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# Climate variability and inter-provincial migration in South America, 1970–2011

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ABSTRACT

We examine the effect of climate variability on human migration in South America. Our analyses draw on over 21 million observations of adults aged 15–40 from 25 censuses conducted in eight South American countries. Addressing limitations associated with methodological diversity among prior studies, we apply a common analytic approach and uniform definitions of migration and climate across all countries. We estimate the effects of climate variability on migration overall and also investigate heterogeneity across sex, age, and socioeconomic groups, across countries, and across historical climate conditions. We also disaggregate migration by the rural/urban status of destination. We find that exposure to monthly temperature shocks has the most consistent effects on migration relative to monthly rainfall shocks and gradual changes in climate over multi-year periods. We also find evidence of heterogeneity across demographic groups and countries. Analyses that disaggregate migration by the rural/urban status of destination suggest that much of the climate-related migration is directed toward urban areas. Overall, our results underscore the complexity of environment-migration linkages and challenge simplistic narratives that envision a linear and monolithic migratory response to changing climates.



## 1. Introduction

The effects of catastrophic events (e.g., extreme drought and flooding) on migration in the developing world often draw the attention of the public and policymakers. However, human migration is also consistently linked to less visible but more pervasive forms of climate variability, such as increased temperature (Gray and Mueller, 2012a,b; Marchiori et al., 2012; Bohra-Mishra et al., 2014; Mueller et al., 2014). Although evidence of such effects is much more robust than it was only ten years ago, nearly all existing studies have been relatively narrow in geographic scope (for an exception see Gray and Wise, 2016). As well, diverse methodologies have been applied across these studies. As a result, the extent to which previous findings are generalizable across populations and contexts is an open question.

Our study addresses these limitations by quantifying human migration responses to climate variability using 25 rounds of census microdata from eight South American countries, and applying a common methodology and uniform definitions of migration and climate. This approach allows us to assess the extent to which climate change is affecting migration patterns across a very large geographic region—nearly an entire continent—and across multiple decades. We are also able to test for differences in climate effects according to affected individuals' sex, age, educational attainment, country of residence, and the type of destination (i.e., urban or rural). Attention to heterogeneity in climate effects is important for our understanding of behavioral responses to environmental change. Variations in response to similar changes in climate suggest systematic differences in the adaptation mechanisms that affected individuals are able or likely to use. Studying such patterns is merited since understanding the contours of how response patterns are distributed is a requisite for designing effective social protection policies vis-à-vis climate impacts. Evidence regarding the composition of climate-induced migration is also necessary to assess the likely social and economic consequences of these migration streams. Recent evidence shows that environmentally-induced migration in developing countries can bear negative consequences on the wages of residents in the receiving communities (Strobl and Valfort, 2015; Maystadt et al., 2016). Yet exactly who these migrants will affect depends on where they go and what skillset they bring to the destination, a question that has motivated large bodies of research on migration in general

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(Aydemir and Borjas, 2007; Sjaastad, 1962; Todaro, 1969). We begin to address this issue here by considering the characteristics of environmentally-induced migrants and the type of destinations they are moving to.

The remainder of the paper proceeds as follows. In the next section, we review existing evidence regarding climate effects on migration and identify key substantive and methodological limits to existing knowledge. We then outline our research objectives, data, and methodology. Next, we present our estimates of overall climate effects on inter-province migration, and test for heterogeneity across demographic groups. We then present estimates of climate effects on inter-province migration by the rural/urban status of destination using a subset of the data that includes information on destinations. As a final set of analyses, we assess whether the effects of climate variability on inter-province migration vary by country and historical climate conditions. We conclude by discussing our results and identifying implications for future research on this topic.

## 2. Climate and migration

As consensus formed around evidence of global anthropogenic climate change, concerns about climate-related migration—and so-called climate or environmental refugees—became increasingly widespread (Myers, 1997). While human migration continues to be one of the main social impacts of climate change, a more nuanced and evidence-based perspective has largely replaced predictions that climate change will uniformly cause large scale (and international) population movements (Black et al., 2011; Fussell et al., 2014; Hunter et al., 2015). The fundamental premise that climatic changes affect human migration patterns has largely not been disputed. The existence of such relationships has been shown across many studies (Bohra-Mishra et al., 2014; Gray and Mueller, 2012a; Hunter et al., 2015; Mueller et al., 2014; Nawrotzki et al., 2015), and is consistent with prior work linking climate anomalies to short-term welfare losses in many developing countries (Paxson, 1992; Jalan and Ravallion, 1999; Dercon, 2004; Kazianga and Udry, 2006). However, recent research has underlined a number of complexities and contingencies with respect to climate effects on migration. These include differences according to the type of climatic change, the demographic characteristics and socioeconomic status of affected populations, and the distance and direction of migration.

Multiple types of climatic variability have been shown to affect migration. Key distinctions among climate measures include that between temperature and rainfall, and according to whether the measure captures short-term shocks or anomalous conditions over longer periods of time (e.g., multiple years). Some prior studies have found significant rainfall effects (Gray and Mueller, 2012a; Henry et al., 2004), but recent findings suggest that temperature anomalies may also have consistent independent effects on migration (Bohra-Mishra et al., 2014; Gray and Wise, 2016; Mueller et al., 2014). Precipitation and temperature can plausibly affect mobility through a number of pathways or mechanisms, such as damaging housing and other physical infrastructure (DeWaard and Curtis, 2016; Fussell and Harris, 2014; Gray and Mueller, 2012b), causing physiological changes that shape household economic outcomes (e.g., lower productivity due to heat stress) (Graff Zivin et al., 2015; Hsiang, 2010), and through sector- or economy-wide impacts (Burke et al., 2015). Among this set of possible pathways, climate effects on migration have been most commonly hypothesized to occur via an agricultural mechanism in areas relying on subsistence agriculture (Kubik and Maurel, 2016; Nawrotzki and Bakhtsiyarava, 2016). In such a context, climate effects have been framed as first affecting agricultural production and then, through related effects on livelihoods, changing migration behavior (Gray and Mueller, 2012b; Mueller et al., 2014).

To this end, research regarding climate effects on agricultural production yields findings generally consistent with the migration literature. For example, evidence that abnormally high or low temperatures have adverse effects on agricultural production (Lobell and Asner, 2003; Lobell and Field, 2007; Peng et al., 2004) corresponds with findings showing strong temperature-migration links (Bohra-Mishra et al., 2014; Mueller et al., 2014). However, careful attention to the magnitude and direction of temperature anomalies appears warranted. As just one example, consider research that suggests that temperature effects on crop yields may be non-linear. In such cases, adverse climate effects on agriculture may only occur beyond certain temperature thresholds, with positive effects occurring as temperatures increase up to that critical value (Schlenker and Roberts, 2009). Likewise, other research has noted that abnormally low temperatures may also adversely affect agricultural production (Almaraz et al., 2008), suggesting the possibility of thresholds at both ends of an optimal temperature range for a given crop or crop system (Bardsley and Hugo, 2010; Bohra-Mishra et al., 2014). The complexity evident in this and other examples provides little in the way of clear hypotheses about the direction of climate effects on human mobility. The effect of warming and cooling on livelihoods (and thus migration) may be contingent upon the magnitude of the change and the critical thresholds present in particular agro-ecological systems affected by climate variability.

In addition to the distinction between temperature and rainfall effects, studies have shown significant climate effects on migration using measures of shocks at different time scales. Examples in the existing literature range from season-specific measures of climatic conditions (Mueller et al., 2014) to multi-year averages (Bohra-Mishra et al., 2014). The choice of measures has substantive implication since the behavioral responses to short-term shocks and slow-onset changes may be quite different. Responses to rapid-onset, short-duration shocks are largely framed in terms of *ex post* risk reduction: migration is a part of household strategies to mitigate the effects of adverse shocks on livelihoods, or to take advantage of a positive shock (Kleemans, 2014). Gradual changes in climatic conditions may also elicit behavioral changes—including migration—but the linkages are less clear since they may reflect differences in perceptions of change, ability to respond, and the availability of other *in situ* responses (Burke and Emerick, 2016; Nawrotzki and DeWaard, 2016).

The potential for heterogeneous outcomes according to individuals' ability to respond is consistent with expectations that climate-migration relationships are also shaped by social, economic, and political conditions in affected areas (Black et al., 2011; Hunter et al., 2015). Prior studies show that migratory responses to climatic variability differ according to demographic characteristics, socioeconomic status, and, in some cases, community-level variables such as migration networks (Nawrotzki et al., 2015). These characteristics are often viewed as correlates to vulnerability, determining both the severity of climate effects (e.g., on food security) and the set of possible responses to these changes. For example, in contexts with sex-segregated labor markets, male household members may be more likely to undertake labor-related migration in response to environmental changes (Gray, 2010). On the other hand, female-headed households may be in precarious economic situations that increase their likelihood of migration (Gray and Mueller, 2012b). Marriage-related migration is also common among women in some contexts. To the extent that marriage has economic implications for the affected households, one would expect these disproportionately female migration streams to be uniquely affected by weather shocks (Findley, 1994; Gray and Muller, 2012a).