Variability of stable isotope ratios in precipitation at Kumamoto and comparison with the deuterium excess in evaporated water vapor

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The deuterium excess ($d\text{-}excess = \delta D - 8 \times \delta^{18}O$) of precipitation is often used for the estimation of the source areas where water vapor is evaporated, because the d-excess is primarily determined by relative humidity, sea surface temperature, and wind speed as water vapor evaporates and is seems to conserved during the atmospheric moisture transportation process. The purpose of this study is to compare with observed d-excess in precipitation at Kumamoto and estimated d-excess in water vapor in the source area.

Meteorological observation and precipitation sampling for stable isotopes ($\delta^{18}O$ and $\delta^{2}H$) have been carried out at Kumamoto University since March 2015. In this study, the seasonal variability of stable isotope ratios in precipitation at Kumamoto were clarified. The stable isotope ratios of precipitation show low in summer (June-August) and high in winter (December-February). In addition, the d-excess values show low in the warm season (May-October) and high in the cold season (November-April). The intercepts of local meteorological water lines (LMWL) in the warm (May-October) and cold (November-April) seasons was much larger than that of global meteorological water line, and the slope of LMWLs in the warm season is larger than that in the cold season. Correlation with monthly averaged $\delta^{18}O$ in precipitation show a significant negative correlation with precipitation amount, however, a significant positive correlation is found with air temperature (i.e. opposite to temperature effect).

For comparing the observed d-excess in precipitation at Kumamoto with the d-excess of evaporated water vapor in the source area, the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to determine the backward trajectories of rain events in summer, winter, approaching typhoon, and torrential rain. From the backward trajectory analyses for 7days, estimated source areas of winter rain events are mainly in the Sea of Japan and the Pacific Ocean near Japan. On the other hand, those in summer rain events are mainly in the Pacific Ocean, Philippine Sea, and the South China Sea far from Japan. The d-excess in water vapor evaporated from the sea surface is estimated by the equation of Merlivat and Jouzel (1979), and sea surface temperature, sea level pressure and specific humidity at 2m are from the COBE-SST and NCEP/NCAR reanalysis. As a result, estimated d-excess in evaporated water vapor during the trajectory which levels are less than 500m are mainly less than 15‰ in summer and more than 20‰ in winter. The slope of regression line between observed and estimated d-excess values is 1.07, the correlation coefficient is 0.88 which is above the statistical significance. However, water vapor is mixing with other air mass during the trajectory from the source area to the precipitation observation site. Further study is required to consider the d-excess in precipitable water and evaporated water during the trajectory by using the isotope-incorporated general circulation model.

Keywords: Kumamoto, precipitation, stable isotope ratio, d-excess, water vapor origin

