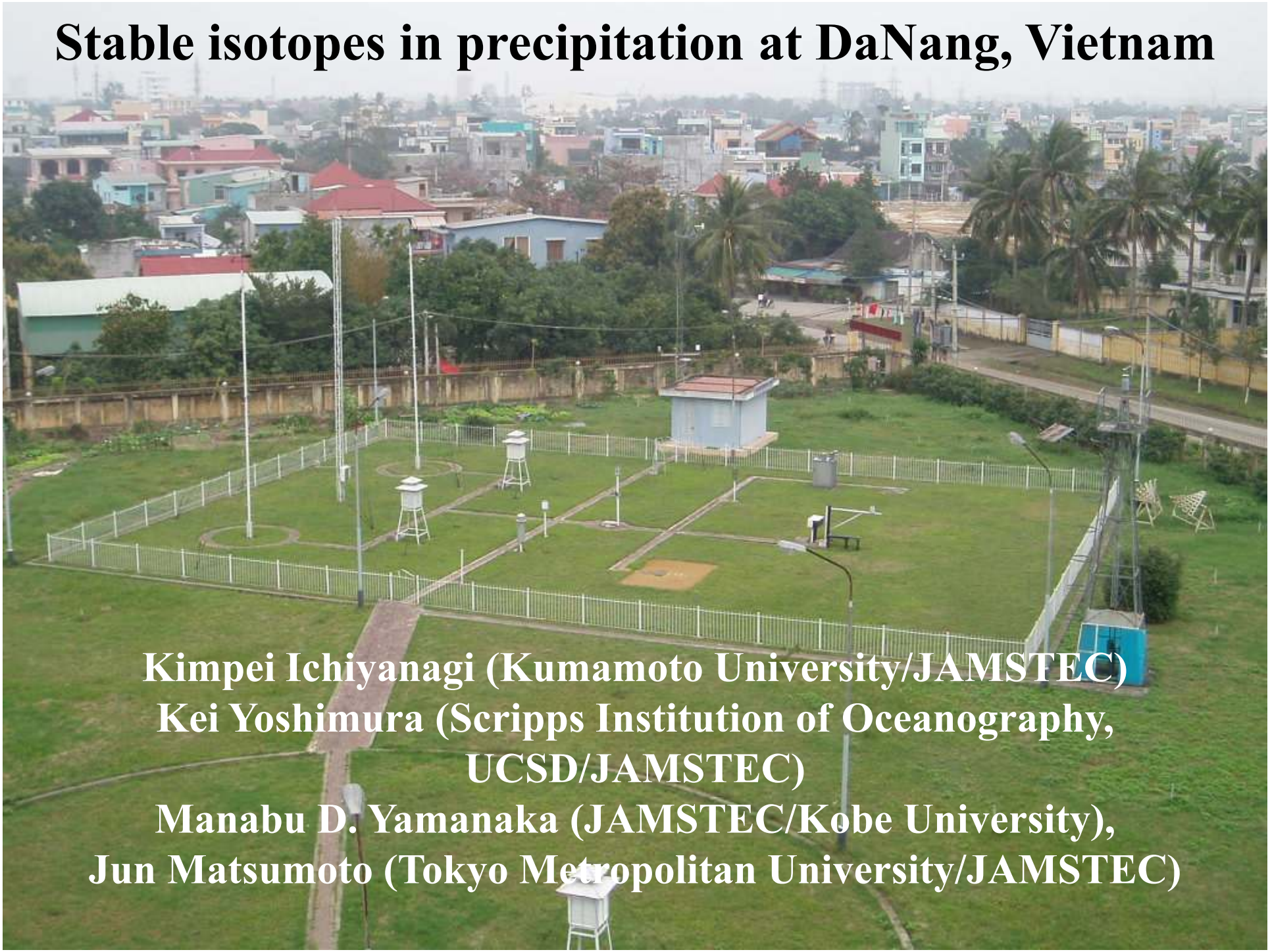
Stable isotopes in precipitation at DaNang, Vietnam



Kimpei Ichiyanagi (Kumamoto University/JAMSTEC)
Kei Yoshimura (Scripps Institution of Oceanography, UCSD/JAMSTEC)
Manabu D. Yamanaka (JAMSTEC/Kobe University),
Jun Matsumoto (Tokyo Metropolitan University/JAMSTEC)

What is stable isotopes of water?

Isotope compositions of Hydrogen and Oxygen

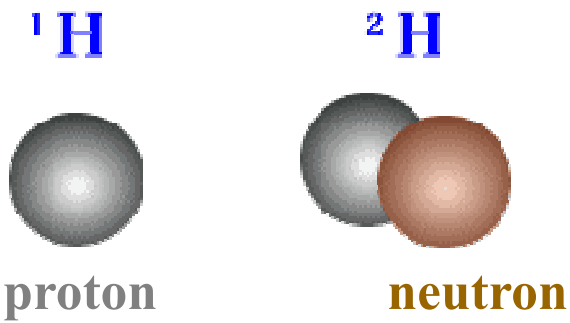
H		O	
^{1}H	99.984%	^{16}O	99.763%
^{2}D	0.0156%	^{17}O	0.0374%
		^{18}O	0.2039%

Isotopes in water

$H_2{}^{16}O$

$H_2{}^{18}O$ $\quad \delta^{18}O$ (‰)

$HD^{16}O$ $\quad \delta D$ (‰)



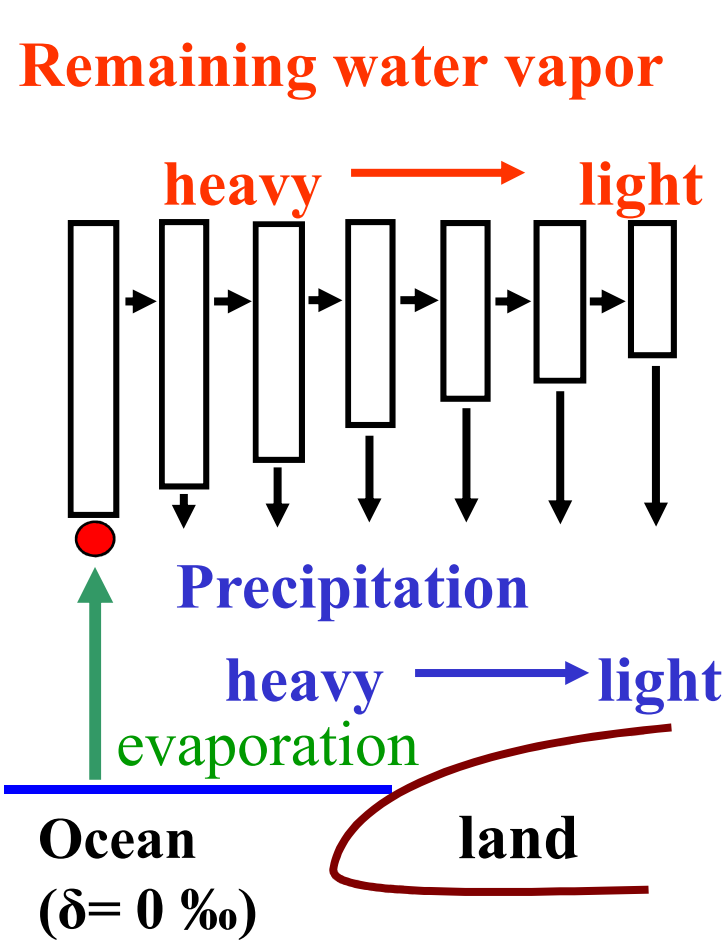
Delta-description for stable isotopes

$\delta = (R_{sample} / R_{reference} - 1) \times 10^3$ (‰)

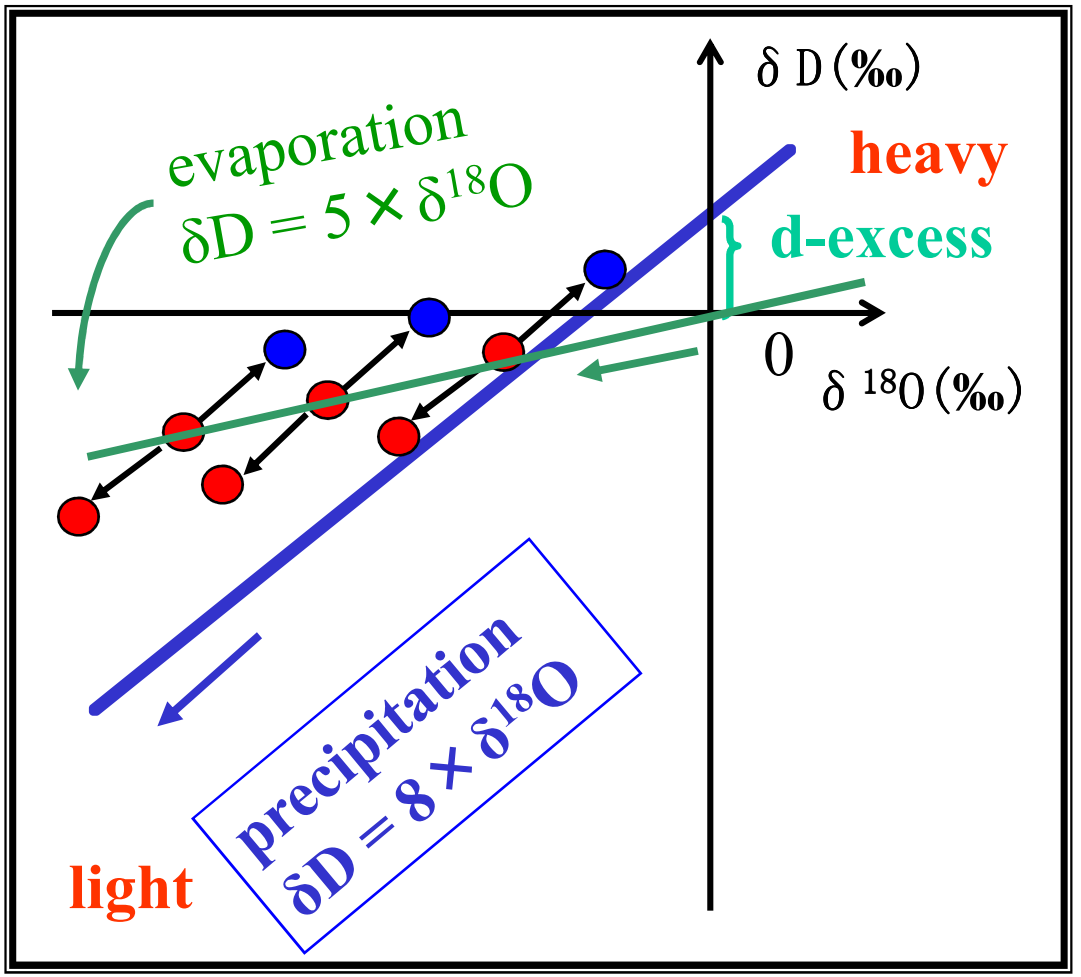
R_{sample} : compositions of samples (D/H), (^{18}O / ^{16}O)

$R_{reference}$: compositions of V-SMOW

Isotopic fractionation in precipitation processes

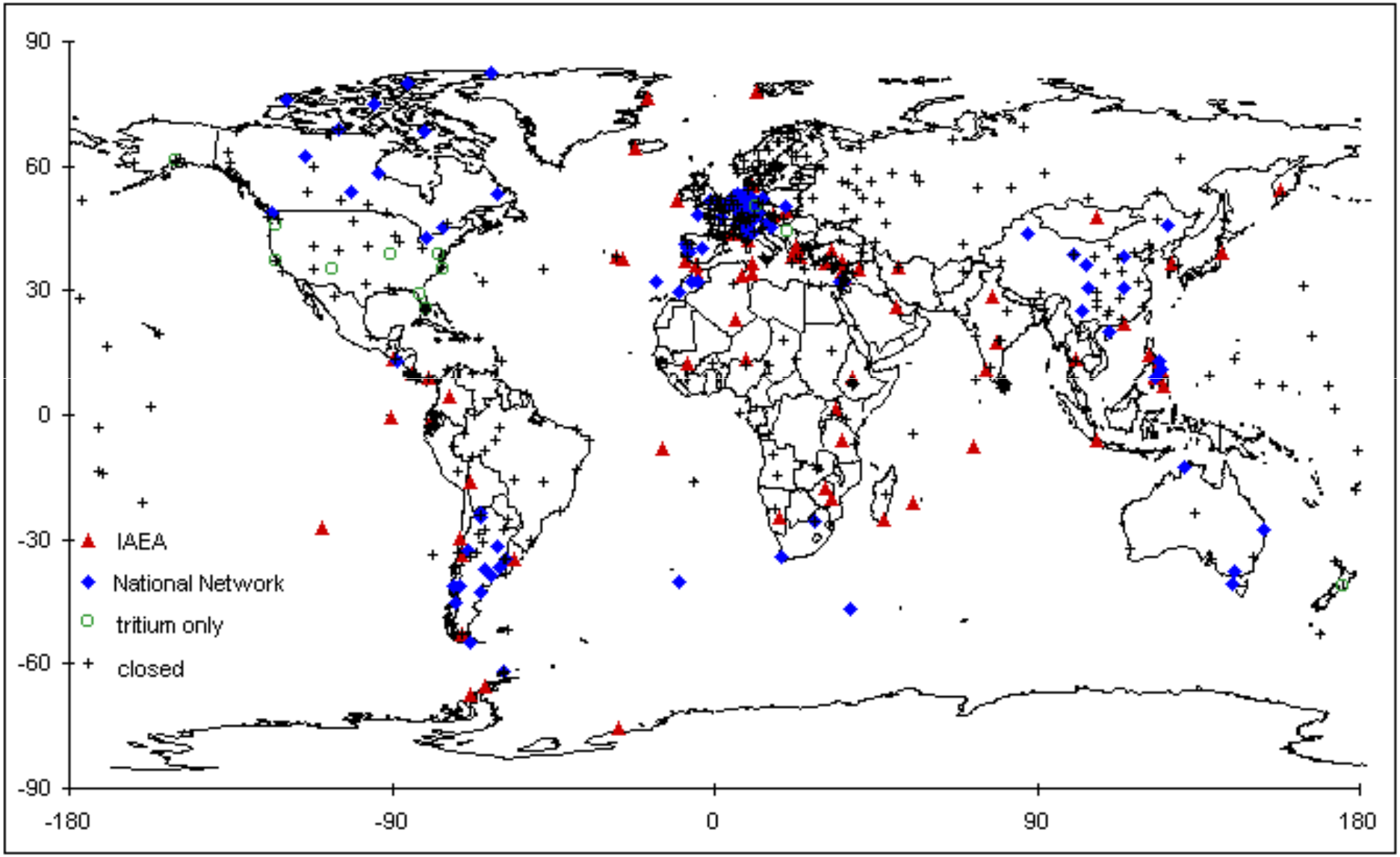


D-excess
$=\delta D - 8\delta^{18}O$

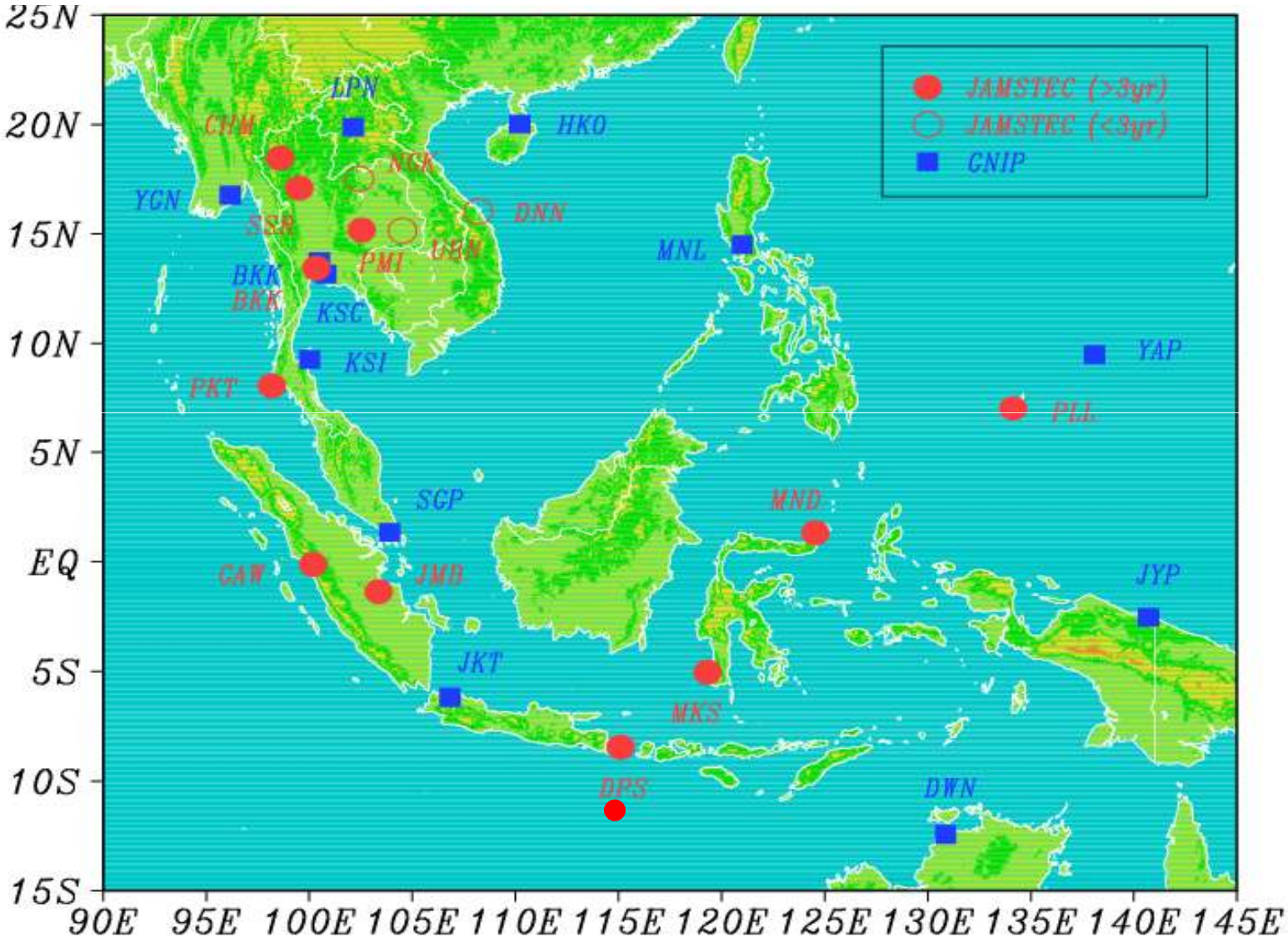


d-excess
Independent on precipitation
Depend on evaporation

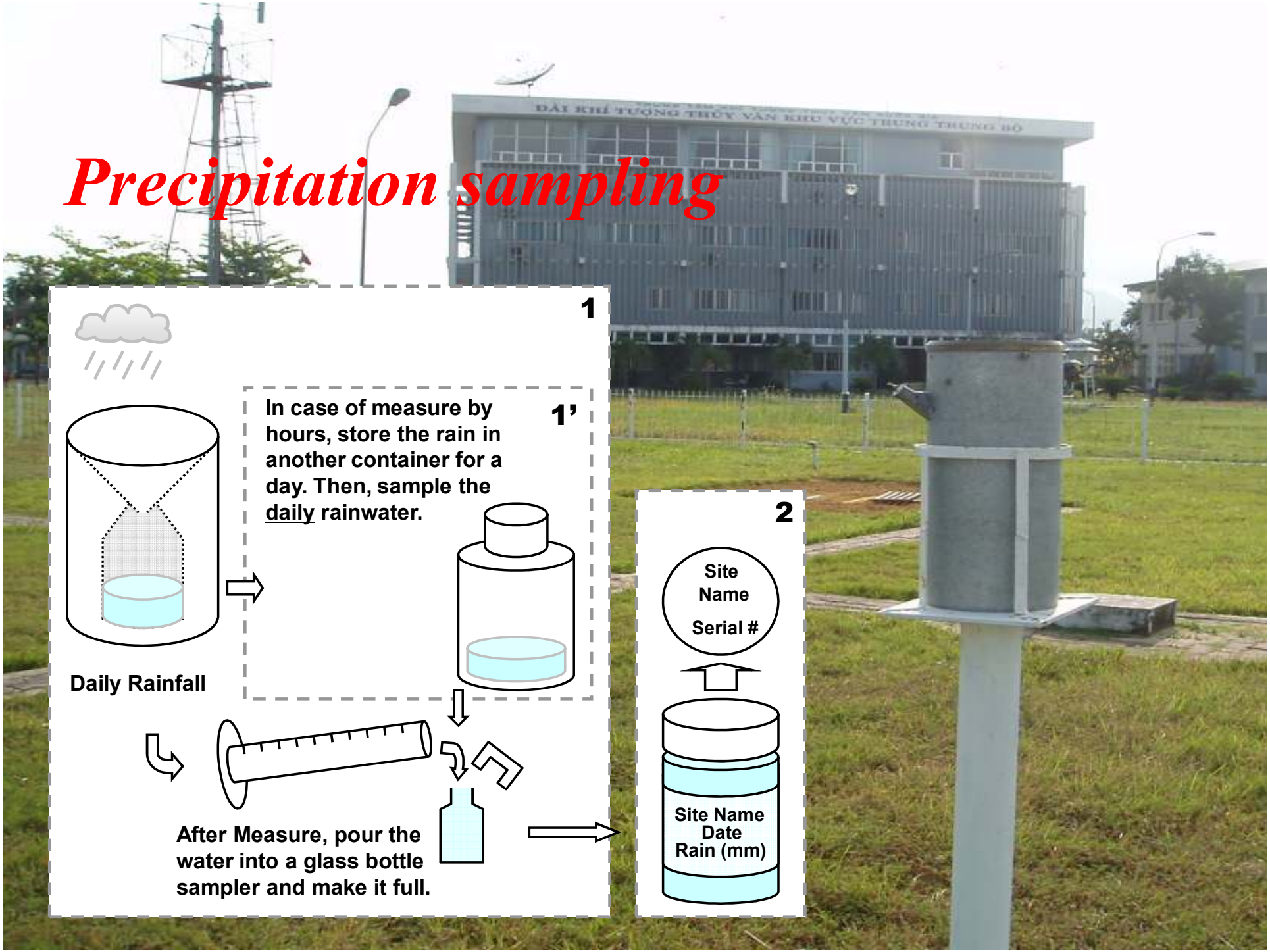
Global Network for Isotopes in Precipitation (GNIP)



JAMSTEC Network of Isotopes in Precipitation (daily, 3-hourly samplings)



Precipitation sampling



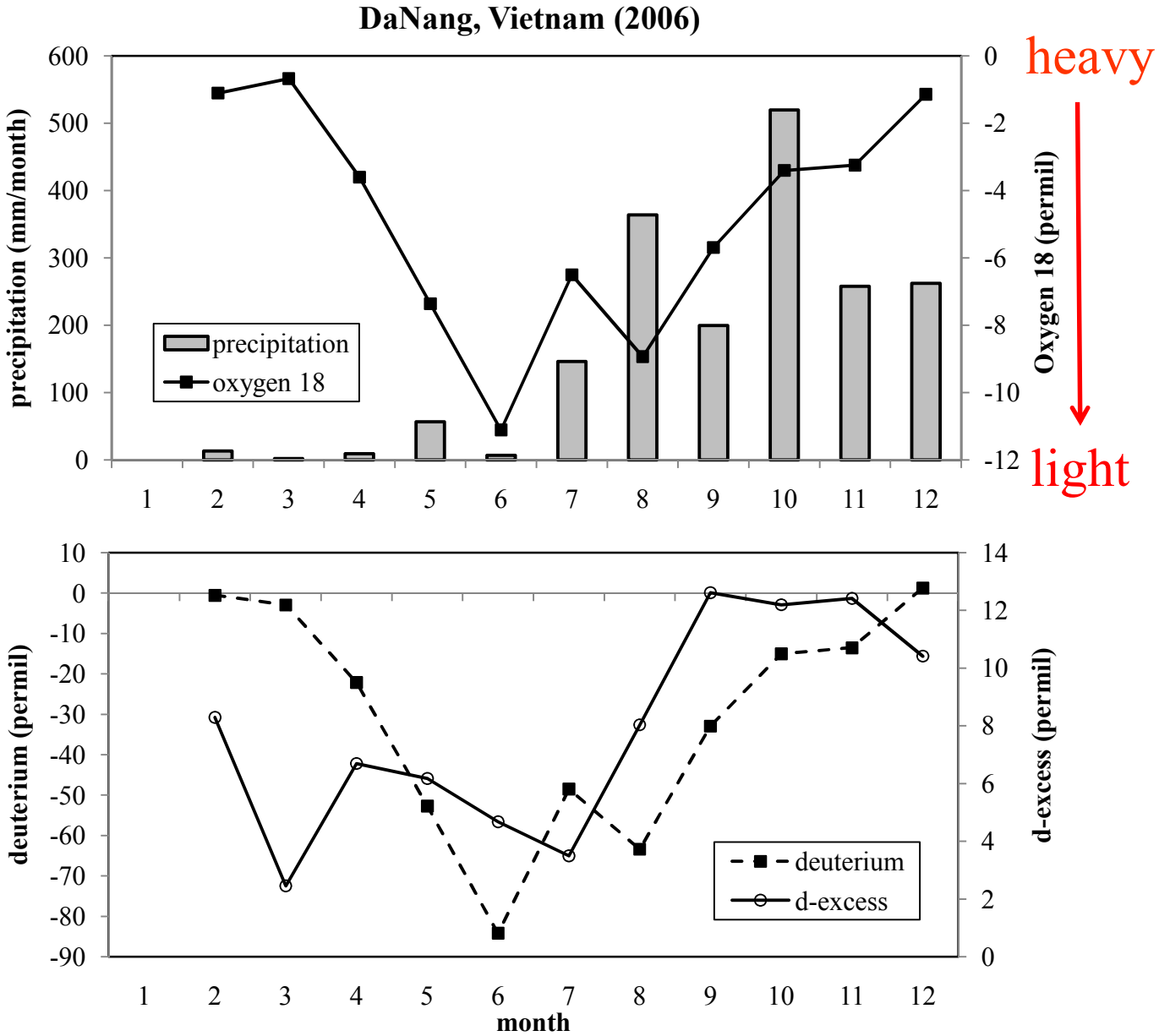


Figure 1. Monthly mean precipitation and $\delta^{18}O$ weighted by the daily precipitation amount (upper panel) at DaNang from February to December 2006. Same as $\delta^{18}O$, but δD and d-excess values (lower panel).

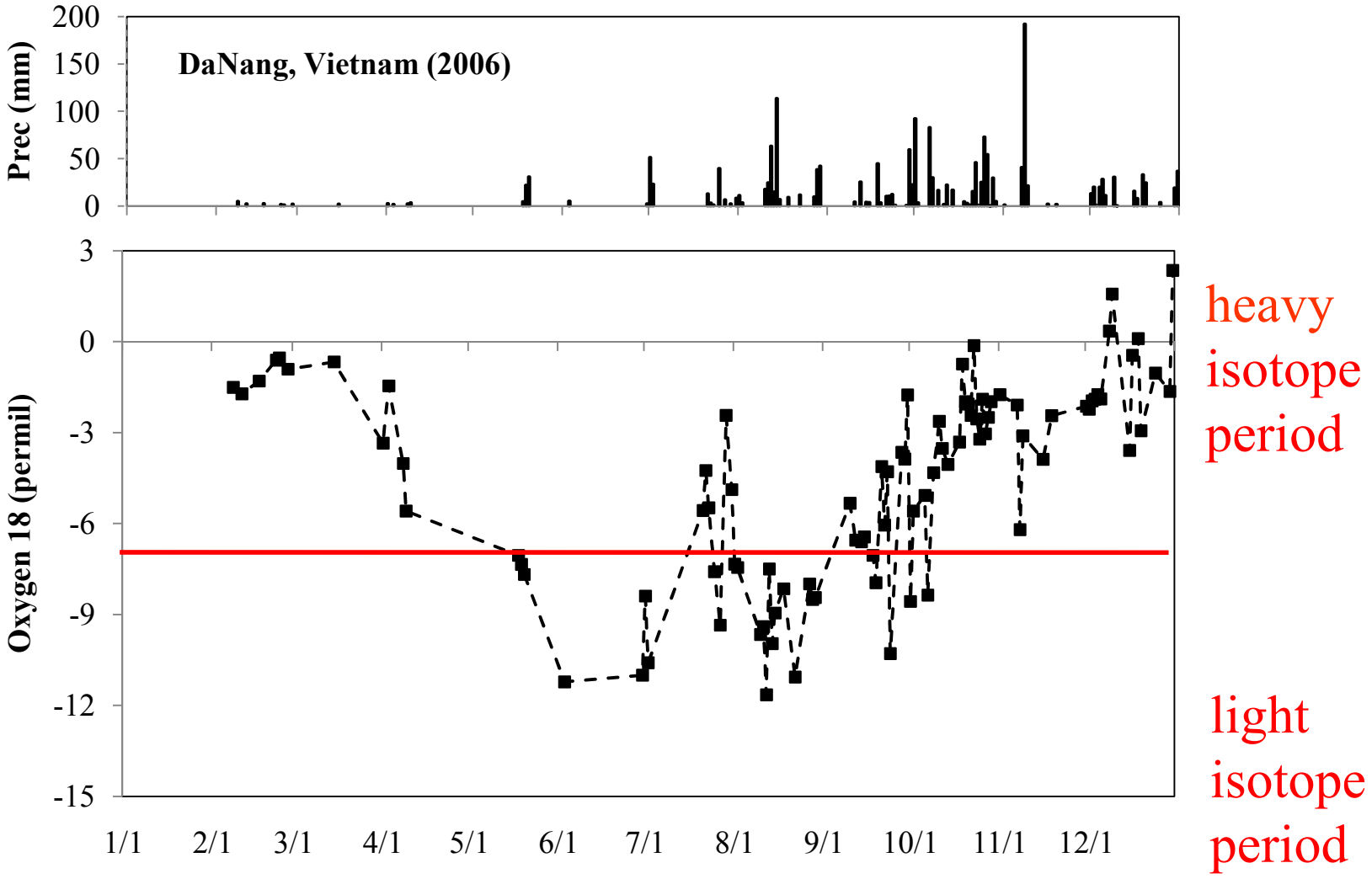


Figure 2. Daily variability in precipitation and $\delta^{18}O$ at DaNang from February to December 2006.

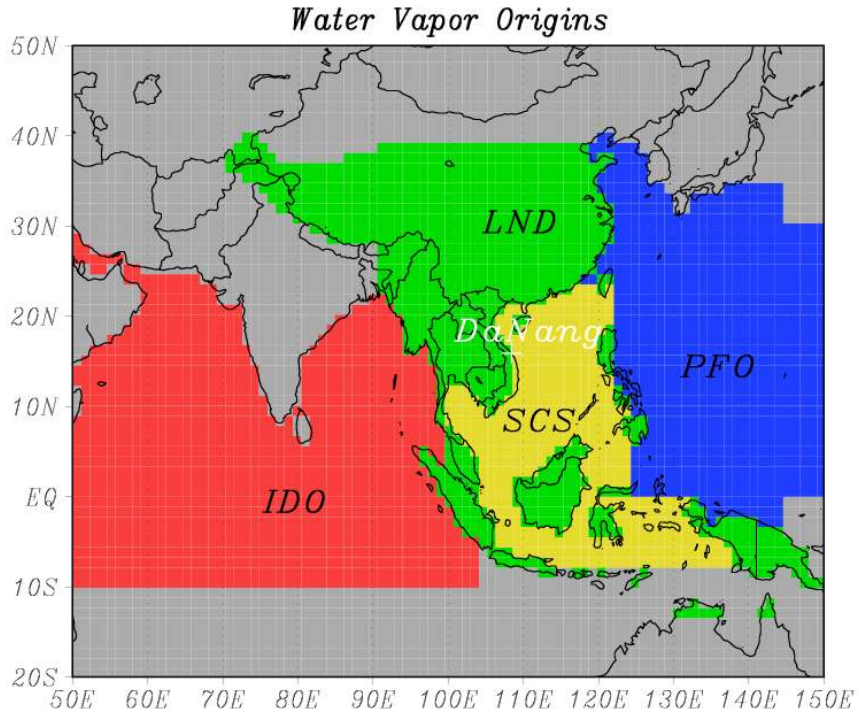


Figure 5. Distribution of the water vapor origins. The monsoon Asia is divided into four regions: Indian Ocean (IDO), South China Sea (SCS), Pacific Ocean (PFO), and Land (LND). Different colors represent different origins.

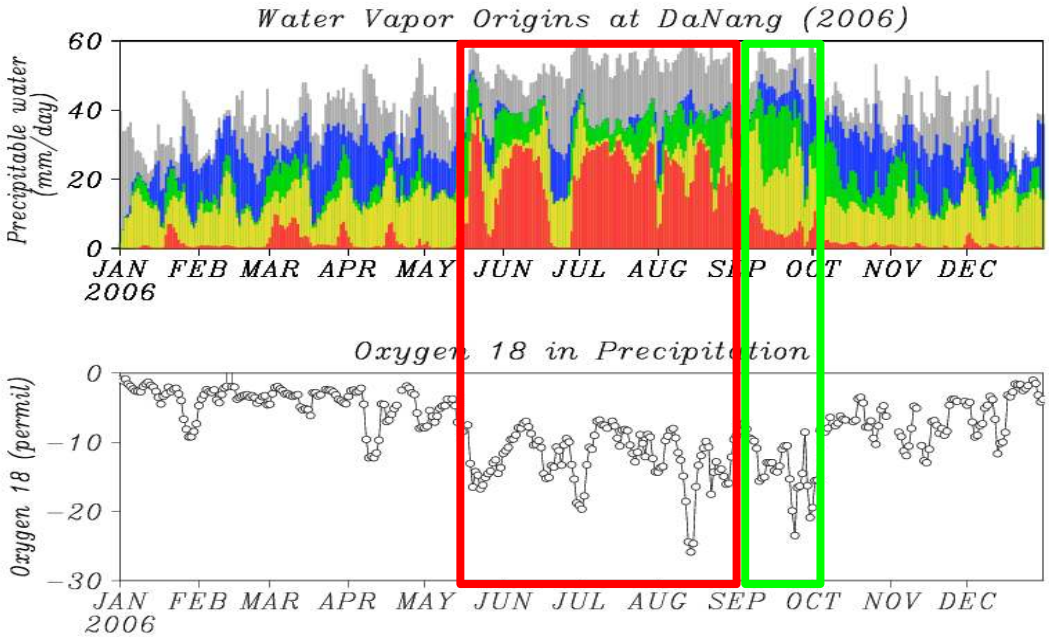


Figure 6. Daily variability of water origin contributions to the total column water simulated by CMA (upper panel) and of $\delta^{18}O$ in precipitation simulated by ICM (lower panel) at DaNang for 2006. The IDO (red), SCS (yellow), PFO (blue), and LND (green) are the same color as Figure 5.

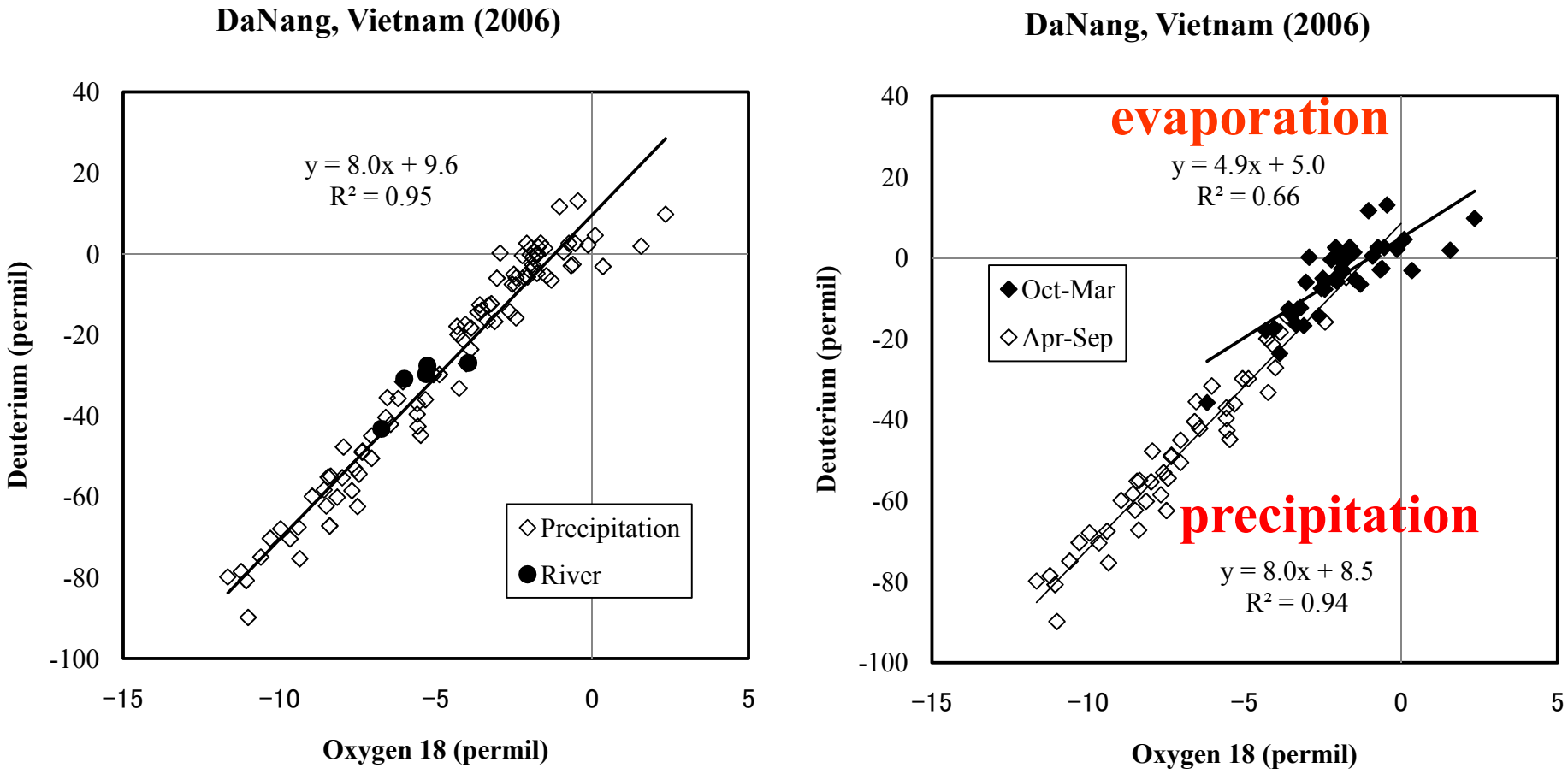


Figure 3. Relationships between daily δD and $\delta^{18}O$ in precipitation during whole period (left panel) and two periods (right panel). The results of river and lake water samples were also shown in the left panel.

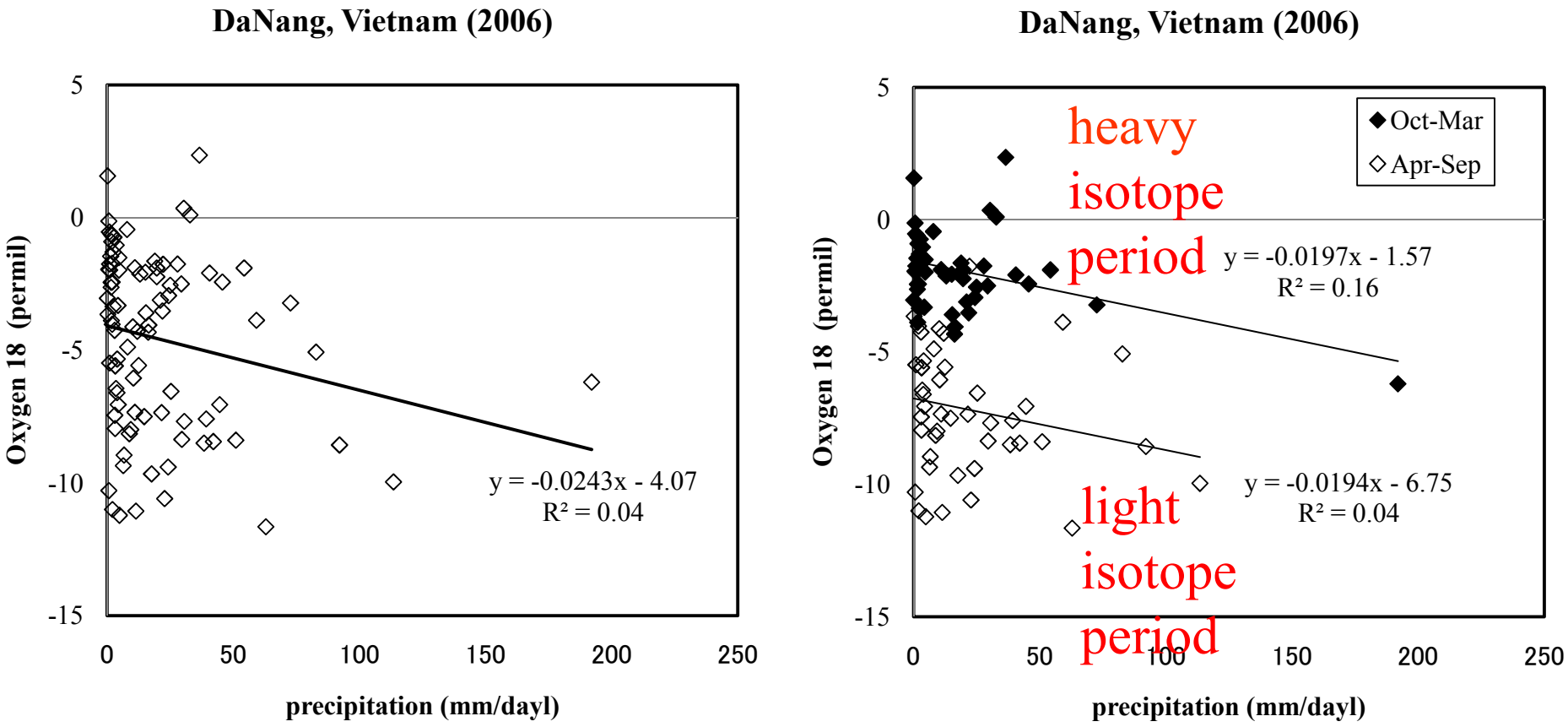


Figure 4. Relationships between daily precipitation amount and $\delta^{18}O$ values during whole period (left panel) and two periods (right panel).

Concluding Remarks

Stable isotopes in precipitation were observed at DaNang in Vietnam from February to December 2006. Depend on the seasonal variability of stable isotope ratios, it can be divided into **light isotope period** (April to September) and **heavy isotope period** (October to March). Daily variability of water origin contributions to the total column water and of $\delta^{18}O$ in precipitation at DaNang for 2006 were simulated by CMA and ICM, respectively. Simulated $\delta^{18}O$ in precipitation by the ICM can be reproduced the seasonal variability well. The water contributions from the **SCS** was corresponded to the heavy isotope period, while the **IDO** contribution was corresponded to the light isotope period. It was suggested the isotopic depletion from May to September was caused by the **rain-out effect** from the IDO to DaNang.


Thank you!

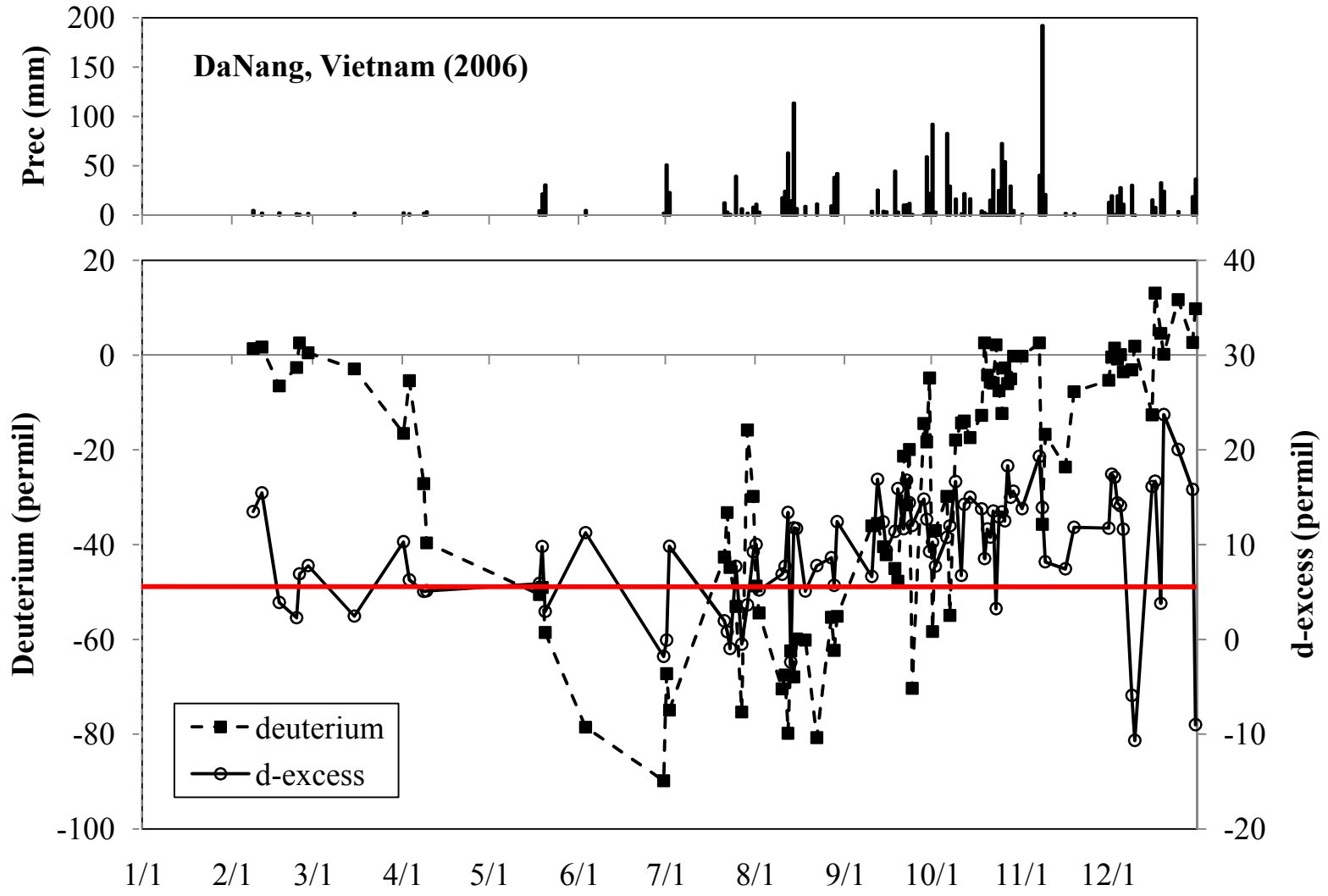


Figure 2. Daily variability of δD and d-excess in precipitation at DaNang from February to December 2006.

Isotope Circulation Model (by Yoshimura et al., 2003)

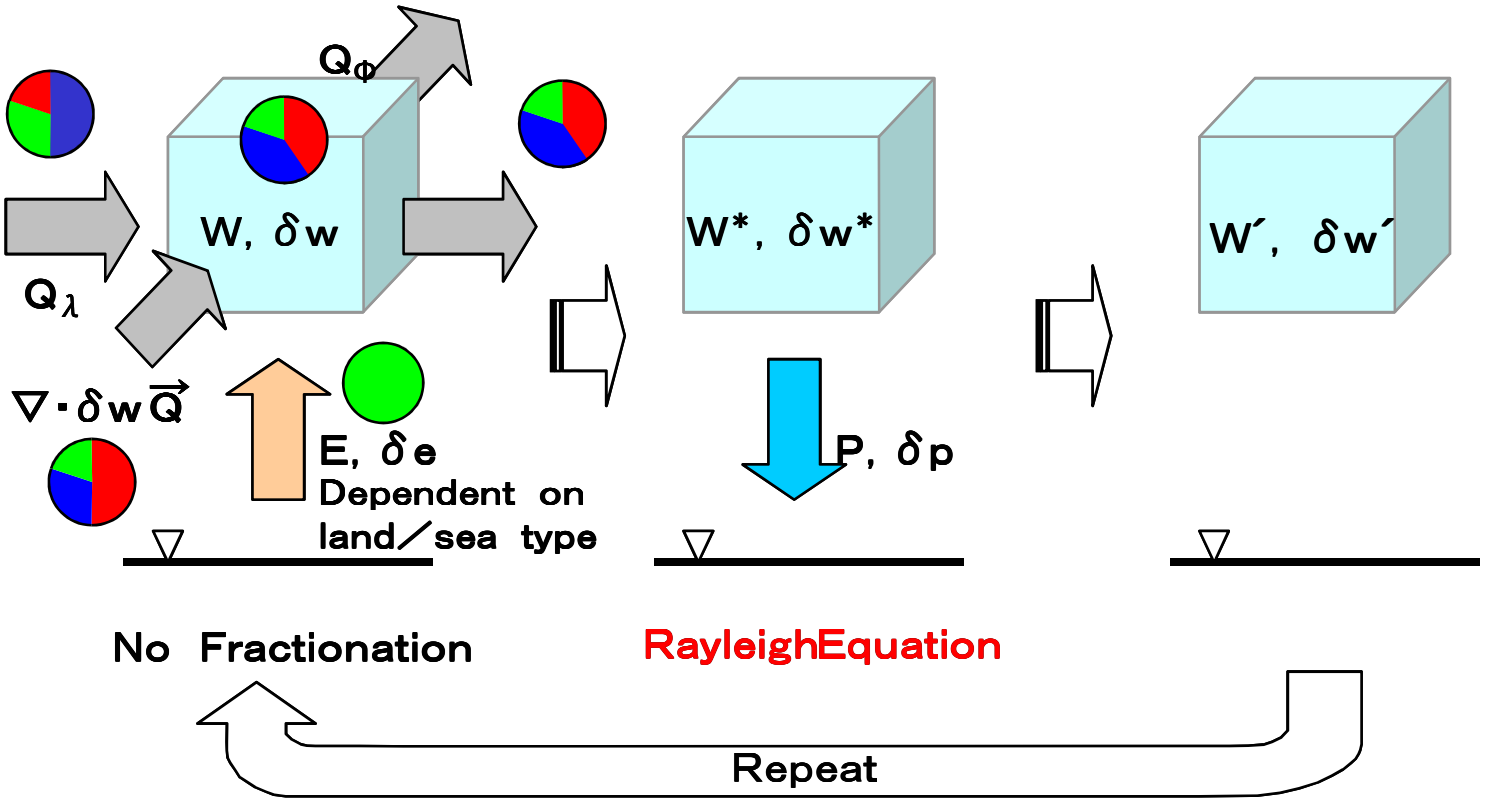
Water & Isotope Budget Equation :

Vertically accumulated Precipitable Water (W) = $W_{t-1} + Q_{\lambda} - Q_{\Phi} + E - P$

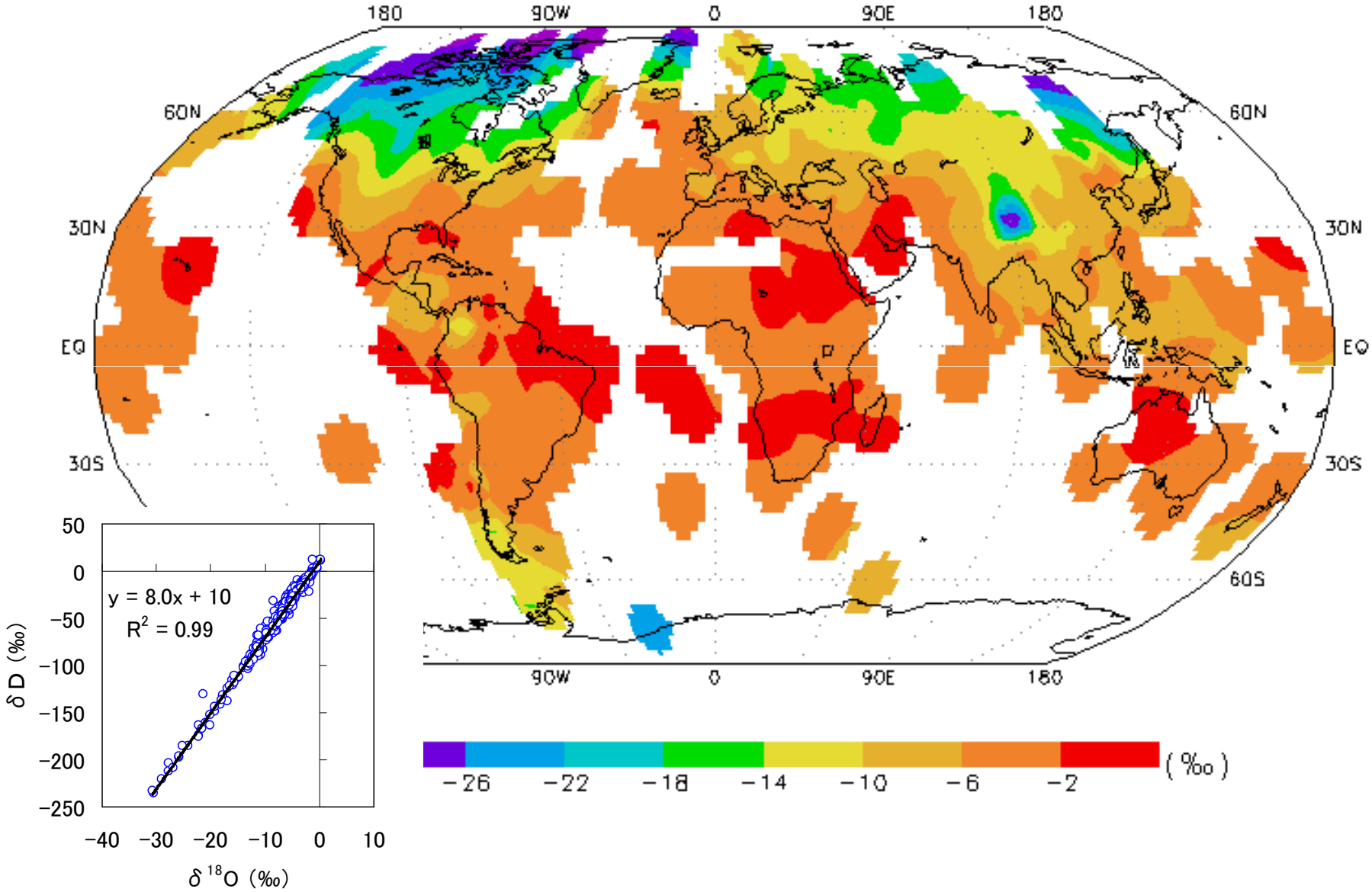
Isotope ratio of W (δw) = ($\delta w^* \times W^* - \delta p \times P$) / W

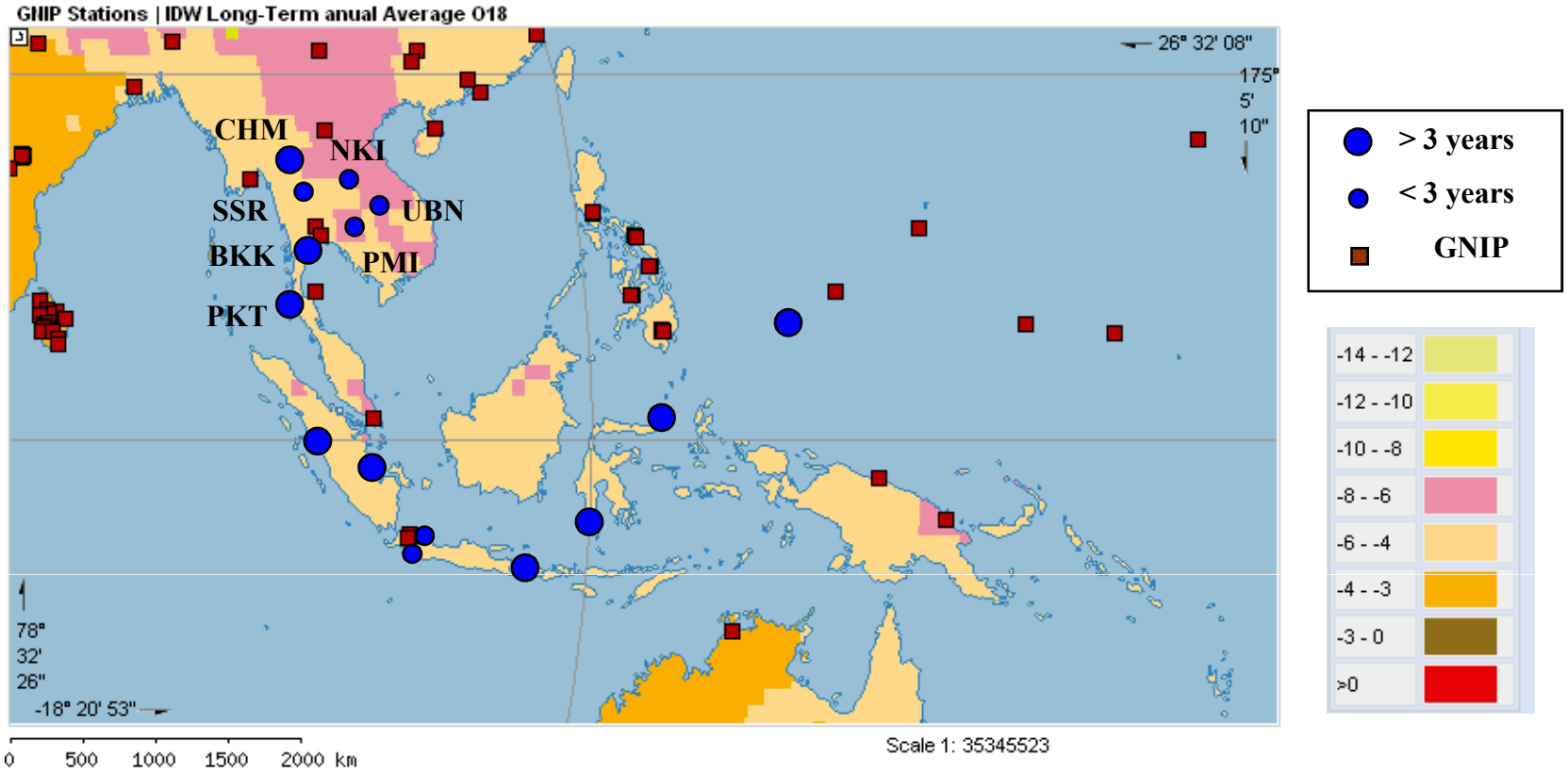
Rayleigh Equation :

Isotope ratio of P (δp) = ($\delta w^* - \delta w \times f$) / ($1 - f$) , Fractionation (f) = W / W*

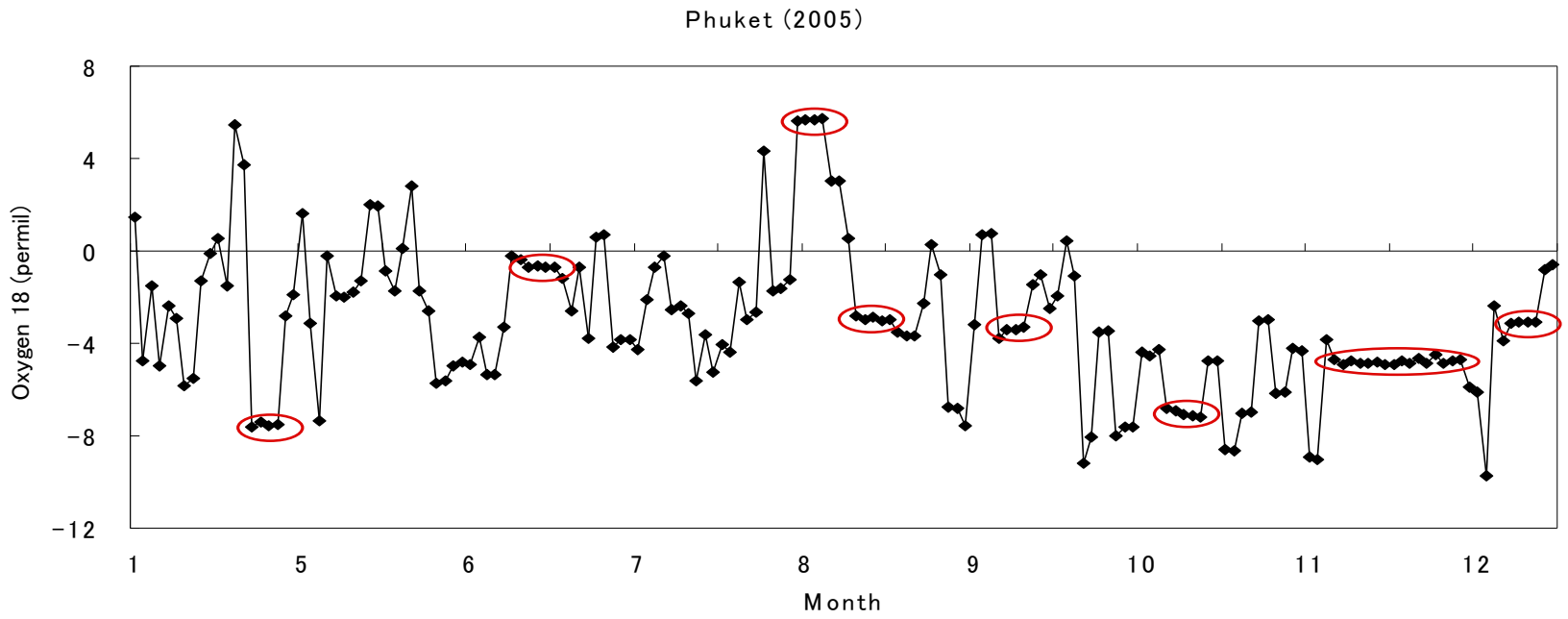


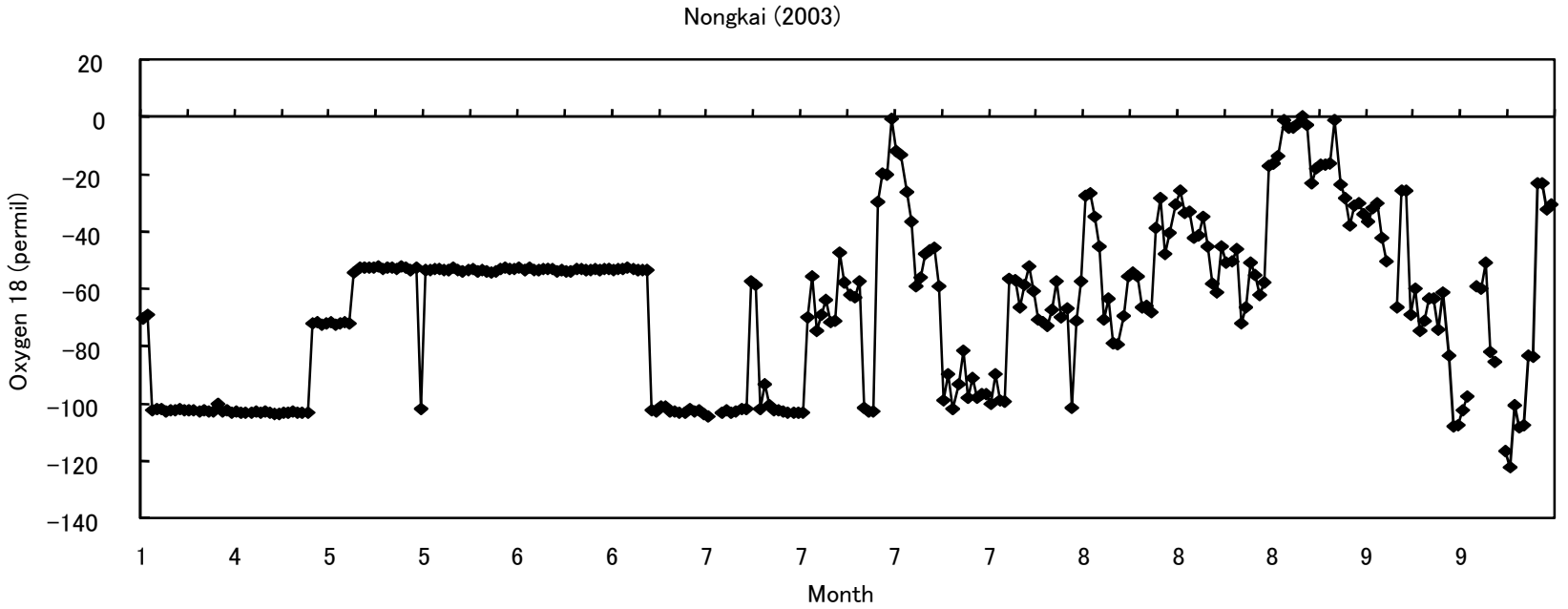
Weighted Annual $\delta^{18}O$





Station	Period	Annual $\delta^{18}O$	amount effect (R^2)	D-O relationship (R^2)
BKK	2001.8-2006.10	-5.63	-0.0108 (0.30)	$\delta D=7.90*\delta^{18}O+8.86$ (0.97)
CHM	2001.8-2005.12	-6.37	-0.0188 (0.33)	$\delta D=7.61*\delta^{18}O+3.96$ (0.95)
PKT	2001.8-2006.1	-5.24	-0.0106 (0.31)	$\delta D=7.07*\delta^{18}O+3.93$ (0.96)
SSR	2002.8-2006.4	-7.28	-0.0248 (0.53)	$\delta D=6.90*\delta^{18}O-1.64$ (0.94)
UBN	2003.7-2005.11	-7.16	-0.0157 (0.43)	$\delta D=7.46*\delta^{18}O+4.94$ (0.98)
NKI	2003.7-10, 2004.1,8,9			
PMI	2003.9-2006.5 (no rain data)			


Phuket (2005)
Oxygen 18 (permil)
8
4
0
-4
-8
-12
1
5
6
7
8
9
10
11
12
Month


Nongkai (2003)
Oxygen 18 (permil)
20
0
-20
-40
-60
-80
-100
-120
-140
1
4
5
5
6
6
7
7
7
7
8
8
8
9
9
Month