LETTER

Reply to Burke et al.: Bias and climate war research

"Warming increases the risk of civil war in Africa," said Burke et al. (1). A more recent study by Buhaug (2) that comes to different conclusions is dismissed on "econometric" grounds and the authors find the subsequent debate on the true causal relationship "unhelpful" (3). Let me start by reiterating three simple facts that apparently are of little interest to Burke et al.:

i. Temperature has increased in most of Africa during the past 30 y. In the same period, the frequency of civil war, large and small, has declined. Both these trends are particularly strong in the past 15 y.

ii. The negative trend in conflict fatalities is even stronger. The casualty estimate for the average civil war in sub-Saharan Africa has decreased from approximately 6,100 deaths per year in the 1980s to "just" 1,600 annual deaths in the 2000s, a decrease of more than 70% in three decades (4).

iii. Temperature is statistically insignificant when added to standard models of civil war. Also, temperature is insignificant in the preferred model specification of Burke et al. (1) if regressed on standard measures of civil war.

In their response (3), Burke et al. raise two objections to the Buhaug study (2). First, they claim that models that fail to include both country-fixed effects and time trends suffer from severe omitted variable bias. Their suggested approach, however, is at odds with virtually all quantitative work on civil war, and if this critique were valid, it would render the civil war literature largely worthless. Indeed, it is quite remarkable that the alleged necessity of the time trends, which are fundamental for their result, has not been picked up by decades of quantitative conflict research.

Second, Burke et al. (3) argue that studying when small wars become larger wars, not when they begin, is interesting. It thus seems that their claim is about escalation rather than risk of civil war. At a minimum, then, their result should be robust to small changes in the severity threshold for major civil war. A more convincing approach would be to demonstrate that the annual rate of battle deaths increases with higher temperatures. As shown in Table 1, temperature fails both these tests.

Let me conclude by adding two more facts:

iv. In Burke et al.'s (1) preferred model, the temperature parameters contribute 0.002 pointed to the model's total explained variance ($R^2 = 0.657$). Linear predictions from this model are for all practical purposes identical to predictions from a model without temperature (Fig. 1). Whatever is explaining civil war in their analysis, it is not climate.

v. The relationship claimed by Burke et al. disappears completely when their original analysis is expanded to include more recent years. These authors now admit this fact (3). Still, for some reason, they keep insisting that the link between warming and civil war is robust. A more plausible interpretation is that their model is extremely sensitive to changes in data and specifications (5).

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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. Buhaug H (2010) Climate not to blame for African civil wars. *Proc Natl Acad Sci USA* 107:16477–16482.
3. Burke MB, Miguel E, Satyanath S, Dykema JA, Lobell DB (2010) Climate robustly linked to African civil war. *Proc Natl Acad Sci USA* 107:E185.
4. Peace Research Institute Oslo (2010) PRIO Battle Deaths Dataset v. 3.0. Available at http://www.prio.no/cscw/datasets/armed-conflict/battle-deaths/. Accessed October 25, 2010.
5. Buhaug H, Hegre H, Strand H (2010) Sensitivity analysis of climate variability and civil war. PRIO Paper. Available at http://www.prio.no/cscw/sicc. Accessed November 17, 2010.

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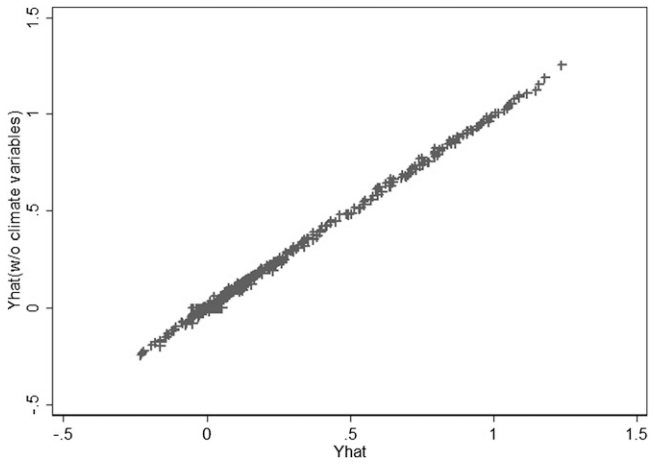

Fig. 1. Prediction scores with and without climate parameters. The figure plots predicted values of civil war for Model 2 of Burke et al. (1) (horizontal axis) and a similar model without climate parameters (vertical axis). The predictions correlate at an *r* value of 0.999. Note also that the linear models predict outside of the range of possible values (0,1), indicating that some observations have a negative civil war "risk," whereas others are more than 100% likely to experience a civil war.

Table 1. Alternative model specifications

Specification	Model 1: War years 1,000+	Model 2: War years 500+	Model 3: War years 2,000+	Model 4: Battle deaths	Model 5: Log battle deaths
Temperature	0.044*	0.008	0.003	−248.4	0.113
	(0.024)	(0.024)	(0.017)	(261.4)	(0.222)
Temperature_{t-1}	0.010	−0.001	−0.008	−19.5	−0.120
	(0.031)	(0.035)	(0.023)	(268.7)	(0.218)
Precipitation	−0.010	0.048	−0.042	−380.5	0.692
	(0.070)	(0.072)	(0.057)	(690.6)	(0.503)
$\text{Precipitation}_{t-1}$	0.054	0.057	−0.052	−96.8	0.191
	(0.051)	(0.075)	(0.054)	(711.6)	(0.506)
Intercept	−1.619	−0.511	0.233	7,350.4	−3.066
	(1.214)	(1.445)	(0.777)	(13,695.7)	(10.118)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Country time trends	Yes	Yes	Yes	Yes	Yes
R^2	0.67	0.69	0.62	0.54	0.72
Civil war observations	125	173	85	226	226
Observations	889	889	889	889	889

Coefficients are ordinary least-squares regression estimates with country-fixed effects and time trends; SEs are in parentheses. All dependent variables generated from the same source (4). Model 1 is a replication of Model 2 of Burke et al. (1); slight differences in estimates are a result of different sources for the conflict variable. Models 2 and 3 apply alternative minimum casualty thresholds for civil war (500 and 2,000 annual deaths, respectively). Models 4 and 5 estimate the effect of climate on the annual number of battle deaths (count and logged estimates, respectively).
*$P < 0.1$.