Air–snow exchange of nitrate: a modelling approach to investigate physicochemical processes in surface snow at Dome C, Antarctica: Supplementary Information

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1 Comparison between surface snow temperature deduced from longwave radiation measurement or modelled

In-situ measurements of snow surface temperature and temperature profile is not straightforward, and a usual way to get this variable is to use measured downwelling and upwelling longwave radiation and further applying Stefan–Boltzmann law to the snow considered as a "grey body":

$$J_{\mathrm{LW\uparrow}} = \varepsilon\sigma T_s^4 + (1 - \varepsilon)E_{\mathrm{LW\downarrow}} \qquad (1)$$

where $J_{\mathrm{LW\uparrow}}$ and $E_{\mathrm{LW\downarrow}}$ are the upwelling and downwelling longwave radiation respectively, ε the snow emissivity (0.97 or 0.98 at DC, Town et al. (2008) and ref. therein) σ the Stefan Boltzman constant and T_s the surface temperature.

Downwelling data is provided by the baseline surface radiation network (BSRN, see for example Vitale, Vito, 2009), upwelling data were provided by Christian Lanconelli (personal communication). We present here the time series for only 2 weeks, but the following analysis were applied to the whole 3 month period for which we got the longwave, upwelling raw data, excluding ~ 8 days at total of wrong or missing data.

As once can see in Fig. 1, the modelled temperature feature a warm bias, with an initial RMSE between modelled and calculated temperature equals to 3.5 K. Applying a constant reduction of -2.65 K to the modelled temperatures (dashed green line) leads to a better fit, with a RMSE reduced to 2.4 K. However, it further appears that diurnal amplitude of the modelled temperature is somewhat smaller than the calculated temperature amplitude. It is possible to correct this by applying a linear relation to get a modified temperature T':

$$T' = a \times T + b \qquad (2)$$

where T is the original modelled temperature, and a and b are adjusted to minimize RMSE. With $a = 1.1825$ and $b = -42.9$ K, we get the optimum fit with calculated temperatures (dashed purple line in Fig. 1), with a RMSE reduced to 2.0 K.

However, as discussed in the main text (see Sect. 2.2.1), since this comparison between modelled and calculated temperatures could not be made over the whole year, we decided to keep the modelled temperatures unchanged when using them as input in our model. Indeed, the longwave radiation data covers only the summer period, during which the sunlight is maximum. Thus, the discrepancy between modelled and measured temperatures might not be the same over the whole year. However, this comparison shows that great care should be devoted to snow surface temperature measurements.

2 Monthly discrepancy analysis

In Table 1 is presented a monthly analysis of the model performance. The model is run in configuration 1 (solid state diffusion inside a layered grain) with boundary condition BC3 (physically-based, prognostic parameterisation of the co-condensation process). In this analysis, a linear regression was used, with the intercept forced at the origin.

References

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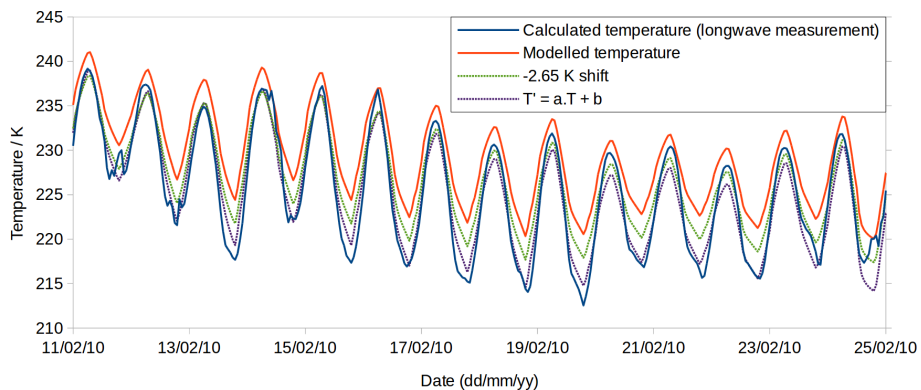   (2009-02), 2009.

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Figure 1. Surface snow temperature deduced from longwave radiation (solid blue line) and modelled temperature used in this study (solid red line). Modelled temperature offseted by -2.65 K is plotted in dashed green line. Modelled temperature modified using a linear function to increase its amplitude (see text) is plotted in dashed purple line.
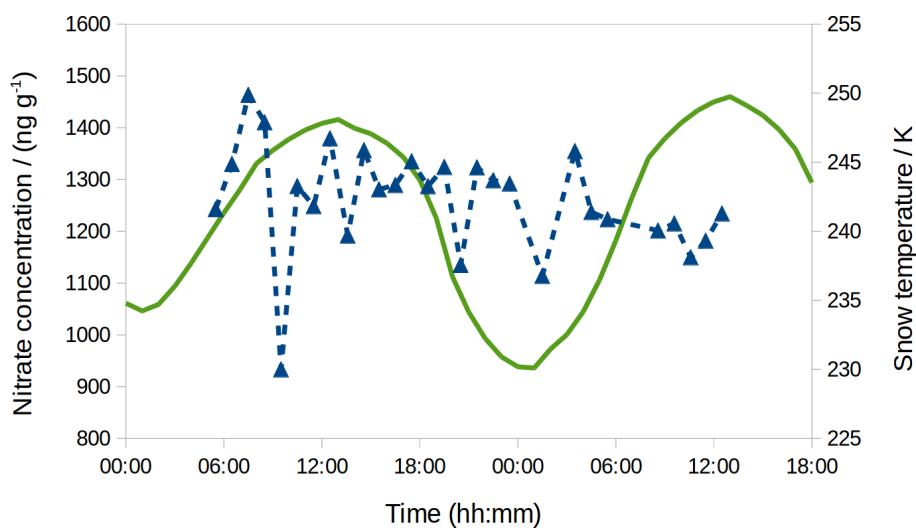

Figure 2. Hourly variations of skin layer nitrate concentration (blue triangles) at DC on 28 and 29 December 2009, and modelled snow surface temperature (green).

Table 1. In table SI 1 are summarized, for each month, the number of data points and the R^2 coefficient obtained using a linear regression with an intercept forced at the origin.

Year	Month	# points	R^2
	February	8	0.93
	March	9	0.95
	April	10	0.99
	May	9	0.91
	June	9	0.97
2009	July	14	0.92
	August	10	0.99
	September	12	0.84
	October	11	0.88
	November	12	0.87
	December	15	0.97
2010	January	11	0.99
Whole dataset		130	0.94