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Supplement of

A glaciochemical study of the 120 m ice core from Mill Island, East Antarctica

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1 Non sea salt sulphate and fractionation

The presence of negative nssSO_4^{2-} values in the Mill Island ice core record indicates that the calculation of nssSO_4^{2-} is not accurate when using the k value from typical seawater composition. A new k value, k' , was calculated following Hall and Wolff (1998).

5 nssSO_4^{2-} (calculated using the sea water ratio of Na^+ to SO_4^{2-}) versus Na^+ data are shown in Fig. S 7. Negative nssSO_4^{2-} concentrations extend down to $\sim -600 \mu\text{Eq/L}$. The new, corrected k value, k' , is obtained by subtracting the regression slope, r from k , i.e., $k' = k - r$. As a result, $k' = 0.049$. The negative nssSO_4^{2-} values from the 97 year ice core record were used for the regression line calculation, rather than only using winter data (Hall and Wolff, 1998). This methodology is due to the ambiguous seasonality in the Mill Island ice core record. The nssSO_4^{2-} record during known volcanic eruption years (1991,
10 1984, and 1964) was excluded.

To verify this result, k' was obtained independently by minimising the correlation coefficient between nssSO_4^{2-} (calculated using a k' range from 0.01 to 0.12 in steps of 0.001) and the associated Na^+ value (?). The correlation coefficient r is a function of k' . The k' value for a correlation coefficient of $r \cong 0$ is at $k' = 0.049$, confirming the simple linear regression method. The zero correlation indicates that the sea salt influence on SO_4^{2-} is removed. Comparing with the LD k' value of 0.087 (Palmer
15 et al., 2002; Plummer et al., 2012), the Mill Island ice core is more highly fractionated.

References

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Wind speed (m/s)	Na ⁺			SO ₄ ²⁻		
	annual	summer	winter	annual	summer	winter
< 5	0.22	0.11	- 0.01	0.15	0.33	- 0.09
5 – 15	- 0.51	- 0.14	- 0.48	- 0.42	- 0.32	- 0.36
> 15	0.18	0.01	0.41	0.18	- 0.09	0.42

Table S 1. Correlations between CFSR wind speed at Mill Island and concentration of Na⁺ and SO₄²⁻ during winter and summer and for the annual average. Bold values indicate significant correlations (i.e., $p < 0.05$.)

	Na ⁺	SO ₄ ²⁻
SIC-W	- 0.28 (0.129)	- 0.49 (0.005)
SIC-C	- 0.47 (0.008)	- 0.52 (0.002)
SIC-E	- 0.53 (0.002)	- 0.55 (0.001)
SIC-S	- 0.53 (0.002)	- 0.58 (0.001)
SIC-SE	- 0.57 (0.001)	- 0.57 (0.001)

Table S 2. Correlation coefficients between annual mean sea ice concentration at each pixel and the annual mean concentration of Na⁺ and SO₄²⁻. Bold numbers indicate $p < 0.01$. The p-value is shown in brackets.

	Na ⁺	SO ₄ ²⁻
SIC-m _{AB}	- 0.56 (0.001)	- 0.58 (0.001)
SIC-m _A	- 0.76 (0.017)	- 0.80 (0.009)
SIC-m _B	- 0.52 (0.012)	- 0.47 (0.029)

Table S 3. Correlation coefficients between annual mean sea ice concentration at SIC-m and the annual mean concentrations of Na⁺ and SO₄²⁻ during the periods of 1979 – 2009 (SIC-m_{AB}), regime A (2001 – 2009, SIC-m_A), and regime B (1979 – 2000, SIC-m_B). The p-value is shown in bracket. Bold numbers indicate $p < 0.05$.

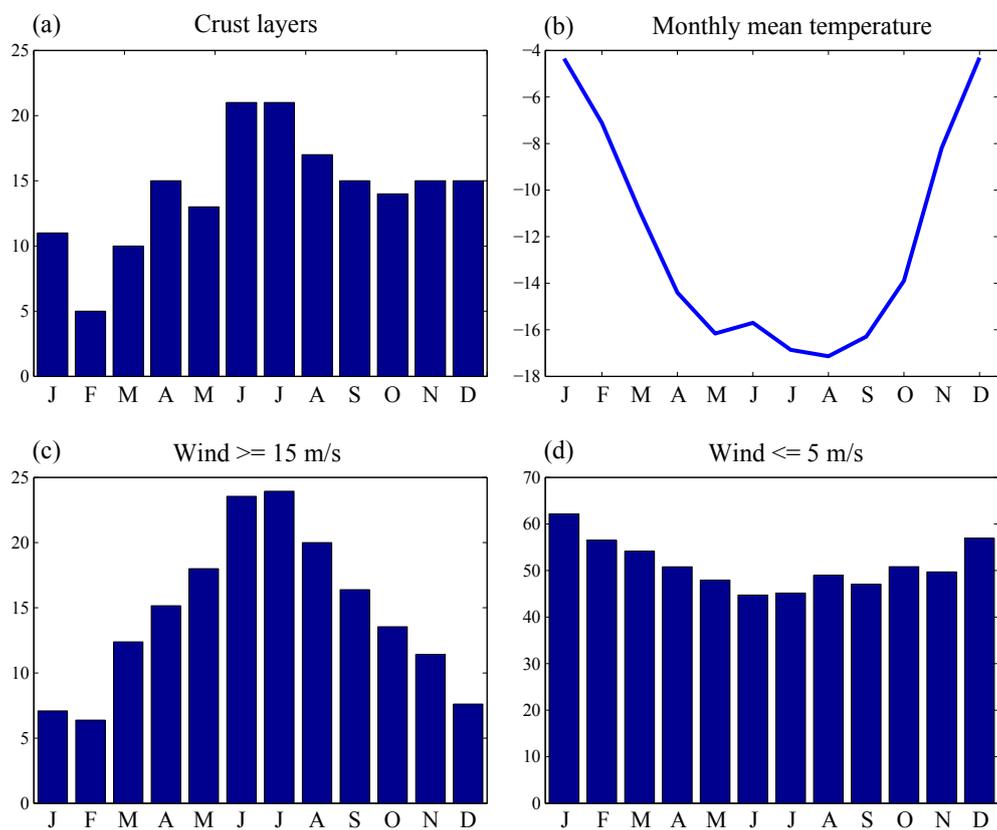


Figure S 1. Figures of a) monthly total crust layers, b) Monthly mean temperature, c) monthly mean number of wind exceed 15 m/s data from six hourly data, d) same as c, but wind speed is less than 5 m/s.

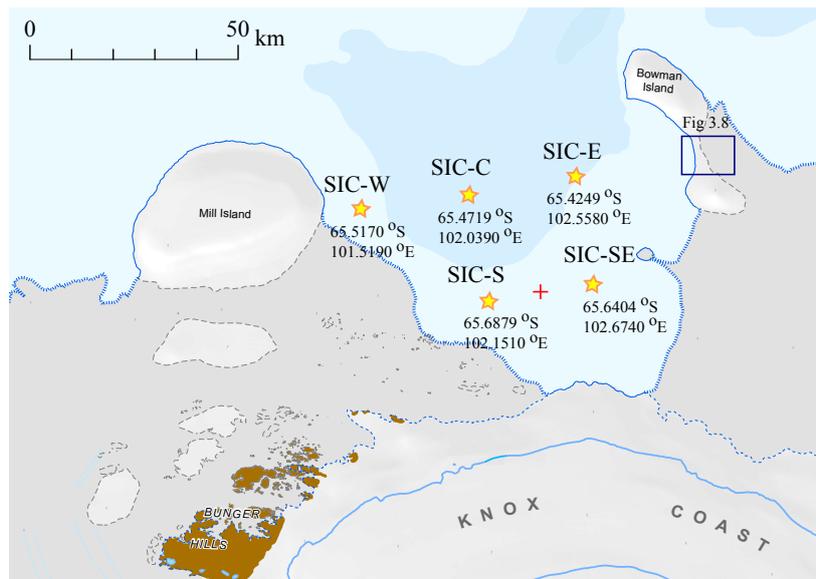


Figure S 2. The coordinates and names of the five sea ice concentration data pixels. The red plus symbol indicates the centroid position of the derived time series SIC-m, formed by averaging SIC-S and SIC-SE. The dark blue rectangle indicates the location of the photograph shown in Figure 3. Map courtesy of the Australian Antarctic Division, © Commonwealth of Australia, 2012.

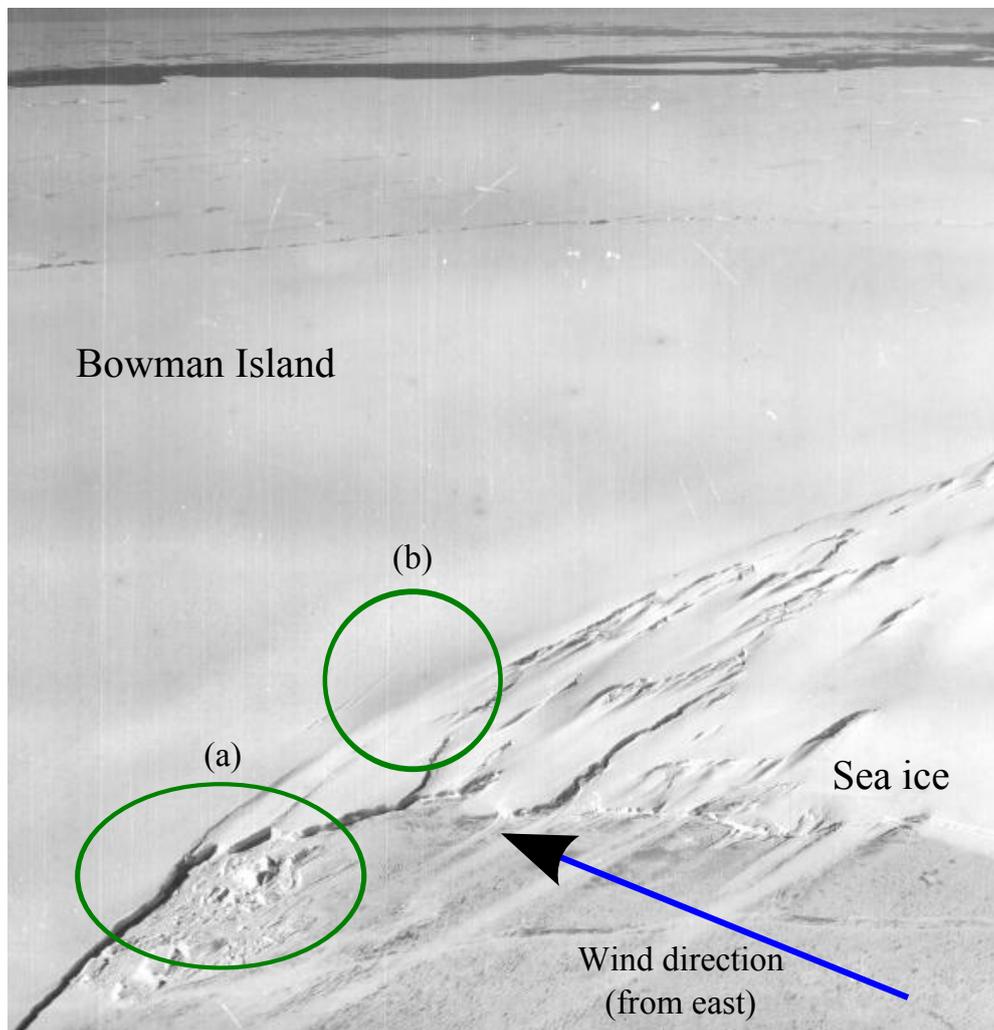


Figure S 3. An aerial photo over Bowman Island on 11th February, 1947. Ellipse a shows an example of the vertical discontinuity from sea level to the ice cap. Circle b demonstrates a clear snow ramp. Some scale is provided by cross-referencing with the rectangle in Figure 2. Photo courtesy of the Australian Antarctic Division, © Commonwealth of Australia, 2015.

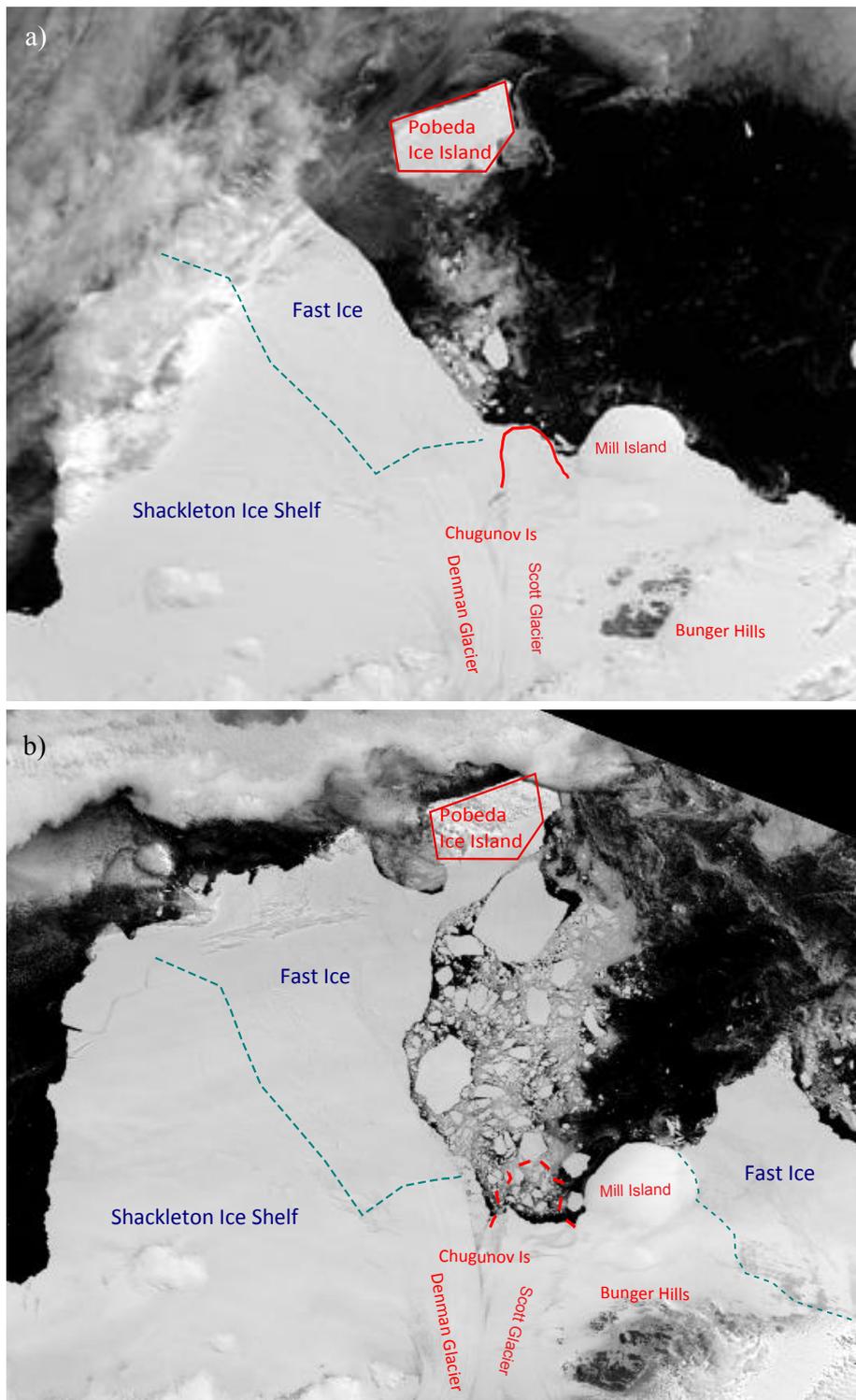


Figure S 4. MODIS images of the Shackleton Ice Shelf and Mill Island area. Green dashed line divides fast ice and ice shelf. a) 14th Feb 2002, b) 29th Dec 2002

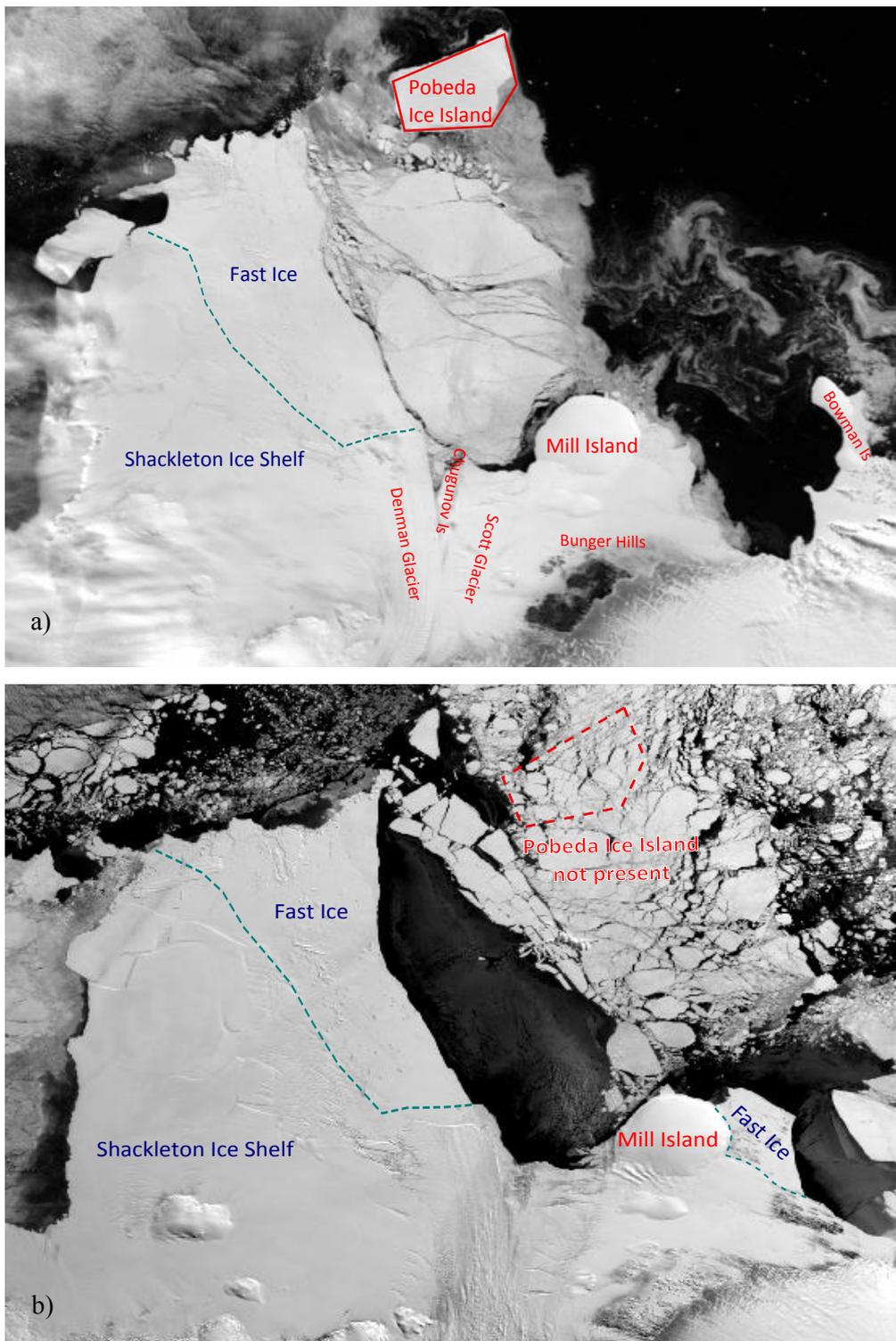


Figure S 5. MODIS images of the Shackleton Ice Shelf and Mill Island area. a) 6th Mar 2003, b) 15th Sep 2004



Figure S 6. A photo of an Automatic Weather Station covered by thick rime ice at Roosevelt Island ($79^{\circ}25'$ S, $162^{\circ}00'$ W), 23rd October, 2011. Photo provided by N. Bertler.

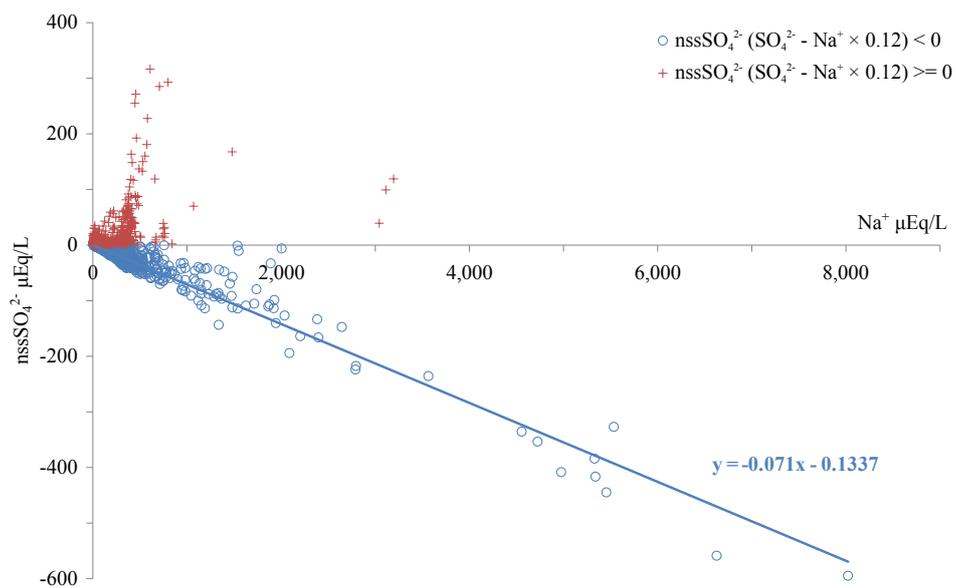


Figure S 7. Scatter plot of nssSO_4^{2-} (calculated using the seawater ratio of sulphate to sodium, 0.12) versus Na^+ . The linear regression line was computed with negative nssSO_4^{2-} values only.