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Impact of black carbon on daytime valley and slope winds in idealised simulations

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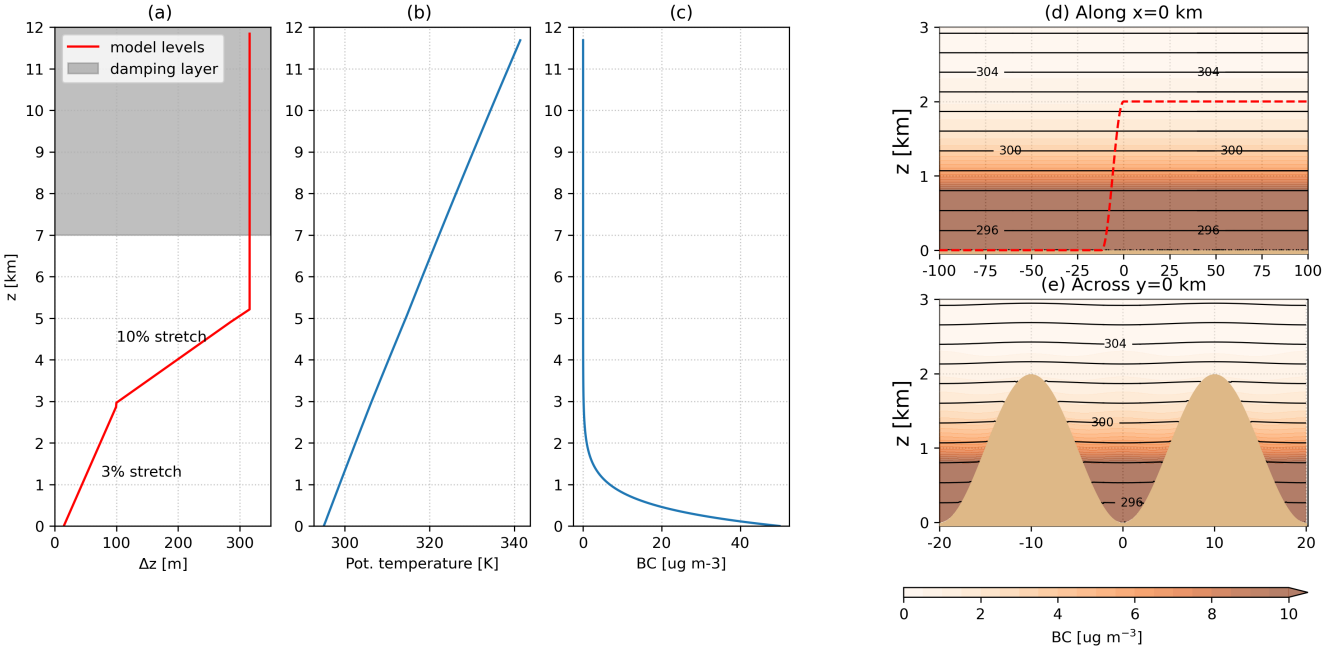

Figure S1. (a) Vertical spacing of model levels on red, grey shaded area mark the vertical span of the damping layer. Spin-up initial vertical profile of **(b)** potential temperature **(c)** black carbon concentration. Corresponding initial distribution of potential temperature as contours and black carbon concentration shaded **(d)** along $x = 0$ (valley centre) and **(e)** across $y > 0$.

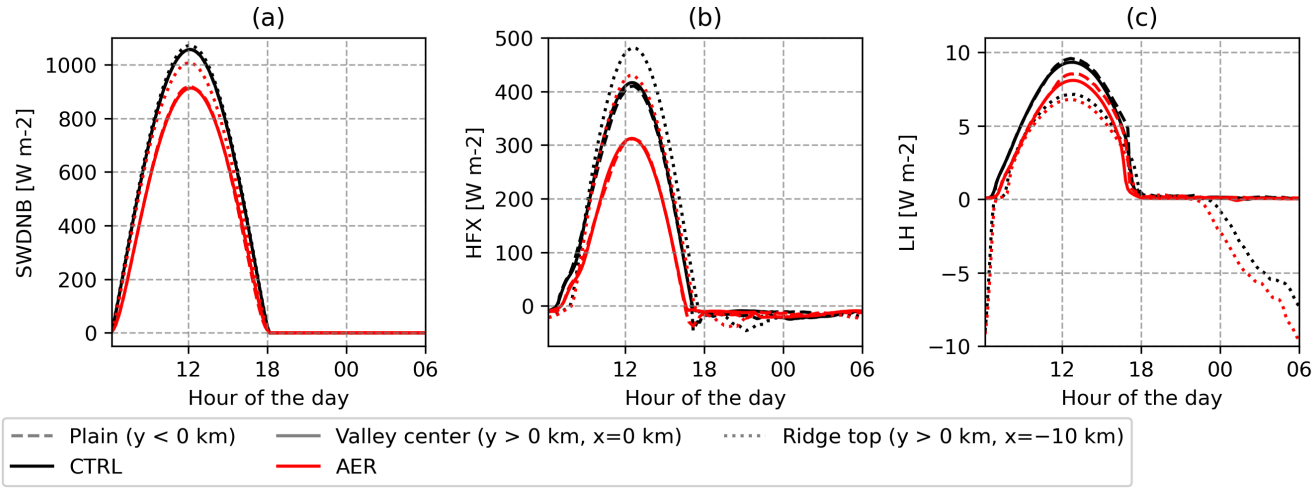

Figure S2. **(a)** Down welling shortwave flux at the surface **(b)** Upward heat flux at the surface **(c)** Latent heat flux at the surface. Instantaneous WRF output every 10 minutes, averaged over the plain (dashed line), valley centre line (solid line) and at the ridge-top (dotted line).

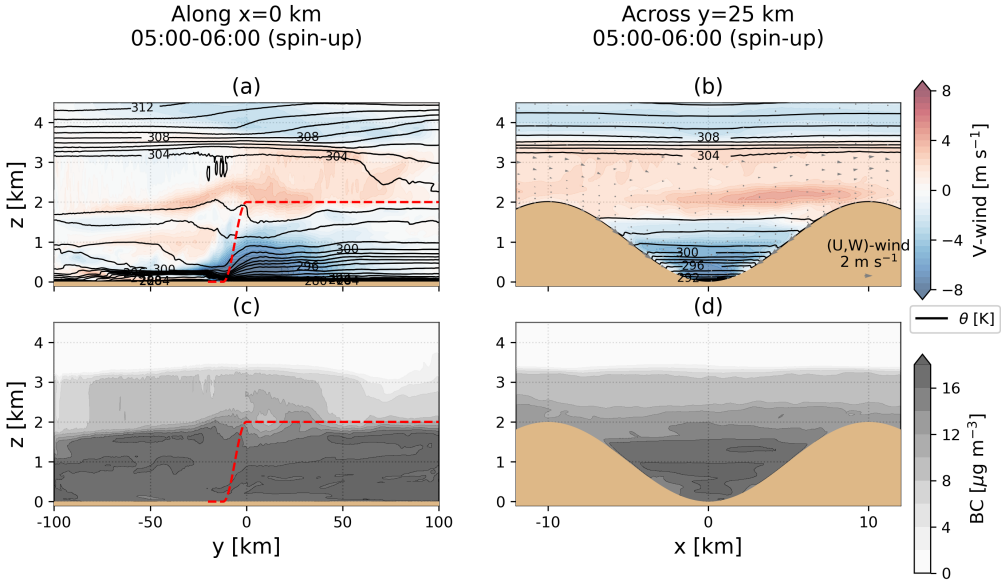

Figure S3. Cross-sections **(a, c)** along the valley centre line and **(b, d)** across the valley at $y = 25$ km averaged on the last hour of the spin-up simulation. **(a-b)** Along-valley wind speed (shaded) and potential temperature (black solid lines). Positive along-valley wind speed refers to up-valley hence right-ward wind in **(a)**. **(c-d)** Black carbon concentration. Red dashed line in **(a,c)** shows the ridge height at $x = \pm 10$ km.

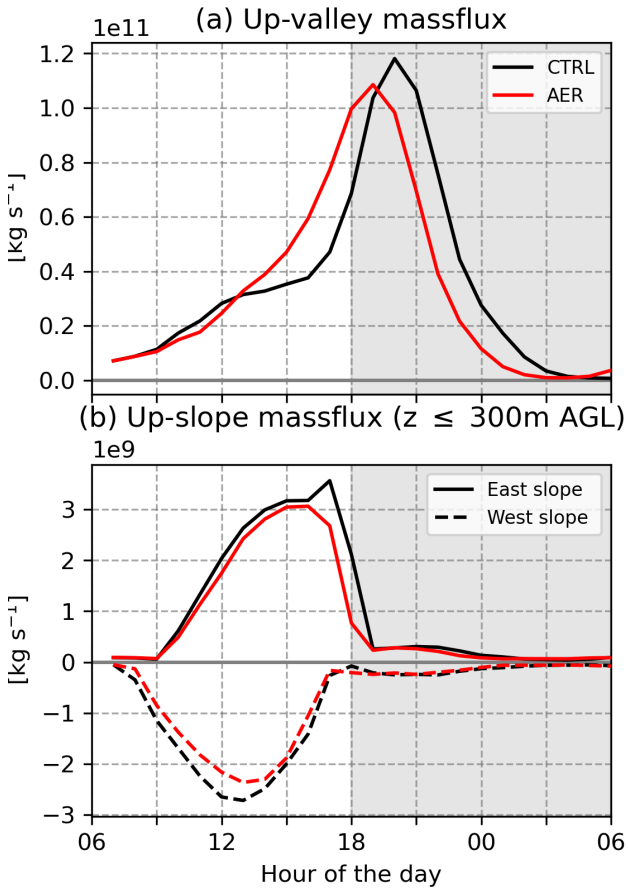

Figure S4. Integrated horizontal massflux in **(a)** up-valley direction meaning the grid boxes with non-positive v-component of the wind are ignored **(b)** up-slope direction meaning the grid boxes with non-positive (non-negative) u-component of the wind are ignored for east slope (west slope). Positive (negative) values refer to up-slope massflux on the east slope (west slope).

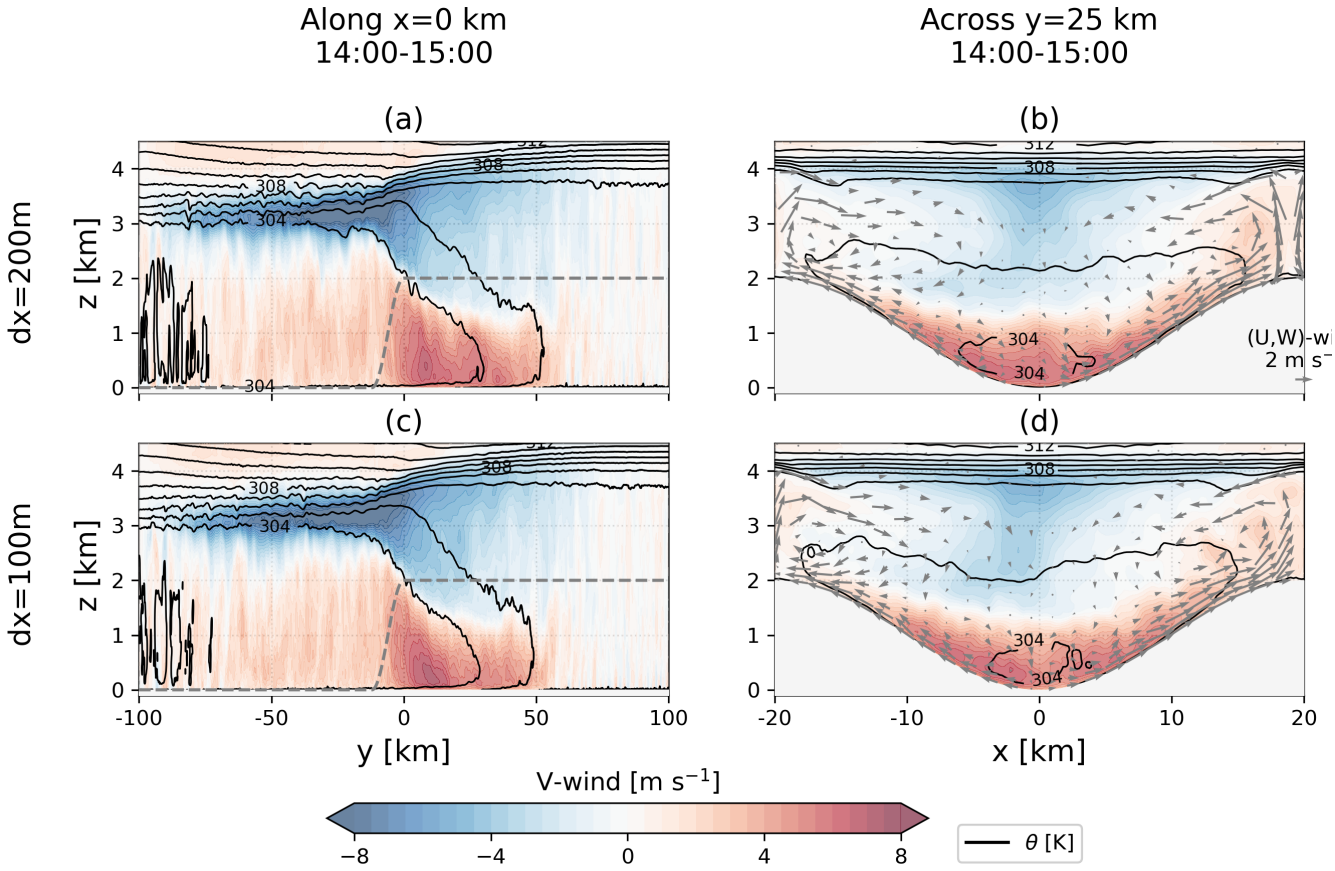

Figure S5. Cross-sections **(a,c)** along the valley centre line and **(b,d)** across the valley at $y = 25$ km averaged between 14:00 and 15:00. Panels **(a-b)** are from the original case `CTRL` and panels **(c-d)** are from the sensitivity simulation with horizontal grid spacing of 100 m. The cross-sections show the along-valley wind speed (shaded) and potential temperature (black solid lines). Positive along-valley wind speed refers to up-valley hence right-ward wind in **(a,c)**. Grey dashed line in **(a,c,e)** show the ridge height at $x = \pm 10$ km.

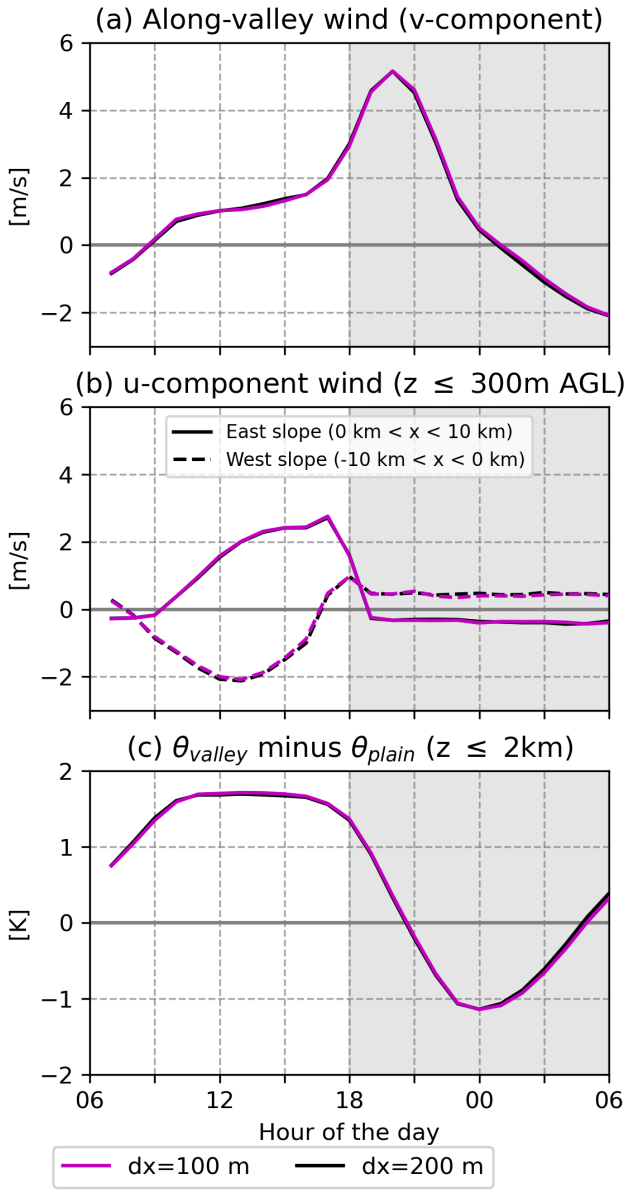

Figure S6. Sensitivity test of the CTRL simulation with horizontal grid spacing of 200 m (original case `CTRL`, shown on black lines) and 100 m (purple lines). Mass-weighted average of the **(a)** v-component of the wind in the valley volume **(b)** u-component of the wind in the nearest 300 m layer from the surface in the valley. **(c)** Mass-weighted potential temperature difference between the valley volume ($y > 0$ km) and the lowest 2 km above the plain ($y < 0$ km).

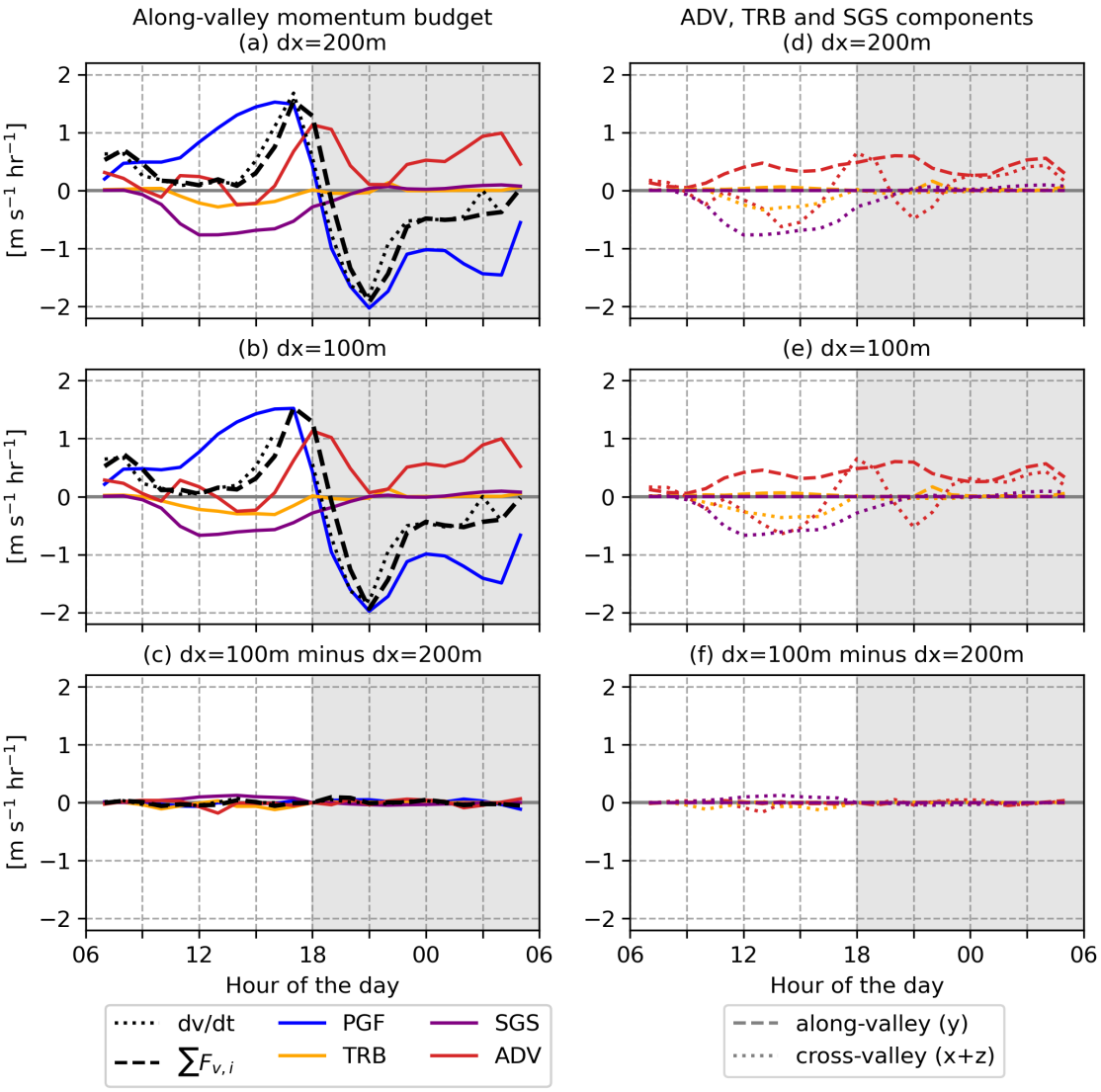

Figure S7. Along-valley momentum budget for the valley volume in **(a)** original CTRL and **(b)** sensitivity run with horizontal grid spacing of 100 m and **(c)** difference between the two cases. Left-hand-side of the Equation 3 in the manuscript for along-valley momentum is shown on black dotted line and the sum of the terms on the right-hand-side as black dashed line, respectively. **(d-f)** Same as (a-c) but for the tendency due to mean advection, resolved turbulence and sub-grid-scale diffusion decomposed into along and cross-valley components. The cross-valley component includes the vertical one.

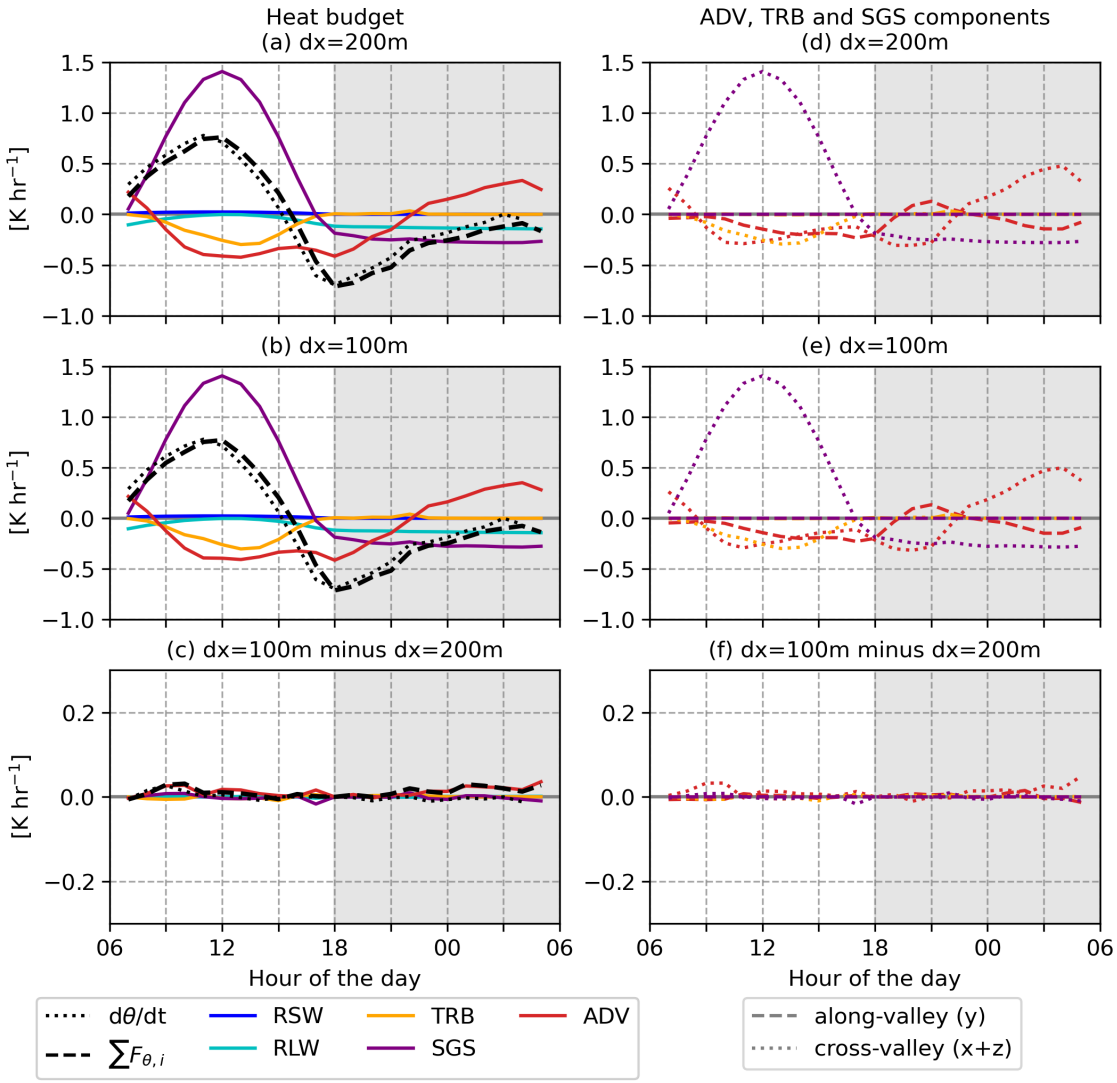

Figure S8. Heat budget for the valley volume in **(a)** original `CTRL` and **(b)** sensitivity run with horizontal grid spacing of 100 m and **(c)** difference between the two cases. Left-hand-side of the Equation 3 in the manuscript for heat is shown on black dotted line and the sum of the terms on the right-hand-side on black dashed line, respectively. **(d-f)** Same as (a-c) but for the tendency due to mean advection, resolved turbulence and sub-grid-scale diffusion decomposed into along and cross-valley components. The cross-valley component includes the vertical one.