

Supplementary material for 'Improved simulation of clouds over the Southern Ocean in a General Circulation Model'

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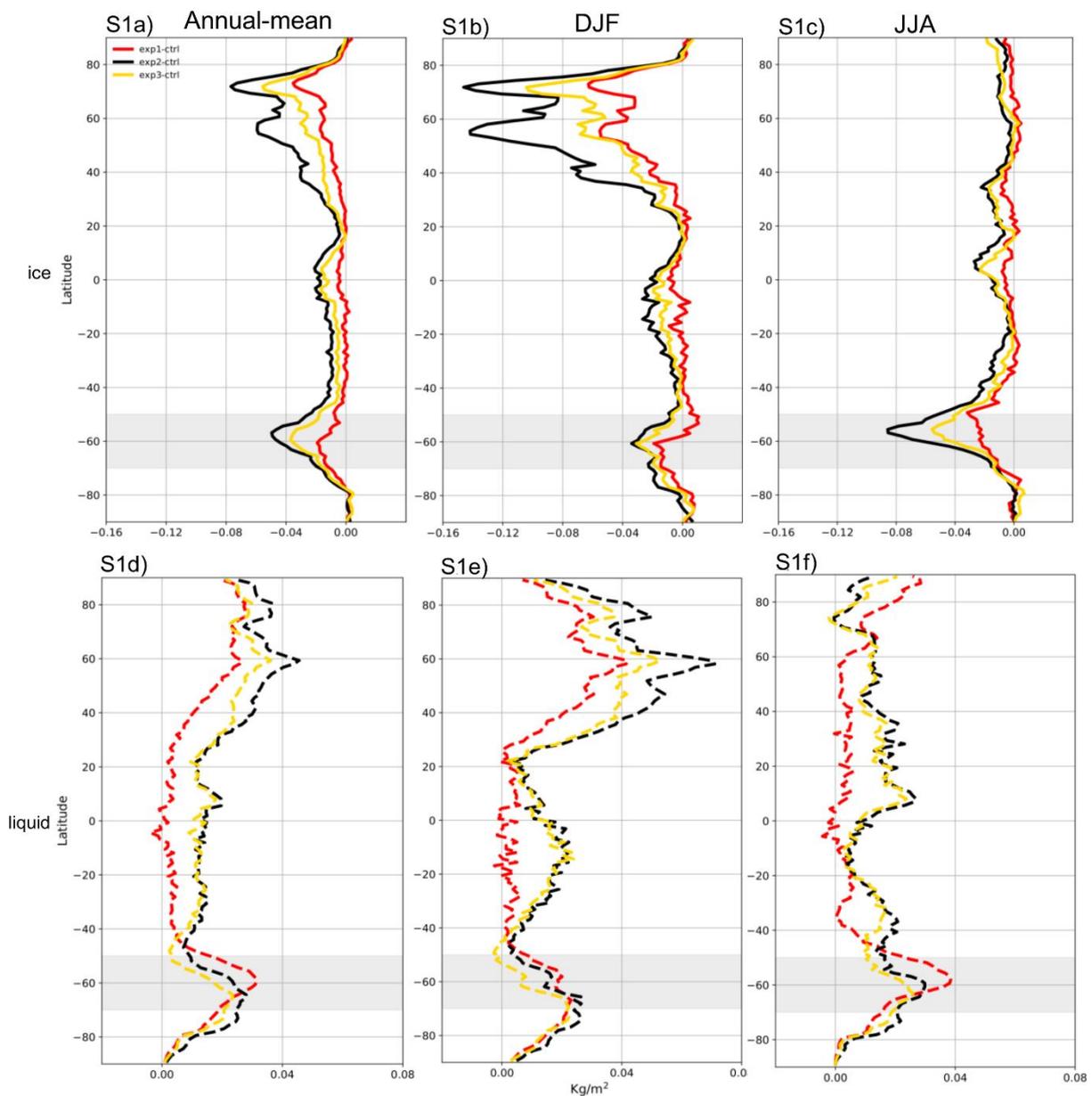


Figure S1. Global distribution of zonally averaged anomalies in IWP (solid lines in S1a to S1c) and LWP (dashed lines in S1d to S1f) over the stratocumulus boundary layer type clouds in the model. The cloud

types considered in the model are: type 2 = boundary layer with stratocumulus over a stable near-surface layer, type 3 = well-mixed boundary layer and type 4 = unstable boundary layer with a decoupled stratocumulus (DSC) layer not over cumulus. The IWP and LWP are calculated collectively over these types. (S1a) and (S1d) represent annual-mean; (S1b) and (S1e) represent DJF mean; (S1c) and (S1f) represent JJA mean. The colour codes are as follows: red = anomaly of exp1 with respect to control, black = anomaly of exp2 with respect to control, yellow = anomaly of exp3 with respect to control. Values are calculated from 12 hourly model output over 20 years. The SO region identified in this study is highlighted in gray.

The interesting thing to note in fig. S1 is that the reduction in the IWP and increase in the LWP over the high-latitudes in both the hemispheres are more pronounced during the corresponding winter seasons (for boundary types 2 to 4). It could be that during winter season, since the cloud top temperatures are closer to freezing temperatures than summer, there is more ice available for reduction to liquid.

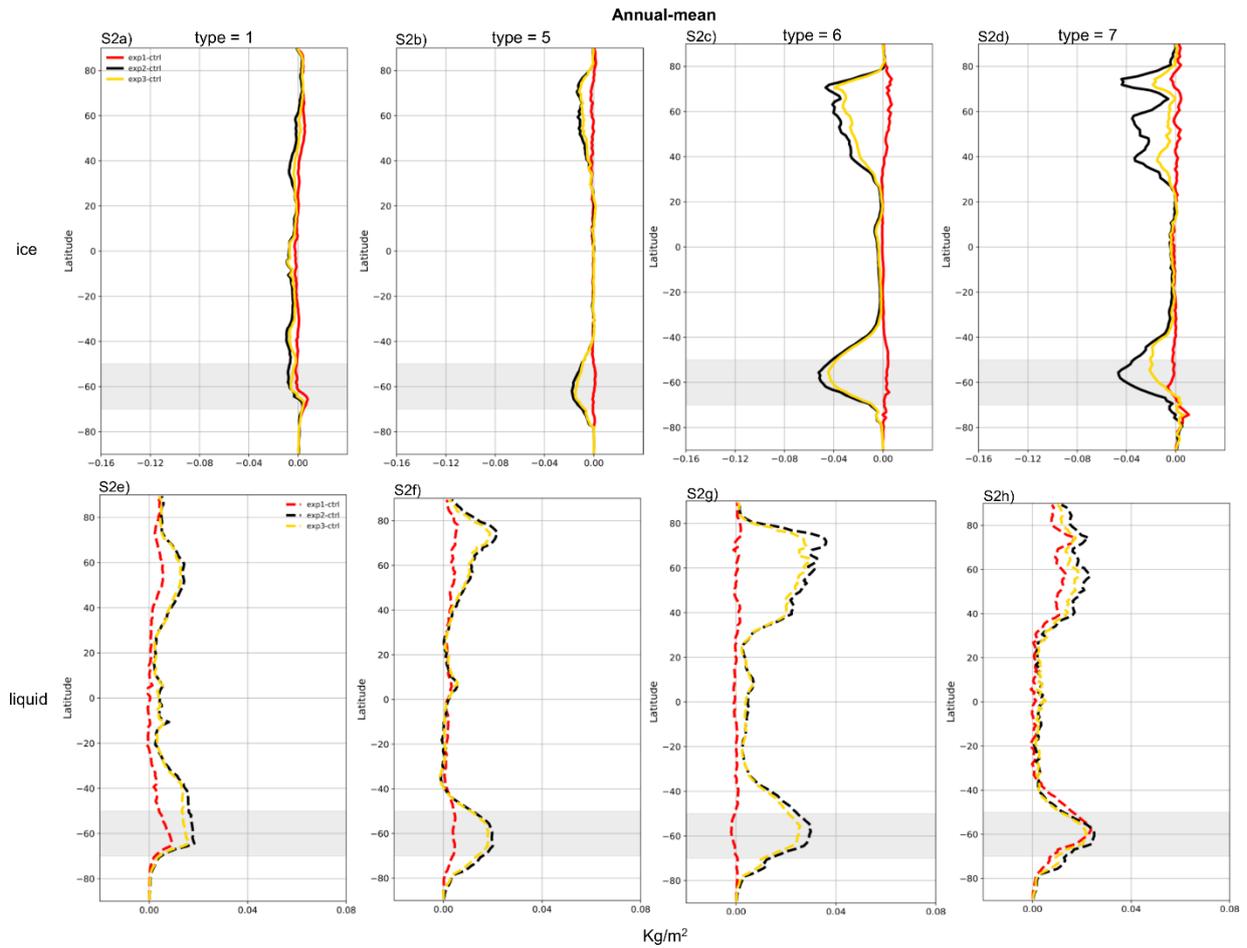


Figure S2. Global distribution of zonally averaged annual-mean anomalies in IWP (solid lines in S2a to S2d) and LWP (dashed lines in S2e to S2h) over the stratocumulus boundary layer type clouds in the model. The cloud types considered in the model are: type 1 = stable boundary layer (with or without cloud), type 5 = boundary layer with de-coupled stratocumulus layer over cumulus, type 6 = cumulus-capped boundary layer and type 7 = shear-dominated unstable layer. The colour codes are as follows: red = anomaly of exp1 with respect to control, black = anomaly of exp2 with respect to control, yellow = anomaly of exp3 with respect to control. Values are calculated from 12 hourly model output over 20 years. The SO region identified in this study is highlighted in gray.

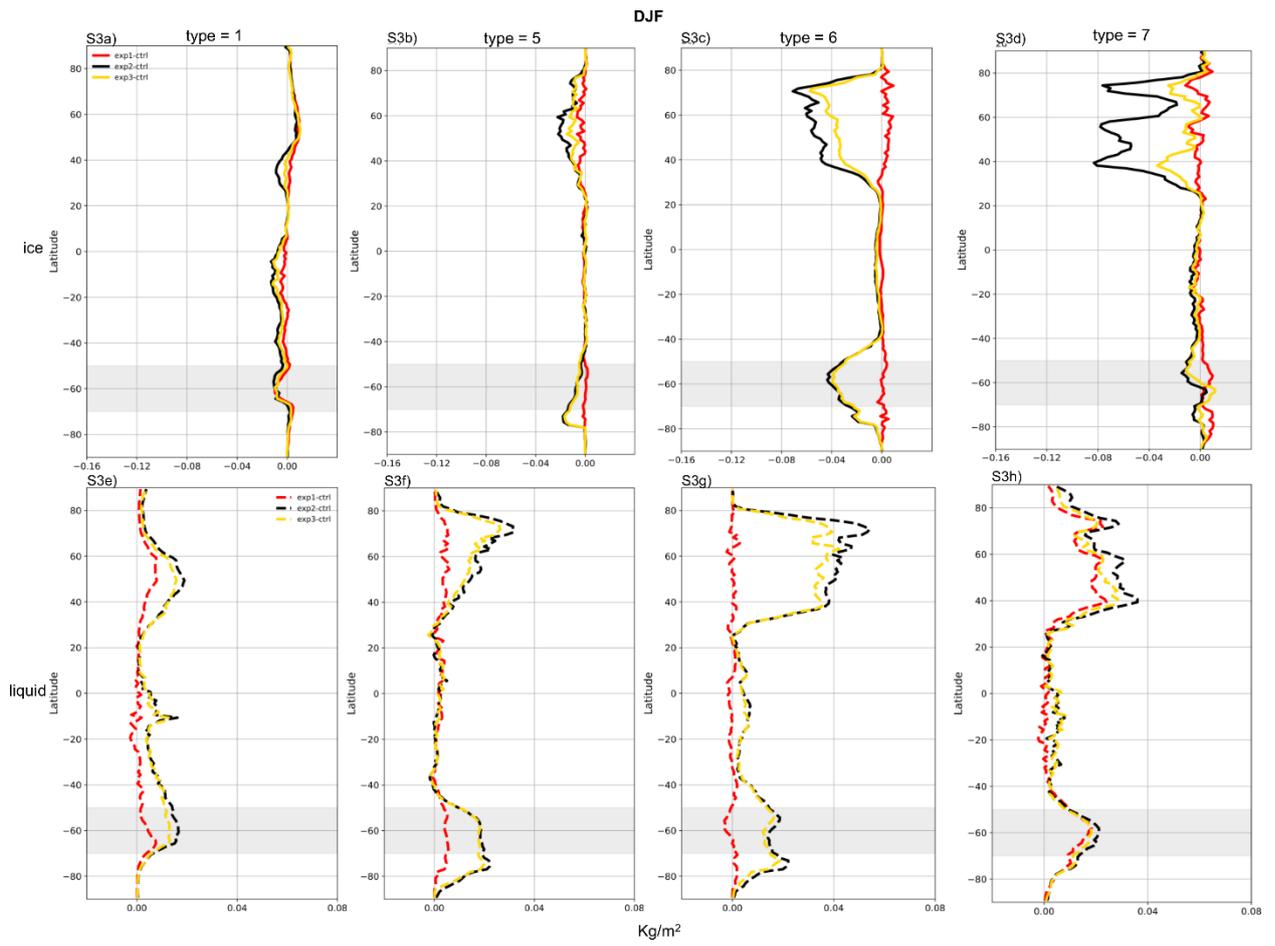


Figure S3. Similar to fig. S2 but for DJF

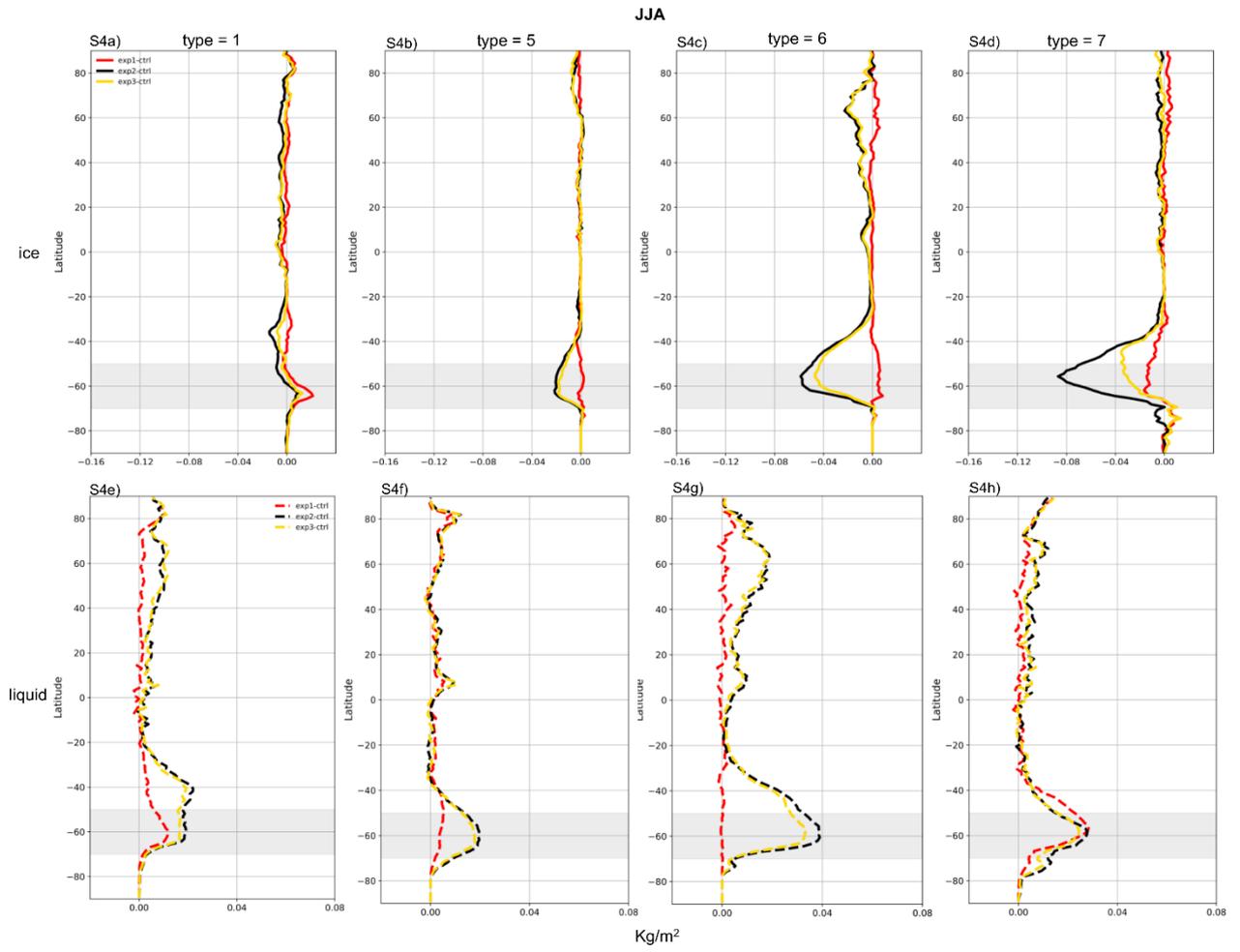


Figure S4. Similar to fig. S2 but for JJA

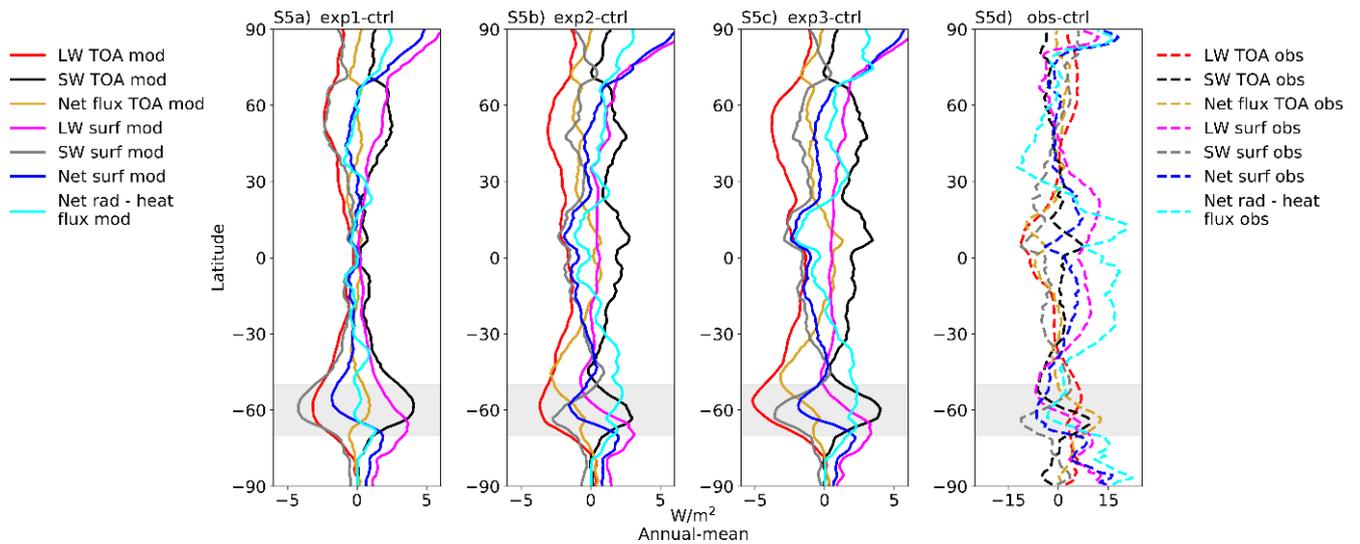


Figure S5. Global distribution of zonally averaged annual-mean radiative flux anomalies in various experiments and observational data with respect to the model control run for the SH. S5a) to S5c) LW and SW radiative fluxes (leaving the TOA as well as the net downward at the surface) for exp1 - control, exp2 - control and exp3 - control respectively. S5d) similar to (S5a) but for observational data - control. The colour codes are as follows: red = LW TOA, black = SW TOA, mustard = LW TOA + SW TOA, magenta = LW surface, gray = SW surface, blue = LW surface + SW surface, cyan = (LW surface + SW surface) - (sensible heat + latent heat). Solid lines represent radiative flux anomalies from model and dashed lines represent anomaly of observational data w.r.t control run. Annual-mean values for model are calculated from 12 hourly output over 20 years. Observational data consist of monthly mean values covering the period 2000-2018. The SO region identified in this study is highlighted in gray.

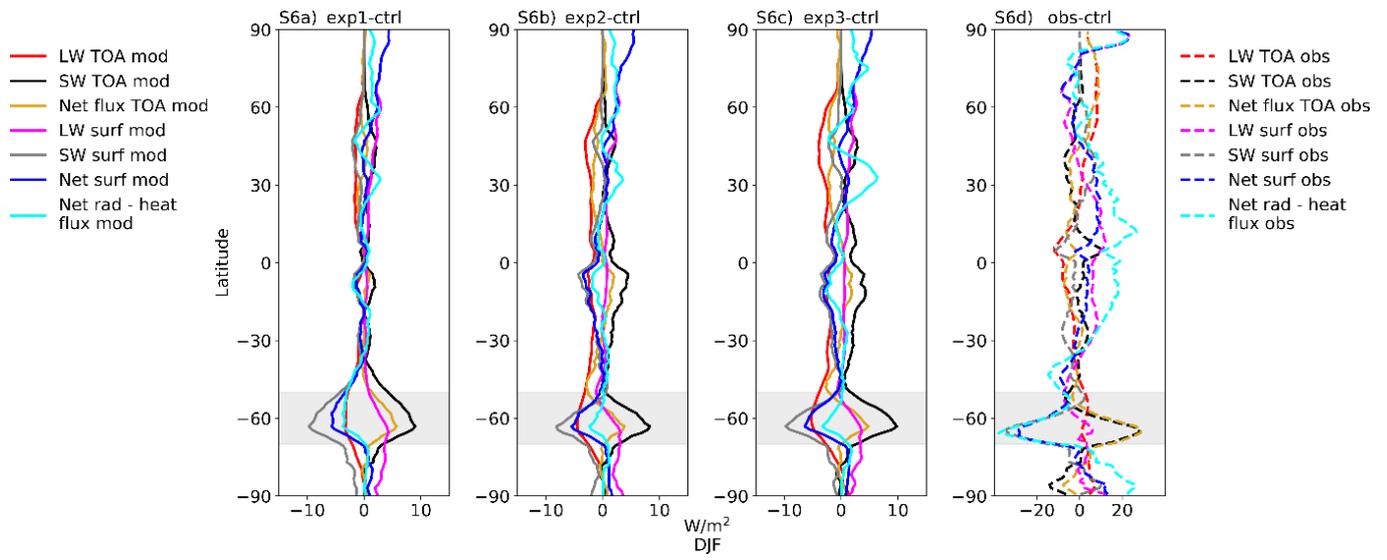


Figure S6. Similar to S5 but for DJF

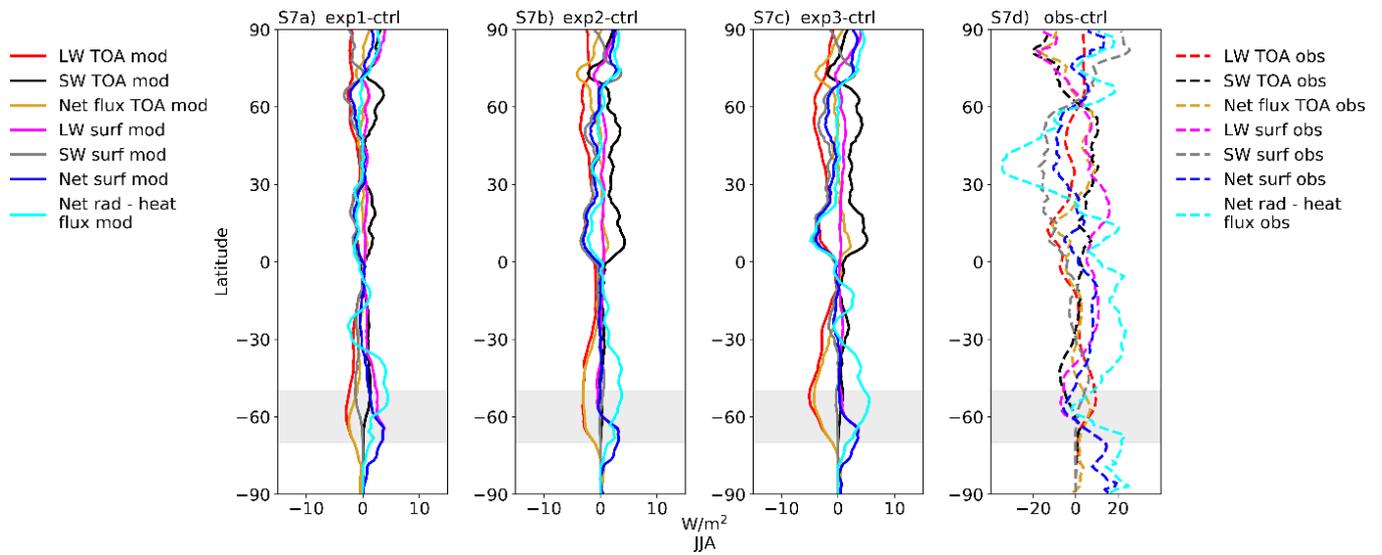


Figure S7. Similar to S5 but for JJA

In general, the response of radiative fluxes to changes in IWP/LWP are mostly pronounced over SH compared to NH.

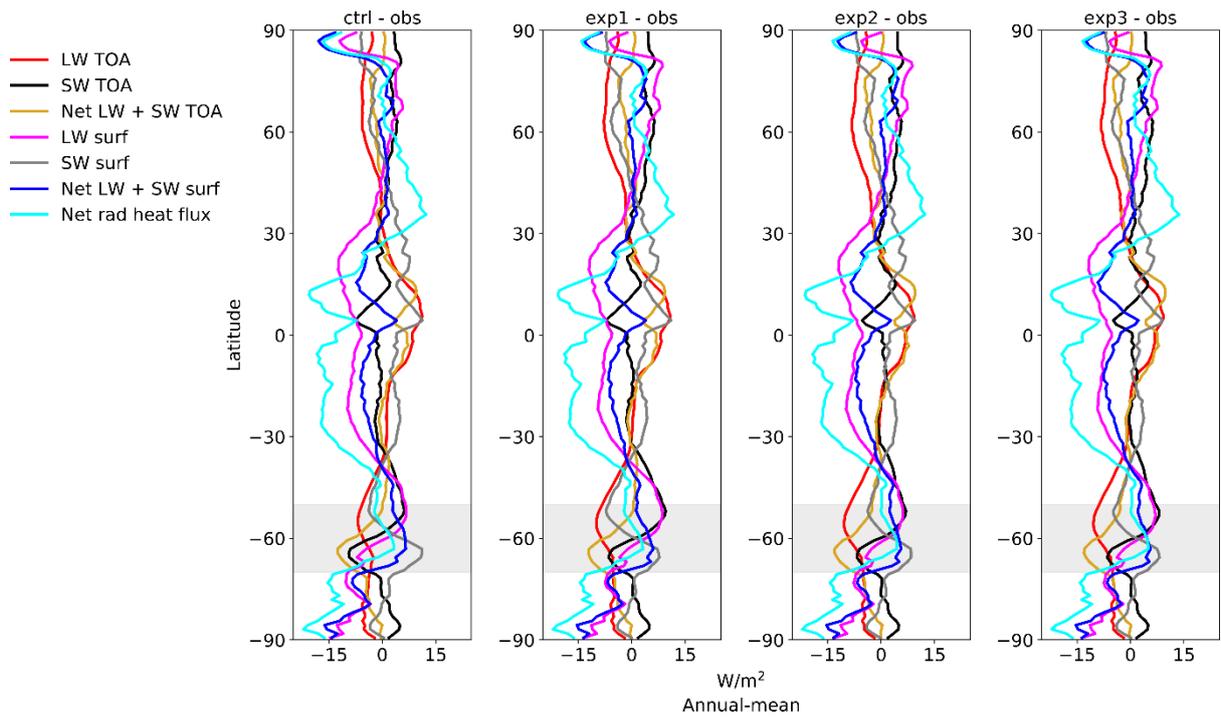


Figure S8. Similar to S5 but for model – observation (annual-mean)

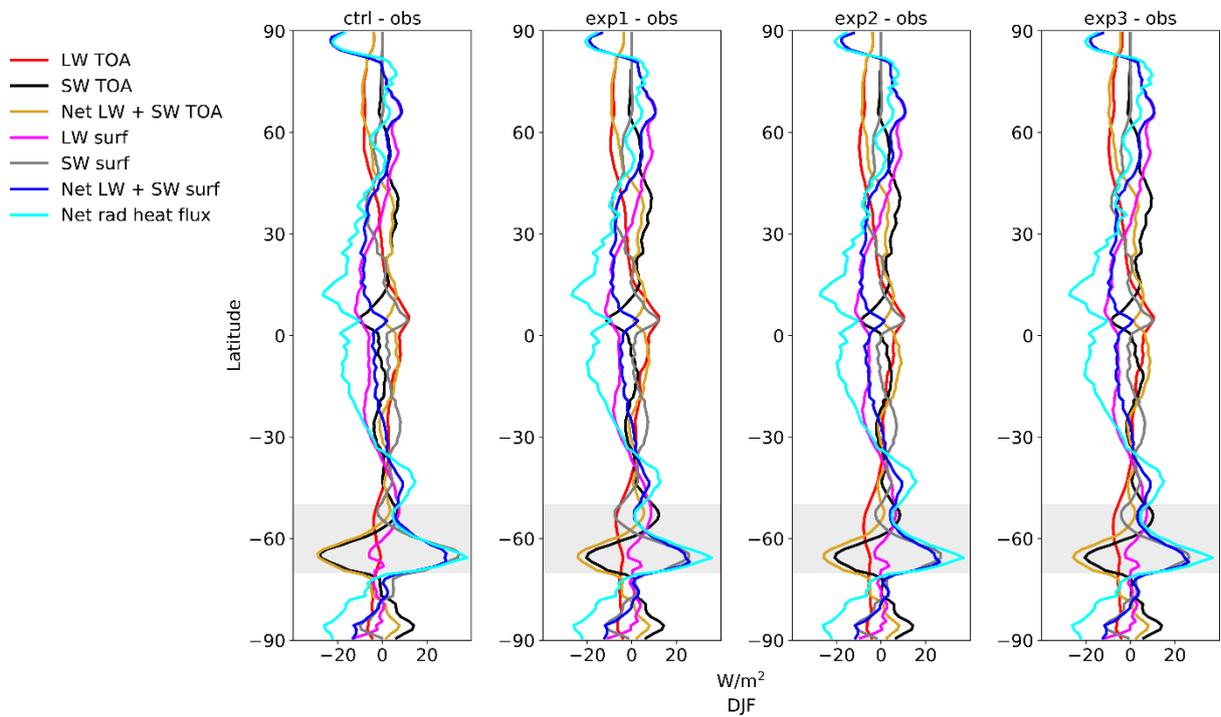


Figure S9. Similar to S5 but for model – observation (DJF)

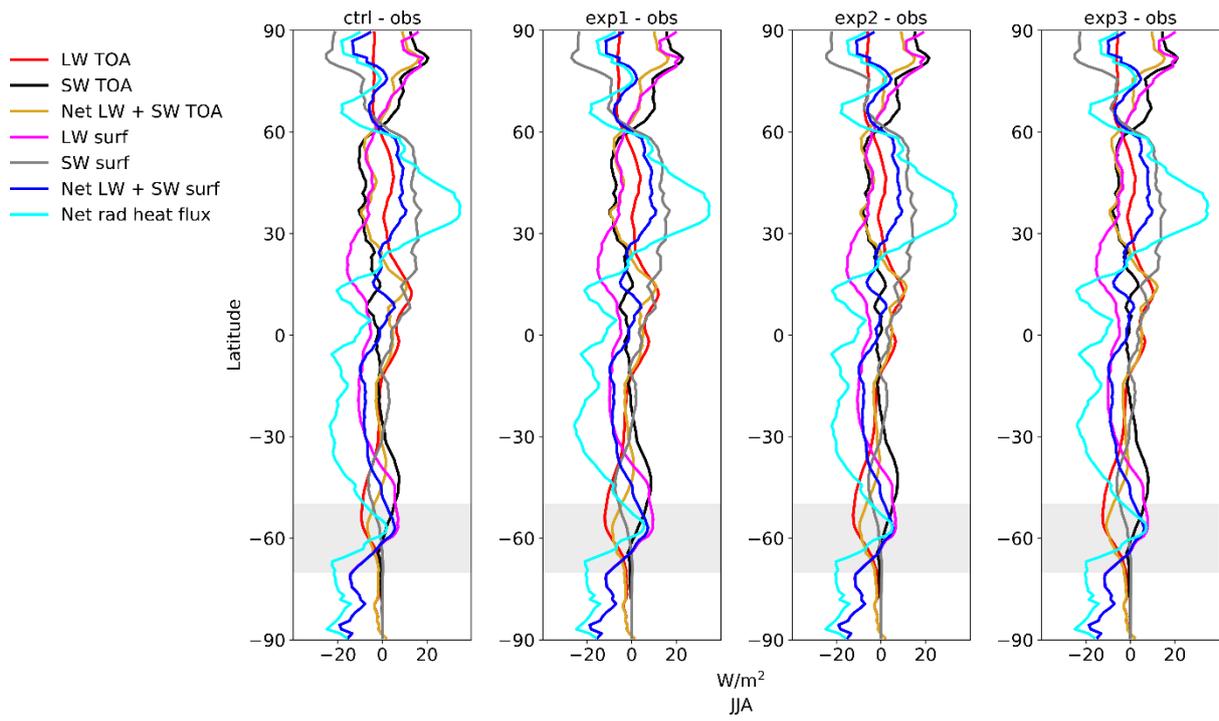


Figure S10. Similar to S5 but for model – observation (JJA)

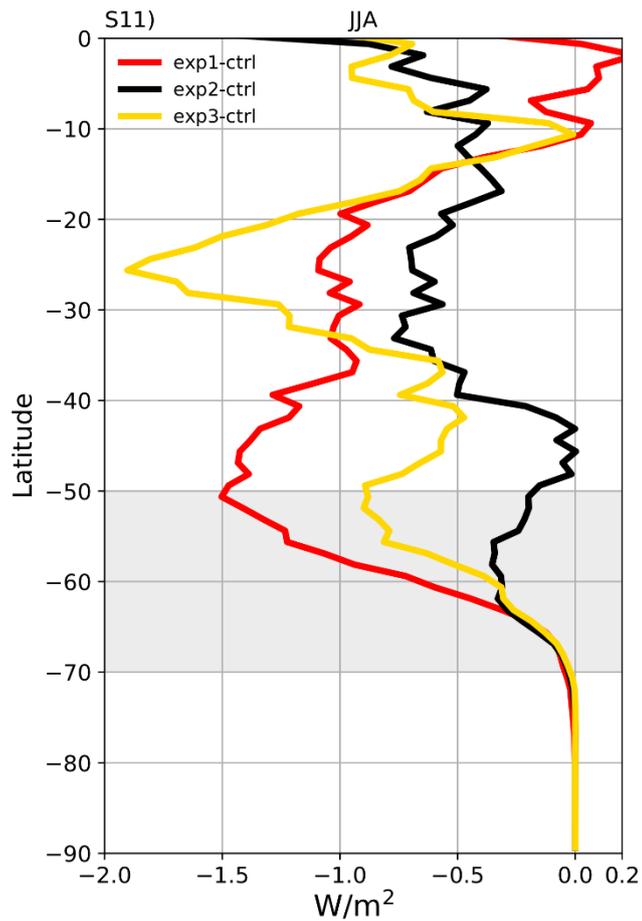


Figure S11. Distribution of zonally averaged SW CRE anomalies over SH in various experiments w.r.t the model control run for JJA mean. The colour codes are as follows: red = anomaly of exp1 with respect to control, black = anomaly of exp2 with respect to control, yellow = anomaly of exp3 with respect to control. Values are calculated from 12 hourly output over 20 years. The SO region identified in this study is highlighted in gray. (Similar to **Figure 5** of the main material but for JJA season)