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Enigmatic Multi-Year Oscillations in Water Isotopic Composition of East Asia: Insights from a Subtropical Reservoir

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A continuous bi-weekly water isotope analysis ($\delta^{18}O$, δD, and d-excess) was done since 2015 from a subtropical reservoir (Feitsui Reservoir) in northern Taiwan. The Feitsui reservoir is an important national freshwater system, as it provides water for the large urban population of Taipei. The isotopic data reveals a multiyear pattern and it closely follows the rainfall isotopic composition. We made a simple mass-balance model using the rainfall isotopic composition, inflow and outflow volumes, and meteorological parameters that fit well (R^2 = 0.55; p-value < 0.05) with the observed isotopic composition of the reservoir. Based on this model, we estimated reservoir isotopic composition for the previous 20 years (2001-2021). The model also well reproduced a few years of historical data reported in the literature. In the model, we noted two conspicuous patterns: (1) multiyear cyclicity in $\delta^{18}O$ and d-excess, and (2) a long-term enriching trend in $\delta^{18}O$. These patterns were not so obvious in rainfall because of the strong seasonality, which gets diluted in the reservoir because of the longer water residence time (~6 months). However, these patterns became visible in rainfall isotopes after removing the seasonal cycles. The observed multiyear patterns do not resemble with the known multiyear global processes, such as ENSO, PDO, and the East Asian Monsoon Index. However, the role of these global processes cannot be ruled out completely. We believe that because of the unique geographical location of the island, multiple moisture sources (South China Sea and central/northern China), dual monsoons (summer and winter monsoons), and complex hydrometeorological processes, the signals of these multiyear global processes get modulated and modified. The long-term enriching trend in $\delta^{18}O$ seems to be a consequence of climate change. The enriching trend is more vivid during the winters than summers. This indicates the possible role of global warming and the expansion of the tropics because the Tropics of Cancer passes through central Taiwan. There also remains a significant knowledge gap in understanding the role of winter monsoons in East Asia. This study highlights the importance and the need for rigorous climatic research in Taiwan because of its unique location which makes it highly sensitive to climate change. This study may also have implications for paleoclimatic studies because it highlights the complex hydrometeorology of the region.