolution, because the bias was improved (worsened) in HRES (LRES). Since the precipitation isotopic ratios are decreased with decreasing the remaining vapor, the positive bias is due to a bias in atmospheric hydrological cycle in the upper moisture stream region. Second, CTRL overestimated precipitation isotopic ratios at high latitudes, especially in cold continental regions such as Siberia, Greenland, and Antarctica. These biases were found in the other simulations, indicating uncertainty of cloud microphysics. The uncertainty is derived from atmospheric humidity process in middle troposphere and short-life bias in liquid cloud. Together, these results suggest that stable water isotopes are helpful for identifying biases associated with cloud microphysics and the atmospheric hydrological cycle. The unique constraints of stable water isotopes revealed cloud microphysics uncertainty and biases in the hydrological simulations.

Keywords: Stable precipitation isotpes, NICAM