

1 Sample collection and isotopic analysis

Surface water samples were collected by deploying a Conductivity Temperature Depth (CTD) rosette from the deck of the research vessel. Surface water samples were collected in a 50ml High-Density Polyethylene air tight bottles. Atmospheric moisture was sampled using cryogenic cold trap, which is custom-made using pyrex tubes where atmospheric vapor was condensed with the help of a freezing mixture of liquid Nitrogen and Ethanol; maintained the temperature at $\approx -80^{\circ}\text{C}$. First, the inlet was connected to the Poly vinyl chloride (PVC) tube which was set at the forecastle of the ship at two different heights as mentioned above. The outlet of the glass trap was connected to a vacuum pump which is maintained at a flow rate of ≈ 250 ml/min. The line was flushed using the pump for at least ≈ 15 Min's before starting the collection process to avoid any sort of residual ambient air inside the tubing and the trap. An Ultra Torr connector (Swagelok) was connected from PVC tubing to the glass flask and from glass trap to the vacuum pump. The sampling time required for generating appreciable amount (2-3ml) of condensed water for isotopic analysis was ≈ 3 to 6 hours depending on the sampling location with greater sampling time at higher latitudes. After the sampling is done both ends of the glass flask was sealed using Parafilm to avoid any air inclusion inside the flask. Atmospheric moisture, condensed inside the cold trap as ice, was allowed to melt at room temperature ($\approx 15-20^{\circ}\text{C}$) and then transferred into 5 ml polyethylene storage vials. All the samples were stored at 4°C . A similar setup for water vapor sampling was presented in the earlier studies Rahul et al. (2016, 2018).

All these samples were shipped to Bangalore for isotopic analysis and the measurements were carried out at the Centre for Earth Sciences, Indian Institute of Science, Bangalore. The protocol followed for the analysis of the gases after equilibration using a Finnigan Gas-bench II attached to a MAT 253 mass spectrometer is described in the (Rangarajan and Ghosh, 2011). For oxygen isotope analysis $200\mu\text{L}$ of water was transferred into an exetainer vial capped with butyl rubber septa and equilibrated with gas mixture 3% CO_2 +97% He for a period of 20 hours. For hydrogen isotopes, the water sample was equilibrated with gas mixture of 3% H_2 +97% He in presence of platinum catalyst (Hokko bead sticks) for a period of 80mins. The isotope ratios are expressed in ‰ using the standard δ notation relative to Vienna Standard Mean Ocean Water (VSMOW). Internal laboratory standards (OASIS-WWW, OASIS-LDK and OASIS-VOULEP) calibrated against the international water standards (VSMOW, Standard Light Antarctic Precipitation, and Greenland Ice Sheet Project) available from International Atomic Energy Agency in Vienna, were used to determine the accuracy and precision of the analysis. To account for intra batch calibration and drift correction, additional internal laboratory standards were measured in a batch. The overall analytical uncertainty on the measurements ($\pm 1\sigma$), as determined from replicate measurements of internal laboratory standards, were respectively $\pm 1.0\text{‰}$ and $\pm 0.1\text{‰}$ for $\delta^2\text{H}$ and $\delta^{18}\text{O}$. Isotopic values are reported here with one standard deviation.

Table 1. SOE-IX meteorological data, water vapor(Nsw) and surface water isotopic composition

Date	Lon	Lat	Tair ($^{\circ}C$)	Pressure (mbar)	Rel. Hum. (%)	Wind Speed(m/s)	SST ($^{\circ}C$)	Water vapor (Nwv) SOE X			$\delta^{18}O_{SW}$ (‰)
								$\delta^{18}O$ (‰)	δ^2H (‰)	dxs (‰)	
08/01/17	57.5	-27.38	29.6	1015.8	69.3	9.7	27	-11.97	-83	12.7	-
08/01/18	57.52	-28.66	29.2	1014.8	68.7	4.8	27	-12	-80.8	15.2	-
09/01/17	57.49	-31.53	26.1	1016.5	69.3	7.6	25	-11.92	-82.1	13.2	0.31
09/01/17	57.5	-32.26	24.1	1016.5	77	14.3	24	-12.16	-84.7	12.7	-
09/01/17	57.51	-33.44	19.8	1018.7	75.2	9.8	21	-12.22	-87.8	10	-
10/01/17	57.5	-35.38	21.5	1019.7	73.5	10.8	19.5	-12.29	-95.7	2.6	0.33
10/01/17	57.51	-36.43	21.2	1017.7	82.9	5.2	19	-10.86	-82.7	4.2	-
11/01/17	57.87	-39.11	13.9	1018.3	72.3	27.3	17	-14.62	-104.6	12.4	-
12/01/17	58.41	-40.07	13.7	1027.8	60.9	9	16	-15.57	-107.7	16.9	-
12/01/17	57.94	-40.08	12.4	1028	67.1	7.8	16.5	-15.91	-110	17.3	-
14/01/17	58.52	-40.09	17.4	1017.8	82.4	25.4	16	-11.96	-91.2	4.5	0.38
13/01/17	57.99	-40.21	13	1025	59.2	11	16.5	-14.88	-100.4	18.7	-
15/01/17	59.46	-41.38	14.2	1022	67.8	15.2	16.5	-14.37	-96.9	18	0.35
16/01/17	61.15	-43.67	16.5	1023.8	71.2	7	17	-14.78	-101.4	16.8	-0.26
16/01/17	62.72	-45.46	11.7	1012.3	91.7	15.3	12	-12.37	-100.6	-1.6	-
17/01/17	64	-47.02	7.3	1003.3	93.3	20	7	-15.19	-129.1	-7.6	-0.12
18/01/17	64.1	-49.02	5.6	1008.6	88.9	20.8	5.5	-13.97	-119	-7.2	-0.12
19/01/17	64.17	-51.05	5.5	1011.7	78.7	21.2	5	-14.4	-117.4	-2.2	-0.07
19/01/17	67	-51.73	4.8	1009.3	99	8.6	5	-12.97	-106.3	-2.5	-
20/01/17	68.49	-54.01	4.5	1006.6	93.7	15.6	4.5	-12.68	-101.1	0.4	0.05
21/01/17	69.29	-57.4	4	996.3	96.4	7.3	3	-13.39	-101.2	5.9	0.03
22/01/17	70.08	-61.95	1	970.2	100	21	2	-19.46	-162.9	-7.3	-0.07
23/01/17	68.34	-64	0.1	976.2	98.3	39.7	0.5	-14.82	-126.9	-8.4	0.18
24/01/17	74.01	-65.99	0.1	983	95.6	14.9	0.5	-20.35	-160.1	2.7	-
25/01/17	72.54	-67.96	-0.5	992.1	96.4	20.6	1.5	-22.62	-182.2	-1.3	-0.61
26/01/17	74.01	-67.99	1	991.3	72.2	7.7	1.5	-22.79	-177.9	4.4	-
26/01/17	74	-68	-0.3	992	83.7	12	1.5	-19.94	-154.9	4.7	-
31/01/17	76	-68	-1.8	978	94.2	5.8	1.5	-24.86	-193.5	5.3	-
27/01/17	74.05	-68.02	1.1	990	65.9	5.7	1.5	-23.33	-182	4.6	-
30/01/17	76.12	-68.04	-0.5	988.5	84.1	14.3	1	-22.17	-174.2	3.1	-
27/01/17	73.93	-68.21	0.1	988.4	80.1	8.2	2	-27.06	-221.4	-4.9	-
28/01/17	74.01	-68.6	-2.1	987	90.4	5.4	2	-27.47	-216.4	3.3	-
31/01/17	75.9	-69.19	-0.9	983.7	100	12.7	2.5	-24.25	-184.1	9.9	-
01/02/17	76.05	-69.34	0.3	991.3	97.9	7.3	0	-27.14	-211.7	5.5	-

Table 2. SOE X meteorological data, water vapor and surface water isotopic data

Date	Lon	Lat	Tair ($^{\circ}C$)	Pressure (mbar)	Rel. Hum. (%)	Wind Speed(m/s)	SST ($^{\circ}C$)	Water vapor (Nwv) SOE X			$\delta^{18}O_{SW}(\text{‰})$
								$\delta^{18}O(\text{‰})$	$\delta^2H(\text{‰})$	dxs (‰)	
10/12/17	57.56	-21.98	26.1	1015.5	75	11.5	-	-12.34	-94.5	4.2	-
11/12/17	57.79	-26.8	28.6	1012.7	71.6	2.7	25	-11.46	-88	3.6	0.53
12/12/17	58	-31.05	21.5	1016	74.5	16.8	21.3	-12.87	-101.4	1.5	0.77
13/12/17	58.2	-35.24	19	1015	55.8	10.9	21	-15.58	-110.1	14.5	0.36
14/12/17	58.49	-39.84	18	1007.1	80.8	7.7	16.5	-12.21	-98.4	-0.8	0.36
15/12/17	57.49	-39.99	14.5	995	84.7	17.4	16.5	-13.54	-100.9	7.4	0.61
16/12/17	58.8	-40.18	14.1	1015	63	18.3	16	-15.56	-110.4	14.1	0.28
17/12/17	58.38	-40.19	16.9	1016.8	77.7	23.9	16.5	-12.11	-97.4	-0.5	-
18/12/17	60.5	-42.89	9.3	1011.5	58	24.8	11	-15.52	-115.7	8.5	-
19/12/17	62.63	-45.69	8.1	1015.2	55	9.3	8	-16.56	-118.2	14.3	0.08
20/12/17	64.35	-48.07	6.9	991.7	80.9	23.6	5	-13.62	-112.2	-3.3	-0.41
21/12/17	63.85	-50.78	4.5	972.1	78	27.3	4.5	-14.31	-120.6	-6.1	-0.55
22/12/17	65.58	-53.07	4.8	970.6	70.2	7.6	4	-14.58	-121.2	-4.5	-0.02
23/12/17	68.23	-54.02	2.3	981.6	82.1	29.2	3	-15.81	-132.3	-5.8	0.02
24/12/17	69.03	-56.43	2.8	993.7	78.4	13.5	2.5	-14.05	-118.6	-6.2	-0.01
25/12/17	70.14	-58.03	3.2	1002.4	70.2	16.7	2	-14.44	-111.2	4.3	-0.57
25-26 Dec 2017	70.12	-59.05	1.8	1002.2	82.1	15.7	0.5	-13.58	-108	0.6	-0.39
26/12/17	71.59	-59.99	1.2	993.2	83.8	13.5	0	-13.35	-112.8	-6	-0.48
27/12/17	71.14	-61.06	0.1	984.9	88.6	19.4	0.5	-13.93	-120.7	-9.3	-0.51
21/01/18	57.17	-61.59	2.1	994.6		22.1	2	-15.99	-130.8	-2.9	-0.32
27/12/18	70.9	-61.66	1.2	985.7	79.4	6.1	0.5	-15.74	-129.2	-3.3	-0.2
17-18 Jan 2018	57.49	-61.99	2.8	986.2	74.3	20.1	1.5	-15.39	-130.4	-7.3	-
28/12/17	69.99	-63.01	-1	990.3	74.2	22.5	1.5	-21.18	-163.3	6.2	-0.59
17/01/18	57.52	-63.05	1.2	974.3	81.6	29.2	1	-16.63	-141.1	-8	-
16-17 Jan 2018	57.42	-64.01	1.9	969.2	83.9	27.6	1	-15.02	-130.4	-10.2	-0.22
14/01/18	66.99	-65.49	-0.7	971.3	79.7	17	0	-15.4	-121.2	2	-0.35
16/01/18	57.85	-65.51	1.3	967.2	84	27	1	-15.7	-141.4	-15.7	-1.05
30/12/18	74.91	-65.51	-0.4	978.5	76.2	6.2	0	-18.88	-148.9	2.1	-0.62
10/01/18	68.81	-65.51	0.3	981	61.3	4	-0.5	-20.4	-151	12.2	-3.45
31/12/18	73.84	-65.52	-0.4	984.5	74	14.1	0	-18.33	-152.8	-6.2	-1.16
31/12/18	72.67	-65.54	-0.3	988	81.5	16.4	-1	-16.77	-157.9	-23.7	-0.8
15/01/18	57.26	-65.58	-0.3	974	72.7	11.1	0.5	-19.64	-155.7	1.4	-
23-30 Jan 2018	74.79	-66.35	-1.4	982	62.5	7	-0.5	-21.11	-161	7.9	-0.64
07/01/18	74.98	-66.43	1.9	981.8	63.5	4.9	0	-18.17	-137.8	7.6	-
01/01/18	73	-66.45	0.9	987.1	77.7	5.6	-0.5	-17.65	-144.9	-3.7	-0.33
09/01/18	74.73	-66.78	0.1	978.4	78.9	25	0	-17.54	-131.6	8.7	-0.57
02/01/18	73.31	-66.8	0.7	990	76.6	8.8	0	-18.48	-142.4	5.4	-0.69

Table 3. SOE-X meteorological data, water vapor(Swv) and surface water isotopic data

Date	Lon	Lat	Tair (⁰ C)	Pressure (mbar)	Rel. Hum. (%)	Wind Speed(m/s)	SST (⁰ C)	Water vapor (Nwv) SOE X			$\delta^{18}O_{SW}(\text{‰})$
								$\delta^{18}O(\text{‰})$	$\delta^2H(\text{‰})$	$\delta^{34}S(\text{‰})$	
25/01/18	57.52	-47.51	9.6	1014.4	89.1	6.3	9	-12.85	-126.6	-23.8	-
01/01/18	73.31	-66.8	-0.8	986.5	85.6	2.3	-0.5	-16.48	-144.5	-12.6	-
28/01/18	58.58	-40.91	17.6	1008.4	87.7	16	16.5	-11.26	-99.8	-9.7	0.75
3-4 Jan 2018	76.47	-66.56	-1.2	995.2	78.7	5.9	0.5	-17.7	-147.8	-6.2	-
02/01/18	74.91	-66.46	0.9	988.6	76	16.3	0	-19.2	-153.1	0.5	-
05/01/18	76.1	-66.64	-0.1	980.5	78.9	13.1	0	-17.35	-138.1	0.7	-
4-5 Jan 2018	76.29	-66.55	-1.5	986	87.8	8.9	2	-17.13	-135.8	1.2	-
29/01/18	57.5	-39.97	13.1	1017.3	61.3	15.7	16	-14.35	-112.3	2.5	-
28/01/18	58.4	-40.16	18	1007.8	87.5	9.9	16.5	-11.38	-88.1	3	-
5-6 Jan 2018	76.22	-66.67	-2.5	980.2	77.3	8.7	0	-20.41	-159.9	3.4	-
03/01/18	76.42	-66.6	0.1	996.7	73	5.1	0.5	-19.34	-149.7	5	-0.87
29/01/18	57.49	-39.99	13.1	1018.4	66.7	11.9	16	-15.12	-114.3	6.7	-0.52
08/01/18	70.71	-65.49	-2.6	981.8	70.8	13.1	1	-21.45	-163.8	7.9	-0.98
10-11 Jan 2018	64.98	-65.5	-0.7	981.8	68.2	5.7	0	-21.37	-161.2	9.8	-
13/01/18	60.93	-65.73	2.5	979.7	67.6	7.6	0.5	-17.14	-124	13.2	-0.72
03/01/18	76.21	-65.87	-0.9	997.3	78.2	3.6	0.5	-17.36	-125.5	13.4	-
25/01/18	57.52	-47.51	9.9	1015.4	92.6	8.4	9	-13.52	-90.4	17.8	-0.72
12/01/18	62.84	-65.45	-0.3	983	76.3	7	0	-17.93	-119.9	23.5	-0.59
11/01/18	64.53	-65.5	1	983.1	71.4	5.4	0.5	-17.69	-109.3	32.3	-

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