Event based analysis on oxygen and hydrogen isotopes of rainwaters in Kyoto

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Introduction

Isotopic signatures of rainwater are useful tool to investigate the origins and hydrometeorological processes of precipitation. Although those isotopic characteristics have often been used for the discussions on the global scale water cycle and precipitation phenomena, those can potentially have useful information for retrieve the origins and processes of precipitation in regional scale, such as the Japanese archipelago.

In order to clarify the generating mechanisms of precipitation and the origins of precipitable water vapor, we investigated the isotopic compositions of rainwaters and climatic and meteorological factors for every rain events in Kyoto.

Method

A rainwater sampler was installed at the campus of the Field Science Education and Research Center, Kyoto University on July 12th in 2007. Samples of fifty-five rain events are collected for six months from summer rainy season to winter dry season. $d^{18}O$ and dD were measured by a mass spectrometer attached with water equilibration device in the Center for Ecological Research, Kyoto University. Meteorological parameters (precipitation, air temperature and relative humidity) have been monitored at the observation field located at near the sampling point. To refer the meteorological situation of the each water sample, the synoptic weather charts for each event were also prepared from the database of the Japan Meteorological Agency.

Results

The event-to-event variations in $d^{18}O$, dD and d-excess values were observed regardless of the season. The d-excess values were less than 10 permil in summer, while those were 20 permil in winter. The correlations were found between the $d^{18}O$ and dD values and air temperature, and also precipitation amount of each event. The correlation between the d-excess values and air temperature was significantly clear. The relationship between the wind direction at 850 to 1000 hPa height and the d-excess value were also found, and the d-excess value increased with the westerly wind. Interestingly, in the most cases of the approach of tropical cyclone or the stationary front, the d-excess value rapidly dropped.

Discussion

The negative correlation between the $d^{18}O$ and dD values and the precipitation amount is one of the common phenomena usually explained by the Rayleigh process in the condensation of precipitable water vapor. Thus, it is considered that the day-to-day variation in $d^{18}O$ and dD values were controlled by the short term meteorological successions including the variations in the cloud formations, such as a convective or an stratiform clouds.

Sinusoidal seasonal variation in the d-excess value showing high value in winter and low in summer has been reported commonly in the Japanese Archipelago. This seasonality has been explained by seasonal change of the anniversary wind. In summer, relatively gentle evaporation on the surface of the Pacific Ocean provide the precipitable water with low d-excess value, and the westerly seasonal wind from the Siberian continent contrastingly causes kinetically active evaporation from the surface of the Japan Sea, resulting the high d-excess values in the winter precipitation. Although the seasonal variation in our d-excess data can be explained by similar mechanism, the day-to-day fluctuation of the d-excess value including occasional drops mainly caused by vapor supply from the Pacific Ocean side with the tropical cyclone or the stationary front. This mechanism was reviled only by the event based sampling in this study in Japan.