

*Supplement of*

**The surface energy balance in a cold-arid permafrost environment, Ladakh Himalaya, India**

**Wani et al.**

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Table S1: Comparison between observed and ESOLIP estimated precipitation from 1 September 2015 to 31 August 2017 at South-Pullu (4727 m a.s.l.).

Year	Annual Sum	
	Field Obs. (mm w.e.)	ESOLIP Est. (mm w.e.)
2015-16	120.3	92.2
2016-17	190.6	292.5
Total	310.9	384.7

Table S2: Comparison of estimated mean monthly surface energy balance components ( $W m^{-2}$ ) for low (2015-16) and high (2016-17) snow years at South-Pullu (4727 m a.s.l.), in the upper Ganglass catchment, Leh.

Month	Rn [ $W m^{-2}$ ]		LE [ $W m^{-2}$ ]		H [ $W m^{-2}$ ]		G [ $W m^{-2}$ ]		F <sub>surf</sub> [ $W m^{-2}$ ]	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Sep	56.3	53.2	8.0	6.2	42.5	40.2	5.1	6.9	0.7	0.0
Oct	30.4	30.4	2.5	1.1	29.1	33.0	-1.2	-3.7	0.0	0.0
Nov	7.1	6.7	1.0	-0.1	19.3	19.5	-13.1	-12.7	0.0	0.0
Dec	0.6	2.1	-0.9	-0.1	20.9	15.6	-19.4	-13.3	0.0	0.0
Jan	-12.9	-19.2	5.9	7.6	-3.3	-9.2	-15.4	-17.7	0.0	0.1
Feb	-20.2	-17.7	12.8	5.3	-22.7	-18.4	-10.2	-4.6	-0.2	0.0
Mar	-1.4	-9.1	19.4	9.1	-13.4	-14.6	-8.2	-4.5	0.9	1.0
Apr	14.8	4.2	21.8	13.7	-10.2	-12.4	-3.8	-0.8	7.0	3.7
May	84.0	25.8	29.4	17.3	34.5	-13.2	20.1	0.0	0.0	21.7
Jun	76.3	70.1	17.9	29.5	37.8	6.5	20.6	18.5	0.0	15.5
Jul	72.5	87.5	12.7	42.6	42.1	20.3	17.7	24.6	0.0	0.0
Aug	63.6	82.3	9.3	35.4	42.2	33.3	12.0	13.5	0.2	0.0
Annual	<b>30.9</b>	<b>26.4</b>	<b>11.6</b>	<b>14.0</b>	<b>18.2</b>	<b>8.4</b>	<b>0.4</b>	<b>0.5</b>	<b>0.7</b>	<b>3.5</b>

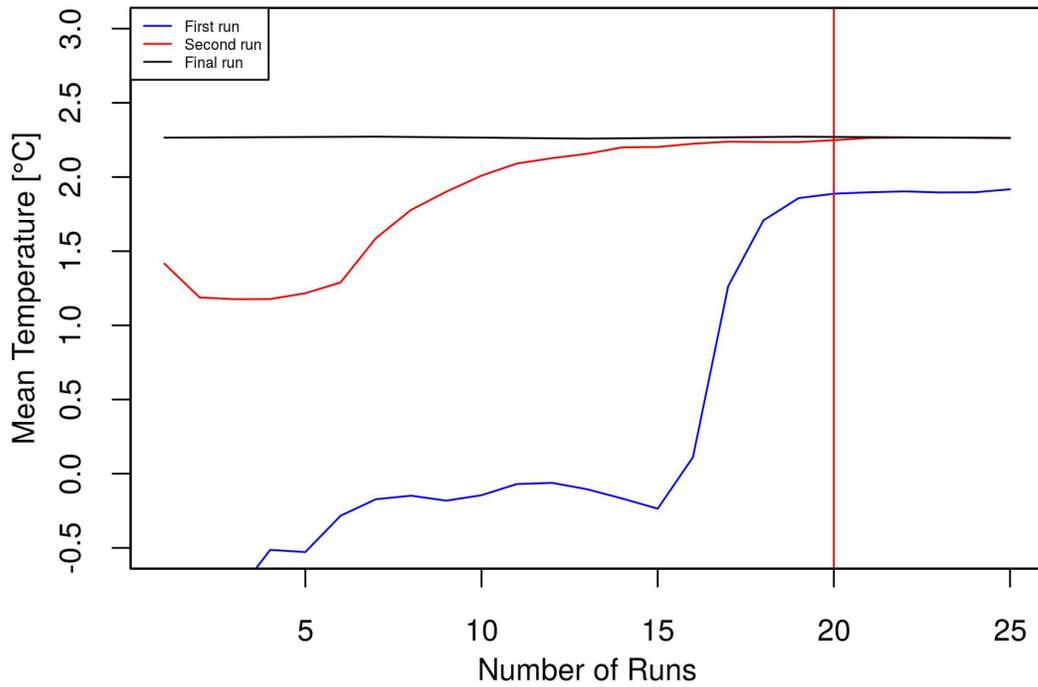


Figure S1: Temperature variations of the model MAGST at 10 cm depth for an increasing number of simulations. Convergence is reached at approximately 25 simulations

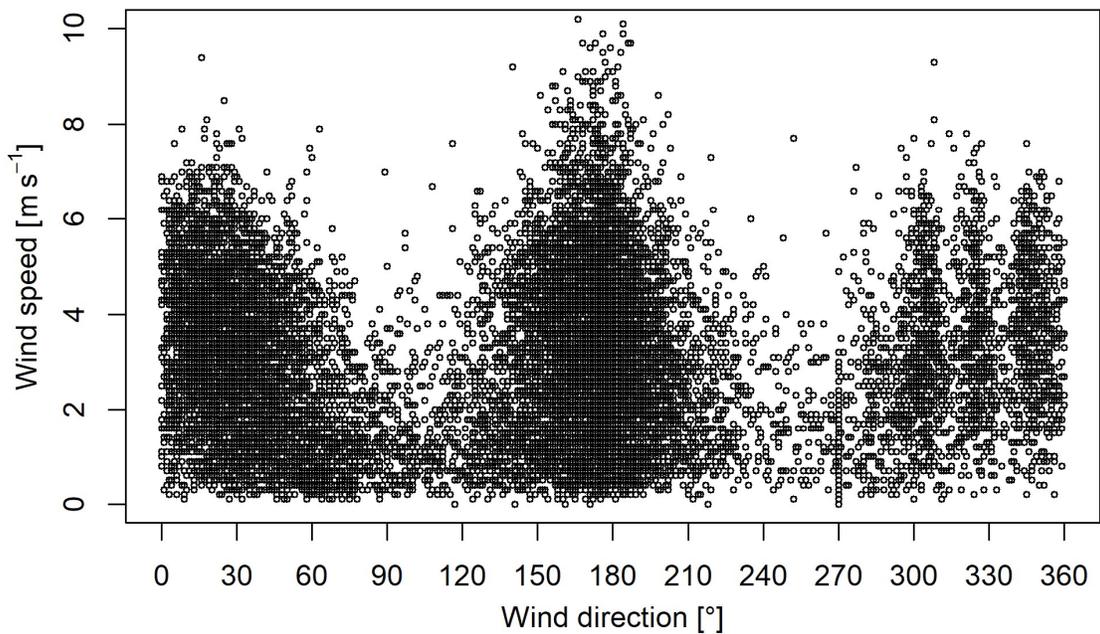


Figure S2: Comparison of hourly observed wind speed ( $\text{m s}^{-1}$ ) as a function of hourly wind direction ( $^{\circ}$ ) at 4727 m a.s.l. in the upper Ganglass catchment, Leh from September 2015 to August 2017.

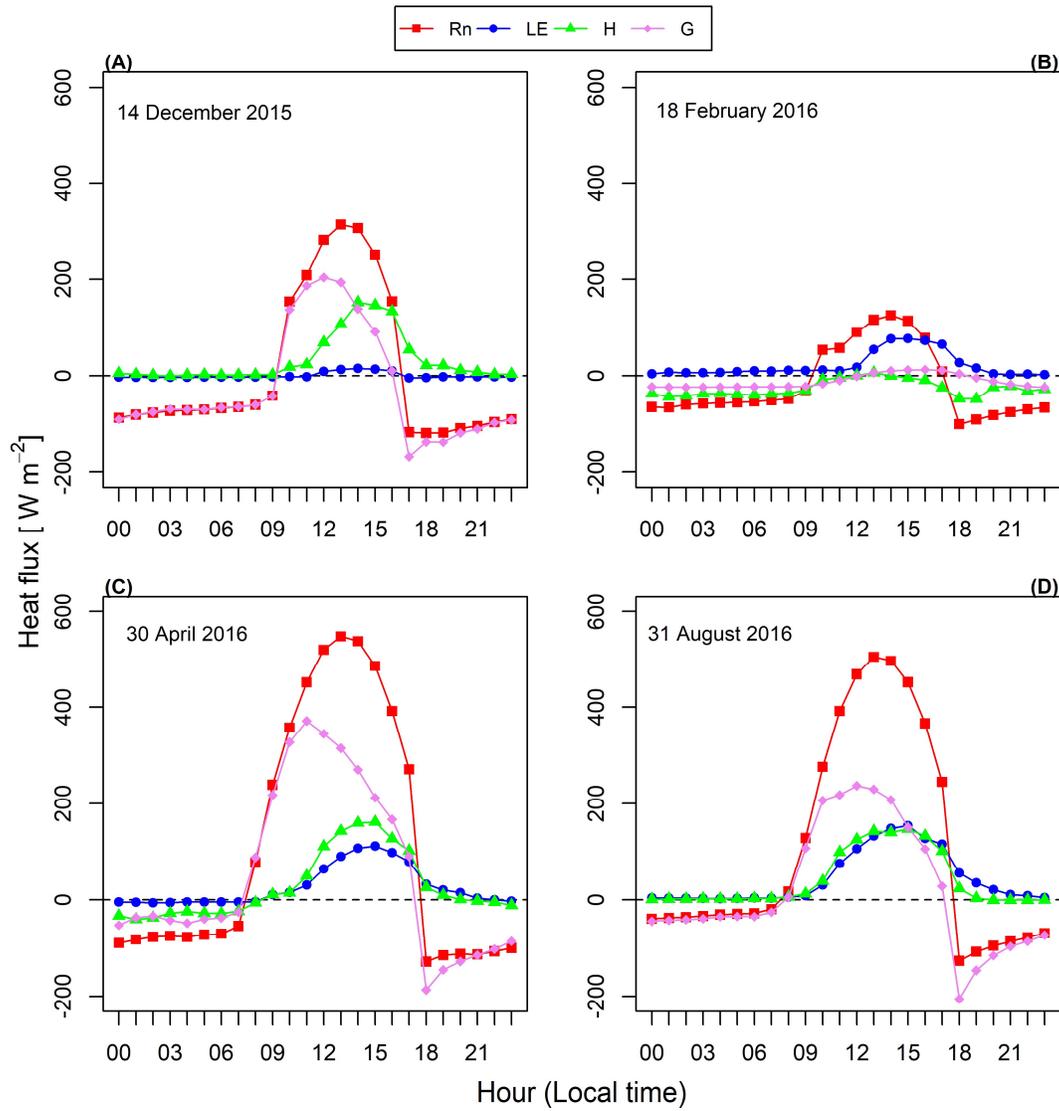


Figure S3: The diurnal change of modelled surface energy fluxes on (A) 14 December 2015, (B) 18 February 2016, (C) 30 April 2016, and (D) 31 August 2016 representing different seasons for the 2015-16 year at South-Pullu (4727 m a.s.l.), in the upper Ganglass catchment, Leh.

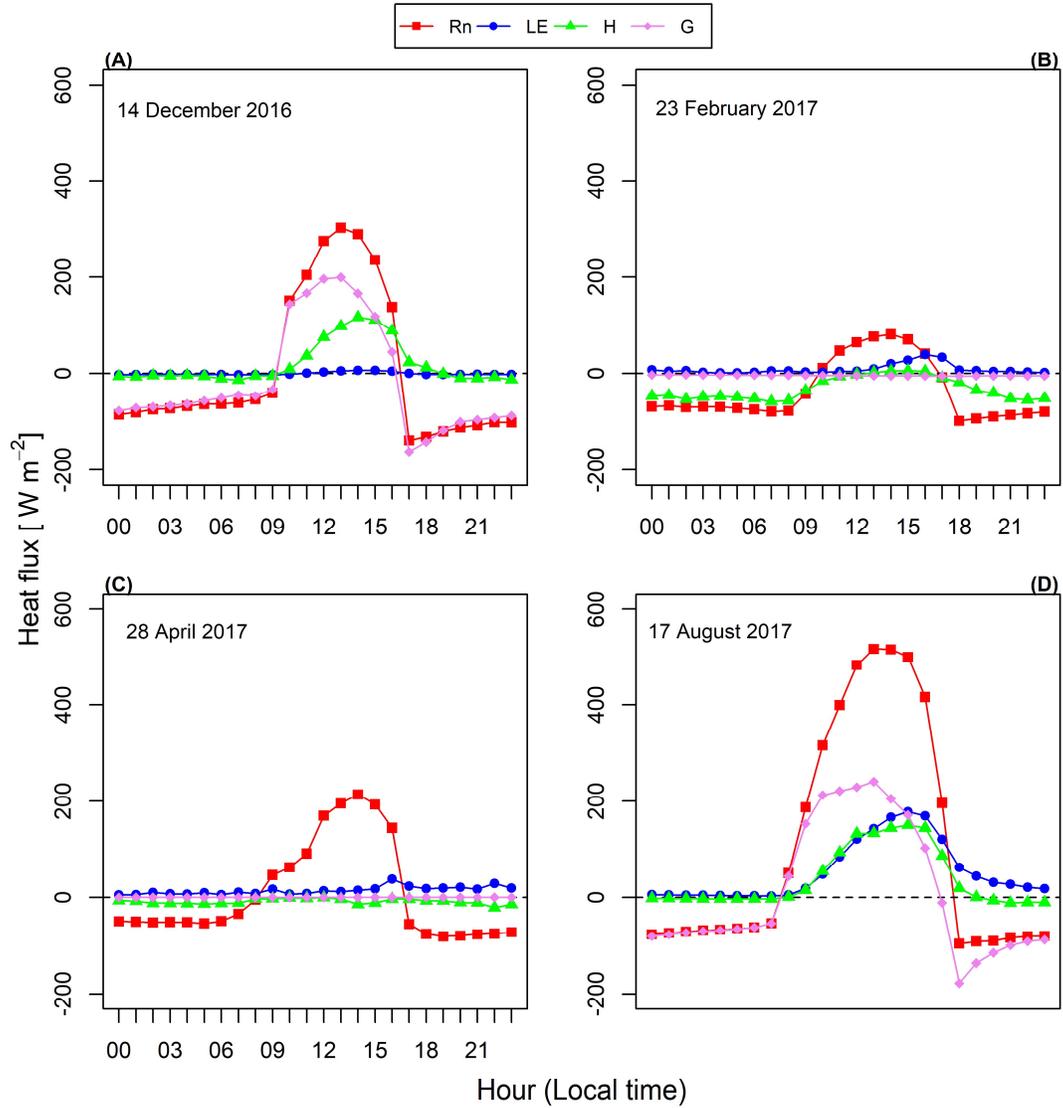


Figure S4: The diurnal change of modelled surface energy fluxes on (A) 14 December 2016, (B) 23 February 2017, (C) 28 April 2017, and (D) 17 August 2017 representing different seasons for the 2016-17 year at South-Pullu (4727 m a.s.l.), in the upper Ganglass catchment, Leh.

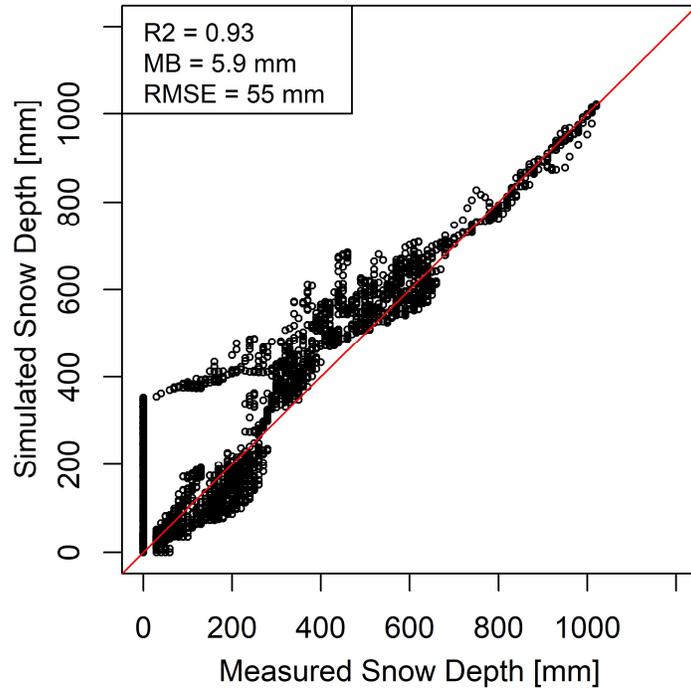


Figure S5: Comparison of hourly observed and GEOTop simulated snow depth at 4727 m a.s.l. in the upper Ganglass catchment, Leh from September 2015 to August 2017. The solid red line is the 1:1 line.

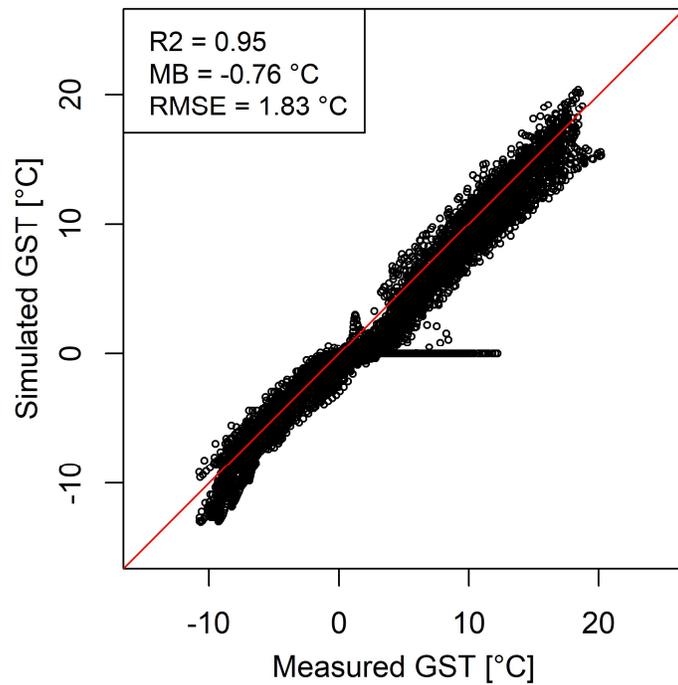


Figure S6: Comparison of hourly observed and GEOTop simulated near-surface ground temperature at 4727 m a.s.l. in the upper Ganglass catchment, Leh from September 2016 to August 2017. The solid red line is the 1:1 line.

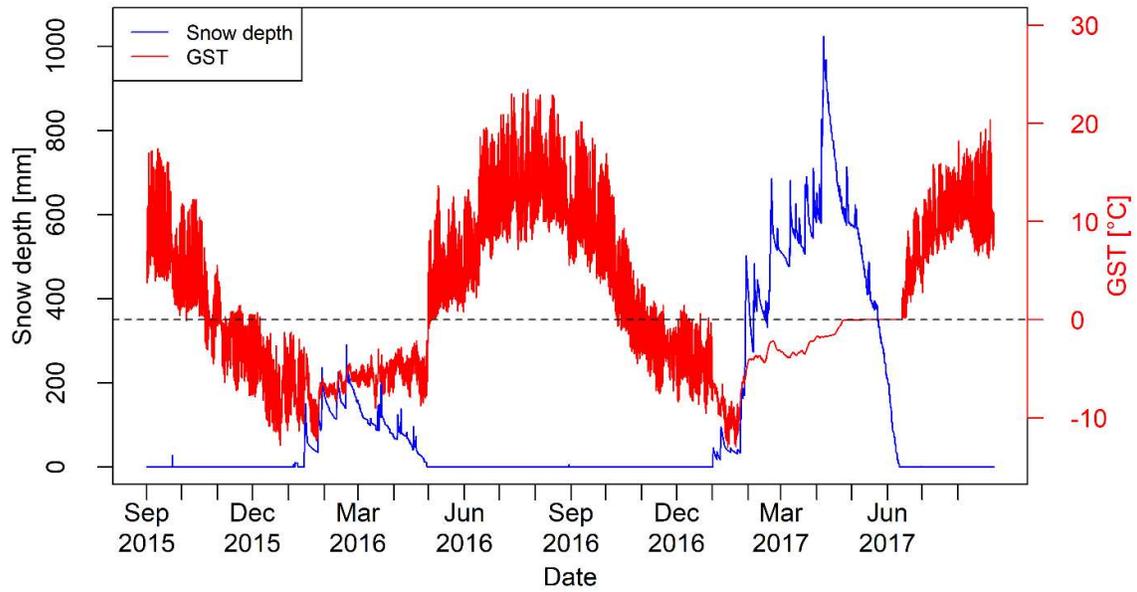


Figure S7: Comparison of GEOtop modelled snow depth and near-surface ground temperature (GST) from 1 September 2015 to 31 August 2017 at South-Pullu (4727 m a.s.l.). The blue line is the modelled snow depth and the red line is the modelled GST. The black dashed line is the 0 °C GST.