Observed warming in dry seasons over northern South America has an anthropogenic origin

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Abstract

In this study, we investigate whether the climate over South America has changed as a result of human activity since the beginning of the industrial revolution and to what extent the recently observed changes in daily minimum (Tmin) and daily maximum (Tmax) temperature are consistent with climate change AR5 projections. To this end, in the first step we assess whether the observed changes are likely to have been due to natural (internal) variability alone, and if not, whether they are consistent with what models simulate as response to anthropogenic forcing. To address this question, we use several data sources: 1) projected response to greenhouse gas (GHG) forcing derived from 30 global climate simulations from CMIP5 archive, 2) projected response to GHG forcing from 1 regional climate model based on RCP4.5 scenario from CORDEX, 3) historical well-mixed greenhouse gas forcing only simulations 4) historical aerosol only forcing simulations with and without the "second indirect effect" of aerosol ("cloud lifetime effect"), 5) estimate of natural (internal) variability provided by 20,000-year of pre-industrial control simulations derived of CMIP5 archive.

Results indicate that, over the past decades, observed warming trends in Tmin and Tmax in dry seasons (JJA, SON) over northern South America can't be just due to natural (internal) variability and that externally forced changes have a significant (at 2.5% level) influence in the observed warming trends. Significance is estimated using long pre-industrial control simulations. We further assess the influence of several key climate modes on daily temperature over SA, such as the El Niño Southern Oscillation (ENSO), the Atlantic Multi-Decadal Oscillation (AMO), the Pacific Decadal Oscillation (PDO), and the Southern Annual Mode (SAM). We assess the robustness of detection results against subtracting from the observations that part of the temperature variability that can be attributed to those four natural modes of climate. The detection of externally forced changes in Tmin and Tmax in dry seasons are robust against the removal of

the fingerprint of the four natural modes. However, in wet season (DJF, MAM) the natural modes of variability explain a substantial portion of Tmax and Tmin variability.

The pattern correlation and regression results clearly illustrate the concerted emergence of greenhouse gas (GHG) signal in the 21st century. However, none of the global and regional climate change projections, used in this study, reproduce the observed warming of up to 0.6 K/Decade in Tmax in 1983-2102 over Amazon Basin in austral spring (SON). Thus, besides the regional manifestation of GHG forcing, other external drivers have an imprint. Further results indicate that the small-scale component (spatial anomalies about the spatial mean trend) of anthropogenic aerosols also have a detectable influence in SON. We further show that there is an increasing trend in the incoming solar radiation over the northern SA in SON, that is larger than could be just due natural (internal) variability and that is distinct from the expected response to GHG forcing. In addition, there is an increasing trend in the incoming solar radiation over the northern SA. Given that the emissions of black carbon from fires are greatly increasing in Amazon region during dry season, we suggest that the positive trend in incoming solar radiation could partly be attributed to changes to clouds due to radiatively absorbing aerosol that increase the net short-wave radiation reaching the surface by reducing cloud cover, producing a daytime warming amplification and consequently increasing diurnal temperature range. Therefore, we suggest that the effect of aerosols-radiation-cloud interactions due to biomass burning aerosols from the large number of fires over Amazon Basin may be a missing driver in climate change projections.