



Supplement of

Freeze–thaw processes correspond to the protection–loss of soil organic carbon through regulating pore structure of aggregates in alpine ecosystems

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Table S1 Basic soil physio-chemical properties

Ecosystem	Soil depth (cm)	Bulk density (g/cm ³)	Soil water content (%)	pH	Organic C (g/kg)	Total N (g/kg)	Particle size composition (%)		
							clay	silt	sand
KPM (meadow)	0-10	0.77±0.	35.76±1	6.50±0.	85.26±2	7.66±2.	9.05±2.6	33.60±6.10	57.35±8.73
		19b	5.01	35	9.38a	22a	5		
	10-30	1.00±0.	32.00±2	6.49±0.	67.12±2	6.94±1.	10.65±3.	35.83±9.05	53.52±12.64
		17a	0.68	19	0.49ab	37ab	74		
	30-50	1.07±0.	24.18±1	7.17±0.	25.35±6	2.66±0.	11.84±2.	34.88±4.98	53.28±7.32
		05a	3.04	32	.78b	45b	57		
PFS (shrubland)	0-10	0.83±0.	42.57±4	6.64±0.	64.42±1	7.00±1.	13.95±0.	47.56±1.25	38.49±1.69
		23	.57a	40	1.22a	12a	56		
	10-30	0.81±0.	32.40±8	6.82±0.	44.11±6	4.30±0.	14.59±0.	46.85±1.00	38.56±1.73
		15	.70ab	22	.88ab	90ab	86		
	30-50	0.96±0.	22.82±0	7.31±0.	36.44±7	3.38±0.	15.05±1.	47.44±3.80	37.50±5.58
		15	.50a	37	.06b	53b	80		

Note: KPM-*Kobresia pygmaea* meadow; PFS- *Potentilla fruticosa* shrub. The properties were measured with samples taken in the unstable freezing period. All data is presented with standard error (n=3). Different lowercase letters denote significant difference between soil layers.

Table S2 Mass proportions of soil aggregates in alpine ecosystems during the seasonal freeze–thaw process

Ecosystem	Aggregate fraction	Mass proportion of aggregates (%)			
		UFP	SFP	UTP	STP
KPM (meadow)	> 2 mm	34.55±6.80ab	41.14±11.36a	29.83±8.72b	38.86±12.90ab
	0.25-2 mm	46.29±5.60a	37.29±7.77b	48.73±6.86a	42.97±11.81ab
	0.053-0.25 mm	16.61±3.64	16.73±5.73	20.27±4.32	15.56±5.09
	<0.053 mm	2.55±0.80a	4.84±2.74a	1.16±0.81b	2.61±1.61ab
PFS (shrubland)	> 2 mm	32.17±5.49	34.52±13.59	26.57±6.66	30.03±8.52
	0.25-2 mm	47.30±5.80a	35.40±6.50b	51.72±8.65a	45.02±7.17a
	0.053-0.25 mm	18.07±3.28b	22.50±7.40a	18.72±4.28ab	21.00±7.10ab
	<0.053 mm	2.49±1.62ab	7.75±3.50a	2.92±2.16b	3.95±3.52ab

Note: Bars represent the mean ± standard error (n=9). Uppercase letters represent significant differences among FT periods (P<0.05).

10 Table S3 Correlations between SOC content and soil structure of soil aggregates in freezing period and thawing period

Thawing period										
	Porosity	Equivalent diameter	Mean volume	Pore surface area density	Pore length density	Pore shape factor	Pd<15	Pd15-30	Pd30-80	Pd>80
TOC	0.428	-0.404	-0.124	0.553	0.718*	0.241	0.420	0.084	0.316	-0.235
POC	0.222	-0.252	0.188	0.339	0.397	0.032	0.639*	0.123	0.410	-0.273
MAOC	0.529	-0.443	-0.479	0.622*	0.865**	0.422	0.013	0.010	0.086	-0.106
Freezing period										
	Porosity	Equivalent diameter	Mean volume	Pore surface area density	Pore length density	Pore shape factor	Pd<15	Pd15-30	Pd30-80	Pd>80
TOC	0.582	-0.507	-0.036	0.326	0.396	0.199	0.811*	-0.834**	-0.503	0.733*
POC	0.521	-0.214	-0.274	0.178	0.428	0.538	0.458	-0.353	-0.146	0.295
MAOC	0.409	-0.498	0.117	0.296	0.234	0.071	0.727*	-0.818*	-0.532	0.727*

Note: * represents the correlation is significant ($P < 0.05$). Pd<15: volume percentage of pores <15 μm , Pd15-30: volume percentage of pores 15-30 μm ; Pd30-80: volume percentage of pores 30-80 μm ; Pd>80: volume percentage of pores >80 μm .

