Supplementary Materials for "A Refined Understanding of the Cloud Longwave Scattering Effects in Climate Model"

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Submitted to *Journal of Advanced Modeling Earth Systems*

Original submission on November 5, 2022

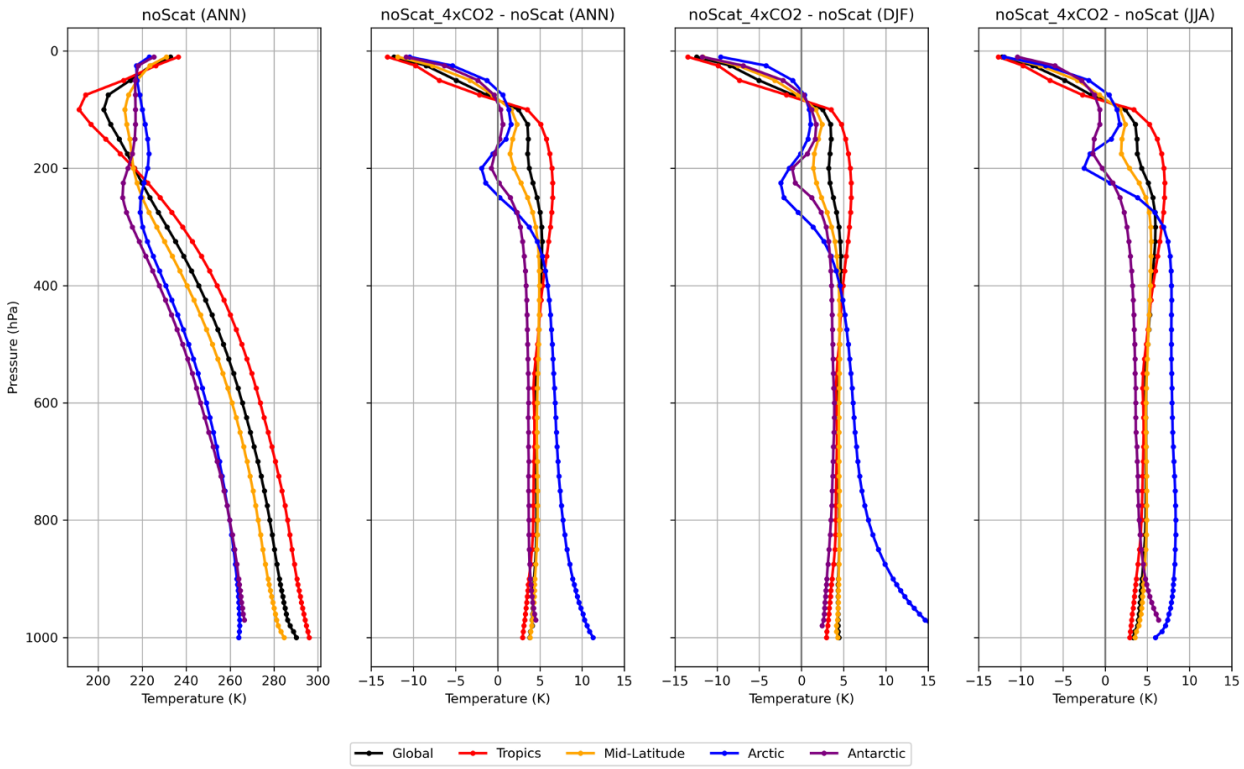


Figure S1. Similar to Figure 2, but the values are the atmospheric temperature changes from the abrupt 4xCO_2 simulation.

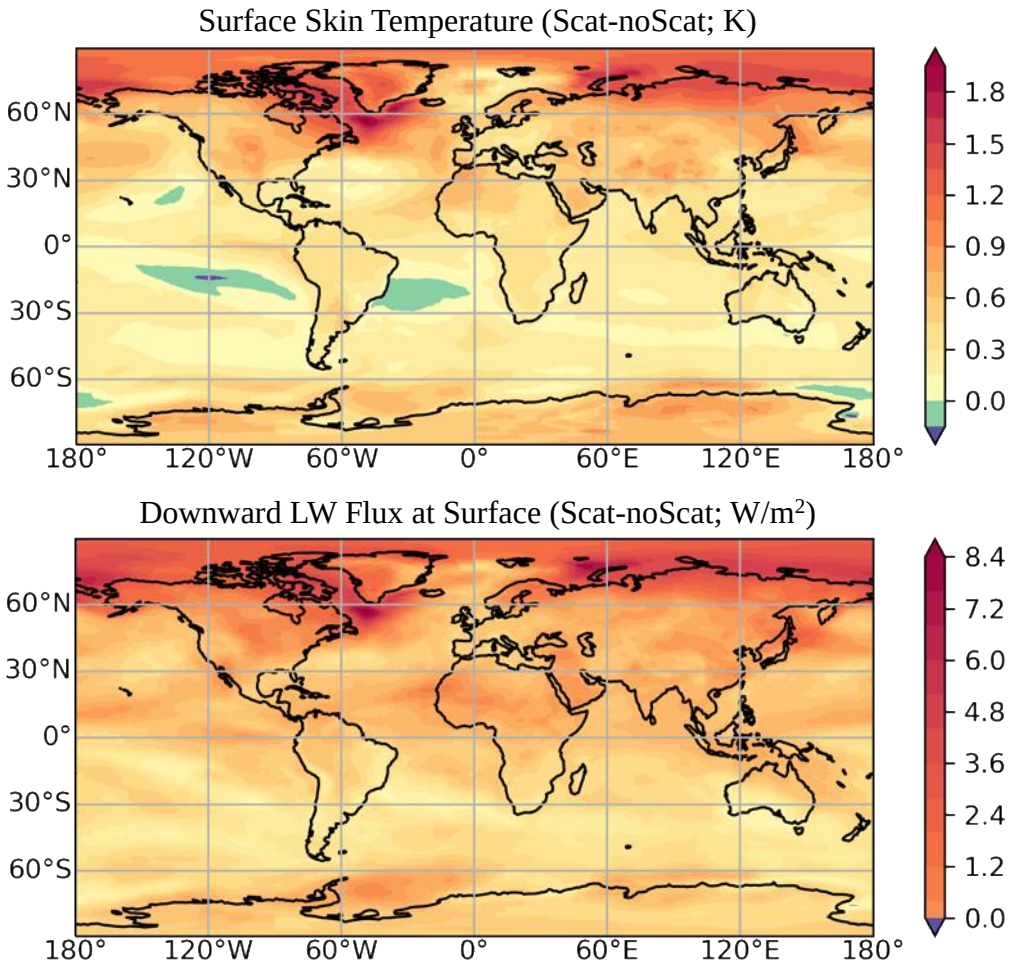


Figure S2. Spatial distribution of the 35-year mean difference in surface skin temperature and downward LW flux after including the cloud LW scattering effect.

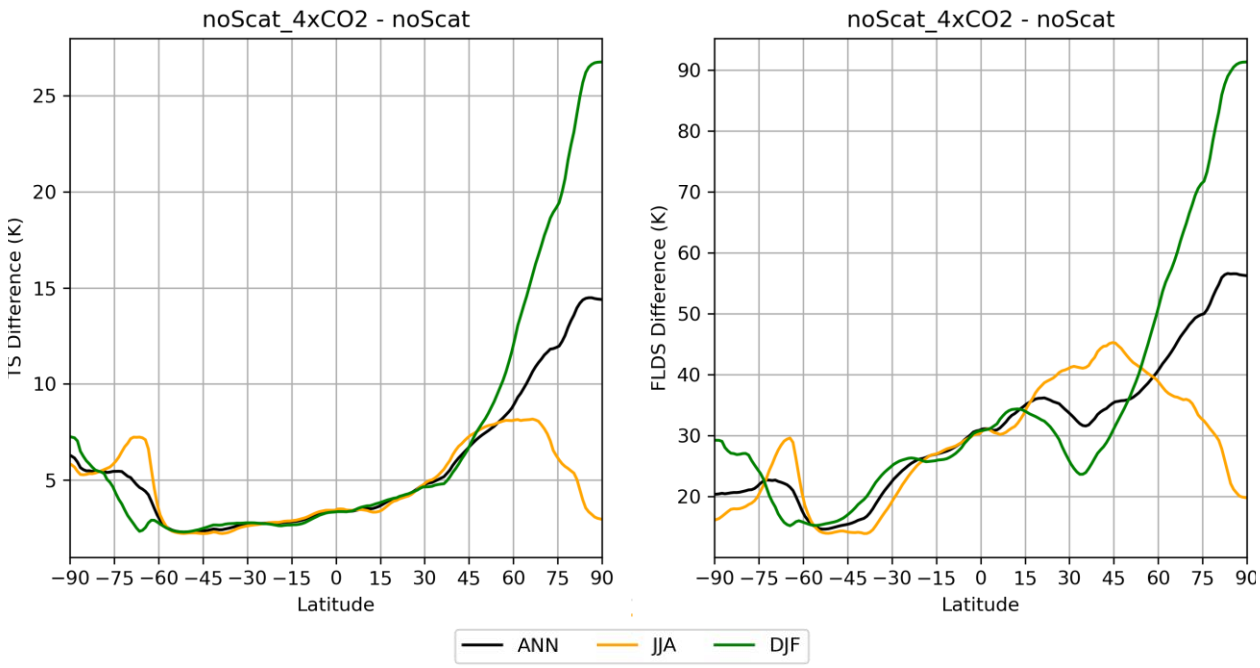


Figure S3. Similar to Figure 3, but the change is due to abrupt 4xCO_2 instead of ice cloud scattering.

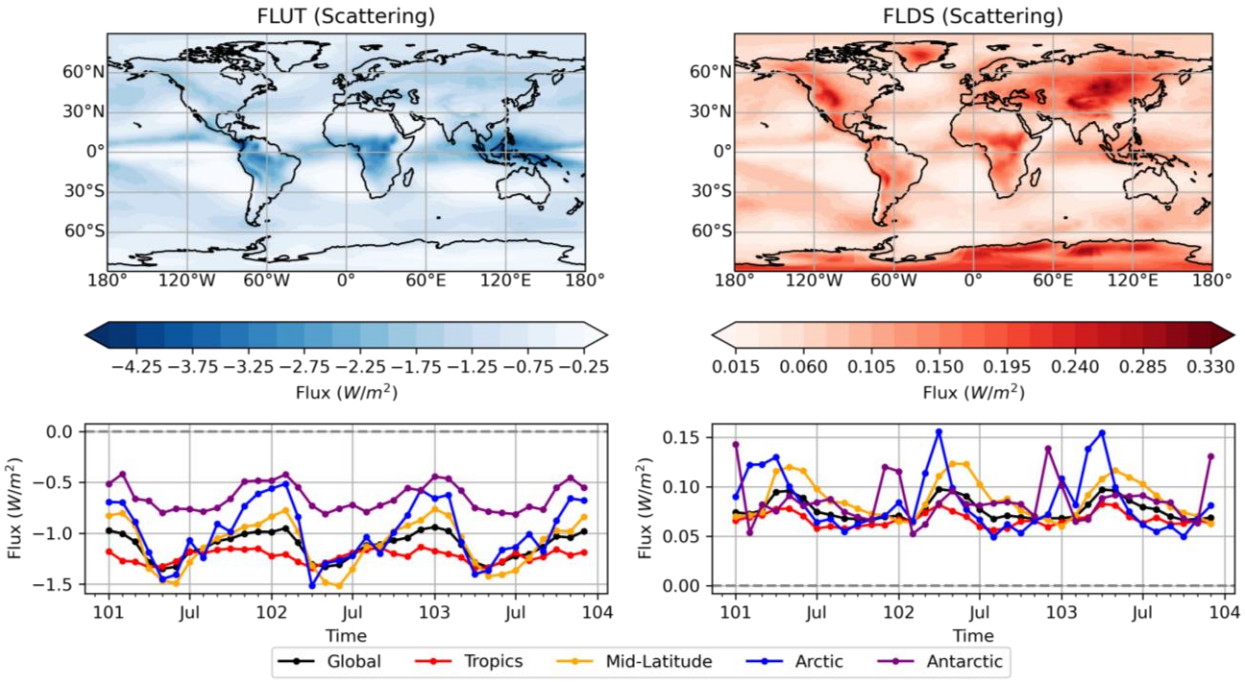
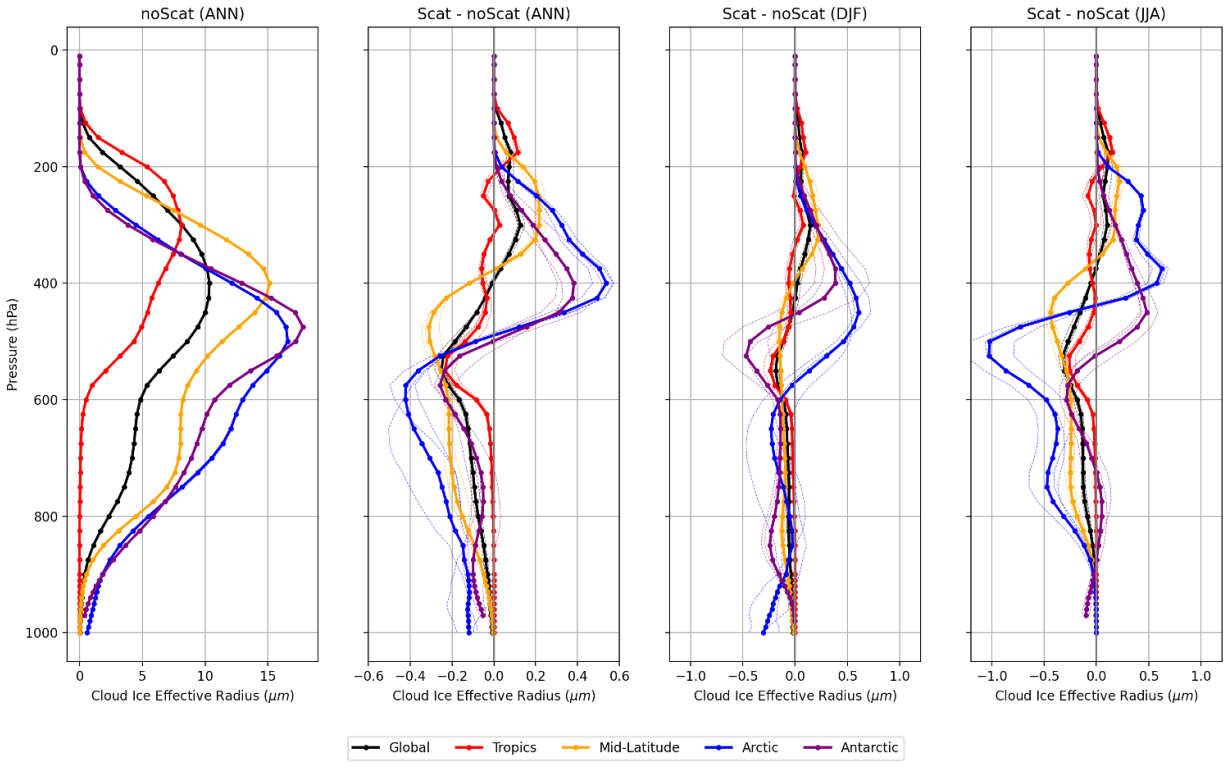


Figure S4. Changes in the upward longwave radiative flux at the top of the atmosphere (FLUT; left column) and the downward longwave radiative flux at the surface (FLDS; right column) due to the direct LW scattering effect. The top row shows the spatial distribution of the three-year mean change, and the bottom row shows the time series of global and regional mean changes in the first three years. Each tick on the x-axis of the bottom panels represents a month starting from January of the year 101.



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41 **Figure S5.** The same as Figure 2, but for the grid-box average of cloud ice particle effective radius.

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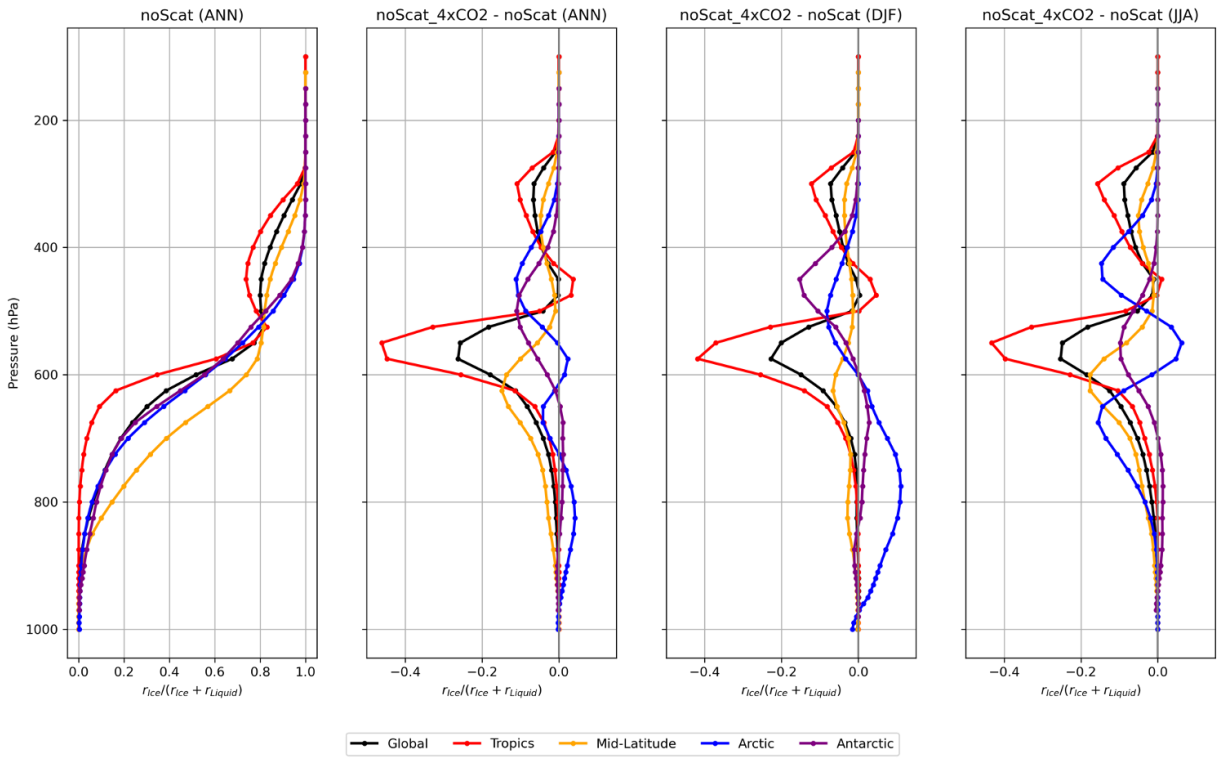
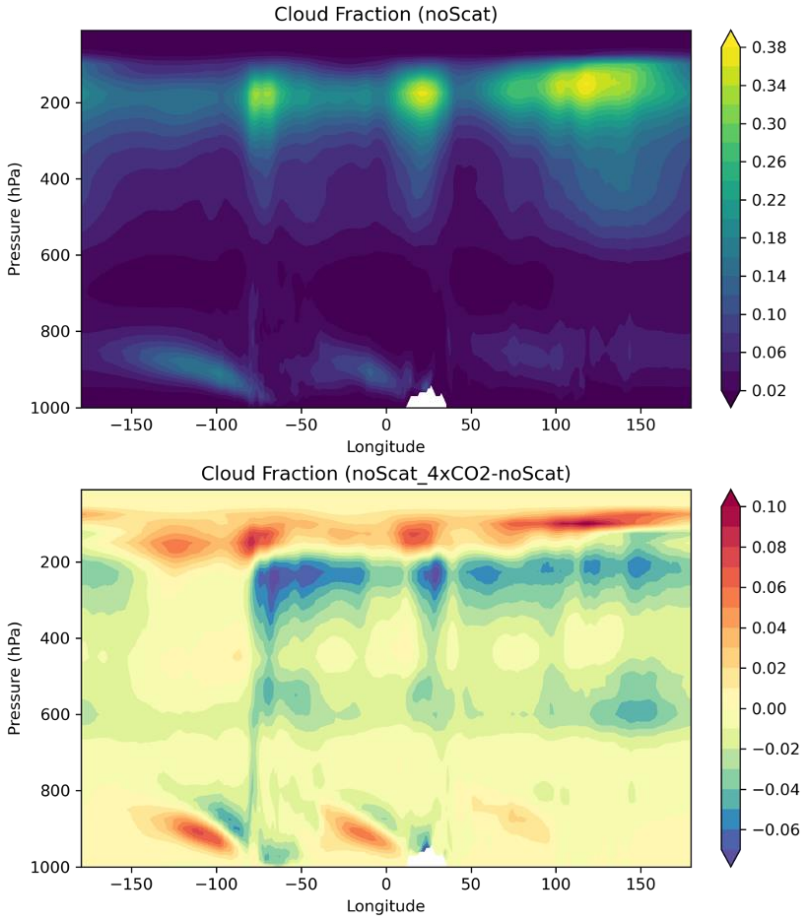


Figure S6. Similar to Figure 5, but the change is from the abrupt 4xCO_2 simulation.



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47 **Figure S7.** Similar to Figure 9, but the change is from the abrupt 4xCO_2 simulation.

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