Supplement of Geosci. Model Dev., 14, 3487–3510, 2021
https://doi.org/10.5194/gmd-14-3487-2021-supplement

Geoscientific Model Development
Open Access

Supplement of

Performance of MAR (v3.11) in simulating the drifting-snow climate and surface mass balance of Adélie Land, East Antarctica

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S1 Measuring surface snow density during a drifting-snow event at D17, Adelie Land, East Antarctica

Measurements of snow density at the surface were performed as part of a comparison experiment between two drifting-snow devices at D17 in late January 2014 (Amory, 2020). Snow density at the surface was measured at regular intervals along the event. At each measuring interval, 10 snow samples were taken on the field with a manual shovel-shaped hollow collector specifically designed by the IGE, and then placed in a closed bag. Density was retrieved by weighting the snow content of the bag in a mobile shelter installed downwind of the measurement structure, knowing the sampling volume of the collector. At each collection, the two most extreme values were discarded, and the average and standard deviation were computed from the 8 remaining samples. This operation was repeated along the experiment until the fresh snow cover became very patchy due to removal by wind. Note that freshly fallen and remobilized snow was easily distinguished from older, denser snow at the surface that resulted from an intense rainfall event in early January (Fig. S1) that smoothed the microrelief and increased density above 500-700 kg m^{-3} after refreezing of both meltwater and rainwater combined with the absence of snowfall during the remainder of the month.

The temporal evolution of measured surface snow density follows a linear increase with time from 220 kg m^{-3} to 340 kg m^{-3} in less than 24 h (Fig. S2). Drifting snow was considered to initiate when the drifting-snow mass flux measured at the lowest 2G-FlowCapt™ sensor rose above 10^{-3} kg m^{-2} s^{-1}.

Figure S1. Photograph of the snow surface at D17 in late January 2014 before the beginning of the snowfall and subsequent drifting-snow event.

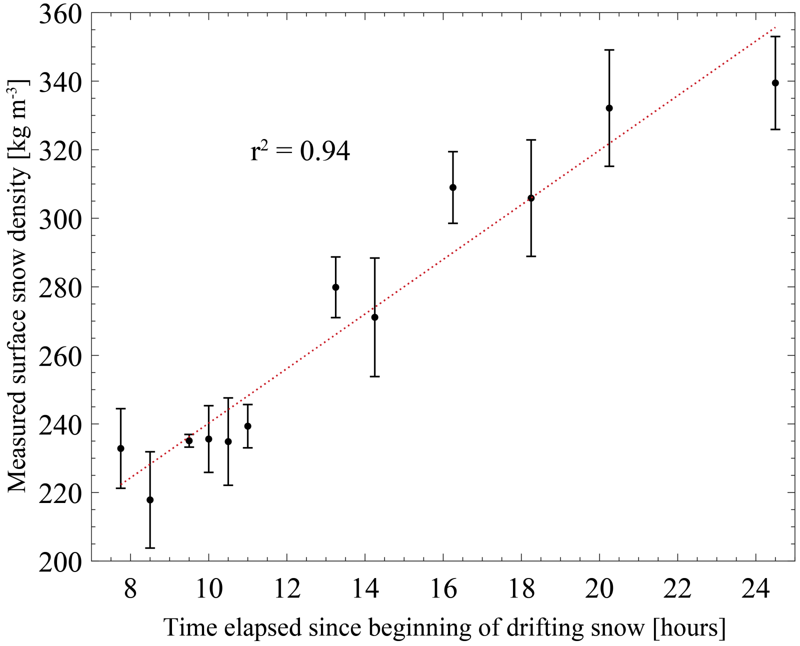

Figure S2. Linear increase in surface snow density measured during a drifting-snow event in late January 2014 at D17 in Adelie Land. The vertical bars denote one standard deviation of the observations in both directions. The red dashed line shows the best linear fit.

S2 Sensitivity to the vertical discretisation

An additional simulation in which the number of vertical levels was increased from 24 (hereafter referred to as M24) to 48 with a doubling in vertical levels in the lowest 100 m (hereafter referred to as M48) was performed to assess the sensitivity of MAR to the vertical discretisation. Although half-hourly records are used for model evaluation in this manuscript, data are rarely made available at such a high temporal frequency, and evaluation of regional climate models at daily resolution is usually preferred (Mottram et al., 2020; Kittel et al., 2020). Since similar statistics were obtained by evaluating the model with the standard discretisation of 24 atmospheric levels at both temporal resolution over one year at D17 (not shown), the sensitivity to a doubling in vertical levels was assessed using daily observations only. Wind speed, air temperature and relative humidity data at D47 were complemented by three-hourly data obtained from another nearby AWS (< 100 m) also labelled D47 and operated by the Antarctic Meteorological Research Center (AMRC) and AWS program (https://amrc.ssec.wisc.edu/) for the period 2009-2018, and resampled at daily resolution. The results of the comparison are shown in Table 3 and reveal a similar model performance for both vertical discretisations.

Table S1. Statistics of simulated (M24 and M48) 2-m wind speed in comparison with automatic weather stations D47 and D17.

Station	slope		bias		rmse		r^2	
	M24	M48	M24	M48	M24	M48	M24	M48
D47	0.77	0.66	1.4	1	3.4	2.4	0.75	0.68
D17	0.75	0.71	-1.5	-2.4	1.9	2.6	0.89	0.8

Table S2. Statistics of simulated (M24 and M48) 2-m air temperature in comparison with automatic weather stations D47 and D17.

Station	slope		bias		rmse		r^2	
	M24	M48	M24	M48	M24	M48	M24	M48
D47	0.97	0.97	0.6	0	1.3	1.4	0.98	0.92
D17	0.95	0.97	-0.7	-0.4	1.3	1.4	0.97	0.94

Table S3. Statistics of simulated (M24 and M48) 2-m air relative humidity with respect to ice in comparison with automatic weather stations D47 and D17.

Station	slope		bias		rmse		r^2	
	M24	M48	M24	M48	M24	M48	M24	M48
D47	0.53	0.58	2.9	2	10.3	10.4	0.44	0.45
D17	0.98	0.69	0.9	-4.2	5.4	7.3	0.6	0.28

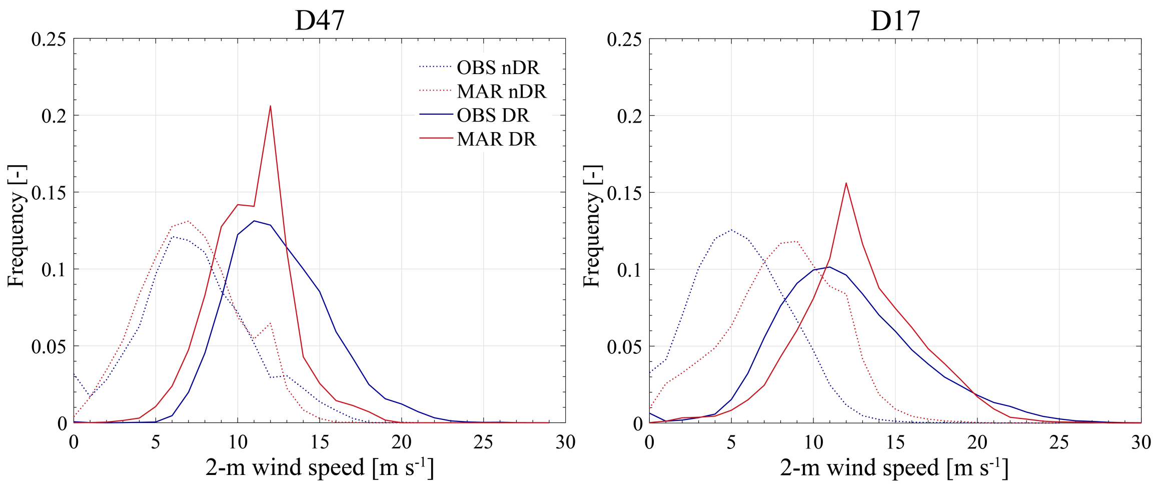

Figure S3. Frequency distribution of observed (red) and simulated (blue) half-hourly 2-m wind speed during (solid curves) and outside of (dashed curves) drifting-snow occurrences (near-surface drifting-snow mass fluxes greater than 10^{-3} kg m^{-2} s^{-1}) at D47 (left) and D17 (right) for the respective observation periods, i.e. 2010–2012 and 2010–2018.

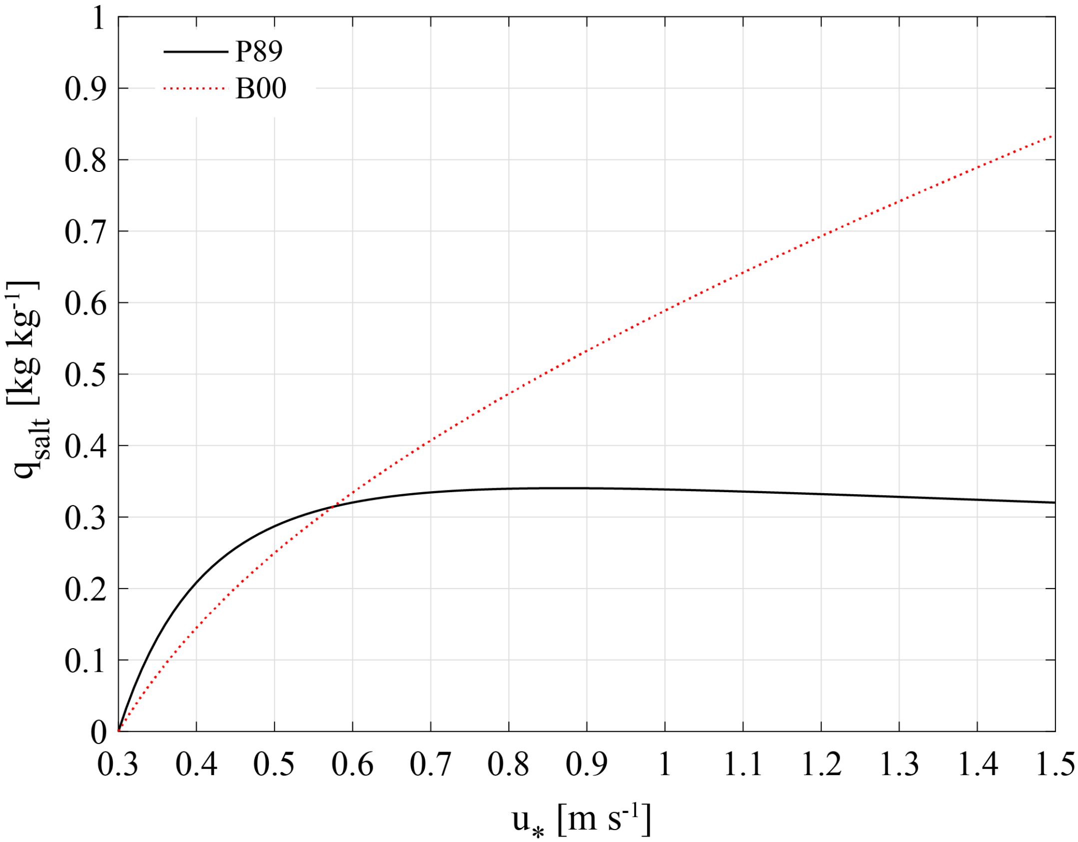

Figure S4. Evolution of q_{salt} as a function of u_* according to the control formulation of Pomeroy (1989) and the alternative proposed by Bintanja (2000), respectively indicated as P89 and B00. .

References

Amory, C.: Drifting-snow statistics from multiple-year autonomous measurements in Adélie Land, East Antarctica, The Cryosphere, 14, 1713–1725, https://doi.org/10.5194/tc-14-1713-2020, 2020.

Bintanja, R.: Snowdrift suspension and atmospheric turbulence. Part II: Results of model simulations, Boundary-Layer Meteorology, 95, 369–395, https://doi.org/10.1023/A:1002643921326, 2000.

Kittel, C., Amory, C., Agosta, C., Jourdain, N. C., Hofer, S., Delhasse, A., , Doutreloup, S., Huot, P.-V., Lang, C., Fichefet, T., and Fettweis, X.: Diverging future surface mass balance between the Antarctic ice shelves and grounded ice sheet, The Cryosphere Discuss., https://doi.org/10.5194/tc-13-3405-2019, 2020.

Mottram, R., Hansen, N., Kittel, C., van Wessem, J. M., Agosta, C., Amory, C., Boberg, F., van de Berg, W. J., Fettweis, X., Gossart, A., van Lipzig, N. P. M., van Meijgaard, E., Orr, A., Phillips, T., Webster, S., Simonsen, S. B., and Souverijns, N.: What is the Surface Mass Balance of Antarctica? An Intercomparison of Regional Climate Model Estimates, The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-333, 2020.

Pomeroy, J. W.: A process-based model of snow drifting, Annals of Glaciology, 13, 237–240, https://doi.org/10.3189/S0260305500007965, 1989.