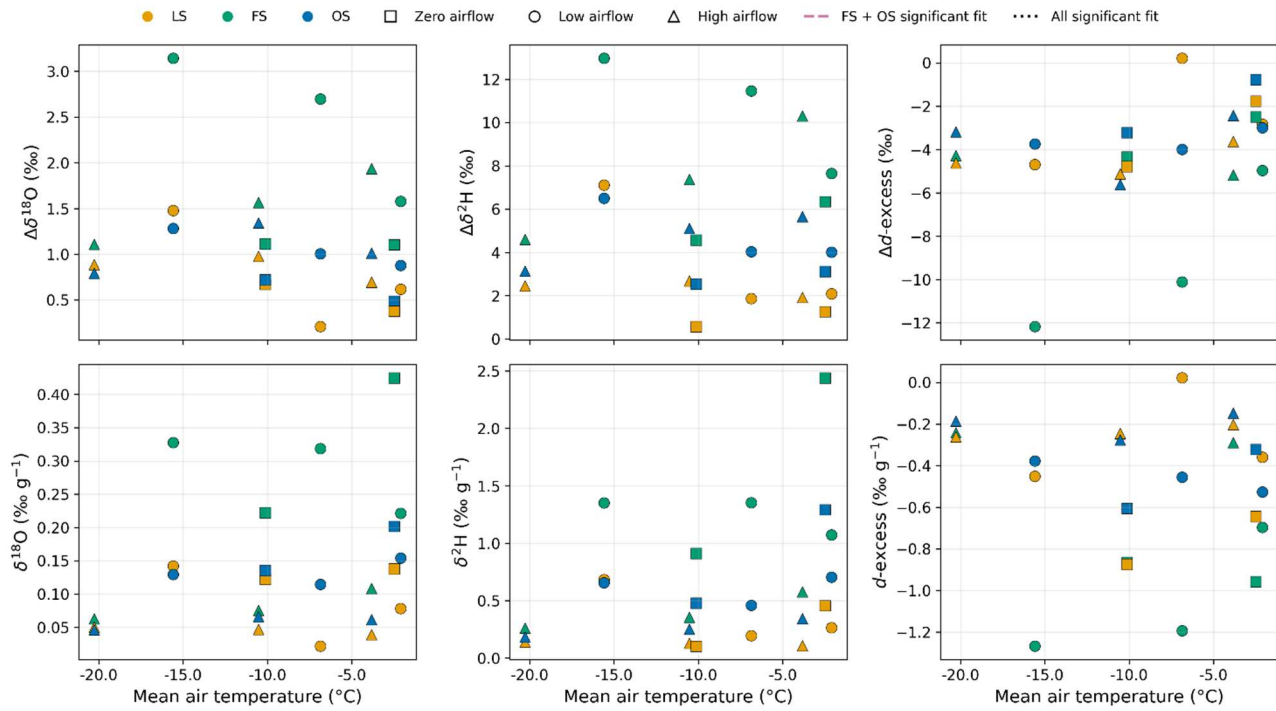
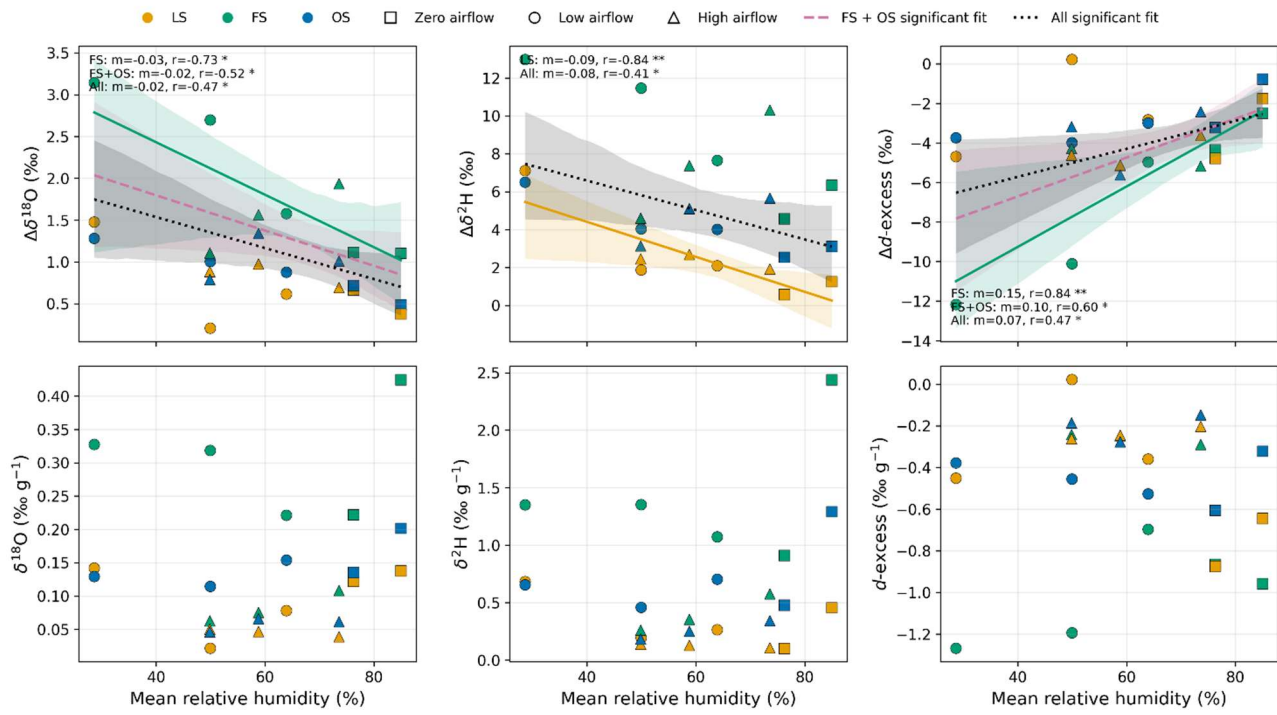


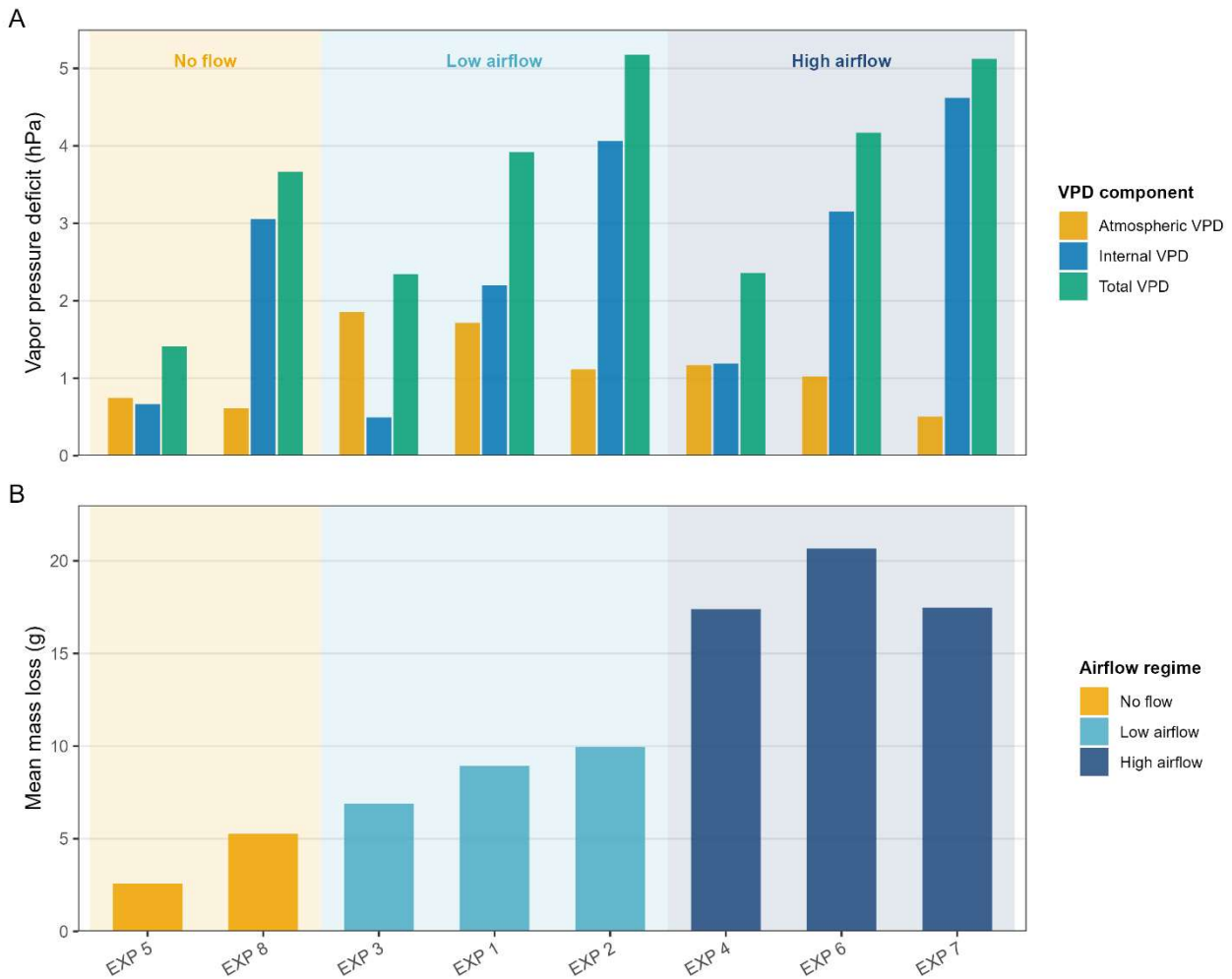
Supplement:



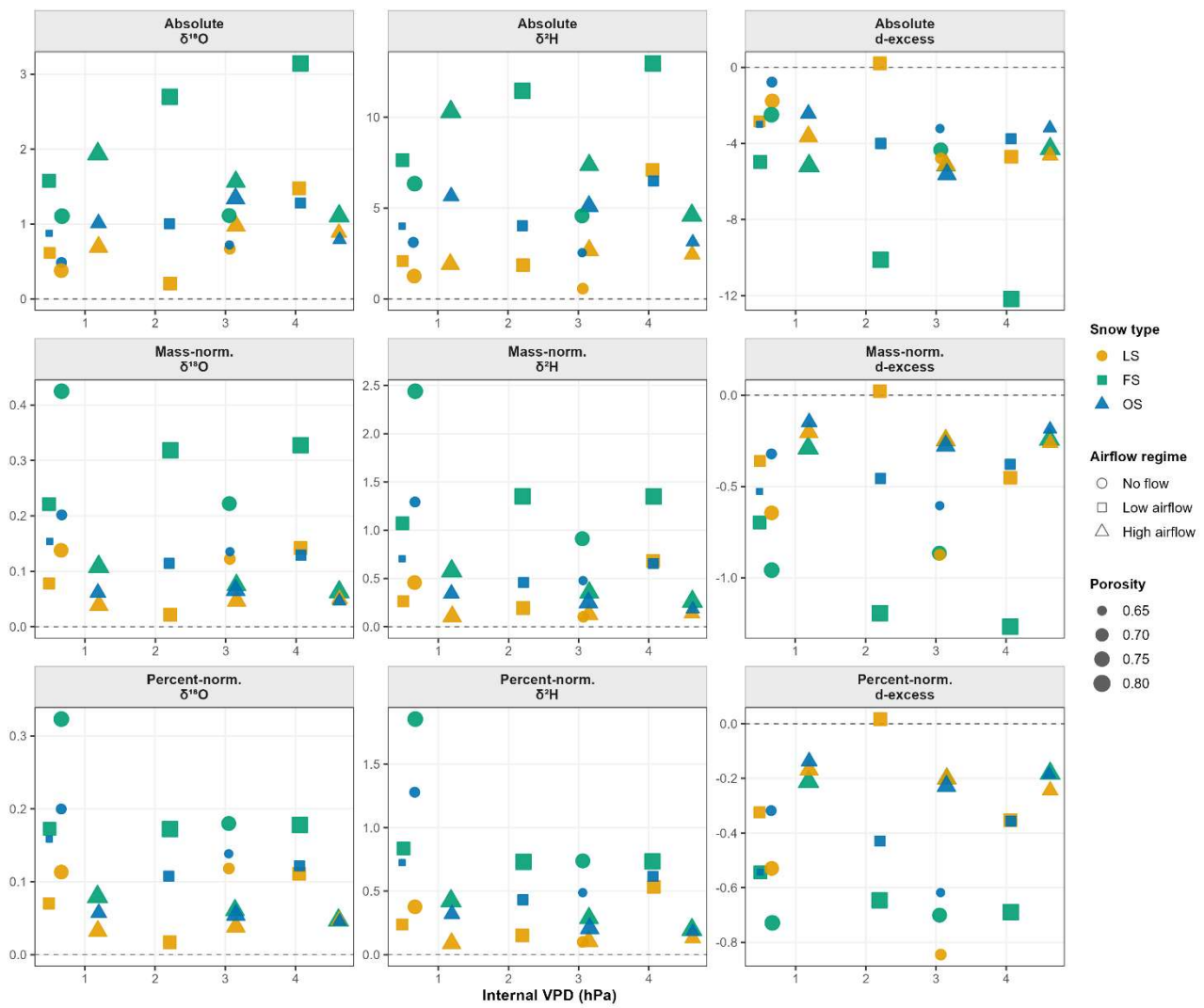
5 **Figure S1 Relationships between isotopic change and mean air temperature. Top row shows absolute isotopic change ($\Delta\delta$, ‰), and bottom row shows mass-normalized isotopic change (‰ g⁻¹) for $\delta^{18}\text{O}$, $\delta^2\text{H}$, and d-excess. Points are colored by snow type (LS, FS, OS) and shaped by airflow treatment (Zero, Low, High). No significant relationships.**



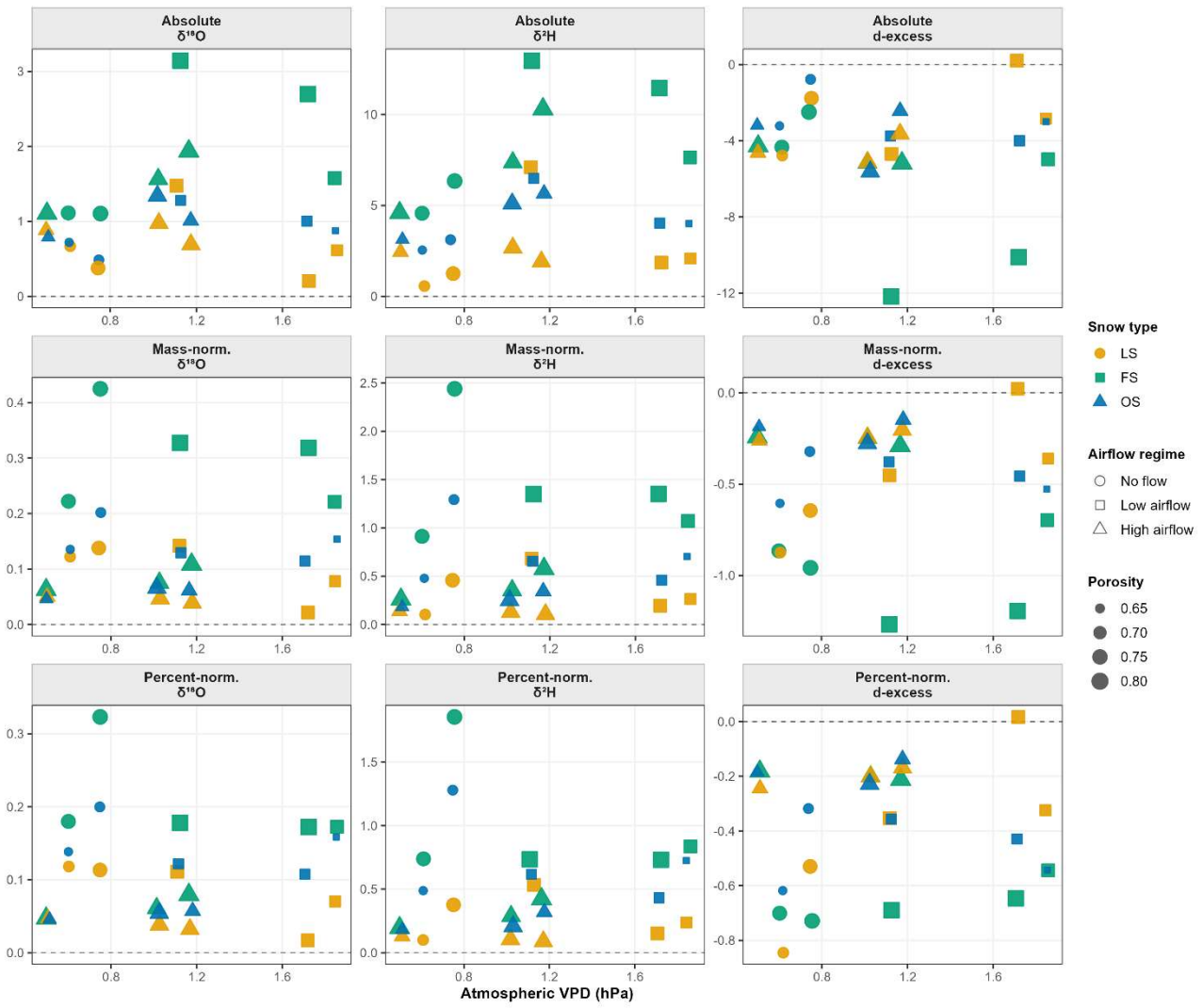
10 **Figure S2 Relationships between isotopic change and mean relative humidity. Top row shows absolute isotopic change ($\Delta\delta$, ‰), and bottom row shows mass-normalized isotopic change (δ , ‰ g⁻¹) for $\delta^{18}\text{O}$, $\delta^2\text{H}$, and d-excess. Points are colored by snow type (LS, FS, OS) and shaped by airflow treatment (Zero, Low, High). Lines indicate significant linear relationships ($p < 0.05$), with dashed lines for combined natural snow types (FS + OS) and dotted lines for all snow types.**



15 **Figure S3 Vapor pressure deficit decomposition and sublimation mass loss across eight experiments ordered by**
airflow regime and by air-to-base-plate temperature difference (ΔT) within each regime. (A) Atmospheric VPD
(orange), internal VPD (blue), and total VPD (green) for each experiment. The atmospheric VPD represents the
difference between saturation vapor pressure at the snow surface, approximated by mean tunnel air temperature and
actual vapor pressure in the tunnel air. The internal VPD represents the difference between saturation vapor
pressure at the base plate (-1°C) and at the snow surface, quantifying the thermodynamic driving force for upward
 20 **vapor flux through the snow matrix from the warm base to the cold surface. (B) Mean mass loss per experiment**
averaged across snow types. Background shading indicates airflow regime: yellow = no flow; light blue = low airflow;
dark blue = high airflow.



25 **Figure S4** Isotopic response metrics as a function of internal vapor pressure deficit across eight experiments. Rows show absolute isotopic change ($\Delta\delta$, ‰), mass-normalised isotopic change ($\% \text{ g}^{-1}$), and percent-normalised isotopic change ($\% \text{ \%}^{-1}$). Columns show $\delta^{18}\text{O}$, $\delta^2\text{H}$, and d-excess. Points are coloured by snow type (LS: orange; FS: green; OS: blue), shaped by airflow regime (circles: no flow; squares: low airflow; triangles: high airflow), and sized by initial bulk porosity. Each panel has independent axis scales.



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Figure S5 As Figure S4 but with atmospheric vapor pressure deficit on the x axis.

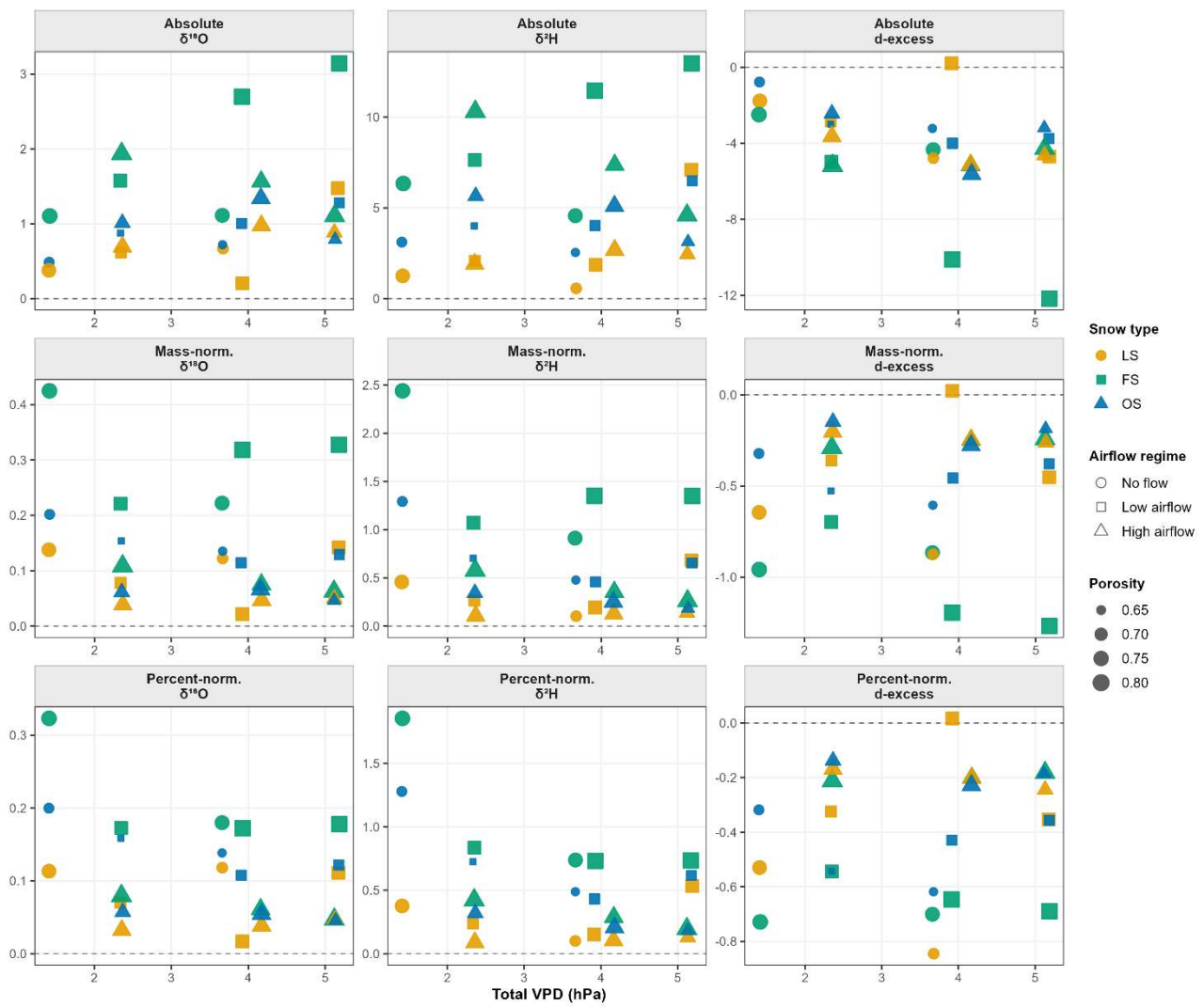


Figure S6 As Figure S4 but with total vapor pressure deficit, the sum of atmospheric and internal components on the x axis.

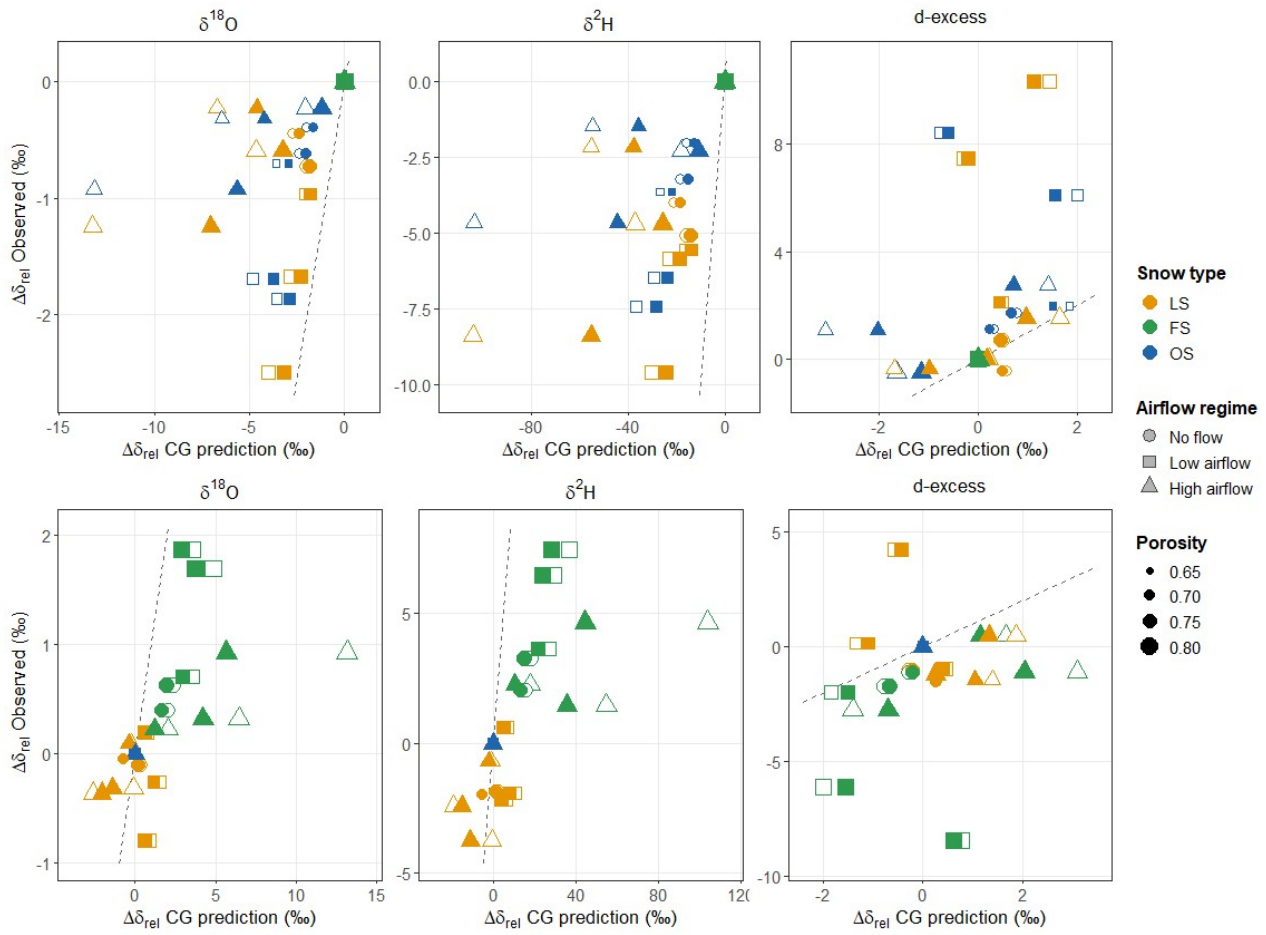
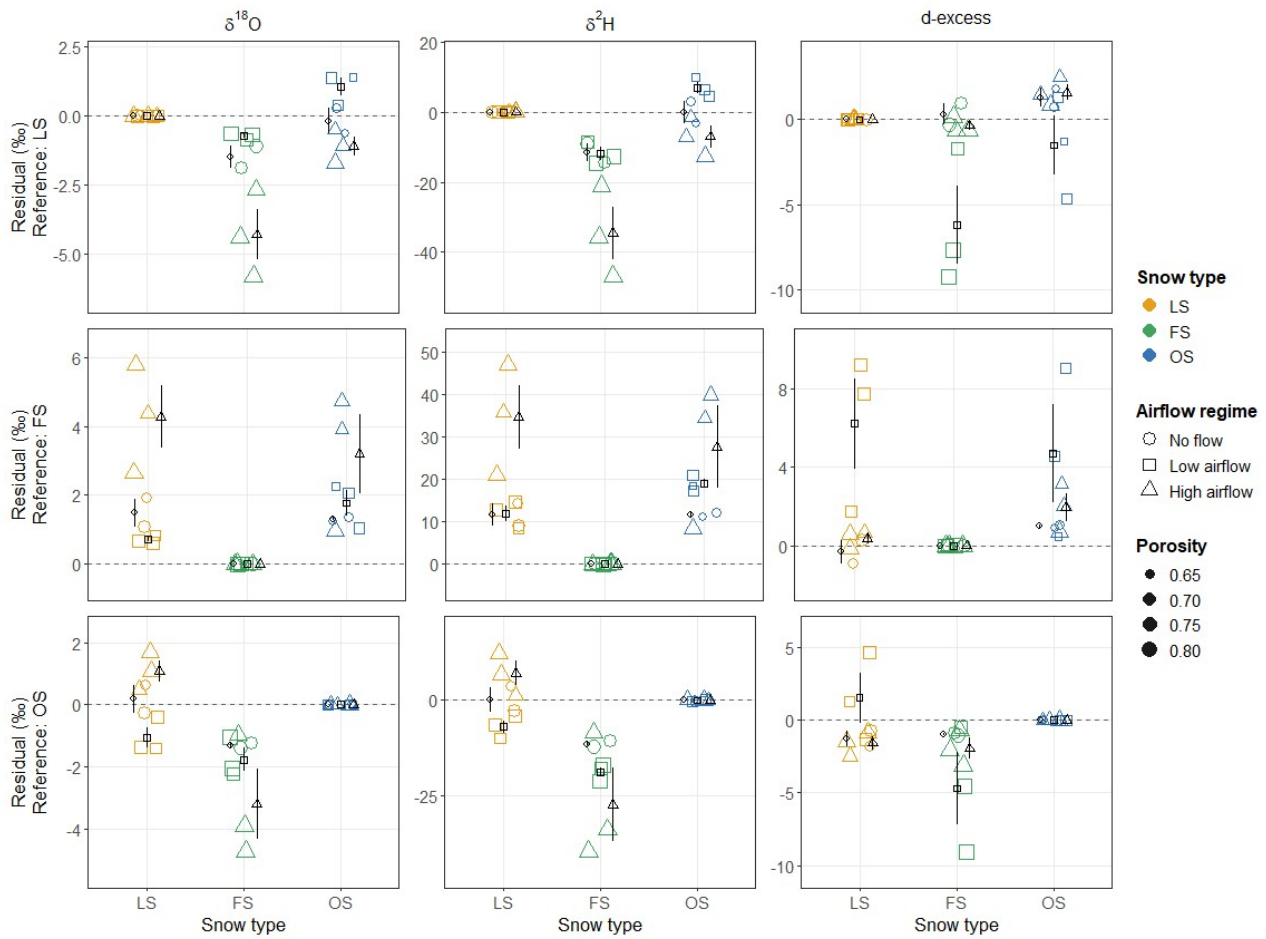


Figure S7 As Figure 6 but with (A) fresh snow (FS) and (B) old snow (OS) used as the experiment-specific reference snow type, for $\delta^{18}\text{O}$, $\delta^2\text{H}$, and d-excess. Symbol colours, shapes, sizes, and hollow/filled convention follow Figure 6. The dashed line denotes the 1:1 relationship.

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45 **Figure S8 Craig-Gordon (CG) time-stepping model residuals ($\Delta\delta_{rel, obs} - \Delta\delta_{rel, CG, ts}$, ‰) by snow type and airflow regime, for three reference snow types: (A) laboratory snow (LS), (B) fresh snow (FS), and (C) old snow (OS). Columns show $\delta^{18}O$, δ^2H , and d-excess. Symbol colour indicates snow type (LS: amber; FS: green; OS: blue), shape indicates airflow regime (circle: no flow; square: low airflow; triangle: high airflow), and size scales with initial bulk porosity. Points are horizontally jittered to reduce overlap. Black bars show group means ± 1 standard error. Positive residuals indicate CG underprediction of enrichment; negative residuals indicate overprediction. Each panel has independent y-axis limits. The reference snow type for each row is identified in the y-axis label of the left-column panels.**

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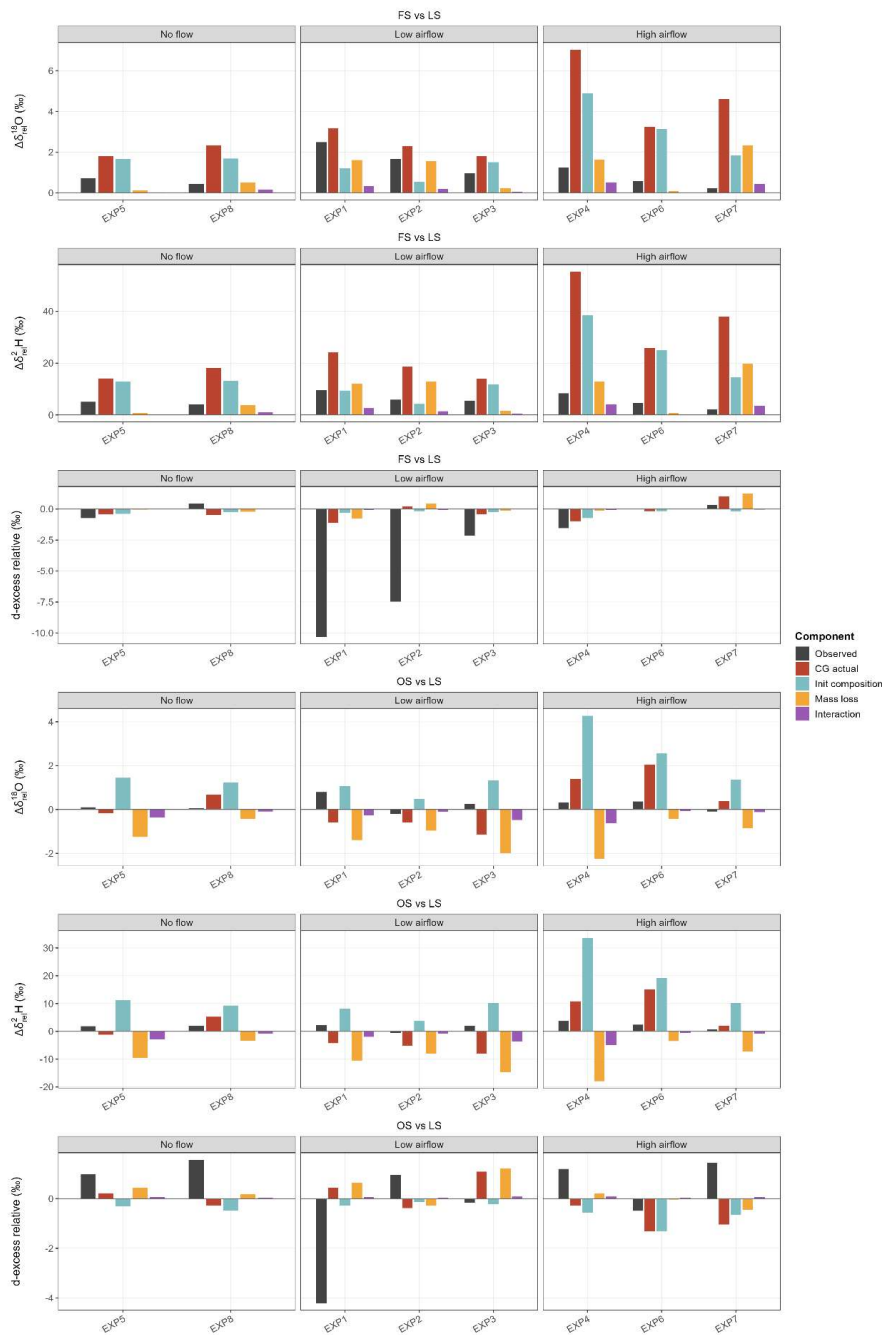


Figure S9 Sensitivity analysis of the Craig-Gordon time-stepping model for snow type pairs with laboratory snow (LS) as reference, decomposing relative isotopic change ($\Delta\delta_{rel}$) into contributions from initial isotopic composition (δ_0 , teal), mass loss fraction (f, orange), their interaction (purple), and the total CG model prediction (CG actual, red), alongside observations (black). Rows show $\Delta\delta^{18}\text{O}$, $\Delta\delta^2\text{H}$, and Δd -excess for FS vs LS (upper three rows) and OS vs LS (lower three rows). Columns group experiments by airflow regime: no flow (EXP5, EXP8), low airflow (EXP1, EXP2, EXP3), and high airflow (EXP4, EXP6, EXP7)

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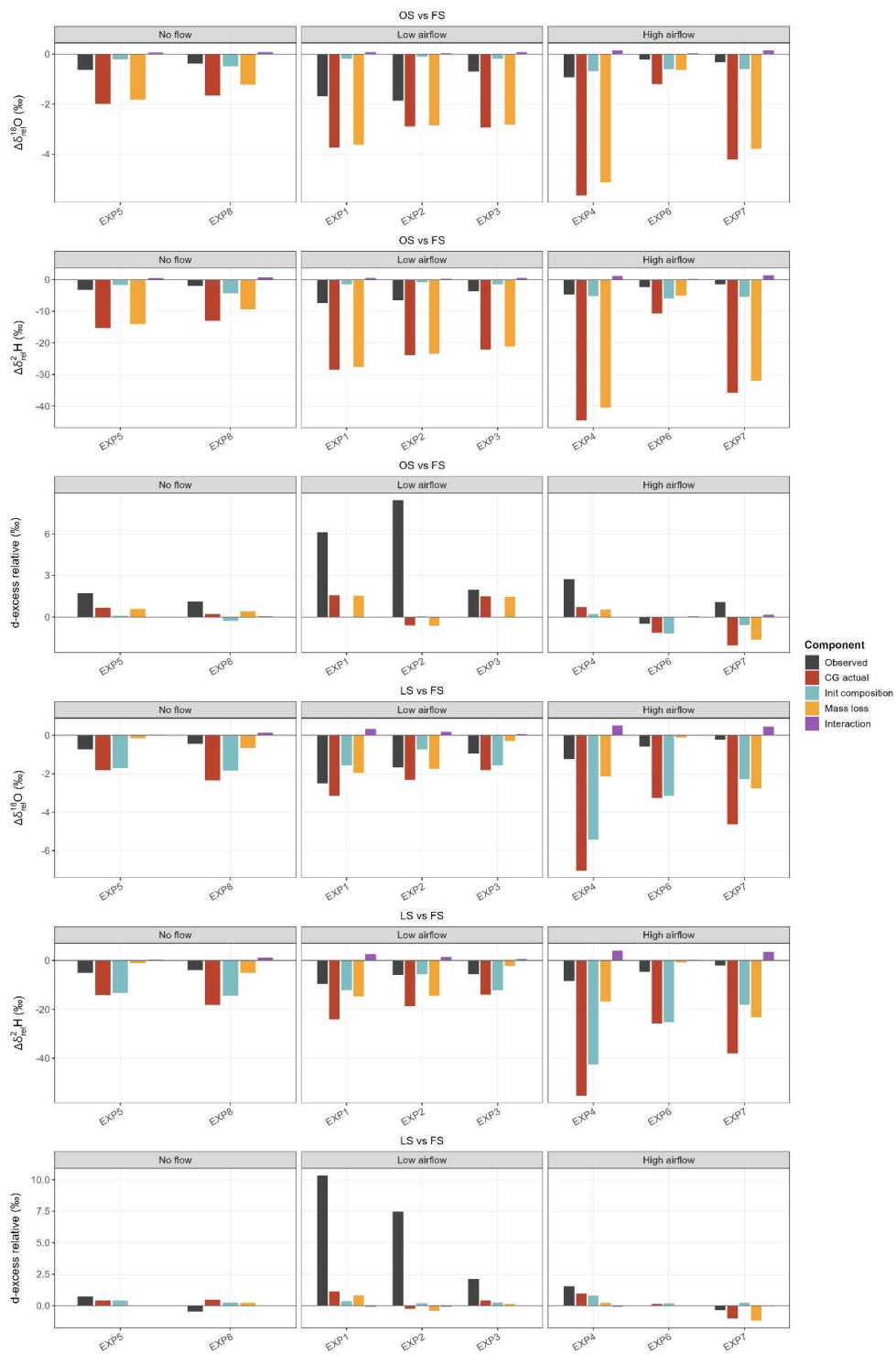
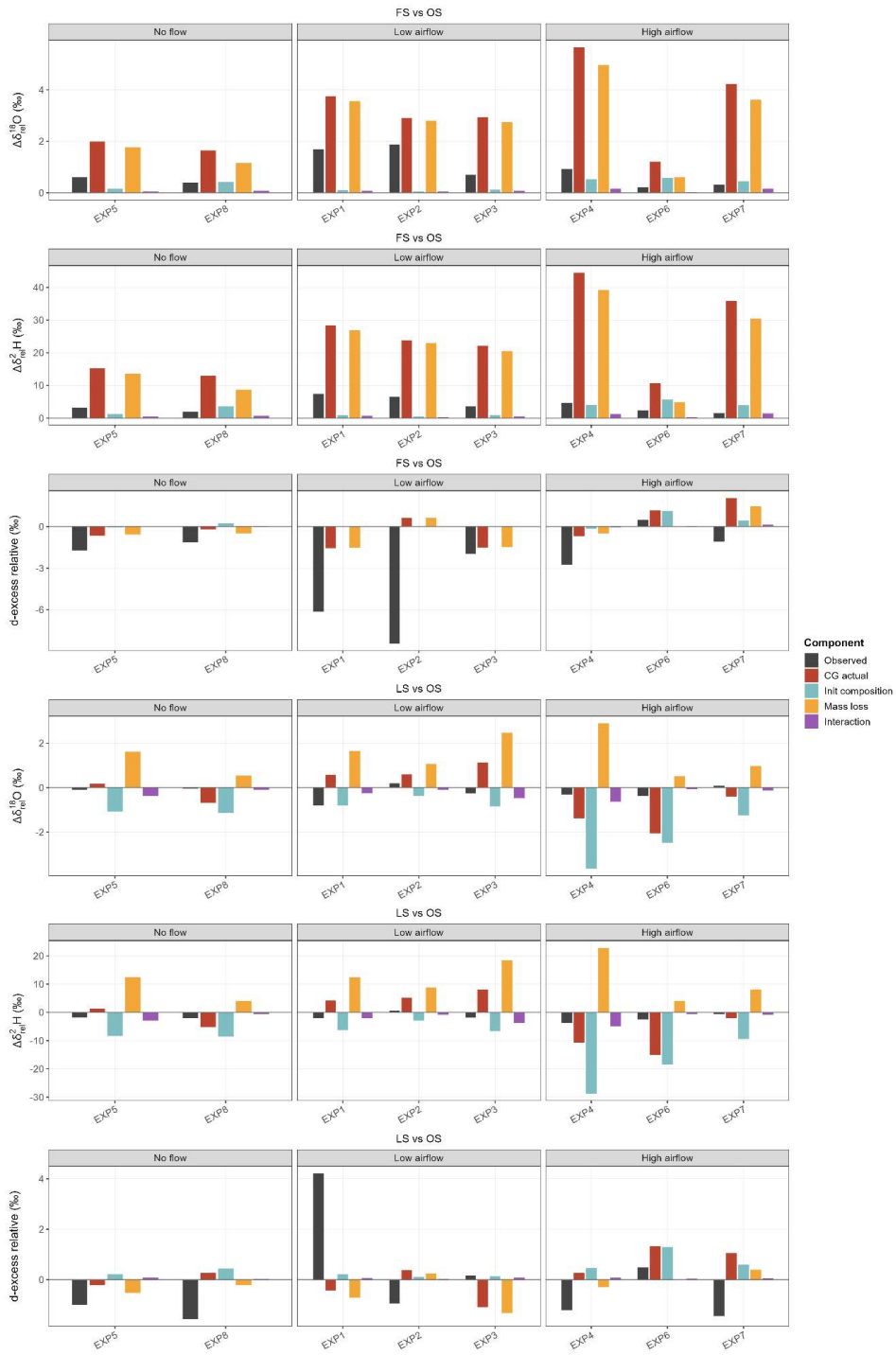


Figure S10. Same as S9 with FS as reference.



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Figure S11 Same as S9 with OS as reference.

Table S1 Data used in this study

Experiment	Sample	Wind regime	Temperature mean (°C)	Temperature SD (°C)	RH mean (%)	RH SD (%)	Porosity initial	Density initial (g cm ⁻³)	Mass change (g)	δ ¹⁸ O initial (‰)	δ ¹⁸ O final (‰)	δ ² H initial (‰)	δ ² H final (‰)	d-excess initial (‰)	d-excess final (‰)
EXP 1	LS	Low Wind	-6.86	0.94	49.95	8.78	0.72	0.25	9.57	-7.25	-7.04	-53.66	-51.8	4.34	4.55
EXP 1	FS	Low Wind	-6.86	0.94	49.95	8.78	0.81	0.18	8.47	-17.56	-14.86	-133.34	-121.89	7.13	-2.99
EXP 1	OS	Low Wind	-6.86	0.94	49.95	8.78	0.67	0.31	8.77	-16.28	-15.28	-123.22	-119.2	7.04	3.04
EXP 2	LS	Low Wind	-15.58	2.49	28.62	7.93	0.72	0.25	10.4	-7.07	-5.59	-53.23	-46.13	3.32	-1.38
EXP 2	FS	Low Wind	-15.58	2.49	28.62	7.93	0.81	0.18	9.6	-17.62	-14.48	-133.88	-120.91	7.11	-5.07
EXP 2	OS	Low Wind	-15.58	2.49	28.62	7.93	0.67	0.31	9.91	-16.2	-14.92	-123.13	-116.64	6.46	2.71
EXP 3	LS	Low Wind	-2.1	0.41	63.94	2.77	0.68	0.29	7.88	-7.16	-6.55	-52.57	-50.49	4.72	1.88
EXP 3	FS	Low Wind	-2.1	0.41	63.94	2.77	0.72	0.25	7.13	-17.47	-15.89	-133	-125.36	6.74	1.77
EXP 3	OS	Low Wind	-2.1	0.41	63.94	2.77	0.64	0.33	5.69	-16.2	-15.33	-123.15	-119.14	6.47	3.47
EXP 4	LS	High Wind	-3.83	1.08	73.61	3.82	0.71	0.27	17.86	-7.26	-6.56	-53.09	-51.18	4.97	1.34
EXP 4	FS	High Wind	-3.83	1.08	73.61	3.82	0.74	0.24	17.87	-17.37	-15.44	-132.36	-122.06	6.61	1.43
EXP 4	OS	High Wind	-3.83	1.08	73.61	3.82	0.67	0.3	16.46	-16.09	-15.08	-122.51	-116.85	6.24	3.8
EXP 5	LS	Zero wind	-2.5	0.42	84.96	3.16	0.71	0.27	2.74	-7.16	-6.78	-53.75	-52.49	3.54	1.78
EXP 5	FS	Zero wind	-2.5	0.42	84.96	3.16	0.73	0.25	2.6	-16.99	-15.88	-129.8	-123.46	6.09	3.6
EXP 5	OS	Zero wind	-2.5	0.42	84.96	3.16	0.65	0.32	2.41	-15.73	-15.24	-120.28	-117.17	5.56	4.79
EXP 6	LS	High Wind	-10.53	1.55	58.81	8.36	0.71	0.27	20.9	-7.07	-6.09	-52.19	-49.52	4.35	-0.78
EXP 6	FS	High Wind	-10.53	1.55	58.81	8.36	0.71	0.26	20.77	-16.41	-14.85	-126.29	-118.92	5.03	-0.12
EXP 6	OS	High Wind	-10.53	1.55	58.81	8.36	0.71	0.27	20.29	-14.66	-13.32	-108.82	-103.71	8.43	2.81
EXP 7	LS	High Wind	-20.26	3.03	49.86	5.5	0.67	0.3	17.64	-7.08	-6.19	-52.4	-49.96	4.21	-0.42
EXP 7	FS	High Wind	-20.26	3.03	49.86	5.5	0.73	0.24	17.64	-17.14	-16.03	-131.69	-127.09	5.46	1.17
EXP 7	OS	High Wind	-20.26	3.03	49.86	5.5	0.65	0.32	17.12	-14.52	-13.73	-108.25	-105.12	7.91	4.72
EXP 8	LS	Zero wind	-10.13	0.68	76.25	11.82	0.66	0.31	5.47	-7.04	-6.38	-51.95	-51.39	4.41	-0.38
EXP 8	FS	Zero wind	-10.13	0.68	76.25	11.82	0.71	0.26	5.01	-17.25	-16.14	-131.79	-127.22	6.21	1.88
EXP 8	OS	Zero wind	-10.13	0.68	76.25	11.82	0.64	0.33	5.32	-14.45	-13.73	-108.04	-105.5	7.57	4.35