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Supplement of

SNOWstorm (v1.0) – a deep-learning based model for near-surface winds and drifting snow in mountain environments

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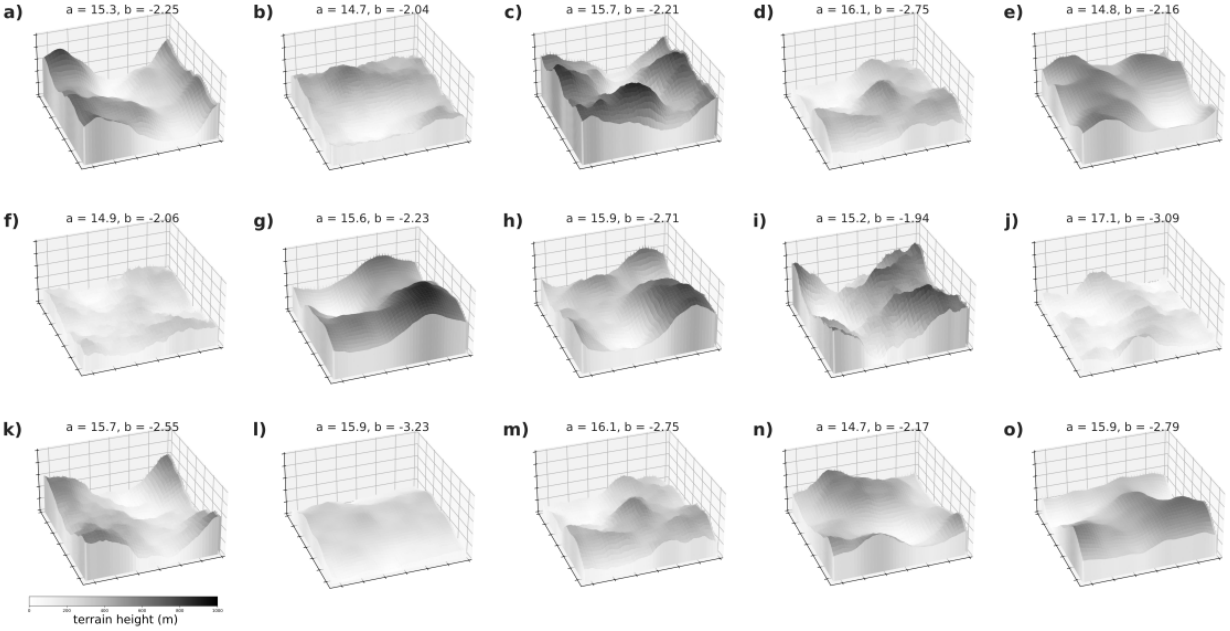

Figure S1. Examples for synthetic topographies with different spectral slope settings a and b (see Eq. 1).

Table S1. Hyperparameters for individual U-Nets for near-surface winds ($wind_{surf}$), snow mass change rate (ΔM_{snow}), vertically integrated sublimation rate (ΔM_{subl}) and vertically integrated snow transport rate (f_{snow})

	$wind_{surf}$	ΔM_{snow}	ΔM_{subl}	f_{snow}
loss function	MSE	MSE	MSE	MAE
batch size	4	12	12	12
initial learning rate	0.01	0.001	0.001	0.01
learning rate reduction	True	True	True	True
weight initialization	Xavier uni	Xavier uni	Xavier uni	Xavier uni
optimizer	SGD	SGD	SGD	SGD

Table S2. Error statistics of coarse-resolution input data (first value: ERA 5, second value: WRF D01, third value: WRF D02) interpolated to locations of observations (Station Hintereis (STH), Im Hinteren Eis (IHE) and station on the glacier (AWS28)), and the grid of HEF-LES, validated against observations for the phase of strongest winds (after 14 UTC) and the full day.

		STH	IHE	AWS28	HEF-LES
after 14 UTC	MAE wind speed ($\mathrm{m\ s^{-1}}$)	8.80 / 1.90 / 1.34	7.88 / 1.50 / 2.42	5.53 / 2.43 / 4.29	8.87 / 3.36 /2.83
	bias wind speed ($\mathrm{m\ s^{-1}}$)	-8.80 / -1.14 / 0.68	-7.88 / 0.52 / 2.25	-5.53 / 2.36 / 4.29	-8.86 / -0.6 / 0.01
full day	MAE wind speed ($\mathrm{m\ s^{-1}}$)	4.41 / 3.57 / 3.22	4.66 / 2.40 / 2.80	3.50 / 2.86 / 3.85	6.07 / 3.11 / 2.98
	bias wind speed ($\mathrm{m\ s^{-1}}$)	-3.85 / 2.05 / 2.92	-4.66 / 1.72 / 2.65	-3.48 / 2.78 / 3.76	-6.00 / -0.06 / 0.39
after 14 UTC	MAE wind dir. (deg)	19.2 / 75.2 / 66.7	27.1 / 90.6 / 77.2	15.4 / 71.1 / 60.8	51.3 / 20.9 / 20.7
full day	MAE wind dir. (deg)	37.7 / 53.7 / 71.1	53.2 / 64.9 / 68.5	34.5 / 52.2 / 71.0	62.2 / 43.5 / 43.4

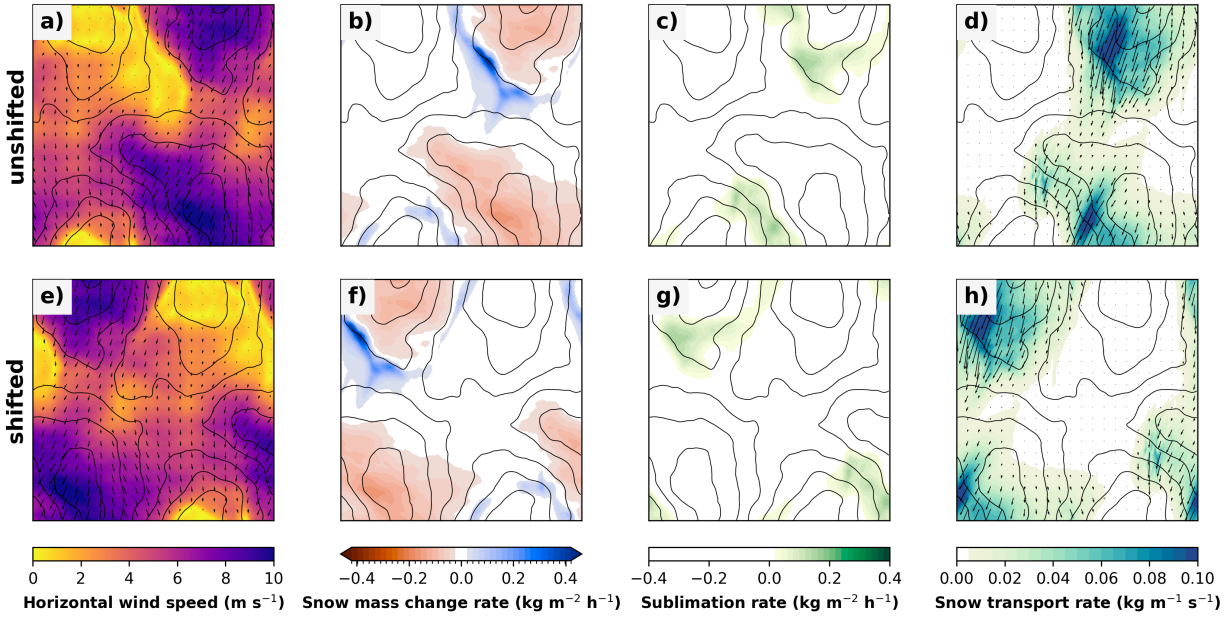

Figure S2. Example of original (a–d) and shifted (e–h) fields of near-surface wind, snow mass change rate, sublimation rate, and vertically integrated snow transport rate for data augmentation, fields have been shifted by 120 grid points in negative x direction.

Table S3. Error statistics of SNOWstorm predictions run with GLO-30 topography (first value: S_ERA_G, second value: S_WD1_G, third value: S_WD2_G) validated against observations at Station Hintereis (STH), Im Hinteren Eis (IHE) and station on the glacier (AWS28) for the phase of strongest winds (after 14 UTC) and the full day.

		STH	IHE	AWS28
after 14 UTC	MAE wind speed (m s^{-1})	5.50 / 2.09 / 2.45	2.64 / 6.32 / 5.05	2.88 / 2.64 / 2.44
	bias wind speed (m s^{-1})	-5.50 / 0.39 / 1.48	-0.75 / 6.32 / 5.05	-2.88 / 2.64 / 2.44
full day	MAE wind speed (m s^{-1})	3.43 / 4.15 / 3.99	2.14 / 4.86 / 4.18	1.95 / 2.84 / 2.61
	bias wind speed (m s^{-1})	-1.61 / 3.37 / 3.54	0.23 / 4.83 / 3.79	-1.70 / 2.84 / 2.61
after 14 UTC	MAE wind dir. (deg)	63.4 / 87.5 / 86.5	79.3 / 95.2 / 95.3	47.4 / 73.2 / 72.5
full day	MAE wind dir. (deg)	95.3 / 97.2 / 98.3	101.7 / 96.9 / 101.3	78.0 / 87.4 / 89.7

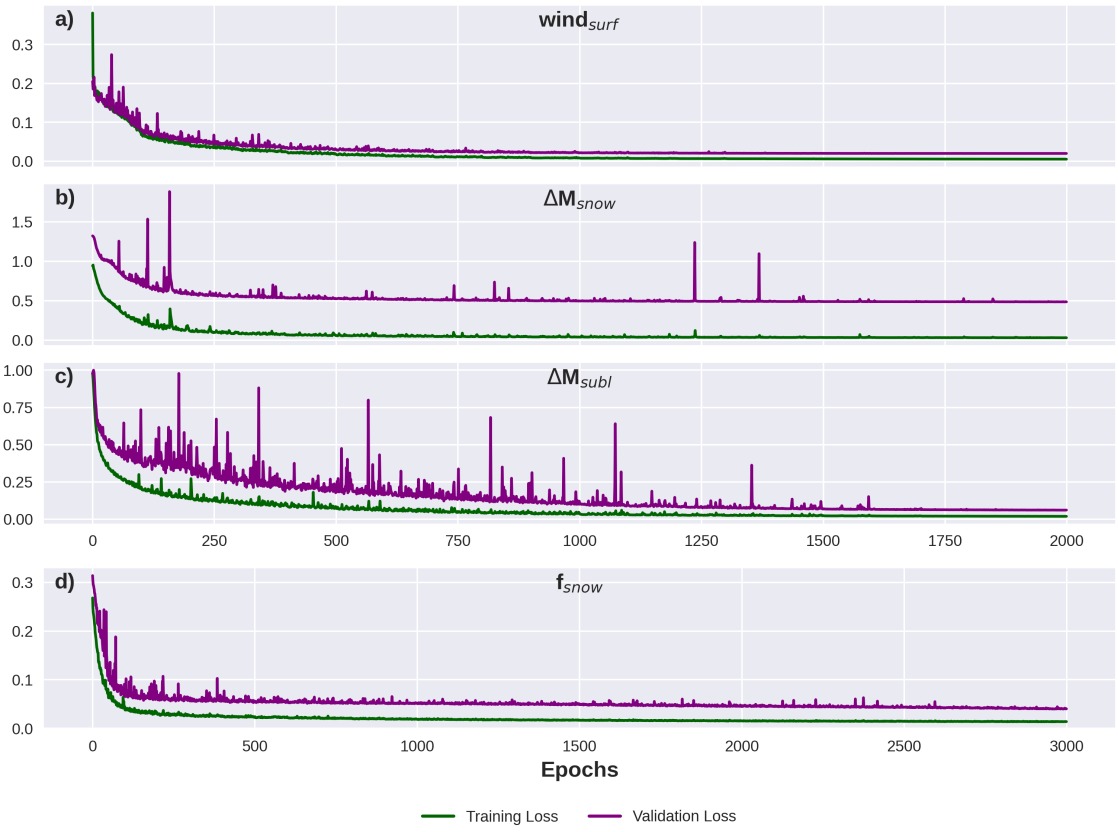

Figure S3. Loss curves for the training of individual U-Nets for near-surface winds ($wind_{surf}$, a), snow mass change rate (ΔM_{snow}, b), vertically integrated sublimation rate (ΔM_{subl}, c) and vertically integrated snow transport rate (f_{snow}, d)

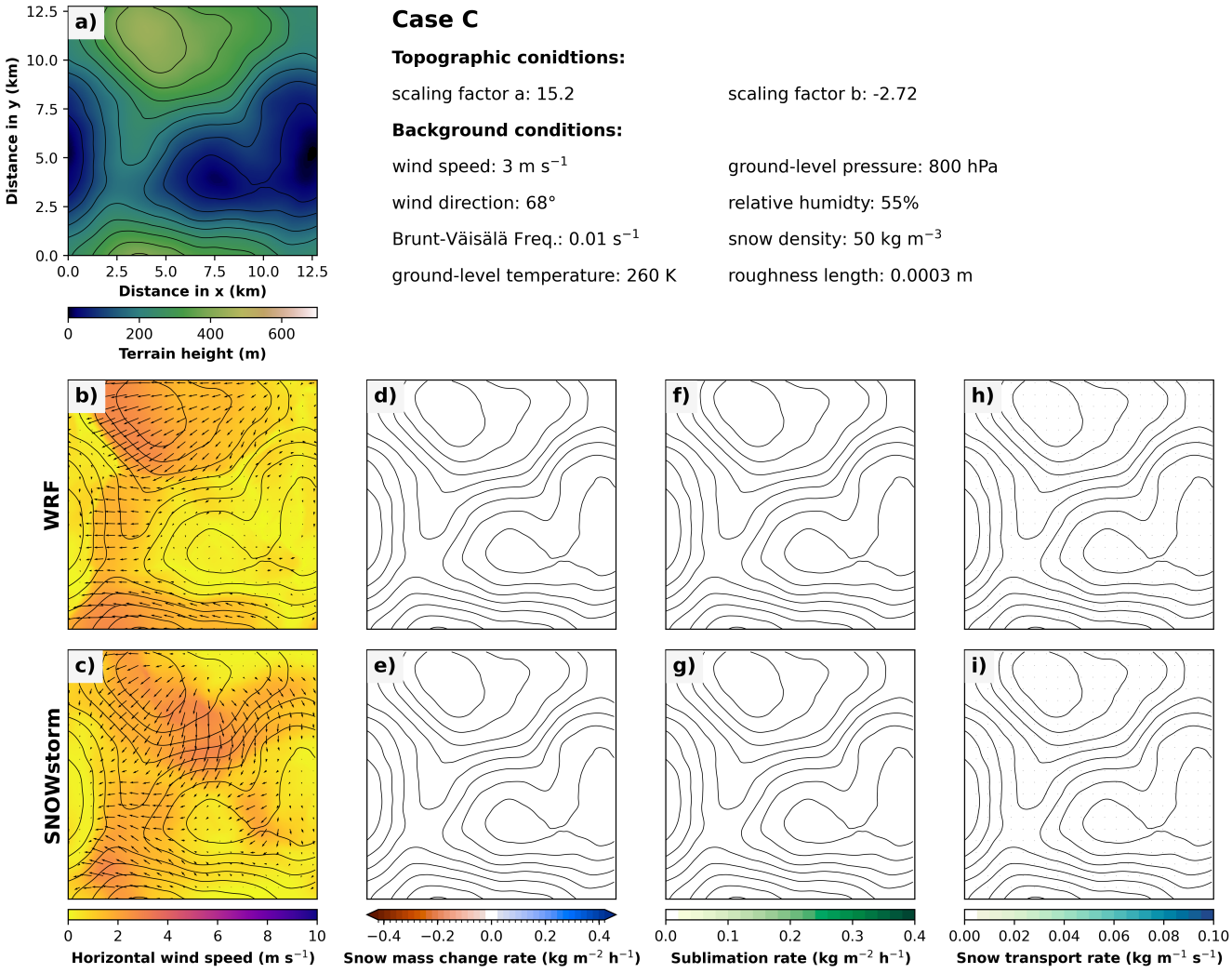

Figure S4. Similar to Fig. 5, but for case C.

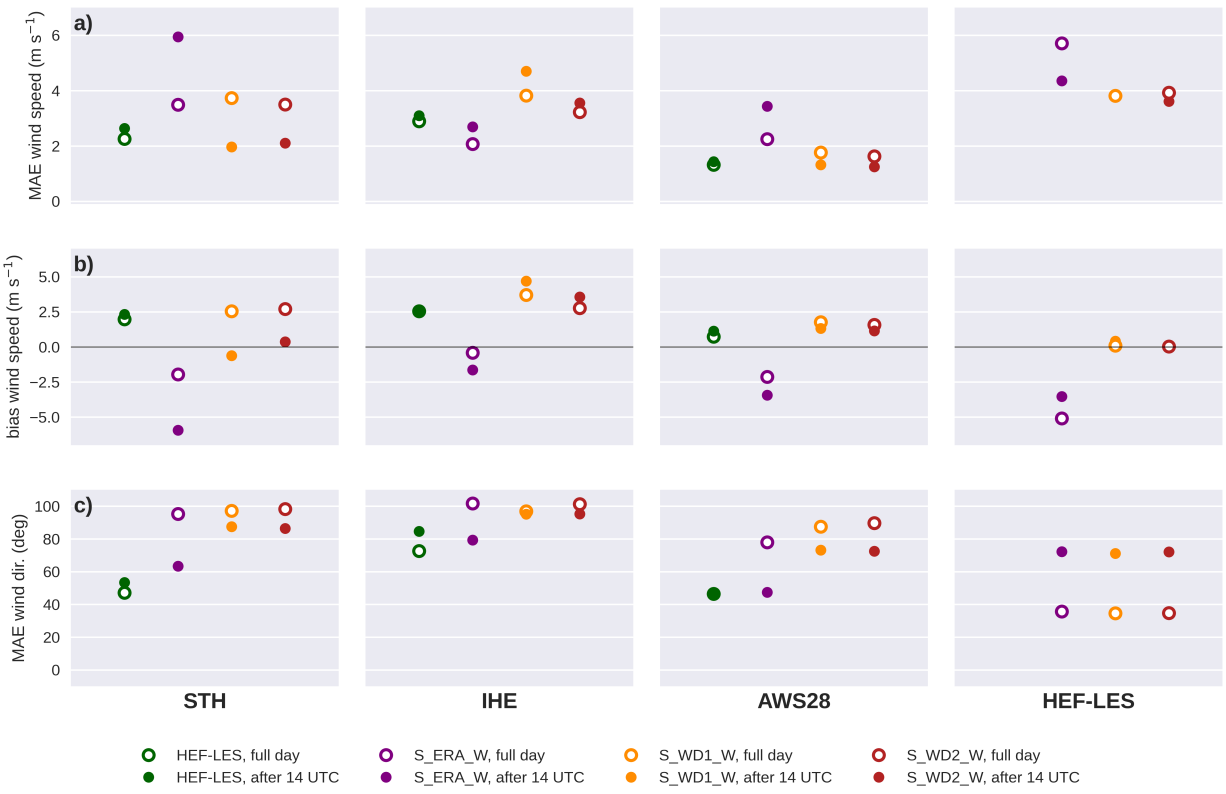

Figure S5. Similar to Fig. 11, but with correction of the height difference between model output and observation, under the assumption of logarithmic wind profile and a neutral stratification.

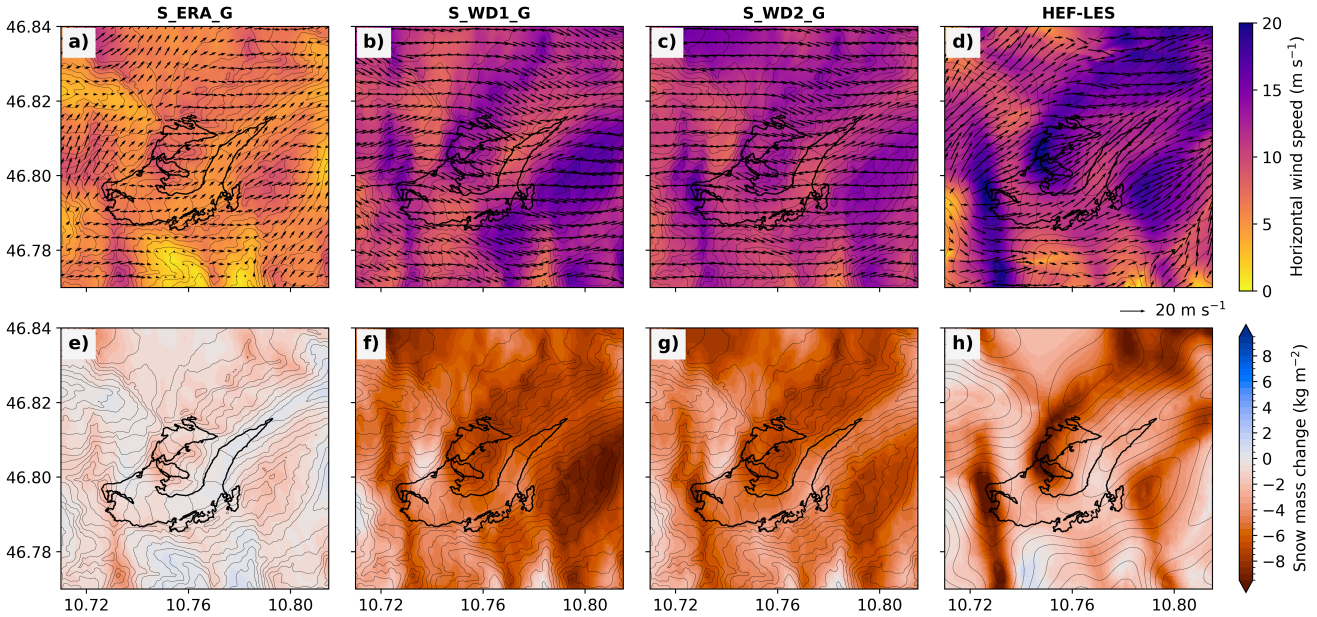

Figure S6. Similar to Fig. 9, but with SNOWstorm driven on GLO-30 topography

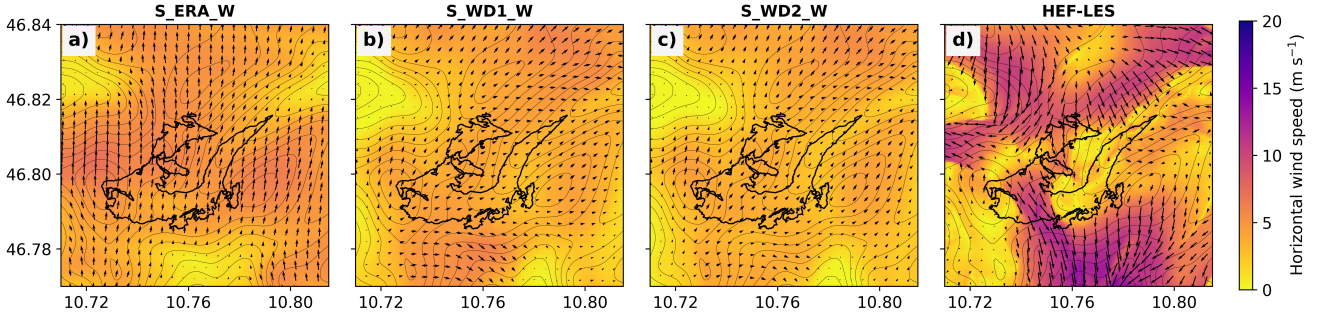

Figure S7. 10 m wind field similar to Fig. 9, but for 8 February 2021 05:00 UTC.

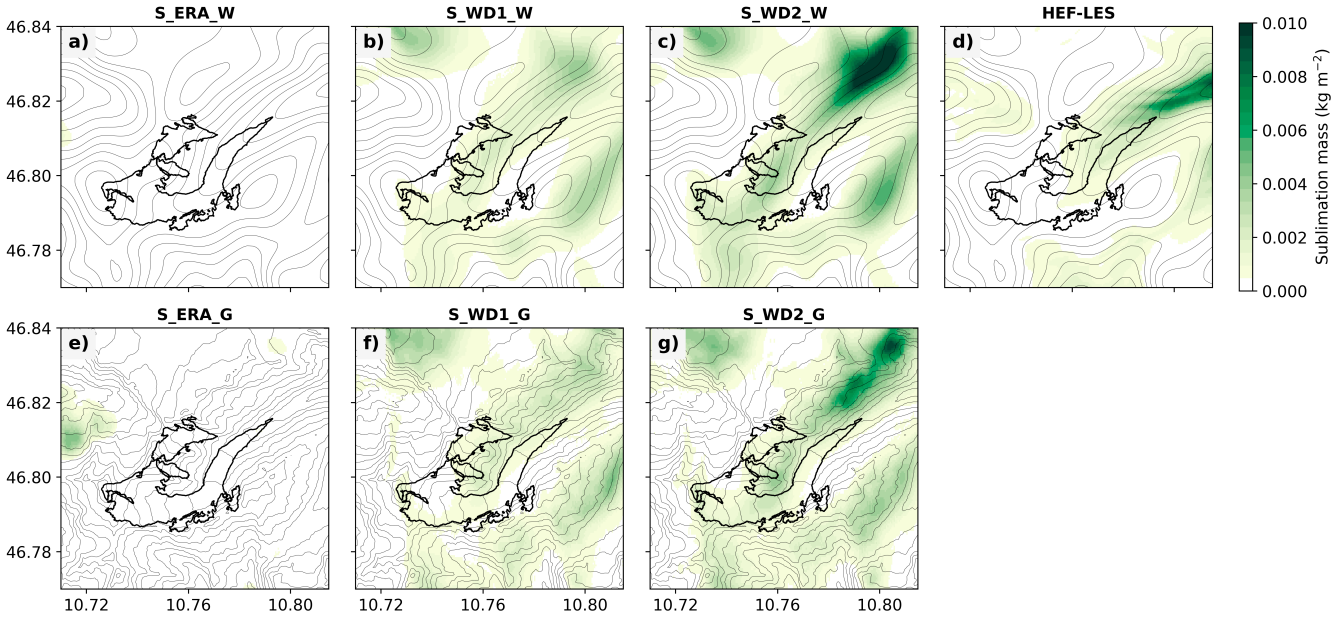

Figure S8. Drifting snow sublimation accumulated for 08 February 2021 predicted by SNOWstorm (a–c, e–g) for experiments with various input data sets and HEF-LES (d). SNOWstorm predictions use HEF-LES topography in a–c and GLO-30 topography in e–g. Model topography and glacier outlines are simlar to Fig. 9