

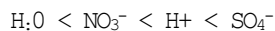
Chemistry of Snow Peak Accumulation and Melt in a Deciduous Forest
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For this paper we have examined

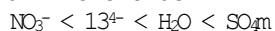
- (a) the variability of water equivalent, pH and concentrations of major anions in the snow falling in a mixed deciduous forest and in a clearing
- (b) the total inputs of these entities at the forest site and in the clearing relative to those measured at the nearby AES CAPMON monitoring site
- (c) the stability of these entities during the accumulation phase of winter, and finally,
- (d) the relative quantities of these entities recovered from the run-off from a 5 m square plastic lined lysimeter after the melt is finished.

VARIABILITY

Variability was measured by deploying bulk collectors fashioned from garbage cans having an area of opening of 1400 cm² and lined with poly-ethylene bags. Collections were made after each major input. Up to 29 and 9 collectors were used in the forest and clearing respectively. Variability is relatively large (C.V. = 0.16 - 0.39) within the forest for the ionic components in wet snow and freezing rain on December 22 and 26 respectively. Water equivalent however, was much less variable (C.V. = 0.03 - 0.14). Interaction with the forest canopy, rather than variable input of precipitation, appears to be the cause of increased spatial variability and enhanced deposition of the ionic components. If the incidences of c.v. > 0.05 are compared the variability increases in the order



at the open site and in the order



in the forest.

The total depositions of water, nitrate, sulphate and hydrogen ions to the bulk collectors and to the nearby AES CAPMON collectors were summed and compared. The results are shown in the table below.

	Dec 22 - Mar 3		Jan 28 - Mar 3	
	AES/OPLN	AES/FOREST	AES/OPEN	AES/FOREST
WATER	0.93	1.08	0.94	1.05
NO ₃	0.90	0.82	0.95	1.01
SO ₄	0.78	0.73	0.92	0.95
H ⁺	0.98	0.99	0.98	1.05

The difference in the two sets is that the period Dec 22-Mar 3 includes the wet snow and freezing rains of Dec 22 and 26. The ratios AES/OPEN and AES/FOREST agree reasonably well for the predominantly dry snow deposition period after January 28. When the wet snow deposition is included, there is a large variability between collectors and they are relatively enriched with respect to the AES site. This is particularly so for sulphate ion.

STABILITY

Stability was investigated by periodically collecting cores from the snow pack and cutting them into 5 cm deep slices. The product of the water equivalent and the concentration of the solutes in each slice gives the loading of each ion. The loadings were then summed from the bottom up and the cumulative loading plotted against the corresponding cumulative water equivalent. Results for B^+ , NO_3^- and SO_4^- for the spring of 1987 are shown in Figure 1. Also plotted there, are the cumulative inputs measured at the CAPMON site and at the forest site using the bulk collectors.

Results for the winter of 1986-87 can be summarized as follows. No melting occurred during the period between Feb 12 to 24. Skies were clear throughout with daytime temperatures approaching within a few degrees of the melting point and low night time temperatures. The loadings of the three ions are almost identical on each date showing that the 3 ions are stable in the pack under the conditions described. It also shows that, if dry deposition occurred in the period, the amounts deposited were too small to detect by the method used. Between February 24 and March 4 warmer temperatures prevailed and snow and rain fell. By March 7 substantial melting had also occurred. These events have caused hydrogen ion to be lost at both the bottom and the top of the pack by March 4. By March 7, however, additions to the top of the pack and melting have resulted in appreciable replenishment of the pack particularly at the top and bottom.

Nitrate appears to be more stable with small losses occurring at the top of the pack by March 4 followed by further losses throughout the pack by the 7th.

MELT

A 5 m square plot was lined with polyethylene sheeting, the edges being delineated by wooden planks 30 cm high and covered with extensions of the polyethylene flooring. Melt water from the lower most corner was channeled to an underground bunker where the volumetric flow of water was continuously monitored and samples taken for analysis. The product of the volumetric flow and the mean concentrations is a measure of the fluxes of the various chemical constituents. The final integral of the fluxes less the amounts added as precipitation over the whole melt period is a measure of the total amount of an entity stored in the pack at the start of the melt. This can be compared with the amounts measured in snow cores taken immediately before the start of the melt.

Results for 1987 and 1988 are shown in the table along with values for 1985. For the latter, precipitation was measured at the AES site only.

The most important results are:

- 1) The amounts of water equivalent by the two methods agree quite well in all cases.

- 2) In 1985, the melt started February 22 and there was a large amount of precipitation during the melt period. The total run-off of both nitrate and sulphate was less than the input during the melt.
- 3) In 1987 there was relatively less precipitation. Losses of both nitrate and sulphate were smaller. The apparent gain of hydrogen ion relative to forest input is not explained. The fact that about half of the precipitation during that melt period was wet snow which was followed by a period of freezing temperatures may account for some of the anomalies.
- 4) In 1988 there was even less precipitation during the melt period. With the exception of hydrogen ion relative to forest inputs, losses from the lined plot were negligible.

CONCLUSIONS

- 1) Substantial differences have been found between the inputs of solutes to the snow pack by the "wet only" protocols at a nearby CAPMON monitoring site and with "bulk" collectors in the forest. The differences appear to be due to interaction between the snow and the forest canopy and are greater when wet snow or rain falls.
- 2) The variability of inputs within the forest is small. For the most part, the standard deviation is less than 5% of the mean when the snow is dry and tends to rise when the snow is wet or mixed with rain.
- 3) The composition of the snow pack is stable in the absence of melting or rain-on-snow events. Melting and rain tend to cause vertical re-distribution of solutes within the pack and relatively much greater loss of solutes than loss of water equivalent.
- 4) The large loss of nitrate ion in the run-off from the lined plot noted in previous years may have been due to large amounts of precipitation during the melt period.

	RUN-OFF	INPUT DURING MELT		NIT STORED AT START OF MELT				
		A-AES	b-FOREST	LINED PLOT a AES	LINED PLOT b FOREST	SNOW CORE c	RATIO a/c	RATIO b/c
WATER 1985	27.75	17.24		10.51		10.51	1.00	
WATER 1987	21.34	7.15	5.10	14.19	16.24	14.52	0.98	1.12
WATER 1988	19.37	3.23	2.22	16.14	17.15	17.33	0.93	0.99
NO3 1985	53.59	0.81		-8.22		25.8		
NO3 1987	30.19	7.98	10.26	22.21	19.93	24.96	0.89	0.84
NO3 1988	46.6	8.66	9.55	37.94	37.05	41.28	0.92	0.90
SO4 1985	42.91	4.77		-1.86		9.30		
SO4 1987	21.11	9.61	12.88	11.5	8.23	12.51	0.92	0.66
SO4 1988	29.67	9.16	11.58	20.51	18.09	19.59	1.05	0.92
NH 1987	843	400	110	443	733	432	1.03	1.70
N. 1988	764	257	79	507	685	750	0.68	0.91

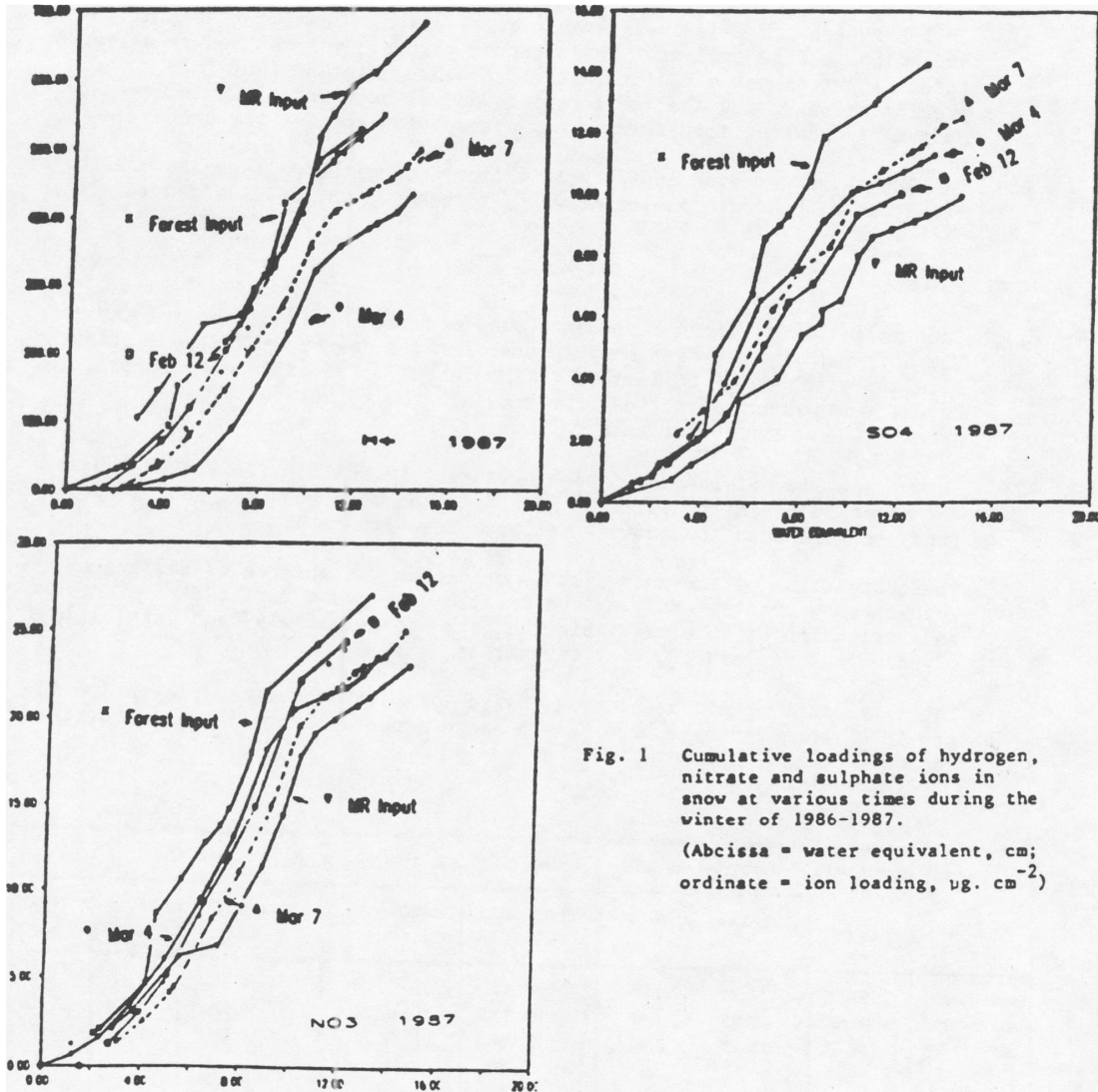


Fig. 1 Cumulative loadings of hydrogen, nitrate and sulphate ions in snow at various times during the winter of 1986-1987. (Abcissa = water equivalent, cm; ordinate = ion loading, $\mu\text{g. cm}^{-2}$)