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Supplement of

Improving snow albedo modeling in the E3SM land model (version 2.0) and assessing its impacts on snow and surface fluxes over the Tibetan Plateau

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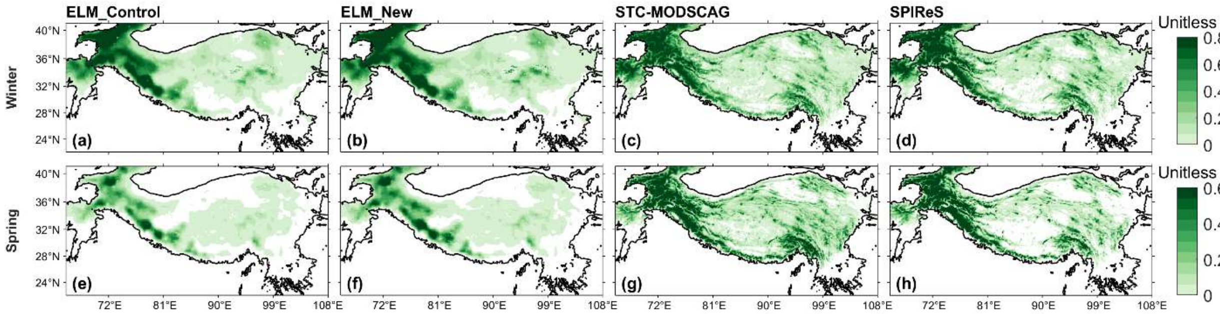

Figure S1: Spatial distributions of f_{sno} estimated from: (a,e) ELM_Control, (b,f) ELM_New, (c,g) STC-MODSCAG/STC-MODDRFS and (d,h) SPIReS for winter (a-d) and spring (r-h). The areas with f_{sno} smaller than 0.01 are masked.

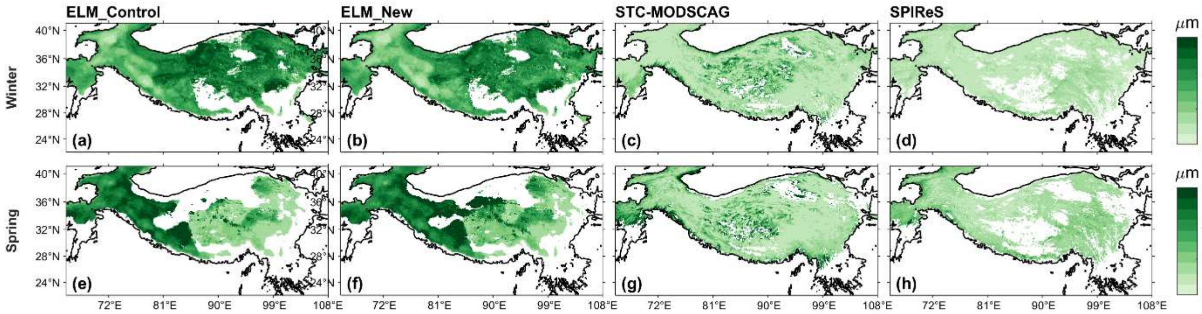

Figure S2: Spatial distributions of snow grain size estimated from: (a,e) ELM_Control, (b,f) ELM_New, (c,g) STC-MODSCAG/STC-MODDRFS and (d,h) SPIReS for winter (a-d) and spring (e-h). The areas with f_{sno} smaller than 0.01 are masked.

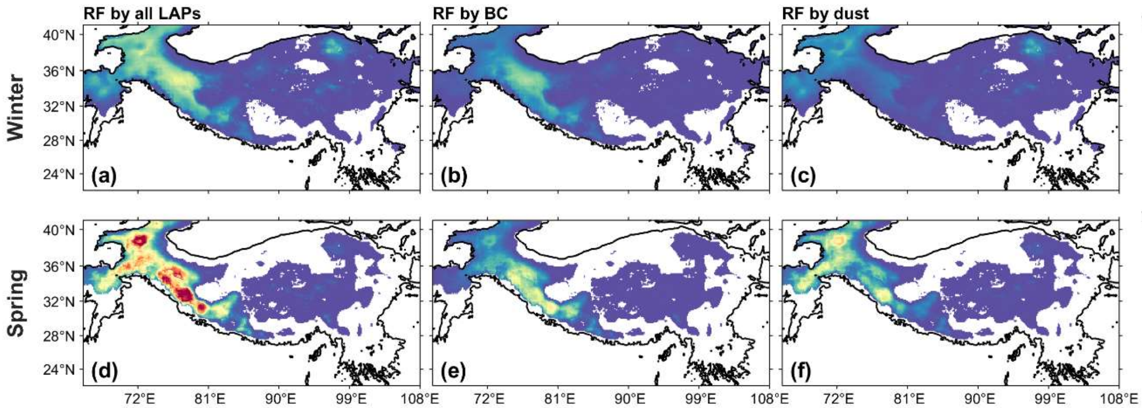

Figure S3. Spatial distributions of RF values from (a,d) all LAPs (BC+dust), (b,e) BC and (c,f) dust for (a-c) winter and (d-f) spring in ELM_Control. The areas with f_{sno} smaller than 0.01 are masked.

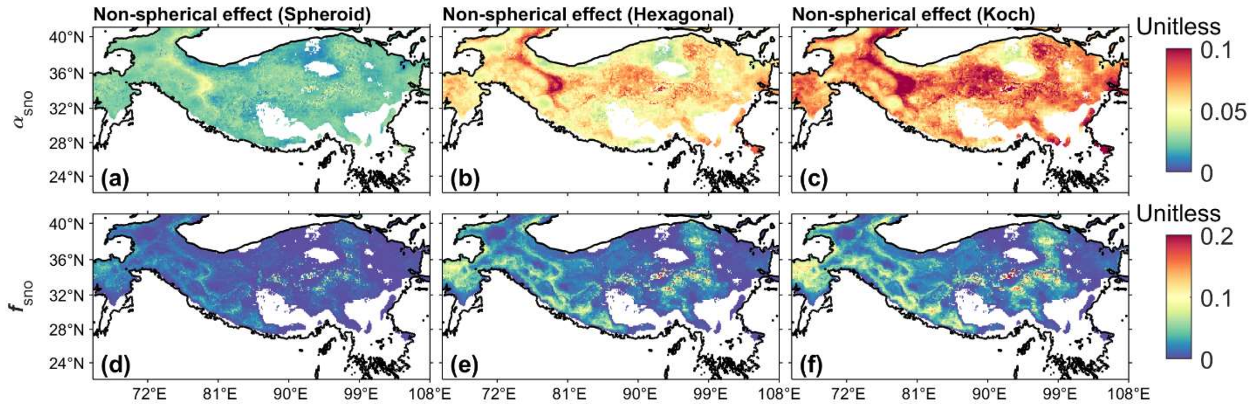

Figure S4: The differences in (a-c) α_{sno} and (d-f) f_{sno} between different snow grain shapes. (a,d) Difference between spheroid and sphere, (b,e) difference between hexagonal plate and sphere and (c,f) difference between Koch snowflake and sphere for winter. The specific calculation methods are listed in Table 2.

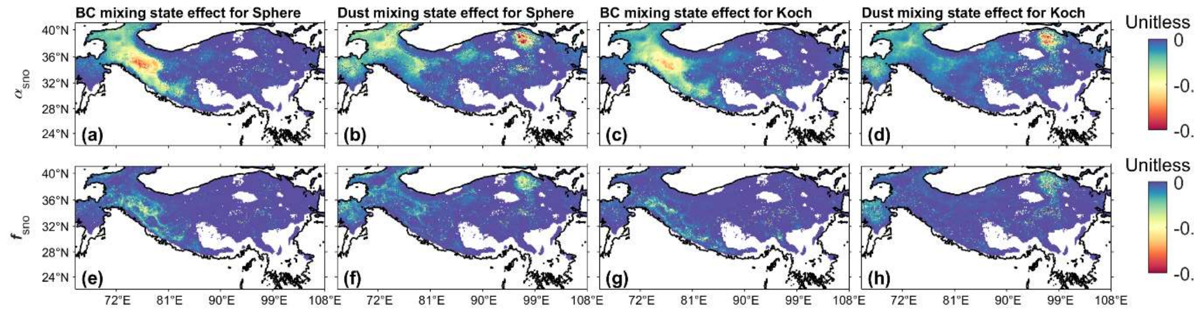

Figure S5: The differences in (a-d) α_{sno} and (e-h) f_{sno} between different mixing states (internal - external) of snow-LAP: (a,e) BC for sphere snow grain shape, (b,f) dust for sphere snow grain shape, (c,g) BC for Koch snowflake grain shape, and (d,h) dust for Koch snowflake grain shape for winter. The specific calculation methods are listed in Table 2.

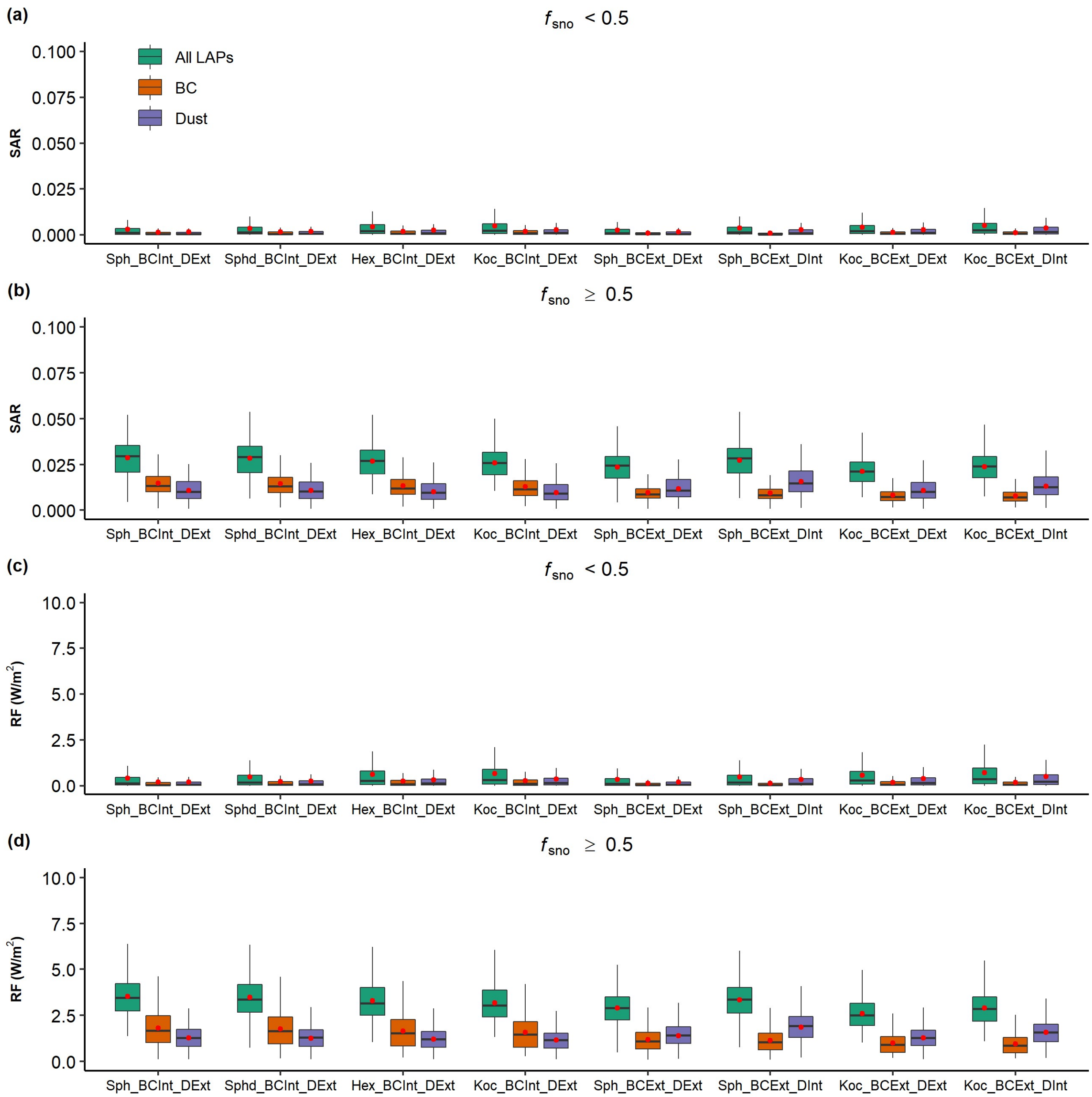

Figure S6: Boxplots of (a,b) SAR and (c,d) RF from all LAPs, BC and dust for different snow cover fractions: (a,c) f_{sno}<0.5 and (b,d) f_{sno}≥0.5 in winter under different cases listed in Table 1. For the case ID labelled in x-axis, the '_PP' suffix is omitted to keep them simplified. Red circles represent the mean values.

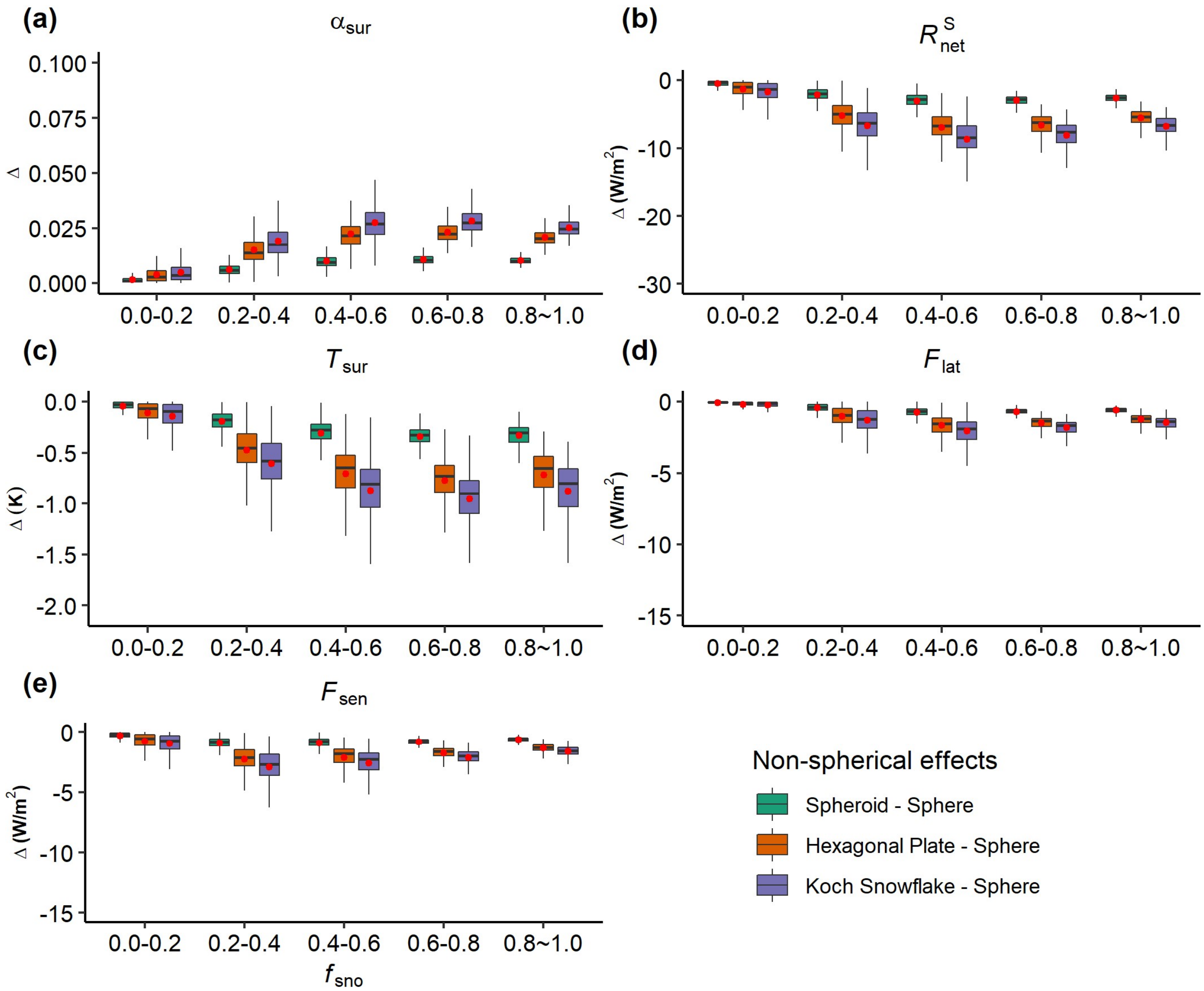

Figure S7: The boxplots of the differences (Δ) in surface energy cycle terms: (a) surface albedo (α_{sur}), (b) net solar radiation ($\boldsymbol{R^{s}_{net}}$), (c) surface temperature (T_{sur}), (d) latent heat flux (F_{lat}) and (e) sensible heat flux (F_{sen}), between different snow grain shapes: spheroid – sphere, hexagonal plate – sphere and Koch snowflake – sphere under different snow cover fractions (f_{sno}) for winter. See Table 2 for the specific calculation methods.

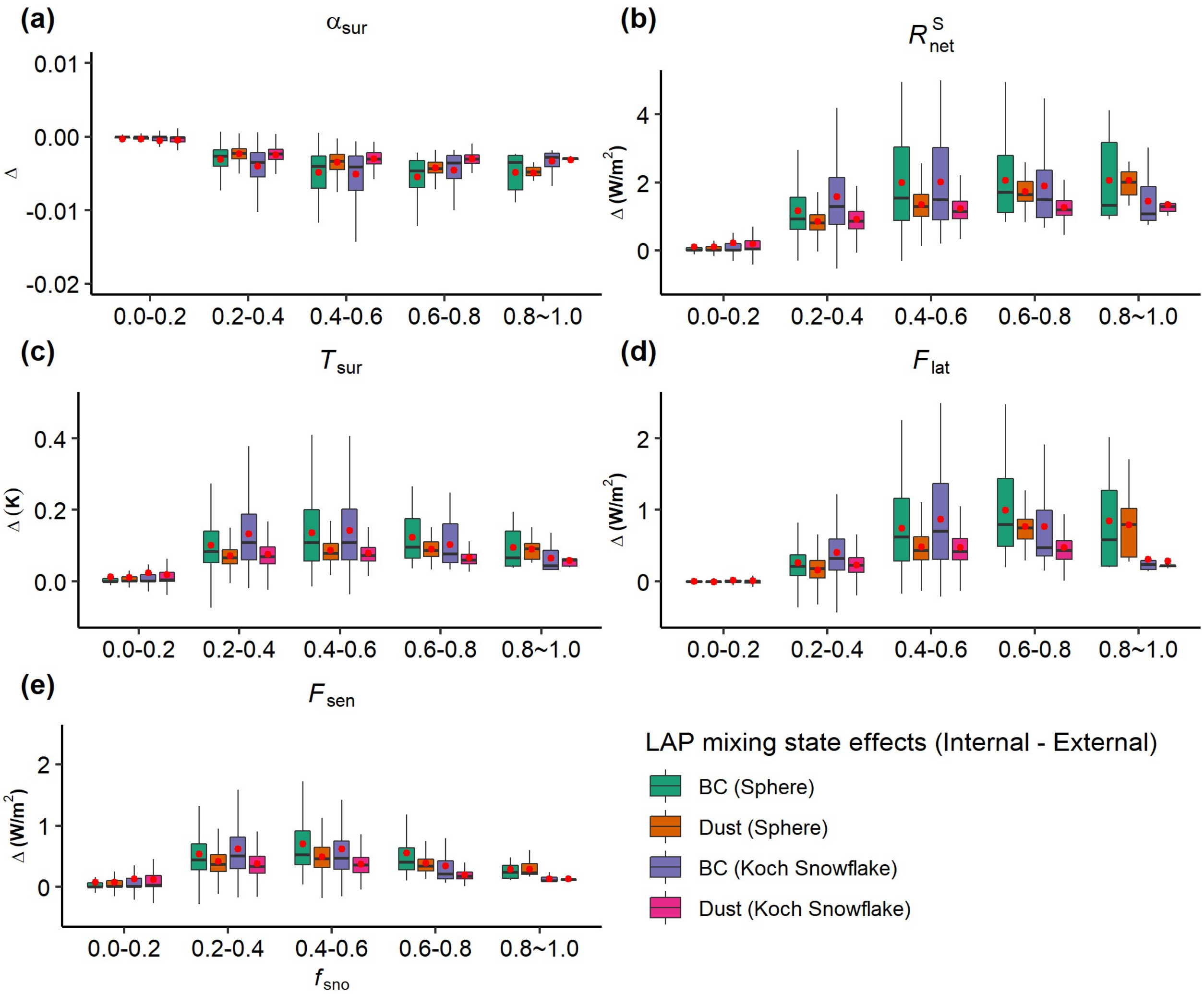

Figure S8: The boxplots of the differences (Δ) in surface energy terms: (a) surface albedo (α_{sur}), (b) net solar radiation ($\boldsymbol{R^{s}_{net}}$), (c) surface temperature (T_{sur}), (d) latent heat flux (F_{lat}) and (e) sensible heat flux (F_{sen}), between different mixing states (internal - external) of snow-LAP: BC(sphere), dust(sphere), BC(Koch snowflake) and dust(Koch snowflake) under different snow cover fractions for spring. See Table 2 for the specific calculation methods.

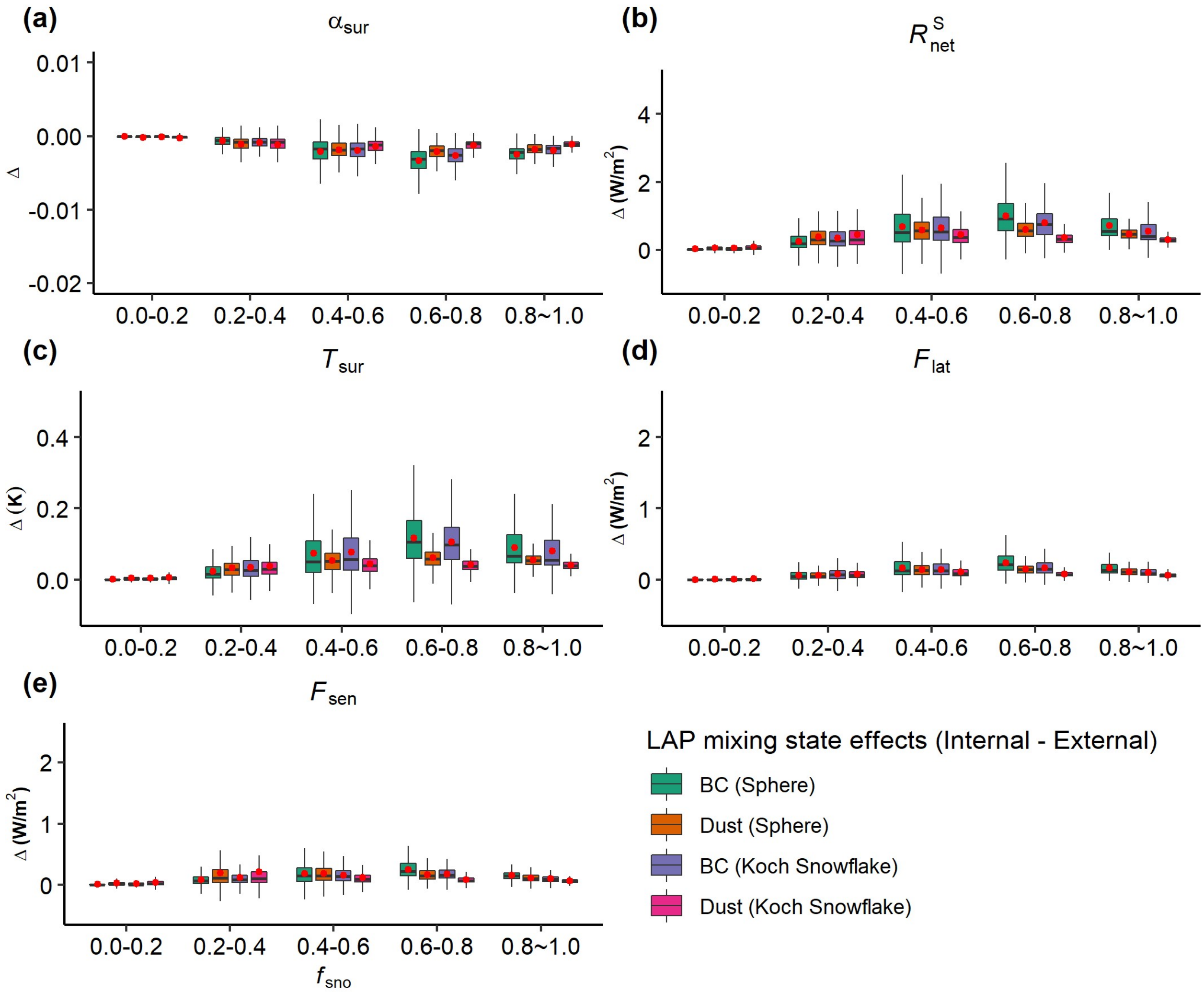

Figure S9: Same as Figure S8 except for winter.

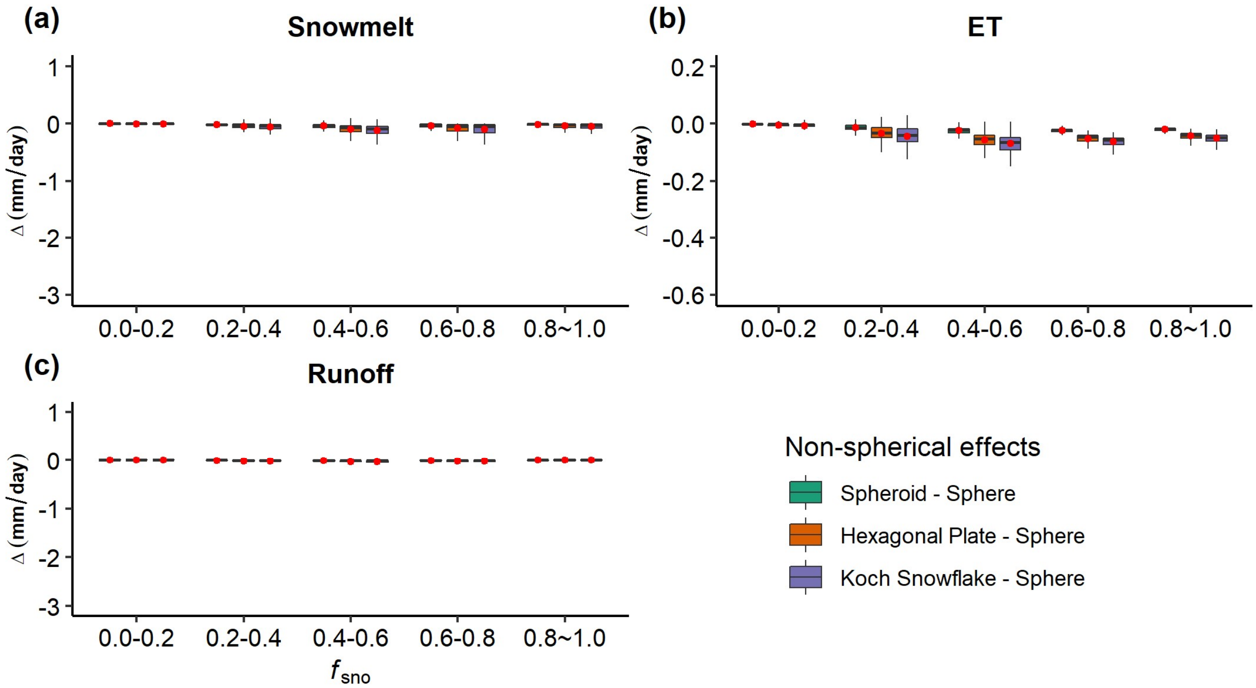

Figure S10: Same as Figure S7, except for hydrological terms: (a) snowmelt, (b) ET, and (c) runoff.

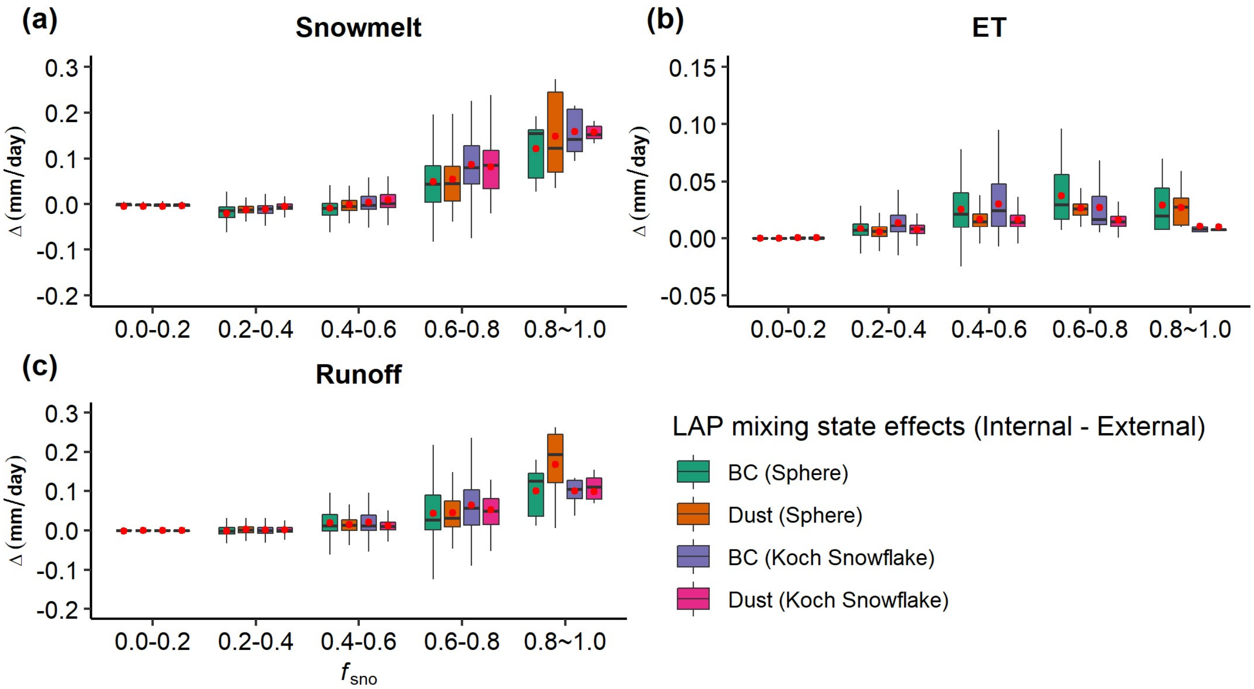

Figure S11: Same as Figure S8, except for hydrological terms: (a) snowmelt, (b) ET, and (c) runoff.

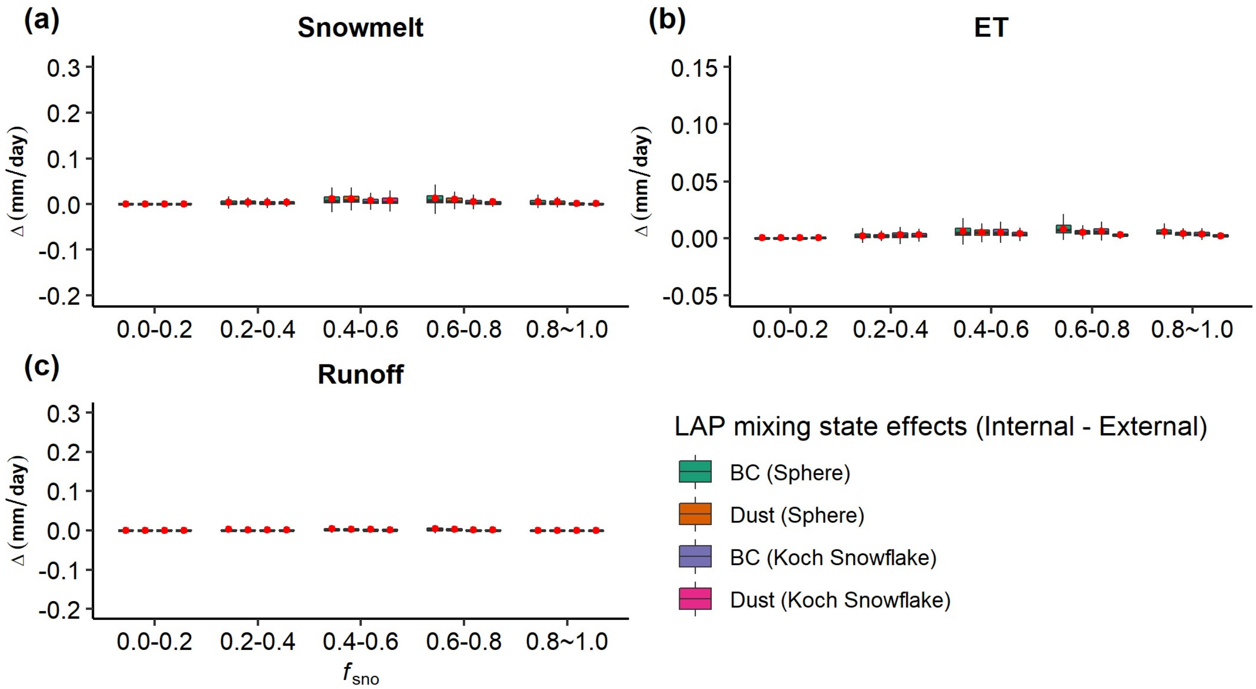

Figure S12: Same as Figure S9, except for hydrological terms: (a) snowmelt, (b) ET, and (c) runoff.

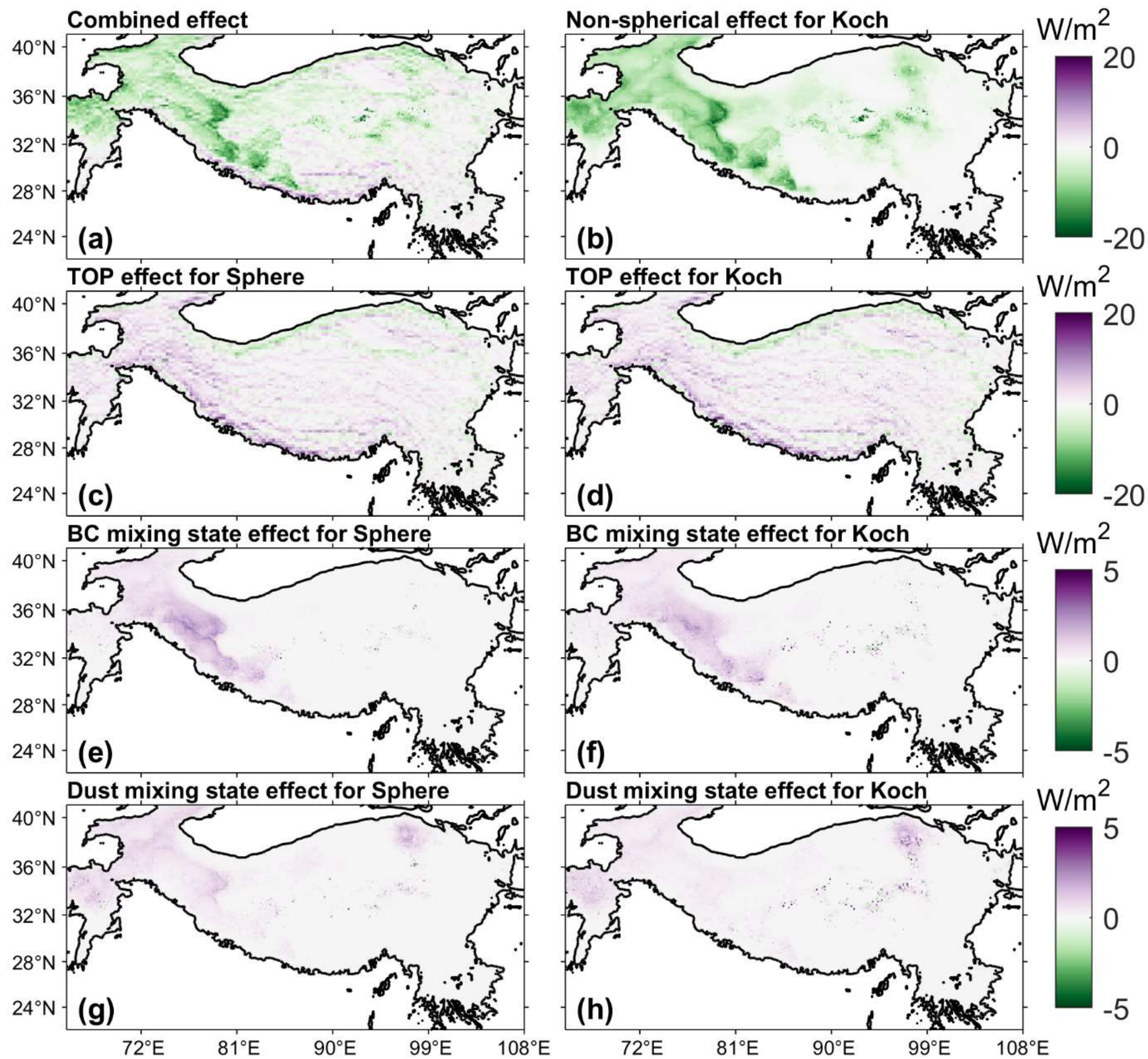

Figure S13: Spatial distributions of the change of net solar radiation contributed by different influencing factors and their combined effects in winter, which are derived based on Table 2.

Table S1. Statistics of RF values induced by different LAPs in winter and spring in the ELM_control and ELM_New simulations.

Case	Aerosol type	Winter maximum	mean	Spring maximum	mean
ELM_Control	All LAPs	6.4	0.7	21.9	1.3
	BC	4.7	0.4	9.2	0.5
	Dust	3.2	0.3	10.2	0.6
ELM_New	All LAPs	8.9	0.8	19.3	1.5
	BC	3.0	0.2	5.4	0.3
	Dust	8.2	0.5	11.9	0.9