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Comment on "The Distribution of Nitrate Content in the Surface Snow of the Antarctic Ice Sheet Along the Route of the 1990 International Trans-Antarctica Expedition" by Qin Dahe, Edward J. Zeller, and Gisela A. M. Dreschhoff

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There are several important mistakes in the paper by *Qin et al.* [1992], referred to hereinafter as QZD, which I must write to correct.

The first and most serious is in their Table 1, and Figure 3, where they discuss nitrate flux. In fact the values quoted are for nitrogen flux and not nitrate. The values are a factor of 62/14 too low. An amended set of their station fluxes is enclosed in my Figure 1 and Table 1.

Additionally, the accumulation rate quoted for the Weyerhaeuser Glacier, their stations 11 and 12, is taken from *Peel and Clausen* [1982] data on Mount Charity accumulation, a very unusual site and not at all representative of the Antarctic Peninsula. Using data from measurements of accumulation along the peninsula allows 10 stations of QZD to be assigned new accumulation rates or rates different from those quoted by QZD, (see Table 1 of this comment)

A third source of error in QZD's Table 1 is the misplacing of the decimal point in several of the flux values of the sites (stations 61, 66, 70-74) with less than 1 kg km^{-2} a^{-1} N.

I present correct versions of QZD, Figure 3, (my Figure 1) and a version of their Figure 2 with concentrations expressed in micromolars (my Figure 2). One great source of confusion in papers dealing with chemical concentrations is the different units used by authors. Quoting nitrate concentrations by the weight fraction of nitrogen caused most of the errors in QZD; expressing concentrations in terms of molarity should be encouraged.

The discussion of the flux values in comparison with other estimates [QZD, p. 6283] is completely at odds with the corrected flux values as calculated above (see Table 1 here). For example, the discussion of Siple, South Pole, and Vostok fluxes (all in kilograms per square kilometer per year) is outlined in Table 2.

The Vostok NO_3 concentration given by *Delmas and Legrand* [1989] is the accepted value rather than the value in the work by *Clausen and Langway* [1989]. Additionally, QZD stations 18 and 19 are close to the Gomez drilling site where NO_3 flux is 8.7 kg km^{-2} a^{-1} [*Clausen and Langway*, 1989], compared with 10-19 kg km^{-2} a^{-1} in my Table 1. By quoting their values for (NO_3-N) fluxes and the earlier fluxes as NO_3 values, QZD make direct comparisons very difficult for the reader. QZD discuss why their surface fluxes are different from previous measurements; in fact we see that the corrected fluxes are rather close to the previous values except for Vostok, where the flux is much higher than previously reported. This would also be the case for South Pole were it not for the South Pole sample having an apparently lower NO_3 concentration than the surrounding samples. Indeed the NO_3 concentrations in the sites above about 1200 m elevation in East Antarctica show values above 1.4 μ*M*, with peaks up to 4 μ*M*. The literature [e.g., *Clausen and Langway*, 1989] values of NO_3 concentrations are generally between 0.25 μ*M* and 0.6 μ*M*, with South Pole having anomalously high concentrations of 1.4 μ*M*.

It has been well observed that NO_3 undergoes extensive postdepositional changes in snow concentration [*Neubauer and Heumann*, 1988], and this was specifically considered to be a possible factor at Vostok [*Mayewski and Legrand*, 1990]. The mechanism is not understood, but factors such as exposure to sunlight, mixing of the snow surface layers, and length of time since the last snowfall influence surface concentrations and must be considered. Without data such as the occurrence of precipitation in the period before the samples of QZD were collected, little can be inferred from the samples of any systematic

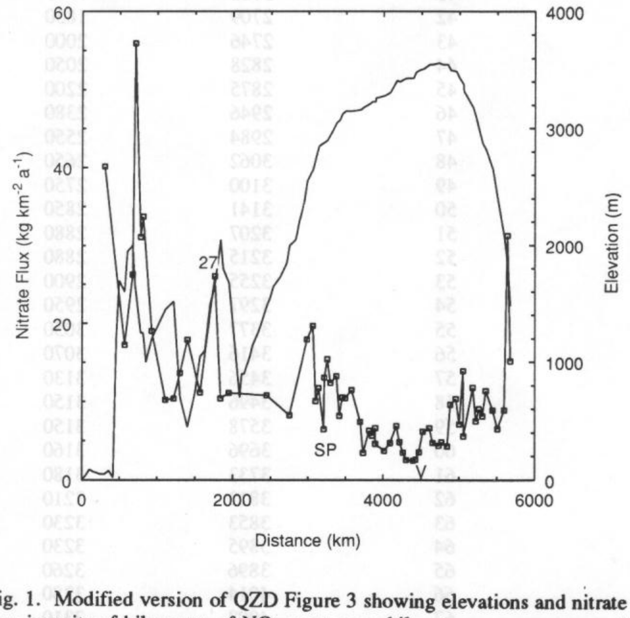

Fig. 1. Modified version of QZD Figure 3 showing elevations and nitrate flux in units of kilograms of NO_3 per square kilomter per year measured in 25-cm surface snow samples along the International Trans-Antarctica Expedition (ITAE) route (QZD). The additional accumulation data from the Antarctic Peninsula shown in Table 1 have been included, allowing extra data points to be plotted. Sampling station 27 and the South Pole (SP) and Vostok (V) stations are marked.

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TABLE 1. Amended Nitrate Concentration and Fluxes at the ITAE Stations

Station	Distance, km	Elevation, m	NO_3, μM	Accumulation, kg m^{-2} a^{-1}	NO_3 Flux, kg km^{-2} a^{-1}
1	0	0	0.26		
2	63	50	0.40		
3	100	90	0.72		
4	153	70	0.72		
5	249	50	0.36		
6	303	50	1.08	600	40.12
7	360	80	0.60		
8	418	20	1.05		
9	59	1200	1.33		
10	497	1700	1.26		
11	570	1600	0.26	1050[a]	17.21
12	607	1950	1.16		
13	676	2000	0.81	520[a]	26.25
14	708	1650	1.48	610[a]	55.92
15	782	1250	0.77	650[a]	31.09
16	814	1250	0.84	650[a]	33.68
17	852	1000	0.56		
18	929	1200	0.89	343[b]	18.99
19	1107	1450	0.48	343[b]	10.18
20	1217	1520	0.51	330[a]	10.38
21	1302	700	0.76	290[a]	13.61
22	1400	450	0.72	400[c]	17.89
23	1503	750	0.60		
24	1569	1050	0.52	344	11.12
25	1633	1100	0.74		
26	1703	1500	0.74		
27	1761	1650	1.05	400	26.04
28	1838	2050	0.56	300	10.36
29	1872	1800	1.17		
30	1949	1680	0.89	200	11.07
31	2092	700	1.16		
32	2116	900	0.77		
33	2148	900	0.37		
34	2224	1050	0.63		
35	2262	1150	0.68		
36	2329	1250	1.19		
37	2369	1320	1.11		
38	2446	1480	1.16	150	10.76
39	2490	1550	1.09		
40	2534	1650	1.68		
41	2622	1730	1.09		
42	2709	1850	1.05		
43	2746	2000	1.33	100	8.24
44	2828	2050	1.40		
45	2875	2200	1.79		
46	2946	2380	1.59		
47	2984	2550	3.52	82	17.90
48	3062	2650	3.96	80	19.66
49	3100	2750	2.13	76	10.03
50	3141	2850	2.33	81	11.69
51	3207	2880	1.22	85	6.44
52	3215	2880	2.59	81	13.02
53	3255	2900	3.35	74	15.37
54	3297	2950	2.93	68	12.35
55	3377	3050	3.81	56	13.22
56	3416	3070	2.64	50	8.17
57	3456	3130	3.46	49	10.50
58	3496	3150	3.50	48	10.42
59	3578	3150	4.01	46	11.45
60	3696	3160	2.78	43	7.41
61	3733	3180	1.31	42	3.42
62	3813	3210	2.53	40	6.27
63	3853	3230	2.33	39	5.63
64	3895	3230	2.81	38	6.61
65	3896	3260	2.05	36	4.58
66	4014	3280	1.71	35	3.72
67	4092	3310	2.30	33	4.71
68	4175	3410	3.58	31	6.88
69	4217	3400	2.58	30	4.80
70	4264	3420	1.93	29	3.47
71	4304	3430	1.53	27	2.56
72	4396	3430	1.59	25	2.46
73	4428	3480	1.83	23	2.61

TABLE 1. (Continued)

Station	Distance, km	Elevation, m	NO_3, μM	Accumulation, kg m^{-2} a^{-1}	NO_3 Flux, kg km^{-2} a^{-1}
74	4475	3500	2.49	23	3.54
75	4525	3510	3.31	30	6.16
76	4611	3550	3.22	33	6.59
77	4655	3550	2.11	36	4.72
78	4733	3560	1.90	37	4.36
79	4772	3550	2.50	31	4.81
80	4844	3550	1.86	37	4.28
81	4886	3500	2.34	66	9.59
82	4958	3490	2.73	61	10.32
83	5002	3430	1.61	71	7.07
84	5052	3380	2.87	78	13.89
85	5059	3320	0.99	91	5.56
86	5179	3180	1.54	123	11.77
87	5221	3093	0.98	123	7.46
88	5262	2980	1.13	129	9.03
89	5307	2870	1.04	126	8.09
90	5351	2820	1.14	160	11.34
91	5441	2650	1.28	112	8.88
92	5505	2400	0.99	106	6.48
93	5591	2080	0.76	189	8.87
94	5634	1850	1.25	403	31.23
95	5673	1480	0.60	406	15.10

[a] *Peel and Clausen* [1982].
[b] *Clausen and Langway* [1989].
[c] *Behrendt* [1965].

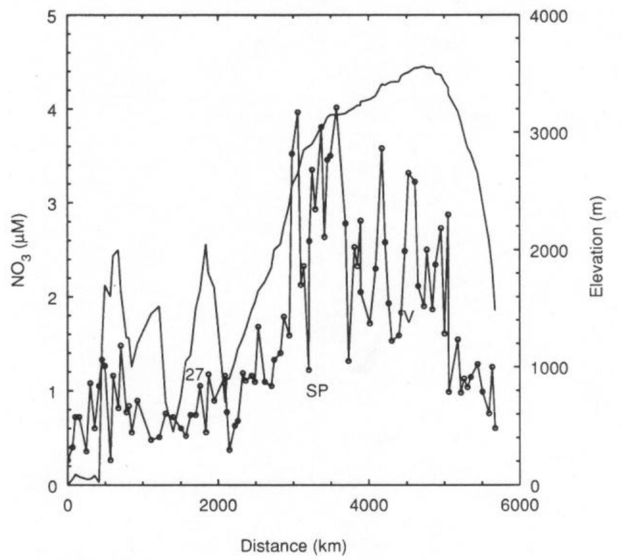

Fig. 2. Modified version of QZD Figure 2 showing elevation and nitrate concentration expressed in micromolars measured in 25-cm surface samples along the ITAE route. Sampling station 27 and the South Pole (SP) and Vostok (V) stations are marked.

TABLE 2. Comparison of Nitrate Fluxes

Siple	South Pole	Vostok	Reference
11.0	7.6	1.3	Clausen and Langway [1989]
-	-	0.4	Delmas and Legrand [1989]
1.8	1.5	0.6	QZD (NO_3-N)
11.1	6.4	2.6	this comment

changes of concentration with latitude, or of their relevance to the NO_3 concentrations at depth.

Furthermore, it is clear that stations 1-50 and 85-95 were sampled through less than a single year of snowfall. There is a strong seasonal cycle of NO_3 concentrations in Antarctic snow, with peaks in summer or spring. The differences in concentration of samples containing austral winter precipitation at stations 1-10 (July and August), spring-midsummer snowfall (September to December) at stations 11-50, and fall snow (February) at stations 81-95 are likely to be very great.

In conclusion I feel that the data set presented by QZD is a good and interesting source that requires careful interpretation.

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