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Estimating degree-day factors of snow based on energy flux components

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Supplementary materials to section 4

S.1 Tables for DDF components (i.e., DDF_L, DDF_H, DDF_E)

Table S1 Longwave radiation component (DDF_L) (mm °C^{-1} d^{-1}) for selected cloudiness (%) and degree-days (°C d)

	DDF_L										
	Cloudiness										
T_{DD} (°C d)	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	-19.08	-17.17	-15.26	-13.35	-11.45	-9.54	-7.63	-5.72	-3.81	-1.90	0.01
2	-8.89	-7.94	-6.99	-6.04	-5.09	-4.14	-3.19	-2.24	-1.29	-0.33	0.62
3	-5.49	-4.86	-4.23	-3.59	-2.96	-2.33	-1.70	-1.07	-0.44	0.19	0.82
4	-3.78	-3.31	-2.84	-2.37	-1.90	-1.42	-0.95	-0.48	-0.01	0.46	0.93
5	-2.75	-2.38	-2.00	-1.63	-1.25	-0.88	-0.50	-0.13	0.25	0.62	1.00
6	-2.06	-1.75	-1.44	-1.13	-0.82	-0.51	-0.20	0.11	0.43	0.74	1.05
7	-1.57	-1.30	-1.04	-0.77	-0.51	-0.24	0.02	0.29	0.55	0.82	1.08
8	-1.19	-0.96	-0.73	-0.50	-0.27	-0.04	0.19	0.42	0.65	0.88	1.11
9	-0.90	-0.69	-0.49	-0.29	-0.08	0.12	0.32	0.53	0.73	0.93	1.14
10	-0.66	-0.48	-0.30	-0.11	0.07	0.25	0.43	0.61	0.79	0.98	1.16
15	0.08	0.19	0.31	0.43	0.54	0.66	0.77	0.89	1.01	1.12	1.24
20	0.48	0.56	0.64	0.72	0.81	0.89	0.97	1.05	1.13	1.21	1.30

Table S2 Sensible heat component (DDF_H) (mm °C^{-1} d^{-1}) for selected altitude (m a.s.l.) and degree-days (°C d), RH= 0%, u = 1.0 m s^{-1}

	DDF_H					
	Altitudes (m a.s.l.)					
T_{DD} (°C d)	0	1000	2000	3000	4000	5000
1	0.806	0.712	0.628	0.555	0.490	0.432
5	0.795	0.703	0.621	0.550	0.486	0.430
10	0.781	0.692	0.613	0.543	0.482	0.427
15	0.767	0.681	0.605	0.537	0.477	0.424
20	0.754	0.671	0.597	0.531	0.473	0.421

Note: DDF_H for any other windspeed can be obtained by just multiplying with the desired windspeed value.

Table S3 Latent heat component (DDF_E) (mm °C^{-1} d^{-1}) for selected relative humidity (%), degree-days (°C d) and wind speed u = 1 (m s^{-1}). DDF_E values are for u=1 m s^{-1}, for a different wind speed these DDF_E values can be multiplied for desired wind speed. Air density values are assumed at an elevation of 0 m a.s.l.

	DDF_E									
	Relative Humidity									
T_{DD} (°C d)	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	-6.91	-6.19	-5.42	-4.62	-3.79	-2.94	-2.07	-1.18	-0.28	0.57
2	-3.42	-3.03	-2.61	-2.18	-1.73	-1.27	-0.80	-0.32	0.15	0.58
3	-2.25	-1.97	-1.67	-1.36	-1.04	-0.71	-0.37	-0.02	0.29	0.60
4	-1.67	-1.44	-1.20	-0.95	-0.69	-0.42	-0.14	0.12	0.37	0.62
5	-1.32	-1.12	-0.91	-0.70	-0.47	-0.24	0.00	0.21	0.42	0.64
6	-1.08	-0.91	-0.72	-0.52	-0.32	-0.11	0.09	0.28	0.47	0.65
7	-0.91	-0.75	-0.58	-0.40	-0.21	-0.02	0.16	0.33	0.50	0.67
8	-0.79	-0.63	-0.47	-0.30	-0.13	0.05	0.21	0.37	0.53	0.69
9	-0.69	-0.54	-0.39	-0.22	-0.06	0.10	0.26	0.41	0.56	0.72
10	-0.61	-0.47	-0.32	-0.16	0.00	0.15	0.30	0.44	0.59	0.74
15	-0.36	-0.23	-0.09	0.06	0.19	0.32	0.46	0.59	0.72	0.86
20	-0.23	-0.09	0.05	0.19	0.32	0.46	0.59	0.73	0.86	1.00

Supplementary materials to section 5

S.2 Comparison of Snow Temperature Calculation by Walter and SNOWPACK

The approach by Walter et al., (2005) uses daily energy balance and a daily time-step for snow-water equivalent simulation. Snow temperature is a lumped variable representing the cold content of the snowpack. An incoming daily net energy flux is first used to raise the (isothermal) snowpack temperature to 0°C, all additional available energy produces melt. An outgoing daily net energy flux lowers the snow temperature.

The SNOWPACK model (Bartelt and Lehning, 2002; Lehning et al., 2002) simulates the physical processes inside a snowpack in detail by a finite element approach. Meteorological forcing data should best be given at an hourly time-step, calculation time-step is usually 15 min with adaptive smaller time-steps if required for numerical stability. Snow temperature is a variable at each node, usually each 2 cm, of the snow profile. For comparison, the snow temperature is averaged over the snowpack profile and aggregated to daily values.

Hourly observed meteorological data from Brunnenkopfhütte test site i.e. air temperature, incoming short wave radiation, albedo, wind speed, relative humidity, and precipitation was used as input for SNOWPACK. For Walter's approach, these hourly values were aggregated to daily input.

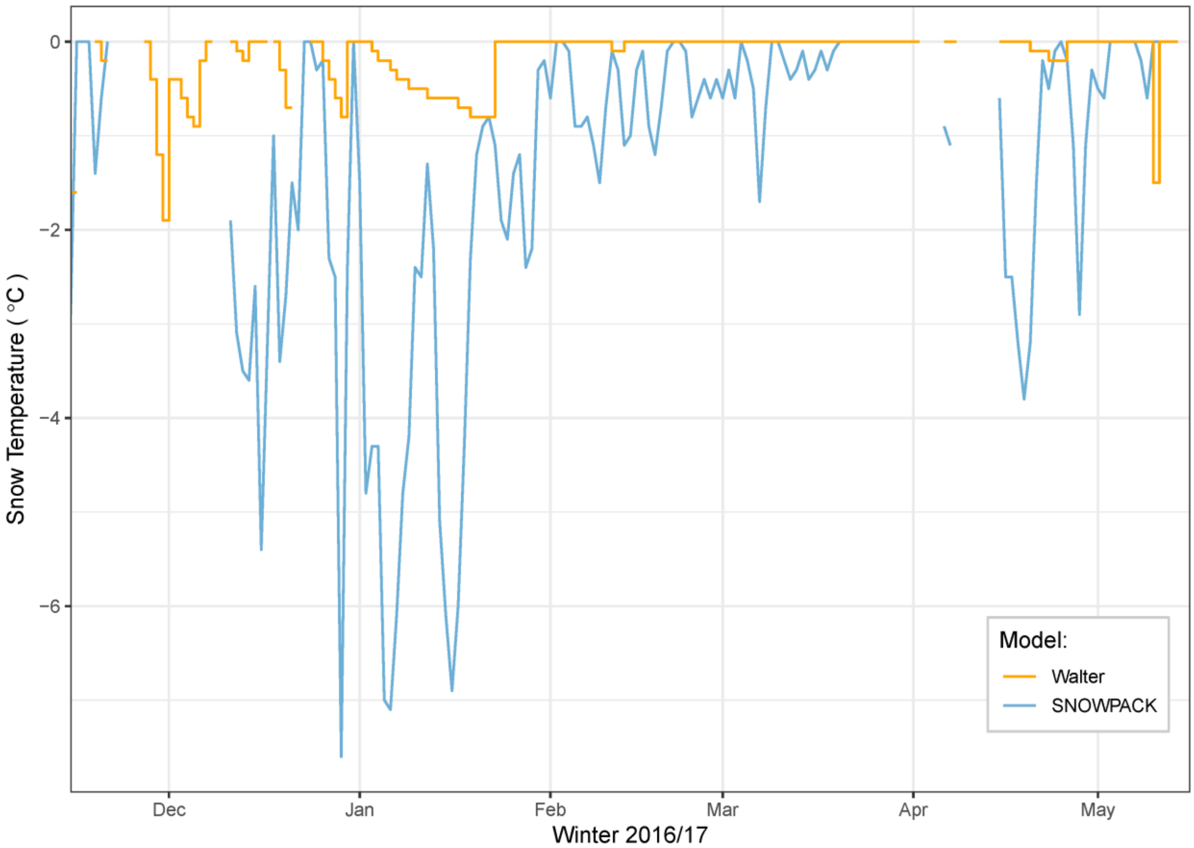

Figure S1 Comparison of Simulated Snow Temperature Winter 2016/2017

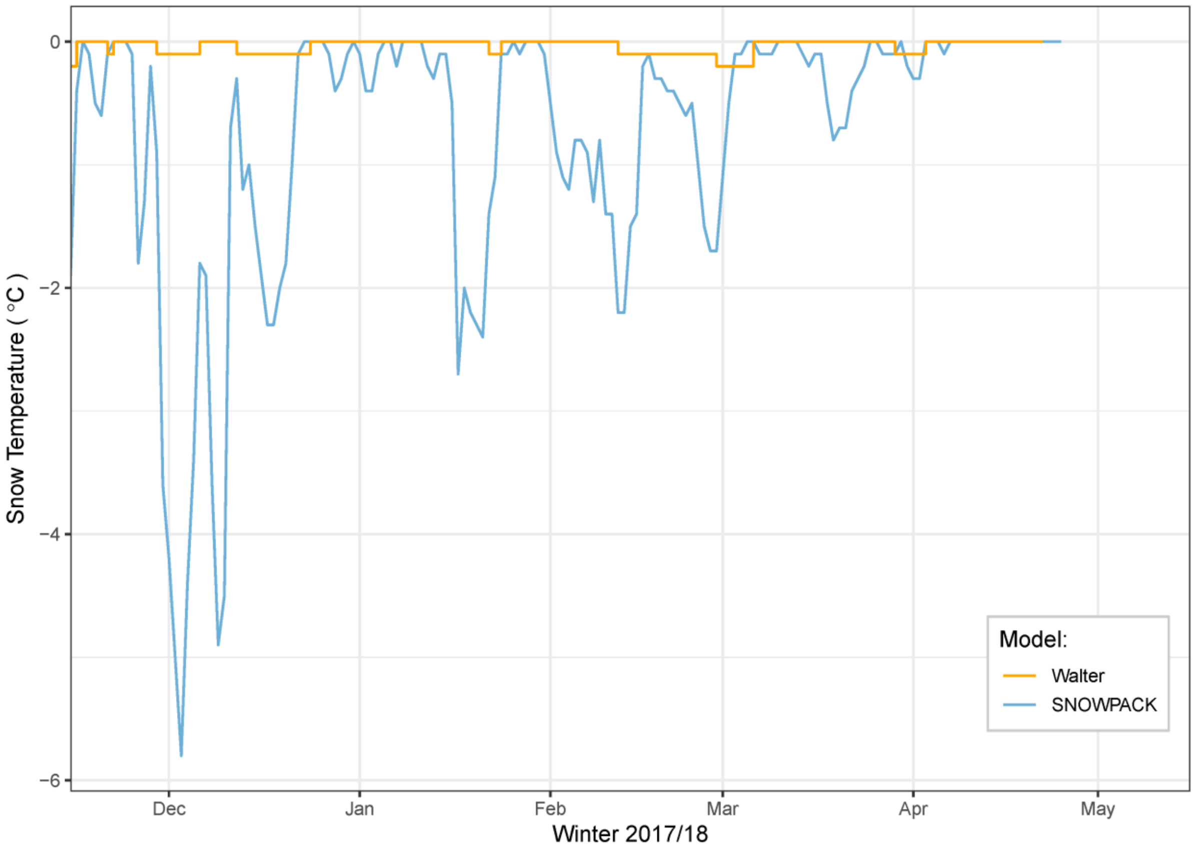

Figure S2 Comparison of Simulated Snow Temperature Winter 2017/2018

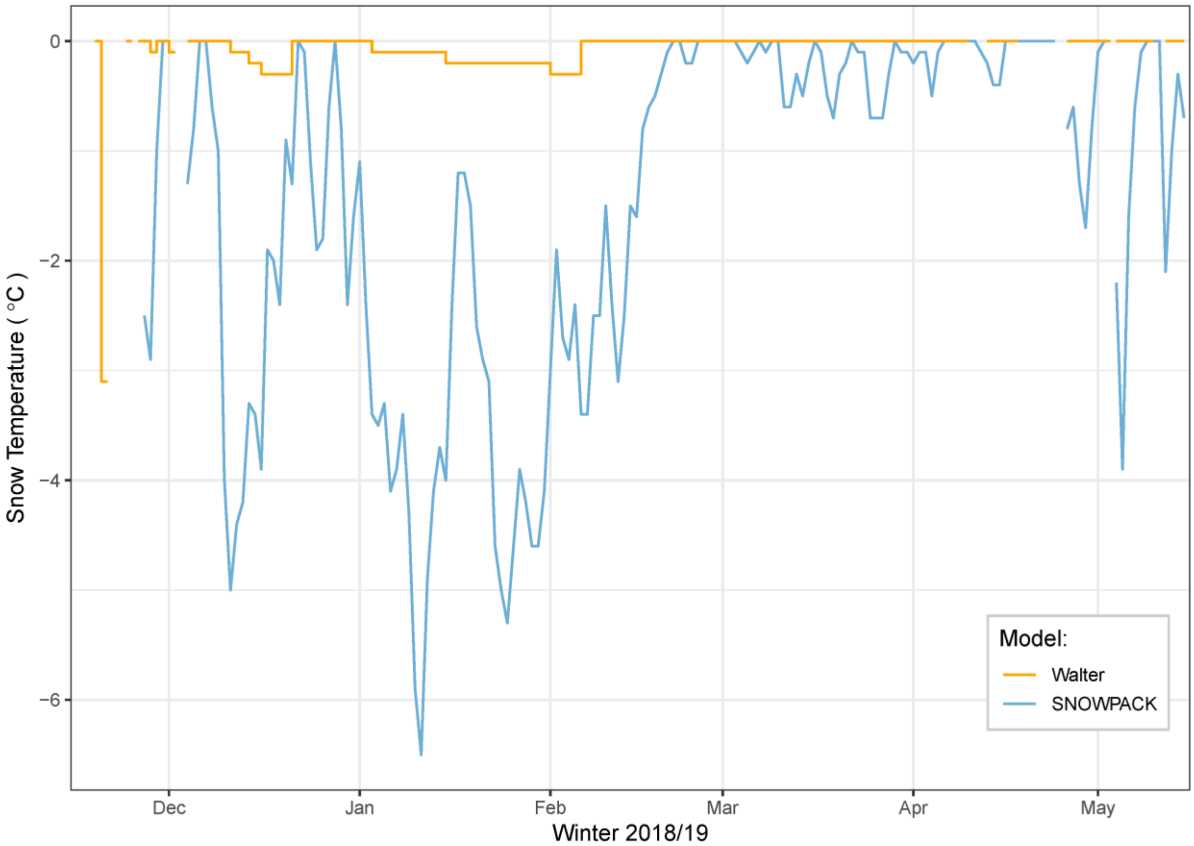

Figure S3 Comparison of Simulated Snow Temperature Winter 2018/2019

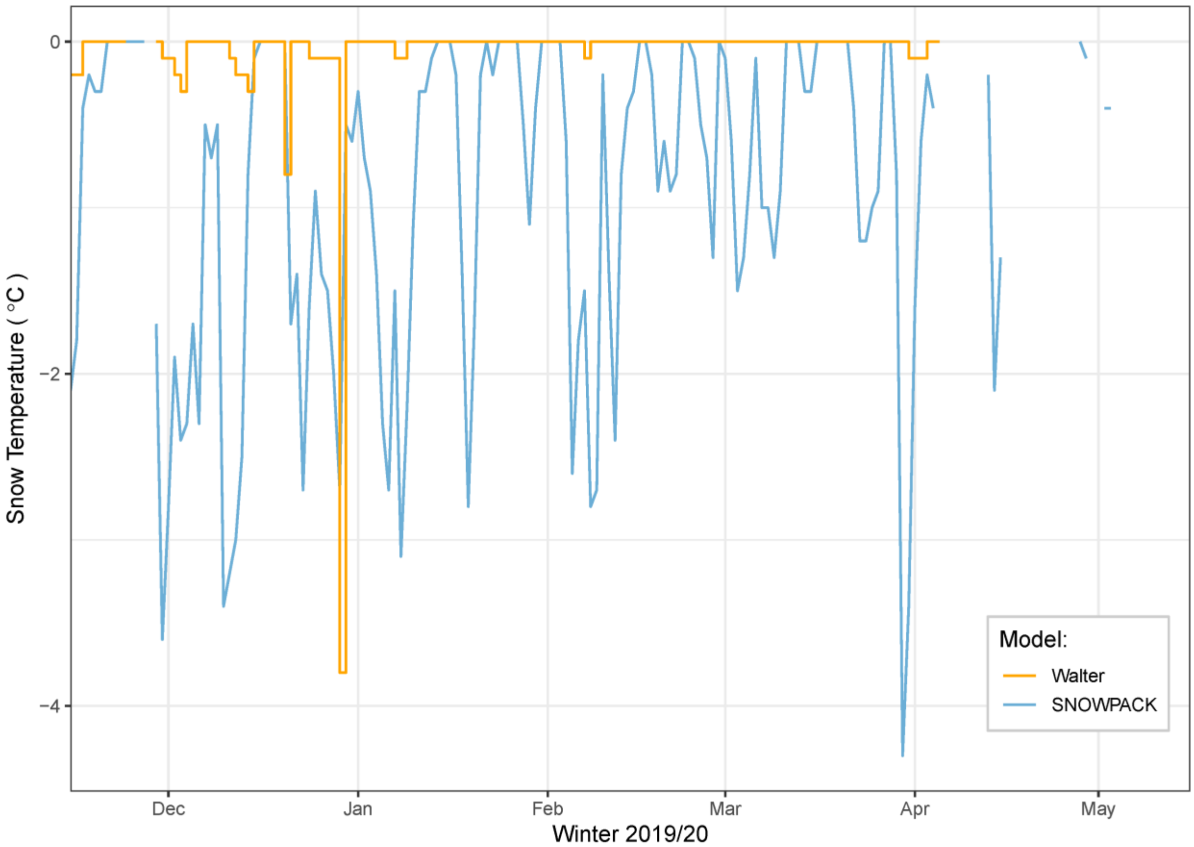

Figure S4 Comparison of Simulated Snow Temperature Winter 2019/2020

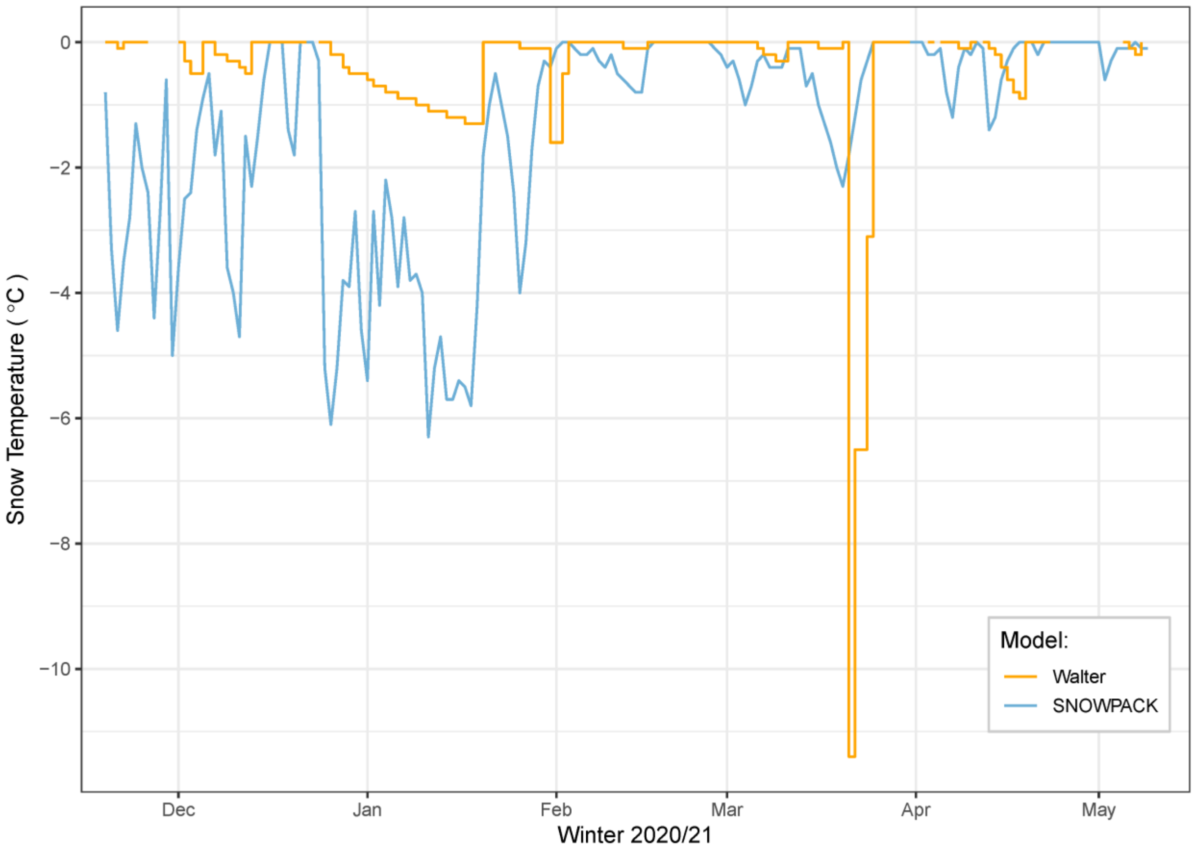

Figure S5 Comparison of Simulated Snow Temperature Winter 2020/2021

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