Session: C36 Poster: Th54A

Structure and mechanisms of tropospheric circulation change in a warming climate

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Model projections generally agree that the tropospheric general circulation widens in a warming climate. The mechanisms behind the widening, on the other hand, are still poorly understood. One confounding factor is that the atmosphere responds directly to radiative forcings, but also indirectly through the resulting sea surface temperatures. A given forcing may thus produce circulation shifts through multiple dynamical mechanisms. In order to isolate the direct and indirect, we examine long time-slice simulations performed with an atmospheric model using perturbed greenhouse gases, stratospheric ozone, and sea surface temperatures. Our work concerns (1) the sensitivity of circulation widening to various forcings, and (2) mechanisms behind the widening. We examine the sensitivity to a given forcing in terms of the annual mean and seasonally varying circulation response. We evaluate previously proposed widening mechanisms by analyzing how the shifts in circulation features relate to each other. We also test whether the same relationships hold on interannual as well as long-term time-scales. Our data reveal year-round widening in simulations with perturbed ozone, greenhouse gases and sea surface temperatures, as well as a pronounced seasonal cycle under all forcings. The mechanisms behind the various circulation responses are discussed.