Equator-to-pole temperature differences and the extra-tropical storm track responses of the CMIP5 climate models

Article

Supplemental Material

Supplementary Material

Title: Equator-to-pole temperature differences and the extra-tropical storm track responses of the CMIP5 climate models

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1 Description of Supplementary Figures 1-4

Supplementary Figures 1-4 show the responses of, and results of the regression between, the storm track responses and the zonal-mean equator-to-pole temperature difference responses using data from the RCP4.5 scenario. The Figures are presented for comparison with their RCP8.5 counterparts shown in Figures 2-5 respectively of the main paper. The method, including models, run numbers and time periods used, are identical to the analysis in the main paper.

As noted in the main paper, the RCP4.5 plots presented here are largely comparable to the RCP8.5 versions. The mean storm track responses (Supplementary Figure 1) and the equator-to-pole temperature difference repsonses (Supplementary Figure 2) are qualitatively similar to the RCP8.5 versions, and appear to scale roughly linearly with the mean global surface temperature responses. With the exception of NH DJF, the regression

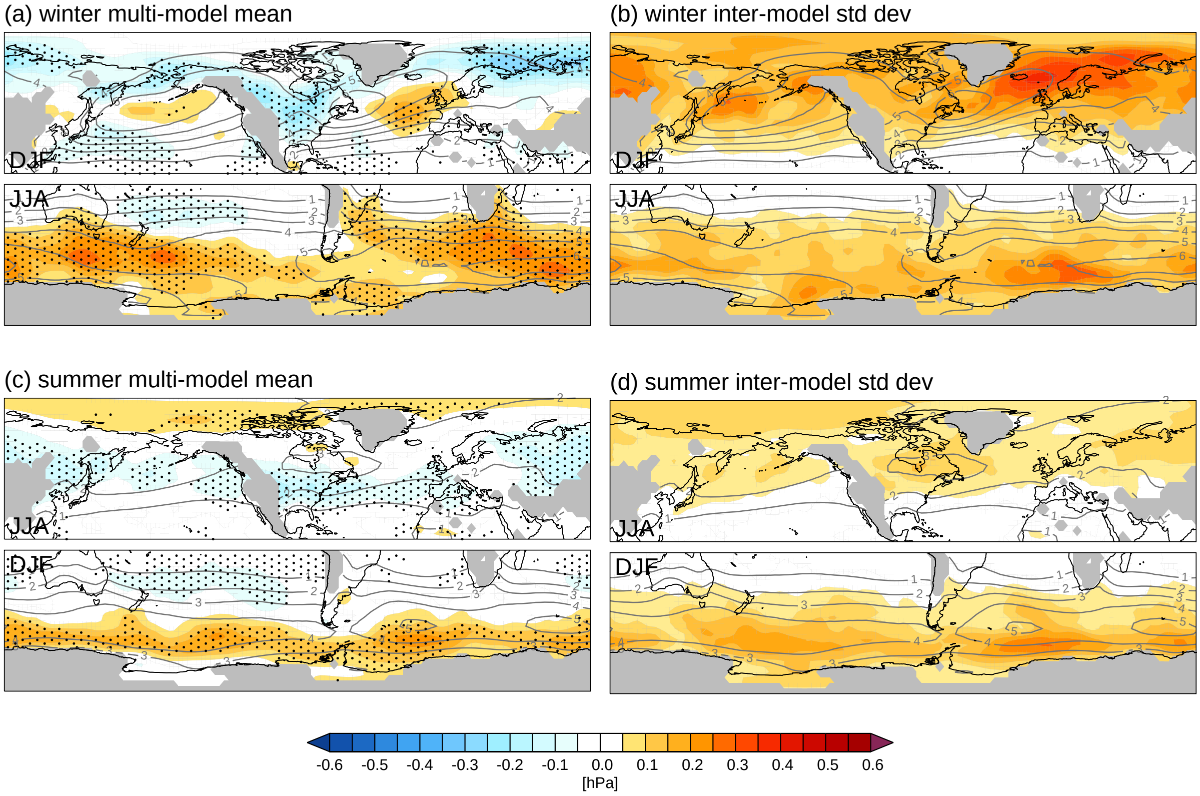

Figure 1: RCP4.5 version of Figure 2 in the main paper.

maps (Supplementary Figure 3) show remarkably similar regression slope values to the RCP8.5 values. The corresponding FVE values (Supplementary Figure 4) are in general smaller in RCP4.5 than RCP8.5 and the regions with significant correlation (stippling in Supplementary Figure 3) are less extensive in RCP4.5 than RCP8.5. These features are consistent with a smaller signal-to-noise ratio in RCP4.5 due to the weaker forcing in that scenario. Regarding NH DJF, there is a strong association between the $\Delta T850$ responses and the storm track responses at the downstream end of the North Atlantic storm track in RCP4.5, a feature which is weaker in RCP8.5. This is apparent in the FVE (Supplementary Figure 4**a**) as well as in the size of the region with a significant correlation (stippling in Supplementary Figure 3**a**). The reason for this difference between the scenarios is not clear from the present analysis. However, the regressions using the longitudinally-confined measures of the equator-to-pole temperature difference presented in Supplementary Material Section 3 do shed some light on the problem.

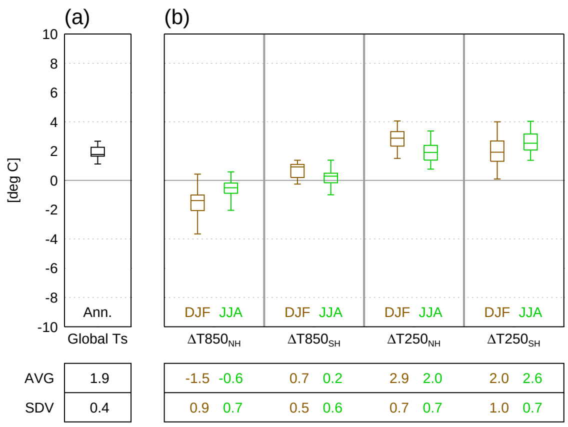

Figure 2: RCP4.5 version of Figure 3 in the main paper.

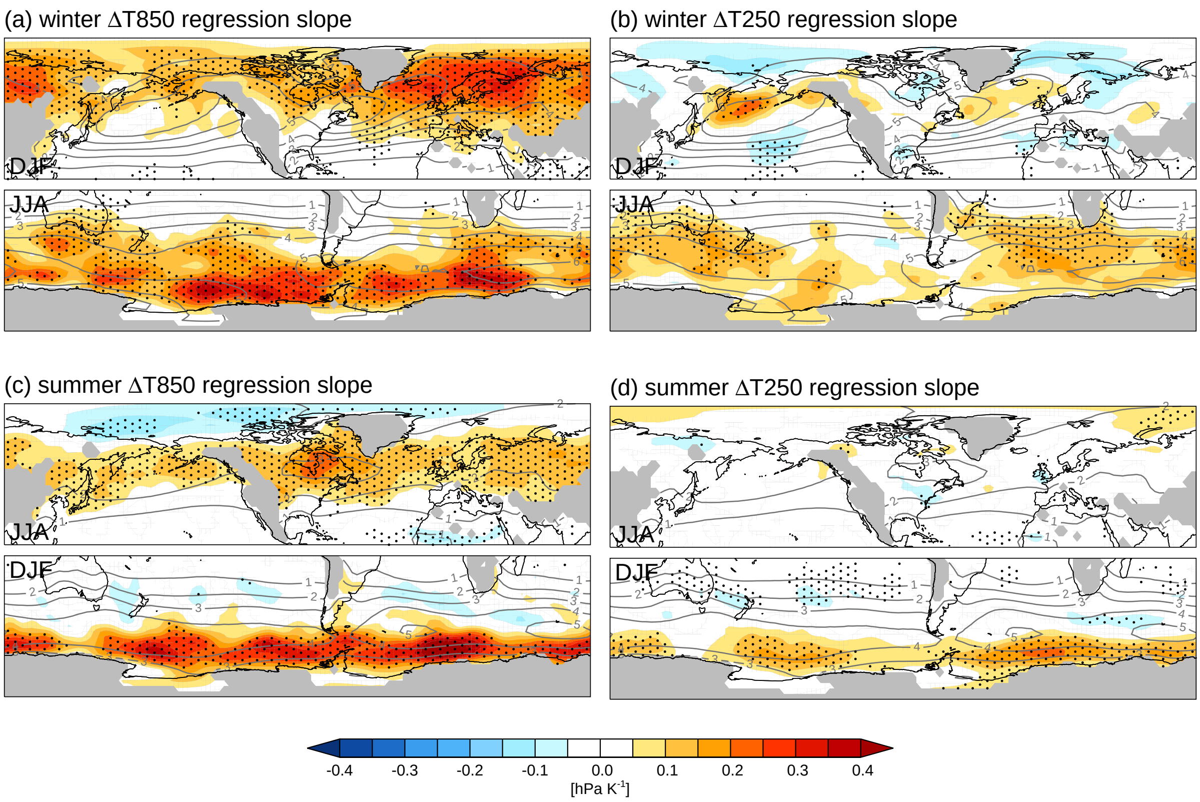

Figure 3: RCP4.5 version of Figure 4 in the main paper.

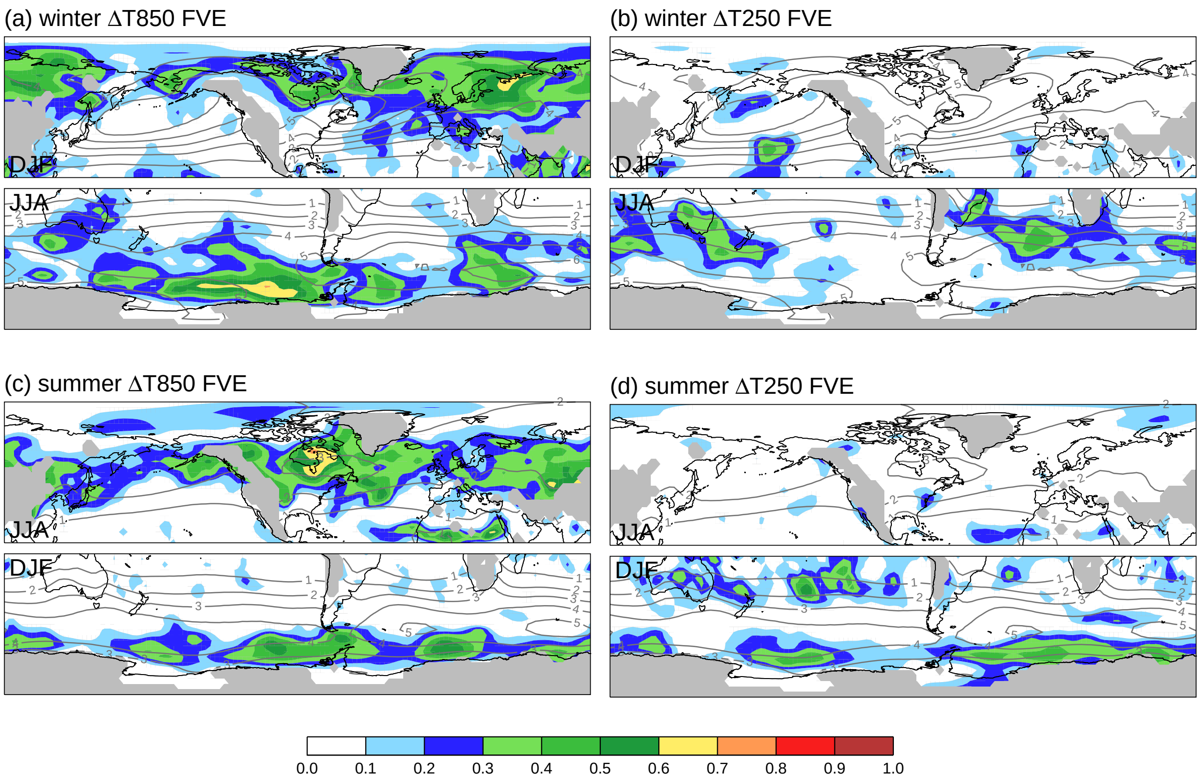

Figure 4: RCP4.5 version of Figure 5 in the main paper.

2 Description of Supplementary Figure 5

Supplementary Figure 5 shows the results of a regression between the storm track responses and the global mean surface temperature responses using data from the RCP8.5 scenario. The Figure is presented for comparison with the the zonal-mean temperature difference regressions of the main paper (Figures 4 and 5). The regression analysis here was performed in a similar fashion to those in the main paper, using Equation (2) with $\Delta T_{\mathrm{resp},i}$ replaced by $T\mathrm{s}_{\mathrm{resp},i}$, the responses of the global mean surface temperature for each model.

The Ts regression maps (Supplementary Figure 5) are qualitatively similar to the $\Delta T250$ regression maps (Figures 4 and 5, panels **b** and **d**, of the main paper) in the SH in both seasons and in the NH in DJF. Consistent with this, the Ts responses are correlated with the $\Delta T250$ responses in these seasons ($r = 0.89$ and 0.79 for SH DJF and JJA and $r = 0.78$ for NH DJF). The FVE maps and the regions of significant correlation however show a weaker association between the storm track responses and the Ts responses than the $\Delta T250$ responses, which suggests that the processes driving the changes are related more closely to the $\Delta T250$ responses than the Ts responses. In contrast to these three seasons, the Ts and $\Delta T250$ regression maps look less similar in NH JJA, and consistent with this, the inter-model correlation between these two variables is smaller ($r = 0.36$) in that season. The reason for this smaller correlation is not clear, but may be related to the differences in the vertical structure of the Arctic warming in summer and winter (e.g. Graversen et al. (2008), Screen & Simmonds (2010)). Interestingly, the JJA storm track response over the Arctic is more stongly associated with the Ts responses than with either of the temperature difference variable responses. This relationship may be due to the influence of Arctic sea-ice loss on the development and life span of Arctic summer cyclones (e.g. Simmonds & Rudeva (2012)), however further work is needed to confirm this result.

3 Description of Supplementary Figures 6 and 7

Supplementary Figures 6 and 7 show the results of the regression analysis between the storm track responses and the Atlantic and Pacific equator-to-pole temperature difference responses using data from the RCP4.5 scenario.

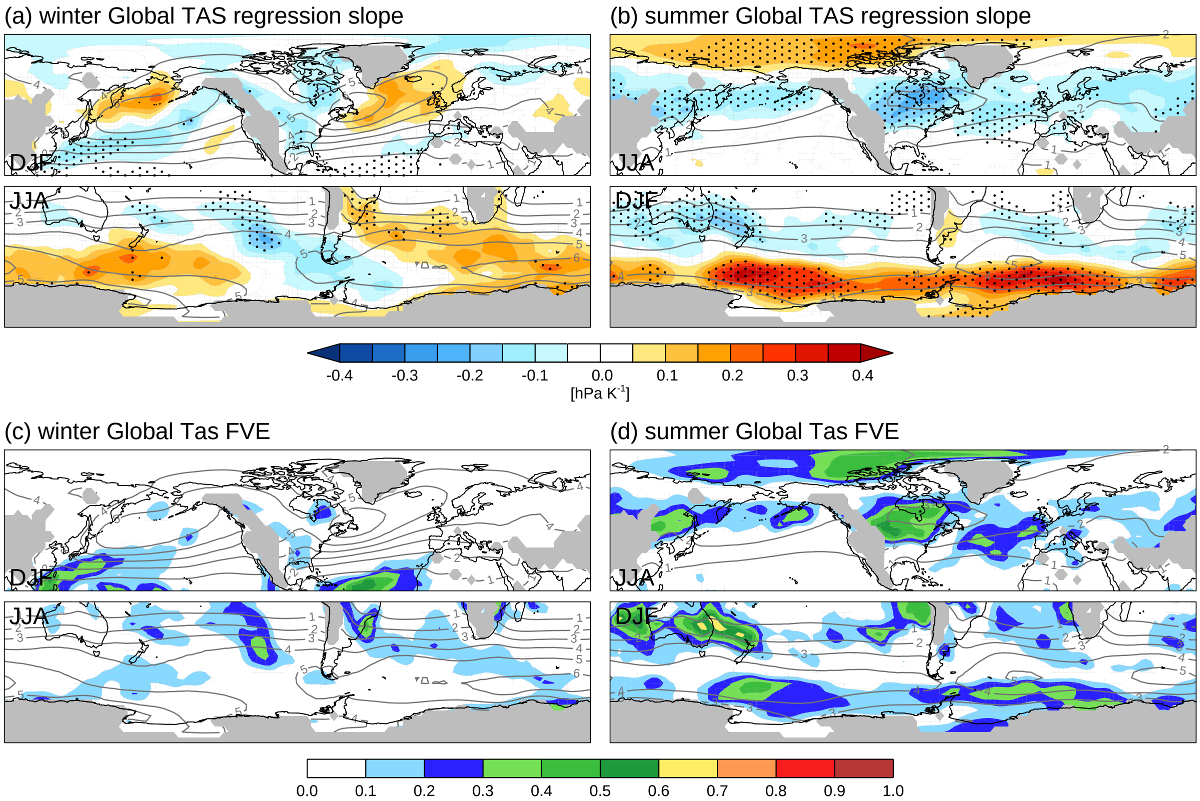

Figure 5: The inter-model regression between the storm track responses and the responses of the global mean surface temperature, Ts. Panels **a** and **b** show the regression slope for winter and summer respectively; *stippling* indicates a significant correlation at the 95% confidence level. Panels **c** and **d** show the fraction of inter-model storm track variance explained by the Ts regression in winter and summer respectively.

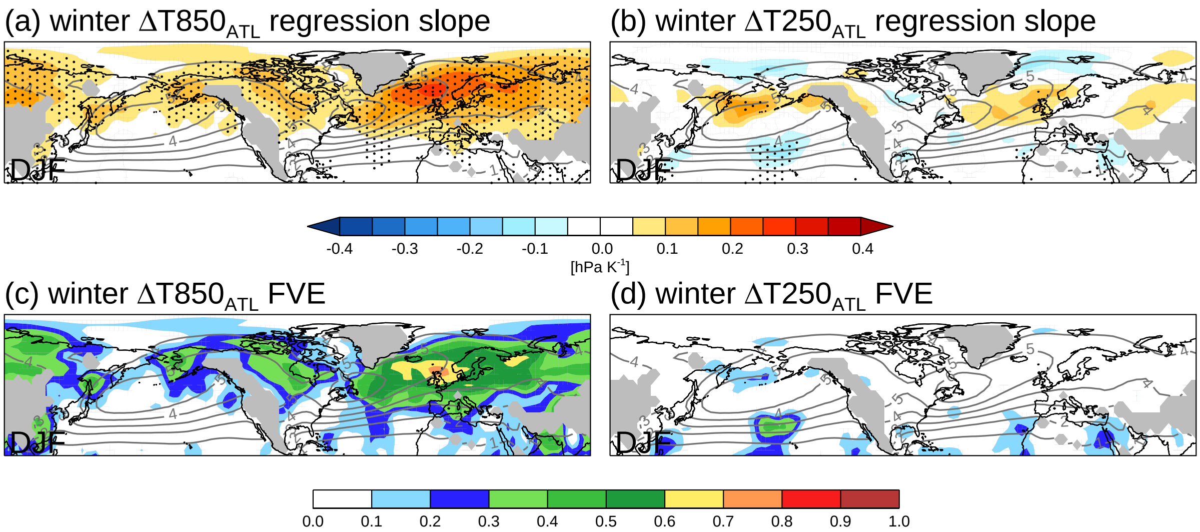

Figure 6: RCP4.5 version of Figure 8 in the main paper.

The Figures are presented for comparison with their RCP8.5 counterparts shown in Figures 8 and 9 respectively of the main paper. The method, including models, run numbers and time periods used, are identical to the analysis in the main paper.

As noted in the main paper, the RCP4.5 plots presented here are largely comparable to the RCP8.5 versions. In particular, the association between the North Atlantic storm track responses and the $\Delta T850_{\mathrm{ATL}}$ responses matches closely the RCP8.5 version, a feature which is not evident in the $\Delta T850$ regression maps of Supplementary Figures 3 and 4 and Figures 4 and 5 of the main paper. Therefore the lack of association between the Atlantic storm track responses and the responses of $\Delta T850$ in RCP8.5 is due to a lack of association between $\Delta T850_{\mathrm{ATL}}$ and $\Delta T850$ in that scenario. Given the dominance of the polar temperature responses in the responses of these temperature differences, it is possible that this difference is due to differences in the relative magnitudes of Atlantic and Pacific sector ice loss in the two scenarios. However, an analysis of the geographical location of the ice loss in the two scenarios, and the corresponding inter-model spreads, is needed to confirm this.

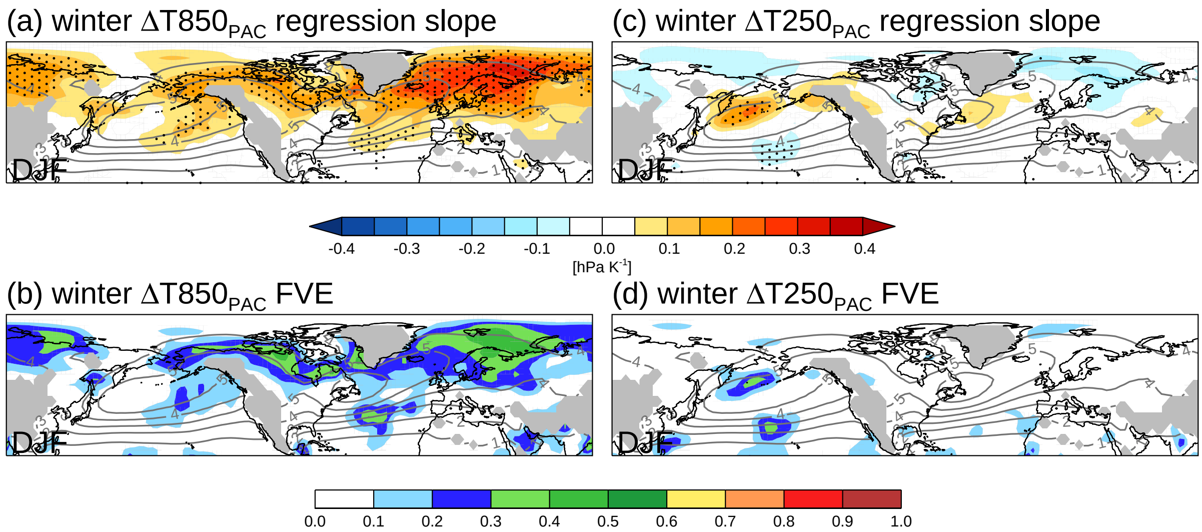

Figure 7: RCP4.5 version of Figure 9 in the main paper.

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Screen, J. A. & Simmonds, I. 2010 The central role of diminishing sea ice in recent Arctic temperature amplification. *Nature* **464**, pp. 1334–1337.

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