



## Reply to Sutton et al.: Relationship between temperature and conflict is robust

In a recent paper, we documented strong historical linkages between temperature and civil conflict in Africa (1). Sutton et al. (2) raise two concerns with our findings: that the relationship between temperature and war is based on common trends and is therefore spurious, and that our model appears overly sensitive to small specification changes. Both concerns reflect a basic misunderstanding of the analysis.

In particular, Sutton et al. (2) worry that temperature might either “proxy” for other causal variables or be correlated over time with other unrelated processes that also affect civil war. The effect of temperature on war clearly occurs through some intermediate channel, and we argue for the likely role of precisely the variables that Sutton et al. (2) mention (soil moisture and agricultural productivity). High temperatures tend to reduce African crop yields and depress rural incomes (3), declines that many benchmark studies implicate in the incidence of civil war (4). However, because variables such as income both affect and are affected by civil conflict, including them directly as regressors is problematic (5), and thus proxy variables (what economists call instrumental variables) (6) must be used. The fact that temperature is a strong instrument for African economic outcomes underpins—rather than undermines—our study.

Furthermore, our econometric approach deals directly with the concern that temperature might be correlated over time with other explanatory variables: we identify the effects of temperature on conflict through year-to-year deviations from country-level average temperature, which are unlikely to be spuriously correlated to unrelated social phenomena. We control for the influence of unrelated trending variables using country-specific time trends that account for trends in conflict finance, decolonization, or any other time-varying unobservable of concern. That our temperature coefficient is robust to inclusion of these time trends suggests that temperature is indeed causal.

The second concern of Sutton et al. (2) is the apparent “gility” of the statistical models we present, evidenced by changes in  $R^2$  across the model specifications shown in ref. 1, table 1. The simple explanation for these changes is listed in the table caption: models 1 and 2 use different control variables than model 3. In particular, models 1 and 2 include country-specific time trends as control variables, whereas model 3 instead uses explicit controls for regime type and income. Because country-specific time trends will pick up the influence of all time-trending variables, models 1 and 2 will soak up more of the variation in our dependent variable and thus yield a higher model  $R^2$ .

Our paper does not argue that temperature is the only—or even the primary—determinant of civil war. Further work is needed to understand how climate affects civil war, and we note this clearly in our paper. The conclusion of Sutton et al. (2) that our study might “discourage meaningful engagement” is curious given the explicit suggestions for public policy engagement we offer in the paper’s conclusion. The temperature effects we document only make the identification of proper engagement strategies more important. We feel that our paper is a contribution to that effort.

**Marshall B. Burke<sup>a,1</sup>, Edward Miguel<sup>b</sup>, Shanker Satyanath<sup>c</sup>, John A. Dykema<sup>d</sup>, and David B. Lobell<sup>e</sup>**

<sup>a</sup>Department of Agricultural and Resource Economics and <sup>b</sup>Department of Economics, University of California, Berkeley, CA 94720; <sup>c</sup>Department of Politics, New York University, New York, NY 10012; <sup>d</sup>School of Engineering and Applied Sciences, Harvard University, Cambridge MA 02138; and <sup>e</sup>Program on Food Security and the Environment, Stanford University, Stanford, CA 94305

1. Burke MB, Miguel E, Satyanath S, Dykema JA, Lobell DB (2009) Warming increases the risk of civil war in Africa. *Proc Natl Acad Sci USA* 106:20670–20674.
2. Sutton A, et al. (2010) Does warming increase the risk of civil war in Africa? *Proc Natl Acad Sci USA* 107:E102.
3. Schlenker W, Lobell DB (2010) Robust negative impacts of climate change on African agriculture. *Environ Res Lett*, 10.1088/1748-9326/5/1/014010.
4. Collier P, Hoeffler A (2004) Greed and grievance in civil war. *Oxf Econ Pap* 56:563–595.
5. Miguel E, Satyanath S, Sergenti E (2004) Economic shocks and civil conflict: An instrumental variables approach. *J Polit Econ* 112:725–753.
6. Wooldridge JM (2002) *Econometric Analysis of Cross Section and Panel Data*. (MIT Press, Cambridge, MA).

Author contributions: M.B.B., E.M., S.S., J.A.D., and D.B.L. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

<sup>1</sup>To whom correspondence should be addressed. E-mail: marshall.burke@berkeley.edu.