CHANGES IN THE CONVECTIVE POPULATION AND ASSOCIATED ENVIRONMENTS IN CONVECTION-ALLOWING REGIONAL CLIMATE SIMULATIONS OVER SOUTH AMERICA

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1) INTRODUCTION

South America is a continent that extends mostly over the Southern Hemisphere, with a considerable meridional extent (10N-55S) that supports a diversity of climate conditions, including tropical, subtropical, and midlatitude characteristics. It has been recognized as one of the places where some of the most intense convective storms on Earth take place, based on TRMM satellite observations (Zipser et al., 2006). This fact has attracted the interest of the scientific community in Atmospheric Sciences to the point of deploying massive international field campaigns in Southeast South America (SESA) such as CACTI (Varble et al., 2021) and RELAMPAGO (Nesbitt et al., 2021). However, there are many other regions across the continent where convective activity has been understudied (e.g., South Pacific, western South America, Patagonia, Andes Mountains). Recently, the Nacional Center for Atmospheric Research (NCAR) has been conducting 20-year convection-permitting simulations over the entire South American continent for current and future climate (the latter using a Pseudo Global Warming (PWG) approach). Hence, these products can be used to explore those regions where sparse data have prevented research on convective activity to be performed before. The main purpose of the present research is to describe the convective population and how it may change under a warmer climate across different subregions in South America.

2) DATA AND METHODS

WRF high-resolution (4km) regional modeling of the atmosphere was conducted over a domain that encompasses the entire South American continent and surrounding oceans. This horizontal resolution allows to resolve convection explicitly in the model. The modeling consists of a 20-year control (CTRL) simulation spanning between 2000 and 2020 and a 20-year future simulation using a PGW approach that applies a perturbation in the thermodynamic environment related to a specific climate warming scenario. The variables utilized correspond to composite reflectivity (for classification of convective and stratiform components of radar echoes) as well as other variables related to dynamic and thermodynamic environments (e.g., geopotential, temperature, specific humidity, winds at different vertical levels). To summarize and compare different results across distinct subregions, the continent will be divided following the IPCC AR6 subregions (Iturbide et al., 2020).

An important step before conducting climatological analysis based on the entire modeling period is to validate the model performance in reproducing the convective/stratiform classification objects from observations properly. This will be conducted for three independent events that took place during the RELAMPAGO field campaign, where strong convection developed over an extensive portion of SESA. GPM satellite-derived reflectivity as well as ground-based radar available during these events will be utilized to conduct the comparison. Thermodynamic and dynamic environments from the CTRL run will be also contrasted to the environments observed by sounding data collected during RELAMPAGO for the same case studies.

To analyze the climatological characteristics of convective radar echoes, we will examine those identified by a classification algorithm developed for this purpose as convective or stratiform. Within the convective category, subcategories of deep convective core (DCC) and wide convective core (WCC) will be defined, based on reflectivity intensity and height thresholds for the former, and reflectivity intensity and horizontal extent thresholds for the latter (Houze et al., 2015). Frequency distribution of the different classification categories will be calculated for all the subregions, so most frequent radar echoes for every subregion as well as subregion differences in categories across South America can be obtained. In addition, a Contoured Frequency by Altitude Diagram (CFAD; Yuter and Houze, 1995) will be generated for every subregion. This is a useful method to compare radar echoes between regions having different absolute frequencies. Finally, a comparison of the CTRL run findings will be contrasted to the PGW run results for a warmer climate. An example figure of the type of present versus future climate comparison that can be made is shown in Figure 1. The ultimate goal is to assess what areas in South America are expecting changes in the convective population, which can give insights about the storm modes becoming more frequent in the future.

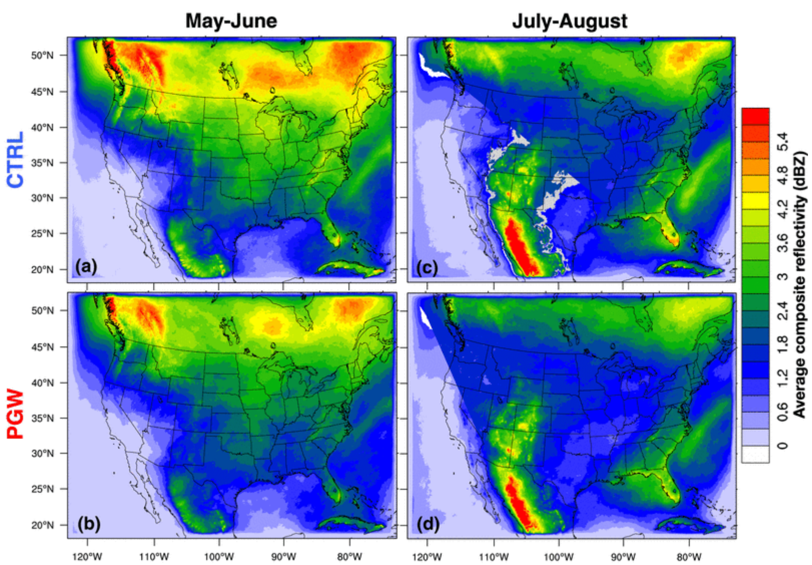

Figure 1. Average composite reflectivity over the CONUS domain in all 13-years of the simulations are shown by season (May–June and July–August) and by simulation type (CTRL and PGW). Taken from Rasmussen et al. (2017).

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