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Isotopic Simulation of Combustion-derived Vapor Emission in Urban Areas Using Regional Spectral Model

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Vapor from anthropogenic emissions accounted for a significant proportion of the urban atmospheric water due to the process of urbanization. Fossil fuel combustion-derived vapor (CDV) is one of the main sources of anthropogenic water. Due to the extremely low d-excess ($\delta D - 8*\delta^{18}O$) value of CDV (-206.7‰ weighted average from different kinds of fossil fuels), stable hydrogen and oxygen isotope can be a promising method to partition CDV from other natural sources. Considering several limitations of long-term in-situ measurement of water isotopes in the urban area, this study explored the possibility to use IsoRSM, an isotopic-enable regional spectral model to simulate the emission situation of CDV.

Two experiments were made respectively in Salt Lake City, USA for one month and in Beijing, China for one year. A fixed emitting rate of CDV with a fixed isotopic ratio was added to the evaporation process of the model in the urban domains (2°×2°) of these two cities, and the result indicated that the addition of CDV could significantly decrease the d-excess of water vapor, especially when the boundary layer was stable. The modified d-excess fitted better with the time series and diurnal variation of in-situ observation than the simulation without CDV in Salt Lake City and in the summer monsoon season of Beijing. Furthermore, the addition of CDV also resulted in an obvious negative correlation between vapor d-excess and specific humidity. In the simulations, the fraction of CDV in the total atmospheric water in January of Salt Lake City reached more than 20% with an average value of 3.4%, and the peak values mainly occurred when the stability of the atmosphere was relatively high. The mean CDV fraction in the monsoon season of Beijing would also be 2.3%. The CDV fraction calculated from vapor d-excess was slightly lower than moisture tracer method. In summary, the bias of d-excess simulation from IsoRSM in the stable boundary layer periods could be improved by adding CDV emission into the local evaporation process.