Temporal Variation in Water Stable Isotope Composition of Precipitation during rainfall

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Introduction

Water stable isotope composition of precipitation has been used to understand the global and regional water cycles. To investgate the regional water cycle, previous studies have relied mostly on changes in daily- to monthly-averaged isotope composition of precipitation. Figure 1 displays an isotopic scheme during evaporation and precipitation. In the figure, however, the exact numbers can vary depending on meteorological factors such as temperature and precipitation rate, even within a single rainfall event. In this study, we monitored the changes in water isotope composition over the course of rainfall events. The results showed that the δD and $\delta^{18}O$ values varied widely from -11.94‰ to -2.18‰ and from -91.44‰ to -14.40‰, respectively. The δD-$\delta^{18}O$ slope for entire samples was 8.18, but those for single events were 6.51, 7.43 and 9.93. Our study stresses the need for high-resolution sampling of precipitation to better understand the regional water cycle.

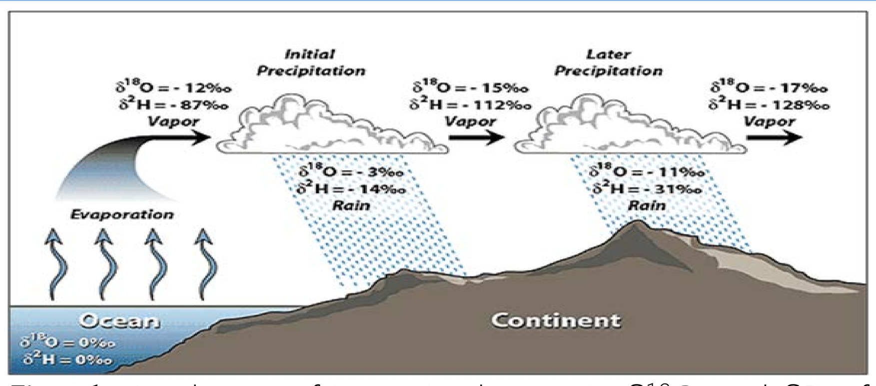

Fig. 1. A scheme of isotopic change in $\delta^{18}O$ and δD of precipitation (based on Hoefs (1997) and Coplen et al. (2000).)

Sampling & Study area

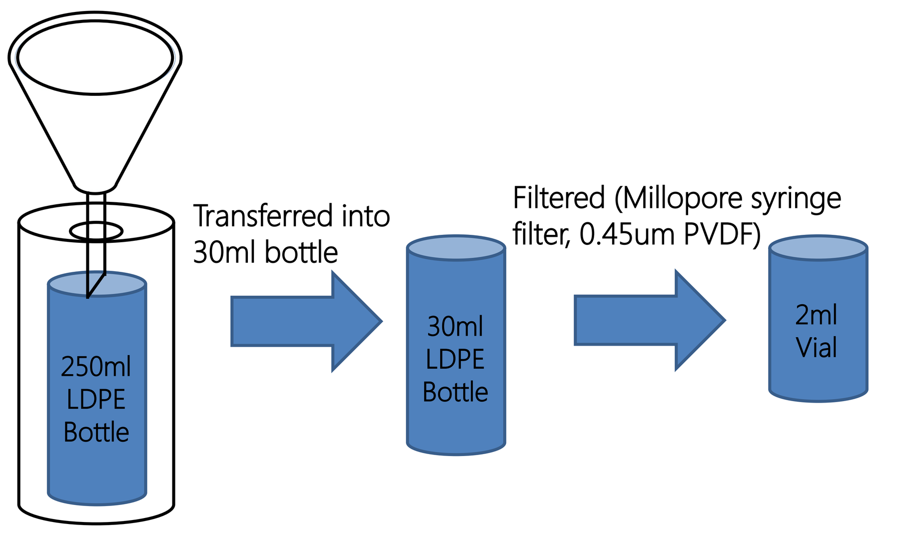

Fig. 2. An manual sampler used in this study. All tools and bottles were dried at 50 ℃ before.

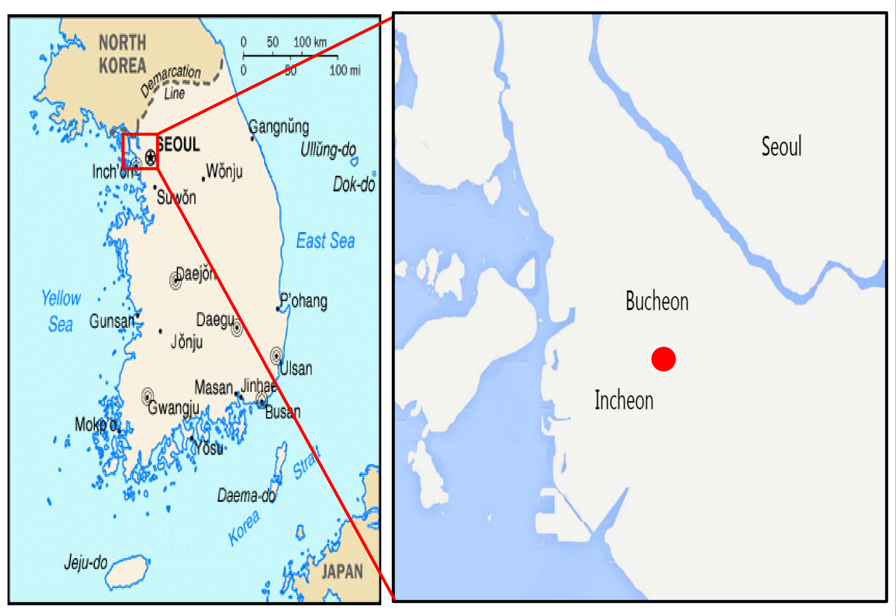

Fig. 3. Map of sampling location.

Experimental Method

$$\delta D\ (‰) = \left[\frac{((D/H)_{sample}) - ((D/H)_{standard})}{((D/H)_{standard})}\right] \times 10^3$$

$$\delta^{18}O\ (‰) = \left[\frac{((^{18}O/^{16}O)_{sample}) - ((^{18}O/^{16}O)_{standard})}{((^{18}O/^{16}O)_{standard})}\right] \times 10^3$$

Deuterium excess (‰) = δD $-8\delta^{18}O$

Standard	Matrix	Reference value δD (‰)	Reference value $\delta^{18}O$ (‰)
V-SMOW2	Water	0	0
GISP		-24.76	-189.5
SLAP2		-427.5	-55.50

Table. 1. δD and $\delta^{18}O$ reference values (‰) of the V−SMOW2, GISP, SLAP2 from IAEA(Internatinal Atomic Energy Agency)

Fig. 3. WS-CRDS (Wavelength-Scanned Cavitity Ring-Down Spectroscopy) used in study(L1102-I, Piccaro, inc.). Precision : $\delta^{18}O$=0.15‰ ,δD=0.9 ‰

Result

Sample Number	Date	Temp (℃)	Precipitation (mm/hour)	Duration	$\delta^{18}O$	δD	Deuterium excess
1	140821	25.1	9.5		-4.20	-36.29	-2.71
2	140829	24.5	Regional torrential rains		-6.81	-49.39	5.10
3	140902	18.5	2.0	23:00~24:00	-4.91	-37.78	1.51
4	140903	17.6	9.0	00:00~01:00	-9.59	-72.19	4.56
5	140903	17.1	16.5	01:00~02:00	-11.18	-78.49	10.93
6	140903	17.3	8.5	02:00~03:00	-11.49	-80.16	11.76
7	140928	19.1	0.5		-8.11	-58.18	6.68
8	140929	19.3	3.0	06:00~08:00	-5.67	-41.89	3.49
9	140929	20.4	2.5	09:00~11:00	-7.56	-53.08	7.42
10	140929	20.1	1.0	11:00~13:00	-7.27	-50.37	7.82
11	140929	19.4	1.5	13:00~15:00	-9.16	-67.80	5.51
12	141002	16.6	8.00		-3.73	-15.56	14.31
13	141020	13.7	1.5	00:00~02:00	-2.18	-14.40	3.03
14	141020	13.4	2.5	02:00-03:00	-4.81	-19.96	18.49
15	141021	14.9	4.5	02:30-03:30	-5.95	-33.47	14.13
16	141021	15.4	2.5	03:30-04:30	-7.49	-81.51	-21.56
17	141021	15.0	1.0	04:30-06:30	-7.07	-59.51	-2.96
18	141021	14.8	3.0	06:30-08:00	-7.02	-43.21	12.94
19	141021	14.1	1.0	12:00-13:00	-8.94	-54.41	17.09
20	141021	13.5	1.0	13:00-14:30	-4.79	-51.70	-13.38
21	141021	13.3	2.0	14:30-15:30	-11.94	-91.44	4.08
22	141021	13.1	2.0	15:30-16:30	-11.65	-90.51	2.68

Table. 2. The sample information and results. The samples were collected from August 21 to October 21, 2014. The meteorological information was obtained from Automatic Weather Station(http://www.kma.go.kr) located about 5 km apart from the sampling location. Event1 : Blue box, Event2 : Red box, Event3 : Green box.

Discussion

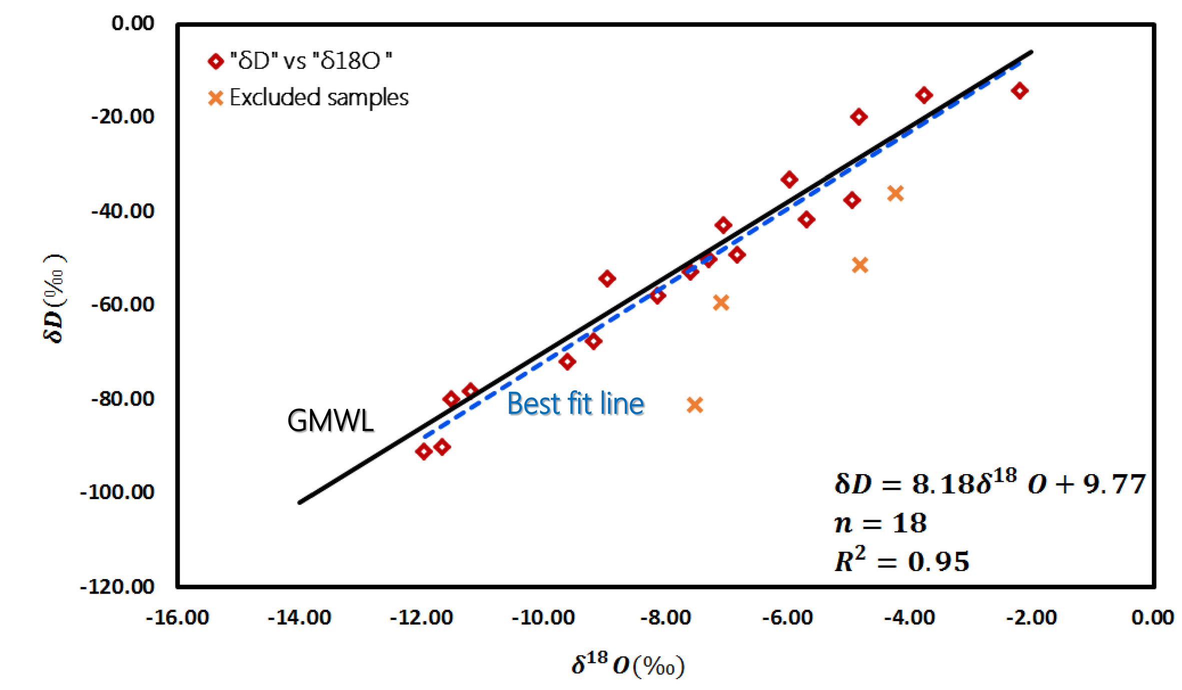

Fig. 4. A linear regression line of δD versus $\delta^{18}O$.

- The black solid line : the Global Meteoric Water Line (GMWL, δD=8$\delta^{18}O$+10).
- The blue dotted lines : Best fit line (δD=8.18$\delta^{18}O$+9.77).
- The samples with the low deuterium excess indicated sample evaporation and were excluded for the best fit line (1, 16, 17 and 20 in Table. 2.).

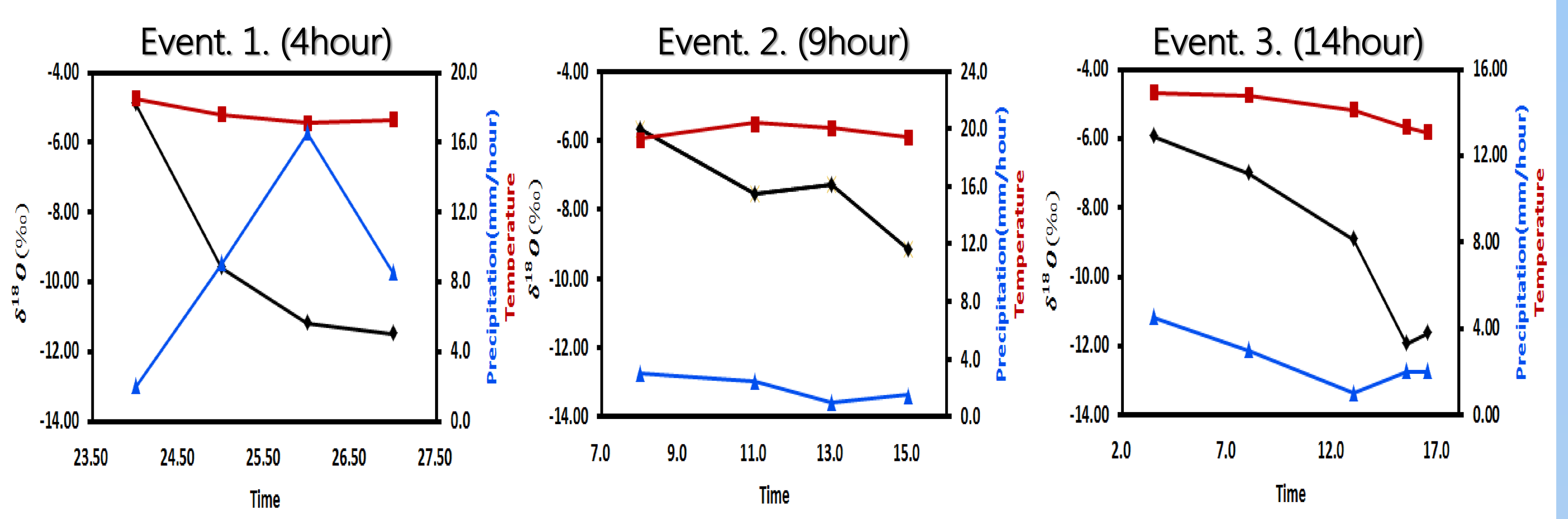

Fig. 5. Temporal changes in $\delta^{18}O$.

- The temperature effect was unclear.
- $\delta^{18}O$ decreased over time: Amount effect (?)

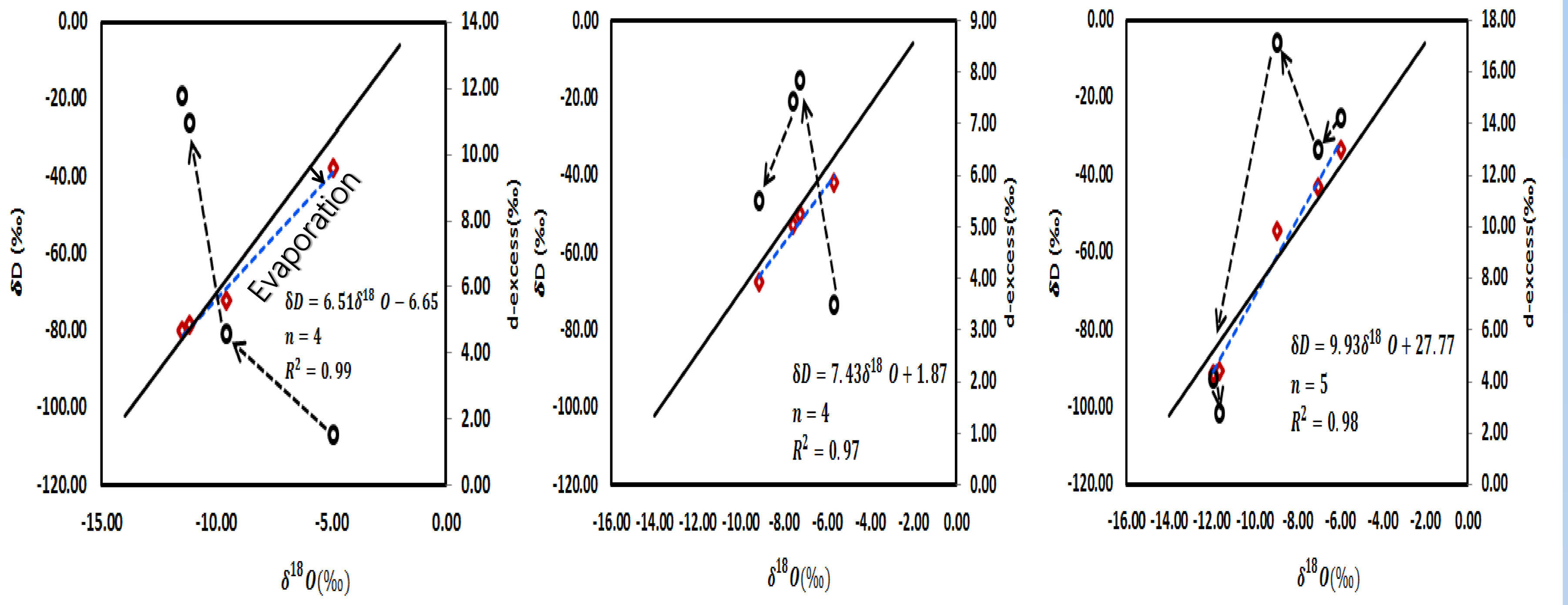

Fig. 6. δD versus $\delta^{18}O$ for each event.

- In natural evaporation, oxygen isotopes are more fractionated than hydrogen isotopes.
  -> Precipitation is relatively enriched in ^{18}O -> Slope becomes lower than 8
- Evaporation increases deuterium excess in water vapor.

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