Supporting Information for "The Role of Climatological State on Driving US Heat Waves Through Rossby Waves Packets"

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Introduction

This document includes a more detailed description of the model used for the three simulations in this work. In addition, two figures with a comparison of the climatological state between the experiments and the reanalysis data.

1. Description of the Dry Core GCM

Idealized general circulation models are commonly used for the study of atmospheric dynamics. This kind of models solve the primitive equations by nudging the temperature toward a prescribed equilibrium temperatures (T_{eq}). Essentially, this process isolates the dynamics from the complex physical parametrizations. However, as the primitive

equations are solved on the sphere, there is some confidence that large-scale dynamics relate to the real atmosphere. In this work, we use the open-access updated version from (Wu & Reichler, 2018) of the spectral dynamical core model proposed by (Held & Suarez, 1994) for the Geophysical Fluid Dynamics Laboratory (GFDL).

The model has horizontal resolution of T42 (64x128 grid) and 40 vertical σ levels between the surface and 0.01 hPa. Rayleigh drag with a prescribed rate, which decreases linearly with height from a surface value k_f to zero at ($\sigma = 0.7$) and higher levels, is used to remove momentum from the low levels, representing the boundary-layer friction. Mathematically, this can be written by:

$$\frac{\partial v}{\partial t} = ... - k_v(\sigma)v \tag{1}$$

Where v represents the wind and σ the vertical sigma level. The damping rate (k_v) follows the form:

$$k_v = k_f max\left(0, \frac{\sigma - \sigma_b}{1 - \sigma_b}\right) \tag{2}$$

where $k_f = 1day^{-1}$ and $\sigma_b = 0.7$ is the vertical level in the model where the top of the boundary layer is defined. The temperature is forced by Newtonian relaxation toward a prescribed equilibrium temperature as follows:

$$\frac{\partial T}{\partial t} = \frac{T - T_{eq}}{\tau} \tag{3}$$

where τ is the prescribed relaxation timescale following the distribution:

$$\tau^{-1} = k_a + (k_s - k_a) max\left(0, \frac{\sigma - \sigma_b}{1 - \sigma_b}\right) cos^4\phi \tag{4}$$

where $k_a = 1/40\ day^{-1}$ and $k_s = 1/4\ day^{-1}$ are parameters to set the distribution of the relaxation coeficient. In this model, the T_{eq} is zonally symmetric and is easily set through parameters. Since the primary purpose of this study is to examine how the atmospheric basic state controls the pattern contained in Rossby Waves driving heat waves, the model includes the iterative procedure proposed by (Chang, 2006) to simulate the climatological basic state of the atmosphere in the idealized model. This consists of iterating the radiative equilibrium temperature profile so that at the end of the iterations, the model climate closely resembles the desired target climate. The iteration uses a fixed equilibrium temperature for each N step (T_{eq}) in a run of Y years. Then, we calculate the model simulated temperature climatology $T_{(N)}$ and correct it concerning basic state from the NCEP reanalysis data T_R. The next iteration step N+1 is calculated according to:

$$T_{eq(N+1)} = T_{eq(N)} - \frac{2}{3}(T_{(N)} - T_R), N = 1, 2, 3... \tag{5}$$

References

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Wu, Z., & Reichler, T. (2018). Towards a more earth-like circulation in idealized models. Retrieved from https://doi.org/ doi: 10.1029/2018MS001356

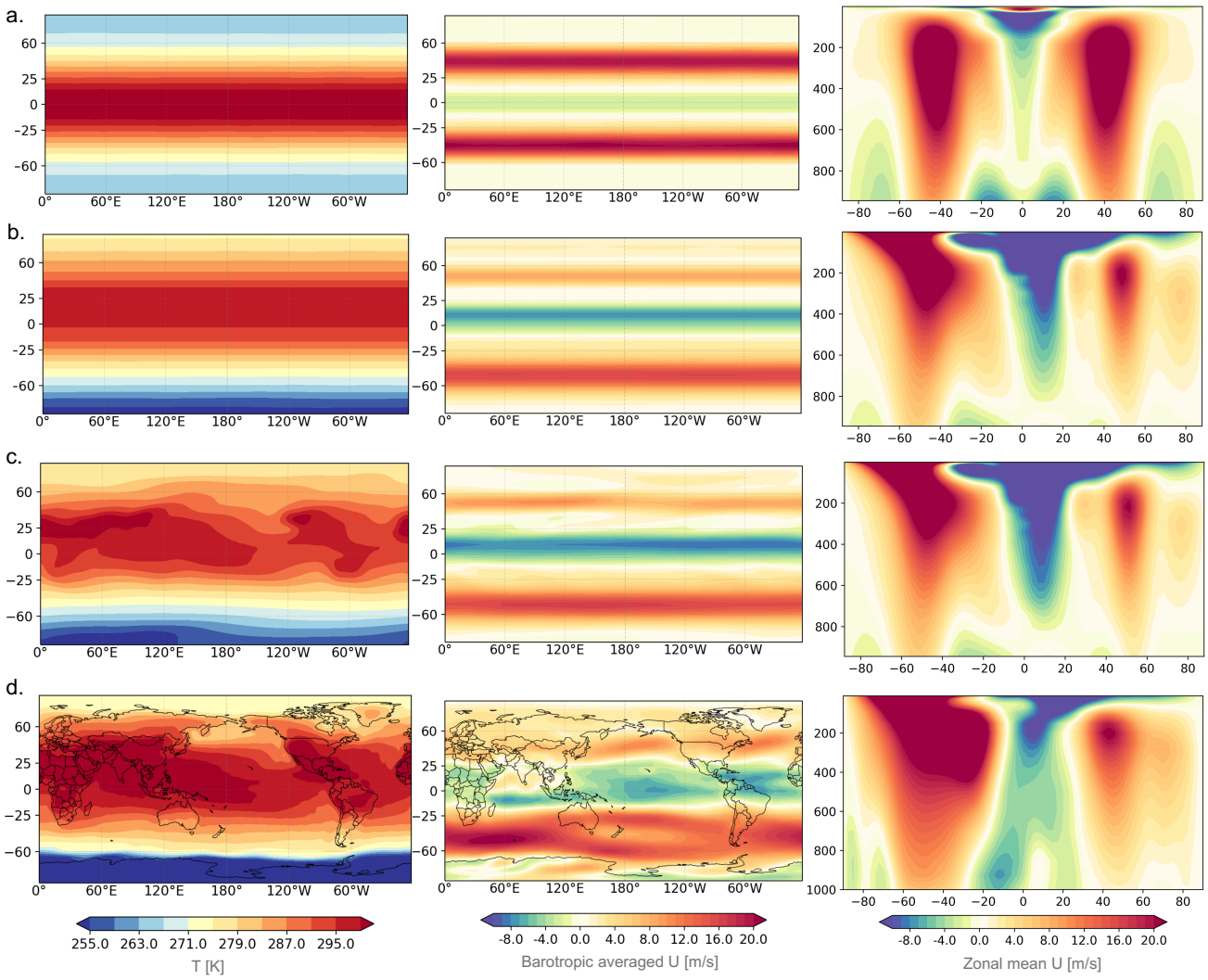

Figure S1. Basic state of the surface air temperature (SAT) (left column), the barotropic averaged zonal wind (middle column) and the vertical distribution of the zonal wind (right column) for the Held and Suarez 1994 (exp1_HS94) experiment (a.), the bias corrected experiment with the symmetrical SAT from NCEP (b.), the bias corrected experiment with the asymmetrical SAT from NCEP (c.) and NCEP (d.).

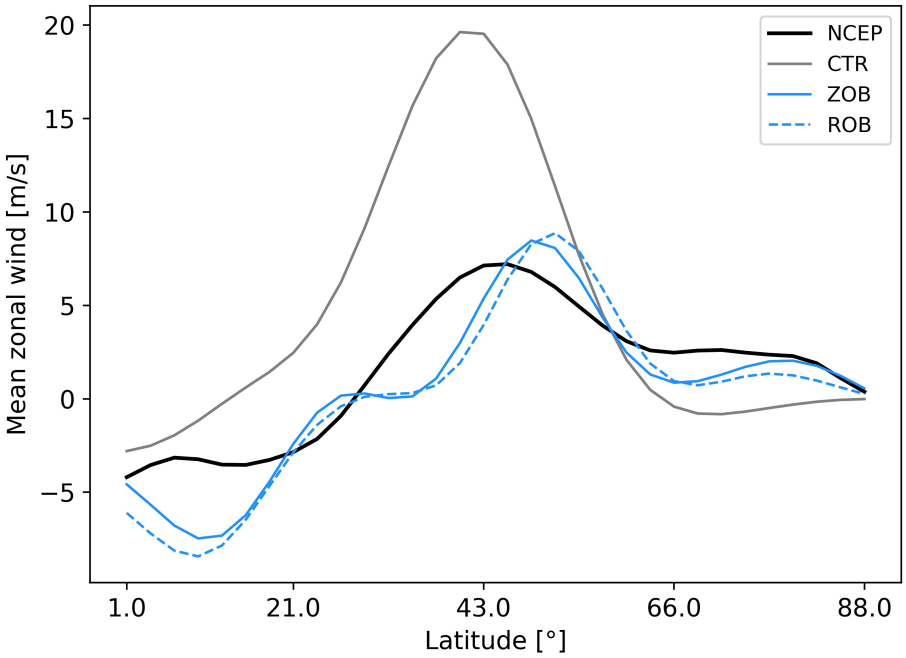

Figure S2. Comparison of the barotropic zonal mean zonal wind between NCEP, the Held and Suarez 1994 (exp1_HS94) experiment and the bias corrected experiments.